CAULMERT LIMITED

Engineering, Environmental & Planning

Consultancy Services

Sundorne Products (Llanidloes) Ltd

BRYN POSTEG LANDFILL SITE (BU7766)

Hydrogeological Risk Assessment Review 2018

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DISCLAIMER

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1 INTRODUCTION

1.1.1.1 Caulmert Limited has been commissioned by Potters Waste Management Limited to undertake a hydrogeological risk assessment review for Bryn Posteg Landfill Site, Permit BU7766.

1.1.1.2 This report supersedes the hydrogeological risk assessment reviews produced by Enviroarm Limited in 2007 and Caulmert Limited in 2010 and 2015 (unsubmitted) and provides an updated environmental context section, together with all of the available environmental monitoring data collected between 2003 and December 2017. The report aims to provide an update to the 2010 review with comparisons to the 2010 data and the current data.

1.1.1.3 The report and subsequent risk assessment also address the concerns raised by NRW with specific regard to the additional waste volume (overtip) and the elevated leachate levels observed in Phase 9.

1.1.1.4 This report utilises the Environment Agency's template for Hydrogeological Risk Assessment Reviews (2009) and adopts the terminology within the Groundwater Regulations 2009.

1.1.1.5 Bryn Posteg landfill site is located approximately 3km southeast of Llanidloes at national grid reference SN 971 821.

1.1.1.6 The following reports have been used for reference purposes:

1. Enviroarm Ltd, 2002, Bryn Posteg Landfill, Regulation 15 Risk Assessment: Hydrogeological conceptual model and risk assessment for Cell P1-P8 Volume 1, Ref. ARM/SCM/BP/RA/2/2002.
2. Enviroarm Ltd, 2003, Bryn Posteg Landfill, Hydrogeological Risk Assessment for Landfill Extension at Bryn Posteg, Ref: ARM/SCM/BPE/RA/1/2003.
3 Enviroarm Ltd, 2007, Hydrogeological Risk Assessment Review December 2007, Ref HRABRYNPOSTEGDEVCEMBER2007PERMITBU1766.
4 Caulmert Limited, 2010, Hydrogeological Risk Assessment Review 2010, Ref 1148.HRA.SV.JRC.V1.0.
5 Caulmert Limited, 2016, Hydrogeological Risk Assessment Review 2015, Ref 2086.01. POT.DK.SV.V1.0.

1.1.1.7 Third party information supplied by Potters Waster Management Ltd has been used in good faith within this document. Caulmert Ltd has not attempted to verify the information.

2 REVIEW OF CONCEPTUAL MODEL

2.1 Sources

2.1.1 Site development

2.1.1.1 Bryn Posteg Landfill Site is located at the site of a former lead mine. The site has been developed over a number of years with the first waste being accepted into Phase 1 in 1982. The site is currently divided into 9 Phases which, in turn, are divided into subcells (Drawing 3400.HRA.01). The current tipping operations are continuing in Phase 9c and 9d. It is noted that in some documentation Cell 9D is referred to as subcells 9D & 9E. This report refers to a combined cell 9D.

2.1.1.2 The development history is summarised in Table 1 below.

Table 1: Site Development

Phase	Filling Period	Base of Cell (mAOD)	Lining Details	Capping Details
1	1982-	310	1m insitu clay (demonstrated by trial pits)	1m compacted boulder clay and 1m of cover soils [1]
2		310	1m clay "target permeability 1×10^{-9}m/s"[1] Permeability range 5.9×10^{-10}m/s to 1.7×10^{-8}m/s with moisture content 11-14%	1m compacted boulder clay and 1m of cover soils [1]
3A, 3B, 3C	1991-1994	311	1m clay "target permeability 1×10^{-9}m/s"[1] Permeability range 5.9×10^{-10}m/s to 1.7×10^{-8}m/s with moisture content 11-14%	Geomembrane cap with cover soils
4A, 4B	1994-1995	311	1m clay "target permeability 1×10^{-9}m/s"[1] Permeability range 5.9×10^{-10}m/s to 1.7×10^{-8}m/s with moisture content 11-14%	Geomembrane cap with cover soils
5	1995-1996	311	1m clay "target permeability 1×10^{-9}m/s"[1] Permeability range 5.9×10^{-10}m/s to 1.7×10^{-8}m/s with moisture content 11-14%	Geomembrane cap with cover soils
6	1996-1998	310	GCL & HDPE liner with CQA by Aspinwall. Underlying clay permeability 5.9×10^{-10}m/s to 1.7×10^{-8} m/s	1m mineral cap
7	1998-2002	310	GCL & HDPE liner with CQA by Evans Logistics and CL Associates Geocomposite underdrainage layer connected to vertical riser	1m mineral cap
8	2002-2003	310	GCL & HDPE liner with CQA by Enviroarm	Temporary restoration
9A		307	0.5m mineral liner with CQA, GCL and Geomembrane 27 perm tests on clay. 4.6×10^{-10} m/s max perm, average 1.36×10^{-10} m/s for base[(2)]	Intermediate cover
9B		307	0.5m mineral liner with CQA, GCL and Geomembrane. 30 permeability tests 1.8×10^{-11}m/s to 2.5×10^{-10}m/s [(2)]	Intermediate cover

Phase	Filling Period	Base of Cell (mAOD)	Lining Details	Capping Details
9C	Ongoing	307	0.5m mineral liner with CQA, GCL and Geomembrane	Operational
9D, (&9E)	Ongoing	307	0.5m mineral liner with CQA, GCL and Geomembrane	Operational

1 Enviroarm Ltd, Regulation 15 Risk Assessment, 2002

2 CQA data reported by Potters Waste Management Ltd

2.1.1.3 It is reported that Phase 9 was excavated to 307 mAOD. The leachate collection system is also reported to comprise a 2m layer of tyres.

2.1.2 Additional Waste

2.1.2.1 Additional waste material has been placed across the central part of the Site and overlays parts of phases 3, 4, 5, 7 and 9. An investigation has been undertaken into the volume of the overtip[1] which concludes that the volume of the over-tip is 250,557 m^3. The maximum over-tip depth is approximately 12.5m.

<u>Hydraulic Properties of the Waste Mass and the Impact on Leachate Abstraction Infrastructure</u>

2.1.2.2 It is recognised that waste depths will vary across the site as a result of the profile of the landform and the geometry of the base. Therefore in order to assess the impact of the over-tip on the leachate management at the Site a conservative estimate of the maximum waste depth is presented in the assessment below.

2.1.2.3 The assessment utilises a base level of 310 mAOD and a maximum over-tip to 350mAOD resulting in an overall waste depth of 40m. Whilst it is understood that the maximum over-tip is approximately 12.5m in depth at the deepest point; a 15m over-tip value has been used to represent worst case scenario for comparison purposes (indicating a designed depth of waste was 25m).

2.1.2.4 The purpose of this assessment is to review how the addition mass of waste may have changed the hydraulic properties of the waste mass at the base of the Site and therefore whether this would have any perceivable impact on the potential to abstract leachate from the Site in accordance with the leachate management plan.

[1] Caulmert 2018, NRW Regulation 61(1) Information Notice – Bryn Posteg Landfill (Notice No.2), ref. 3824.CAU.XX.XX.CO.Y.01

2.1.2.5 Research papers have been published into the hydraulic properties of waste over the last 20 years or so. The key documents used in this assessment include:

- Beaven R.P and Powrie W. 1995, Hydrogeological and geotechnical properties of refuse using a large scale compression Cell, Proceedings Sardinia 95, Fifth International Landfill Symposium.
- Beaven R.P, 1999, The hydrogeological and geotechnical properties of household waste in relation to sustainable landfilling.
- Powrie W., Beaven R.P, Hudson A.P, March 2005, Factors affecting the hydraulic conductivity of waste, International Workshop: Hydro-Physio-Mechanics of Landfills, Grenoble 1 University France

2.1.2.6 These papers are based on empirical relations established through a test cell located at Pitsea Landfill Site. Investigations undertaken by Beaven *et al* in 1995 have indicated that for 'crude domestic waste taken from near to the tipping face, the wet density was between 0.5T/m^3 and 0.75T/m^3 (depending on the degree of saturation).

2.1.2.7 Using this empirical data the thickness of waste can be converted to applied pressures as kPa. It is recognised that this is a broad estimate as the density of waste will also change with depth.

2.1.2.8 As noted above, for this assessment the maximum height of the over-tip used is 15m above the pre-settlement profile.

Table 2: Additional waste density assessment

	Waste Thickness	Density Used (T/m^3)	Calculated Pressure (kPa)
Design depth	25m	0.7	171
Over-tip	40m	0.7	275
Aged design depth	25m	1.0	245
Aged waste over-tip	40m	1.0	392
Additional Waste	15m	0.7	103
Additional Waste	15m	1.0	147
Fresh Waste	1m	0.7	6.86

2.1.2.9 On the basis of the above details the effect of the over-tip would be to increase the applied pressure on the waste at the base of the Site by between approximately 103 kPa and 145 kPa.

2.1.2.10 The results of the hydraulic conductivity testing under applied pressures were presented by Beaven et al at specific applied pressures (see below). Although some interpretation can be applied the table below presents the results at the applied pressures which best represent the conditions at the Site.

Table 3: Extract of results from Beaven 1995

Applied Pressure (kPa)	Hydraulic Conductivity	Units	Comments
165	~3 x 10^{-6}	m/s	Considered representative of aged waste **without** over-tip
322	~8 x 10^{-7}	m/s	Considered representative of aged waste **with** over-tip
600	~1 x 10^{-7}	m/s	

2.1.2.11 On the basis of the above details, whilst there is potentially a reduction in the permeability of the waste in the site of approximately half an order of magnitude, the hydraulic conductivities recorded (8 x 10^{-7} m/s) for the lowest layers of the waste mass; the vertical permeability of the compacted waste is still significantly higher (by a factor of 800) than the design permeability of the cap (1 x 10^{-9} m/s).

2.1.2.12 As a consequence any infiltration through the cap should be able to be captured and managed by the existing and operational leachate collection and abstraction infrastructure.

2.1.2.13 In conclusion, the over-tip is unlikely to adversely affect the capability of the leachate collection and abstraction infrastructure and consequently will not result in an increased potential for pollution of the environment.

2.1.3 Leachate Levels

2.1.3.1 The leachate levels are monitored at the site on a monthly basis. Unfortunately high gas pressures have resulted in odour issues and a number of the leachate sumps have been sealed with agreement from NRW to try and reduce these issues. It is recognised that this must only be a short term solution and the leachate monitoring wells should be reinstated as soon as possible.

2.1.3.2 Consequently the current leachate level data is restricted to accessible points. Ground levels presented on the 2007, 2009 and 2010 topographic surveys have been used to estimate the leachate levels as mAOD. It is noted that this is an approximation as it does not take into account the height of the well above ground level nor the increase in datum levels between survey dates, consequently there are occasions when the leachate levels are reported below the base of the site.

2.1.3.3 The leachate levels are permitted at 1m above the base of the site. The leachate hydrographs presented in Appendix 1 indicate that leachate levels have been below the compliance levels for the majority of the time between 2010 and 2015, however the levels in the past 2 years are more uncertain. Negative leachate heads are recorded in RMLP9C and RMLP9D however this reflects the extension of the leachate towers with additional concrete rings and a lag between this at the update of the datum – cover levels. These two locations are observed to have 10m of leachate accumulate in May 2016 with a rapid decrease in March 2017. This rapid decrease in levels is associated with enhanced leachate extraction over a 7 week period.

2.1.3.4 A spike in leachate levels is observed in all wells in January and February 2016. The variability within the database provides added uncertainty to the interpretation of risk and therefore it is recommended that all wells be surveyed and rest leachate levels established.

2.1.3.5 LCP1 typically has leachate levels around 314 mAOD although the depth of the base of these Phases (1&2) is unknown. The leachate levels in LCP7 and LCP8 are typically at 311.4mAOD and in LCP8 at 311; and with the bases of the Phases LCP7 & LCP8 are assumed to be at 310.75 mAOD, the leachate levels in LCP7 and LCP8 are within the Permit levels. The bases of Phase 9 is assumed to be 307 mAOD, and the general leachate levels in RMLP9C and RMLP9D are 307.7 mAOD for both and therefore within the permit limits.

2.1.3.6 NRW have identified a period of significant elevated leachate levels in Phase 9 of particular concern. The data reports leachate head of over 10m in these cells over a period of 9 months. There is some degree of uncertainty in the validity of this data and the rise in levels (9m) occurs within a 1 month period. This is unusual in so much that the accumulation of such high leachate levels in the base of the site would usual be expected to be part of a gradual and continuing trend over a number of months. The significance of such a head within these cells will be assessed as part of the risk assessment review.

2.1.3.7 It is strongly recommended that the leachate levels are reviewed on collection of the data such that any similar rises can be validated at the time of occurrence. In addition, it is reiterated that the elevation of the leachate sumps are surveyed along with the annual topographic survey and that these datum levels are transcribed into the database.

Table 4: Leachate Depths (m)

		LCP1	LCP7	LCP8	RMLP9C	RMLP9D
2010	Min	0.04	0.30	0.05		
	Max	0.96	1.03	0.85		
	Average	0.39	0.70	0.46		

		LCP1	LCP7	LCP8	RMLP9C	RMLP9D
	Count	12	12	12		
2011	Min	0.15	0.54	0.13		
	Max	0.98	0.96	0.64		
	Average	0.57	0.76	0.43		
	Count	12	12	12		
2012	Min	0.89	0.51	0.24		
	Max	1.56	1.76	1.23		
	Average	1.04	0.93	0.86		
	Count	12	12	12		
2013	Min	0.81	0.54	0.60	0.63	0.31
	Max	1.11	0.96	0.90	0.77	0.72
	Average	0.92	0.71	0.71	0.69	0.55
	Count	12	12	9	9	9
2014	Min	0.70	0.46	0.65	0.58	0.67
	Max	1.04	0.66	0.80	0.80	0.92
	Average	0.84	0.56	0.75	0.70	0.77
	Count	12	12	12	12	12
2015	max	0.9	0.8	0.87	0.68	0.77
	min	0.68	0.46	0.53	-2.42*	-3.23*
	average	0.82	0.61	0.71	-1.12*	-1.81*
	Count	12	12	12	12	12
2016	max	0.96	8.66	6.89	10.11	10.46
	min	0.71	0.38	0.28	-0.72*	0.07
	average	0.83	2.67	2.11	6.15	6.79
	Count	12	12	12	12	12
2017	max	0.96	1.05	1.65	10.11	10.36
	min	0.71	0.25	0.85	0.6	0.5
	average	0.85	0.66	1.15	3.85	3.85
	Count	9	9	9	9	9

Note: all values are in meters above the base. Also noted that negative values are presented within the dataset. These negative values are likely to be due to a delay in the update of datum values within the spreadsheets relative to operations.

2.1.3.8 ***Perched Leachate*:** Flooded gas extraction wells within the waste mass have had leachate abstraction pumps installed to control the perched leachate encountered within these wells. Limited information is available on the perched leachate elevation as levels are only recorded during scheduled pump maintenance. It is recommended that 'rest' leachate levels are recorded in the gas wells to establish the head of perched leachate.

2.1.4 Water Balance

2.1.4.1 A water balance calculation was undertaken in March 2014[2] for the site. This report was required to predict the rate of leachate generation in the landfill over its active lifetime and beyond, for the purpose of ensuring that the leachate treatment capacity at the leachate treatment plant on site will have sufficient capacity to treat the leachate under normal weather conditions.

2.1.4.2 The water balance for the landfill was calculated using an Excel model developed from the calculation guidelines outlined within Waste Management Paper 26B[3]. The amount of leachate generated was calculated based on the interaction between the effective rainfall at the site, the areas of active infill, temporary and permanent restoration, the infilling rate and waste absorptive capacity.

2.1.4.3 The water balance considered two potential scenarios where effective rainfall (ER) was 60% of the total rainfall (TR) during the summer months and a second options where ER was 40% of TR during the summer months.

Table 5: Total and effective rainfall (ER) data used in the water balance for the site

Month	Total monthly Rainfall* (TR, mm)	Scenario 1 (60 % TR)		Scenario 2 (40 % TR)	
		Factor	Total ER	Factor	Total ER
January	106.9	1	106.9	1	106.9
February	93.5	1	93.5	1	93.5
March	53.1	1	53.1	1	53.1
April	47.3	0.6	28.4	0.4	18.9
May	75.6	0.6	45.4	0.4	30.3
June	75.5	0.6	45.3	0.4	30.2
July	86.5	0.6	51.9	0.4	34.6
August	69.0	0.6	41.4	0.4	27.6
September	57.2	0.6	34.3	0.4	22.9
October	71.8	1	71.8	1	71.8
November	113.4	1	113.4	1	113.4
December	116.7	1	116.7	1	116.7

*Average rainfall data at Bryn Posteg Landfill Site based on data from 2009 -2018.

[2] Caulmert Ltd, 2014, Bryn Posteg Landfill Site, Water Balance Calculations, 1925.4.POT.SBD.AKS.B0
[3] Waste Management Paper 26B: Landfill design, construction, and operational practice, Department of the Environment, 1997, Volume 1.

2.1.4.4 This updated water balance reviews the current potential leachate generation and predicts the potential generation when the site is fully capped and restored. Conservatively this model (updated) version assumes that the adsorptive capacity of the waste mass has been fully utilised which is based on the observation that elevated leachate levels have been recorded at the site. Therefore the assessment of the water balance simplifies to the uncapped areas, temporary restored areas and permanently capped areas. Our current understanding of these capping phases is presented below.

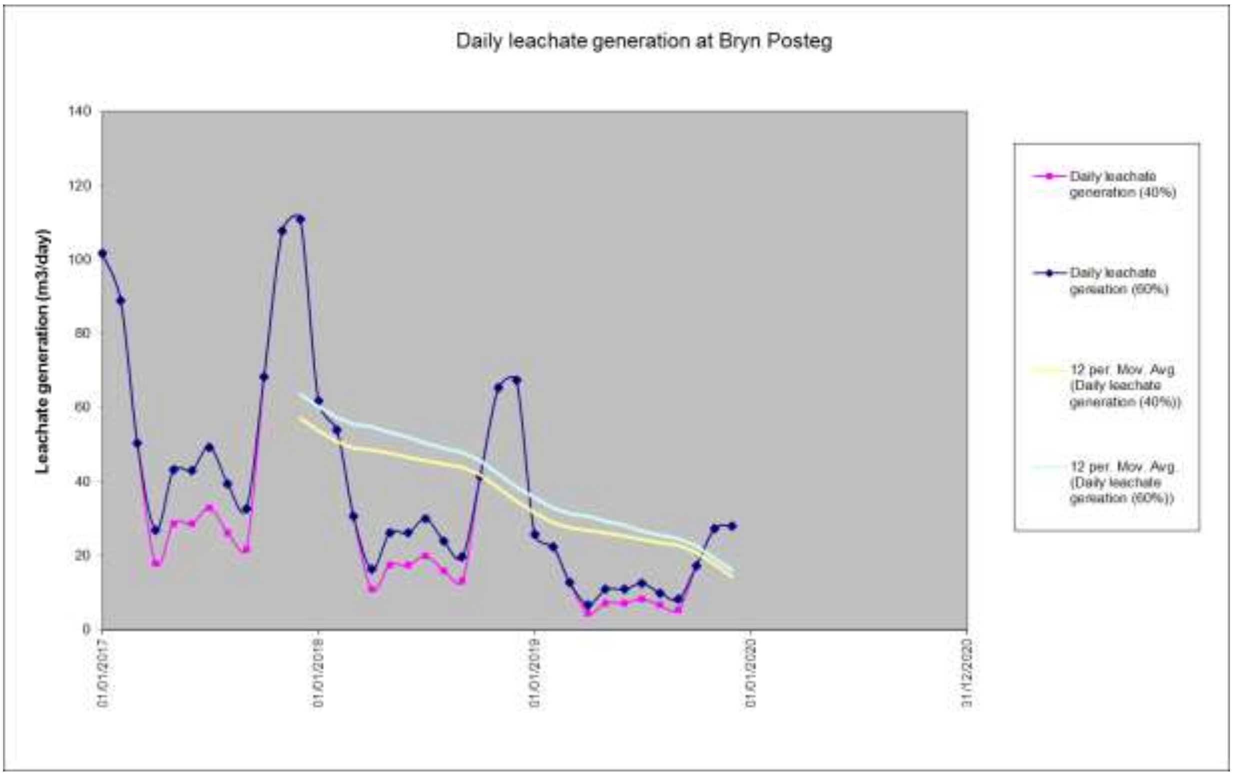
Table 6: Capping and Restoration Dates

Cell	Cap status	Date capped	Area m^2
1	Permanent	1986	3863
2	Permanent	1986	13677
3A	Permanent	2009	8504
3B	Permanent	2009	8035
3C	Permanent	1992	6421
4A	Permanent	2017	8239
4B	Permanent	2017	6936
5	Permanent	1998	10567
6	Permanent	2000	6762
7	Permanent	2003	8626
8	Permanent	2006	8346
9A	Permanent	2009	8938
9B	Permanent	2017	8895
9C	Permanent	2017	14432
9D	Active	2018	22415

2.1.4.5 The results below and presented in the graph show the calculated results of leachate generation as m^3 per day and m^3 per month for both calculation scenarios, with running average trend lines within a period of 12 months. The figures indicate the variability of leachate generation in each year, and are therefore more useful for evaluating the maximum rate of leachate generation.

Table 7: Leachate generation rates

	Daily generation (m^3/day)				Monthly Generation (m^3 / month)			
	Scenario 1 (60 % TR)		Scenario 2 (40 % TR)		Scenario 1 (60 % TR)		Scenario 1 (40 % TR)	
	Max	Average	Max	Average	Max	Average	Max	Average
Current (2018)	67.4	38.6	67.4	35	2021	1157	2021	1039
Closed Future	28.1	16.1	28.1	14.5	844	483	844	433



2.1.1 Leachate is currently abstracted from the site and discharged via to the leachate treatment plant together with a component of surface water. Therefore currently, the actual volume of leachate treated cannot be adequately assessed and utilised to calibrate the water balance calculation. It is recommended that dedicated counters are at least installed on the leachate system to differentiate between the total leachate and surface water treated.

2.1.5 Leachate source term

2.1.5.1 Table 8 below compares the current values from 2010 to 2017 with the range of values that have been collected between 2005 and 2009.

Table 8: Comparison of Source Data

Parameter	Unit	Min	Max	Avg	95%ile	2005 - 2009 excl 2008 Modelled Values	2010 - 2017modelled values	Comment
Ammoniacal Nitrogen as N	mg/l	52.8	2400	984	1886	0.5-2660	54.4 - 2120	The data range is smaller since the previous HRA, with a similar range in values
Chloride	mg/l	-	-	-	-	184-2990	-	There is no measured data for chloride
Cadmium , Total as Cd	mg/l	<0.0006	0.0025	0.001	0.002	0.001-0.007	<0.0006 - 0.0042	The maximum values have decreased since the previous review period.
Nickel , Total as Ni	mg/l	0.015	0.451	0.148	0.363	<0.005-0.18	0.011 - 0.283	Both the min and max are higher than reported in the previous two HRA's.
Zinc, Total as Zn	mg/l	0.09	10.7	1.455	6.688	0.034-1.3	0.02 - 6.29	The minimum and maximum values are higher than has been previously reported.
2,4 - D	ug/l	<0.1	<10	2.644	8	<0.5-1.81	<0.05 - 7.7	There is a smaller range of data since the previous HRA.
Dichloroprop	ug/l	<0.1	<6.5	2.480	6.5	<0.1-3.43	0.06 - 9.25	The modelled values are lower than the previous review period.
Mecoprop	ug/l	1.09	84.8	34	81	0.29-38.3	1.78 - 75.4	There is a greater range in the data in this review period.
Toluene	ug/l	<5	23.2	12.27	22	<1-99	<1 - 99	There is a smaller range of data since the previous HRA.
m, p - xylene	ug/l	<10	18.5	12.607	20	<1-53	1.3 - 53	There is a smaller range of data since the previous HRA.
4 - methyphynil	ug/l	-	-	-	-	<0.01-4.9	<0.001 - 4.99	Not monitored throughout this review period.

2.1.5.2 Over this review period, the majority of substances have recorded concentration ranges similar (within 10%) or lower than those previously modelled, however increases are observed for mecoprop, dichlorprop and nickel. Due to the long travel times and the potential degradation of mecoprop and dichlorprop within the environment, the modelled is not overly sensitive to these parameters, however the risk assessment has been updated to reflect these current ranges.

2.1.5.3 It is noted that chloride concentration has not been recorded since 2009.

2.1.5.4 The data has also been reviewed with respect to the presence of hazardous substances within the leachate at the site. This analysis is performed annually and all data from 2014 to 2017 has been reviewed. Table 6 below indicates the hazardous substances which have been recorded on at least 1 occasion in the leachate at the site.

Table 9: Hazardous substances detected above the laboratory detection limit 2015 -2017

Hazardous Substance	Unit	Max concentration (2015-2017)	Average concentration (with)	No of samples	No of results >Detection limit
1,2,4-Trichlorobenzene	ng/l	2000.00	198.56	32	2
2,4 - D	ug/l	10.00	1.81	32	1
Cadmium , Total as Cd	mg/l	0.00	0.00	32	8
Chlorfenvinphos	ug/l	0.40	0.08	32	13
Cyanide, Total as CN	mg/l	0.14	0.03	32	10
Demeton-s-methyl	ug/l	2.00	1.19	3	4
Diazinon	ug/l	0.60	0.10	32	20
Dicamba	ug/l	10.00	1.69	32	5
Dichlobenil	ng/l	400.00	91.66	32	3
Dichlorprop	ug/l	19.90	2.98	32	7
Fenthion	ug/l	0.46	0.10	32	2
Hexachlorobenzene	ng/l	400.00	72.28	32	1
Isoproturon	ug/l	21.00	5.16	32	1
MCPA	ug/l	20.70	2.28	32	1
Mercury, Total as Hg	mg/l	0.01	0.00	32	1
Phorate	ug/l	0.80	0.12	32	1
TPH >C10-C16	ug/l	1870.00	479.57	23	5
TPH >C16-C24	ug/l	927.00	238.48	23	8
TPH >C24-C40	ug/l	871.00	178.65	23	5
TPH >C6-C40	ug/l	3310.00	835.00	19	9
TPH >C6-C8	ug/l	238.00	76.00	23	1
TPH >C8-C10	ug/l	278.00	99.91	23	4

2.1.5.5 The above table indicates that the most commonly identified hazardous substances within leachate are TPH >C6-C40 (3310 ug/l). As expected the speciated TPH indicates that there are a wide range of complex organic compounds also within the leachate which record some of the highest concentrations. However as these results represent a group of compounds they cannot be modelled discretely.

2.1.5.6 A times series graph has been produced for ammoniacal nitrogen. The chart indicates that the Phases 4 & 7 contain the strongest leachate with respect to this parameter. The graph is quite variable indicating that the concentration of ammoniacal nitrogen varies over the monitoring period with the lowest concentrations occurring in the winter period which may suggest an influx of surface water or infiltration over the winter months.

2.1.5.7 Overall the leachate quality is similar to published typical leachate quality for domestic landfill sites as presented in the LandSim Manual. In comparison to the 2010 review, there are fewer hazardous substances above detection limit, however of those substances there is a similar number of occurrences above detection limit. As with the 2010 review, the most commonly detected substance were the TPHs, dichlorprop, dicamba and cadmium.

2.1.5.8 There is no monitoring data available for chloride, therefore no comparison can be made against the 2010 review. It is recommended that chloride is included in the analysis to provide further evidence on the strength of the leachate on a cell by cell basis.

2.2 Pathways

2.2.1 Summary of Geological Setting

2.2.1.1 A series of investigations has been undertaken as part of the development of the site, including the installation of numerous groundwater and gas monitoring boreholes. These have been recorded and are not repeated here. A summary of the geological conditions is presented below. Cross-sections for the site are presented on Drawings 2086.03 and 2086.04.

2.2.1.2 The site is located in an area of boulder clay overlying the Llandovey Series. Locally the boulder clay is describes as soft grey orange mottled sandy silty clay with mudstone fragments and gravel becoming stiff with depth. These deposits are generally less than 4m in thickness with a maximum depth of 13.5m in BH3/99. Gravel lenses have been identified in trial pits within Phase 9 area and in borehole 3 and 4. Water strikes have been recorded in the drillers logs within the drift deposits.

2.2.1.3 The Llandovery Series comprises mudstones and shales. Locally these comprise weathered mudstone and clay at the surface with the mudstone rock head reported to be on average 3.4m below the base of the site (Enviroarm 2003). The mudstones contain closed spaced fractures with fracture sets reported at 60 and 90 degrees. Fine clays are reported to fill the discontinuities. The general dip of the strata is estimated to be 20 degrees north to northwest (Enviroarm 2003).

2.2.1.4 No site specific data is available on the purifying properties of the soils. CEC values were obtained, however these are no longer valid with respect to the modelling technique. Partition coefficients have been sourced from the literature and are described in Section 3 below.

2.2.1.5 No additional data is available on the geological setting.

2.2.2 Summary of Hydrology

2.2.2.1 The site lies within the River Severn Catchment area.

2.2.2.2 The site specific rainfall data is reported from Garth Fawr station which had an average annual rainfall of 1244 mm/yr between 1993 and 2000. The average annual evapotranspiration from bare soils is presented as 375.5 mm/yr. This indicated that the effective rainfall is approximately 868 mm/yr. It is noted that this is a broad estimate and does not include soil moisture deficits or transpiration by grass. Older data for the area suggests that the evapotranspiration from grassland is likely to be 450 mm/yr (MAFF: The agricultural climate of England and Wales 1976).

2.2.2.3 The models assume an average infiltration to the waste mass of 868 mm/yr with a normal distribution and standard deviation of 87.

2.2.2.4 Surface water drainage comprises a perimeter catchment ditch which channels surface water along the southern boundary of Phase 8 and discharges to the Nant Y Bradnant. Water from the north of the site is discharged into the Afon Dulas.

2.2.2.5 The site is located on a shallow saddle between two summits to the south (400m AOD and 379m AOD), a hill (349mAOD) to the east (with a valley between it and the summit to the south) a low rise to the north (345 mAOD) and a further hill to the westnorthwest (>350mAOD). Consequently there are numerous small streams which arise in marshy conditions on the hillside. The closest of these appear to be two 'issues' at elevations of 335 mAOD and 330mAOD on the southwestern installation boundary. A stream to the south of the site appears to disappear down a disused mine shaft in the eastern corner of the site. There are further issues to the north of the site.

2.2.2.6 The elevation of the issues implies that they are associated with localised groundwater within the boulder clay.

2.2.2.7 No additional data is available on the hydrological setting. Routine monitoring is undertaken at the site at SW1 (also referred to as P1) and SW2 (also referred to as P2). The environmental monitoring data is presented in Appendix 3. This data indicates that in general the ammoniacal nitrogen concentrations are generally in compliance at SW1 with the exception of some exceedances in 2015 and 2016 which are accompanied by elevated chloride concentrations. Elevated ammoniacal nitrogen concentrations are also observed in SW2 in 2016. These are accompanied by elevated chloride concentrations during this time period. In 2017 the surface water quality returned to background levels for both monitoring points.

2.2.2.8 Suspended solids concentrations were more variable with the highest exceedances in SW1 occurring in 2013 and further exceedance in 2015. Whereas in SW2, the suspended solids are more frequently elevated above the compliance limit from 2015 (although variable in concentration).

2.2.2.9 BOD has only exceeded the compliance limit of 20mg/l on one occasion in 2014 in SW1.

2.2.3 Summary of Hydrogeology

2.2.3.1 The site is shown on the Groundwater Vulnerability Sheet 20 to be located on a non-aquifer with negligible permeability. There are no known groundwater abstractions within 500m of the site boundary.

2.2.3.2 The investigations undertaken during the development of the site have identified two separate water bodies: a shallow groundwater within the boulder clay/drift deposits and a deep groundwater located in the Llandovery Series rocks. Groundwater flow in the boulder clay will be intergranular flow dictated by the location of the sand and gravel lenses. The mudstones of the Llandovery Series have a very low primary porosity and as such the groundwater flow within these deposits will be governed by fracture flow.

2.2.3.3 Analysis of groundwater levels within the perimeter boreholes, and also the perimeter gas monitoring wells, is consistent with previous years. The water levels remain variable across the site which reflects the bedded nature of the underlying geology and the dominantly fracture flow mechanism.

Shallow Deposits (W2 and W9)

2.2.3.4 As previously reported in 2010, the groundwater level data indicates that the groundwater levels within the superficial boulder clay are heavily dependent on the presence or absence of sand and gravel lenses such that there does not appear to be a uniform water body or gradient across the site and consequently no groundwater contour plot has been provided. In addition, the base levels of the phases indicate that the boulder clay has typically been removed during the development of the site and consequently the pathway to the shallow groundwater is through the side wall lining system only.

2.2.3.5 A groundwater collection drain was installed around Phases 2 and 3 which diverted groundwater to the Nant y Bradnant. It is understood that this system remains in operation to date. A groundwater collection drain has also been installed around Phases 6, 7 & 8.

2.2.3.6 The permeability of remoulded bulk samples of the boulder clay has been shown to be able to attain values of 1×10^{-10}m/s. (Enviroarm 2003). Literature values for the insitu permeability of a stiff clay suggests that these are in the order of 1×10^{-8} to 1×10^{-9}m/s (Fetter 1994).

Llandovery Series Mudstone (W1, W3, W4, W5, W6, W7, W8, W10 and W11)

2.2.3.7 The groundwater levels in the 'deep' boreholes are also complicated partly since it appears that the seal on a number of these wells may be allowing shallow groundwater into the borehole and secondly because the water levels appear to be dependent on the depth of the screened section and the fractures intersected. The hydrographs presented in Appendix 1 indicate that the groundwater levels in all of the boreholes are relatively consistent throughout the year and do not display significant variation during the seasons, with the exception of some anomalous changes due to human/technological errors. Therefore the groundwater flow direction based on this monitoring data is anticipated to be consistent throughout the year. There is no significant change in groundwater levels or flow direction and therefore the hydraulic gradient of 0.025 remains valid.

2.2.3.8 Groundwater well W11 is consistently dry through the review period and is therefore not suitable for the continued monitoring of the landfill site.

2.2.3.9 There appears to be a conflict in the permeability data presented for the Llandovery Series Rocks. Permeability tests undertaken by Tyssen's (date unknown) on core samples (102 mm cores) indicate that the permeability of the mudstones is between 4×10^{-13}m/s and 7×10^{-13} m/s (2 samples). In comparison the packer tests undertaken indicate permeabilities over a 1m test section of between 1.4×10^{-6} m/s and 3.8×10^{-5} m/s.

These values were reported to be highly conservative based on observations that the fractures extend beyond the 1m packer test section. These values are also higher than regionally published information which was reported to be 1.15 x 10^{-7}m/s.

2.2.3.10 The Llandovery Series rocks are considered to be strongly anisotropic with vertical permeabilities likely to be significantly lower than the horizontal permeabilities. The core samples, by virtue of the sampling methodology, are likely to represent the vertical permeability of these mudstones, whereas the packer tests and regional data is more likely to represent the bulk transmissivity of these strata.

2.2.3.11 The borehole logs indicate that groundwater is present in discrete fractures at depth, with some boreholes intersecting fractures and indicating a piezometric surface and other remaining dry.

2.2.3.12 In addition the historic mining activities beneath the site may influence the groundwater flow direction and fracture connectivity beneath the site. There is a mine adit present at 50m below former ground levels which equates to approximately 290mAOD.

Groundwater Quality

2.2.3.13 The current permit requires the following groundwater monitoring to be undertaken:

Monthly:	pH, electrical conductivity	
Quarterly:	Ammoniacal nitrogen	(2 mg/L),
	Cadmium	(0.0056 mg/l),
	Chloride	(69 mg/l),
	Nickel	(0.12 mg/l),
	Toluene	(0.004 mg/l),
	Xylene	(0.003 mg/l),
	Zinc	(0.85 mg/l),
	Ethylbenzene	(0.001mg/l),
	Mecoprop	(0.0001 mg/l),
	2,4-D	(0.0001 mg/l).
Annual:	Hazardous substance screen.	

2.2.3.14 Ammoniacal nitrogen concentrations are variable, however, after 2011 only 1 breach of the compliance limit (2 mg/l) has been recorded, in W7 in May 2015, where the concentration of ammoniacal nitrogen was 2.85 mg/l. Aside from this breach all other locations have had concentrations below the compliance limit throughout the current review period. In the absence of any other leachate indicator species, the ammoniacal nitrogen concentrations in the groundwater are not considered to the associated with the permitted waste deposits, however are more likely to be associated with the peat deposits and possibly agricultural sources. The variability in concentrations is consistent with the existing conceptual model.

2.2.3.15 Cadmium concentrations typically range between 0.0003 mg/l and 0.0029 mg/l. This is lower than the maximum of 0.004 mg/l in the previous review period. Cadmium in the groundwater is likely to be associated with the mineralisation of the area (lead and zinc mine). There is no general increase in concentrations over time and therefore the concentrations are considered to be representative of background levels. None of the concentrations have exceeded the revised compliance level of 0.0056 mg/l.

2.2.3.16 The chloride concentrations exhibit a distinct difference in concentrations between groundwater in W1 and the remaining boreholes. Typically the concentrations are relatively stable and less than 100 mg/l, however the concentrations in W1 are highly variable / erratic with concentrations ranging from 149 mg/l to 727 mg/l between March 2010 and December 2017. It is also noted that the concentrations of sodium in this borehole are also significantly higher (average 170 mg/l) than the other locations (typically around 10 mg/l) and therefore it is concluded that this borehole has been impacted by rock salt from the nearby road which remains consistent with the existing conceptual model. A detailed study was undertaken in April 2017 and submitted to NRW with respect to the perceived elevated chloride concentrations in this borehole. This letter demonstrated a 1:1 ionic balance between sodium and chloride concentrations which is usually accepted as evidence that the borehole is impacted by salt. The mechanism for road salt to impact this boreholes is potentially complex. The presence of boulder clay/ superficial deposits are considered to represent a leaky aquifer in this area such that there is a lag between the application of the road salt and the observed concentrations within the water quality of W1. As a result the peak concentrations are delayed and more dispersed than may be expected within a granular superficial aquifer. Nevertheless, all the geochemical indicators suggest that the chloride is due to salt and as indicated above, there are no other potential sources of salt other than the adjacent highway.

2.2.3.17 The nickel concentrations have remained consistently below 0.05 mg/l as per the previous review period, showing no breaches of the compliance level of 0.12 mg/l. The nickel concentrations are also likely to be associated with the mineralisation within the area.

2.2.3.18 With the exception of December 2010 and March 2011, the toluene concentrations were consistently below the compliance level of 0.004 mg/l. The compliance level was breached twice in W1, with concentrations of 0.014 mg/l in December 2010 and 0.028 mg/l in March 2011. The maximum concentration of 0.06 mg/l was identified in W8 in March 2011. There are no discernible trends.

2.2.3.19 The xylene concentrations have remained the same as in the previous review period, with all measurements since 2014 being recorded at detection limits. The maximum concentration of Xylene was recorded in March 2011 in W1 at 0.001 mg/l, still far below the limit of 0.003 mg/l.

2.2.3.20 Ethylbenzene was monitored on a quarterly basis. Throughout the current review period no concentrations above detection limit were recorded. The highest recording remains the concentration of 0.5 ug/l in W1 in 2011.

2.2.3.21 The mecoprop concentrations were generally below the laboratory detection limit of 0.04 µg/l, except for one instance in W5 in June 2016 where the concentration was 0.23 ug/l. This is a reduction in the 6 exceedances of the 0.1 ug/l limit which were recorded in the previous review period.

2.2.3.22 All concentrations of 2-4 D were below the laboratory detection limit however it is noted that on occasions this detection limit is above the compliance criteria of 0.1 ug/l. It is recommended that the laboratory detection limits are reviewed.

2.2.3.23 The review of the monitoring data has indicated that total PAH levels were identified above detection limits 16 times since 2014. 6 of these incidences were in W1, where the concentrations were 0.1 ug/l. This was the maximum concentration recorded, with all other detections not exceeding 0.07 ug/l. These low levels of organics and particularly PAHs may be associated with runoff from peaty or marshy areas. TPH has also been recorded in most wells on at least one occasion. The concentrations are consistently the long carbon chain lengths which may be due to peat. The speciated TPH results in W1 also indicates that this is predominantly long carbon chains C24-C40. The highest concentration are observed in W1 with a maximum of 429 ug/l. Based on the presence of road salt within this borehole, it is likely that the TPH is also associated with road runoff.

2.2.3.24 In summary, there does not appear to be any discernible change in groundwater chemistry since the 2010 review and as such the groundwater chemistry can be used as the background quality levels for the modelling. In addition, the groundwater monitoring data does not indicate any significant impact from the site on the groundwater at the site. Borehole W1 appears to be impacted by an off-site source, most probably the road, as there are periodically elevated levels of chloride, sodium and some other substances which are not mirrored in any other boreholes.

2.3 Receptors

2.3.1 Summary of Receptors

2.3.1.1 Potential receptors of water-borne contaminants from the Site are:

- Groundwater
- Surface water bodies
- Abstraction points

2.3.1.2 The groundwater receptor for hazardous substances is considered to be the point of entry (without dilution) for hazardous substances to enter the water table beneath the base of the site. This is consistent with the Groundwater Regulations 2009.

2.3.1.3 The groundwater receptor for non-hazardous substances is considered to be groundwater in the down gradient monitoring boreholes within the Llandovery Series rocks. It is noted that the water table intersected in the boulder clay is at a higher elevation than the leachate levels in all cells. The recent groundwater level monitoring does not show a distinct groundwater flow directions, therefore the generalised flow towards the east used in the 2010 review will be applied in the modelling.

2.3.1.4 Surface water bodies: These include the issues and stream located around the perimeter of the site.

2.3.1.5 Abstractions: There are no known groundwater abstractions within 500m of the site boundary.

2.3.2 Review of Environmentally Acceptable Levels

2.3.2.1 The environmentally acceptable levels for the site are defined on the basis of the background groundwater quality within the Llandovery Series rocks. The environmentally acceptable limits for hazardous substances are defined as the minimum reporting values.

Table 10: Environmentally Acceptable Limits

Parameter	Category	EAL 2015	Justification
Ammoniacal Nitrogen	Mobile cation	2 mg/l	As agreed in 2010, based on 2010 HRA review.
Chloride	Mobile anion	250 mg/l	UK Drinking water standards
Cadmium	Hazardous metal	0.0019 mg/l	No change as based on environmental monitoring data as agreed in 2010 HRA review.
Nickel	Mobile metal	0.029 mg/l	No change as based on environmental monitoring data as agreed in 2010 HRA review.

Parameter	Category	EAL 2015	Justification
Zinc	Mobile metal	0.2 mg/l	No change as based on environmental monitoring data as agreed in 2010 HRA review.
Mecoprop	Acid herbicide	187 ug/l	Re classified as non-hazardous. Revised EAL based on Water Framework Directive MAC value
Toluene	Hydrophobic organic	0.004 mg/l	MRV (hydrogeological risk assessment guidance)
Xylene	Hydrophobic organic	0.003 mg/l	MRV (hydrogeological risk assessment guidance)
2,4-D	Pesticide	0.0001 mg/l	MRV (hydrogeological risk assessment guidance)
Ethyl Benzene	Hydrophobic organic	0.001 mg/l	MRV set at laboratory detection limit
4 methylphenol	Hydrophilic organic	0.01 mg/l	MRV set at laboratory detection limit

‘# units changed to ug/l for hazardous for consistency with report

2.4 Summary of Key Changes

2.4.1.1 The review of the environmental setting and monitoring data over the past 5 years indicated that the leachate source term has shown a little variation. There has been an increase in some metals, such as zinc and nickel, along with 2,4-D, dichlorprop and mecoprop. However there has also been a general decrease in the number of hazardous substances being detected, and of those being detected there is little to no increase in concentrations. Additionally, there has even been an overall decrease in ammoniacal nitrogen and cadmium since the 2010 review. Therefore in summary there does not appear to be any significant change in the leachate source term.

3 HYDROGEOLOGICAL RISK ASSESSMENT

3.1 Numerical Modelling

3.1.1 Justification for Modelling Approach and Software

3.1.1.1 The conceptual model presented in the 2003 risk assessment and the environmental setting above, both indicate that there is an unsaturated zone present beneath the base of the site and therefore the probabilistic modelling tool LandSim is appropriate for assessing the site.

3.1.1.2 The model parameters are compared to the risk assessment submitted in 2010 and a review undertaken in 2016.

3.1.1.3 The site has be operating since 1982 and as such the probabilistic models are calibrated as far as possible against the monitoring data. This calibration has been undertaken at the 50%ile. Model results are presented at the 50%ile and the 95%ile in compliance with standard industry practise.

3.1.1.4 The scenarios assessed comprise:

3.1.1.5 Scenario 1 site is operated in accordance with its Permit with leachate levels maintained at 1m above the base of each phase. The management period is set to 20,000 years to reflect the intention to manage leachate level until such time that the site does not pose a risk to the environment. This model has been updated to reflect the additional waste height above Phases 3, 4 and 9.

3.1.1.6 A second scenario (Scenario 2) is assessed with leachate levels at 2m above the base of the site in all cells. This assessment allows the evaluation of the sensitivity of the models to leachate heads. This model has been updated to reflect the additional waste height above Phases 3, 4 and 9.

3.1.1.7 A failure scenario (scenario 3) is also assessed with the management period set to 60 years, representing failure of the leachate management systems in the near future. This model has been updated to reflect the additional waste height above Phases 3, 4 and 9.

3.1.1.8 A further model (scenario 4) has been developed to assess the impact of the elevated leachate levels recorded in 2016 in Phase 9. The model is not sophisticated enough to be able to force high leachate levels for a period and then reduced back into compliance within a discrete period. The model is therefore highly conservative and assumes high leachate levels for the duration of the management control period (20,000 yrs).

3.1.2 Model Parameterisation

3.1.2.1 The following tables indicate the model parameters used and compare these with the values used in the 2010 risk assessment. The comparison of the source term is presented in Section 2 above.

Table 11: Model Parameters

Parameter	Values HRA 2010	Values 2015	Comment
General parameters valid for all Phases – unless otherwise stated			
Infiltration to waste (mm/yr)	No(868,87)	No(868,87)	No change from previous model. Calculated using rainfall between 1999-2003.
Infiltration to Geomembrane cap	No(30,3)	No(30,3)	No change. Industry standard value for when the cap is performing as designed. Values allowed to decay with time (LandSim Default Values)
Infiltration to mineral cap	No (50,5)	No (50,5)	No change. Industry standard value for when the cap is performing as designed
Infiltration to grass land	No(167,17)	No(167,17)	No change. Value adjusted to represent infiltration through the cover soils when cap has degraded. 20% of effective rainfall has been selected as the profile of the site will shed the majority of rainfall to the perimeter of the site.
Waste Porosity	Un(0.25,0.35)	Un(0.25,0.35)	No Change. Typical values for domestic waste
Waste field capacity	Un(0.1,0.2)	Un(0.1,0.2)	No Change. Typical values for domestic waste
Waste thickness	35	40	Maximum of 40 m in overtip
Waste Density	Un(0.8,1.2)	Un(0.8,1.2)	No Change. Typical values for domestic waste
Leachate head	1	1	Single value model at 1m for compliance with permit requirements, modelled at 2m for sensitivity analysis.
Saturated hydraulic conductivity	logtr(1.15E-7,5.8E-6,3.85E-5)	logtr(1.15E-7,5.8E-6,3.85E-5)	No change. Based on regional data and packer tests
Effective porosity of saturated zone (fraction)	Un(0.005,0.01)	Un(0.005,0.01)	No change. Assumed fracture porosity
Hydraulic gradient	0.025	0.025	No change. Considered to remain valid
Phase 1 &2			
Infiltration to waste (mm/yr)	No(868,87)	No(868,87)	No change: Calculated using rainfall between 1999-2003.
Infiltration to cap	No(50.5)	No(50.5)	No change: Mineral cap
Liner thickness (m)	Un(1,1.1)	Un(1,1.1)	No change: Represented natural clay in the base of the site
Clay Permeability	Un(1E-10,5E-10)	Un(1E-10,5E-10)	No change: CQA data
Liner porosity	0.11	0.11	No change: Natural moisture content
Liner Density	Un(1.8,2)	Un(1.8,2)	No change: Natural clay – recompacted
Base of cell		Approx. 313.4 mAOD	Base of cell based on sump elevation.

