WITHYHEDGE LANDFILL

HYDROGEOLOGICAL RISK ASSESSMENT REVIEW

Report Number 2365r2v1d0524

Commissioned by

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1 INTRODUCTION

Resources Management UK Limited (RML) operates the Withyhedge Landfill Site at Bowling Farm, Rudbaxton, approximately 5.5 km north of Haverfordwest in Pembrokeshire. The site is a non-hazardous landfill that covers approximately 53 ha. The site currently comprises two phases known as Phase 1 & 2 with Phase 3 to be soon developed in accordance with Permit requirements. Phase 1 is classified as a non–hazardous landfill but has historically accepted a restricted number of hazardous wastes including asbestos. Phase 2 is a non- hazardous landfill. Both of the sites were operated by RML and were permitted as separate facilities until a variation was issued to consolidate the two sites into one. The location of each phase is shown on Drawing 2365-1 (which along with all the drawings in this report were created for the Variation Application).

At the start of 2022, the Dauson Environmental Group acquired RML. As part of the acquisition, all parties recognised that there were aspects of the site not in compliance with the Permit which is why NRW were provided with plans for a range of site improvements, several of which are ongoing. As part of the improvements, a Permit Variation application is required to revise the completed profile of the landfill.

To support the Permit Variation, this report has been independently prepared by Geotechnology Ltd on behalf of RML, in response to the Permit requirement to undertake a Hydrogeological Risk Assessment Review (HRAR) every 6 years. The review covers all three phases of the site.

Since the need for the Permit Variation was identified, the site has been served a series of Notices by NRW. In this review the focus is on the hydrogeological aspects rather than the aspects covered by the Notices.

1.1 Objectives

The site has been subject to a series of HRARs, with the most recent being in 2019 prepared by TerraConsult Ltd (TCL). This review followed several earlier approved studies undertaken by Golders and AIG:

- Golder Associates, November 2007 – Hydrogeological Risk Assessment, Withyhedge Landfill Phase 1 (report reference 07514290132.500)
- Golder Associates, June 2005 – Section B Hydrogeological Risk Assessment Withyhedge Landfill Phase 2 (report reference 04529421.502/A.0)
- AIG Consulting Ltd, 2003, Withyhedge Landfill Site, Hydrogeological Risk Assessment Review Report No: 5605/HRA v1 Date: November 2003

At its core, this HRAR comprises a review and update of the existing conceptual hydrogeological model and assessment of multiple lines of evidence, including computer simulation, of long-term predicted behaviour. The aims are to ensure that the site understanding and assessments are current and that the conclusions reached in the previously approved HRAR remain valid.

2 HISTORICAL AND FUTURE DEVELOPMENT

2.1 Location

Withyhedge landfill site is situated on the southern side of the Rudbaxton Water valley 6km north of Haverfordwest in Pembrokeshire, Wales. The site is centred on Ordnance Survey Grid Reference SM966215 and lies in a remote location with only a handful of rural dwellings within a kilometre of the site. The nearest settlement is Spittal, a village 2km to the northeast whilst a kilometre to the south is the hamlet of Rudbaxton with several houses and a church, as shown in Figure 2-1.

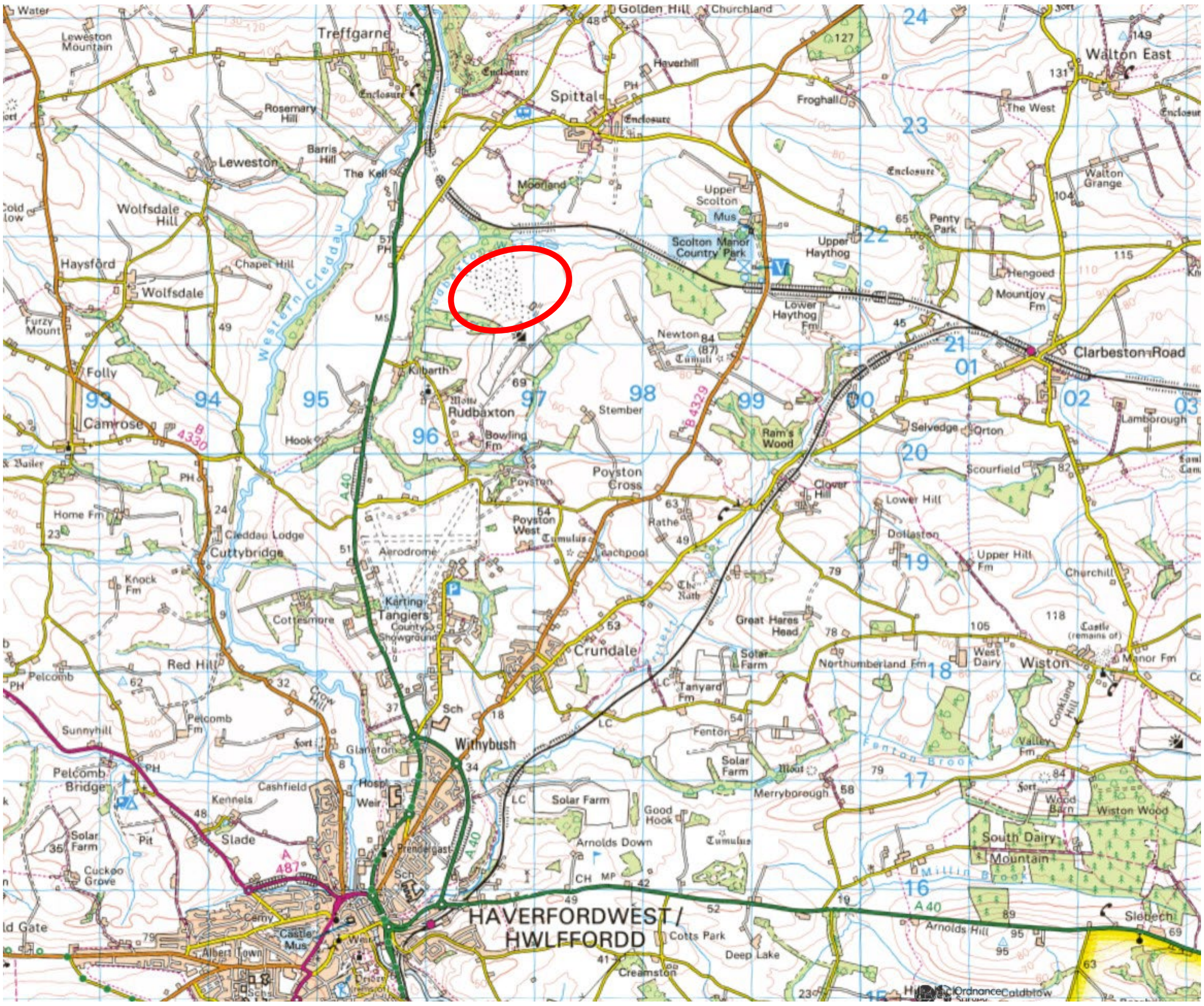


Figure 2-1 Site Location

There is no public access to the site and the nearest public road is the A40 some 500m to the west on the opposite side of the valley. Surrounded by agricultural land used for farming (including high intensity dairy farming) and solar energy, access to the site is along a 1.5km long private access road off an unclassified road between the A40 and Poyston Cross.

The site topography drains northward towards Rudbaxton Water, a small tributary of the Western Cleddau which it meets 3km to the southwest.

2.2 Previous Development

Withyhedge Landfill commenced operations in the 1980s under a local authority resolution allowing the disposal of municipal refuse. At the time there was no requirement for technical precautions to provide environmental protection so disposal activities were simply configured to facilitate disposal operations. Development commenced at the eastern end of the site in what is now referred to as Phase 1, as shown on Drawing 2365-2. A series of 10 east to west orientated cells each approximately 30m wide were developed directly on the ground surface; anecdotal evidence suggests that in places this was directly onto in-situ soils and in places directly onto bedrock. There is no form of basal barrier beneath these 10 cells which occupy the red area within Phase 1 indicated on Figure 2-2.

In October 1995 an attempt was made to restrict shallow perched groundwater from entering the landfill cells in Phase 1. CL Associates carried out a trial pit investigation and found that the superficial deposits were typically between 1 and 2m deep and were underlain by weathered and unweathered shales. A design for a "Groundwater Cut-off" was produced comprising a backfilled trench lined with GCL on the downslope side. The trench was excavated 0.5m into the shales, mistakenly thinking that the groundwater was perched on top of the intact bedrock. The design did not recognise that the flow of groundwater is principally fracture flow in the open fractures within the shale bedrock down to a depth of 10m or so. The works comprised a GCL panel laid to depths of between 2m and 3.5m below ground level in a trench excavated on the upslope side of Phase 1. The backfilled trench was then used to form the surface water ditch that is still seen along the southern boundary of Phase 1. The trench continued down the eastern side of Phase 1.

Anecdotal information suggests that the groundwater cut-off was ineffective. This is to be expected as the cut-off was only just deep enough to hit the top of the water bearing stratum. Without positive drainage on the upgradient side pressure differential cannot be achieved with the design and therefore groundwater in the shale bedrock is free to move beneath the cut-off unhindered. The cut-off however may have been useful in isolating groundwater perched in lenses within the glacial deposits and accordingly, works on the southern edge of Phase 1 may have benefited from the cut-off. However, the presence of the shallow GCL embedded into the top of the shale does not influence groundwater flow beneath the site.

With the advent of the Waste Management Licencing Regulations in the late 1990's, the engineering standards were improved and 3 subsequent cells (indicated orange on Figure 2-2) were provided with a 1 metre thick recompacted site won mineral liner. Evidence from more recent work at the site reveals that the locally won clay has a very low permeability when recompacted and there is a reasonable expectation that these cells have a liner permeability of around 1×10^{-9} m/s.

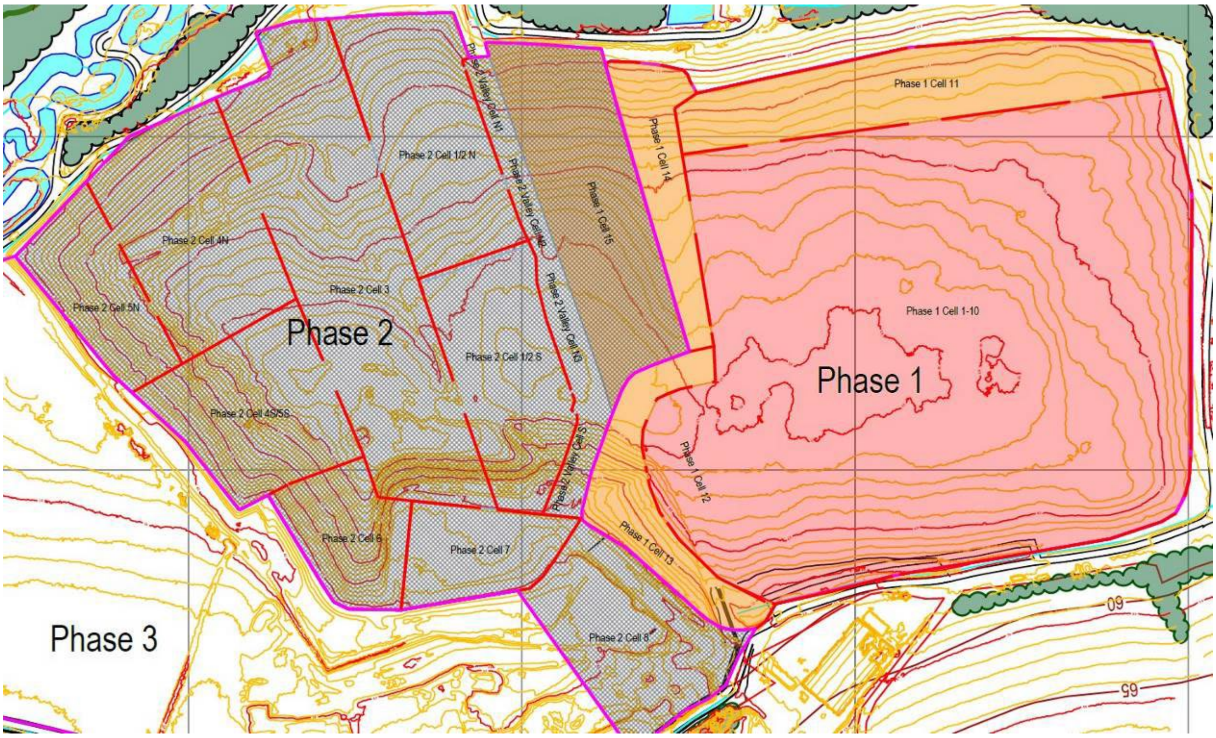


Figure 2-2 Previous Development Phases

Following the introduction of Environmental Permitting and the requirements of the Landfill Directive in the early 2000's, the engineering approach to the site changed and composite lining systems were introduced. The final cell of Phase 1 was constructed when these requirements were apparent and accordingly Cell 15 of Phase 1 was constructed as a composite of a welded 2mm HDPE liner over 1m thickness of compacted site won mineral. This being the case, the engineering standards and hence environmental protection afforded by Phase 1 Cell 15 is the same as that of the remainder of Phase 2. For this reason, for the purposes of this HRA, Phase 1 Cell 15 has been drawn into Phase 2 as shown by the hatching on Figure 2-2. Cells 11,13 and 14 for the purposes of the HRA have been conservatively assumed to have no liner and have remained for assessment within Phase 1 which comprises the unhatched red and orange areas on Figure 2-2.

Phase 2 comprises a series of 13 Cells which were sized and shaped to meet operational needs. Accordingly, the cells are not of uniform size, shape or volume, though the feature that they share is a common approach to engineering – they are each Landfill Directive compliant and have been developed over a composite lining system. The lining system commenced with a flexible membrane liner (fml) over 1m of recompacted site won mineral but this was amended from Cell 3 to a fml over a geotextile clay liner over 0.5m of site won recompacted mineral. An equivalence study found that this provided equivalent or better protection than the original design. The three-layer basal liner is still in use today with the construction of the last Cell of Phase 2 in Cell 8.

The quantification of waste volumes in the site is a little problematic as the levels for the base of the deposits were not recorded for most of Phase 1. The exception to this is a single CQA Validation report for Cell 13 which provides details of the mineral liner levels. Accordingly a "best estimate" has been made to define the underside of the deposit in Phase 1. For Phase 2, matters are simpler as each cell has a CQA Validation report that includes as-built surveys of the lining system. This has allowed the underside of Phase 2 to be determined reasonably well, though the use of local coordinates and levels in certain reports is not helpful.

The remaining part of the landfill occupies land to the west of the Central Ditch. For the purposes of the HRA this yet to be developed part is termed Phase 3. The engineering for Phase 3 will be the same as that for Phase 2 with a three layer basal lining system set at a level that preserves an unsaturated zone. For the purposes of volume assessment, the base has been set at 1.5m above the wintertime groundwater high levels. The top of the landfill has been assumed for these calculations to be that proposed in the Variation that this HRA supports.

It is estimated that the entire volume of Withyhedge Landfill site comprising the existing wastes in Phase 1 & 2 and the proposed wastes in Phase 3 (and a small existing void in Phase 2) amounts to 6,409,867m^3. The waste in Phase 1 and the first half of Phase 2 comprises municipal refuse from street collections at a time when recycling was not common. The second half of Phase 2 comprises a modified waste stream – a MRF had been developed adjacent to the site and residual wastes were being disposed along with commercial inputs. The rate of input also increased from an average of around 110,000t pa in Phase 1 to near 200,000t pa for Phase 2. Current inputs are close to the site Permit limit of 250,000t pa.

2.3 Proposed Development

Future disposal operations at Withyhedge (after the completion of Cell 8) will take place in Phase 3 identified on Drawing 2365-3. This has been designated a different Phase as it comprises land to the west of the Central Ditch, so topographic falls have changed direction. This area originally had few ground investigation boreholes and environmental monitoring wells and the Permit conditions made clear that advancing into this area could only be undertaken once supplementary data was available to better understand the hydrogeology.

In 2019, a comprehensive ground investigation was carried out in Phase 3 and a substantial dataset is now available. This HRA has been prepared to show that the engineering can be carried out without needing to change the design philosophy. Future disposal will, therefore, be carried out on a series of composite lined cells each set with a base level of no less than 1m above the winter groundwater highs as determined by site monitoring records. The Phase will be divided into a series of Cells which are schematically illustrated on Drawing 2365-3. The remaining void space amounts to 2,638,624m^3 which will take in the region of 11 years to complete at current input levels.

This HRA is supporting a variation to the Permit to revise the profile of the landfill. Previous overfilling has been identified by the new owners of the operating company and this requires either removal or revision to approved levels. The variation seeks to allow the previous overtip (now beneath an established restoration surface and cap) to remain and also modifies the shape of the restoration surface for Phase 3 to draw it away from Rudbaxton Water whilst also producing a more imaginative landscape profile and better ecological after use proposals. Overall, the retention of the existing overtip and the revised profile change the overall volume by 4.8% or 320,307m^3.

Once each cell is completed and levels achieve the design surface, the area will be progressively capped with a fml barrier with a drainage geocomposite and restoration soil to establish the landform profile and gradients shown on Drawings 2365-4 and 2365-5.

2.4 Technical Precautions

Previous HRAs have determined through simulation the technical precautions required for the landfill to operate without threatening the local environment. The precautions include:

- An unsaturated zone of 1.0m or greater beneath the lining system
- A composite lining system comprising an artificial sealing liner fabricated from high density polyethylene over an artificially established geological barrier comprising a geotextile clay liner over 0.5m thickness of recompacted site won mineral with a permeability of $1e^{-8}$m/s or less
- A limit on the leachate head on the liner of 1.0m across the base of the landfill
- A progressive cell by cell capping system to limit infiltration into the waste mass after disposal operations are complete
- A surface water management system to collect runoff from the site to facilitate a controlled release to Rudbaxton Water

As these technical precautions have been approved by the waste regulator, this HRA is not proposing to change any of these aspects, and therefore these will also apply to Phase 3.

3 ENVIRONMENTAL SETTING

A review of available data has revealed that Withyhedge Landfill lies in close proximity to one protected site: Rudbaxton Water and its riverbanks lie within the Afonydd Cleddau Special Area of Conservation (designated in 2004) and within the Afon Cleddau Gorllewinol Site of Special Scientific Interest (designated in 2003). Both protected areas share a common boundary. A map of the designated sites adjacent to the landfill is shown below on Figure 3-1.

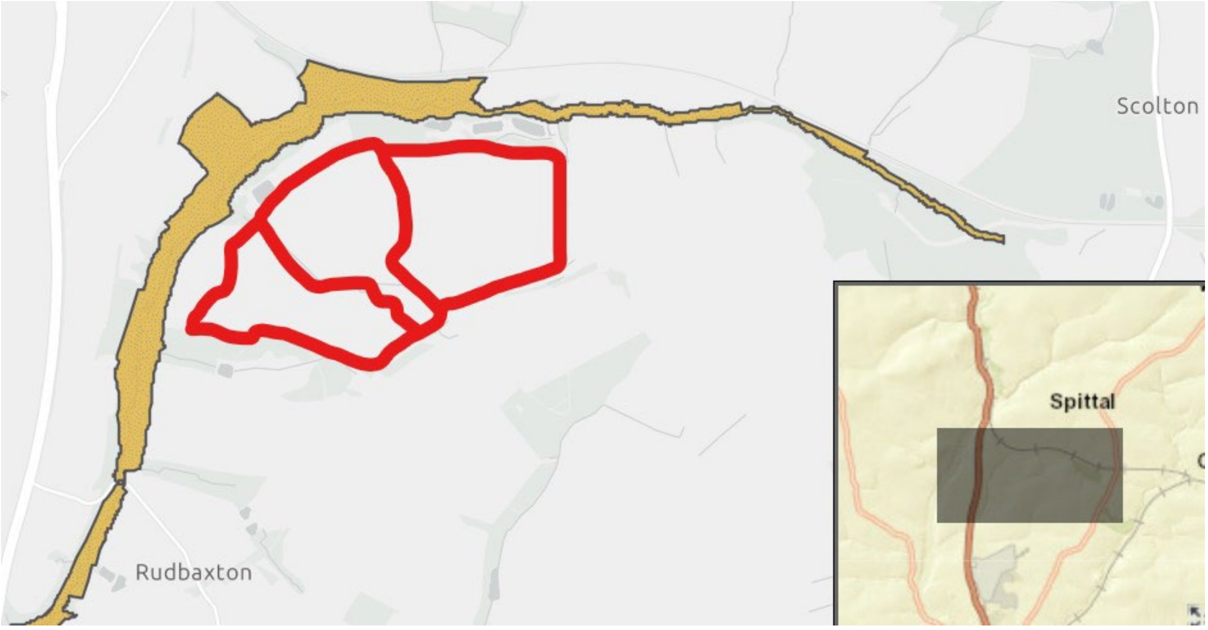


Figure 3-1 Protected Sites (brown) near Landfill (red)

The site is in a remote location to the northeast of Haverfordwest and is not visible from the south or east as it occupies the southern slope of the Rudbaxton Water valley. The site is visible from a small number of farms on the agricultural land to the north and also from Spittal, a village situated 1km to the northeast of the site. The site is partly visible from the A40 Haverfordwest to Fishguard road.

The site is located within an agricultural area with open fields to the east, fields and woodland to the west, woodland and Rudbaxton Water to the north and agricultural land now used for solar energy production to the south.

3.1 Meteorology

Available meteorological data from Haverfordwest Airport meteorological station shown in Figure 3-2 indicates that over the last 12 years the average rainfall amounts to 1058.1mm pa. The met station is some 3km to the southwest of the landfill site at a similar elevation.

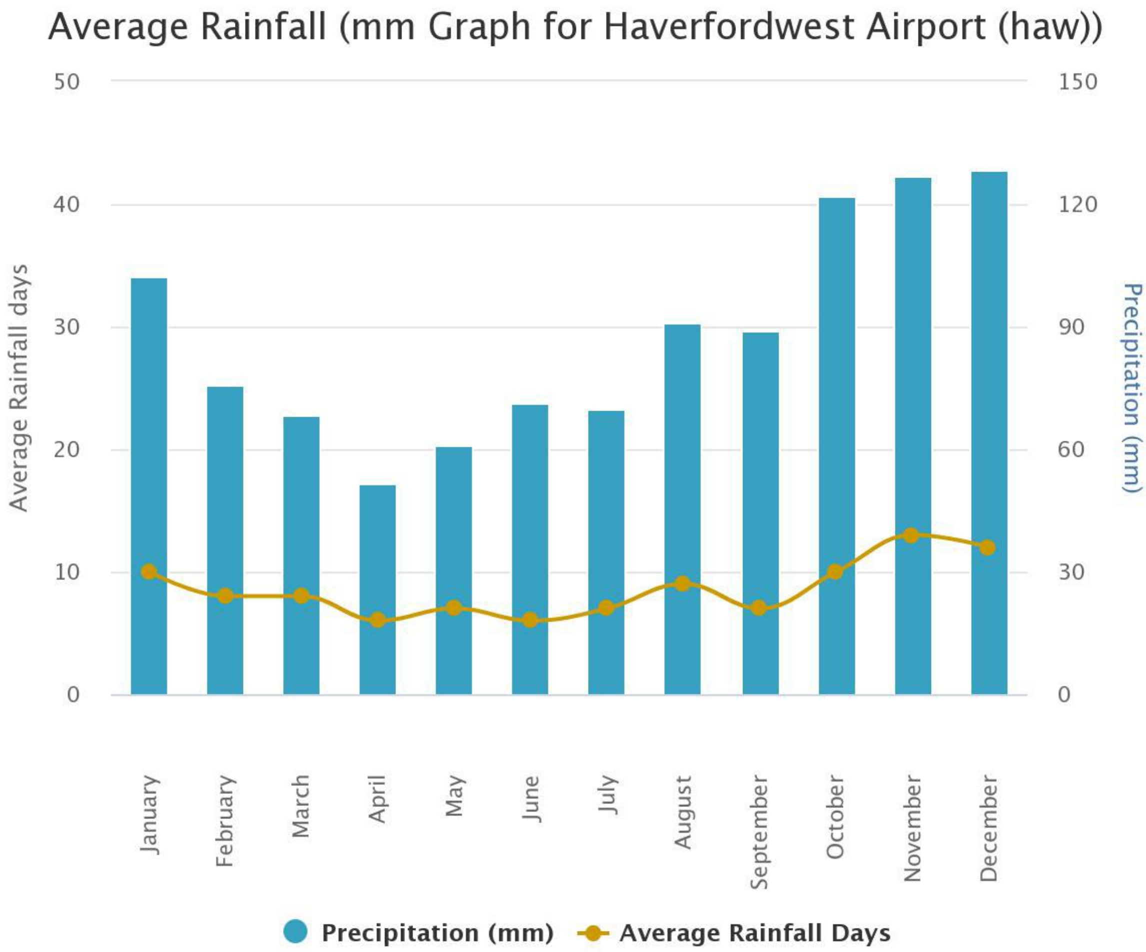


Figure 3-2 Rainfall Data 2010-2022 at Haverfordwest Airport

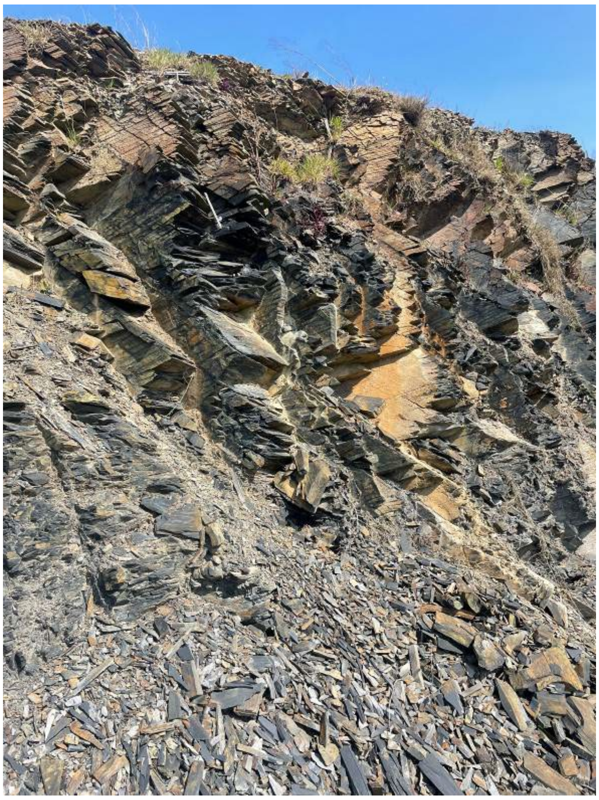
The effective rainfall experienced in the area has been estimated by the Met Office using its MORECS modelling package. It has indicated that effective rainfall at the landfill site would be 745mm pa. Of the effective rainfall, a proportion will infiltrate into the ground to recharge groundwater with the remainder flowing over the ground as runoff and contributing to surface water flow.

3.2 Geology

The bedrock geology in the area comprises fractured low permeability Ordovician shale with limited capacity to provide usable groundwater resource other than at a very localized scale for individual farms. The bedrock accordingly is classified by NRW as a Secondary B aquifer. Superficial deposits are thin and of very low permeability so there is no superficial aquifer designation beneath the site. The site is not within a groundwater Source Protection Zone and it is classified as being in an area of medium groundwater vulnerability.

Withyhedge Landfill is situated on an Ordovician argillaceous formation (known as the Meidrim Shales) which dips southward at an angle of approximately 20 degrees. The rock material is classified as a fine grained low grade metasediment and accordingly has little capacity to transmit water within its pore spaces; groundwater flow in the bedrock, therefore, will be principally in fractures, with little flow in the rock material.

A detailed examination of rock excavations within the site has been made and this has revealed that the bedrock is the same across the site – exposures have been inspected within the bank of Rudbaxton Water, the unnamed eastern side stream, the central ditch alongside Phase 2 and the borrow pit (extending from the central ditch to the upgradient edge of the landfill area). An adjacent quarry to the south of the site has also been examined, so there is significant exposure of the near surface solid (bedrock) geology over the whole of the site. Photographs of some of these exposure are provided in Plate 3-1.



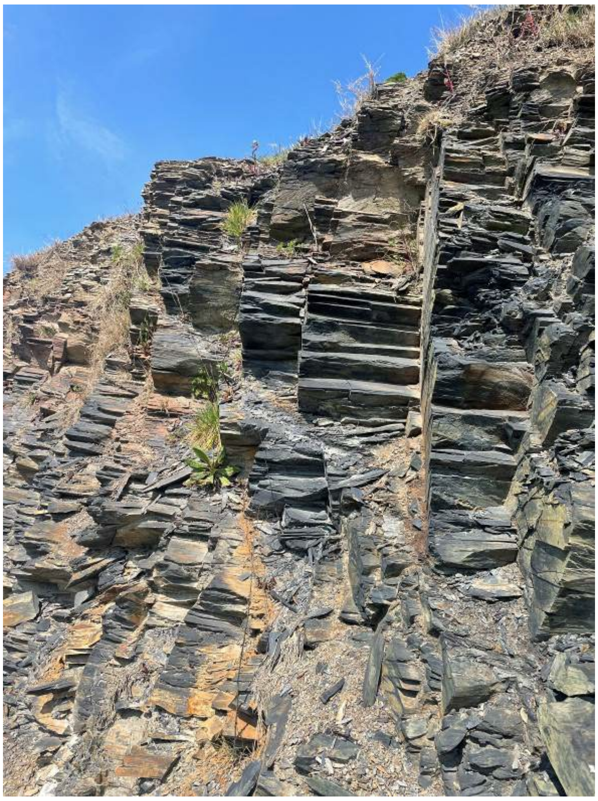


Plate 3-1 Selected exposures of bedrock on site
(note widespread orange ochre staining on discontinuities compared to rock mass)

The bedrock exposures have also provided an opportunity to examine the superficial deposits. Two distinct soils have been identified on site – a residual soil caused by the weathering of the underlying Meidrim Shales (Head Deposits) and an alluvial clay. Both soils originate in periglacial activity, with a weathering profile of up to 3m into the bedrock causing fragmentation and softening of the near surface bedrock and subsequent soil washing removing fine material to the valley floor. The clays are present at up to 2m thickness in the valley bottoms, though in places they are absent. The clays are interbedded locally with sand and gravelly sand. The head deposits are typically a metre or less and often show a fining upward sequence with colluvial clays dominant at the top of the layer and splintery softened shale at the base of the layer. The base of the soil grades into the top of the weathered bedrock. Both soils transmit water poorly, the clays especially so, hence their use as a source of mineral for the low permeability barriers beneath the wastes.

The strata in this area have been subjected to tectonic deformation, developing a consistent fabric within the bedrock. North/south compressive forces have resulted in a series of folds oriented with their axes aligned from west to east. Beneath the site, the strata dip southward at between 20^0 and 40^0 from horizontal. The strata have been subject to diagenetic and low-grade metamorphic processes that have resulted in much of the continuity of the bedding structure within the rock being lost. Currently, very low persistence (sub 0.5m) bedding features are seen occasionally at the site with more persistent bedding features being rare. Bedding discontinuities are typically less than 300mm. The discontinuous nature of the low persistence bedding feature means that groundwater flow along bedding is unlikely to be significant. The flow of groundwater therefore is predominantly in the sub-vertical fracture system that passes through the strata.

The geological inspection of rock outcrops and core from previous drilling has confirmed the nature of the rock material and the impersistent bedding features but it has also provided an opportunity to examine fractures within the bedrock, the principal flow path for groundwater. The fractures have been formally recorded in accordance with BS5930 and the ISRM recommended methods for discontinuity description. This dataset has been gathered so that the discontinuity geometry can be understood, an essential element when considering groundwater flow through the discontinuities beneath the site.

The discontinuity dataset has been recorded using the GeoID smartphone app, an application developed for this purpose. The discontinuity descriptions have been made onto logging sheets so that discontinuity characteristics can be analysed statistically if required. The GeoID app has been used to produce a plot of the discontinuity orientations using stereographic projection.

Figure 3-3 shows the results of the pole plots for the discontinuity orientation data gathered from the site. Each discontinuity is represented on the plot by a single dot (the pole to the discontinuity) and a great circle to record its orientation. It can be seen that the data is not a randomly distributed network of orientation but comprises several readily identified clusters or sets. Each set has been banded for analysis by an envelope and the average orientation of the data falling within each window has been derived. The sets of data identified by the kinematic analysis are therefore the dominant 2 sub-vertical clusters centred on 80/20 and 75/070 and a low angled southerly dipping set. The two sets of discontinuities provide a three dimensional fracture network to transmit groundwater.

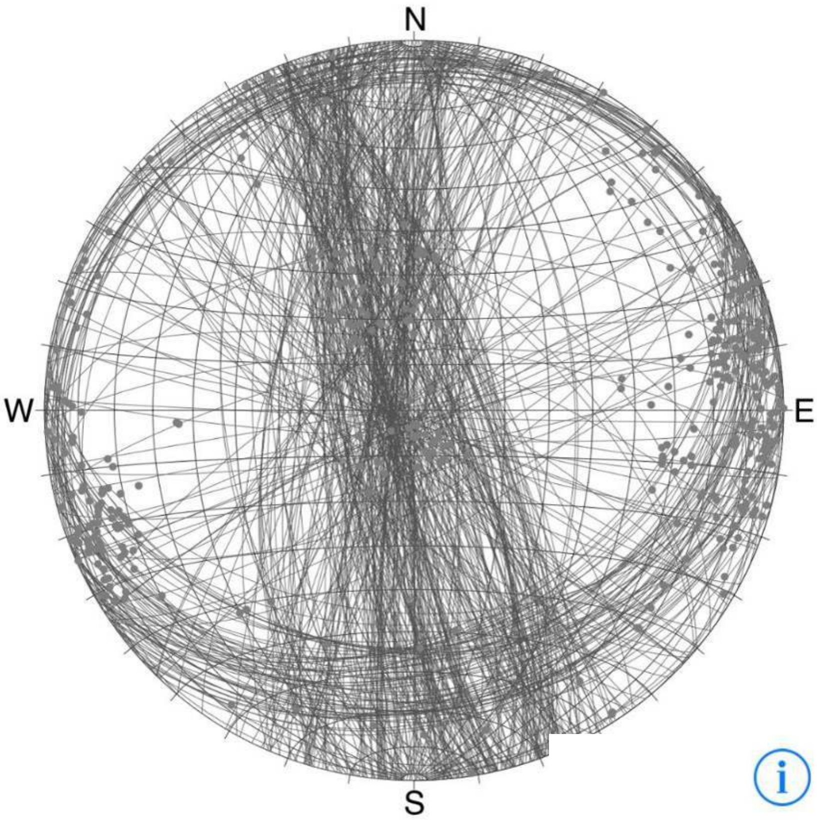


Figure 3-3 Pole and Great Circle plot of fracture discontinuities

A statistical analysis of the dataset (gathered to avoid sampling bias) reveals that 40% of the discontinuities fall into the 80/260 set and 16% fall into the similar 75/075 set. 19% of the dataset comprises bedding surfaces dipping towards the south. This indicates a very strong structural fabric to the rock mass and it is expected that, as discontinuities form the only credible groundwater flow path, groundwater flow will be strongly influenced by this. With only 7% of the discontinuities being normal to the principal set it is expected that groundwater flow will not be isotropic – groundwater is likely to flow in the preferred direction of the principal discontinuity set, from south-southwest to north-northeast.

The flow of groundwater through the discontinuities will also be strongly influenced by persistence. An analysis of persistence (shown on Figure 3-3) reveals that the dominant joint set also exhibits a high persistence, whilst cross-joints exhibit a significantly lower persistence. Bedding features have extremely limited persistence and restrict groundwater flows.

As groundwater is able to flow more freely through open fractures the rock faces have been carefully examined to look for variations in aperture. In general terms the discontinuities close to rockhead (within 2.5m of rockhead) are seen to pass through a weathering zone, where the black pyritic shales have been weathered to friable brown splintery weak rock. In this horizon fractures may have soil or sediment infill but form a generally open series of discontinuities.

Discontinuities in the weathered zone rarely show any identifiable pyrite – instead brown goethite and hydrous iron minerals coat the discontinuity walls. This is an indication of the circulation of water and oxygen through the discontinuities. This is evident in Plate 3-1.

Beneath the weathered horizon, the upper part of the black shales (to a depth of 2-3m below the base of the weathering) contains open fractures as well as many tighter discontinuities. The open fractures show iron staining and the weathering of pyrite, indicating the flow of water and oxygen to this level, though the state of weathering of the rock mass, which remains largely unweathered, suggests less interaction between bedrock and oxygenated recharge than in the weathered zone.

A few of the excavations across the site have extended to depths of greater than 5-6m below ground level. Boreholes have also been drilled into this zone and both exposures and borehole cores show that the bedrock is unweathered. Fractures and discontinuities within this zone are tighter and are coated with visibly unweathered crystalline pyrite, suggesting less interaction with oxygenated water.

3.3 Hydrogeology

Pumping tests undertaken during ground investigation works has shown that groundwater can be extracted though the sequence appears to be tightening with depth. The tight nature of the discontinuities together with the lack of weathering suggests groundwater flow within the strata at this depth is limited.

It has been noted that during the installation of new groundwater wells across parts of the site (principally Phase 3) variable head permeability tests recorded bulk permeabilities of between $1e^{-8}$ m/s and $1e^{-5}$ m/s. The range of values is considered to be indicative of drilling into a fractured rock mass with small flow between principal water bearing fractures. Unfortunately, the dataset was gathered from tests with response zones covering the entire length of the borehole and so are not suitable to distinguish between the tighter bedrock horizons identified beneath the weathered zone.

An examination of the groundwater levels in the numerous boreholes distributed across the site, as shown on Drawing 2365-7, has been made using monthly groundwater dips. This has revealed that groundwater levels are seasonal, as shown by the example of groundwater levels adjacent to Rudbaxton Water on Figure 3-4.

The data have also been used to derive plots of groundwater levels across the site on the same date. It would be expected that a fracture flow regime dominated by a series of disconnected discontinuities would yield a very irregular groundwater surface, with nearby boreholes showing significantly different levels. This is not the case.

An examination of Drawing 2365-7 shows that the groundwater levels in the boreholes when plotted onto a plan produce a rather regular and consistent surface. Locally, (for example around BH18 and BH19), sharp differences in groundwater level are seen, pointing at a disconnection between adjacent boreholes, but generally the surface displays regular variation. This strongly indicates a well interconnected network of fractures that allow pseudo-equilibrium to develop. However, the strong fabric developed in the bedrock by its fracture system will make flow easier in a south to north direction. It would be expected that the flow is responding to groundwater head developed in an interconnected fracture system but its direction is strongly influenced by the rock fabric. Groundwater is expected to flow principally south to north.

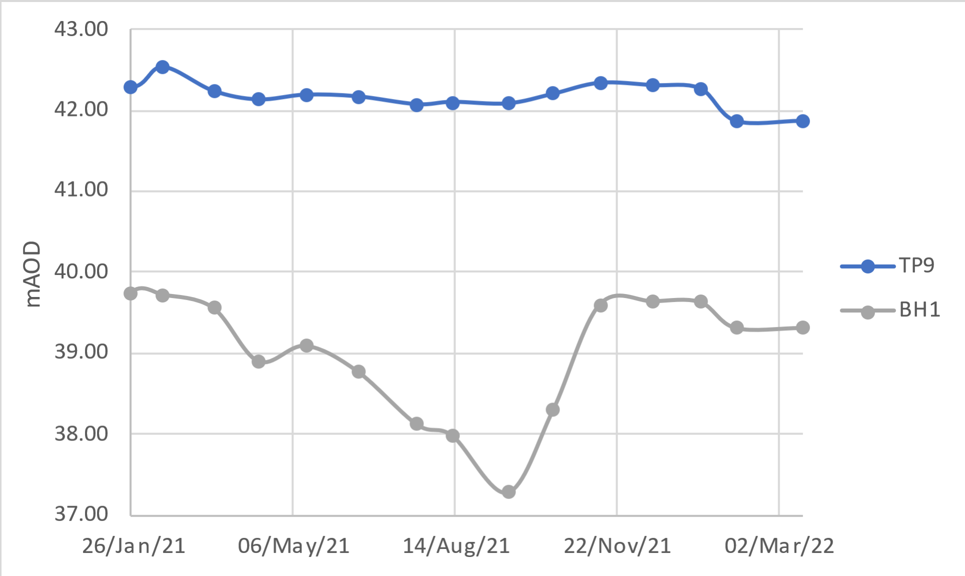


Figure 3-4 Example of Seasonal Variations in Downgradient Groundwater Levels

The geological study carried out at the site and its subsequent analysis leads to clear conclusions that are supported by published work:

- groundwater does not flow through the bedrock material
- groundwater flows along fractures within the bedrock and not uniformly through the rock mass
- the discontinuities with the rock mass provide a strongly developed fabric which will result in anisotropic groundwater flow
- the openness of the fracture is greatest closest to the ground surface allowing more groundwater interaction with strata in the shallow zone
- deeper fractures are tighter and groundwater flow becomes significantly less with depth
- groundwater has been shown by pump tests to be occurring over depths of around 10m

Due to the local hydrogeological conditions all groundwater passing beneath the site eventually discharges into Rudbaxton Water as base flow. As the northern site boundary is the centreline of the stream and the groundwater flows from south to north, the only piece of land that could have groundwater quality being influenced by the landfill is in the area between the northern edge of the landfill and the site boundary. All of this land lies within the site and also has very limited potential to ever be developed in the future and accordingly, groundwater as a resource will not be compromised by landfilling operations. Furthermore, any groundwater abstractions in farms within the area will not be downgradient of the landfill and will not be affected by the landfill. The principle controlled water receptor is Rudbaxton Water, as set out in previously approved HRAs.

3.4 Hydrology

Withyhedge landfill is situated on the southern side of an east to west valley that conveys Rudbaxton Water, a tributary to the Western Cleddau river which runs north to south approximately 1km to the west of the site. Rudbaxton Water joins the Western Cleddau approximately 3km to the southwest of the site after it has joined Poyston Water, another tributary to the south of the site.

The Rudbaxton Water catchment is shown on Figure 3-5, with the main flow and numerous unnamed side streams exaggerated in heavy blue lines. Rudbaxton Water rises in Scolton Manor Country Park some 1.5km to the east of the site and flows westward to the site where it turns southwards toward its confluence with the Western Cleddau. Numerous side streams enter the main flow in the vicinity of the site with 5 entering from the northern side of the valley and 4 from the southern side.

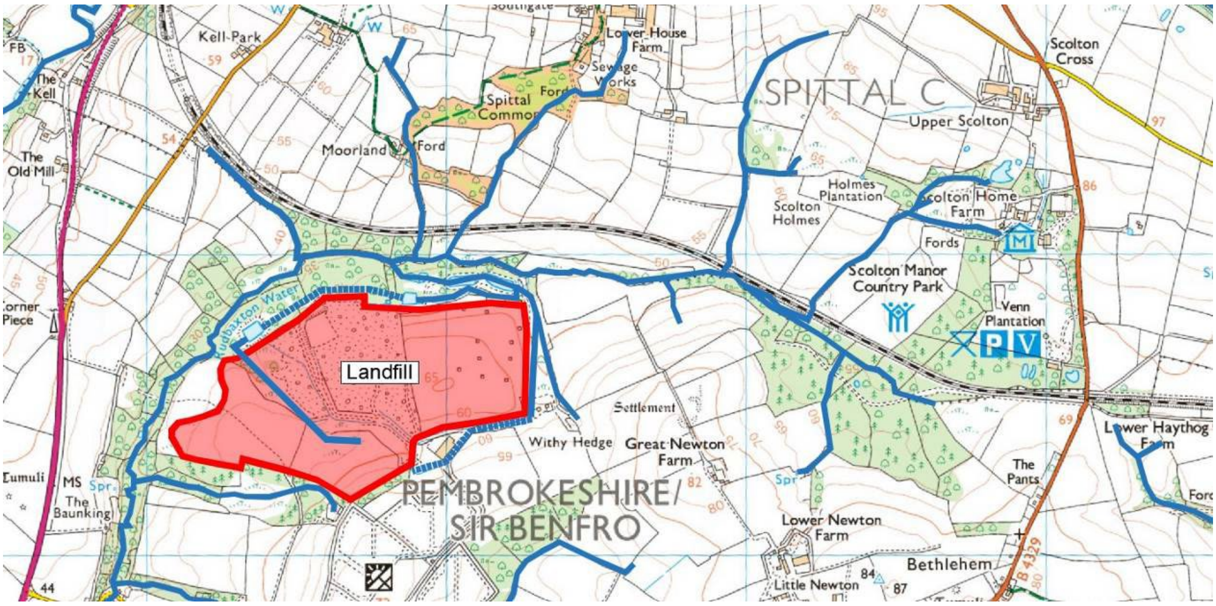


Figure 3-5 Hydrology

Rudbaxton Water is a modest stream, with an average flow of around 165 litres/second at Rudbaxton Bridge to the south of the site and around 77 litres/second at the upstream edge of the site. The 95th percentile low flow has been estimated by Environment Agency Wales (predecessor to NRW) at 9.5 litres/second. An estimate made on site after protracted dry weather in September 2022 at a part of the groundwater monitoring cycle when levels are at annual minima indicates a flowrate of 12.5 litres/second passing the site. A photograph of the stream under average conditions is shown on Plate 3-2.

Rudbaxton Water is principally recharged by surface water runoff and secondly by base-flow resulting from water infiltrating into the ground and discharging into the streambed.

The geological data on the site reveals that it is underlain by fractured low permeability strata belonging to the Meidrim and Hendre Shale Formations which are part of the Drefach Group, Ordovician in Age. Thus, base flow recharge is caused by groundwater flowing through the fractured shale bedrock. Whilst it is not clear how effectively the cycle of recharge, flow and discharge takes place in the catchment, the likelihood is that any rejected recharge (a phenomenon noted in these strata) will report as run-off and still remain within the catchment. There is no means to calculate losses from the catchment other than through Rudbaxton Water, so it is an underlying assumption that all rainfall landing within the catchment leaves the catchment as surface water in Rudbaxton Water.

Plate 3-2 Rudbaxton Water adjacent to landfill site (February 2022)

Figure 3-6 shows the entire catchment of Rudbaxton Water above Rudbaxton Bridge divided into sub-catchments for discussion and analysis purposes. Fourteen sub-catchments have been identified by topographic analysis with topographic highs (ridges) forming watersheds with the surface water flowing in streams and ditches in the intervening valleys. For clarity, the watersheds dividing the sub-catchments are indicated as magenta lines on Figure 3-6 with blue lines indicating watercourses. The names of each of the sub-catchments are labelled to allow reference.

The plan area of each of the sub-catchments has been established from a CAD version of Figure 3-6. The plan areas are tabulated on Table 3-1 in square metres. The total catchment of Rudbaxton Water above the bridge is 6.96 million square metres or 696 Hectares. Using the effective rainfall figure of 745mm provided by the Met Office this amounts to a total effective rainfall volume of 5.2million cubic meters. If all of the effective rainfall reports to Rudbaxton Water (either as runoff or base flow) then the average flow at Rudbaxton Bridge will amount to 0.164 cumecs or 164 litres per second. This value accords very well with the value of 165 litres/second obtained from EAW.

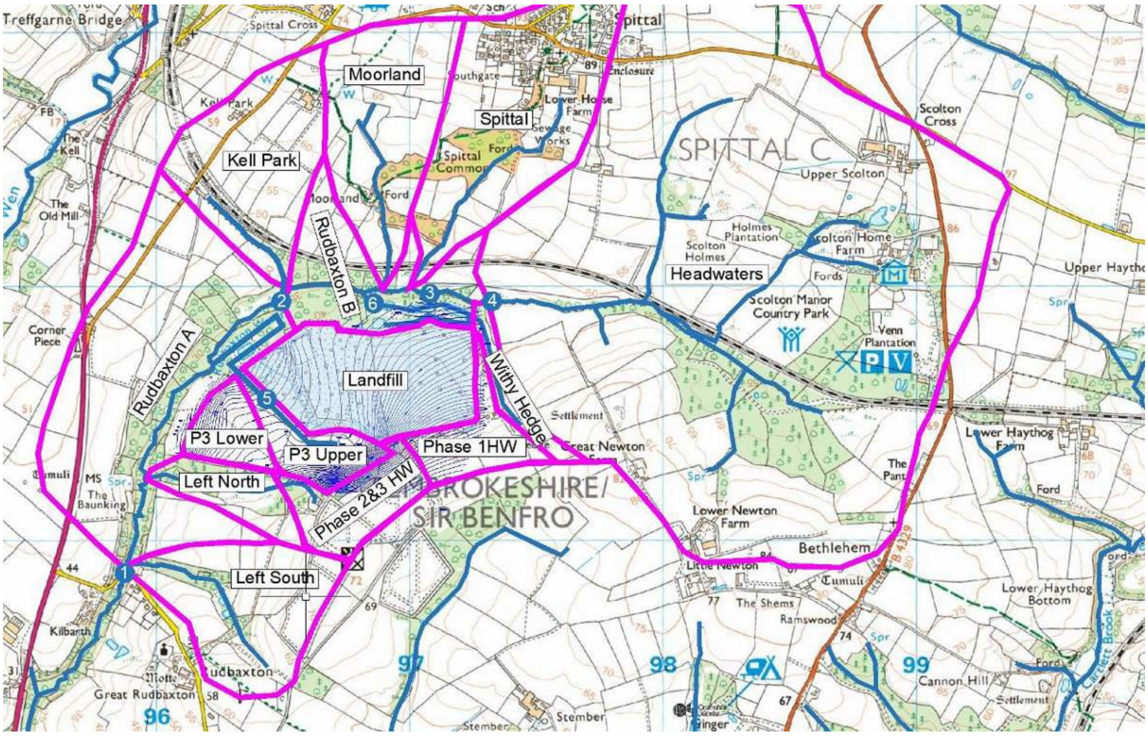


Figure 3-6 Rudbaxton Water Catchment Sub-Divisions

Table 3-1 Catchment Analysis

Sub-catchment	Area m²	Eff Rainfall m³ pa	Infiltration m³ pa	Runoff m³ pa	Runoff l/s	Baseflow l/s
Headwaters	3253592	2423926	871963	1551963	49.21	27.65
Spittal	538823	401423	144405	257019	8.15	4.58
Moorland	384589	286519	103070	183449	5.82	3.27
Kell Park	368032	274184	98633	175551	5.57	3.13
Rudbaxton A North	749879	558660	200968	357692	11.34	6.37
Rudbaxton A Landfill Offset	101711	75775	27259	48516	1.54	0.86
Left South	336615	250778	90213	160565	5.09	2.86
Left North	112163	83561	30060	53502	1.70	0.95
Phase 2 & 3 Headwater	144906	107955	38835	69120	2.19	1.23
P3 Upper	107271	79917	28749	51168	1.62	0.91
P3 Lower	82054	61130	21990	39140	1.24	0.70
Landfill	34004	253332	6801	246531	7.82	0.00
Phase 1 Headwater	115001	85676	30820	54855	1.74	0.98
Withyhedge	55537	41375	14884	26491	0.84	0.47
Rudbaxton B North	161856	120583	43377	77205	2.45	1.38
Rudbaxton B Landfill Offset	110411	82256	29590	52666	1.67	0.94
Total Catchment	**6962483**	**5187050**	**1752025**	**3352769**	**106.32**	**55.34**

Table 3-1 summarises the analysis of each sub-catchment and quantifies infiltration (based upon MORECS data) and runoff (based upon effective rainfall minus infiltration) to provide a picture of surface water and groundwater flow in each part of the catchment. Such an analysis provides useful data for Rudbaxton Water, the receiving watercourse for landfill emissions and also leads to an understanding of groundwater flow volumes for those parts of the catchment that are receiving emissions to groundwater.

A more detailed plan of the site shown on Figure 3-7 indicates the current surface water flows and features on and around the site. Surface water from around the site is collected in a series of ditches which all empty into the current four pond surface water system. Water cycles through the four ponds finally ending at the polishing pond from where it discharges via Discharge Point D1. There are proposals to further develop the surface water system with a series of ponds scheduled for construction adjacent to Phase 2 in 2024. A third set of ponds will be developed when Phase 3 progresses beyond the Western Ditch.

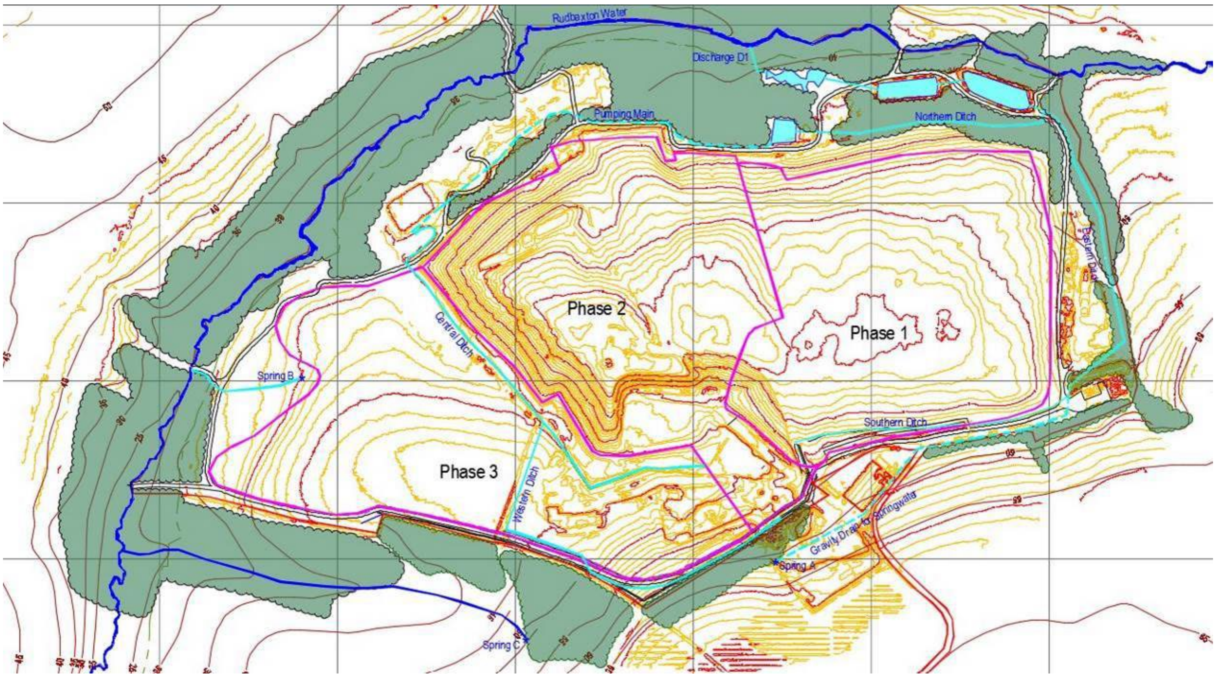


Figure 3-7 On-site surface water features

The plan shows that there are three springs in close proximity to Phase 3, one to the southeast (Spring A), one to the west (Spring B) and one to the south (Spring C). Spring A is an ephemeral spring comprising both flow along a sub-vertical joint surface aligned south to north and a surface water runoff contribution. The spring was originally the source of a small stream which ran northwards across the original ground surface within Phase 2. In order to develop Phase 2, the flow was diverted westward by the excavation of the central ditch which acts as a western perimeter drain for Phase 2. The flow from the spring is modest at a fraction of a litre per second under normal conditions. In heavy flows the spring could issue 0.5 l/s but in summertime it is dry.

As part of the landfill development it was proposed that the spring flow would be permanently diverted to the west of the site around the western perimeter drain. As this has only just commenced construction, the spring was diverted through a gravity drainage pipe to the eastern ditch and accordingly the spring flow now passes eastwards around the site to join into the site surface water ponds. There is no proposal to re-route this as the drain is working effectively. There are no longer surface water flows from Spring A through the site.

Spring B lies at the western edge of the site and under the existing approved restoration surface will be buried beneath the waste mass. It too is an ephemeral spring but this only flows during wetter periods and then produces a very small flow. Often this appears to be simply a wet boggy patch of ground within the field. The revised proposal draws the edge of the waste mass away from the western boundary and leaves the spring location open. However, it is suspected that the spring is fed by recharge from within the Phase 3 area and the consequence of progressive filling will be progressive recharge shading. It is expected that the spring will dry up as the landfill advances.

Spring C lies outside the site to the south. It is shown at the head of a small side stream though inspection has failed to find a spring – instead there appears to be an area of wet ground where a small quarry has been dug in the past. Flows from this are very small and do not cross into the site, remaining in the valley to the south of Phase 3.

As the landfill develops, the Central Drain will be lost beneath waste deposits. A western drain is to be completed to take surface runoff from the cap around the toe of the waste mass and into a new collection and management system to be built close to the location of Spring B. Currently, the Central Ditch discharges to a pond from where it is pumped into the top pond of the Phase 1 management system. When the system becomes fully operational in 2024, the Central Ditch will discharge into the new ponds and will then be discharged to Rudbaxton Water via discharge point D2.

The performance of the existing surface water collection system has been validated by regular monitoring of Discharge D1. This shows that even though the system was installed to collect only the Phase 1 surface water, it has reliably kept discharges within the permitted levels despite the addition of Phase 2 drainage.

A new surface water collection system will be installed to collect surface water from Phase 2. The capacity of the ponds is greater than that at Phase 1 even though the area drained is larger, so it is anticipated that discharge D2 will perform as well as D1. The surface water ponds in Phase 2 will collect water from the Central and western ditches as well as any runoff from construction works from new cells. Locally, construction lagoons may supplement the Phase 2 ponds.

Once landfill development crosses the western ditch in to the northwestern field the smaller pond system for Phase 3 will be installed and discharge D3 will come on-stream.

4 OVERVIEW OF CURRENT MONITORING

The performance of the landfill technical precautions will be reflected in the chemistry and flow of ground and surface water around the site. Simulations have been made in various approved HRAs to predict performance in terms of future concentrations and this HRA has reviewed the available datasets gathered to monitor performance. The means to show compliance with Permit limits, whether the site is performing as expected and the potential for harm at the receptor is monitoring and accordingly the Permit includes a monitoring schedule based upon the needs identified in previous assessments. The monitoring data is also useful to inform future assessments.

A technical precaution has been introduced to limit the head of leachate on the basal liner and accordingly the head of leachate has to be monitored to show compliance with the Permit limit. Leachate composition also has to be monitored as the concentration and range of substances of significance in the leachate is an important factor when considering the escape of substances by leakage.

The conceptual model shows leachate substances leaking from the landfill to become entrained in groundwater passing beneath the site. Accordingly, the flow of groundwater needs to be understood and this can only be achieved by examining well distributed groundwater level data from around the site. Because of the seasonal nature of groundwater rising and falling a good temporal distribution is also required. Accordingly, groundwater level monitoring in the boreholes upgradient, downgradient and cross gradient is undertaken. Groundwater chemistry is a critical aspect to the assessment of the potential impact on the receptor. Groundwater chemistry upgradient and downgradient needs to be understood to quantify the effect of leachate leakage on groundwater chemistry. Accordingly, groundwater chemistry is a monitoring requirement both upgradient and downgradient of the site. This monitoring data can be used to determine whether the site is performing as predicted in the various assessments carried out and whether the concentration of substances is sufficiently high to raise concern about its potential impact on the receptor.

Surface water monitoring is also required by the Permit. The quality of the receiving watercourse upstream and downstream of the site and at several other points is measured by routine monitoring. The composition and flowrate of surface water collected at the site and discharged directly into Rudbaxton Water is also monitored. However, an omission from the current monitoring regime is the flowrate of the receiving watercourse, Rudbaxton Water and other tributaries. It is not understood why flowrate of the receiving watercourse is not measured as this would allow mass balances to be undertaken to provide a better assessment of the impact of substances on the Rudbaxton Water quality.

4.1 Review of Available Dataset

The existing monitoring regime has been implemented to satisfy Permit conditions which are in turn based upon a risk-based design carried out in the previously approved HRAs and HRA reviews. The monitoring of groundwater levels and chemistry has been carried out on a monthly basis and it would be expected that a large and reliable dataset would have been produced. However, a detailed review of the dataset has revealed that the data may not be as reliable as expected.

Whilst the groundwater has been monitored and sampled as required by the Permit, several shortcomings in the way in which the groundwater has been sampled and analysed have been identified and these may offer an explanation for the spikes and outliers in the dataset seen in the analytical results.

Observations of the sampling being undertaken revealed that the wells are not purged before the sample is taken. Instead samples are taken immediately so that the first water is removed from the borehole. This has been confirmed to have been the case for many years. Samples of groundwater removed from the wells are poured directly into the sample jars without any filtering. As the samples are not subsequently filtered at the laboratory for total element analysis and samples may contain suspended solids, this would offer a sound explanation for some of the spikes and elevated concentrations identified in the analytical data.

Analytical data has also been presented in an inconsistent report format. This has caused issues when datasets have been combined as a number of instances of data column transposition have been identified. The units are inconsistent and accordingly, when datasets are combined, orders of magnitude errors occur.

There appears to have been discrepancies in the analysis and reporting of Phenol. Whilst the LandSim model, the HRAs and the Permit refer to Phenol there are examples of the laboratory reporting total phenols rather than Phenol. This has resulted in wide variations in concentration over short periods of time which are not fully understood i.e. at times total phenols has been reported as phenol resulting in a wide variation of data points.

During the production of this HRA the available dataset has been scrutinized and wherever anomalous data or data outside the expected range is noted this has been closely investigated. On many occasions, an error has been spotted that has led to the discrepancy and a correction applied. However, where the reason for the anomaly cannot be identified with certainty, the anomalies have remained in the dataset. The consequence of this is that large parts of the dataset are consistent and in this there is confidence. However, there are also within the dataset potentially spurious values and there is a lower degree of confidence that these are real data, as they may have been influenced by the various factors described above. However, in the absence of evidence of error they remain in the dataset and therefore form part of the analysis.

Having identified shortcomings in the way in which the dataset has been gathered, analysed and reported, confidence in the dataset going forward can only be achieved by addressing past issues. Accordingly, future sampling and testing work will be carried out in accordance with a work instruction drafted by Geotechnology and issued by RML. The work instruction covers sampling methodology, sample preparation in the field (filtering and preservation), specification of determinants together with reporting units and a reporting pro-forma requirement. The work instruction will also cover RMLs oversight of the datasets as they are produced (data review requirements). By standardizing all aspects of the sampling and testing, the future dataset will be completely reliable in all aspects.

4.2 Leachate

As noted in previous HRAs, leachate continues to be circumneutral with pH 7-8 and electrical conductivity up to ~25000-30000 microS/cm. Monitoring has revealed that it is characterised by elevated concentrations of a relatively small number of key parameters often found in non-hazardous landfill leachate and typically low or absent levels of hazardous substances. Temporal plots of variations in leachate chemistry are provided in Appendix 1.

4.3 Groundwater

As shown in Drawing 2365-11, there is an extensive groundwater monitoring network with many boreholes spaced less than 50m apart around the landfill. Some of the downgradient monitoring positions are within ~10m of the landfill edge.

Some boreholes are considered to intersect fractures whilst others intersect the rock matrix through which little groundwater would be expected to quickly pass. Previous studies have also shown, to the agreement of all parties, that background groundwater is naturally mineralised with acidic pH due to the passage of groundwater along fractures containing pyrite. As the pyrite naturally oxidises and weathers it would be expected to release protons, sulphate, iron and a range of trace metals. Groundwater is typically <3m below ground-level in close proximity to the edge of the waste deposition area.

Comparison of the groundwater quality recently encountered with the range of current Permit emission limits is provided in the following tables. Breaches of the emissions limits are highlighted grey. It is evident that there are different emission limits for boreholes in close proximity along the northern and southern boundary of the landfill. Reference to Drawing 2365-7 indicates that some of these borehole positions (BH105 and BH20) are considered upgradient of the landfill. It is unclear why limits were set at such positions and so this HRA review suggests an alternate set.

During compilation of this report it has become apparent that the analysis of trace metals is not performed on filtered samples and that previously issued data has contained typographical errors. The analysis of groundwater samples without filtration at 0.45 micron would offer a reasonable explanation for the trace metal (Cd, Ni) breaches highlighted grey in tables below. Apart from the trace metal breaches, there are no persistent breaches of the currently approved emission limits.

Table 4-1 Comparison of data from TP9, TP11, TP12, AIGH BH104, BH20 with Permit Emission Limits

Parameter	Emission Limit	Q1	Q2	Q3	Q4
2022					
Ammoniacal Nitrogen	12 mg/l	2.1	2.9	3.7	0.11
Chloride	250 mg/l	66.7	57.5	48.5	48.1
Nickel	0.05 mg/l	0.209 (BH20)	0.144 (BH20)	0.0253	0.0108
Phenol	0.15 mg/l (0.03) mg/l	0.14 (BH20)	<0.0025	<0.01	<0.01
Cadmium	0.0095 mg/l (0.0001)mg/l	0.0023	0.0011	0.0022	0.0063
Mecoprop	0.0001 mg/l (0.00004) mg/l	<0.0001	<0.0001	<0.0001	<0.0001
Naphthalene	0.00001 mg/l	<0.00005	<0.00005	<0.00005	<0.00005
2023					
Ammoniacal Nitrogen	12 mg/l	2.1	1.9	2	1.3
Chloride	250 mg/l	69.2	61.2	66.7	62.8
Nickel	0.05 mg/l	0.0162	0.047	0.0253	0.0177
Phenol	0.15 mg/l (0.03) mg/l	<0.0005	<0.02	<0.01	<0.01
Cadmium	0.0095 mg/l (0.0001)mg/l	<0.00011	0.0006	0.0013	0.00015
Mecoprop	0.0001 mg/l (0.00004) mg/l	<0.0001	0.0001	<0.0001	<0.0001
Naphthalene	0.00001 mg/l	<0.00005	<0.00013	<0.00005	<0.00005
Note: BH20 decommissioned August 2023					

Table 4-2 Comparison of BH1, BH2, BH102 (now BH3), and AIGBH105 with Permit Emission Limits

Parameter	Emission Limit	Q1*	Q2	Q3	Q4
2022					
Cadmium	0.002mg/l	0.011 (BH105)	0.018 (BH105)	0.00099	0.001
Phenol	0.15 mg/l (0.001mg/l)	0.08 (BH105)	<0.0025	<0.0025	<0.0025
2023					
Cadmium	0.002mg/l	0.00075	0.001	0.0009	0.0006
Phenol	0.15 mg/l (0.001mg/l)	<0.0005	<0.02	<0.01	0.02
Note: BH102 previously known as BH3. Limits in brackets are superseded.					

Table 4-3 Comparison of BH1, with Permit Emission Limits

Parameter	Limit	Q1	Q2	Q3	Q4
2022					
Naphthalene	0.00003 mg/l	<0.00005	<0.00005	<0.00005	<0.00005
Nickel	0.02 mg/l	<0.0015	0.0069	0.0062	<0.0015
Ammoniacal Nitrogen	1.328 mg/l (0.8 mg/l)	0.75	0.1	0.07	0.36
Chloride	117 mg/l (55 mg/l)	47.7	85.6	46.4	15.9
Mecoprop	0.00003 mg/l (0.00002 mg/l)		0	0	0
2023					
Naphthalene	0.00003 mg/l	<0.00005	<0.00012	<0.00005	<0.00005
Nickel	0.02 mg/l	0.0024	<0.0015	<0.0015	<0.0015
Ammoniacal Nitrogen	1.328 mg/l (0.8 mg/l)	<0.01	0.05	0.03	0.18
Chloride	117 mg/l (55 mg/l)	60.7	40.8	28.8	17.3
Mecoprop	0.00003 mg/l (0.00002 mg/l)	<0.0001	0.00003	<0.0001	<0.0001
Note: Naphthalene detection limit above emission limit. Limits in brackets are superseded.					

Table 4-4 Comparison of BH2 with Permit Emission Limits

Parameter	Limit	Q1	Q2	Q3	Q4
2022					
Naphthalene	0.00006 mg/l	<0.00005	<0.00005	<0.00005	<0.00005
Nickel	0.02 mg/l	<0.0015	<0.0015	0.0048	<0.0015
Ammoniacal Nitrogen	5.2 mg/l	0.17	0.05	0.9	0.67
Chloride	180 mg/l	40.3	43.7	96.2	31.8
Mecoprop	0.0001 mg/l	<0.00005	<0.00005	<0.00005	<0.00005
2023					
Naphthalene	0.00006 mg/l	<0.00005	0.00002	<0.00005	<0.00005
Nickel	0.02 mg/l	<0.0015	<0.0015	<0.0015	<0.0015
Ammoniacal Nitrogen	5.2 mg/l	<0.01	0.05	0.03	0.86
Chloride	180 mg/l	29.2	22.3	29.1	20.9
Mecoprop	0.0001 mg/l	<0.0001	<0.00002	<0.0001	<0.0001

Table 4-5 Comparison of BH102 (now BH3) with Permit Emission Limits

Parameter	Limit	Q1	Q2	Q3	Q4
2022					
Naphthalene	0.00006 mg/l	<0.00005	<0.0005	<0.0005	<0.0005
Nickel	0.02 mg/l	0.006	0.0117	0.017	0.0114
Ammoniacal Nitrogen	55 mg/l	0.03	0.12	0.72	0.1
Chloride	310 mg/l	179	178	220	225
Mecoprop	0.0004 mg/l	<0.00005	<0.0001	<0.0001	<0.0001
2023					
Naphthalene	0.00006 mg/l	<0.00005	<0.00071	<0.00005	<0.00005
Nickel	0.02 mg/l	0.0111	0.009	0.0106	0.0132
Ammoniacal Nitrogen	55 mg/l	0.29	0.22	2.2	2.2
Chloride	310 mg/l	0.00075	0.001	0.0009	0.0006
Mecoprop	0.0004 mg/l				

Table 4-6 Comparison of BH105 with Permit Emission Limits

Parameter	Emission Limit	Q1	Q2	Q3	Q4
2022					
Naphthalene	0.0001 mg/l	<0.00005	<0.00005	<0.00005	<0.00005
Nickel	0.031 mg/l	0.507	1.3	0.0164	0
Ammoniacal Nitrogen	0.5 mg/l	2.7	0.89	0.21	0.36
Chloride	50 mg/l	19.5	21.3	39.3	24
Mecoprop	0.0001 mg/l (0.00002 mg/l)	<0.0001	<0.0001	<0.0001	<0.0001
2023					
Naphthalene	0.0001 mg/l	<0.00005	0.00005	<0.00005	<0.00005
Nickel	0.031 mg/l	<0.0015	<0.0015	<0.0015	0.0024
Ammoniacal Nitrogen	0.5 mg/l	0.35	0.43	0.35	0.06
Chloride	50 mg/l	5.3	23.1	23.3	26.6
Mecoprop	0.0001 mg/l (0.00002 mg/l)	<0.0001	<0.00002	<0.0001	<0.0001
Note: Mecoprop analytical detection limit above emission limit					

Analysis has also revealed that groundwater (and surface water) is naturally mineralised in trace metals. For instance, this can be seen by evaluation of the concentration of Nickel in upgradient and downgradient groundwater (summarised in Table 4-7) and also surface water upstream of the site (summarised in Figure 4-1). The data clearly shows detectable levels of Nickel in background media at concentrations that sometimes exceed Environmental Quality Standards (EQS). The most likely reason for the ubiquitous presence of several trace metals in the geosphere is thought to be due to the weathering of pyrite in the Meidrim shales which has been found to contain several trace metals (see results in Appendix 2). Such processes have also been confirmed previously with the observation (and agreement by all parties) that acidic pH events (<pH ~5) sometimes observed in groundwater and surface water are the products of the oxidation of pyrite within the weathering horizon of the shales.

Table 4-7 Nickel in upgradient and downgradient groundwater

Nickel	Down	Up
EQS - AA	0.004	0.004
99 percentile	0.05	0.05382
95 percentile	0.03	0.02974
90 percentile	0.01	0.02194
50 percentile	0.005	0.0058
10 percentile	0.0025	0.0015
5 percentile	0.0015	0.0015
1 percentile	0.0015	

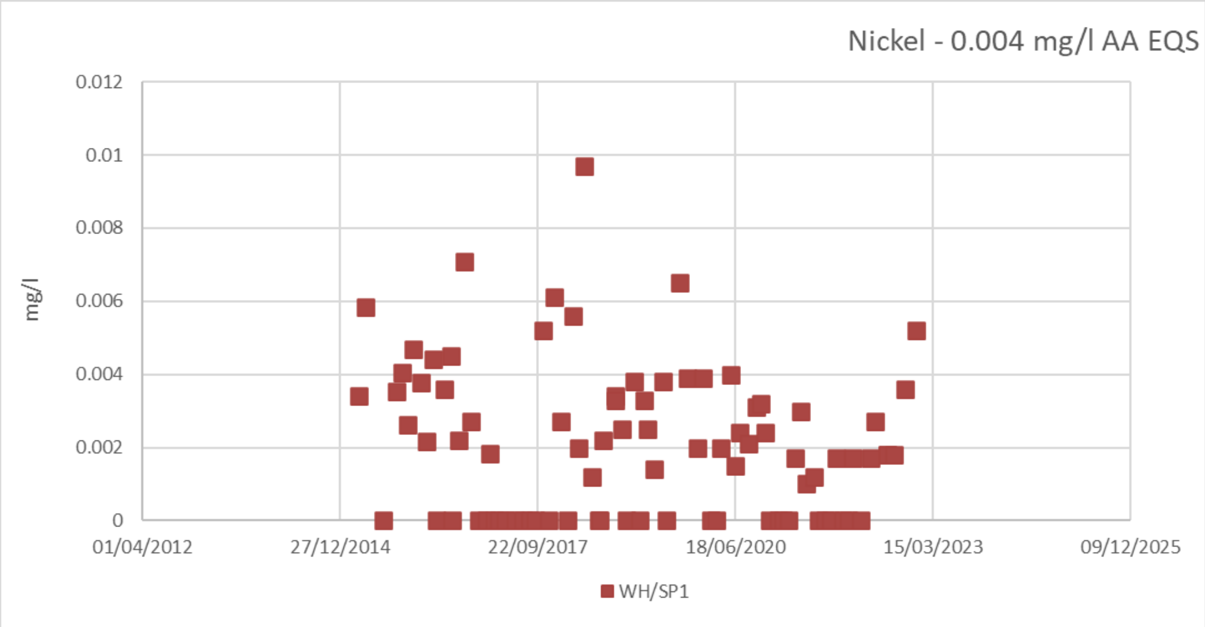


Figure 4-1 Nickel in Surface Water Upstream

4.4 Surface Water

Surface water run-off from restored phases at the site is channelled into a sequence of lagoons that are to be extended. These lagoon systems discharge into Rudbaxton Water.

As the site is located in a rural agricultural catchment underlain by pyritiferous shale and where there are potentially several diffuse sources of pollution in close proximity, there is a challenge to discern the cause of fluctuations in water quality. Several of the parameters monitored may be influenced by other processes and activities occurring within the catchment, some of which have developed and been permitted since the landfill was granted planning permission and an Environmental Permit and the ecological sites designated.

Surface water quality monitoring is undertaken at lagoon discharge point D1, north of Phase 1. Rudbaxton Water is also monitored monthly at points SP1, SP3, SP5, SP6 and SP7. These latter monitoring points do not have specified compliance limits.

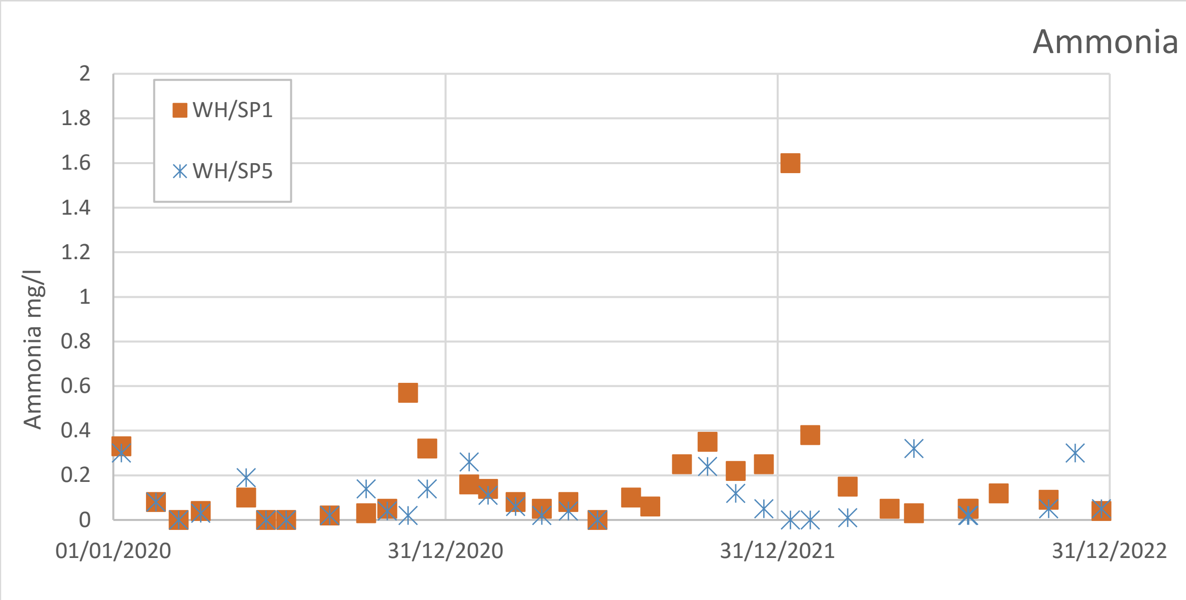
Table 4-8 provides a comparison of the maximum results observed at D1 during 2022 and 2023 with the Permit emission limits. This reveals no recent exceedances.

