Silent Valley Waste Services Limited

Silent Valley Landfill

2016 Third Quarterly Monitoring Report (July to September)

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1 Introduction

This 2016 Third Quarterly Monitoring Report presents the surface water, groundwater, landfill gas and leachate results for the monitoring undertaken in the period July to September 2016 in accordance with the Silent Valley Environmental Permit (Permit no. MP3835SV, Ref. [1]). The permit has been amended as of 04/03/2016 to reflect the fact that the landfill is no longer accepting waste and is in the closure and aftercare phase. As a result of this the monitoring regimes have also been altered.

A total of seven groundwater wells, twelve surface water locations, fifteen gas monitoring wells and nine leachate monitoring wells/drain outfalls have been monitored during this period. The assessment of the monitoring results against relevant screening criteria is also presented.

The data has been collected as referenced in Schedule 3 of the Consolidated Permit amended as of 04/03/16 (Ref. [1]).

This report makes reference to the 2015 Annual Monitoring Report (Ref. [4]) and the 2016 First and Second Quarterly Monitoring Reports (Ref. [29 & 31]).

2 The Site

2.1 Site Location and Description

The site is currently occupied by Silent Valley Landfill and is located at National Grid Reference SO185 071, as shown on **Figure 1**.

The landfill area is bounded by steep valley sides to the west, north and east. The Cwm Merddog Nature Reserve, which is a designated SSSI site, is located to the south. The Nant Merddog stream runs down the valley and to the south of the site. Where the landfill is present, it has been diverted into a pipeline that passes to the east of the landfill.

Access to the landfill site is via a minor road which ascends the hillside from the village of Waun Lwyd, Cwm, Ebbw Vale.

The site lies in a partially infilled valley at a level of between 300m AOD and 420m AOD. The landfilled waste rises from the southern toe in a mound with an approximate maximum elevation of 405m AOD. The southern toe line of the landfill crosses the valley with levels ranging approximately from 310m AOD to 360m AOD and gradients of between 1 in 4 and 1 in 2.

No waste has been accepted at the landfill since August 2011.

The earthworks for the capping of the Phase 1 Landfill, that was found to not have a Landfill Directive compliant capping, has now been completed. The capping will prevent infiltration into the Phase 1 landfill and consequently is expected to achieve a reduction in leachate production within the landfill (refer to **Appendix A**).

2.2 Summary of cut-off and Monitoring systems

As part of the engineered mitigation measures pursuant to conditions included in the Permit for the site (Ref.[1]), a groundwater cut-off has been implemented by installing a line of pumping wells at the southern toe of the landfill to prevent the migration of any leachate-impacted groundwater downstream of landfill.

Phase 1 of this scheme was carried out in 2005 with the installation of eleven trial pumping and two monitoring wells. Phase 2 works were carried out between November 2006 and February 2007 and the pumping system was installed and commissioned in October 2007.

The system has been maintained and improved since October 2007, with the installation of an automatic water level monitoring system in 2009 and the addition of a stand-by compressor in 2010. Replacement pumps and low-draw pumps were also installed in a number of wells in early 2009.

In November 2009, new leachate monitoring wells were installed following a series of pumping tests at three locations. Between June and July 2010, further works have been undertaken to install additional monitoring and pumping wells and to replace one monitoring well.

Details of these improvement works are provided in **Appendix A**.

On-going non-compliance with regards to the non-hazardous species of ammoniacal nitrogen and chloride at one of the compliance wells, GW9, has been identified, as discussed in previous monitoring reports, and investigation works to address this have been undertaken. These are presented in the issued report (Ref. [5]) and are summarised in Appendix A. These works included a walkover of the area downstream of the site within the SSSI, with the relevant permissions of the NRW, to investigate the presence and quality of potential groundwater breakouts and streams inputting to the Nant Merddog. The walkover identified two break-outs and a monitoring regime has since been implemented at sampling locations SW1 to SW10 (refer to Section 3.3.1) with the objective to sample and analyse these waters for the presence of landfill leachate species. A full year of monitoring has been completed in January 2015 and the findings of this monitoring are presented and discussed in an updated issue version of the GW9 report, originally submitted to NRW in September 2013 and issued in May 2015 (Ref. [5]). Monitoring of the outbreak locations has now been included within the permit requirements until further review.

3 Monitoring Regime

3.1 Rainfall

Rainfall is measured at intervals of 0.5hrs daily, and measurements are used in the assessment of leachate and groundwater monitoring results.

3.2 Leachate

Monitoring of leachate for both leachate quality and leachate levels (to confirm leachate heads) is undertaken in accordance with the Aftercare Phase Environmental and Infrastructure Monitoring Program (Ref. [6]) and with sections S3.1 and S3.7 of the Consolidated Permit (Ref. [1])

3.2.1 Monitoring locations and frequency of monitoring

The following locations are monitored:

- Monitoring wells LC1A, LC2A, LC4A, LC5A, for leachate quality and leachate levels. These now replace wells LC1, LC2, LC4 and LC5 which were originally included in the Permit:
  - LC1A is located within Cell 1 of the landfill, on the eastern flank of the valley, in an area completed to the final level by 1996;
  - LC2A is located in Cell 2, on the northern flank of the landfill. This well is near to the base of the old valley bottom. Leachate in this area may be slightly diluted by groundwater ingress but this is not considered as significant as that present at the landfill toe. The waste in this area was placed by approximately 2000;
  - LC4A is located in Cell 4, on the north-western flank of the landfill, within relatively recently placed refuse (waste placed around 2002). Similarly to LC1A, this well is located away from the valley 'drain';
  - LC5A is located in Cell 5, on the western flank of the landfill. Waste in this area was lastly placed in August 2011;
- Monitoring wells L1A and L1B, for leachate quality and leachate levels (leachate levels from these wells however are not considered in the assessment of leachate head – see Section 3.2.2 below);
- Monitoring well L1, for leachate heads only;
- Leachate drain outfalls LP3A and LP4 feeding into a concrete holding leachate lagoon at the toe of the landfill, for leachate quality only. LP4 is a small direct input into the lagoon including the leachate pumped directly from Cell 5. LP3A monitors the combined leachate from several pipes/drains, which is collected in a sump and then pumped to the lagoon from where it is discharged to the foul sewer. The following flows are monitored from LP3A:
  - LP1: BSC outfall pipe at the toe of the landfill;
  - LP2: Armco outfall pipe at the toe of the landfill;
  - LP2A: combined outfall from LP2 and other groundwater (weep hole) inputs from LP3, LP5, LP6 and LP7.

  LP1 and LP2A are also monitored individually in addition to the monitoring locations agreed in the Permit (Ref. [1]). The results from these are discussed as part of the results obtained from LP3A.

The locations of the monitoring wells and leachate lagoons are presented on **Figure 2**.

Monitoring for leachate quality is undertaken quarterly in LC1A, LC2A, LC4A, LC5A, L1A, L1B, LP3A and LP4 for the determinand suite included in Table 6 and Table 7 of the Aftercare Phase Environmental and Infrastructure Monitoring Program report (Ref. [6]), as required by the Permit (Ref. [1]). A hazardous substance suite is to be carried out every four years in LC1A, LC2A, LC4A, LC5A, L1A, L1B, LP3A and LP4, as per the revised Permit (Ref. [1]).

Monitoring for leachate levels was previously undertaken **monthly** at LC1A, LC2A, LC4A, LC5A, L1A, L1B and L1. However following the new requirements from the amended permit monitoring of these levels is now undertaken **quarterly**.

3.2.2 Compliance criteria

Assessment limits have been set for leachate head and composition as agreed in the Aftercare Phase Environmental and Infrastructure Monitoring Program report (Ref. [6]) and in the Hydrogeological Risk Assessment (Ref. [8]). These are summarised in Tables 3.1 and 3.2 below.

3.2.2.1 Leachate head

As noted in Table 3.1, it is required that the monthly average leachate head level above the base of the landfill in LC1A, LC2A, LC4A, LC5A and L1 is less than 3m. The average leachate head compliance value was derived from the Hydrogeological Risk Assessment (Ref. [8]) undertaken in 2004, when limited leachate monitoring results were available and it was necessary to assume a probability density function for modelling the leachate head. The 3m head is considered the maximum head at which the landfill would be acting as if a liner had been placed at the bottom of the landfill in the 1980’s.

The leachate levels in L1A and L1B, although monitored, are not included in the calculation of the monthly leachate head average. These wells are located close together, but their response zones are at different depths within the waste. The measurements for L1A are considered to represent a perched leachate head and the records for L1B (with the response zone located at the bottom of the old valley) are likely to reflect an inflow of groundwater rather than a head of leachate above the base of the landfill (Ref. [5] and [11]). Because of the inflow of groundwater, leakage out of the landfill in this zone is considered minimal, and the measurements from L1B are considered to reflect a diluted leachate similar to that discharged from the landfill’s toe drains. Excluding leachate heads measurements from L1B from the monthly averages, as reported previously in other annual monitoring reports, is consistent with the assessment made in the Hydrogeological Risk Assessment (Ref. [8]) and the derivation of the assessment limit.

Table 3.1: Leachate Assessment Limits

Measurement	Assessment limit	Assessment Test
Leachate Head/Level	Maximum head assumed in risk assessment (3m)	Mean leachate head measured in wells as set out in the Permit, exceeds assessment limit on three consecutive surveys.
Leachate Composition	Maximum concentration assumed in risk assessment	Mean concentration from wells in waste mass exceeds assessment limit on three consecutive surveys.

3.2.2.2 Leachate quality

Assessment limits for the contaminants for leachate quality, listed in Table 3.2, below have also been set out in the Hydrogeological Risk Assessment (Ref. [8]), based on data from leachate wells L1, L1A and L1B.

For monitoring leachate quality a reduced suite of contaminants are tested for on a quarterly basis as per the amended permit [1]. The revised suite of contaminants tested are present below:

- Manganese (mg/l)
- Mercury (mg/l)
- Nickel (mg/l)
- Zinc (mg/l)
- pH (pH units)
- Conductivity (uS/cm)
- Alkalinity as $CaCO_3$ (mg/l)
- Ammoniacal Nitrogen (mg/l)
- Chloride (mg/l)
- Sulphate (mg/l)
- Redox Potential (mV)
- Total Organic Carbon (TOC) (mg/l)
- Dissolved Oxygen (DO) (mg/l)
- Suspended Solids (mg/l)
- Dissolved Solids (mg/l)

The assessment limits are compared with the calculated mean contaminant concentrations from the monitoring wells in waste the mass. If the mean concentrations from wells in the waste mass exceed the assessment levels on three consecutive surveys, contingency actions will be triggered, as described in the Aftercare Phase Environmental and Infrastructure Monitoring Program report (Ref. [6]) and summarised in Table 3.3.

Table 3.2 Leachate Acceptable Maximum Concentrations AMCs (from Ref. [8])

Contaminant	Acceptable Maximum Concentration AMCs (mg/l)
NH_3	526
Chloride	1408
Sulphate	999
Nickel	0.0681
Zinc	1.38
Mercury	0.56 µg/l

Table 3.3: Leachate Monitoring Contingency Actions (from Ref. [8])

Contingency Action	Response Time
Report to EA including initial assessment of possible causes	1 month
Report to EA on re-appraisal of risk to groundwater and surface water and options for corrective measures	3 months
If risks are acceptable revise assessment criteria as appropriate. Continue monitoring. If risks are not acceptable implement agreed corrective actions (i.e. increase monitoring and frequency as agreed with the EA)	6 months

3.3 Surface Water

Surface water sampling of the Nant Merddog is undertaken in accordance with the sampling protocols defined in the Aftercare Phase Environmental and Infrastructure Monitoring Program Report (Ref. [6]).

3.3.1 Monitoring locations and frequency of monitoring

Monitoring of surface water quality is currently being undertaken at the locations listed in Table 3.4 below in order to identify any adverse impact resulting from escape of leachate from the landfill, particularly in relation to the Nant Merddog.

Monitoring point locations are marked on **Figure 2** and **Figure 3**.

Table 3.4: Surface Water Monitoring Locations

Monitoring Point		Location
Upstream locations	SWU	On the Nant Merddog, north (upstream) of landfill
	SW2AI	On drainage ditch system on northern perimeter of landfill. The ditch intercepts surface water run-off from the area north of the landfill and discharges to the Nant Merddog
	SWW4	On drainage ditch system north of the landfill, at point where the northern perimeter ditch system joins the eastern perimeter ditch system
	SWW1	On ditch system north-west of the landfill
	SWW2	On ditch system north-west of the landfill
Downstream locations	SWD	On the Nant Merddog, approximately 70m downstream of the landfill (15m downstream of the point where the diverted stream joins its original course).
	SWD1	On the Nant Merddog, approximately 300m downstream of SWD
	SW1, SW2, SW3, SW9 and SW10	A stream, feeding into the Nant Merddog some 190m downstream of SWD issuing on the eastern slope of the valley
	SW4, SW5, SW6	A potential groundwater out-break, feeding into the Nant Merddog some 155m downstream of SWD issuing on the eastern slope of the valley
	SW7	Nant Merddog immediately downstream of the above confluence
	SW8	Nant Merddog immediately downstream of the above stream confluence

Surface water sampling locations SW1 to SW10 have been set up and monitored since December 2013 following the recommendations made in the Arup 2011 report on investigations into the western flank of the cut-off system (Ref. [11]) and a walkover through the SSSI south of the landfill in November 2013. The monitoring regime was implemented in order to confirm the presence of landfill leachate species in these groundwater breakouts and the impact to the Nant Merddog.

Originally the monitoring frequency regime was as follows:

- monthly monitoring of locations SWD and SDW1 for a comprehensive suite;
- monthly monitoring of locations SWU, SWW1, SWW2, SW2AI, SWW4 for a limited suite;
- six-monthly monitoring of locations SWW1, SWW2, SWU, SW2AI, SWW4 for a comprehensive suite;
- monthly monitoring of surface water monitoring locations SW1 to SW10 for ammoniacal nitrogen, chloride and mercury.

However the regime has now altered for surface water monitoring and is in accordance to the amended requirements of the Permit (Ref. [1]), as follows:

- **quarterly** monitoring for locations SWD and SDW1 for a comprehensive suite;
- **six-monthly** monitoring for locations SWU, SWW1, SWW2, SW2AI, SWW4 for a comprehensive suite;
- **monthly** monitoring of the surface water monitoring locations SW1 to SW10 continuous for ammoniacal nitrogen, chloride and mercury.

3.3.2 Compliance criteria

The compliance criteria for surface water quality are the Environmental Quality Standards (EQS) which are appropriate for the Nant Merddog for all contaminants for which these are available, as defined in Table 13 of the Aftercare Phase Environmental and Infrastructure Monitoring Program report (Ref. [6]).

For monitoring surface water a reduced suite of contaminants are tested for on a quarterly basis as per the amended permit [1]. The revised suite of contaminants tested are present below:

- Manganese (mg/l)
- Mercury (mg/l)
- Nickel (mg/l)
- Zinc (mg/l)
- pH (pH units)
- Conductivity (uS/cm)
- Alkalinity as $CaCO_3$ (mg/l)
- Ammoniacal Nitrogen (mg/l)
- Chloride (mg/l)
- Sulphate (mg/l)
- Redox Potential (mV)
- Total Organic Carbon (TOC) (mg/l)
- Dissolved Oxygen (DO) (mg/l)
- Suspended Solids (mg/l)

Site specific EQS values for freshwater have been derived, where applicable (typically for heavy metals including nickel and zinc), based on the annual average concentration of water hardness in the Nant Merddog downstream of the landfill. This was calculated using calcium concentrations measured at SWD and SWD1. The water hardness ranged from 66 to 102mg/l as $CaCO_3$ during the three-monthly monitoring period in 2010. The average concentration was calculated at 89.8mg/l as $CaCO_3$, placing the Nant Merddog in the 50-100 mg/l as $CaCO_3$ Freshwater EQS hardness range. Therefore, EQS values, when dependent on the hardness, were selected for this range. All compliance criteria values are set out in **Table 3.5**.

The hardness of the Nant Merddog has also been measured upstream of the landfill at SWU, with values ranging between 13 and 19mg/l as $CaCO_3$.

Table 3.5: Compliance Criteria for the Nant Merddog

Contaminant	EQS (µg/l)	Compliance Criteria (µg/l)	Notes
Ammoniacal Nitrogen (unionised)	15	15	EQS
Sulphate	400 mg/l	400 mg/l	EQS
Chloride	250 mg/l	250 mg/l	EQS
Nickel (Dissolved)	50 – 200 *	100	EQS
Zinc (Total)	8 – 125 *	50	EQS
Mercury (Total)	1	1	EQS
Manganese	30	30	EQS

Notes:
* denotes hardness-dependent EQS values.

As discussed in the Aftercare Phase Environmental and Infrastructure Monitoring Program report (Ref. [6]), background water quality monitoring upstream of the landfill indicates that concentrations of some determinands may exceed the compliance criteria in some cases. The assessment of breaches of compliance criteria therefore includes an assessment of background levels. Such breaches may be acceptable in cases where they result from background levels. No Assessment Levels are set, but assessment is made by monitoring the data for trends of increasing contaminant concentrations.

3.4 Groundwater

Monitoring of groundwater is undertaken in accordance with Table S3.9 of the Permit (Ref. [1]), the Environment Agency guidance on groundwater monitoring (Ref. [12]) and in line with the monitoring schedule agreed with the Environment Agency, as discussed in the 2010 Annual Monitoring Report (Ref. [13]).

3.4.1 Monitoring locations and frequency of monitoring

Taking in to account the changes to the permit, the following locations are currently monitored:

- Monitoring wells GW3A, GW4 and GW11A, located upstream of the landfill (referred to as 'upstream wells');
- Monitoring wells GW6, GW7, GW9, GW10, and GW12, located downstream of the landfill (referred to as 'downstream wells' or 'compliance wells');

GW11A could not be monitored during the third quarter due to the location being covered by fill material during the construction of the Waste Transfer Station. The locations of the monitoring wells are presented on **Figure 2**.

Changes to the permit include the removal of monitoring wells GW1, GW5 and GW8 from the monitoring regime.

All wells were originally monitored for groundwater quality and groundwater levels were recorded in the compliance wells, at monthly intervals. The groundwater monitoring is now conducted **quarterly** rather than monthly.

For details of previous monitoring undertaken at the site, refer to **Appendix B**.

3.4.2 Compliance criteria

Control and Trigger Levels have been developed for those contaminants addressed in the Hydrogeological Risk Assessment (Ref. [14]) as shown in **Table 3.6**. These contaminants cover a range of substances indicative of landfill leachate contamination which are potentially harmful to downstream groundwater and to the aquatic environment of the Nant Merddog.

The Control Levels allow the identification of any unexpected or adverse trends in the monitoring data and should be treated as an early warning system to enable investigative or corrective measures to be implemented, particularly where Trigger Levels might be breached.

Trigger Levels are specific compliance levels, or regulatory standards. They are defined as criteria at which significant adverse environmental effects and/or breaches of legislation have occurred. Such effects would be consistent with the groundwater having been polluted.

As discussed in the Hydrogeological Risk Assessment Supplementary Revision (Ref. [14]), during routine reviews of the groundwater monitoring results, it was noted that for certain contaminants (e.g. mercury, zinc and manganese), background concentrations measured upstream of the landfill in groundwater and surface water exceeded the applied Control and Trigger Levels wells (or in the case of manganese, the corresponding EQS), particularly following high rainfall events. As a result, a review of the background levels and their likely origin was undertaken and revised Control and Trigger Levels (or in the case of manganese, assessment level) were proposed and agreed with the Environment Agency, as presented in Table 3.6.

Table 3.6: Groundwater Control and Trigger Levels (and Assessment Level for manganese)

Determinand	Control Levels (mg/l)		Trigger Level (mg/l)
	A	B	
Ammoniacal Nitrogen	0.8*	0.9*	1.0*
Chloride	210*	230*	250*
Mercury	0.0001**	0.00015**	0.0002**
Nickel	0.03*	0.04*	0.05*
Sulphate	300*	350*	400*
Zinc	0.02**	0.035**	0.05**
Manganese	-	-	1.0**

Notes:

* From Hydrogeological Risk Assessment (Ref. [8]).

** From Hydrogeological Risk Assessment Supplementary Revision (Ref. [14]) and Groundwater Monitoring: Trigger Levels report (Ref. [15]).

For contaminants where Control and Trigger Levels do not exist, site-specific EQS values for freshwater have been derived, where applicable (typically for heavy metals including nickel and zinc), based on the annual average concentration of water hardness in the Nant Merddog (also refer to Section 3.2.2) and used in the assessment.

3.5 Landfill Gas

Landfill gas monitoring is carried out in accordance with the requirements of the Permit (Ref. [1]).

3.5.1 Monitoring locations and frequency of monitoring

The following locations are monitored for landfill gas (methane and carbon dioxide):

- GWM1 to GMW10;
- GMW12 to GMW14;
- GMW17 and GMW18.

These wells are located around the site perimeter, as shown on **Figure 2**.

The original well GMW1 was damaged at some point in the past and was replaced with GAS01 in February 2007. For ease of reference, this well is now referred to as GMW1.

All wells are monitored monthly.

3.5.2 Compliance criteria

Control and Trigger Levels for landfill gas have been established by Golder Associates (Ref. [16]).

For each monitored well, up to three monitoring points (valves) have been installed at different depths. Trigger and Control Levels have therefore been set for each monitoring point, where appropriate.

Currently, no Control and Trigger Levels are set for GMW1, GMW8, GMW9, GMW10, GMW17 and GMW18. GMW8, 9 and 10 are located within 20m of the waste mass, in conflict with the Environment Agency's guidance on landfill gas management (Ref. [17]), which recommends perimeter wells be located at a distance greater than 20m from the boundary of the waste. To overcome this, additional wells (GWM12, 13, 14 17 and 18) were installed at a greater distance from the landfill boundary, and Trigger Levels derived for GWM12, GWM13 and GMW14. Monitoring at GAS01 (now GMW1), GMW17 and GMW18 is now required by the Permit (Ref. [1]), however there are still no Control and Trigger Levels for these locations.

As stated by Golder Associates (Ref. [16]), single exceedances need no immediate action. However, ongoing exceedances require the informing of the relevant people and organisation and appropriate measures of identification and solutions identified.

4 Monitoring Results

4.1 Rainfall

Measured rainfall data is illustrated in **Appendix C**, **Figures C1** to **C3**.

Figure C1 shows daily rainfall totals for the period July 2013 to June 2016 and highlights the dates when samples have been taken for analysis from the downstream compliance wells GW6, GW7, GW9, GW10, and GW12.

Figure C2 shows monthly rainfall totals for the same period, with monthly leachate head average data for 2015 for comparison, as further discussed in **Section 4.2.2**.

Figure C3 shows monthly rainfall from July 2010 to June 2016.

July 2016 had a considerably lower monthly rainfall total compared to the first two quarters in 2016 with a total of 25.4mm. This monthly rainfall level was also lower than July 2015 when 62.3mm of rain fell.

August 2016 had a higher monthly rainfall total than July 2016 with 78.5mm of rain falling over the month. This was considerably lower than the August 2015 total of 147.5mm.

September 2016 had 93.5mm of rainfall which is more than the September 2015 monthly total of 57.4mm.

The combined total for the first three quarters of 2016 is 911.2mm. If we compare this to the first three quarters of 2015 only 678.4mm of rain fell. These results mean that so far in 2016 there have been elevated levels of rainfall compared to the same time period in 2015.

4.2 Leachate

4.2.1 Leachate Quality Monitoring

Leachate quality monitoring results from within the waste body and from leachate standpipes are presented in **Appendix D**, **Table D1**. Leachate is now tested for a reduced suite of contaminants, see section 3.2.2. Contaminant concentrations' averages and Acceptable Maximum Concentrations (ACMs) for mercury, nickel, zinc, ammoniacal nitrogen, chloride and sulphate are also shown in the table.

In accordance with the Permit requirements, the leachate quality monitoring has been undertaken quarterly, in July 2016.

The average values for each of the monitored contaminants from the third quarter were all below the AMC values. The average value of ammoniacal nitrogen, recorded as 265mg/l has dropped back below the AMC value of 526mg/l, compared to the elevated quarterly value recorded in April of 627mg/l.

For the respective AMCs refer to **Table 3.2**.

It should be noted that mercury has been consistently recorded below the laboratory analytical detection limit of 0.1µg/l in all the analysed samples. This is a continuing trend since 2013, when mercury was also reported below the laboratory analytical detection limit during all the four monitoring rounds in each year.

Consequently, the monitored concentrations of mercury have not only been below the Acceptable Maximum Concentration (refer to **Table 3.2**), but also below the Trigger Level set for the groundwater compliance wells (see **Table 3.6**).

4.2.2 Leachate Levels Monitoring

Field monitoring readings report the depths to leachate from the top of each well casing. The leachate head for each well is calculated as follows:

> The leachate level (mAOD) is calculated by subtracting the depth to leachate (m) from the well head elevation (mAOD). The leachate level (mAOD) is then subtracted from the base of landfill level (mAOD).

The well height and ground level elevations were re-surveyed in 2015 and these levels have been used to calculate the leachate elevation for this quarter and also for re-calculating the leachate head levels for the first two quarters of 2016. Leachate levels monitoring results are presented in **Appendix D**, **Table D2.**

The quarterly average leachate heads were calculated for July with an average leachate head level of 2.68m recorded. The average level for July was the highest of the year so far with June recording the lowest at 2.46m, however all have still remained well within the 3m limit stipulated in the Permit (Ref. [1]).

The monthly leachate head averages generally show a good correlation with the rainfall data, with higher leachate heads typically associated with higher rainfall, as shown on **Appendix C**, **Figure C2**. The figure shows a peak leachate head in July 2016, and is also affected by the absence of readings in March.

As discussed in the Quarterly and Annual Monitoring reports for 2015 (Ref. [2], [21], [22]), the monthly leachate head in LC5A showed a continuous rising trend throughout 2015, with the highest recorded value of 4.96m in October 2015. This was a continuing trend from 2014. The level of leachate in LC5A dropped back down to below 4m during the beginning of 2016, increasing to a maximum of 4.96m in July 2016 suggesting a rising trend throughout this year. A review of the monitoring results and investigation on the possible causes of the level increase in LC5A is currently being undertaken. A topographical survey re-measuring the height of well casing above ground level at each leachate well locations was undertaken in 2015 and the revised levels have been used to calculate leachate head during 2016. Further initial recommendations include undertaking well development works and permeability tests in LC5A. The permeability tests should be undertaken in a period of dry weather to avoid the influence of rainfall.