Unsaturated thickness	Un(1,3)	Un(1,3)	No change: Conservative assumption as base depth unknown. Distance based on cell base and elevation of upper groundwater ~310 mAOD
Unsaturated zone porosity	0.11	0.11	No change: Recorded natural moisture content of the clay
Unsaturated zone permeability	Logtr(1E-10,7E-10,8E-10)	Logtr(1E-10,7E-10,8E-10)	No change: Based on permeability results investigation into the permeability of the natural clay in phase 8
Phase 3,4,5			
Infiltration to Geomembrane cap	No(30,3)	No(30,3	No change – geomembrane cap
Clay Liner thickness	Un(0.9,1)	Un(0.9,1)	Conservative assumption based on a target thickness of 1m
Clay Permeability	Un(2.6E-10,6.5E-10)	Un(2.6E-10,6.5E-10)	No change, values as reported in original HRA and subsequent reviews. No further information available. Moisture content distribution changed for consistency with other pathways
Liner porosity/ moisture content	Tr(0.05,0.05,0.1)	Un(0.05,0.1)	
Liner Density	Un(1.85,1.935)	Un(1.85,1.935)	
Cell Base		Approx 310.5	Based on elevation of LCP2 and LCP3
Unsaturated thickness	Un(8.63,13.8)	Un(11,13.8)	No significant change in water levels and therefore modelled pathways remain unchanged. Depth to lower aquifer (297-299 mAOD) as shallow aquifer against side walls and groundwater drain installed. Shallow aquifer only considered to be at risk from lateral leakage.
Unsaturated zone porosity	Un(0.005,0.1)	LogUn(0.005,0.1)	Boulder clay has been excavated, the site base sits on mudstone. The lower value of 0.5% represents the fracture porosity whereas the higher value 10% represents an assumed porosity of the weather upper profile described as a stiff clay.
Unsaturated zone permeability	LogUn(4E-13,1E-10)	LogUn(4E-13,1E-10)	Based on permeability results from the cores and site investigation and vertical permeabilities of mudstones. The maximum permeability has been limited by the presence of a weathered mudstone zone and also by model calibration.
Phase 6,7			
Infiltration to cap	No(50.5)	No(50,5)	Mineral cap
Waste Porosity	Un(0.25,0.35)	Un(0.25,0.35)	Typical values for domestic waste
Waste field capacity	Un(0.1,0.2)	Un(0.1,0.2)	Typical values for domestic waste
Waste thickness	35	35	Maximum waste thickness
Geomembrane liner defects	LandSim default values	LandSim default values	The liner was installed under CQA procedures and therefore it is considered reasonable to use the default defect rates as no other information is available.
Liner thickness (m)	Un(0.006,0.01)	Un(0.5,0.51)	Model corrected to include properties of the geological barrier – in situ mudstone.
Clay Permeability	Un(7.7E-12,1.8E-11)	Un(3e-10,8e-10)	Bulk properties for combine GCL and clay. Range generated from Max GCL and Max clay properties and min GCL and min Clay properties:

			Manufacturer perm data for GCL Un(7.7E-12,1.8E-11) m/s Clay perm data- site specific: (5.9e-10, 1.7e-8) m/s
Liner porosity	Un(0.01,0.02)	Un(0.1,0.2)	Average moisture content- assumed values for GCL and mudstone
Liner Density	Un(1.7,1.9)	Un(1.7,1.9)	Average moisture content- assumed values for GCL and mudstone
Base of Phase		Approx 310.5 mAOD	Based on sump elevation
Unsaturated thickness	Un(7.8,8.75)	Un(11,13.8)	Based on base of site and 2014 water levels in deep aquifer
Unsaturated zone porosity	Un(0.005,0.01)	Un(0.005,0.01)	Boulder clay has been excavated, the site base sits on mudstone. The lower value of 0.5% represents the fracture porosity whereas the higher value 10% represents an assumed porosity of the weather upper profile described as a stiff clay.
Unsaturated zone permeability	Logtr(4E-13,1E-9,1E-8)	Logtr(4E-13,1E-9,1E-8)	Based on permeability results from the cores and site investigation and vertical permeabilities of mudstones. The maximum permeability has been adjusted to represent more typical values for a fractured mudstone
Phase 8 (as Phase 6 & 7, plus)			
Clay Permeability	Un(7.7E-12,1.8E-11)	Un(3e-10,8e-10)	Bulk properties for combine GCL and clay. Range generated from Max GCL and Max clay properties and min GCL and min Clay properties: Manufacturer perm data for GCL Un(7.7E-12,1.8E-11) m/s Clay perm data- site specific: (5.9e-10, 1.7e-8) m/s
Base elevation		Approx. 310.5	Based on LCP8 elevation
Unsaturated thickness	Un(7.8,8.75)	Un(11,13.8)	Based on base of site and 2014 water levels- deep aquifer
Phase 9			
Infiltration to cap	No(50.5)	No(30,3)	Geomembrane cap – design change
Liner thickness (m)	Un(1,1.1)	Un(0.5,0.51)	GCL and Clay
Liner Permeability	Logun(1.8E-11,2.5E-10)	Logun(1.8E-11,2.2E-10)	Bulk properties for combine GCL and clay. Range generated from average GCL (1e-11) and Max clay properties and min GCL and min Clay properties: Manufacturer perm data for GCL Un(7.7E-12,1.8E-11) m/s Clay perm data- site specific: (1.8e-11, 2.5e-10) m/s
Liner porosity	Un(0.1,0.18)	Un(0.1,0.2)	Average moisture content- assumed values for GCL and mudstone
Liner Density	Un(1.8,1.9)	Un(1.7,1.9)	Average moisture content- assumed values for GCL and mudstone
Base elevation		307 mAOD	Based on sump elevation data
Unsaturated thickness		Un(8,10)	Based on base of site and 2014 water levels- deep aquifer
Unsaturated zone porosity	Un(0.005,0.01)	Un(0.005,0.01)	Boulder clay has been excavated, the site base sits on mudstone. The lower value of 0.5% represents the fracture porosity whereas the higher value 10%

			represents an assumed porosity of the weather upper profile described as a stiff clay.
Unsaturated zone permeability	Logtr(4E-13,1E-9,1E-8)	Logtr(4E-13,1E-9,1E-8)	Based on permeability results from the cores and site investigation and vertical permeabilities of mudstones. The maximum permeability has been adjusted to represent more typical values for a fractured mudstone

Table 12: Partition coefficients

Parameter	Kd (ml/g) KOC for organics	Justification
2,4-D	Un(20-136)	Values for Toxnet, environmental fate
Ammoniacal Nitrogen	Un (0.5,2)	LandSim help files
Cadmium	222.2	Consistent with previous report
Chloride	0	Conservative tracer
Mecoprop	Tr(5.3,12.5,13.7)	Values for Toxnet, environmental fate
Nickel	85.7	Consistent with previous report
Toluene	Un(131,242)	Consistent with previous report
Zinc	20.7	Consistent with previous report
4 Methylphenol	Un(1.98,2.81)	Values for Toxnet, environmental fate
Ethylbenzene	520	Values for Toxnet, environmental fate
Fraction of organic carbon	0.0037 (fraction)	Consistent with previous report

This table has been duplicated from the 2010 report for ease of reading. There are no changes to the parameter values since the 2010 review. Toluene, xylene, 4 methyl phenol, ethyl benzene and 2,4 D have been modelled as volatile organics with active gas abstraction and biodegradation within the liner.

3.2 Emissions to Groundwater

3.2.1 Hazardous Substances

3.2.1.1 The predicted impact from hazardous substances are presented in Table 8 below:

Table 13: Scenario 1 Hazardous Substances

Parameter	Phase 3,4,5		Phase 6,7,		Phase 8		Phase 9		Phase 1,2	
	95%ile	50%ile	95%ile	50%ile	95%ile	50%ile	95%ile	50%ile	95%ile	50%ile
Cadmium (ug/l) (years to peak)	<1e-5	<1e-5	5e-3 (20,000)	1 e-3 (20000)	8e-4 (20,000)	2e-4 (20000)	<1e-5	<1e-5	0.02 (20000)	1e-5)
Toluene (ug/l)	<1e-5	<1e-5	0.002 (170)	<1e-5	0.001 (170)	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5
Xylene (ug/l)	<1e-5	<1e-5	7e-4 (400)	<1e-5	3e-4 (470)	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5
2,4-D (ug/l)	0.5 (2000)	0.02 (2000)	0.3 (9000)	0.02 (13000)	0.2 (16000)	0.08 (16000)	0.06 (12000)	0.006 (12000)	0.1 (1300)	0.006 (1300)
4methlyphenol (ug/l)	<1e-5	<1e-5	14 (12000)	<1e-5	14 (12000)	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5
Ethyl benzene (ugl)	<1e-5	<1e-5	0.05 (12000)	<1e-5	0.04 (12000)	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5

Note: where the concentrations are very low and did not plot, a minimum values is presented without time data.

3.2.1.2 It is noted that only 4 methylphenol is predicted to have any discernible concentrations at the base of the unsaturated zone for the existing cells. The predicted concentration in Phase 9 (future cells) is at the laboratory detection limit and therefore there will be no discernible release from these cells. It is also noted that the range of concentrations of this parameter in leachate vary from less than detection to 4900 ug/l. The high concentrations are found sumps which have subsequently been sealed due to gas and odours. It is tentatively suggested that these high concentrations are associated with these issues and therefore likely to be a transient event rather than present a long term risk at the site.

Table 14: Scenario 2: leachate levels at 2m Hazardous Substances

Parameter	Phase 3,4,5		Phase 6,7,		Phase 8		Phase 9		Phase 1,2	
	95%ile	50%ile	95%ile	50%ile	95%ile	50%ile	95%ile	50%ile	95%ile	50%ile
Cadmium (ug/l) (years to peak)	<1e-9	<1e-9	0.01 (20000)	0.006 (20,000)	0.004 (20,000)	0.001 (20000)	<1e-5	<1e-5	4e-9 (20,000)	<1e-9
Toluene (ug/l)	<1e-5	<1e-5	0.01 (114)	<1e-5	0.006 (114)	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5
Xylene (ug/l)	<1e-5	<1e-5	0.04 (170)	<1e-5	0.02 (280)	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5
2,4-D (ug/l)	0.07 (8,000)	<1e-5	0.04 (8,000)	<1e-5	0.05 (12,000)	<1e-5	0.03 (12,000)	<1e-5	0.01 (1,000)	<1e-5
4methlyphenol (ug/l)	<1e-5	<1e-5	0.05 (12,000)	<1e-5	0.05 (12,000)	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5
Ethyl benzene (ugl)	<1e-5	<1e-5	1 (10,000)	<1e-5	2 (10,000)	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5

Note: where the concentrations are very low and did not plot, a minimum values is presented without time data.

3.2.1.3 The above table indicates that with 2m leachate heads in all cells rather than just in Phase 9 (according to the leachate monitoring data), there will only be a release of 4 methylphenol from all cells, see above explanation. Cadmium concentrations are also predicted to be below the MRV.

Table 15: Scenario 3: Suspension of Leachate Control Hazardous Substances

Parameter	Phase 3,4,5		Phase 6,7,		Phase 8		Phase 9		Phase 1,2	
	95%ile	50%ile	95%ile	50%ile	95%ile	50%ile	95%ile	50%ile	95%ile	50%ile
Cadmium (ug/l) (years to peak)	0.002 (16,500)	0.0004 (16,500)	0.001 (20,000)	<1e-5	0.2 (20,000)	0.01 (20,000)	0.0003 (20,000)	<1e-5	0.01 (16000)	0.008 (7000)
Toluene (ug/l)	<1e-5	<1e-5	0.003 (220)	<1e-5	0.004 (220)	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5
Xylene (ug/l)	<1e-5	<1e-5	0.01 (220)	<1e-5	8e-4 (220)	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5

Parameter	Phase 3,4,5		Phase 6,7,		Phase 8		Phase 9		Phase 1,2	
	95%ile	50%ile	95%ile	50%ile	95%ile	50%ile	95%ile	50%ile	95%ile	50%ile
2,4-D (ug/l)	2 (2000)	0.1 (2000)	0.2 (8000)	0.02 (12000)	0.7 (970)	0.03 (12000)	0.7 (6000)	0.05 (4000)	0.8 (970)	0.04 (970)
4methlyphenol (ug/l)	165 (10)	<1e-5	12 (12000)	<1e-5	243 (31)	<1e-5	0.02 (4000)	<1e-5	0.006 (450)	<1e-5
Ethyl benzene (ugl)	<1e-5	<1e-5	0.04 (14000)	<1e-5	9 (2000)	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5

Note: where the concentrations are very low and did not plot, a minimum values is presented without time data.

Table 16: Scenario 4: Elevated Leachate Phase 9

Parameter	Phase 3,4,5		Phase 6,7,		Phase 8		Phase 9		Phase 1,2	
	95%ile	50%ile	95%ile	50%ile	95%ile	50%ile	95%ile	50%ile	95%ile	50%ile
Cadmium (ug/l) (years to peak)	0.002 (16,500)	0.0004 (16,500)	0.001 (20,000)	<1e-5	0.2 (20,000)	0.01 (20,000)	0.0003 (20,000)	<1e-5	0.02 (6000)	0.008 (7000)
Toluene (ug/l)	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5
Xylene (ug/l)	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5
2,4-D (ug/l)	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5
4methlyphenol (ug/l)	165 (10)	<1e-5	68 (31)	<1e-5	206 (31)	<1e-5	0.1 (48)	<1e-5	40 (41)	<1e-5
Ethyl benzene (ugl)	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5	<1e-5

Note: where the concentrations are very low and did not plot, a minimum values is presented without time data.

3.2.1.4 The above table indicates that in general there will be no release of hazardous substances above the minimum reporting values at the base of the unsaturated zone with the exception of 4 methylphenol, see above discussion.

3.2.2 Non Hazardous Substances

3.2.2.1 The non-hazardous substances are assessed at the down gradient monitoring borehole and include for dilution within the aquifer.

Table 17: Non hazardous substances Scenarios 1 & 2

Parameter		Scenario 1		Scenario 2	
	EAL	95%ile	50%ile	95%ile	50%ile
Ammoniacal Nitrogen (mg/l)	2	0.1 (3000)	0.01 (2000)	0.5 (2000)	0.06 (2000)
Chloride (mg/l)	250	36 (155)	3.8 (155)	55 (155)	5 (155)
Nickel (mg/l)	0.1	1e-6 (20,000)	<1e-10	5e-6 (20000)	<5e-6
Zinc (mg/l)	0.8	5e-4 (20,000)	4e-5 (20000)	0.002 (20000)	0.0002 (20000)
Mecoprop (ug/l)	18	0.3 (10128)	0.04 (14000)	0.6 (12000)	0.1 (12000)

3.2.2.2 The above table indicates that there is no predicted impact from non-hazardous substances on the groundwater beneath the base of the site with either a 1m or 2m leachate head.

3.2.2.3 The assessment of the suspension of management control after 60 years predicts the following results.

Table 18: Non hazardous substances Scenario 3 &4

Parameter		Scenario 3		Scenario 4	
	EAL	95%ile	50%ile	95%ile	50%ile
Ammoniacal Nitrogen (mg/l)	2	8 (2000)	2 (1500)	10 (1250)	2.2 (1000)
Chloride (mg/l)	250	107 (950)	14 (262)	113 (787)	13 (312)
Mecoprop (ug/l)	18	2.2 (2000)	0.3 (2000)	8 (2000)	1 (2000)
Nickel (mg/l)	0.1	0.02 (20000)	0.002 (20000)	2e-5 (20,000)	4e-6 (20000)
Zinc (mg/l)	0.8	0.016 (12,000)	0.003 (8000)	0.014 (12,000)	0.002 (8000)

3.2.2.4 The above table indicates that if leachate management was suspended following 60 years, there would be no pollution caused by non-hazardous substances at the 50%ile. The results also indicate that the effect of 10m of leachate in phase 9 only is unlikely to have a discernible impact on the groundwater based on the 50%ile.

3.3 Sensitivity Analysis

3.3.1.1 The sensitivity analysis indicates that the model is sensitive to the fracture porosity of the underlying mudstone. This controls the dilution of the non-hazardous substances within the aquifer. The sensitivity analysis indicates that if the fracture porosity is reduced to 1% the model predicts that there should be a discernible impact from chloride and ammoniacal nitrogen in the down gradient monitoring boreholes within 22 years. The site has been operating since 1982 (28 years) and there is no discernible impact on the groundwater quality.

3.4 Review of Technical Precautions

3.4.1.1 The monitoring data indicates that the site is in compliance with the Groundwater Regulations 2009. The technical precautions employed at the site include:

3.4.1.2 Capping: A combination of geomembrane and mineral caps have been employed at the site. It is noted that some areas are temporarily restored and consequently would be anticipated to be generating more leachate than if they were capped. The leachate management system appears to be able to control the leachate levels to 1m above the base of the site based on the current leachate monitoring data.

3.4.1.3 Lining design: The site is fully constructed.

3.4.1.4 Leachate Control: the current leachate drainage systems appear to be able to control the leachate levels in accordance with the Permit condition of 1m above the base of the site. The apparent slightly elevated leachate levels in Phase 9 may be due to erroneous base levels or datum levels for the wells.

3.4.1.5 Groundwater control: A groundwater drain is constructed in the shallow boulder clay deposits around the site. This drain aids the stability of the site and minimises the potential for groundwater to seep through the lining system into the waste mass

4 REQUISITE SURVEILLANCE

4.1 Leachate, Monitoring Schedule

4.1.1.1 The leachate monitoring schedule currently comprises:

Table 17 : Leachate Monitoring Regime

Parameter	Units	Frequency	Monitoring Point	Comment
Leachate Level	mbgl	Monthly	LCP1/2/3/6/7/8, and RML9A/9B/9C/9D	It is noted only 1,4, 5, 9c and 9a are currently accessibly and that the others have been temporarily sealed. It is recommended that monitoring is instated at the earliest opportunity
Ammoniacal Nitrogen	mg/l as N	Monthly	LCP1/2/3/6/7/8, and RML9A/9B/9C/9D *[subject to accessibility]*	
pH	-	Monthly		
Cadmium	mg/l	6 monthly		
Chromium	mg/l	6 monthly		
Copper	mg/l	6 monthly		
Nickel	mg/l	6 monthly		
Lead	mg/l	6 monthly		
Zinc	mg/l	6 monthly		
Cyanide	mg/l	6 monthly		
List 1 suite	ug/l*	Annually		

* Variable detection limits and units apply to individual compounds within this suite

4.1.1.2 It is recommended that chloride is added to the monthly monitoring suite above.

4.2 Groundwater Monitoring Schedule

4.2.1 Monitoring infrastructure

4.2.1.1 The groundwater is monitored around the perimeter of the site in boreholes W1 to W11 installed within the Llandovery Series rocks. The location of the monitoring wells are shown on Drawing 1148.02. A number of wells exhibit some evidence of perched water or surface water entering the wells resulting in elevated readings. These boreholes will be replaced as part of the proposed development works. It is recommended that future boreholes have short targeted screened sections.

4.2.1.2 The groundwater monitoring requirements as presented in the permit include:

Table 18 Groundwater Monitoring Requirements:

Parameter	Units	Frequency	Monitoring point
Levels	mbgl, mAOD	Monthly	W1-W11
pH	-	Monthly	W1-W11
Sulphate	mg/l	Monthly	W1-W11
Electrical Conductivity	uS/cm	Monthly	W1-W11
Ammoniacal Nitrogen	mg/l	Quarterly	W1-W11
Cadmium	mg/l	Quarterly	W1-W11
Chloride	mg/l	Quarterly	W1-W11
Nickel	mg/l	Quarterly	W1-W11
Toluene	mg/l	Quarterly	W1-W11
Xylene	mg/l	Quarterly	W1-W11
Zinc	mg/l	Quarterly	W1-W11
Ethyl Benzene	mg/l	Quarterly	W1-W11
2,4 D	mg/l	Quarterly	W1-W11
Mecoprop	mg/l	Quarterly	W1-W11
Annual suite	ug/l	Annual	W1-W11
Total alkalinity (mg/l) (as Ca CO3 at pH4.5)		Quarterly	W1-W11
PAH	(mg/l)	Quarterly	W1-W11
BTEX		Annually	W1-W11
K	(mg/l)	Quarterly	W1-W11
Ca	(mg/l)	Quarterly	W1-W11
Mg	(mg/l)	Quarterly	W1-W11
Fe	(mg/l)	Quarterly	W1-W11
Cr	(mg/l)	Quarterly	W1-W11
Cu	(mg/l)	Quarterly	W1-W11
Pb	(mg/l)	Quarterly	W1-W11
Bicarbonate HCO3	(mg/l)	Quarterly	W1-W11
Nitrate	(mg/l)	Quarterly	W1-W11
Arsenic	(mg/l)	Quarterly	W1-W11
Cyanide	(mg/l)	Quarterly	W1-W11

Mercury	(mg/l)	Quarterly	W1-W11
Selenium	(mg/l)	Quarterly	W1-W11
Manganese	(mg/l)	Quarterly	W1-W11
Silver	(mg/l)	Quarterly	W1-W11
Phenol	(mg/l)	Quarterly	W1-W11
Na	(mg/l)	Quarterly	W1-W11

4.2.2 Groundwater Compliance Values

4.2.2.1 No boreholes show any impact from leachate, however W1 appears to have been impacted by chloride and sodium. It is therefore proposed to use the data from boreholes W2 to W11 to determine the baseline groundwater quality. It is noted that this includes down gradient boreholes, but since there is discernible difference in water quality across the site, this information has been used to generate a slightly larger and theoretically more robust dataset. The monitoring data assessed ranged from 2010 to 2014 . All outliers have been excluded from the calculations and all records less than detection limit have been assumed to be at their detection limit.

4.2.2.2 The control levels for non-hazardous substances are set and the mean plus two standard deviations of the dataset. The compliance levels for non-hazardous substance are set at the mean plus three standard deviations.

Table 19: Groundwater Control & Compliance Levels

		Average	Stdev	Max	Control Level	compliance Level	Justification
Ammoniacal Nitrogen as N	mg/l	0.4	0.5	4.1	1.5	2.0	Based on GW quality for W2-W11
Cadmium	mg/l	0.0010	0.0015	0.0100	0.0	0.0056	
Chloride	mg/l	19.12	16.74	92	53	69	
Nickel	mg/l	0.017	0.033	0.23	0.08	0.12	
Zinc	mg/l	0.109	0.25	1.81	0.6	0.85	
Mecoprop	ug/l				18	187	EQS (EA Chemical Standards Database, Annual average and MAC)
Toluene	mg/l	Hazardous substance				0.004	EA guidance 2004
Xylene	mg/l	Hazardous substance				0.003	EA guidance 2004

Ethyl Benzene	mg/l	Hazardous substance	0.001	Lab detection limit
24-D	mg/l	Hazardous substance	0.0001	Lab detection limit

4.3 Surface Water Monitoring Schedule

4.3.1.1 There are no proposed changes to the surface water monitoring schedule on the basis of this review. The monitoring requirements are defined in the Permit as:

Table 20: Surface Monitoring Requirement

Parameter	Units	Frequency	Monitoring point
Electrical Conductivity	uS/cm	Monthly	P1-P2
Ammoniacal Nitrogen	mg/l	Monthly	P1-P2
Chloride	mg/l	Monthly	P1-P2
pH	-	Monthly	P1-P2
Suspended solids	mg/l	Monthly	P1-P2
BOD	mg/l	Monthly	P1-P2
COD	mg/l	Monthly	P1-P2
Water flow		Monthly	P1-P2
Dissolved Oxygen	mg/l	Quarterly	P1-P2
Temperature		Quarterly	P1-P2
Hydrocarbons	mg/l	Quarterly	P1-P2
List 1	various	6 monthly	P1-P2

5 CONCLUSIONS

5.1.1.1 The site continues to generate a leachate containing hazardous and non-hazardous substances. The leachate quality appears to have matured since the 2010 risk assessment but is comparable to the model ranges for 2007.

5.1.1.2 The technical precautions at the site have prevented hazardous substances from entering the groundwater to date. The risk assessment indicates that the measures will provide sufficient protection at the 95%ile for the future risks based on the current source term. The model predicts no impact from non-hazardous substances with either a 1m or 2m leachate head.

5.1.1.3 The groundwater compliance levels are considered to remain valid although Mecoprop has been reclassified as non-hazardous and therefore the compliance level should be set at the EQS. The minimum reporting values for hazardous substances have been reviewed against the Environment Agency Guidance 2008 Technical Memo and also the lowest achievable laboratory detection limits.

Increase in waste review conclusions

5.1.1.4 Review of the impacts of the increase in waste thickness has not changed the overall risk from the site to the groundwater environment. The additional waste mass has not significantly changed the duration of the source term such that there is a discernible change in the predicted impact of the site on the groundwater environment.

Increase in leachate (phase 9) conclusions

5.1.1.5 In model of the increase in Phase 9 indicated that although the predicted leachate rate from this cell is greater the overall risks presented by the site remain within the environmentally acceptable limits at the 50%ile. In addition, it should be noted that this is a transient effect (leachate levels) now returned to within compliance and therefore although potentially an increase in the amount of leachate escaping occurred, the model does not reflect the reality that the leachate levels have been reduced back to compliance and therefore the model results should be treated with caution.

Chloride in W1

5.1.1.6 The report reviews the chloride concentrations within this borehole and assesses the concentrations against the sodium concentrations on an ionic balance basis. This indicates that there is equal ions of sodium and chloride (within 10%) which indicates that this borehole is impacted by salt. The groundwater quality does indicate a seasonality with maximum concentrations observed in January and slow decreasing to December. It is considered likely that this reflects the slow percolation through the superficial deposits resulting in a more prolonged and diffuse impact on the water quality in the underlying limestone throughout the year.

5.1.1.7 In conclusion, the information presented in this report and the risk assessment based on this information has demonstrated that the site remains in compliance with the requirements of EPR 2015. The environmental monitoring data has been scrutinised assessed for trends and indicates that there is no discernible impact from the site on the groundwater quality within the Llandovery Series.

Recommendations

5.1.1.8 A number of recommendations have been made throughout this report. These are summarised below:

- Survey elevation of all leachate wells on an annual basis and transcribe elevation to database.
- Dip 'rest' leachate levels within all gas infrastructure to understand the perched leachate hand
- Add chloride to the leachate monitoring suite

DRAWINGS

NOTES

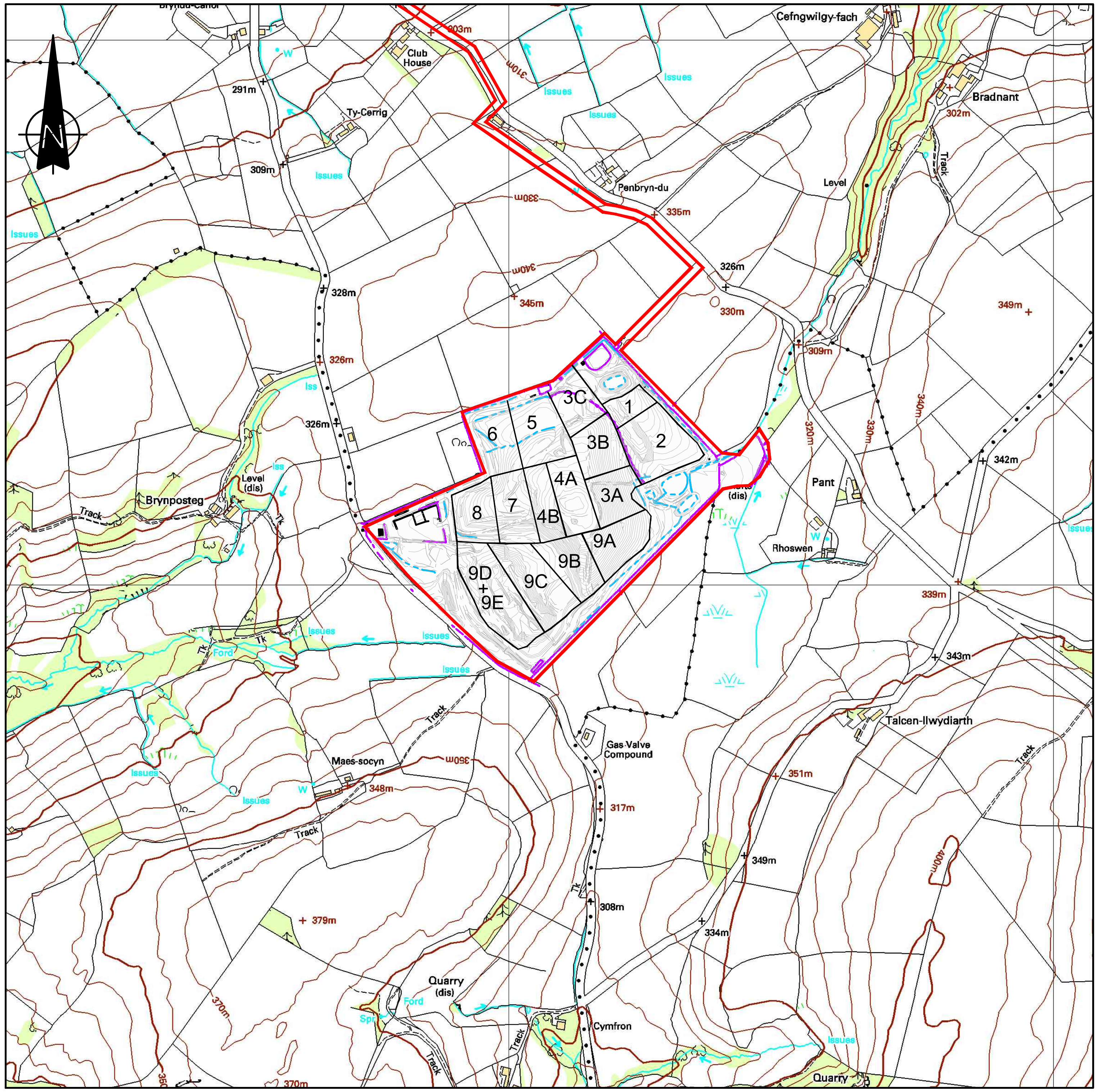
1. ORDNANCE SURVEY DATA USED IN ACCORDANCE WITH THE OS INTERNAL BUSINESS LICENSE (PLOT NUMBER 22977) AND ONLY FOR THE PURPOSES OF SUBMISSION TO LOCAL AUTHORITY AND GOVERNMENT BODIES

LEGEND

INSTALLATION BOUNDARY

PHASE BOUNDARY

1 PHASE NUMBER



REV	MODIFICATIONS	BY	CH	AP	DATE

POTTERS WASTE MANAGEMENT

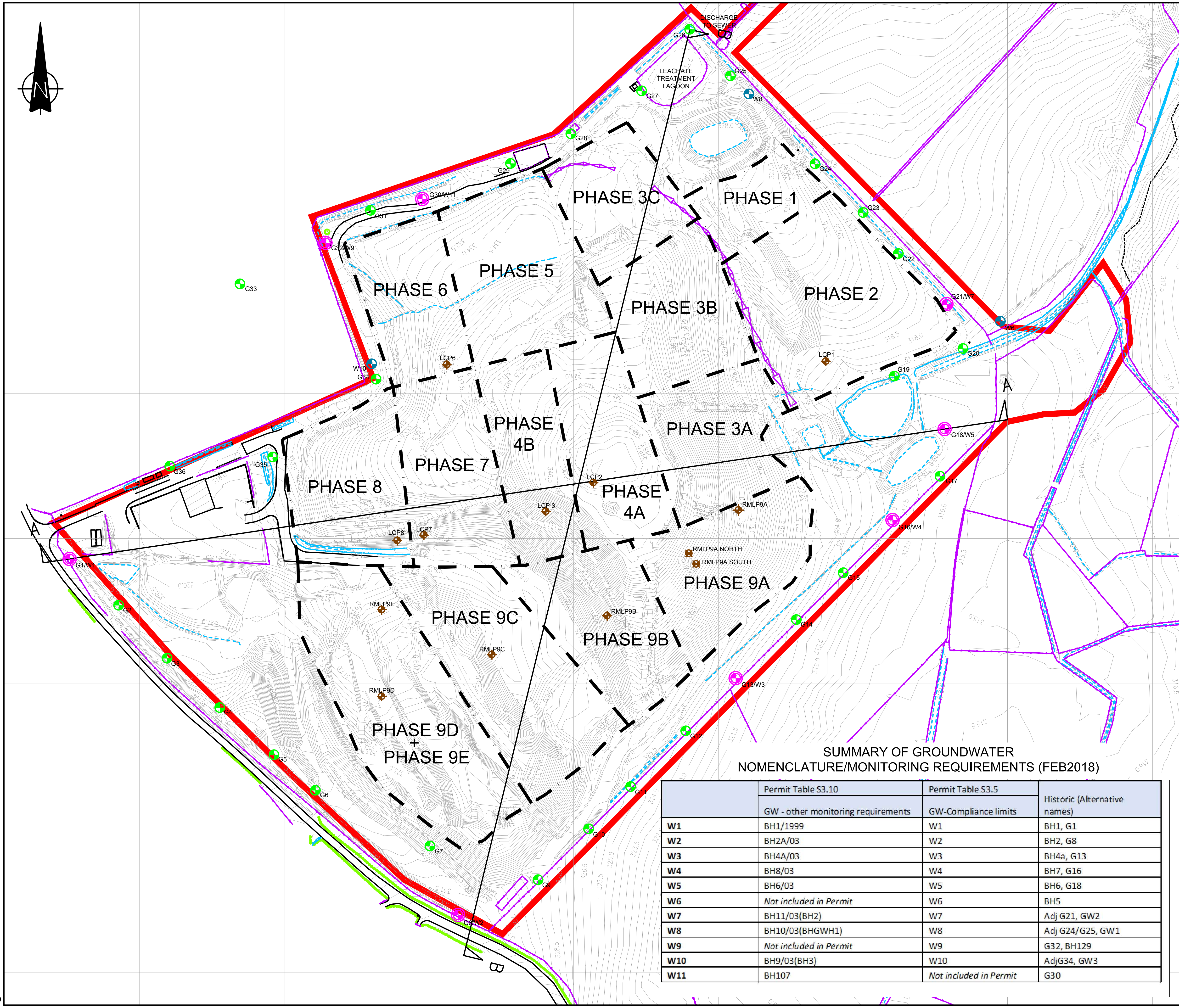
BRYN POSTEG

SITE LOCATION PLAN

DRAWN BY EW	DATE 21.02.2018
CHECKED BY SV	SCALE @ A3 1:10,000
APPROVED BY SV	ISSUE Fn / REVISION -
DRAWING NUMBER 3400.01	

Caulmert
Engineering, Environmental and Planning

CAD FILE REF: S:\Public\Clients\P\Potters Waste Management\3400 Bryn posteg HRA 2017\6-Drawings & Models\02-WIP\CAD\2D\Internal\3400.01.dwg



SUMMARY OF GROUNDWATER NOMENCLATURE/MONITORING REQUIREMENTS (FEB2018)

	Permit Table S3.10 GW - other monitoring requirements	Permit Table S3.5 GW-Compliance limits	Historic (Alternative names)
W1	BH1/1999	W1	BH1, G1
W2	BH2A/03	W2	BH2, G8
W3	BH4A/03	W3	BH4a, G13
W4	BH8/03	W4	BH7, G16
W5	BH6/03	W5	BH6, G18
W6	*Not included in Permit*	W6	BH5
W7	BH11/03(BH2)	W7	Adj G21, GW2
W8	BH10/03(BHGWH1)	W8	Adj G24/G25, GW1
W9	*Not included in Permit*	W9	G32, BH129
W10	BH9/03(BH3)	W10	AdjG34, GW3
W11	BH107	*Not included in Permit*	G30

NOTES

1. SURVEY INFORMATION PROVIDED BY POTTERS WASTE MANAGEMENT, REF: BRYN_POSTEG_SITE_SURVEY -220110.LSS.

2. FOR CROSS SECTIONS REFER TO DWG NO: 3400.HRA.03 AND 3400.HRA.04.

LEGEND

- EXISTING GAS MONITORING BOREHOLE
- EXISTING GROUNDWATER MONITORING BOREHOLE
- EXISTING GAS MONITORING BOREHOLE WITH GROUNDWATER MONITORING BOREHOLE
- EXISTING LEACHATE COLLECTION POINT
- APPROXIMATE PHASE BOUNDARIES

REV	MODIFICATIONS	BY	CH	AP	DATE

POTTERS WASTE MANAGEMENT

BRYN POSTEG

ENVIRONMENTAL MONITORING PLAN

DRAWN BY EW	DATE 21.02.2018
CHECKED BY SV	SCALE @ A3 1:2500
APPROVED BY SV	ISSUE Fn / REVISION -
DRAWING NUMBER 3400.02	

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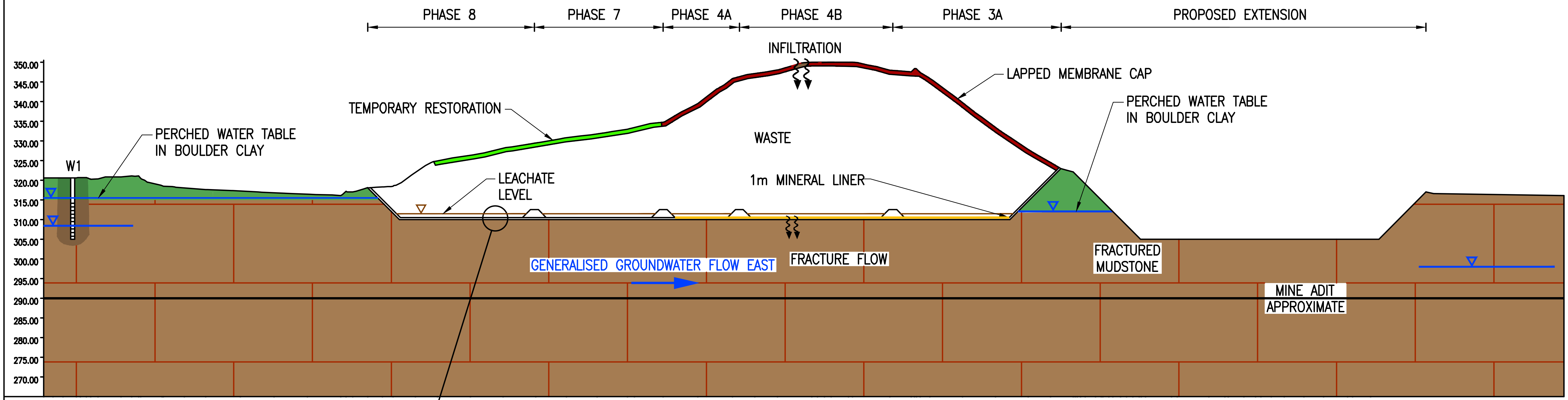

SECTION A–A

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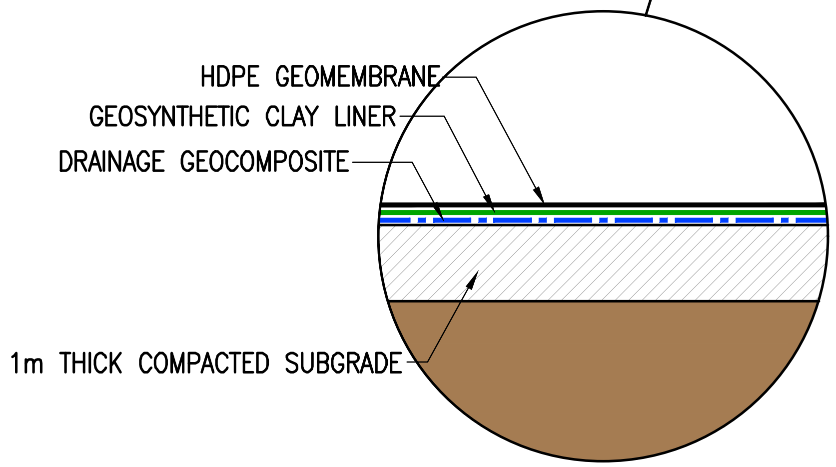

TYPICAL BASAL LINING DETAIL

SCALE: 1:100

NOTES

LEGEND

- BOULDER CLAY
- LLANDOVERY ROCKS
- PLAIN PIPE
- SCREENED SECTION
- WATER LEVEL

REV	MODIFICATIONS	BY	CH	AP	DATE

POTTERS WASTE MANAGEMENT

BRYN POSTEG

CROSS SECTION A

DRAWN BY EW	DATE 21.02.2018	
CHECKED BY SV	SCALE @ A3 AS SHOWN	
APPROVED BY SV	ISSUE Fn	REVISION -
DRAWING NUMBER 3400.03		

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CAD FILE REF: S:\Public\Clients\P\Potters Waste Management\3400 Bryn posteg HRA 2017\6-Drawings & Models\02-WIP\CAD\2D\Internal\3400.03.dwg

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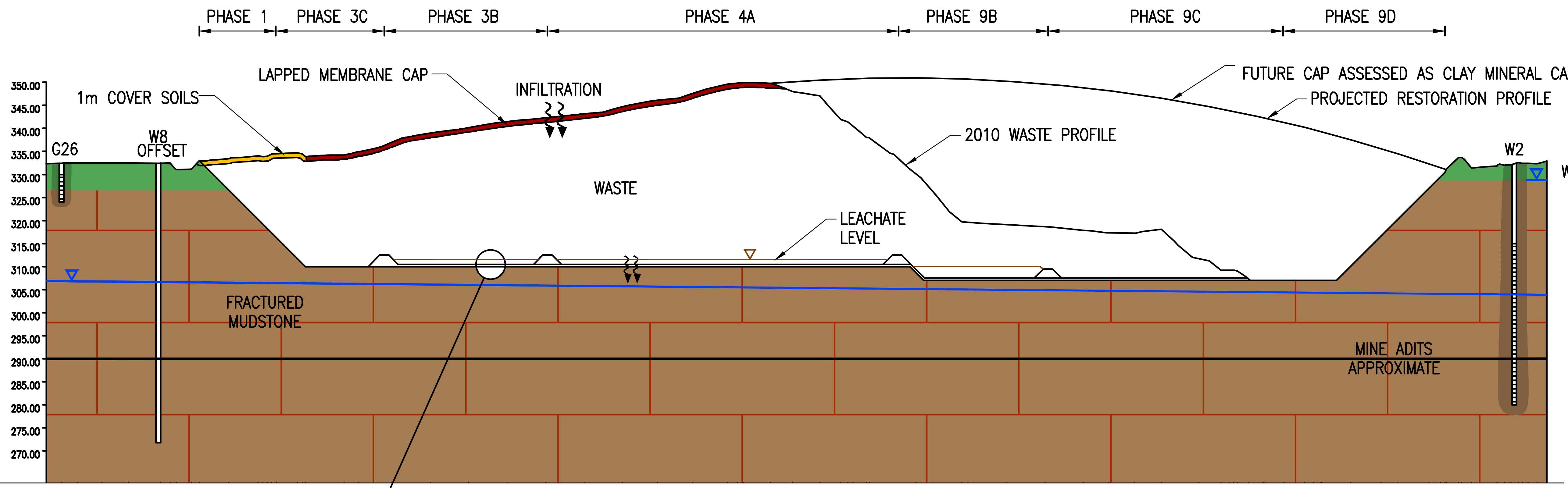
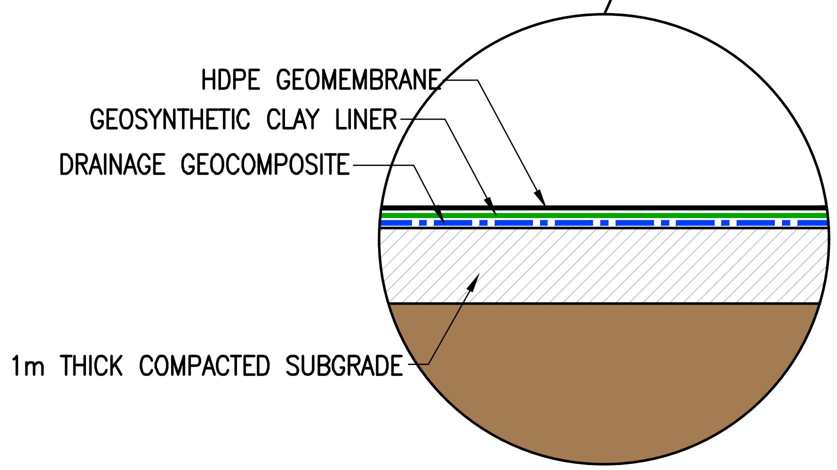


SECTION B–B

SCALE: HORIZONTALLY 1:2000 VERTICALLY 1:4000



TYPICAL BASAL LINING DETAIL

SCALE: 1:100

NOTES

LEGEND

- BOULDER CLAY
- LLANDOVERY ROCKS
- PLAIN PIPE
- SCREENED SECTION
- WATER LEVEL

REV	MODIFICATIONS	BY	CH	AP	DATE

POTTERS WASTE MANAGEMENT

BRYN POSTEG

CROSS SECTION B

DRAWN BY EW	DATE 21.02.2018
CHECKED BY SV	SCALE @ A3 AS SHOWN
APPROVED BY SV	ISSUE Fn / REVISION -

DRAWING NUMBER 3400.04

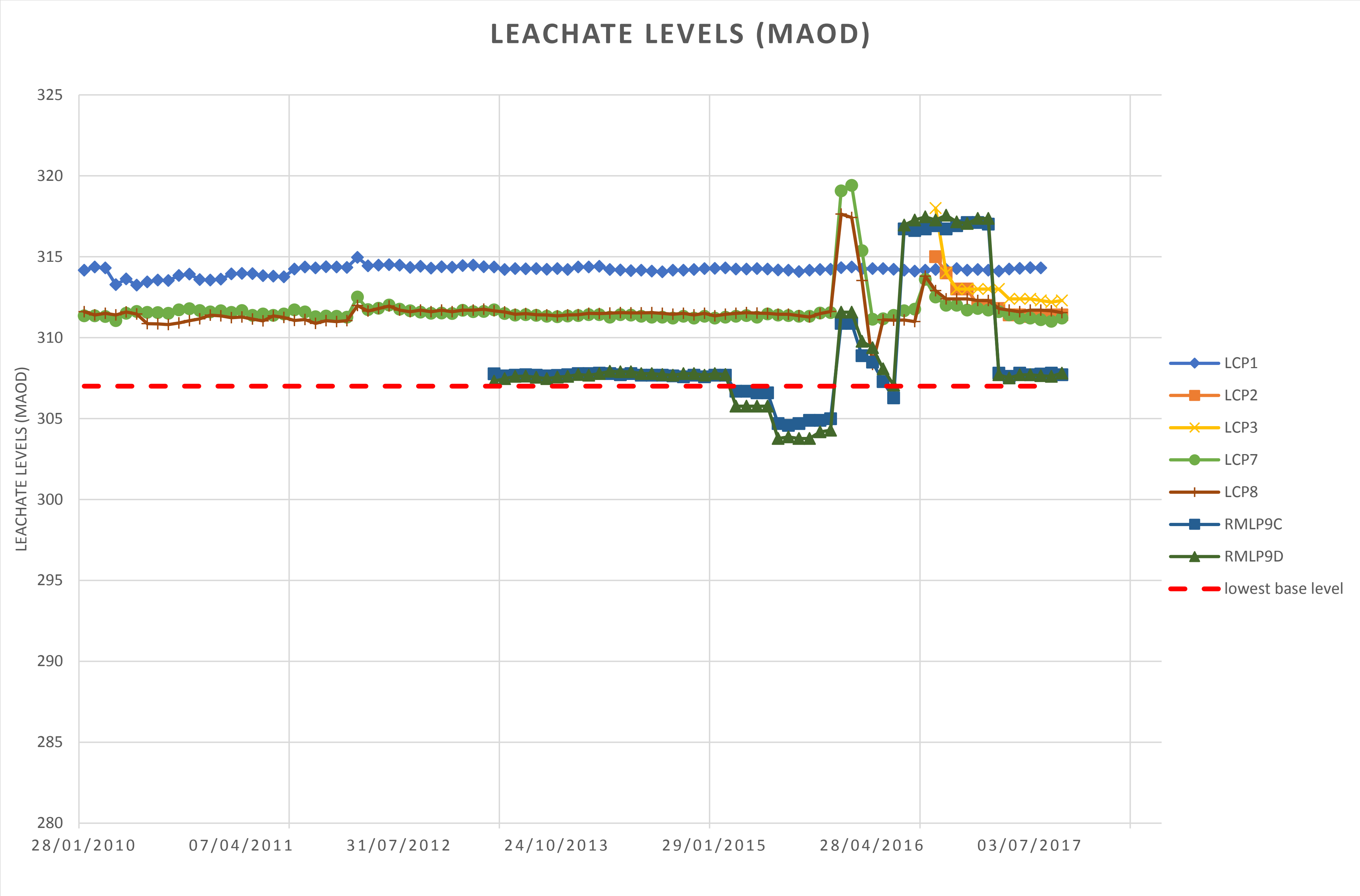
Caulmert
Engineering, Environmental and Planning