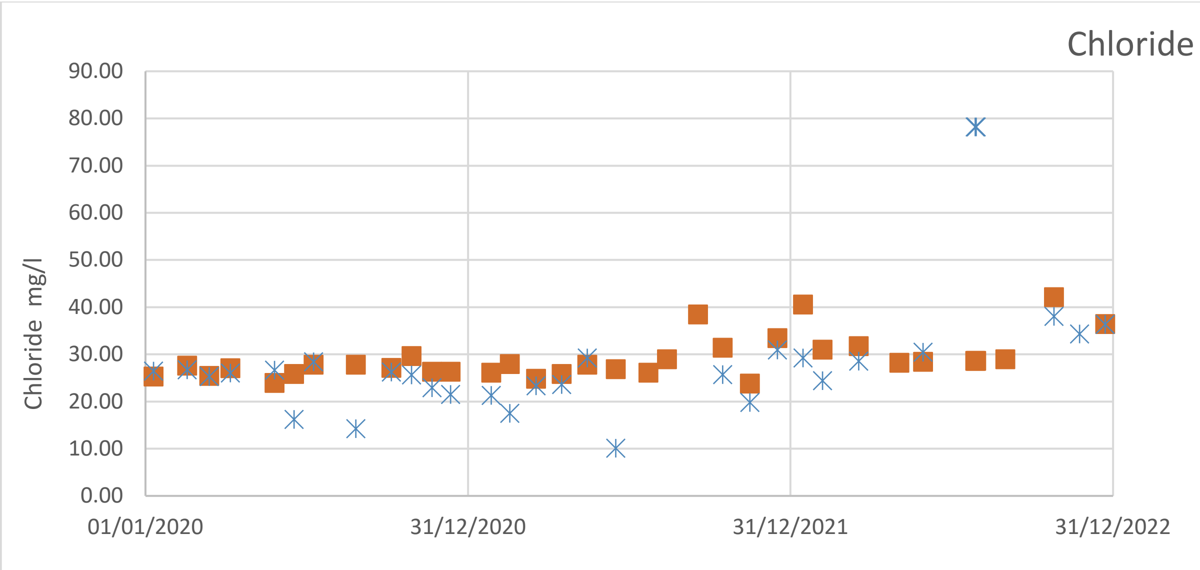
Table 4-8 Comparison of spot water quality (maximum concentrations) at D1 with Permit Emission Limits

Parameter	Limit (incl unit)	Q1	Q2	Q3	Q4
2022					
pH	6 to 9 (pH units)		7.2 - 7.6	7.4	6.8 - 6.9
Total Suspended solids	30 (mg/l)	<1.5	27.2	8	22.8
Ammoniacal Nitrogen	0.5 (mg/l)	0.05	0.22	0.06	0.32
Biological Oxygen Demand	17 (mg/l)	6	2.7	0	1.6
Chemical Oxygen Demand	150(mg/l)	21	4	9	15
Chloride	250 (mg/l)	29.2	32.8	40	29.9
2023					
pH	6 to 9 (pH units)	7.5	7.6	7.3	7.3
Total Suspended solids	30 (mg/l)	7.2	1.6	<1.5	<1.5
Ammoniacal Nitrogen	0.5 (mg/l)	0.08	0.1	0.09	0.09
Biological Oxygen Demand	17 (mg/l)	2.6	1.7	5.3	5.3
Chemical Oxygen Demand	150(mg/l)	8	5	17	17
Chloride	250 (mg/l)	35.9	27.1	30	30

Selected indicators of water quality in Rudbaxton Water as it passes alongside Phase 1 and groundwater are included in Appendix 3 with select surface water data summarised in Figure 4-2. The data indicates surface water to be typically circumneutral with EC <300 microS/cm. The time series record interestingly reveals a short-term acidic 'event' in July 2022 which causes pH to temporarily drop to 3.2, EC to reach over 1800 microS/cm and trace metals, such as Nickel, to be found at increased concentration. As noted previously, this event is considered to be the result of acidic water present in the stream at the time of sampling as a consequence of oxidation of exposed pyrite in the underlying bedrock shales. This is discussed further in later sections.

Currently, the status of Rudbaxton Water is understood to satisfy the requirements of a Moderate Category surface water body. The watercourse is below 80m AOD, has an alkalinity of between 10 and 50 and is a Type 2 river. Accordingly, the EQS applied to the stream should reflect the guidance for Type 2 rivers. However, it is understood that NRW aspires to raise the category of Rudbaxton Water to Good, and this will require a tighter EQS to be applied. For example, the EQS for a Moderate Category stream for ammoniacal nitrogen would be 0.75mg/l but for a Good Category stream it would be 0.3mg/l.





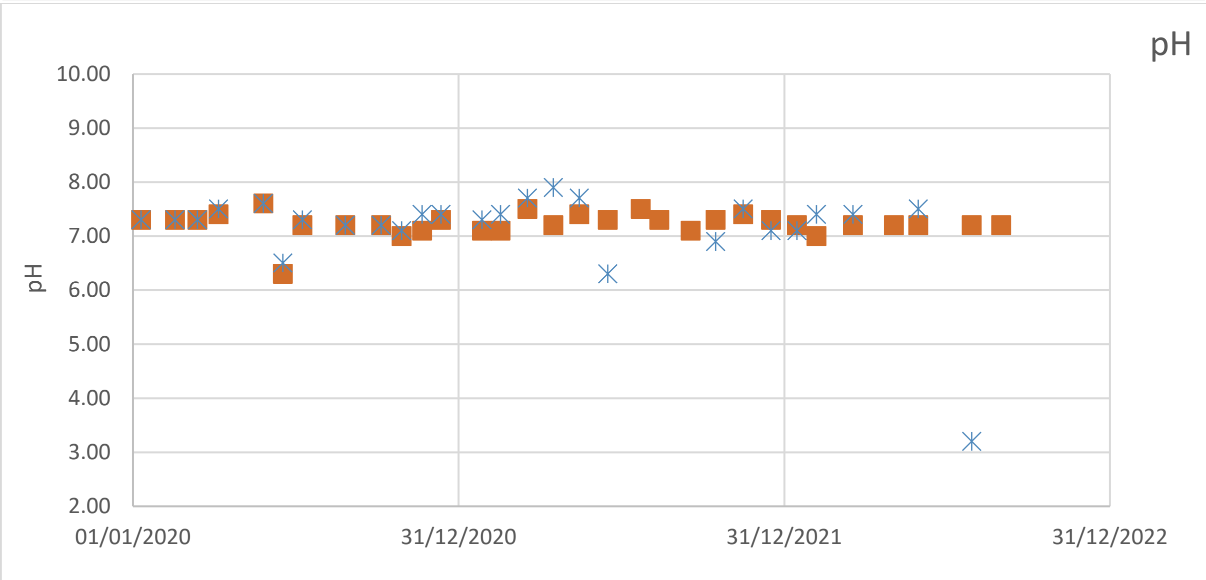


Figure 4-2 Ammonia, Chloride and pH in Rudbaxton Surface Water
(SP1 upstream and SP5 downstream of Phase 1)

Recent monitoring data reveals that, at times, surface water upstream of the site (SP1) contains ammoniacal nitrogen above analytical detection limit and freshwater Environmental Quality Standards (EQS) of 0.3 mg/l. However, there is a decline in average ammonia concentration as it passes the site, as summarised in Table 4-9. Reassuringly, the data suggests that water quality is good in Rudbaxton Water and that there is no significant deterioration in water quality as it passes unlined Phase 1. This, in-turn, suggests that current groundwater quality adjacent to the unlined landfill is not discernibly impacting surface water quality.

Table 4-9 Average Ammonia (mg/l) in Rudbaxton Water passing site

	SP1	**SP5**
EQS	0.3	0.3
2020	0.13	0.08
2021	0.14	0.10
2022	0.25	0.08
2023	0.11	0.12
Note - <DL replaced with =DL for statistical assessment		

5 UPDATED CONCEPTUAL SITE MODEL

An understanding of the way in which the site interacts with the local aqueous environment has been developed from the information in the preceding sections and consideration of previously approved HRARs. This understanding can be illustrated graphically as a conceptual site model (CSM). Previous CSMs have portrayed the site in a single rather complicated model but this ignores subtle differences in groundwater flow patterns and also differences in the technical precautions adopted in the engineering of each phase. In this HRAR, due to the different engineering standards between Phase 1 and Phase 2 & 3 the current understanding is illustrated as two CSMs. Ultimately, this has led to the development of two LandSim models that are discussed in the following chapter.

5.1 Phase 1

The CSM for Phase 1 is illustrated on Figure 5-1. It shows the groundwater flowing through the fractured bedrock aquifer is recharged by rainfall falling on the high ground to the south (to the right on the illustration). The groundwater flows in the near surface fractures beneath the landfill toward Rudbaxton Water, the lowest point on the cross section. Further recharge from rainfall is also shown between the waste mass and the stream. The groundwater flows into Rudbaxton Water as base flow.

Effective rainfall on the waste mass mostly runs off or is intercepted by the capping system and removed after percolation through the cover soils. The runoff is directed through the surface water management system and from there discharges as clean water into Rudbaxton Water. A small proportion of the rainfall enters the waste mass and forms leachate. The leachate is not perched on a lining system and is free to percolate into the bedrock beneath. As it does so the concentration of leachate substances in groundwater increases, indicated by a change in colour of the groundwater flow arrows.

The concentration of landfill substances in the groundwater beneath the landfill will be a consequence of the groundwater flow beneath the site, the leachate leakage rate into the ground and the concentration of the substances in the leachate source. As the groundwater continues its passage toward Rudbaxton Water through the ground, natural processes will attenuate certain substances so that the concentration reduces. Further dilution from infiltration in the ground between the waste mass and the stream will also reduce concentration further.

The impact that the contaminated groundwater will have on Rudbaxton Water will be a consequence of the contaminant flux arriving as baseflow (i.e. flow and concentration), the flow (and concentration) of Rudbaxton Water and the tolerable levels of substances in Rudbaxton Water. The technical assessment of this process forms part of this report but has been carried out and approved previously in earlier technical reports. The conclusion reached previously is that the substances from Phase 1 will not appear in sufficient concentration in Rudbaxton Water to exceed Environmental Quality Standards set for the protected watercourse.

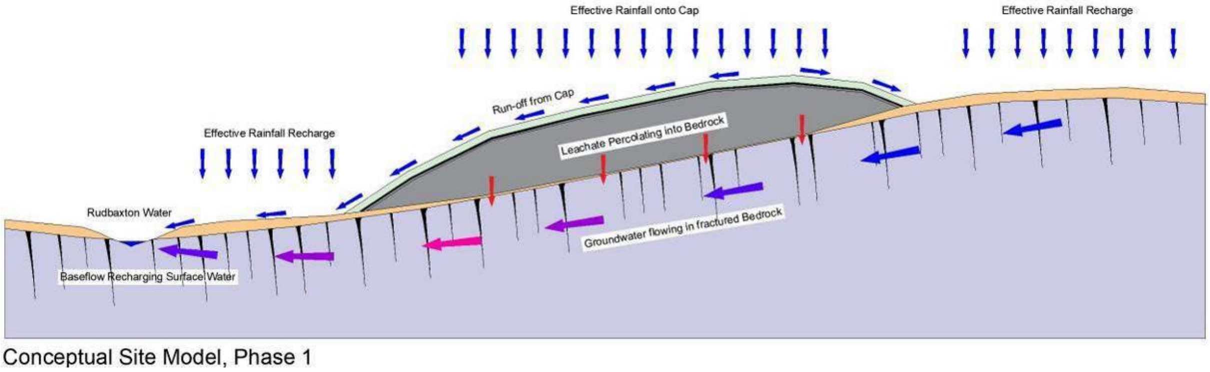


Figure 5-1 CSM for Phase 1

5.2 Phase 2 & 3

Phase 2 & 3 are a single landfill mass that meets the requirements of the Landfill Directive. Both phases have the same technical precautions and therefore both are shown on a single CSM, as shown in Figure 5-2. The model differs from that shown on the Phase 1 CSM as it has a lining system and a leachate collection and removal system, but in other respects is very similar.

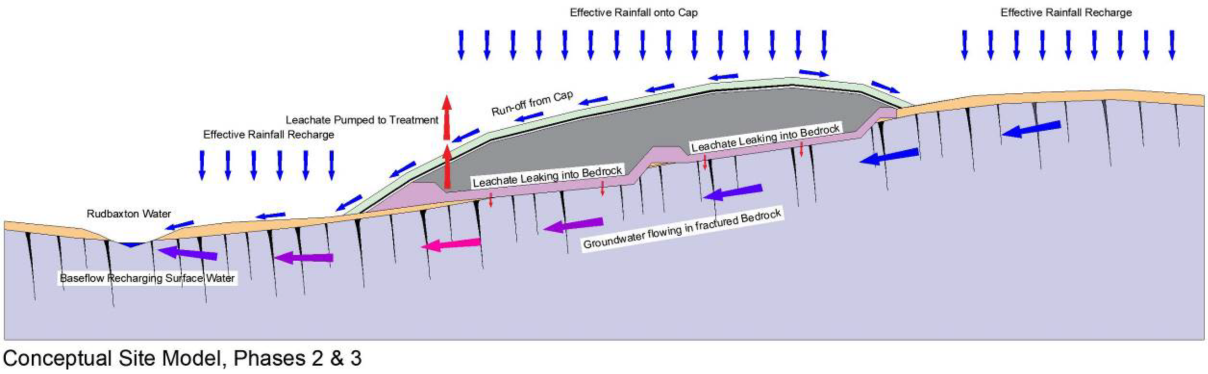


Figure 5-2 CSM for Phase 2 and 3

The principal difference between the two conceptual models is the profound reduction in leakage from the waste mass into the geology and groundwater beneath. Due to an effective composite lining system and a leachate collection system that limits leachate head on the liner, leachate leakage is only a fraction of the leakage from Phase 1. Conceptually, therefore, it can be concluded that if all other variables remain the same between Phases the concentration of substances in groundwater beneath Phase 2 & 3 will be significantly less than the concentration beneath Phase 1. If this is the case and groundwater flows are similar, the flux of pollutants to Rudbaxton Water will be significantly less than it is in Phase 1. This leakage and the potential cumulative effects on Rudbaxton Water are considered in the subsequent quantitative modelling of the CSMs.

6 SIMULATION AND MODELLING

As LandSim 2.5 is still the validated model for assessing the long-term risks to the water environment from landfills, this HRAR has continued to use this model for all numerical modelling. In this HRAR, the quantitative predictions made by the model are used as one line of evidence to evaluate the risks to Rudbaxton Water, the principal receptor. The aim of the modelling review is to ensure that the HRA is not divorced from the reality of the landfill facility. This link is made explicit by the reliance of the HRA on the essential and technical precautions at the landfill and leachate chemistry source term. With regards to the construction of the landfill lining systems and leachate quality, fundamental assumptions were made in the original HRA and subsequent HRA reviews, all of which have been approved by the waste regulator. Given the approval for these elements many have been retained for consistency but since then additional landfill cells have been constructed with increasing levels of sophistication under strict CQA. Monitoring has also allowed leachate evolution to be observed and groundwater and surface water quality observed as part of a comprehensive performance monitoring programme. This review, therefore, considers all of these multiple lines of evidence to assess the long-term performance of the landfill.

The LandSim models for each phase are titled:

- Phase 1.sim
- Phase 2&3.sim

The model input and output files are included in Appendix 4 and 5 for Phase 1 and Appendix 6 and 7 for Phase 2 & 3. The input parameters are discussed further in the following sections.

6.1 Cell Geometry & Engineering

In the previously approved HRAs, a rather complicated site layout was modelled, as revealed by the screenshot of the model interface in Figure 6-1. This reveals that the compliance well (labelled 1) was located downgradient of Phase 2 & 3 and so the assessment was not fully assessing cumulative impacts. Rather than pursuing this complex and incomplete arrangement, two models have been developed: one for Phase 1 and one for Phase 2 & 3. The model interface from each of these models are shown in Figures 6-2 and 6-3, with the modelled compliance well for each phase also shown. In this HRA review the outputs from each of these models have been combined in a mass balance assessment allowing the full cumulative impact on Rudbaxton Water to be assessed (see Section 8.1).

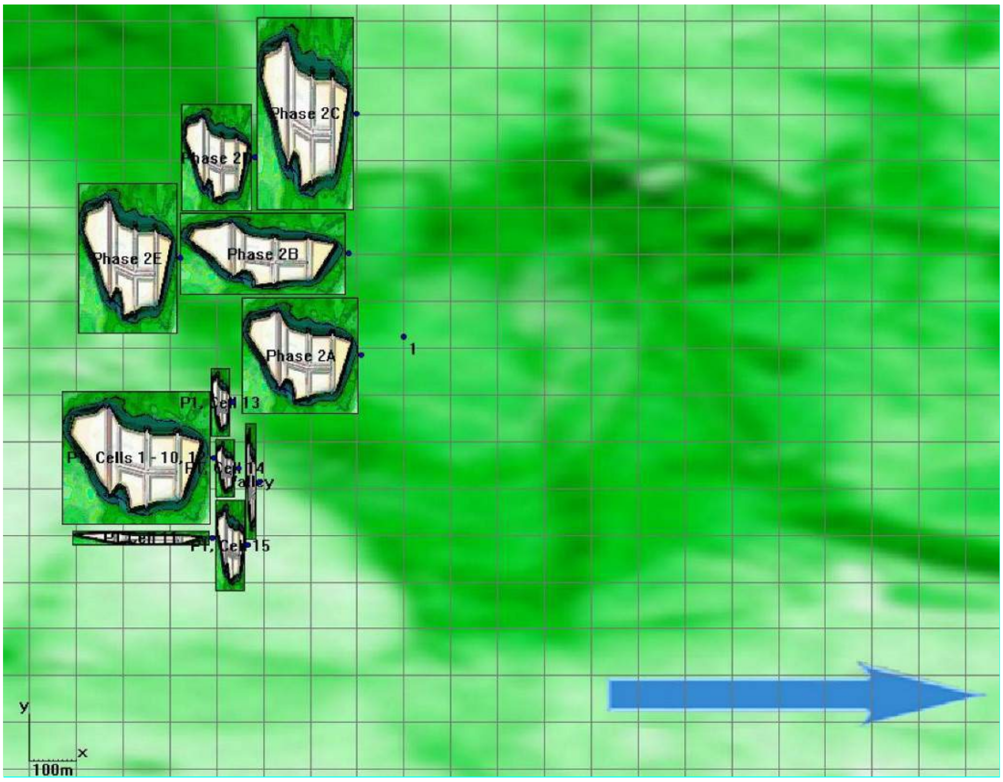


Figure 6-1 Previous LandSim Model Configurations

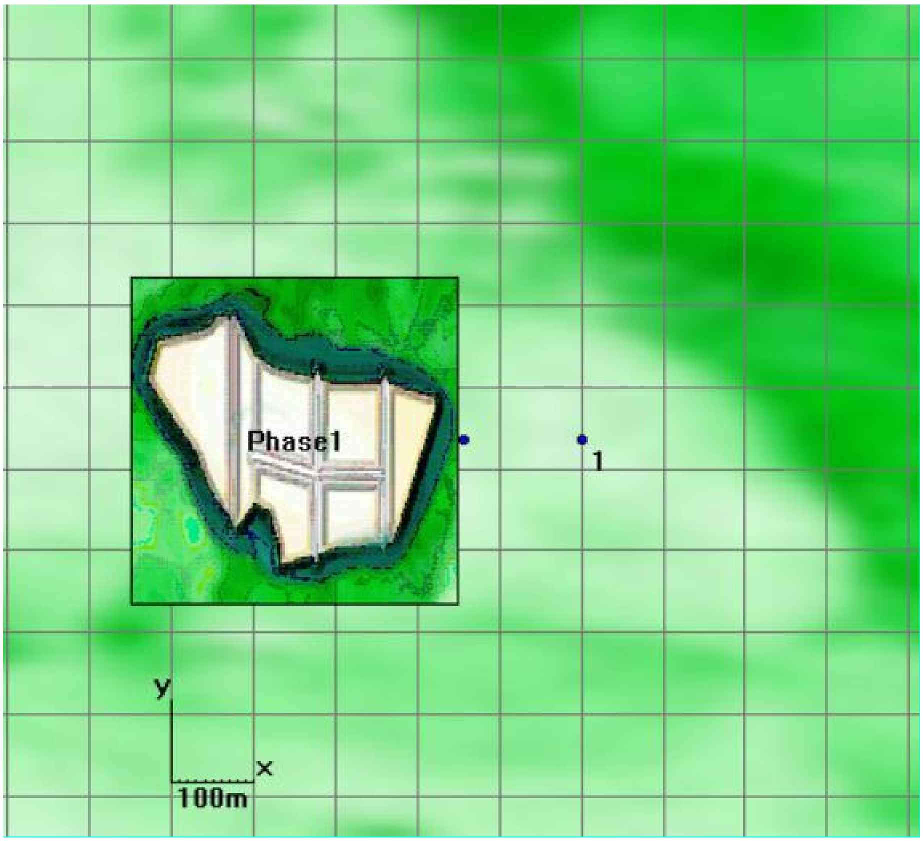


Figure 6-2 Phase 1 Model Configuration

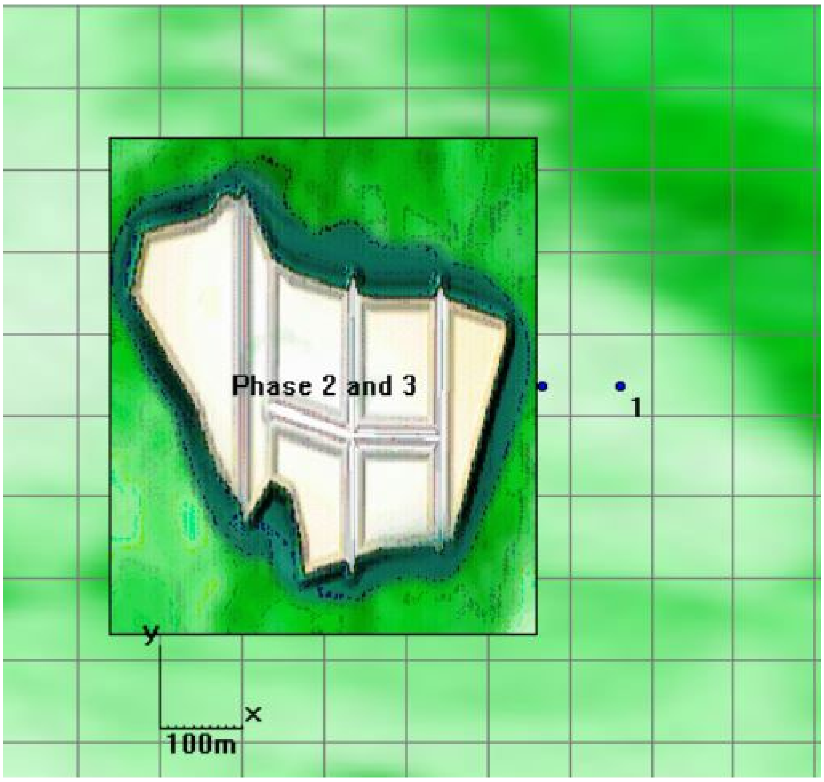


Figure 6-3 Phase 2 & 3 Model Configuration

The justification and development of this approach is illustrated on Drawing 2365-8 that shows the stepwise approach adopted to represent the current site conditions in Landsim. As can be seen, groundwater contours pass from south to north beneath both phases. To represent this in Landsim, the phases have been rotated whilst taking into account the relative position of the downgradient compliance well and the different levels of engineering control of each phase, with Phase 1 unlined and Phase 2 & 3 lined.

Setting up the modelling in this refined and simplified way also allows the impact to date of the unlined Phase 1 landfill to be directly compared against the results of the monitoring programme, which provides a useful way of verifying the model assumptions and outputs. This subsequently allows the predicted discharges from the new phases to be placed into context and validity of the predictions.

The Phase 1 unlined landfill has been approximated in the model by a single cell with a basal area of 14.82 Ha and waste thickness between 8 and 18m. The cell is modelled with no lining system.

Phase 2 & 3 are modelled as two cells of the same dimension with a composite Engineered Barrier System (EBS).

The Meteorological Office data shows an effective rainfall of 745mm per year (as reported in the Golder HRA, Section 3.1). Infiltration over the catchment has been estimated by data received from the Met Office (MORECS) and previously reported by Golder Associates as being 268mm per annum. This figure is close to the value of infiltration recharge to the Ordovician and Silurian mudstone strata reported by the BGS of 316mm per annum. This value has been retained having been previously used in approved HRA.

This data is used in both models.

6.2 Receptor

In line with previous HRAR, the principal receptor is surface water quality in Rudbaxton Water, which runs east to west along the toe of the northern site boundary. The distance between the edge of the landfill along this northern boundary and the stream is between 30m and 150m. In this zone, groundwater in the underlying shales is present at unproductive quantities to support viable extraction but it comprises a viable pathway to the receptor.

6.3 Leachate Source

In the previously approved HRAR the leachate inventory was represented by the inclusion of 8 parameters. To evaluate whether these parameters and concentrations are still representative of landfill performance, leachate chemistry has been evaluated.

Table 6-1 contains a tabulated statistical summary of selected leachate data gathered across Phase 1 and Phase 2 during the past decade whilst temporal series charts for each Phase are provided in Appendix 1.

Alongside the tabulated leachate data are Annual Average (AA) and Maximum Absolute Concentration (MAC) Environmental Quality Standards (EQS). To identify parameters that are elevated in leachate, the ratio between the median leachate concentration and the EQS has been calculated and included in the right-hand column.

The comparison indicates that:

- ammonia (and to a lesser extent chloride) are still good potential indicators of leachate quality as the ratio of leachate conc. to EQS is above 1, particularly in the case of ammonia
- Mecoprop (a herbicide), naphthalene and xylene have been either below or only slightly above the EQS. As shown by the time series charts in Figure 6-4, the occurrence of these substances is not persistent
- Phenols are still potentially good indicators of leachate quality but some of the reporting is considered to be potentially spurious, as discussed in Section 4

Table 6-1 Comparison of Leachate Chemistry and EQS

	Environmental Quality Standards (mg/l)		Leachate Chemistry (mg/l)			Dilution factor
	EQS AA	EQS MAC	Min	Most likely (Median)	95th percentile	(Median / EQS)
Previous Modelled Parameters						
Ammoniacal Nitrogen as N	0.3		0.01	785	2100	2616
Chloride	250	Not applicable	0.8	379.2	2924	1.5
Nickel	0.004	0.034	0.001	0.12775	0.3135	31.9
Cadmium	0.00008	0.00045 - 0.0009	0	0.00011	0.002374	1.3
Phenol	0.0077	0.046 (95th percentile)	0.010	1.65	28.725	214.2
Mecoprop	0.018	0.187	0.0001	0.0011	0.07436	0.06
Naphthalene	0.002	0.13	0.00002	0.0006	0.00998	0.3
Xylene	0.03		0.001	0.0091	0.01666	0.30
Other parameters						
Arsenic	0.05		0.001	0.084	1.2	1.68
Benzene	0.01	0.05	0.001	0.0046	0.00762	0.46
BOD	4		0.6	120	1051.2	30
Boron	2		0.009	4.5465	20.955	2.2
Chromium	0.0047	0.032 (95th percentile)	0.001	0.251	1.255	53.4
Cobalt	0.003	0.1	0.001	0.0275	34.88	9.1
Copper	0.001 (bioavailable)		0.001	0.0859	1.793061	85.9
Fluoride	5	15	0.06	0.3	12.46	0.06
Iron	1	Not applicable	0.019	4.7	19.331	4.7
Lead	0.0012	0.014	0.002	0.01311	0.06335	10.9
Manganese	0.123		0.001	0.832	2.14	6.7
Mercury		0.00007	0.0001	0.00022	0.6331	3.1
Sulphate	400	Not applicable	0.02	112.4	1174	0.2
Toluene	0.074	0.38	0.001	0.0044	0.02605	0.05
Vanadium	0.02		0.001	0.0681	59.5	3.4
Zinc	0.0109	Not applicable	0.001	0.0836	0.5794	7.6
Anthracene	0.0001		0.0003	0.0004	0.00122	4
Fluoranthene	0.0063	0.12	0.001	0.0009	0.0015	0.14

- Nickel is found in leachate at concentrations above EQS but as noted in Section 4, several trace metals are ubiquitous in the geosphere, potentially limiting their usefulness as an indicator of landfill leakage and not all samples have been appropriately filtered to reveal the dissolved concentration.
- Cadmium has also continued to be above the EQS at times, particularly if the lowest EQS is used as a yardstick. However, review of the time series charts in Figure 6-4 indicates a ‘spikey’ inconsistent occurrence, some of which may be due to analytical issues relating to sample filtration and measurement of total element concentration rather than dissolved. This may have also affected the concentration of other parameters.

Given potential shortcomings in data quality and new surface waer management system to be installed, a further interim review of the HRA is proposed for 2026 to allow additional data to be gathered according to a new monitoring programme. At the same time, further consideration will be given to the presence of other substances and trace organics which are currently at low concentrations.

At this junction, the updated LandSim models are still based on the substances previously modelled with the exception of Xylene which has been removed due to the lack of analytical detection. A similar argument could be made for Naphthalene and Mecoprop but these substances have been detected more frequently and their retention in the modelling provides a useful indicator of trace organic substances.

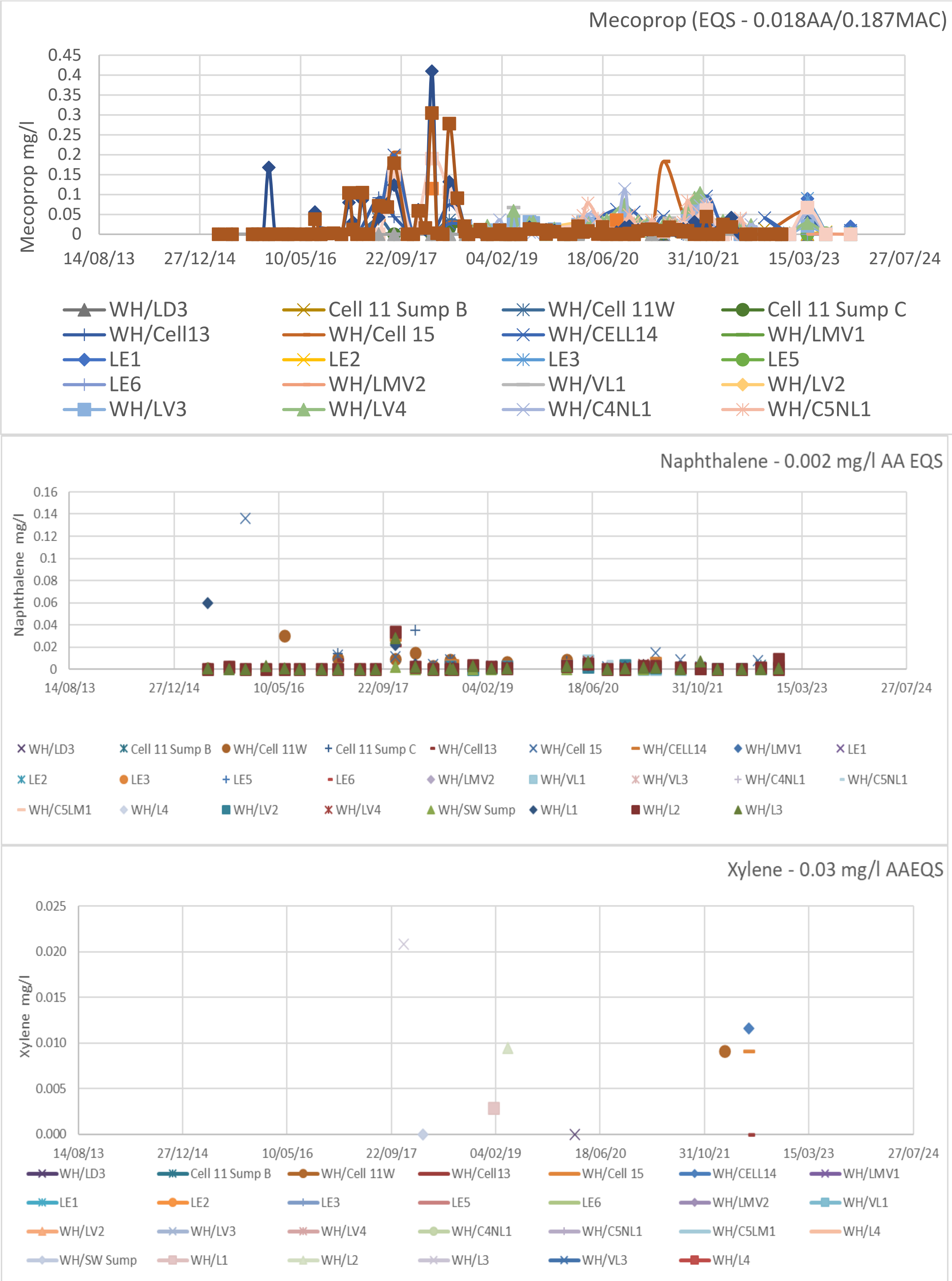


Figure 6-4 Detection of Mecoprop, Naphthalene and Xylene in Phase 1 & 2 Leachate

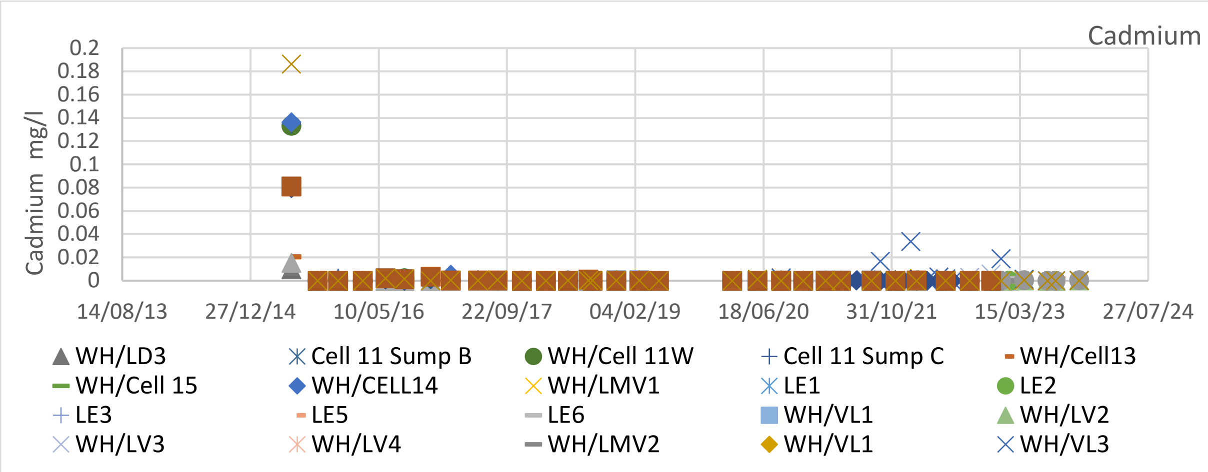


Figure 6-5 Cadmium occurrence in Phase 1 & 2 leachate

Within the LandSim model, each substance is described according to a statistical Probability Density Function (PDF) aimed at capturing their occurrence. Two sets of PDFs have been developed, one for each landfill phase and these are summarised in Table 6-2. Each PDF has been developed following a statistical review of each parameter to understand the statistical characteristics of the underlying sample population that requires statistical representation in the computer simulation. This has been achieved using numerical assessments and also review of the histograms presented in Figures 6-6 and 6-7. Based on this analysis, the minimum, median and 95 percentile values calculated for each dataset have been used to represent the minimum, most likely and maximum values within the LandSim leachate inventory. The new inventory and the shape of the PDF is summarised in Table 6-2. All of the substances are classified as non-hazardous pollutants and it is evident that the concentration ranges encompassed by the PDFs are similar for both models.

Table 6-2 Updated LandSim Inventory and PDFs

	Ammoniacal Nitrogen
Phase 1 model	LOGTRIANGULAR(0.01,660,2285)
Phase 2 & 3 model	LOGTRIANGULAR(10,1060,2000)
	Cadmium
Phase 1 model	LOGTRIANGULAR(8e-05,0.001,0.002)
Phase 2 & 3 model	LOGTRIANGULAR(8e-5,0.0001,0.002)
	Chloride
Phase 1 model	LOGTRIANGULAR(0.8,270,3200)
Phase 2 & 3 model	LOGTRIANGULAR(10,1100,2600)
	Mecoprop
Phase 1 model	LOGTRIANGULAR(0.0001,0.001,0.1)
Phase 2 & 3 model	LOGTRIANGULAR(0.0001,0.006,0.1)
	Naphthalene
Phase 1 model	LOGTRIANGULAR(2e-05,0.0006,0.01)
Phase 2 & 3 model	LOGTRIANGULAR(2e-05,0.0006,0.01)
	Nickel
Phase 1 model	LOGTRIANGULAR(0.001,0.1,0.3)
Phase 2 & 3 model	LOGTRIANGULAR(0.001,0.17,0.3)
	Phenols
Phase 1 model	LOGTRIANGULAR(0.01,1.1,112)
Phase 2 & 3 model	LOGTRIANGULAR(0.01,7.3,142)

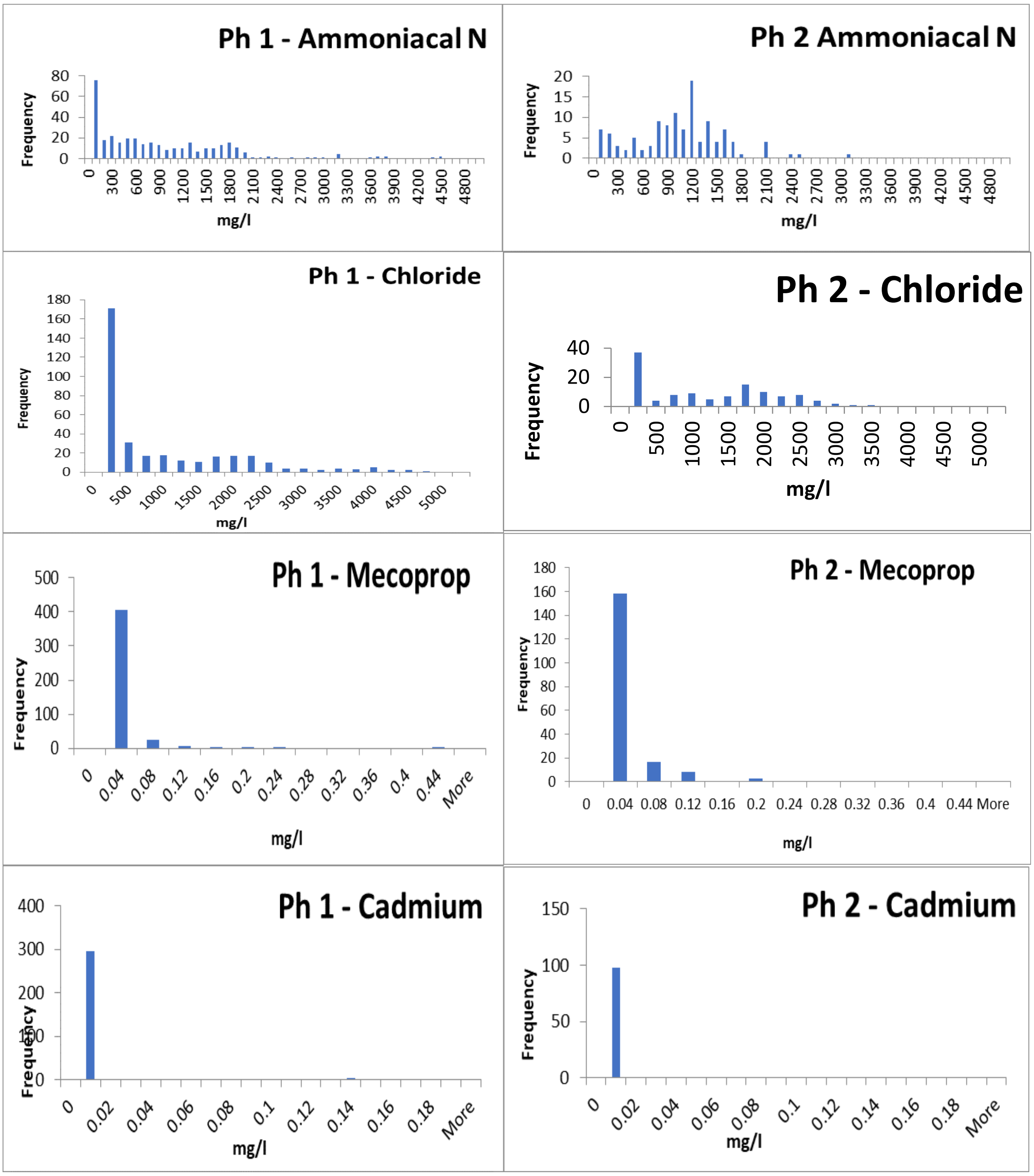


Figure 6-6 Histograms of Cadmium, Mecoprop, Chloride and Ammoniacal Nitrogen in Phase 1 & Phase 2 leachate

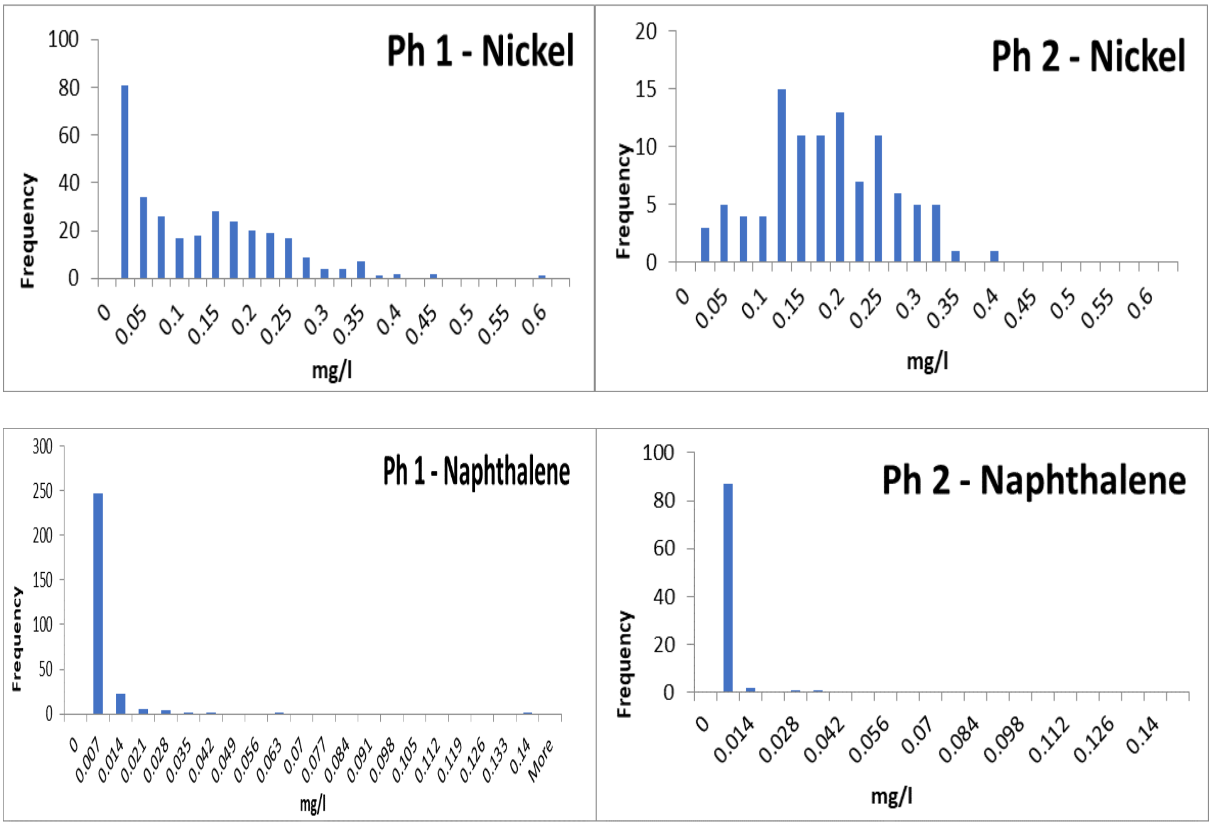


Figure 6-7 Histograms of Naphthalene and Nickel in Phase 1 & Phase 2 leachate

The maximum values of the new PDFs for Cadmium and Nickel are less than the maximum values modelled in the 2018 HRAR whilst the PDFs for all other parameters are slightly higher, although still lower than the concentrations modelled in the approved 2008 HRA.

6.4 Leachate Elevation & Management

The Permit requires leachate depth to be no more than 1m in each of the sumps. To ensure the model provides a robust assessment of risks to the geosphere the leachate head in Phase 2 has been fixed at 1m. This is clearly an over-estimate of the risk posed as each sump is fitted with a float controlled pump and the leachate is not the same depth across the base of each cell due to their sloping design i.e. it will only be up to 1m deep in the sump rather than across the whole cell footprint.

For Phase 1, the previously approved Golder HRA model was developed to leak all of the leachate produced to groundwater. This was achieved by specifying a 100m head of leachate on a 1m thick mineral liner, a curious approach given that it is known that the landfill has neither a 1m mineral liner or a 100m leachate head. Whilst this approach seems to have the merit of conservatively discharging all the leachate produced through the basal liner, the attenuation properties applied to the imaginary liner meant that the leakage was significantly attenuated. As this combination of underlying assumptions is clearly not representative of reality it has been subject to first principles revision.

In this assessment "No Engineered Barrier" has been selected in the LandSim model inputs, to reflect the reality that there is no liner. A series of dummy runs were carried out to determine the fixed leachate head that leaks all of the anticipated leachate to groundwater. The volume of leachate lost to groundwater from the capped Phase is conservatively assumed to be the entire leachate produced by leakage through the cap. This is clearly a conservative assumption as some of the leachate is collected by the extraction system and pumped out to treatment. The result of the dummy runs is that a fixed leachate head of 0.2m on the "No Engineered Barrier System" will discharge an annual volume equivalent to the calculated cap leakage.

6.5 Pathways

The pathways present have not changed since the previous HRAR but a review of site conditions has been made with the benefit of new bedrock exposures which have developed as a consequence of site development. As the findings have implications for the passage of groundwater, this aspect is discussed below and graphically illustrated in the updated conceptual site models.

Groundwater flows beneath the site through a network of fractures which appear to form a 3-dimensional lattice of fractures that allows a coherent groundwater surface to develop. Previous models have specified the groundwater passing beneath the site by determining the groundwater flux based upon a water balance calculation. The groundwater flux has previously been restricted to an aquifer thickness of 5m, which from the conceptual site model may seem appropriate. However, the latest phase of ground investigation and well installation has revealed that water flows through the bedrock to a depth of 10m. Accordingly, the flux has been applied to a 10m thick aquifer for this model.

6.5.1 Attenuation Properties

The LandSim models have been developed specifically to examine the fate of pollutants in the geosphere and require attenuation parameters to be input so that predictions on emissions can be made. In order to evaluate attenuation, a study was undertaken by Golder Associates using samples of site won materials (clay liner materials and Meidrim Shale bedrock) and solutions of various substances of interest. This enabled derivation of site specific distribution coefficients (Kd values) for ammoniacal nitrogen and cadmium in the mineral liner and Meidrim Shale and also the fraction of organic carbon. Retardation factors for other parameters modelled are literature based. As all of these values have been used in the previously approved HRAR they have also been adopted in this review.

6.6 Geological Units

These details have not been altered from the previously approved simulations. A vertical pathway has not been selected.

6.7 Groundwater Flow

The conceptual hydrogeological model of the site includes groundwater flowing northwards beneath the site. Groundwater levels have been measured in the monitoring infrastructure around the site and this has shown that the groundwater surface elevation falls from the high ground to the south of the site toward the valley base in the north. In response to the drop in head, groundwater flows through a network of fractures in the low permeability shale bedrock. Groundwater is sourced from infiltration recharge on high ground to the south of the site and is thought to be discharged into Rudbaxton Water, the lowest part of the catchment to the north. Rudbaxton Water is considered to be the receptor for groundwater which enters the surface water as baseflow.

In this assessment, analysis of groundwater flow occurring within each sub-catchment has been made for both models.

6.7.1 Phase 1

The volume of groundwater flowing toward downgradient wells can therefore be established by catchment analysis. This has been estimated by an analysis of the catchment upstream of Phase 1 and the catchment between Phase 1 and the downgradient well (as the wells are some distance from the edge of the waste mass). The upgradient catchment area lies on the narrow strip of higher ground to the south of Phase 1 and amounts to 115,000m^2 (area labelled Phase 1HW (headwaters) on Figure 3-6). The catchment downgradient of Phase 1 (between the landfill and Rudbaxton Water) amounts to 50,500m^2, and is part of the catchment labelled Rudbaxton B Landfill Offset on Figure 3-6.

The infiltration to groundwater over the catchment has been estimated by data received from the Met Office (MORECS) and reported by Golder Associates as being 268mm per annum. The flow of groundwater toward Rudbaxton Water therefore amounts to 1.4 litres per second:

(((Upgradient Area + Downgradient Area)*recharge infiltration) x litres conversion)/(No of seconds per annum)

(((115000+50500) x 0.268) x 1000)/(365 x 24 x 60 x 60) = 1.4l/s

Golder's approach to groundwater flow in a previously approved HRA LandSim model was to directly input groundwater flux, rather than allowing it to be calculated by LandSim from gradient and permeability. The flux estimated by Golder on the basis of groundwater recharge was 5.5e^{-7}m/s with an aquifer thickness of 5m and a porosity of 0.22. This calculation estimates a flow of 0.875l/s beneath Phase 1, which is very close to the 0.97l/s upgradient contribution to the 1.4l/s total flow estimated above.

Using the same approach, the groundwater flux in the Phase 1 model has been reduced to 3.6e^{-7}m/s so that the flow amounts to 1.0 l/s

6.7.2 Phase 2

Similarly, for the Phase 2 & 3 model, the upgradient catchment area lies on the narrow strip of higher ground to the south of the landfill and amounts to 144906m^2: this area is labelled Phase 2 & 3 HW on Figure 3-6 and Table 3-1. The downgradient catchment to the north of Phase 2 & 3 (between the wells and landfill) amounts to 35129m^2 and this area is part of Rudbaxton A Landfill Offset and part of Rudbaxton B Landfill Offset on Figure 3-6 and Table 3-1.

Using the same calculation as outlined in the previous section and the infiltration figure reported by Golder Associates of 268 mm, the flow of groundwater toward Rudbaxton Water beneath Phase 2 & 3 amounts to 1.53 litres per second:

(((Upgradient Area + Downgradient Area) x recharge infiltration) x litres conversion)/(No of seconds per annum)

(((144906+35129) x 0.268) x 1000)/(365 x 24 x 60 x 60) = 1.53l/s

Similarly, for Phase 2 & 3 combined the flow rate based upon catchment analysis is 1.53l/s. However, a small ephemeral spring is present directly above Phase 3 and though this has been shown to be partly recharged by groundwater and partly the result of surface water flow, the presence of the spring and its diversion into a piped drain means that the calculated groundwater recharge may be a slight overestimate. For this reason the groundwater recharge has been reduced by 0.3l/s to conservatively account for groundwater recharge loss. Accordingly, the flux specified in LandSim is 2e-7m/s to total the estimated recharge minus the spring diversion.

6.8 Landfill Liner Performance

There is no engineered barrier system for Phase 1.

For Phase 2 & 3 the same composite lining system is used, comprising a compacted clay liner overlain by a flexible membrane liner. Since Cell 3 the AEGB has comprised a thinner clay layer of 500mm thickness, supplemented with a Geotextile Clay Liner. An examination of the performance of the site won clay has shown that the permeability of clay does not exceed $1e^{-9}ms^{-1}$ and is frequently an order of magnitude less than this.

For the assessment the equivalent permeability of the gcl/ccl has been calculated. LandSim does not allow the mineral/gcl/fml composite to be input directly so instead a calculation of the equivalent mineral thickness has been made using the combined properties of the site won mineral and the Bentomat gcl used at the site. The specification for the Bentomat indicates it has a thickness of no less that 1cm and a permeability of no more than $2e^{-11}ms^{-1}$. Thus, in combination with 0.5m thickness of site won clay the AEGB can be modelled as a 0.51m thick liner with a combined permeability of $5.1e^{-10}ms^{-1}$ for Phase 2 & 3.

6.9 Unsaturated Zone

Leakage from the landfill leaks directly into the Meidrim Shales, with an unsaturated zone thickness specified for Phase 1 in accordance with previous HRAs to represent the variation in unsaturated zone thickness. For Phase 2 & 3 the unsaturated zone thickness has been specified as 1m, the minimum required by current Permit requirements.

6.10 Baseflow

It is assumed that the entire groundwater flow beneath Phases 1 and 2&3 including any entrained substances from leachate will report to Rudbaxton Water as baseflow. Accordingly, the downgradient concentrations calculated by LandSim in combination with the calculation of leakage and groundwater flow gives a rational means to calculate substance flux into the receiving water course.

7 PREDICTED CONCENTRATIONS IN GROUNDWATER

LandSim is a predictive tool that allows the concentration of substances in a groundwater well downgradient of the landfill to be estimated over selected timeframes. As all models are simplified representations of reality, the results should be viewed as one line of evidence to aid assessment. Other lines of evidence include hand calculations and the results from the surface water and groundwater monitoring programme.

At Withyhedge, Geotechnology is fortunate to be able to evaluate the suitability of the LandSim model assumptions and predictions by comparison of the outputs with actual performance monitoring data and mass balance calculation. This is because Phase 1 is not a proposed future landfill but a completed landfill that has had no waste deposited within it for 30 years. This provides a really useful opportunity to compare the LandSim predictions for the 30year time slice against hand calculations assessing leakage rates and the measured concentrations of substances in groundwater and surface water. In combination, these multiple lines of evidence provide an important insight to evaluate the model results and provide a pathway to verify the model assumptions, outputs and long-term predictions.

Before the LandSim predictions of the pollutant concentrations in groundwater at the downgradient monitoring wells are considered, a mass balance approach is first introduced and the predicted rate of leachate leakage and dilution evaluated. The calculations are subsequently used to help place some of the LandSim predictions into context.

7.1 Leachate Leakage & Dilution in Groundwater

7.1.1 Phase 1

As noted in Section 6.7, groundwater flow beneath the site can be quantified by different approaches and previous HRA's have approached this by:

- calculating flow by calculation from groundwater gradient and permeability
- calculating flux by calculation of recharge area and recharge infiltration

It is considered that these two approaches are useful but can be further refined and supported by considering mass balance, in which the flowrate of groundwater can be quantified by using the concentration of a key mobile unattenuated pollutant (such as Chloride) in upgradient groundwater, leachate and downgradient groundwater. Fortunately, the site has a mature dataset of chloride data in established monitoring wells that are not influenced by many of the factors that make certain determinants unreliable as a basis for chemical mass balances. Accordingly, rather than take one approach to groundwater flow calculations and evaluation of leachate flux and dilution, this report has considered different approaches.

A mass balance approach can be used to examine the entrainment of pollutants into groundwater beneath Phase 1. This offers a means to estimate the flow of leachate to groundwater, as other methods are not available: it is known that not all of the infiltration through the Phase 1 cap is emitted to groundwater as active leachate pumping is being undertaken. There are no construction records for Phase 1 so it is not possible to calculate theoretical leakage through the base of the landfill.

Anecdotal information suggests that Phase 1 was constructed on an in-situ (or informally engineered) geological barrier. This provides a degree of resistance to percolation into groundwater beneath the site and is consistent with the presence of leachate at the pumping sumps. Golder Associates estimated that the infiltration through the polyethylene cap over Phase 1 is limited to 30mm per annum, hence the leachate production per annum is 4842m^3 as the surface area of the unlined landfill is 161,403m^2. (Note that this comprises a part of the existing landfill area of 340043m^2 indicated on Figure 3-6 and quantified on Table 3-1).

The proportion of the 4842m^3 that is extracted by the leachate collection and pumping system is not precisely known, and hence so is the proportion of the leachate being discharged to groundwater. A mass balance using Chloride concentration and flowrate has been carried out as a means to approximate the current flows of leachate to groundwater and dilution. Chloride has been chosen as it is a substance that does not attenuate by degradation or reactivity in the ground, is highly soluble and mobile and is well represented in the existing dataset.

The mass balance approach requires the volume of groundwater flowing toward downgradient wells to be established by catchment analysis. This has been estimated by an analysis of the catchment upstream of Phase 1, as detailed in Section 6.7 and shown to be 1.41l/s.

The concentration of chloride in upgradient wells (i.e. typical background concentration for Phase 1) has been measured at BH25 and BH26, with averages of 30 and 29mg/l respectively. For the purposes of this assessment, it is considered to be 29.5mg/l. The downgradient wells have been measured at BHTP9 and BHTP11 at concentrations of 53 and 53mg/l respectively. For this assessment it is considered to be 53mg/l. The concentration increase is assumed to be solely due to the entrainment of leachate leakage from the unlined Phase 1 to groundwater flowing northward beneath the site.

The concentration of chloride in the leachate within Phase 1 is monitored at several leachate monitoring positions with the data statistically summarised in Figure 7-1. Geotechnology has used the last 9 years data to establish the median chloride concentration in Phase 1 wells. The median concentration for chloride in Phase 1 is 270mg/l.

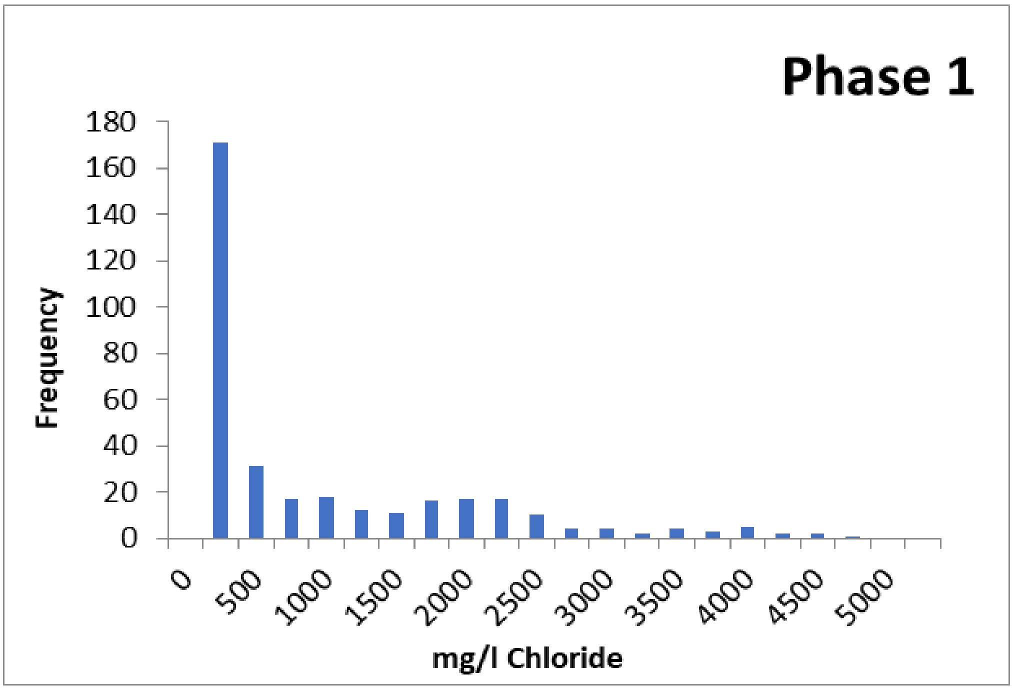


Figure 7-1 Occurrence of Chloride in Phase 1 Leachate Wells

Previous HRAs have assumed that all the leachate produced in Phase 1 is emitted to groundwater through leakage. This is clearly not the case as leachate abstraction removes some of the leachate, though this conservative assumption is retained for this assessment. The 4842m^3 pa calculated above as the total leachate production of Phase 1 amounts to a flowrate of 0.15litres/second. This leachate is entrained into the groundwater flow of 1.4litres/second.

A mass balance calculation has been carried out to determine the concentration of chloride in the downgradient groundwater well after the groundwater has received the leachate emission from Phase 1. The background groundwater concentration of 29.5mg/l will be increased by the leachate discharge by the amount calculated below:

Upgradient groundwater flux: 1.4l/s @ 29.5mg/l = 41.3mg
Leachate flux: 0.15l/s @ 270mg/l = 40.5mg
Final concentration calculated in downgradient groundwater= (41.3 + 40.5)/(1.4+0.15) = 52.7mg/l

This estimate aligns very closely with the average downgradient chloride concentration of 53mg/l and provides confidence that this general mass balance approach can be used as another line of evidence as the calculation is sound and its underlying assumptions reasonable. The calculation also supports the catchment analysis derivation of groundwater flow amounting to 1.4 l/sec which was used in the Phase 1 model.

Accordingly, the rise in concentration is the result of 0.15 litres of leachate emission per litre of groundwater flowing to the well, a dilution ratio of 1:9.4 i.e. 1.4/0.15 l/s.

7.1.2 Phase 2 & 3

For Phase 1 the mass balance approach is the only method available that is rooted in actual data. Previous attempts to produce LandSim models of the site have used unrealistic assumptions and have made models of uncertain engineering, as noted in Section 6.4. However, for Phase 2 & 3, where detailed engineering specifications have been used, and will continue to be used, to provide modern containment lining systems and where leachate is controlled to defined levels, modelling is an appropriate means to consider leakage.

Phase 2 is nearing completion and is underlain by an engineered lining system comprising either a composite of 1m thick locally derived clays overlain with 2mm welded fml or a composite of 0.5m thick locally derived clays overlain with a gcl and a 2mm welded fml. In either case the lining system performance can be modelled realistically in LandSim. Phase 3 will continue to use the same technical precautions and comprise 0.5m thick clays overlain with a gcl and a 2mm welded fml.

The LandSim model produced for this part of the assessment comprises two landfill cells comprising a single Phase, with Phase 2 & 3 modelled as a single cell. The length of the cell is the maximum downgradient distance to provide the maximum possible emission to groundwater. The entire Phase is modelled to experience a sustained 1m leachate head across the entire base area. This is clearly highly conservative as it is the sump area that experiences greatest heads and at the sumps the Permit requires that head remains below 1m. It is therefore inevitable that much of the footprint of the actual landfill experiences much lower leachate head.

The LandSim model indicates a 95th percentile leachate leakage rate of 2916 litres/day at 100years after the start of the simulation, representative of steady state conditions in the medium term. This equates to a leakage rate of just 0.034litres/sec for the combined area of Phase 2 & 3.

The 1.53l/s flowing beneath the landfill will receive the landfill emissions calculated to be 0.034 l/s which will result in dilution of 1:45 i.e. 1.53 / 0.034l/s.

Clearly, the dilution factor for Phase 2 & 3 is significantly greater than that of Phase 1, as summarised in Table 7-1, which also includes groundwater flow, leakage and dilution for direct comparison.

Table 7-1 Groundwater Flow and Leachate Dilution

Phase	Groundwater flow	Landfill Leakage	Dilution
	l/s	l/s	
1	1.4	0.150	9.33
2&3 Combined	1.53	0.034	45

This aspect is considered further during the evaluation of the LandSim predictions and assessment of emissions to the receptor.

7.2 LandSim Predictions for Phase 1

The model includes evaluation of a selection of species that behave differently in the environment; some are mobile whilst some are subject to a range of attenuation processes. This range in species behaviour enables the predicted behaviours to be conceptually extended to other potential contaminants that share similar behaviours.

7.2.1 Chloride

Following on from the mass-balance, the first substance to be evaluated is Chloride. This is selected as a substance that is not typically significantly attenuated within the geosphere so its behaviour should simply follow the dilution model introduced in the previous section and it is useful to compare the results of that calculation, the actual monitoring data and the LandSim outputs. Because the mass balance has been based upon the most likely source concentration and the annual average groundwater flow, it is appropriate to compare the results for the 50th percentile model output.

The LandSim model predicts a 50th percentile concentration at the downgradient well of 34.9mg/l (as shown in Figure 7-2) which when added to the upgradient average concentration of 29.5mg/l gives an estimated well concentration of 64.4mg/l. The concentration of chloride estimated by the simple mass balance based on an average dilution model is 52.7 mg/l in the downgradient wells. This compares favourably with the average downgradient chloride concentration of 53mg/l. This close correlation between the predictions and performance monitoring verifies the basic assumptions made in the mass balance about the quantity of groundwater moving through the system and the leakage rate and concentration of chloride in the leachate.

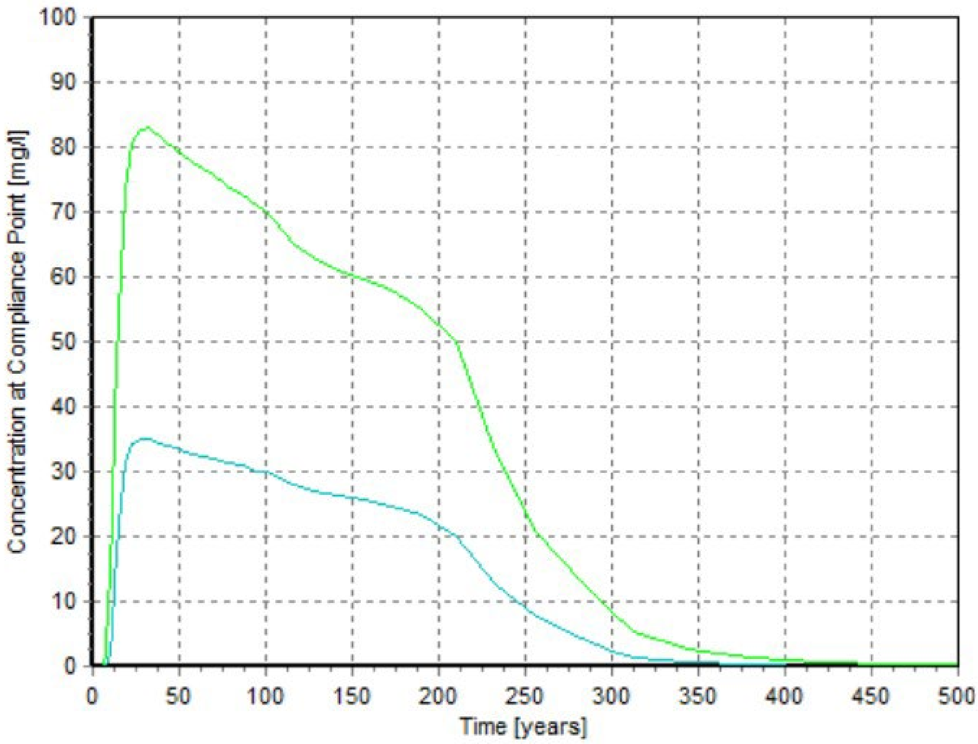


Figure 7-2 Prediction of Chloride concentration at Phase 1 Compliance Well
(green line = 95th and blue line = 50th percentiles)

The results for chloride from both mass balance and LandSim agree well with the measured concentrations downgradient of the landfill. This provides confidence in the 50th percentile simulation of unretarded substances though it is noted that the LandSim model is predicting higher concentrations than have been measured suggesting a conservative model. The LandSim model is considered to be conservative because:

- The area of the model is slightly larger than the footprint of the cells
- The model has been constructed to leak the entire leachate production to groundwater despite leachate pumping occurring in reality (although this impact is not seen in chloride mass balance)
- No account is taken of the basic clay lining system present in many of the cells
- No account is taken of the formal lining system in Cells 12, 13, 14 and 15

Even the higher concentrations in groundwater are, however, less than 35% of the freshwater EQS of 250 mg/l.

7.2.2 Ammonia

A mass balance approach is not suitable for evaluating substances that attenuate in the geosphere and so the more sophisticated modelling approach is required. The LandSim models developed include the attenuation parameters determined by site specific testing so that predictions of attenuated concentrations at the downgradient wells can be made. The LandSim model has already been seen to make small overestimates of substances that do not attenuate so it would be expected that if the bulk attenuation properties are accurate, the model would predict corresponding small overestimates of concentrations at the downgradient wells.

The predicted concentration at the downgradient wells have been expressed in the Landsim output as a probability distribution, ranging from zero at the first percentile to 17.41mg/l at the 99th percentile. The 50th percentile is 0.77mg/l, as shown in Figure 7-3. The available Phase 1 downgradient dataset for ammonia amounts to 450 measurements, so about half of the 1001 runs of the LandSim model. The distribution of the measurements has also been made for comparison with the LandSim predictions, ranging from 0.01mg/l at the first percentile to 5.7mg/l at the 99th percentile. The 50th percentile is 0.04mg/l.

Table 7-2 provides a comparison of the probability distributions predicted by LandSim with the monitoring dataset. The side-by-side comparison reveals the LandSim model is overestimating quite significantly the concentration of ammoniacal nitrogen at the Phase 1 downgradient wells. The reason for the disparity in concentrations is not due to the hydraulics of the system as these have been verified using mass balance for Chloride so it must be either an overestimate of source concentration or an underestimate of attenuation. Given the large dataset available for source concentration it is likely to be mostly due to an underestimate of attenuation, though both mechanisms may be contributory.

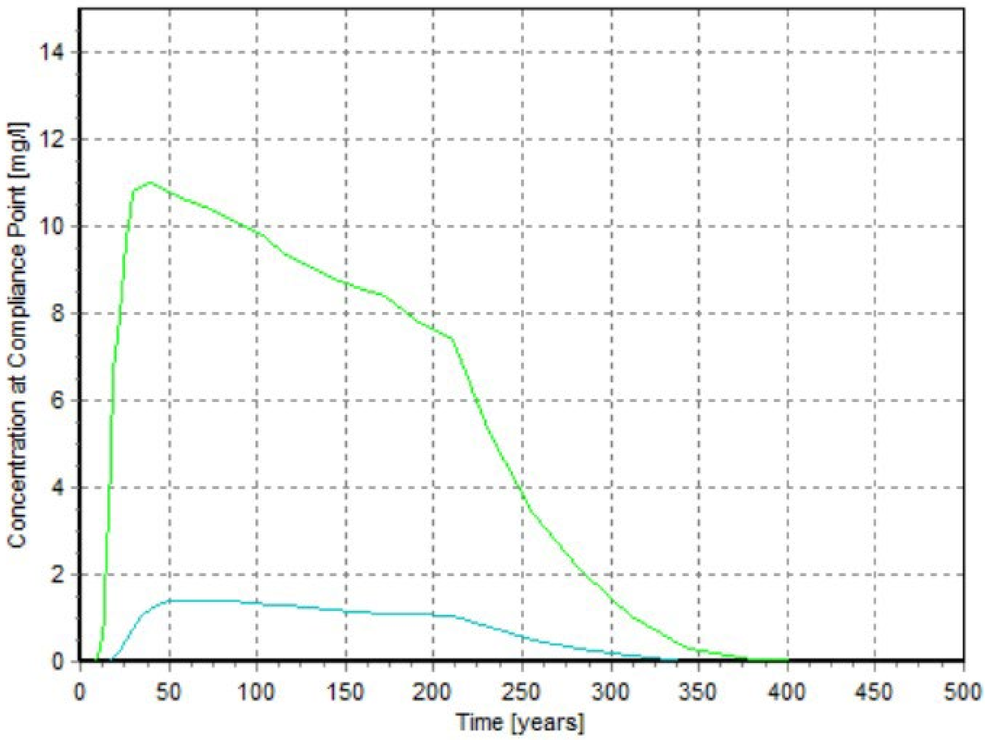


Figure 7-3 Prediction of Ammoniacal Nitrogen concentration at Phase 1 Compliance Well

(green line = 95th and blue line = 50th percentiles)

Table 7-2 Comparison of actual and predicted ammoniacal nitrogen downgradient of Phase 1

	Actual Data (Wells downgradient of Phase 1)	LandSim Phase 1
	mg/l	mg/l
99 percentile	5.743	17.4091
95 percentile	2.15	10.8238
90 percentile	0.18	6.8193
50 percentile	0.04	0.7732
10 percentile	0.01	0.0089
5 percentile	0.01	0.0006
1 percentile	0.01	3.40E-08

The idea of ammonia potentially being retarded more than estimated by site specific measurements of attenuation is discussed later.

7.2.3 Nickel and Cadmium

Nickel and Cadmium were selected as substances of interest in the previous HRAs. The full reasoning behind this selection is unclear as the long-term monitoring reveals background groundwater and surface water to be naturally mineralised with several trace metals including Nickel and Cadmium, as discussed in Section 4.

For consistency with previous assessments, the modelling has included assessment of Nickel and Cadmium. The outputs shown in Figure 7-4 and 7-5 indicate that the concentration of both metals leaving the site are predicted to be below detection limits not just for the 30year time slice but for every other time slice.

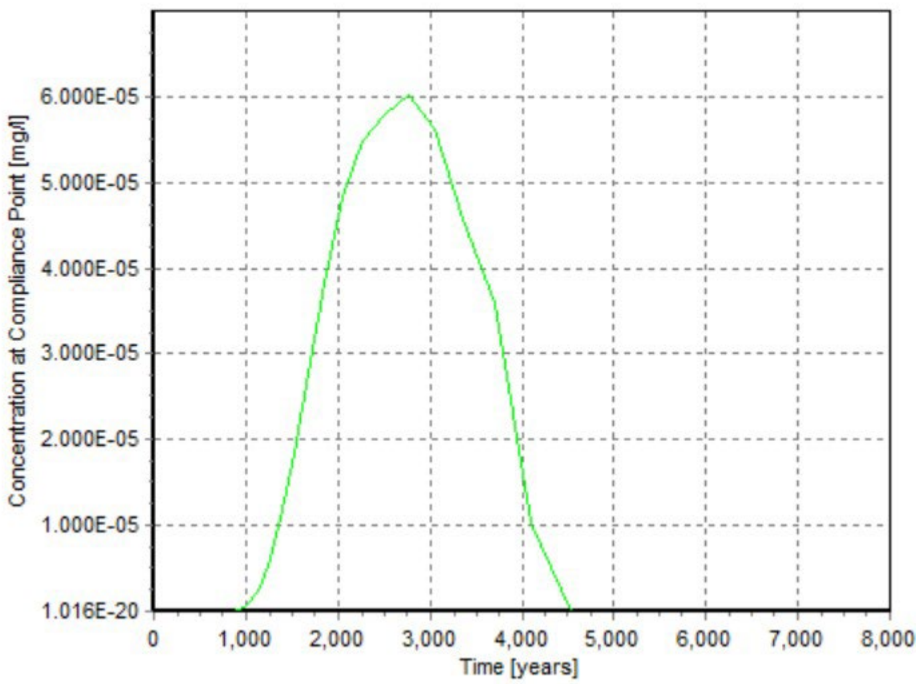


Figure 7-4 Predicted Nickel concentrations at Compliance Well downgradient of Phase 1

(green line = 95th , blue line showing 50th percentile not visible at this scale)

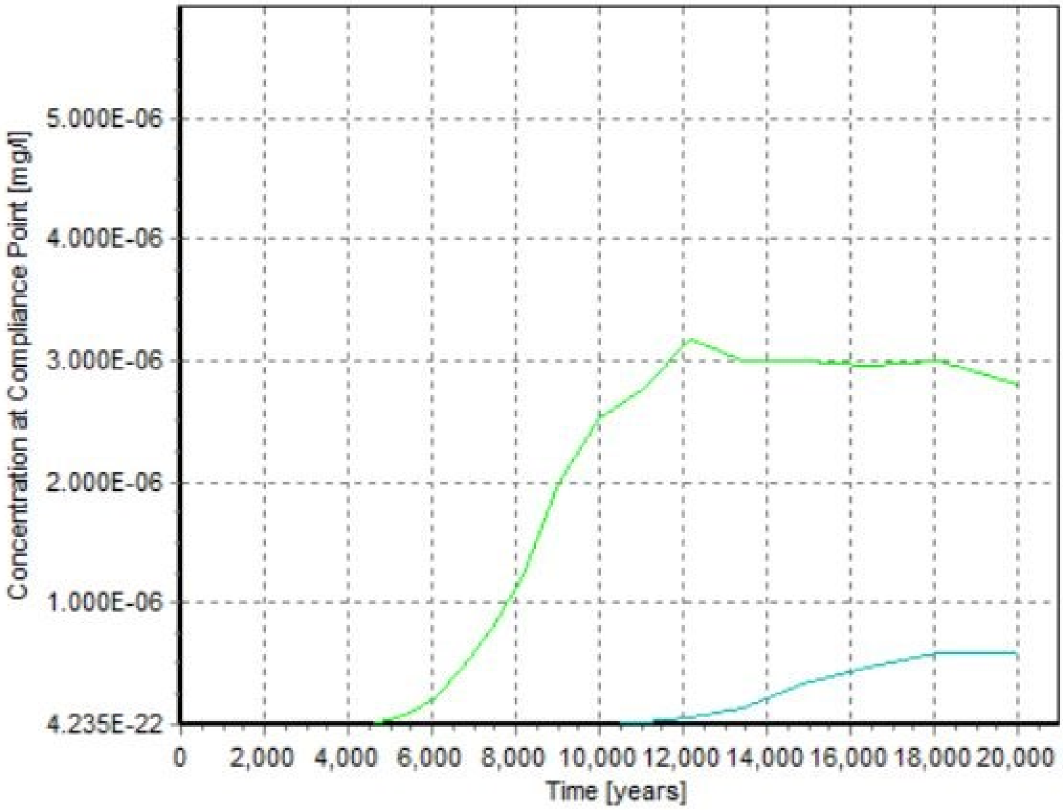


Figure 7-5 Predicted Cadmium concentrations at Compliance Well downgradient of Phase 1

(green line = 95th , blue line showing 50th percentile not visible at this scale)

7.2.4 Phenol

Due to uncertainty regarding the differentiation of phenol with total phenols, the leachate inventory was raised an order of magnitude higher than that used in 2018. Despite this conservative approach the model predicts extremely low levels at the downgradient compliance well, as shown in Figure 7-6. Such levels will not be discernible.