Leachate pumping in the area of LC5A is currently being undertaken from gas extraction wells nearby and it is recommended that this is continued.

The average leachate head per year has been increasing since 2013 where the average leachate head was 1.01m and the max leachate head was 2.45m. In 2014 the average leachate head had increased to 1.14m and the max leachate head value was 3.95m. The increasing trend continued in 2015 where the average leachate head was 1.81m and the max leachate head was recorded at 4.96m. So far in 2016 the average leachate head has risen again to 2.56m and the current max value for leachate head is 4.81m. The extent of the increase in average leachate head in 2016 is likely due to the revised elevation levels being used to calculate the leachate head.

All the max leachate values have been recorded at LC5A which is showing the strongest increasing trend. The other wells are also showing a slight increasing trend but not to the same degree as LC5A. The leachate head levels for the remainder of 2016 will be scrutinised and further analysed.

No significant variations of the leachate heads have been observed in the remaining leachate wells, with the monitored levels of L1, LC1A, LC2A and LC4A generally comparable during 2016. The levels have increased from 2015 however this is likely due to revised survey data being used in the calculations for 2016.

4.3 Surface Water

4.3.1 Surface Water Quality Monitoring

The surface water quality monitoring results are presented in **Appendix D**, **Tables D3** and **D4**, and graphically in **Appendix C**, **Figure C4**.

Commentaries are provided for upstream and downstream monitoring points in the Nant Merddog, including locations SW1 to SW10 downstream of the landfill, as discussed below.

4.3.1.1 SWU, SW2A1, SWW4, SWW1 and SWW2 (upstream of the landfill)

As the monitoring of these locations is now six-monthly rather than monthly, as stated by the amended permit, there are no results for this quarter for the locations stated above.

4.3.1.2 SWD and SWD1 (downstream of the landfill)

A full suite of determinands is analysed on downstream samples SWD and SWD1 on a quarterly basis, as discussed in **Section 3.3.1**.

No ammoniacal nitrogen was recorded at these sampling locations in the third quarter of 2016, with concentrations measured below the laboratory detection limit of 0.41mg/l, as during the first and second quarters and the entire of 2015 and 2014. The calculated concentration of unionised ammoniacal nitrogen for both locations was above the assessment level of 0.015mg/l in the third quarter of 2016.

Chloride and sulphate concentrations were reported below the applied EQS of 250mg/l for chloride and 400mg/l for sulphate. The chloride concentration values in the two sampling locations in the third quarter of 2016 were 6.0mg/l at SWD and 11.2mg/l at SWD1. Sulphate concentrations were also well below the EQS freshwater level with values of 97.9mg/l and 93.5mg/l at SWD and SWD1 respectively.

Zinc concentrations in the third quarter tested below the detection limit of 0.018mg/l for both SWD and SWD1 which continues the trend for this year with only SWD testing above the detection limit with a value of 0.048mg/l in January. But this value was still below the EQS freshwater value.

Manganese was detected at concentrations below the applied EQS of 0.03mg/l at both SWD and SWD1 with concentrations of 0.0077mg/l and 0.0070mg/l respectively.

Nickel was also detected well below the applied EQS of 0.1mg/l in the third monitoring quarter.

All the other concentrations for contaminants with available EQS values were measured below the laboratory detection limits.

4.3.1.3 SW1 to SW10 (downstream of the landfill)

Surface water sampling at SW1 to SW10 has been carried out since December 2013, comprising rounds of sampling for testing of ammoniacal nitrogen, chloride and mercury. Sampling was not able to be undertaken at locations SW9 in July and SW9 and SW10 in August due to them being dry.

During the reporting period, ammoniacal nitrogen was measured below the laboratory detection limit of 0.41mg/l at all monitoring points. The unionised ammoniacal nitrogen concentration could not be calculated as no pH sampling was undertaken throughout the third quarter.

Chloride was also measured well below the EQS limit during the whole of the second quarter. The chloride concentration levels fluctuated between the highest point of 75.5mg/l at SW4 in July and the lowest point of 5.5mg/l at SW8 and WS10 in September. Furthermore SW4 had consistently the highest concentration of chloride and SW8 had consistently the lowest concentration of chloride across the third quarter.

Mercury was below the detection level of 0.10ug/l for July, August and September which is carrying on the trend as none of the monitoring points have tested above the detection level since May 2014.

4.4 Groundwater

4.4.1 Groundwater Quality Monitoring

Groundwater quality monitoring results are presented in graphical format in **Appendix C**, **Figures C6** and **C7** and in tabular format in **Appendix D**, **Table D5.** In the table, exceedances of the compliance criteria are highlighted using a colour-coded legend.

Chloride and ammoniacal nitrogen are the two main indicators of groundwater contamination by landfill leachate at the site. Chloride, in particular, is not attenuated in the groundwater by processes other than dilution, and would be expected to be present wherever leachate contamination occurs.

The groundwater quality monitoring results are detailed in the following sub-sections.

Commentaries are provided for both upstream and downstream compliance wells. As reported in previous monitoring reports, the results from the latter have been compiled in relation to the different sandstone strata in which they are installed, i.e. S1, S2 and S3.

As mentioned earlier, in the monitoring regime section, the monitoring frequency of groundwater testing has now changed and is now quarterly rather than monthly. Therefore the monitoring was undertaken only in July within this reporting period. The monitoring suite has also been reduced and no longer includes copper.

4.4.1.1 Upstream Groundwater wells GW3A, GW4 and GW11A

GW3A and GW4 monitor the sandstone strata classified as S3-East and GW11 has been installed in the sandstone strata classified as S2-West. However the upstream well GW11A was not sampled as the well was inaccessible due to the construction of the Waste Transfer Station.

During the third quarter of 2016, ammoniacal nitrogen concentrations were measured below the laboratory limit of detection of 0.41mg/l in both upstream wells, GW3A and GW4.

Chloride was measured at below the control and trigger levels at concentrations of 12.5mg/l for GW3A and 33.6mg/l for GW4.

Mercury concentrations were recorded below the laboratory limit of detection of 0.1µg/l in all the upstream wells.

Zinc concentrations continue to exceed the applied Trigger Level of 0.05 mg/l in GW3A and GW4 with concentrations measured at 0.0607mg/l and 0.0672mg/l respectively.

The elevated levels of zinc in both upstream groundwater and surface water have been recorded since mid-2010. These results suggest a zinc source other than the landfill.

Manganese concentrations continue to be elevated at the GW4 well recording a level of 1.36mg/l which is above the assessment level. This result indicates a source of manganese other than the landfill. Manganese is a typical contaminant of mine drainage, which is considered to be impacting the groundwater in the locale of the landfill.

In the upstream wells, sulphate concentrations were recorded at 66.6mg/l in GW4 and 110.0mg/l in GW3A. These values are well below any of the assessment criteria.

No other exceedances were detected during the reporting period in the upstream wells.

4.4.1.2 Downstream Groundwater well GW10

GW10 has been installed in the sandstone strata classified as S3-East.

Ammoniacal nitrogen was measured below the laboratory detection limit of 0.41mg/l and therefore below the trigger level of 1mg/l as set out in the Permit. Unionised ammoniacal nitrogen was recorded below the EQS freshwater level of 0.015mg/l.

Chloride was measured at a low concentration of 24.6mg/l.

Mercury was measured below the laboratory detection limit of <0.1ug/l in July compared to a level of 0.16ug/l in April 2016, recorded above the control levels.

In July manganese concentrations were measured below both the assessment level and the EQS freshwater level with a result of 0.0137mg/l being recorded.

Zinc concentrations were once again measured above the compliance level in July with a level of 0.0791mg/l being recorded. This level exceeds the 0.05mg/l trigger level. The absence or low levels of leachate species in GW10 during the monitored months and the elevated zinc concentrations (above the Freshwater EQS, Control and Trigger Levels) also recorded in the upstream wells throughout the reporting period suggest a source of zinc other than the landfill.

4.4.1.3 Downstream Groundwater well GW9

GW9 has been installed in the sandstone strata classified as S2-East.

GW9 continues to be non-compliant for ammoniacal nitrogen in relation to the Trigger Level of 1mg/l (refer to previous monitoring reports, Reference [2], [4]). Investigation works to address this have been undertaken in 2014 and are presented in a separate report (Reference [11]).

The ammoniacal nitrogen concentration was above the trigger level with a concentration of 8.70mg/l being recorded for July 2016. However, this level has reduced considerably since April when a level of 19.10mg/l was recorded. As a result of the elevated ammoniacal nitrogen concentrations, the calculated unionised ammoniacal nitrogen concentration is also elevated at GW9 and above the compliance criteria (Freshwater EQS) for July with a recorded level of 0.0652mg/l but again lower than the level recorded in April of 0.6545mg/l.

Mercury concentrations were recorded below the laboratory limit of detection.

Zinc concentrations continued to exceed control level A of 0.02mg/l but the July concentration of 0.0515mg/l also exceeded the trigger level of 0.05mg/l, as it did in February 2016. Elevated concentrations of zinc were monitored in the upstream wells during the reporting period (refer to section 4.4.1.1). This suggests that a source of zinc other than the landfill exists.

Manganese rose above the assessment and EQS freshwater levels for July with a recorded value of 0.401mg/l but is still below the assessment level of 1.0mg/l. This still represents a difference to the first quarter where January had a manganese concentration of 1.32mg/l which was well above the assessment level. Elevated background manganese concentrations have been observed in the upstream groundwater wells during the reporting period, suggesting a source of manganese other than the landfill.

The chloride concentration for April was 56.3mg/l which is well below the control and trigger levels.

No other exceedances were detected in GW9 during the reporting period.

4.4.1.4 Downstream Groundwater well GW12

GW12 has been installed in the sandstone strata classified as S2-West.

The concentration of ammoniacal nitrogen has dropped below the trigger level of 1mg/l and the control levels of 0.8mg/l and 0.9mg/l. In January and February the levels of ammoniacal nitrogen were 10.2mg/l and 9.54mg/l respectively and in April the ammoniacal nitrogen level was 0.85mg/l, still above the control level A value of 0.8mg/l. In July the level dropped to <0.41mg/l with a unionised ammoniacal nitrogen level of 0.0029mg/l which is below the EQS freshwater level.

Mercury levels in July tested above the trigger level with a value of 0.82ug/l being recorded. This is higher than the second quarter level of 0.2ug/l recorded in April. Leachate quality testing did not detect mercury, therefore considering the presence of mercury in the groundwater entering the landfill, the elevated mercury in the groundwater is not considered to originate from the landfill.

Zinc continued to be measured at increasing concentrations above the Control and Trigger Levels, following a similar trend since 2014. The value recorded for July was 0.504mg/l which is above the trigger level and following the same trend shown previously for this monitoring well.

Copper has previously been recorded during the first two quarters of 2016. Copper has not been tested this quarter as it is no longer considered a substance of concern and therefore is no longer part of the suite of testing as set out within the Permit[1].

Sulphate recorded an exceedance of the Control Level (300mg/l) in January 2016 at 385mg/l, and in February 2016 at 361mg/l with a higher level of 422mg/l recorded in April 2016 which was above the EQS freshwater level and shows an increasing trend from 2015. However, the reading from this quarter is 216.0mg/l which is well below the compliance levels. The increasing trend of sulphate concentration at GW12 can be shown by looking at the yearly average sulphate concentrations in 2014, 149.2mg/l which rose to 222.9mg/l in 2015 and so far in 2016 the average is 346.0mg/l. However, this quarter may signify the start of a downward trend in sulphate levels.

Elevated concentrations of manganese were reported above the EQS level of 0.03mg/l in January and February during the first quarter. However during the second quarter manganese levels had fallen down to 0.007mg/l and during the third quarter in July manganese was recorded at a level of 0.0159mg/l, which is below the compliance levels.

No other exceedances were recorded at this well during the third quarter.

4.4.1.5 Downstream Groundwater wells GW6 and GW7

GW6 and GW7 have been installed in the centre of the valley in the sandstone strata classified as S1.

Ammoniacal nitrogen concentrations were once again below the analytical detection limit for July at both wells. The unionised ammoniacal nitrogen levels were recorded below the EQS freshwater level in both wells also. The recorded temperature has increased and pH readings have decreased at GW7 compared to April therefore the calculated level of unionised ammoniacal nitrogen had dropped below the EQS freshwater level.

Sulphates were also measured within compliance levels in both wells with 90.6mg/l at GW6 and 86.4mg/l at GW7.

The GW6 well has recorded mercury, 0.29ug/l, above the trigger level of 0.2ug/l for this quarter. This is following elevated levels of mercury, 0.13ug/l and 0.12ug/l recorded in February and April respectively, above the control level A value of 0.1ug/l. The recorded concentrations are still below the EQS freshwater level. GW7 measured below the compliance level for mercury in July. Leachate quality testing did not detect mercury and therefore considering the presence of mercury in groundwater entering the landfill, landfill is not considered a source of the elevated mercury within the groundwater.

Manganese concentrations were recorded above the EQS freshwater level (0.03mg/l) in July at 0.249mg/l in GW7. No other exceedances of manganese were recorded in GW6. This is a continuing trend since 2015, and the elevated background manganese concentrations in the first and second quarters of 2016 has been observed at the upstream groundwater wells GW3A and GW4, suggesting a source of manganese other than the landfill.

Zinc continues to exceed the Control and Trigger levels this year, following a trend since 2015. Zinc was measured at 0.36mg/l at GW6 which is above the trigger level. GW7 exceeded the control level A but below the trigger level with a 0.0322mg/l level being recorded. There is evidence of high levels of zinc upstream above the level recorded in GW7 but at a lower level than that recorded in GW6. Considering that the zinc concentrations measured in the landfill leachate are significantly lower than those in the compliance wells, landfill is unlikely to be a source of these exceedances.

No other exceedances were recorded at this well during the third quarter.

4.4.2 Groundwater Levels Monitoring

Groundwater levels have been monitored in the compliance wells GW6, GW7, GW9, GW10 and GW12, as discussed in **Section 3.4**. The monitoring results are illustrated graphically in **Appendix C**, **Figure C8**. Prior to this quarter groundwater levels were monitored monthly. However, as stated in the monitoring regime, groundwater levels are now monitored quarterly according to the amended permit.

Water levels in all monitored wells continue to be recorded at broadly similar levels in each well. There is a slight increase in GW9 with the groundwater level rising by 0.75m compared to the level recorded in April. The general lack of variation is consistent with the locations of the compliance wells, i.e. some 30m downstream of the pumping cut-off system that is expected to exert a controlling influence on groundwater levels downstream of the landfill.

4.5 Landfill Gas

4.5.1 Landfill Gas Quality Monitoring

The landfill gas monitoring results are presented in **Appendix D**, **Table D6** for the period January to September 2016. The results are discussed in detail in the sub-sections below for both monitored gases (methane and carbon dioxide).

No readings were obtained from GMW14 since March 2014 due to its location being within an area of cattle quarantine paddock. Due to the previously detected elevated levels of carbon dioxide at this location in 2013, recommendations in relation to repositioning GMW14 as discussed in previous monitoring reports remain valid (Ref. [2], [3] and [4]). Considering the recorded concentrations to date, monitoring of landfill gas in GMW14 should be undertaken on a regular basis and contingency actions implemented, if necessary.

4.5.1.1 Methane

Methane concentrations were recorded below the respective Control and Trigger Levels (where available) in all monitoring locations with levels recorded between 0% and 0.2%.

GMW3 recorded levels of 1.2% and 3.3% in April and May respectively which are both above the trigger level of 1%. The level then dropped back down to 0.2% in June and continued to be low throughout the third quarter. This was the only well with any exceedances this year and is the first recorded exceedance since April 2013.

High levels of methane were detected in all three valves of GMW10 throughout the third quarter, measuring a high of 32.5% in the Red Valve in July, 35.7% in the Yellow Valve in September and 25.9% in the White Valve in July. GMW9 also recorded high levels of Methane in the Yellow Valve with 43.4% in July, 42.5% in August and 43.8% in September. For these, no Control/Trigger Levels are available. As noted in the previous monitoring report (Ref. [4]), elevated methane concentrations in the yellow valve of GMW9 typically correspond to low or very low concentrations being measured in the well's red and white valves. This continues to be observed in this reporting period.

Elevated levels of methane continue to be measured in the monitoring well GMW8 (yellow valve), where the maximum recorded concentration in this reporting period was 6.6% in July.

As discussed in **Section 3.5.1**, GMW8, 9 and 10 are located within 20m of the waste mass, where elevated methane concentrations are anticipated.

Very low or no levels of methane were detected in GMW17 and GMW18, where Control or Trigger Levels are also not available.

4.5.1.2 Carbon Dioxide

Carbon dioxide concentrations were recorded below the respective Control and Trigger Levels, where available, in the majority of monitoring locations with the exception of GMW2, GMW6 and GMW13. The red control level of 1% was slightly exceeded in GMW2 throughout the third quarter with 1.2% recorded in July, 1.5% in August and 1.8% in September. This is the first time this location has exceeded any of the compliance levels since August 2015. The red valve trigger level of 4.3% was exceeded in GMW6 in August with a recorded level of 4.8%. A reading could not be taken in September due to the installation being flooded. The yellow trigger level for GMW13 was exceeded during all three months of the third quarter with 7.1% recorded in July, 8.2% in August and 6.6% in September. Similar exceedances have been observed in GMW13 in the past, since it continues to exhibit levels above the Trigger Level of 6%. GMW13 is located on the north-western flank of the valley, outside the waste mass. It is considered likely that this well is detecting ground gas concentrations from the local bedrock geology and marsh land in the vicinity of the well.

No readings were taken for GMW14. Readings for GMW1 were taken during the third quarter with slightly elevated carbon dioxide reading of 1.3% in the red valve recorded in August. Elevated levels of carbon dioxide continue to be recorded in GMW8 and GMW9. No Control/Trigger Levels have been derived for these locations.

In GMW8 the highest readings in the reporting period were measured in September at 14.5% in the yellow valve, while at GMW9 a level of 24.0% was recorded in August in the yellow valve. The carbon dioxide concentrations measured in GWM9 are higher than those measured within any of the gas monitoring wells, a trend continuing from 2014. Elevated carbon dioxide concentrations in the yellow valve in GMW9 were recorded since August 2013, when levels rose to 31.6% and remained above 20% for the remainder of the year. In the first half of 2013, carbon dioxide was recorded between 0 and 3.3%.

In July and September GMW10 recorded elevated levels of carbon dioxide in the yellow valve with 14.8% and 15.4% respectively. This carried on a trend from February to May this quarter, however in June the level dropped down to 1.6% for the yellow valve and in August the level dropped down to 5.3%. Higher carbon dioxide levels were also recorded in the red valve during the months of July and September with readings of 13.9% and 15.0% respectively. However, no control or trigger levels have been derived for this monitoring location.

At GMW17 no readings were taken in August or September, however in July a level of 6.1% was recorded in the yellow valve. Readings were not taken in July for GMW18 but a reading of 3.9% was recorded in the yellow valve, the highest this year. A reading of 7.2% was recorded in the white valve in September, the highest this quarter.

5 Conclusions

5.1 Leachate

During the third quarter of 2016 the leachate quality monitoring was tested for a reduced number of determinands and on a quarterly basis. As set out in Section 3.2.2.2, if the mean contaminant concentrations from the wells in the waste mass exceed the assessment levels on three consecutive surveys, contingency actions will be triggered, as described in the Aftercare Phase Environmental and Infrastructure Monitoring Program report (Ref. [6]) and summarised in Table 3.3.

The average contaminant concentrations were all recorded below their respective AMC values and are therefore deemed compliant.

There are high concentrations of ammoniacal nitrogen and chloride within the leachate as expected. If high concentrations of ammoniacal nitrogen and chloride are also found at the downstream groundwater it will act as an indicator that the pumping system may have issues as leachate is most likely entering the groundwater.

The quarterly average leachate head for the third quarter was calculated at 2.68m with the average across the 2016 period to date ranging between 2.46m and 2.68m, well within the 3m limit stipulated in the Permit (Ref. [1]).

An increasing trend in leachate head has been noted in LC5A, with the leachate level steadily rising since 2013. This trend seems to be continuing during the 2016 period, with leachate head levels reaching 4.81m in July. However, the monthly average level for all the wells has remained below the required 3.0m.

From the initial review of the monitoring results, well development works and permeability tests are recommended at this location to investigate the well performance and permeability of the materials in the vicinity of the well. It is also recommended to continue the leachate pumping from the gas extraction wells in the area of LC5A.

A topographical survey at the location of each leachate monitoring well along with the re-measurement of the current heights of each well's casing in relation to the current ground level was undertaken in 2015 in order to verify any potential settlement or change to the wells arrangement. These levels have been adopted in to the leachate head calculations for 2016. Monitoring of leachate will continue in accordance with the agreed programme and the relevant Permit conditions.

5.2 Surface Water

SWU, SW2AI, SWW1, SWW2 and SWW4

As mentioned in the amended monitoring regime the monitoring of these wells is now conducted six-monthly rather than monthly so no data was recorded for the third quarter at these wells.

SWD and SWD1

The surface water results for the monitoring points located downstream of the landfill indicate no significant environmental impact on this receptor. Ammoniacal nitrogen, nickel, mercury and zinc were recorded at less than detectable levels in SWD and SWD1 with chloride, sulphate, manganese and nickel all measured below the respective Freshwater EQS. Unionised ammoniacal nitrogen was recorded above the freshwater EQS value of 0.015mg/l in both SWD and SWD1 at levels of 0.0293mg/l and 0.0291mg/l respectively. This is due to an increase of temperature which is to be expected at this time of year. A similar exceedance was recorded in July 2015.

Concentrations of sulphate are showing an increasing trend from the first quarter but the concentrations are still well below the EQS freshwater level with a highest value of 97.9mg/l being recorded at SWD in July 2016. Sulphate has been detected in the groundwater upstream wells during the reporting period, therefore suggesting a source of sulphate other than the landfill.

SW1 – SW10

Monitoring of these downstream locations is still conducted monthly as of the amended permit [29].

At all monitoring locations no result was recorded above the detection level for mercury and ammoniacal nitrogen throughout July, August and September. Mercury has not been recorded above the detection level at any of the monitoring locations since May 2014. Ammoniacal nitrogen tested for levels above the detection level in February during the first quarter but no pH values were recorded so the unionised ammoniacal nitrogen level could not be calculated.

Chloride levels remained well below the EQS freshwater concentration level of 250mg/l throughout the third quarter. This shows that the pumps are effective at stopping the leachate, which has high levels of chloride, from leaching into the Nant Merddog downstream of the landfill.

Surface water monitoring will continue in accordance with the agreed programme and the relevant Permit conditions.

5.3 Groundwater

Upstream Wells

During the third quarter the upstream wells GW3A and GW4 showed elevated levels of zinc and manganese. The levels of zinc were above the trigger level at both wells and the level of manganese was above the assessment level at well GW4. These elevated concentrations upstream suggest there are other sources than the landfill for these determinands.

Steel works waste deposited to the north of the landfill and old mine workings in the area are likely to be the source of the elevated levels of sulphate and zinc. Manganese is also a typical contaminant of mine drainage, which is considered to be impacting the groundwater in the locale of the landfill.

Downstream Wells / Compliance Wells

The results of the monitoring of the compliance wells has indicated that generally the pumping system at the toe of the landfill is continuing to successfully control the potential egress of leachate from the landfill. No issues associated with pump failure within the cut-off system have been recorded during this reporting period.

Generally, the elevated concentrations of manganese and zinc observed in the downstream wells are likely to reflect background concentrations. This is because zinc and manganese concentrations are low in the leachate testing therefore it is not coming from the landfill.

Ammoniacal nitrogen in GW9 was also reported above the Trigger Level. The level of ammoniacal nitrogen was recorded as 8.7mg/l for July which was lower than the recorded levels for the first two quarters, which had increased from 2015. The monitoring results have been showing a general decreasing trend since 2012, when capping works were undertaken in the eastern plateau, and temporary increasing trends are considered likely to be associated with seasonal variations and periods of persistent elevated rainfall. The previous inadequacy of the Phase 1 capping has now been addressed and therefore should hopefully aim to reduce the elevated ammoniacal nitrogen concentrations. Further monitoring in will be undertaken and results analysed in subsequent reports to determine whether the new capping addresses the issue.

The monitoring of the downstream environmental impact of the non-compliance at GW9 (sampling and analysis of the Nant Merddog and identified stream and break outs in the SSSI) is currently on-going. The available monitoring results to date have been incorporated into this report and show that these streams are impacted by low concentrations of ammoniacal nitrogen and chloride, however no unacceptable impact on the Nant Merddog has been identified. The GW9 report has now been updated and resubmitted to NRW (Ref. [5]). As discussed in the report, it is considered that the on-going non-compliance at GW9 is due to the heavily fractured stratum in that locale that prevents the pumping system from intercepting all leachate-impacted groundwater.

Zinc was monitored in GW9 at concentrations above the Control Level in January and above the Trigger Level in February during the first quarter and above the control level A with a value of 0.0273mg/l in the second quarter. Levels of zinc marginally increased in July to above the trigger level of 0.05mg/l with a value of 0.0515mg/l. Elevated concentrations of zinc were monitored in the upstream wells during the reporting period, hence suggesting the presence of a source of zinc external to the landfill as discussed above.

In GW10, the elevated ammoniacal nitrogen and chloride concentrations that were monitored in February continue to drop to normal levels during the third quarter. Ammoniacal nitrogen was below the detection level of 0.41mg/l and chloride rose to 24.6mg/l in July compared to 19.5mg/l in April but was still low. Mercury levels were recorded below the control and trigger levels in July, dropping from 0.16ug/l in April to below level of detection in July. Leachate did not test for above the detection level for mercury at any of the wells so the landfill is not considered to be the source of mercury.

Zinc and manganese had been recorded above the EQS value in GW10 during the first quarter. However in the second quarter the manganese level had now dropped below the EQS level to below the detection level, with zinc still above the trigger level as it was in the first quarter. In the third quarter the manganese level remains below the EQS freshwater level and zinc levels still exceed the trigger level. Since elevated concentrations of zinc and manganese have also been recorded in the upstream wells and no or low levels of leachate species have been detected in GW10, it is considered likely that a source of zinc and manganese other than the landfill exists which impacts on the groundwater monitored by GW10.