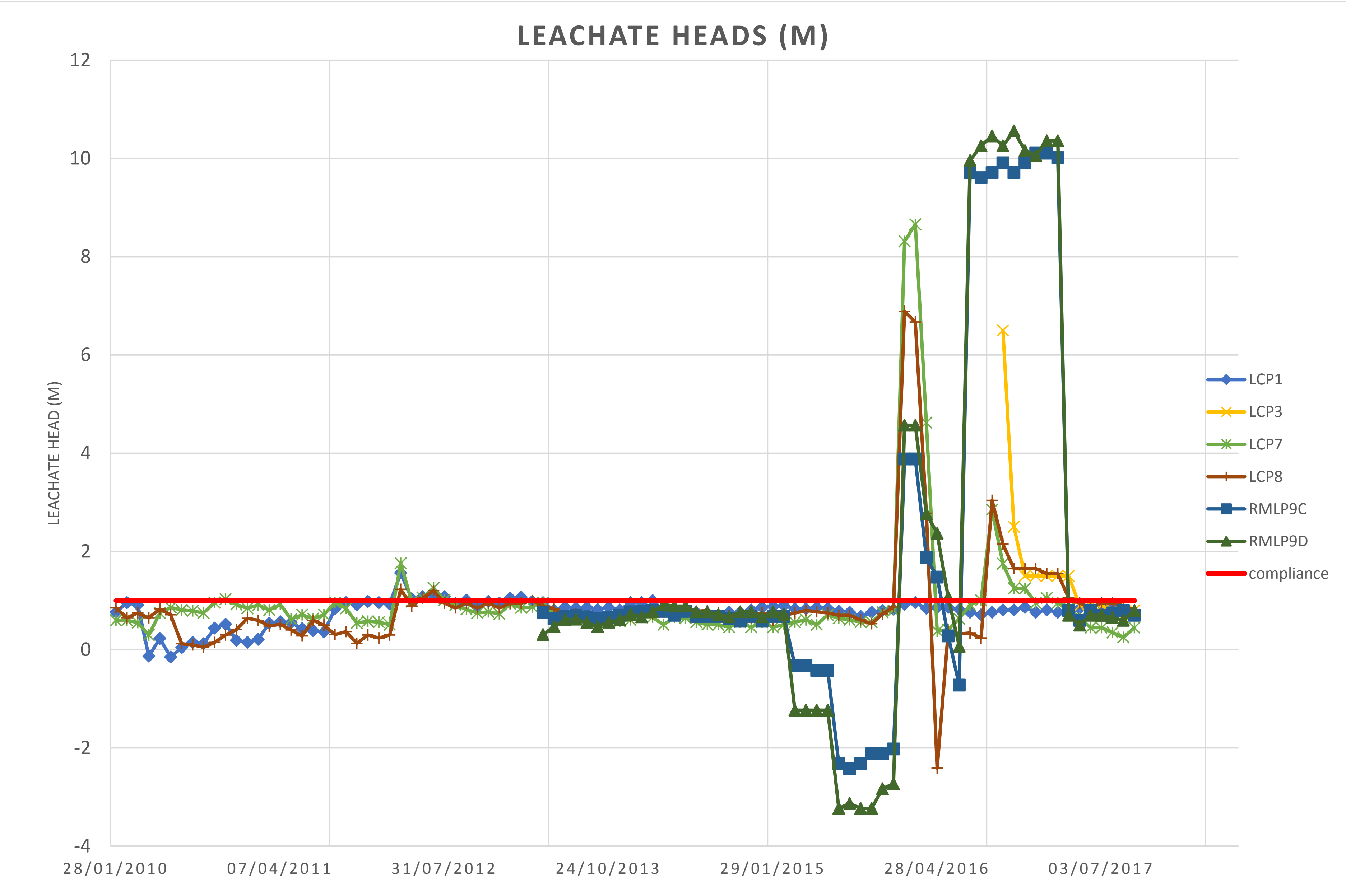
APPENDIX 1

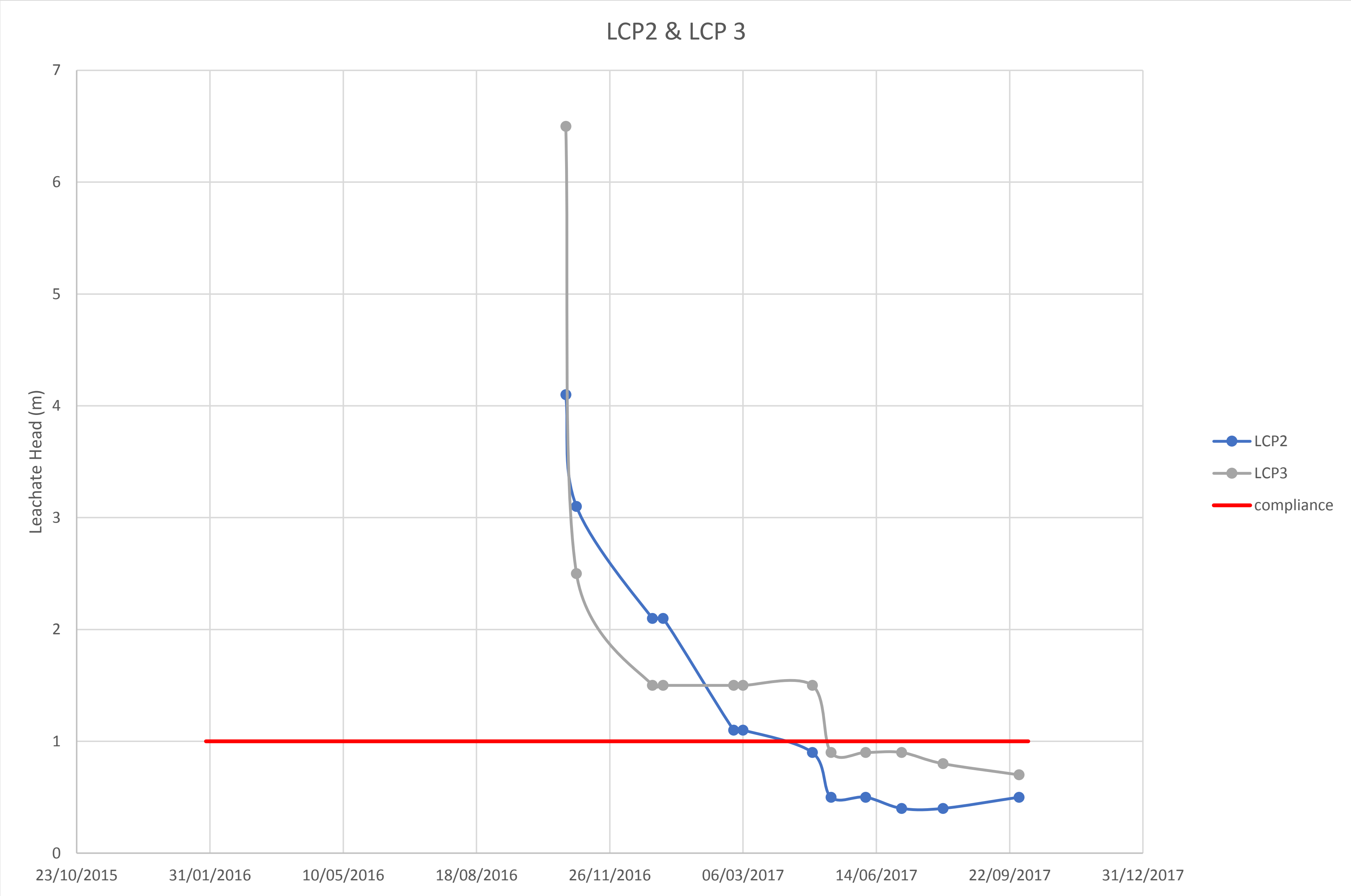
Leachate Levels time series charts

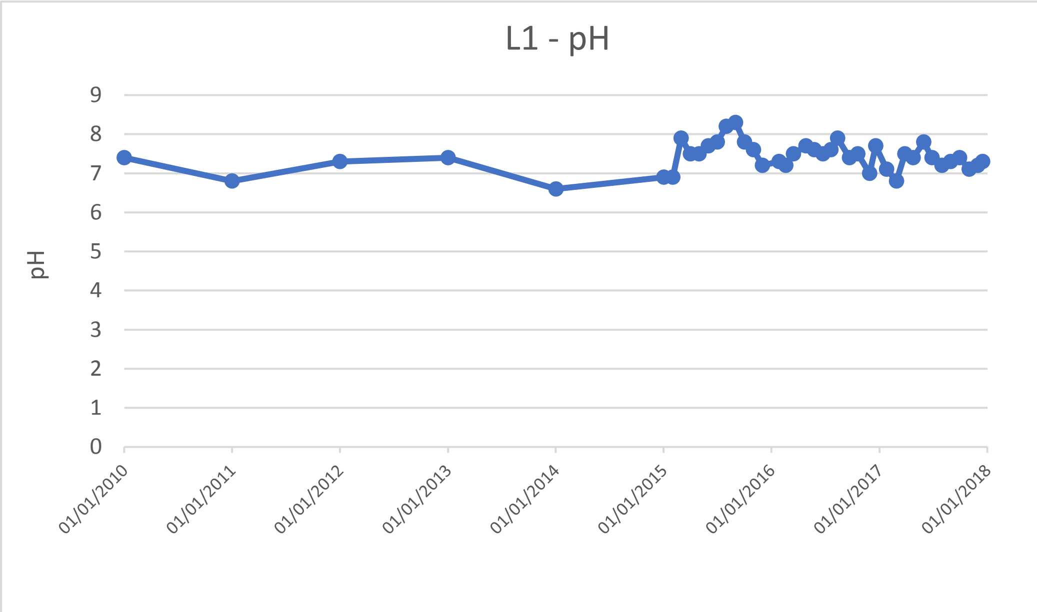
Leachate quality time series charts

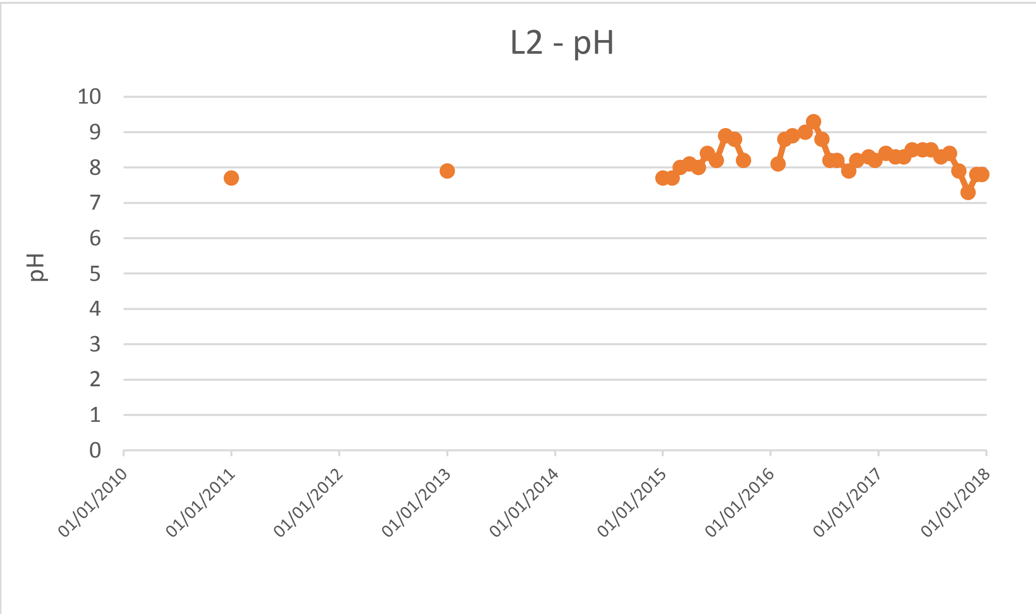
Database provide in electronic version.

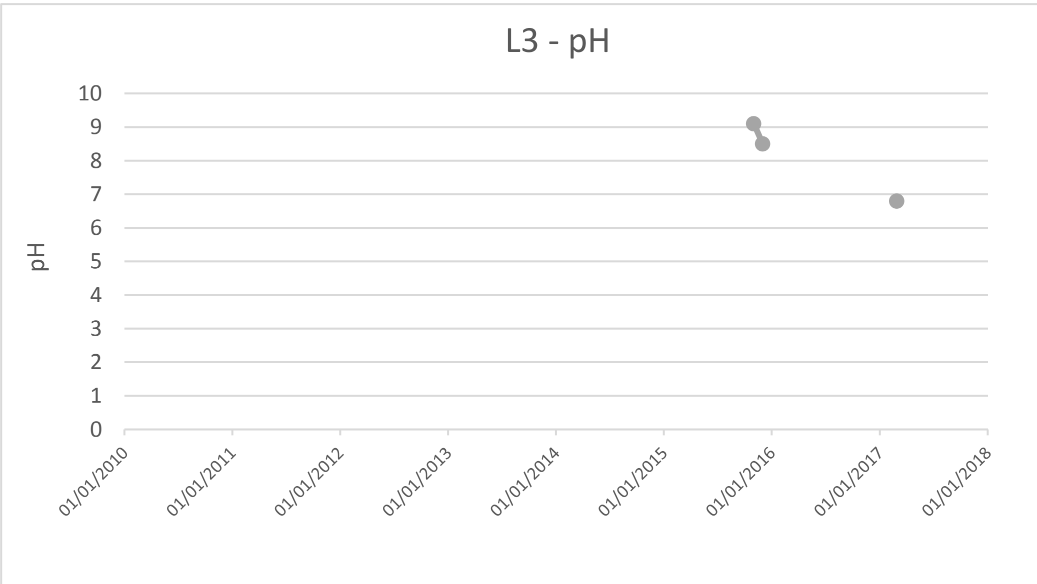

LEACHATE LEVELS (MAOD)
LEACHATE LEVELS (MAOD)
325
320
315
310
305
300
295
290
285
280
28/01/2010
07/04/2011
31/07/2012
24/10/2013
29/01/2015
28/04/2016
03/07/2017
LCP1
LCP2
LCP3
LCP7
LCP8
RMLP9C
RMLP9D
lowest base level

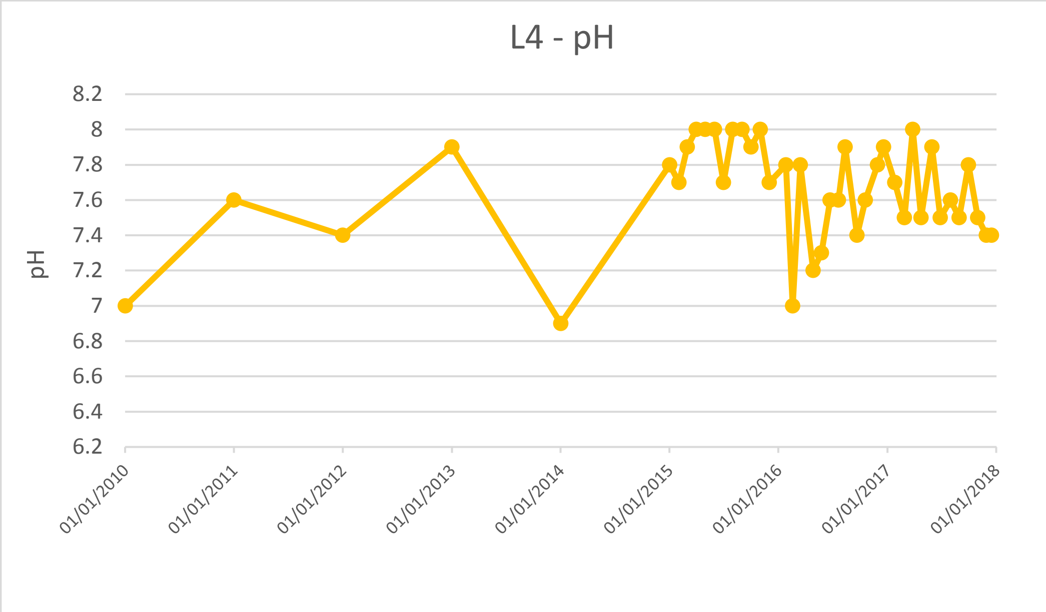

LEACHATE HEADS (M)
LEACHATE HEAD (M)
12
10
8
6
4
2
0
-2
-4
28/01/2010
07/04/2011
31/07/2012
24/10/2013
29/01/2015
28/04/2016
03/07/2017
LCP1
LCP3
LCP7
LCP8
RMLP9C
RMLP9D
compliance

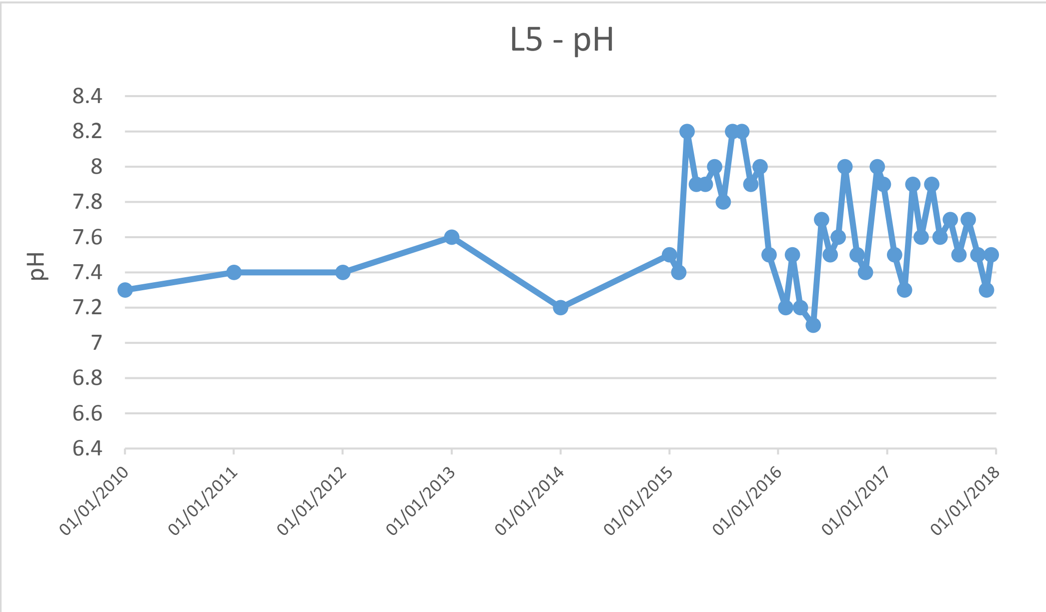

LCP2 & LCP 3
Leachate Head (m)
7
6
5
4
3
2
1
0
23/10/2015
31/01/2016
10/05/2016
18/08/2016
26/11/2016
06/03/2017
14/06/2017
22/09/2017
31/12/2017
LCP2
LCP3
compliance

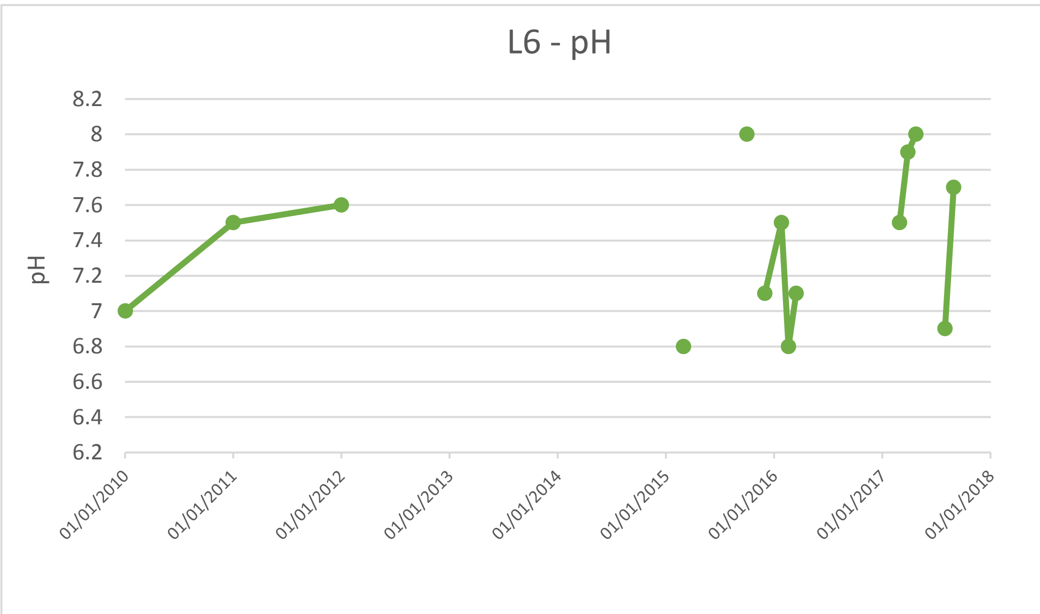

L1 - pH
pH
9
8
7
6
5
4
3
2
1
0
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018

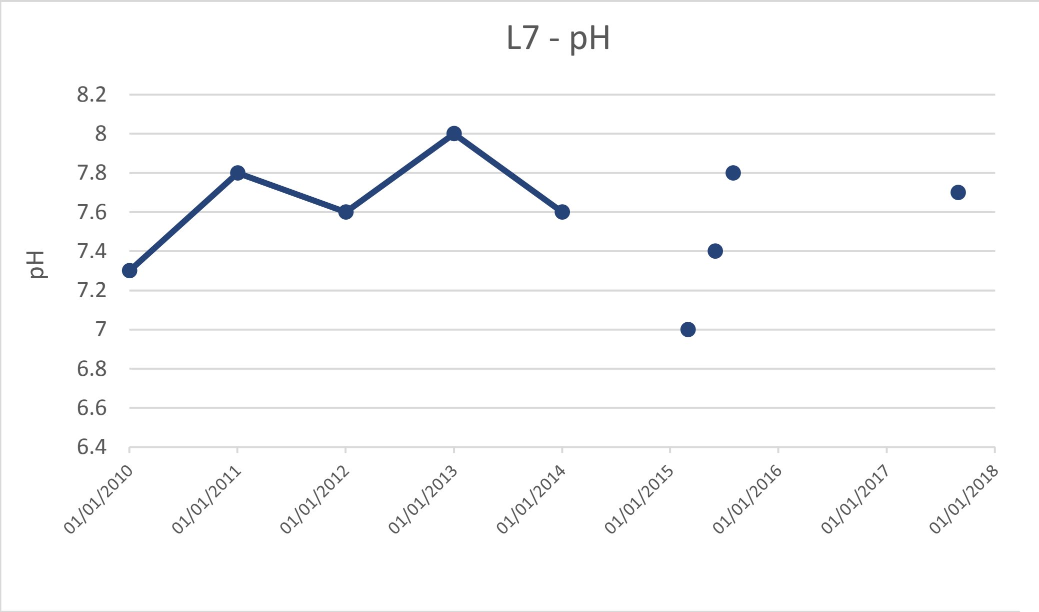

L2 - pH
pH
10
9
8
7
6
5
4
3
2
1
0
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018

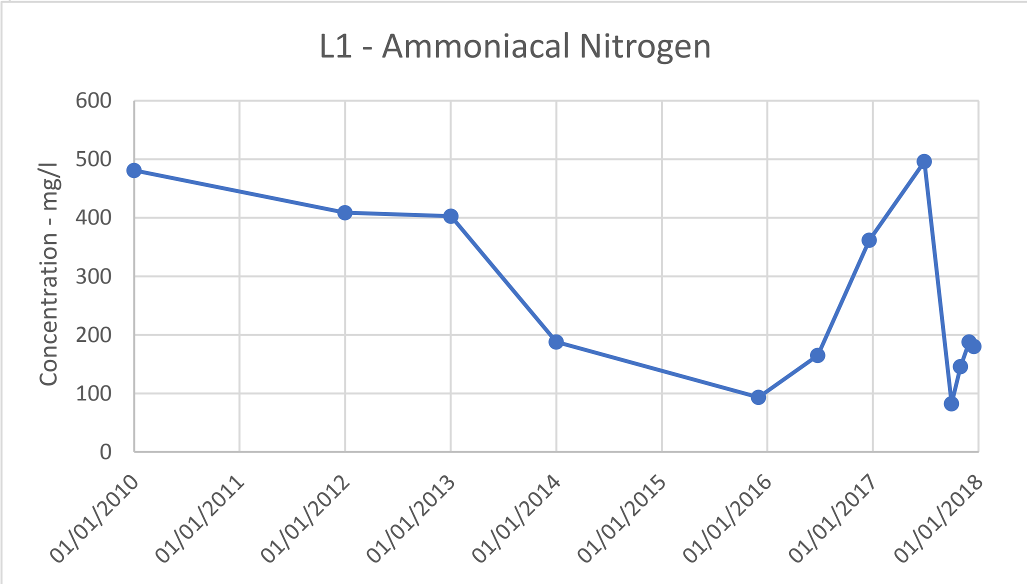

L3 - pH
pH
10
9
8
7
6
5
4
3
2
1
0
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018

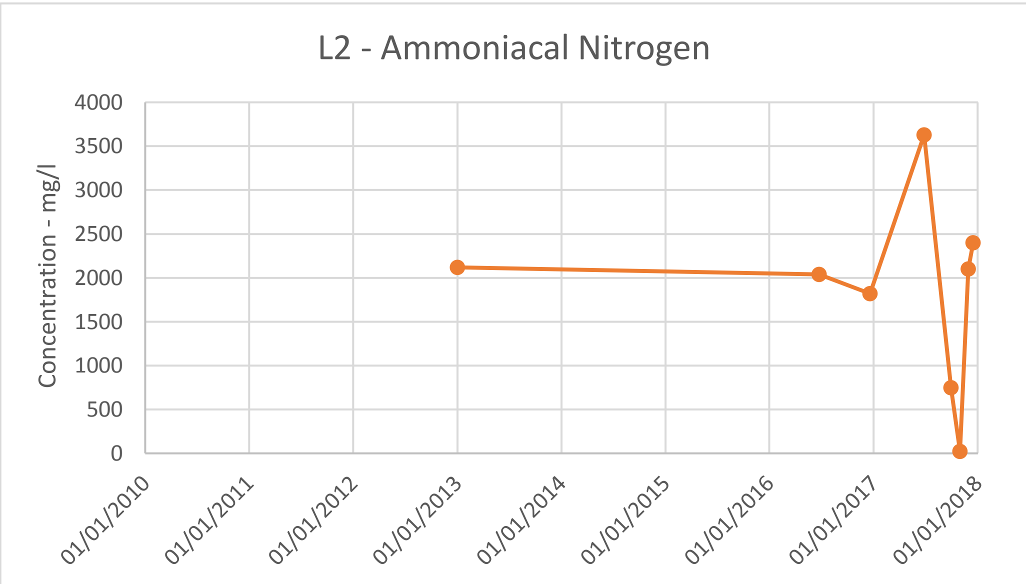

L4 - pH
pH
8.2
8
7.8
7.6
7.4
7.2
7
6.8
6.6
6.4
6.2
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018

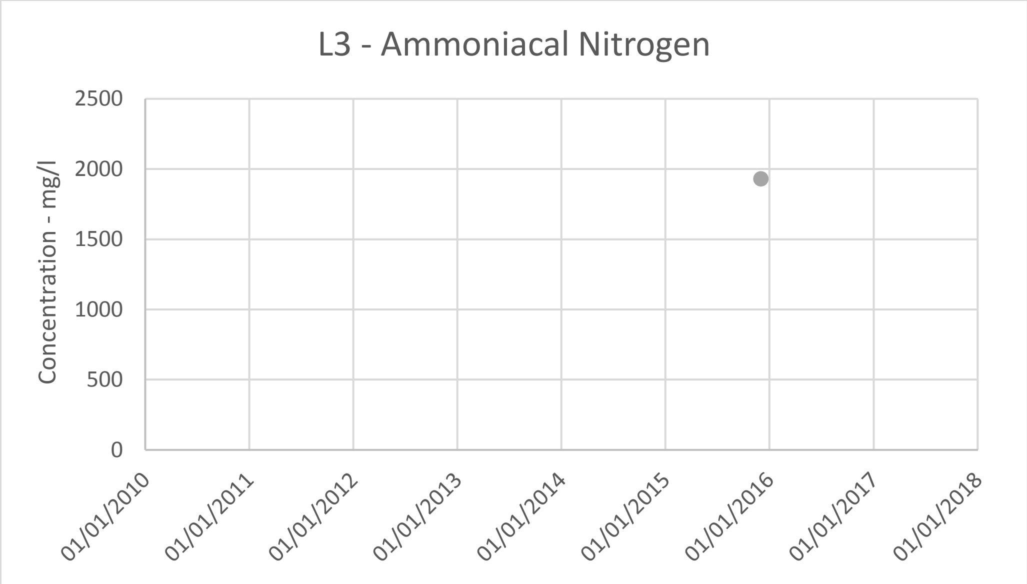

L5 - pH
pH
8.4
8.2
8
7.8
7.6
7.4
7.2
7
6.8
6.6
6.4
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018

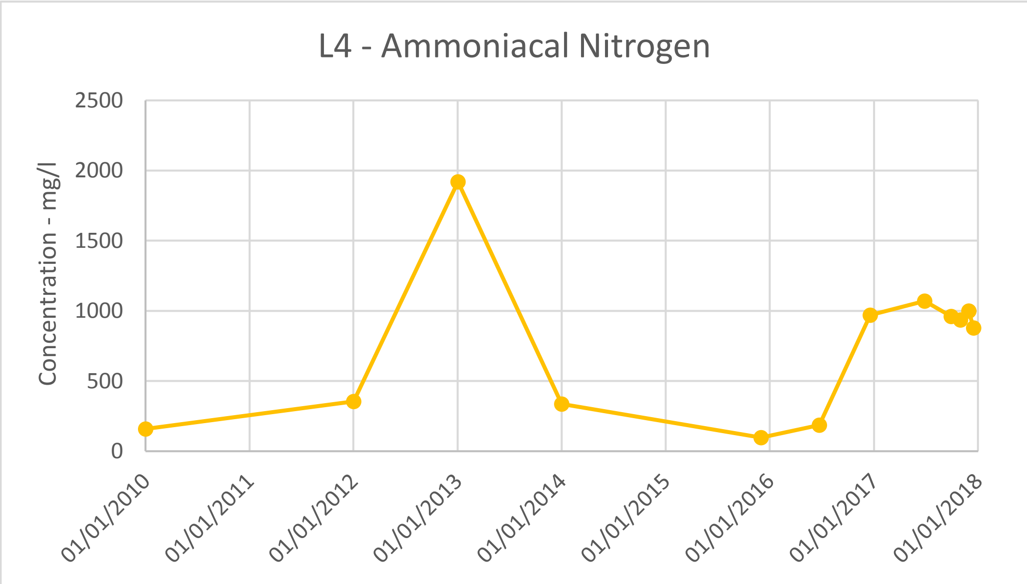

L6 - pH
pH
8.2
8
7.8
7.6
7.4
7.2
7
6.8
6.6
6.4
6.2
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018

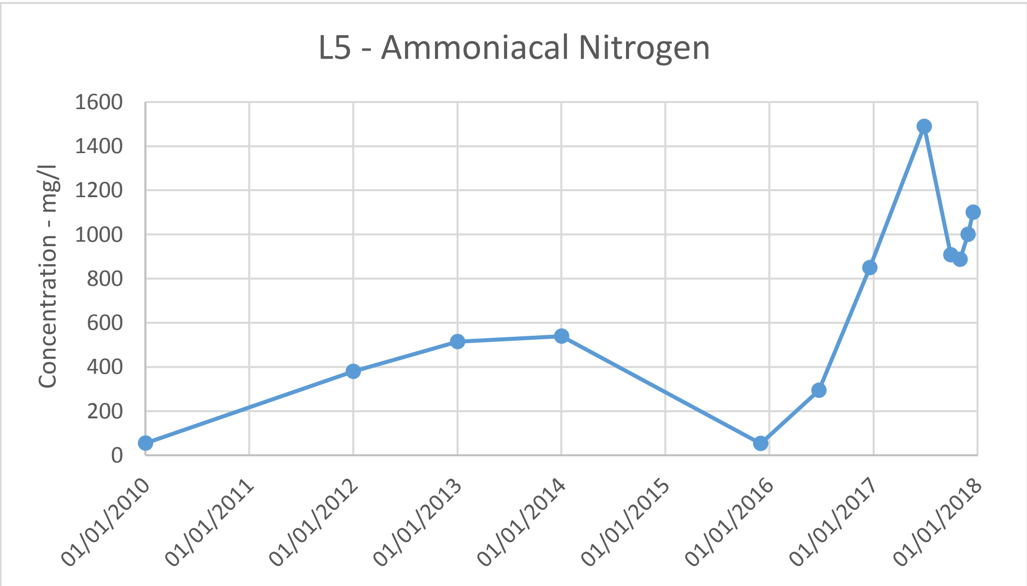

L7 - pH
pH
8.2
8
7.8
7.6
7.4
7.2
7
6.8
6.6
6.4
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018

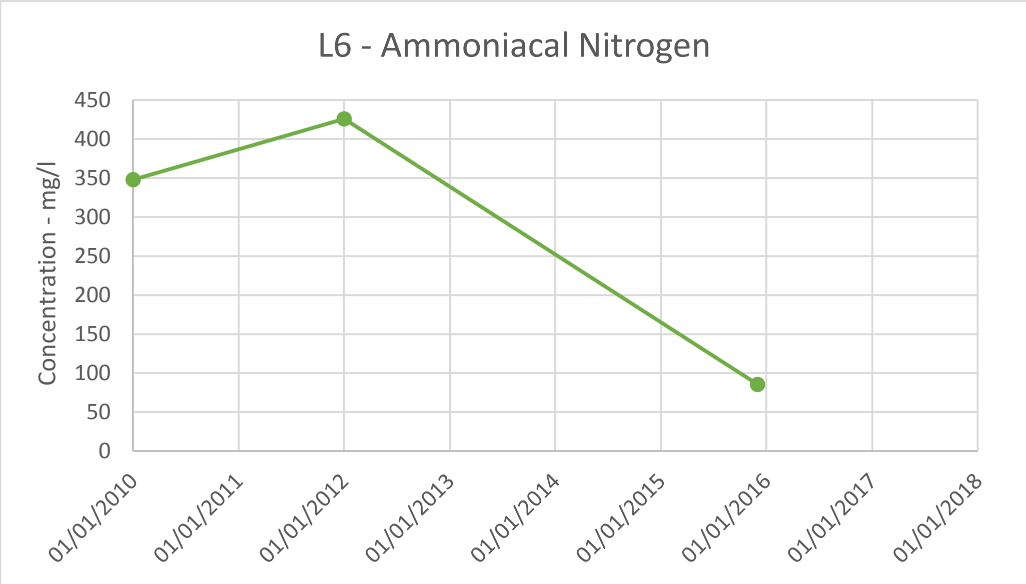

L1 - Ammoniacal Nitrogen
Concentration - mg/l
600
500
400
300
200
100
0
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018

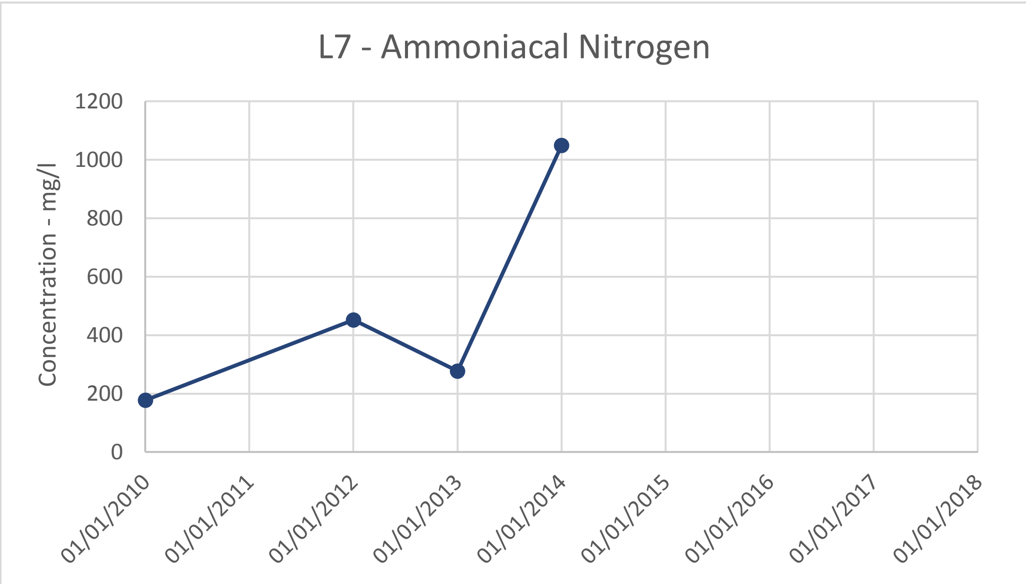

L2 - Ammoniacal Nitrogen
Concentration - mg/l
4000
3500
3000
2500
2000
1500
1000
500
0
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018

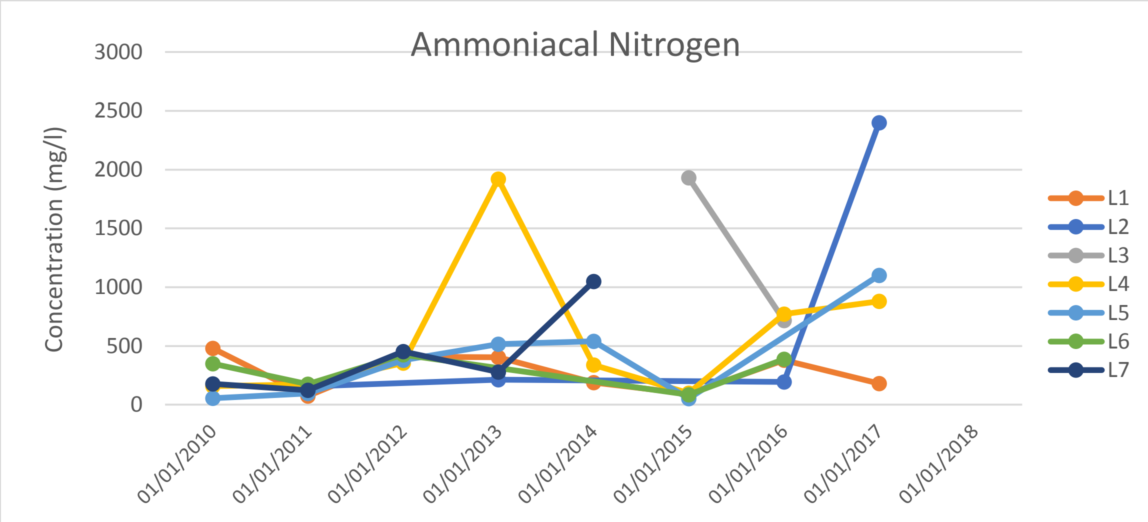

L3 - Ammoniacal Nitrogen
Concentration - mg/l
2500
2000
1500
1000
500
0
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018

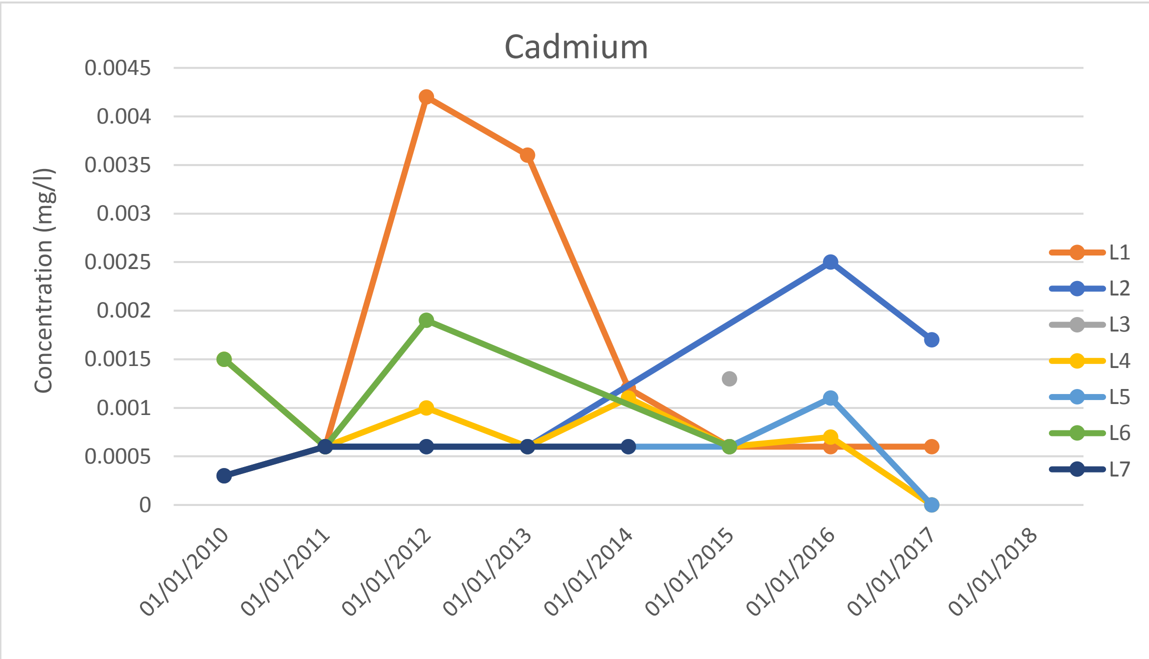

L4 - Ammoniacal Nitrogen
Concentration - mg/l
2500
2000
1500
1000
500
0
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018

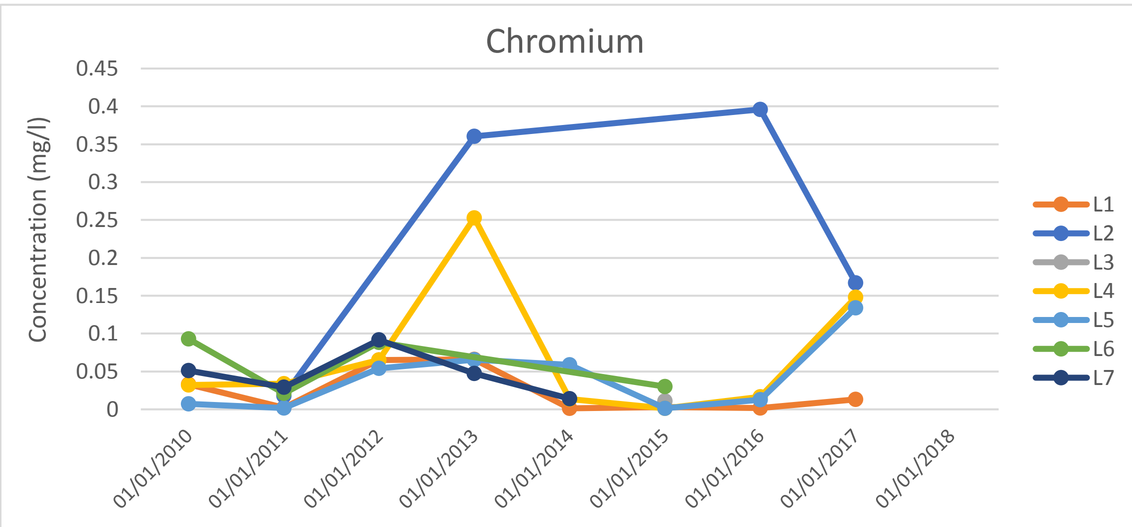

L5 - Ammoniacal Nitrogen
Concentration - mg/l
1600
1400
1200
1000
800
600
400
200
0
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018

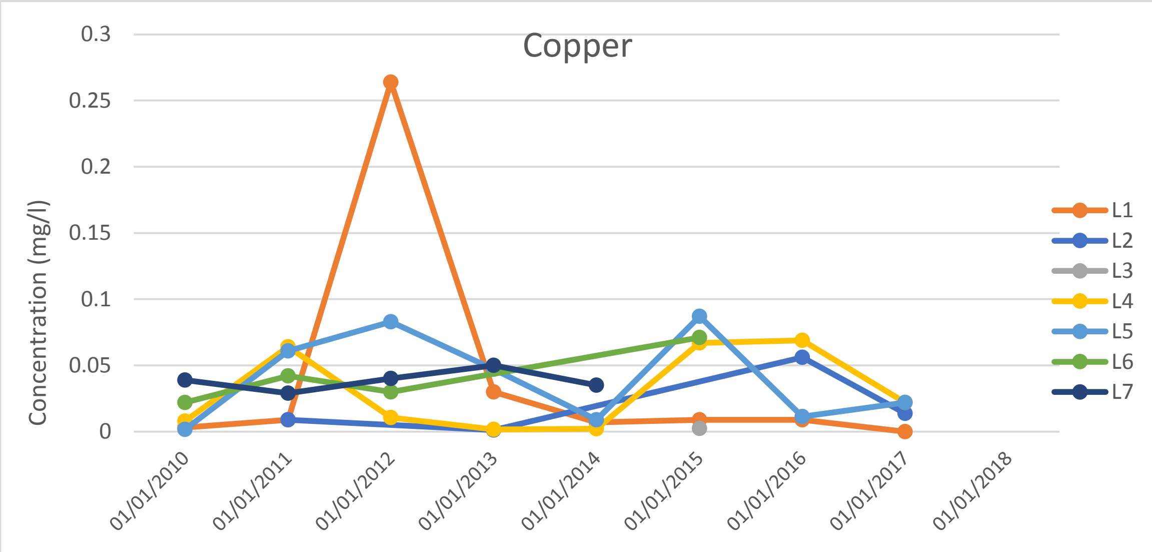

L6 - Ammoniacal Nitrogen
Concentration - mg/l
450
400
350
300
250
200
150
100
50
0
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018

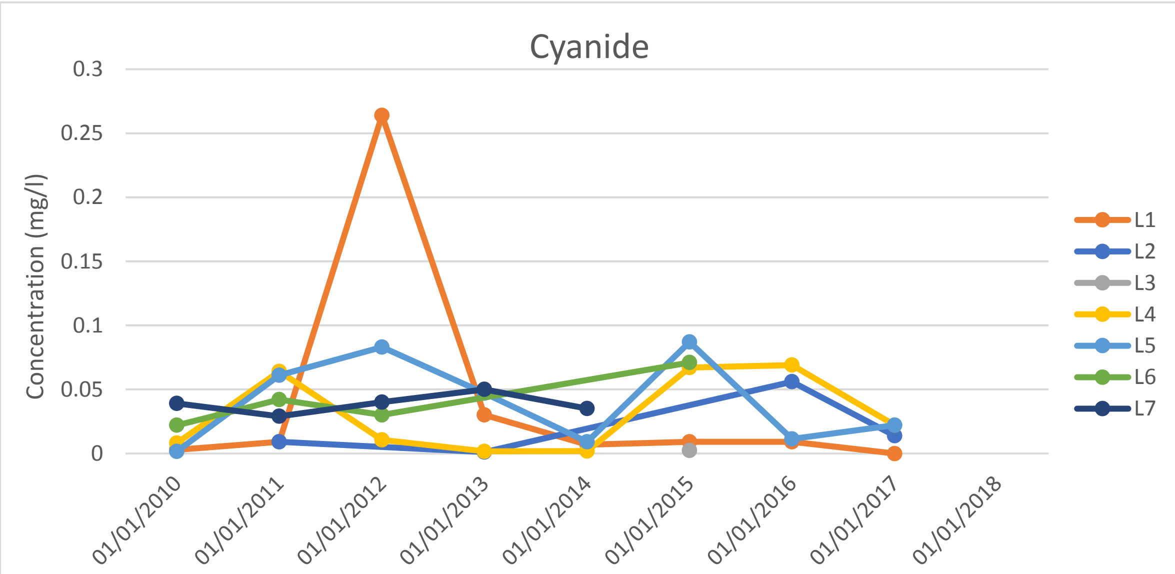

L7 - Ammoniacal Nitrogen
Concentration - mg/l
1200
1000
800
600
400
200
0
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018

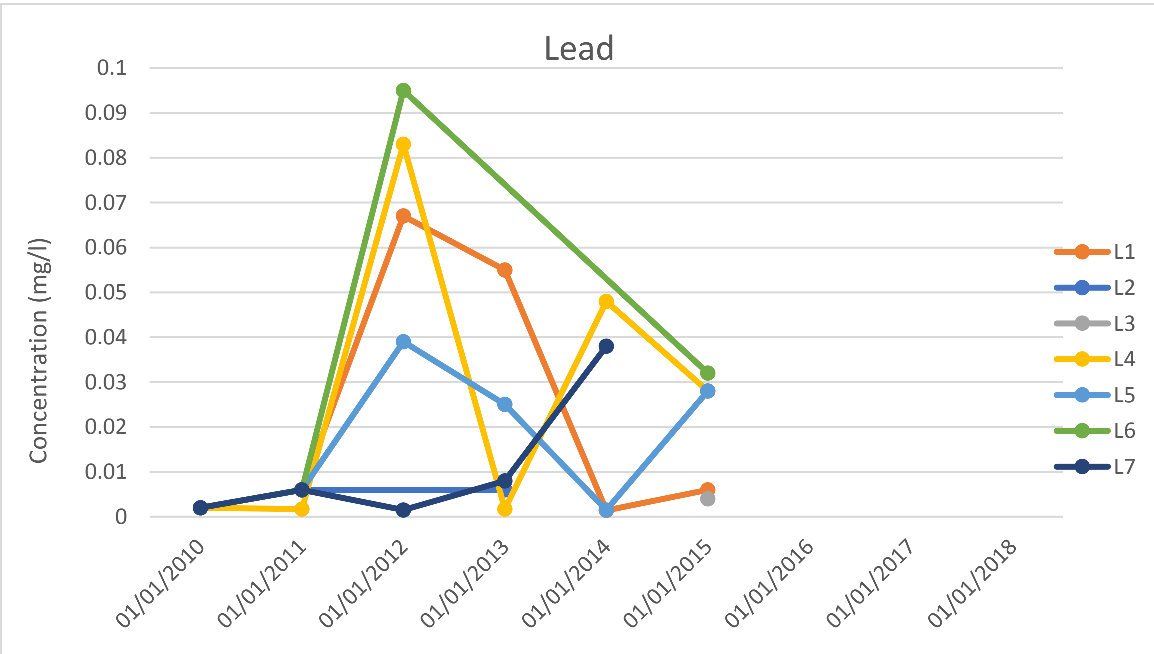

Ammoniacal Nitrogen
Concentration (mg/l)
3000
2500
2000
1500
1000
500
0
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018
L1
L2
L3
L4
L5
L6
L7

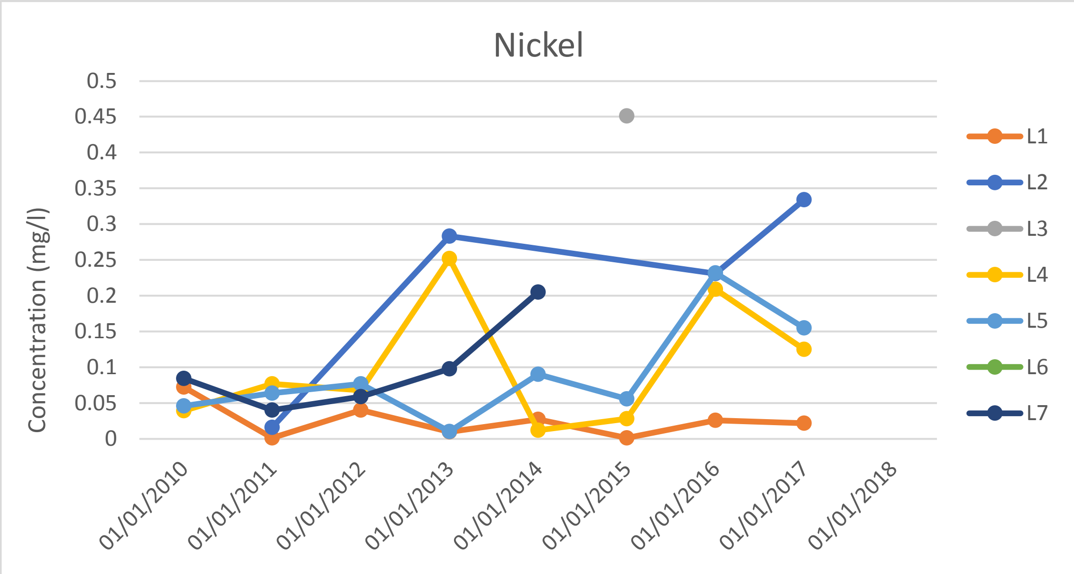

Cadmium
Concentration (mg/l)
0.0045
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018
L1
L2
L3
L4
L5
L6
L7

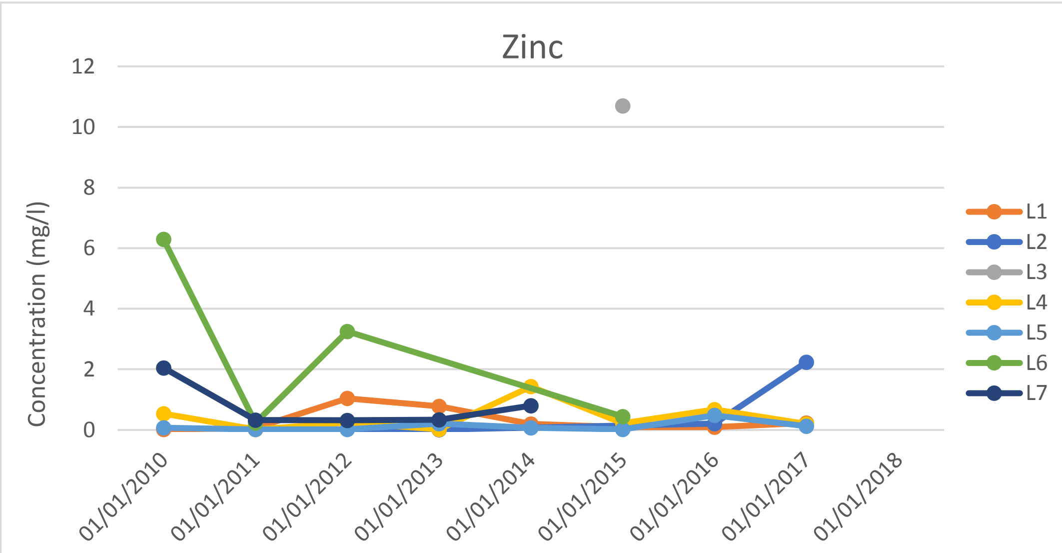

Chromium
Concentration (mg/l)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018
L1
L2
L3
L4
L5
L6
L7