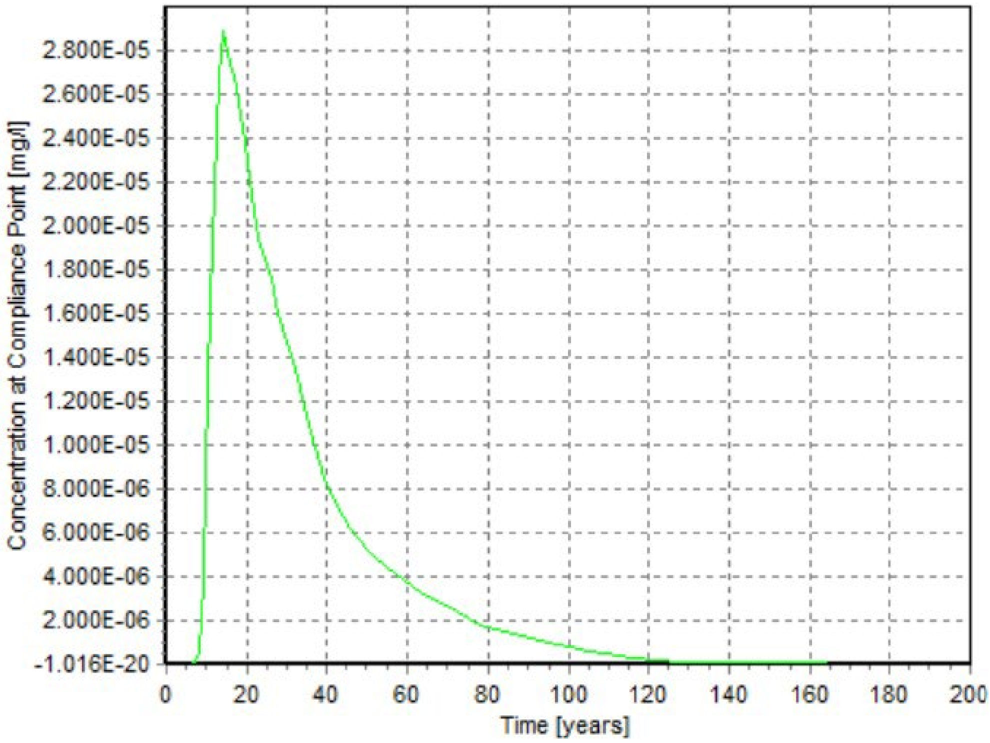


Figure 7-6 Predicted concentration of Phenol at Phase 1 downgradient Compliance Well

(green line = 95th percentile, blue line showing 50th percentile not visible at this scale)

7.2.5 Mecoprop and Naphthalene

The other non-hazardous substances are predicted to be at such low levels that they also are not be likely to be perceptible. The small predicted increases in concentration downgradient of the site are summarised in Table 7-3 for mecoprop. Naphthalene is not predicted to be present at any of the corresponding time slices.

Table 7-3 Predicted increases in downgradient groundwater

Downgradient of Phase 1						Downgradient of Phase 2&3			
Ammonia									
Percentile %	**At 30 years**	**At 100 years**	**At 300 years**	**At 1000 years**		**At 30 years**	**At 100 years**	**At 300 years**	**At 1000 years**
1	3.4E-08	0.03	0.0042	0		0	5.0E-17	2.7E-05	4.0E-05
5	0.0006	0.12	0.0193	0		0	4.8E-11	0.0002	0.0003
10	0.0089	0.20	0.0089	0		0	9.0E-09	0.0006	0.0006
50	0.77	1.33	0.21	0		0	4.8E-05	0.0102	0.0131
90	6.82	6.80	0.98	0		0	0.0045	0.14	0.16
95	10.82	9.84	1.44	0		0	0.0106	0.25	0.32
99	17.41	15.49	2.38	0		0	0.04	0.55	0.66
Chloride									
1	7.61	6.04	0.23	0		0	0.07	0.43	0.02
5	11.71	10.08	0.43	1.3E-08		0	0.15	0.86	0.08
10	15.13	12.99	0.60	5.3E-08		0	0.21	1.24	0.21
50	34.91	29.84	2.42	1.6E-06		0	1.06	5.59	2.89
90	67.96	58.00	6.21	7.4E-06		0	2.85	14.63	10.18
95	82.79	70.04	8.26	1.0E-05		0	3.72	18.30	13.60
99	111.33	91.44	11.59	1.6E-05		0	5.52	23.47	18.23
Mecoprop									
1	0	0	0	0		0	0	0	0
5	0	0	0	0		0	0	0	0
10	0	0	0	0		0	0	0	0
50	0	0	0	0		0	0	0	0
90	6.2E-13	5.4E-13	2.5E-14	0		0	0	0	0
95	4.3E-12	3.5E-12	1.9E-13	0		0	0	3.1E-18	1.7E-18
99	5.2E-11	4.7E-11	2.8E-12	0		0	2.3E-17	1.0E-16	7.7E-17
Nickel									
1		0	0	0		0	0	0	0
5		0	0	4.9E-17		0	0	0	0
10		0	0	1.6E-16		0	0	0	0
50		0	3.1E-17	4.2E-10		0	0	0	0
90		4.9E-17	1.2E-16	3.0E-07		0	0	0	0
95		9.2E-17	1.5E-16	7.1E-07		0	0	0	0
99		1.5E-16	2.4E-16	1.8E-06		0	0	0	0
Phenols									
1	0	0	0	0		0	0	0	0
5	0	0	0	0		0	0	0	0
10	0	5.8E-16	0	0		0	0	0	0
50	0	7.5E-10	0	0		0	0	4.2E-17	0
90	0	2.8E-07	0	0		0	0	3.7E-13	0
95	0	8.4E-07	7.7E-12	0		0	0	1.9E-12	0
99	0	3.8E-06	2.0E-10	0		0	0	2.1E-11	5.1E-18

7.3 LandSim Predictions for Phase 2 & 3

7.3.1 Non-Hazardous Pollutants in Groundwater

Unlike Phase 1, which is unlined, detailed engineering lining systems have been installed under CQA supervision and approved by the waste regulator beneath Phase 2. The same designs, technical precautions and level for supervision will also be used during the construction of Phase 3.

As noted earlier, the LandSim model indicates a 95th percentile leachate leakage rate of 2916 litres/day at 100 years after the start of the simulation, representative of steady state conditions in the medium term. This equates to a leakage rate of 0.034litres/sec (30ml per second) for the combined area of Phases 2 and 3. The predicted rate of leakage over the next several thousand years is graphically illustrated in Figure 7-7 which is an output from the Landsim simulation for Phase 2 and 3.

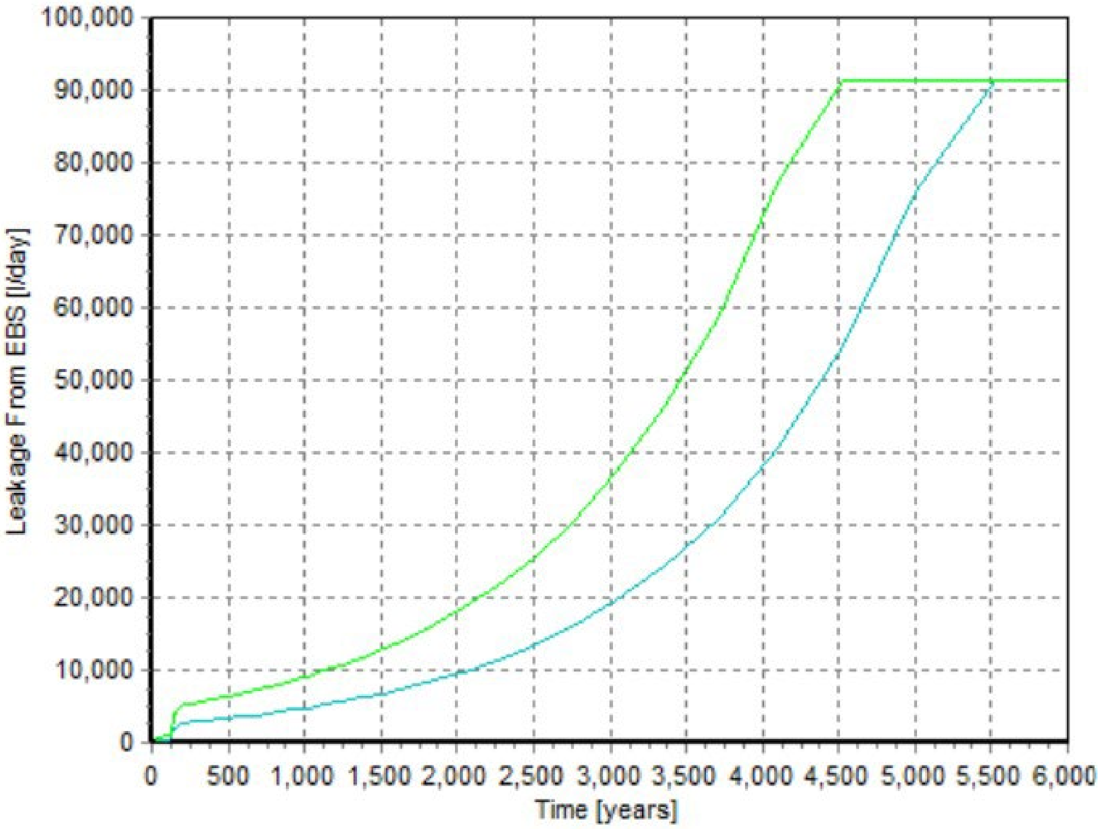


Figure 7-7 Leakage from engineered Barrier System (EBS) beneath Phase 2 & 3
(green line = 95th percentile, blue line = 50th percentile)

Despite Phase 2 & 3 occupying twice the footprint of unlined Phase 1 and therefore receiving twice the rainfall, the rate of predicted leakage is considerably less than that from Phase 1 due to the containment engineering. Accordingly, the rate of dilution is higher beneath Phase 2 & 3, as confirmed in Figure 7-8 and outlined by the previous hand calculation.

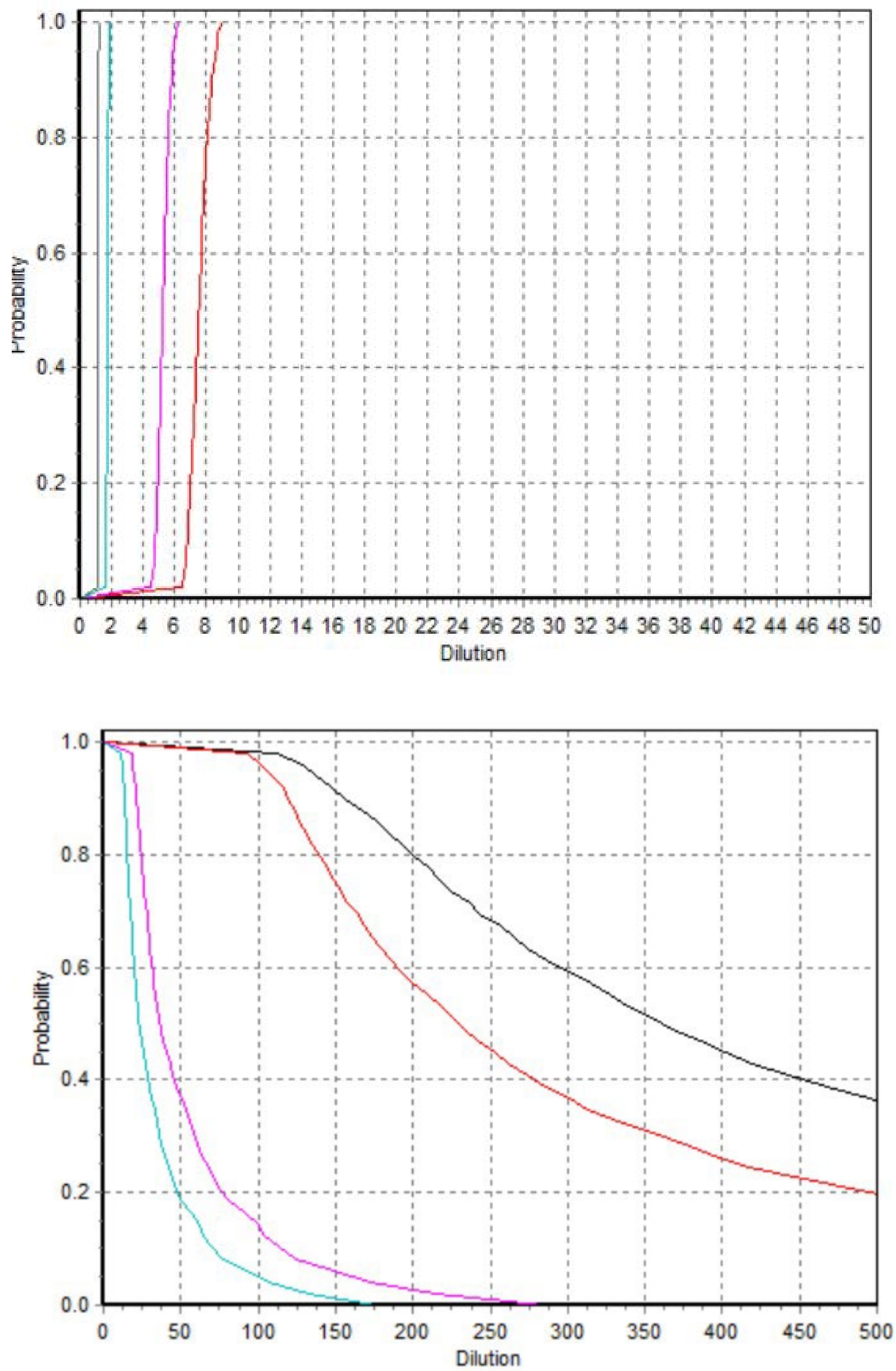


Figure 7-8 Dilution of leachate discharge from Phase 1 (top) and Phase 2 & 3 (bottom) in groundwater
(black line = 30 years, blue line = 1000 years)

With similar leachate inventories but higher rates of dilution below Phase 2 & 3 it is reasonable to conclude that the current and proposed phases will have a fraction of the influence on groundwater (and hence Rudbaxton Water) that Phase 1 has had and will have. As Phase 1 is not currently having an unacceptable effect on Rudbaxton Water, the logical conclusion would be that this situation will persist.

Table 7-9 summarises the predicted concentrations of all modelled parameters at the Phase 2 & 3 downgradient compliance point with several parameters also shown graphically in Figures 7-10 to 7-12. The reason that the other parameters modelled are not shown graphically is that the concentrations predicted are imperceptible and will not be discernible in groundwater.

The model outputs from Phase 2 & 3 clearly predict very small contributions to groundwater of chloride and ammoniacal nitrogen and imperceptible levels of all other non-hazardous pollutants.

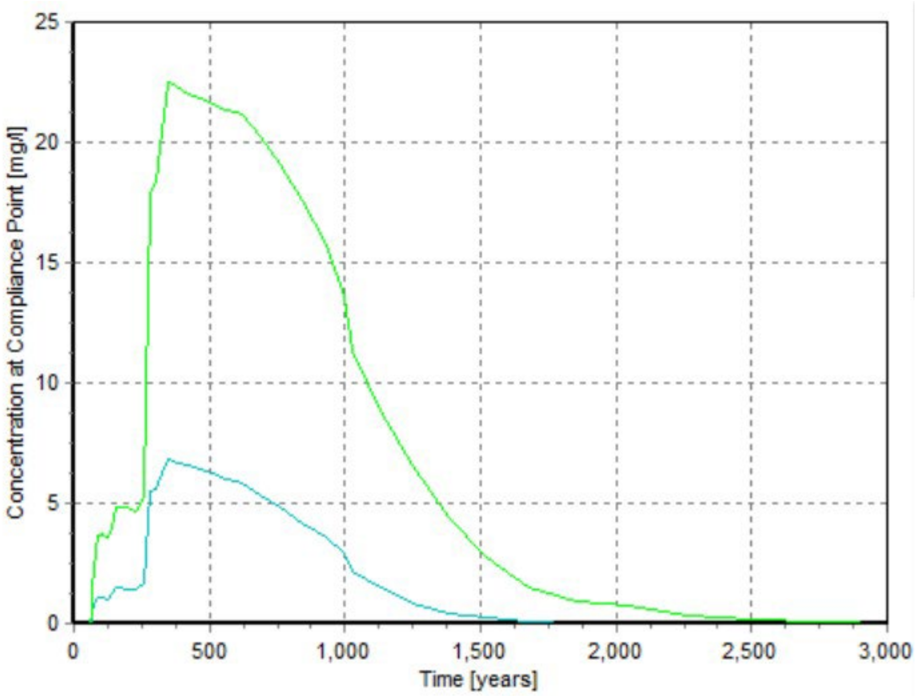


Figure 7-9 Predicted Chloride concentrations at Compliance Well downgrading of Phase 2 & 3

(green line = 95th percentile, blue line = 50th percentile)

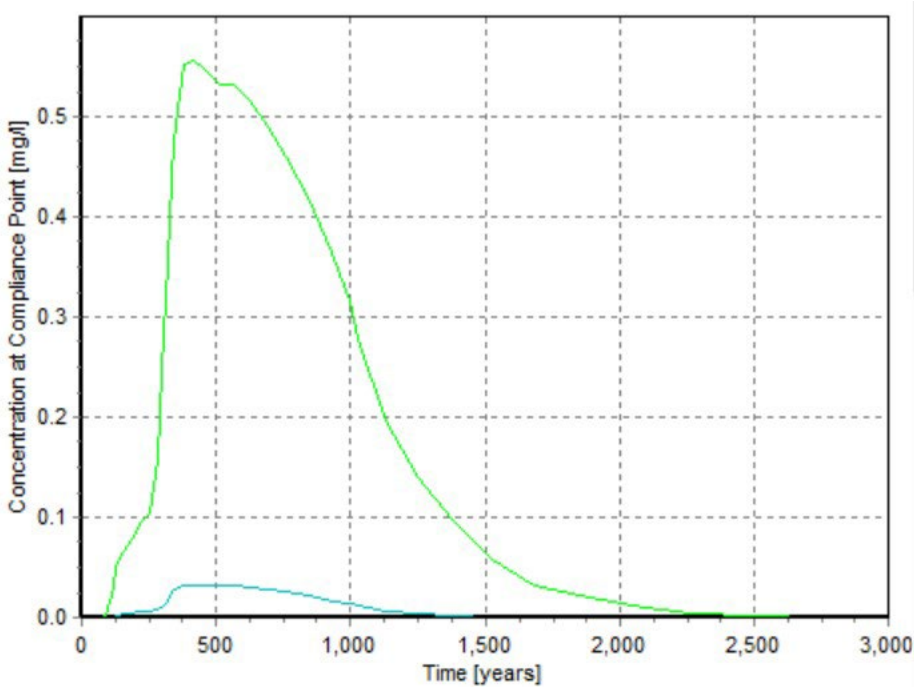


Figure 7-10 Figure Predicted Ammoniacal Nitrogen concentrations at Compliance Well downgradient of Phase 2 & 3

(green line = 95th percentile, blue line = 50th percentile)

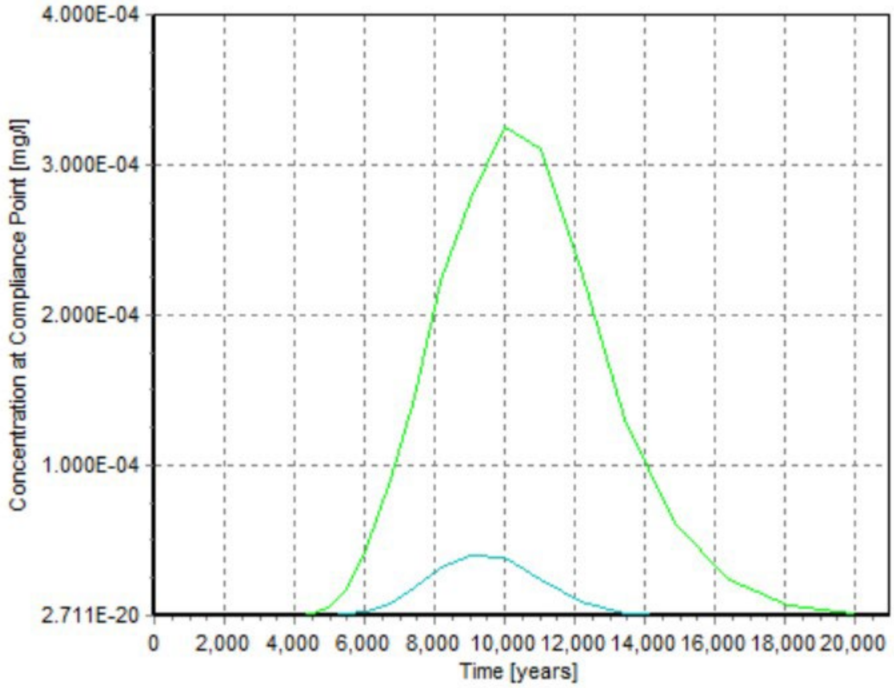


Figure 7-11 Predicted Nickel concentrations at Compliance Well downgradient of Phase 2 & 3

(green line = 95th percentile, blue line = 50th percentile)

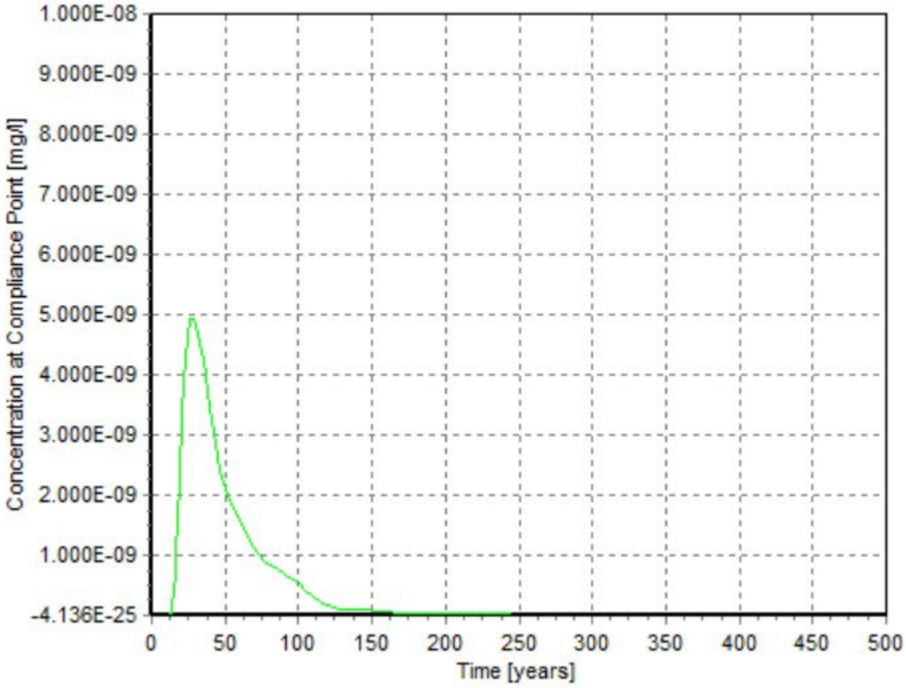


Figure 7-12 Predicted Phenol concentrations at Compliance Well downgradient of Phase 2 & 3

(green line = 95th percentile, blue line = 50th percentile)

8 EMISSIONS TO SURFACE WATER RECEPTOR

The predicted concentrations of non-hazardous pollutants Nickel, Cadmium, Mecoprop, Naphthalene and Phenol are predicted to be at levels where they will not likely be detectable (or discernible against background in the case of Nickel and Cadmium) in groundwater and below EQS. Chloride is also predicted to peak at concentrations well below freshwater EQS of 250 mg/l with just over 80 mg/l predicted downgradient of Phase 1 at the 95th percentile and less than 5mg/l from Phase 2 & 3. As these substances will not cause breach of the EQS in groundwater it is evident that the surface water receptor should be protected. The following discussion is based on evaluating this aspect further with particular consideration given to ammonia and also the potential cumulative impact on surface water from all phases of landfill.

8.1 Cumulative Impact

An underlying agreement in all previously approved HRAs is that all of the groundwater flowing beneath the site will percolate through the bedrock strata, eventually discharging into the stream as base-flow, and that Rudbaxton Water is the receptor. The entire pollutant flux from all phases of landfill will arrive by this pathway along with surface run-off. The flux of contaminants moving through this system can be conceptually summarised as a mass balance which is illustrated in Figure 8-1.

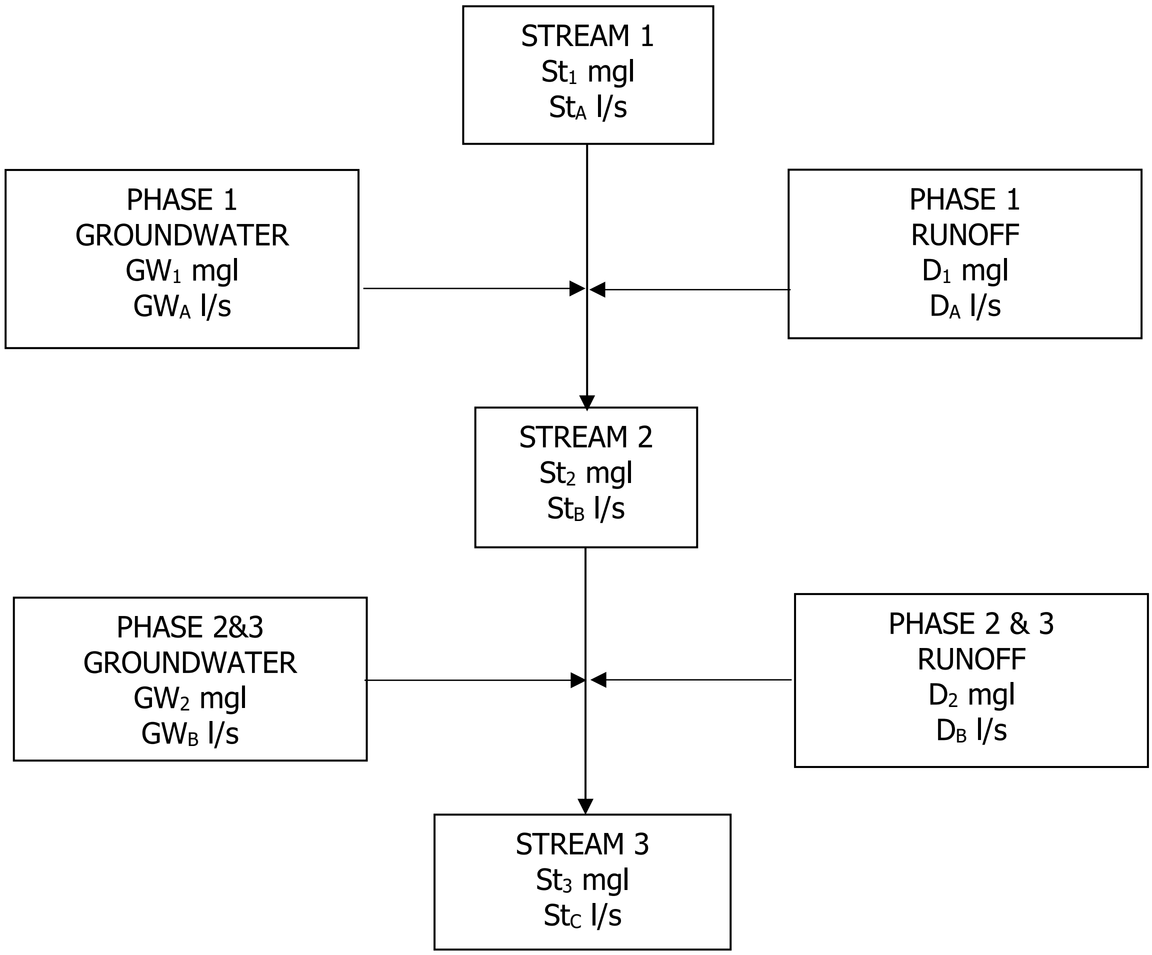


Figure 8-1 Conceptual Cumulative Flux of Contaminants in Catchment

In this simplified model, Rudbaxton Water is designated as Stream 1 upstream of Phase 1, Steam 2 downstream of Phase 1 and Stream 3 downgradient of Phase 2 & 3. The flux of contaminants from each landfill phase and run-off are also identified. As we have estimates of each contributory component from monitoring and modelling, we can calculate the concentration at Stream 2 and then Stream 3, using the following computation:

Concentration in surface water (St_C) = Flux in GW downgradient of landfill phase + Flux in stream + Run-off flux / Groundwater flow + stream flow + run-off flow

Key components of the model are considered further below:

Stream 1. As discussed in Section 3, Rudbaxton Water is a modest stream, with an average flow of around 77 litres/second at the upstream edge of the site. The 95th percentile low flow has been estimated by EAW at 9.5 litres/second at Rudbaxton Bridge. The water chemistry is monitored and so the contaminant flux can be calculated.

Groundwater. We know from calculation and modelling the average flow of combined groundwater flow and leachate leakage; downgradient of Phase 1 it is 1.55 l/s (comprising 1.4 l/s groundwater and 0.15 l/sec leakage) and downgradient of Phase 2&3 it is 1.564 l/s (comprising 1.53 l/s groundwater flow and 0.034 l/s leachate leakage). Groundwater downgradient of Phase 1 is monitored allowing contaminant flux to be calculated. For Phase 2 & 3 the contaminant concentrations predicted by LandSim can be used to calculate flux. These are summarised in Table 8-1 alongside the predictions for Phase 1 for comparison which highlights the significantly lower emissions predicted for Phase 2 & 3.

Run-off. Surface water run-off from each Phase can be estimated using the same calculation discussed in Section 3.4 by multiplying the surface area of each phase by the effective rainfall of 745mm. For Phase 1, the combined surface area of the landfill and the land between the downgradient edge and Rudbaxton Water is 237,798m^2 and for Phase 2 & 3 it is 454,410m^2. This equates to average run-off of 5.6l/sec at Phase 1 and 10.7l/sec for Phase 2 & 3.

Table 8-1 Predicted increases in downgradient groundwater

	Chloride	Ammoniacal Nitrogen	Cadmium	Nickel	Phenol	Mecoprop	Naphthalene
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Phase 1							
Max 50%ile	34.9	1.33	0	4.2E-10	7.5E-10	0	0
Max 95%ile	82.8	10.82	0	7.1E-07	8.4E-07	4.3E-12	0
Phase 2&3							
Max 50%ile	5.6	0.01	0	0	4.2E-17	0	0
Max 95%ile	18.3	0.32	0	0	1.9E-12	3.1E-18	0
Values presented are maximum values from Table 7-3							

Using this information, 3 assessments of potential cumulative impact have been made and are summarised in Tables 8-2 through to 8-4. The output from each assessment is the predicted concentration in surface water downstream of each landfill phase, which is provided in the penultimate row of each table.

Assessment 1.

This assessment evaluates the contribution of landfill leakage at 50^{th} percentile on average surface water flow of 77/l/sec.

Assessment 2.

This assessment evaluates the contribution of landfill leakage at 95^{th} percentile on average surface water flow of 77 l/sec.

Assessment 3.

This assessment evaluates the contribution of landfill leakage at 95th percentile on low flow surface water flow (9.5 l/sec).

Table 8-2 Assessment 1 – 50th percentile emissions and average SW flow

Stream 1								
Upstream of landfill (average)	77	l/sec						
	Chloride	**Ammoniacal Nitrogen**	**Cadmium**	**Nickel**	**Phenol**	**Mecoprop**	**Naphthalene**	**Units**
Average Flux	2271.5	14.6	0.00847	0.1617	0	0	0	mg/s
Phase 1 Run-off								
Runoff	5.62	l/sec						
Runoff chemistry	15	0.01	0	0	0	0	0	mg/l
Runoff Flux	84.3	0.056	0.0000	0.0000	0.0000	0.0000	0.0000	mg/s
Phase 1 Groundwater								
Flow+leakage	1.55	l/sec						
Groundwater Flux	82.2	0.5	0.0031	0.0155	0.062	0.00217	0.00155	mg/s
Stream 2								
Flow	84.17	l/sec						
Predicted concentration (average)	28.96	0.181	0.0001	0.0021	0.0007	0.0000	0.0000	mg/l
Flux at Stream 2	2437.9	15.2	0.0116	0.1772	0.0620	0.0022	0.0016	mg/s
Phase 2 & 3 run-off								
Runoff	10.73	l/sec						
Runoff chemistry	15	0.01	0	0.001	0	0	0	mg/l
Run-off Flux	161.0	0.1	0.0000	0.0107	0.0000	0.0000	0.0000	mg/s
Phase 2&3 Groundwater								
Flow+leakage	1.56	l/sec						
Landsim predicted leachate concentrations at compliance well								
Max 50th percentile	5.59	0.01	0	0	4.22E-17	0	0	mg/l
Combined	28.6	0.1	0.002	0.03	4.21676E-17	0	0	mg/l
Groundwater flux	44.7	0.2	0.003128	0.04692	6.59501E-17	0	0	mg/s
Stream 3								
EQS (AA)	250	0.3	0.00008	0.004	0.0077	0.018	0.002	mg/l
Predicted concentration (StC)	**27.4**	**0.16**	**0.00015**	**0.0024**	**0.0006**	**0.00002**	**0.00002**	**mg/l**
Flow (calculated)	96.47	l/sec						

Table 8-3 Assessment 2 – 95th percentile emissions and average SW flow

STREAM 1								
Upstream of landfill (average)	77	l/sec						
	Chloride	**Ammoniacal Nitrogen**	**Cadmium**	**Nickel**	**Phenol**	**Mecoprop**	**Naphthalene**	
Average Flux	2271.5	14.6	0.00847	0.1617	0	0	0	mg/l
Phase 1 Run-off								
Runoff	5.62	l/sec						
Runoff chemistry	15	0.01	0	0	0	0	0	mg/l
Runoff Flux	84.3	0.056	0.0000	0.0000	0.0000	0.0000	0.0000	mg/s
Phase 1 Groundwater								
Flow+leakage	1.55	l/sec						
GW Flux	82.2	0.5	0.0031	0.0155	0.062	0.00217	0.00155	mg/s
Stream 2								
Flow	84.17	l/sec						
Predicted concentration (average)	29.0	0.2	0.0001	0.0021	0.0007	0.0000	0.0000	
Flux at Stream 2	2437.9	15.2	0.0116	0.1772	0.0620	0.0022	0.0016	mg/s
Phase 2 & 3 run-off								
Runoff	10.73	l/sec						
Runoff chemistry	15	0.01	0	0.001	0	0	0	mg/l
Run-off Flux	161.0	0.1	0.0000	0.0107	0.0000	0.0000	0.0000	mg/s
Groundwater Phase 2&3								
Flow+leakage	1.56	l/sec						
Max 95th percentile emissions	18.3	0.3	0	0	1.9E-12	3.1E-18	0	mg/l
Background groundwater	23	0.1	0.002	0.03	0	0	0	mg/l
Combined	41.3	0.4	0.002	0.030	1.8773E-12	3.0756E-18	0	mg/l
Ph 2&3 Groundwater flux	64.6	0.6	0.003	0.047	2.9361E-12	4.81024E-18	0	mg/s
Stream 3								
EQS (AA)	250	0.3	0.00008	0.004	0.0077	0.018	0.002	mg/l
Predicted concentration (StC)	**27.6**	**0.17**	**0.00015**	**0.0024**	**0.0006**	**0.00002**	**0.00002**	**mg/l**
Flow (calculated)	96.47	l/sec						

Table 8-4 Assessment 3 – Surface water low flow and 95th percentile emissions

STREAM 1								
Low flow	9.5	l/sec						
	Chloride	**Ammoniacal Nitrogen**	**Cadmium**	**Nickel**	**Phenol**	**Mecoprop**	**Naphthalene**	
Average SW @ SP1 (2020-2022)	29.5	0.2	0.0001	0.0021	0	0	0	mg/l
Average Flux	280.3	1.8	0.0010	0.0200	0	0	0	mg/s
Phase 1 Run-off								
Runoff	0.69	l/sec						
Runoff chemistry	15	0.01	0	0	0	0	0	mg/l
Runoff Flux	10.4	0.007	0.0000	0.0000	0.0000	0.0000	0.0000	mg/s
Phase 1 Groundwater								
Groundwater Flow	1.4	l/s						
Flow+leakage	1.55	l/s						
Groundwater downgradient Ph 1 (TP9, TP11)	53	0.33	0.0020	0.0100	0.04	0.0014	0.001	mg/l
GW Flux	82.2	0.5	0.0031	0.0155	0.062	0.00217	0.00155	mg/s
Stream 2								
Flow	11.74	l/sec						
Predicted concentration (average)	31.8	0.2	0.0004	0.0030	0.0053	0.0002	0.0001	mg/l
Flux at Stream 2	372.8	2.3	0.0041	0.0355	0.0620	0.0022	0.0016	mg/s
Phase 2 & 3 run-off								
Runoff	1.3	l/sec						
Runoff chemistry	15	0.01	0	0	0	0	0	mg/l
Run-off Flux	19.8	0.013	0	0	0	0	0	mg/s
Ph 2&3 Groundwater flux	64.6	0.6	0.0031	0.0469	2.936E-12	4.81E-18	0	mg/s
Stream 3								
EQS (AA)	250	0.3	0.00008	0.004	0.0077	0.018	0.002	mg/l
Predicted concentration (StC)	31.3	0.20	0.00050	0.0056	0.0042	0.00015	0.00011	mg/l
Flow (calculated)	14.62							l/sec

These simple and conservative dilution models clearly indicate that even under the most conservative assumptions of predicted low flow conditions, surface water quality in Rudbaxton Water downstream of all landfill phases is protected. The concentration of ammonia and chlorine, the key contaminants of concern, remain below the freshwater EQS despite numerous conservative assumptions.

The assessments also confirm that the levels of phenols, mecoprop and naphthalene will not be discernible and that cadmium and nickel occurrence is controlled by the background water quality (which includes analysis of unfiltered groundwater and surface water samples) as there are no predicted emissions from Phase 2 & 3 of these potential pollutants.

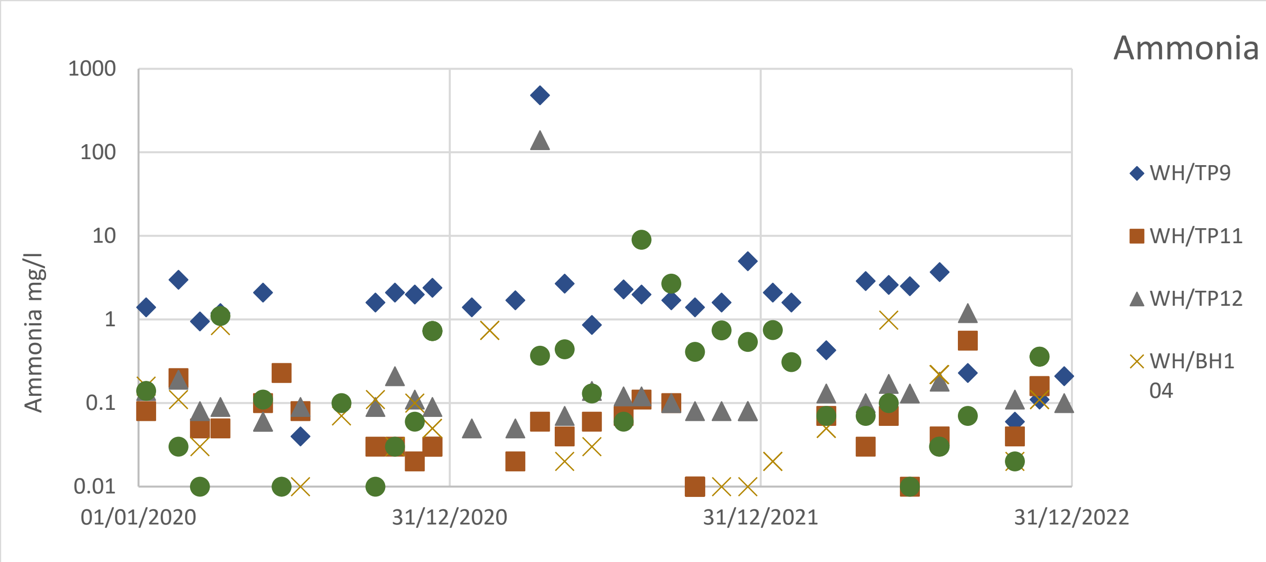
The key conservative assumptions underpinning the assessments include:

- The assessment does not take into account further dilution of the predicted concentrations by surface water and groundwater contributions from the northern part of the catchment. This is a significant and important simplification to acknowledge as average surface water flow downstream of the site at Rudbaxton Bridge is around 165l/sec. As these models take no account of contributions from the northern part of the catchment, the maximum flow predicted downstream of the site is 96 l/sec (see last row of Table 8-2). Therefore, further dilution of the predicted downstream surface water concentrations is expected.
- All natural attenuation processes that occur in the sub-surface are ignored in the simple dilution models. Such processes have been predicted by laboratory testing and are thought to be occurring because of the lack of deterioration in the quality of Rudbaxton Water as it passes the unlined Phase 1. This can be seen by review of the time series charts (in Figure 8-2) of the monitoring data gathered at SP1 (upgradient of the site) and SP5. Throughout this time of compliance, the Landsim model predicts emissions from Phase 1 to be at their predicted peak (see Figure 7-3) and actual monitoring has revealed groundwater along the boundary of Phase 1 to contain concentrations above EQS (see Figure 8-2). Despite the concentration of ammoniacal nitrogen being persistently above 1mg/l and reaching 9 mg/l, the surface water average has remained below the EQS as it passes from SP1 to SP5. As highlighted earlier, this suggests that ammoniacal nitrogen is being retarded to a greater extent than estimated by the site-specific measurements.
- Assessments ignore declining source term and are based on conservative static (non-probabilistic) inputs for each landfill phase. For instance, in the low flow model in Table 8-4 the flux of groundwater and landfill leakage is maintained despite surface water flow and run-off flow being reduced to 12% of their average flows which is the measured reduction in streamflow indicated by EAW (reducing to 9.5 l/s from 77 l/sec in Rudbaxton Water). In reality, under such meteorological conditions, the conceptual site model suggests groundwater baseflow contributions would also be reduced in response to the lower rates of rainfall and therefore effective recharge.

In this context, the assessment provides further lines of evidence that surface water quality in Rudbaxton Water will not deteriorate due to the leakage from the landfill.

Table 8-5 Average Ammonia in Rudbaxton Water passing Phase 1

	SP1 (upgradient Phase 1)	**SP5 (downgradient Phase 1)**
EQS	0.3	0.3
2020	0.13	0.08
2021	0.14	0.10
2022	0.25	0.08
2023	0.11	0.12
Note <DL replaced with =DL for statistical assessment		



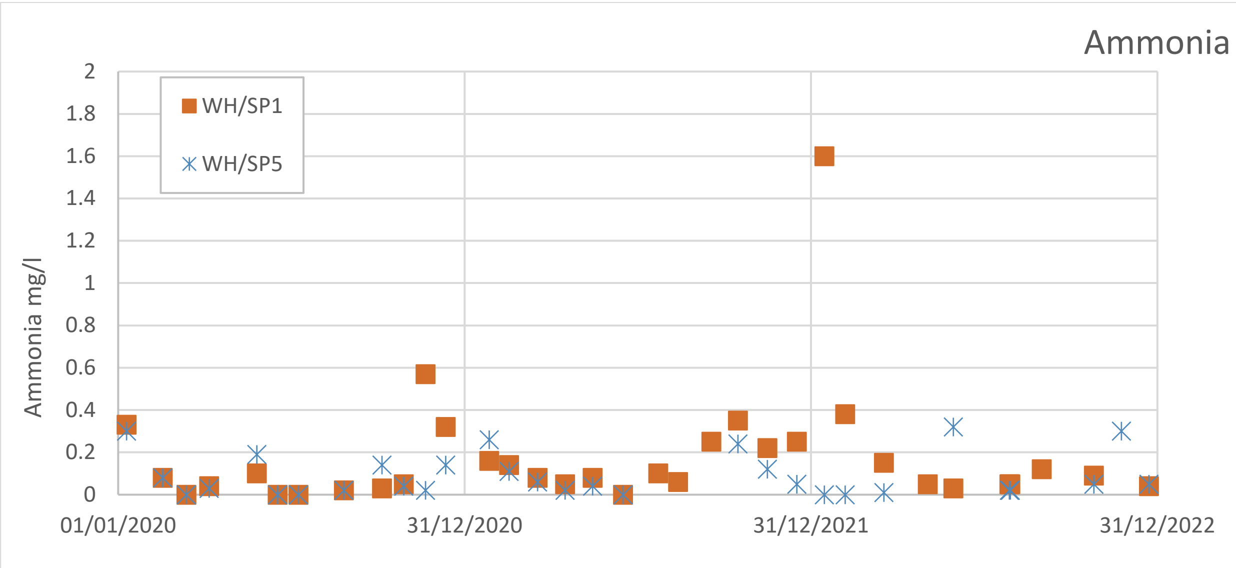


Figure 8-2 Variation of ammoniacal nitrogen in Phase 1 downgradient groundwater (top) and Rudbaxton surface water (bottom)

9 TECHNICAL PRECAUTIONS

9.1 Environmental Protection

Conservative probabilistic simulation of future leachate generation coupled with performance monitoring of Phase 1 has shown that even under worst-case conditions, potential cumulative impacts will not cause pollution. As the simulations are based on the approved technical precautions, future cells will continue to adopt the approved engineering controls comprising:

- An unsaturated zone of 1.0m or greater beneath the lining system
- A composite lining system comprising an artificial sealing liner fabricated from high density polyethylene over an artificially established geological barrier comprising a geotextile clay liner over 0.5m thickness of recompacted site won mineral with a permeability of $1e^{-8}$m/s or less
- A limit on the leachate head on the liner of 1.0m across the base of the landfill
- A progressive cell by cell capping system to limit infiltration into the waste mass after disposal operations are complete
- A surface water management system to collect runoff from the site to facilitate a controlled release to Rudbaxton Water

9.2 Sensitivity Analysis

One of the technical precautions that has previously been the subject of discussion is the thickness of the unsaturated zone. This is understood to be because the thickness of the unsaturated zone was considered to be integral to protecting the environment from landfill emissions.

In order to assess this aspect, a sensitivity analysis has been performed where the thickness of the unsaturated zone beneath Phase 2 & 3 has been varied in thickness from 0.05m to 1.5m. As shown by the predicted concentrations at the downgradient compliance well in Figures 9-1 to 9-3, there is only a small impact on the predicted concentration of ammonia. When the unsaturated zone is just 0.05m thick, the predicted 95th percentile concentration is 1.75mg/l, reducing to 0.95 mg/l when the unsaturated zone is 1.5m thick. The thickness clearly impacts the concentration detected at the downgradient well but the impact is modest and future cells will retain the approved thickness of 1m as this provides a practical and achievable protection.

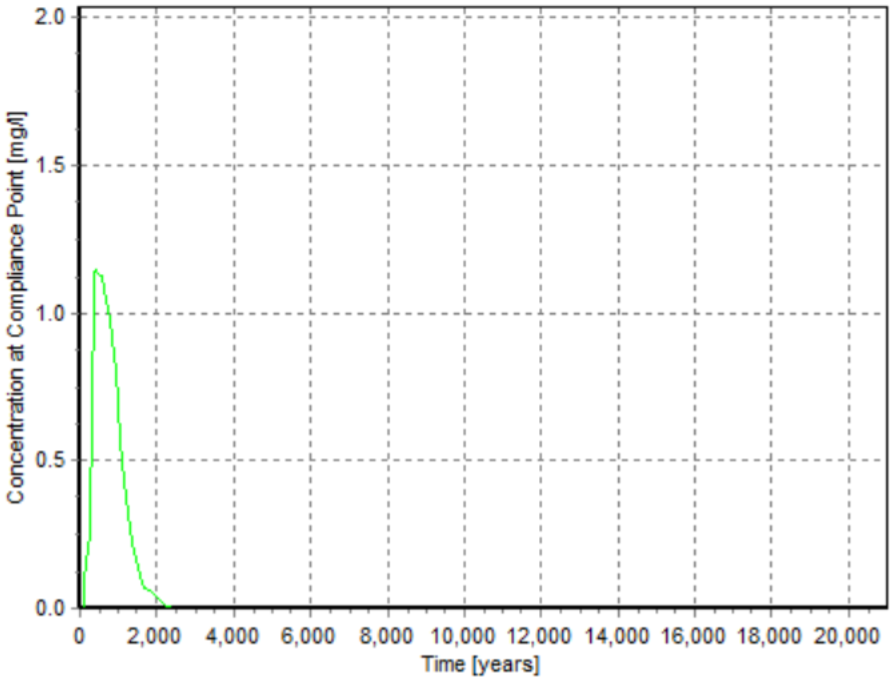


Figure 9-1 95th Percentile Peak Concentration of Amm Nitrogen with 1m Unsaturated Zone

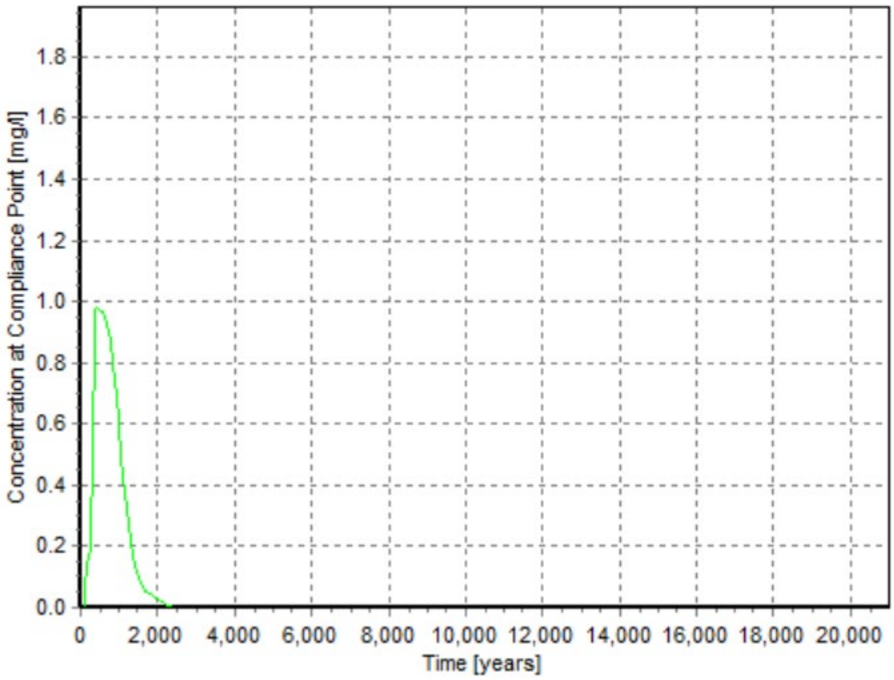


Figure 9-2 95th Percentile Peak Concentration of Amm Nitrogen with 1.5m Unsaturated Zone

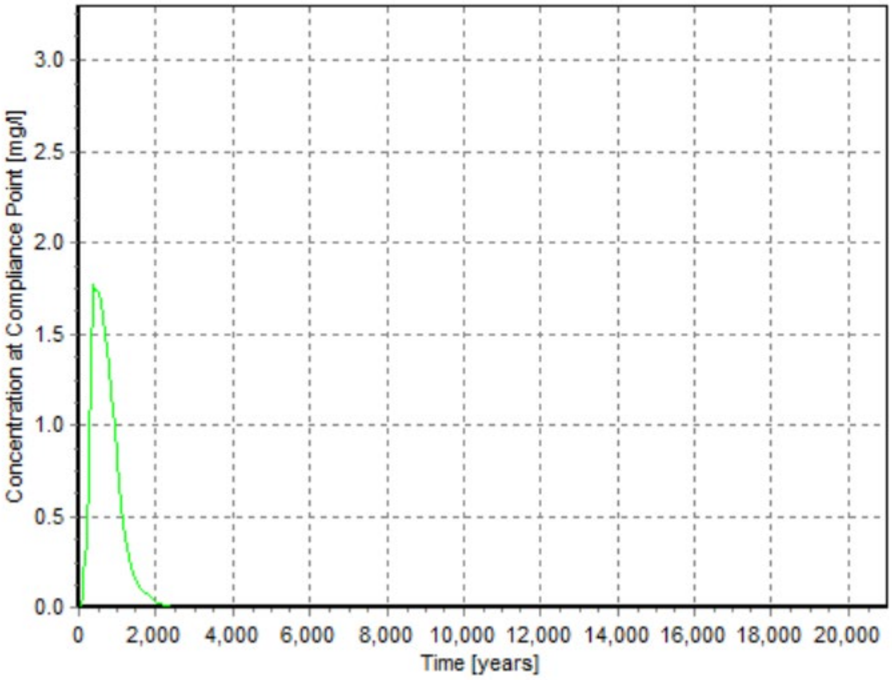


Figure 9-3 95th Percentile Peak Concentration of Amm Nitrogen with 0.05m Unsaturated Zone

10 REQUISITE SURVEILLANCE

10.1 Purpose, Context & Terminology

There is a comprehensive monitoring network in place and monitoring has been ongoing for many years. This has allowed background conditions to be characterised and the environmental impact of the landfill phases to be evaluated. The programme also highlights other contributions to the catchment.

Improvements to the programme have been identified, however. These rationalise the monitoring commitments whilst ensuring environmental protection and continued landfill performance monitoring. The key aspects of the rationalisation are:

- Removal of trigger levels from groundwater monitoring points considered to be upgradient of the landfill
- Improving consistency in the analytical schedule across the environmental media monitored i.e. consistency in the analytical schedules implemented for leachate, surface and groundwater
- Routinely monitoring key landfill performance indicators within a structured risk based framework
- Expanding the surface water monitoring network to encompass measurements of flow and contributions from other parts of the catchment
- Focussing of groundwater monitoring at downgradient wells closest to toe of landfill
- Modification to the aim of leachate pumping from Phase 1
- Ensuring sample collection and sample analysis is focussed on presentation of representative samples and data

These improvements are detailed in the following section and should be agreed with NRW before implementation.

New monitoring programmes for surface water, groundwater and leachate are proposed. The programmes continue to include at least one groundwater monitoring position upgradient and two positions downgradient of the site, surface water sample points upstream and downstream and leachate sample points in each cell. Flexibility in the monitoring programme will allow it to expand as the landfill develops into Phase 3.

10.2 Management Structure

Monitoring is the ultimate responsibility of the Permit holder. In its current configuration its implementation requires input from a series of parties. The currently involved parties are identified in Table 10-1.

Table 10-1 Monitoring Programme Management

Party	Outline of Roles and Responsibility
RML	Permit Compliance Ensure monitoring is undertaken in accordance with Permit requirements Reviews data against trigger and assessment levels Reports data directly to NRW
Decus	Appointed by RML to undertake the collection and laboratory analysis of leachate, groundwater and surface water Undertakes on-site measurement of landfill gas and perimeter gas Reports data to RML to allow comparison with Trigger and Control Levels, identification of breaches and timely reporting to NRW

10.3 Surface Water

To better understand the causes of fluctuations in surface water quality and other contributing sources within the wider catchment, revised surface water monitoring points and techniques (flow) are proposed. These are detailed in Tables 10-2 and 10-3 and identified on Drawing 2365-10. The new monitoring programme is summarised in Table 10-4.

Table 10-2 New Surface Water Monitoring Positions

Location ID	Description
SP1	Rudbaxton Water upstream of the site.
SP10	Un-named stream on opposite side of catchment to landfill. Catchment receives run-off from surrounding agricultural land and sewerage treatment works before joining Rudbaxton Water.
SP11	Un-named stream on opposite side of catchment to landfill. Catchment receives run-off from surrounding agricultural land and sewerage treatment works before joining Rudbaxton Water.
SP12	Un-named stream on opposite side of catchment to landfill. Opposite side of catchment to landfill. Catchment receives run-off from surrounding agricultural land before joining Rudbaxton Water
SP5	Rudbaxton Water mid-way along northern suite boundary and downstream of Phase 1 and contributions from opposite side of catchment
SP9	Discharge from deep drain prior to discharge to surface water treatment system
SP7	Rudbaxton Water downstream of site and contributions from opposite side of catchment

Surface water discharges from the on-site surface water management system will also be monitored at the positions listed in Table 10-3.

Table 10-3 Surface Water Discharge Locations

Location ID	Location description
D1	Discharge from surface water system receiving run-off from Phase 1
D2	Discharge from surface water system receiving run-off from Phase 2 (to be constructed)
D3	Discharge from surface water system receiving run-off from Phase 3 (to be constructed)

Table 10-4 Proposed Surface Water Monitoring Programme

Measurement type	Location	Frequency
Flow	D1, D2, D3	Continuous (12-hourly) following installation
Quality	SP1, SP5, SP7, SP9, SP10, SP11, SP12, D1, D2, D3	Monthly Suite SWA – see Table 10-7

10.3.1 Groundwater

There is an extensive groundwater monitoring network with many boreholes spaced less than 50m apart around the landfill. Some of the downgradient monitoring positions are within ~10m of the landfill edge. Some boreholes are considered to intersect fractures whilst others intersect the rock matrix through which little groundwater would be expected to quickly pass. The groundwater wells are also used for ground gas monitoring. Some boreholes are fitted with conventional 50mm standpipes while others comprise large diameter 100mm wells.

The new monitoring programme is summarised in Table 10-5 with the monitoring positions identified on Drawing 2365-11.

Table 10-5 Groundwater Monitoring Programme

Measurement type	Frequency	Location
Groundwater level below datum/m	Monthly	**Phase 1** Upgradient: BH17, BH18, BH24, BH25, BH26 Cross-gradient: GW1, BH27, BH28, BH34, TP10, Downgradient: TP9, TP11, TP12, BH104 **Phase 2 & 3** Upgradient: BH14, BH15, BH16, BH33 Cross-gradient: BH10, BH11, BH12, BH13, BH29 Downgradient: BH1, BH2, BH3, BH4, BH5, BH6, BH7, BH8, BH9, BH30 **Boreholes to be decommissioned and no longer subject to quality monitoring:** BH19, BH20, BH31, BH32, BH35, BH36, BH37, BH105 BH18 to be replaced with BH18R due to new road construction
Well depth below datum/m	Annually	As above
Groundwater Quality	Monthly Suite GWA	**Phase 1** Downgradient: TP9, TP11, TP12, BH104 **Phase 2 & 3** Downgradient: BH1, BH2, BH3, BH4, BH5, BH6, BH8, BH30
Groundwater Quality	Quarterly Suite GWB and Annually Suite GWC	**Phase 1** Upgradient: BH17, BH18, BH24, BH25, BH26 Cross-gradient: GW1, BH27, BH28, BH34, TP10, Downgradient: TP9, TP11, TP12, BH104 **Phase 2 & 3** Upgradient: BH14, BH15, BH16, BH33 Cross-gradient: BH10, BH11, BH12, BH13, BH29 Downgradient: BH1, BH2, BH3, BH4, BH5, BH6, BH7, BH8, BH9, BH30
Note See Table 10-7 for all analytical schedules		

10.3.2 Leachate

The site comprises a combination of old dilute and disperse landfill cells that are now capped (Phase 1) and a series of engineered cells (Phase 2 & 3), some of which are also capped. A consistent monitoring programme in each phase is proposed with the positions shown on Drawing 2365-12 and the programme summarised in Table 10-6.

Table 10-6 Leachate monitoring

Measurement type	Location	Frequency
PHASE 1 CLOSED LANDFILL		
Leachate level below datum at sumps / m	Phase 1 sumps: LW1, LW2, LW4, LE1 – LE6, SWsump, LD3, CELL11sumpW (formerly sumpB), CELL11sumpE (formerly sump), CELL13sump1 (formerly Cell13sump), CELL13sump2, Cell14sump, Cell 15sump	Monthly
Monitoring point base below datum at sumps / m		Annually
Leachate composition at sumps		Six Monthly Suite LA
PHASE 2 & 3 LANDFILL		
Leachate level below datum at sumps and monitoring wells / m	Phase 2 sumps: LV1- LV4, L1-L5, C4NL1, C5NL1, C4/5SL1 (formerly C4LS), C6L1, C7L1, C8L1	Monthly
Monitoring point base below datum at sumps and monitoring wells / m	Phase 2 monitor wells: LMV1, LMV2, LM1, LM2, LM3(S), LM3(N), LM4, LM5, C4NLM1, C4NLM2, C5NLM1, C5NLM2, C4/5SLM1, C4/5SLM2, C6LM1, C7LM1, C8LM1 Phase 3 sump : One sump per landfill cell Phase 3 monitoring wells: One monitor well per hectare per cell	Six Monthly
Leachate composition in sumps	Phase 2 sumps: LV1- LV4, L1-L5, C4NL1, C5NL1, C4/5SL1 (formerly C4LS), C6L1, C7L1, C8L1 Phase 3 sumps : One sump per cell	Monthly Suite LA Every 2 years Suite LB

The revised leachate monitoring programme includes:

- monitoring SW Sump, to the south of Phase 1, which previously could not be located.
- renaming of Cell 11 Sump B and C to Cell Sump West and East so that their positions can be better understood.
- ensuring that one sump and two wells are monitored in each cell.

10.4 Analytical Schedule

As the site is located in a rural agricultural catchment underlain by pyritiferous shale and where there are potentially several diffuse sources of pollution in close proximity, there is a challenge to discern the cause of fluctuations in water quality. Historical environmental monitoring and assessment has focussed on key indicators of potential landfill leachate such as ammonia, chloride, BOD and COD alongside trace metals and a range of organics including phenols, naphthalene and xylene. Non-hazardous pollutants and hazardous substances have also been monitored.

Several of these parameters may be influenced by other processes and activities occurring within the catchment, some of which have developed and been permitted since the landfill was granted planning permission and an Environmental Permit and the sensitive ecological sites designated. This includes:

- Dairy farming and the application of slurry to the fields on the northern banks of Rudbuxton Water that drain into the same catchment. It is understood that the farm practice involves feeding and cutting silage several times a year.
- Discharge from sewerage treatment plant at Spittal, upstream of the site. According to Welsh Water there were 323 storm water overflow releases in 2021 with a combined duration of over 2700 hours.
- Natural passage of groundwater through the weathered horizon of the shale where pyrite is being oxidised along fractures releasing trace metals, such as Nickel, as well as sulphate, and sometimes resulting in groundwater with very acidic pH (<5). Such acidic groundwater can increase trace metal mobility and all parties have recognised that background groundwater is, in parts, naturally mineralised due to these processes.

As some of these processes may contribute the same pollutants to the catchment as the approved Phase I dilute and disperse landfill, distinguishing future contributions from the landfill as part of a risk-based monitoring framework is not straightforward and will require long-term commitment and flexibility. Reassuringly, there is no significant impact associated with the unlined Phase 1 landfill and as Phase 2 & 3 benefit from higher levels of environmental engineering controls, this situation is not predicted to change.

In this context, the analytical schedule and the evaluation of Trigger and Control levels should not be viewed as fixed. Emerging contaminants are continually being discovered and their environment fate better understood and there are processes occurring within the catchment that are not under the control of the operator. For this reason, the conceptual site model and analytical schedule will need to be subject to future review and potential modification. In response to the annual screening of leachate for hazardous substances, new substances may be added to the monitoring suites.

Table 10-7 Analytical Schedule for Surface Water, Groundwater & Leachate

	Surface Water	Groundwater			Leachate	
Parameter	**Monthly**	**Monthly**	**Quarterly**	**Annually**	**Six monthly**	**Every 2 years**
	Suite SWA	**Suite GWA**	**Suite GWB**	**Suite GWC**	**Suite LA**	**Suite LB**
pH	Y	Y	Y	Y	Y	
EC	Y	Y	Y	Y	Y	
Temperature	Y		Y	Y	Y	
Dissolved oxygen	Y		Y	Y	Y	
Ammoniacal Nitrogen	Y	Y	Y	Y	Y	
Chloride	Y	Y	Y	Y	Y	
Nickel (filtered)	Y		Y	Y	Y	
Cadmium (filtered)	Y		Y	Y	Y	
Mecoprop	Y		Y	Y	Y	
Naphthalene	Y		Y	Y	Y	
Phenol	Y		Y	Y	Y	
Phenols (total)	Y		Y	Y	Y	
BOD	Y					
COD	Y					
Phosphate	Y					
Copper (filtered)			Y	Y	Y	
TSS (surface water only)	Y					
Calcium			Y	Y	Y	
Magnesium			Y	Y	Y	
Sodium			Y	Y	Y	
Potassium			Y	Y	Y	
Alkalinity			Y	Y	Y	
Sulphate			Y	Y	Y	
Cyanide			Y	Y	Y	
Iron (filtered)			Y	Y	Y	
Manganese (filtered)			Y	Y	Y	
Mercury (filtered)	Y		Y	Y	Y	
Chromium (filtered)			Y	Y	Y	
Lead (filtered)			Y	Y	Y	
Zinc (filtered)			Y	Y	Y	
Nitrate			Y	Y	Y	
Nitrite			Y	Y	Y	
Hazardous substance screen				Y		Y

The analytical schedule retains many of the elements of the existing schedule so that there is a continued long-term period of consistency. This position will need to be reviewed once there are 36 months of monitoring in place from both the new and existing surface water and groundwater locations and updated monitoring and analytical protocols implemented. These new protocols are to include:

- Installation of dedicated monitoring infrastructure to facilitate purging and sampling in suitable wells, where feasible
- Analysis of samples after filtration for determination of trace metals with filtration undertaken on site, where feasible
- Use of appropriate fixatives for stabilisation of sample at point of sampling e.g., Nitric acid for filtered metals, sulphuric acid for ammoniacal nitrogen, Sodium Hydroxide for cyanide, nitrite or nitrate
- Use of glass bottles / vials for organics

11 NEW TRIGGERS AND CONTROLS

Monitoring includes measurements undertaken for compliance purposes and those undertaken to assess landfill performance. In this document, the terms compliance and assessment have the following meanings:

Compliance Trigger Levels
The process of complying with a regulatory standard (e.g. maximum leachate head). Under the Landfill Directive, the compliance level for groundwater quality is specifically termed a 'Trigger level'.

Assessment Control Levels
The process of evaluating the significance of a departure from predicted conditions by reference to an adverse trend in data or the breach of a specified limit. Under the Landfill Directive, the assessment criterion for groundwater quality is specifically termed the 'Control level'.

11.1 Approach

Previously approved groundwater compliance levels appear to have been set above observed groundwater concentrations to limit the opportunity for Permit breach. With the benefit of additional data and improved conceptual understanding of the catchment and the contribution of groundwater passing beneath the landfill, an additional approach is taken in this review. In line with other approved reviews however, the principle receptor remains surface water in Rudbaxton Water. For this reason, compliance levels are set for groundwater wells between the toe of the landfill and Rudbaxton Water that are focussed on protection of this resource.

Trigger levels were previously set for BH105. Reference to Drawing 2365-7 demonstrates that this borehole position is upgradient of landfill operations. In this review, trigger levels have not been set at any upgradient wells as this is not protective of the environment. Rather, the list of compliance wells has been extended to include positions that will ultimately be downgradient of each phase of landfill development. Moving from east to west on Drawing 2365-11, the wells at which compliance levels have been set are TP9, TP11, TP12, BH104, BH1, BH2, BH3, BH4, BH5, BH6, BH30 and BH8.

The list of currently approved trigger levels is summarised in Table 11-1. Apart from mecoprop and naphthalene, the range of trigger levels are above EQS. For naphthalene and mecoprop the values are several orders of magnitude below EQS despite both substances not being classified as priority hazardous substances or predicted to be at elevated concentration. Trigger levels were previously also set at different concentrations for boreholes in close proximity. For example, the ammoniacal nitrogen trigger level at BH102 (now referred to as BH3) was 55 mg/l, 5.2 mg/l at BH2 and 1.328 at BH1 mg/l despite the wells being in close proximity.

Having a range of groundwater limits at different locations can be difficult to regulate and lead to difficulties in identification and understanding of breaches. Similarly, having groundwater limits for non-hazardous pollutants well below surface water EQS can lead to unnecessary burden on laboratory testing, seeking very low limits in a matrix subject to interference and therefore potentially leading to false positives.

Based on the current conceptual understanding and to facilitate data evaluation and regulation, consistent groundwater trigger levels are proposed at compliance wells downgradient of the landfill. These are also summarised in Table 11-1 with the rationale behind their derivation detailed in the following sections. A new methodology for identifying a breach has also been developed and is also presented.

Table 11-1 Existing and Proposed Groundwater Trigger Levels

Substance	Mecoprop		Naphthalene		Phenol		Cadmium		Chloride		Ammoniacal Nitrogen	
Units	**mg/l**		**mg/l**		**mg/l**		**mg/l**		**mg/l**		**mg/l**	
Borehole	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	
TP9	0.0001	0.018	0.00001	0.002	0.15	0.15	0.0095	0.0095	250	500	12	12
TP11	0.0001	0.018	0.00001	0.002	0.15	0.15	0.0095	0.0095	250	500	12	12
TP12	0.0001	0.018	0.00001	0.002	0.15	0.15	0.0095	0.0095	250	500	12	12
BH104	0.0001	0.018	0.00001	0.002	0.15	0.15	0.0095	0.0095	250	500	12	12
BH1	0.00003	0.018	0.00003	0.002	0.15	0.15	0.002	0.0095	117	500	1.328	12
BH2	0.0001	0.018	0.00006	0.002	0.15	0.15	0.002	0.0095	180	500	5.2	12
BH3	0.0004	0.018	0.00006	0.002	0.15	0.15	0.002	0.0095	310	500	55	12
BH4		0.018		0.002		0.15		0.0095		500		12
BH5		0.018		0.002		0.15		0.0095		500		12
BH6		0.018		0.002		0.15		0.0095		500		12
BH30		0.018		0.002		0.15		0.0095		500		12
BH8		0.018		0.002		0.15		0.0095		500		12

11.1.1 Groundwater Trigger Levels for Mecoprop and Naphthalene

It is an underlying assumption that all the groundwater flowing beneath the site will percolate through the bedrock strata, eventually discharging into the stream as base-flow, and that the entire pollutant flux from the landfill to the stream will arrive by this pathway. As discussed earlier, even under low-flow conditions, there is significant dilution of groundwater as it enters Rudbaxton Water.

Despite this dilution (and ignoring any potential retardation processes), conservative groundwater trigger levels for mecoprop and naphthalene have been set at the surface water EQS. If this concentration is not breached in groundwater, we can be confident that the surface water receptor is protected.

11.1.2 Groundwater Trigger Levels for Nickel, Cadmium and Phenol

As discussed earlier, Nickel, Cadmium and Phenol are detected at concentrations above EQS in upgradient groundwater and the LandSim modelling predicts very low emissions. For this reason, it is suggested that the currently approved trigger limits are retained but reviewed in three years following implementation of several changes to the monitoring regime, particularly the analysis of Cadmium and Nickel in samples that have first been filtered at 0.45 micron. This will provide more confidence in altering the trigger levels, most likely to a lower concentration.

11.1.3 Groundwater Trigger Level for Chloride

Given the dilution groundwater will receive as it enters surface water throughout the annual cycle, a trigger level based on a four-fold uplift of the surface water EQS of 250 mg/l could be justified. However, to add a further element of protection, it is suggested setting the trigger level for chloride at 500 mg/l which is still protective of surface water whilst taking into account background water chemistry variations.

11.1.4 Groundwater Trigger Level for Ammoniacal Nitrogen

For ammonia, RML seeks to retain the existing approved trigger level of 12 mg/l. This is because monitoring has revealed retardation of ammonia as it passes beneath the landfill and that Rudbaxton water has met EQS in recent years despite models predicting peak release from Phase 1. With time, it is expected this compliance level will be further revised downwards with increasing confidence to reflect the declining source term at the site.

11.2 Identification of a Breach

Trigger levels are based on concentrations to be evaluated each time monitoring is undertaken at the respective downgradient compliance wells. Rather than a single occurrence of a potentially elevated measurement at a single well prompting identification of a Permit breach, as is currently the case, an alternate approach has been devised which is set out in the flowchart presented in Figure 11-1. The flowchart also indicates the actions to be prompted if a breach were identified.

The alternate approach still protects surface water and ensures timely actions are taken in the event of a breach but first allows data quality and errors to be ruled out and / or evaluated. This will ensure that there is added confidence to data integrity and implementation of appropriate actions.

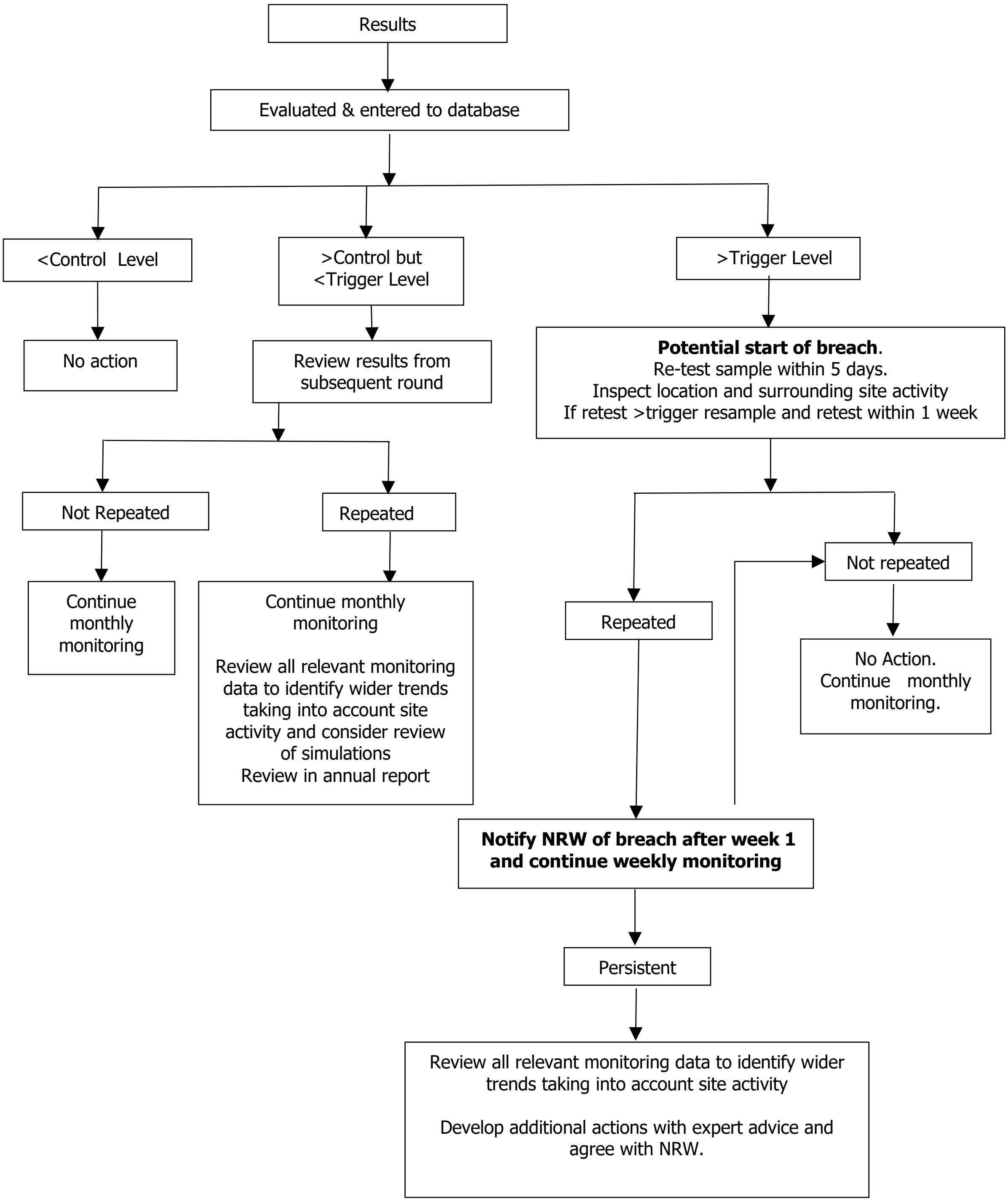


Figure 11-1 Identification of Trigger Level Breach and Response Actions

11.3 Groundwater Control Levels

Control levels are intended to draw the attention of site management to the potential development of trends in monitoring data that were not predicted before a compliance trigger level is breached. In this context, breach of a control level should not prompt regulatory action but provide opportunity for timely investigations, assessments or corrective measures that can be taken prior to a potential breach of a compliance trigger level. Control levels, therefore, need to be at lower concentrations than trigger levels.

Control levels are summarised in Table 11-2 and have been set at 50% of the compliance trigger level concentrations. Lower control levels could be potentially justified but given the conservative methodology used to derive the trigger levels and the monitoring data gathered to date, this level is considered to be currently appropriate.

Table 11-2 Groundwater Control Levels

Substance	Mecoprop	Naphthalene	Nickel	Phenol	Cadmium	Chloride	Ammoniacal Nitrogen
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
TP9	0.009	0.001	0.025	0.075	0.001	250	5
TP11	0.009	0.001	0.025	0.075	0.001	250	5
TP12	0.009	0.001	0.025	0.075	0.001	250	5
BH104	0.009	0.001	0.025	0.075	0.001	250	5
BH1	0.009	0.001	0.025	0.075	0.001	250	5
BH2	0.009	0.001	0.025	0.075	0.001	250	5
BH3	0.009	0.001	0.025	0.075	0.001	250	5
BH4	0.009	0.001	0.025	0.075	0.001	250	5
BH5	0.009	0.001	0.025	0.075	0.001	250	5
BH6	0.009	0.001	0.025	0.075	0.001	250	5
BH30	0.009	0.001	0.025	0.075	0.001	250	5
BH8	0.009	0.001	0.025	0.075	0.001	250	5

11.4 Leachate Depth

Leachate head should still not exceed 1m above base of any extraction sump.

11.5 Phase 1 Leachate Extraction Targets

Table S4.1 of the current Permit requires the Operator to extract a minimum leachate volume of 1,278m^3 per annum (241m^3 per well) from wells LE1 to LE6 Phase 1. The justification for this precise amount is unknown but each well is pumped continuously using float switches throughout the year in order to maintain the lowest practical leachate head. However, many wells are often found dry. As such, it is not always practicable to comply with the minimum extraction requirements. RML, therefore, seeks removal of the requirement to pump a certain volume but is satisfied with the requirement to maintain leachate levels at a practical minimum (0.6m). This would align Phase 1 with Phase 2 & 3 where the maximum head is the basis of the compliance limit.