Groundwater contained within the sandstone strata S2-west monitored by GW12 showed a large exceedance in ammoniacal nitrogen during the first quarter. It is likely that these exceedances are associated with the heavy rainfall experienced in the first quarter of 2016. The level of ammoniacal nitrogen fell from the high levels of 10.2mg/l and 9.54mg/l in January and February respectively, to just 0.85mg/l in April and continued to fall in the third quarter in July to below the level of detection of <0.41mg/l. This shows a decreasing trend and therefore it is likely that heavy rainfall was the cause of the high levels during the first quarter as less rain fell in April and July. The results need to be continually monitored to confirm the decreasing trend, especially during months of expected heavy rainfall.

GW12 also tested for high levels of mercury recorded above the trigger level. The last trigger level exceedance was recorded in December 2015 and the EQS freshwater level was exceeded at similar time of year in 2015. Leachate quality testing did not detect mercury, therefore the elevated mercury in the groundwater is not considered to originate from the landfill.

GW12 recorded a lower level of sulphate of 216mg/l in July which has dropped compared to the results from the first and second quarter, breaking from the increasing trend which goes as far back as November 2015. Low levels of sulphate were recorded in the upstream groundwater wells with GW3A and GW4 recording 110.0mg/l and 66.6mg/l respectively in July which is lower than GW12 in July. Therefore further investigation is required of the GW12 well in subsequent reports to check if the sulphate results are now beginning to decrease.

Zinc was recorded at a concentration of 0.504mg/l in July at GW12. As previously mentioned, zinc is also found at elevated concentrations in the upstream wells, indicating the presence of a source of zinc other than the landfill.

Elevated levels of zinc and manganese also continued to be recorded within sandstone strata S1, monitored by GW6 and GW7; these, however, coincided with elevated background concentrations, suggesting a contamination source other than the landfill. No elevated concentrations of ammoniacal nitrogen, chlorides and sulphates were recorded in these wells.

5.4 Landfill Gas

The gas monitoring results showed compliance with the set Control and Trigger Levels in the majority of gas monitoring locations with the only exceptions being GMW2, GMW6 and GMW13 for carbon dioxide.

Methane concentrations were recorded below the respective Control and Trigger Levels (where available) in all monitoring locations.

GMW3 had levels of methane that were over the trigger level for the white valve with 1.2% in April and 3.3% in May with the trigger level being 1%. These are the first trigger level exceedances at GMW3 since 2013. However in June the level fell back down to 0.2% at the white valve which is at a depth of 3.5m and continued to be low throughout the third quarter.

Highly elevated levels of methane continue to be measured in monitoring wells GMW8 (yellow valve), GMW9 (yellow valve) and GMW10 (all three valves). However, no Control/Trigger Levels are available for these locations.

Very low or no levels of methane were detected in GMW17 and GMW18, where Control or Trigger Levels are also not available.

Carbon dioxide continues to be recorded above the Control and/or Trigger Levels in the yellow valve of GMW13 throughout the third quarter. This well is considered to be impacted by the presence of marshland and bedrock geology on which this is located. It is recommended that gas analysis is carried out at this location and the Control/Trigger Levels reassessed as necessary. For the first time since August 2015 GMW2 has exceeded the red control level in July, August and September although not by a significant margin and GMW6 only slightly exceeded the red trigger level in August.

Monitoring in GMW14 was not carried out due to its location within a cattle quarantine paddock and therefore it is currently unclear if elevated levels of carbon dioxide recorded in the previous years indicate an increased trend in concentrations of this landfill gas. It is therefore recommended that carbon dioxide levels are closely monitored in GMW14 during the subsequent monitoring rounds at this well location and, should an increased trend in concentrations or a prolonged period of elevated concentrations be identified, appropriate contingency actions undertaken. If the required monitoring frequency cannot be sustained due to the current location of GMW14, it is recommended that a new monitoring location is installed within the Permit requirements.

Elevated levels of carbon dioxide also continue to be measured in GMW8, GMW9 and GMW10. However, no Control/Trigger Levels have been derived for these locations.

No readings were taken in GMW1 throughout the first quarter monitoring period or in April or May in the second quarter. A reading was taken in June with a high reading of 35.1% recorded. Readings were taken in July, August and September with a slightly elevated reading of 1.3% recorded in August, significantly lower than the reading from April. In order to mitigate the elevated levels of carbon dioxide previously recorded in GMW1, it was proposed to drill two additional gas pumping wells in its vicinity. These works have been carried out in February 2015 at the locations shown in **Figure 2**. The elevated level recorded in June following nine months of no monitoring may be due to a pocket of carbon dioxide being generated during the installation of the other two pumping wells. The following readings may be a sign that the additional gas pumping wells are working sufficiently to decrease the carbon dioxide levels at GWM1. Further data from GMW1 will be required to confirm if these low readings are likely to be consistent.

Gas monitoring will continue in accordance with the agreed programme and the relevant Permit conditions

References

[1] Environment Agency, Silent Valley Landfill Site, Pollution Prevention and Control (England and Wales) Regulations 2000, Landfill (England and Wales) Regulations 2002, Permit number MP3835SV, November 2005, Permit amended as of 04/03/16.

[2] Arup, Silent Valley Landfill, 2015 Annual Monitoring Report, document reference 2016/9448, 31st March 2016.

[3] Arup, Silent Valley Landfill, IPPC Application response to Schedule 4 Notice requiring further information, April 2005.

[4] Arup, Silent Valley Landfill, 2014 Annual Monitoring Report, document reference 15/9326, 18th February 2015.

[5] Arup, Silent Valley Landfill, Interim GW9 and Nant Merddog W, Issue May 2015.

[6] Arup, Silent Valley Landfill, Aftercare Phase Environmental and Infrastructure Monitoring Program, Issue June 2013.

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Figures

A4

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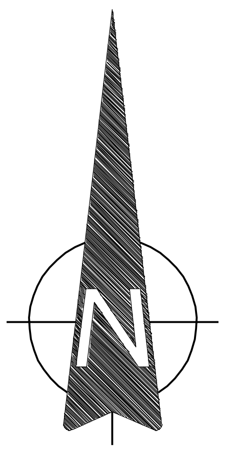
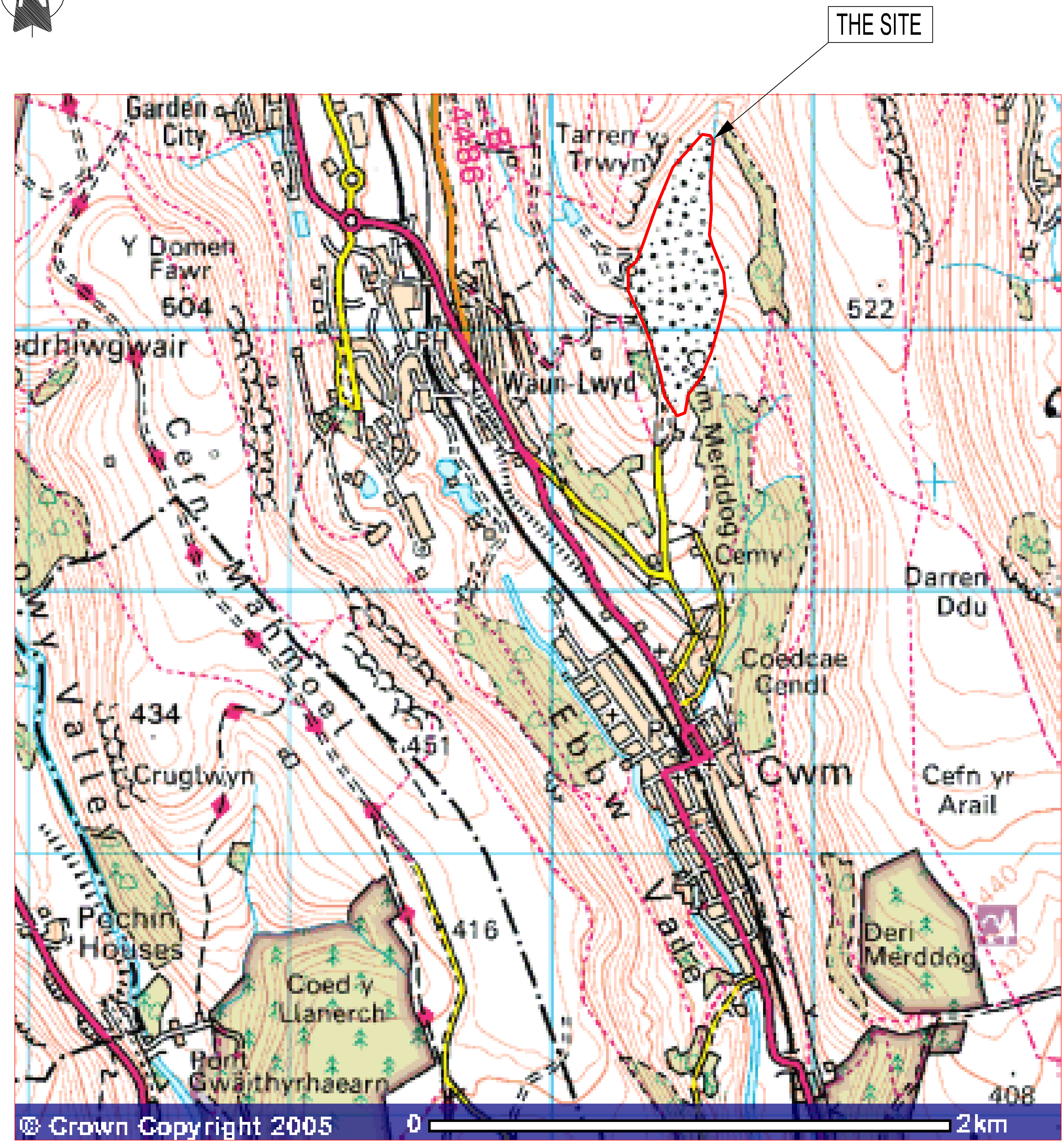
Job Title	Silent Valley Landfill
Drawing Title	Site Location
Scale at A4	N.T.S
Plot ID	zfigure1.dgn
Drawing Status	Information
Job No	115825
Drawing No	Figure 1
Issue	I0

I0	02/05/07	RP		
	Issued For Information			





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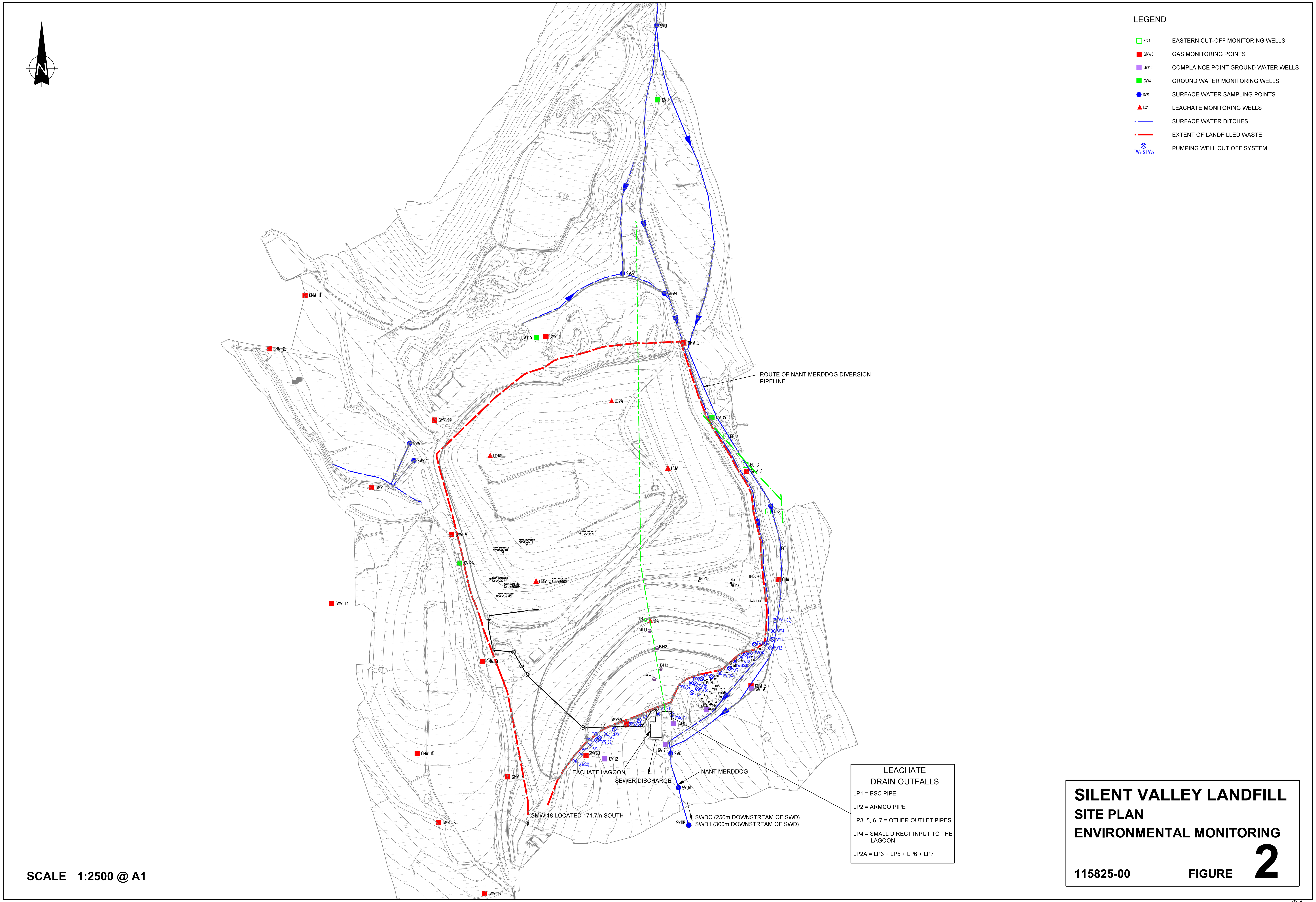
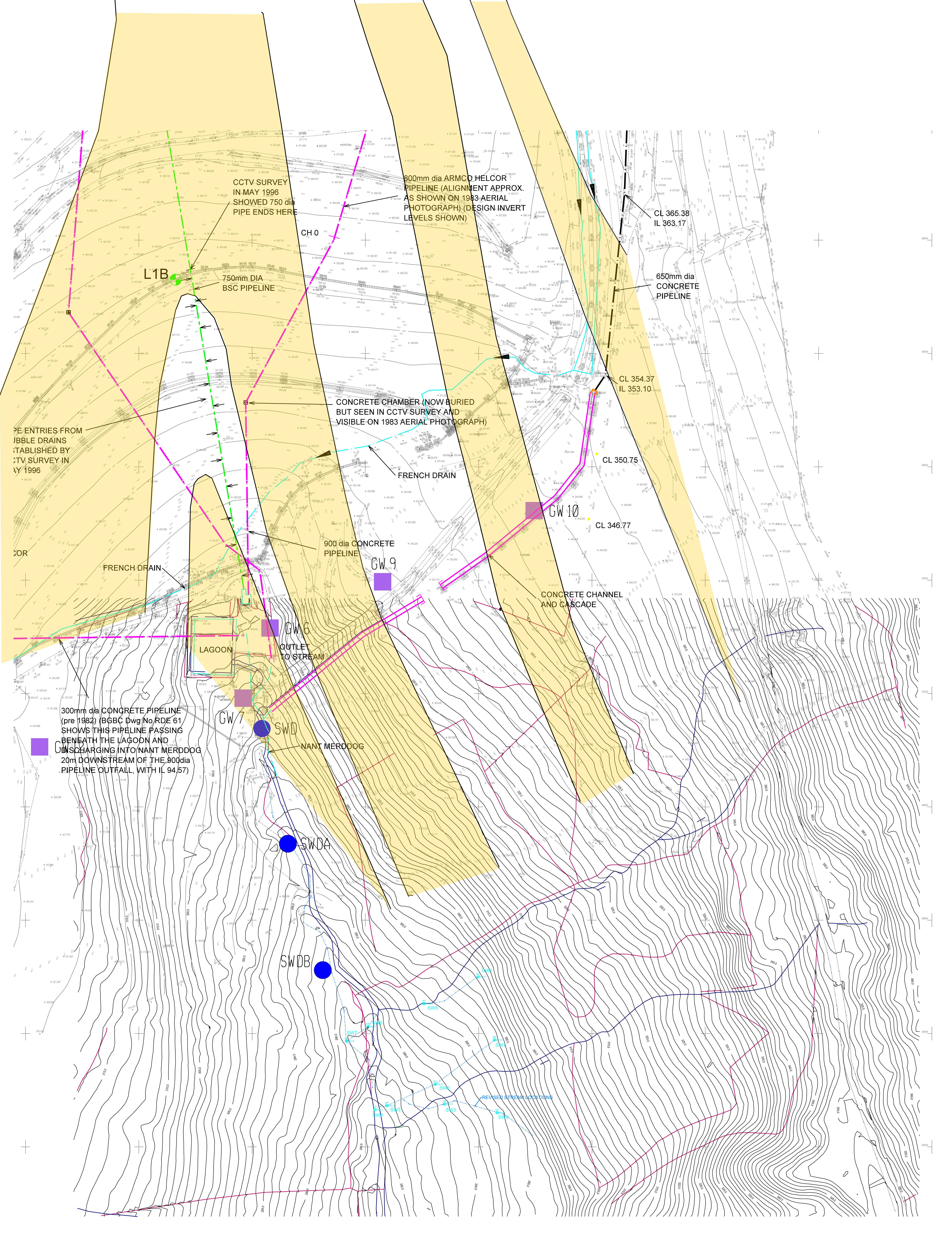


SILENT VALLEY LANDFILL
SITE PLAN
ENVIRONMENTAL MONITORING

115825-00 FIGURE **2**

J:\115000\115825-00\4 Internal Project Data\4-30 Drawings\4-33 Civil\Figure 2 Site_Plan_Env_Monitor_Prog.dgn


CCTV SURVEY
IN MAY 1996
SHOWED 750 dia
PIPE ENDS HERE
800mm dia ARMCO HELCOR
PIPELINE (ALIGNMENT APPROX.
AS SHOWN ON 1983 AERIAL
PHOTOGRAPH) (DESIGN INVERT
LEVELS SHOWN)
CL 365.38
IL 363.17
CH 0
L1B
750mm DIA
BSC PIPELINE
650mm dia
CONCRETE
PIPELINE
CL 354.37
IL 353.10
CONCRETE CHAMBER (NOW BURIED
BUT SEEN IN CCTV SURVEY AND
VISIBLE ON 1983 AERIAL PHOTOGRAPH)
PE ENTRIES FROM
JBBLE DRAINS
STABLISHED BY
CTV SURVEY IN
AY 1996
FRENCH DRAIN
CL 350.75
GW 10
CL 346.77
900 dia CONCRETE
PIPELINE
GW 9
FRENCH DRAIN
CONCRETE CHANNEL
AND CASCADE
GW 6
OUTLET
TO STREAM
LAGOON
GW 7
SWD
300mm dia CONCRETE PIPELINE
(pre 1982) (BGBC Dwg No RDE 61
SHOWS THIS PIPELINE PASSING
BENEATH THE LAGOON AND
DISCHARGING INTO NANT MERDDOG
20m DOWNSTREAM OF THE 900dia
PIPELINE OUTFALL, WITH IL 94.57)
NANT MERDDOG
SWDA
SWDB
REVISED STREAM LOCATIONS

Appendix A

Details of cut-off and monitoring systems

A1 Pumping cut-off system and monitoring

The following is a summary of the activities that have taken place at the site in relation to the pumping and monitoring system since its installation in 2007.

2007 **October:** The pumping system became operational.

2008 **November/December:** A programme of inspection and maintenance was undertaken to check the level and performance of each well and pump following the findings of the January to September 2008 interim report (Reference [24]), which indicated that the cut-off system operated less efficiently post high rainfall events, with concentrations within the compliance wells temporarily increasing. A number of wells were found to be silting up and required cleaning. Details are presented in the Annual Monitoring Report 2008 (Reference [25]).

2009 **January:** The majority of wells were successfully cleaned. The base of wells TW2, TW7, PW4 and PW10 were found to be above the depth shown on the logs. Deeper replacement wells were installed at TW2, TW6 and TW7, (called TW2A, TW6A and TW7A), construction details as shown in the sketch at the end of this Appendix;

February: Low-draw pumps were installed to improve the situation at PW4, PW7, PW10 and PW14;

March: Existing pumps were replaced with more robust pumps, to cope with silting and iron hydroxide deposition;

April: Pumping from these replacement wells commenced;

November/December: The pumps in wells TW2A and TW6A were overwhelmed during periods of very heavy rainfall, producing impacts in the compliance wells downstream, at GW9 and GW12 and monthly average leachate heads often in excess of permitted values. There was concern that the monitored heads may have been influenced by perched leachate bodies, the monitoring wells having been constructed with slag gravel response zones extending through the body of the landfill. As a result, two more pumping wells were installed alongside each of wells TW2A and TW6A, with the aim that these wells would provide support to the existing wells and prevent further migration of leachate. Pumping tests and the installation of new leachate monitoring wells at the locations of LC1, LC2 and LC4 (LC1A, LC2A and LC4A) were undertaken to obtain additional information on the leachate heads. The new wells were installed with 3m long response zones in contact with the base of the landfill and isolated from potential perched leachate bodies higher up within the landfill mass. As such, they are representative for measuring the hydrostatic head of leachate that acts on the base of the landfill and potentially drives leakage. The wells have consistently indicated leachate heads that are much lower than those measured previously in the corresponding former monitoring wells LC1, LC2 and LC4. This is considered strong evidence that the average leachate heads derived previously were influenced by perched leachate bodies.

2010 **February:** Wells TW2B, TW2C, TW6B and TW6C were installed alongside wells TW2A and TW6A. The monitoring results indicate there has been an improvement of water quality in GW12 in relation to ammoniacal nitrogen and chloride (i.e. in TW2A, only one exceedance of the compliance limit for ammoniacal nitrogen and no exceedances for chloride were recorded since the installation of the new pumps). However, this improvement was not replicated at GW9 downstream of TW6A, B and C. Extensive investigations including sampling and laboratory analyses have been undertaken to confirm the source of the leachate species encountered in GW9 and measures to address this issue have been undertaken (see Reference [8]). The investigations identified an uncapped plateau area on the eastern flank of the landfill and concluded that one of the sources of the leachate monitored in GW9 may be groundwater infiltrating into the waste body from this uncapped area and flowing towards GW9 within fractured mudstone and sandstone layers, in line with the geological and hydrogeological model also presented in the report. Part of the leachate body in the uncapped waste was also considered to be flowing towards a gabion mattress-lined ditch located on the eastern flank of the landfill. This leachate was found to be diluted by the surface waters flowing in the ditch and potentially by groundwater from the valley sides, and was also considered likely to be impacting GW9. The capping of the eastern plateau was completed in August 2011 (see below).

June/July: A replacement monitoring well LC5A was drilled adjacent to LC5. A back-up compressor has been installed to provide support to the compressor currently in use at Silent Valley.

August: The new leachate well, LC5A, was commissioned and subsequently monitored in accordance with the quarterly monitoring regime.

2011 Leachate pumping was temporarily ceased due to bio-fouling of the pumps and wells. The pumping was shortly after reinstated using gas extraction wells and the pumping continues to date.

August: The capping of the eastern plateau was completed. Since its installation, the levels of ammoniacal nitrogen and chloride in GW10 were observed to have significantly reduced towards the end of 2011; however, these continued to be above the compliance level in GW9 and further sampling was recommended to monitor the trend.

2012: No specific maintenance or upgrades on the monitoring infrastructure were required or undertaken in 2012.

2013 **March to July:** The pump in PW12, which pumps from sandstone strata S3, was found to be not working. Following a number of maintenance works, the pump was still found to be failing. On reinstatement of the electronic groundwater monitoring system in July (see further details below), it was evident that the pump in this location was continuing to have issues. The pump was consequently changed in August and the groundwater levels within the well have since returned to the required level. Maintenance issues were also recorded in the eastern section of the cut-off system, wells between April and September 2013 in TW10.

December: Although there is no current evidence to suggest issues with the efficacy of the BSC pipe located in the southern flank of Phase 1 landfill, SVWS commissioned the installation of four additional leachate monitoring wells (BH1 to BH4) along the alignment of the BSC pipe in December. The objective is for these boreholes to be monitored to confirm both the nature and level of leachate within the Phase 1 area and any long-term trends in leachate level (note that monitoring has temporarily ceased due to the works undertaken for the capping of Phase 1 landfill – see following sentence). During the installation of these wells, observations indicated that the capping of Phase 1 landfill was not typical of a low permeability capping system and further investigations, including the excavation of 19no shallow trial pits, confirmed that the existing capping was likely to not be preventing infiltration of rainwater. SVWS are currently undertaking works to improve the capping of the Phase 1 area in order to achieve a reduction in the leachate production and achieve regulatory compliance (see below).

2014 **July:** Earthworks for the installation of the capping system in Phase 1 landfill commenced. A combination of cut and fill is used to slacken the existing landfill slope angles to a maximum gradient of 1V:2.5H to achieve a stable angle for the capping system.

July to September: Further issues were identified within the eastern section of the cut-off system, particularly in TW11, and also in TW10 and PW14, all installed within the Sandstone S3 stratum. Pump failure was recorded in TW11 from July the 7th till September the 4th. After a number of attempts, the pump was finally retrieved and further delay in a pump reinstatement was caused by the delivery of required replacement parts. In addition, pumps installed in TW10 and PW14 repeatedly failed after service, however are now fully operational.

2015 **January:** capping of Phase 1 landfill is ongoing, with the earthworks largely complete. In addition to the new capping, improvements are also being made to both the surface water drainage and the leachate drain at the toe of the landfill. A new access track has also been constructed across the landfill to provide access for construction and future maintenance.

A1.1 Electronic Monitoring System

Since April/May 2009, the water levels within the pumping wells have been continuously monitored using electronic devices installed within the wells, so-called ‘divers’. These send water level data at a specified frequency directly to an office-based computer, allowing continuous remote monitoring of the efficiency of the cut-off system. This has enabled immediate investigation and remedial actions to be taken when the water level within any well has risen unacceptably or abnormally.

In March 2013, however, problems have occurred with some of the modems, devices collecting data and sending this information to the office-based computer. During the repair period, the efficiency of parts of the pumping system was monitored manually. The modems have been successfully reinstalled in July 2013 and no further issues have been recorded since then.