Copper
Concentration (mg/l)
0.3
0.25
0.2
0.15
0.1
0.05
0
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018
L1
L2
L3
L4
L5
L6
L7


Cyanide
Concentration (mg/l)
0.3
0.25
0.2
0.15
0.1
0.05
0
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018
L1
L2
L3
L4
L5
L6
L7


Lead
Concentration (mg/l)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018
L1
L2
L3
L4
L5
L6
L7


Nickel
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Concentration (mg/l)
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018
L1
L2
L3
L4
L5
L6
L7

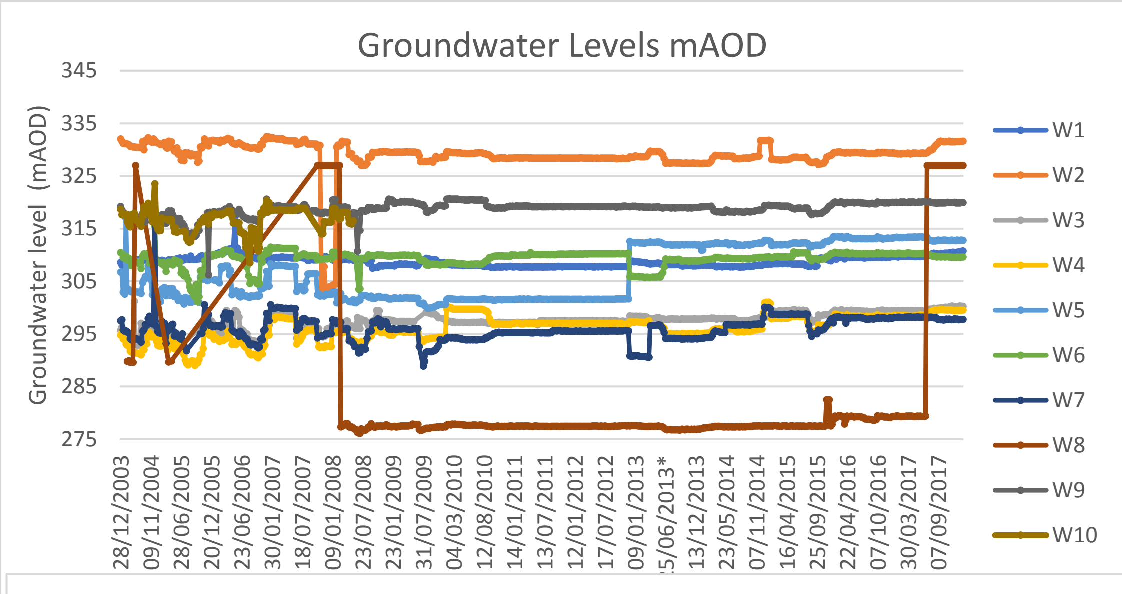

Zinc
12
10
8
6
4
2
0
Concentration (mg/l)
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018
L1
L2
L3
L4
L5
L6
L7

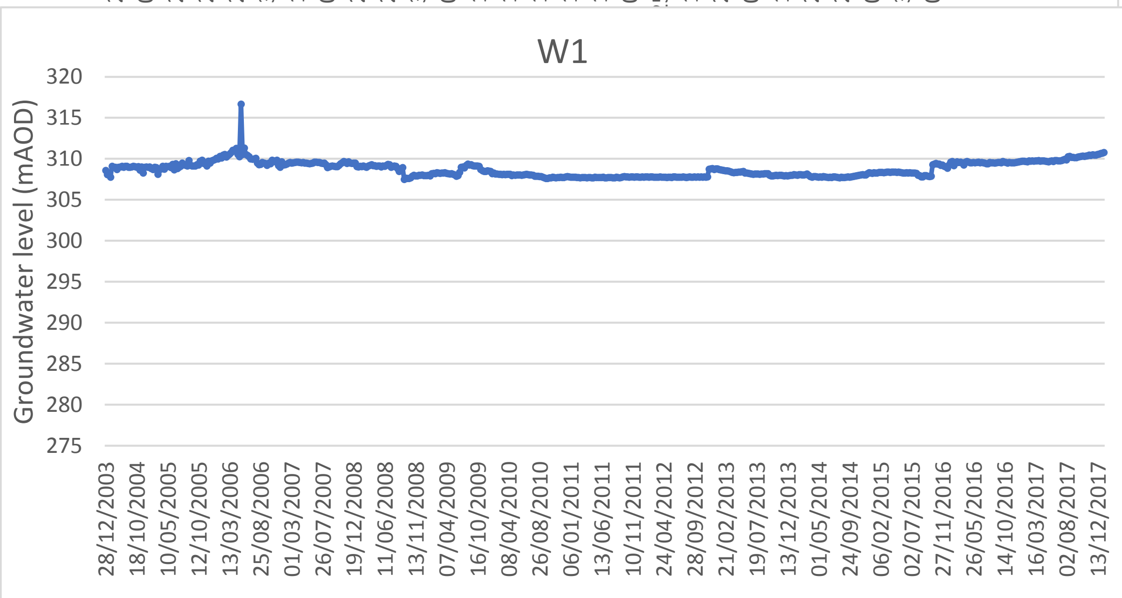
APPENDIX 2

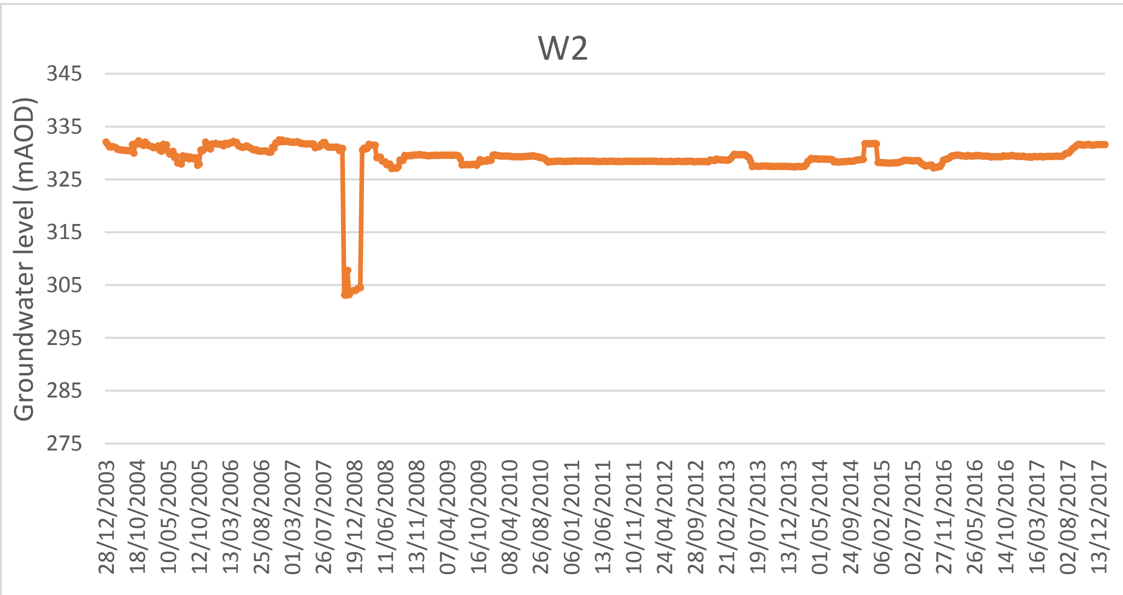
Groundwater levels – Time series charts

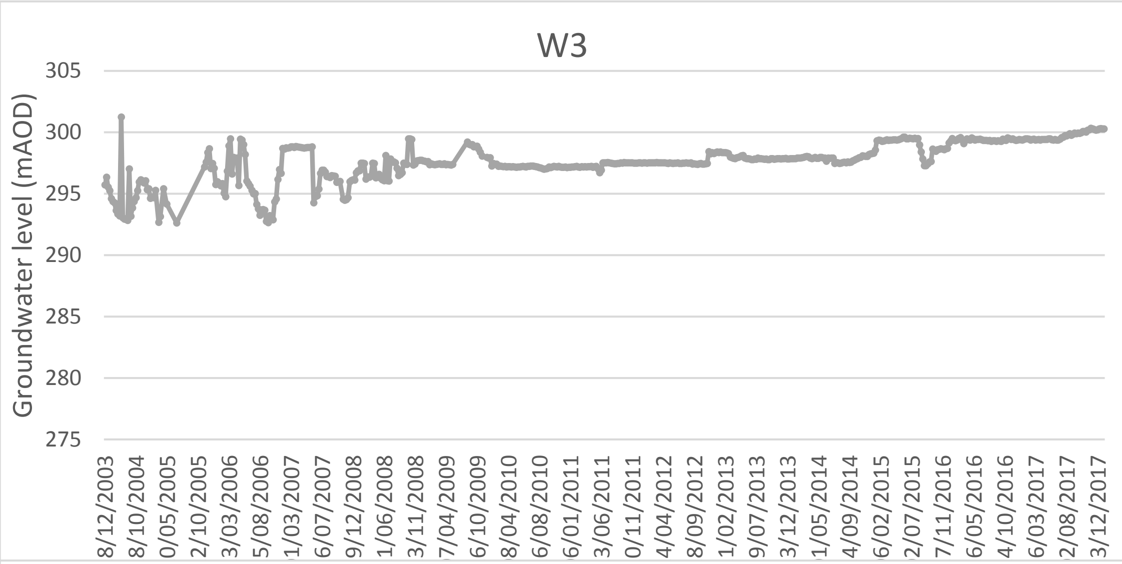
Groundwater quality – Time series charts

Database provided in electronic format.


Groundwater Levels mAOD
Groundwater level (mAOD)
345
335
325
315
305
295
285
275
28/12/2003
09/11/2004
28/06/2005
20/12/2005
23/06/2006
30/01/2007
18/07/2007
09/01/2008
23/07/2008
23/01/2009
31/07/2009
04/03/2010
12/08/2010
14/01/2011
13/07/2011
12/01/2012
17/07/2012
09/01/2013
13/12/2013
23/05/2014
07/11/2014
16/04/2015
25/09/2015
22/04/2016
07/10/2016
30/03/2017
07/09/2017
W1
W2
W3
W4
W5
W6
W7
W8
W9
W10


W1
Groundwater level (mAOD)
320
315
310
305
300
295
290
285
280
275
28/12/2003
18/10/2004
10/05/2005
12/10/2005
13/03/2006
25/08/2006
01/03/2007
26/07/2007
19/12/2008
11/06/2008
13/11/2008
07/04/2009
16/10/2009
08/04/2010
26/08/2010
06/01/2011
13/06/2011
10/11/2011
24/04/2012
28/09/2012
21/02/2013
19/07/2013
13/12/2013
01/05/2014
24/09/2014
06/02/2015
02/07/2015
27/11/2016
26/05/2016
14/10/2016
16/03/2017
02/08/2017
13/12/2017


W2
Groundwater level (mAOD)
345
335
325
315
305
295
285
275
28/12/2003
18/10/2004
10/05/2005
12/10/2005
13/03/2006
25/08/2006
01/03/2007
26/07/2007
19/12/2008
11/06/2008
13/11/2008
07/04/2009
16/10/2009
08/04/2010
26/08/2010
06/01/2011
13/06/2011
10/11/2011
24/04/2012
28/09/2012
21/02/2013
19/07/2013
13/12/2013
01/05/2014
24/09/2014
06/02/2015
02/07/2015
27/11/2016
26/05/2016
14/10/2016
16/03/2017
02/08/2017
13/12/2017


W3
Groundwater level (mAOD)
305
300
295
290
285
280
275
8/12/2003
8/10/2004
0/05/2005
2/10/2005
3/03/2006
5/08/2006
1/03/2007
6/07/2007
9/12/2008
1/06/2008
3/11/2008
7/04/2009
6/10/2009
8/04/2010
6/08/2010
6/01/2011
3/06/2011
0/11/2011
4/04/2012
8/09/2012
1/02/2013
9/07/2013
3/12/2013
1/05/2014
4/09/2014
6/02/2015
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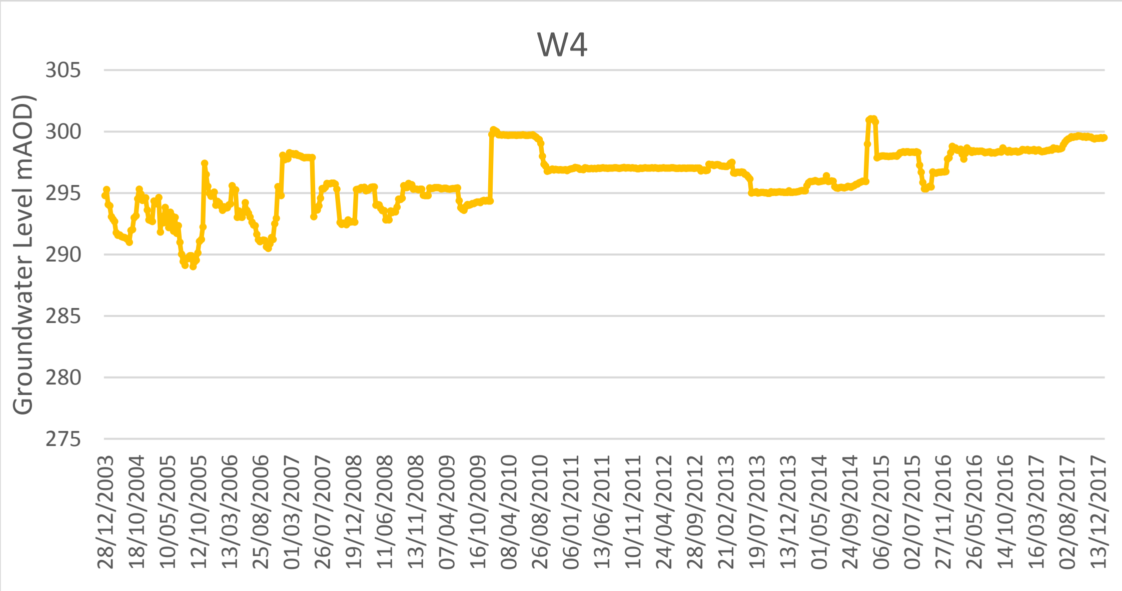
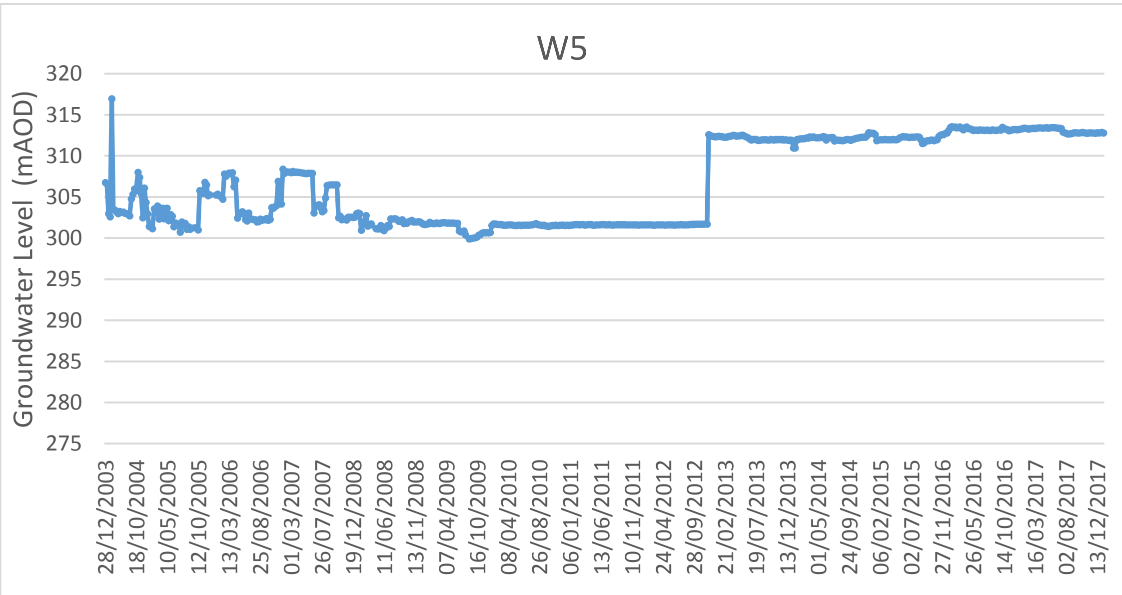
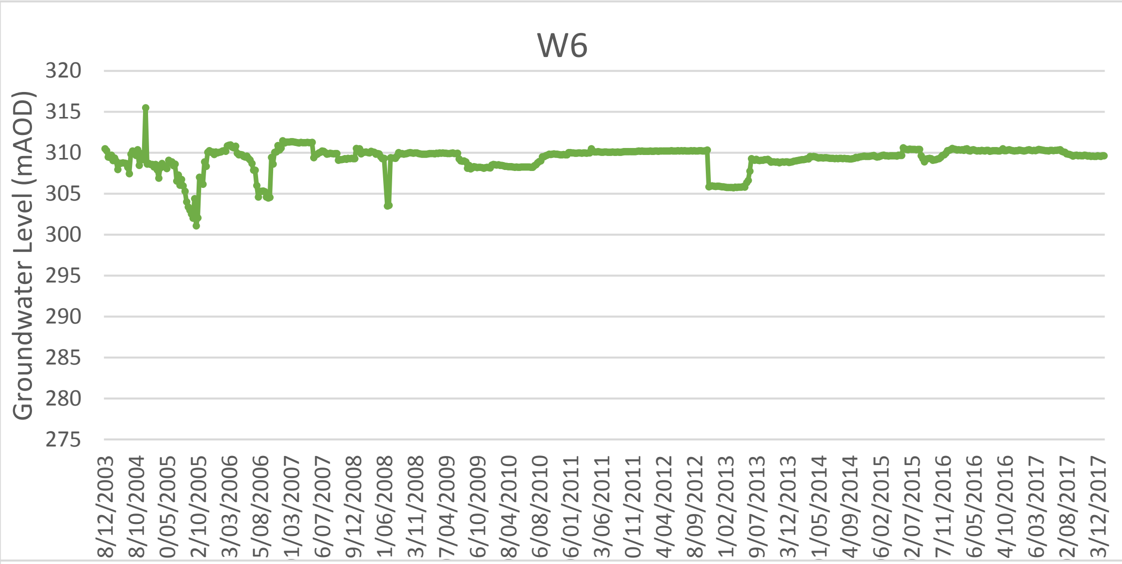
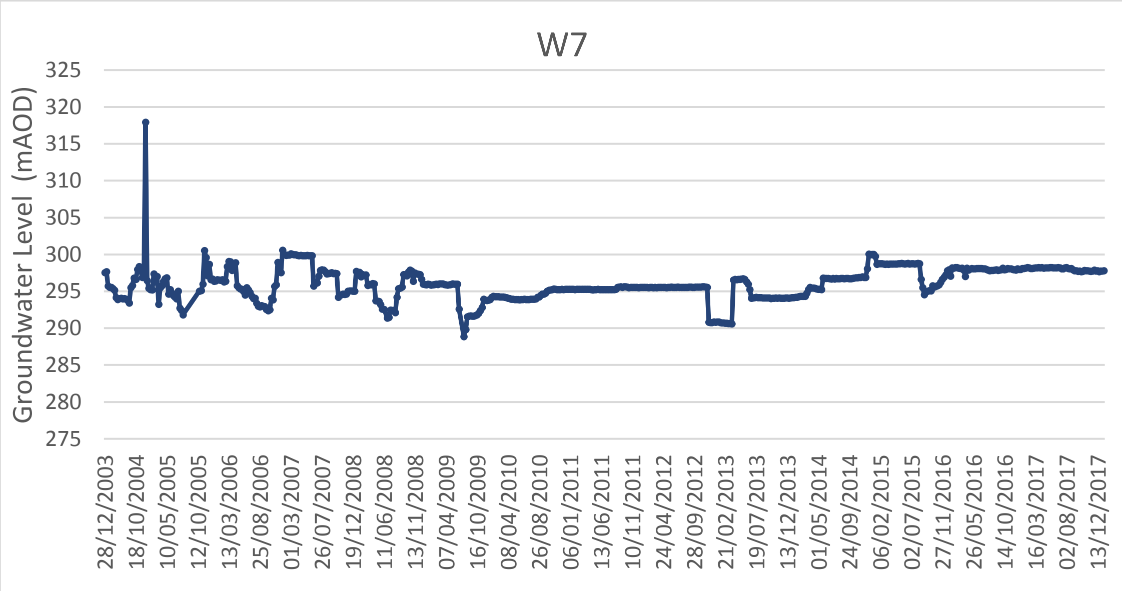
7/11/2016
6/05/2016
4/10/2016
6/03/2017
2/08/2017
3/12/2017


W4
Groundwater Level mAOD)
305
300
295
290
285
280
275
28/12/2003
18/10/2004
10/05/2005
12/10/2005
13/03/2006
25/08/2006
01/03/2007
26/07/2007
19/12/2008
11/06/2008
13/11/2008
07/04/2009
16/10/2009
08/04/2010
26/08/2010
06/01/2011
13/06/2011
10/11/2011
24/04/2012
28/09/2012
21/02/2013
19/07/2013
13/12/2013
01/05/2014
24/09/2014
06/02/2015
02/07/2015
27/11/2016
26/05/2016
14/10/2016
16/03/2017
02/08/2017
13/12/2017


W5
Groundwater Level (mAOD)
320
315
310
305
300
295
290
285
280
275
28/12/2003
18/10/2004
10/05/2005
12/10/2005
13/03/2006
25/08/2006
01/03/2007
26/07/2007
19/12/2008
11/06/2008
13/11/2008
07/04/2009
16/10/2009
08/04/2010
26/08/2010
06/01/2011
13/06/2011
10/11/2011
24/04/2012
28/09/2012
21/02/2013
19/07/2013
13/12/2013
01/05/2014
24/09/2014
06/02/2015
02/07/2015
27/11/2016
26/05/2016
14/10/2016
16/03/2017
02/08/2017
13/12/2017


W6
Groundwater Level (mAOD)
320
315
310
305
300
295
290
285
280
275
8/12/2003
8/10/2004
0/05/2005
2/10/2005
3/03/2006
5/08/2006
1/03/2007
6/07/2007
9/12/2008
1/06/2008
3/11/2008
7/04/2009
6/10/2009
8/04/2010
6/08/2010
6/01/2011
3/06/2011
0/11/2011
4/04/2012
8/09/2012
1/02/2013
9/07/2013
3/12/2013
1/05/2014
4/09/2014
6/02/2015
2/07/2015
7/11/2016
6/05/2016
4/10/2016
6/03/2017
2/08/2017
3/12/2017


W7
Groundwater Level (mAOD)
325
320
315
310
305
300
295
290
285
280
275
28/12/2003
18/10/2004
10/05/2005
12/10/2005
13/03/2006
25/08/2006
01/03/2007
26/07/2007
19/12/2008
11/06/2008
13/11/2008
07/04/2009
16/10/2009
08/04/2010
26/08/2010
06/01/2011
13/06/2011
10/11/2011
24/04/2012
28/09/2012
21/02/2013
19/07/2013
13/12/2013
01/05/2014
24/09/2014
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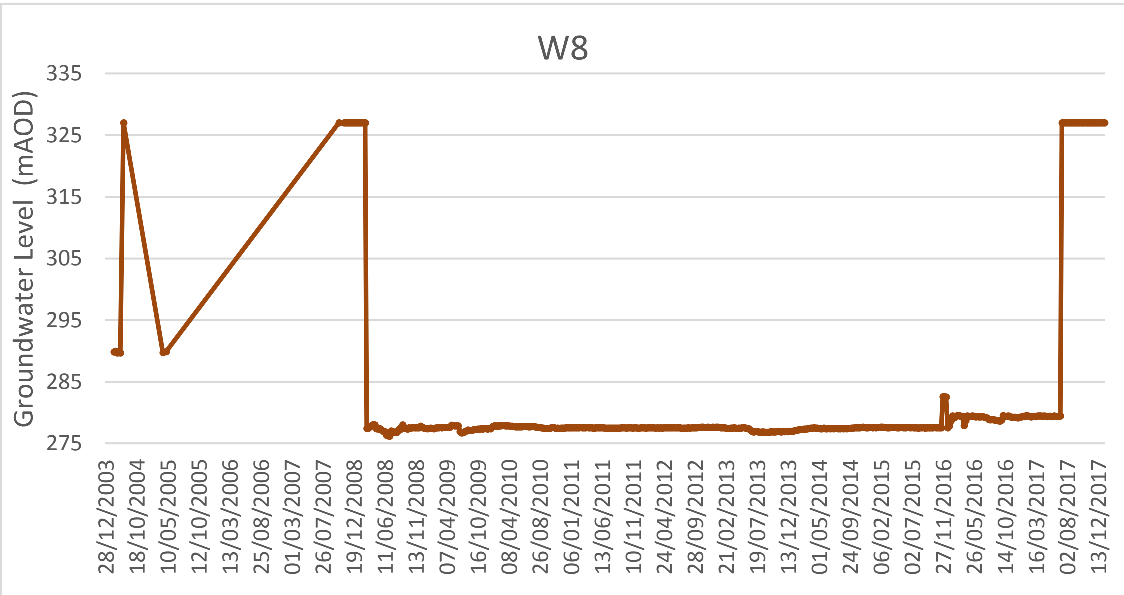
02/07/2015
27/11/2016
26/05/2016
14/10/2016
16/03/2017
02/08/2017
13/12/2017


W8
Groundwater Level (mAOD)
335
325
315
305
295
285
275
28/12/2003
18/10/2004
10/05/2005
12/10/2005
13/03/2006
25/08/2006
01/03/2007
26/07/2007
19/12/2008
11/06/2008
13/11/2008
07/04/2009
16/10/2009
08/04/2010
26/08/2010
06/01/2011
13/06/2011
10/11/2011
24/04/2012
28/09/2012
21/02/2013
19/07/2013
13/12/2013
01/05/2014
24/09/2014
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02/07/2015
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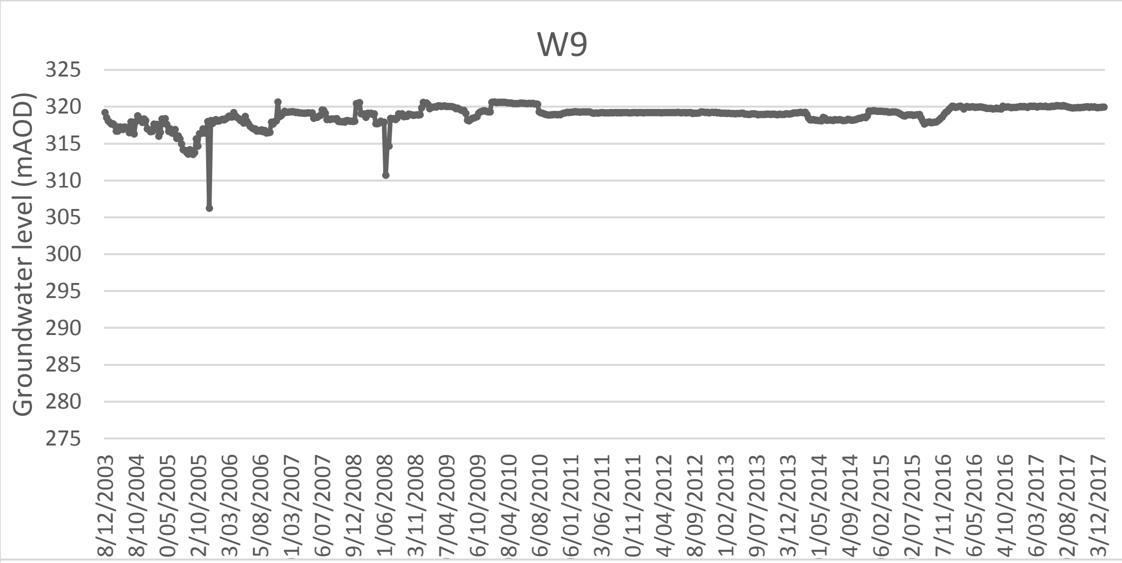
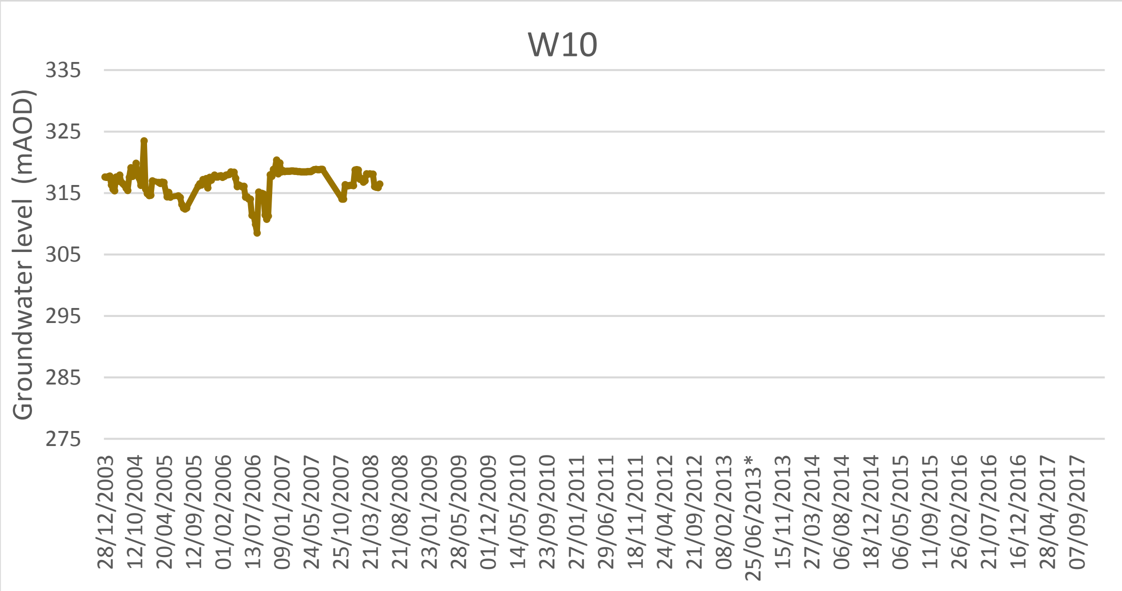
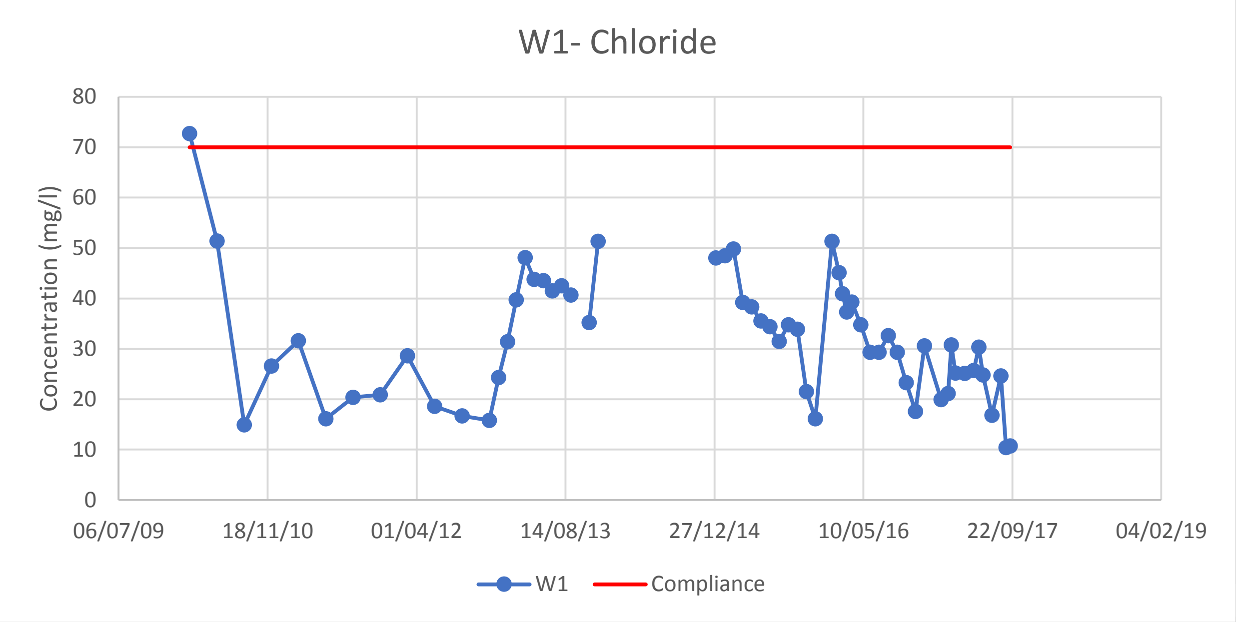
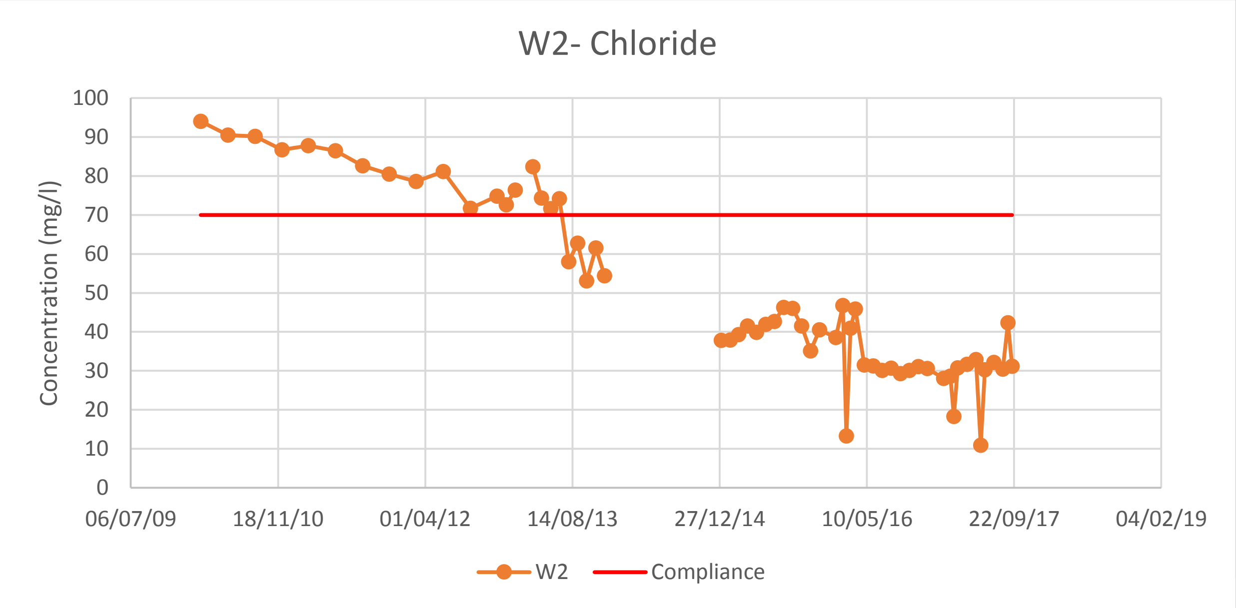
14/10/2016
16/03/2017
02/08/2017
13/12/2017

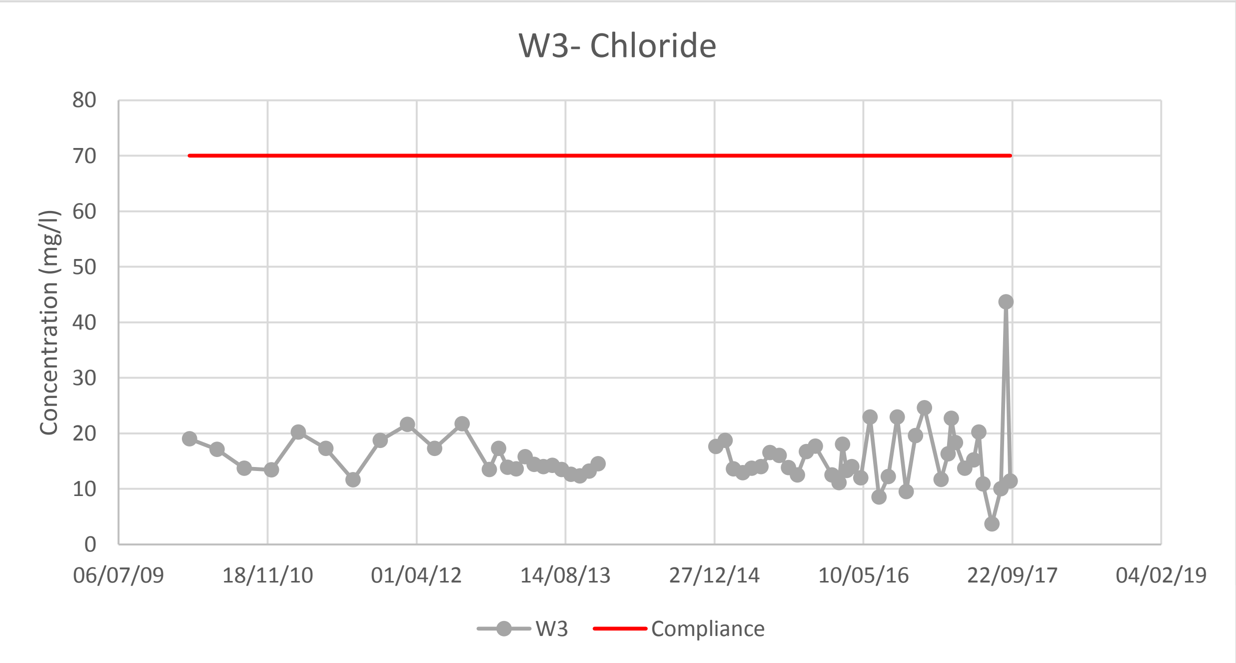


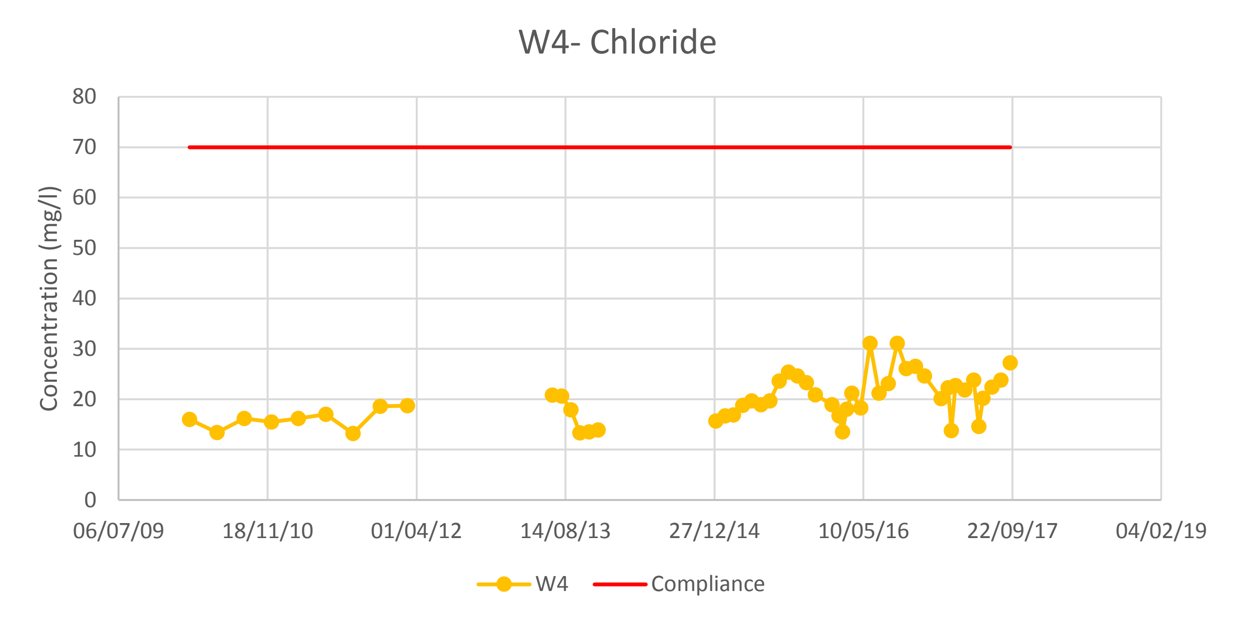


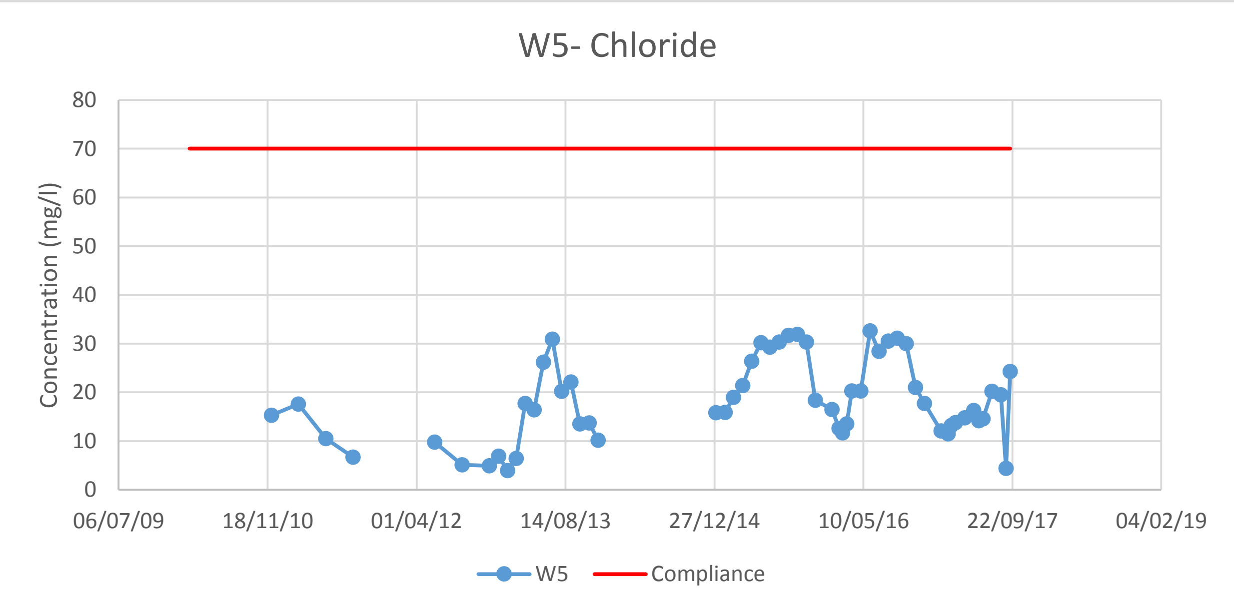
W11 - Reported as Dry

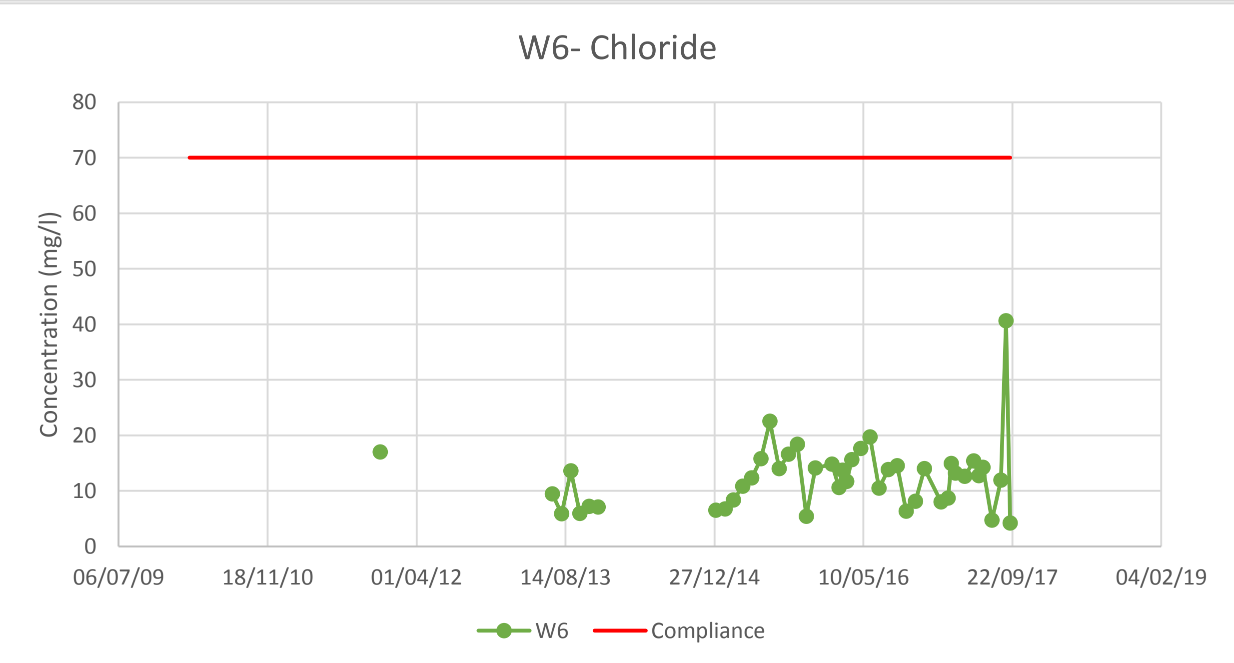

W1- Chloride
80
70
60
50
40
30
20
10
0
Concentration (mg/l)
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W1
Compliance

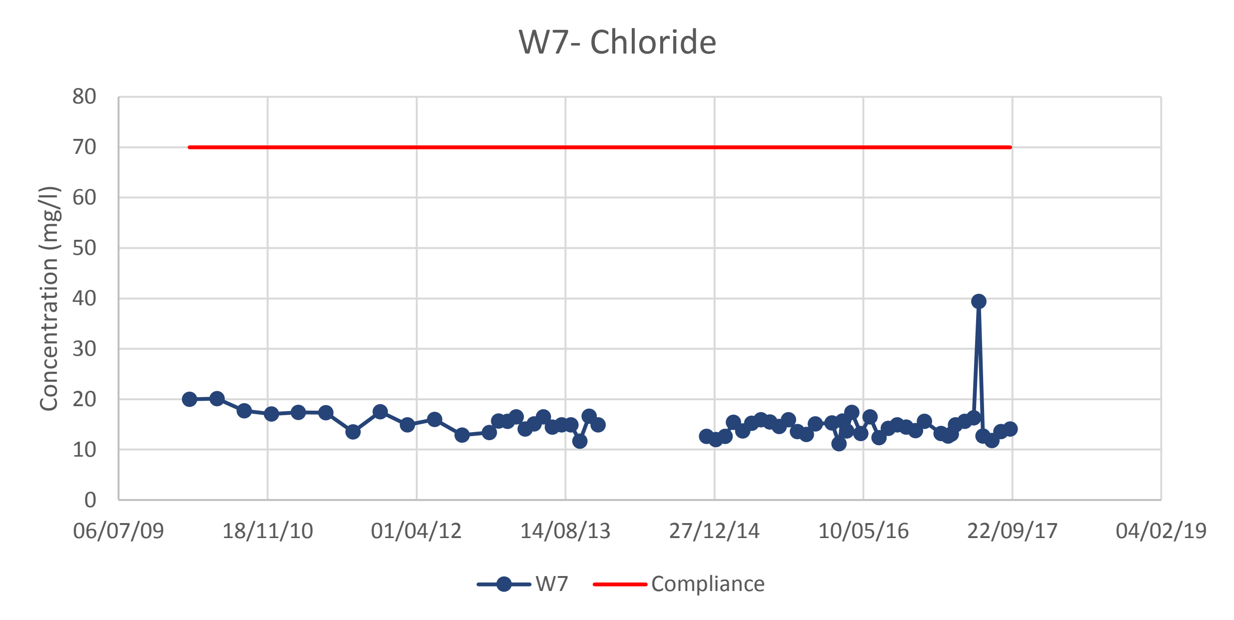

W2- Chloride
100
90
80
70
60
50
40
30
20
10
0
Concentration (mg/l)
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W2
Compliance

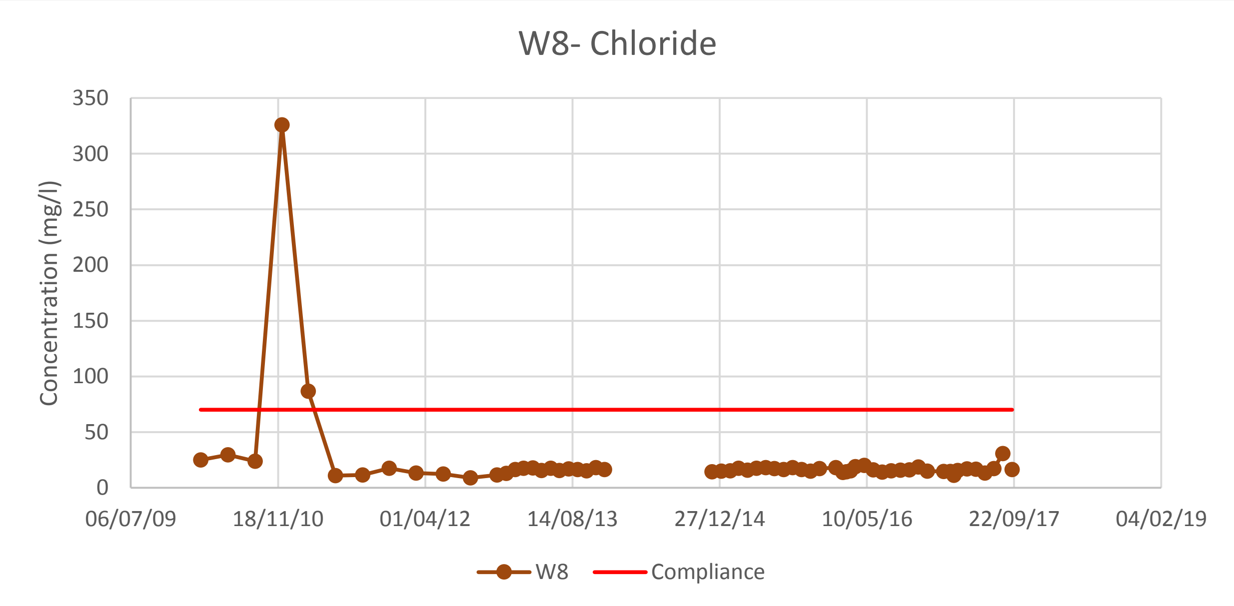

W3- Chloride
80
70
60
50
40
30
20
10
0
Concentration (mg/l)
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W3
Compliance