It has been noted that the wells have not been drilled systematically into the 10 separate cells in Phase 1. There are no plans of the 10 cells available but various sources describe east to west oriented cells, each 30m wide extending across the Phase. The layout of the 6 leachate wells are clustered into the centre of the site and it is likely that they intersect only some of the cells, with some of these always being dry. It is thought that the specification of a target quantity to be removed stems from a water balance rather than an assessment of what can practically be achieved from the wells as they have been installed.

12 LANDFILL CLOSURE AND SURRENDER

Landfill closure is an on-going process between the time when the site is 'closed' and ceases accepting waste for disposal and 'definitive closure' when the waste regulator agrees that the site may enter the aftercare phase.

Definitive closure of the landfill will be granted by the waste regulator following review of the reports requested in the Closure Notice and a final on-site inspection. Following definitive closure, the Aftercare Monitoring period will last until the authorisation is successfully surrendered. During this period, the agreed Aftercare Monitoring Plan will be followed and the operator shall continue monitoring and maintaining the landfill for as long as the waste regulator considers the landfill poses a hazard to the environment. The landfill can only be surrendered when the waste regulator accepts that the landfill does not pose a hazard to the environment. The aftercare period will likely last for many years.

The ultimate surrender application will need to contain a site report describing the condition of the site relative to the condition of the site as described in the original site application. The application will also need to contain a description of any steps that have been taken to avoid any pollution risk on the site resulting from the operation of the installation, or to return the site to a satisfactory state.

12.1 Completion Criteria

Completion of the landfill is defined as the point at which the landfill has stabilised physically, chemically and biologically to such a degree that the undisturbed contents of the site are unlikely to cause pollution of the environment or harm to human health. At completion, post monitoring procedures are no longer required and the licensing permit can be surrendered. Completion can only occur if certain criteria are met during the post closure monitoring.

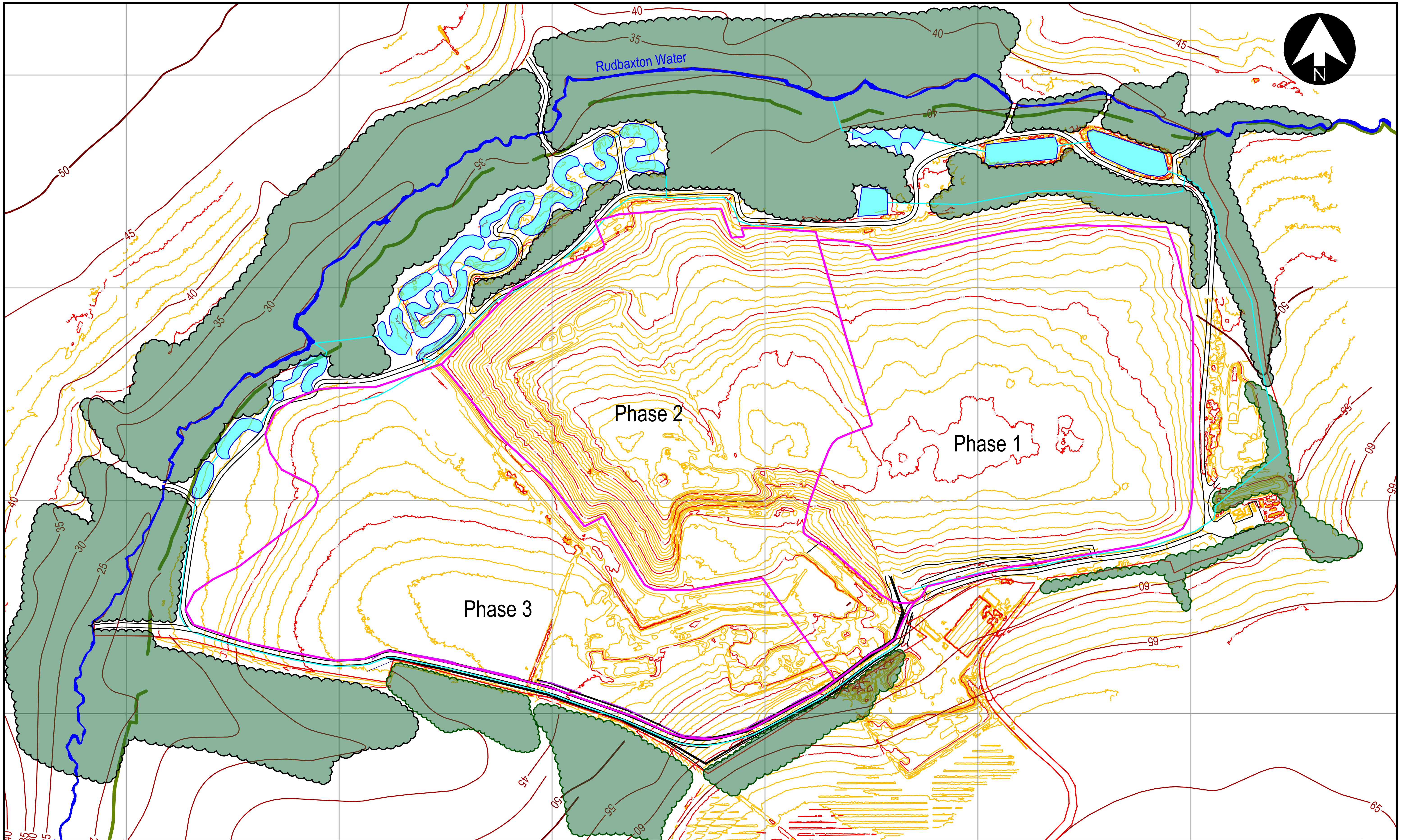
13 SUMMARY

Predicted leakage from Phase 2 & 3 is considerably less than the rate of leakage from Phase 1, despite Phase 1 being less than half the area of Phase 2 & 3. Accordingly, a simple proposition given that the leachate is of similar strength, would be that Phase 2 & 3 in combination will have a fraction of the influence on the groundwater (and hence Rudbaxton Water) that Phase 1 is currently having. As monitoring shows that Phase 1 is not currently having an unacceptable effect on Rudbaxton Water, the logical conclusion would be that this situation will persist through the remaining development of Phase 3. This position has been quantitatively evaluated through several lines of evidence including simulation, performance modelling and mass balance assessment of potential cumulative impacts. The assessments indicate that the approved technical precautions will continue to prevent unacceptable discharges and emissions.

Whilst the modelling and other lines of evidence provide assurance that the approved technical precautions will continue to protect the environment, an interim review of the HRA is to be carried out in 2026, following implementation of the proposed new monitoring programme.

References

1. Glendining, S J. 1981. Hydrogeological reconnaissance study: Dyfi Valley, Wales. Institute of Geological Sciences Technical Report, ENPU 81-2



LEGEND

	Surface Water Features
	Woodland
	Hedge/Scrub
C7LS	Leachate Extraction Sump
C7LM1	Leachate Monitoring Well
	Permit boundary (as original WML boundary)
	Landfill Phases
	Regional contour (mAOD)
	Contours - Normal (1.0m)
	Contours - Prominent (5.0m)

NOTE

Digital survey model generated using Pix4D image processing software. Imagery acquired by DJI Mavic 3E RTK photogrammetry survey on 25 April 2023. Survey control installed using Topcon Hiper SR dGPS Rover.

Survey model includes non topographic features such as buildings, equipment and vegetation.

OS Grid spacing at 250m

PROJECT

Withyhedge Landfill Permit Variation

TITLE

2023 Site Plan

DRAWING NUMBER		
2365/1		
SCALE AT A3	DATE	DRAWN
1:4000	07.23	KJT

NOTE

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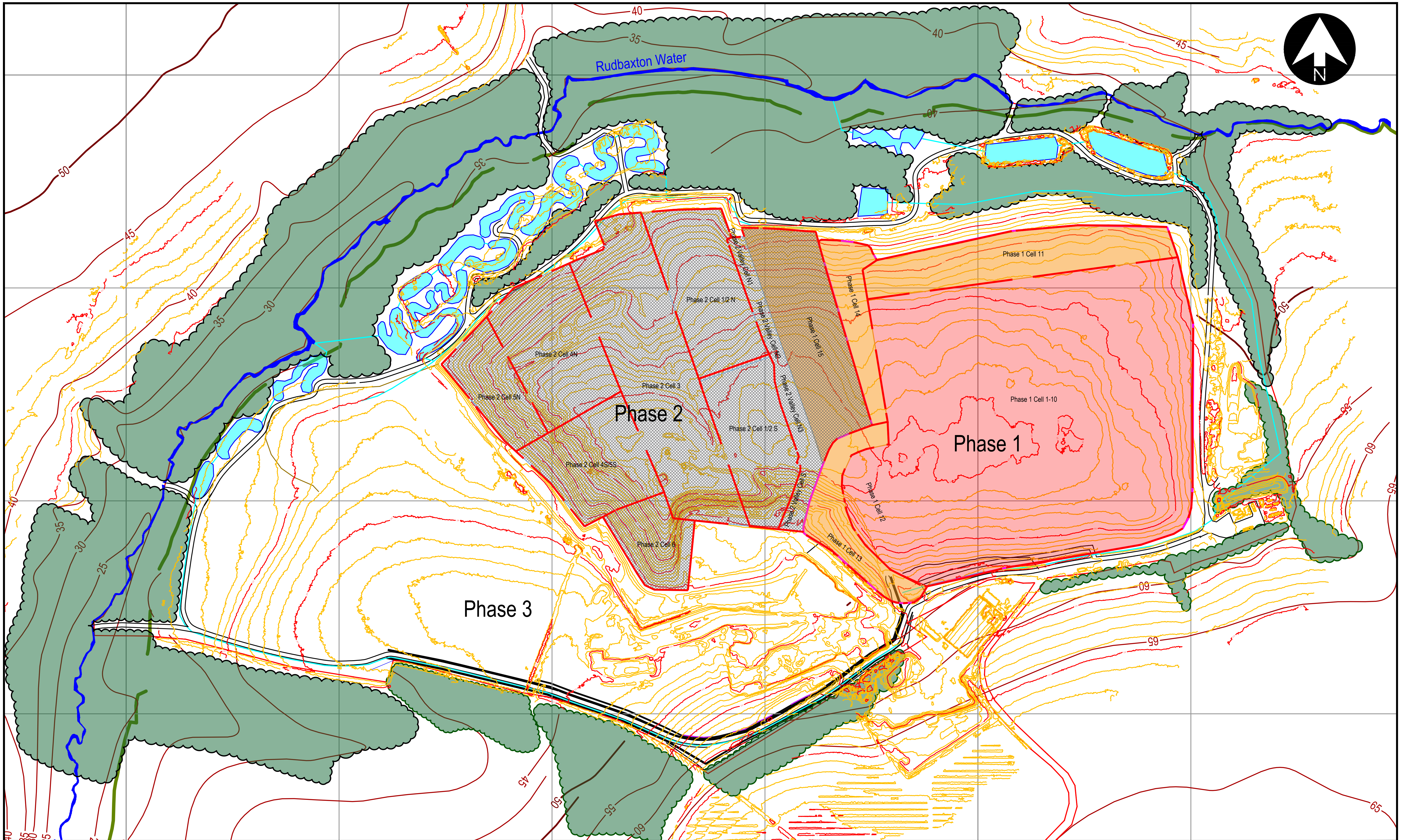
GEO TECHNOLOGY



LEGEND

- Surface Water Features
- Woodland
- Permit boundary (as original WML boundary)
- Landfill Phases
- Regional contour (mAOD)
- Contours - Normal (1.0m)
- Contours - Prominent (5.0m)
- Area Boundary
- Cell Boundary
- No Basal Liner
- 1m Mineral Liner
- 1m Mineral Liner/fml
- gcl/0.5m mineral liner/fml

NOTE

Digital survey model generated using Pix4D image processing software. Imagery acquired by DJI Mavic 3E RTK photogrammetry survey on 25 April 2023. Survey control installed using Topcon Hiper SR dGPS Rover.

Survey model includes non topographic features such as buildings, equipment and vegetation.

OS Grid spacing at 250m

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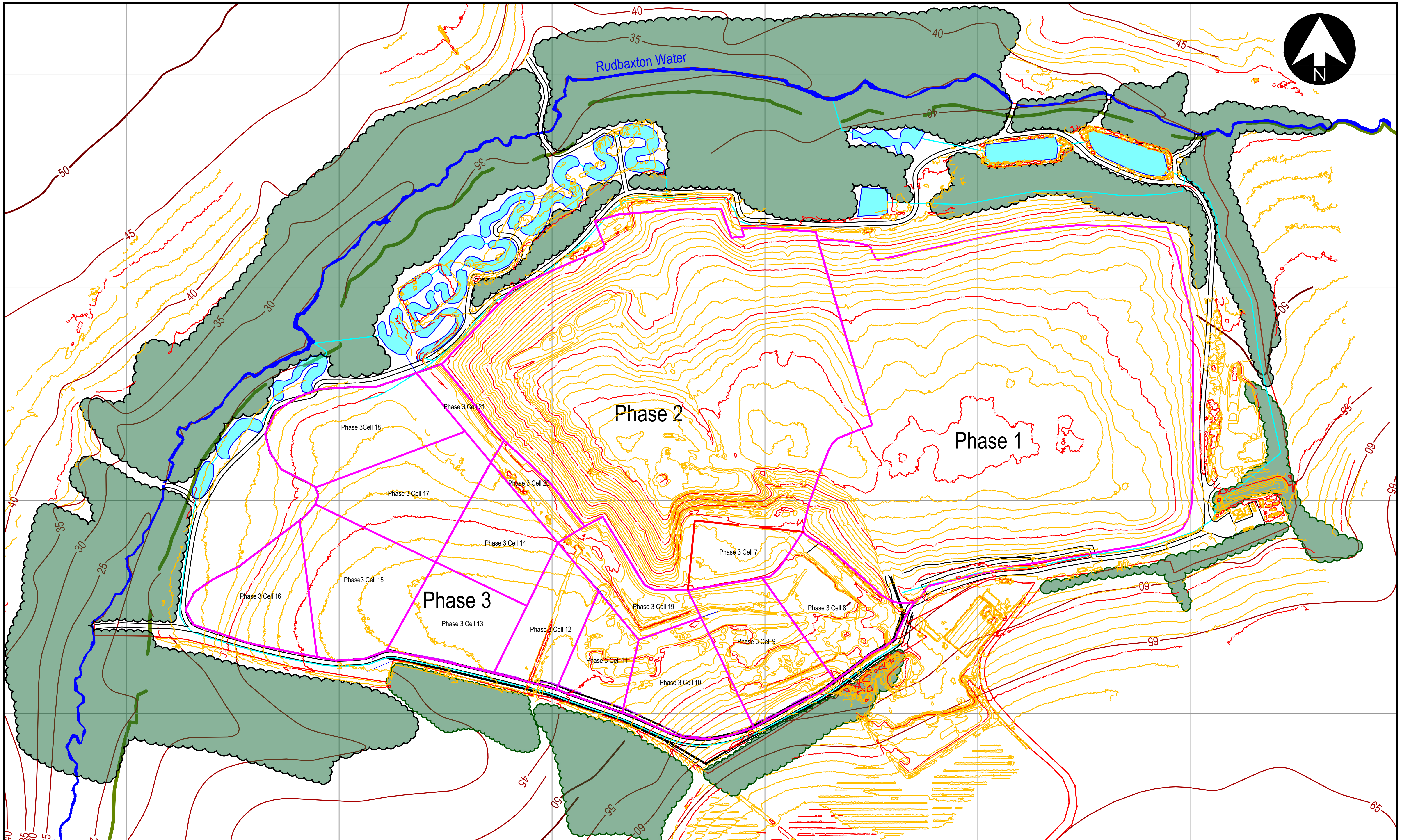
PROJECT: **Withyhedge Landfill Permit Variation**

TITLE: **Existing Landfill Cells**

DRAWING NUMBER		
2365/1		
SCALE AT A3	DATE	DRAWN
1:4000	07.23	KJT

NOTE

GEO TECHNOLOGY



LEGEND

- Surface Water Features
- Woodland
- Permit boundary (as original WML boundary)
- Landfill Phases
- Regional contour (mAOD)
- Contours - Normal (1.0m)
- Contours - Prominent (5.0m)
- Area Boundary
- Cell Boundary
- No Basal Liner
- 1m Mineral Liner
- 1m Mineral Liner/fml
- gcl/0.5m mineral liner/fml

NOTE

Digital survey model generated using Pix4D image processing software. Imagery acquired by DJI Mavic 3E RTK photogrammetry survey on 25 April 2023. Survey control installed using Topcon Hiper SR dGPS Rover.

Survey model includes non topographic features such as buildings, equipment and vegetation.

OS Grid spacing at 250m

PROJECT

Withyhedge Landfill
Permit Variation

TITLE

Proposed Landfill Cells

DRAWING NUMBER		
2365/3		
SCALE AT A3	DATE	DRAWN
1:4000	**07.23**	**KJT**
NOTE		

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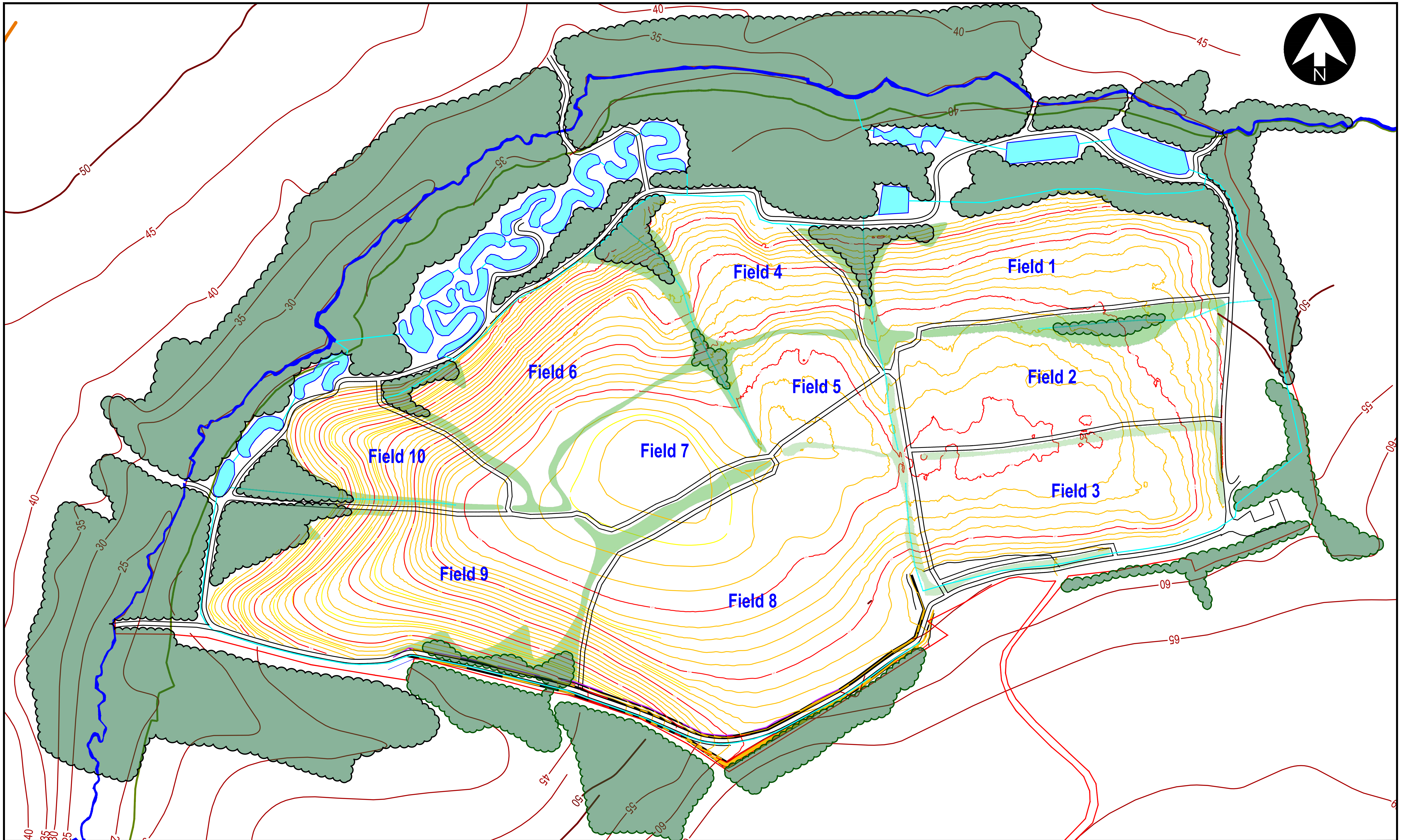
Geo TECHNOLOGY



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LEGEND

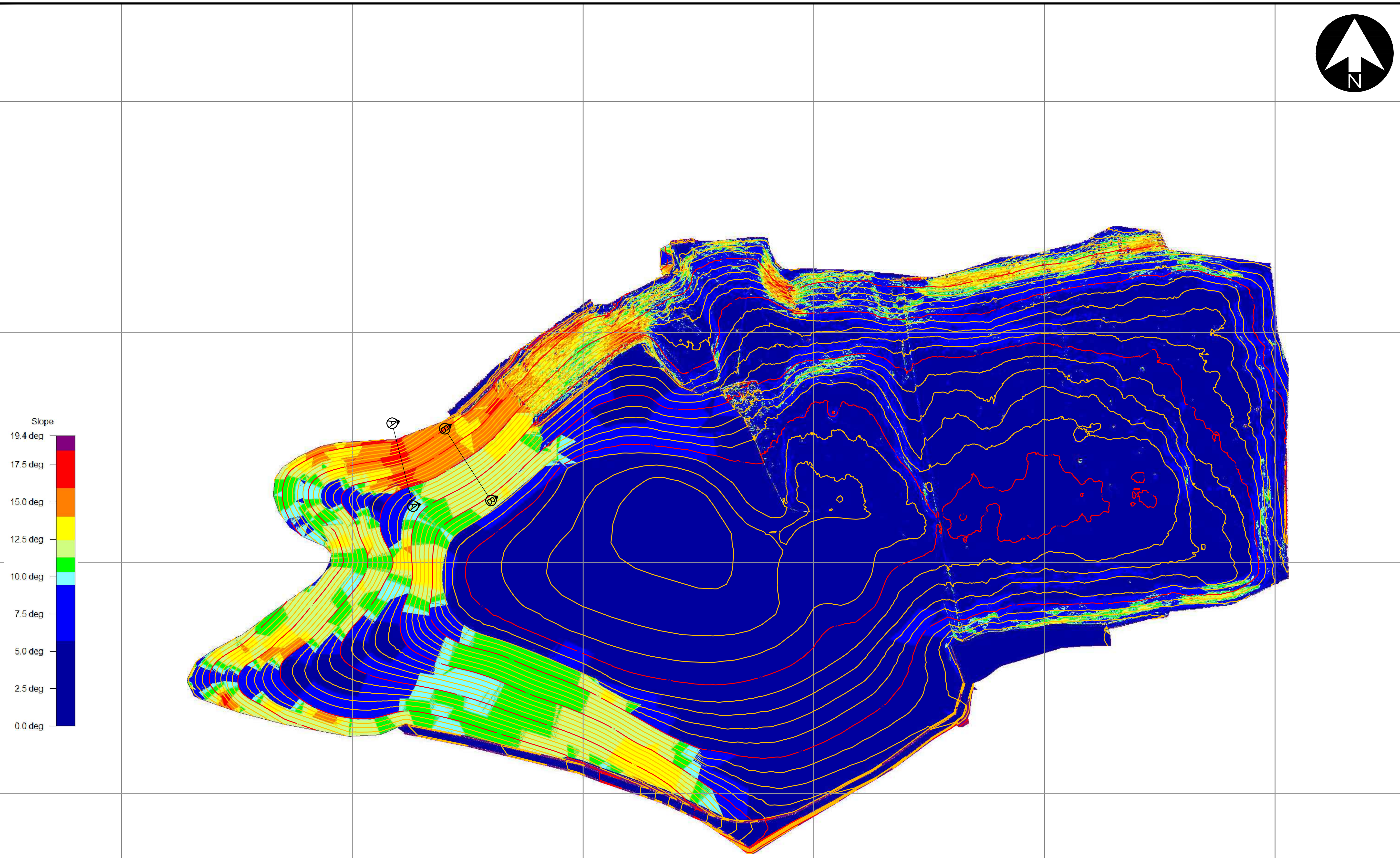
- Areas of existing and proposed woodland
- Areas of proposed scrub regeneration
- Permit boundary (as original WML boundary)
- Landfill Phases
- Afonydd Cleddau SAC boundary
- Regional contour (mAOD)
- Proposed Pre-Settlement Restoration Contours - Normal (1.0m)
- Proposed Pre-Settlement Restoration Contours - Prominent (5.0m)

PROJECT
Withyhedge Landfill
Permit Variation

TITLE
Proposed Pre-Settlement Landform and Landscaping Details

DRAWING NUMBER		
2365/4		
SCALE AT A3	DATE	DRAWN
1:4000	04.23	KJT
NOTE		

GeO TECHNOLOGY



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LEGEND

Ⓐ———Ⓐ Cross Section (A steepest, B highest)

PROJECT

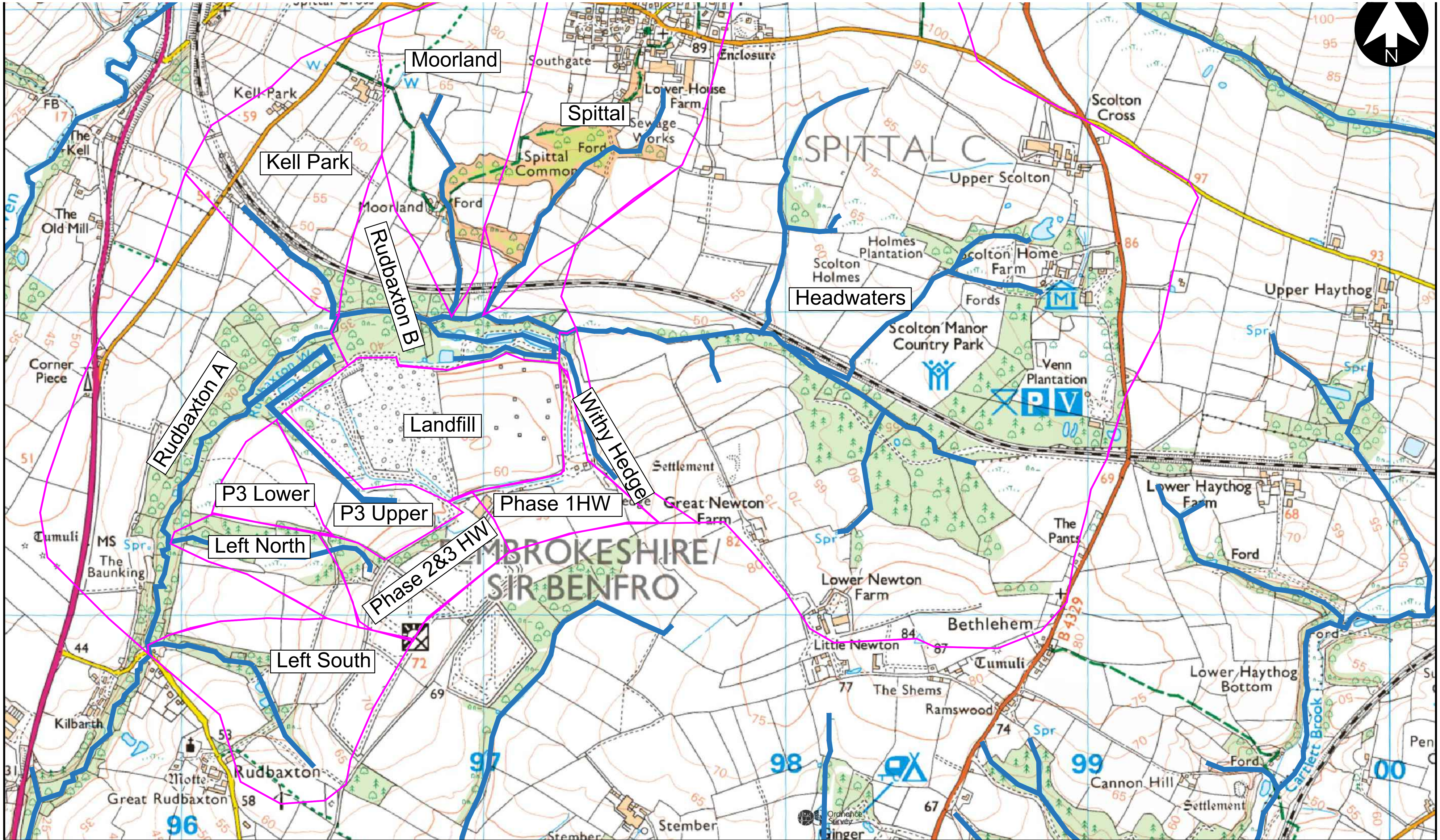
Withyhedge Landfill
Permit Variation

TITLE

Proposed Restoration Surface Gradient

DRAWING NUMBER		
2365/5		
SCALE AT A3	DATE	DRAWN
1:4000	04.23	KJT
NOTE		

GEO TECHNOLOGY



LEGEND

Catchment Boundary

Spittal Catchment Name

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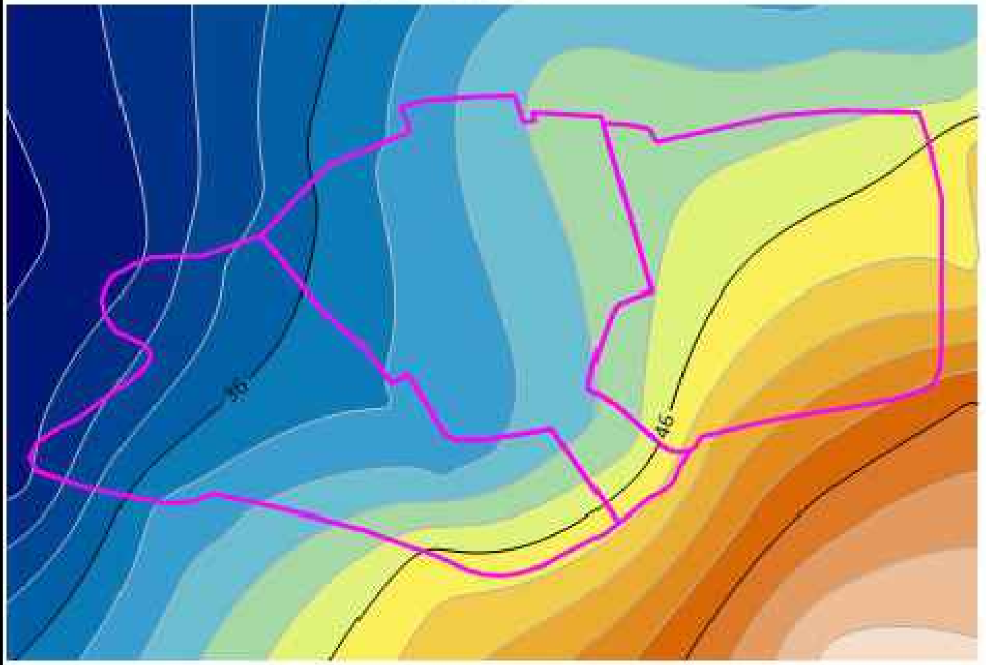
PROJECT	DRAWING NUMBER		
Withyhedge Landfill Permit Variation	**2365/6**		
	SCALE AT A3	DATE	DRAWN
	as shown	**04.23**	**KJT**
TITLE	NOTE		
Hydrology and Water Catchments			

GEO

September 2020



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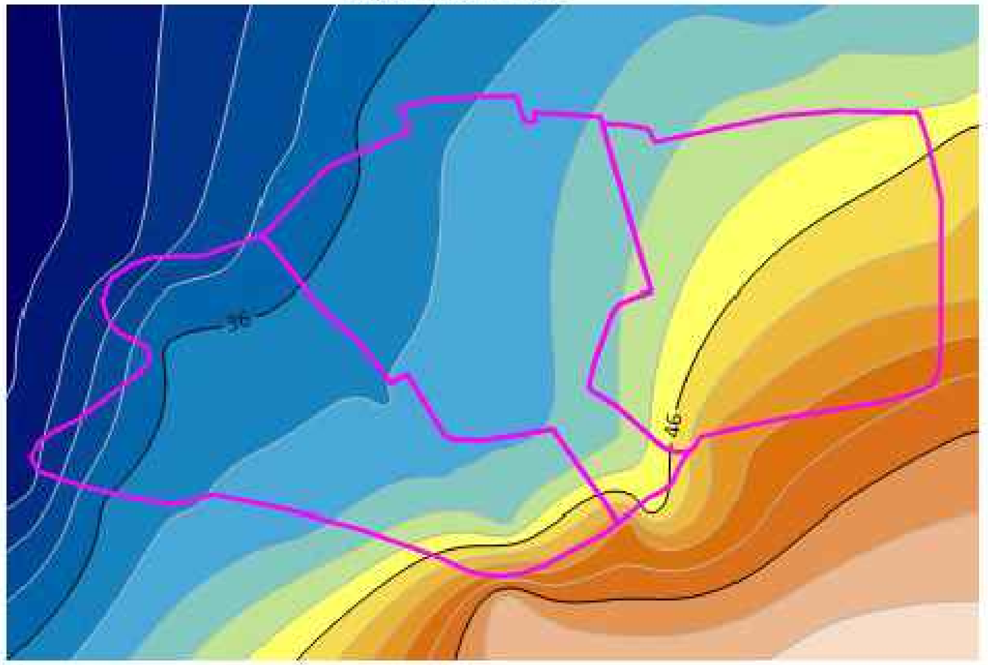

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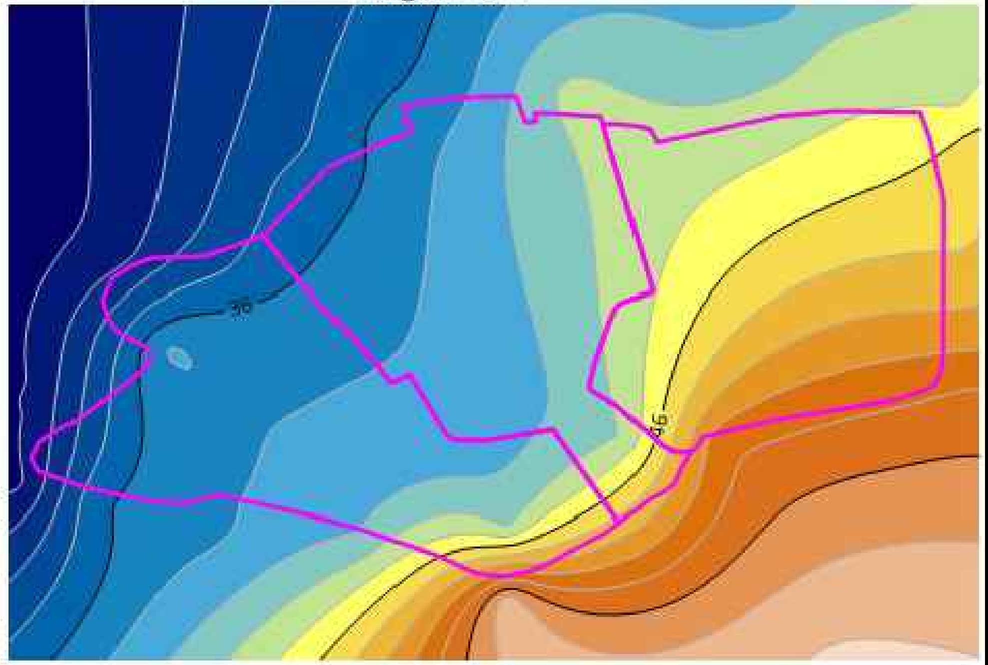
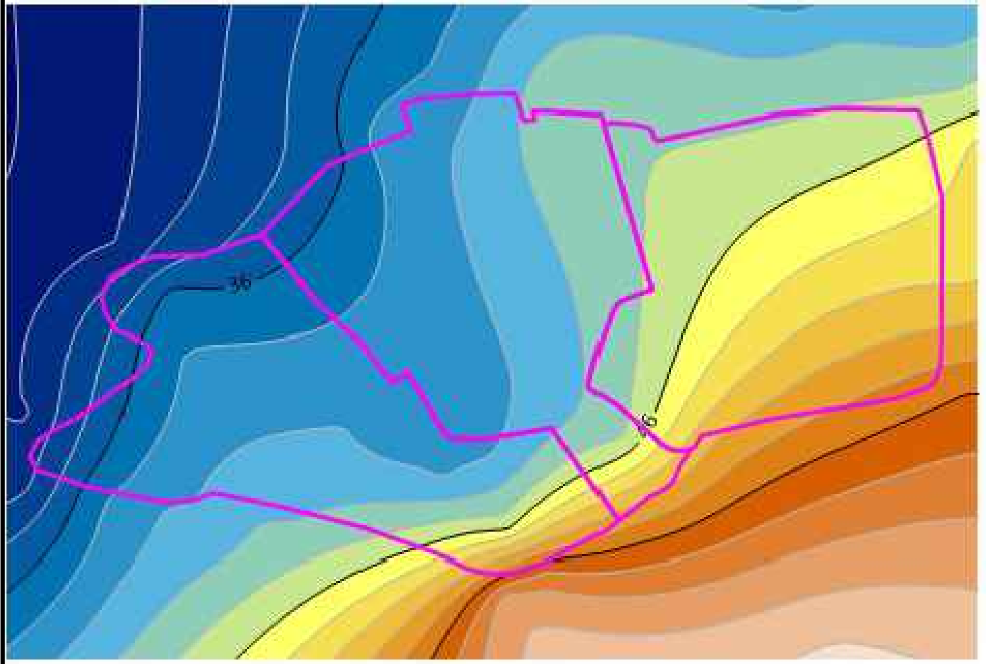


December 2020



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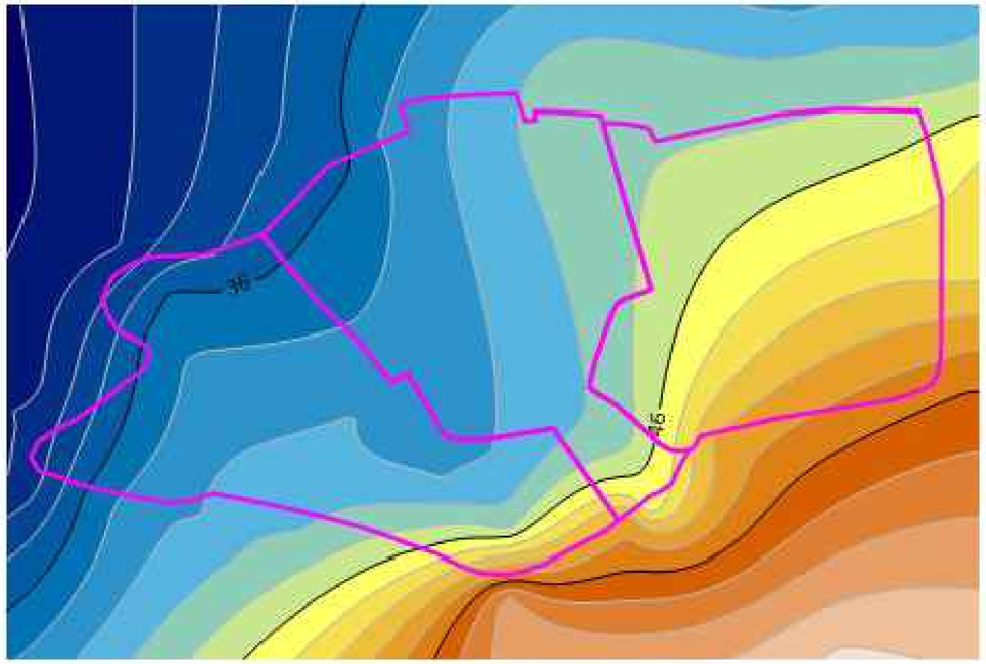
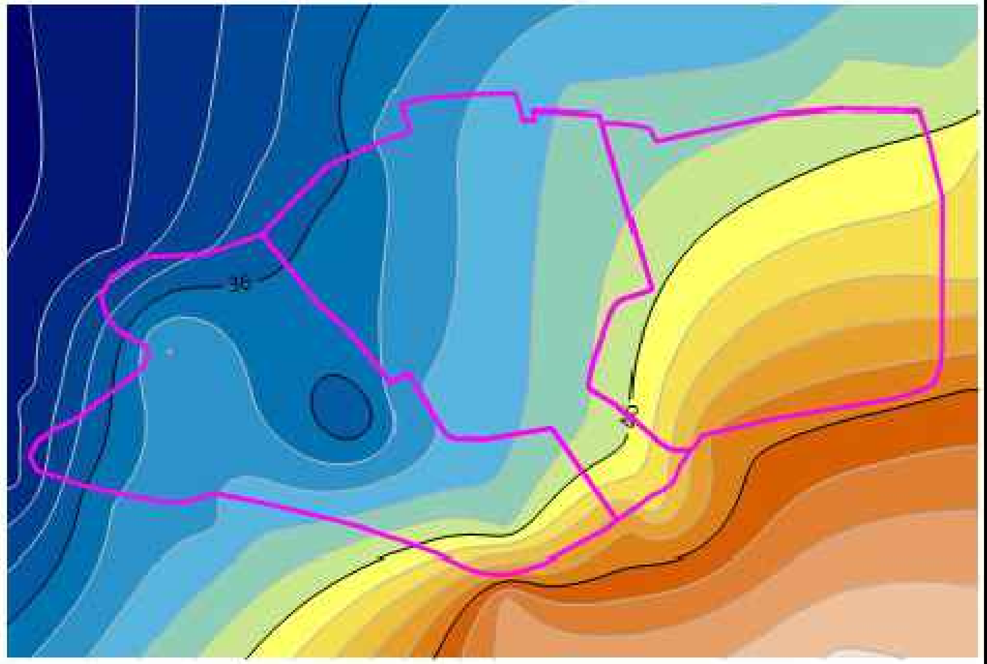


November 2022



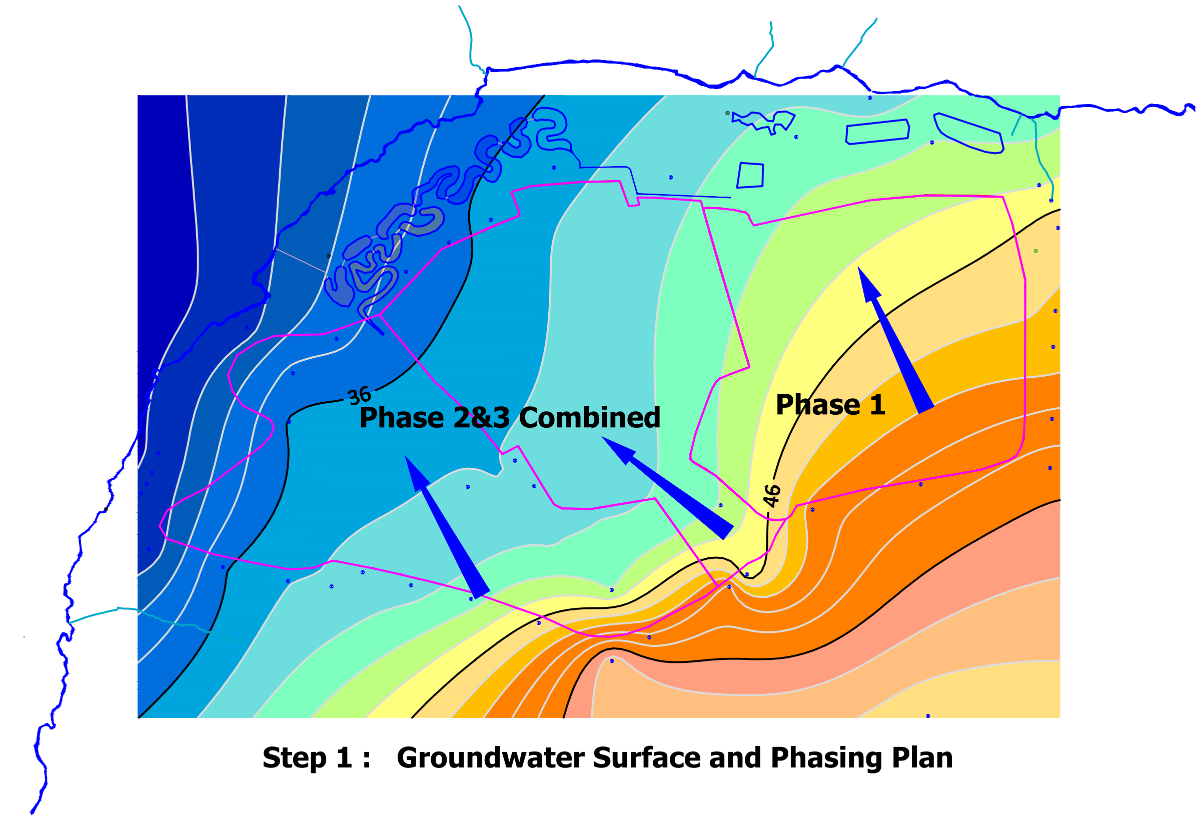
RESOURCES MANAGEMENT UK LTD

LEGEND

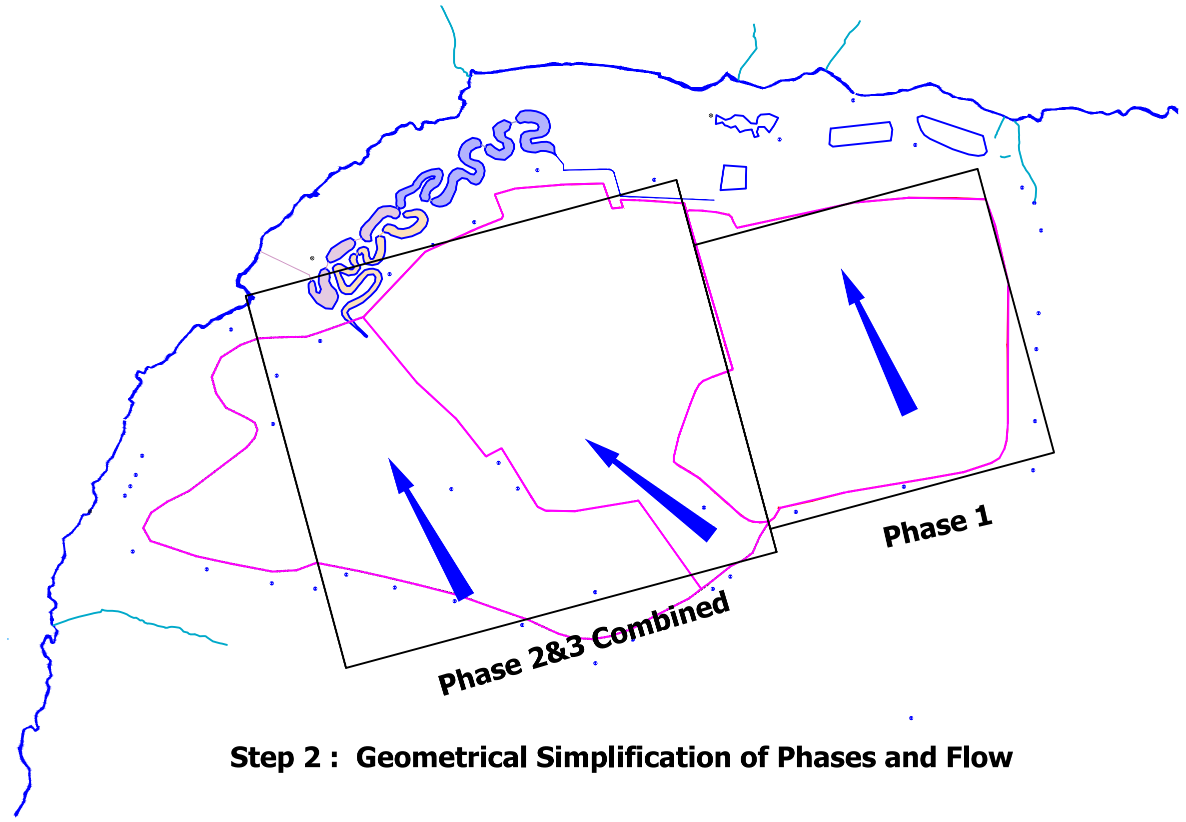
Phase Boundary

PROJECT	DRAWING NUMBER		
Withyhedge Landfill Permit Variation	**2365/7**		
	SCALE AT A3 **1:11000**	DATE **04.23**	DRAWN **KJT**
TITLE **Groundwater Level Timeseries**	NOTE		

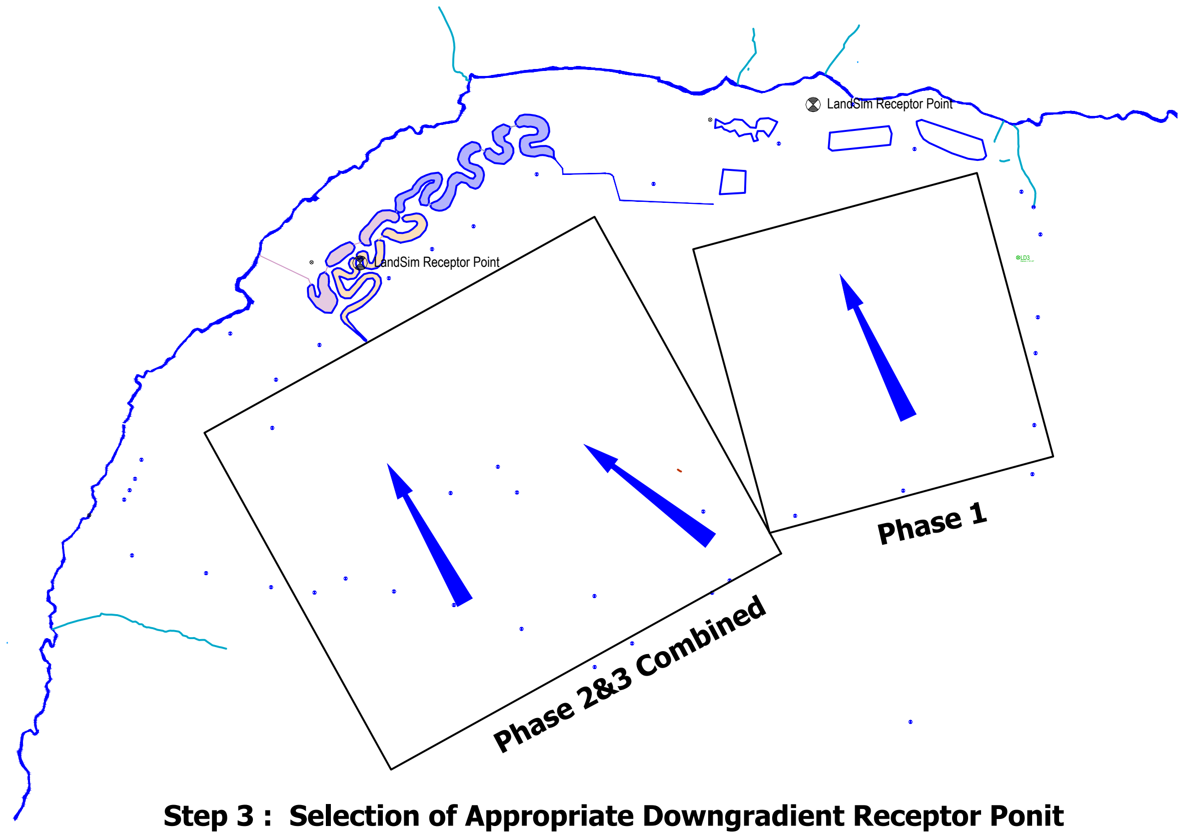
GEO TECHNOLOGY



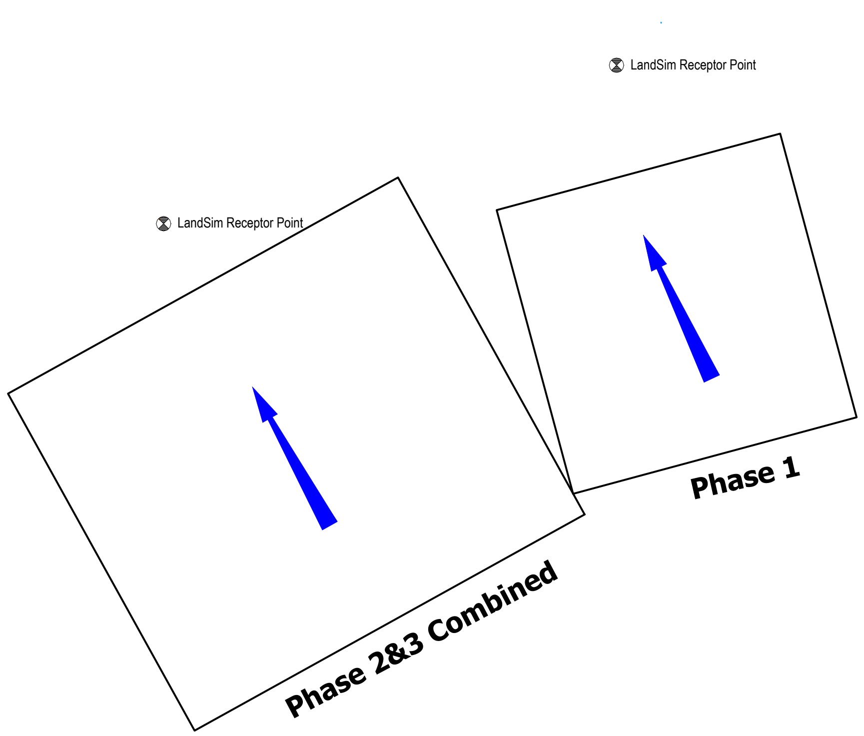
Step 1 : Groundwater Surface and Phasing Plan



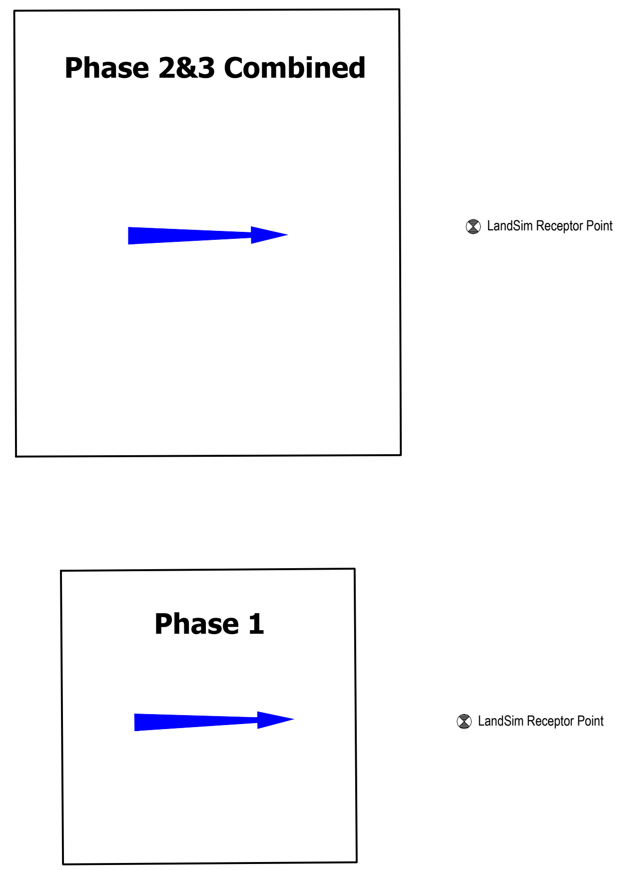
Step 2 : Geometrical Simplification of Phases and Flow



Step 3 : Selection of Appropriate Downgradient Receptor Ponit



Step 4 : Isolation of Model Phases and Representative Flow



Step 5 : Rotation to Model Flow Direction

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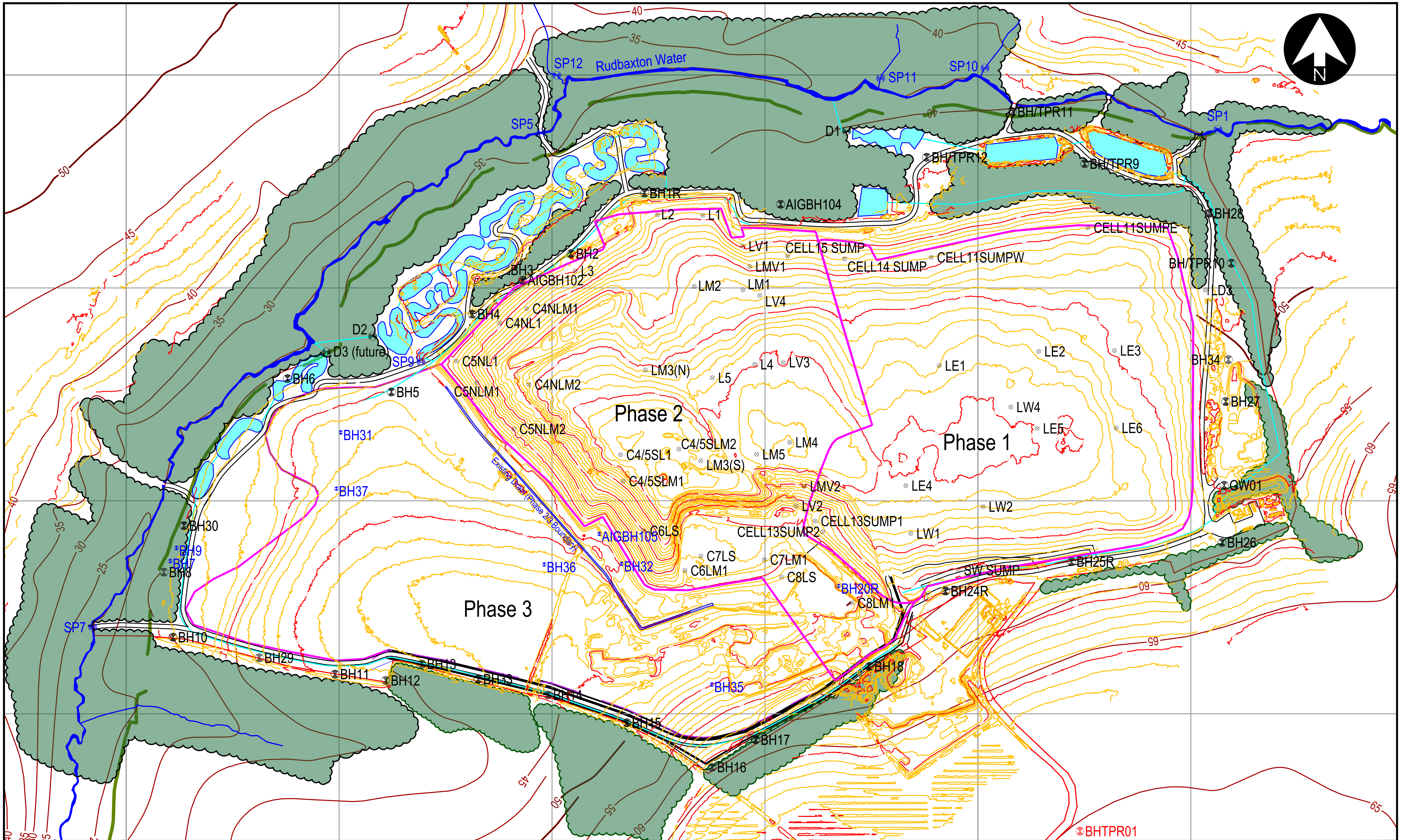
LEGEND	
⦿	Monitoring Well
——	Phase Boundary

PROJECT	DRAWING NUMBER		
Withyhedge Landfill Permit Variation	2365/8		
	SCALE AT A3: 1:11000	DATE: 04.23	DRAWN: KJT
TITLE: **LandSim Simplification**	NOTE		



LEGEND

Surface Water Features	Permit boundary (as original WML boundary)
Woodland	Landfill Phases
Hedge/Scrub	Regional contour (mAOD)
	Contours - Normal (1.0m)
C7LS Leachate Extraction Sump	Contours - Prominent (5.0m)
C7LM1 Leachate Monitoring Well	SP12 Surface Water Monitoring Point
BH4 Landfill Monitoring Well	D2 Discharge Monitoring Point

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NOTE

Digital survey model generated using Pix4D image processing software. Imagery acquired by DJI Mavic 3E RTK photogrammetry survey on 25 April 2023. Survey control installed using Topcon Hiper SR dGPS Rover.

Survey model includes non topographic features such as buildings, equipment and vegetation.

OS Grid spacing at 250m

PROJECT

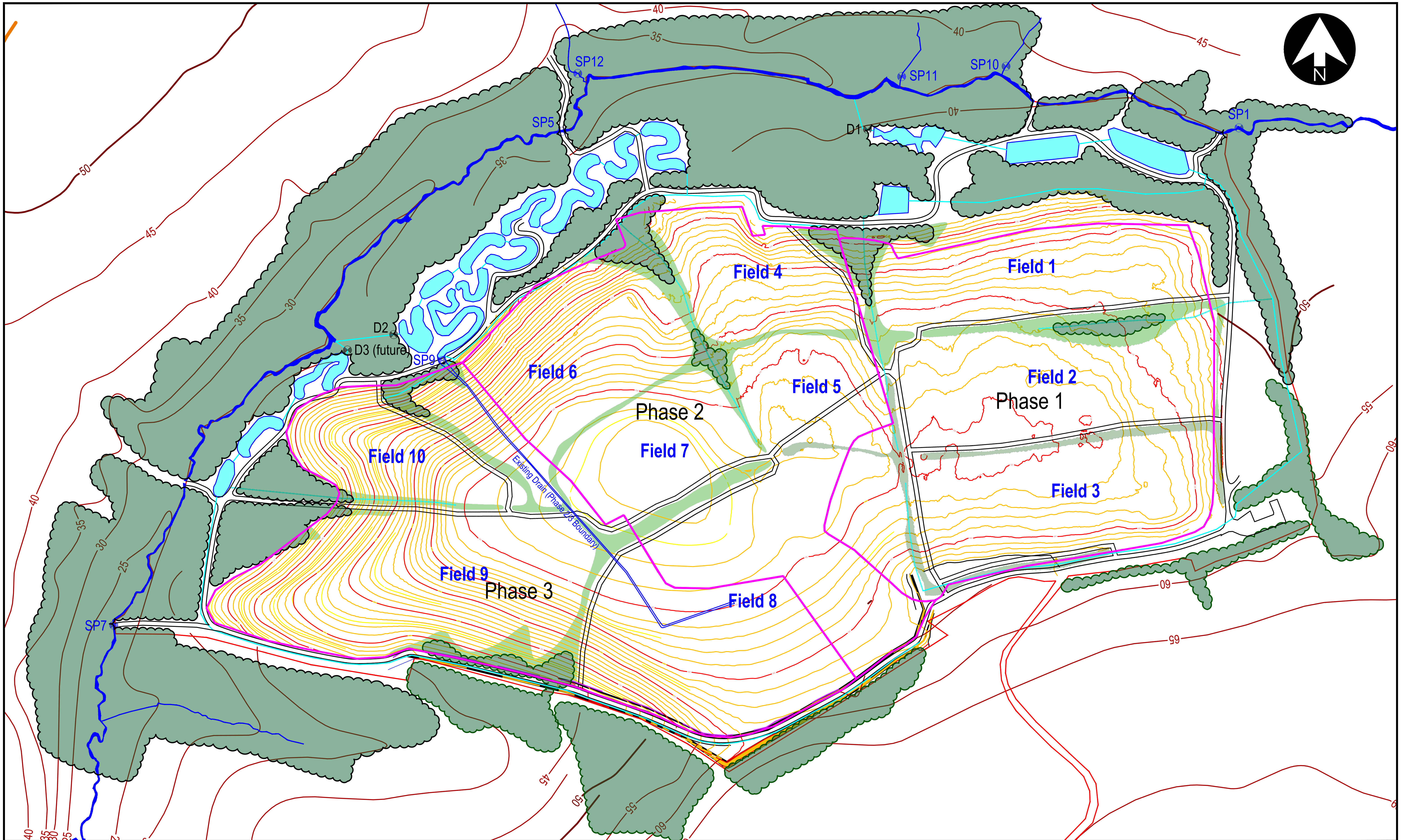
Withyhedge Landfill Permit Variation

TITLE

Existing Landfill Monitoring Infrastructure

DRAWING NUMBER		
2365/9		
SCALE AT A3	DATE	DRAWN
1:4000	07.23	KJT
NOTE		

GEO TECHNOLOGY



LEGEND

- Areas of Proposed Scrub Regeneration
- Areas of woodland
- Surface Water Ponds
- SP12 Surface Water Monitoring Point
- D2 Discharge Monitoring Point
- Permit boundary (as original WML boundary)
- Phase Boundary
- Regional contour (mAOD)
- Proposed Pre-Settlement Restoration Contours - Normal (1.0m)
- Proposed Pre-Settlement Restoration Contours - Prominent (5.0m)

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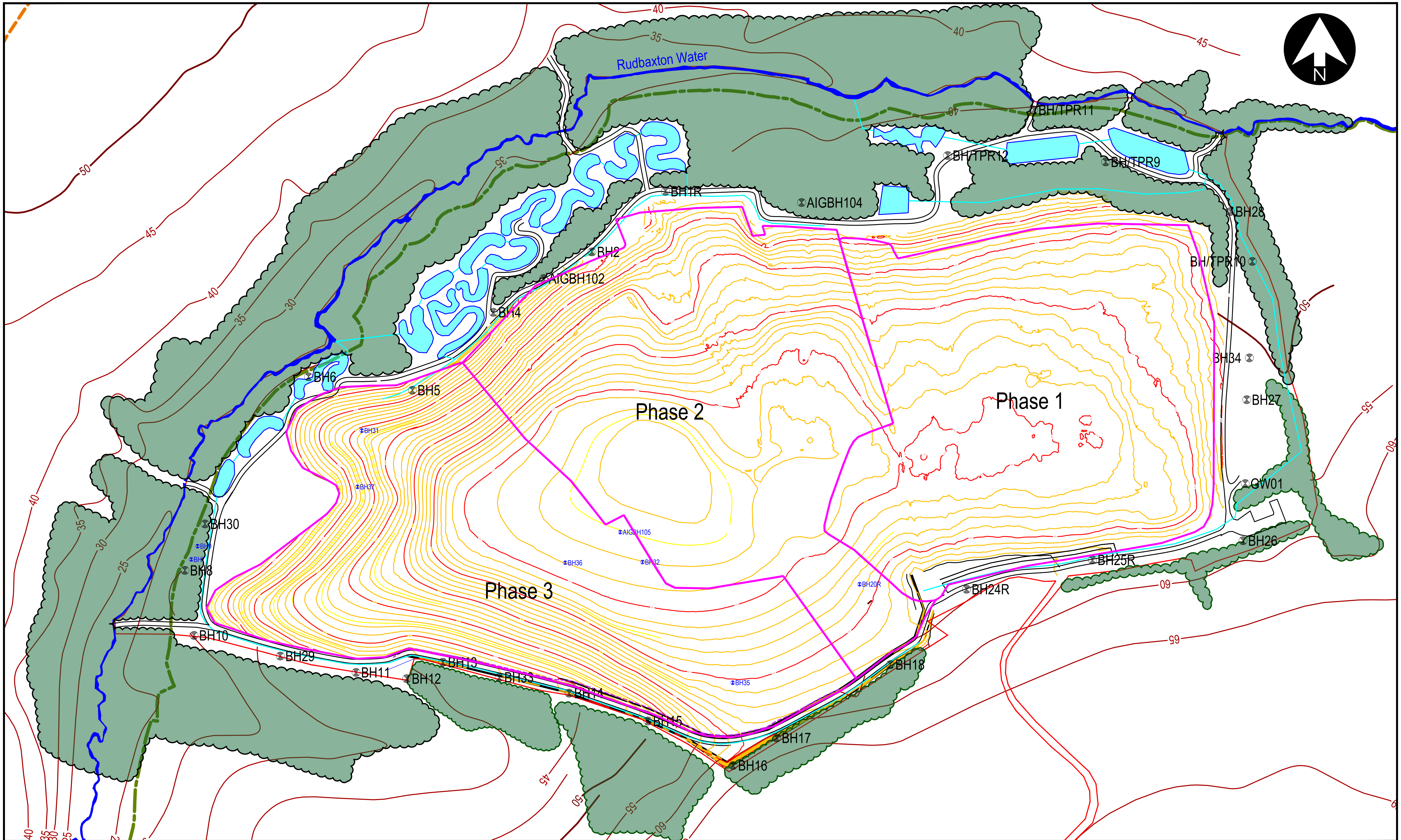
PROJECT	**Withyhedge Landfill Permit Variation**
TITLE	**Surface Water Monitoring Points**
DRAWING NUMBER	2365/10
SCALE AT A3	1:4000
DATE	04.23
DRAWN	KJT
NOTE	

GEO TECHNOLOGY



LEGEND

	Surface Water Features
	Woodland
	Hedge/Scrub
BH4	Monitoring Well
BH36	Monitoring Well to be lost during filling
	Permit boundary (as original WML boundary)
	Landfill Phases
	Regional contour (mAOD)
	Proposed Pre-Settlement Restoration Contours - Normal (1.0m)
	Proposed Pre-Settlement Restoration Contours - Prominent (5.0m)

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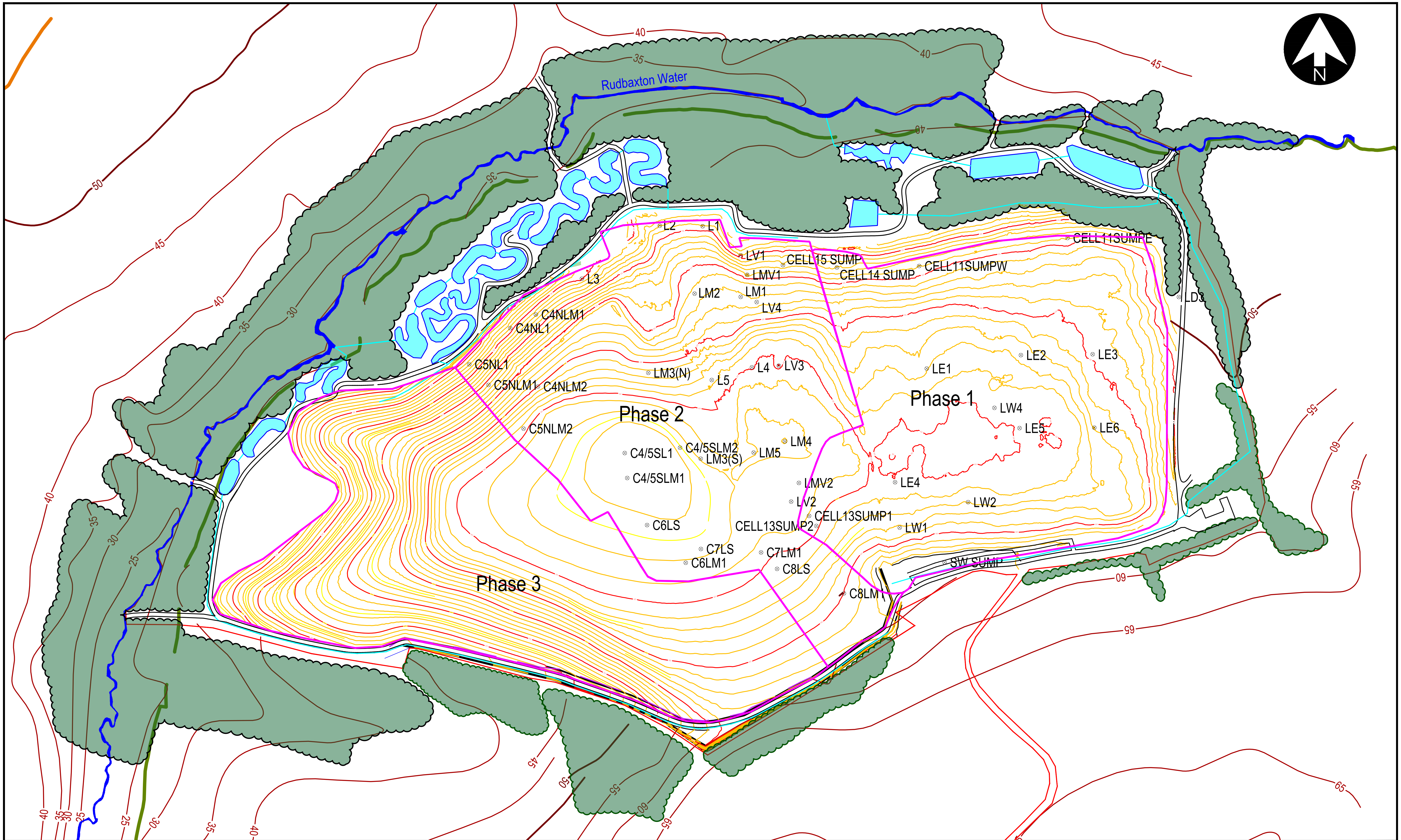
PROJECT
Withyhedge Landfill Permit Variation

TITLE
Groundwater Monitoring Wells

DRAWING NUMBER		
2365/11		
SCALE AT A3	DATE	DRAWN
1:4000	04.23	KJT
NOTE		

Geo TECHNOLOGY



LEGEND

	Surface Water Features
	Woodland
	Hedge/Scrub
C7LS	Leachate Extraction Sump
C7LM1	Leachate Monitoring Well
	Permit boundary (as original WML boundary)
	Landfill Phases
	Regional contour (mAOD)
	Proposed Pre-Settlement Restoration Contours - Normal (1.0m)
	Proposed Pre-Settlement Restoration Contours - Prominent (5.0m)

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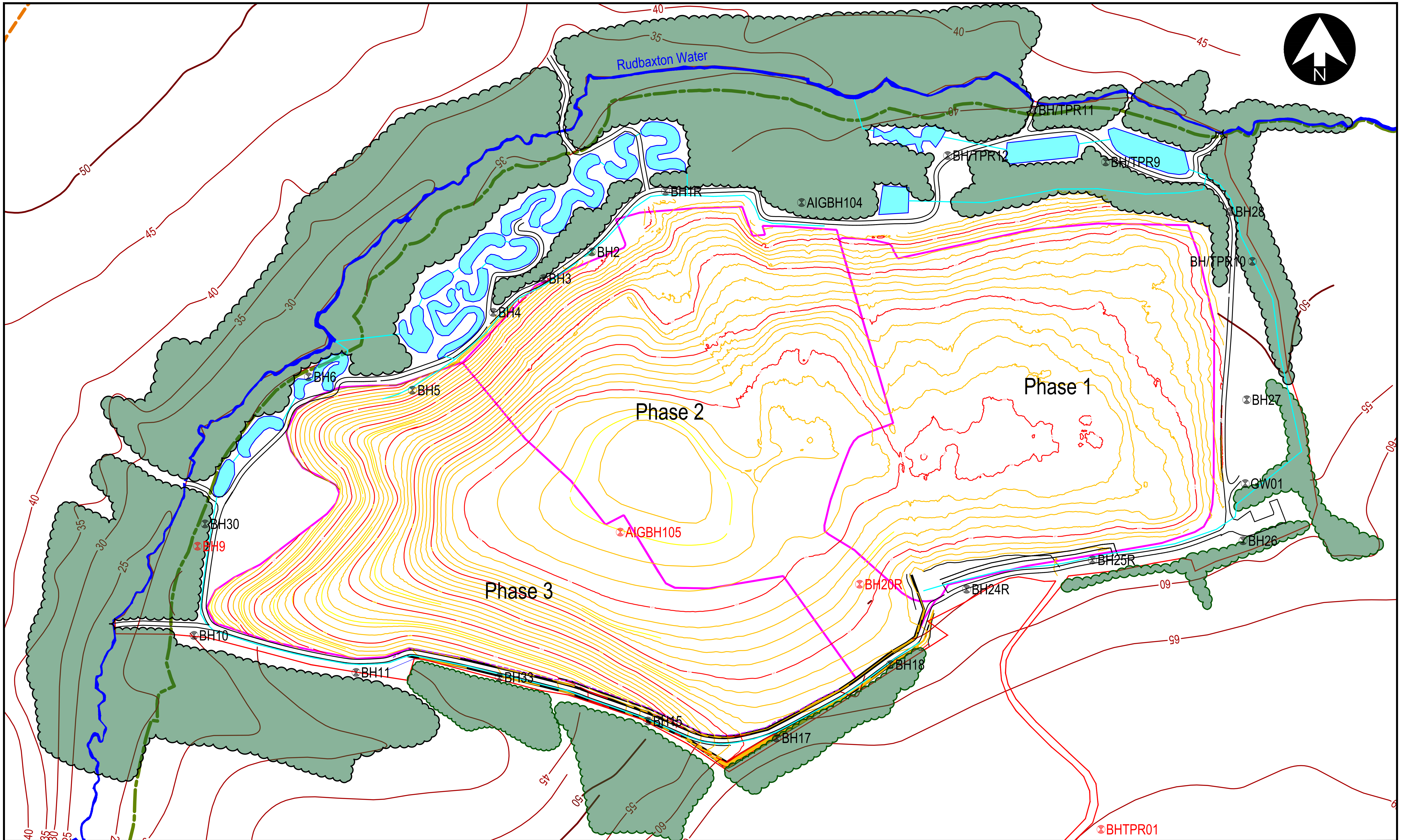
PROJECT
Withyhedge Landfill
Permit Variation

TITLE
Leachate Monitoring Wells

DRAWING NUMBER		
2365/12		
SCALE AT A3	DATE	DRAWN
1:4000	04.23	KJT
NOTE		

GEO TECHNOLOGY



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LEGEND

- Surface Water Features
- Woodland
- Hedge/Scrub
- BH4 Landfill Gas Monitoring Well
- BH9 Decomissioned Landfill Gas Monitoring Well
- Permit boundary (as original WML boundary)
- Landfill Phases
- Regional contour (mAOD)
- Proposed Pre-Settlement Restoration Contours - Normal (1.0m)
- Proposed Pre-Settlement Restoration Contours - Prominent (5.0m)