A1.2 Future maintenance and reinforcement

The pumping well cut-off system is considered to be both robust and flexible. There is considerable redundancy in its design, both in terms of the spacing of the wells and the capacity of the pumps. The system can be easily modified or augmented by the addition of new wells as necessary (as has already taken place in 2008, 2009 and early 2010). In addition to this, the electronic monitoring system, together with routine on-going maintenance of the wells and pumps and provision of replacement pumps, enables corrective actions to be taken in advance of any acute problem that could have an adverse impact on the local groundwater environment. It is clear that for the significant majority of the site, the pumping system is preventing the impact of leachate species from within the body of the waste (or discharge zone as per the Groundwater Regulations 2009 incorporated into EPN2012) on the groundwater. Where there is the one non-compliance, GW9, Silent Valley has undertaken extensive investigations and works (References [7] and [8]).

Appendix B

Previous Site Monitoring

B1 Groundwater Monitoring

There are eight monitoring wells located upstream of the landfill site, where background groundwater quality monitoring has been carried out. These are GW2A, GW3A, GW4, GW11A and EC1 to EC4. Of these, GW2A, EC3 and EC4 were frequently dry and therefore a sample could not always be collected. The EC wells were installed in April 2008 as part of the initial feasibility study into an eastern pumping cut-off system and were included into routine monitoring in October 2008 until June 2010.

B2 Surface Water Monitoring

Locations S1 to S6 and SW2AO (see table below) were monitored from October 2008 to April 2010 in order to check the background quality of groundwater emerging from the eastern hillside, to supplement existing information and particularly identify any trends associated with the passage of water through abandoned mine workings and associated mudstone/seat- earth strata. Each of the monitoring locations comprised a perennial stream originating from groundwater issues.

Table B1: Former surface water monitoring locations

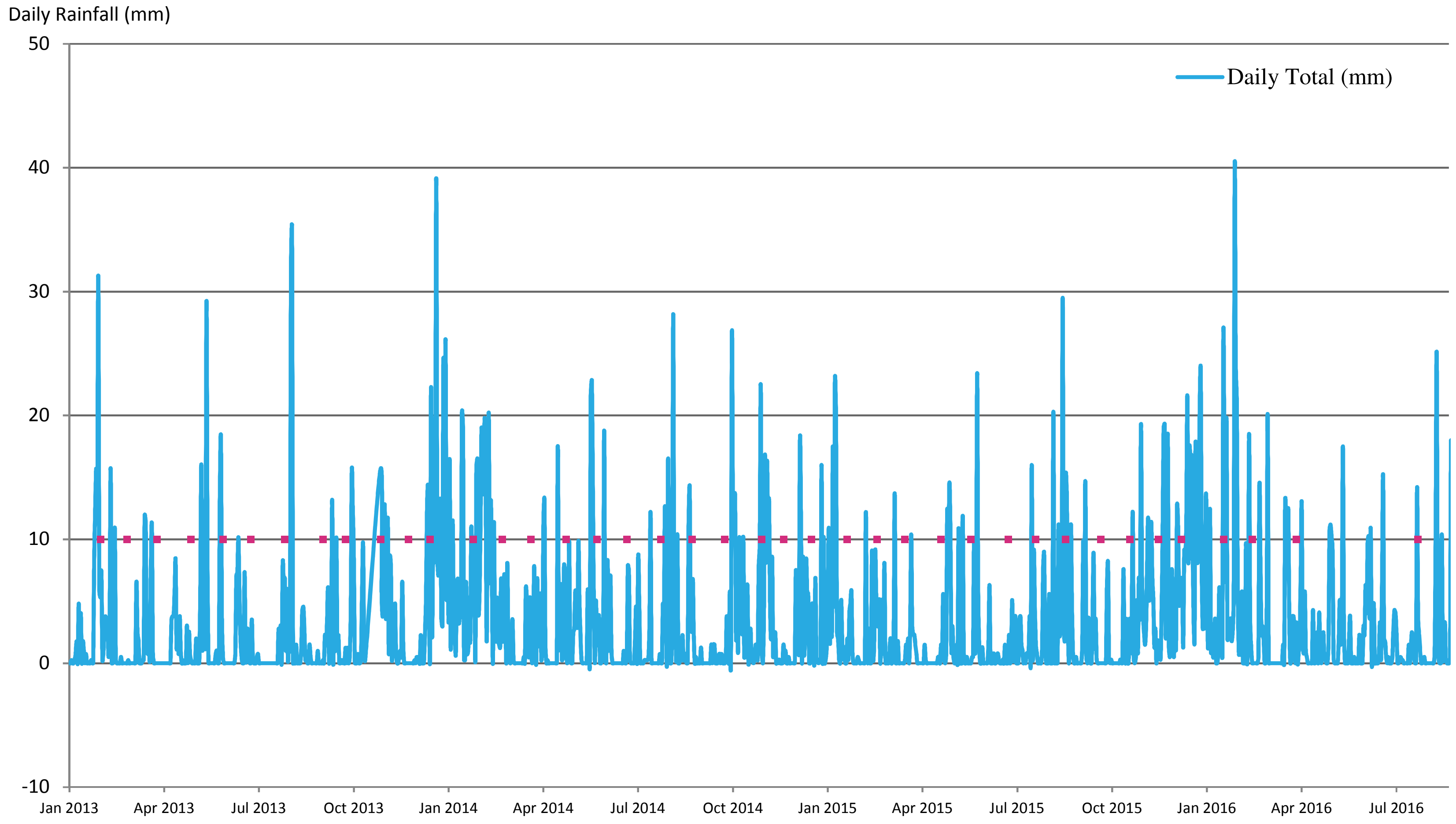
Monitoring Point	Location
S1	A stream, located 20m east of the landfill; approximately 100m north of the recorded landslide; emerging from the backfill of a former opencast site.
S2	A stream, located 20m east of the landfill; 100m south of S1, emerging from within the recorded landslide.
S3	A stream, located 350m downstream of the point where the diverted Nant Merddog joins its original course; the sampling point S3 is located approximately 150m upstream of the confluence with the Nant Merddog; the stream originates from issues downhill of the Old Tramway Path.
S4	A stream, located 650m south-east of the landfill, issuing from the foot of a cliff above the Old Tramway Path; the sampling point S4 is located approximately 10-20m above the path.
S5	A stream, located 70m south of S4; the stream crosses the pathway; the sampling point is located directly downstream of the path.
S6	A stream, located just outside the fence perimeter, the sampling point is located some 20m south of compliance well GW10.
SW2AO	Aqua-pipe outfall discharging to Nant Merddog (pipe buried beneath landfill in north-south direction) – sampling point abandoned, pipe is collapsed and collecting leachate from landfill, and was subsequently diverted into the leachate lagoon sump.

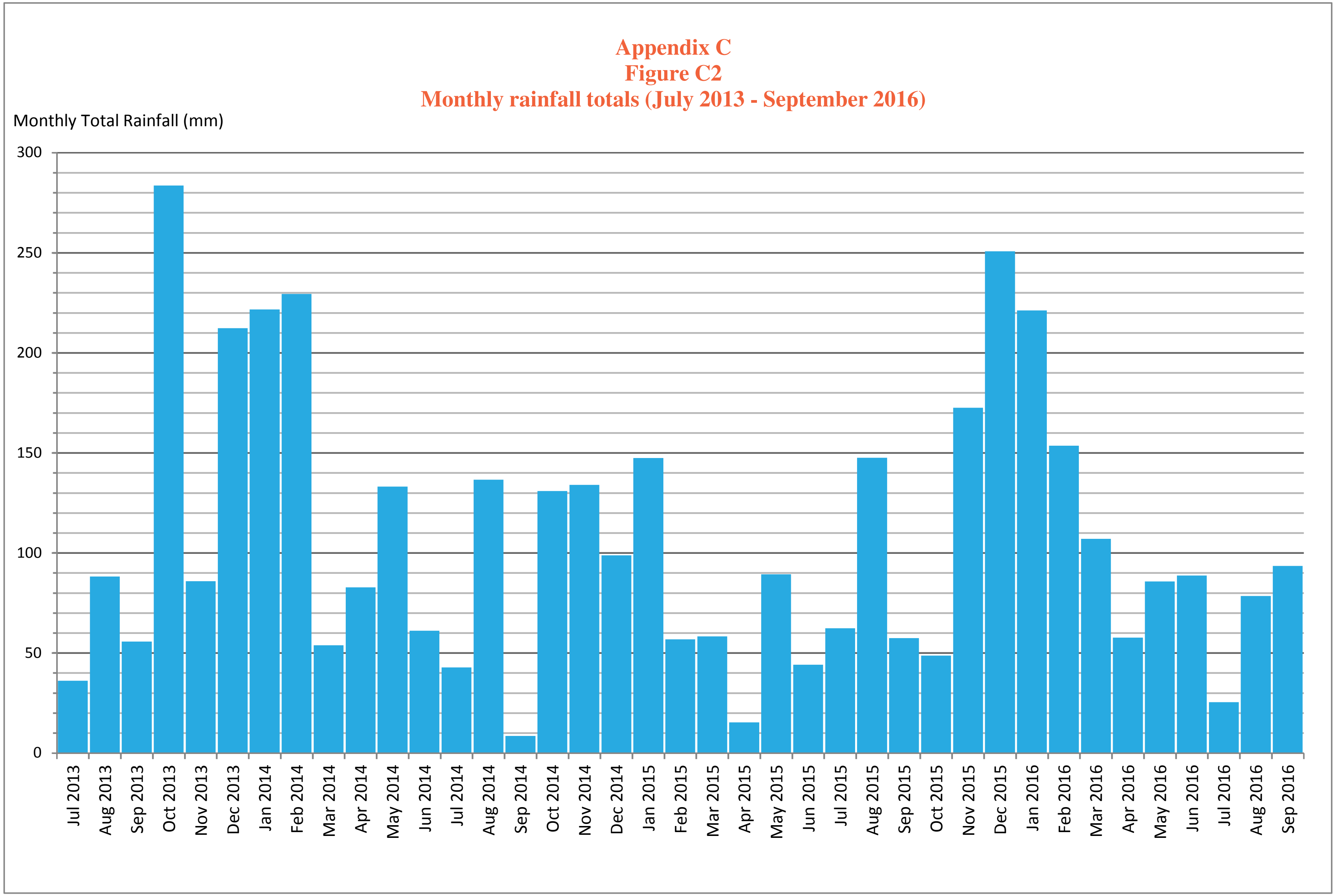
Between February and April 2010, water hardness in the Nant Merddog was undertaken in monthly rounds in order to select appropriate hardness dependant EQS levels. Previously, hardness data used was for the River Ebbw Fawr at the confluence of the Nant Big and the Nant Merddog.

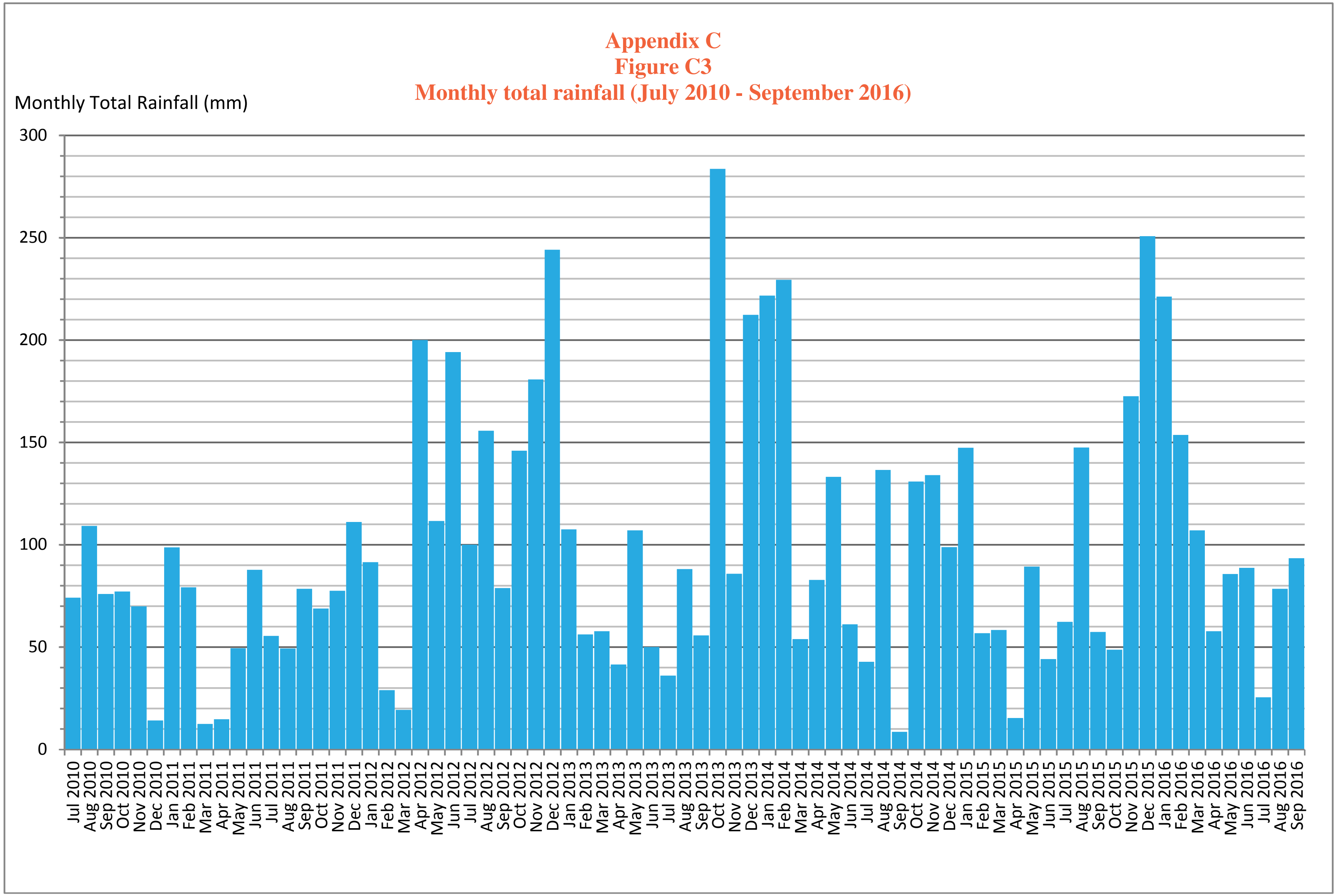
Appendix C

Monitoring Results - Graphs

Appendix C
Figure C1
Daily rainfall totals and sampling events (January 2013 - September 2016)




Appendix C
Figure C2
Monthly rainfall totals (July 2013 - September 2016)
Monthly Total Rainfall (mm)
300
250
200
150
100
50
0
Jul 2013
Aug 2013
Sep 2013
Oct 2013
Nov 2013
Dec 2013
Jan 2014
Feb 2014
Mar 2014
Apr 2014
May 2014
Jun 2014
Jul 2014
Aug 2014
Sep 2014
Oct 2014
Nov 2014
Dec 2014
Jan 2015
Feb 2015
Mar 2015
Apr 2015
May 2015
Jun 2015
Jul 2015
Aug 2015
Sep 2015
Oct 2015
Nov 2015
Dec 2015
Jan 2016
Feb 2016
Mar 2016
Apr 2016
May 2016
Jun 2016
Jul 2016
Aug 2016
Sep 2016


Appendix C
Figure C3
Monthly total rainfall (July 2010 - September 2016)
Monthly Total Rainfall (mm)
300
250
200
150
100
50
0
Jul 2010
Aug 2010
Sep 2010
Oct 2010
Nov 2010
Dec 2010
Jan 2011
Feb 2011
Mar 2011
Apr 2011
May 2011
Jun 2011
Jul 2011
Aug 2011
Sep 2011
Oct 2011
Nov 2011
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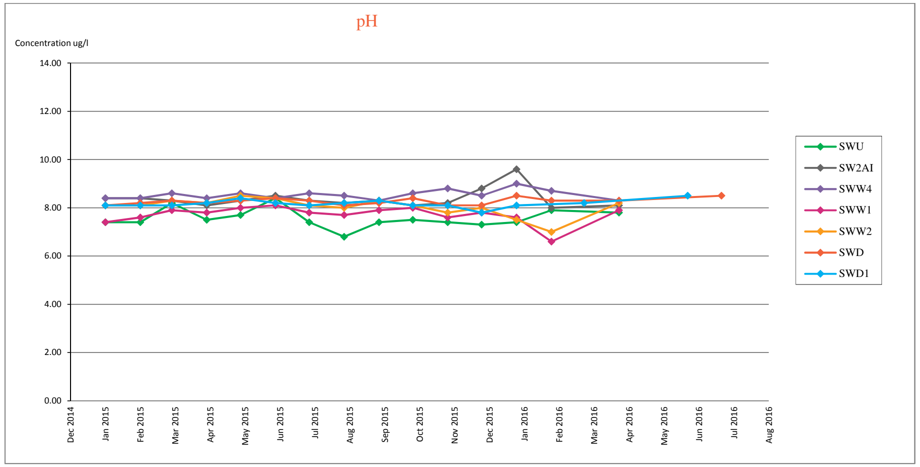
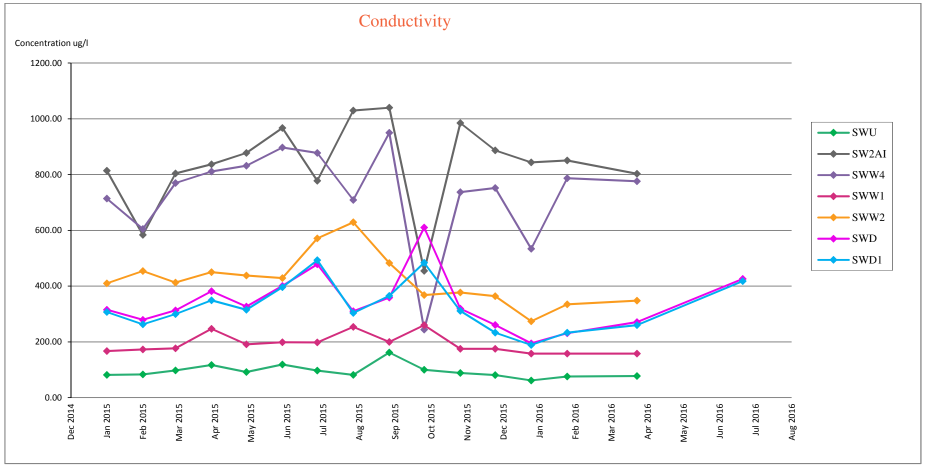
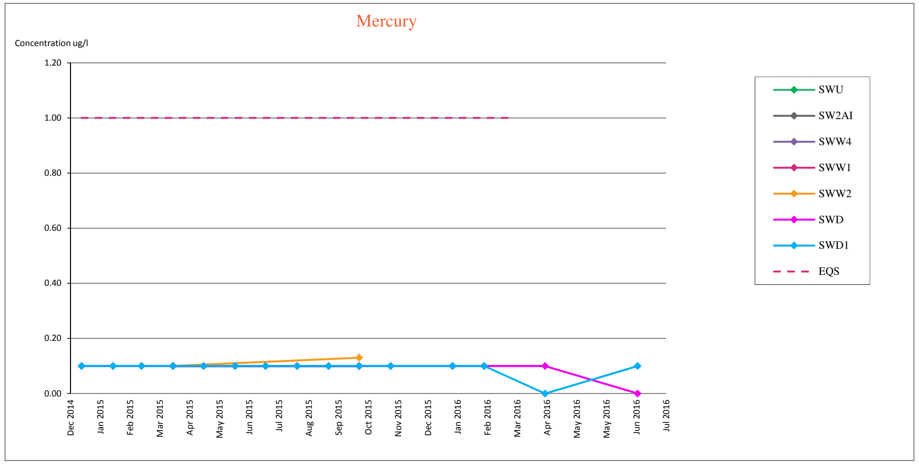
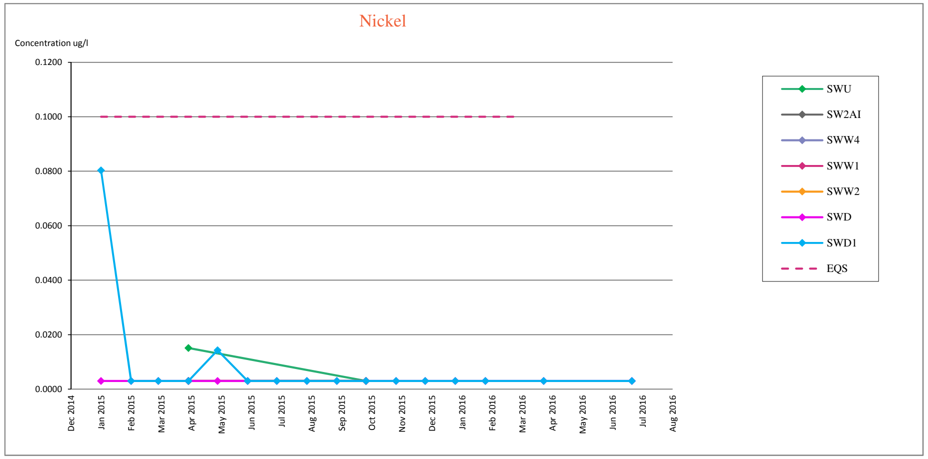
Jul 2016
Aug 2016
Sep 2016