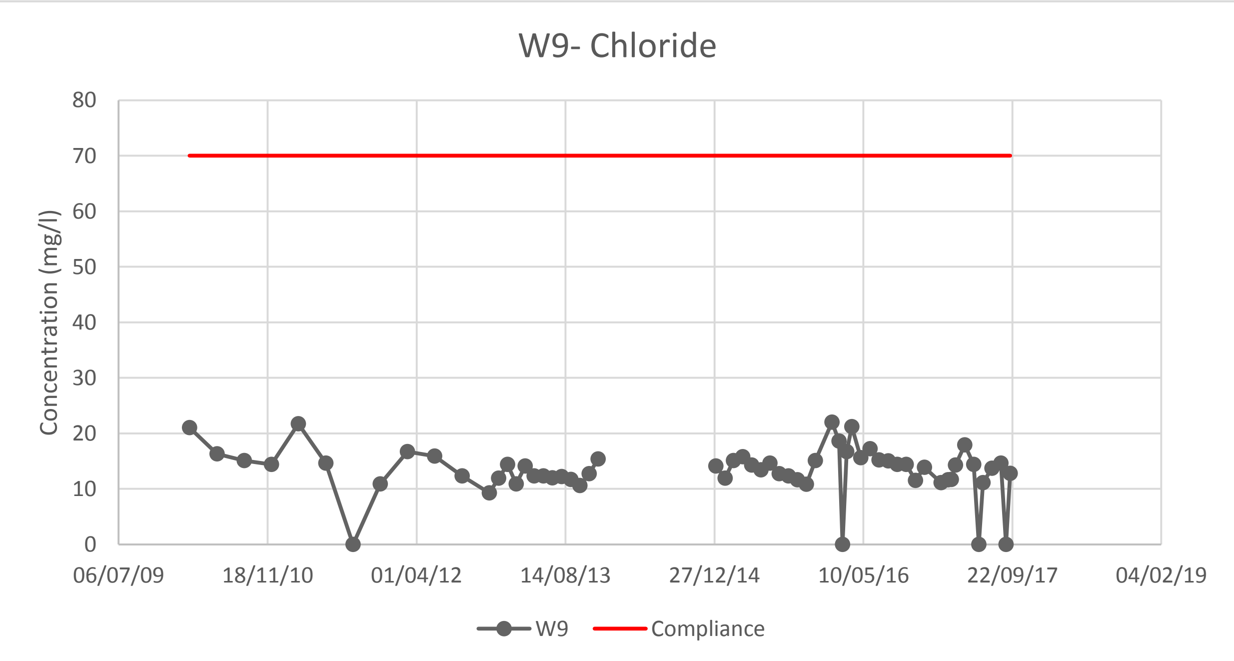

W4- Chloride
Concentration (mg/l)
80
70
60
50
40
30
20
10
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W4
Compliance

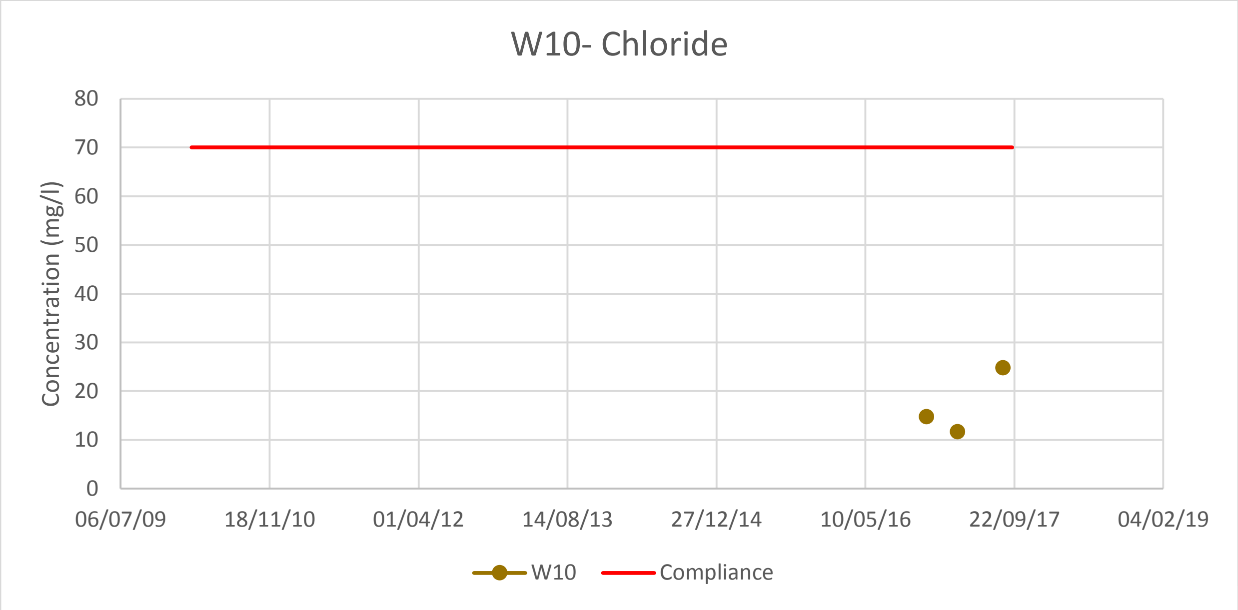

W5- Chloride
Concentration (mg/l)
80
70
60
50
40
30
20
10
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W5
Compliance

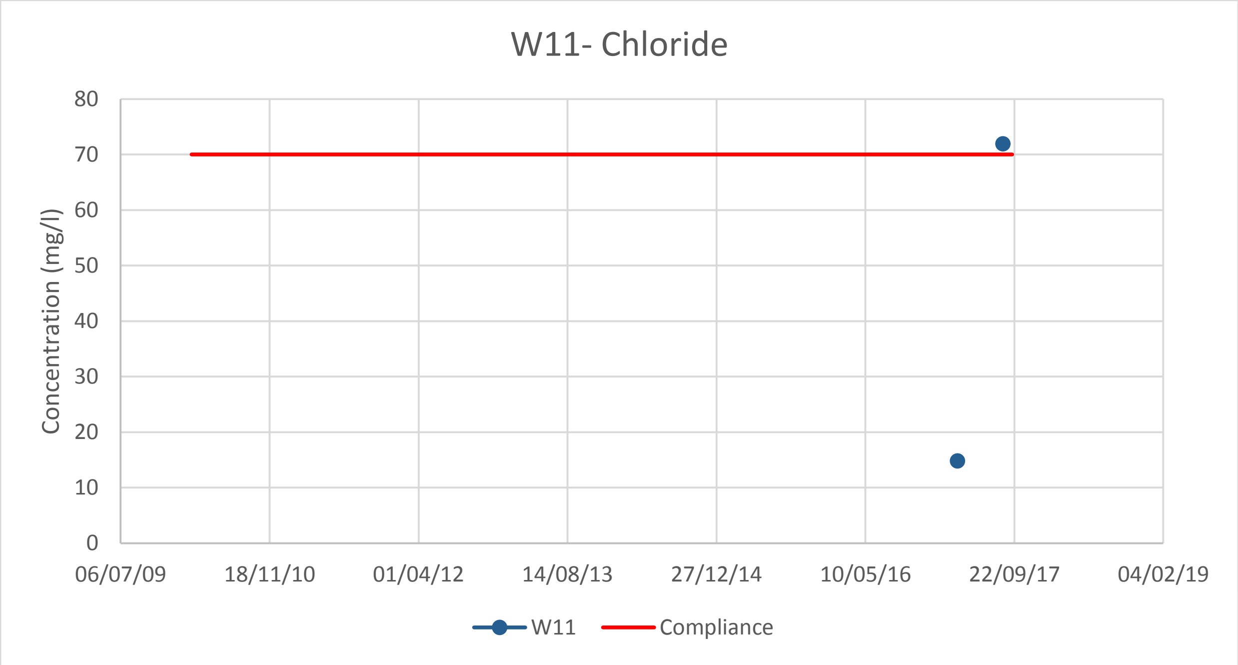

W6- Chloride
Concentration (mg/l)
80
70
60
50
40
30
20
10
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W6
Compliance

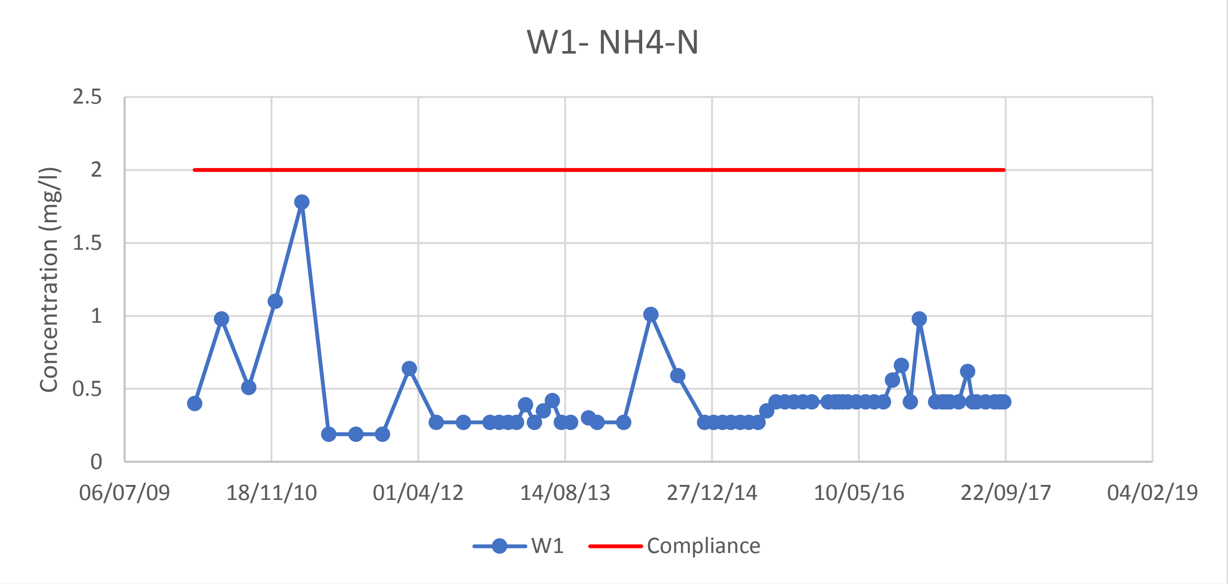

W7- Chloride
Concentration (mg/l)
80
70
60
50
40
30
20
10
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W7
Compliance

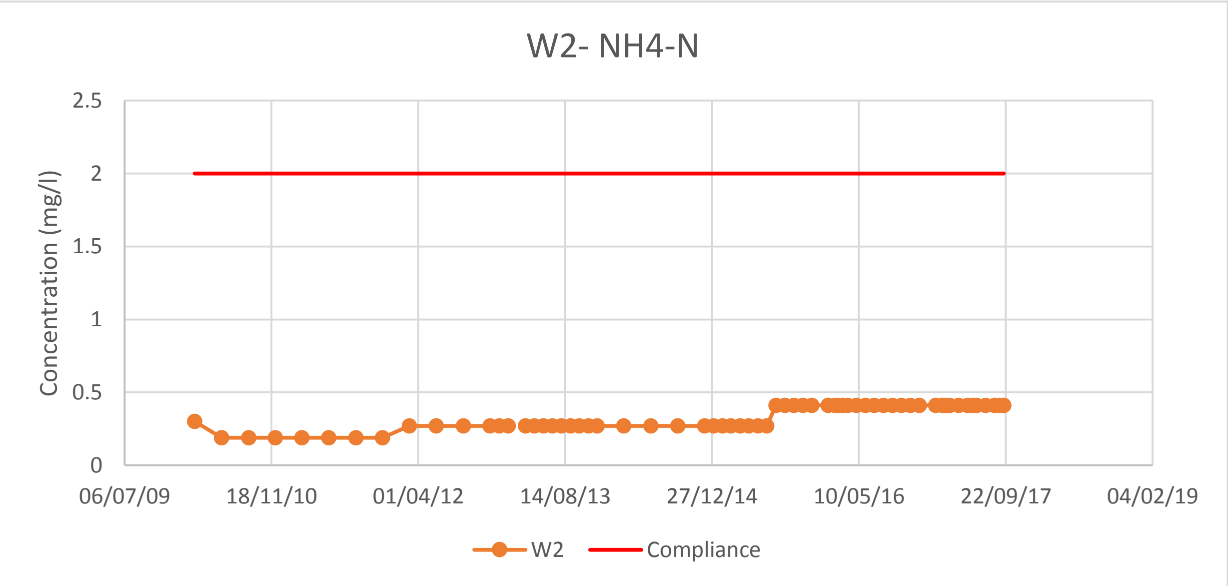

W8- Chloride
Concentration (mg/l)
350
300
250
200
150
100
50
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W8
Compliance

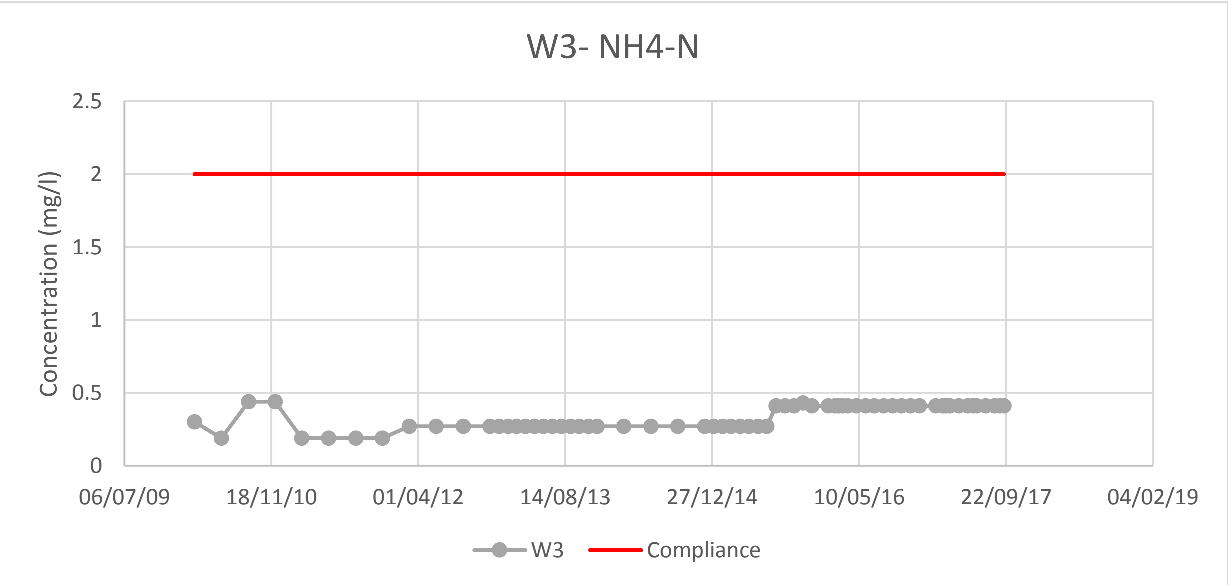

W9- Chloride
Concentration (mg/l)
80
70
60
50
40
30
20
10
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W9
Compliance

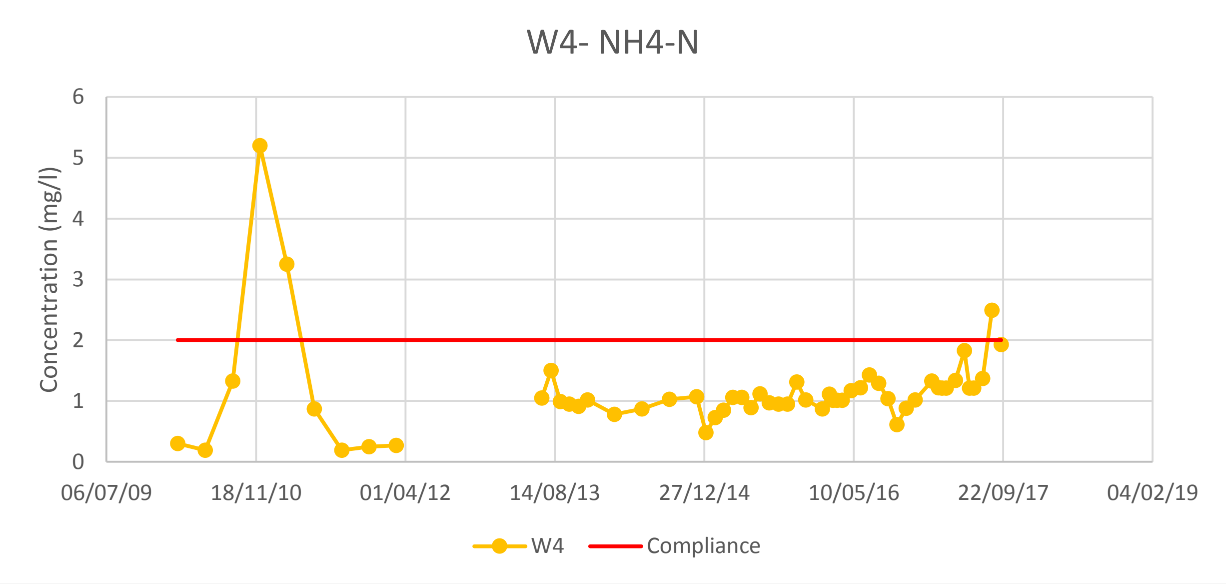

W10- Chloride
Concentration (mg/l)
80
70
60
50
40
30
20
10
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W10
Compliance

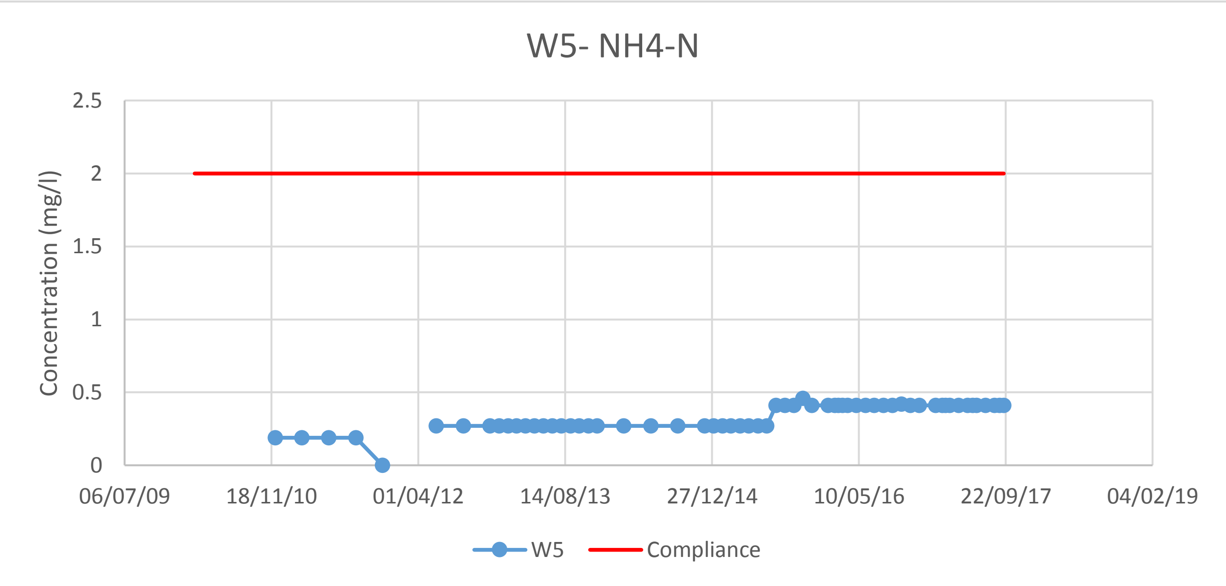

W11- Chloride
Concentration (mg/l)
80
70
60
50
40
30
20
10
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W11
Compliance

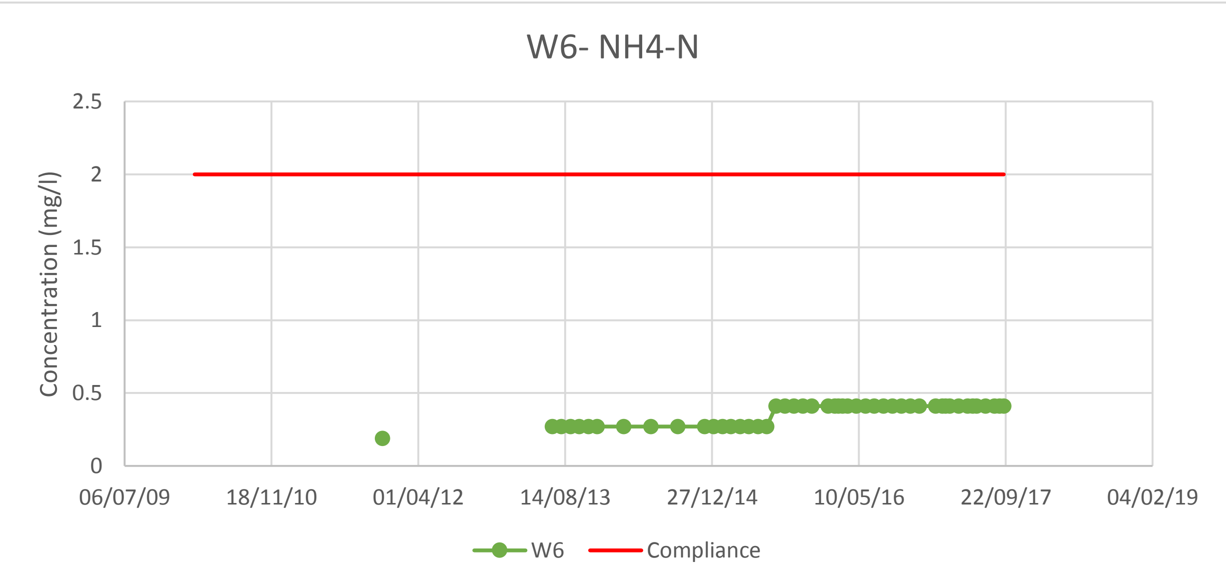

W1- NH4-N
Concentration (mg/l)
2.5
2
1.5
1
0.5
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W1
Compliance

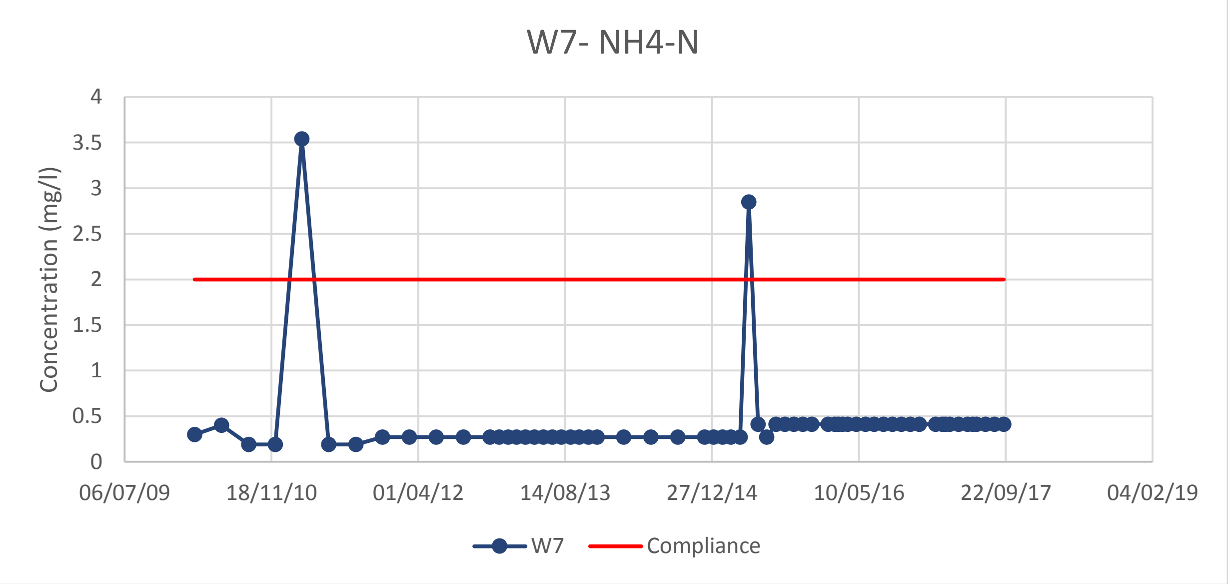

W2- NH4-N
Concentration (mg/l)
2.5
2
1.5
1
0.5
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W2
Compliance

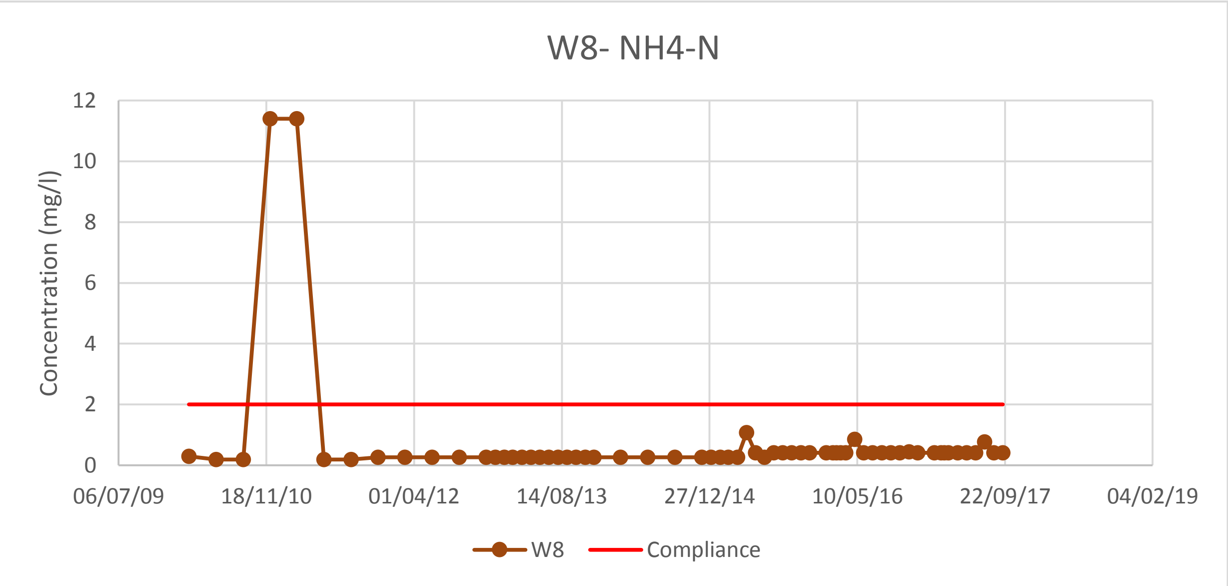

W3- NH4-N
Concentration (mg/l)
2.5
2
1.5
1
0.5
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W3
Compliance

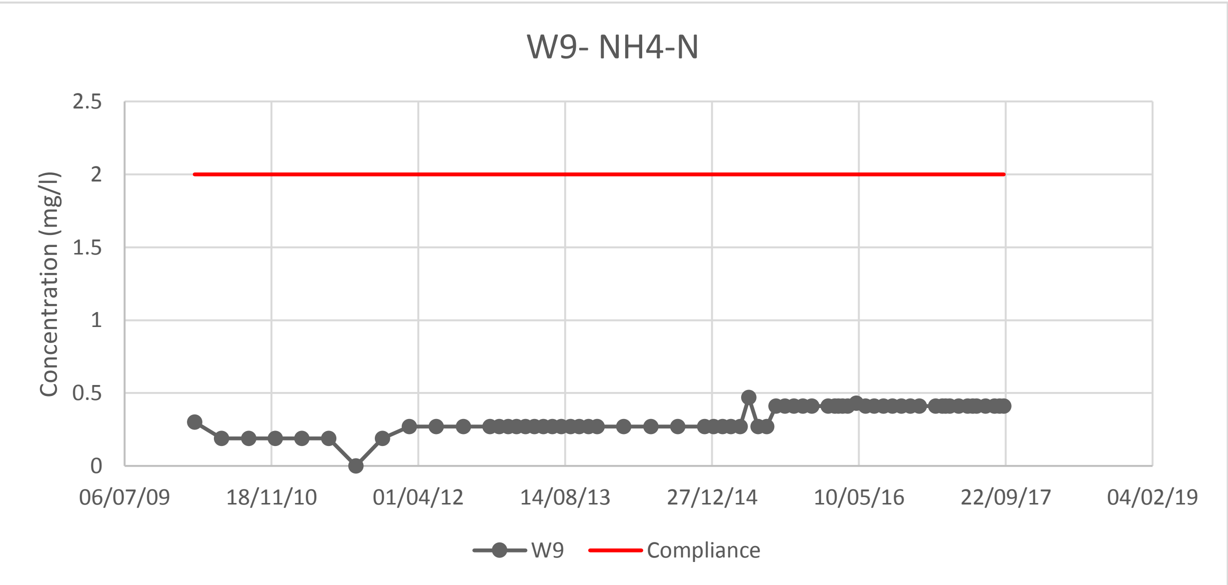

W4- NH4-N
Concentration (mg/l)
6
5
4
3
2
1
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W4
Compliance

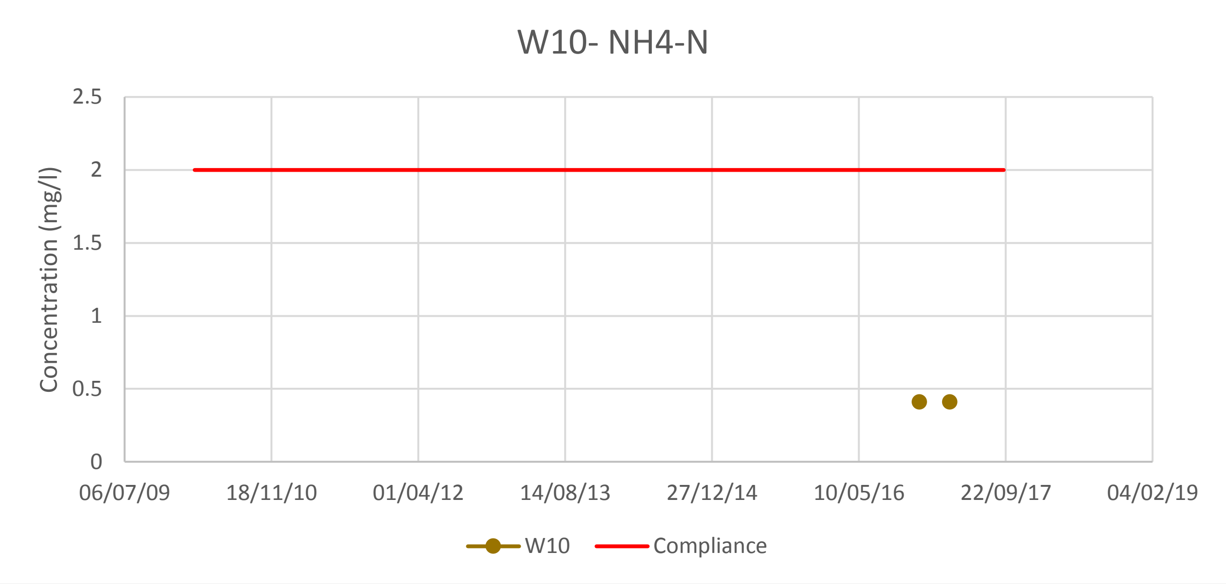

W5- NH4-N
Concentration (mg/l)
2.5
2
1.5
1
0.5
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W5
Compliance

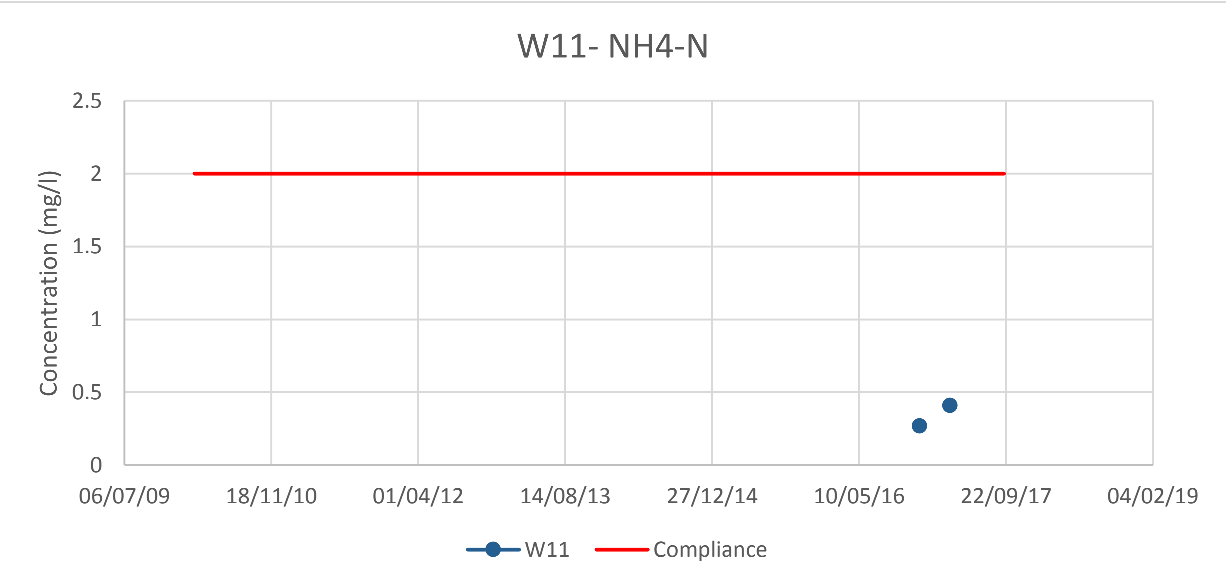

W6- NH4-N
Concentration (mg/l)
2.5
2
1.5
1
0.5
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W6
Compliance

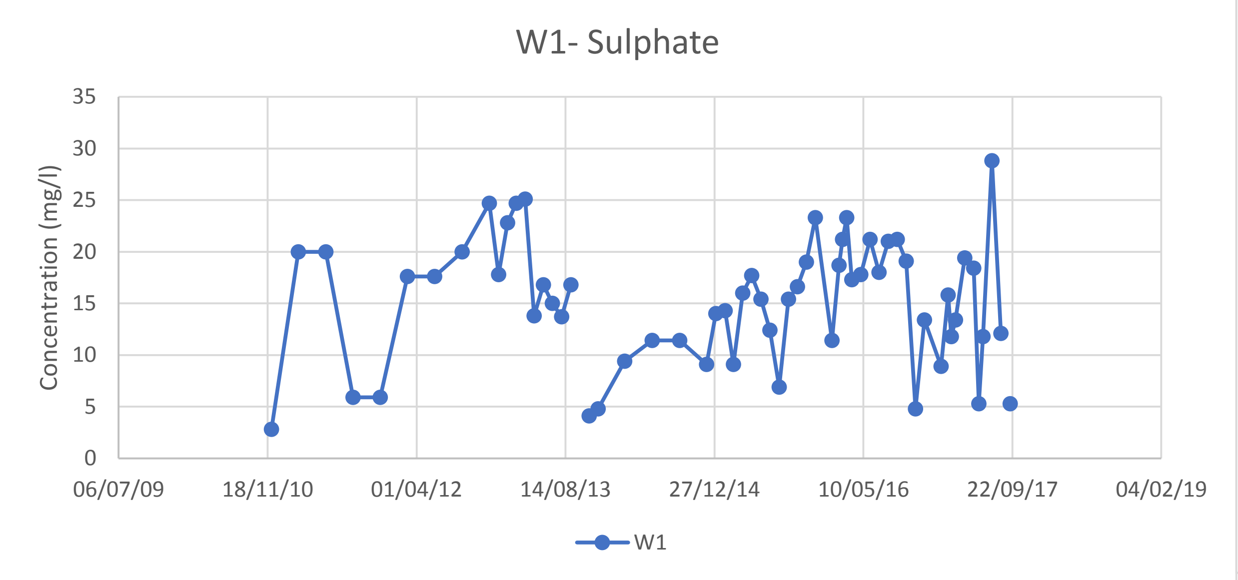

W7- NH4-N
Concentration (mg/l)
4
3.5
3
2.5
2
1.5
1
0.5
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W7
Compliance

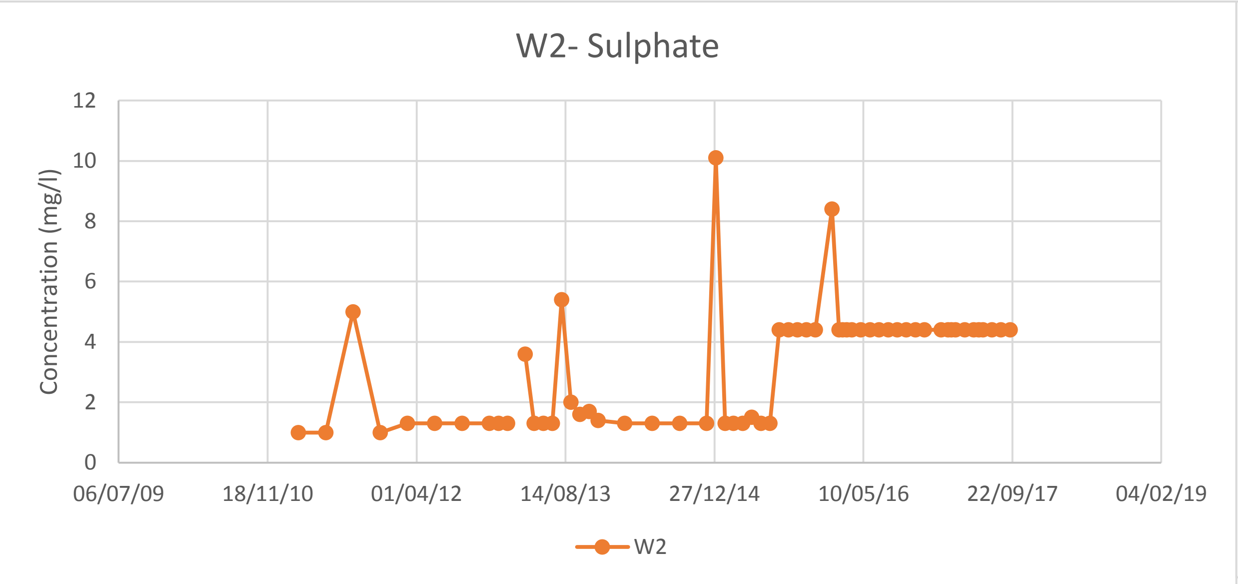

W8- NH4-N
Concentration (mg/l)
12
10
8
6
4
2
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W8
Compliance

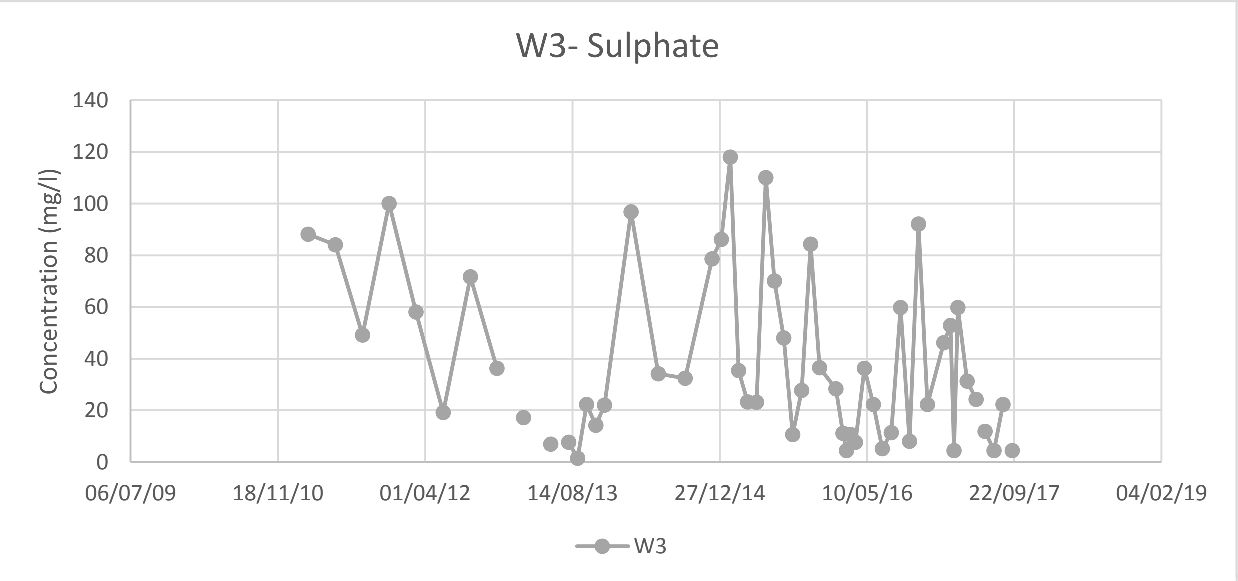

W9- NH4-N
Concentration (mg/l)
2.5
2
1.5
1
0.5
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W9
Compliance

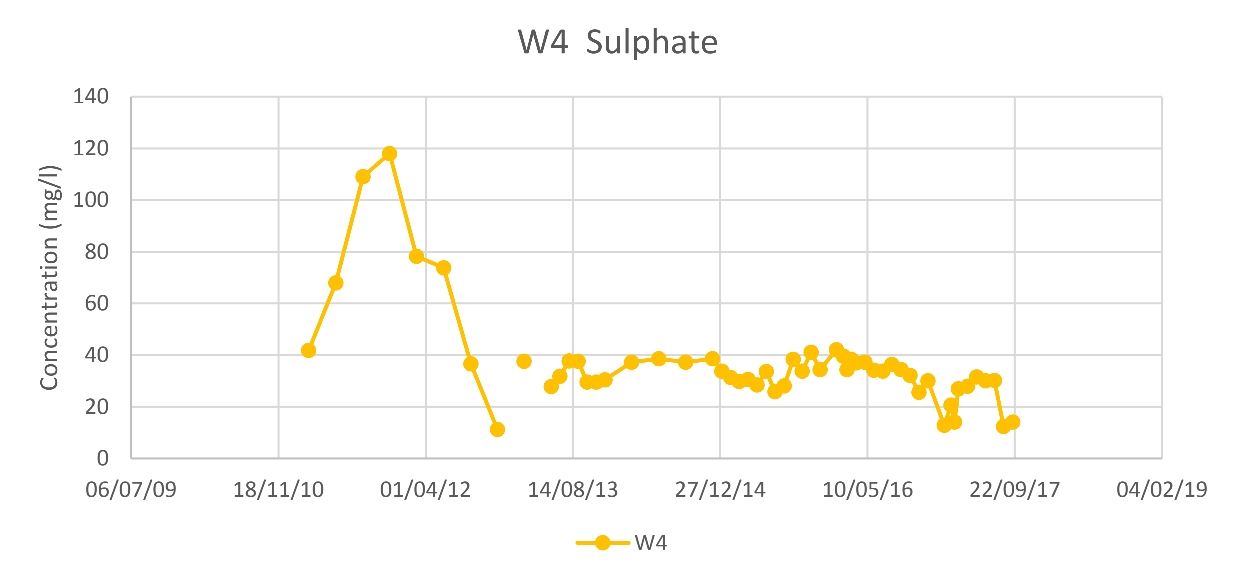

W10- NH4-N
Concentration (mg/l)
2.5
2
1.5
1
0.5
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W10
Compliance

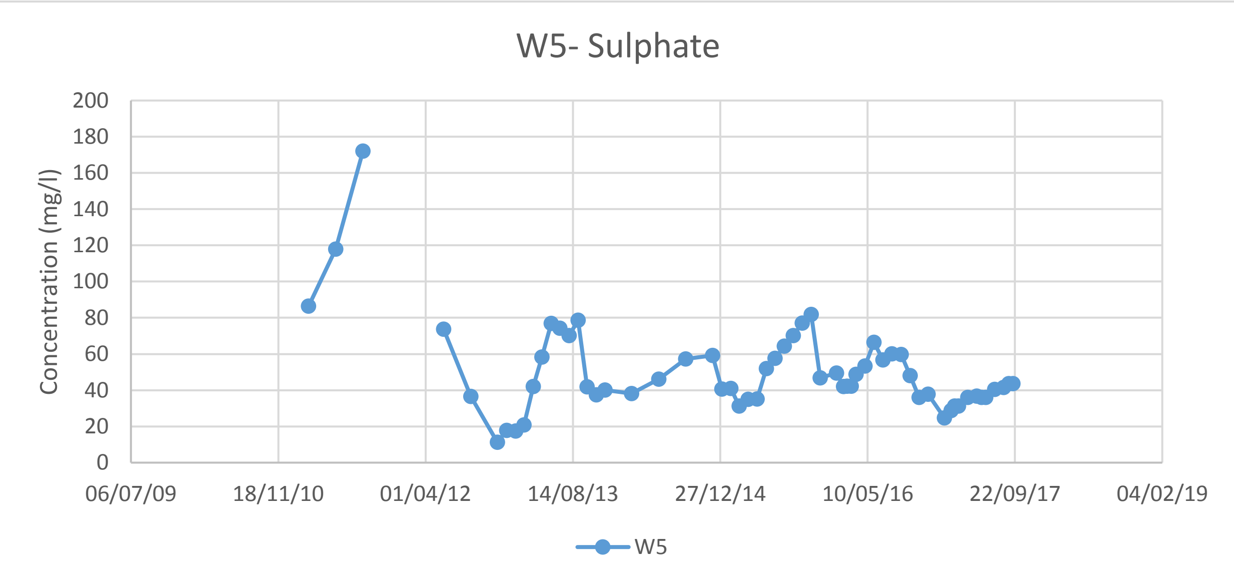

W11- NH4-N
Concentration (mg/l)
2.5
2
1.5
1
0.5
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W11
Compliance

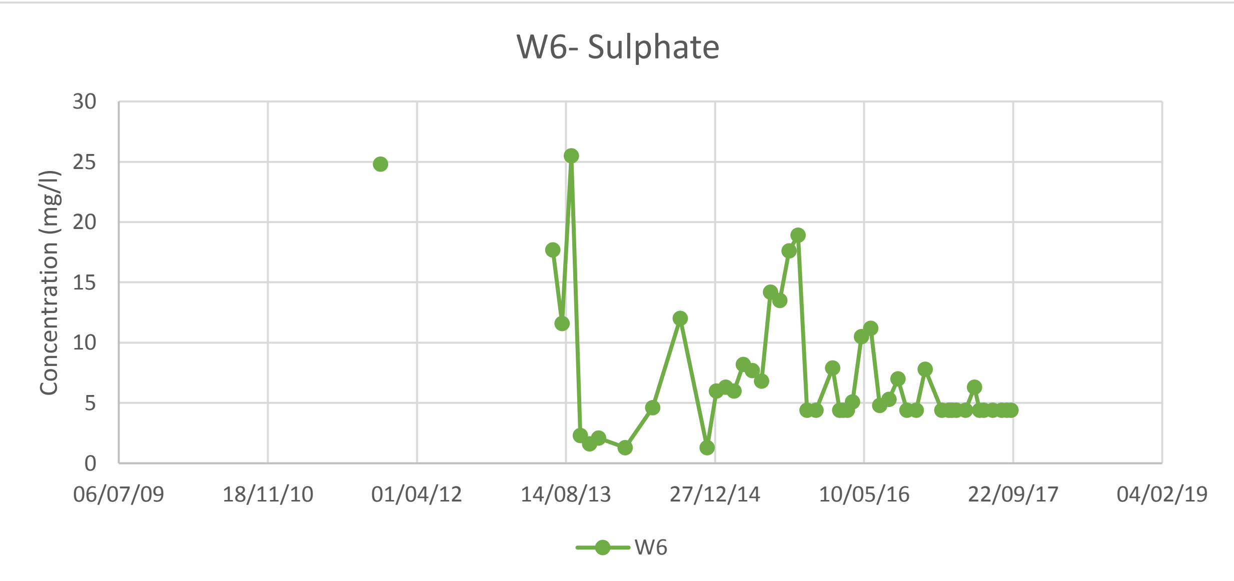

W1- Sulphate
Concentration (mg/l)
35
30
25
20
15
10
5
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W1

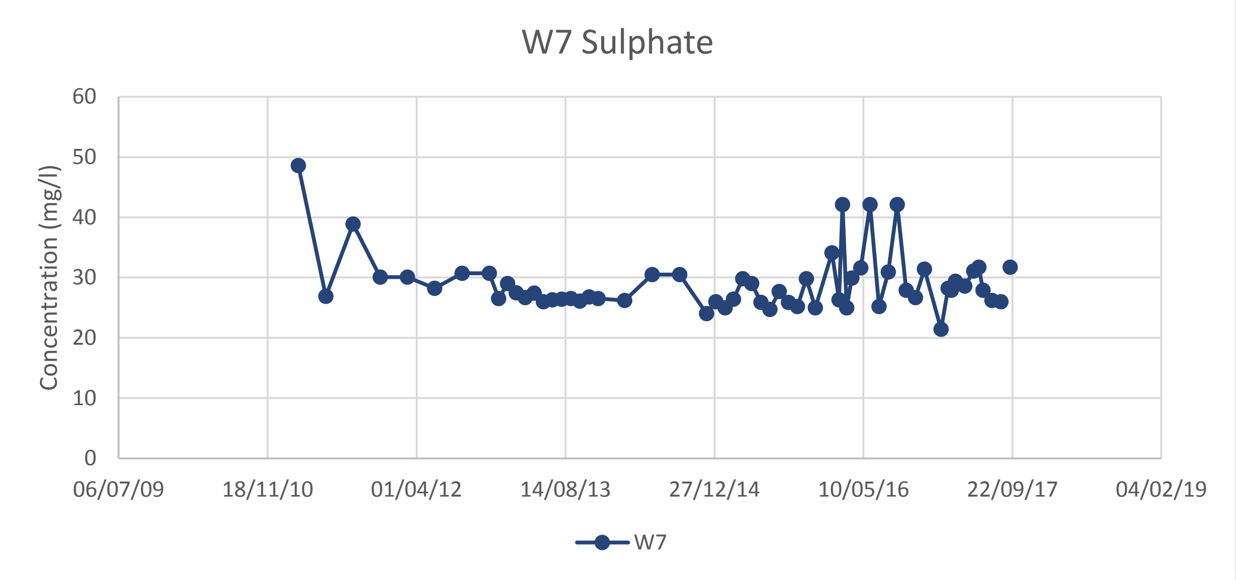

W2- Sulphate
Concentration (mg/l)
12
10
8
6
4
2
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W2