PROJECT

Withyhedge Landfill
Permit Variation

TITLE

Perimeter Landfill Gas Monitoring Wells

DRAWING NUMBER		
2365/13		
SCALE AT A3	DATE	DRAWN
1:4000	04.23	KJT
NOTE		

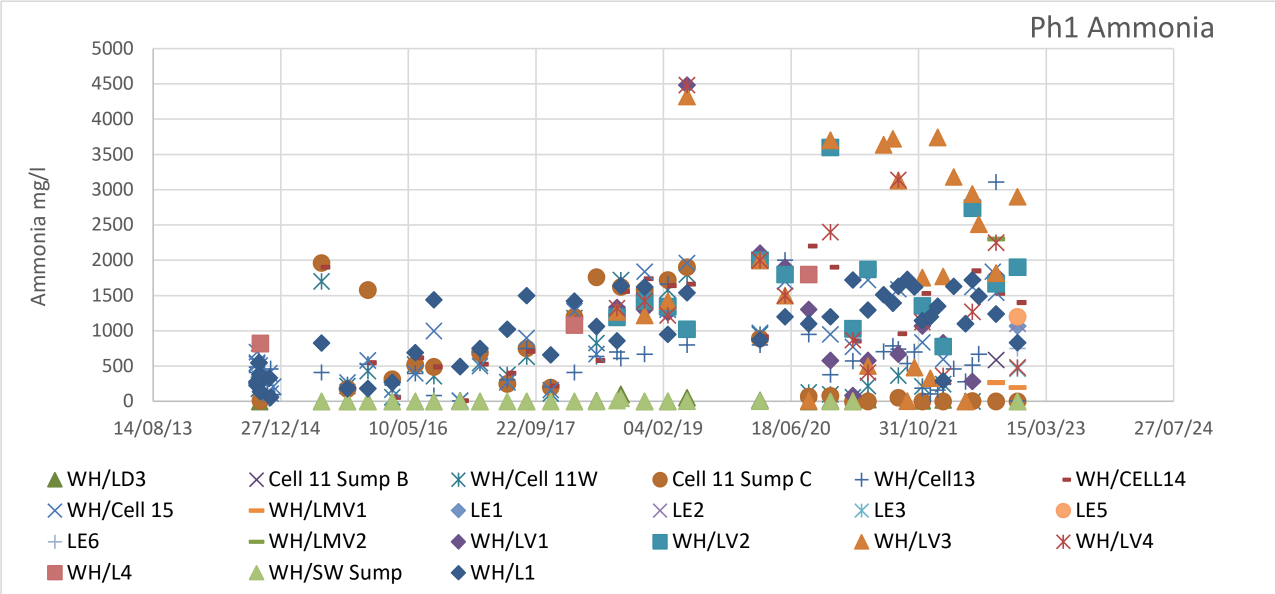
Geo TECHNOLOGY

WITHYHEDGE LANDFILL

HYDROGEOLOGICAL RISK ASSESSMENT REVIEW

Report Number 2365r2v1d0524

APPENDIX 1
TEMPORAL PLOTS OF LEACHATE CHEMISTRY


Ph1 Ammonia
Ammonia mg/l
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
18/06/20
31/10/21
15/03/23
27/07/24
WH/LD3
Cell 11 Sump B
WH/Cell 11W
Cell 11 Sump C
WH/Cell13
WH/CELL14
WH/Cell 15
WH/LMV1
LE1
LE2
LE3
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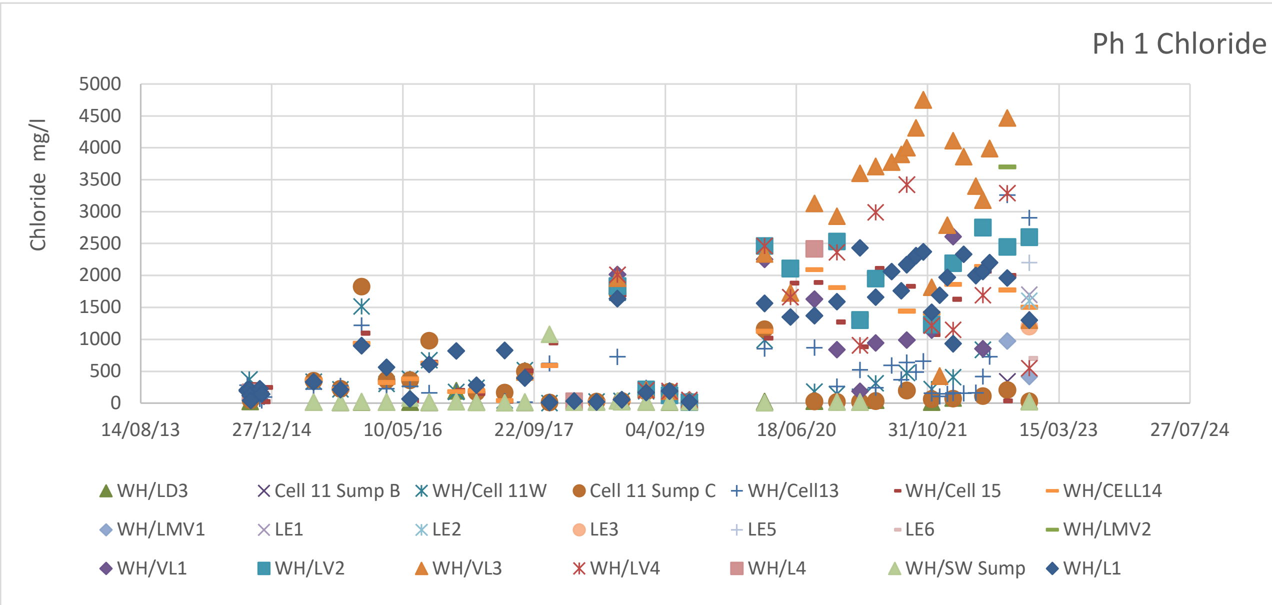
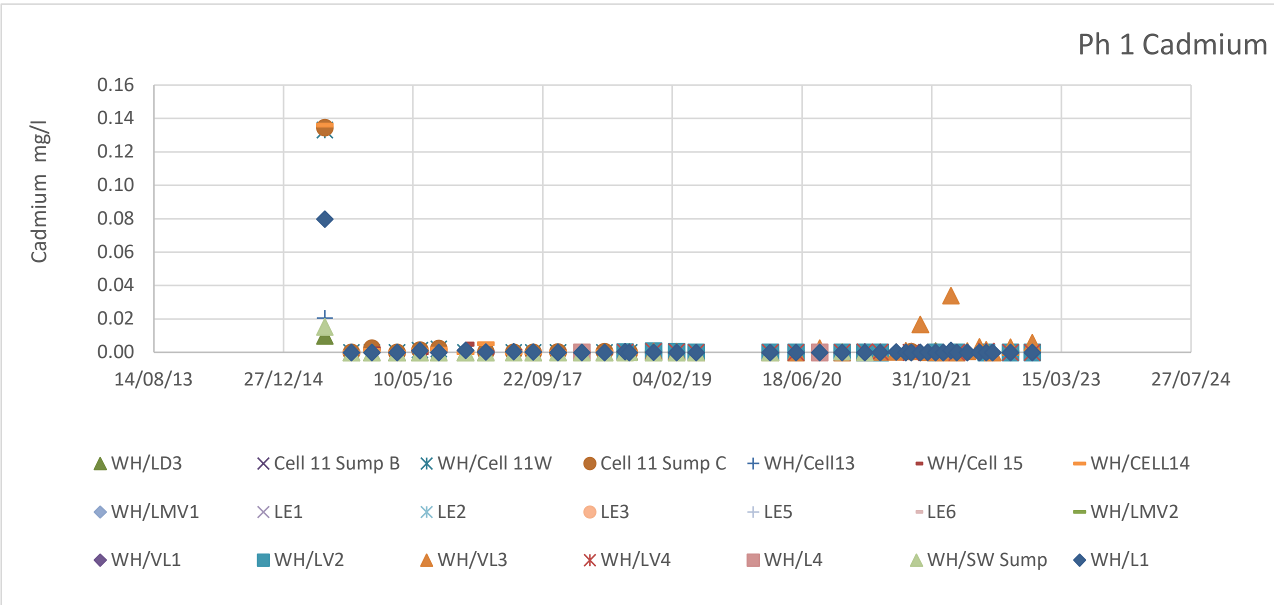
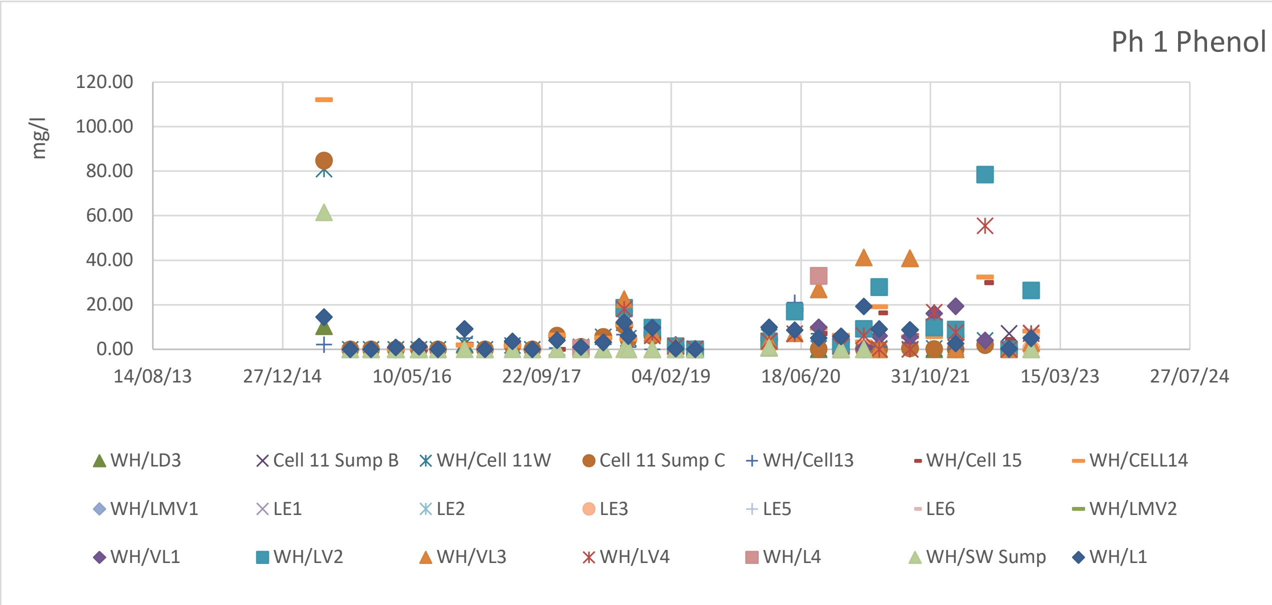
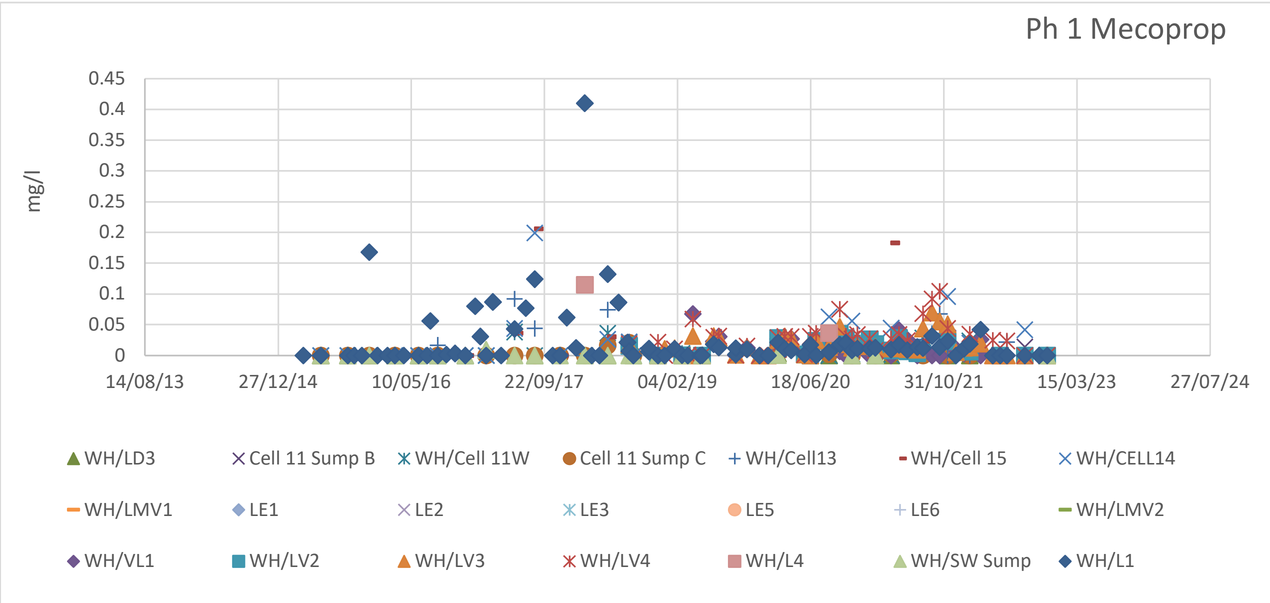
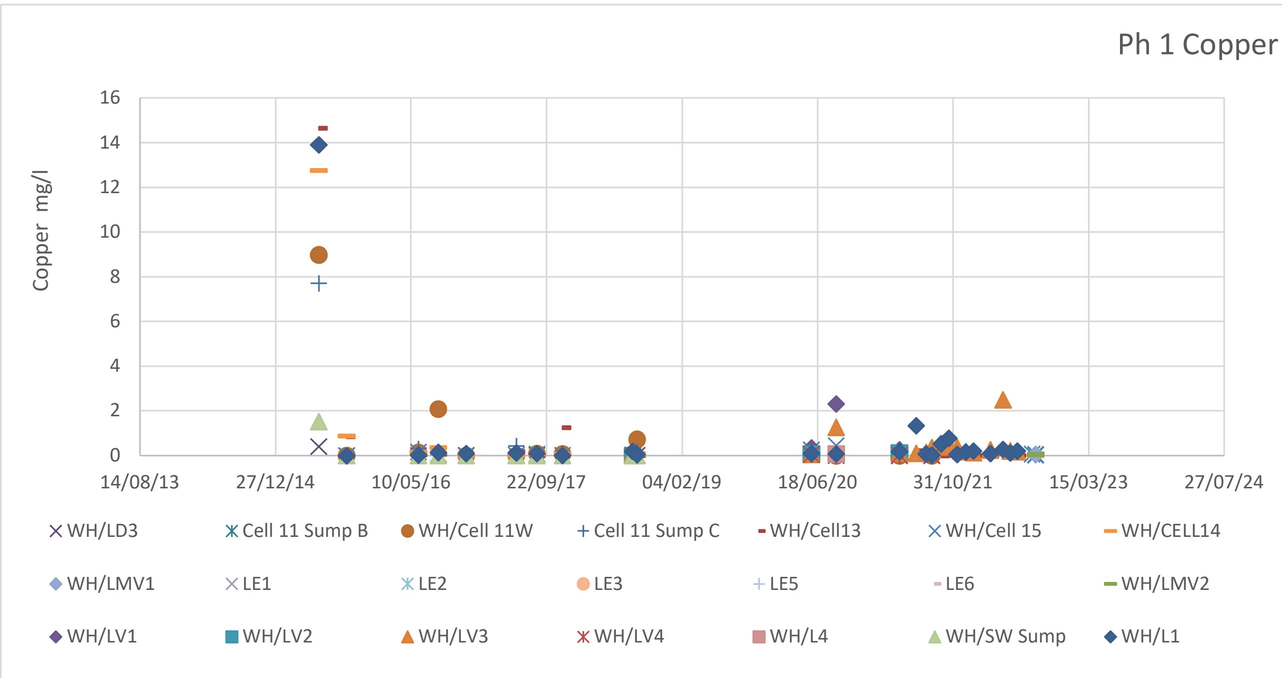
WH/SW Sump
WH/L1

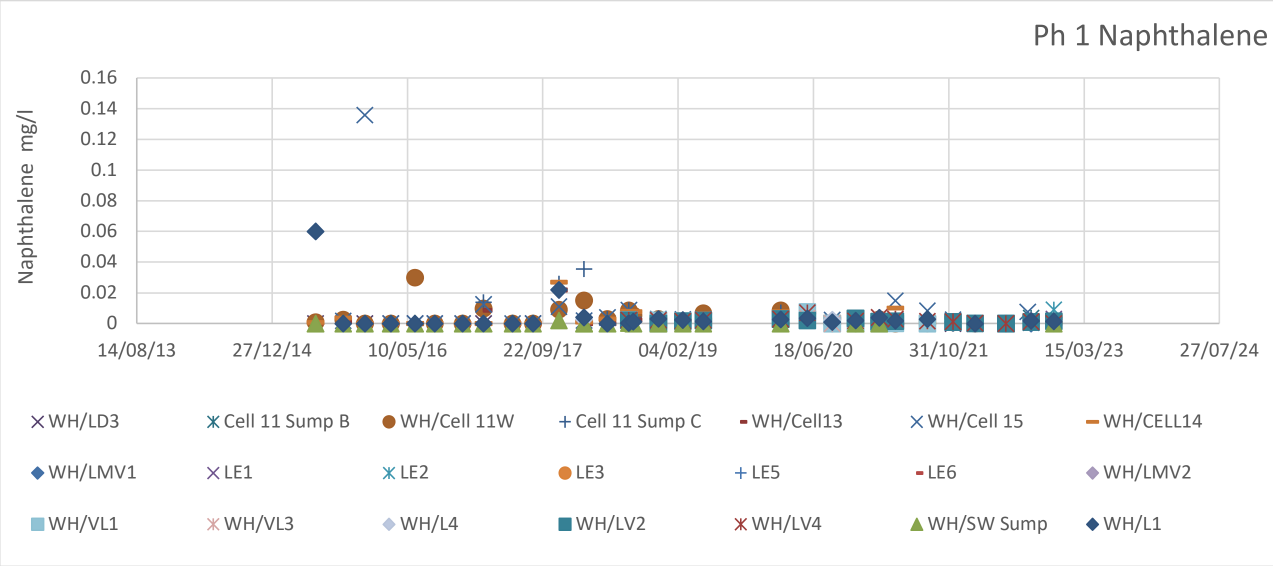

Ph 1 Chloride
Chloride mg/l
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
18/06/20
31/10/21
15/03/23
27/07/24
WH/LD3
Cell 11 Sump B
WH/Cell 11W
Cell 11 Sump C
WH/Cell13
WH/Cell 15
WH/CELL14
WH/LMV1
LE1
LE2
LE3
LE5
LE6
WH/LMV2
WH/VL1
WH/LV2
WH/VL3
WH/LV4
WH/L4
WH/SW Sump
WH/L1

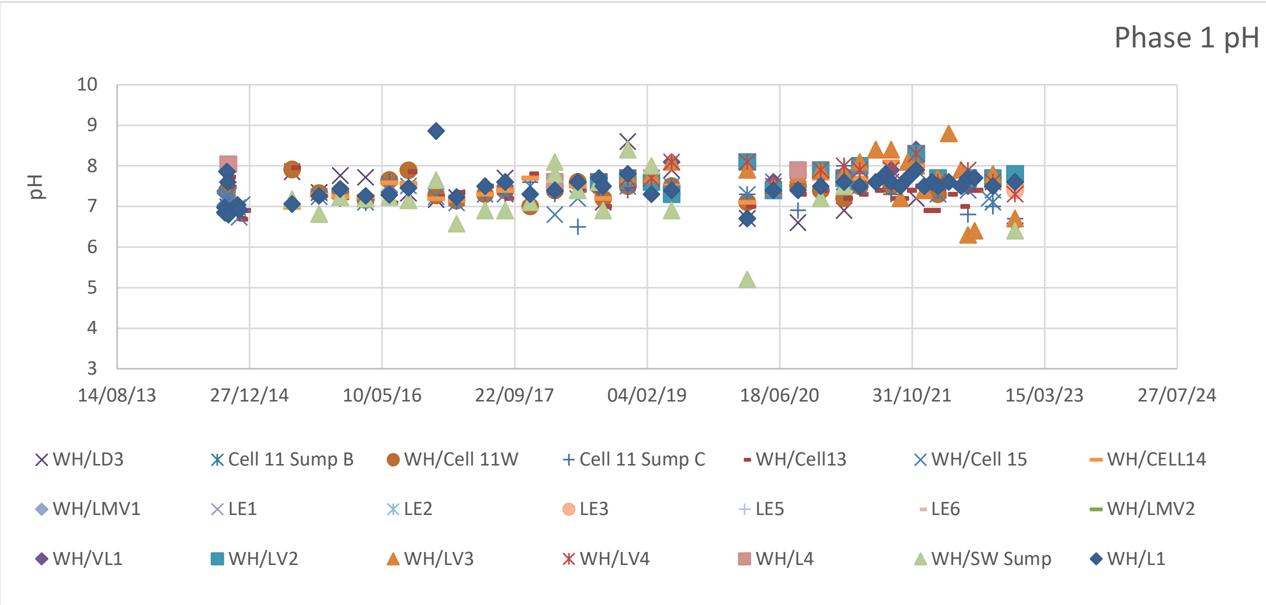

Ph 1 Cadmium
Cadmium mg/l
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
18/06/20
31/10/21
15/03/23
27/07/24
WH/LD3
Cell 11 Sump B
WH/Cell 11W
Cell 11 Sump C
WH/Cell13
WH/Cell 15
WH/CELL14
WH/LMV1
LE1
LE2
LE3
LE5
LE6
WH/LMV2
WH/VL1
WH/LV2
WH/VL3
WH/LV4
WH/L4
WH/SW Sump
WH/L1

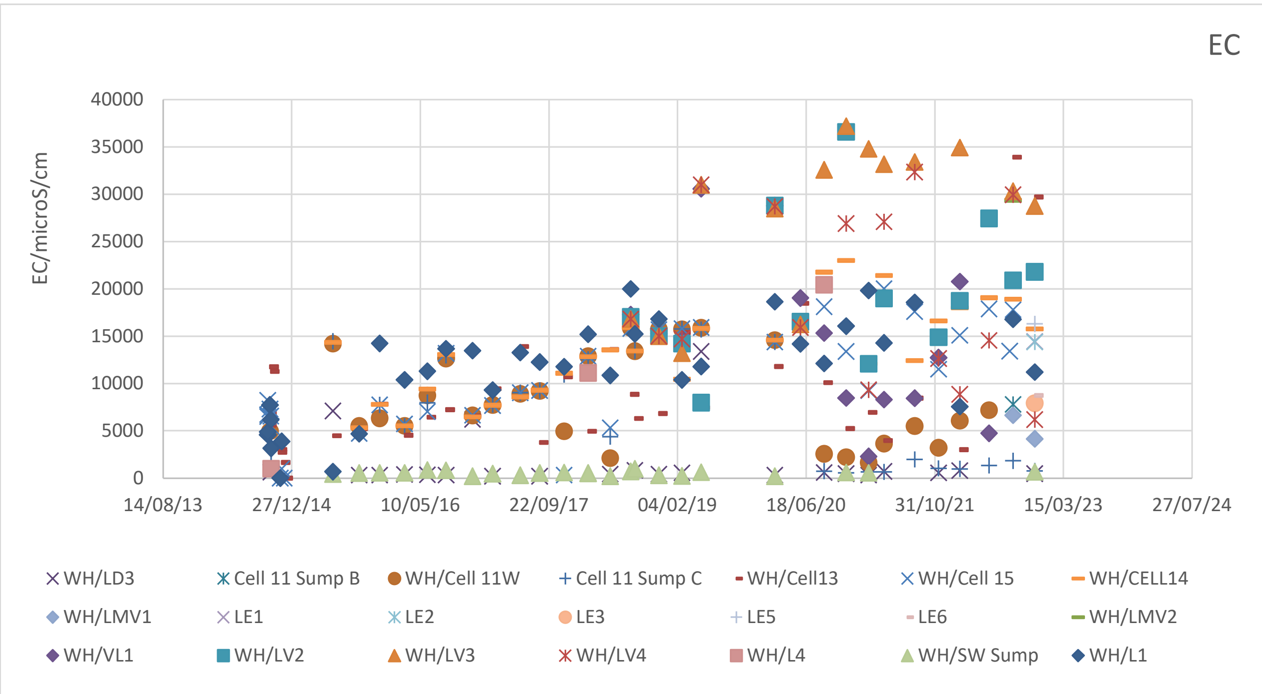

Ph 1 Phenol
mg/l
120.00
100.00
80.00
60.00
40.00
20.00
0.00
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
18/06/20
31/10/21
15/03/23
27/07/24
WH/LD3
Cell 11 Sump B
WH/Cell 11W
Cell 11 Sump C
WH/Cell13
WH/Cell 15
WH/CELL14
WH/LMV1
LE1
LE2
LE3
LE5
LE6
WH/LMV2
WH/VL1
WH/LV2
WH/VL3
WH/LV4
WH/L4
WH/SW Sump
WH/L1

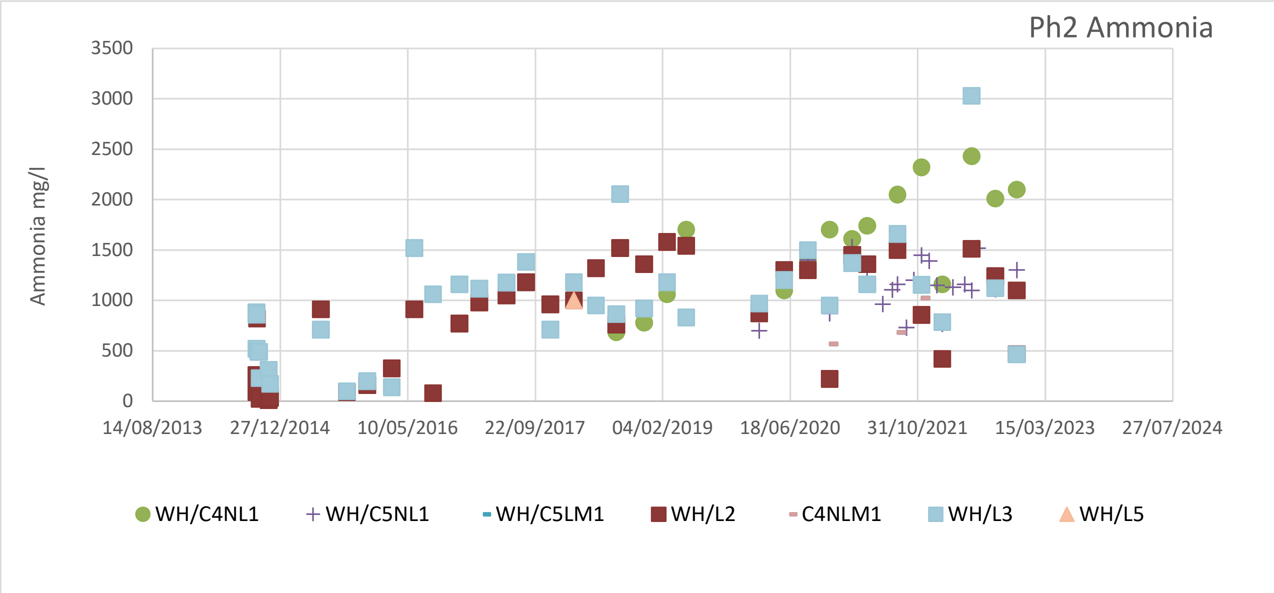

Ph 1 Mecoprop
mg/l
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
18/06/20
31/10/21
15/03/23
27/07/24
WH/LD3
Cell 11 Sump B
WH/Cell 11W
Cell 11 Sump C
WH/Cell13
WH/Cell 15
WH/CELL14
WH/LMV1
LE1
LE2
LE3
LE5
LE6
WH/LMV2
WH/VL1
WH/LV2
WH/LV3
WH/LV4
WH/L4
WH/SW Sump
WH/L1

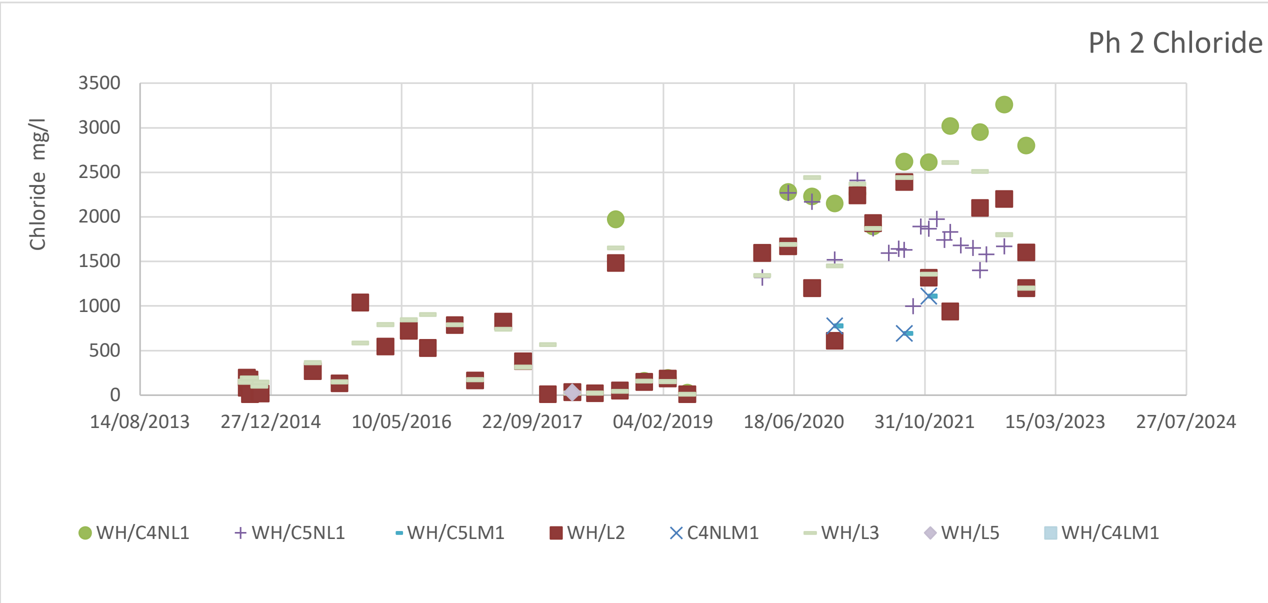

Ph 1 Copper
Copper mg/l
16
14
12
10
8
6
4
2
0
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
18/06/20
31/10/21
15/03/23
27/07/24
WH/LD3
Cell 11 Sump B
WH/Cell 11W
Cell 11 Sump C
WH/Cell13
WH/Cell 15
WH/CELL14
WH/LMV1
LE1
LE2
LE3
LE5
LE6
WH/LMV2
WH/LV1
WH/LV2
WH/LV3
WH/LV4
WH/L4
WH/SW Sump
WH/L1

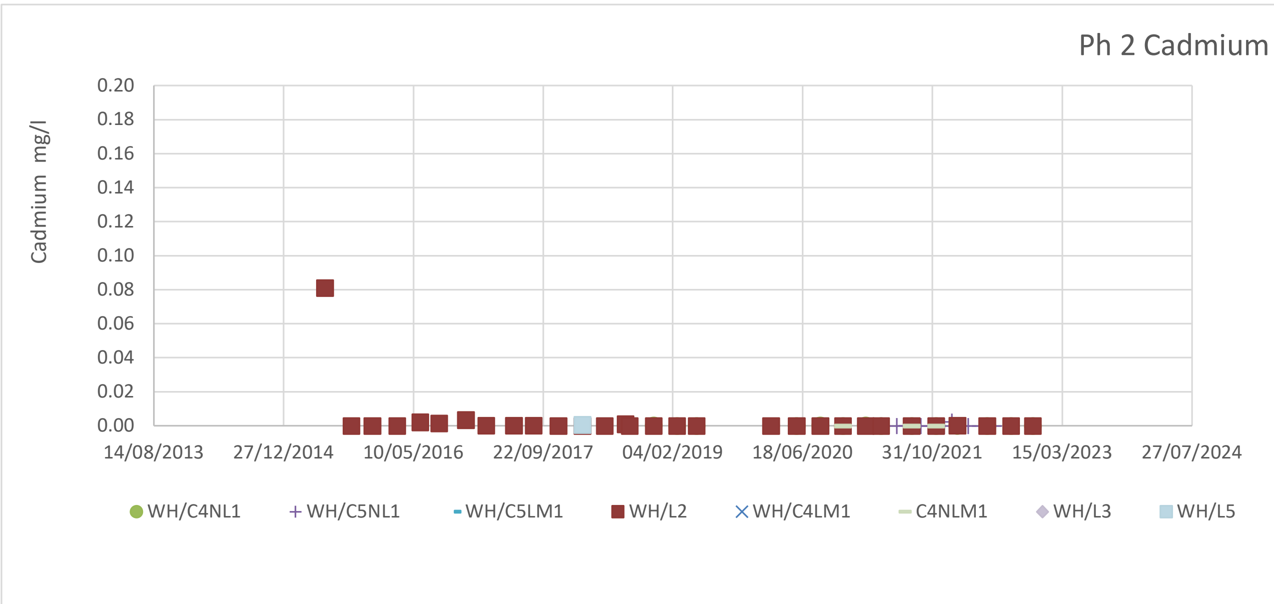

Ph 1 Naphthalene
Naphthalene mg/l
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
18/06/20
31/10/21
15/03/23
27/07/24
WH/LD3
Cell 11 Sump B
WH/Cell 11W
Cell 11 Sump C
WH/Cell13
WH/Cell 15
WH/CELL14
WH/LMV1
LE1
LE2
LE3
LE5
LE6
WH/LMV2
WH/VL1
WH/VL3
WH/L4
WH/LV2
WH/LV4
WH/SW Sump
WH/L1

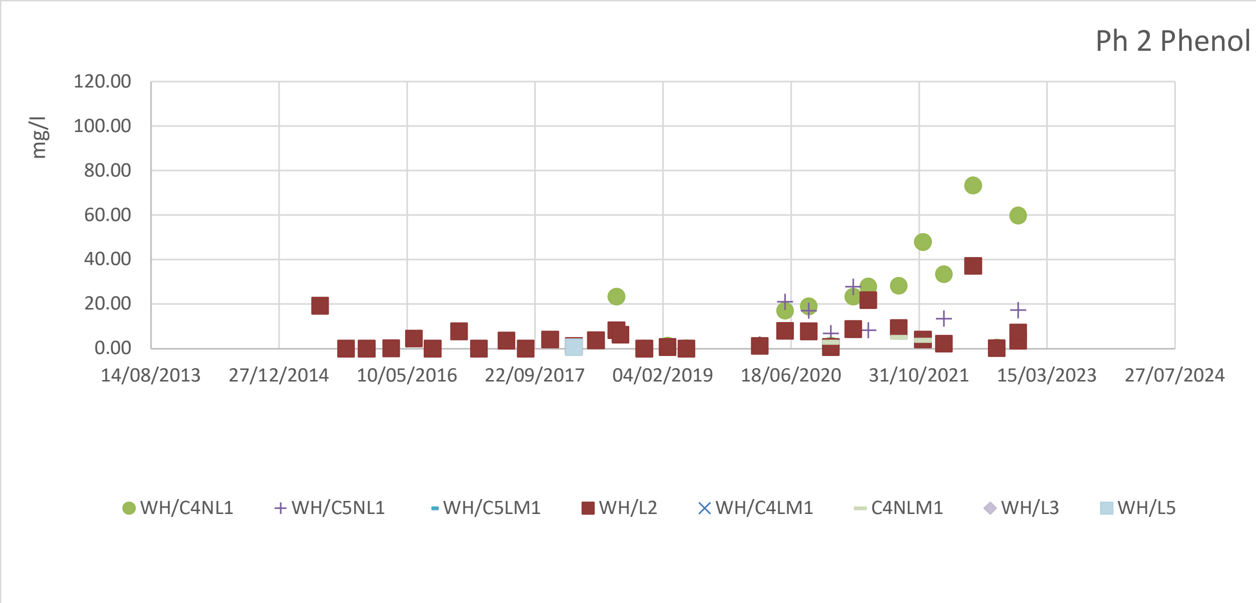

Phase 1 pH
pH
10
9
8
7
6
5
4
3
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
18/06/20
31/10/21
15/03/23
27/07/24
WH/LD3
Cell 11 Sump B
WH/Cell 11W
Cell 11 Sump C
WH/Cell13
WH/Cell 15
WH/CELL14
WH/LMV1
LE1
LE2
LE3
LE5
LE6
WH/LMV2
WH/VL1
WH/LV2
WH/LV3
WH/LV4
WH/L4
WH/SW Sump
WH/L1

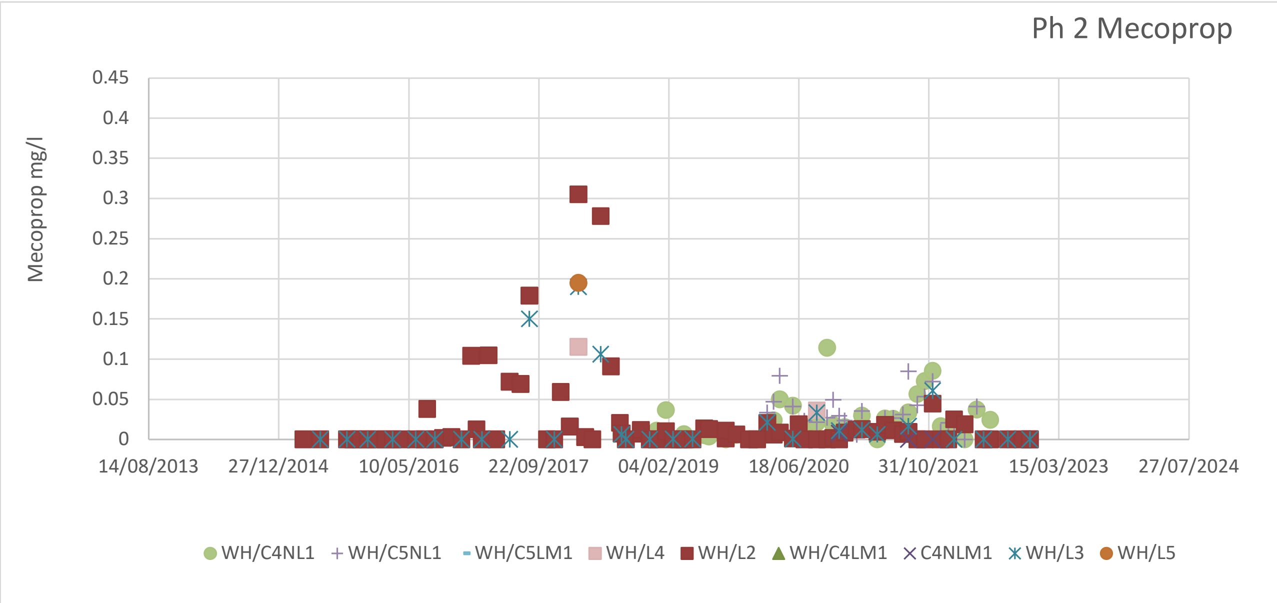

EC
EC/microS/cm
40000
35000
30000
25000
20000
15000
10000
5000
0
14/08/13
27/12/14
10/05/16
22/09/17
04/02/19
18/06/20
31/10/21
15/03/23
27/07/24
WH/LD3
Cell 11 Sump B
WH/Cell 11W
Cell 11 Sump C
WH/Cell13
WH/Cell 15
WH/CELL14
WH/LMV1
LE1
LE2
LE3
LE5
LE6
WH/LMV2
WH/VL1
WH/LV2
WH/LV3
WH/LV4
WH/L4
WH/SW Sump
WH/L1

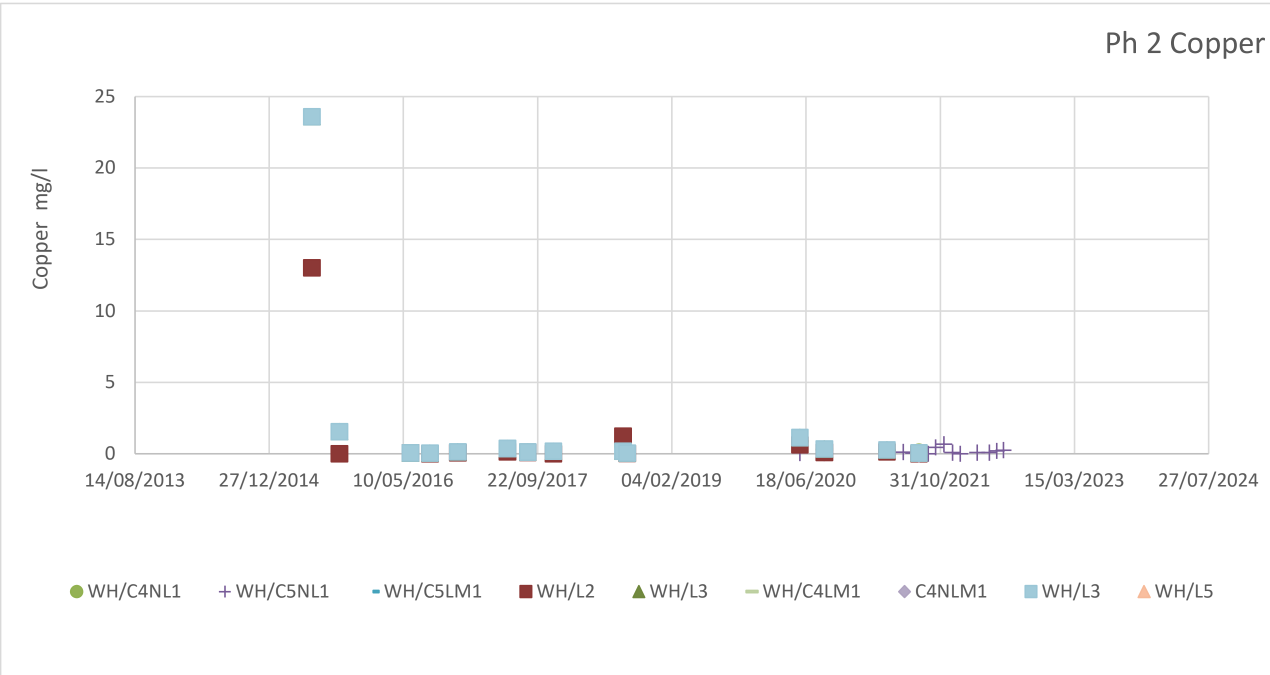

Ph2 Ammonia
Ammonia mg/l
3500
3000
2500
2000
1500
1000
500
0
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/C4NL1
WH/C5NL1
WH/C5LM1
WH/L2
C4NLM1
WH/L3
WH/L5

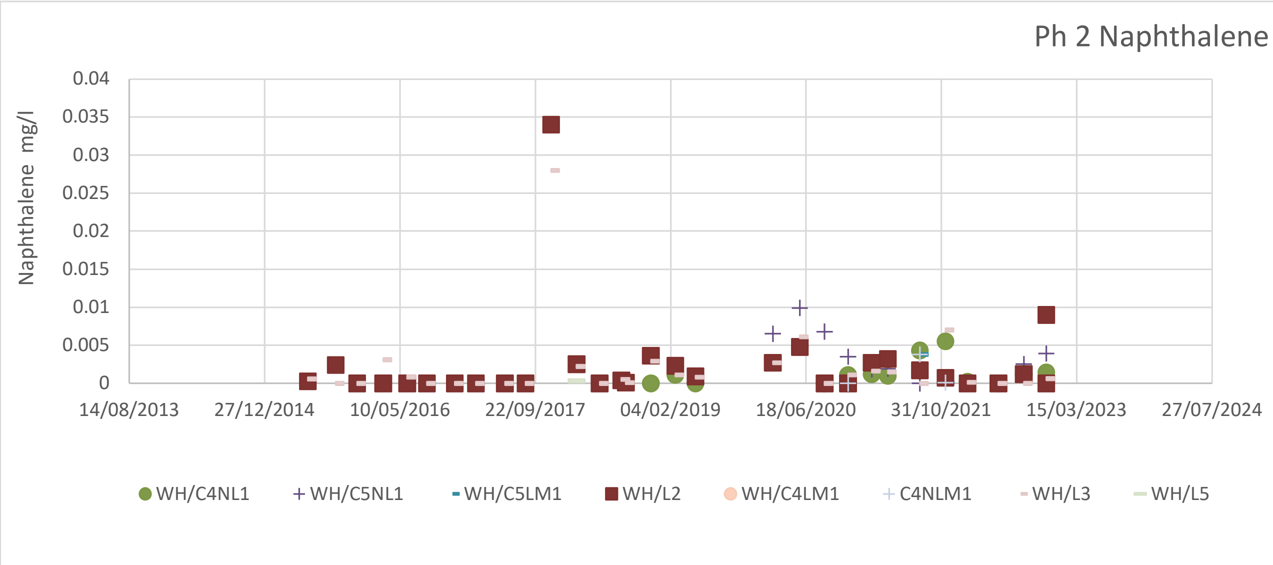

Ph 2 Chloride
Chloride mg/l
3500
3000
2500
2000
1500
1000
500
0
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/C4NL1
WH/C5NL1
WH/C5LM1
WH/L2
C4NLM1
WH/L3
WH/L5
WH/C4LM1

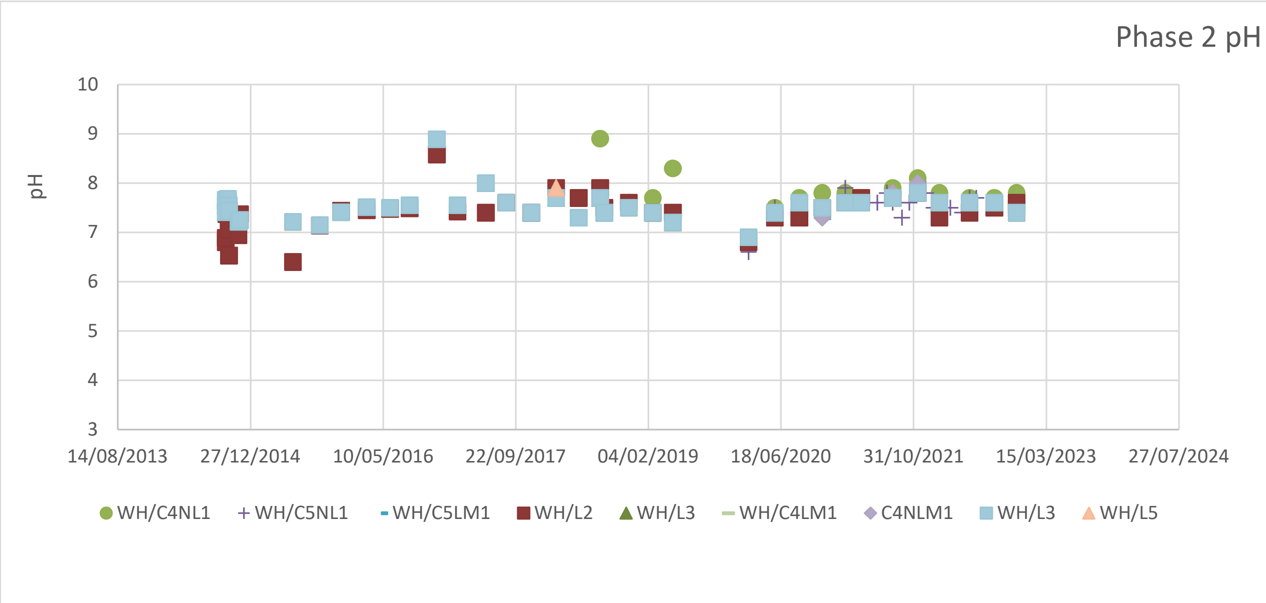

Ph 2 Cadmium
Cadmium mg/l
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/C4NL1
WH/C5NL1
WH/C5LM1
WH/L2
WH/C4LM1
C4NLM1
WH/L3
WH/L5

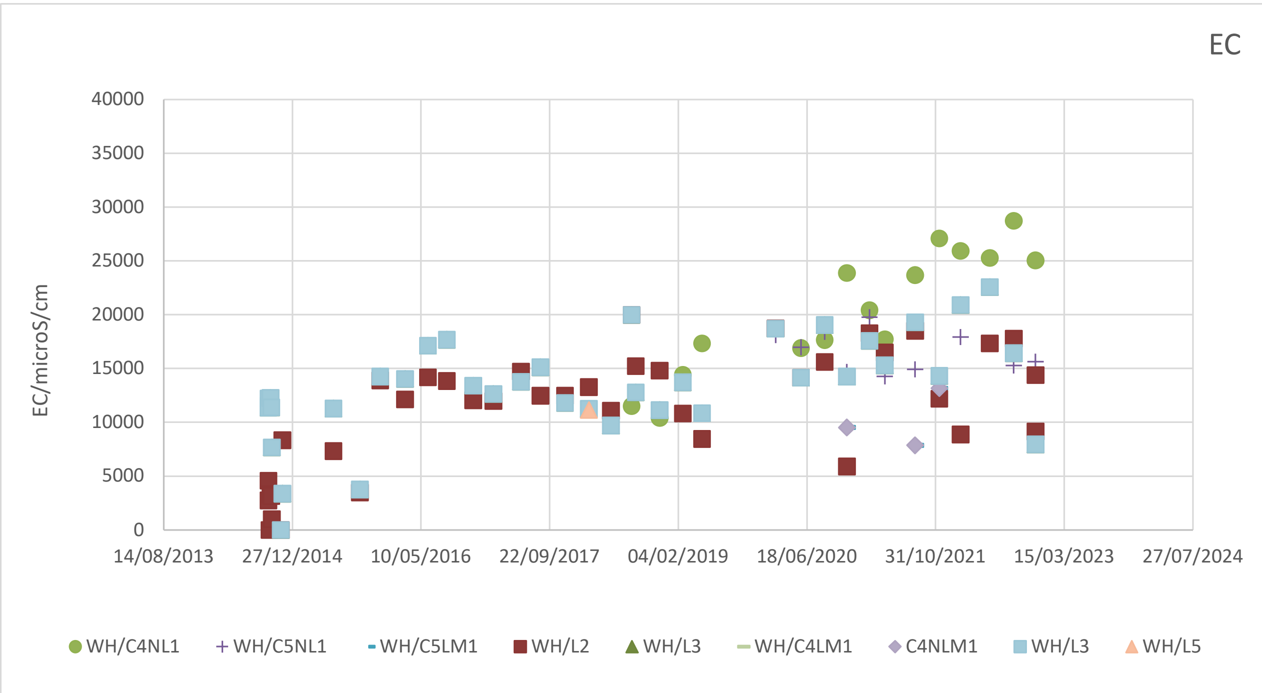

Ph 2 Phenol
mg/l
120.00
100.00
80.00
60.00
40.00
20.00
0.00
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/C4NL1
WH/C5NL1
WH/C5LM1
WH/L2
WH/C4LM1
C4NLM1
WH/L3
WH/L5


Ph 2 Mecoprop
Mecoprop mg/l
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/C4NL1
WH/C5NL1
WH/C5LM1
WH/L4
WH/L2
WH/C4LM1
C4NLM1
WH/L3
WH/L5


Ph 2 Copper
Copper mg/l
25
20
15
10
5
0
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/C4NL1
WH/C5NL1
WH/C5LM1
WH/L2
WH/L3
WH/C4LM1
C4NLM1
WH/L3
WH/L5


Ph 2 Naphthalene
Naphthalene mg/l
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/C4NL1
WH/C5NL1
WH/C5LM1
WH/L2
WH/C4LM1
C4NLM1
WH/L3
WH/L5


Phase 2 pH
pH
10
9
8
7
6
5
4
3
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/C4NL1
WH/C5NL1
WH/C5LM1
WH/L2
WH/L3
WH/C4LM1
C4NLM1
WH/L3
WH/L5


EC
EC/microS/cm
40000
35000
30000
25000
20000
15000
10000
5000
0
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/C4NL1
WH/C5NL1
WH/C5LM1
WH/L2
WH/L3
WH/C4LM1
C4NLM1
WH/L3
WH/L5

WITHYHEDGE LANDFILL

HYDROGEOLOGICAL RISK ASSESSMENT REVIEW
Report Number 2365r2v1d0524

APPENDIX 2
ANALYSIS OF PYRITE

Resource Management UK Ltd.
Withyhedge Landfill
Rudbuxton
Haverfordwest
SA62 4DB

Decus Research Limited
ExCAL House
Capel Hendre Industrial Estate
Ammanford
Carmarthenshire
SA18 3SJ

Tel: 01269 844558
Fax: 01269 841867
Email: info@decusuk.co.uk

Certificate of Analysis Number: 6523

Project/Site name:	Withyhedge		Samples Taken:	27/02/2023
Quotation Number:	-		Samples Received:	27/02/2023
Order Number:	-		Date Instructed:	27/02/2023
Sample Matrix:	Pyrite Sample		Analysis Complete:	10/03/2023
			Report Issued:	13/03/2023
			Sampled By:	Client

Amendment Records:

None

Approved by: Adam Whitehouse
Signature: [signature]
Title: Laboratory Manager

Decus RESEARCH

Client: Resource Management UK Ltd.

CERTIFICATE OF ANALYSIS 6523

Results of analysis of 1 sample received on the 27/02/2023

Report Date
13/03/2023

Code	Determinand	Units	*	Sample Identification			
Laboratory Sample Number:				**010323010**	**-**	**-**	**-**
Client Sample Reference:				Pyrite Sample	-	-	-
Sample Date:				27/02/2023	-	-	-
Sample Matrix:				Rock	-	-	-
METALS-S	Copper	$mg.kg^{-1}$	N	6.9	-	-	-
METALS-S	Chromium	$mg.kg^{-1}$	N	<10	-	-	-
METALS-S	Zinc	$mg.kg^{-1}$	N	1100	-	-	-
METALS-S	Nickel	$mg.kg^{-1}$	N	155	-	-	-
METALS-S	Cadmium	$mg.kg^{-1}$	N	<10	-	-	-
METALS-S	Lead	$mg.kg^{-1}$	N	<10	-	-	-
METALS-S	Arsenic	$mg.kg^{-1}$	N	327	-	-	-
METALS-S	Aluminium	$mg.kg^{-1}$	N	11400	-	-	-
METALS-S	Boron	$mg.kg^{-1}$	N	<10	-	-	-
METALS-S	Barium	$mg.kg^{-1}$	N	545	-	-	-
METALS-S	Beryllium	$mg.kg^{-1}$	N	<10	-	-	-
METALS-S	Iron	$mg.kg^{-1}$	N	220000	-	-	-
METALS-S	Manganese	$mg.kg^{-1}$	N	<10	-	-	-
METALS-S	Vanadium	$mg.kg^{-1}$	N	<10	-	-	-
METALS-S	Sulphur	$mg.kg^{-1}$	N	216000	-	-	-
METALS-S	Mercury	$mg.kg^{-1}$	N	<10	-	-	-

* Accreditation Status
Tests marked ‘A’ hold UKAS accreditation
Tests marked ‘N’ do not hold UKAS accreditation
Tests marked ‘S - A’ were sub-contracted to an approved laboratory with accreditation on the specific method
Tests marked ‘S - N’ were sub-contracted to an approved laboratory without accreditation on the specific method
Any comments or interpretations are beyond the scope of UKAS accreditation

Analytical Method	**Method Code**	**Accreditation Status**
Determination of Metals in solids by ICP-OES (In-house method)	METALS-S	None

Disposal Times:
All water samples will be retained for a period of two weeks and all soil samples retained for a period of one month following the date of the issued certificate.
All results only relate to the items tested.
This report supersedes any previous versions issued by the laboratory.
A full list of determinants relating to abbreviations such as PAHs, VOCs, SVOCs, PCBs etc. is available upon request.
Where results have been labelled as deviating for any reason, the data may not be representative of the sample at the point of sampling:

- *[I/S]:* Insufficient Sample
- *[U/S]:* Unsuitable Sample
- *[A]:* Date of Sampling not supplied
- *[B]:* Sample age exceeds recommended storage time
- *[C]:* Samples not received in appropriate containers
- *[D]:* Broken Container
- < "Less Than"
- > "Greater Than"

Where any sub-contracted results have been noted as deviating by the laboratory in question, their deviations codes will be applied and detailed.
Accreditation statements are correct at the time of issue.
This report shall not be reproduced in part without the approval of Decus Research Ltd, nor used in any way as to lead to misrepresentation of the results or their implications.
Uncertainties of measurement values are available upon request.

***********************************END OF REPORT***********************************

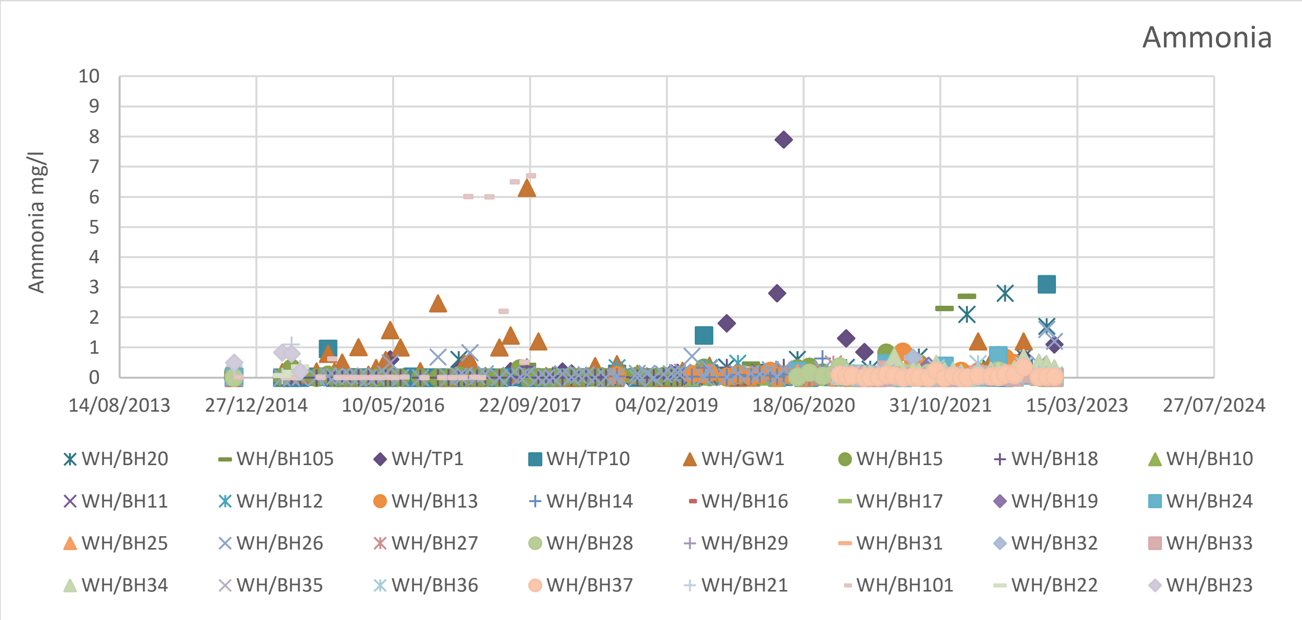
* Accreditation Status
Tests marked 'A' hold UKAS accreditation
Tests marked 'N' do not hold UKAS accreditation
Tests marked 'S - A' were sub-contracted to an approved laboratory with accreditation on the specific method
Tests marked 'S - N' were sub-contracted to an approved laboratory without accreditation on the specific method
Any comments or interpretations are beyond the scope of UKAS accreditation

WITHYHEDGE LANDFILL

HYDROGEOLOGICAL RISK ASSESSMENT REVIEW

Report Number 2365r2v1d0524

APPENDIX 3
SURFACE WATER AND GROUNDWATER QUALITY


Ammonia
Ammonia mg/l
0
1
2
3
4
5
6
7
8
9
10
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/BH20
WH/BH105
WH/TP1
WH/TP10
WH/GW1
WH/BH15
WH/BH18
WH/BH10
WH/BH11
WH/BH12
WH/BH13
WH/BH14
WH/BH16
WH/BH17
WH/BH19
WH/BH24
WH/BH25
WH/BH26
WH/BH27
WH/BH28
WH/BH29
WH/BH31
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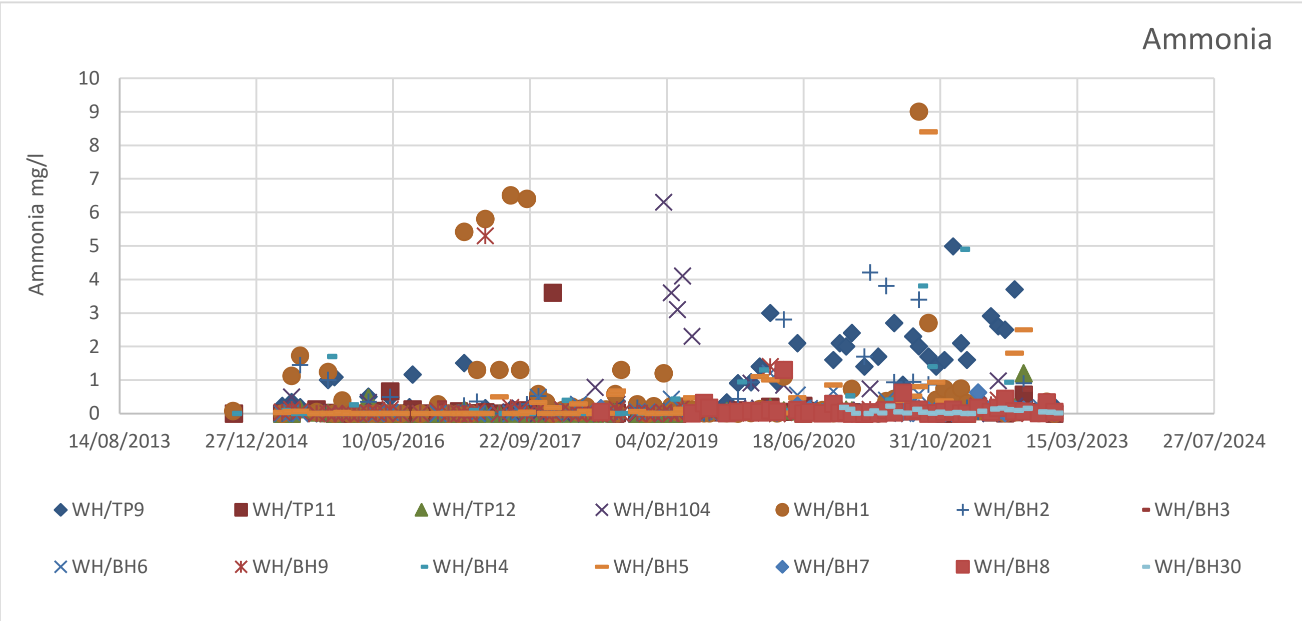
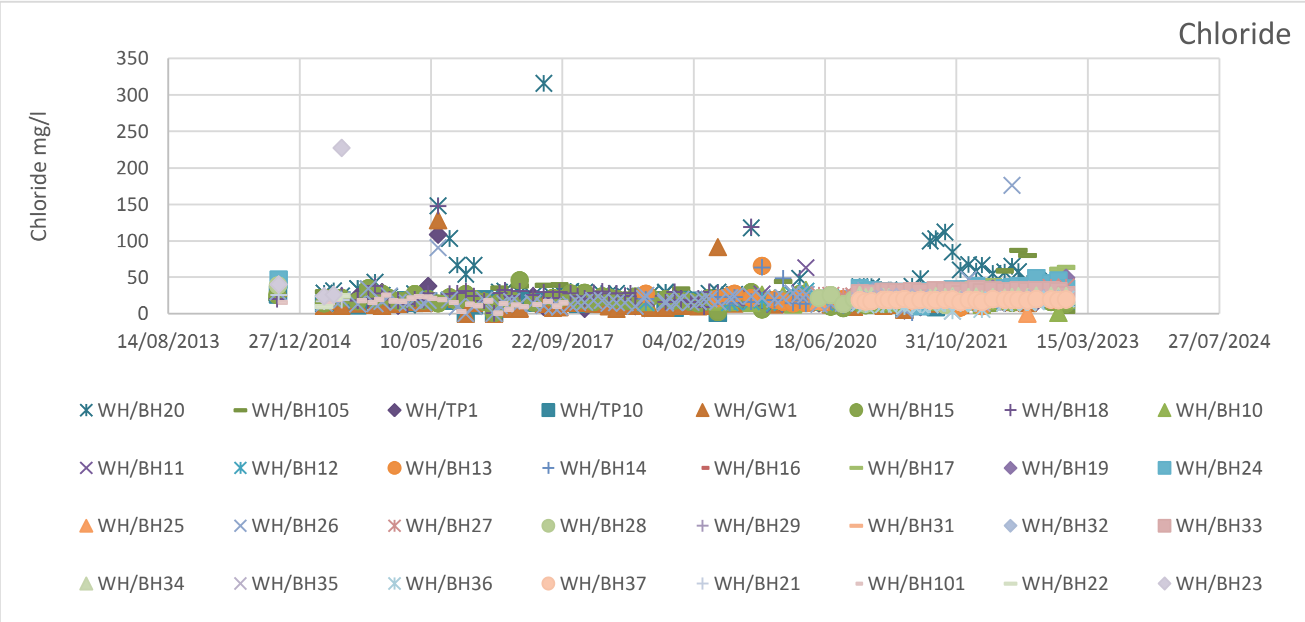
WH/BH22
WH/BH23


Ammonia
Ammonia mg/l
0
1
2
3
4
5
6
7
8
9
10
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/TP9
WH/TP11
WH/TP12
WH/BH104
WH/BH1
WH/BH2
WH/BH3
WH/BH6
WH/BH9
WH/BH4
WH/BH5
WH/BH7
WH/BH8
WH/BH30


Chloride
Chloride mg/l
350
300
250
200
150
100
50
0
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/BH20
WH/BH105
WH/TP1
WH/TP10
WH/GW1
WH/BH15
WH/BH18
WH/BH10
WH/BH11
WH/BH12
WH/BH13
WH/BH14
WH/BH16
WH/BH17
WH/BH19
WH/BH24
WH/BH25
WH/BH26
WH/BH27
WH/BH28
WH/BH29
WH/BH31
WH/BH32
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WH/BH36
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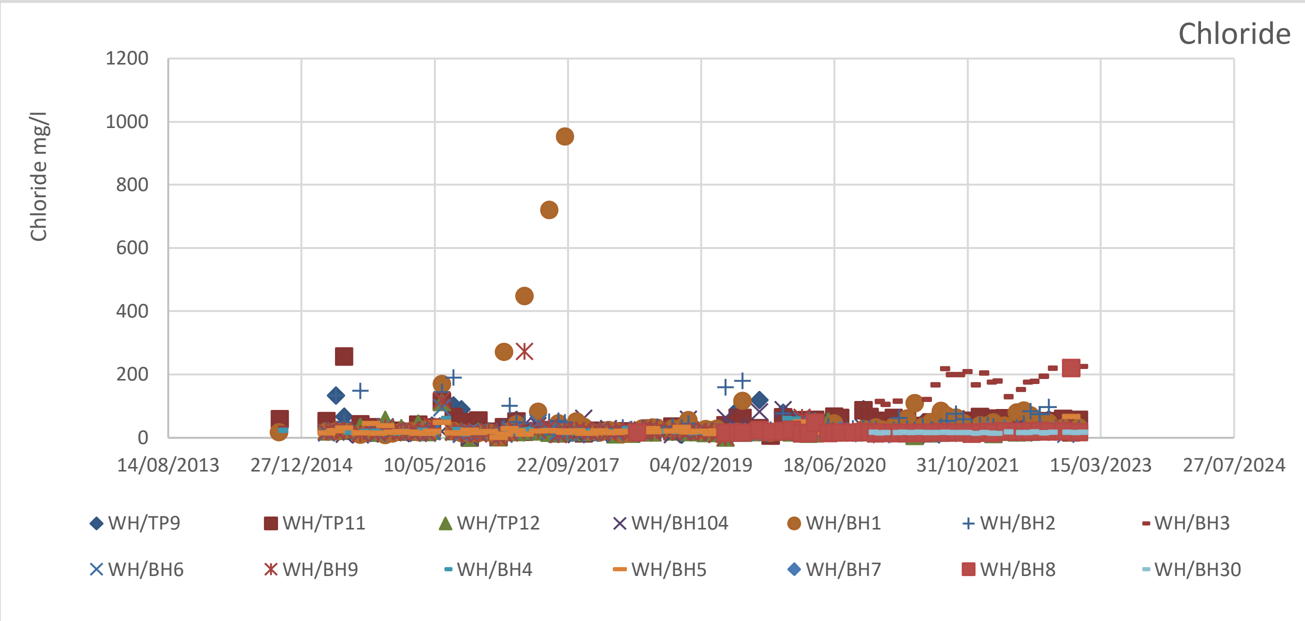
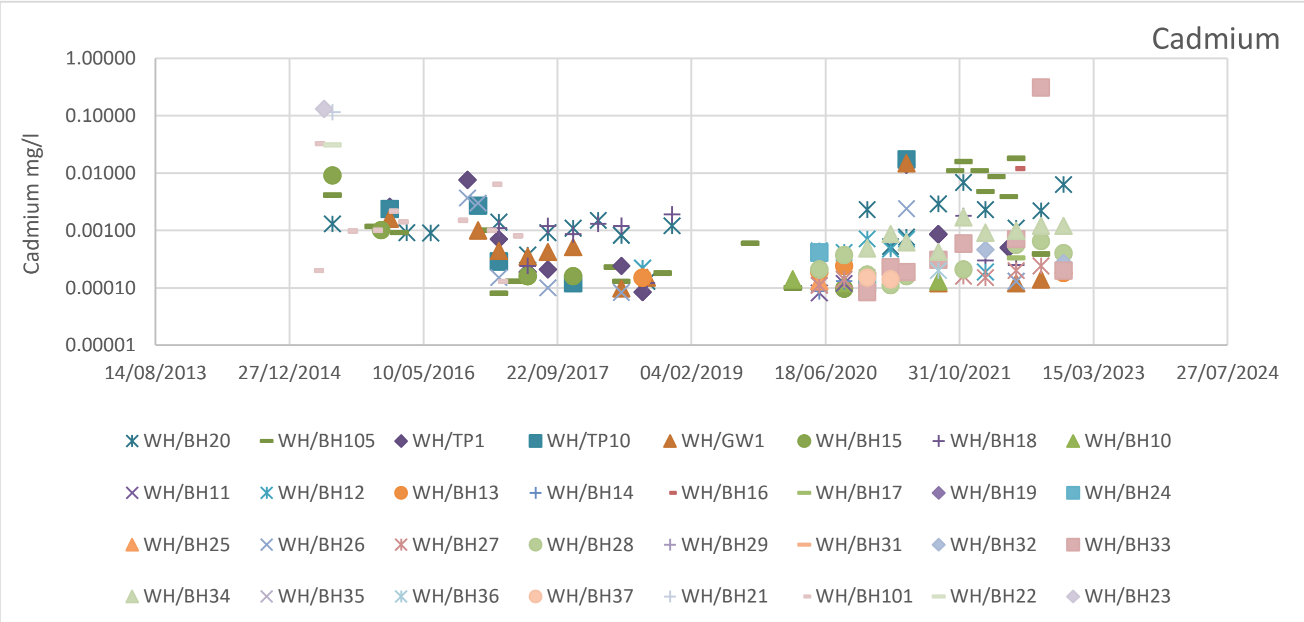
WH/BH21
WH/BH101
WH/BH22
WH/BH23


Chloride
Chloride mg/l
1200
1000
800
600
400
200
0
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/TP9
WH/TP11
WH/TP12
WH/BH104
WH/BH1
WH/BH2
WH/BH3
WH/BH6
WH/BH9
WH/BH4
WH/BH5
WH/BH7
WH/BH8
WH/BH30