APPENDIX C
Figure C4
Surface water monitoring graphs

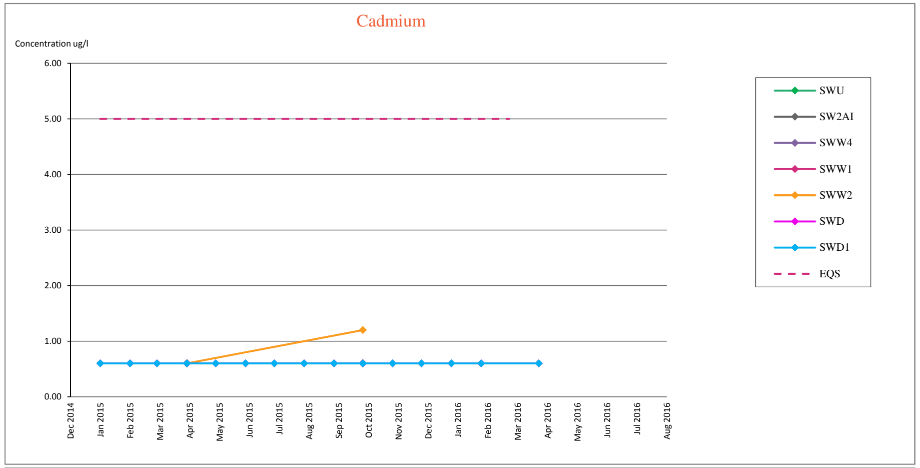


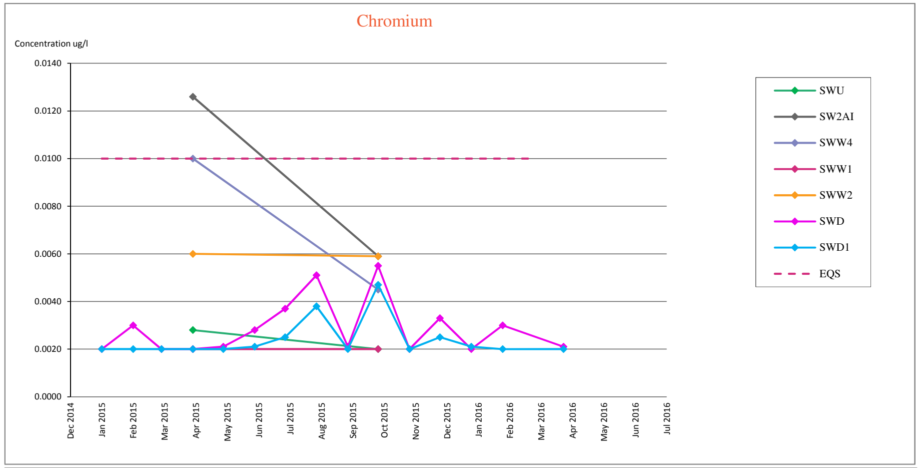


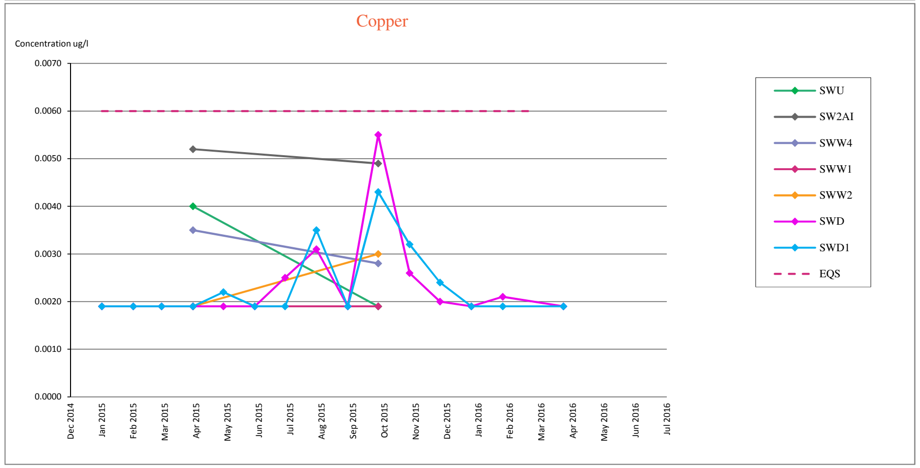


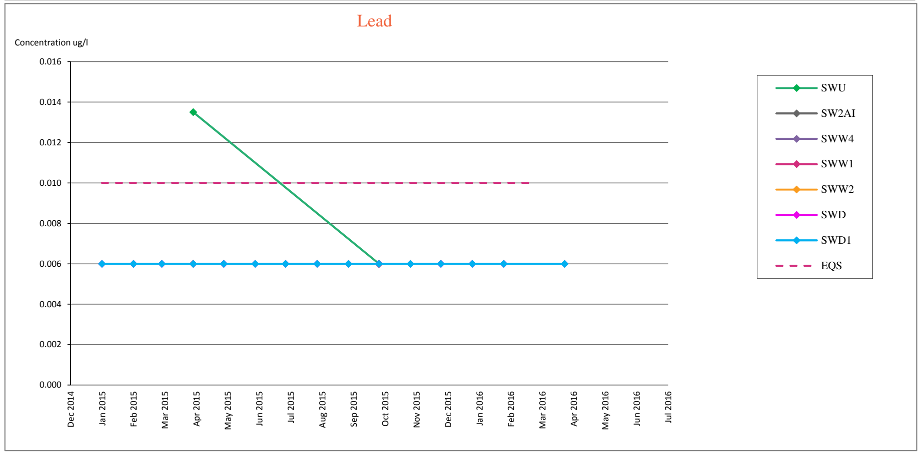


APPENDIX C
Figure C4
Surface water monitoring graphs

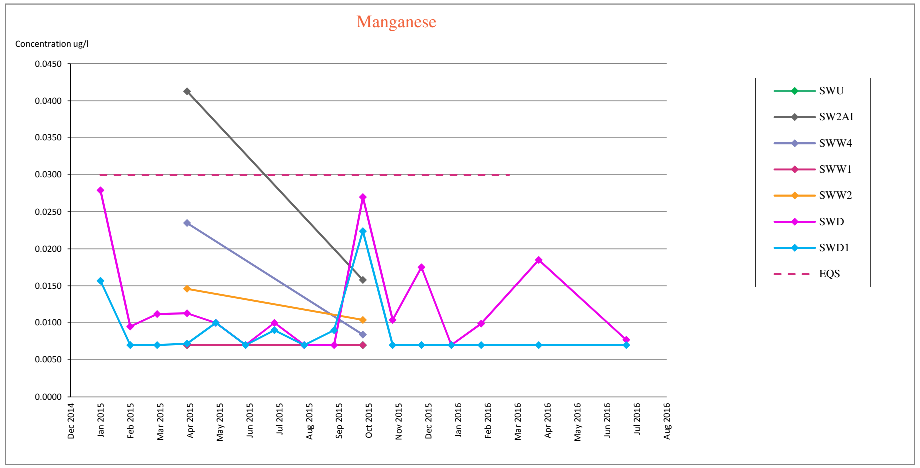


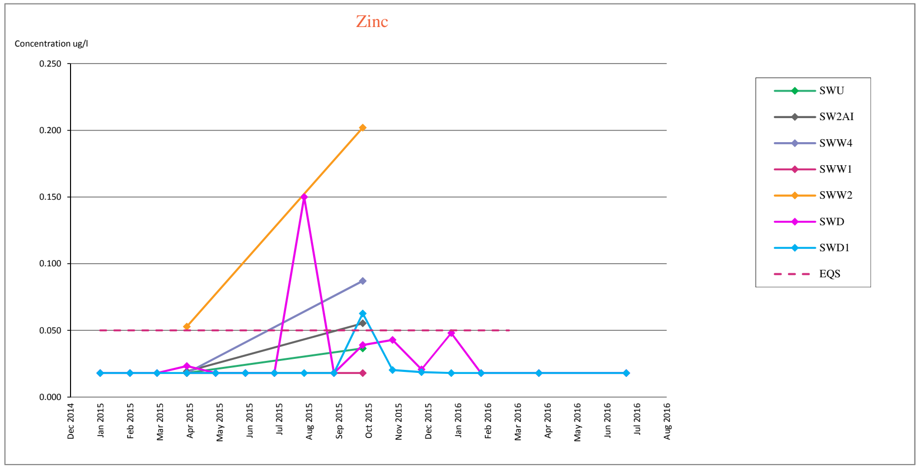


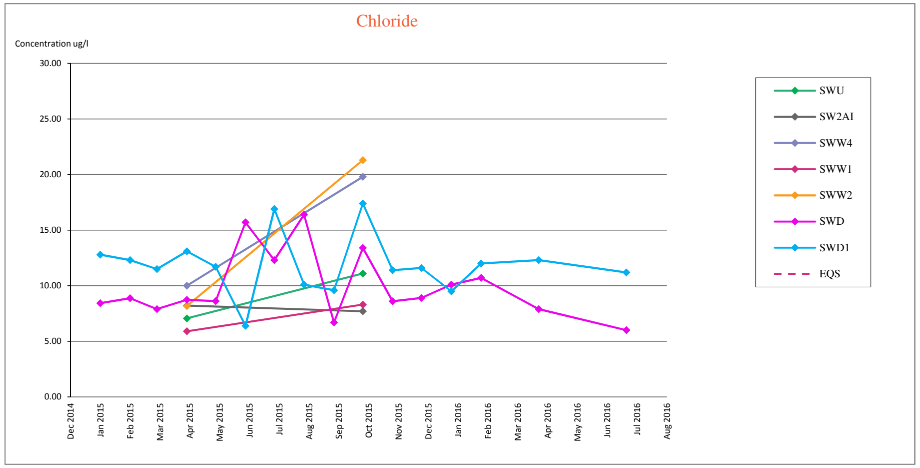


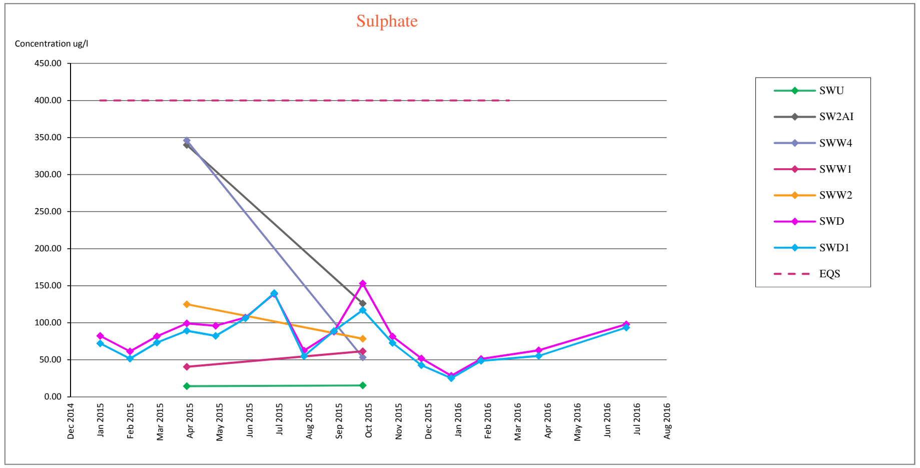


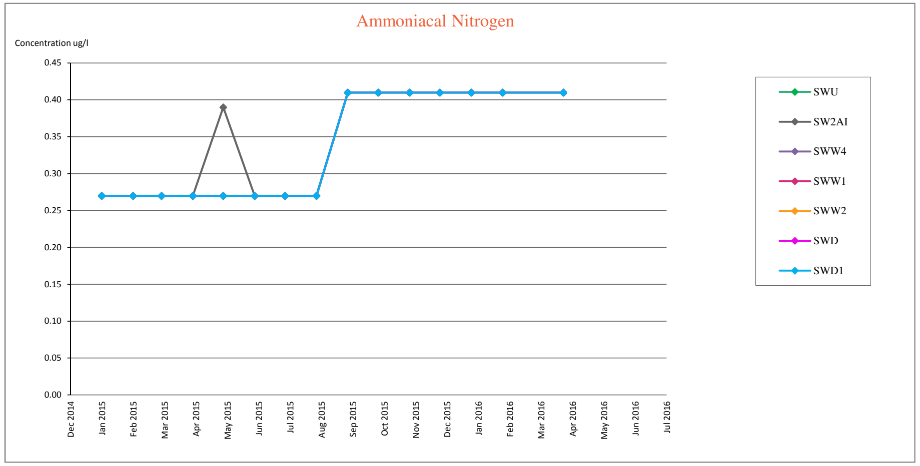
APPENDIX C
Figure C4
Surface water monitoring graphs










Ammoniacal Nitrogen
Concentration ug/l
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Dec 2014
Jan 2015
Feb 2015
Mar 2015
Apr 2015
May 2015
Jun 2015
Jul 2015
Aug 2015
Sep 2015
Oct 2015
Nov 2015
Dec 2015
Jan 2016
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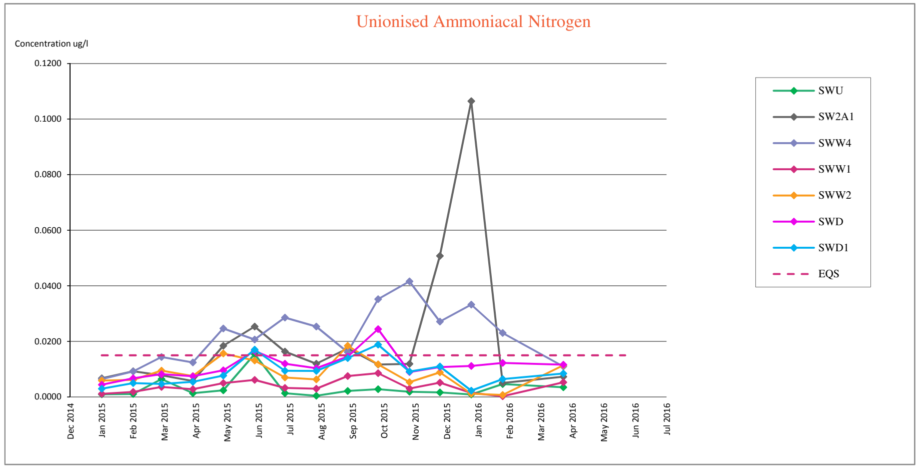
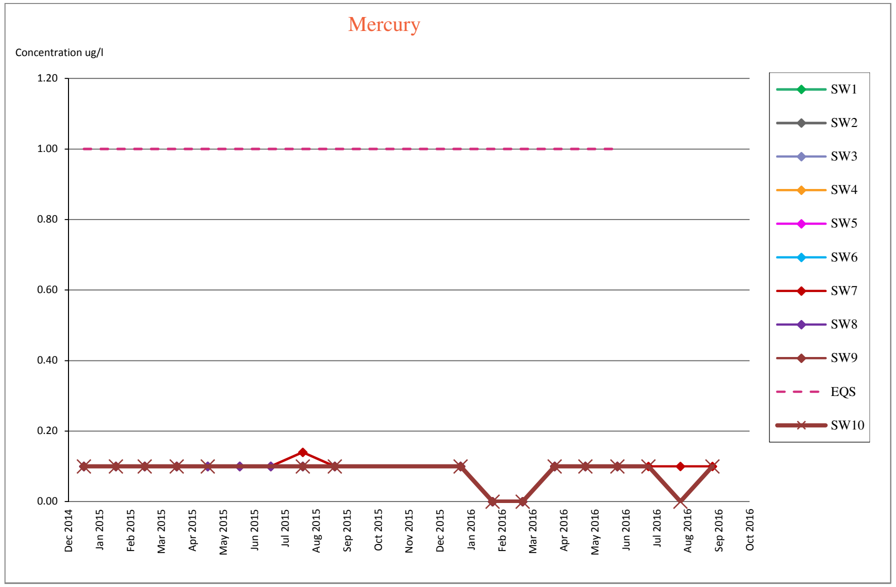
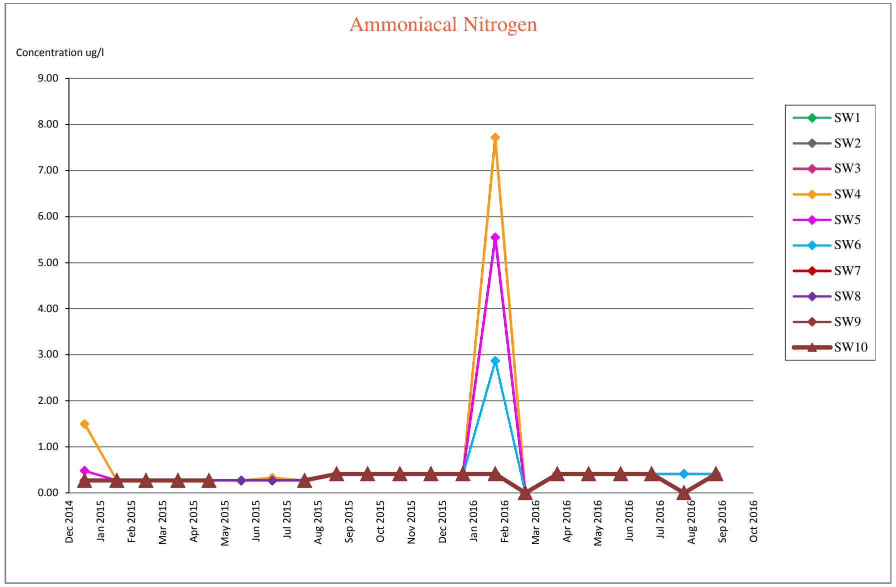
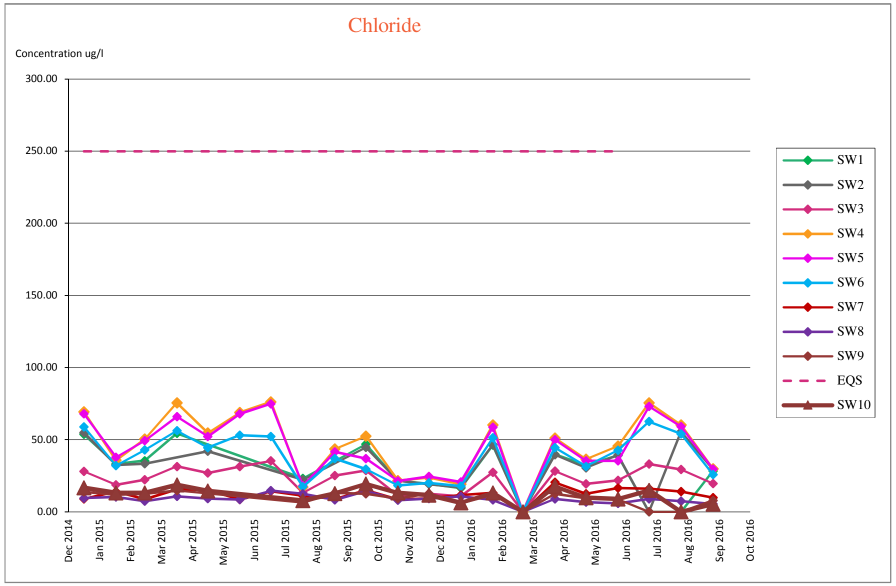
SWW1
SWW2
SWD
SWD1


Unionised Ammoniacal Nitrogen
Concentration ug/l
0.1200
0.1000
0.0800
0.0600
0.0400
0.0200
0.0000
Dec 2014
Jan 2015
Feb 2015
Mar 2015
Apr 2015
May 2015
Jun 2015
Jul 2015
Aug 2015
Sep 2015
Oct 2015
Nov 2015
Dec 2015
Jan 2016
Feb 2016
Mar 2016
Apr 2016
May 2016
Jun 2016
Jul 2016
SWU
SW2A1
SWW4
SWW1
SWW2
SWD
SWD1
EQS

APPENDIX C
Figure C5
Surface water monitoring graphs (SW1 to SW10)

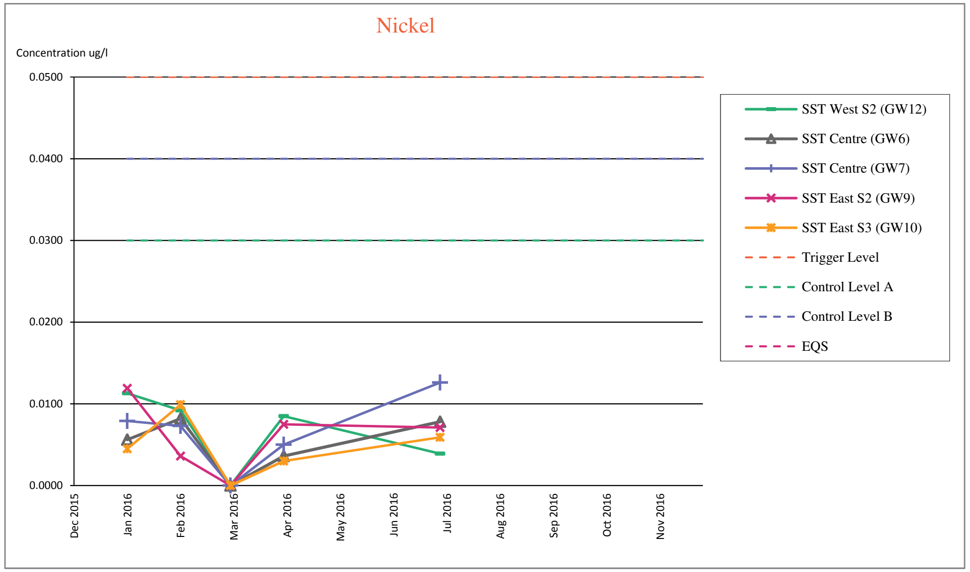


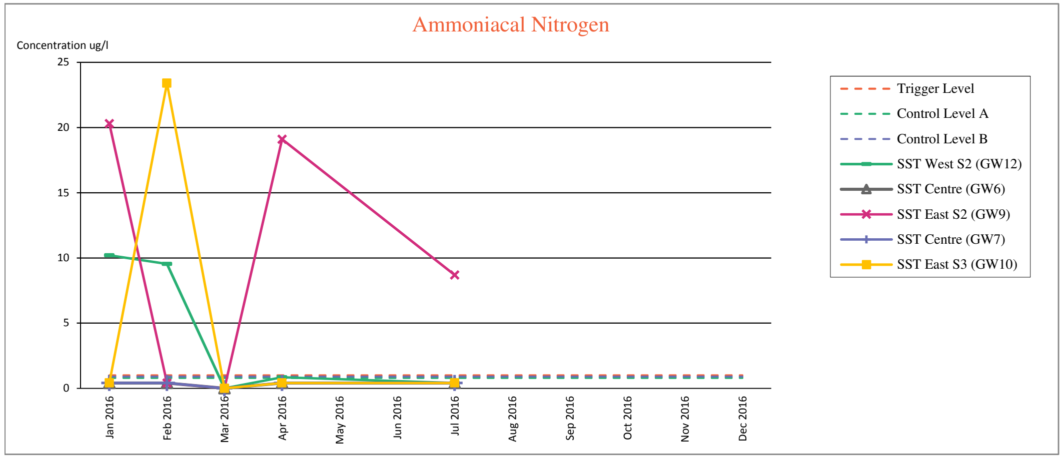


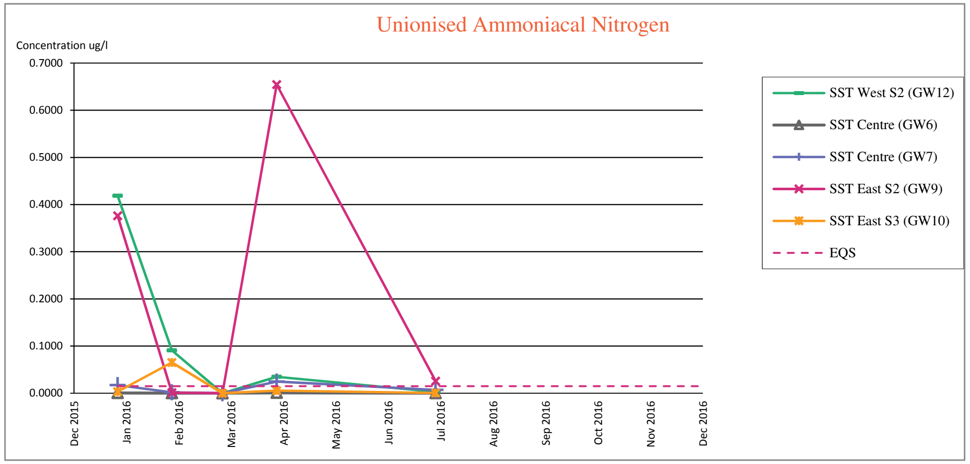


APPENDIX C
Figure C6
Groundwater quality monitoring results - Compliance wells graphs

Compliance wells graphs

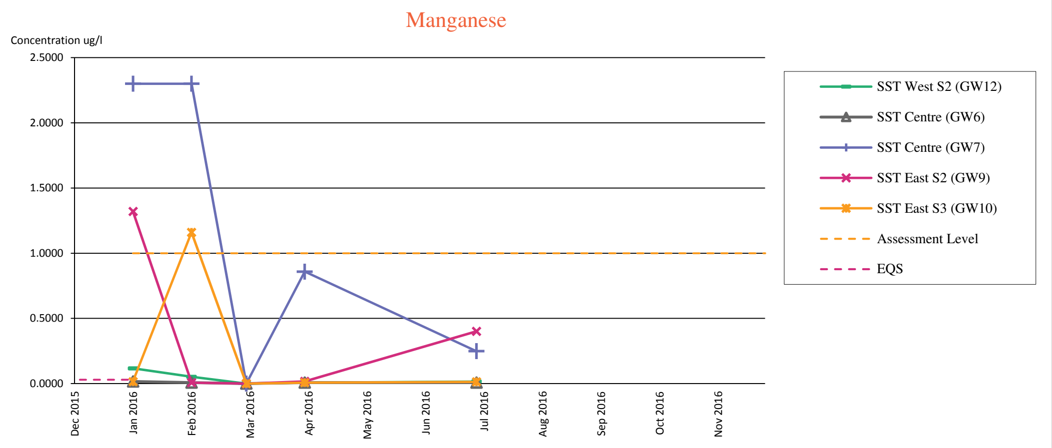


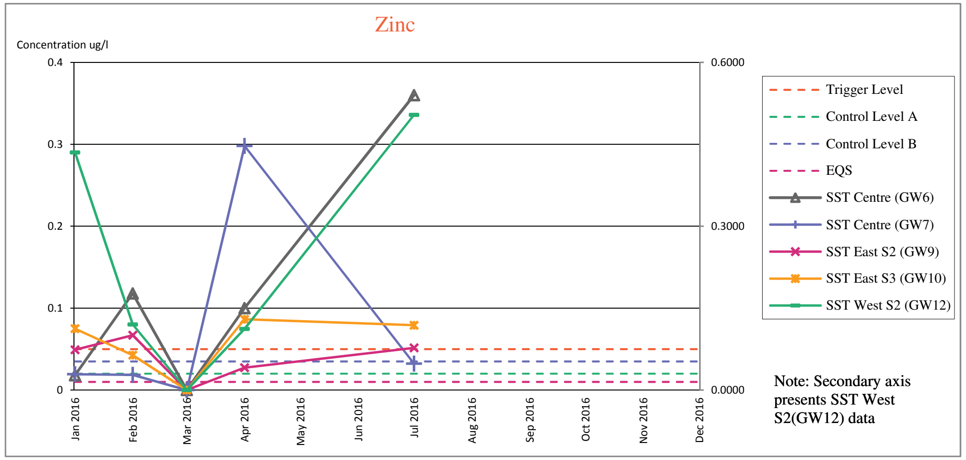


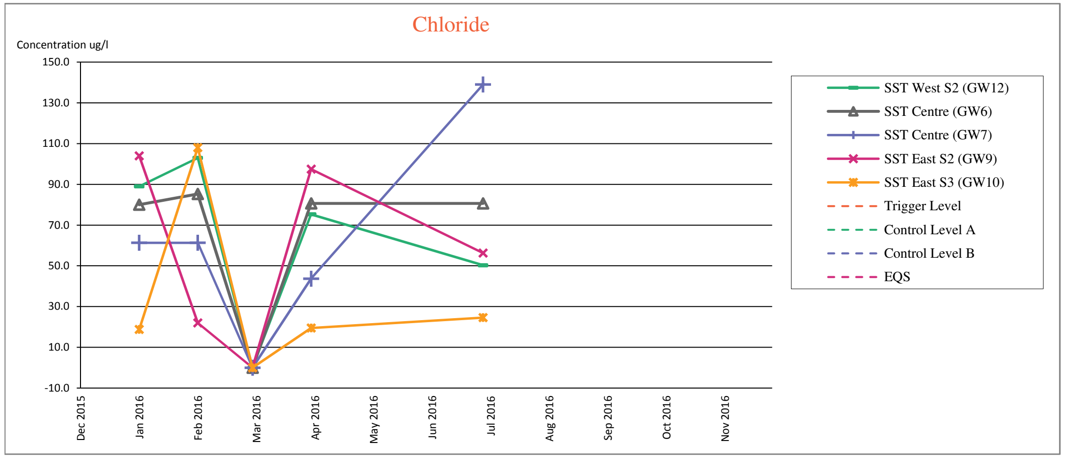


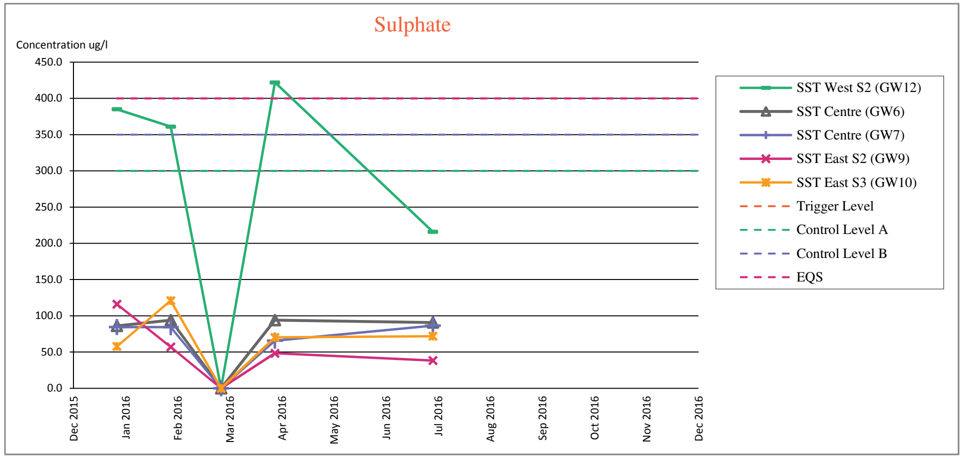
APPENDIX C
Figure C6
Groundwater quality monitoring results - Compliance wells graphs