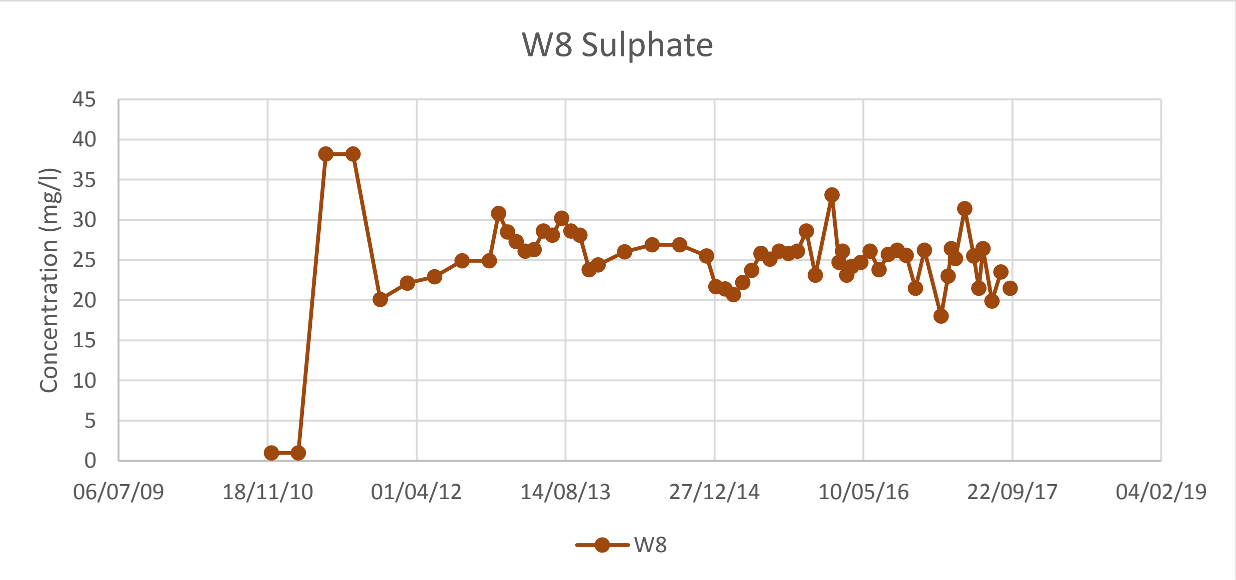

W3- Sulphate
Concentration (mg/l)
140
120
100
80
60
40
20
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W3

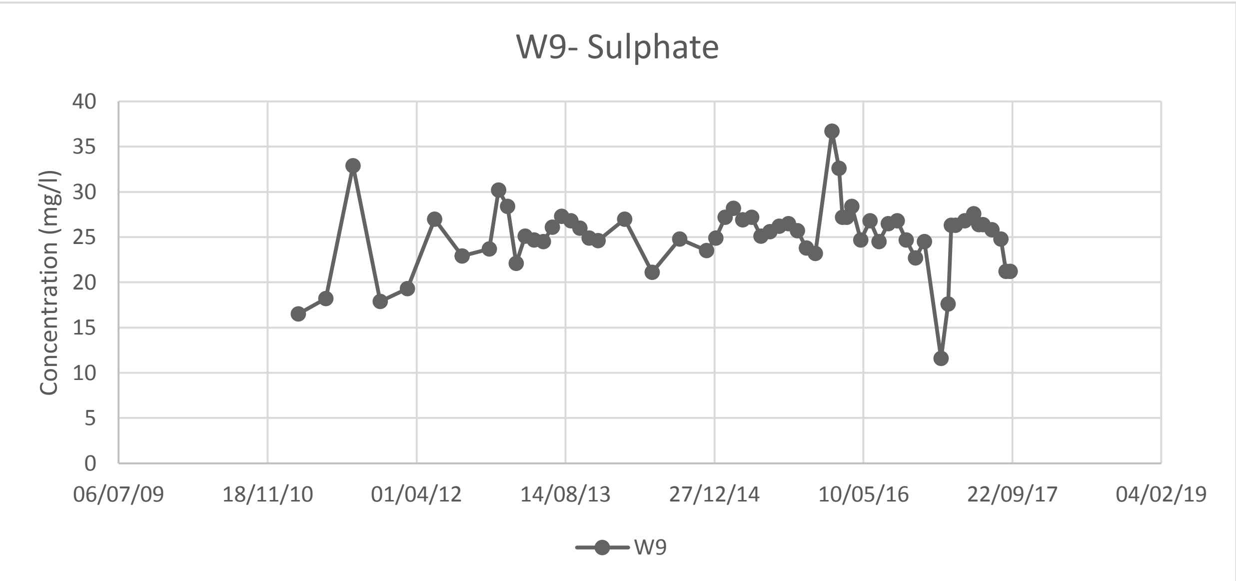

W4 Sulphate
Concentration (mg/l)
0
20
40
60
80
100
120
140
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W4

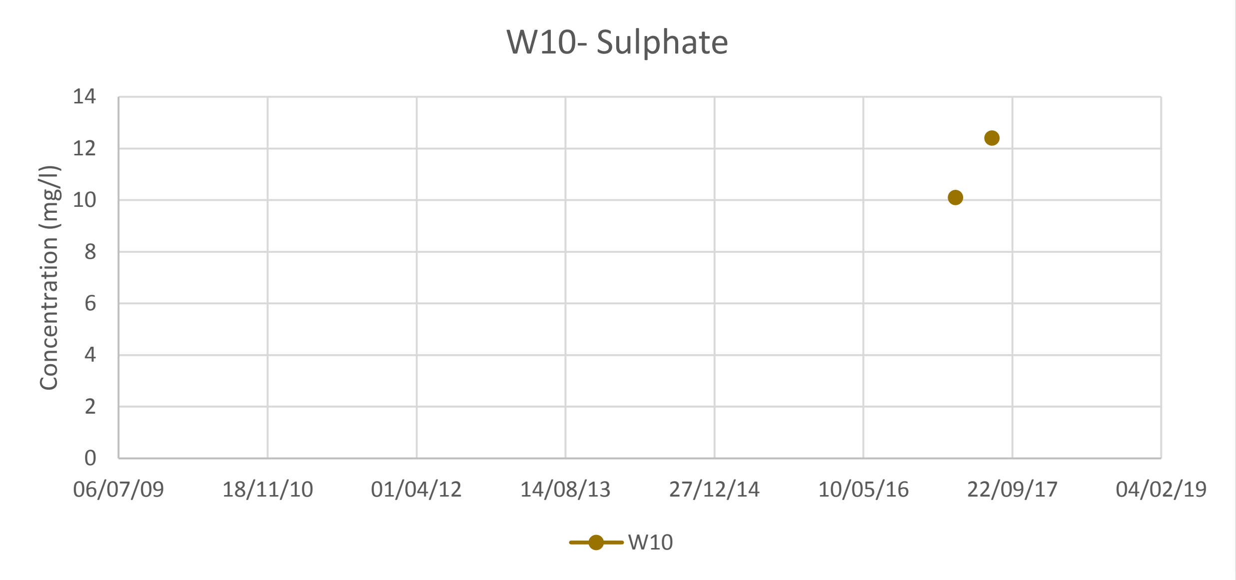

W5- Sulphate
Concentration (mg/l)
0
20
40
60
80
100
120
140
160
180
200
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W5

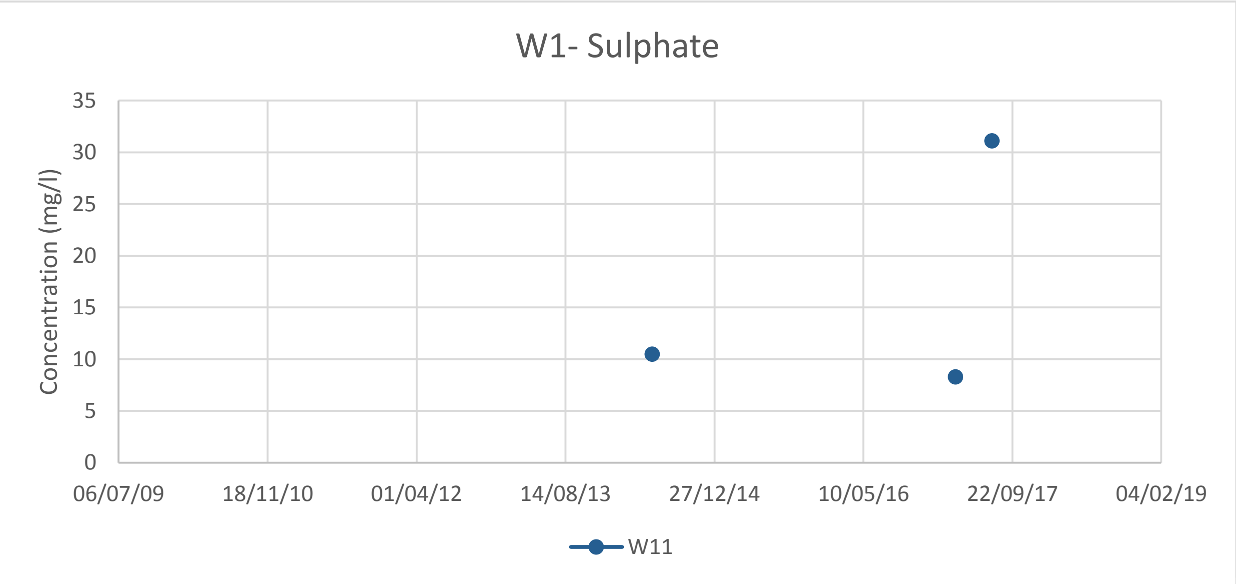

W6- Sulphate
Concentration (mg/l)
0
5
10
15
20
25
30
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W6

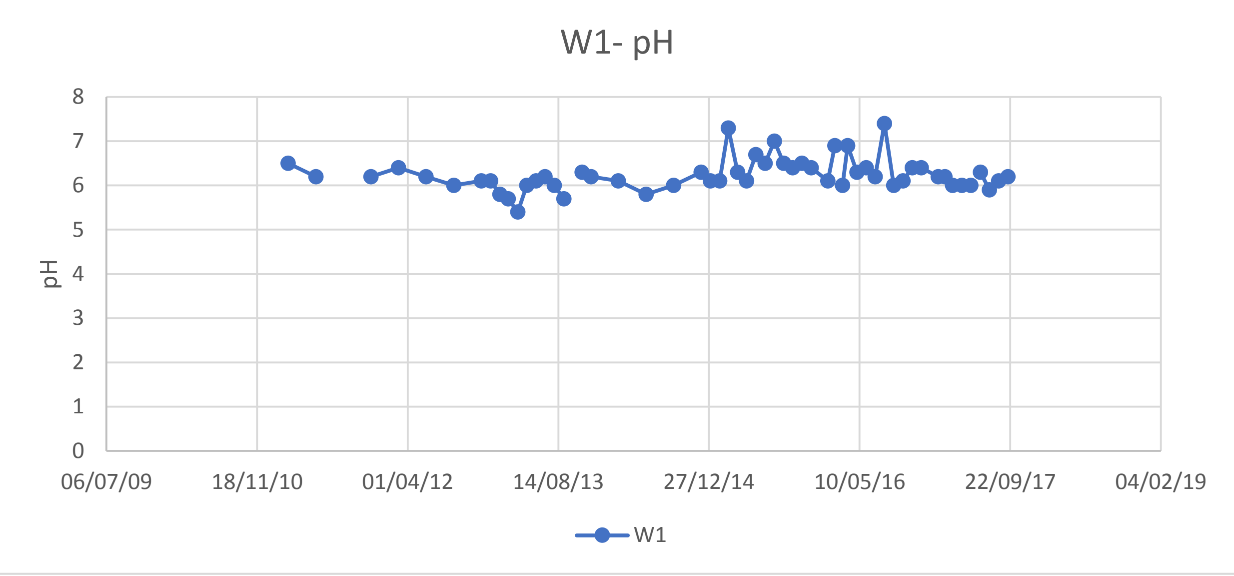

W7 Sulphate
Concentration (mg/l)
60
50
40
30
20
10
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W7

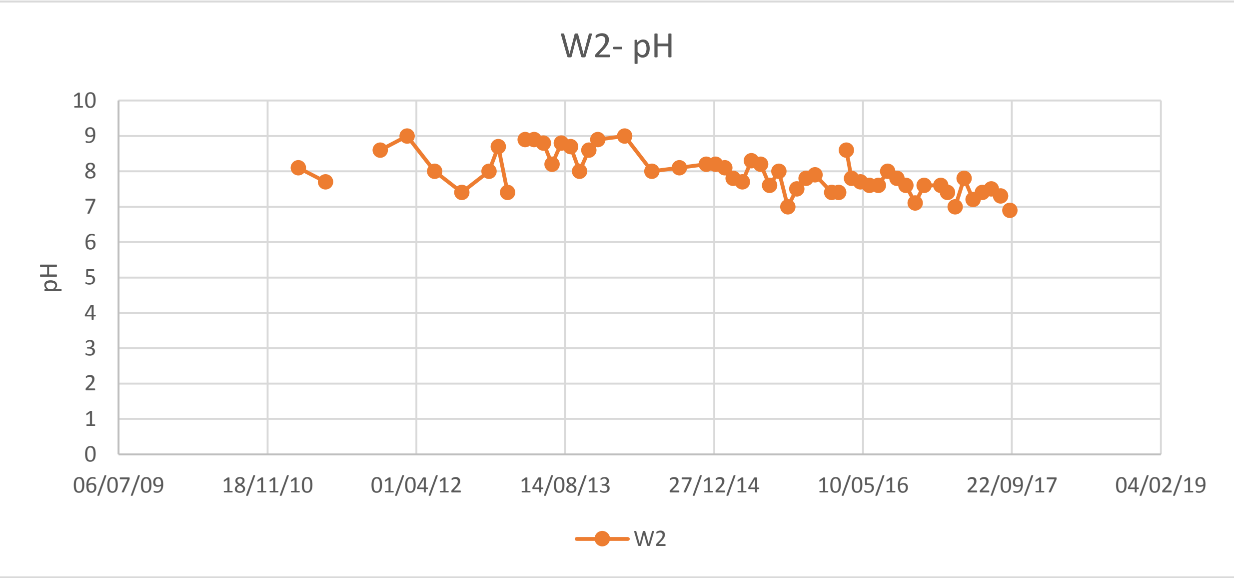

W8 Sulphate
Concentration (mg/l)
45
40
35
30
25
20
15
10
5
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W8

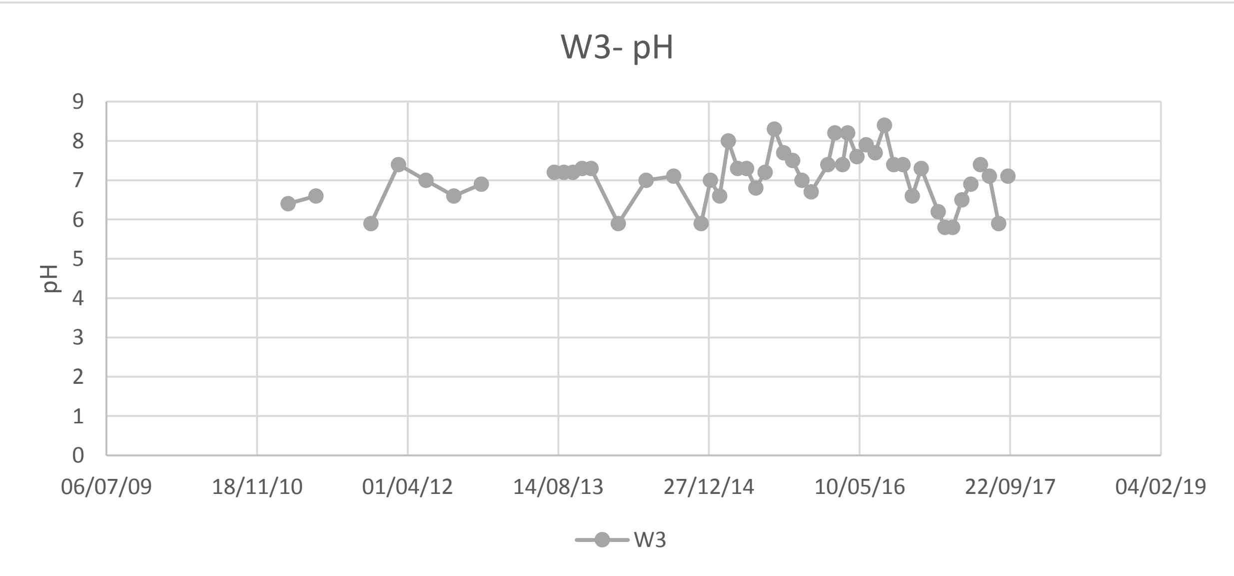

W9- Sulphate
Concentration (mg/l)
40
35
30
25
20
15
10
5
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W9

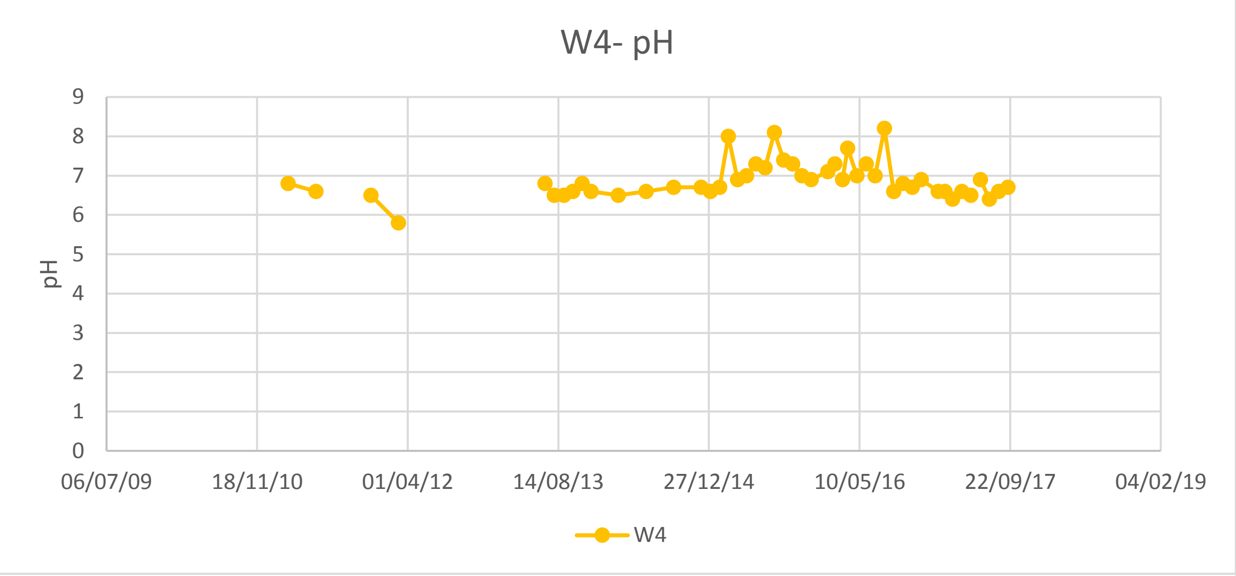

W10- Sulphate
Concentration (mg/l)
0
2
4
6
8
10
12
14
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W10

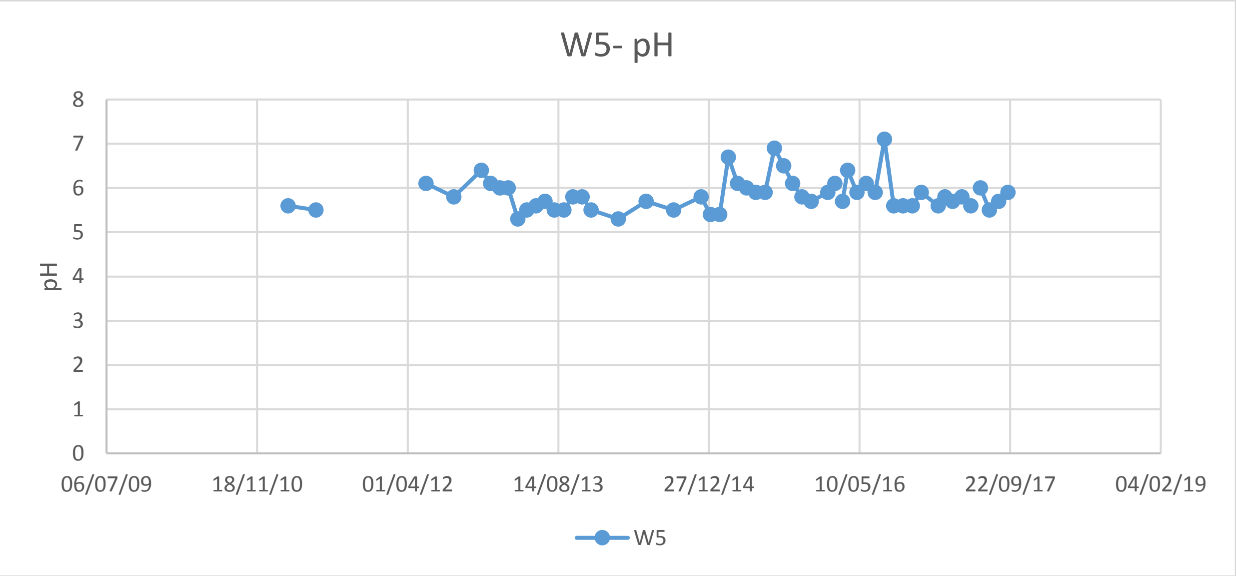

W1- Sulphate
Concentration (mg/l)
0
5
10
15
20
25
30
35
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W11

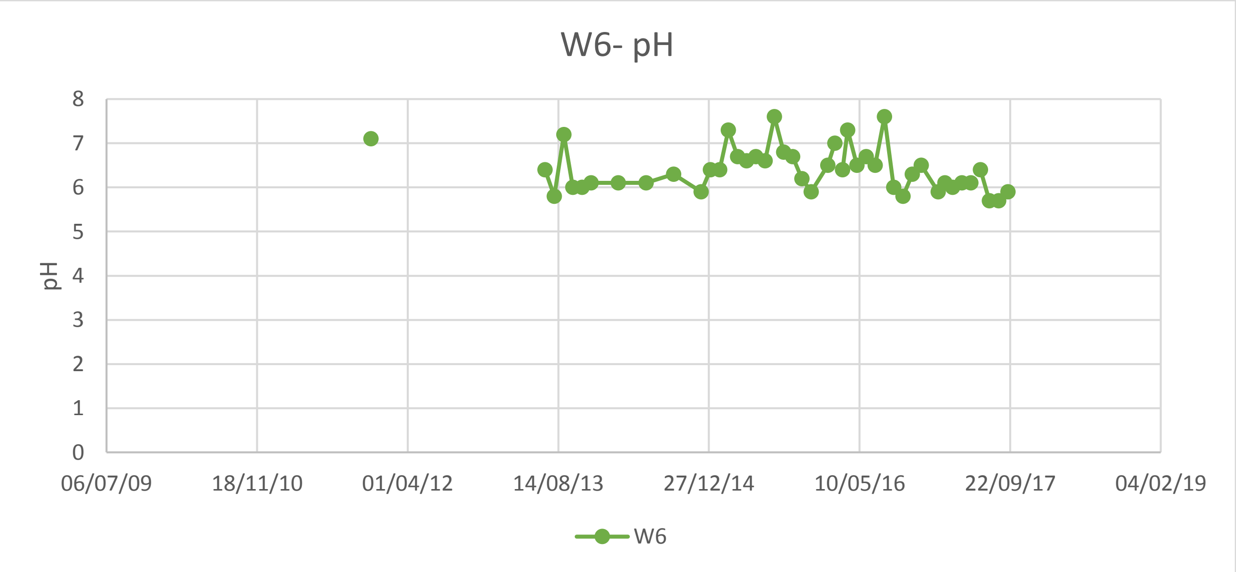

W1- pH
8
7
6
5
4
3
2
1
0
pH
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W1

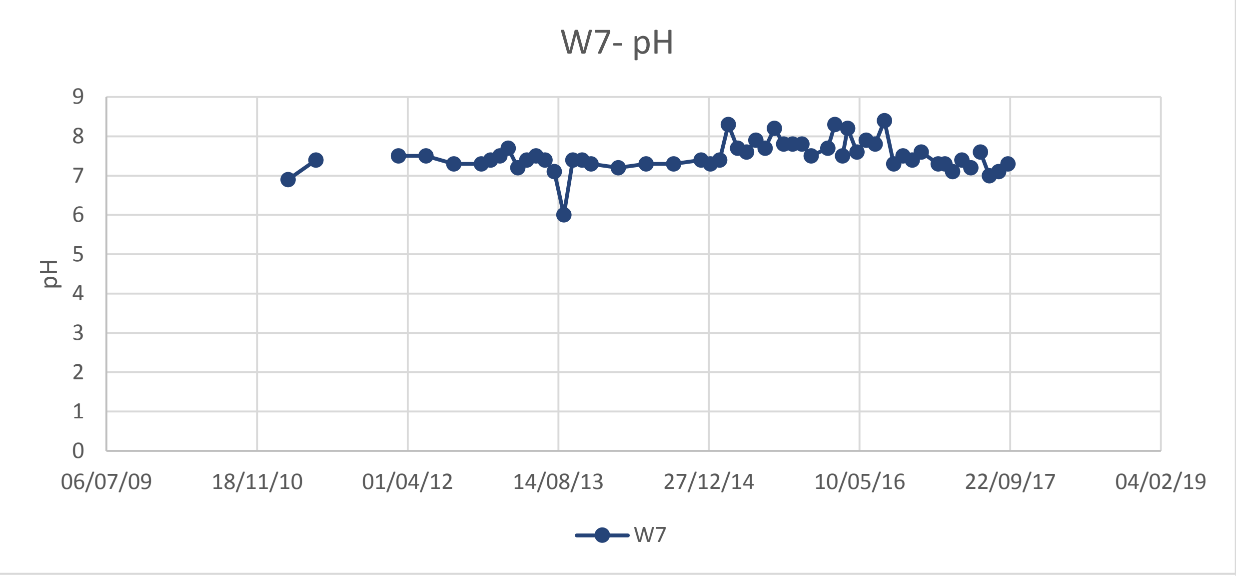

W2- pH
10
9
8
7
6
5
4
3
2
1
0
pH
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W2

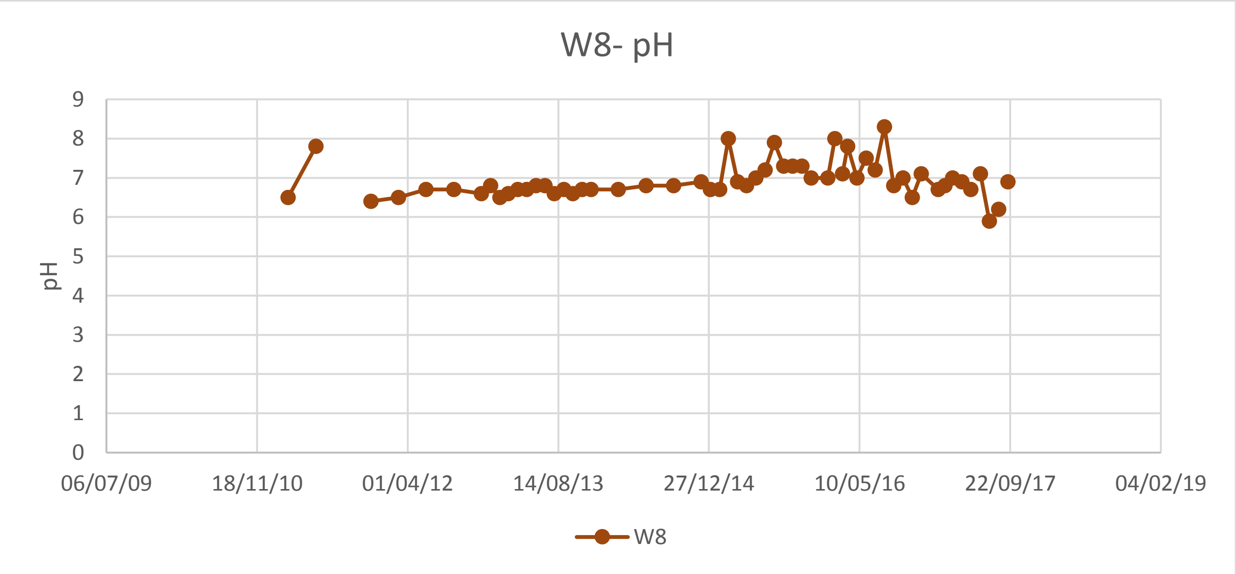

W3- pH
9
8
7
6
5
4
3
2
1
0
pH
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W3

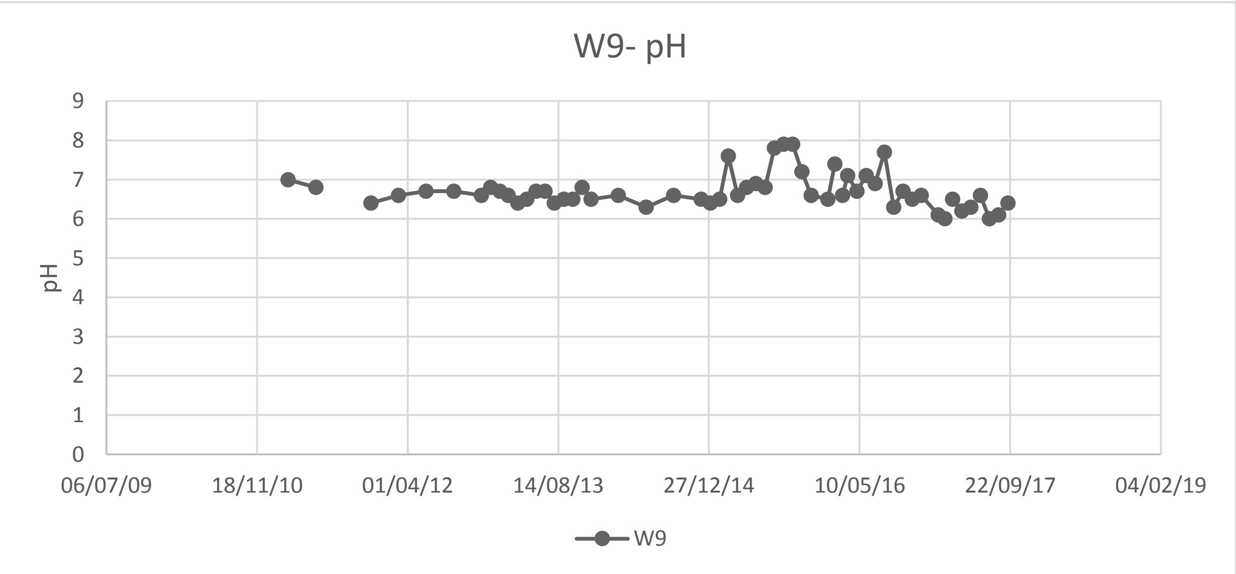

W4- pH
9
8
7
6
5
4
3
2
1
0
pH
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W4

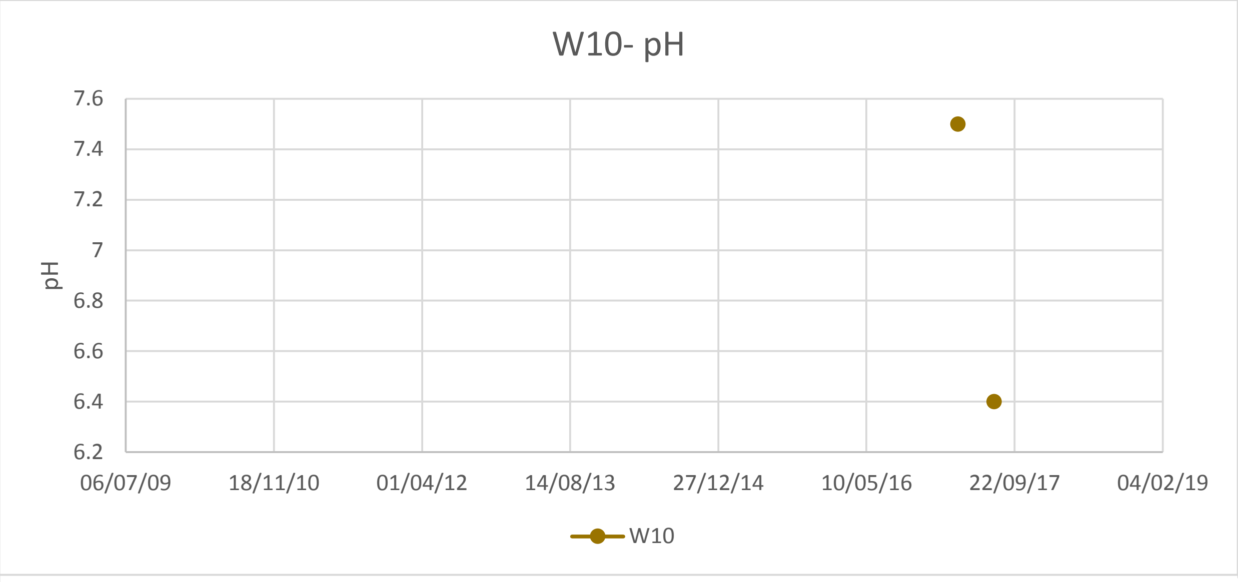

W5- pH
8
7
6
5
4
3
2
1
0
pH
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W5

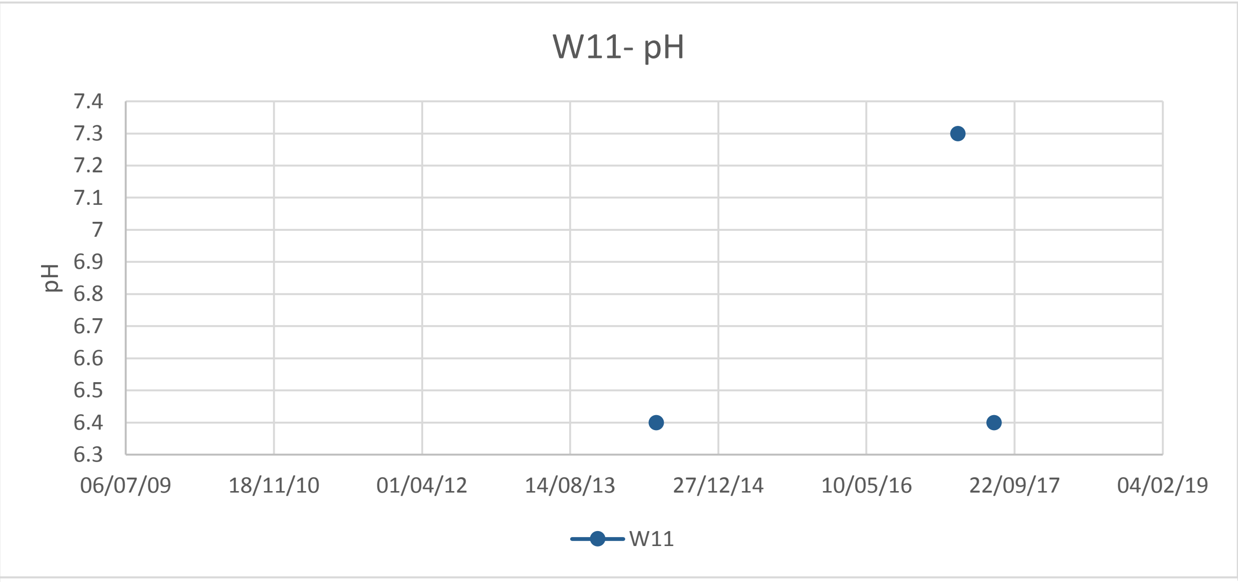

W6- pH
8
7
6
5
4
3
2
1
0
pH
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W6

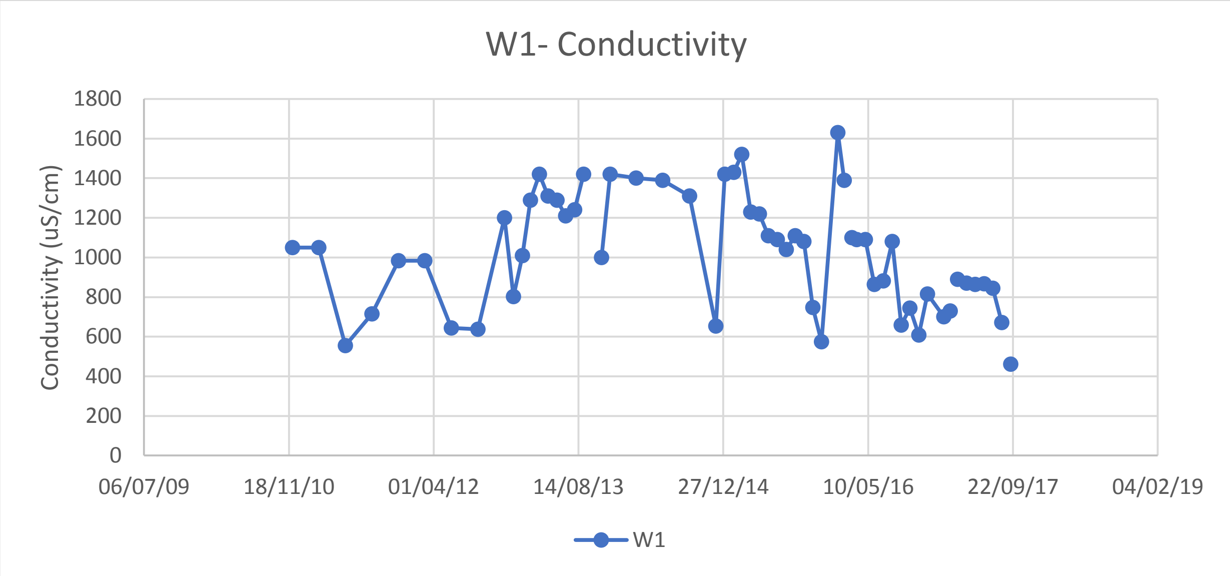

W7- pH
pH
0
1
2
3
4
5
6
7
8
9
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W7

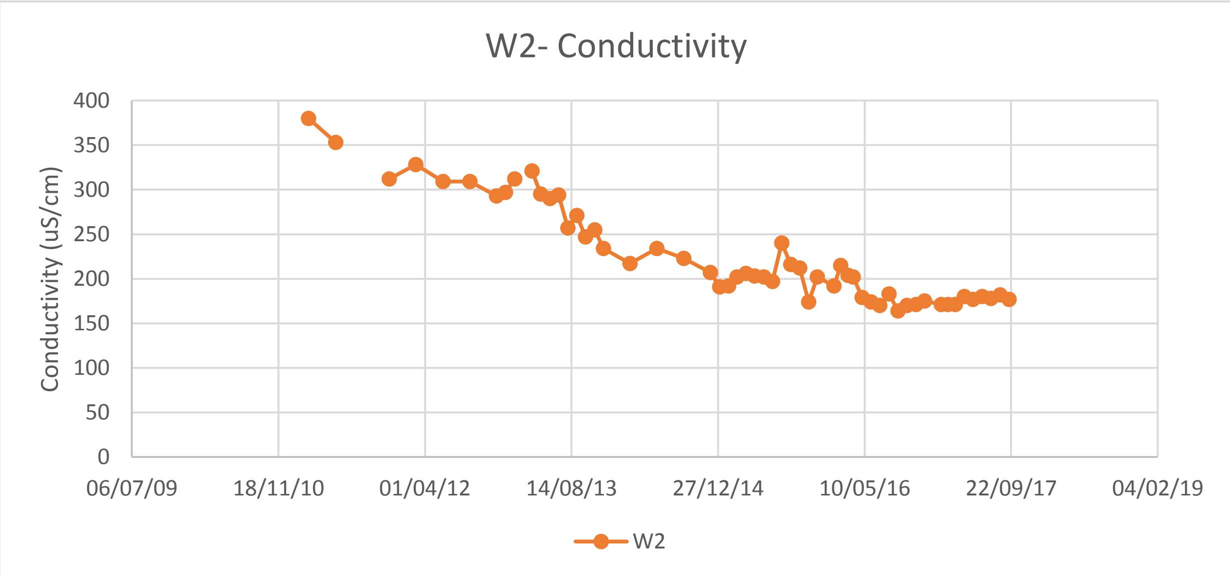

W8- pH
pH
0
1
2
3
4
5
6
7
8
9
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W8

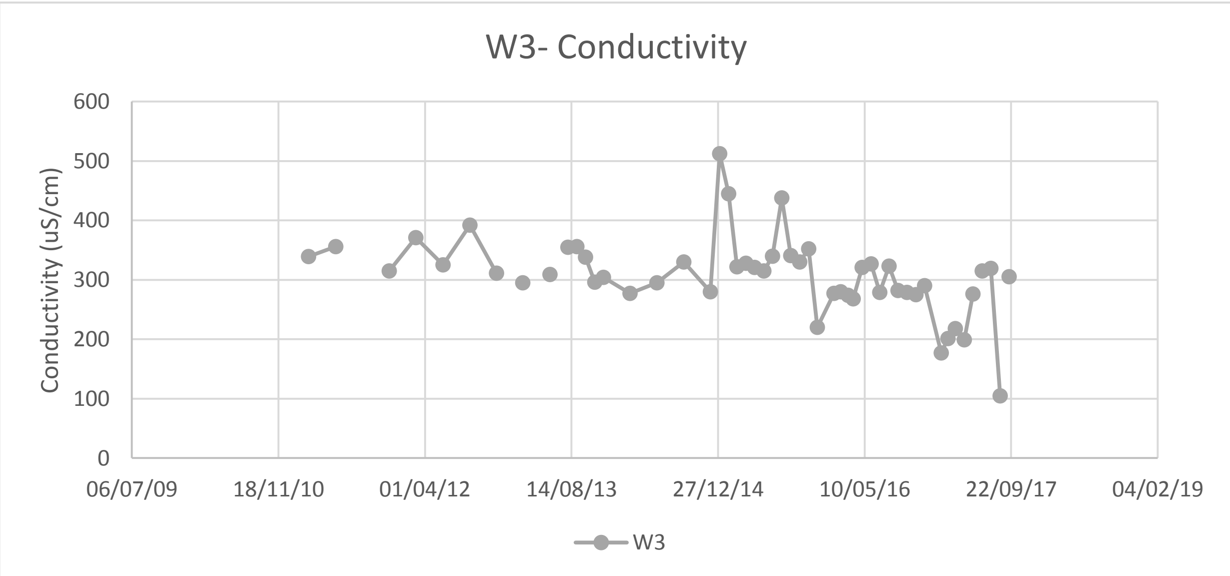

W9- pH
pH
0
1
2
3
4
5
6
7
8
9
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W9

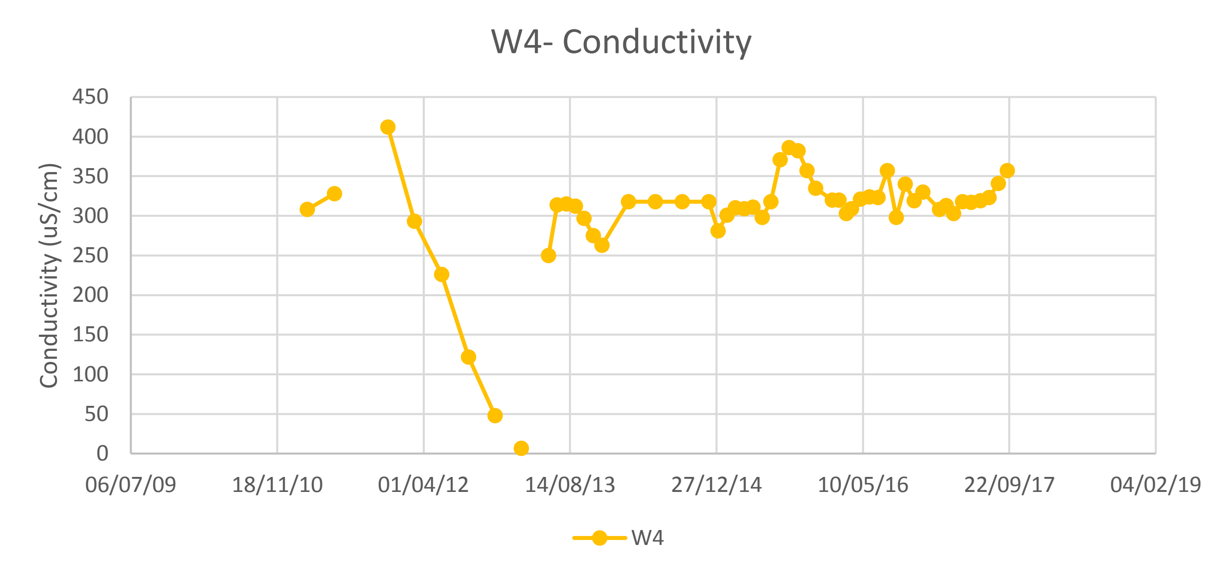

W10- pH
pH
7.6
7.4
7.2
7
6.8
6.6
6.4
6.2
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W10

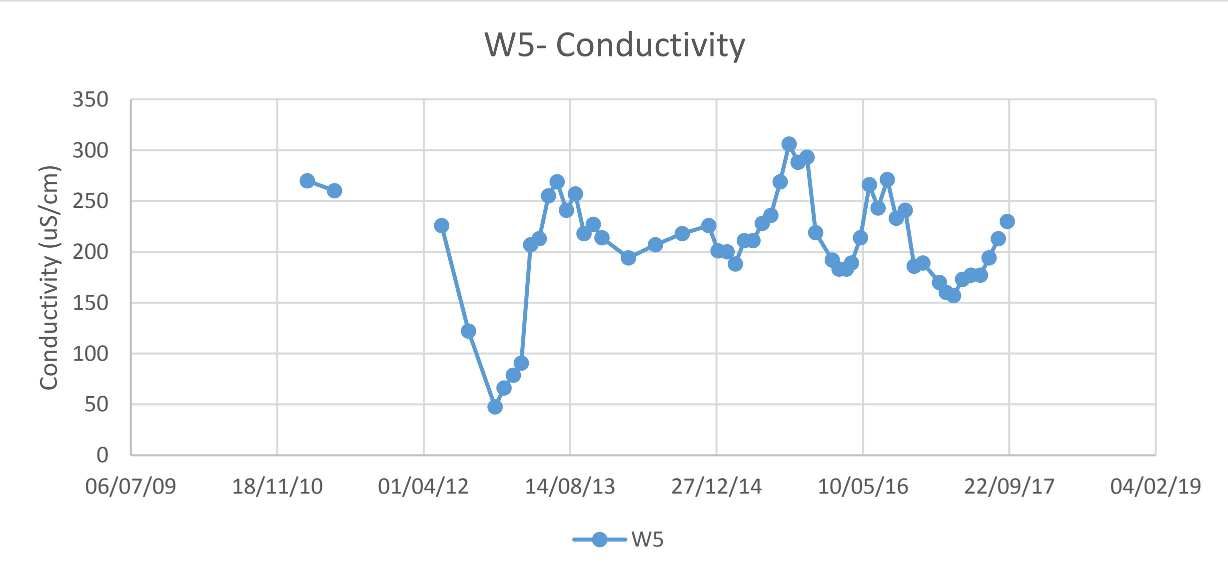

W11- pH
pH
7.4
7.3
7.2
7.1
7
6.9
6.8
6.7
6.6
6.5
6.4
6.3
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W11

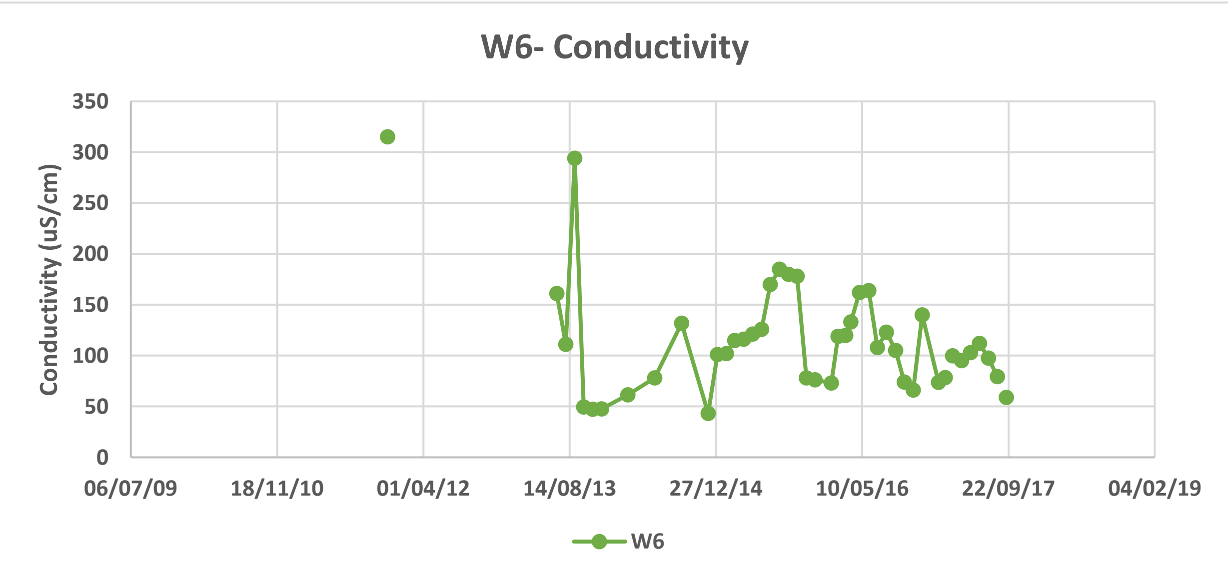

W1- Conductivity
Conductivity (uS/cm)
1800
1600
1400
1200
1000
800
600
400
200
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W1