Cadmium
Cadmium mg/l
1.00000
0.10000
0.01000
0.00100
0.00010
0.00001
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/BH20
WH/BH105
WH/TP1
WH/TP10
WH/GW1
WH/BH15
WH/BH18
WH/BH10
WH/BH11
WH/BH12
WH/BH13
WH/BH14
WH/BH16
WH/BH17
WH/BH19
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WH/BH25
WH/BH26
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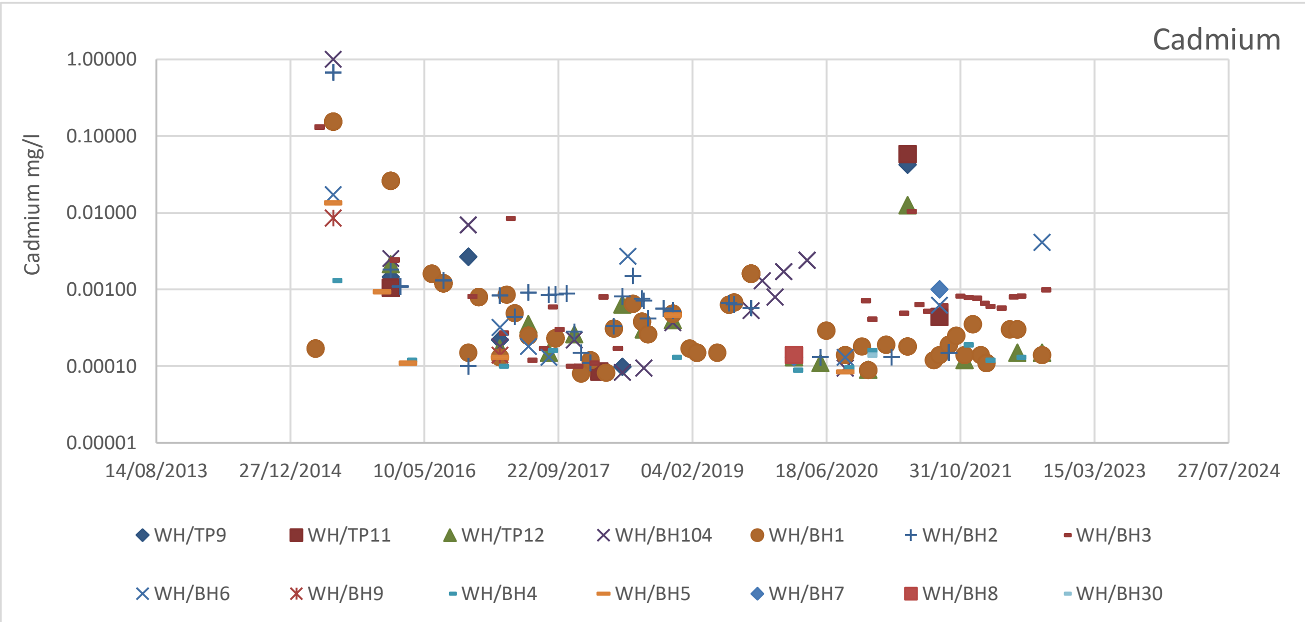
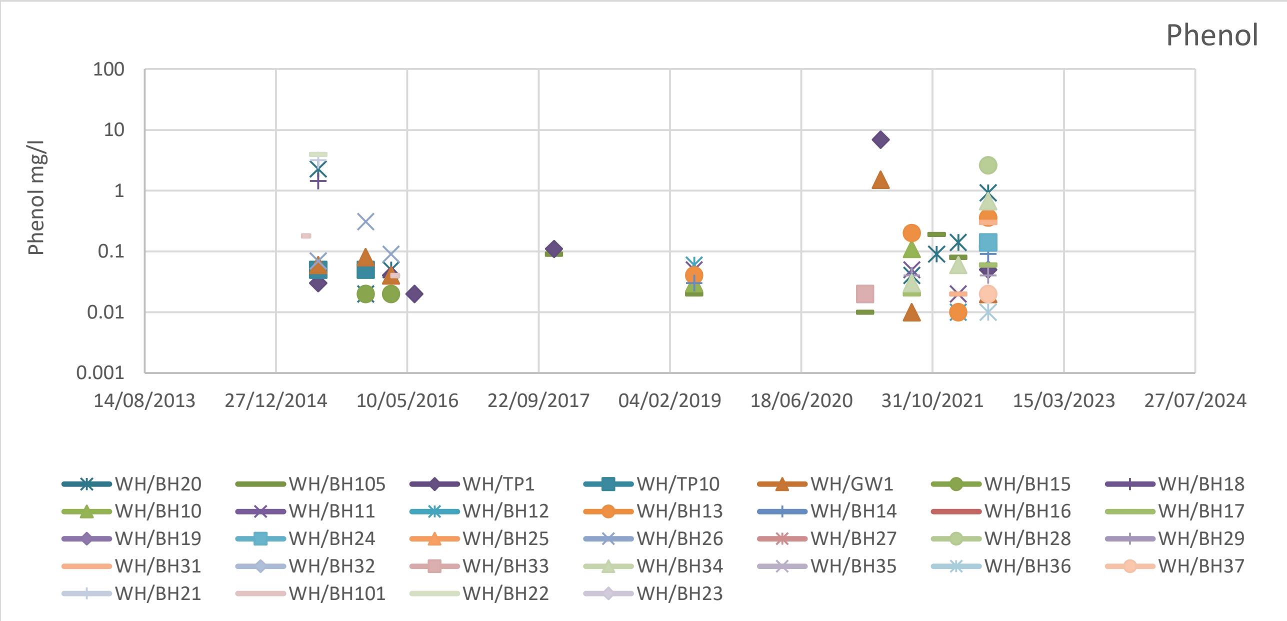
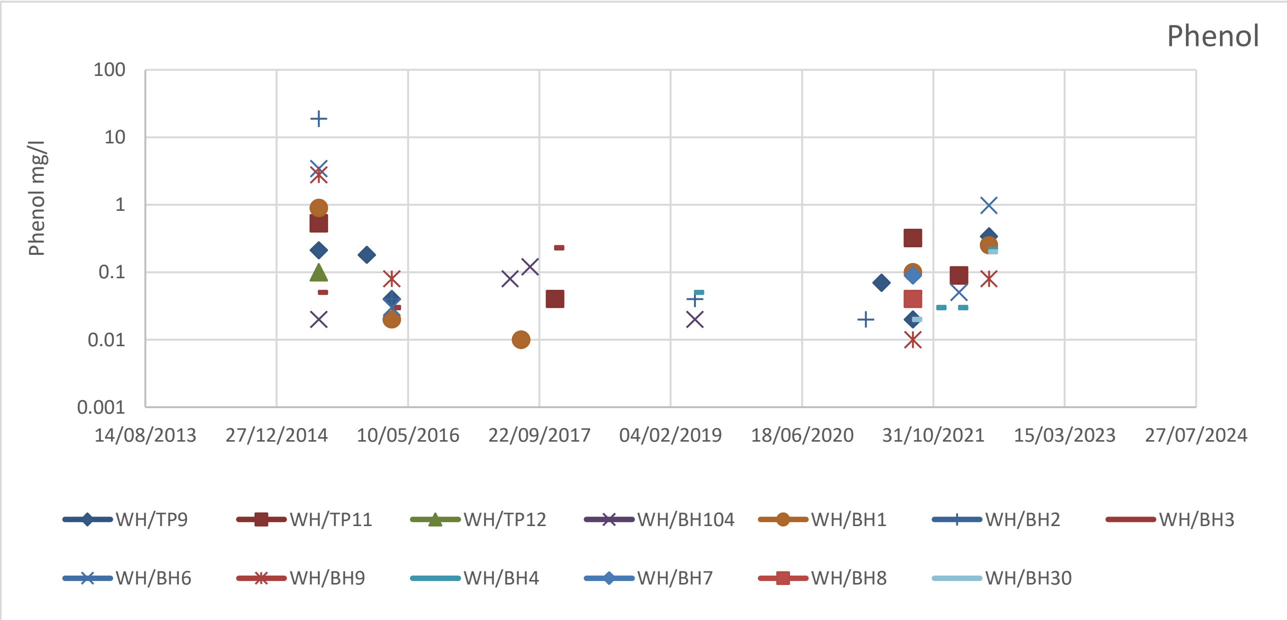
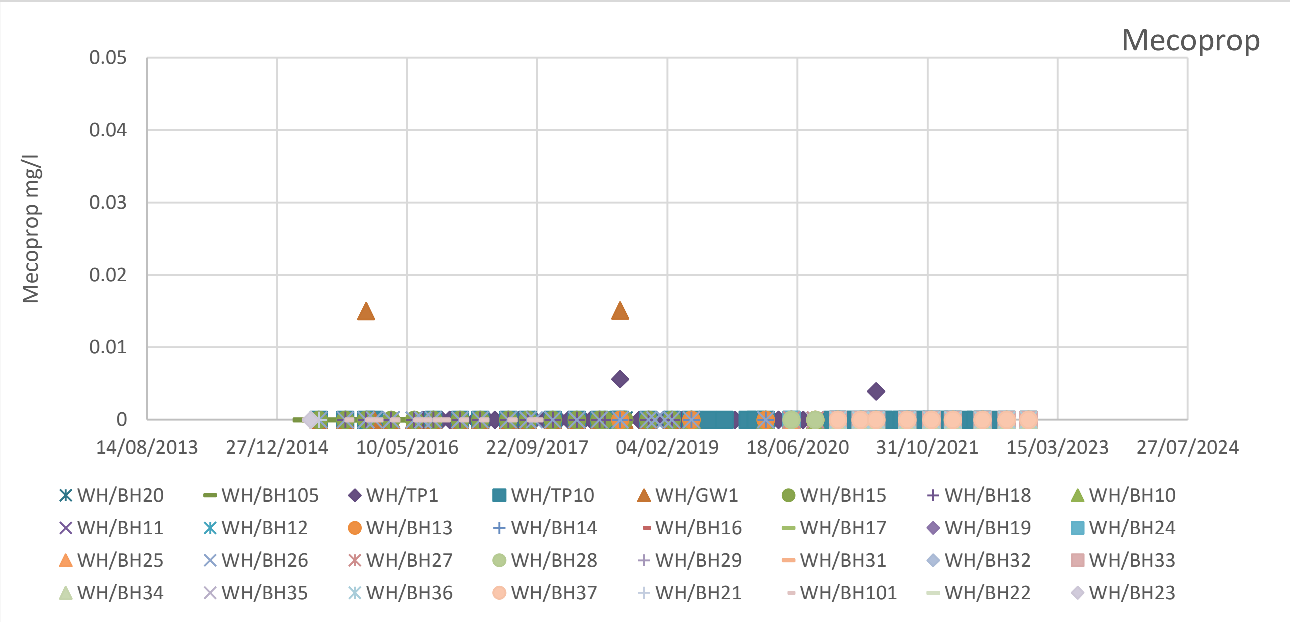
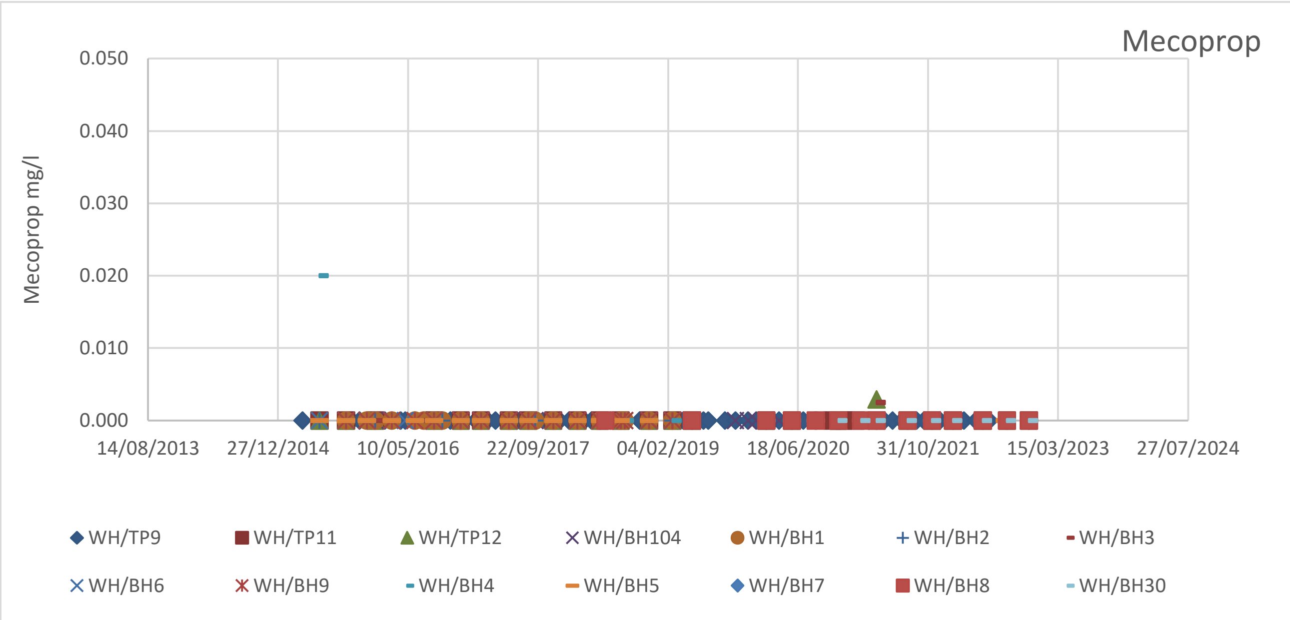
WH/BH22
WH/BH23

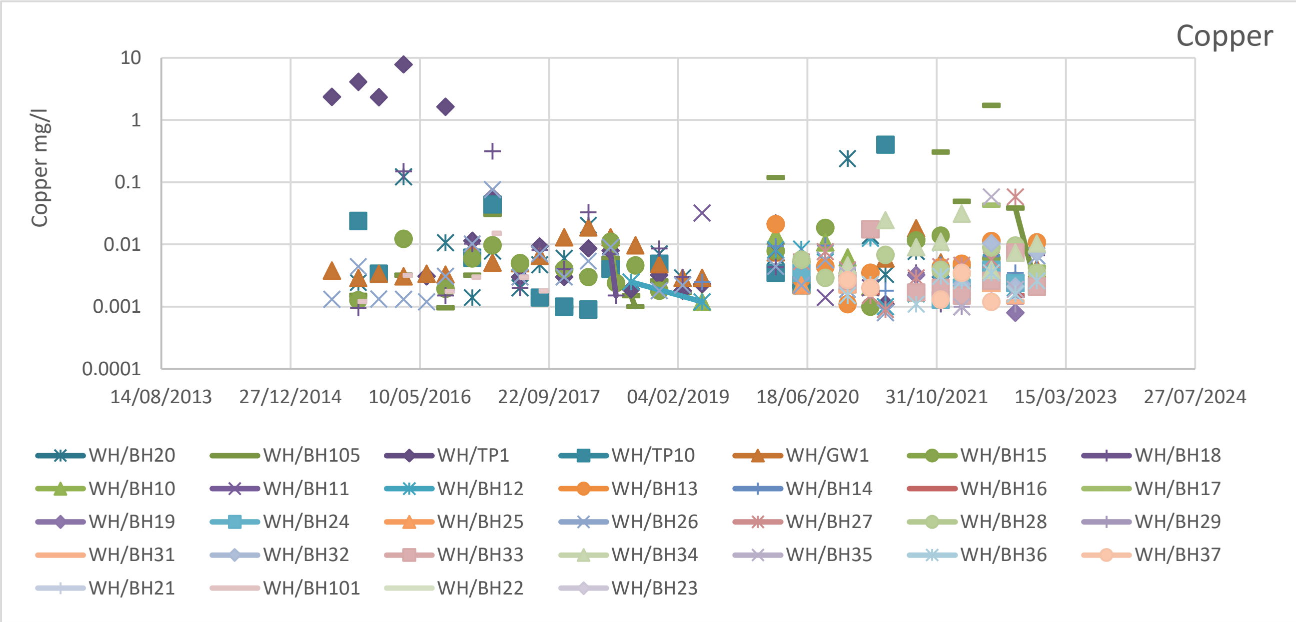

Cadmium
Cadmium mg/l
1.00000
0.10000
0.01000
0.00100
0.00010
0.00001
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/TP9
WH/TP11
WH/TP12
WH/BH104
WH/BH1
WH/BH2
WH/BH3
WH/BH6
WH/BH9
WH/BH4
WH/BH5
WH/BH7
WH/BH8
WH/BH30


Phenol
Phenol mg/l
100
10
1
0.1
0.01
0.001
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/BH20
WH/BH105
WH/TP1
WH/TP10
WH/GW1
WH/BH15
WH/BH18
WH/BH10
WH/BH11
WH/BH12
WH/BH13
WH/BH14
WH/BH16
WH/BH17
WH/BH19
WH/BH24
WH/BH25
WH/BH26
WH/BH27
WH/BH28
WH/BH29
WH/BH31
WH/BH32
WH/BH33
WH/BH34
WH/BH35
WH/BH36
WH/BH37
WH/BH21
WH/BH101
WH/BH22
WH/BH23


Phenol
Phenol mg/l
100
10
1
0.1
0.01
0.001
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/TP9
WH/TP11
WH/TP12
WH/BH104
WH/BH1
WH/BH2
WH/BH3
WH/BH6
WH/BH9
WH/BH4
WH/BH7
WH/BH8
WH/BH30


Mecoprop
Mecoprop mg/l
0.05
0.04
0.03
0.02
0.01
0
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/BH20
WH/BH105
WH/TP1
WH/TP10
WH/GW1
WH/BH15
WH/BH18
WH/BH10
WH/BH11
WH/BH12
WH/BH13
WH/BH14
WH/BH16
WH/BH17
WH/BH19
WH/BH24
WH/BH25
WH/BH26
WH/BH27
WH/BH28
WH/BH29
WH/BH31
WH/BH32
WH/BH33
WH/BH34
WH/BH35
WH/BH36
WH/BH37
WH/BH21
WH/BH101
WH/BH22
WH/BH23


Mecoprop
Mecoprop mg/l
0.050
0.040
0.030
0.020
0.010
0.000
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/TP9
WH/TP11
WH/TP12
WH/BH104
WH/BH1
WH/BH2
WH/BH3
WH/BH6
WH/BH9
WH/BH4
WH/BH5
WH/BH7
WH/BH8
WH/BH30



Copper
10
1
0.1
0.01
0.001
0.0001
Copper mg/l
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/BH20
WH/BH105
WH/TP1
WH/TP10
WH/GW1
WH/BH15
WH/BH18
WH/BH10
WH/BH11
WH/BH12
WH/BH13
WH/BH14
WH/BH16
WH/BH17
WH/BH19
WH/BH24
WH/BH25
WH/BH26
WH/BH27
WH/BH28
WH/BH29
WH/BH31
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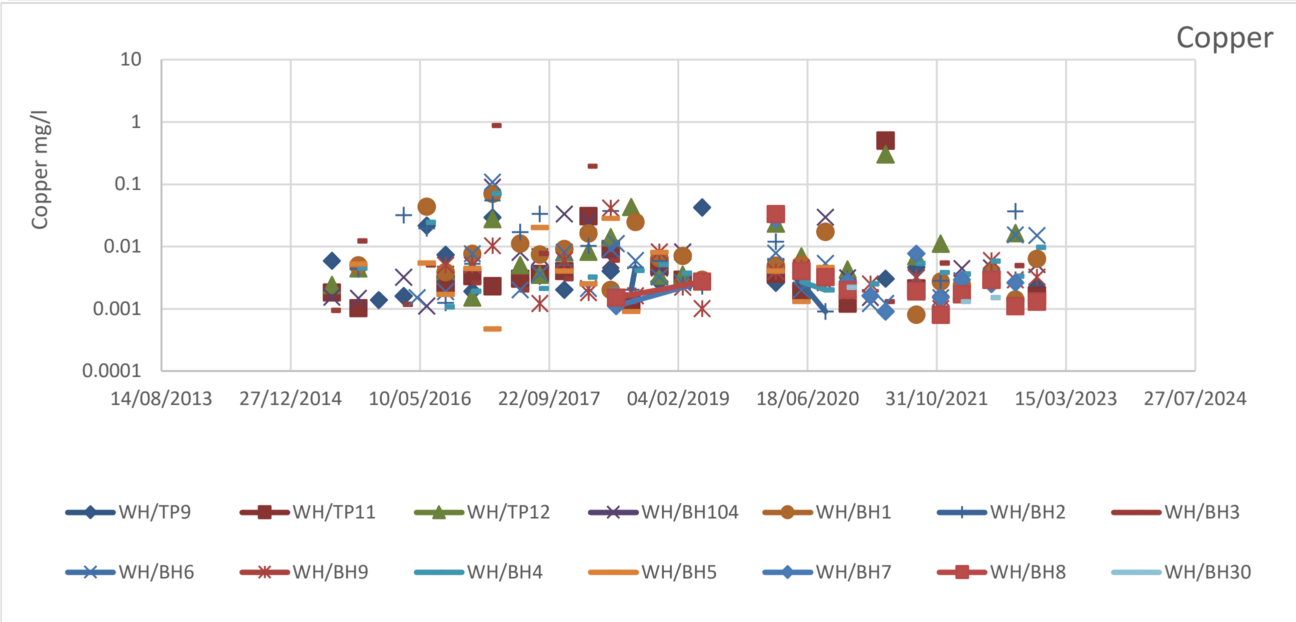
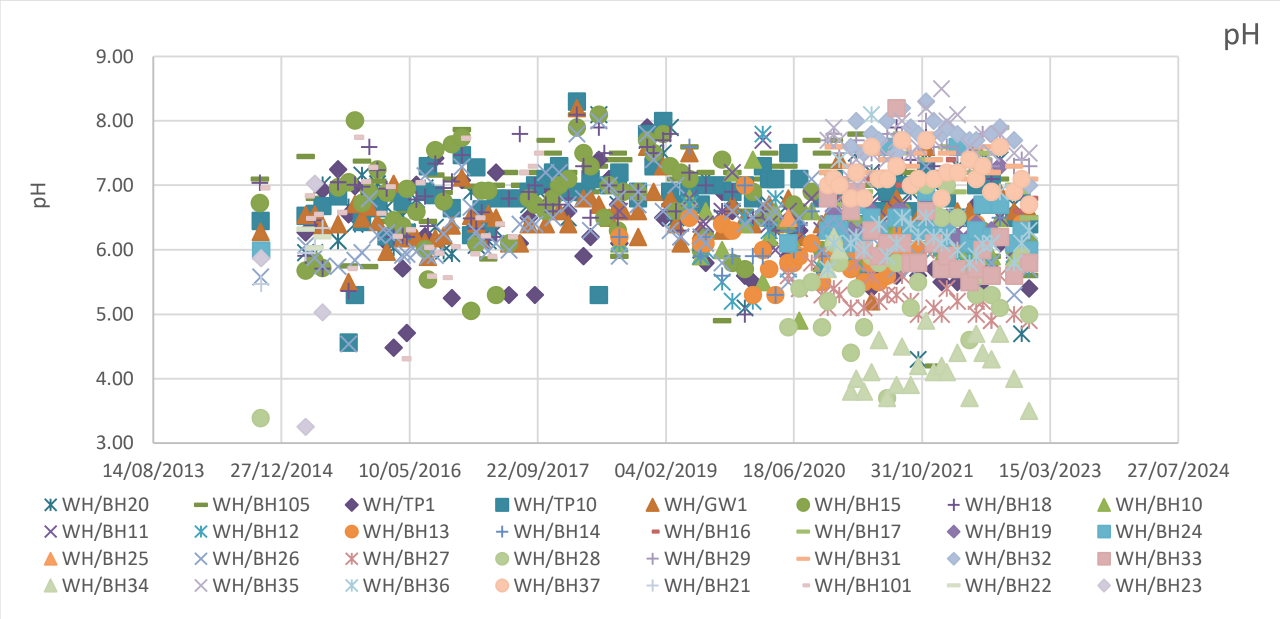
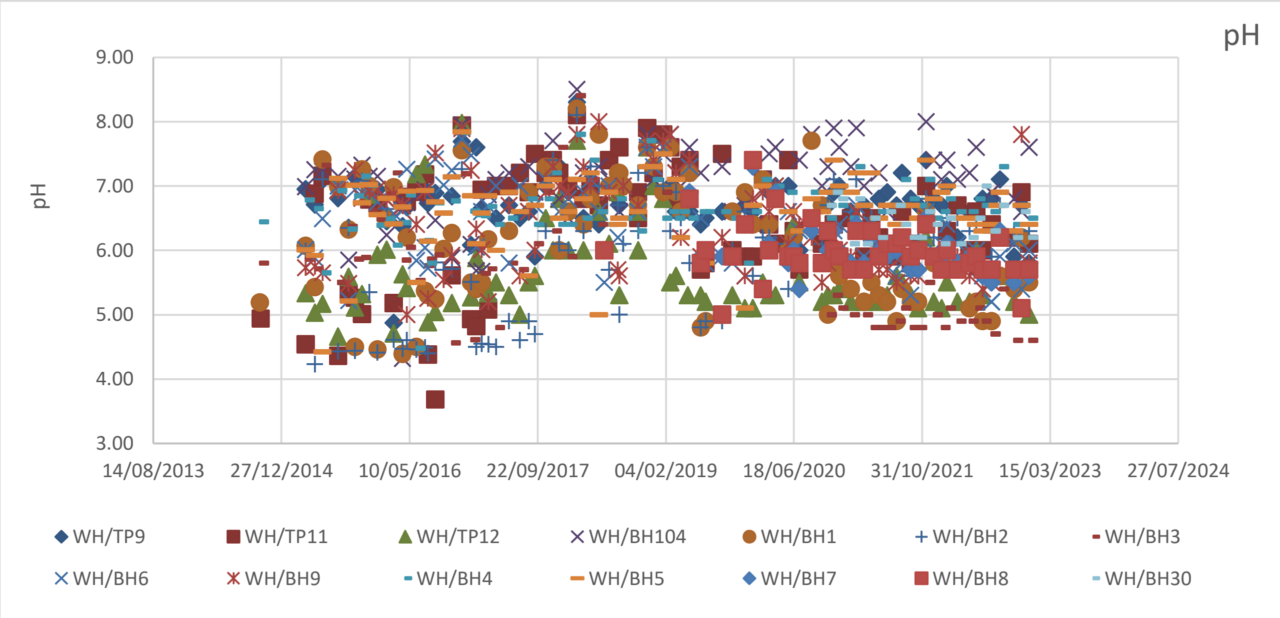
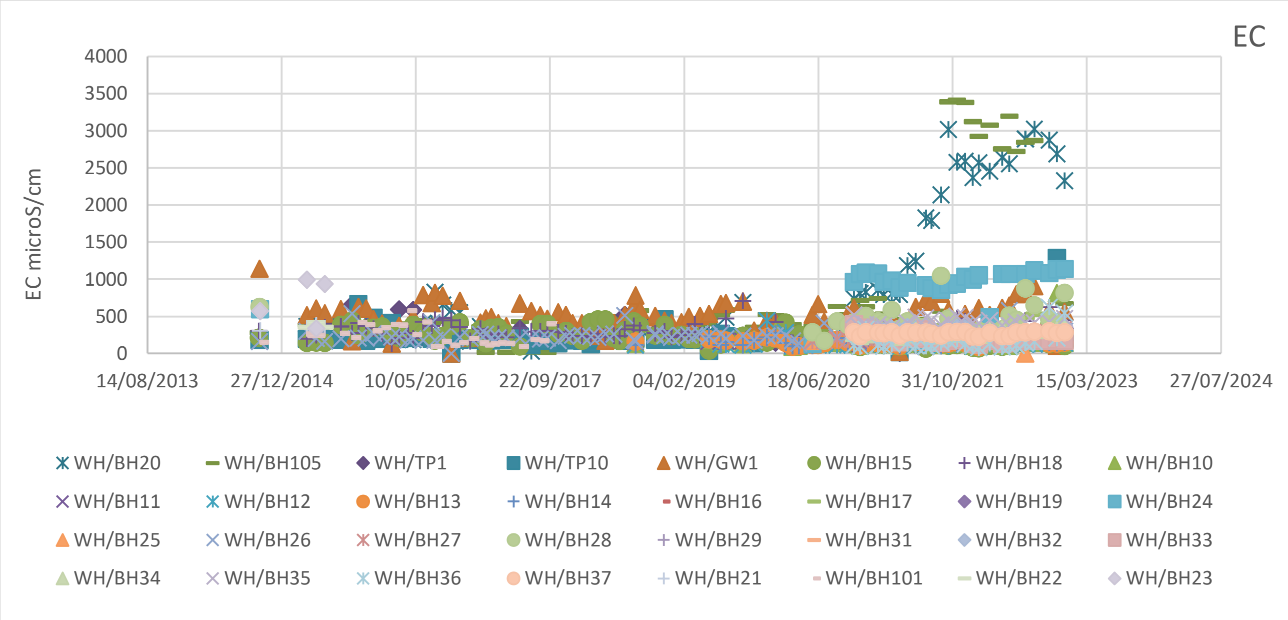
WH/BH34
WH/BH35
WH/BH36
WH/BH37
WH/BH21
WH/BH101
WH/BH22
WH/BH23



Copper
10
1
0.1
0.01
0.001
0.0001
Copper mg/l
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/TP9
WH/TP11
WH/TP12
WH/BH104
WH/BH1
WH/BH2
WH/BH3
WH/BH6
WH/BH9
WH/BH4
WH/BH5
WH/BH7
WH/BH8
WH/BH30


pH
9.00
8.00
7.00
6.00
5.00
4.00
3.00
pH
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/BH20
WH/BH105
WH/TP1
WH/TP10
WH/GW1
WH/BH15
WH/BH18
WH/BH10
WH/BH11
WH/BH12
WH/BH13
WH/BH14
WH/BH16
WH/BH17
WH/BH19
WH/BH24
WH/BH25
WH/BH26
WH/BH27
WH/BH28
WH/BH29
WH/BH31
WH/BH32
WH/BH33
WH/BH34
WH/BH35
WH/BH36
WH/BH37
WH/BH21
WH/BH101
WH/BH22
WH/BH23


pH
9.00
8.00
7.00
6.00
5.00
4.00
3.00
pH
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/TP9
WH/TP11
WH/TP12
WH/BH104
WH/BH1
WH/BH2
WH/BH3
WH/BH6
WH/BH9
WH/BH4
WH/BH5
WH/BH7
WH/BH8
WH/BH30


EC
EC microS/cm
4000
3500
3000
2500
2000
1500
1000
500
0
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/BH20
WH/BH105
WH/TP1
WH/TP10
WH/GW1
WH/BH15
WH/BH18
WH/BH10
WH/BH11
WH/BH12
WH/BH13
WH/BH14
WH/BH16
WH/BH17
WH/BH19
WH/BH24
WH/BH25
WH/BH26
WH/BH27
WH/BH28
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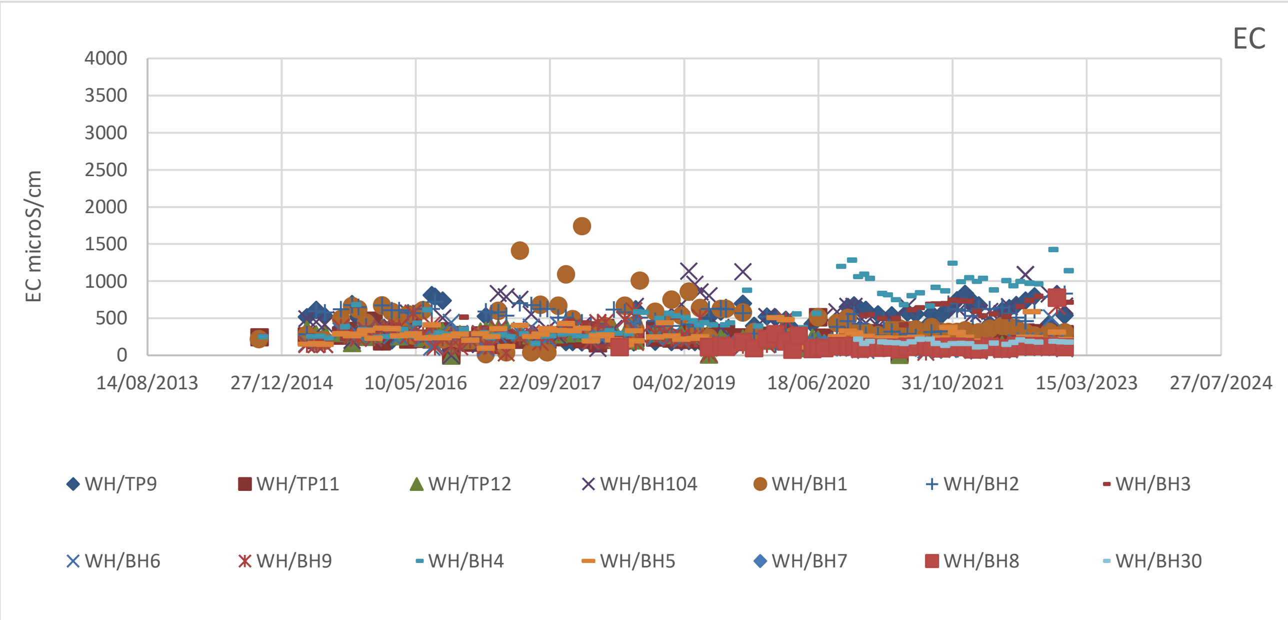
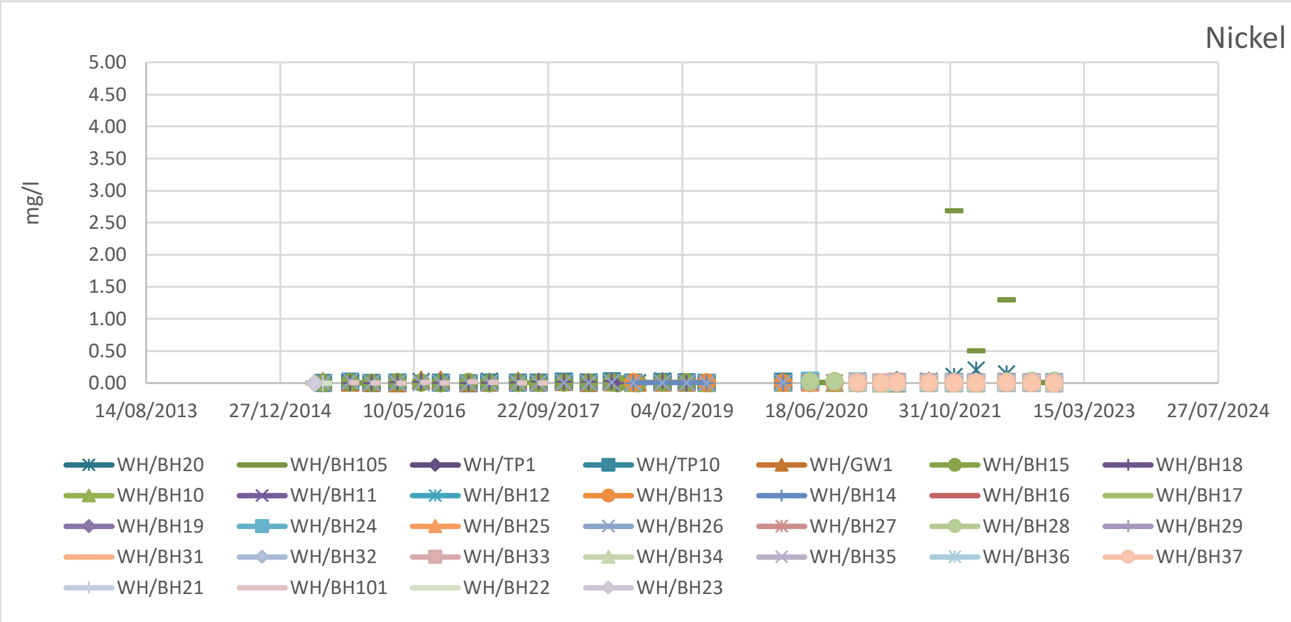
WH/BH31
WH/BH32
WH/BH33
WH/BH34
WH/BH35
WH/BH36
WH/BH37
WH/BH21
WH/BH101
WH/BH22
WH/BH23


EC
EC microS/cm
4000
3500
3000
2500
2000
1500
1000
500
0
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/TP9
WH/TP11
WH/TP12
WH/BH104
WH/BH1
WH/BH2
WH/BH3
WH/BH6
WH/BH9
WH/BH4
WH/BH5
WH/BH7
WH/BH8
WH/BH30


Nickel
mg/l
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/BH20
WH/BH105
WH/TP1
WH/TP10
WH/GW1
WH/BH15
WH/BH18
WH/BH10
WH/BH11
WH/BH12
WH/BH13
WH/BH14
WH/BH16
WH/BH17
WH/BH19
WH/BH24
WH/BH25
WH/BH26
WH/BH27
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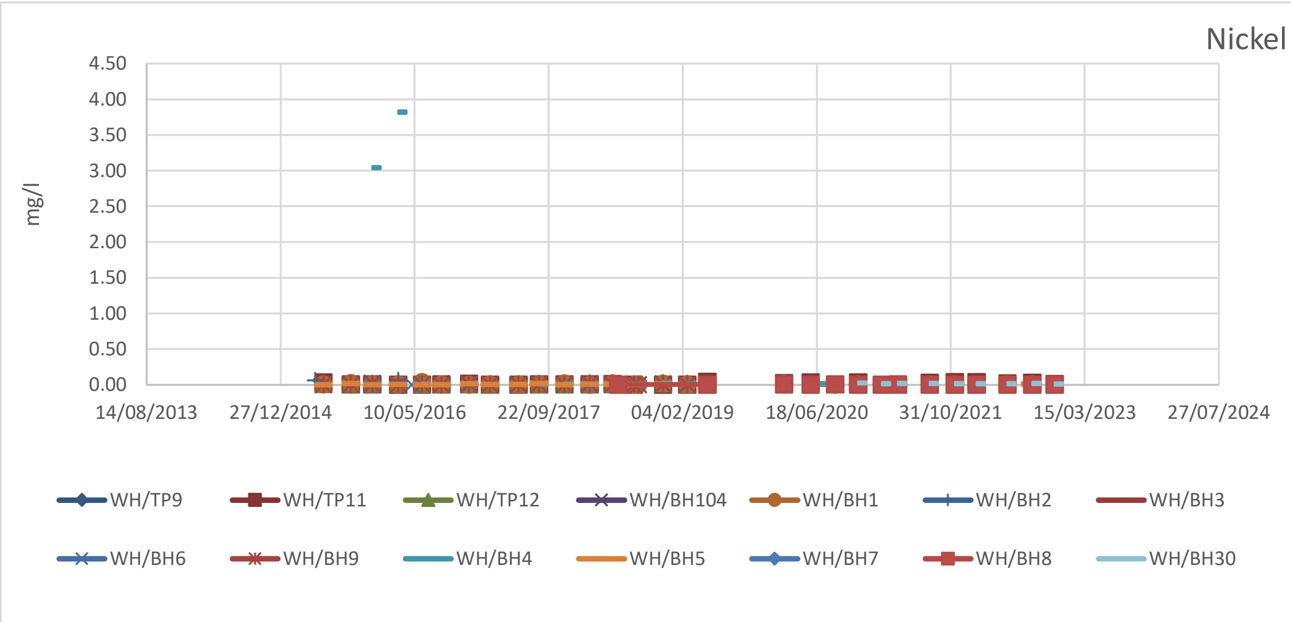
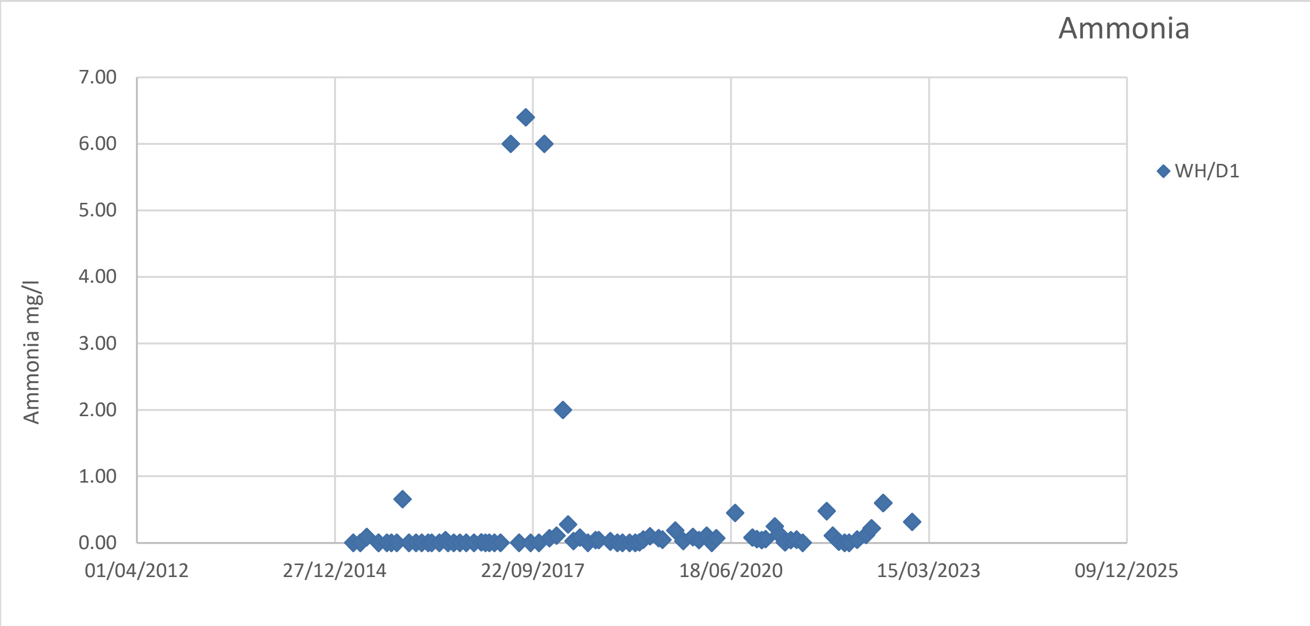
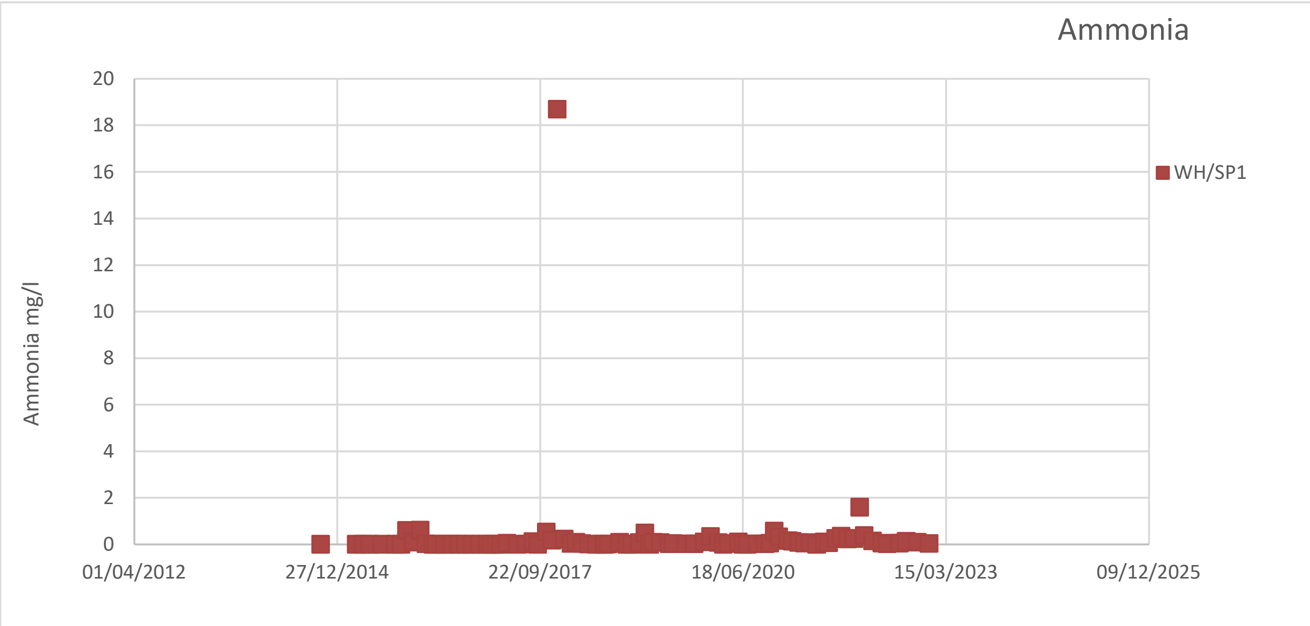
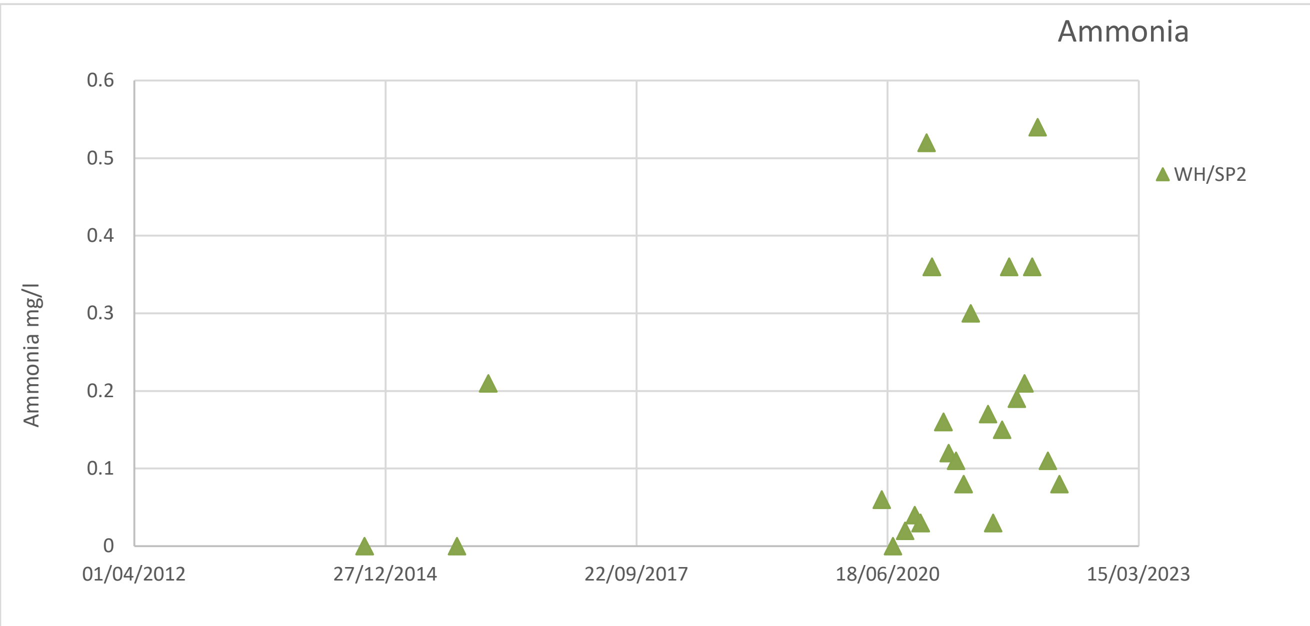
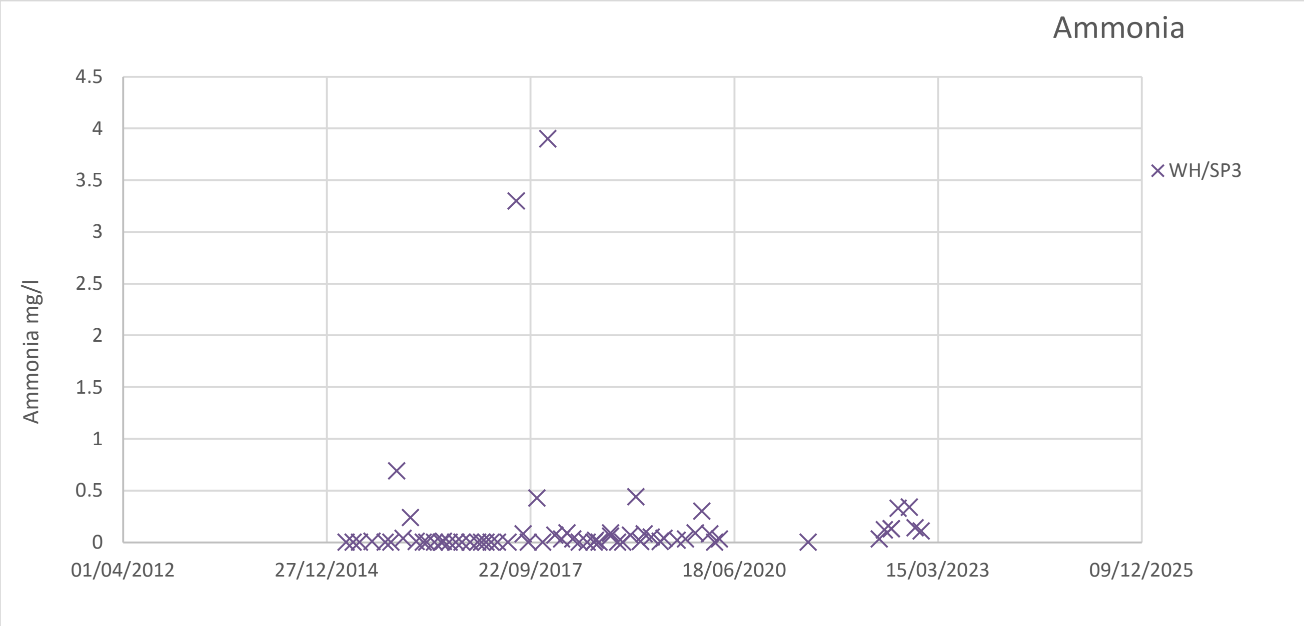
WH/BH31
WH/BH32
WH/BH33
WH/BH34
WH/BH35
WH/BH36
WH/BH37
WH/BH21
WH/BH101
WH/BH22
WH/BH23

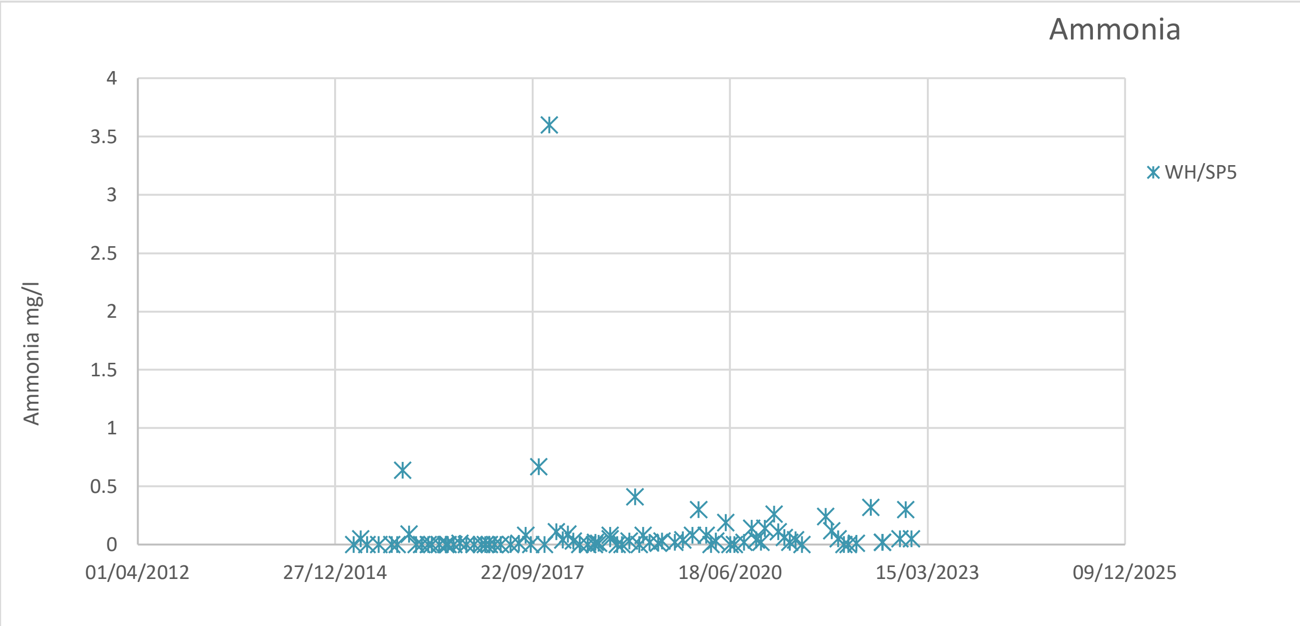

Nickel
mg/l
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
15/03/2023
27/07/2024
WH/TP9
WH/TP11
WH/TP12
WH/BH104
WH/BH1
WH/BH2
WH/BH3
WH/BH6
WH/BH9
WH/BH4
WH/BH5
WH/BH7
WH/BH8
WH/BH30

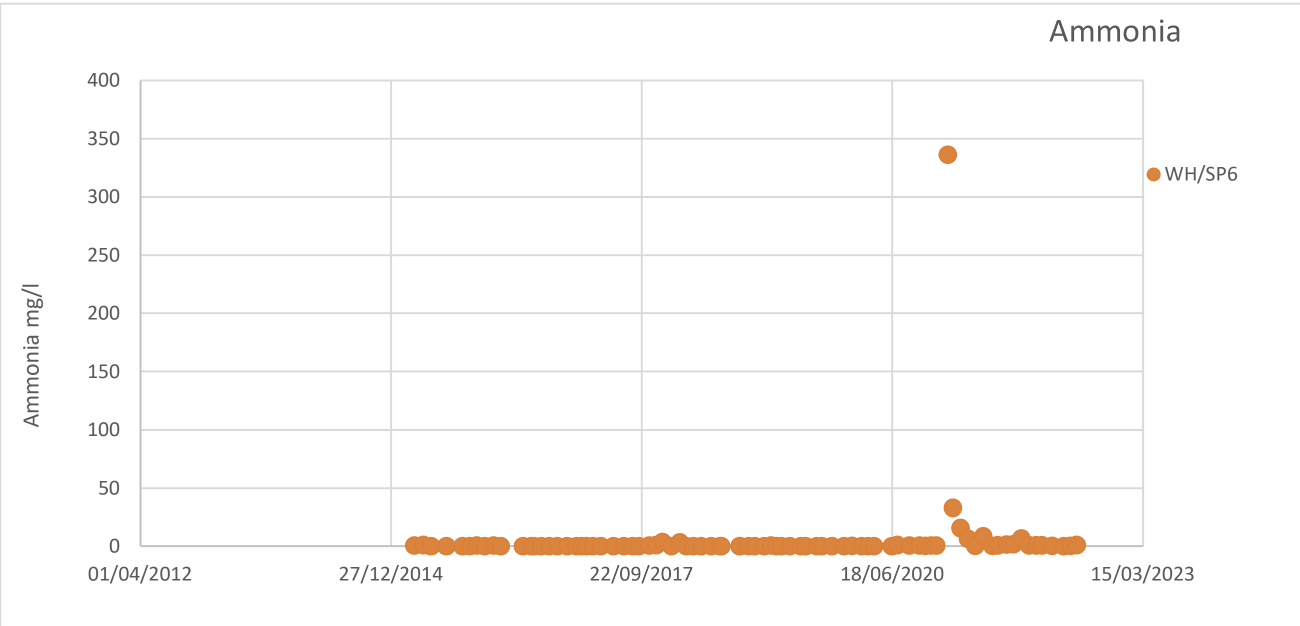

Ammonia
Ammonia mg/l
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/D1

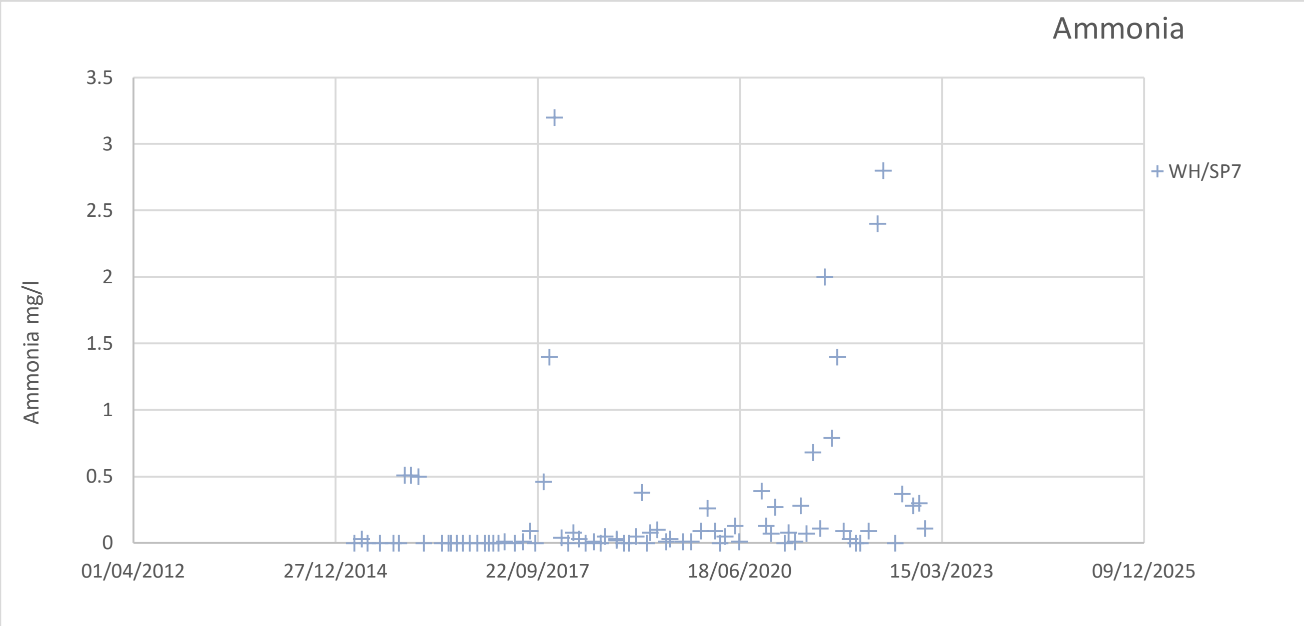

Ammonia
Ammonia mg/l
20
18
16
14
12
10
8
6
4
2
0
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/SP1


Ammonia
Ammonia mg/l
0.6
0.5
0.4
0.3
0.2
0.1
0
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
WH/SP2

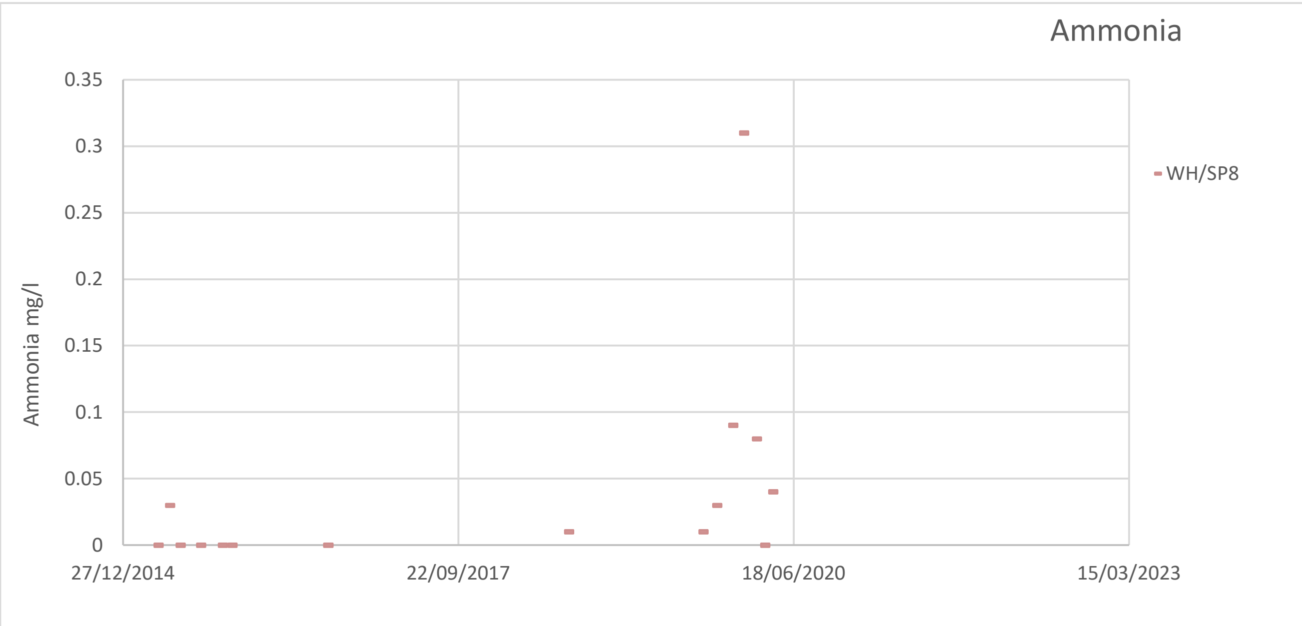

Ammonia
Ammonia mg/l
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/SP3


Ammonia
Ammonia mg/l
4
3.5
3
2.5
2
1.5
1
0.5
0
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/SP5

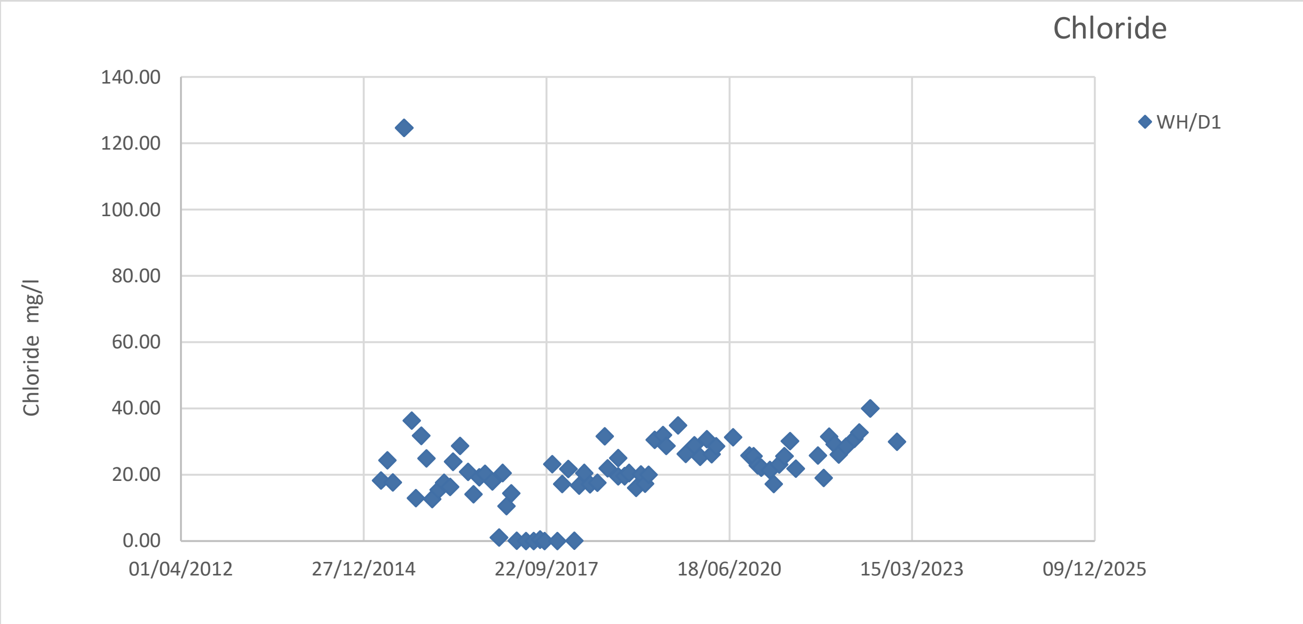

Ammonia
Ammonia mg/l
400
350
300
250
200
150
100
50
0
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
WH/SP6

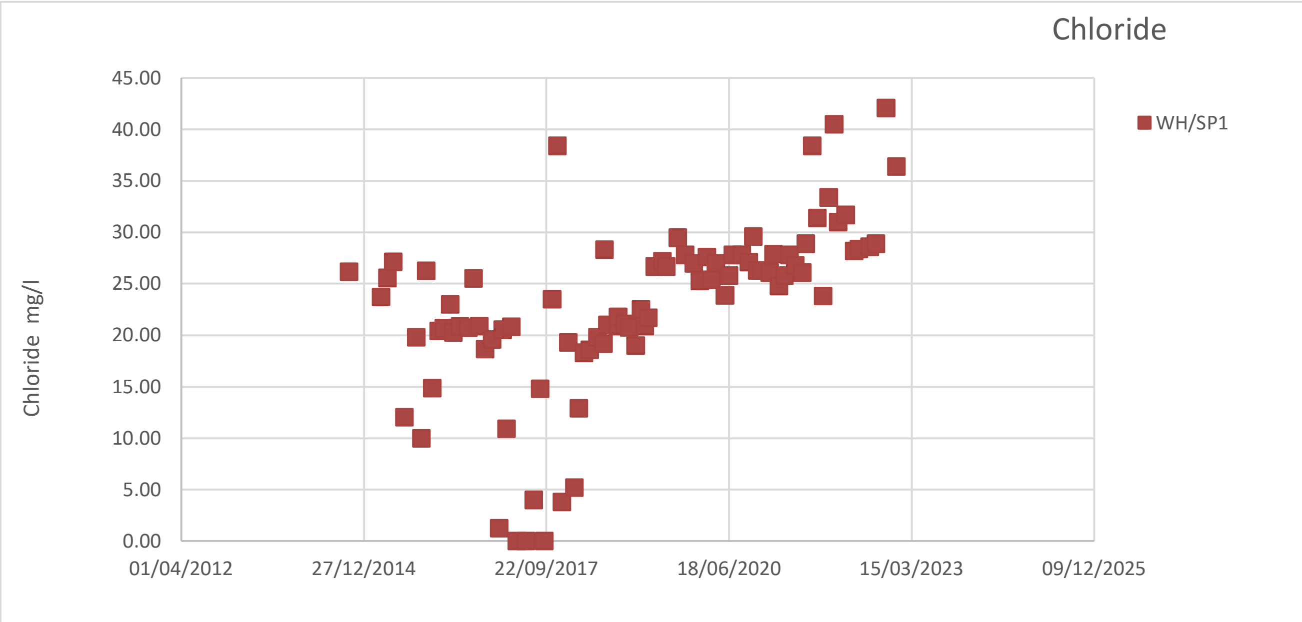


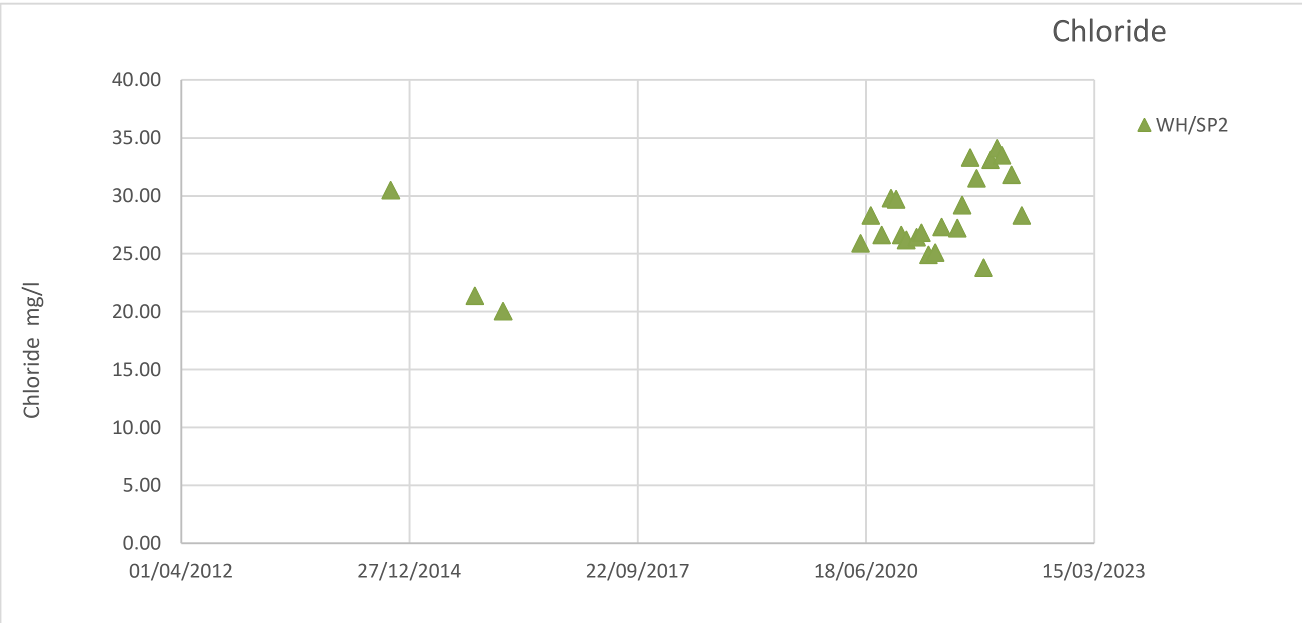
Ammonia
3.5
3
2.5
2
1.5
1
0.5
0
Ammonia mg/l
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/SP7

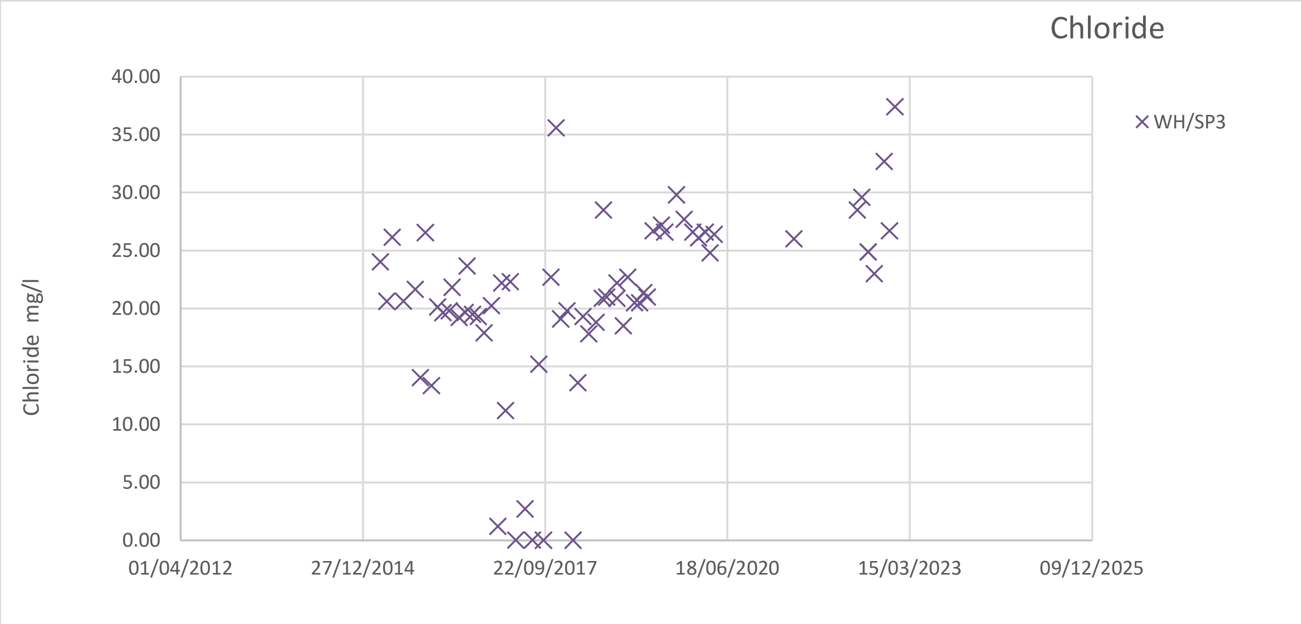


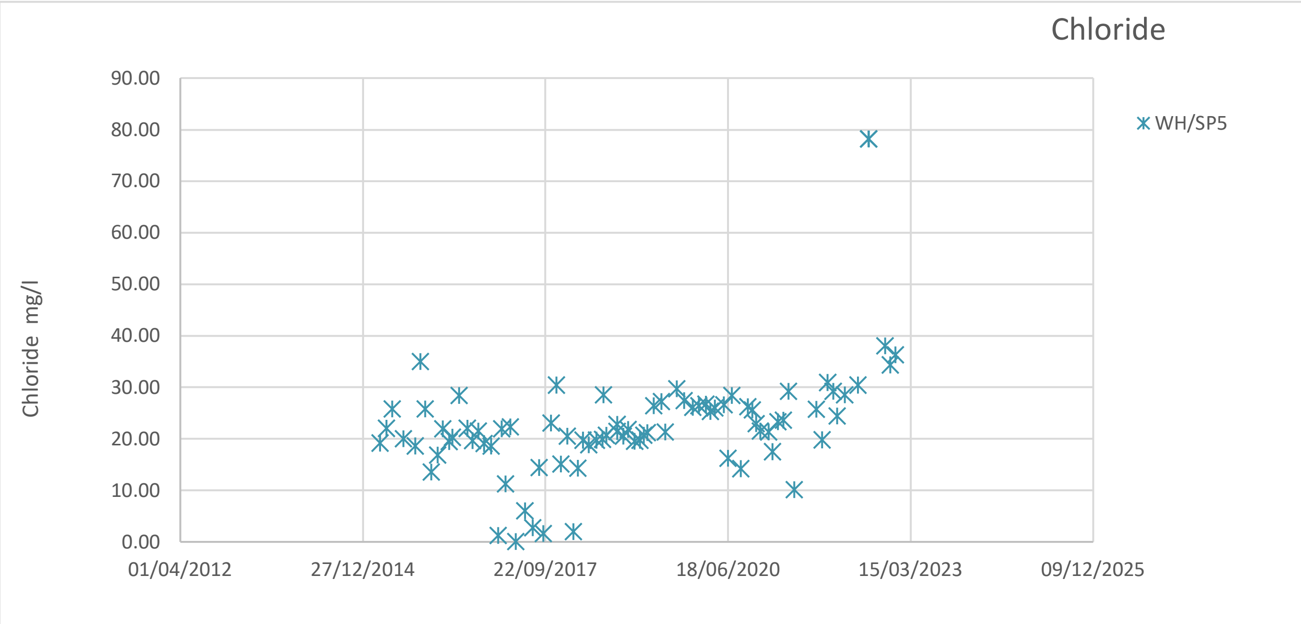
Ammonia
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Ammonia mg/l
27/12/2014
22/09/2017
18/06/2020
15/03/2023
WH/SP8

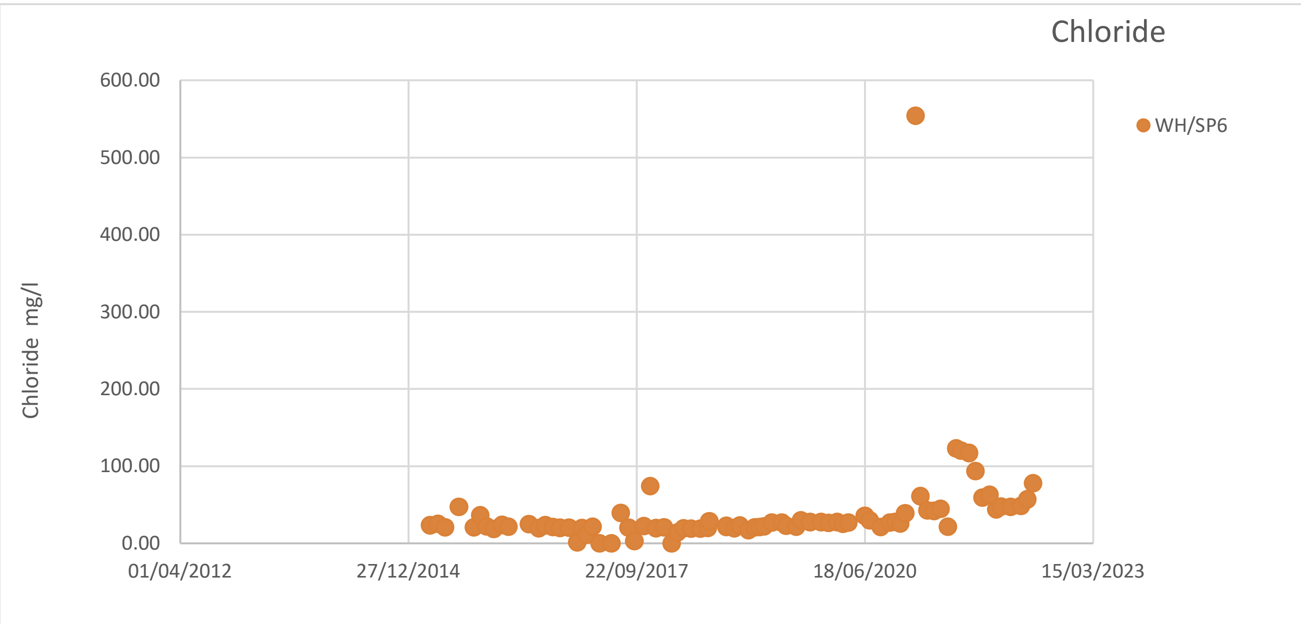

Chloride
Chloride mg/l
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/D1

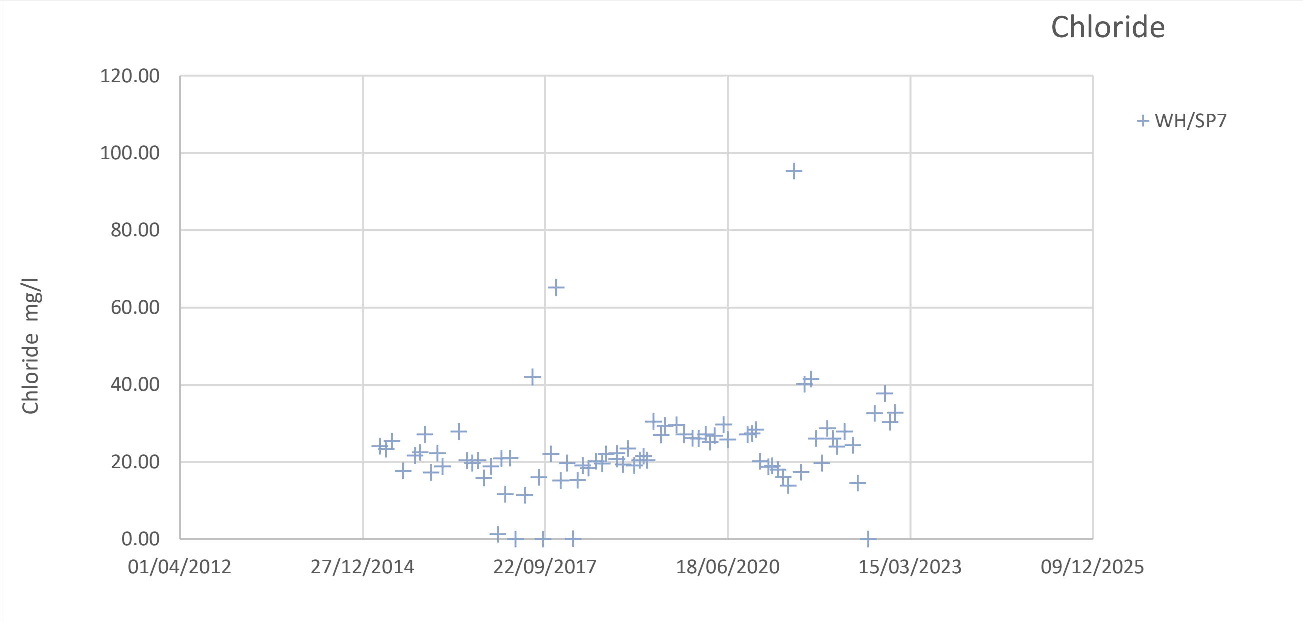

Chloride
Chloride mg/l
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/SP1

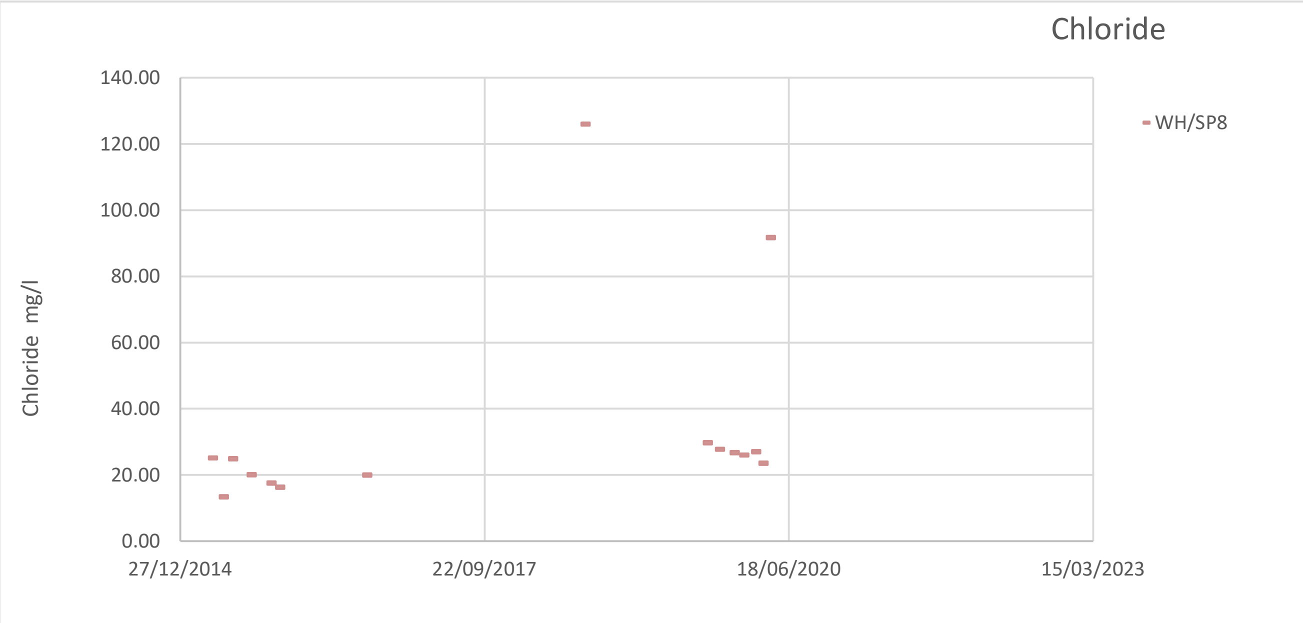

Chloride
Chloride mg/l
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
WH/SP2

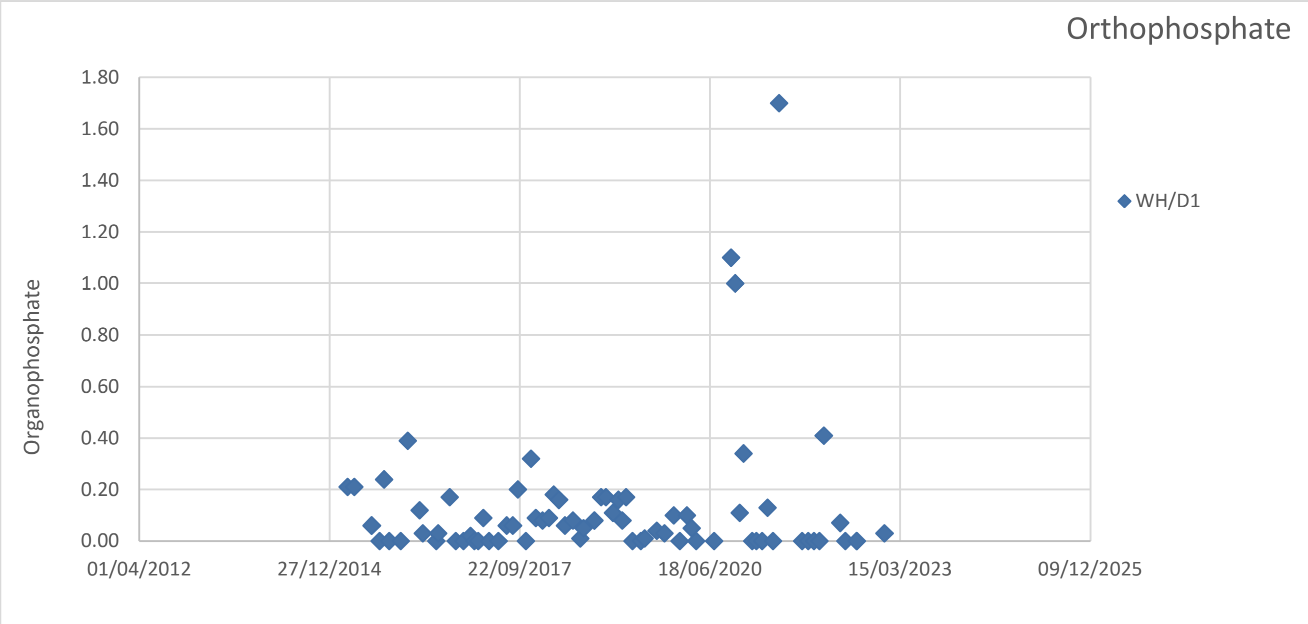

Chloride
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Chloride mg/l
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/SP3