Compliance wells graphs



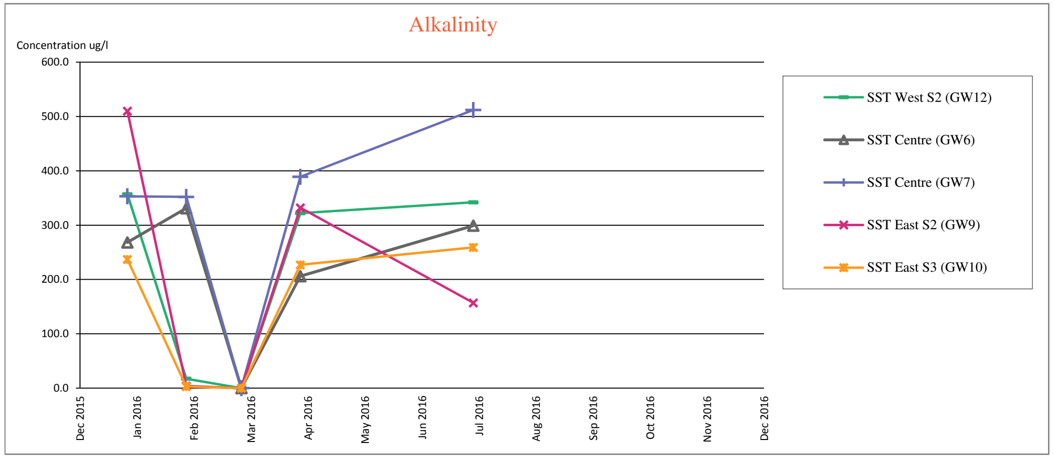


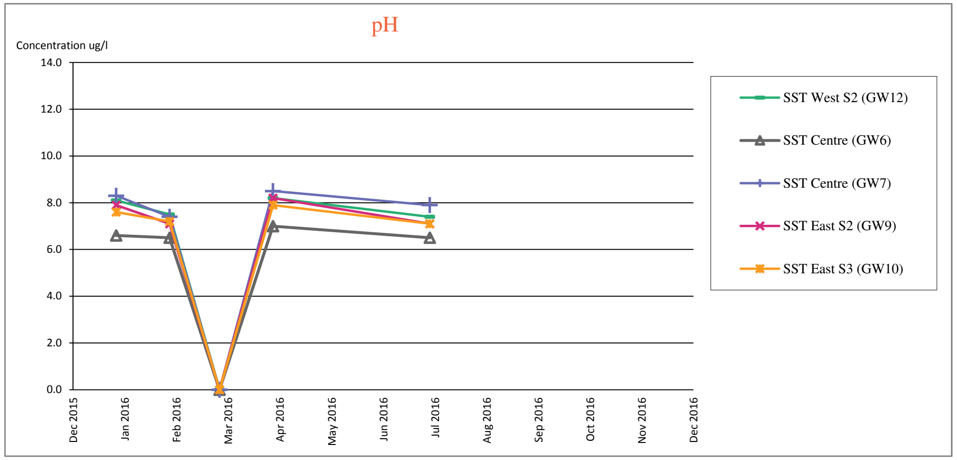




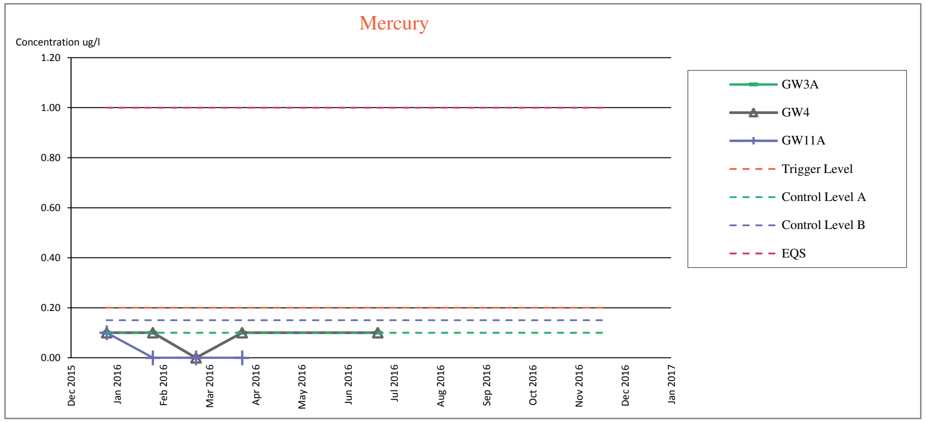
APPENDIX C
Figure C6
Groundwater quality monitoring results - Compliance wells graphs

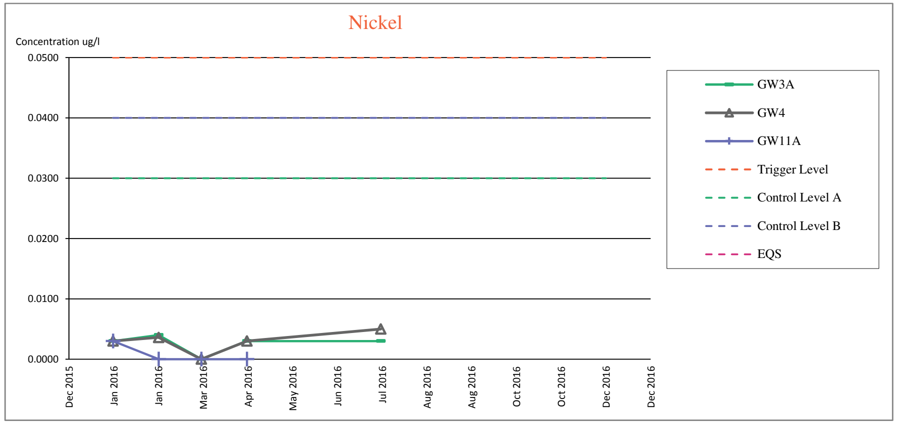
Compliance wells graphs

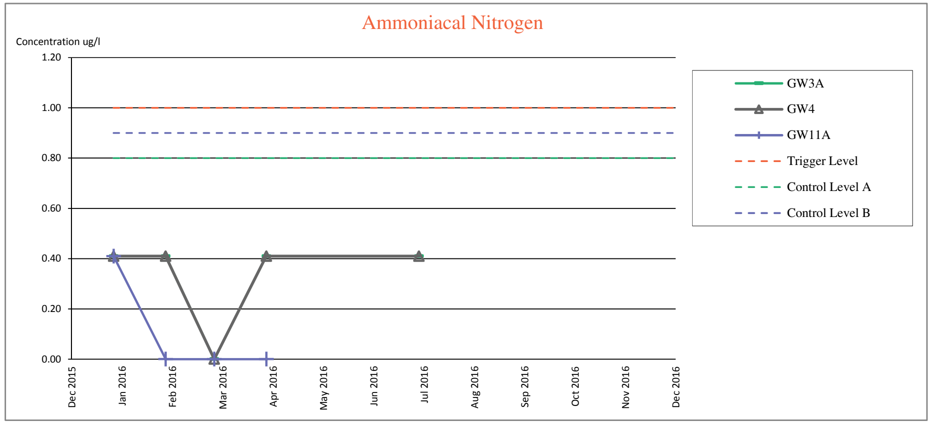


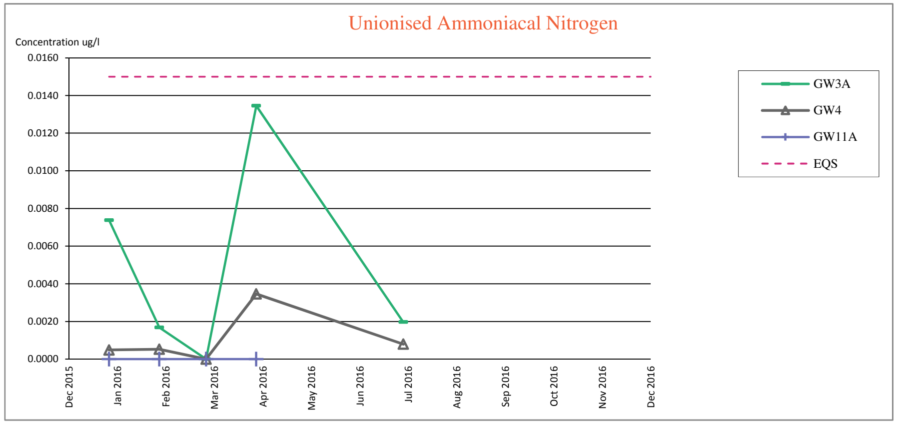


APPENDIX C
Figure C7
Groundwater quality monitoring results - Upstream wells graphs

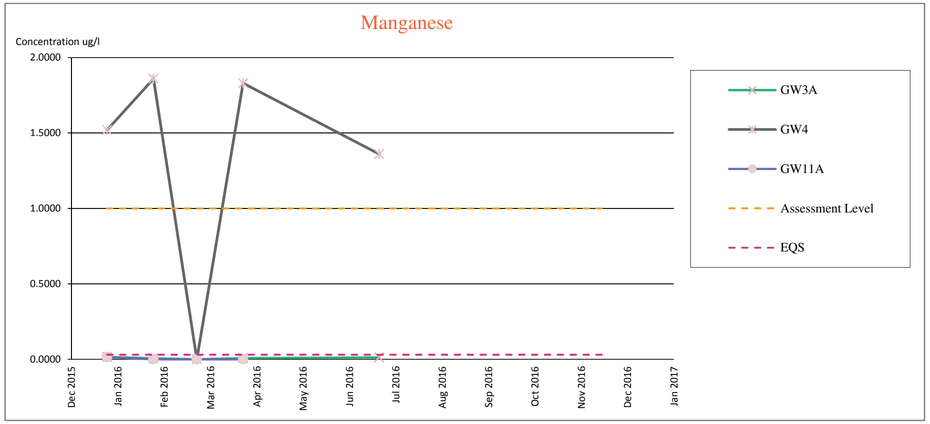


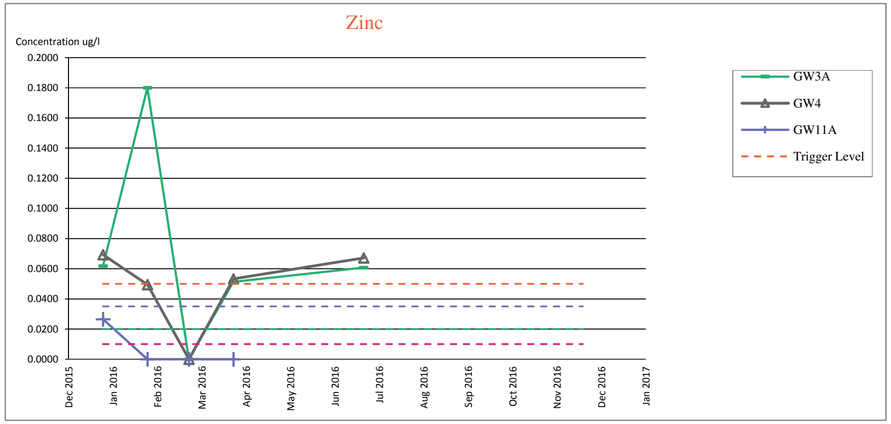


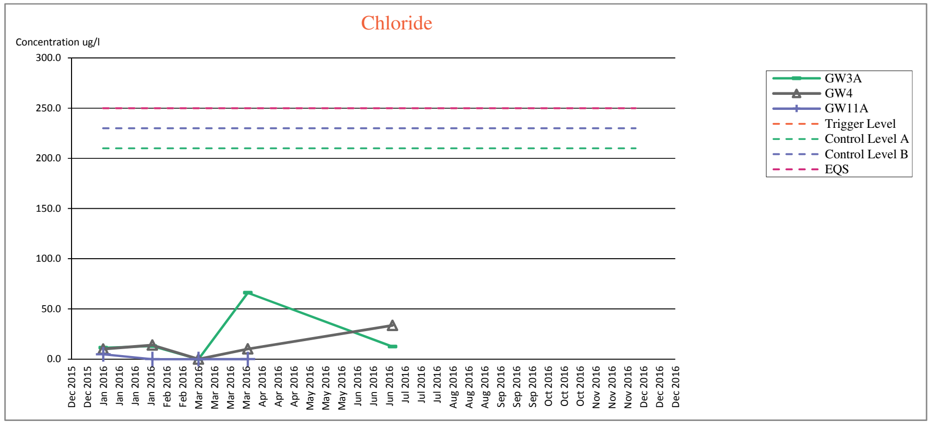


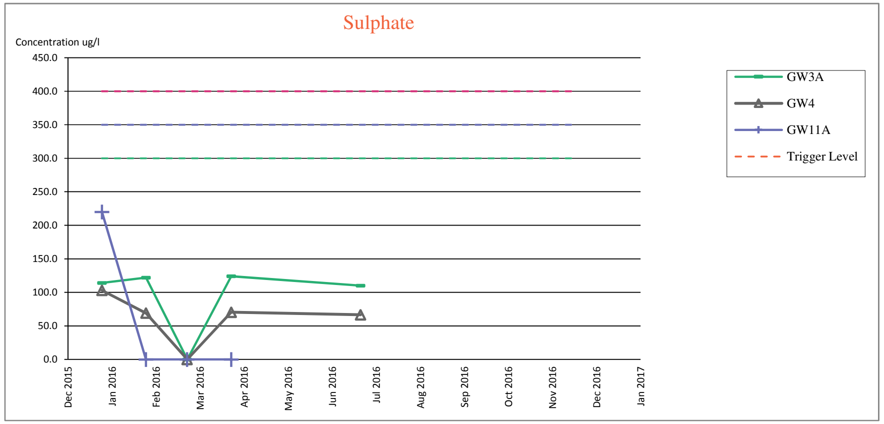


APPENDIX C
Figure C7
Groundwater quality monitoring results - Upstream wells graphs

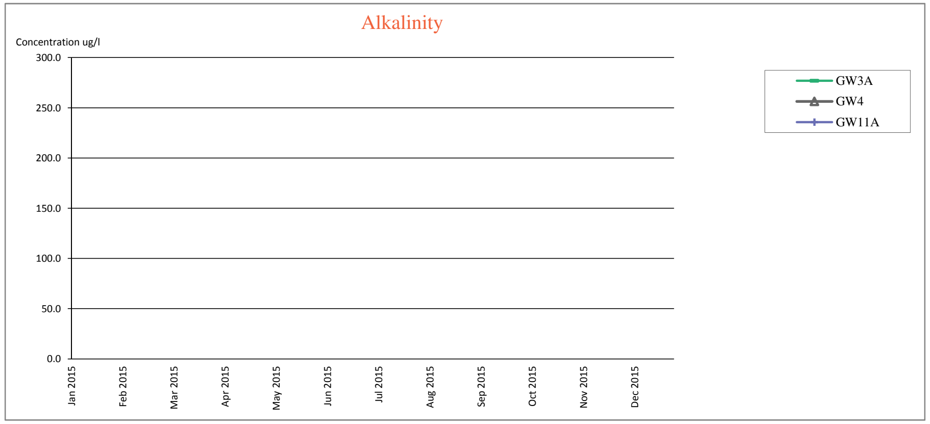


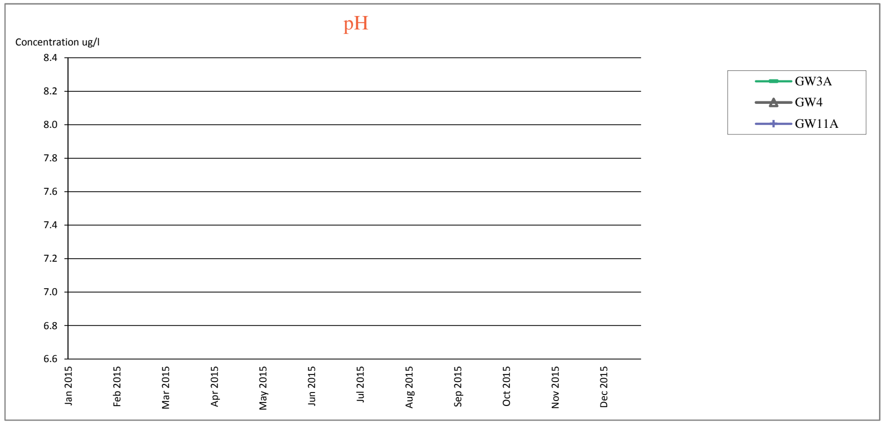




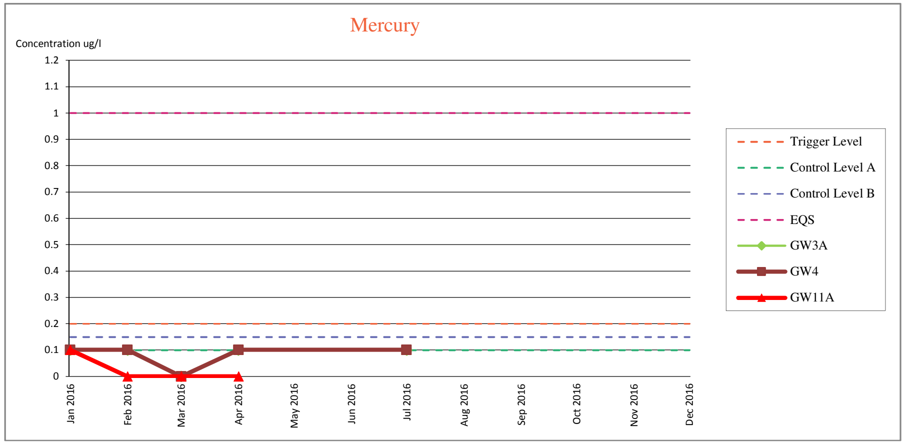


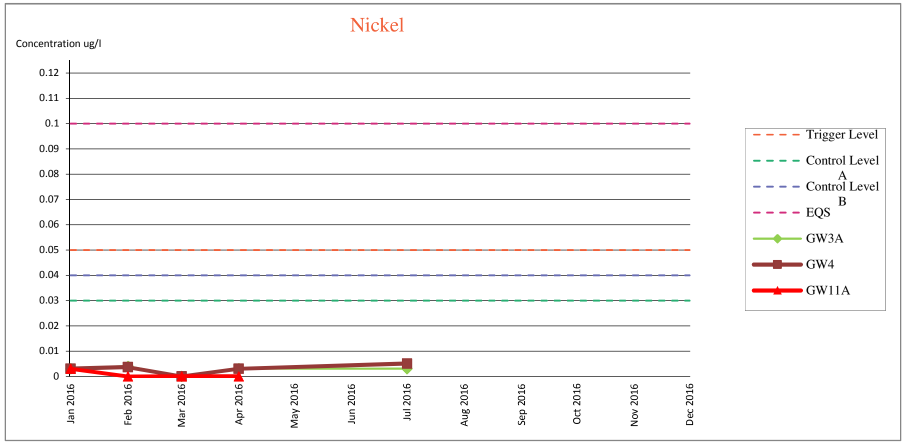
APPENDIX C
Figure C7
Groundwater quality monitoring results - Upstream wells graphs

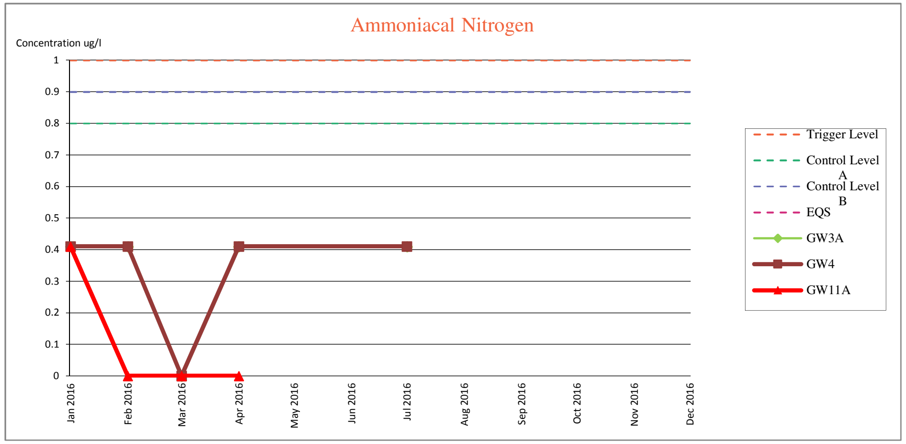


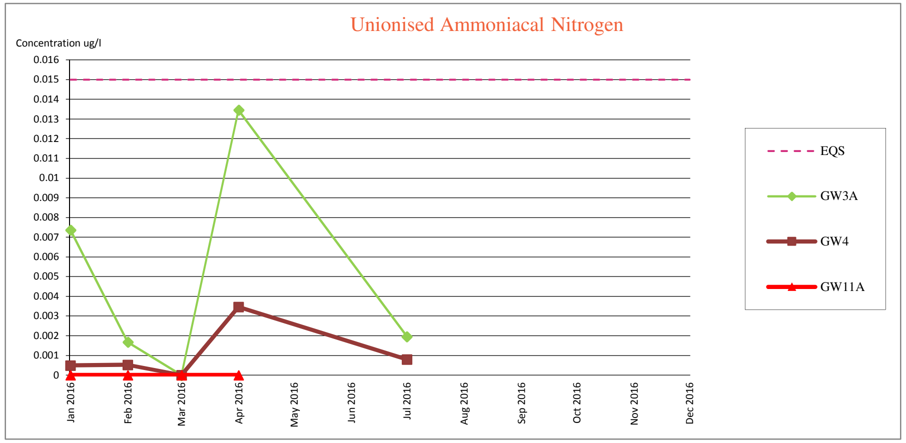


APPENDIX C
Figure C7
Groundwater quality monitoring results - Upstream wells graphs

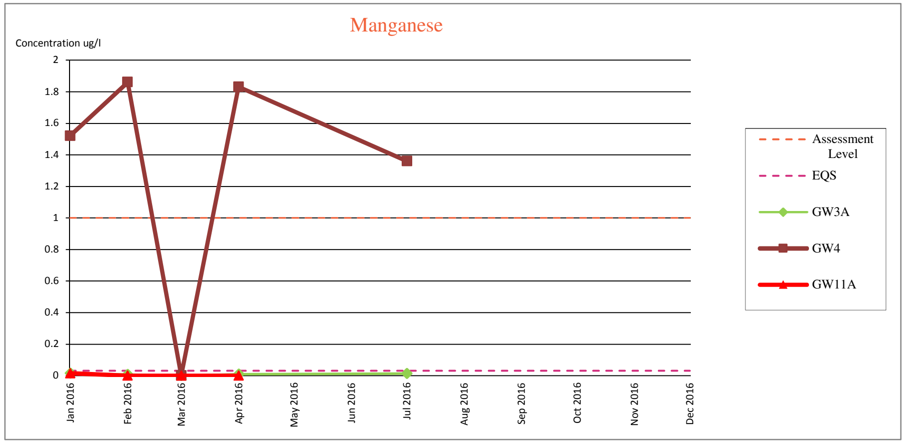


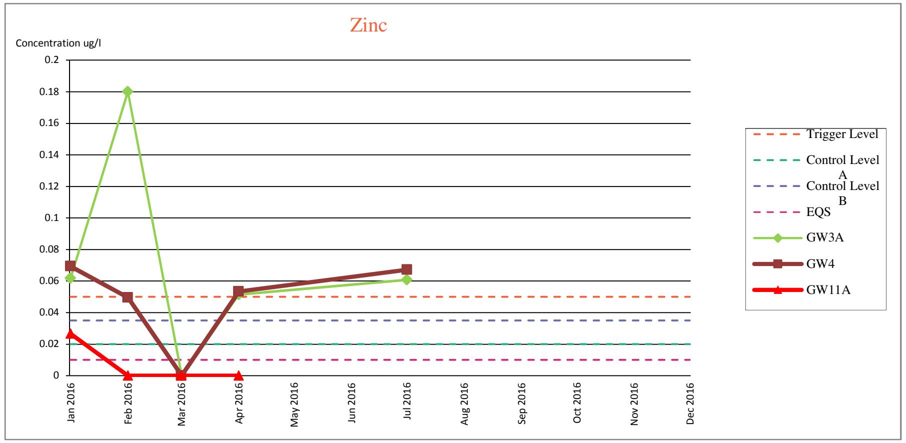


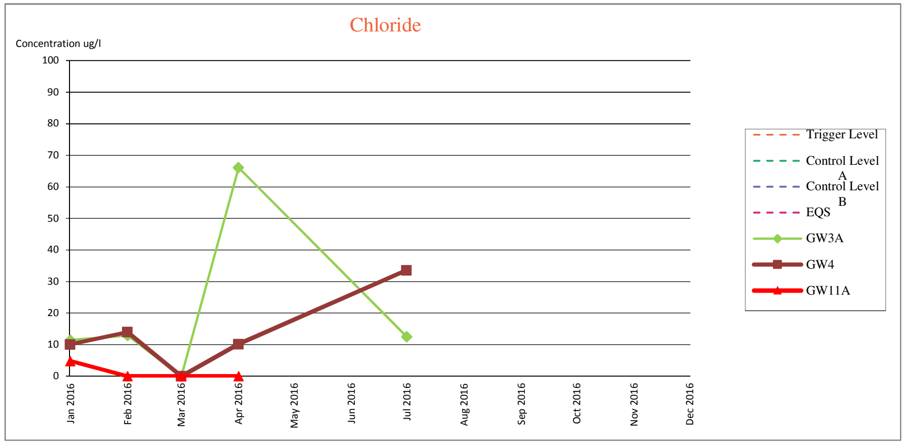


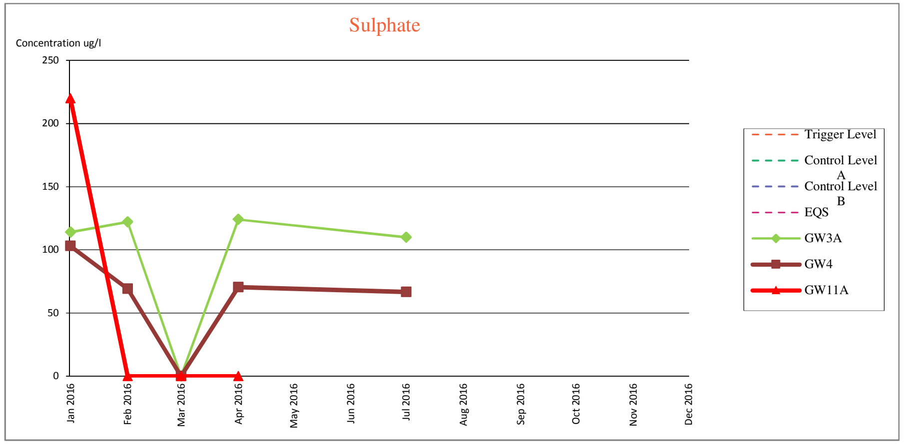


APPENDIX C
Figure C7
Groundwater quality monitoring results - Upstream wells graphs