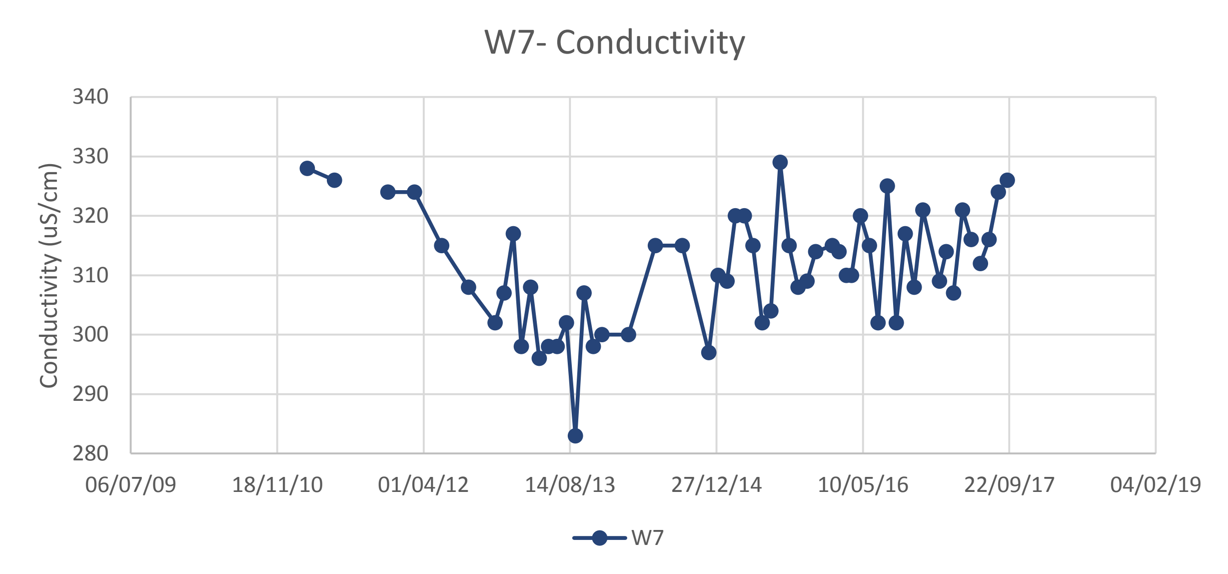

W2- Conductivity
Conductivity (uS/cm)
400
350
300
250
200
150
100
50
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W2

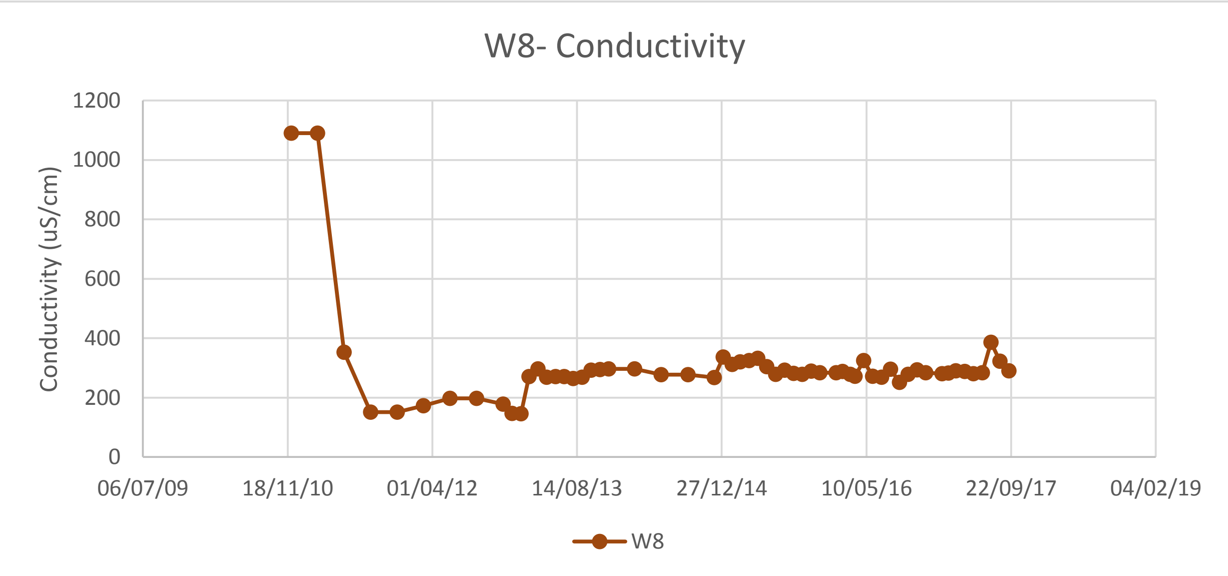

W3- Conductivity
Conductivity (uS/cm)
600
500
400
300
200
100
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W3

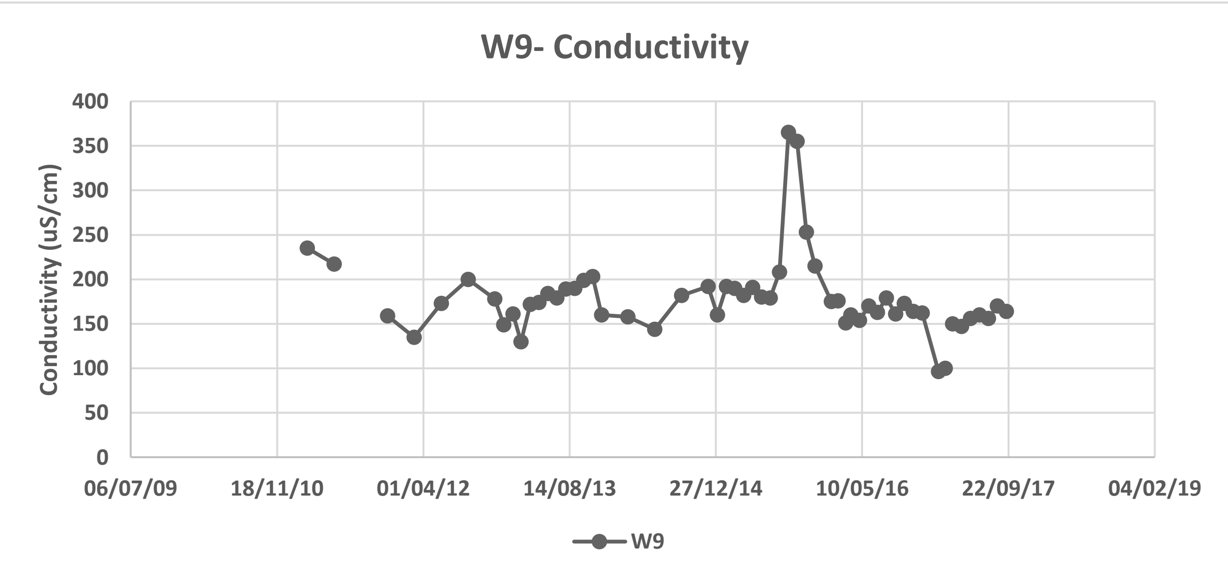

W4- Conductivity
Conductivity (uS/cm)
450
400
350
300
250
200
150
100
50
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W4

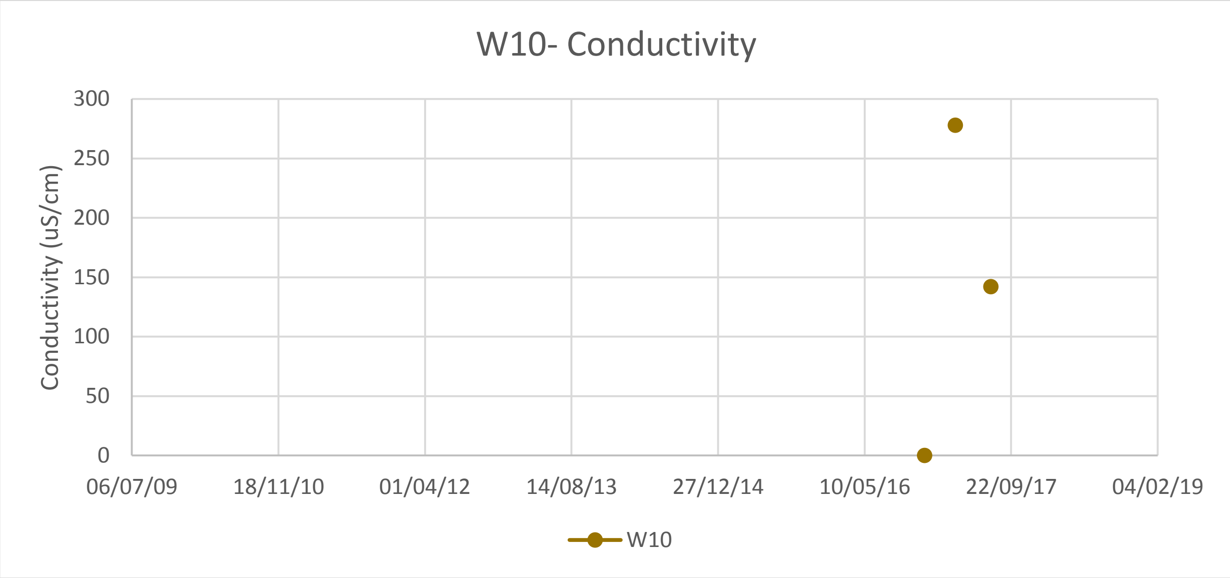

W5- Conductivity
Conductivity (uS/cm)
350
300
250
200
150
100
50
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W5

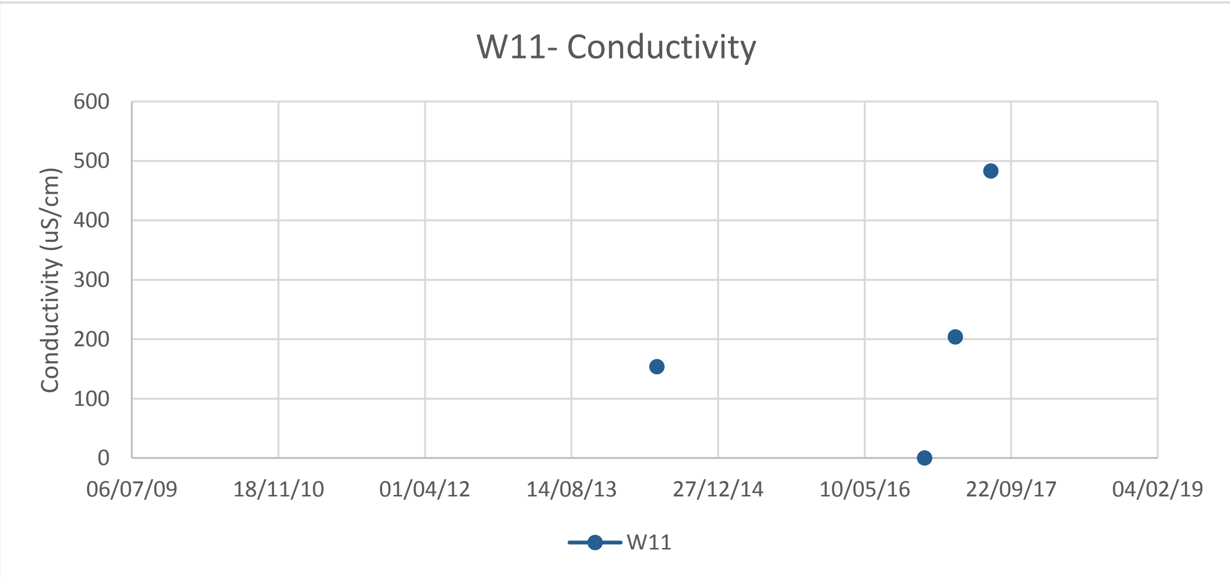

W6- Conductivity
Conductivity (uS/cm)
350
300
250
200
150
100
50
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W6

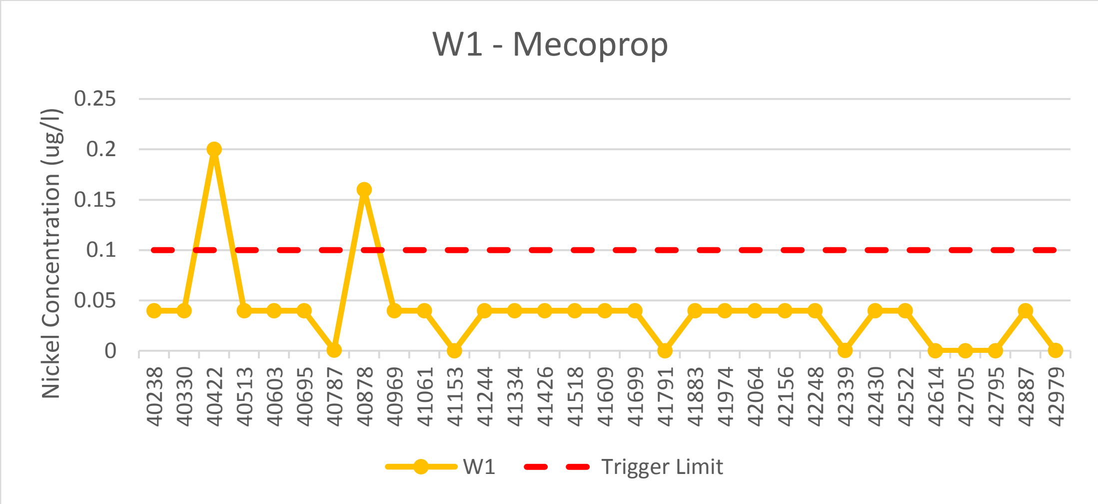

W7- Conductivity
340
330
320
310
300
290
280
Conductivity (uS/cm)
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W7

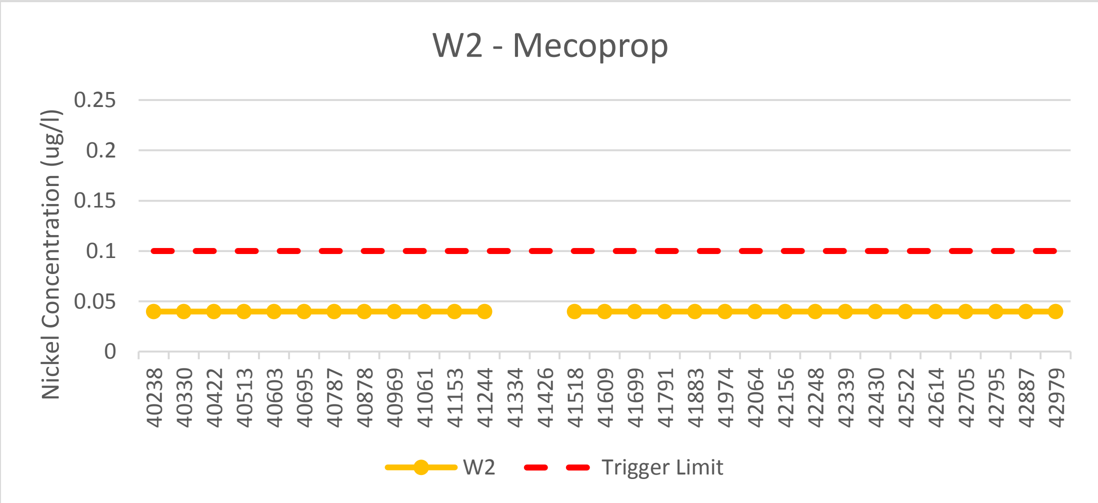

W8- Conductivity
1200
1000
800
600
400
200
0
Conductivity (uS/cm)
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W8

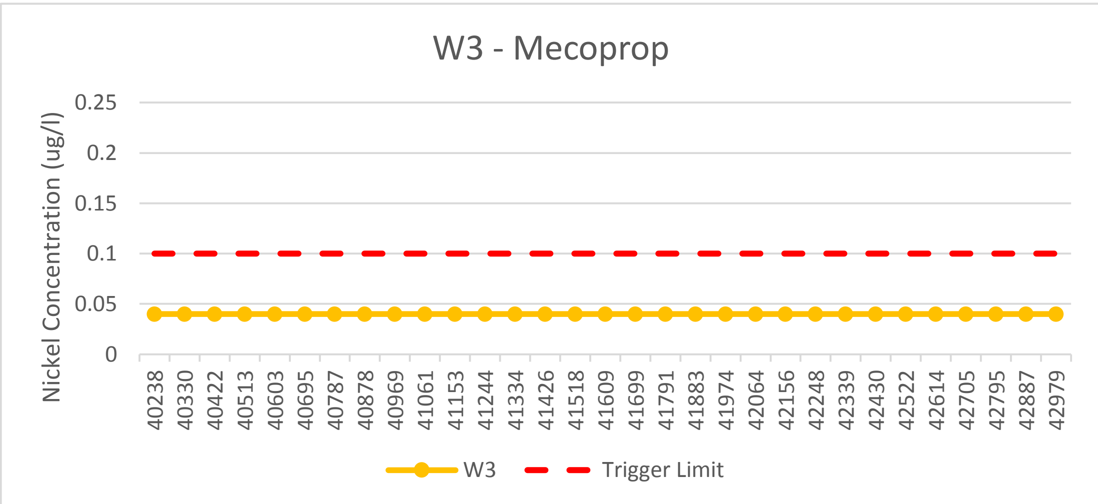

W9- Conductivity
400
350
300
250
200
150
100
50
0
Conductivity (uS/cm)
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W9

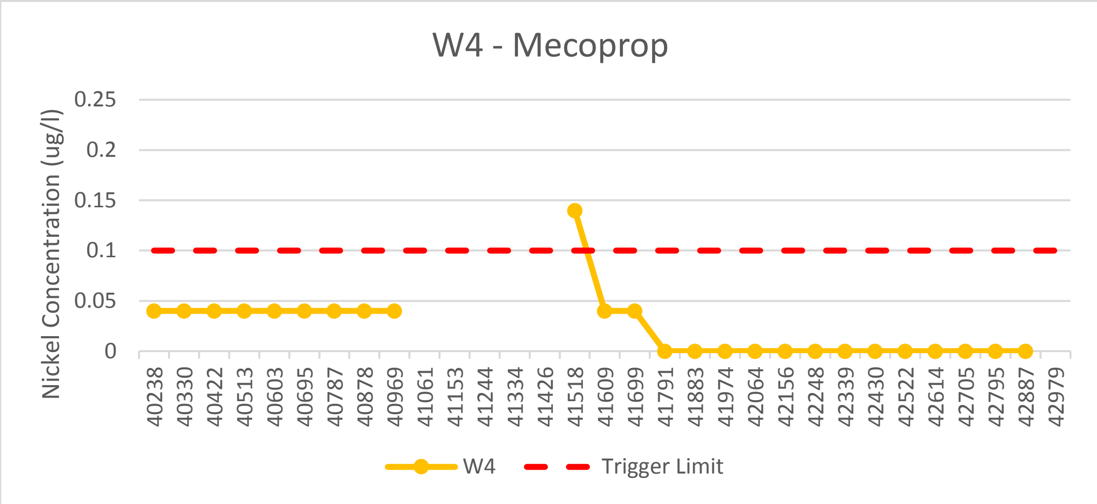

W10- Conductivity
Conductivity (uS/cm)
300
250
200
150
100
50
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W10

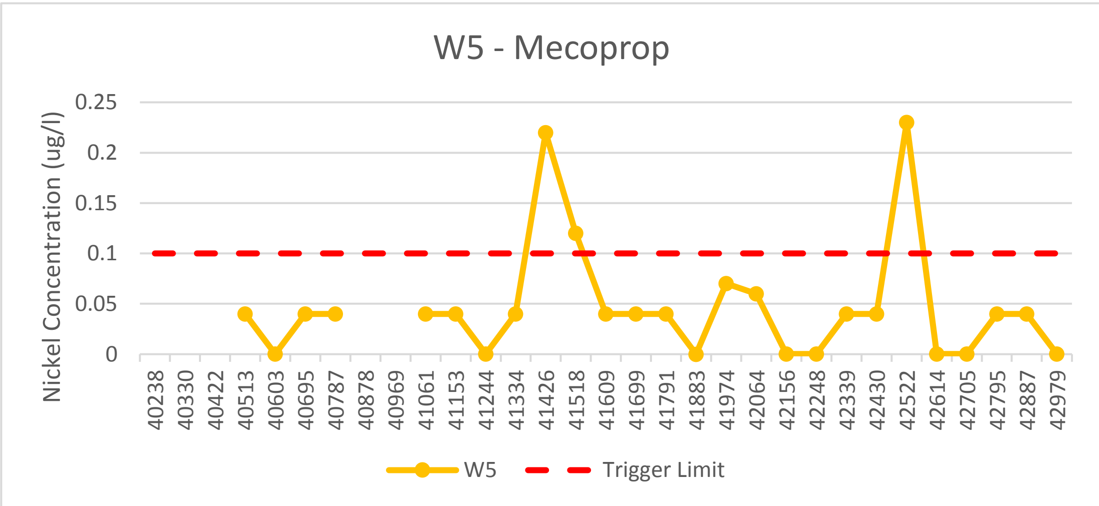

W11- Conductivity
Conductivity (uS/cm)
600
500
400
300
200
100
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
W11

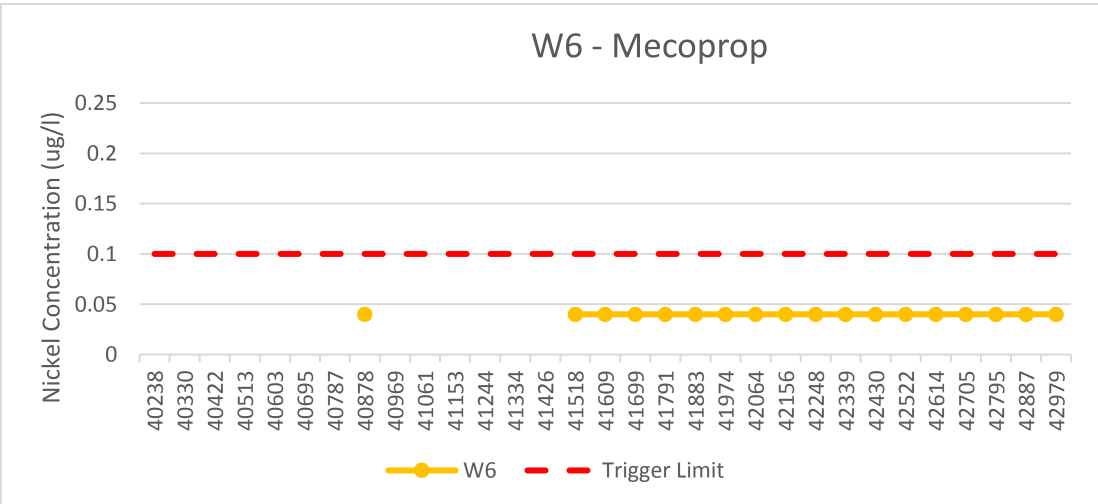

W1 - Mecoprop
Nickel Concentration (ug/l)
0.25
0.2
0.15
0.1
0.05
0
40238
40330
40422
40513
40603
40695
40787
40878
40969
41061
41153
41244
41334
41426
41518
41609
41699
41791
41883
41974
42064
42156
42248
42339
42430
42522
42614
42705
42795
42887
42979
W1
Trigger Limit

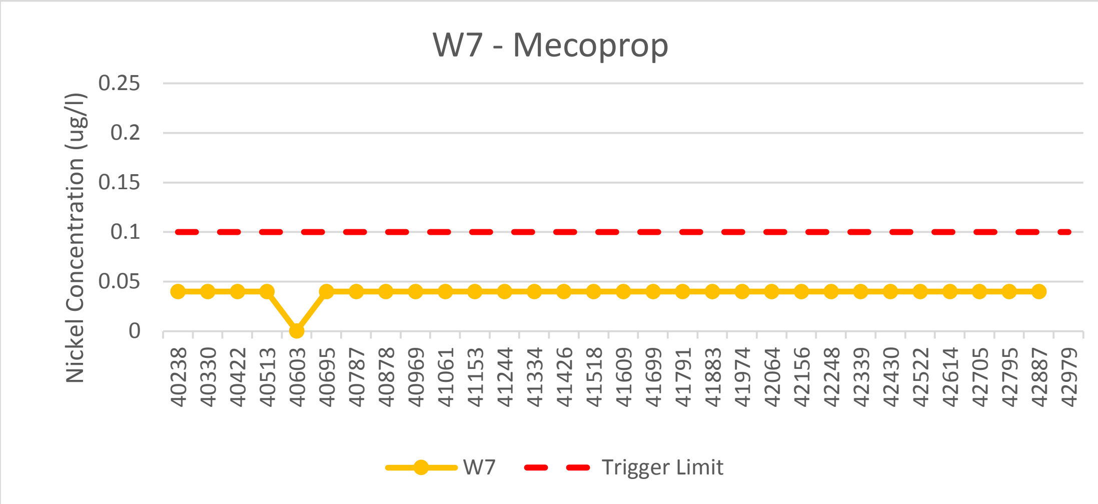

W2 - Mecoprop
Nickel Concentration (ug/l)
0.25
0.2
0.15
0.1
0.05
0
40238
40330
40422
40513
40603
40695
40787
40878
40969
41061
41153
41244
41334
41426
41518
41609
41699
41791
41883
41974
42064
42156
42248
42339
42430
42522
42614
42705
42795
42887
42979
W2
Trigger Limit

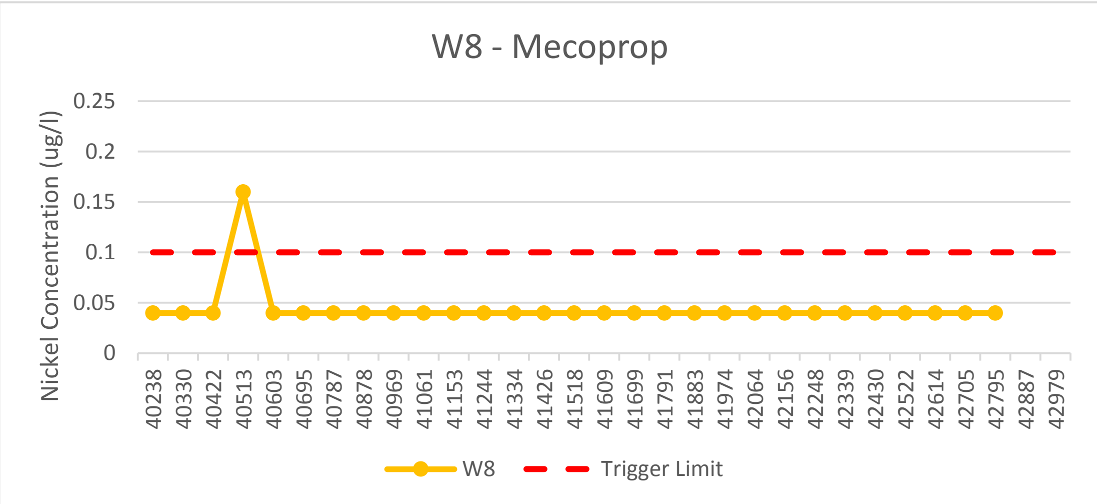

W3 - Mecoprop
Nickel Concentration (ug/l)
0.25
0.2
0.15
0.1
0.05
0
40238
40330
40422
40513
40603
40695
40787
40878
40969
41061
41153
41244
41334
41426
41518
41609
41699
41791
41883
41974
42064
42156
42248
42339
42430
42522
42614
42705
42795
42887
42979
W3
Trigger Limit

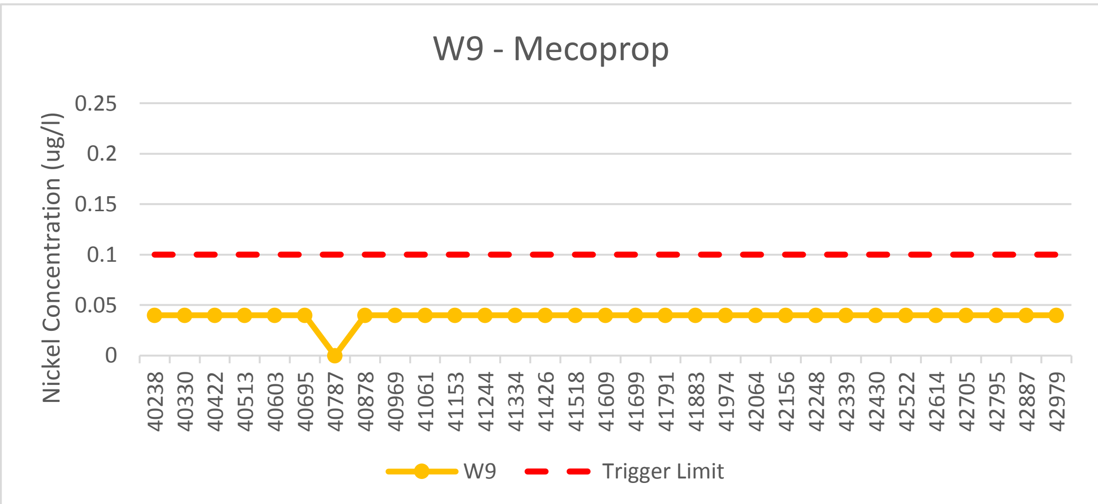

W4 - Mecoprop
Nickel Concentration (ug/l)
0.25
0.2
0.15
0.1
0.05
0
40238
40330
40422
40513
40603
40695
40787
40878
40969
41061
41153
41244
41334
41426
41518
41609
41699
41791
41883
41974
42064
42156
42248
42339
42430
42522
42614
42705
42795
42887
42979
W4
Trigger Limit

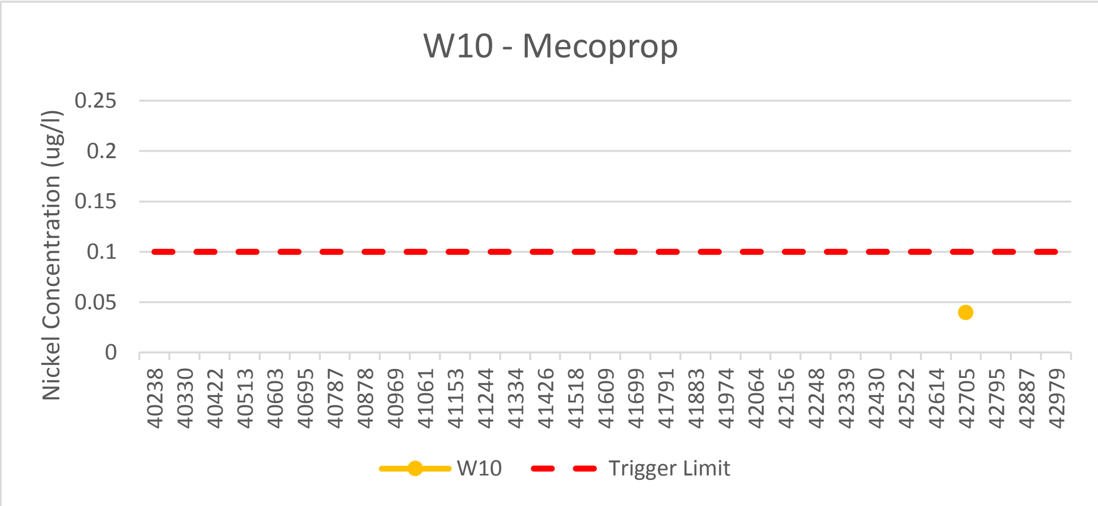

W5 - Mecoprop
Nickel Concentration (ug/l)
0.25
0.2
0.15
0.1
0.05
0
40238
40330
40422
40513
40603
40695
40787
40878
40969
41061
41153
41244
41334
41426
41518
41609
41699
41791
41883
41974
42064
42156
42248
42339
42430
42522
42614
42705
42795
42887
42979
W5
Trigger Limit

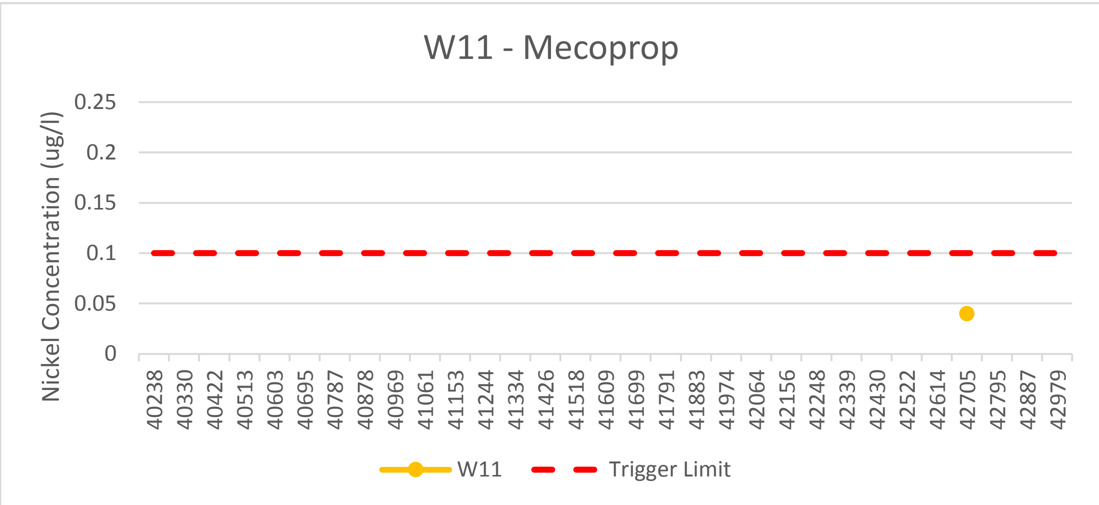

W6 - Mecoprop
Nickel Concentration (ug/l)
0.25
0.2
0.15
0.1
0.05
0
40238
40330
40422
40513
40603
40695
40787
40878
40969
41061
41153
41244
41334
41426
41518
41609
41699
41791
41883
41974
42064
42156
42248
42339
42430
42522
42614
42705
42795
42887
42979
W6
Trigger Limit


W7 - Mecoprop
Nickel Concentration (ug/l)
0.25
0.2
0.15
0.1
0.05
0
40238
40330
40422
40513
40603
40695
40787
40878
40969
41061
41153
41244
41334
41426
41518
41609
41699
41791
41883
41974
42064
42156
42248
42339
42430
42522
42614
42705
42795
42887
42979
W7
Trigger Limit


W8 - Mecoprop
Nickel Concentration (ug/l)
0.25
0.2
0.15
0.1
0.05
0
40238
40330
40422
40513
40603
40695
40787
40878
40969
41061
41153
41244
41334
41426
41518
41609
41699
41791
41883
41974
42064
42156
42248
42339
42430
42522
42614
42705
42795
42887
42979
W8
Trigger Limit

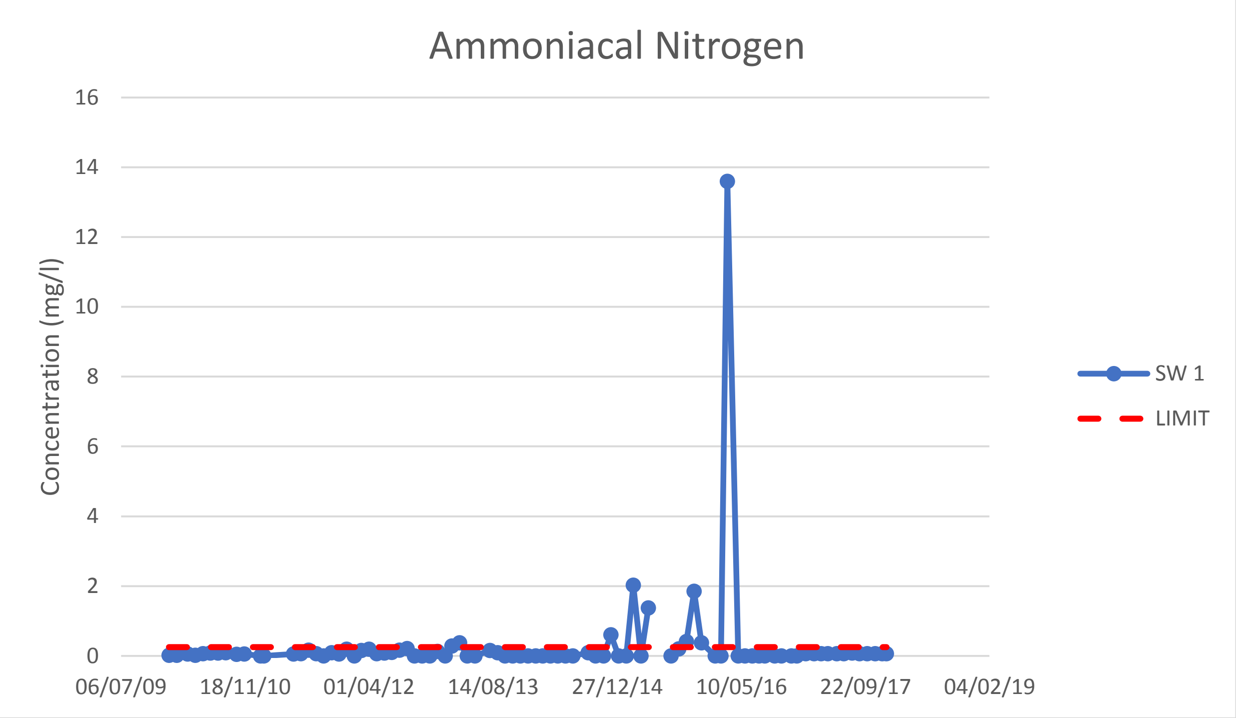

W9 - Mecoprop
Nickel Concentration (ug/l)
0.25
0.2
0.15
0.1
0.05
0
40238
40330
40422
40513
40603
40695
40787
40878
40969
41061
41153
41244
41334
41426
41518
41609
41699
41791
41883
41974
42064
42156
42248
42339
42430
42522
42614
42705
42795
42887
42979
W9
Trigger Limit

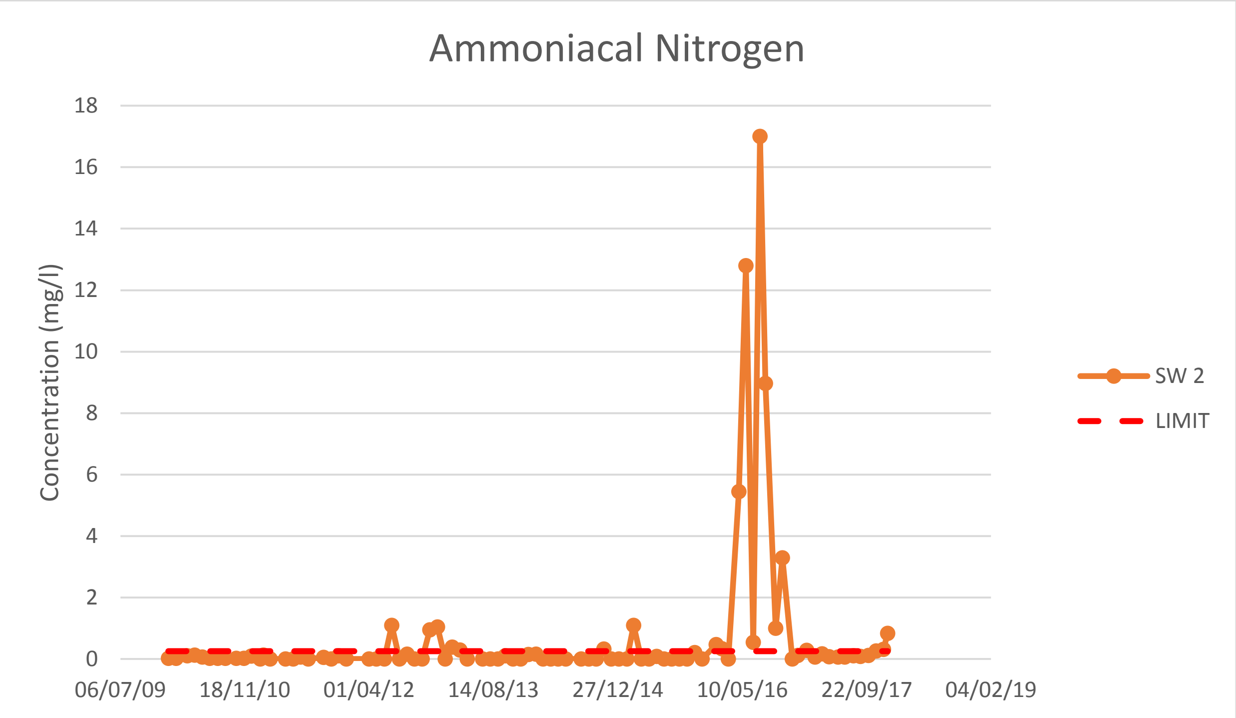

W10 - Mecoprop
Nickel Concentration (ug/l)
0.25
0.2
0.15
0.1
0.05
0
40238
40330
40422
40513
40603
40695
40787
40878
40969
41061
41153
41244
41334
41426
41518
41609
41699
41791
41883
41974
42064
42156
42248
42339
42430
42522
42614
42705
42795
42887
42979
W10
Trigger Limit

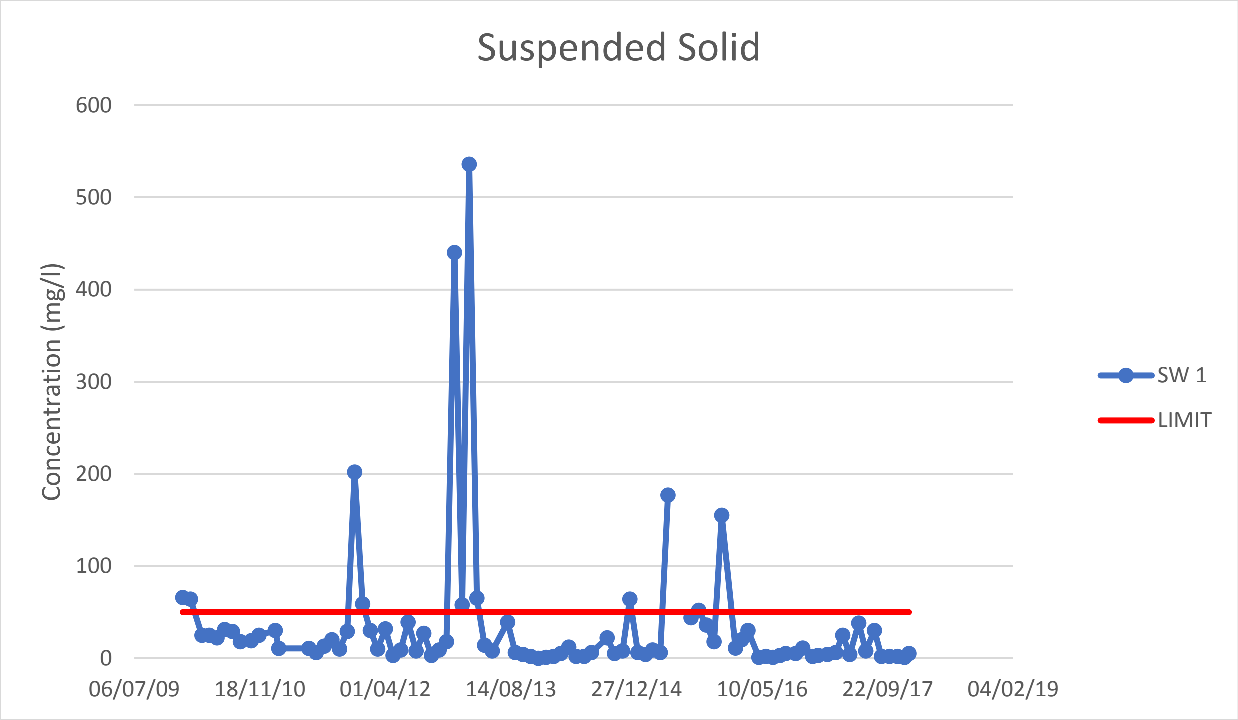

W11 - Mecoprop
Nickel Concentration (ug/l)
0.25
0.2
0.15
0.1
0.05
0
40238
40330
40422
40513
40603
40695
40787
40878
40969
41061
41153
41244
41334
41426
41518
41609
41699
41791
41883
41974
42064
42156
42248
42339
42430
42522
42614
42705
42795
42887
42979
W11
Trigger Limit

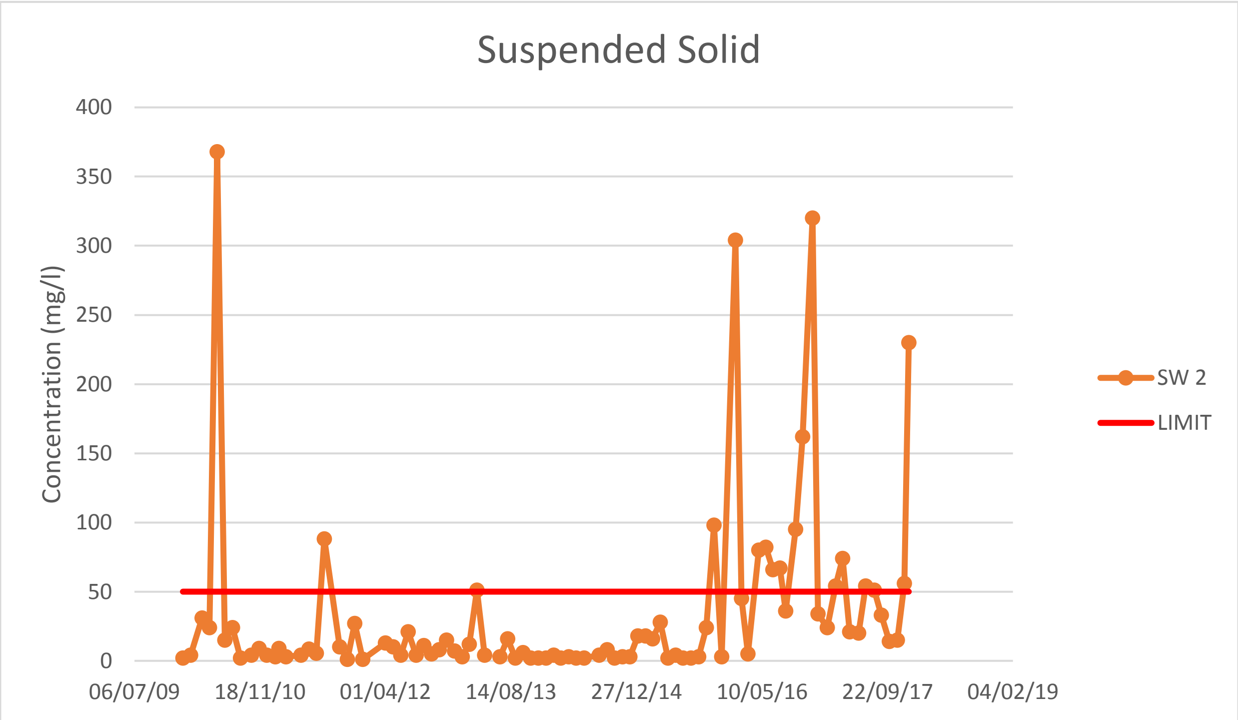
APPENDIX 3

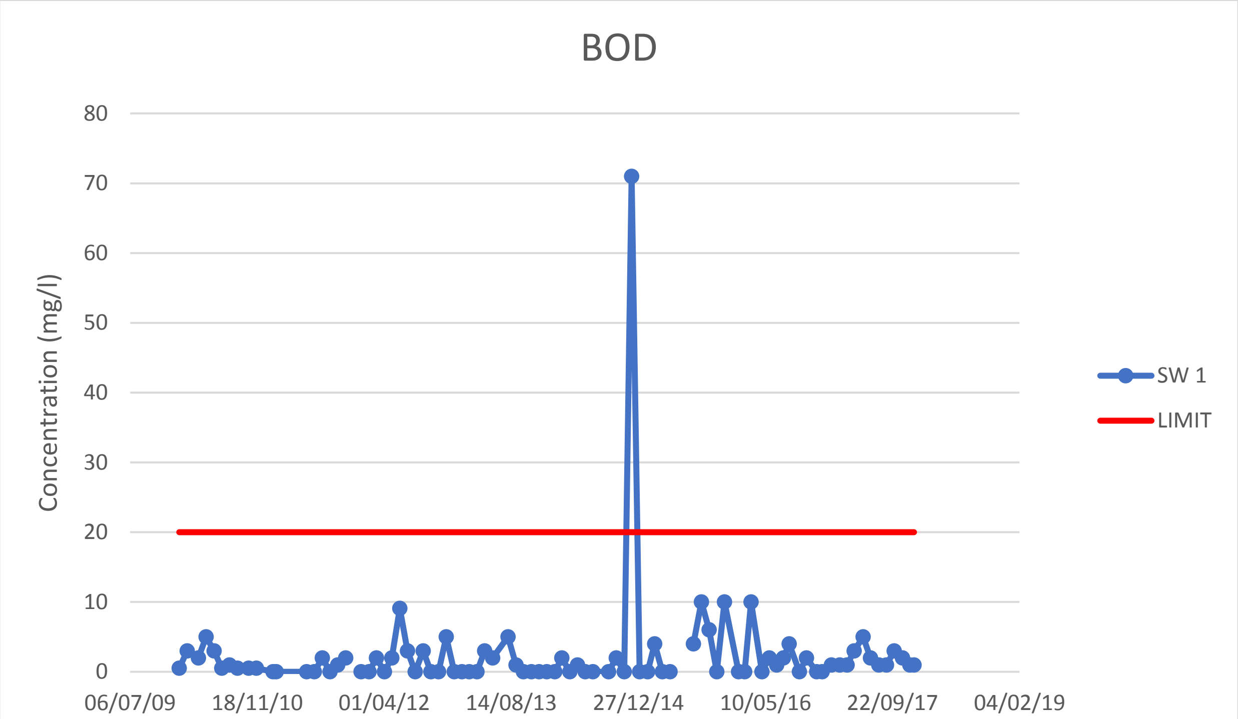
Surface water quality

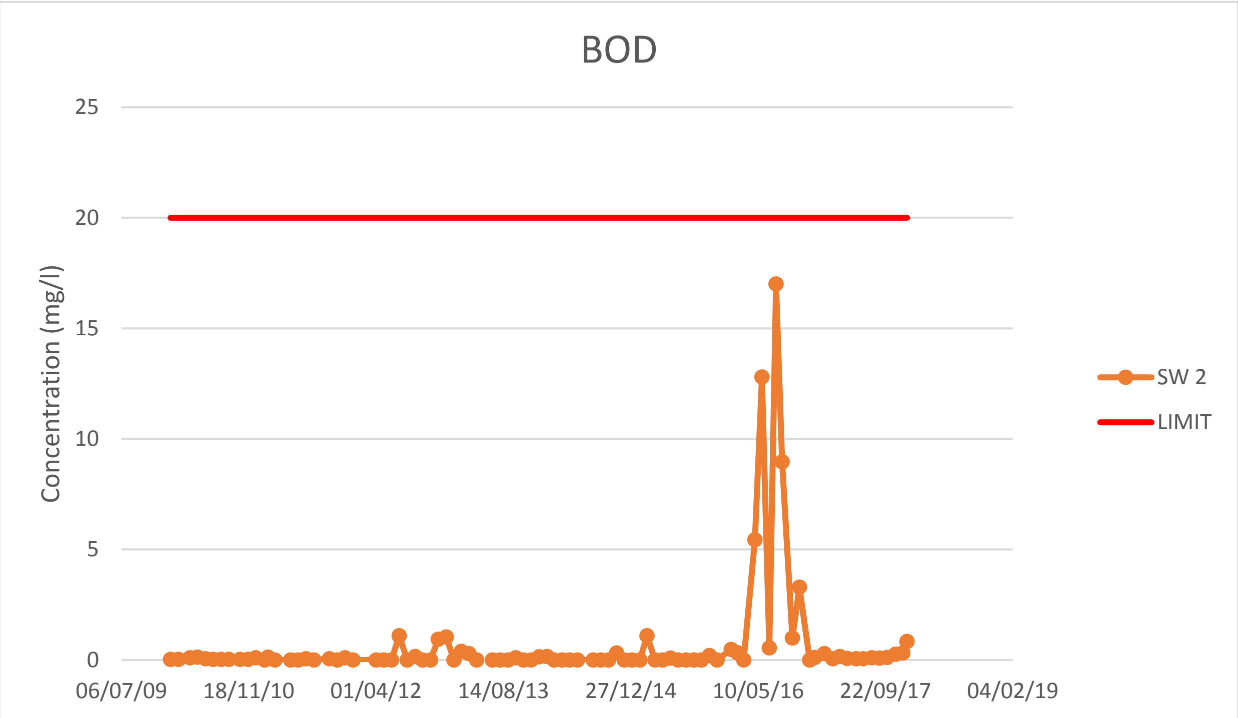

Ammoniacal Nitrogen
Concentration (mg/l)
16
14
12
10
8
6
4
2
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
SW 1
LIMIT