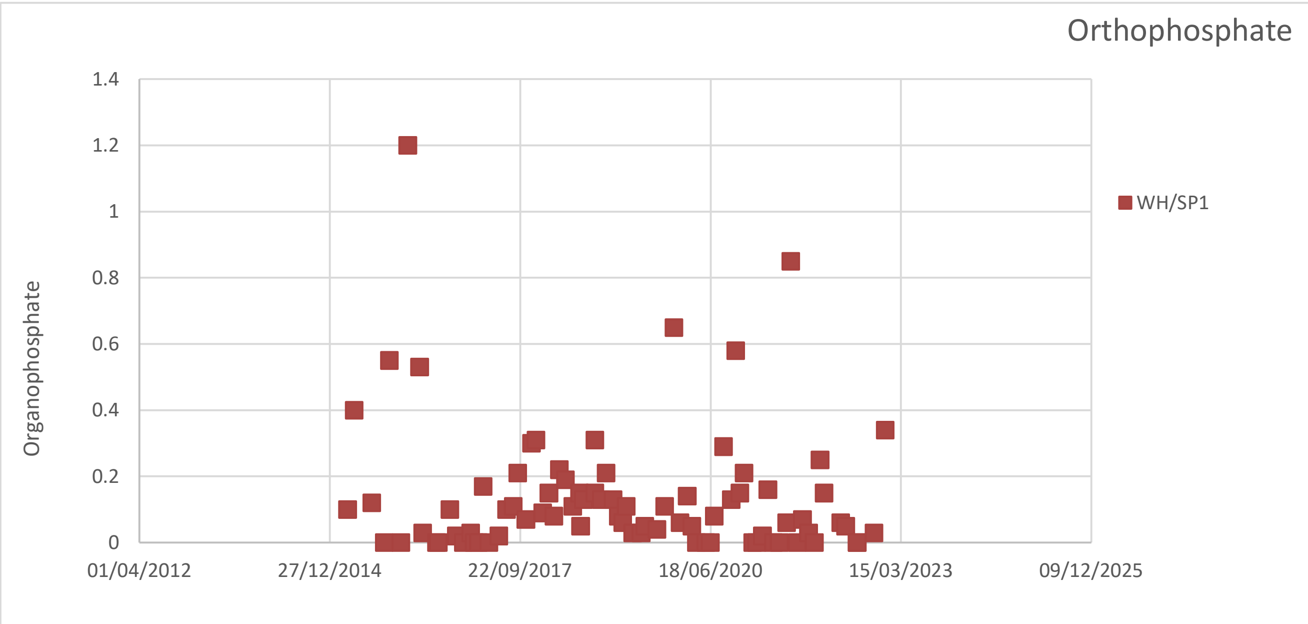

Chloride
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Chloride mg/l
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/SP5

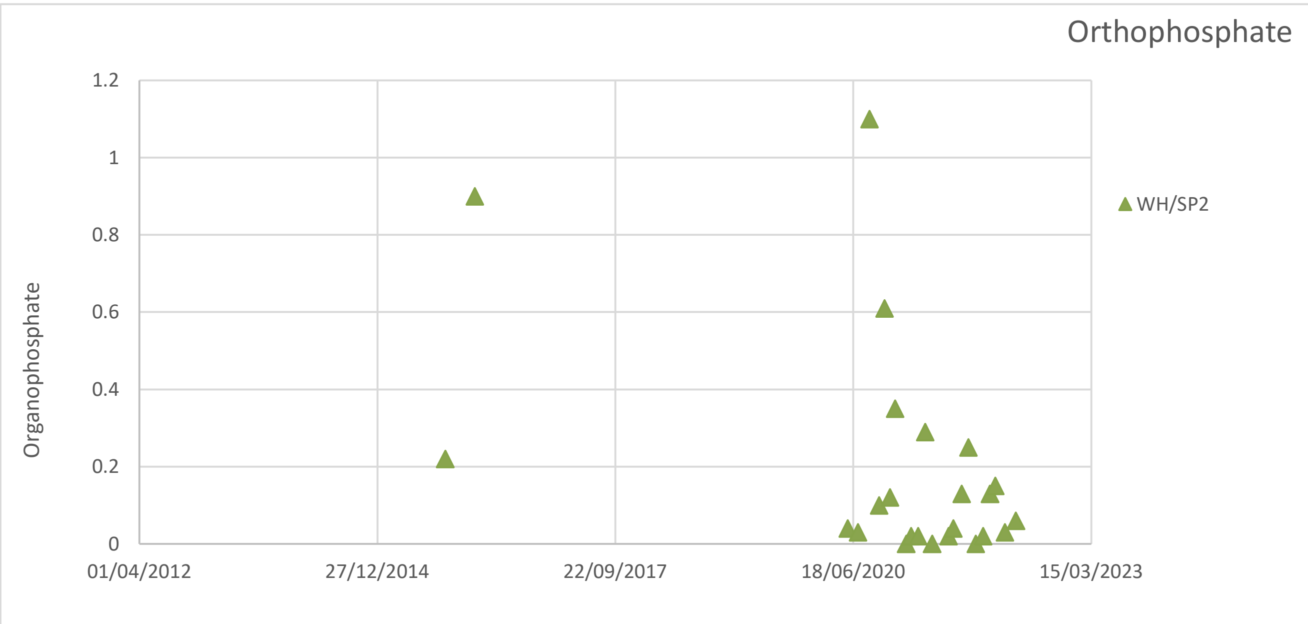

Chloride
600.00
500.00
400.00
300.00
200.00
100.00
0.00
Chloride mg/l
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
WH/SP6

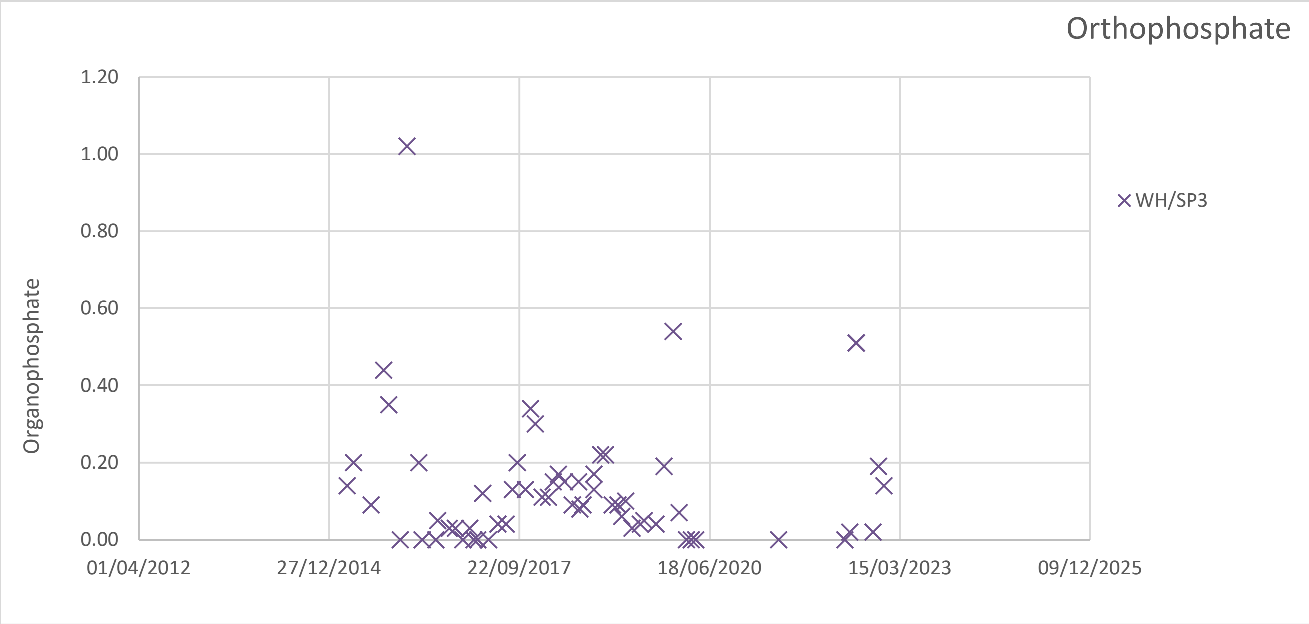

Chloride
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Chloride mg/l
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/SP7

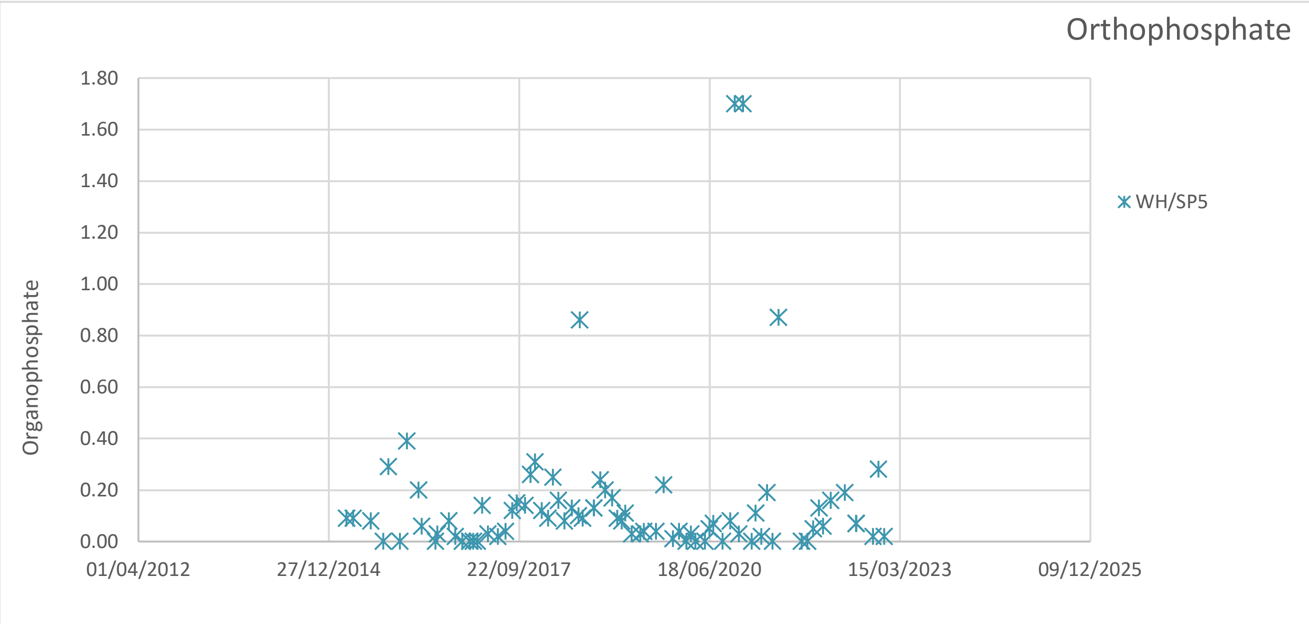

Chloride
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Chloride mg/l
27/12/2014
22/09/2017
18/06/2020
15/03/2023
WH/SP8

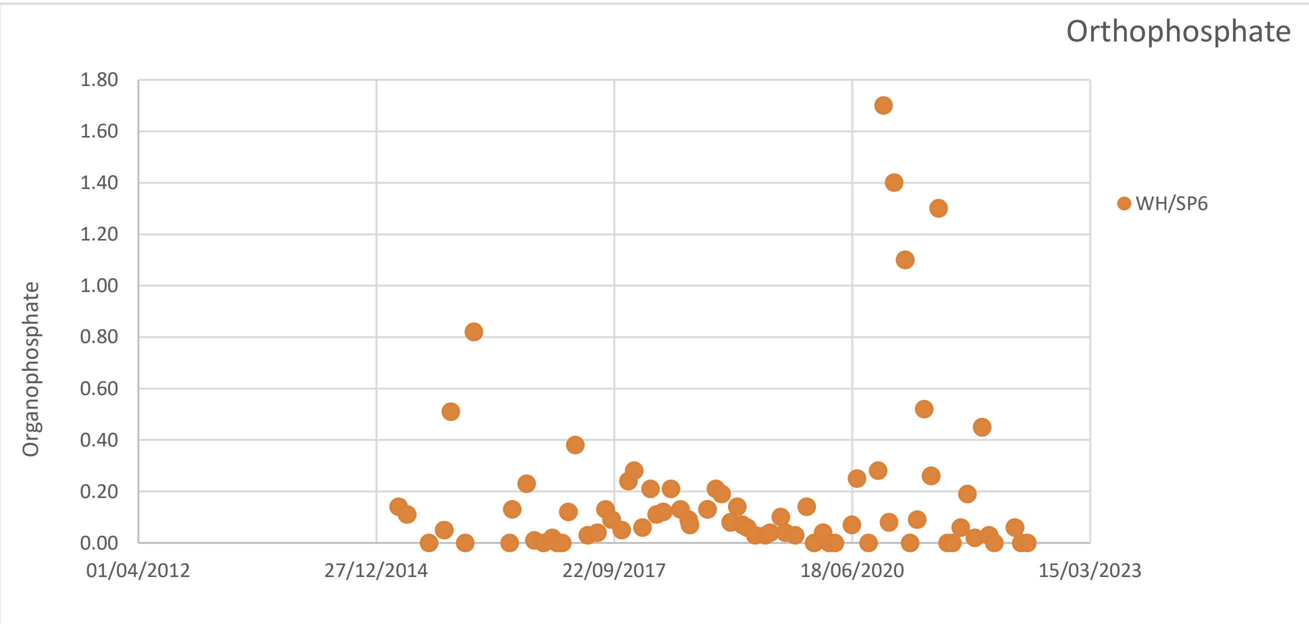

Orthophosphate
Organophosphate
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/D1

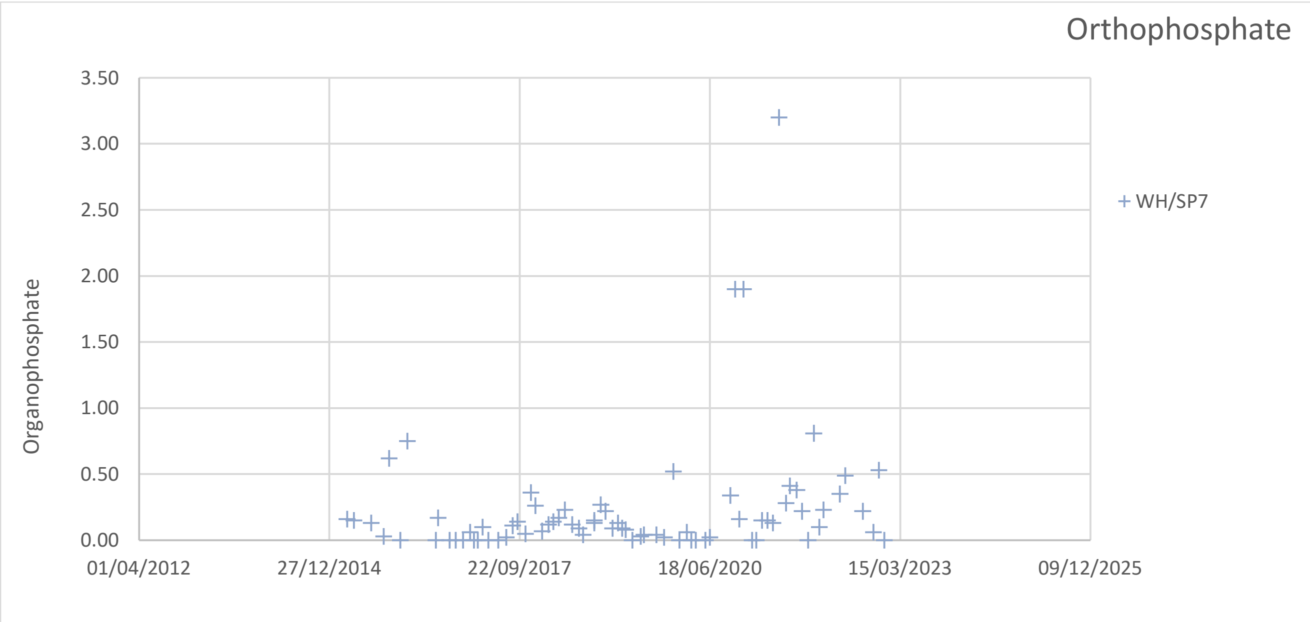

Orthophosphate
Organophosphate
1.4
1.2
1
0.8
0.6
0.4
0.2
0
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/SP1

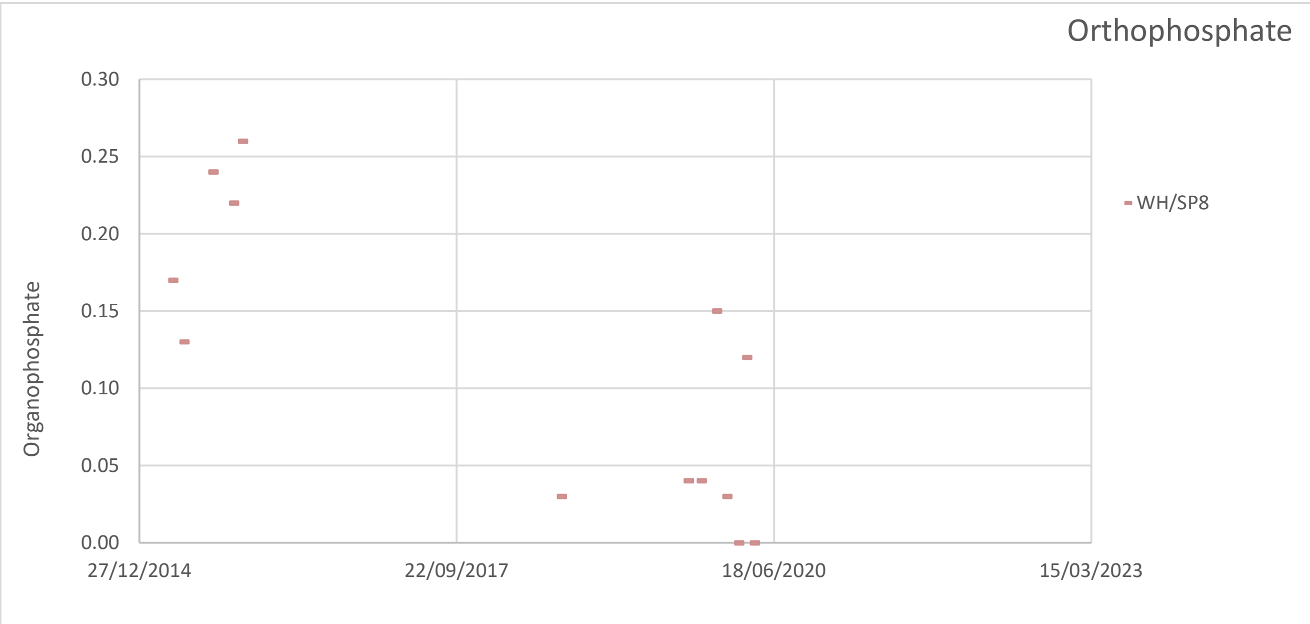

Orthophosphate
Organophosphate
1.2
1
0.8
0.6
0.4
0.2
0
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
WH/SP2

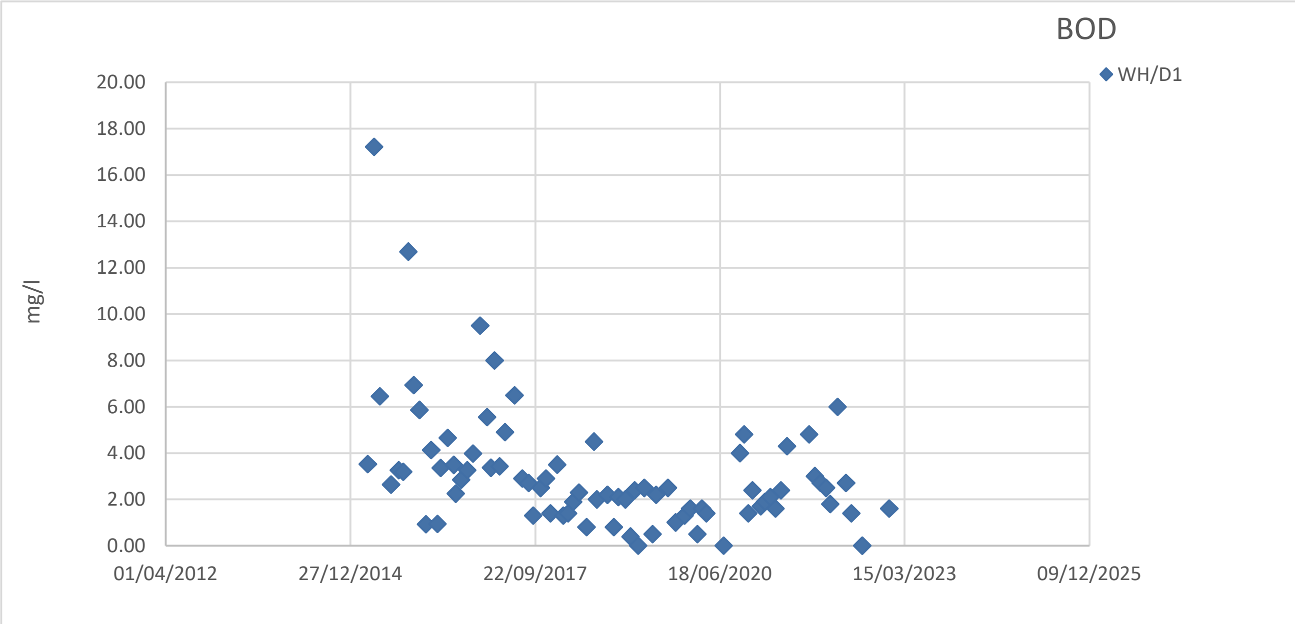

Orthophosphate
Organophosphate
1.20
1.00
0.80
0.60
0.40
0.20
0.00
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/SP3

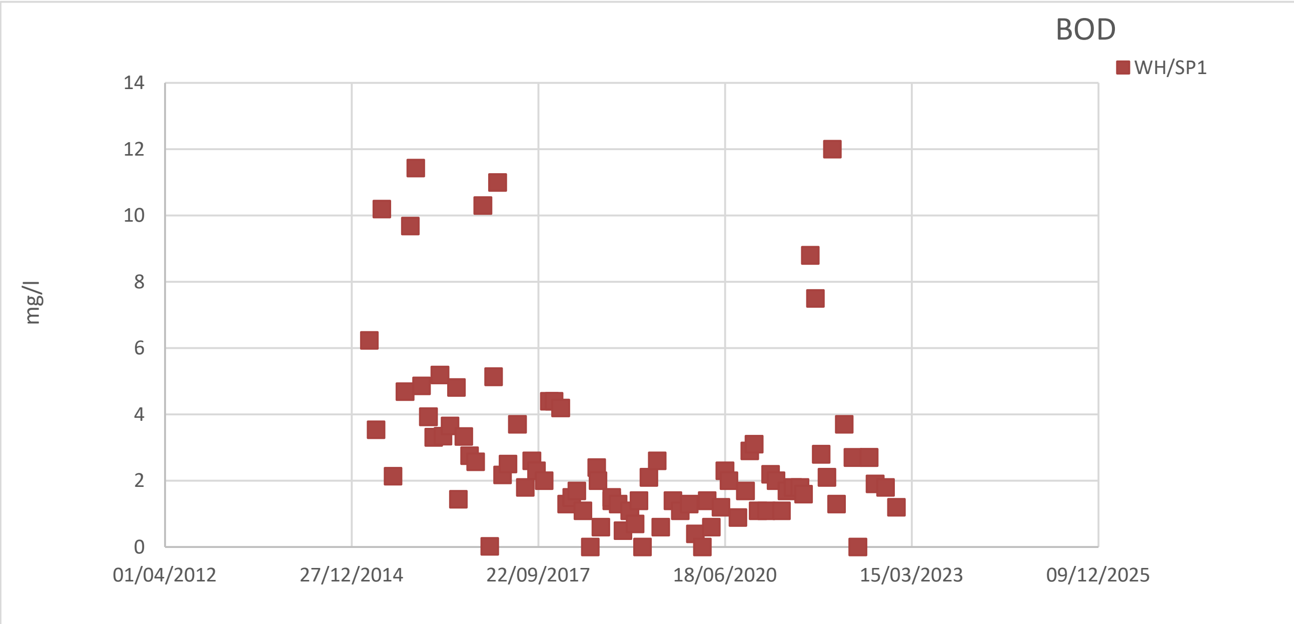

Orthophosphate
Organophosphate
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/SP5

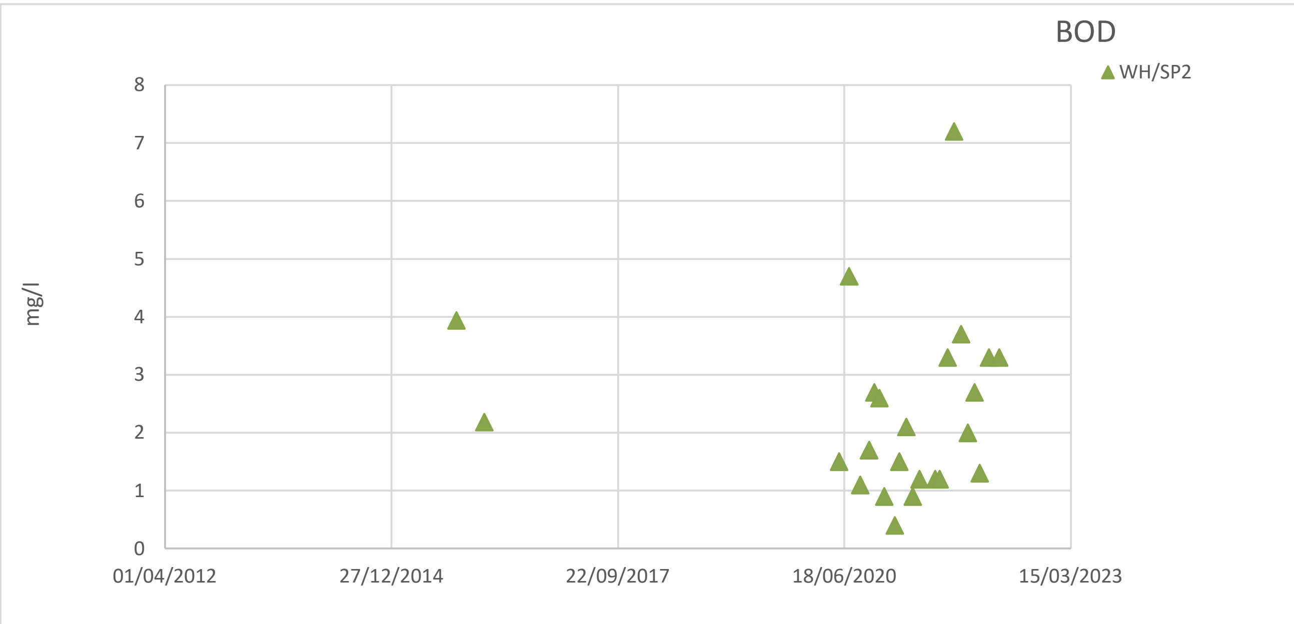

Orthophosphate
Organophosphate
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
WH/SP6

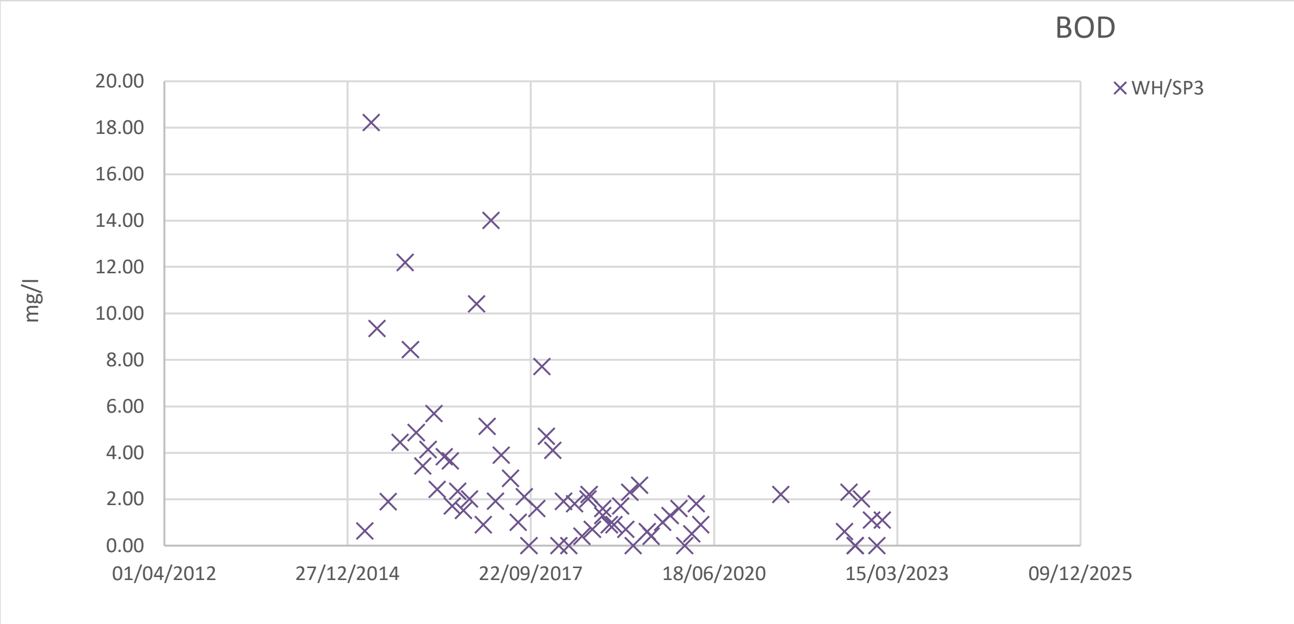

Orthophosphate
Organophosphate
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/SP7

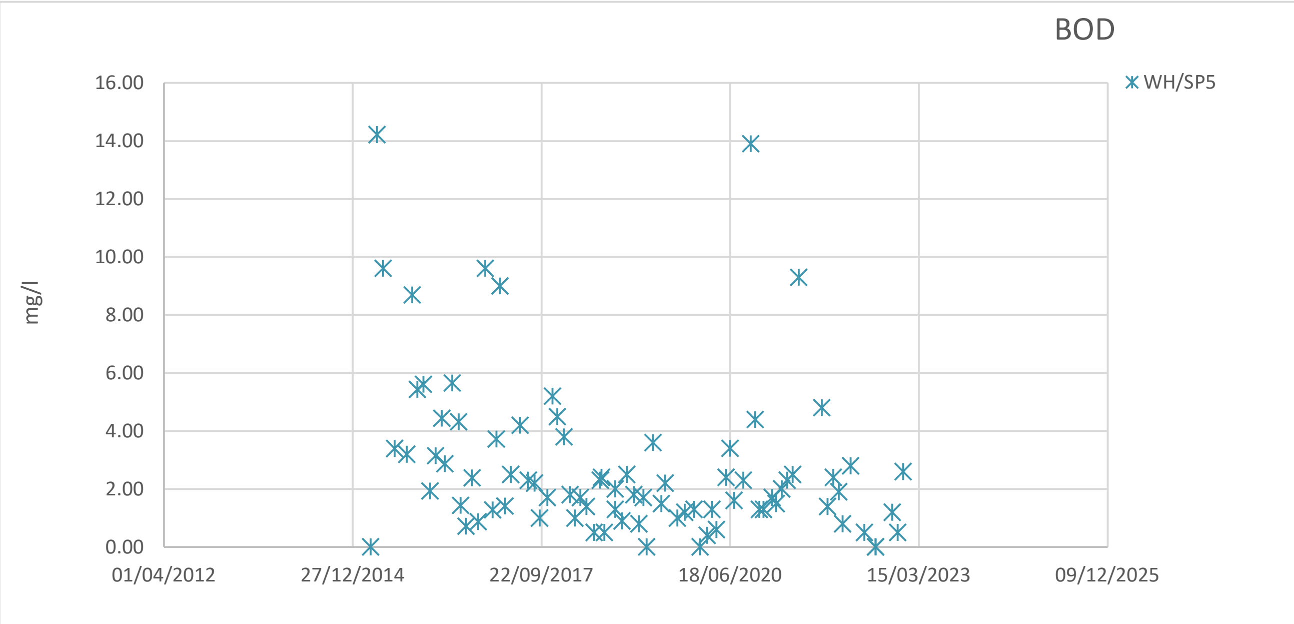

Orthophosphate
Organophosphate
0.30
0.25
0.20
0.15
0.10
0.05
0.00
27/12/2014
22/09/2017
18/06/2020
15/03/2023
WH/SP8

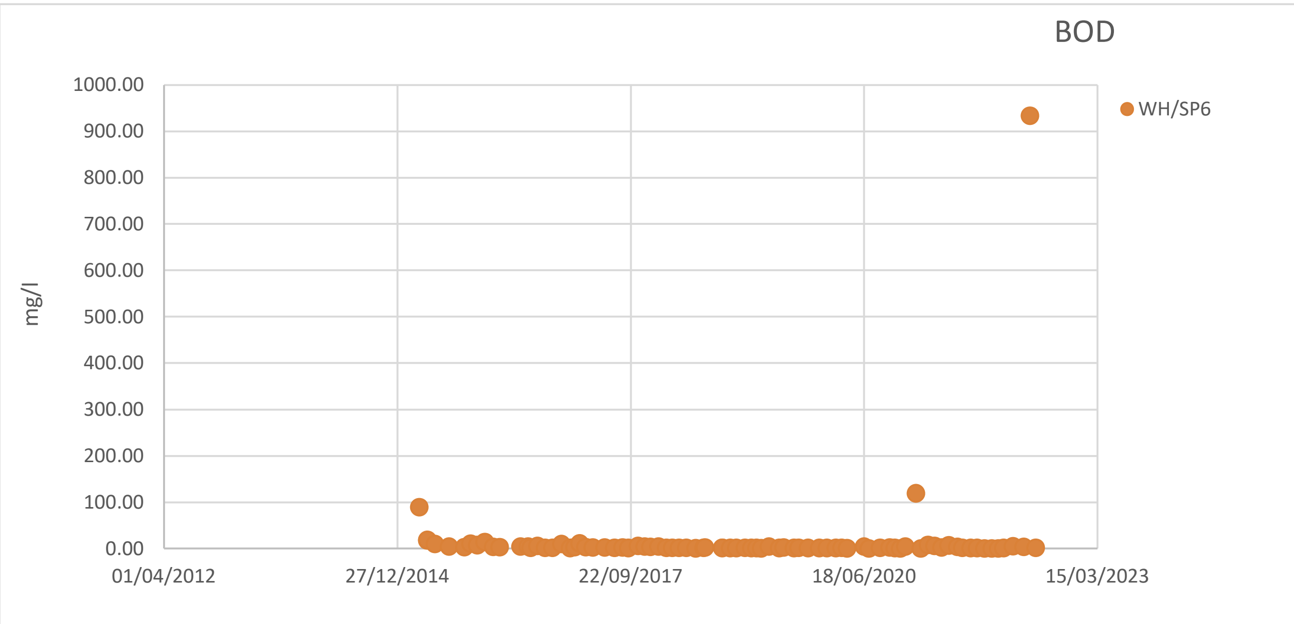

BOD
WH/D1
mg/l
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025

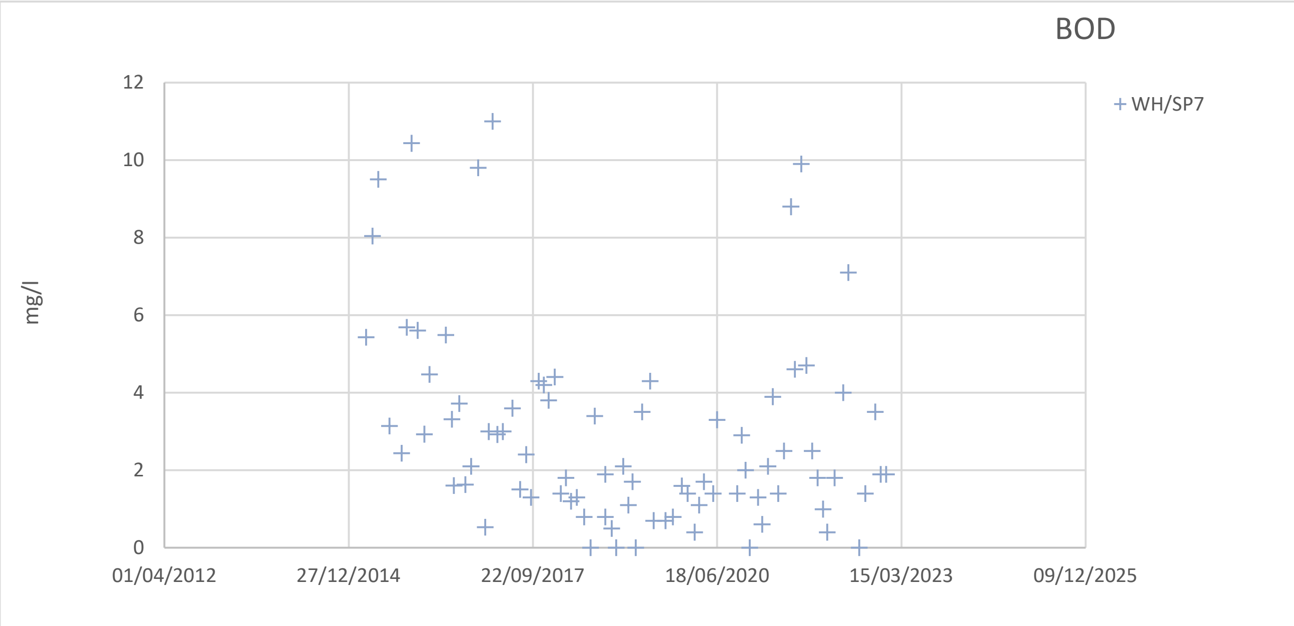

BOD
WH/SP1
mg/l
14
12
10
8
6
4
2
0
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025


BOD
WH/SP2
mg/l
8
7
6
5
4
3
2
1
0
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023

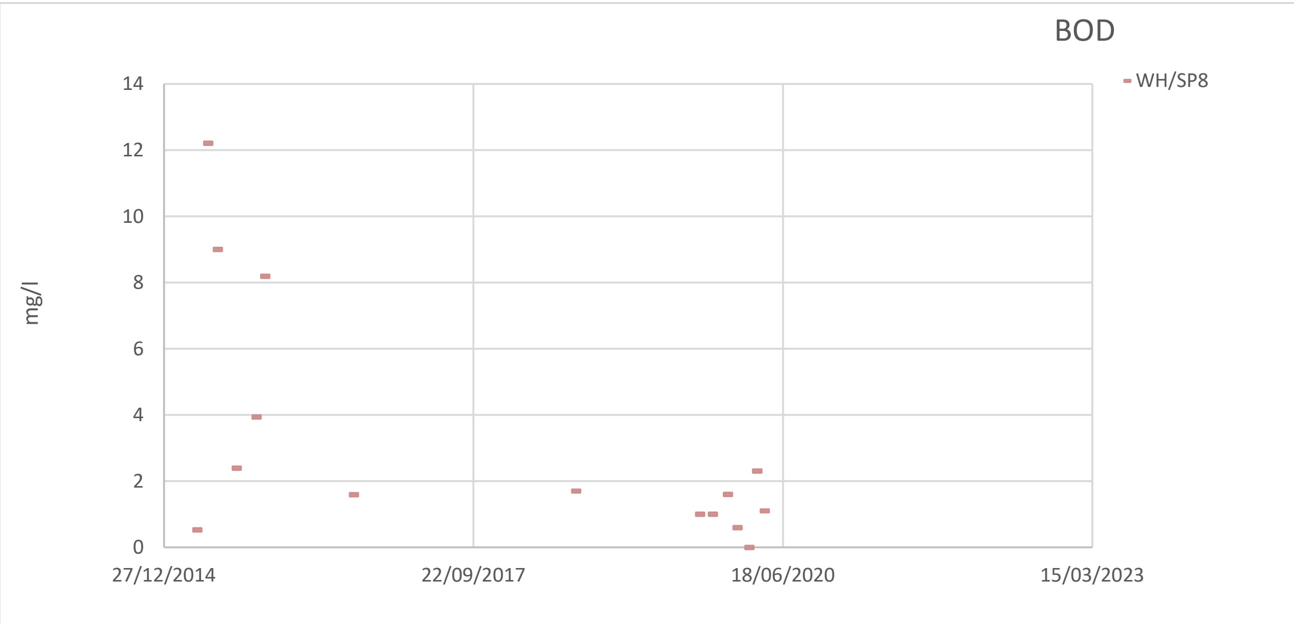

BOD
WH/SP3
mg/l
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025


BOD
WH/SP5
mg/l
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025

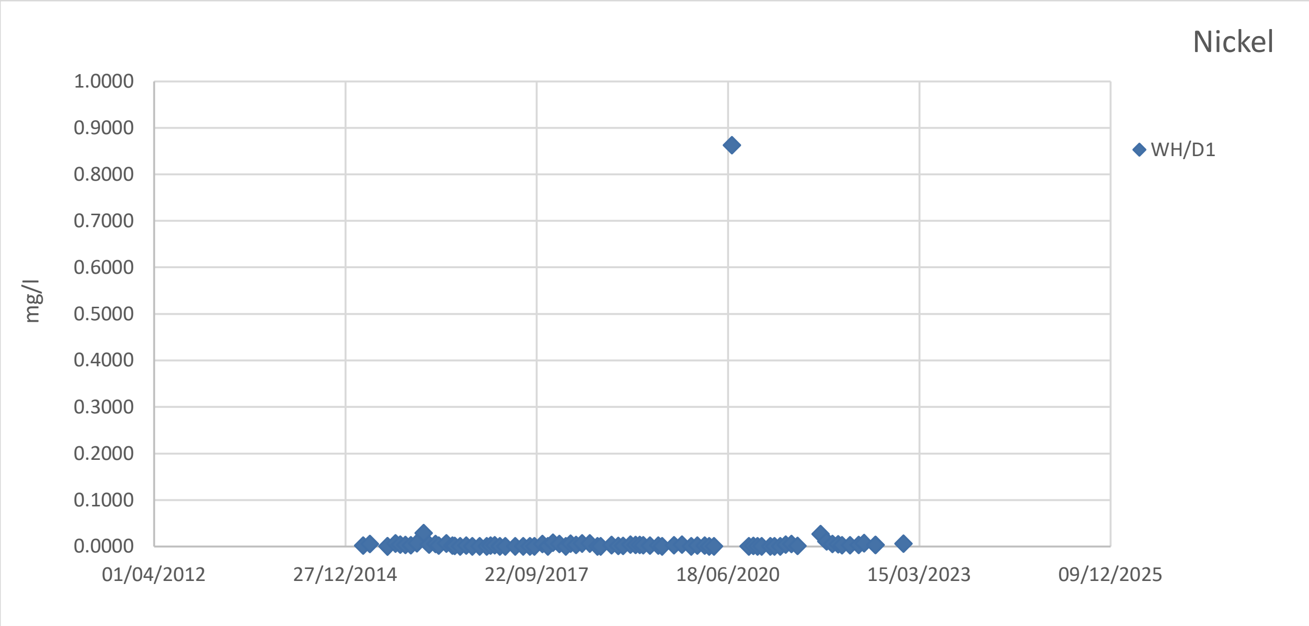

BOD
WH/SP6
mg/l
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023

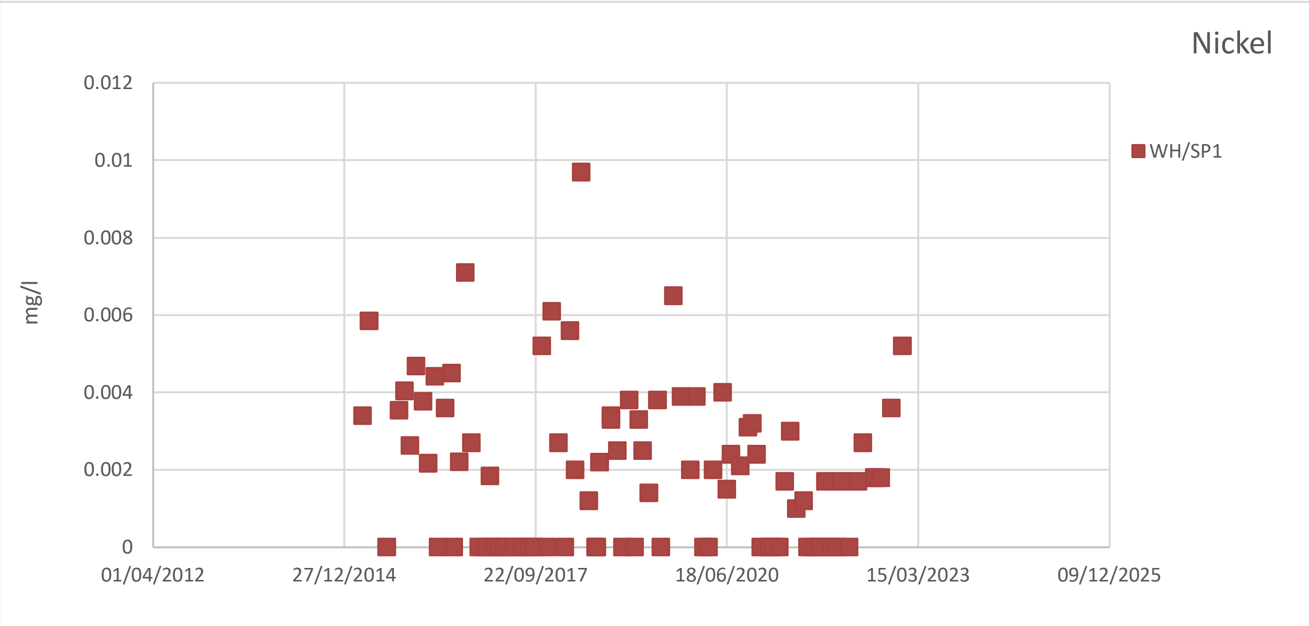


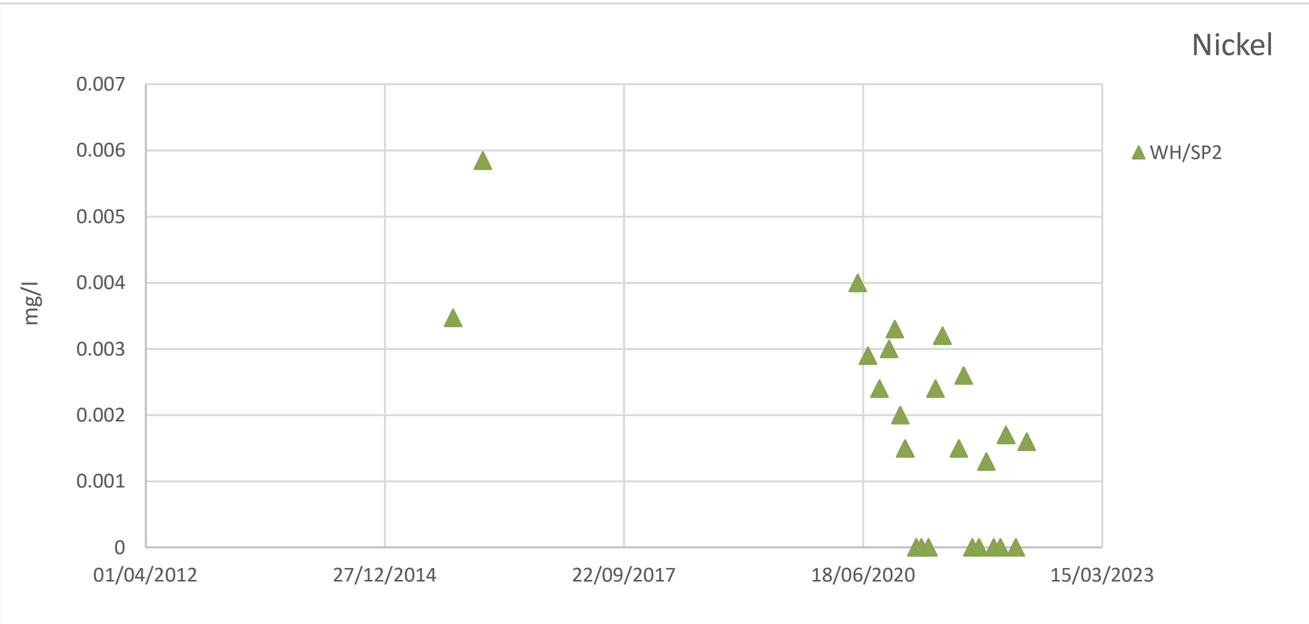
BOD
WH/SP7
mg/l
0
2
4
6
8
10
12
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025

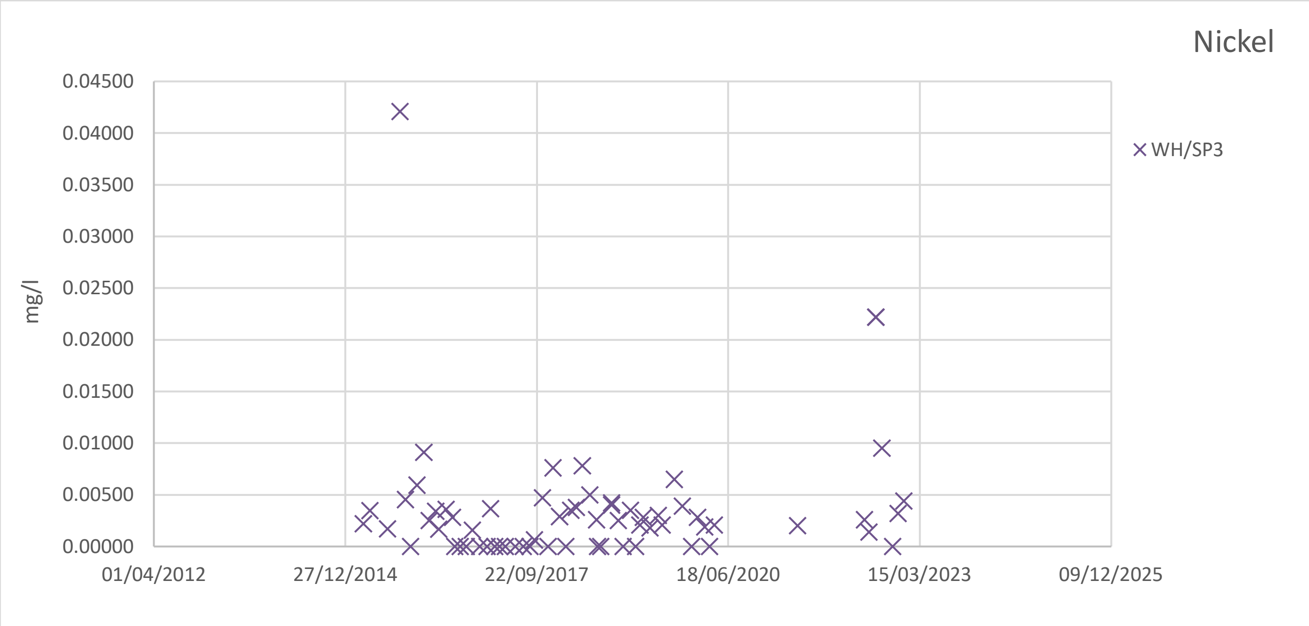


BOD
WH/SP8
mg/l
0
2
4
6
8
10
12
14
27/12/2014
22/09/2017
18/06/2020
15/03/2023

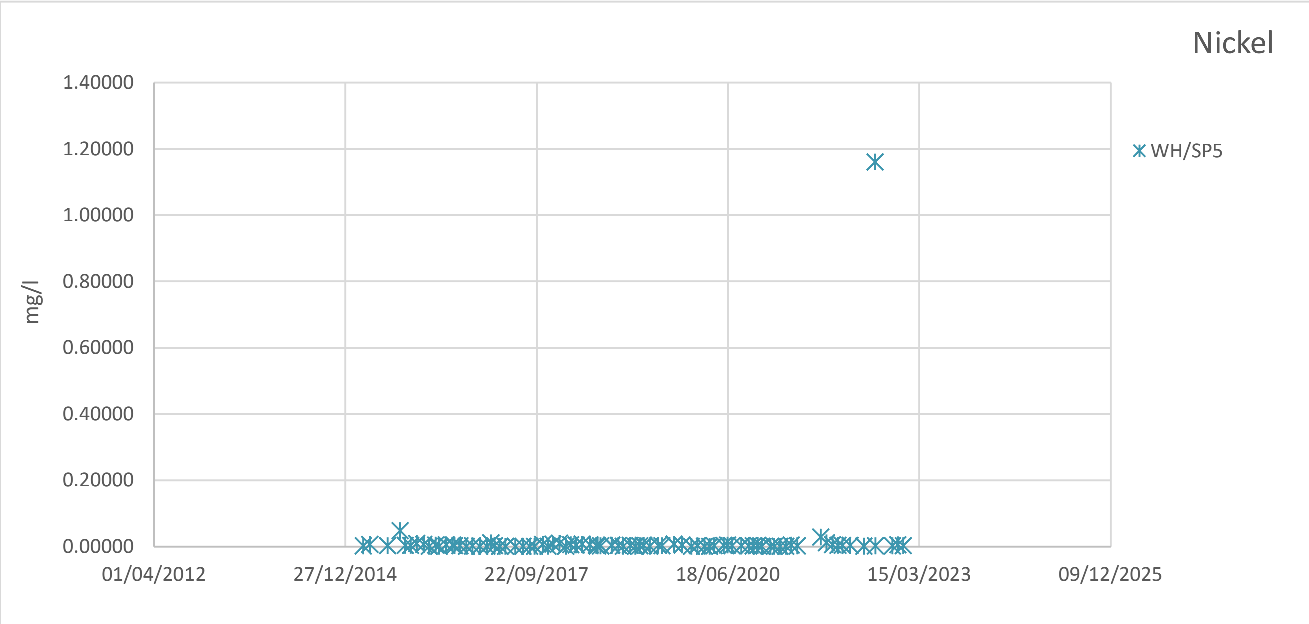

Nickel
mg/l
1.0000
0.9000
0.8000
0.7000
0.6000
0.5000
0.4000
0.3000
0.2000
0.1000
0.0000
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/D1


Nickel
mg/l
0.012
0.01
0.008
0.006
0.004
0.002
0
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/SP1

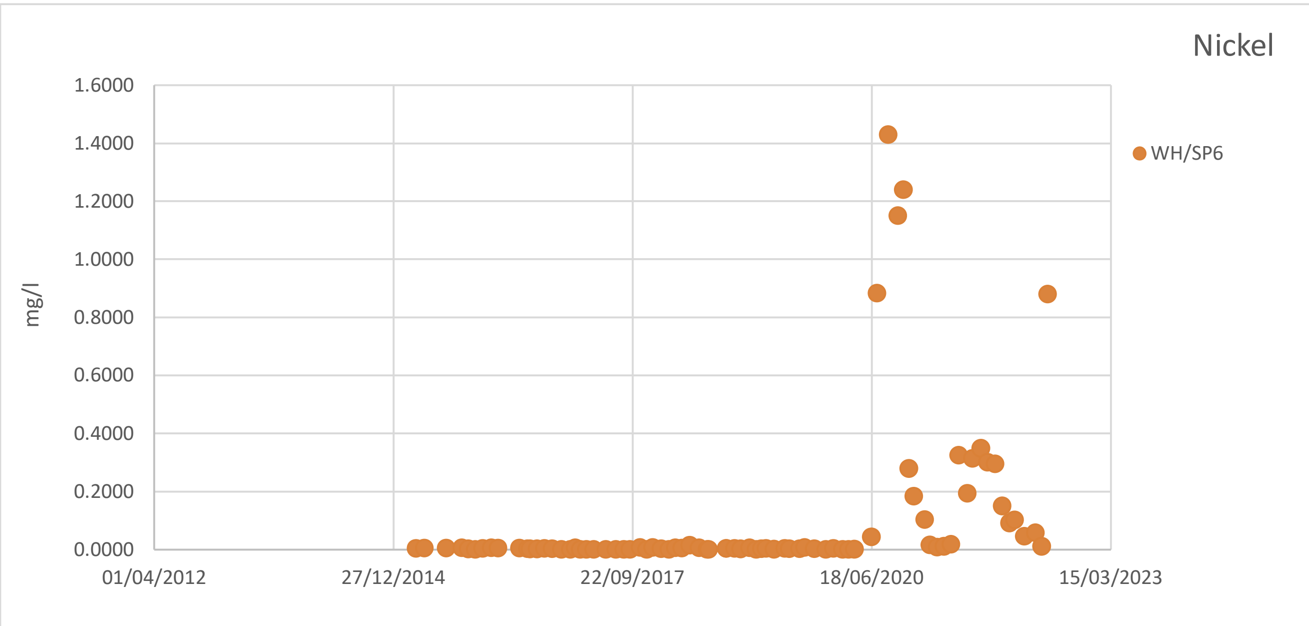

Nickel
mg/l
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
WH/SP2



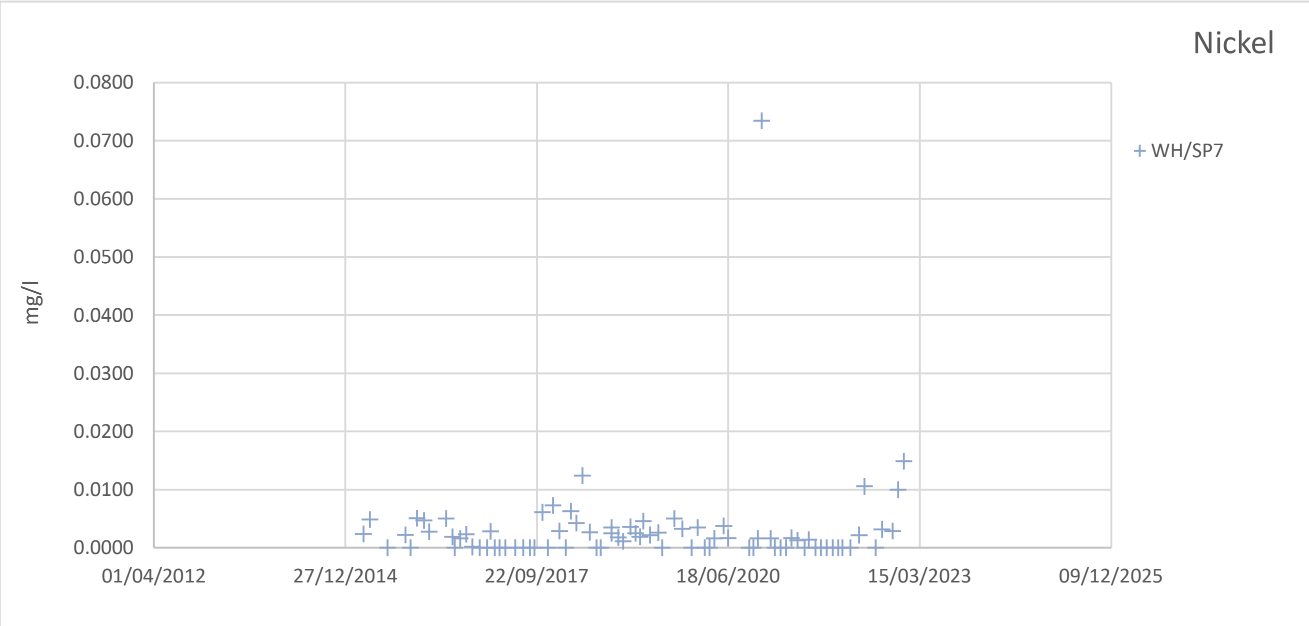
Nickel
mg/l
0.04500
0.04000
0.03500
0.03000
0.02500
0.02000
0.01500
0.01000
0.00500
0.00000
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/SP3

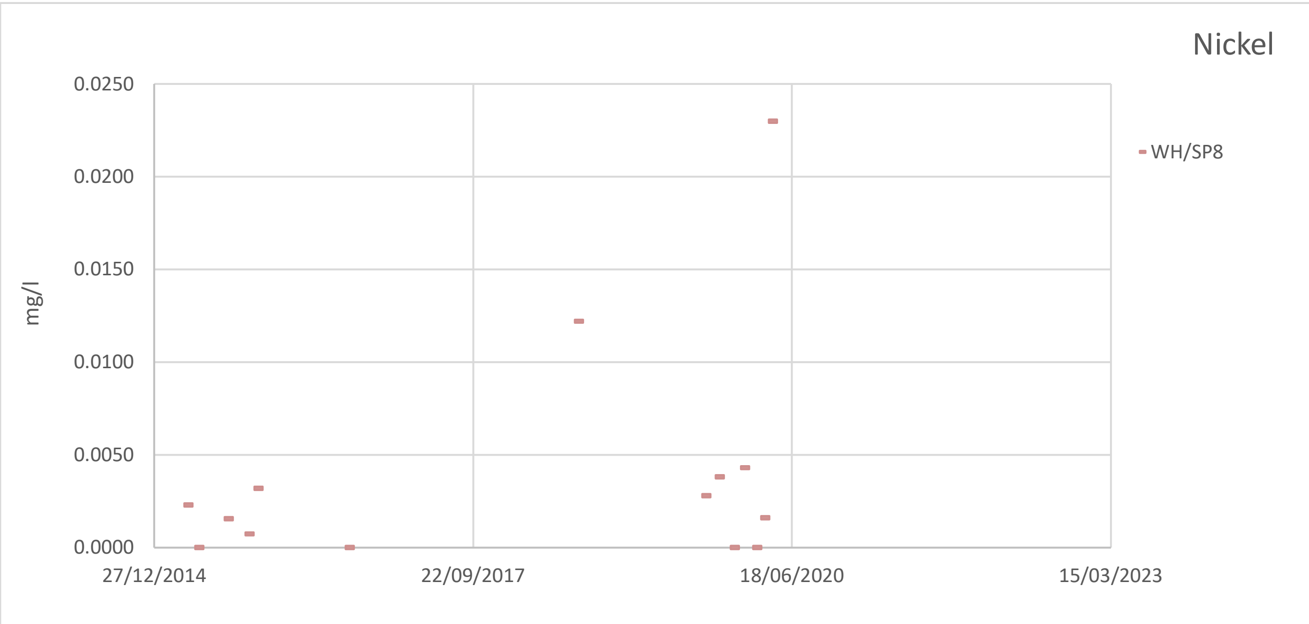


Nickel
mg/l
1.40000
1.20000
1.00000
0.80000
0.60000
0.40000
0.20000
0.00000
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/SP5



Nickel
mg/l
1.6000
1.4000
1.2000
1.0000
0.8000
0.6000
0.4000
0.2000
0.0000
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
WH/SP6


Nickel
mg/l
0.0800
0.0700
0.0600
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
01/04/2012
27/12/2014
22/09/2017
18/06/2020
15/03/2023
09/12/2025
WH/SP7


Nickel
mg/l
0.0250
0.0200
0.0150
0.0100
0.0050
0.0000
27/12/2014
22/09/2017
18/06/2020
15/03/2023
WH/SP8

WITHYHEDGE LANDFILL

HYDROGEOLOGICAL RISK ASSESSMENT REVIEW

Report Number 2365r2v1d0524

APPENDIX 4
PHASE 1 LANDSIM MODEL INPUTS

Calculation Settings

Number of iterations: 1001

Results calculated using sampled PDFs

Full Calculation

Clay Liner:

Retarded values used for simulation

No Biodegradation

Unsaturated Pathway:

Retarded values used for simulation

Biodegradation

Saturated Vertical Pathway:

No Vertical Pathway

Aquifer Pathway:

Retarded values used for simulation

Biodegradation

Timeslices at: 30, 100, 300, 1000

Decline in Contaminant Concentration in Leachate

Ammoniacal_N	Non-Volatile
c (kg/l): 0.59	m (kg/l): 0
Cadmium	Non-Volatile
c (kg/l): 0.1589	m (kg/l): 0.0823
Chloride	Non-Volatile
c (kg/l): 0.2919	m (kg/l): 0.0298
Mecoprop	Non-Volatile
c (kg/l): 0.57	m (kg/l): 0
Naphthalene	Volatile
Half life (years): 10	
Nickel	Non-Volatile
c (kg/l): -0.1479	m (kg/l): 0.0987
Phenols	Volatile
Half life (years): 10	
Xylene	Volatile
Half life (years): 10	

Contaminant Half-lives (years)

Unsaturated Pathway:

Ammoniacal_N	UNIFORM(5,10)
Cadmium	SINGLE(1e+009)
Chloride	SINGLE(1e+009)
Mecoprop	UNIFORM(0.027,0.25)
Naphthalene	SINGLE(0.7)
Nickel	SINGLE(1e+009)
Phenols	UNIFORM(0.14,0.82)
Xylene	SINGLE(1)

Aquifer Pathway:

Ammoniacal_N	UNIFORM(5,10)
Cadmium	SINGLE(1e+009)
Chloride	SINGLE(1e+009)
Mecoprop	UNIFORM(0.027,0.25)
Naphthalene	SINGLE(0.7)
Nickel	SINGLE(1e+009)
Phenols	UNIFORM(0.14,0.82)
Xylene	SINGLE(1)

Background Concentrations of Contaminants

Justification for Contaminant Properties

Input values based upon site specific testing undertaken for Golder HRA (2008)

All units in milligrams per litre

Phase: Phase1

Infiltration Information

Cap design infiltration (mm/year):	SINGLE(30)
Infiltration to waste (mm/year):	SINGLE(30)
Infiltration to grassland (mm/year):	SINGLE(268)
End of filling (years from start of waste deposit):	14
Start of cap degradation (years from end of waste deposit):	250
End of cap degradation (years from end of waste deposit):	1000

Justification for Specified Infiltration

Infiltration to grassland from MORECS data and infiltration through fml cap form Golder and Sita HRAs

Duration of management control (years from the start of waste disposal): 120

Cell dimensions

Cell width (m):	385
Cell length (m):	385
Cell top area (ha):	16.16
Cell base area (ha):	14.8225
Number of cells:	1
Total base area (ha):	14.8225
Total top area (ha):	16.16
Head of Leachate when surface water breakout occurs (m)	SINGLE(5)
Waste porosity (fraction)	UNIFORM(0.49,0.52)
Final waste thickness (m):	UNIFORM(8,18)
Field capacity (fraction):	UNIFORM(0.4,0.43)
Waste dry density (kg/l)	UNIFORM(0.39,0.49)

Justification for Landfill Geometry

Based on Site Plan

Source concentrations of contaminants

All units in milligrams per litre

Declining source term

Ammoniacal_N	LOGTRIANGULAR(0.01,660,2285)
	Data are spot measurements of Leachate Quality
Cadmium	LOGTRIANGULAR(8e-005,0.001,0.002)
	Data are spot measurements of Leachate Quality
Chloride	LOGTRIANGULAR(0.8,270,3200)
	Data are spot measurements of Leachate Quality
Mecoprop	LOGTRIANGULAR(0.0001,0.001,0.1)
	Substance to be treated as List 1
Naphthalene	LOGTRIANGULAR(2e-005,0.0006,0.01)
	Data are spot measurements of Leachate Quality
Nickel	LOGTRIANGULAR(0.001,0.1,0.3)
	Data are spot measurements of Leachate Quality
Phenols	LOGTRIANGULAR(0.01,1.1,112)
	Data are spot measurements of Leachate Quality
Xylene	UNIFORM(0.001,0.012)
	Substance to be treated as List 1

Justification for Species Concentration in Leachate
Based on Geotechnology review of available dataset and pdf review

Drainage Information

Fixed Head.
Head on EBS is given as (m): SINGLE(0.2)

Justification for Specified Head
Based on backcalculation to ensure all leachate lost to groundwater

Barrier Information

There is no barrier

Justification for Engineered Barrier Type
No barrier in Phase 1

Mydrim Shale pathway parameters

Modelled as unsaturated pathway

Pathway length (m):	UNIFORM(0.01,3)
Flow Model:	porous medium
Pathway moisture content (fraction):	TRIANGULAR(0.213,0.236,0.292)
Pathway Density (kg/l):	TRIANGULAR(1.785,1.9402,1.979)

Justification for Unsat Zone Geometry
Input values from Golder Phase 1 HRA (2008)

Pathway hydraulic conductivity values (m/s):	LOGUNIFORM(2.2e-008,4.1e-005)

Justification for Unsat Zone Hydraulics Properties
Input values from Golder Phase 1 HRA (2008)

Pathway longitudinal dispersivity (m):	LOGUNIFORM(0.001,0.3)

Justification for Unsat Zone Dispersion Properties
Input values from Golder Phase 1 HRA (2008)

Retardation parameters for Mydrim Shale pathway

Modelled as unsaturated pathway

Uncertainty in Kd (l/kg):

Ammoniacal_N	LOGUNIFORM(0.02647,0.6929)
Cadmium	LOGTRIANGULAR(694,3927,3927)
Chloride	SINGLE(0)
Mecoprop: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(11,25)
Naphthalene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1288)
Nickel	SINGLE(85.7)
Phenols: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(22,27)
Xylene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1590)
Fraction of Organic Carbon (fraction)	TRIANGULAR(0.002,0.005,0.019)

Justification for Kd Values by Species
Input values from site specific testing reported in Golder Phase 1 HRA (2008)

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(149,551)
Pathway width (m):	SINGLE(402)

Mydrim Shales pathway parameters

No Vertical Pathway

Meidrim Shales pathway parameters

Modelled as aquifer pathway.

Mixing zone (m):

Calculated. Aquifer Thickness:	SINGLE(10)

Justification for Aquifer Geometry
Based on Site Plan and conceptual site model

Darcy flux (m/s):	LOGNORMAL(2.5e-007,2.5e-008)
Pathway porosity (fraction):	TRIANGULAR(0.213,0.236,0.292)

Justification for Aquifer Hydraulics Properties
Based on catchment analysis in HRA

Pathway longitudinal dispersivity (m):	UNIFORM(1,60)
Pathway transverse dispersivity (m):	UNIFORM(0.3,20)

Justification for Aquifer Dispersion Details
Assumed 10% of flow length for longitudinal dispersivity and 3% for transverse dispersivity as used in Golder HRA

Retardation parameters for Meidrim Shales pathway

Modelled as aquifer pathway.