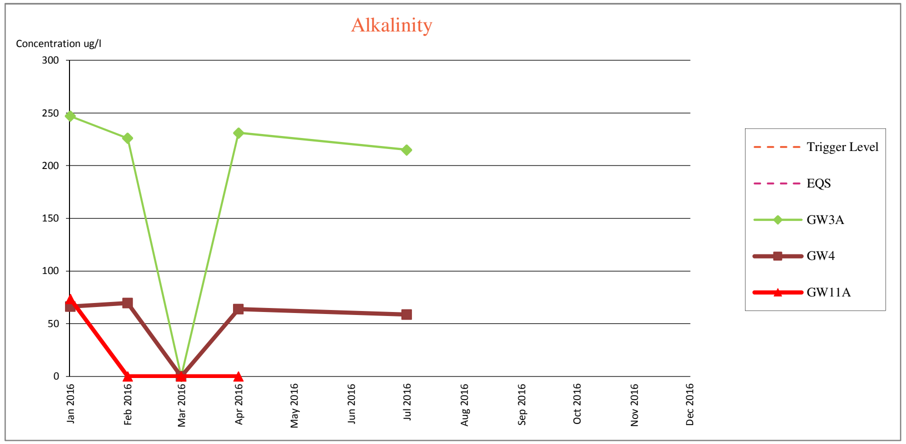


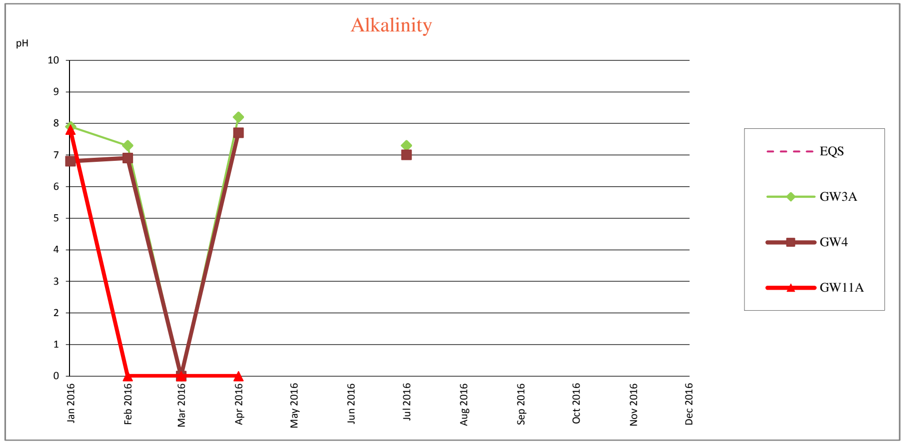


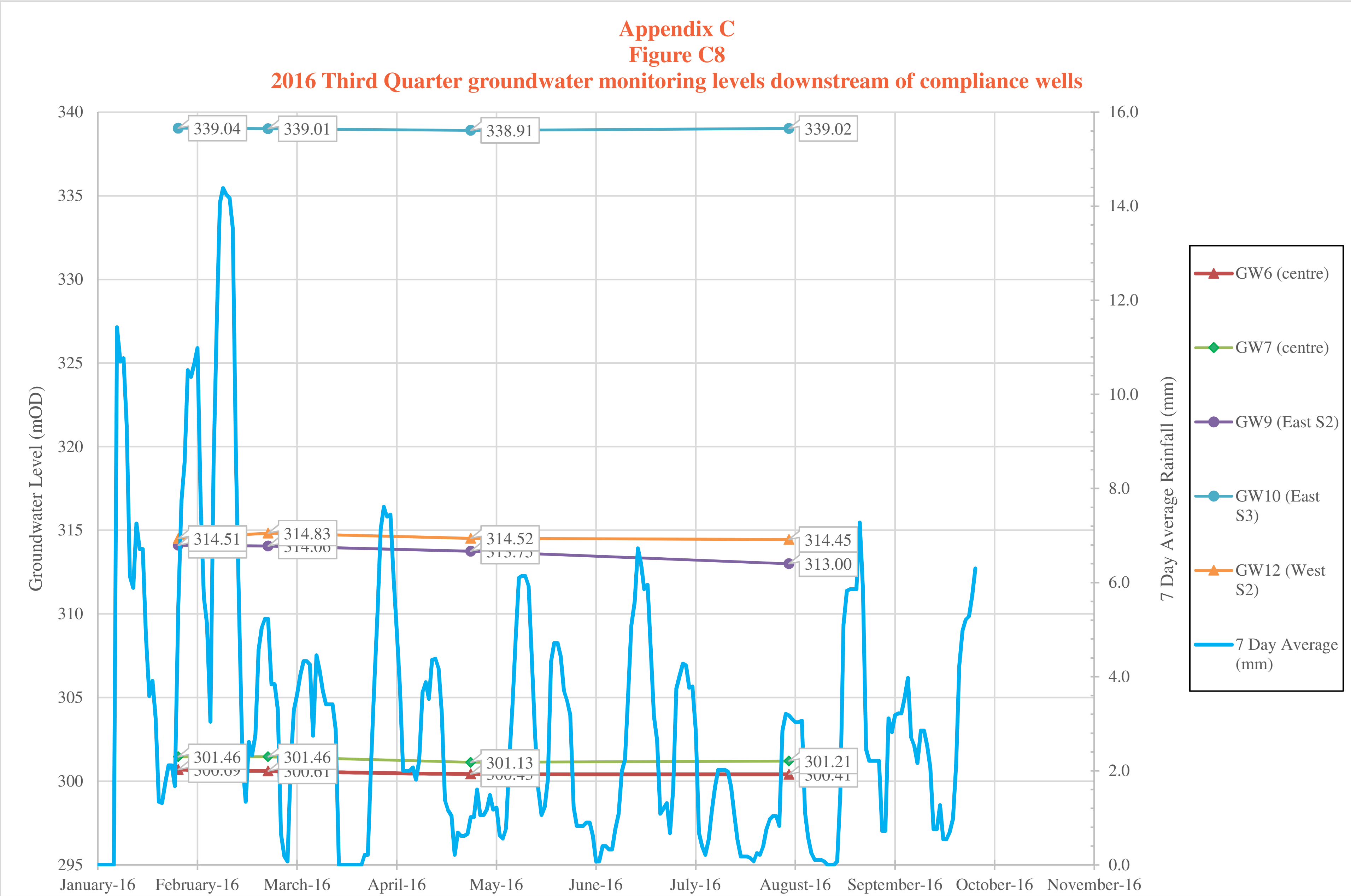




APPENDIX C
Figure C7
Groundwater quality monitoring results - Upstream wells graphs






Appendix C
Figure C8
2016 Third Quarter groundwater monitoring levels downstream of compliance wells
Groundwater Level (mOD)
7 Day Average Rainfall (mm)
340
335
330
325
320
315
310
305
300
295
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
January-16
February-16
March-16
April-16
May-16
June-16
July-16
August-16
September-16
October-16
November-16
339.04
339.01
338.91
339.02
314.51
314.83
314.52
314.45
313.00
301.46
301.46
301.13
301.21
GW6 (centre)
GW7 (centre)
GW9 (East S2)
GW10 (East S3)
GW12 (West S2)
7 Day Average (mm)

Appendix D

Monitoring Results - Tables

Appendix D
Table D1
Leachate Monitoring Results

July 2016

LOCATION	Units		L1A		L1B	LC1A		LC2A		LC4A		LC5A	Maximum concentration (mg/l)	Average concentration (mg/l)	Acceptable Maximum Concentration (AMC) (mg/l)		LP3A		LP4
Date Sampled	-																		
Manganese in filtrate as Mn	mg/l		0.0347		0.136	N/S		0.105		0.704		0.14	**0.704**	**0.22394**	**--**		0.206		0.186
Mercury, filt trace as Hg	mg/l	<	0.0001	<	0.0001	N/S	<	0.0001	<	0.0001	<	0.0001	**0.0001**	**0.0001**	**0.00056**	<	0.0001	<	0.0001
Nickel in filtrate as Ni	mg/l		0.027		0.025	N/S		0.0793		0.0229		0.185	**0.185**	**0.03855**	**0.0681**		0.0154		0.0078
Zinc, ultra-low filtered as Zn	mg/l		0.279		0.0547	N/S		0.257		0.0985		0.214	**0.279**	**0.1723**	**1.380**		0.025		0.0218
pH	pH Units		8.1		8.3	N/S		8.4		7.8		8.4	**8.4**	**8.15**	**--**		8.4		8.4
Conductivity- Electrical 20C	uS/cm		1880		2830	N/S		8490		4100		20300	**20300**	**4325**	**--**		2090		2110
Alkalinity as CaCO3	mg/l		894		747	N/S		5100		2670		12900	**12900**	**2352.75**	**--**		390		797
Ammoniacal Nitrogen as N	mg/l	<	0.41		66.2	N/S		703		289		2060	**2060**	**264.6525**	**526**		21.7		64.6
Chloride as Cl	mg/l		148		312	N/S		844		211		1810	**1810**	**378.75**	**1408**		219		163
Sulphate as SO4	mg/l		167		375	N/S		8.51	<	4.4	<	4.4	**375**	**138.7275**	**999**		302		137
Redox Potential (see note 4)	mV		-237		-209	N/S		-216		-255		-252	**-209**	**-229.25**	**--**		-204		-199
Total Suspended Solids	mg/l		556		58	N/S		510		50		240	**556**	**293.5**	**--**		6		46
Solids, Total Dissolved 180 deg (	mg/l		1380		2020	N/S		4510		2000		9470	**9470**	**2477.5**	**--**		1510		1280
Dissolved Oxygen, Fixed	mg/l		1.8		4	N/S	<	0.5	<	0.5	<	0.5	**4**	**1.7**	**--**		6.9		3.7
TOC (filtered)	mg/l		15.5		45.6	N/S		278		30.5		1210	**1210**	**92.4**	**--**		33.1		27.4

Notes
1. < denotes 'less than'.
2. L1A,L1B, LC1A, LC2A,LC4A, LC5A: Wells in Waste.
3. -- denotes 'no acceptable maximum concentration available'.
4. The redox potential was not measured on site and there is a possibility that it has changed between sampling and analysis
5. LC5A is a replacement for LC5 well.
6. NS denotes 'not sampled.
No monthly average leachate levels above Maximum Acceptable Concentration (MAC)

Appendix D
Table D2
Leachate Head Levels

Well	Parameter	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
LC1A	Elevation of base of landfill mAOD	357.62	357.62	N/S	357.62	357.62	357.62	357.62	N/S	N/S			
	Elevation at top of casing mAOD	398.88	398.88	N/S	398.88	398.88	398.88	398.88	N/S	N/S			
	Depth to leachate from top of casing (m)	40.40	40.40	N/S	40.40	40.29	40.38	40.32	N/S	N/S			
	Leachate elevation (mAOD)	358.48	358.48	N/S	358.48	358.59	358.51	358.56	N/S	N/S			
	Calculated leachate head (m)	0.86	0.86	N/S	0.86	0.97	0.88	0.94	N/S	N/S			
	Calculated quarterly average leachate head (m)		0.86			0.90		0.94	N/S	N/S			
LC2A	Elevation of base of landfill mAOD	362.49	362.49	N/S	362.49	362.49	362.49	362.49	N/S	N/S			
	Elevation at top of casing mAOD	401.26	401.26	N/S	401.26	401.26	401.26	401.26	N/S	N/S			
	Depth to leachate from top of casing (m)	35.94	35.82	N/S	35.70	35.83	35.80	35.82	N/S	N/S			
	Leachate elevation (mAOD)	365.32	365.44	N/S	365.56	365.43	365.46	365.44	N/S	N/S			
	Calculated leachate head (m)	2.83	2.95	N/S	3.07	2.94	2.97	2.95	N/S	N/S			
	Calculated quarterly average leachate head (m)		2.89			2.99		2.95	N/S	N/S			
LC4A	Elevation of base of landfill mAOD	372.27	372.27	N/S	372.27	372.27	372.27	372.27	N/S	N/S			
	Elevation at top of casing mAOD	401.24	401.24	N/S	401.24	401.24	401.24	401.24	N/S	N/S			
	Depth to leachate from top of casing (m)	26.98	26.97	N/S	26.91	26.98	26.97	26.97	N/S	N/S			
	Leachate elevation (mAOD)	374.26	374.27	N/S	374.33	374.26	374.27	374.27	N/S	N/S			
	Calculated leachate head (m)	1.99	2.00	N/S	2.06	1.99	2.00	2.00	N/S	N/S			
	Calculated quarterly average leachate head (m)		2.00			2.02		2.00	N/S	N/S			
LC5A	Elevation of base of landfill mAOD	350.14	350.14	N/S	350.14	350.14	350.14	350.14	N/S	N/S			
	Elevation at top of casing mAOD	380.98	380.98	N/S	380.98	380.98	380.98	380.98	N/S	N/S			
	Depth to leachate from top of casing (m)	26.33	26.66	N/S	26.84	26.15	26.88	26.03	N/S	N/S			
	Leachate elevation (mAOD)	354.65	354.32	N/S	354.14	354.83	354.11	354.95	N/S	N/S			
	Calculated leachate head (m)	4.51	4.18	N/S	4.00	4.69	3.97	4.81	N/S	N/S			
	Calculated quarterly average leachate head (m)		4.35			4.22		4.81	N/S	N/S			
L1	Casing height (mAOD)	356.80	356.80	N/S	356.80	356.80	356.80	356.80	N/S	N/S			
	Leachate (mbgl)	dry	21.02	N/S	dry	dry	dry	dry	N/S	N/S			
	Leachate (m AOD)	-	-	N/S					N/S	N/S			
	Base of landfill (m AOD)	336.80	336.80	N/S	336.80	336.80	336.80	336.80	N/S	N/S			
	Depth of well from top of casing (m)	21.03	21.03	N/S	21.03	21.03	21.03	21.03	N/S	N/S			
	Base of well (m AOD)	336.80	336.80	N/S	336.80	336.80	336.80	336.80	N/S	N/S			
	Calculated leachate head (m)	-	-	N/S	-	-	-	-	N/S	N/S			
L1A*	Casing height (mAOD)	354.84	354.84	N/S	354.84	354.84	354.84	354.84	N/S	N/S			
	Leachate (mbgl)	18.70	16.43	N/S	16.95	18.13	18.80	19.29	N/S	N/S			
	Leachate (m AOD)	336.14	338.41	N/S	337.89	336.71	336.04	335.55	N/S	N/S			
	Base of landfill (m AOD)	316.64	316.64	N/S	316.64	316.64	316.64	316.64	N/S	N/S			
	Depth of well from top of casing (m)	21.12	21.07	N/S	21.05	20.95	20.93	20.95	N/S	N/S			
	Base of well (m AOD)	334.84	334.84	N/S	334.84	334.84	334.84	333.89	N/S	N/S			
	Calculated leachate head (m)	19.50	21.77	N/S	21.25	20.07	19.40	18.91	N/S	N/S			
L1B*	Casing height (mAOD)	354.34	354.34	N/S	354.34	354.34	354.34	354.34	N/S	N/S			
	Leachate (mbgl)	25.15	25.02	N/S	24.50	25.40	25.58	25.80	N/S	N/S			
	Leachate (m AOD)	329.19	329.32	N/S	329.84	328.94	328.76	328.54	N/S	N/S			
	Base of landfill (m AOD)	319.60	319.60	N/S	319.60	319.60	319.60	319.60	N/S	N/S			
	Depth of well from top of casing (m)	35.50	35.50	N/S	34.90	34.90	34.85	34.87	N/S	N/S			
	Base of well (m AOD)	319.34	319.34	N/S	319.34	319.34	319.34	319.34	N/S	N/S			
	Calculated leachate head (m)	9.59	9.72	N/S	10.24	9.34	9.16	9.20	N/S	N/S			

2016	Monthly Leachate Head Averages (m)
January	2.55
February	2.50
March	N/S
April	2.50
May	2.65
June	2.46
July	2.68
August	N/S
September	N/S
October	
November	
December	

Assessment Level (m)
3

Minimum monthly leachate head average
Maximum monthly leachate head average

Notes:

1. LC1A top of casing not reduced. LC1A top of casing is 750mm above ground level.

2. LC2A top of casing reduced by 1190mm is 780mm above GL and approx. level with top of casing for LC2.

3. LC4A top of casing reduced by 1940mm is 260mm above GL and approx. level with top of casing for LC4.

4. LC2A and LC4A reduced (protruding pipe length cut) on 23 Feb 10.

5. Levels in L1 were not measured in February and March due to the capping works resrainin access to the well location.

* Well not included in monthly average.

** Cover level re-surveyed in September 2009.

Note: L1 is generally dry or with very little water in it.

Appendix D
Table D2
Leachate Head Levels

Appendix D
Table D3
Surface Water Monitoring Results

Month	Location		Date	Arsenic (FILT) ICPMS	Mercury, ultra-low total as Hg	Redox Potential	Cadmium, ultra-low total as Cd	Calcium in Filtrate as Ca	Chromium in Filtrate as Cr	Copper in Filtrate as Cu	Iron in filtrate as Fe	Lead in filtrate as Pb	Magnesium in filtrate as Mg	Manganese in filtrate as Mn	Nickel in filtrate as Ni	Potassium in filtrate as K	Sodium in filtrate as Na	Zinc, ultra-low total as Zn
				mg/l	ug/l	mV	ug/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Freshwater EQS**				0.05	1	-	5	-	0.01*	0.006*	1	0.01*	-	0.03	0.1*	-	-	0.05*
July	Upstream of Landfill	SWU	Six-monthly	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SW2AI		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SWW4		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	NW Ditch System	SWW1	Six-monthly	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SWW2		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	Downstream of Landfill	SWD	04/08/2016	N/S	< 0.10	-189	N/S	N/S	N/S	N/S	N/S	N/S	N/S	0.0077	< 0.0030	N/S	N/S	< 0.018
		SWD1	04/08/2016	N/S	< 0.10	-190	N/S	N/S	N/S	N/S	N/S	N/S	N/S	< 0.0070	< 0.0030	N/S	N/S	< 0.018
August	Upstream of Landfill	SWU	Six-monthly	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SW2AI		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SWW4		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	NW Ditch System	SWW1	Six-monthly	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SWW2		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	Downstream of Landfill	SWD	Quarterly	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SWD1		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
September	Upstream of Landfill	SWU	Six-monthly	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SW2AI		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SWW4		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	NW Ditch System	SWW1	Six-monthly	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SWW2		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	Downstream of Landfill	SWD	Quarterly	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SWD1		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
Minimum				< 0.0000	< 0.1000	-190.0	< 0.00	0.00	< 0.000	< 0.000	< 0.000	< 0.000	0.0	< 0.007	< 0.003	0.000	0.000	< 0.0180
Maximum				0.0000	< 0.1000	-189.0	< 0.00	0.00	0.0000	0.0000	< 0.000	0.000	0.0	0.008	0.003	0.000	0.000	0.0180
Count				0.00	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.00	0.00	0.00	2.00

Exceedance of EQS
Upstream of Nant Merddog
Downstream of Nant Merddog

Notes

- \- The redox potential was not measured on site and there is a possibility that it has changed between sampling and analysis
- -- Not analysed
- * Water hardness data obtained from SWU, SWD and SWD1 is between 50 and 100mg/l.
- ** Unionised ammoniacal nitrogen based on measured Temperature and pH; unionised ammoniacal nitrogen = total ammonia/$(1+10^{(10.055-(0.0324*Tc)-pH)})$, where T°C is
- *** Reporting limits raised for TPH due to sample matrix.
- EQS Environmental Quality Standard EQS 1 for freshwater is derived to protect the most sensitive aquatic life.
- NW North Western (ditch system)

Appendix D
Table D3
Surface Water Monitoring Results

pH	Conductivity-Electrical 20C	Alkalinity as CaCO3	Ammonia cal Nitrogen as N	Unionised Ammonia cal Nitrogen **	Measured surface water temperature	Chloride as Cl	Nitrogen, Total Oxidised as N	Sulphate as SO4	Solids, Suspended	Dissolved oxygen	BOD + ATU (5 day)	COD (Total)	TOC (Filtered)	TPH >C6-C40***	TPH >C6-C8***	TPH >C8-C10***	TPH >C16-C24***	TPH >C24-C40***
	uS/cm	mg/l	mg/l	mg/l	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	ug/l	ug/l	ug/l	ug/l	ug/l
-	-	-	-	0.015**	-	250	-	400	-	-	-	-	-	-	-	-	-	-
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
8.50	426.00	N/S	< 0.41	0.0239	13.60	6.00	N/S	97.90	3	8.9			3.2					
8.50	418.00	N/S	< 0.41	0.0291	13.50	11.20	N/S	93.50	6	8.6			3.2					
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
8.5	418.0	0.00	< 0.41	0.0239	13.50	6.00	< 0.00	93.50	3.00	< 8.60	< 0.00	< 0.00	< 3.20	< 0.00	< 0.00	< 0.00	< 0.00	< 0.00 <
8.5	426.0	0.00	0.41	0.03	13.60	11.20	0.00	97.90	6.00	8.90	0.00	0.00	3.20	0.00	0.00	0.00	0.00	0.00
2.00	2.00	0.00	2.00	2.00	2.00	2.00	0.00	2.00	2.00	2.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00

Appendix D
Table D3
Surface Water Monitoring Results

TPH >C10-C16***	Acetic acid	Iso-butyric acid	Iso-valeric acid	N-butyric acid	N-valeric acid	Propionic acid	Volatile acids,Total
ug/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
-	-	-	-	-	-	-	-
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
0.00	< 0.00	< 0.00	< 0.00	< 0.00	< 0.00	< 0.00	< 0.00
0.00	< 0.00	< 0.00	< 0.00	< 0.00	< 0.00	< 0.00	< 0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix D
Table D4
Surface water monitoring SW1 to SW10

MONTH	LOCATION	DATE		Mercury, ultra-low total as Hg		Ammoniacal Nitrogen as N		Chloride as Cl
				ug/l		mg/l		mg/l
	Freshwater EQS			1		n/a		250
January	SW1	28/01/2016	<	0.10	<	0.41		16.6
	SW2	28/01/2016	<	0.10	<	0.41		17
	SW3	28/01/2016	<	0.10	<	0.41		10.8
	SW4	28/01/2016	<	0.10		0.41		19.2
	SW5	28/01/2016	<	0.10		0.41		20.7
	SW6	28/01/2016	<	0.10	<	0.41		17.8
	SW7	28/01/2016	<	0.10	<	0.41		11.6
	SW8	28/01/2016	<	0.10	<	0.41		10.8
	SW9	28/01/2016	<	0.10	<	0.41		6.1
	SW10	28/01/2016	<	0.10	<	0.41		6.4
February	SW1	24/02/2016	<	*Not sampled*	<	0.41		46.3
	SW2	24/02/2016	<	*Not sampled*	<	0.41		46.6
	SW3	24/02/2016	<	*Not sampled*	<	0.41		27.4
	SW4	24/02/2016	<	*Not sampled*	<	7.72		60.2
	SW5	24/02/2016	<	*Not sampled*	<	5.55		58.6
	SW6	24/02/2016	<	*Not sampled*	<	2.87		51.3
	SW7	24/02/2016	<	*Not sampled*	<	0.41		13.3
	SW8	24/02/2016	<	*Not sampled*	<	0.41		8.3
	SW9	24/02/2016	<	*Not sampled*	<	0.41		11.8
	SW10	24/02/2016	<	*Not sampled*	<	0.41		13.3
March	SW1	-	<	*Not sampled*	<	*Not sampled*		*Not sampled*
	SW2	-	<	*Not sampled*	<	*Not sampled*		*Not sampled*
	SW3	-	<	*Not sampled*	<	*Not sampled*		*Not sampled*
	SW4	-	<	*Not sampled*	<	*Not sampled*		*Not sampled*
	SW5	-	<	*Not sampled*	<	*Not sampled*		*Not sampled*
	SW6	-	<	*Not sampled*	<	*Not sampled*		*Not sampled*
	SW7	-	<	*Not sampled*	<	*Not sampled*		*Not sampled*
	SW8	-	<	*Not sampled*	<	*Not sampled*		*Not sampled*
	SW9	-	<	*Not sampled*	<	*Not sampled*		*Not sampled*
	SW10	-	<	*Not sampled*	<	*Not sampled*		*Not sampled*
April	SW1	07/04/2016	<	0.10	<	0.41		39.80
	SW2	07/04/2016	<	0.10	<	0.41		39.70
	SW3	07/04/2016	<	0.10	<	0.41		28.30
	SW4	07/04/2016	<	0.10	<	0.41		51.10
	SW5	07/04/2016	<	0.10	<	0.41		50.00
	SW6	07/04/2016	<	0.10	<	0.41		44.40
	SW7	07/04/2016	<	0.10	<	0.41		20.50
	SW8	07/04/2016	<	0.10	<	0.41		9.00
	SW9	07/04/2016	<	0.10	<	0.41		12.50
	SW10	07/04/2016	<	0.10	<	0.41		17.60
May	SW1	25/05/2016	<	0.10	<	0.41		32.20
	SW2	25/05/2016	<	0.10	<	0.41		30.60
	SW3	25/05/2016	<	0.10	<	0.41		19.50
	SW4	25/05/2016	<	0.10	<	0.41		36.40
	SW5	25/05/2016	<	0.10	<	0.41		35.40
	SW6	25/05/2016	<	0.10	<	0.41		31.50
	SW7	25/05/2016	<	0.10	<	0.41		12.60
	SW8	25/05/2016	<	0.10	<	0.41		6.70
	SW9	25/05/2016	<	0.10	<	0.41		9.50
	SW10	25/05/2016	<	0.10	<	0.41		9.80
June	SW1	30/06/2016	<	0.10	<	0.41		39.20
	SW2	30/06/2016	<	0.10	<	0.41		39.40
	SW3	30/06/2016	<	0.10	<	0.41		21.90
	SW4	30/06/2016	<	0.10	<	0.41		45.60
	SW5	30/06/2016	<	0.10	<	0.41		35.40
	SW6	30/06/2016	<	0.10	<	0.41		42.80
	SW7	30/06/2016	<	0.10	<	0.41		16.50
	SW8	30/06/2016	<	0.10	<	0.41		5.80
	SW9	30/06/2016	<	0.10	<	0.41		8.70
	SW10	30/06/2016	<	0.10	<	0.41		8.90
July	SW1	-	<	*Not sampled*	<	*Not sampled*	<	*Not sampled*
	SW2	-		*Not sampled*	<	*Not sampled*	<	*Not sampled*
	SW3	04/08/2016	<	0.10	<	0.41		33.20
	SW4	04/08/2016	<	0.10	<	0.41		75.50
	SW5	04/08/2016	<	0.10	<	0.41		73.00
	SW6	04/08/2016	<	0.10	<	0.41		62.60
	SW7	04/08/2016	<	0.10	<	0.41		16.10

Appendix D
Table D4
Surface water monitoring SW1 to SW10

	SW8	04/08/2016	<	0.10	<	0.41		8.90
	SW9		<	*Not sampled*	<	*Not sampled*	<	*Not sampled*
	SW10	04/08/2016	<	0.10	<	0.41		14.90
August	**SW1**	-	<	*Not sampled*	<	*Not sampled*	<	*Not sampled*
	SW2	26/08/2016	<	0.10	<	0.41		55.50
	SW3	26/08/2016	<	0.10	<	0.41		29.50
	SW4	26/08/2016	<	0.10	<	0.41		60.20
	SW5	26/08/2016	<	0.10	<	0.41		59.10
	SW6	26/08/2016	<	0.10	<	0.41		54.00
	SW7	26/08/2016	<	0.10	<	0.41		14.10
	SW8	26/08/2016	<	0.10	<	0.41		7.40
	SW9	-	<	*Not sampled*	<	*Not sampled*	<	*Not sampled*
	SW10	-	<	*Not sampled*	<	*Not sampled*	<	*Not sampled*
September	**SW1**	27/09/2016	<	0.10	<	0.41		28.40
	SW2	27/09/2016	<	0.10	<	0.41		29.30
	SW3	27/09/2016	<	0.10	<	0.41		19.70
	SW4	27/09/2016	<	0.10	<	0.41		29.80
	SW5	27/09/2016	<	0.10	<	0.41		29.70
	SW6	27/09/2016	<	0.10	<	0.41		25.90
	SW7	27/09/2016	<	0.10	<	0.41		9.90
	SW8	27/09/2016	<	0.10	<	0.41		5.50
	SW9	27/09/2016	<	0.10	<	0.41		7.80
	SW10	27/09/2016	<	0.10	<	0.41		5.50
Minimum			<	0.1000	<	0.41		5.50
Maximum				0.10		7.72		75.50
	Count			64.00		74.00		74.00

Notes:
pH values based on measured pH at SWD and SWD1.