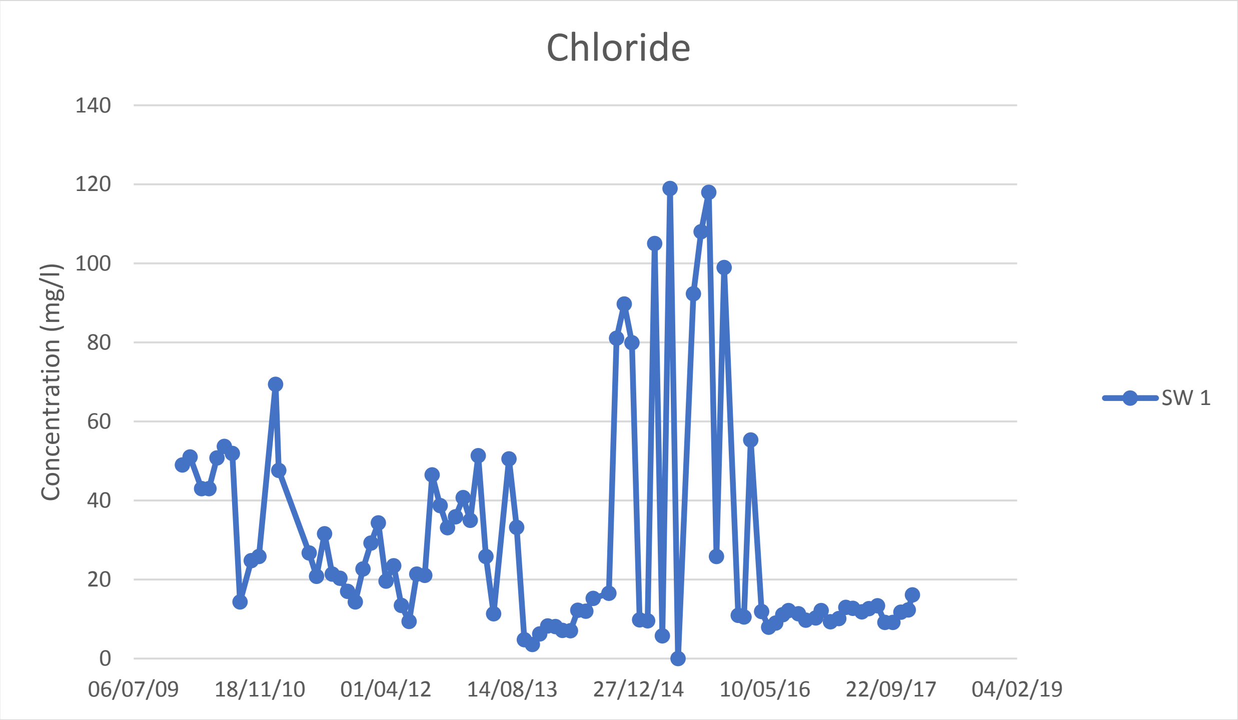

Ammoniacal Nitrogen
Concentration (mg/l)
18
16
14
12
10
8
6
4
2
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
SW 2
LIMIT

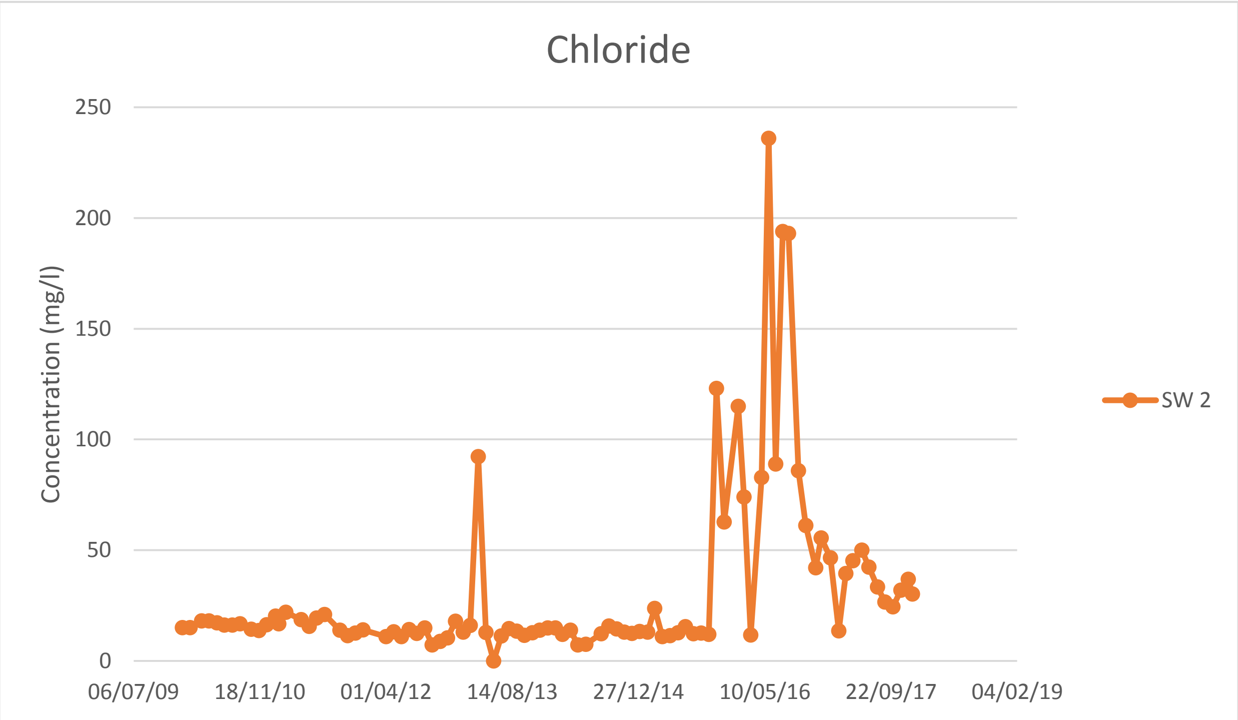

Suspended Solid
Concentration (mg/l)
600
500
400
300
200
100
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
SW 1
LIMIT

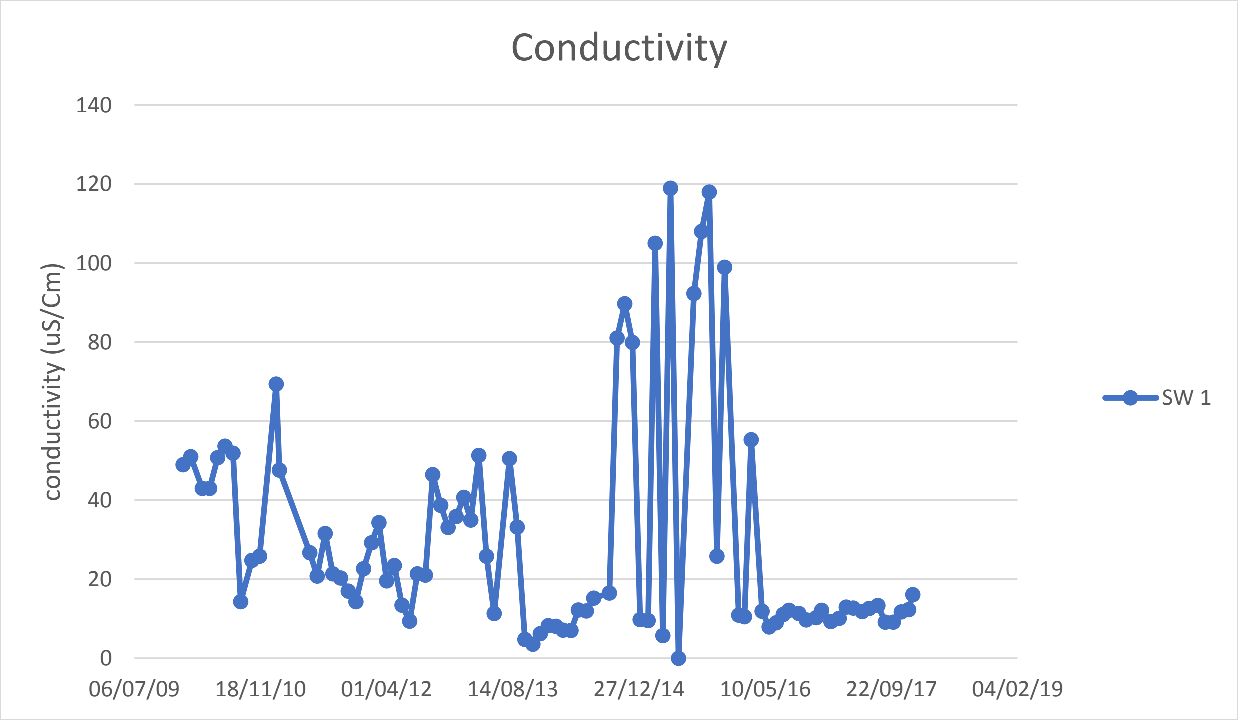

Suspended Solid
Concentration (mg/l)
400
350
300
250
200
150
100
50
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
SW 2
LIMIT

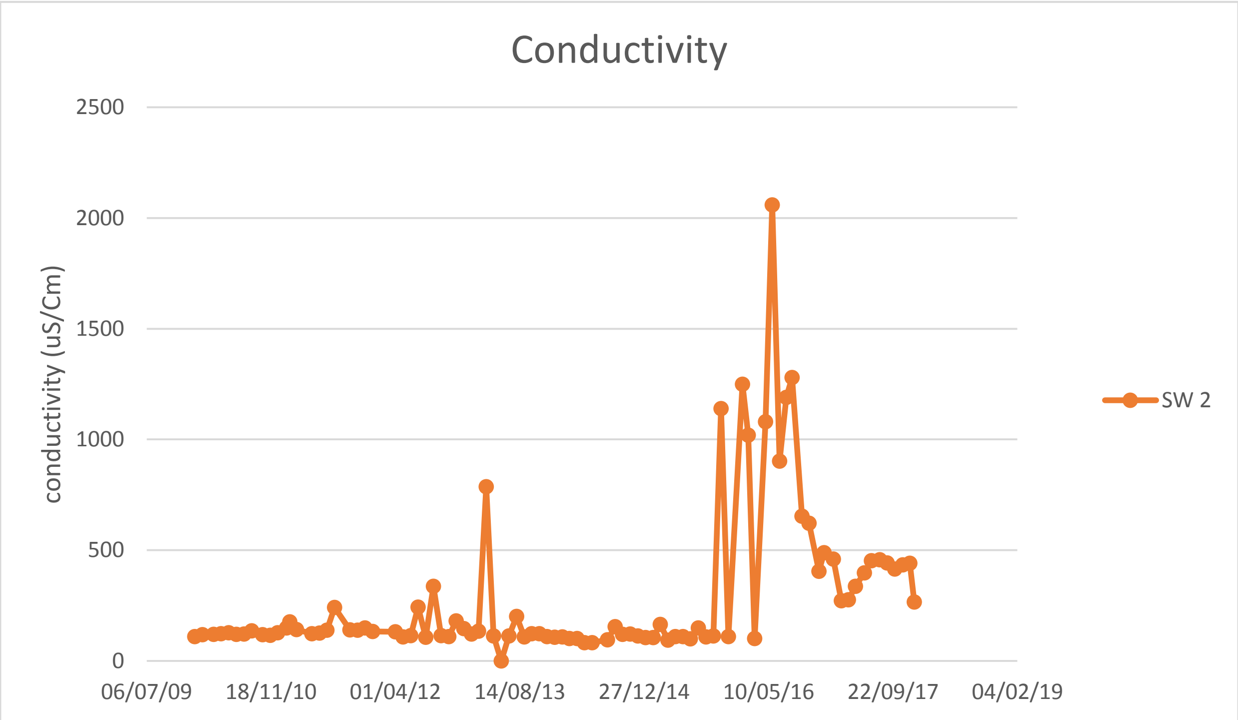

BOD
80
70
60
50
40
30
20
10
0
Concentration (mg/l)
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
SW 1
LIMIT

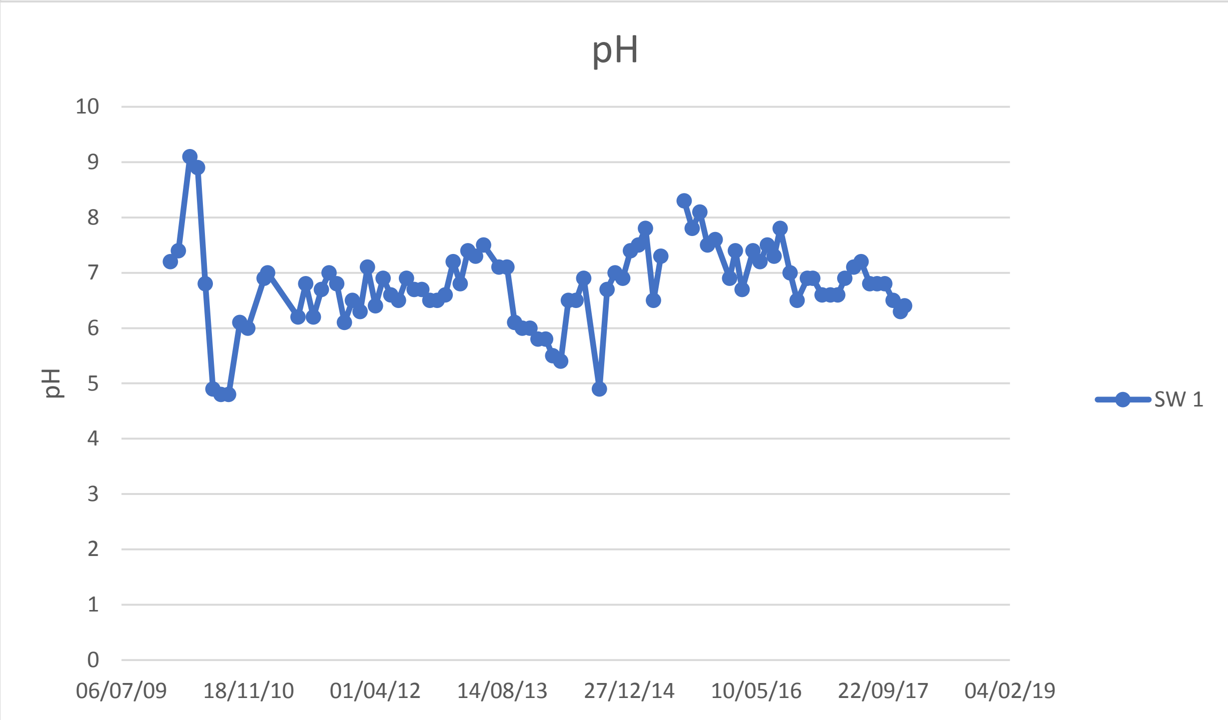

BOD
25
20
15
10
5
0
Concentration (mg/l)
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
SW 2
LIMIT

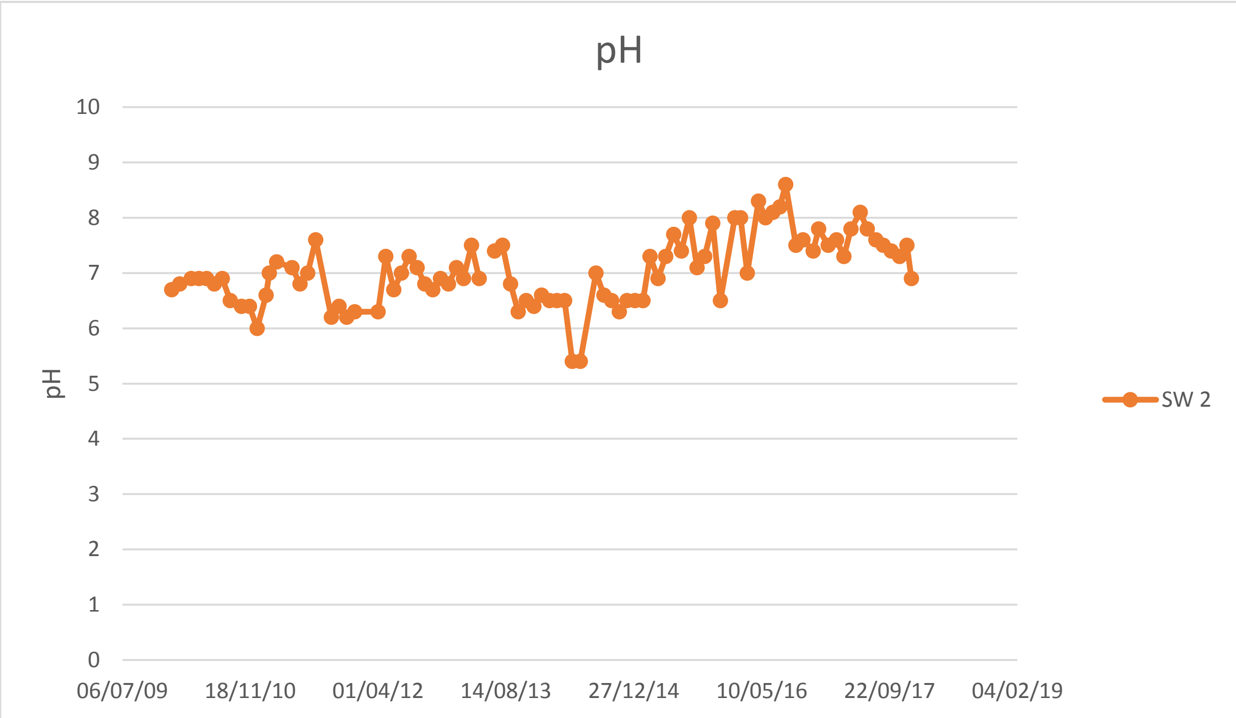

Chloride
Concentration (mg/l)
0
20
40
60
80
100
120
140
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
SW 1


Chloride
Concentration (mg/l)
0
50
100
150
200
250
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
SW 2


Conductivity
conductivity (uS/Cm)
140
120
100
80
60
40
20
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
SW 1


Conductivity
conductivity (uS/Cm)
2500
2000
1500
1000
500
0
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
SW 2


pH
10
9
8
7
6
5
4
3
2
1
0
pH
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
SW 1


pH
10
9
8
7
6
5
4
3
2
1
0
pH
06/07/09
18/11/10
01/04/12
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
SW 2

APPENDIX 4

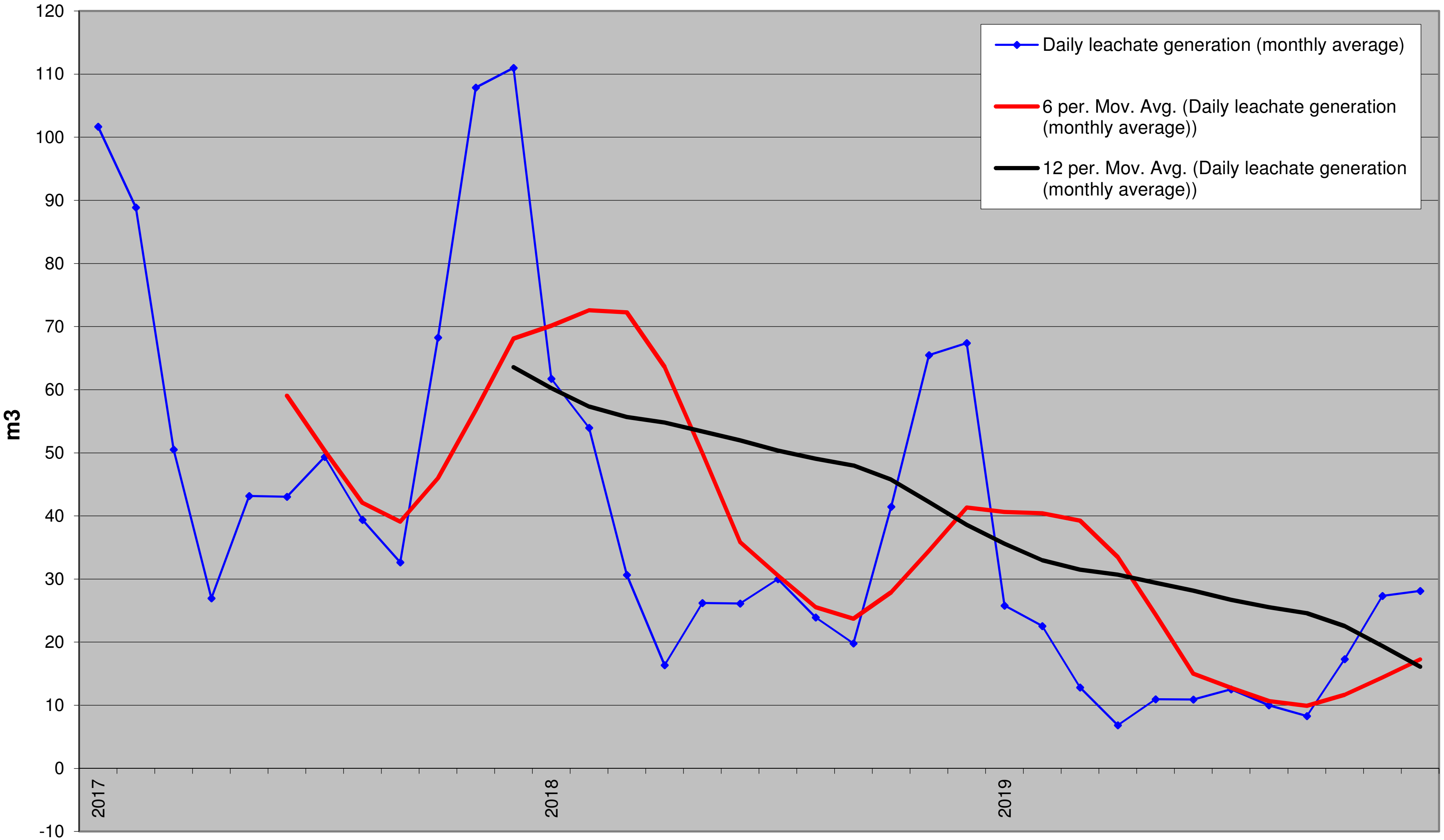
LandSim models:

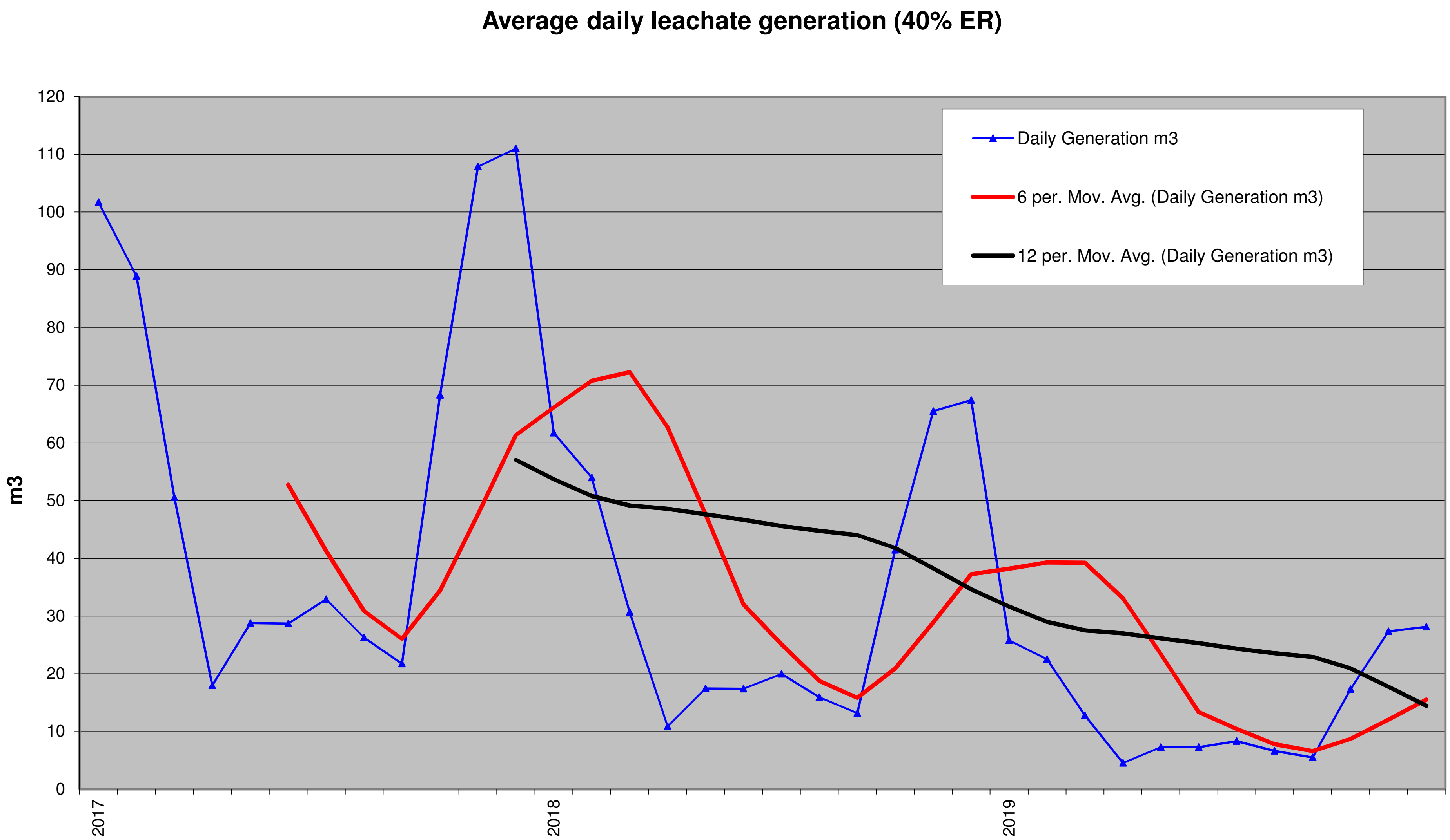
Electronic format only.

APPENDIX 5

Water Balance Calculations

Average daily leachate generation (60% ER)





Average daily leachate generation (40% ER)
m3
120
110
100
90
80
70
60
50
40
30
20
10
0
2017
2018
2019
Daily Generation m3
6 per. Mov. Avg. (Daily Generation m3)
12 per. Mov. Avg. (Daily Generation m3)

Bryn Posteg: Massbalance leachate generation

Waste Density	1	Mg/m3
Abs Capacity	0.03	m3 per m3
Effective Rainfall (Winter)	100%	of TR(monthly values)
Effective Rainfall (Summer)	60%	of TR(monthly values)
infiltration rate temporarily restored	50%	(monthly values)
Infiltration rate fully restored	**5% of ER**	(monthly values)

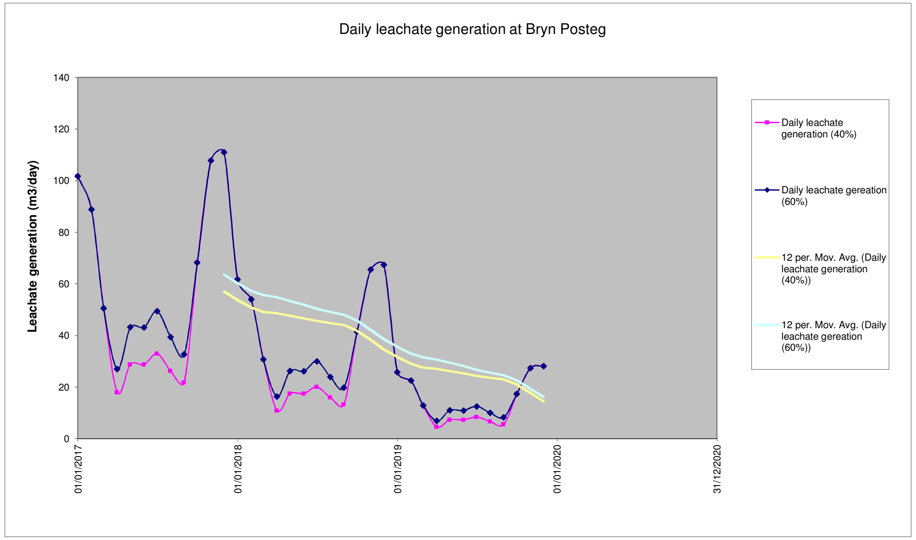
Year	Month	Active Phase	Temp restored phase Up to and Incl	restored phase Up to and Incl	Effective Rainfall mm	Active Catchment Area m^2	Active Infiltration m^3	Temp restored phase	Temp rest area m^2	Temp rest infiltration m3	Restored Phase	Restored Area m^2	Restored Infiltration m3	Waste Input tons/month	Total Water m3	Cumulative Water m3	Absorptive Capacity m3	Cumulative Absorptive Capacity m3	Cumulative Generation m3	Monthly Generation m3	Daily Generation m3	Seasonal to yearly total
2017	Jan	Cell 9D		Cells 1-9C	106.9	22415	2397.1			0.0	Cells 1-9C	122241	653.6		3050.7	3050.7		0.0	3050.7	3050.7	101.7	
	Feb	Cell 9D		Cells 1-9C	93.5	22415	2095.3			0.0	Cells 1-9C	122241	571.3		2666.6	5717.3		0.0	5717.3	2666.6	88.9	
	Mar	Cell 9D		Cells 1-9C	53.1	22415	1191.1			0.0	Cells 1-9C	122241	324.8		1515.9	7233.2		0.0	7233.2	1515.9	50.5	7233.2
	Apr	Cell 9D		Cells 1-9C	28.4	22415	635.6			0.0	Cells 1-9C	122241	173.3		808.9	8042.1		0.0	8042.1	808.9	27.0	
	May	Cell 9D		Cells 1-9C	45.4	22415	1017.3			0.0	Cells 1-9C	122241	277.4		1294.7	9336.8		0.0	9336.8	1294.7	43.2	
	Jun	Cell 9D		Cells 1-9C	45.3	22415	1014.8			0.0	Cells 1-9C	122241	276.7		1291.6	10628.4		0.0	10628.4	1291.6	43.1	
	Jul	Cell 9D		Cells 1-9C	51.9	22415	1164.0			0.0	Cells 1-9C	122241	317.4		1481.4	12109.7		0.0	12109.7	1481.4	49.4	
	Aug	Cell 9D		Cells 1-9C	41.4	22415	928.4			0.0	Cells 1-9C	122241	253.1		1181.5	13291.2		0.0	13291.2	1181.5	39.4	
	Sep	Cell 9D		Cells 1-9C	34.3	22415	769.8			0.0	Cells 1-9C	122241	209.9		979.7	14270.9		0.0	14270.9	979.7	32.7	7037.7
	Oct	Cell 9D		Cells 1-9C	71.8	22415	1609.7			0.0	Cells 1-9C	122241	438.9		2048.6	16319.5		0.0	16319.5	2048.6	68.3	
	Nov	Cell 9D		Cells 1-9C	113.4	22415	2542.4			0.0	Cells 1-9C	122241	693.3		3235.7	19555.2		0.0	19555.2	3235.7	107.9	
	Dec	Cell 9D		Cells 1-9C	116.7	22415	2615.9			0.0	Cells 1-9C	122241	713.3		3329.2	22884.4		0.0	22884.4	3329.2	111.0	22884.4
2018	Jan		Cell 9D	Cells 1-9C	106.9		0.0	Cell 9D	22415	1198.6	Cells 1-9C	122241	653.6		1852.2	24736.6		0.0	24736.6	1852.2	61.7	
	Feb		Cell 9D	Cells 1-9C	93.5		0.0	Cell 9D	22415	1047.6	Cells 1-9C	122241	571.3		1619.0	26355.5		0.0	26355.5	1619.0	54.0	
	Mar		Cell 9D	Cells 1-9C	53.1		0.0	Cell 9D	22415	595.5	Cells 1-9C	122241	324.8		920.3	27275.9		0.0	27275.9	920.3	30.7	13005.0
	Apr		Cell 9D	Cells 1-9C	28.4		0.0	Cell 9D	22415	317.8	Cells 1-9C	122241	173.3		491.1	27767.0		0.0	27767.0	491.1	16.4	
	May		Cell 9D	Cells 1-9C	45.4		0.0	Cell 9D	22415	508.7	Cells 1-9C	122241	277.4		786.1	28553.0		0.0	28553.0	786.1	26.2	
	Jun		Cell 9D	Cells 1-9C	45.3		0.0	Cell 9D	22415	507.4	Cells 1-9C	122241	276.7		784.1	29337.2		0.0	29337.2	784.1	26.1	
	Jul		Cell 9D	Cells 1-9C	51.9		0.0	Cell 9D	22415	582.0	Cells 1-9C	122241	317.4		899.4	30236.5		0.0	30236.5	899.4	30.0	
	Aug		Cell 9D	Cells 1-9C	41.4		0.0	Cell 9D	22415	464.2	Cells 1-9C	122241	253.1		717.3	30953.9		0.0	30953.9	717.3	23.9	
	Sep		Cell 9D	Cells 1-9C	34.3		0.0	Cell 9D	22415	384.9	Cells 1-9C	122241	209.9		594.8	31548.6		0.0	31548.6	594.8	19.8	4272.8
	Oct		Cell 9D	Cells 1-9C	71.8		0.0	Cell 9D	22415	804.8	Cells 1-9C	122241	438.9		1243.8	32792.4		0.0	32792.4	1243.8	41.5	
	Nov		Cell 9D	Cells 1-9C	113.4		0.0	Cell 9D	22415	1271.2	Cells 1-9C	122241	693.3		1964.5	34756.9		0.0	34756.9	1964.5	65.5	
	Dec		Cell 9D	Cells 1-9C	116.7		0.0	Cell 9D	22415	1307.9	Cells 1-9C	122241	713.3		2021.2	36778.1		0.0	36778.1	2021.2	67.4	13893.7
2019	Jan			All Cells	106.9		0.0			0.0	All Cells	144656	773.5		773.5	37551.6	0.0	0.0	37551.6	773.5	25.8	
	Feb			All Cells	93.5		0.0			0.0	All Cells	144656	676.1		676.1	38227.7	0.0	0.0	38227.7	676.1	22.5	
	Mar			All Cells	53.1		0.0			0.0	All Cells	144656	384.3		384.3	38612.0	0.0	0.0	38612.0	384.3	12.8	7063.4
	Apr			All Cells	28.4		0.0			0.0	All Cells	144656	205.1		205.1	38817.1	0.0	0.0	38817.1	205.1	6.8	
	May			All Cells	45.4		0.0			0.0	All Cells	144656	328.3		328.3	39145.4	0.0	0.0	39145.4	328.3	10.9	
	Jun			All Cells	45.3		0.0			0.0	All Cells	144656	327.5		327.5	39472.9	0.0	0.0	39472.9	327.5	10.9	
	Jul			All Cells	51.9		0.0			0.0	All Cells	144656	375.6		375.6	39848.4	0.0	0.0	39848.4	375.6	12.5	
	Aug			All Cells	41.4		0.0			0.0	All Cells	144656	299.6		299.6	40148.0	0.0	0.0	40148.0	299.6	10.0	
	Sep			All Cells	34.3		0.0			0.0	All Cells	144656	248.4		248.4	40396.4	0.0	0.0	40396.4	248.4	8.3	1784.4
	Oct			All Cells	71.8		0.0			0.0	All Cells	144656	519.4		519.4	40915.8	0.0	0.0	40915.8	519.4	17.3	
	Nov			All Cells	113.4		0.0			0.0	All Cells	144656	820.4		820.4	41736.2	0.0	0.0	41736.2	820.4	27.3	
	Dec			All Cells	116.7		0.0			0.0	All Cells	144656	844.1		844.1	42580.3	0.0	0.0	42580.3	844.1	28.1	5802.1

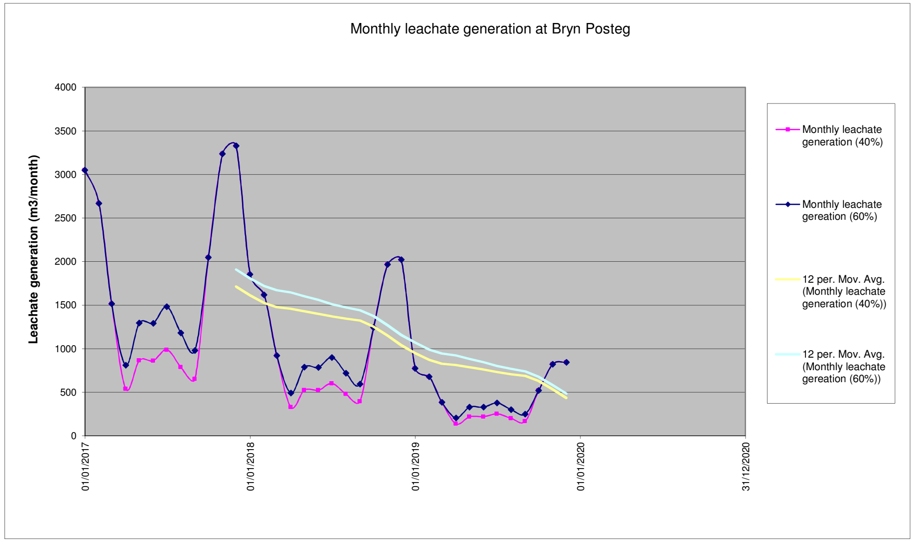
Bryn Posteg: Massbalance leachate generation

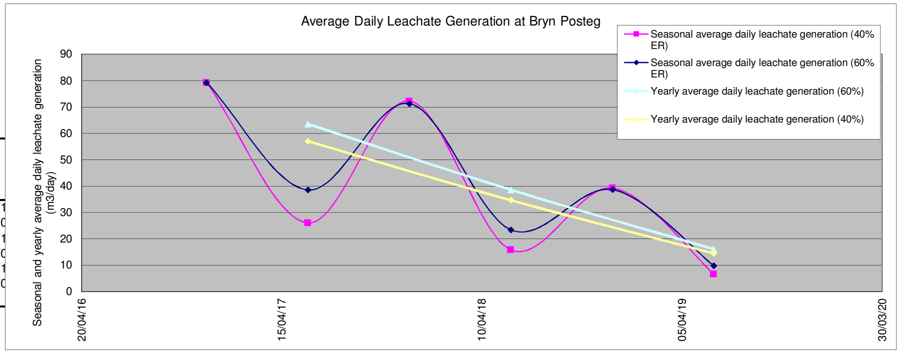
Waste Density	1	Mg/m3
Abs Capacity	0.03	m3 per m3
Effective Rainfall (Winter)	100%	of TR(monthly values)
Effective Rainfall (Summer)	40%	of TR(monthly values)
infiltration rate temporarily restored	50%	(monthly values)
Infiltration rate fully restored	**5% of ER**	(monthly values)

Year	Month	Active Phase	Temp restored phase Up to and Incl	restored phase Up to and Incl	Effective Rainfall mm	Active Catchment Area m^2	Active Infiltration m^3	Temp restored phase	Temp rest area m^2	Temp rest infiltration m3	Restored Phase	Restored Area m^2	Restored Infiltration m3	Waste Input tons/month	Total Water m3	Cumulative Water m3	Absorptive Capacity m3	Cumulative Absorptive Capacity m3	Cumulative Generation m3	Monthly Generation m3	Daily Generation m3	Seasonal to yearly total
2017	Jan	Cell 9D		Cells 1-9C	106.9	22415	2397.1			0.0	Cells 1-9C	122241	653.6		3050.7	3050.7		0.0	3050.7	3050.7	101.7	
	Feb	Cell 9D		Cells 1-9C	93.5	22415	2095.3			0.0	Cells 1-9C	122241	571.3		2666.6	5717.3		0.0	5717.3	2666.6	88.9	
	Mar	Cell 9D		Cells 1-9C	53.1	22415	1191.1			0.0	Cells 1-9C	122241	324.8		1515.9	7233.2		0.0	7233.2	1515.9	50.5	7233.2
	Apr	Cell 9D		Cells 1-9C	18.9	22415	423.7			0.0	Cells 1-9C	122241	115.5		539.3	7772.5		0.0	7772.5	539.3	18.0	
	May	Cell 9D		Cells 1-9C	30.3	22415	678.2			0.0	Cells 1-9C	122241	184.9		863.1	8635.6		0.0	8635.6	863.1	28.8	
	Jun	Cell 9D		Cells 1-9C	30.2	22415	676.6			0.0	Cells 1-9C	122241	184.5		861.0	9496.6		0.0	9496.6	861.0	28.7	
	Jul	Cell 9D		Cells 1-9C	34.6	22415	776.0			0.0	Cells 1-9C	122241	211.6		987.6	10484.2		0.0	10484.2	987.6	32.9	
	Aug	Cell 9D		Cells 1-9C	27.6	22415	618.9			0.0	Cells 1-9C	122241	168.8		787.7	11271.9		0.0	11271.9	787.7	26.3	
	Sep	Cell 9D		Cells 1-9C	22.9	22415	513.2			0.0	Cells 1-9C	122241	139.9		653.1	11925.0		0.0	11925.0	653.1	21.8	4691.8
	Oct	Cell 9D		Cells 1-9C	71.8	22415	1609.7			0.0	Cells 1-9C	122241	438.9		2048.6	13973.6		0.0	13973.6	2048.6	68.3	
	Nov	Cell 9D		Cells 1-9C	113.4	22415	2542.4			0.0	Cells 1-9C	122241	693.3		3235.7	17209.3		0.0	17209.3	3235.7	107.9	
	Dec	Cell 9D		Cells 1-9C	116.7	22415	2615.9			0.0	Cells 1-9C	122241	713.3		3329.2	20538.5		0.0	20538.5	3329.2	111.0	20538.5
2018	Jan		Cell 9D	Cells 1-9C	106.9		0.0	Cell 9D	22415	1198.6	Cells 1-9C	122241	653.6		1852.2	22390.7		0.0	22390.7	1852.2	61.7	
	Feb		Cell 9D	Cells 1-9C	93.5		0.0	Cell 9D	22415	1047.6	Cells 1-9C	122241	571.3		1619.0	24009.6		0.0	24009.6	1619.0	54.0	
	Mar		Cell 9D	Cells 1-9C	53.1		0.0	Cell 9D	22415	595.5	Cells 1-9C	122241	324.8		920.3	24930.0		0.0	24930.0	920.3	30.7	13005.0
	Apr		Cell 9D	Cells 1-9C	18.9		0.0	Cell 9D	22415	211.9	Cells 1-9C	122241	115.5		327.4	25257.4		0.0	25257.4	327.4	10.9	
	May		Cell 9D	Cells 1-9C	30.3		0.0	Cell 9D	22415	339.1	Cells 1-9C	122241	184.9		524.0	25781.4		0.0	25781.4	524.0	17.5	
	Jun		Cell 9D	Cells 1-9C	30.2		0.0	Cell 9D	22415	338.3	Cells 1-9C	122241	184.5		522.8	26304.2		0.0	26304.2	522.8	17.4	
	Jul		Cell 9D	Cells 1-9C	34.6		0.0	Cell 9D	22415	388.0	Cells 1-9C	122241	211.6		599.6	26903.7		0.0	26903.7	599.6	20.0	
	Aug		Cell 9D	Cells 1-9C	27.6		0.0	Cell 9D	22415	309.5	Cells 1-9C	122241	168.8		478.2	27382.0		0.0	27382.0	478.2	15.9	
	Sep		Cell 9D	Cells 1-9C	22.9		0.0	Cell 9D	22415	256.6	Cells 1-9C	122241	139.9		396.5	27778.5		0.0	27778.5	396.5	13.2	2848.5
	Oct		Cell 9D	Cells 1-9C	71.8		0.0	Cell 9D	22415	804.8	Cells 1-9C	122241	438.9		1243.8	29022.2		0.0	29022.2	1243.8	41.5	
	Nov		Cell 9D	Cells 1-9C	113.4		0.0	Cell 9D	22415	1271.2	Cells 1-9C	122241	693.3		1964.5	30986.7		0.0	30986.7	1964.5	65.5	
	Dec		Cell 9D	Cells 1-9C	116.7		0.0	Cell 9D	22415	1307.9	Cells 1-9C	122241	713.3		2021.2	33008.0		0.0	33008.0	2021.2	67.4	12469.5
2019	Jan			All Cells	106.9		0.0			0.0	All Cells	144656	773.5		773.5	33781.5	0.0	0.0	33781.5	773.5	25.8	
	Feb			All Cells	93.5		0.0			0.0	All Cells	144656	676.1		676.1	34457.5	0.0	0.0	34457.5	676.1	22.5	
	Mar			All Cells	53.1		0.0			0.0	All Cells	144656	384.3		384.3	34841.9	0.0	0.0	34841.9	384.3	12.8	7063.4
	Apr			All Cells	18.9		0.0			0.0	All Cells	144656	136.7		136.7	34978.6	0.0	0.0	34978.6	136.7	4.6	
	May			All Cells	30.3		0.0			0.0	All Cells	144656	218.8		218.8	35197.5	0.0	0.0	35197.5	218.8	7.3	
	Jun			All Cells	30.2		0.0			0.0	All Cells	144656	218.3		218.3	35415.8	0.0	0.0	35415.8	218.3	7.3	
	Jul			All Cells	34.6		0.0			0.0	All Cells	144656	250.4		250.4	35666.2	0.0	0.0	35666.2	250.4	8.3	
	Aug			All Cells	27.6		0.0			0.0	All Cells	144656	199.7		199.7	35865.9	0.0	0.0	35865.9	199.7	6.7	
	Sep			All Cells	22.9		0.0			0.0	All Cells	144656	165.6		165.6	36031.5	0.0	0.0	36031.5	165.6	5.5	1189.6
	Oct			All Cells	71.8		0.0			0.0	All Cells	144656	519.4		519.4	36550.9	0.0	0.0	36550.9	519.4	17.3	
	Nov			All Cells	113.4		0.0			0.0	All Cells	144656	820.4		820.4	37371.2	0.0	0.0	37371.2	820.4	27.3	
	Dec			All Cells	116.7		0.0			0.0	All Cells	144656	844.1		844.1	38215.3	0.0	0.0	38215.3	844.1	28.1	5207.4

	Daily leachate generation Total	Daily leachate generation up to 110 mAOD	Daily leachate generation SWLP only	Daily leachate generation closed			Monthly leachate generation Total	Monthly leachate generation up to 110 mAOD	Monthly leachate generation SWLP only	Monthly leachate generation closed			Daily leachate generation Total	Daily leachate generation up to 110 mAOD	Daily leachate generation SWLP only	Daily leachate generation closed			Monthly leachate generation Total	Monthly leachate generation up to 110 mAOD	Monthly leachate generation SWLP only	Monthly leachate generation closed
Date	0.6	0.6	0.6	0.6		Date	0.6	0.6	0.6	0.6		Date	0.4	0.4	0.4	0.4		Date	0.4	0.4	0.4	0.4







Rainfall data from site weather station

Total Rainfall (mm)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Average (10 year)	Previous model values (mm)
jan		91.0	48.3	98.0	129.1	67.6	186.4	122.6	138.6	49.7	138.1	106.9	103.4
feb		11.0	42.5	105.8	48.9	58.9	235.2	122.8	110.9	135.8	63.0	93.5	83.7
mar		44.4	49.2	15.8	15.2	60.8	46.5	93.8	99.1	106.5	0.0	53.1	37.1
apr		60.9	32.1	10.2	130.3	27.9	52.9	23.7	68.7	18.5		47.3	31.4
may		81.7	43.5	73.7	63.0	91.8	137.4	103.8	51.3	34.6		75.6	42.4
jun		47.5	54.5	109.3	160.6	52.7	40.9	47.9	101.5	64.3		75.5	50.9
jul	51.4	156.8	114.6	134.6	108.0	62.8	30.6	93.8	34.9	78.0		86.5	69.2
aug	0	45.2	65.4	48.7	88.7	63.8	119.7	96.1	46.2	116.6		69.0	37.4
sep	0	37.6	88.4	73.9	78.5	45.1	10.4	34.2	80.2	124.0		57.2	38.8
oct	0	58.0	31.2	64.5	99.8	154.3	128.3	40.7	48.8	92.6		71.8	81.6
nov	0	276.3	103.5	72.1	104.9	110.5	88.1	209.9	108.6	60.5		113.4	133.4
dec	29.4	77.4	31.9	173.2	180.2	156.2	138.2	219.0	45.6	116.0		116.7	123.8
Annual total		987.8	705.2	979.7	1207.0	952.3	1214.5	1208.3	934.4	997.1		966.7	833.2

	TR	ER 60%
Jan	106.9	106.9
Feb	93.5	93.5
Mar	53.1	53.1
Apr	47.3	28.4
May	75.6	45.4
Jun	75.5	45.3
Jul	86.5	51.9
Aug	69.0	41.4
Sep	57.2	34.3
Oct	71.8	71.8
Nov	113.4	113.4
Dec	116.7	116.7

	TR	ER summer months 40%
Jan	106.9	106.9
Feb	93.5	93.5
Mar	53.1	53.1
Apr	47.3	18.9
May	75.6	30.3
Jun	75.5	30.2
Jul	86.5	34.6
Aug	69.0	27.6
Sep	57.2	22.9
Oct	71.8	71.8
Nov	113.4	113.4
Dec	116.7	116.7

Caulmert
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