Appendix D
Table D5
Groundwater Monitoring Results

Location	Month	Date	Test reference number	Redox Potential	Arsenic (FILT) ICPMS	Mercury, filt trace as Hg	Cadmium in filtrate as Cd	Calcium in Filtrate as Ca	Chromium in Filtrate as Cr	Copper in Filtrate as Cu	Iron in filtrate as Fe	Lead in filtrate as Pb	Magnesium in filtrate as Mg	Manganese in filtrate as Mn	Nickel in filtrate as Ni	Potassium in filtrate as K	Sodium in filtrate as Na
				mV	mg/l	ug/l	ug/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Trigger Level					--	(0.2ª)	--	--	--	--	--	--	--		0.05	--	--
Control Level A					--	(0.1ªª)	--	--	--	--	--	--	--	--	0.03	--	--
Control Level B					--	(0.15ªª)	--	--	--	--	--	--	--	--	0.04	--	--
EQS Freshwater					0.05	1	5	--	0.01^	0.006^	1	0.01^	--	0.03	0.1^	--	--
Assessment Level					--	--	--	--	--	--	--	--	--	(1.0ª)	--	--	--
UPSTREAM WELLS																	
SST East S3																	
GW3A	Jul-16	02/08/16	1546940	-152		< 0.10								0.0120	< 0.0030		
	Aug-16		Quarterly														
	Sep-16																
GW4	Jul-16	02/08/16	15464941	-162		< 0.10								1.3600	0.0050		
	Aug-16		Quarterly														
	Sep-16																
SST West S2																	
GW11A	Jul-16	N/S	N/S	N/S	< N/S	< N/S	< N/S	N/S	< N/S	< N/S	< N/S	< N/S	N/S	N/S	< N/S	N/S	N/S
	Aug-16		Quarterly														
	Sep-16																
DOWNSTREAM WELLS / COMPLIANCE WELLS																	
SST West S2																	
GW12	Jul-16	02/08/16	15464949	-193		0.82								0.0159	0.0039		
	Aug-16		Quarterly														
	Sep-16																
SST Centre																	
GW6	Jul-16	05/08/16	15464943	-157		0.29								0.0074	0.0078		
	Aug-16		Quarterly														
	Sep-16																
GW7	Jul-16	02/08/16	15464944	-176		< 0.10								0.2490	0.0126		
	Aug-16		Quarterly														
	Sep-16																
GW14	Jul-16	N/S	N/S	N/S	< N/S	< N/S	< N/S	N/S	< N/S	< N/S	< N/S	< N/S	N/S	N/S	< N/S	N/S	N/S
	Aug-16		Quarterly														
	Sep-16																
SST East S2																	
GW9	**Jul-16**	02/08/16	15464945	-213		< 0.10								0.4010	0.0071		
	Aug-16		Quarterly														
	Sep-16																
SST East S3																	
GW10	Jul-16	02/08/16	15464946	-198		< 0.10								0.0137	0.0059		
	Aug-16		Quarterly														
	Sep-16																
TOE OF LANDFILL (JUST NORTH OF COMPLIANCE WELLS																	
SST West S2																	
GW5	Jul-16	N/S	N/S	N/S	< N/S	< N/S	< N/S	N/S	< N/S	< N/S	< N/S	< N/S	N/S	N/S	< N/S	N/S	N/S
	Aug-16		Quarterly														
	Sep-16																
GW8	Jul-16	N/S	N/S	N/S	< N/S	< N/S	< N/S	N/S	< N/S	< N/S	< N/S	< N/S	N/S	N/S	< N/S	N/S	N/S
	Aug-16		Quarterly														
	Sep-16																
SST Centre																	
GW1	Jul-16	N/S	N/S	N/S	< N/S	< N/S	< N/S	N/S	< N/S	< N/S	< N/S	< N/S	N/S	N/S	< N/S	N/S	N/S
	Aug-16		Quarterly														
	Sep-16																

Exceedance of Control Level
Exceedance of Trigger Level
Exceedance of freshwater EQS
Exceedance of Assessment Level

Notes

* The redox potential was not measured on site and there is a possibility that it has changed between sampling and analysis{*/}
**This sample has been analysed for Zinc Total as Zn outside recommended stability times. It is therefore possible that the results provided may be compromised.
*** Unionised ammoniacal nitrogen based on measured Temperature and pH; unionised ammoniacal nitrogen = total ammonia/$(1+10^{(10.055-(0.0324*Tc)-pH)})$, where TºC is measured water
^ Ammonia result confirmed on duplicate analysis.
^^ Reporting limits raised for EH analysis due to sample matrix.
^^^ Unable to analyse for Total COD due to sample matrix interference {/*}
NM temperature not measured on site therefore 10ºC is applied for the unionised ammoniacal nitrogen calculation
Downstream water hardness data obtained from the EA is EQS band 50 to 100mg/l.
Empty' denotes not enough water in well for sample

Appendix D
Table D5
Groundwater Monitoring Results

Location	Month	Date	Test reference number	Zinc, total as Zn	pH	Electrical Conductivity 20C	Alkalinity as CaCO3	Ammoniacal Nitrogen as N	Unionised Ammoniacal Nitrogen ***	Measure water temperature	Chloride as Cl	Nitrogen, Total Oxidised as N	Sulphate as SO4	D.O. concentration	BOD + ATU (5 day)	COD (Total)	TOC (Filtered)	TPH >C6-C40	TPH >C6-C8
				mg/l	pH units	uS/cm	mg/l	mg/l	mg/l	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	ug/l	ug/l
Trigger Level				**(0.05ᵃ)**	**--**	**--**	**--**	**1**	**--**	**--**	**250**	**--**	**400**	**--**	**--**	**--**	**--**	**--**	**--**
Control Level A				**(0.02ᵃᵃ)**	**--**	**--**	**--**	**0.8**	**--**	**--**	**210**	**--**	**300**	**--**	**--**	**--**	**--**	**--**	**--**
Control Level B				**(0.035ᵃᵃ)**	**--**	**--**	**--**	**0.9**	**--**	**--**	**230**	**--**	**350**	**--**	**--**	**--**	**--**	**--**	**--**
EQS Freshwater				**0.01^**	**--**	**--**	**--**	**--**	**0.015**	**--**	**250**	**--**	**400**	**--**	**--**	**--**	**--**	**--**	**--**
Assessment Level				**--**	**--**	**--**			**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**
UPSTREAM WELLS																			
SST East S3																			
GW3A	Jul-16	02/08/16	1546940	0.0607	7.3	560.0	215.0	< 0.41	0.0020	13.5	12.5		110.0	7.7			2.5		
	Aug-16		Quarterly																
	Sep-16																		
GW4	Jul-16	02/08/16	15464941	0.0672	7.0	352.0	58.6	< 0.41	0.0008	10.6	33.6		66.6	3.0			1.1		
	Aug-16		Quarterly																
	Sep-16																		
SST West S2																			
GW11A	Jul-16	N/S	N/S	N/S	N/S	N/S	N/S	< N/S	N/S	N/S	N/S	N/S	N/S	N/S	< N/S	N/S	N/S	< N/S	< N/S
	Aug-16		Quarterly																
	Sep-16																		
DOWNSTREAM WELLS / COMPLIANCE WELLS																			
SST West S2																			
GW12	Jul-16	02/08/16	15464949	0.5040	7.4	982.0	342.0	< 0.41	0.0029	15.8	50.3		216.0	12.2			4.0		
	Aug-16		Quarterly																
	Sep-16																		
SST Centre																			
GW6	Jul-16	05/08/16	15464943	< 0.3600	6.5	781.0	299.0	< 0.41	0.0003	12.9	80.6		90.6	2.8			3.8		
	Aug-16		Quarterly																
	Sep-16																		
GW7	Jul-16	02/08/16	15464944	0.0322	7.9	1450.0	512.0	< 0.41	0.0071	12.3	139.0		86.4	3.0			16.8		
	Aug-16		Quarterly																
	Sep-16																		
GW14	Jul-16	N/S	N/S	N/S	N/S	N/S	N/S	< N/S	N/S	N/S	N/S	N/S	N/S	N/S	< N/S	N/S	N/S	< N/S	< N/S
	Aug-16		Quarterly																
	Sep-16																		
SST East S2																			
GW9	**Jul-16**	02/08/16	15464945	0.0515	7.1	650.0	157.0	8.70	0.0258	13.2	56.3		38.3	1.1			5.3		
	Aug-16		Quarterly																
	Sep-16																		
SST East S3																			
GW10	Jul-16	02/08/16	15464946	0.0791	7.1	605.0	259.0	< 0.41	0.0005		24.6		71.9	7.1			5.7		
	Aug-16		Quarterly																
	Sep-16																		
TOE OF LANDFILL (JUST NORTH OF COMPLIANC																			
SST West S2																			
GW5	Jul-16	N/S	N/S	N/S	N/S	N/S	N/S	< N/S	N/S	N/S	N/S	N/S	N/S	N/S	< N/S	N/S	N/S	< N/S	< N/S
	Aug-16		Quarterly																
	Sep-16																		
GW8	Jul-16	N/S	N/S	N/S	N/S	N/S	N/S	< N/S	N/S	N/S	N/S	N/S	N/S	N/S	< N/S	N/S	N/S	< N/S	< N/S
	Aug-16		Quarterly																
	Sep-16																		
SST Centre																			
GW1	Jul-16	N/S	N/S	N/S	N/S	N/S	N/S	< N/S	N/S	N/S	N/S	N/S	N/S	N/S	< N/S	N/S	N/S	< N/S	< N/S
	Aug-16		Quarterly																
	Sep-16																		

	Exceedance of Control Level
	Exceedance of Trigger Level
	Exceedance of freshwater EQS
	Exceedance of Assessment Level

Appendix D
Table D5
Groundwater Monitoring Results

Location	Month	Date	Test reference number	TPH >C8-C10	TPH >C16-C24	TPH >C24-C40	TPH >C10-C16	Acetic acid	Iso-butyric acid	Iso-valeric acid	N-butyric acid	N-valeric acid	Propionic acid	Volatile acids,Total
				ug/l	ug/l	ug/l	ug/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	Trigger Level			--	--	--	--	--	--	--	--	--	--	--
	Control Level A			--	--	--	--	--	--	--	--	--	--	--
	Control Level B			--	--	--	--	--	--	--	--	--	--	--
	EQS Freshwater			--	--	--	--	--	--	--	--	--	--	--
	Assessment Level			--	--	--	--	--	--	--	--	--	--	--
UPSTREAM WELLS														
SST East S3														
	Jul-16	02/08/16	1546940											
GW3A	Aug-16		Quarterly											
	Sep-16													
	Jul-16	02/08/16	15464941											
GW4	Aug-16		Quarterly											
	Sep-16													
SST West S2														
	Jul-16	N/S	N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S
GW11A	Aug-16		Quarterly											
	Sep-16													
DOWNSTREAM WELLS / COMPLIANCE WELLS														
SST West S2														
	Jul-16	02/08/16	15464949											
GW12	Aug-16		Quarterly											
	Sep-16													
SST Centre														
	Jul-16	05/08/16	15464943											
GW6	Aug-16		Quarterly											
	Sep-16													
	Jul-16	02/08/16	15464944											
GW7	Aug-16		Quarterly											
	Sep-16													
	Jul-16	N/S	N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S
GW14	Aug-16		Quarterly											
	Sep-16													
SST East S2														
	Jul-16	02/08/16	15464945											
GW9	Aug-16		Quarterly											
	Sep-16													
SST East S3														
	Jul-16	02/08/16	15464946											
GW10	Aug-16		Quarterly											
	Sep-16													
TOE OF LANDFILL (JUST NORTH OF COMPLIANC														
SST West S2														
	Jul-16	N/S	N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S
GW5	Aug-16		Quarterly											
	Sep-16													
	Jul-16	N/S	N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S
GW8	Aug-16		Quarterly											
	Sep-16													
SST Centre														
	Jul-16	N/S	N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S	< N/S
GW1	Aug-16		Quarterly											
	Sep-16													

	Exceedance of Control Level
	Exceedance of Trigger Level
	Exceedance of freshwater EQS
	Exceedance of Assessment Level

Appendix D
Table D6
Landfill Gas Monitoring Results

		METHANE (% by Volume)												CARBON DIOXIDE (% by Volume)												
Location	**Valve**	**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-16**	**Feb-16**	**Mar-16**	**Apr-16**	**May-16**	**Jun-16**	**Jul-16**	**Aug-16**	**Sep-16**	**Oct-16**	**Nov-16**	**Dec-16**	**Comments**
GMW2	Red Valve	nt	0	0	0	0	0	0	0.1	0.1				nt	0.2	0.1	0.1	0.4	0.8	1.2	1.5	1.8				Red Valve, 25.5m depth
	Yellow Valve	nt	0	0	0	0	0	0	0.1	0.1				nt	0	0	0	0	0	0	0.2	0.1				Yellow Valve,14m depth
	White Valve	nt	0	0	0	0	0	0	0.1	0.1				nt	4.2	2.5	0.4	0.8	1.6	1.8	2.1	0.1				White Valve, 4m depth
	Trigger Levels	1	1	1	1	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	
	Control Levels	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	-	-	-	-	-	-	-	-	-	-	-	-	
	Trigger Level Red	-	-	-	-	-	-	-	-	-	-	-	-	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	
	Trigger Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	
	Trigger Level White	-	-	-	-	-	-	-	-	-	-	-	-	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	
	Control Level Red	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1	
	Control Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	
	Control Level White	-	-	-	-	-	-	-	-	-	-	-	-	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	
GMW3	Red Valve	nt	0	0	0	0	0	0.1	0.1	0.1				nt	6	2.4	5.4	5.6	5.6	5.7	5.5	4.5				Red Valve, 19m depth
	Yellow Valve	nt	0	0	0	0	0	0.1	0.1	0.1				nt	0	0	0.1	0	0.1	0	0	0.1				Yellow Valve,9m depth
	White Valve	nt	0	0.2	1.2	3.3	0.2	0.1	0.2	0.1				nt	1.7	22.3	4.1	5.1	12.7	4.4	9.7	0.2				White Valve, 3.5m depth
	Trigger Levels	1	1	1	1	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	
	Control Levels	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	-	-	-	-	-	-	-	-	-	-	-	-	
	Trigger Level Red	-	-	-	-	-	-	-	-	-	-	-	-	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	
	Trigger Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	
	Trigger Level White	-	-	-	-	-	-	-	-	-	-	-	-	24.02	24.02	24.02	24.02	24.02	24.02	24.02	24.02	24.02	24.02	24.02	24.02	
	Control Level Red	-	-	-	-	-	-	-	-	-	-	-	-	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	
	Control Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	
	Control Level White	-	-	-	-	-	-	-	-	-	-	-	-	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	
GMW4	Red Valve	nt	0	0	0	0	0	0.1	0.2	0.1				nt	0	0	0	0	0	0	0	0				Red Valve, 30m depth
	Yellow Valve	nt	0	0	0	0	0	0.1	0.1	0.1				nt	0	0	0	0.2	0	0	0.1	0				Yellow Valve,20m depth
	White Valve	nt	0	0	0	nt	0.1	0.1	0.2	0.1				nt	0	0.1	0.1	nt	0	0.1	0.3	0				White Valve, 5m depth
	Trigger Levels	1	1	1	1	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	
	Control Levels	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	-	-	-	-	-	-	-	-	-	-	-	-	
	Trigger Level Red	-	-	-	-	-	-	-	-	-	-	-	-	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	
	Trigger Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	
	Trigger Level White	-	-	-	-	-	-	-	-	-	-	-	-	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	
	Control Level Red	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1	
	Control Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	
	Control Level White	-	-	-	-	-	-	-	-	-	-	-	-	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	
GMW5	Red Valve	nt	0	0	0	0	0.1	0.2	0.2	0.1				nt	6.2	6.1	6	6	5.9	5.9	6.2	6.6				Red Valve, 26.3m depth
	Yellow Valve	nt	0	0	0	0	0.1	0.2	0.2	0.1				nt	3.6	3.8	0.5	1	1.3	1.8	2.1	2.9				Yellow Valve,15m depth
	White Valve	nt	0	0	0	0	0.1	0.2	0.2	0.1				nt	4.9	3.8	3.5	3.3	2	3.7	3.3	3.9				White Valve, 5m depth
	Trigger Levels	1	1	1	1	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	
	Control Levels	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	-	-	-	-	-	-	-	-	-	-	-	-	
	Trigger Level Red	-	-	-	-	-	-	-	-	-	-	-	-	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48	
	Trigger Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	
	Trigger Level White	-	-	-	-	-	-	-	-	-	-	-	-	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	
	Control Level Red	-	-	-	-	-	-	-	-	-	-	-	-	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	
	Control Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	
	Control Level White	-	-	-	-	-	-	-	-	-	-	-	-	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	
GMW6	Red Valve	nt	0	0	0	0	0.1	0.2	0.2	w				nt	1.8	1.7	1.9	2.3	0	3.5	4.8	w				Red Valve, 26.3m depth
	Yellow Valve	nt	0	0	0	0	0.1	0.2	0.2	0.1				nt	3.4	2.6	2.5	3.1	0.1	1.6	2	2.1				Yellow Valve,15m depth
	White Valve	nt	0	0	0	0	0.1	0.2	0.2	0.1				nt	2.4	0	1.2	1.5	0.7	1.2	1.1	1.2				White Valve, 5m depth
	Trigger Levels	1	1	1	1	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	
	Control Levels	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	-	-	-	-	-	-	-	-	-	-	-	-	
	Trigger Level Red	-	-	-	-	-	-	-	-	-	-	-	-	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	
	Trigger Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-	5	5	5	5	5	5	5	5	5	5	5	5	
	Trigger Level White	-	-	-	-	-	-	-	-	-	-	-	-	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	
	Control Level Red	-	-	-	-	-	-	-	-	-	-	-	-	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	
	Control Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	
	Control Level White	-	-	-	-	-	-	-	-	-	-	-	-	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	
GMW7	Yellow Valve	nt	0	0	0	0	0.1	0.2	0.2	0.2				nt	0.1	0.5	0.3	0.3	0.1	0.6	0.9	0.6				Yellow Valve,12 depth
	White Valve	nt	0	0	0	0	0.1	0.2	0.2	0.1				nt	0.1	0.7	0.3	0.3	0.1	0.6	0.9	0.7				White Valve, 5m depth
	Trigger Levels	1	1	1	1	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	
	Control Levels	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	-	-	-	-	-	-	-	-	-	-	-	-	
	Trigger Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	
	Trigger Level White	-	-	-	-	-	-	-	-	-	-	-	-	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	
	Control Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	
	Control Level White	-	-	-	-	-	-	-	-	-	-	-	-	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	
GMW12	Red Valve	nt	0	0	0	0	0.1	0.2	0.2	0.2				nt	0.1	0.2	0.2	0	0	0.4	0.1	0.6				Red Valve, 26.3m depth
	Yellow Valve	nt	0	0	0	0.2	0.1	0.2	0.2	0.2				nt	0.1	0.2	0.2	0	0	0.3	0.1	0.6				Yellow Valve,15m depth
	White Valve	nt	0	0	0	0	0.1	0.2	0.2	0.2				nt	0.1	0.2	0.3	0	0	0.4	0.2	0.8				White Valve, 5m depth
	Trigger Level Red	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	
	Trigger Level Yellow	1	1	1	1	1	1	1	1	1	1	1	1	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	
	Trigger Level White	1	1	1	1	1	1	1	1	1	1	1	1	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	
	Control Level Red	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	4	4	4	4	4	4	4	4	4	4	4	4	
	Control Level Yellow	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	
	Control Level White	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5	5	5	5	5	5	5	5	5	5	5	5	
GMW13	Red Valve	nt	0	0	0	0	0.2	0.2	0.2	0.2				nt	1.9	1.2	1.3	1.1	0.6	1.9	1.4	2				Red Valve, 26.3m depth
	Yellow Valve	nt	0.2	0.1	0	0	0.2	0.2	0.2	0.2				nt	7.8	8.2	7.8	9.4	0	7.1	8.2	6.6				Yellow Valve,15m depth
	White Valve	nt	0	0	0	0	0.3	0.2	0.2	0.2				nt	4.6	3.5	4.3	3.6	0	3.6	4	4.2				White Valve, 5m depth
	Trigger Level Red	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	
	Trigger Level Yellow	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	6	6	6	6	6	6	6	6	6	6	6	6	
	Trigger Level White	1	1	1	1	1	1	1	1	1	1	1	1	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	
	Control Level Red	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	
	Control Level Yellow	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	
	Control Level White	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5.32	5.32	5.32	5.32	5.32	5.32	5.32	5.32	5.32	5.32	5.32	5.32	
GMW14	Red Valve	nt	nt	nt	nt	nt	nt	nt	nt	nt				nt	nt	nt	nt	nt	nt	nt	nt	nt				Red Valve, 26.3m depth
	Yellow Valve	nt	nt	nt	nt	nt	nt	nt	nt	nt				nt	nt	nt	nt	nt	nt	nt	nt	nt				Yellow Valve,15m depth
	White Valve	nt	nt	nt	nt	nt	nt	nt	nt	nt				nt	nt	nt	nt	nt	nt	nt	nt	nt				White Valve, 5m depth
	Trigger Level Red	1	1	1	1	1	1	1	1	1	1	1	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	
	Trigger Level Yellow	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	
	Trigger Level White	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	
	Control Level Red	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	1	1	1	1	1	1	1	1	1	1	1	
	Control Level Yellow	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	
	Control Level White	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	
GMW1**	Red Valve	nt	nt	nt	nt	nt	0.2	0.3	0.4	0.4				nt	nt	nt	nt	nt	0.4	0.6	1.3	1				Red Valve, 23.5m depth
	Yellow Valve	nt	nt	nt	nt	nt	35.1	26.1	17.9	12.6				nt	nt	nt	nt	nt	10.2	12	11.8	12				Yellow Valve,14.7m depth
	White Valve	nt	nt	nt	nt	nt	1.3	0.2	0.2	0.1				nt	nt	nt	nt	nt	1.4	0.1	0.1	0.1				White Valve, 6.5m depth
GMW8*	Yellow Valve	nt	8.6	10.3	8.6	7.6	7	6.6	5.7	4.2				nt	14.4	13.5	14.1	13.6	13.7	12.7	13.7	14.5				Yellow Valve,17.5m depth
	White Valve	nt	0	0	0	0	0.1	0.2	0.2	0.2				nt	5.6	5.5	5.4	4.7	5.3	5.4	5.4	5.9				White Valve, 5.7m depth
GMW9*	Red Valve	nt	0	0	0	0	0.1	0.3	0.2	0.2				nt	2.2	2.2	2.2	1.9	2	1.8	1.9	2.1				Red Valve, 27m depth
	Yellow Valve	nt	53.8	51.4	47	43.9	43.8	43.4	42.5	43.8				nt	18.3	19.6	22.8	23	23.9	23.3	24	23.5				Yellow Valve,15m depth
	White Valve	nt	0.1	0.1	0.1	0	0.2	0.3	0.3	0.3				nt	0.3	0.1	0.3	0.1	0.3	0	0.1	0.4				White Valve, 8.5m depth
GMW10*	Red Valve	nt	0.2	0	0	0	0.1	32.5	10.6	29.3				nt	3.9	2.8	4.2	6	2.9	13.9	5.3	15				Red Valve, 19.5m depth
	Yellow Valve	nt	72.9	71.9	68.9	69.8	5.1	28.7	0.2	35.7				nt	10.4	11.2	13.6	14.1	1.6	14.8	5.3	15.4				Yellow Valve,15m depth
	White Valve	nt	3	0.2	0	0	0.1	25.9	1.9	22				nt	5.3	2.4	4.3	6.5	3.6	13.5	5.3	14.5				White Valve, 8m depth
GMW17**	Red Valve	nt	0	nt	nt	0	0.2	0.2	nt	nt				nt	4.1	nt	nt	1.2	1.2	1.2	nt	nt				Red Valve, 26.3m depth
	Yellow Valve	nt	0	nt	nt	0	0.2	0.2	nt	nt				nt	0	nt	nt	5.8	5.6	6.1	nt	nt				Yellow Valve,15m depth
	White Valve	nt	0	nt	nt	0	0.2	0.2	nt	nt				nt	0	nt	nt	0.8	4.1	1.2	nt	nt				White Valve, 5m depth
GMW18**	Yellow Valve	nt	0	0	0	0	0.2	nt	0.2	0.3				nt	0	0	0.7	0	0	nt	3.9	0				Yellow Valve,12 depth
	White Valve	nt	0	0	0	0	0.2	nt	0.2	0.2				nt	4.7	0.4	8.4	5.9	7.4	nt	4	7.2				White Valve, 5m depth

Notes:
1. Water denotes 'water in well - reading abandoned'.
2. NT denotes 'reading not taken'.
3. Readings were not taken in March due to unspecified reasons.
4. NT in GMW17 is due to cattle feeding area at location of the well.
5. NT in GMW14 is due to cattle quarantine paddock around well location.
6. NT in GMW7 due to capping contract soil stockpile machinery working above well location.
7. Where the asterisc (*) is present, no trigger levels have been set, as high levels of methane and carbon dioxide gas are recorded. This is likely to be associated with the presence of bog/marshland.
8. Where two asterisks (**) are present, no trigger levels have been set, as not require by the Permit (Reference [2]).

Exceedance of Trigger
Exceedance of Control