Uncertainty in Kd (l/kg):

Ammoniacal_N	UNIFORM(0.02647,0.6929)
Cadmium	TRIANGULAR(694,3927,3927)
Chloride	SINGLE(0)
Mecoprop: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(11,25)
Naphthalene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1288)
Nickel	SINGLE(85.7)
Phenols: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(22,27)
Xylene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1590)
Fraction of Organic Carbon (fraction)	TRIANGULAR(0.002,0.005,0.019)

Justification for Aquifer Kd Values by Species

Input values from Golder Phase 1 HRA (2008)

Pathway Density (kg/l):	TRIANGULAR(1.785,1.9402,1.979)

WITHYHEDGE LANDFILL

HYDROGEOLOGICAL RISK ASSESSMENT REVIEW

Report Number 2365r2v1d0524

APPENDIX 5
PHASE 1 LANDSIM MODEL OUTPUTS

Concentration of Ammoniacal_N in groundwater [mg/l]

At 30 years

01% of values less than 3.43361E-008
05% of values less than 0.000641252
10% of values less than 0.00892318
50% of values less than 0.773247
90% of values less than 6.81928
95% of values less than 10.8238
99% of values less than 17.4091

Minimum 0	Maximum 31.2436	
Mean 2.375	Std. Dev. 3.7136	Variance 13.7909

At 100 years

01% of values less than 0.0305761
05% of values less than 0.123202
10% of values less than 0.199404
50% of values less than 1.33187
90% of values less than 6.79797
95% of values less than 9.84417
99% of values less than 15.4875

Minimum 0.0075382	Maximum 28.3904	
Mean 2.63017	Std. Dev. 3.31557	Variance 10.993

At 300 years

01% of values less than 0.00420853
05% of values less than 0.0193162
10% of values less than 0.0317669
50% of values less than 0.207246
90% of values less than 0.982205
95% of values less than 1.44371
99% of values less than 2.38065

Minimum 0.000695161	Maximum 3.3347	
Mean 0.386579	Std. Dev. 0.481766	Variance 0.232098

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Concentration of Ammoniacal_N in groundwater [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Concentration of Cadmium in groundwater [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Concentration of Cadmium in groundwater [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 5.8712E-007

90% of values less than 2.23637E-006

95% of values less than 2.80175E-006

99% of values less than 4.47223E-006

Minimum 0 Maximum 8.91083E-006

Mean 9.22652E-007 Std. Dev. 1.1038E-006 Variance 1.21836E-012

Concentration of Chloride in groundwater [mg/l]

At 30 years

01% of values less than 7.60597
05% of values less than 11.7141
10% of values less than 15.1274
50% of values less than 34.913
90% of values less than 67.9631
95% of values less than 82.7881
99% of values less than 111.325

Minimum 4.05184	Maximum 138.527	
Mean 39.418	Std. Dev. 22.3923	Variance 501.417

At 100 years

01% of values less than 6.04496
05% of values less than 10.078
10% of values less than 12.9942
50% of values less than 29.8415
90% of values less than 58.0023
95% of values less than 70.0364
99% of values less than 91.4438

Minimum 3.35995	Maximum 121.115	
Mean 33.7673	Std. Dev. 19.084	Variance 364.199

At 300 years

01% of values less than 0.229058
05% of values less than 0.428655
10% of values less than 0.600949
50% of values less than 2.41885
90% of values less than 6.20707
95% of values less than 8.26178
99% of values less than 11.5915

Minimum 0.0463421	Maximum 16.3714	
Mean 3.04021	Std. Dev. 2.51448	Variance 6.32263

At 1000 years

01% of values less than 0
05% of values less than 1.28904E-008
10% of values less than 5.31271E-008
50% of values less than 1.58756E-006
90% of values less than 7.3702E-006
95% of values less than 1.00321E-005
99% of values less than 1.6228E-005

Minimum 0	Maximum 2.45727E-005	
Mean 2.89532E-006	Std. Dev. 3.60932E-006	Variance 1.30272E-011

Concentration of Chloride in groundwater [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Concentration of Mecoprop in groundwater [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 6.21271E-013
95% of values less than 4.29362E-012
99% of values less than 5.18036E-011

Minimum 0	Maximum 7.61016E-010	
Mean 2.74741E-012	Std. Dev. 2.79278E-011	Variance 7.79963E-022

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 5.44026E-013
95% of values less than 3.5442E-012
99% of values less than 4.74617E-011

Minimum 0	Maximum 6.3641E-010	
Mean 2.36474E-012	Std. Dev. 2.36885E-011	Variance 5.61147E-022

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 2.46505E-014
95% of values less than 1.90691E-013
99% of values less than 2.82591E-012

Minimum 0	Maximum 4.63053E-011	
Mean 1.74935E-013	Std. Dev. 1.87423E-012	Variance 3.51274E-024

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Concentration of Mecoprop in groundwater [mg/l]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Concentration of Naphthalene in groundwater [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Concentration of Naphthalene in groundwater [mg/l]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Concentration of Nickel in groundwater [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 4.86237E-017
95% of values less than 9.19937E-017
99% of values less than 1.5059E-016

Minimum 0	Maximum 2.2919E-016	
Mean 1.26012E-017	Std. Dev. 3.18336E-017	Variance 1.01338E-033

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 3.06166E-017
90% of values less than 1.18669E-016
95% of values less than 1.53053E-016
99% of values less than 2.36806E-016

Minimum 0	Maximum 1.06331E-015	
Mean 4.87268E-017	Std. Dev. 6.49519E-017	Variance 4.21875E-033

At 1000 years

01% of values less than 0
05% of values less than 4.92206E-017
10% of values less than 1.6036E-016
50% of values less than 4.21574E-010
90% of values less than 2.98324E-007
95% of values less than 7.06094E-007
99% of values less than 1.76804E-006

Minimum 0	Maximum 3.39384E-006	
Mean 1.14586E-007	Std. Dev. 3.46971E-007	Variance 1.20389E-013

Concentration of Nickel in groundwater [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Concentration of Phenols in groundwater [mg/l]

At 30 years

01% of values less than 0
05% of values less than 1.63126E-017
10% of values less than 1.1372E-014
50% of values less than 1.28845E-008
90% of values less than 4.45917E-006
95% of values less than 1.46617E-005
99% of values less than 6.28267E-005

Minimum 0	Maximum 0.000312049	
Mean 3.22387E-006	Std. Dev. 1.58353E-005	Variance 2.50758E-010

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 5.81586E-016
50% of values less than 7.46857E-010
90% of values less than 2.79403E-007
95% of values less than 8.43369E-007
99% of values less than 3.82425E-006

Minimum 0	Maximum 1.95556E-005	
Mean 1.94068E-007	Std. Dev. 9.79174E-007	Variance 9.58781E-013

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 7.6891E-012
99% of values less than 2.03892E-010

Minimum 0	Maximum 1.75607E-009	
Mean 8.34293E-012	Std. Dev. 7.44887E-011	Variance 5.54857E-021

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Concentration of Phenols in groundwater [mg/l]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 2.07466E-018
99% of values less than 5.49569E-017

Minimum 0	Maximum 1.34462E-015	
Mean 4.67891E-018	Std. Dev. 5.51123E-017	Variance 3.03736E-033

Concentration of Xylene in groundwater [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Concentration of Xylene in groundwater [mg/l]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Approx. time to Peak Conc. Ammoniacal_N at Offsite Compliance Point [years]

01% of values less than 28
05% of values less than 32
10% of values less than 35
50% of values less than 52
90% of values less than 70
95% of values less than 78
99% of values less than 78

Minimum 23	Maximum 86	
Mean 52.2537	Std. Dev. 13.4742	Variance 181.554

Approx. time to Peak Conc. Cadmium at Offsite Compliance Point [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 14859
90% of values less than 20000
95% of values less than 20000
99% of values less than 20000

Minimum 0	Maximum 20000	
Mean 12354.5	Std. Dev. 7737.36	Variance 5.98667E+007

Approx. time to Peak Conc. Chloride at Offsite Compliance Point [years]

01% of values less than 17
05% of values less than 19
10% of values less than 21
50% of values less than 28
90% of values less than 32
95% of values less than 35
99% of values less than 35

Minimum 16	Maximum 43	
Mean 27.4106	Std. Dev. 4.58064	Variance 20.9822

Approx. time to Peak Conc. Mecoprop at Offsite Compliance Point [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 13
90% of values less than 1131
95% of values less than 1131
99% of values less than 1379

Minimum 0	Maximum 1523	
Mean 429.249	Std. Dev. 552.341	Variance 305081

Approx. time to Peak Conc. Naphthalene at Offsite Compliance Point [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Approx. time to Peak Conc. Nickel at Offsite Compliance Point [years]

01% of values less than 1000
05% of values less than 1000
10% of values less than 1131
50% of values less than 1681
90% of values less than 2499
95% of values less than 3046
99% of values less than 4100

Minimum 0	Maximum 8202	
Mean 1806.83	Std. Dev. 707.877	Variance 501089

Approx. time to Peak Conc. Phenols at Offsite Compliance Point [years]

01% of values less than 9
05% of values less than 10
10% of values less than 11
50% of values less than 16
90% of values less than 28
95% of values less than 13458
99% of values less than 14859

Minimum 0	Maximum 16406	
Mean 1016.44	Std. Dev. 3554.25	Variance 1.26327E+007

Approx. time to Peak Conc. Xylene at Offsite Compliance Point [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 14859	
Mean 14.8442	Std. Dev. 469.648	Variance 220569

Phase: Phase1

Source Concentration of Ammoniacal_N [mg/l]

At 30 years

01% of values less than 12.5686
05% of values less than 32.6699
10% of values less than 50.727
50% of values less than 163.76
90% of values less than 339.853
95% of values less than 397.989
99% of values less than 510.78
Minimum 2.34849 Maximum 648.713
Mean 184.192 Std. Dev. 113.175 Variance 12808.5

At 100 years

01% of values less than 10.263
05% of values less than 26.6249
10% of values less than 40.649
50% of values less than 128.515
90% of values less than 270.937
95% of values less than 319.73
99% of values less than 403.169
Minimum 1.71962 Maximum 525.316
Mean 145.398 Std. Dev. 90.6681 Variance 8220.7

At 300 years

01% of values less than 0.00076178
05% of values less than 0.00211854
10% of values less than 0.00513835
50% of values less than 0.137007
90% of values less than 1.16418
95% of values less than 1.55385
99% of values less than 2.88814
Minimum 6.11435E-005 Maximum 4.26528
Mean 0.384488 Std. Dev. 0.571405 Variance 0.326504

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 2.03092E-030
99% of values less than 7.14777E-022
Minimum 0 Maximum 3.18278E-016
Mean 4.31399E-019 Std. Dev. 1.0563E-017 Variance 1.11577E-034

Phase: Phase1

Source Concentration of Ammoniacal_N [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase1

Source Concentration of Cadmium [mg/l]

At 30 years

01% of values less than 0.000352442
05% of values less than 0.000428589
10% of values less than 0.000473573
50% of values less than 0.000650389
90% of values less than 0.000837814
95% of values less than 0.000914073
99% of values less than 0.00101534
Minimum 0.000289637 Maximum 0.00116115
Mean 0.000656158 Std. Dev. 0.000144713 Variance 2.09418E-008

At 100 years

01% of values less than 0.000340225
05% of values less than 0.000413009
10% of values less than 0.000454298
50% of values less than 0.000618567
90% of values less than 0.000795558
95% of values less than 0.000854734
99% of values less than 0.000959499
Minimum 0.000280241 Maximum 0.00110405
Mean 0.000623037 Std. Dev. 0.000133675 Variance 1.7869E-008

At 300 years

01% of values less than 5.3343E-005
05% of values less than 6.3932E-005
10% of values less than 7.57437E-005
50% of values less than 0.000151259
90% of values less than 0.000215079
95% of values less than 0.000231729
99% of values less than 0.000252234
Minimum 4.77391E-005 Maximum 0.000268872
Mean 0.000148874 Std. Dev. 5.24383E-005 Variance 2.74977E-009

At 1000 years

01% of values less than 9.6764E-026
05% of values less than 2.27215E-023
10% of values less than 1.19482E-021
50% of values less than 2.40658E-015
90% of values less than 1.89085E-011
95% of values less than 3.68059E-010
99% of values less than 1.80762E-008
Minimum 9.05815E-029 Maximum 7.98644E-007
Mean 1.41744E-009 Std. Dev. 2.59327E-008 Variance 6.72506E-016

Phase: Phase1

Source Concentration of Cadmium [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Phase: Phase1

Source Concentration of Chloride [mg/l]

At 30 years

01% of values less than 45.9631
05% of values less than 73.1524
10% of values less than 94.7391
50% of values less than 214.71
90% of values less than 430.467
95% of values less than 509.564
99% of values less than 625.086

Minimum 28.2718	Maximum 799.796	
Mean 243.848	Std. Dev. 135.697	Variance 18413.8

At 100 years

01% of values less than 30.8624
05% of values less than 56.8451
10% of values less than 72.4471
50% of values less than 166.212
90% of values less than 331.013
95% of values less than 382.967
99% of values less than 503.972

Minimum 20.5833	Maximum 643.216	
Mean 186.158	Std. Dev. 103.478	Variance 10707.7

At 300 years

01% of values less than 0.000345724
05% of values less than 0.00111104
10% of values less than 0.00240538
50% of values less than 0.0996507
90% of values less than 0.644253
95% of values less than 0.926553
99% of values less than 1.54863

Minimum 0.000122277	Maximum 2.43746	
Mean 0.237481	Std. Dev. 0.340345	Variance 0.115834

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 1.01671E-023

Minimum 0	Maximum 3.91448E-018	
Mean 4.87642E-021	Std. Dev. 1.25672E-019	Variance 1.57934E-038

Phase: Phase1

Source Concentration of Chloride [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase1

Source Concentration of Mecoprop [mg/l]

At 30 years

01% of values less than 0.000132395
05% of values less than 0.000212254
10% of values less than 0.000316284
50% of values less than 0.00170219
90% of values less than 0.0131968
95% of values less than 0.0239183
99% of values less than 0.0595426
Minimum 0.000102011 Maximum 0.0837802
Mean 0.00544516 Std. Dev. 0.0103544 Variance 0.000107213

At 100 years

01% of values less than 0.000103523
05% of values less than 0.000168119
10% of values less than 0.000248326
50% of values less than 0.00134548
90% of values less than 0.0102629
95% of values less than 0.0191704
99% of values less than 0.0490159
Minimum 7.87333E-005 Maximum 0.0680944
Mean 0.00432607 Std. Dev. 0.00823134 Variance 6.77549E-005

At 300 years

01% of values less than 5.83773E-009
05% of values less than 2.55372E-008
10% of values less than 6.01773E-008
50% of values less than 2.16096E-006
90% of values less than 2.68803E-005
95% of values less than 6.63591E-005
99% of values less than 0.000171699
Minimum 1.89187E-009 Maximum 0.000493986
Mean 1.2605E-005 Std. Dev. 3.63908E-005 Variance 1.32429E-009

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 5.34584E-026
Minimum 0 Maximum 2.3586E-020
Mean 4.85108E-023 Std. Dev. 1.01335E-021 Variance 1.02688E-042

Phase: Phase1

Source Concentration of Mecoprop [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Phase: Phase1

Source Concentration of Naphthalene [mg/l]

At 30 years

01% of values less than 3.15155E-005
05% of values less than 4.42643E-005
10% of values less than 5.2858E-005
50% of values less than 0.000115133
90% of values less than 0.000219146
95% of values less than 0.000252232
99% of values less than 0.000313289

Minimum 1.86976E-005	Maximum 0.000449963	
Mean 0.000128467	Std. Dev. 6.56217E-005	Variance 4.3062E-009

At 100 years

01% of values less than 2.46214E-007
05% of values less than 3.45815E-007
10% of values less than 4.12953E-007
50% of values less than 8.99477E-007
90% of values less than 1.71208E-006
95% of values less than 1.97056E-006
99% of values less than 2.44757E-006

Minimum 1.46075E-007	Maximum 3.51533E-006	
Mean 1.00365E-006	Std. Dev. 5.12669E-007	Variance 2.6283E-013

At 300 years

01% of values less than 2.34808E-013
05% of values less than 3.29795E-013
10% of values less than 3.93823E-013
50% of values less than 8.57809E-013
90% of values less than 1.63277E-012
95% of values less than 1.87927E-012
99% of values less than 2.33418E-012

Minimum 1.39308E-013	Maximum 3.35248E-012	
Mean 9.57154E-013	Std. Dev. 4.8892E-013	Variance 2.39042E-025

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase1

Source Concentration of Naphthalene [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Phase: Phase1

Source Concentration of Nickel [mg/l]

At 30 years
01% of values less than 0.0178354
05% of values less than 0.0249342
10% of values less than 0.030036
50% of values less than 0.0531327
90% of values less than 0.0810817
95% of values less than 0.0883195
99% of values less than 0.108187
Minimum 0.0103086 Maximum 0.13085
Mean 0.0545957 Std. Dev. 0.0198977 Variance 0.000395919

At 100 years
01% of values less than 0.0168962
05% of values less than 0.0233807
10% of values less than 0.0274672
50% of values less than 0.0480436
90% of values less than 0.072848
95% of values less than 0.0797277
99% of values less than 0.0949752
Minimum 0.00997511 Maximum 0.116669
Mean 0.0491841 Std. Dev. 0.0173513 Variance 0.000301066

At 300 years
01% of values less than 0.000326125
05% of values less than 0.000516429
10% of values less than 0.00076358
50% of values less than 0.00304179
90% of values less than 0.00599537
95% of values less than 0.00672574
99% of values less than 0.00748745
Minimum 0.00018168 Maximum 0.00876039
Mean 0.00320947 Std. Dev. 0.00197136 Variance 3.88627E-006

At 1000 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 1.38137E-024
90% of values less than 1.24781E-016
95% of values less than 4.62776E-014
99% of values less than 8.52839E-011
Minimum 0 Maximum 1.5975E-009
Mean 7.01124E-012 Std. Dev. 8.37987E-011 Variance 7.02222E-021

Phase: Phase1

Source Concentration of Nickel [mg/l]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase1

Source Concentration of Phenols [mg/l]

At 30 years

01% of values less than 0.0509203
05% of values less than 0.0993455
10% of values less than 0.140278
50% of values less than 0.488012
90% of values less than 1.34163
95% of values less than 1.71066
99% of values less than 2.47168
Minimum 0.0339182 Maximum 3.70955
Mean 0.646301 Std. Dev. 0.537291 Variance 0.288681

At 100 years

01% of values less than 0.000397815
05% of values less than 0.000776136
10% of values less than 0.00109592
50% of values less than 0.00381259
90% of values less than 0.0104815
95% of values less than 0.0133646
99% of values less than 0.01931
Minimum 0.000264986 Maximum 0.0289809
Mean 0.00504922 Std. Dev. 0.00419758 Variance 1.76197E-005

At 300 years

01% of values less than 3.79386E-010
05% of values less than 7.40181E-010
10% of values less than 1.04515E-009
50% of values less than 3.63597E-009
90% of values less than 9.99594E-009
95% of values less than 1.27454E-008
99% of values less than 1.84154E-008
Minimum 2.5271E-010 Maximum 2.76383E-008
Mean 4.81531E-009 Std. Dev. 4.00313E-009 Variance 1.6025E-017

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 3.07979E-030
90% of values less than 8.46689E-030
95% of values less than 1.07958E-029
99% of values less than 1.55985E-029
Minimum 0 Maximum 2.34106E-029
Mean 3.99524E-030 Std. Dev. 3.48008E-030 Variance 1.2111E-059

Phase: Phase1

Source Concentration of Phenols [mg/l]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase1

Source Concentration of Xylene [mg/l]

At 30 years

01% of values less than 0.000145562
05% of values less than 0.000193358
10% of values less than 0.000269101
50% of values less than 0.000821501
90% of values less than 0.00136131
95% of values less than 0.00142186
99% of values less than 0.00148565

Minimum 0.000128105 Maximum 0.00149824
Mean 0.000814323 Std. Dev. 0.000395976 Variance 1.56797E-007

At 100 years

01% of values less than 1.1372E-006
05% of values less than 1.51061E-006
10% of values less than 2.10235E-006
50% of values less than 6.41798E-006
90% of values less than 1.06353E-005
95% of values less than 1.11083E-005
99% of values less than 1.16066E-005

Minimum 1.00082E-006 Maximum 1.1705E-005
Mean 6.3619E-006 Std. Dev. 3.09356E-006 Variance 9.57013E-012

At 300 years

01% of values less than 1.08452E-012
05% of values less than 1.44063E-012
10% of values less than 2.00496E-012
50% of values less than 6.12066E-012
90% of values less than 1.01426E-011
95% of values less than 1.05937E-011
99% of values less than 1.10689E-011

Minimum 9.54459E-013 Maximum 1.11627E-011
Mean 6.06718E-012 Std. Dev. 2.95025E-012 Variance 8.70398E-024

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Phase: Phase1

Source Concentration of Xylene [mg/l]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Phase: Phase1

Concentration of Ammoniacal_N at base of Unsaturated Zone [mg/l]

At 30 years

01% of values less than 11.8941
05% of values less than 32.3672
10% of values less than 50.4491
50% of values less than 163.634
90% of values less than 338.979
95% of values less than 397.54
99% of values less than 499.544

Minimum 2.32137	Maximum 646.073	
Mean 182.9	Std. Dev. 112.063	Variance 12558.1

At 100 years

01% of values less than 10.3026
05% of values less than 27.0921
10% of values less than 42.5662
50% of values less than 138.16
90% of values less than 291.664
95% of values less than 339.059
99% of values less than 435.308

Minimum 1.9004	Maximum 543.857	
Mean 156.375	Std. Dev. 96.5048	Variance 9313.19

At 300 years

01% of values less than 0.351541
05% of values less than 0.954524
10% of values less than 1.55277
50% of values less than 8.01348
90% of values less than 26.9147
95% of values less than 34.5956
99% of values less than 51.1151

Minimum 0.055442	Maximum 74.946	
Mean 11.7993	Std. Dev. 11.2386	Variance 126.306

At 1000 years

01% of values less than 0
05% of values less than 2.25447E-008
10% of values less than 7.71486E-008
50% of values less than 1.68494E-006
90% of values less than 9.33999E-006
95% of values less than 1.31902E-005
99% of values less than 2.01432E-005

Minimum 0	Maximum 2.95863E-005	
Mean 3.36516E-006	Std. Dev. 4.42416E-006	Variance 1.95732E-011

Phase: Phase1

Concentration of Ammoniacal_N at base of Unsaturated Zone [mg/l]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 2.5321E-016
50% of values less than 2.40575E-014
90% of values less than 1.17917E-013
95% of values less than 1.84507E-013
99% of values less than 3.96149E-013

Minimum 0	Maximum 1.05848E-012	
Mean 4.89189E-014	Std. Dev. 8.31103E-014	Variance 6.90733E-027

Phase: Phase1

Concentration of Cadmium at base of Unsaturated Zone [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 8.1843E-009
99% of values less than 0.000351819

Minimum 0	Maximum 0.000581449	
Mean 6.23415E-006	Std. Dev. 5.04802E-005	Variance 2.54825E-009

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 3.90981E-008
95% of values less than 4.05726E-005
99% of values less than 0.000534866

Minimum 0	Maximum 0.000902912	
Mean 1.61913E-005	Std. Dev. 8.32255E-005	Variance 6.92648E-009

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 9.13185E-005
95% of values less than 0.000332895
99% of values less than 0.000521534

Minimum 0	Maximum 0.000764817	
Mean 3.68019E-005	Std. Dev. 0.000113312	Variance 1.28396E-008

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 2.30295E-010
90% of values less than 3.05415E-005
95% of values less than 4.34274E-005
99% of values less than 7.39984E-005

Minimum 0	Maximum 0.000124159	
Mean 8.38942E-006	Std. Dev. 1.68343E-005	Variance 2.83394E-010

Phase: Phase1

Concentration of Cadmium at base of Unsaturated Zone [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 5.97934E-019

90% of values less than 1.38964E-011

95% of values less than 3.1081E-010

99% of values less than 1.82983E-007

Minimum 0	Maximum 1.61108E-006	
Mean 8.25621E-009	Std. Dev. 8.28585E-008	Variance 6.86553E-015

Phase: Phase1

Concentration of Chloride at base of Unsaturated Zone [mg/l]

At 30 years

01% of values less than 47.1261
05% of values less than 75.7478
10% of values less than 96.5468
50% of values less than 220.305
90% of values less than 443.483
95% of values less than 525.728
99% of values less than 650.42

Minimum 29.0894	Maximum 817.22	
Mean 251.267	Std. Dev. 140.053	Variance 19614.7

At 100 years

01% of values less than 36.5084
05% of values less than 64.0504
10% of values less than 80.775
50% of values less than 186.477
90% of values less than 370.527
95% of values less than 434.819
99% of values less than 559.823

Minimum 23.9129	Maximum 702.239	
Mean 209.543	Std. Dev. 116.341	Variance 13535.2

At 300 years

01% of values less than 0.521424
05% of values less than 1.03832
10% of values less than 1.55964
50% of values less than 7.86309
90% of values less than 23.3892
95% of values less than 28.6454
99% of values less than 42.746

Minimum 0.107965	Maximum 61.1075	
Mean 10.4864	Std. Dev. 9.62018	Variance 92.5478

At 1000 years

01% of values less than 0
05% of values less than 4.25016E-009
10% of values less than 3.32472E-008
50% of values less than 1.12302E-006
90% of values less than 6.97396E-006
95% of values less than 8.96596E-006
99% of values less than 1.61916E-005

Minimum 0	Maximum 3.9389E-005	
Mean 2.49584E-006	Std. Dev. 3.67869E-006	Variance 1.35327E-011

Phase: Phase1

Concentration of Chloride at base of Unsaturated Zone [mg/l]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 2.36851E-015
50% of values less than 3.26724E-014
90% of values less than 1.46361E-013
95% of values less than 2.21512E-013
99% of values less than 5.96175E-013

Minimum 0	Maximum 1.67028E-012	
Mean 6.88116E-014	Std. Dev. 1.33648E-013	Variance 1.78618E-026

Phase: Phase1

Concentration of Mecoprop at base of Unsaturated Zone [mg/l]

At 30 years

01% of values less than 6.22344E-009
05% of values less than 1.27887E-006
10% of values less than 9.75729E-006
50% of values less than 0.000356192
90% of values less than 0.00409782
95% of values less than 0.00875294
99% of values less than 0.0215209

Minimum 0	Maximum 0.0651131	
Mean 0.00168103	Std. Dev. 0.0043239	Variance 1.86961E-005

At 100 years

01% of values less than 5.32202E-009
05% of values less than 1.11937E-006
10% of values less than 8.85239E-006
50% of values less than 0.000310907
90% of values less than 0.00350034
95% of values less than 0.00726729
99% of values less than 0.0184554

Minimum 0	Maximum 0.0562699	
Mean 0.00143773	Std. Dev. 0.00370521	Variance 1.37286E-005

At 300 years

01% of values less than 3.59584E-010
05% of values less than 9.24664E-008
10% of values less than 3.99196E-007
50% of values less than 1.87036E-005
90% of values less than 0.00022924
95% of values less than 0.000485555
99% of values less than 0.00113367

Minimum 0	Maximum 0.00354475	
Mean 0.000100577	Std. Dev. 0.000269519	Variance 7.26405E-008

At 1000 years

01% of values less than 0
05% of values less than 3.07E-016
10% of values less than 2.39173E-014
50% of values less than 3.49701E-012
90% of values less than 6.11029E-011
95% of values less than 1.62072E-010
99% of values less than 4.27764E-010

Minimum 0	Maximum 1.7748E-009	
Mean 3.30996E-011	Std. Dev. 1.16753E-010	Variance 1.36313E-020

Phase: Phase1

Concentration of Mecoprop at base of Unsaturated Zone [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 7.5806E-019

95% of values less than 1.61166E-018

99% of values less than 5.72051E-018

Minimum 0 Maximum 1.87419E-017

Mean 3.56344E-019 Std. Dev. 1.40995E-018 Variance 1.98797E-036

Phase: Phase1

Concentration of Naphthalene at base of Unsaturated Zone [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 3.5796E-014
50% of values less than 5.14664E-008
90% of values less than 3.91522E-005
95% of values less than 8.0555E-005
99% of values less than 0.000195578
Minimum 0 | Maximum 0.000325415
Mean 1.2905E-005 | Std. Dev. 3.59588E-005 | Variance 1.29304E-009

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 7.24589E-016
50% of values less than 2.09293E-009
90% of values less than 1.70701E-006
95% of values less than 3.51499E-006
99% of values less than 8.06243E-006
Minimum 0 | Maximum 1.23757E-005
Mean 5.51123E-007 | Std. Dev. 1.52191E-006 | Variance 2.3162E-012

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 3.35021E-013
90% of values less than 2.54397E-010
95% of values less than 5.5689E-010
99% of values less than 1.23231E-009
Minimum 0 | Maximum 1.72036E-009
Mean 8.56421E-011 | Std. Dev. 2.3507E-010 | Variance 5.52581E-020

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 3.03965E-018
99% of values less than 4.94295E-017
Minimum 0 | Maximum 3.53045E-015
Mean 8.76668E-018 | Std. Dev. 1.33722E-016 | Variance 1.78817E-032

Phase: Phase1

Concentration of Naphthalene at base of Unsaturated Zone [mg/l]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 1.33657E-019

Minimum 0 Maximum 1.13334E-018
Mean 3.82824E-021 Std. Dev. 4.15843E-020 Variance 1.72925E-039

Phase: Phase1

Concentration of Nickel at base of Unsaturated Zone [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 4.90176E-013
90% of values less than 0.0391239
95% of values less than 0.056437
99% of values less than 0.0845055

Minimum 0	Maximum 0.1083	
Mean 0.0086549	Std. Dev. 0.0195876	Variance 0.000383676

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0.0187327
90% of values less than 0.0644033
95% of values less than 0.0738958
99% of values less than 0.0868447

Minimum 0	Maximum 0.105685	
Mean 0.0260648	Std. Dev. 0.026594	Variance 0.000707242

At 300 years

01% of values less than 6.89761E-009
05% of values less than 0.0090576
10% of values less than 0.0109929
50% of values less than 0.0248172
90% of values less than 0.0521841
95% of values less than 0.0614307
99% of values less than 0.0843146

Minimum 0	Maximum 0.116302	
Mean 0.0286092	Std. Dev. 0.0174034	Variance 0.00030288

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 5.20856E-009
90% of values less than 1.64887E-006
95% of values less than 1.45909E-005
99% of values less than 0.000494416

Minimum 0	Maximum 0.00440983	
Mean 2.25199E-005	Std. Dev. 0.00020367	Variance 4.14815E-008

Phase: Phase1

Concentration of Nickel at base of Unsaturated Zone [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 2.84241E-018

90% of values less than 2.38071E-017

95% of values less than 4.94032E-017

99% of values less than 1.49529E-016

Minimum 0 Maximum 3.96563E-016

Mean 1.10446E-017 Std. Dev. 2.76871E-017 Variance 7.66575E-034

Phase: Phase1

Concentration of Phenols at base of Unsaturated Zone [mg/l]

At 30 years

01% of values less than 0.00931326
05% of values less than 0.0632033
10% of values less than 0.0987092
50% of values less than 0.466634
90% of values less than 1.52903
95% of values less than 2.08019
99% of values less than 3.1089

Minimum 4.57721E-005	Maximum 4.57345	
Mean 0.68073	Std. Dev. 0.669064	Variance 0.447646

At 100 years

01% of values less than 0.000411087
05% of values less than 0.00271848
10% of values less than 0.0040861
50% of values less than 0.0193465
90% of values less than 0.0649201
95% of values less than 0.0873348
99% of values less than 0.135096

Minimum 2.01782E-006	Maximum 0.200178	
Mean 0.0286314	Std. Dev. 0.0283947	Variance 0.000806257

At 300 years

01% of values less than 6.20741E-008
05% of values less than 4.0236E-007
10% of values less than 6.26772E-007
50% of values less than 2.91071E-006
90% of values less than 1.0202E-005
95% of values less than 1.37349E-005
99% of values less than 2.07937E-005

Minimum 3.35145E-010	Maximum 3.21994E-005	
Mean 4.44509E-006	Std. Dev. 4.51962E-006	Variance 2.0427E-011

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 1.62634E-012
95% of values less than 3.94912E-012
99% of values less than 1.48937E-011

Minimum 0	Maximum 9.4199E-011	
Mean 8.97803E-013	Std. Dev. 4.49855E-012	Variance 2.0237E-023

Phase: Phase1

Concentration of Phenols at base of Unsaturated Zone [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 3.61512E-018

50% of values less than 1.92159E-016

90% of values less than 1.11152E-015

95% of values less than 1.47998E-015

99% of values less than 2.38631E-015

Minimum 0	Maximum 8.3782E-015	
Mean 4.07271E-016	Std. Dev. 6.23347E-016	Variance 3.88561E-031

Phase: Phase1

Concentration of Xylene at base of Unsaturated Zone [mg/l]

At 30 years
01% of values less than 0
05% of values less than 0
10% of values less than 4.66167E-013
50% of values less than 1.04165E-006
90% of values less than 0.000326524
95% of values less than 0.000667679
99% of values less than 0.00145136
Minimum 0 Maximum 0.00200377
Mean 0.000102319 Std. Dev. 0.000271787 Variance 7.3868E-008

At 100 years
01% of values less than 0
05% of values less than 5.85172E-016
10% of values less than 1.77048E-013
50% of values less than 3.62555E-008
90% of values less than 1.41257E-005
95% of values less than 2.93578E-005
99% of values less than 6.20201E-005
Minimum 0 Maximum 8.87669E-005
Mean 4.39061E-006 Std. Dev. 1.15971E-005 Variance 1.34493E-010

At 300 years
01% of values less than 0
05% of values less than 0
10% of values less than 1.49886E-017
50% of values less than 5.81321E-012
90% of values less than 2.24182E-009
95% of values less than 4.66411E-009
99% of values less than 9.49518E-009
Minimum 0 Maximum 1.41193E-008
Mean 6.8707E-010 Std. Dev. 1.80026E-009 Variance 3.24092E-018

At 1000 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 1.38428E-017
95% of values less than 6.47466E-017
99% of values less than 9.06755E-016
Minimum 0 Maximum 4.91588E-015
Mean 3.60325E-017 Std. Dev. 2.76993E-016 Variance 7.67249E-032

Phase: Phase1

Concentration of Xylene at base of Unsaturated Zone [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 1.11283E-019

95% of values less than 2.94143E-019

99% of values less than 9.30886E-019

Minimum 0 Maximum 3.54374E-018

Mean 4.76556E-020 Std. Dev. 1.97723E-019 Variance 3.90942E-038

Phase: Phase1

Approx. time to Peak Conc. Ammoniacal_N at Base of Unsaturated Zone [years]

01% of values less than 5
05% of values less than 6
10% of values less than 6
50% of values less than 6
90% of values less than 7
95% of values less than 7
99% of values less than 9

Minimum 4	Maximum 16	
Mean 6.16783	Std. Dev. 0.786005	Variance 0.617804

Approx. time to Peak Conc. Cadmium at Base of Unsaturated Zone [years]

01% of values less than 190
05% of values less than 312
10% of values less than 380
50% of values less than 2263
90% of values less than 6728
95% of values less than 9056
99% of values less than 14859

Minimum 39	Maximum 20000	
Mean 3150.12	Std. Dev. 3119.45	Variance 9.73095E+006

Approx. time to Peak Conc. Chloride at Base of Unsaturated Zone [years]

01% of values less than 5
05% of values less than 5
10% of values less than 6
50% of values less than 6
90% of values less than 6
95% of values less than 6
99% of values less than 7

Minimum 3	Maximum 16	
Mean 5.97203	Std. Dev. 0.470337	Variance 0.221217

Approx. time to Peak Conc. Mecoprop at Base of Unsaturated Zone [years]

01% of values less than 5
05% of values less than 6
10% of values less than 6
50% of values less than 6
90% of values less than 6
95% of values less than 7
99% of values less than 9

Minimum 0	Maximum 17	
Mean 6.07093	Std. Dev. 0.616412	Variance 0.379964

Approx. time to Peak Conc. Naphthalene at Base of Unsaturated Zone [years]

01% of values less than 0
05% of values less than 6
10% of values less than 6
50% of values less than 13
90% of values less than 26
95% of values less than 32
99% of values less than 35

Phase: Phase1

Approx. time to Peak Conc. Naphthalene at Base of Unsaturated Zone [years]

01% of values less than 0
05% of values less than 6
10% of values less than 6
50% of values less than 13
90% of values less than 26
95% of values less than 32
99% of values less than 35
Minimum 0 Maximum 39
Mean 14.1119 Std. Dev. 8.07177 Variance 65.1535

Approx. time to Peak Conc. Nickel at Base of Unsaturated Zone [years]

01% of values less than 17
05% of values less than 35
10% of values less than 52
50% of values less than 156
90% of values less than 282
95% of values less than 344
99% of values less than 512
Minimum 7 Maximum 761
Mean 168.097 Std. Dev. 105.185 Variance 11063.9

Approx. time to Peak Conc. Phenols at Base of Unsaturated Zone [years]

01% of values less than 5
05% of values less than 5
10% of values less than 5
50% of values less than 6
90% of values less than 6
95% of values less than 6
99% of values less than 10
Minimum 4 Maximum 16
Mean 6.01598 Std. Dev. 0.806067 Variance 0.649744

Approx. time to Peak Conc. Xylene at Base of Unsaturated Zone [years]

01% of values less than 0
05% of values less than 6
10% of values less than 7
50% of values less than 16
90% of values less than 32
95% of values less than 39
99% of values less than 47
Minimum 0 Maximum 57
Mean 17.6474 Std. Dev. 10.6976 Variance 114.439

Phase: Phase1

Concentration of Ammoniacal_N at Phase Monitor Well [mg/l]

At 30 years

01% of values less than 0.10548
05% of values less than 0.382786
10% of values less than 0.698586
50% of values less than 3.73278
90% of values less than 13.171
95% of values less than 16.9184
99% of values less than 25.6012

Minimum 0.0104705	Maximum 40.4485	
Mean 5.55202	Std. Dev. 5.59382	Variance 31.2908

At 100 years

01% of values less than 0.144197
05% of values less than 0.554243
10% of values less than 0.851261
50% of values less than 3.59622
90% of values less than 11.6409
95% of values less than 15.2468
99% of values less than 22.3195

Minimum 0.0727308	Maximum 35.9046	
Mean 5.1635	Std. Dev. 4.85033	Variance 23.5257

At 300 years

01% of values less than 0.0141112
05% of values less than 0.0569716
10% of values less than 0.0902768
50% of values less than 0.42309
90% of values less than 1.6032
95% of values less than 2.23551
99% of values less than 3.31354

Minimum 0.00317498	Maximum 4.50798	
Mean 0.672388	Std. Dev. 0.703137	Variance 0.494401

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase1

Concentration of Ammoniacal_N at Phase Monitor Well [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Phase: Phase1

Concentration of Cadmium at Phase Monitor Well [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 1.95179E-018
Mean 6.48017E-021 Std. Dev. 8.97755E-020 Variance 8.05963E-039

Phase: Phase1

Concentration of Cadmium at Phase Monitor Well [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 1.63143E-008

90% of values less than 1.34069E-007

95% of values less than 1.83425E-007

99% of values less than 3.09257E-007

Minimum 0	Maximum 4.65005E-007	
Mean 4.72278E-008	Std. Dev. 6.94553E-008	Variance 4.82404E-015

Phase: Phase1

Concentration of Chloride at Phase Monitor Well [mg/l]

At 30 years

01% of values less than 6.61375
05% of values less than 10.24
10% of values less than 13.0893
50% of values less than 30.2485
90% of values less than 58.3813
95% of values less than 71.3776
99% of values less than 94.5971
Minimum 3.55351 Maximum 118.784
Mean 34.0501 Std. Dev. 19.2597 Variance 370.935

At 100 years

01% of values less than 5.1946
05% of values less than 8.68209
10% of values less than 11.3079
50% of values less than 25.8221
90% of values less than 49.949
95% of values less than 60.007
99% of values less than 77.9475
Minimum 2.93047 Maximum 103.007
Mean 28.9607 Std. Dev. 16.2922 Variance 265.436

At 300 years

01% of values less than 0.192732
05% of values less than 0.360682
10% of values less than 0.512051
50% of values less than 2.06612
90% of values less than 5.29856
95% of values less than 6.94378
99% of values less than 9.97361
Minimum 0.0405416 Maximum 13.4172
Mean 2.58085 Std. Dev. 2.13514 Variance 4.55884

At 1000 years

01% of values less than 0
05% of values less than 1.14428E-008
10% of values less than 3.51938E-008
50% of values less than 1.03041E-006
90% of values less than 4.5712E-006
95% of values less than 6.07152E-006
99% of values less than 9.73543E-006
Minimum 0 Maximum 1.46855E-005
Mean 1.75757E-006 Std. Dev. 2.18017E-006 Variance 4.75314E-012

Phase: Phase1

Concentration of Chloride at Phase Monitor Well [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Phase: Phase1

Concentration of Mecoprop at Phase Monitor Well [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 3.35671E-013
90% of values less than 1.18538E-009
95% of values less than 4.87574E-009
99% of values less than 4.73385E-008

Minimum 0	Maximum 1.24226E-007	
Mean 1.48593E-009	Std. Dev. 8.23963E-009	Variance 6.78914E-017

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 2.89455E-013
90% of values less than 1.04164E-009
95% of values less than 4.31797E-009
99% of values less than 3.91755E-008

Minimum 0	Maximum 1.02491E-007	
Mean 1.28426E-009	Std. Dev. 7.08017E-009	Variance 5.01289E-017

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 8.60689E-015
90% of values less than 9.35045E-011
95% of values less than 3.19861E-010
99% of values less than 2.35727E-009

Minimum 0	Maximum 1.21276E-008	
Mean 1.1333E-010	Std. Dev. 7.26231E-010	Variance 5.27412E-019

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase1

Concentration of Mecoprop at Phase Monitor Well [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Phase: Phase1

Concentration of Naphthalene at Phase Monitor Well [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 1.71102E-017

Minimum 0	Maximum 1.85897E-015	
Mean 4.60471E-018	Std. Dev. 7.53451E-017	Variance 5.67688E-033

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 9.54272E-019

Minimum 0	Maximum 1.05111E-016	
Mean 2.58162E-019	Std. Dev. 4.29955E-018	Variance 1.84861E-035

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase1

Concentration of Naphthalene at Phase Monitor Well [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Phase: Phase1

Concentration of Nickel at Phase Monitor Well [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 4.38529E-016
95% of values less than 6.06997E-016
99% of values less than 7.85965E-016

Minimum 0	Maximum 1.00712E-015	
Mean 1.08693E-016	Std. Dev. 2.0734E-016	Variance 4.29899E-032

At 300 years

01% of values less than 0
05% of values less than 4.8961E-018
10% of values less than 5.453E-017
50% of values less than 8.06656E-016
90% of values less than 1.41744E-009
95% of values less than 7.51647E-009
99% of values less than 3.84683E-008

Minimum 0	Maximum 1.7929E-007	
Mean 1.73176E-009	Std. Dev. 9.63451E-009	Variance 9.28238E-017

At 1000 years

01% of values less than 0
05% of values less than 7.53443E-016
10% of values less than 3.26266E-012
50% of values less than 1.27252E-005
90% of values less than 9.15381E-005
95% of values less than 0.000118032
99% of values less than 0.000181376

Minimum 0	Maximum 0.000259786	
Mean 3.07163E-005	Std. Dev. 4.22529E-005	Variance 1.78531E-009

Phase: Phase1

Concentration of Nickel at Phase Monitor Well [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Phase: Phase1

Concentration of Phenols at Phase Monitor Well [mg/l]

At 30 years

01% of values less than 2.54366E-015
05% of values less than 3.09475E-011
10% of values less than 1.86502E-009
50% of values less than 6.4336E-006
90% of values less than 0.000271451
95% of values less than 0.000483385
99% of values less than 0.00151271

Minimum 0	Maximum 0.00522763	
Mean 0.000103992	Std. Dev. 0.000329154	Variance 1.08342E-007

At 100 years

01% of values less than 1.14003E-016
05% of values less than 1.42518E-012
10% of values less than 9.87257E-011
50% of values less than 3.5609E-007
90% of values less than 1.52746E-005
95% of values less than 2.67315E-005
99% of values less than 7.86905E-005

Minimum 0	Maximum 0.000311157	
Mean 5.85321E-006	Std. Dev. 1.89858E-005	Variance 3.60462E-010

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 1.55564E-012
90% of values less than 1.78919E-009
95% of values less than 3.78185E-009
99% of values less than 1.2665E-008

Minimum 0	Maximum 6.38082E-008	
Mean 7.90315E-010	Std. Dev. 3.35863E-009	Variance 1.12804E-017

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase1

Concentration of Phenols at Phase Monitor Well [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 1.21151E-018

Minimum 0	Maximum 1.23932E-017	
Mean 6.2944E-020	Std. Dev. 6.77347E-019	Variance 4.58799E-037

Phase: Phase1

Concentration of Xylene at Phase Monitor Well [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 1.00609E-018
99% of values less than 1.22323E-015

Minimum 0	Maximum 1.24203E-013	
Mean 3.95993E-016	Std. Dev. 5.88055E-015	Variance 3.45809E-029

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 7.3958E-017

Minimum 0	Maximum 7.20795E-015	
Mean 2.32062E-017	Std. Dev. 3.42381E-016	Variance 1.17225E-031

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase1

Concentration of Xylene at Phase Monitor Well [mg/l]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase1

Approx. time to Peak Conc. Ammoniacal_N at Phase Monitor Well [years]

01% of values less than 21
05% of values less than 23
10% of values less than 26
50% of values less than 39
90% of values less than 52
95% of values less than 52
99% of values less than 57

Minimum 16	Maximum 64	
Mean 38.2298	Std. Dev. 8.71408	Variance 75.9352

Approx. time to Peak Conc. Cadmium at Phase Monitor Well [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 9056
90% of values less than 18114
95% of values less than 20000
99% of values less than 20000

Minimum 0	Maximum 20000	
Mean 8837.58	Std. Dev. 6090.44	Variance 3.70935E+007

Approx. time to Peak Conc. Chloride at Phase Monitor Well [years]

01% of values less than 13
05% of values less than 16
10% of values less than 16
50% of values less than 21
90% of values less than 26
95% of values less than 28
99% of values less than 30

Minimum 13	Maximum 32	
Mean 21.5245	Std. Dev. 3.95394	Variance 15.6337

Approx. time to Peak Conc. Mecoprop at Phase Monitor Well [years]

01% of values less than 0
05% of values less than 0
10% of values less than 7
50% of values less than 10
90% of values less than 1131
95% of values less than 1131
99% of values less than 1249

Minimum 0	Maximum 1379	
Mean 215.254	Std. Dev. 438.451	Variance 192239

Phase: Phase1

Approx. time to Peak Conc. Naphthalene at Phase Monitor Well [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 26

Minimum 0	Maximum 28	
Mean 0.572428	Std. Dev. 3.745	Variance 14.025

Approx. time to Peak Conc. Nickel at Phase Monitor Well [years]

01% of values less than 1000
05% of values less than 1131
10% of values less than 1131
50% of values less than 1379
90% of values less than 1681
95% of values less than 1681
99% of values less than 3046

Minimum 380	Maximum 5519	
Mean 1458.48	Std. Dev. 382.793	Variance 146531

Approx. time to Peak Conc. Phenols at Phase Monitor Well [years]

01% of values less than 8
05% of values less than 9
10% of values less than 9
50% of values less than 11
90% of values less than 16
95% of values less than 19
99% of values less than 28

Minimum 6	Maximum 14859	
Mean 69.1409	Std. Dev. 798.043	Variance 636873

Approx. time to Peak Conc. Xylene at Phase Monitor Well [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 32
99% of values less than 39

Minimum 0	Maximum 11039	
Mean 13.2008	Std. Dev. 348.943	Variance 121761

Phase: Phase1

Flow to Leachate Treatment Plant [l/day]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Phase: Phase1

Flow to Leachate Treatment Plant [l/day]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase1

Head on EBS [m]

At 1000 years

01% of values less than 1.001E-010
05% of values less than 1.001E-010
10% of values less than 1.001E-010
50% of values less than 1.001E-010
90% of values less than 1.001E-010
95% of values less than 1.001E-010
99% of values less than 1.001E-010

Minimum 1.001E-010	Maximum 1.001E-010	
Mean 1.001E-010	Std. Dev. 1.15746E-017	Variance 1.33972E-034

At infinity

01% of values less than 1.001E-010
05% of values less than 1.001E-010
10% of values less than 1.001E-010
50% of values less than 1.001E-010
90% of values less than 1.001E-010
95% of values less than 1.001E-010
99% of values less than 1.001E-010

Minimum 1.001E-010	Maximum 1.001E-010	
Mean 1.001E-010	Std. Dev. 1.15746E-017	Variance 1.33972E-034

Phase: Phase1

Surface Breakout [l/day]

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase1

Leakage through EBS [l/day]

At 100 years

01% of values less than 13273.1
05% of values less than 13273.1
10% of values less than 13273.1
50% of values less than 13273.1
90% of values less than 13273.1
95% of values less than 13273.1
99% of values less than 13273.1

Minimum 13273.1	Maximum 13273.1	
Mean 13273.1	Std. Dev. 0.00255435	Variance 6.52473E-006

At 300 years

01% of values less than 20433.5
05% of values less than 20433.5
10% of values less than 20433.5
50% of values less than 20433.5
90% of values less than 20433.5
95% of values less than 20433.5
99% of values less than 20433.5

Minimum 20433.5	Maximum 20433.5	
Mean 20433.5	Std. Dev. 0.000612066	Variance -3.74625E-007

At 1000 years

01% of values less than 118573
05% of values less than 118573
10% of values less than 118573
50% of values less than 118573
90% of values less than 118573
95% of values less than 118573
99% of values less than 118573

Minimum 118573	Maximum 118573	
Mean 118573	Std. Dev. 0.0177112	Variance 0.000313686

At infinity

01% of values less than 294795
05% of values less than 401107
10% of values less than 594196
50% of values less than 1.18573E+006
90% of values less than 1.18573E+006
95% of values less than 1.18573E+006
99% of values less than 1.18573E+006

Minimum 284413	Maximum 1.18573E+006	
Mean 1.07247E+006	Std. Dev. 251742	Variance 6.33738E+010

Phase: Phase1

Aquifer Flow [m³/year]

At 30 years

01% of values less than 30192.1
05% of values less than 31874.7
10% of values less than 32851.5
50% of values less than 36500.1
90% of values less than 40885.8
95% of values less than 42130.8
99% of values less than 44459.4

Minimum 0	Maximum 47561.6	
Mean 36651.1	Std. Dev. 3325.35	Variance 1.10579E+007

At 100 years

01% of values less than 30192.1
05% of values less than 31874.7
10% of values less than 32851.5
50% of values less than 36500.1
90% of values less than 40885.8
95% of values less than 42130.8
99% of values less than 44459.4

Minimum 0	Maximum 47561.6	
Mean 36651.1	Std. Dev. 3325.35	Variance 1.10579E+007

At 300 years

01% of values less than 32807.4
05% of values less than 34490.1
10% of values less than 35466.8
50% of values less than 39115.4
90% of values less than 43501.1
95% of values less than 44746.2
99% of values less than 47074.7

Minimum 0	Maximum 50176.9	
Mean 39263.8	Std. Dev. 3355.07	Variance 1.12565E+007

At 1000 years

01% of values less than 68652.9
05% of values less than 70335.5
10% of values less than 71312.3
50% of values less than 74960.9
90% of values less than 79346.6
95% of values less than 80591.6
99% of values less than 82920.2

Minimum 0	Maximum 86022.4	
Mean 75073.4	Std. Dev. 3918.54	Variance 1.5355E+007

Phase: Phase1

Aquifer Flow [m³/year]

At infinity

01% of values less than 139738
05% of values less than 178197
10% of values less than 248929
50% of values less than 463728
90% of values less than 468637
95% of values less than 470036
99% of values less than 472699

Minimum 0	Maximum 475802	
Mean 423425	Std. Dev. 92493.2	Variance 8.55499E+009

WITHYHEDGE LANDFILL

HYDROGEOLOGICAL RISK ASSESSMENT REVIEW

Report Number 2365r2v1d0524

APPENDIX 6
PHASE 2 & 3 LANDSIM MODEL INPUTS

Calculation Settings

Number of iterations: 1001

Results calculated using sampled PDFs

Full Calculation

Clay Liner:

Retarded values used for simulation

No Biodegradation

Unsaturated Pathway:

Retarded values used for simulation

Biodegradation

Saturated Vertical Pathway:

No Vertical Pathway

Aquifer Pathway:

Retarded values used for simulation

Biodegradation

Timeslices at: 30, 100, 300, 1000

Decline in Contaminant Concentration in Leachate

Ammoniacal_N — Non-Volatile
c (kg/l): 0.59 — m (kg/l): 0

Cadmium — Non-Volatile
c (kg/l): 0.1589 — m (kg/l): 0.0823

Chloride — Non-Volatile
c (kg/l): 0.2919 — m (kg/l): 0.0298

Mecoprop — Non-Volatile
c (kg/l): 0.57 — m (kg/l): 0

Naphthalene — Volatile
Half life (years): 10

Nickel — Non-Volatile
c (kg/l): -0.1479 — m (kg/l): 0.0987

Phenols — Volatile
Half life (years): 10

Xylene — Volatile
Half life (years): 10

Contaminant Half-lives (years)

Unsaturated Pathway:

Ammoniacal_N	UNIFORM(5,10)
Cadmium	SINGLE(1e+009)
Chloride	SINGLE(1e+009)
Mecoprop	UNIFORM(0.027,0.25)
Naphthalene	SINGLE(0.7)
Nickel	SINGLE(1e+009)
Phenols	UNIFORM(0.14,0.82)
Xylene	SINGLE(1)

Aquifer Pathway:

Ammoniacal_N	UNIFORM(5,10)
Cadmium	SINGLE(1e+009)
Chloride	SINGLE(1e+009)
Mecoprop	UNIFORM(0.027,0.25)
Naphthalene	SINGLE(0.7)
Nickel	SINGLE(1e+009)
Phenols	UNIFORM(0.14,0.82)
Xylene	SINGLE(1)

Background Concentrations of Contaminants

Justification for Contaminant Properties

Input values taken from SITA Valley Infill HRA (2008)

All units in milligrams per litre

Phase: Phase 2 and 3

Infiltration Information

Cap design infiltration (mm/year):	SINGLE(30)
Infiltration to waste (mm/year):	SINGLE(338)
Infiltration to grassland (mm/year):	SINGLE(268)
End of filling (years from start of waste deposit):	10
Start of cap degradation (years from end of waste deposit):	250
End of cap degradation (years from end of waste deposit):	1000

Justification for Specified Infiltration
Input values taken from Golder Phase 2 HRA (2005)

Duration of management control (years from the start of waste disposal): 100

Cell dimensions

Cell width (m):	280
Cell length (m):	500
Cell top area (ha):	15.4
Cell base area (ha):	14
Number of cells:	2
Total base area (ha):	28
Total top area (ha):	30.8001
Head of Leachate when surface water breakout occurs (m)	SINGLE(3)
Waste porosity (fraction)	UNIFORM(0.1,0.25)
Final waste thickness (m):	UNIFORM(3,27)
Field capacity (fraction):	UNIFORM(0.08,0.15)
Waste dry density (kg/l)	UNIFORM(0.8,1.07)

Justification for Landfill Geometry
Input values taken from CAD Drawing of proposed landfill

Source concentrations of contaminants

All units in milligrams per litre

Declining source term

Ammoniacal_N	LOGTRIANGULAR(10,1060,2000)
	Data are spot measurements of Leachate Quality
Cadmium	LOGTRIANGULAR(8e-005,0.0001,0.002)
	Substance to be treated as List 1
Chloride	LOGTRIANGULAR(10,1100,2600)
	Data are spot measurements of Leachate Quality
Mecoprop	LOGTRIANGULAR(0.0001,0.006,0.1)
	Data are spot measurements of Leachate Quality
Naphthalene	LOGTRIANGULAR(2e-005,0.0006,0.01)
	Data are spot measurements of Leachate Quality
Nickel	LOGTRIANGULAR(0.001,0.17,0.3)
	Data are spot measurements of Leachate Quality
Phenols	LOGTRIANGULAR(0.01,7.3,142)
	Data are spot measurements of Leachate Quality
Xylene	LOGTRIANGULAR(0.001,0.01,0.02)
	Substance to be treated as List 1

Justification for Species Concentration in Leachate
Input based on Geotechnology review of available verified dataset

Drainage Information

Fixed Head.

Head on EBS is given as (m): SINGLE(1)

Justification for Specified Head
Permit Requirement

Barrier Information

There is a composite barrier

Justification for Engineered Barrier Type
Input values taken from Golder Phase 2 HRA (2005)

Liner installed under CQA	
Design thickness of clay (m):	SINGLE(0.5)
Density of clay (kg/l):	TRIANGULAR(1.7,1.8,1.87)
Pathway moisture content (fraction):	TRIANGULAR(0.23,0.265,0.3)
Onset of FML degradation (years since filling commenced)	150
Pathway longitudinal dispersivity (m):	SINGLE(0.05)
Time for area of defects to double (years)	100

Membrane defects (number per hectare):

Pin holes:	Minimum 0, Maximum 5
Holes:	Minimum 0, Maximum 2
Tears:	Minimum 0, Most Likely 0, Maximum 0

The most likely value for the PDFs representing the density of pinholes and holes will move from the minimum value selected above to the maximum value selected above over the time period before FML degradation commences

Justification for Composite: Flexible Membrane Liner
Design adopted for whole site with permeability calculated as equivalent permeability from gcl & mineral components

Hydraulic conductivity of mineral lower liner (m/s):	SINGLE(5.4e-010)

Justification for Composite: Clay or BES Substrate Properties
Input values taken from Design of Phase 2

Retardation parameters for clay liner

Uncertainty in Kd (l/kg):	
Ammoniacal_N	TRIANGULAR(0.125,0.883,2.4)
Cadmium	LOGTRIANGULAR(127,11147,16657)
Chloride	SINGLE(0)
Mecoprop: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(11,25)
Naphthalene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1288)
Nickel	SINGLE(85.7)
Phenols: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(22,27)
Xylene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1590)
Fraction of Organic Carbon (fraction)	UNIFORM(0.001,0.004)

Justification for Liner Kd Values by Species
Input values taken from Golder Phase 2 HRA (2005) and Golders (Dec 2006).

Mydrim Shales pathway parameters

Modelled as unsaturated pathway

Pathway length (m):	SINGLE(1)
Flow Model:	porous medium
Pathway moisture content (fraction):	TRIANGULAR(0.25,0.29,0.34)
Pathway Density (kg/l):	UNIFORM(1.53,1.95)

Justification for Unsat Zone Geometry
Input values taken from Golder Phase 2 HRA afterv review of CQA Validation reports for Phase 2

Pathway hydraulic conductivity values (m/s): LOGUNIFORM(2.2e-008,4.1e-005)

Justification for Unsat Zone Hydraulics Properties
Input values taken from Golder Phase 2 HRA (2005)

Pathway longitudinal dispersivity (m): SINGLE(0.1)

Justification for Unsat Zone Dispersion Properties
Input values taken from Golder Phase 2 HRA (2005)

Retardation parameters for Mydrim Shales pathway

Modelled as unsaturated pathway	
Uncertainty in Kd (l/kg):	
Ammoniacal_N	TRIANGULAR(0.119,0.535,2.4)
Cadmium	LOGTRIANGULAR(127,11147,16657)
Chloride	SINGLE(0)
Mecoprop: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(11,25)
Naphthalene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1288)
Nickel	SINGLE(85.7)
Phenols: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(22,27)
Xylene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1590)
Fraction of Organic Carbon (fraction)	LOGTRIANGULAR(0.002,0.005,0.019)

Justification for Kd Values by Species
Input values taken from Golder Phase 2 HRA (2005)

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(100,625)
Pathway width (m):	SINGLE(610)

Mydrim Shales pathway parameters

No Vertical Pathway

Meidrim Shales pathway parameters

Modelled as aquifer pathway.

Mixing zone (m):

Calculated. Aquifer Thickness: SINGLE(10)

Justification for Aquifer Geometry

Based on engineered design and values from Golders (2005), Golders (Dec2006) and Golders (2008)

Darcy flux (m/s): LOGNORMAL(2e-007,2e-008)

Pathway porosity (fraction): TRIANGULAR(0.213,0.236,0.292)

Justification for Aquifer Hydraulics Properties

Recalculated from Water Balance with allowance for Spring Diversion

Pathway longitudinal dispersivity (m): UNIFORM(1,60)

Pathway transverse dispersivity (m): UNIFORM(0.3,20)

Justification for Aquifer Dispersion Details

Assumed 10% of flow length for longitudinal dispersivity and 3% for transverse dispersivity.

Retardation parameters for Meidrim Shales pathway

Modelled as aquifer pathway.

Uncertainty in Kd (l/kg):

Ammoniacal_N	UNIFORM(0.02647,0.6929)
Cadmium	TRIANGULAR(694,3927,3927)
Chloride	SINGLE(0)
Mecoprop: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(11,25)
Naphthalene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1288)
Nickel	SINGLE(85.7)
Phenols: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(22,27)
Xylene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1590)

Fraction of Organic Carbon (fraction) TRIANGULAR(0.002,0.005,0.019)

Justification for Aquifer Kd Values by Species

Input values from Golder Phase 1 HRA (2008)

Pathway Density (kg/l): TRIANGULAR(1.785,1.9402,1.979)

WITHYHEDGE LANDFILL

HYDROGEOLOGICAL RISK ASSESSMENT REVIEW
Report Number 2365r2v1d0524

APPENDIX 7
PHASE 2 & 3 LANDSIM MODEL OUTPUTS

Concentration of Ammoniacal_N in groundwater [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 5.03469E-017
05% of values less than 4.77135E-011
10% of values less than 9.01966E-009
50% of values less than 4.83778E-005
90% of values less than 0.00445647
95% of values less than 0.0105727
99% of values less than 0.0382551

Minimum 0	Maximum 0.160884	
Mean 0.00211743	Std. Dev. 0.00850535	Variance 7.2341E-005

At 300 years

01% of values less than 2.72946E-005
05% of values less than 0.000204561
10% of values less than 0.00057044
50% of values less than 0.0102485
90% of values less than 0.139383
95% of values less than 0.248537
99% of values less than 0.547656

Minimum 1.43501E-005	Maximum 0.984959	
Mean 0.0495041	Std. Dev. 0.107541	Variance 0.0115651

At 1000 years

01% of values less than 4.0127E-005
05% of values less than 0.000284951
10% of values less than 0.000586879
50% of values less than 0.0131407
90% of values less than 0.157622
95% of values less than 0.315481
99% of values less than 0.655027

Minimum 6.4236E-006	Maximum 1.98034	
Mean 0.0645702	Std. Dev. 0.143924	Variance 0.0207142

Concentration of Ammoniacal_N in groundwater [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 4.41996E-016

Mean 5.17555E-019 Std. Dev. 1.41732E-017 Variance 2.0088E-034

Concentration of Cadmium in groundwater [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Concentration of Cadmium in groundwater [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 3.25398E-018

Minimum 0	Maximum 7.84633E-011	
Mean 1.12586E-013	Std. Dev. 2.63252E-012	Variance 6.93017E-024

Concentration of Chloride in groundwater [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years

01% of values less than 0.0705189
05% of values less than 0.150552
10% of values less than 0.211996
50% of values less than 1.06457
90% of values less than 2.84763
95% of values less than 3.71843
99% of values less than 5.51738
Minimum 0.035152 Maximum 7.30551
Mean 1.35807 Std. Dev. 1.16572 Variance 1.35891

At 300 years

01% of values less than 0.431924
05% of values less than 0.86429
10% of values less than 1.24043
50% of values less than 5.59415
90% of values less than 14.6271
95% of values less than 18.2958
99% of values less than 23.4713
Minimum 0.117109 Maximum 30.7334
Mean 6.91951 Std. Dev. 5.51032 Variance 30.3636

At 1000 years

01% of values less than 0.0181987
05% of values less than 0.076835
10% of values less than 0.21119
50% of values less than 2.88841
90% of values less than 10.1791
95% of values less than 13.5957
99% of values less than 18.2324
Minimum 0.00292113 Maximum 27.8524
Mean 4.17761 Std. Dev. 4.35666 Variance 18.9805

Concentration of Chloride in groundwater [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 1.05014E-013

95% of values less than 2.15106E-013

99% of values less than 1.31341E-012

Minimum 0 Maximum 1.40134E-011

Mean 1.00785E-013 Std. Dev. 8.02781E-013 Variance 6.44458E-025

Concentration of Mecoprop in groundwater [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 2.27983E-017

Minimum 0	Maximum 1.75262E-015	
Mean 3.61729E-018	Std. Dev. 6.12027E-017	Variance 3.74577E-033

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 3.0756E-018
99% of values less than 1.01624E-016

Minimum 0	Maximum 5.07551E-015	
Mean 1.59174E-017	Std. Dev. 2.23088E-016	Variance 4.97682E-032

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 1.71794E-018
99% of values less than 7.73572E-017

Minimum 0	Maximum 1.47884E-015	
Mean 5.51144E-018	Std. Dev. 6.57781E-017	Variance 4.32676E-033

Concentration of Mecoprop in groundwater [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Concentration of Naphthalene in groundwater [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Concentration of Naphthalene in groundwater [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Concentration of Nickel in groundwater [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Concentration of Nickel in groundwater [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 2.13488E-007

95% of values less than 1.24696E-006

99% of values less than 4.59018E-006

Minimum 0 Maximum 1.29025E-005

Mean 2.01083E-007 Std. Dev. 9.57442E-007 Variance 9.16696E-013

Concentration of Phenols in groundwater [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 1.55262E-014
90% of values less than 1.27816E-010
95% of values less than 6.95065E-010
99% of values less than 1.04833E-008

Minimum 0	Maximum 4.43162E-008	
Mean 3.55196E-010	Std. Dev. 2.5432E-009	Variance 6.46787E-018

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 4.21676E-017
90% of values less than 3.66555E-013
95% of values less than 1.8773E-012
99% of values less than 2.11654E-011

Minimum 0	Maximum 1.08475E-010	
Mean 9.11583E-013	Std. Dev. 6.62199E-012	Variance 4.38508E-023

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 5.14709E-018

Minimum 0	Maximum 7.11923E-017	
Mean 2.76952E-019	Std. Dev. 3.12986E-018	Variance 9.79604E-036

Concentration of Phenols in groundwater [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Concentration of Xylene in groundwater [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Concentration of Xylene in groundwater [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Approx. time to Peak Conc. Ammoniacal_N at Offsite Compliance Point [years]

01% of values less than 344
05% of values less than 344
10% of values less than 380
50% of values less than 420
90% of values less than 464
95% of values less than 512
99% of values less than 565

Minimum 312	Maximum 624	
Mean 417.503	Std. Dev. 48.621	Variance 2364

Approx. time to Peak Conc. Cadmium at Offsite Compliance Point [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 20000

Minimum 0	Maximum 20000	
Mean 339.66	Std. Dev. 2585.44	Variance 6.68452E+006

Approx. time to Peak Conc. Chloride at Offsite Compliance Point [years]

01% of values less than 282
05% of values less than 282
10% of values less than 300
50% of values less than 344
90% of values less than 344
95% of values less than 344
99% of values less than 380

Minimum 282	Maximum 380	
Mean 336.825	Std. Dev. 21.5919	Variance 466.21

Approx. time to Peak Conc. Mecoprop at Offsite Compliance Point [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 312
99% of values less than 344

Minimum 0	Maximum 512	
Mean 26.0859	Std. Dev. 90.6974	Variance 8226.01

Approx. time to Peak Conc. Naphthalene at Offsite Compliance Point [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Approx. time to Peak Conc. Nickel at Offsite Compliance Point [years]

01% of values less than 8202
05% of values less than 8202
10% of values less than 8202
50% of values less than 9056
90% of values less than 11039
95% of values less than 11039
99% of values less than 12189
Minimum 7428 Maximum 18114
Mean 9537.53 Std. Dev. 1099.22 Variance 1.20828E+006

Approx. time to Peak Conc. Phenols at Offsite Compliance Point [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 78
90% of values less than 86
95% of values less than 86
99% of values less than 95
Minimum 0 Maximum 105
Mean 62.6414 Std. Dev. 32.3355 Variance 1045.58

Approx. time to Peak Conc. Xylene at Offsite Compliance Point [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Source Concentration of Ammoniacal_N [mg/l]

At 30 years
01% of values less than 149.379
05% of values less than 225.688
10% of values less than 265.032
50% of values less than 451.231
90% of values less than 667.437
95% of values less than 714.875
99% of values less than 800.68
Minimum 92.0474 Maximum 895.292
Mean 458.285 Std. Dev. 152.499 Variance 23255.8

At 100 years
01% of values less than 90.001
05% of values less than 143.452
10% of values less than 182.529
50% of values less than 342.734
90% of values less than 536.958
95% of values less than 588.985
99% of values less than 688.952
Minimum 33.5218 Maximum 774.81
Mean 351.694 Std. Dev. 136.239 Variance 18561.2

At 300 years
01% of values less than 33.1932
05% of values less than 62.7509
10% of values less than 99.3324
50% of values less than 252.102
90% of values less than 431.016
95% of values less than 480.74
99% of values less than 579.082
Minimum 8.55239 Maximum 645.954
Mean 260.943 Std. Dev. 125.615 Variance 15779.1

At 1000 years
01% of values less than 1.33208E-008
05% of values less than 3.93563E-006
10% of values less than 0.000312768
50% of values less than 2.078
90% of values less than 18.3143
95% of values less than 24.3291
99% of values less than 33.8626
Minimum 1.53295E-010 Maximum 48.4208
Mean 6.08402 Std. Dev. 8.17833 Variance 66.8851

Phase: Phase 2 and 3

Source Concentration of Ammoniacal_N [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Source Concentration of Cadmium [mg/l]

At 30 years

01% of values less than 8.63728E-005
05% of values less than 9.7783E-005
10% of values less than 0.000106488
50% of values less than 0.000223547
90% of values less than 0.000746308
95% of values less than 0.000988688
99% of values less than 0.00148351
Minimum 8.15593E-005 Maximum 0.00171956
Mean 0.00033709 Std. Dev. 0.000295539 Variance 8.73433E-008

At 100 years

01% of values less than 8.63728E-005
05% of values less than 9.7783E-005
10% of values less than 0.000106488
50% of values less than 0.000219456
90% of values less than 0.00070847
95% of values less than 0.000911371
99% of values less than 0.00139928
Minimum 8.15593E-005 Maximum 0.00164052
Mean 0.000322598 Std. Dev. 0.000272601 Variance 7.43115E-008

At 300 years

01% of values less than 8.63728E-005
05% of values less than 9.7783E-005
10% of values less than 0.000106488
50% of values less than 0.000214431
90% of values less than 0.000660431
95% of values less than 0.000844168
99% of values less than 0.00127897
Minimum 8.15593E-005 Maximum 0.0015462
Mean 0.000305984 Std. Dev. 0.00024813 Variance 6.15684E-008

At 1000 years

01% of values less than 1.87458E-005
05% of values less than 5.06915E-005
10% of values less than 8.61318E-005
50% of values less than 0.000141922
90% of values less than 0.000254935
95% of values less than 0.000310374
99% of values less than 0.000426409
Minimum 9.57152E-007 Maximum 0.000600769
Mean 0.00015567 Std. Dev. 7.83808E-005 Variance 6.14355E-009

Phase: Phase 2 and 3

Source Concentration of Cadmium [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 9.89868E-011

90% of values less than 0.000124885

95% of values less than 0.000133752

99% of values less than 0.000142906

Minimum 0 Maximum 0.000144974

Mean 3.75695E-005 Std. Dev. 5.36416E-005 Variance 2.87742E-009

Phase: Phase 2 and 3

Source Concentration of Chloride [mg/l]

At 30 years

01% of values less than 153.998
05% of values less than 240.815
10% of values less than 286.186
50% of values less than 503.632
90% of values less than 756.932
95% of values less than 859.527
99% of values less than 1050.39
Minimum 87.8097 Maximum 1160.88
Mean 512.965 Std. Dev. 187.113 Variance 35011.3

At 100 years

01% of values less than 85.4581
05% of values less than 150.854
10% of values less than 189.147
50% of values less than 359.986
90% of values less than 587.483
95% of values less than 663.673
99% of values less than 812.092
Minimum 60.4192 Maximum 957.318
Mean 376.502 Std. Dev. 158.599 Variance 25153.7

At 300 years

01% of values less than 27.1042
05% of values less than 62.2695
10% of values less than 94.0342
50% of values less than 252.196
90% of values less than 457.289
95% of values less than 511.255
99% of values less than 639.877
Minimum 12.8419 Maximum 783.98
Mean 267.223 Std. Dev. 140.333 Variance 19693.4

At 1000 years

01% of values less than 5.72413E-010
05% of values less than 2.2028E-007
10% of values less than 3.56154E-005
50% of values less than 1.03601
90% of values less than 10.8933
95% of values less than 15.178
99% of values less than 22.6054
Minimum 2.79809E-012 Maximum 27.7483
Mean 3.75448 Std. Dev. 5.3531 Variance 28.6556

Phase: Phase 2 and 3

Source Concentration of Chloride [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase 2 and 3

Source Concentration of Mecoprop [mg/l]

At 30 years

01% of values less than 0.0018646
05% of values less than 0.00277909
10% of values less than 0.00370465
50% of values less than 0.00812902
90% of values less than 0.0153651
95% of values less than 0.0181986
99% of values less than 0.0242544
Minimum 0.000990723 Maximum 0.0276172
Mean 0.00901071 Std. Dev. 0.0047852 Variance 2.28981E-005

At 100 years

01% of values less than 0.00139889
05% of values less than 0.0019558
10% of values less than 0.00260585
50% of values less than 0.00617011
90% of values less than 0.0123076
95% of values less than 0.0145514
99% of values less than 0.0198059
Minimum 0.000803366 Maximum 0.0244689
Mean 0.00695449 Std. Dev. 0.00394473 Variance 1.55609E-005

At 300 years

01% of values less than 0.000629338
05% of values less than 0.00108773
10% of values less than 0.00152963
50% of values less than 0.00455104
90% of values less than 0.00970549
95% of values less than 0.0117423
99% of values less than 0.0158149
Minimum 0.000322098 Maximum 0.0210118
Mean 0.00519856 Std. Dev. 0.00334586 Variance 1.11948E-005

At 1000 years

01% of values less than 1.11075E-012
05% of values less than 2.05597E-010
10% of values less than 8.2849E-009
50% of values less than 4.56053E-005
90% of values less than 0.000381068
95% of values less than 0.000532246
99% of values less than 0.000973626
Minimum 7.71223E-015 Maximum 0.00141534
Mean 0.000135474 Std. Dev. 0.000204421 Variance 4.17881E-008

Phase: Phase 2 and 3

Source Concentration of Mecoprop [mg/l]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase 2 and 3

Source Concentration of Naphthalene [mg/l]

At 30 years

01% of values less than 0.00025688
05% of values less than 0.000367883
10% of values less than 0.000454919
50% of values less than 0.000901099
90% of values less than 0.00170928
95% of values less than 0.00194179
99% of values less than 0.00246993

Minimum 0.000165124	Maximum 0.00381923	
Mean 0.00100717	Std. Dev. 0.000498949	Variance 2.4895E-007

At 100 years

01% of values less than 2.00687E-006
05% of values less than 2.87408E-006
10% of values less than 3.55405E-006
50% of values less than 7.03983E-006
90% of values less than 1.33537E-005
95% of values less than 1.51702E-005
99% of values less than 1.92963E-005

Minimum 1.29003E-006	Maximum 2.98377E-005	
Mean 7.86849E-006	Std. Dev. 3.89804E-006	Variance 1.51947E-011

At 300 years

01% of values less than 1.9139E-012
05% of values less than 2.74094E-012
10% of values less than 3.38941E-012
50% of values less than 6.71371E-012
90% of values less than 1.27351E-011
95% of values less than 1.44674E-011
99% of values less than 1.84024E-011

Minimum 1.23027E-012	Maximum 2.84555E-011	
Mean 7.50397E-012	Std. Dev. 3.71746E-012	Variance 1.38195E-023

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase 2 and 3

Source Concentration of Naphthalene [mg/l]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase 2 and 3

Source Concentration of Nickel [mg/l]

At 30 years

01% of values less than 0.0208753
05% of values less than 0.0320475
10% of values less than 0.0377824
50% of values less than 0.0664724
90% of values less than 0.09988
95% of values less than 0.109441
99% of values less than 0.127534

Minimum 0.00813187	Maximum 0.175928	
Mean 0.0680031	Std. Dev. 0.0238016	Variance 0.000566518

At 100 years

01% of values less than 0.0191469
05% of values less than 0.0281798
10% of values less than 0.0341496
50% of values less than 0.0578097
90% of values less than 0.0872787
95% of values less than 0.0964861
99% of values less than 0.11141

Minimum 0.0075544	Maximum 0.152209	
Mean 0.0596989	Std. Dev. 0.0208614	Variance 0.000435196

At 300 years

01% of values less than 0.0158832
05% of values less than 0.022461
10% of values less than 0.0278073
50% of values less than 0.0494021
90% of values less than 0.0770762
95% of values less than 0.0840054
99% of values less than 0.0991543

Minimum 0.00688562	Maximum 0.126851	
Mean 0.0511846	Std. Dev. 0.0189948	Variance 0.000360801

At 1000 years

01% of values less than 8.88083E-007
05% of values less than 1.72162E-005
10% of values less than 0.000109584
50% of values less than 0.00597215
90% of values less than 0.0151588
95% of values less than 0.0171732
99% of values less than 0.020121

Minimum 3.85228E-008	Maximum 0.027563	
Mean 0.00687928	Std. Dev. 0.00580974	Variance 3.37531E-005

Phase: Phase 2 and 3

Source Concentration of Nickel [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 4.11914E-028

95% of values less than 4.15182E-025

99% of values less than 3.4952E-022

Minimum 0 Maximum 2.30765E-017

Mean 2.53079E-020 Std. Dev. 7.3168E-019 Variance 5.35356E-037

Phase: Phase 2 and 3

Source Concentration of Phenols [mg/l]

At 30 years
01% of values less than 1.1924
05% of values less than 2.07284
10% of values less than 2.82083
50% of values less than 7.84093
90% of values less than 16.831
95% of values less than 20.9365
99% of values less than 27.3954
Minimum 0.540998 Maximum 32.8521
Mean 9.1395 Std. Dev. 5.8782 Variance 34.5532

At 100 years
01% of values less than 0.00931559
05% of values less than 0.0161941
10% of values less than 0.0220378
50% of values less than 0.0612572
90% of values less than 0.131492
95% of values less than 0.163566
99% of values less than 0.214027
Minimum 0.00422655 Maximum 0.256657
Mean 0.0714024 Std. Dev. 0.0459234 Variance 0.00210896

At 300 years
01% of values less than 8.88404E-009
05% of values less than 1.54439E-008
10% of values less than 2.10169E-008
50% of values less than 5.84195E-008
90% of values less than 1.25401E-007
95% of values less than 1.55989E-007
99% of values less than 2.04112E-007
Minimum 4.03075E-009 Maximum 2.44767E-007
Mean 6.80946E-008 Std. Dev. 4.3796E-008 Variance 1.91809E-015

At 1000 years
01% of values less than 7.52507E-030
05% of values less than 1.30815E-029
10% of values less than 1.7802E-029
50% of values less than 4.94832E-029
90% of values less than 1.06219E-028
95% of values less than 1.32128E-028
99% of values less than 1.72889E-028
Minimum 3.41418E-030 Maximum 2.07326E-028
Mean 5.76784E-029 Std. Dev. 3.70966E-029 Variance 1.37616E-057

Phase: Phase 2 and 3

Source Concentration of Phenols [mg/l]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Source Concentration of Xylene [mg/l]

At 30 years

01% of values less than 0.00135621
05% of values less than 0.00192886
10% of values less than 0.00235353
50% of values less than 0.00661368
90% of values less than 0.0126721
95% of values less than 0.0142891
99% of values less than 0.0168083

Minimum 0.00106704	Maximum 0.0198414	
Mean 0.00715383	Std. Dev. 0.00391809	Variance 1.53515E-005

At 100 years

01% of values less than 1.05954E-005
05% of values less than 1.50692E-005
10% of values less than 1.83869E-005
50% of values less than 5.16694E-005
90% of values less than 9.90007E-005
95% of values less than 0.000111634
99% of values less than 0.000131314

Minimum 8.33624E-006	Maximum 0.000155011	
Mean 5.58893E-005	Std. Dev. 3.06101E-005	Variance 9.36979E-010

At 300 years

01% of values less than 1.01045E-011
05% of values less than 1.43711E-011
10% of values less than 1.75351E-011
50% of values less than 4.92758E-011
90% of values less than 9.44144E-011
95% of values less than 1.06462E-010
99% of values less than 1.25231E-010

Minimum 7.95005E-012	Maximum 1.4783E-010	
Mean 5.33002E-011	Std. Dev. 2.91921E-011	Variance 8.52177E-022

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase 2 and 3

Source Concentration of Xylene [mg/l]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Concentration of Ammoniacal_N at base of Clay Liner [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 45.6369
05% of values less than 83.3458
10% of values less than 111.754
50% of values less than 255.652
90% of values less than 455.015
95% of values less than 516.876
99% of values less than 638.705

Minimum 24.2925	Maximum 727.851	
Mean 271.559	Std. Dev. 133.96	Variance 17945.3

At 300 years

01% of values less than 41.2988
05% of values less than 77.9341
10% of values less than 113.331
50% of values less than 263.45
90% of values less than 443.013
95% of values less than 496.983
99% of values less than 590.349

Minimum 12.5508	Maximum 658.976	
Mean 273.5	Std. Dev. 125.968	Variance 15867.9

At 1000 years

01% of values less than 0
05% of values less than 0.000273271
10% of values less than 0.00416225
50% of values less than 4.80043
90% of values less than 29.9722
95% of values less than 40.0768
99% of values less than 55.4038

Minimum 0	Maximum 74.561	
Mean 10.877	Std. Dev. 13.4356	Variance 180.514

Phase: Phase 2 and 3

Concentration of Ammoniacal_N at base of Clay Liner [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 6.15675E-015

95% of values less than 1.11664E-014

99% of values less than 2.00344E-014

Minimum 0 Maximum 1.88691E-013

Mean 2.28234E-015 Std. Dev. 7.74444E-015 Variance 5.99764E-029

Phase: Phase 2 and 3

Concentration of Cadmium at base of Clay Liner [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 3.01673E-017	
Mean 9.85857E-020	Std. Dev. 1.57662E-018	Variance 2.48574E-036

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 4.17602E-017
95% of values less than 4.17916E-014
99% of values less than 8.57212E-009

Minimum 0	Maximum 6.33363E-008	
Mean 3.68911E-010	Std. Dev. 3.84152E-009	Variance 1.47573E-017

Phase: Phase 2 and 3

Concentration of Cadmium at base of Clay Liner [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 4.95981E-017

90% of values less than 3.68174E-005

95% of values less than 8.40201E-005

99% of values less than 0.000115647

Minimum 0 Maximum 0.000141856

Mean 9.37775E-006 Std. Dev. 2.61292E-005 Variance 6.82733E-010

Phase: Phase 2 and 3

Concentration of Chloride at base of Clay Liner [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 87.045
05% of values less than 154.078
10% of values less than 191.988
50% of values less than 365.13
90% of values less than 594.59
95% of values less than 672.02
99% of values less than 822.169

Minimum 63.9563	Maximum 964.55	
Mean 381.676	Std. Dev. 159.338	Variance 25388.5

At 300 years

01% of values less than 30.9349
05% of values less than 67.5527
10% of values less than 100.957
50% of values less than 261.446
90% of values less than 469.004
95% of values less than 521.094
99% of values less than 656.235

Minimum 15.1497	Maximum 800.872	
Mean 276.667	Std. Dev. 142.316	Variance 20253.8

At 1000 years

01% of values less than 0
05% of values less than 2.39188E-005
10% of values less than 0.00111182
50% of values less than 2.66642
90% of values less than 20.0052
95% of values less than 26.667
99% of values less than 39.3313

Minimum 0	Maximum 48.5145	
Mean 7.09596	Std. Dev. 9.33773	Variance 87.1932

Phase: Phase 2 and 3

Concentration of Chloride at base of Clay Liner [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 6.97487E-017

90% of values less than 7.66944E-015

95% of values less than 1.24241E-014

99% of values less than 3.26263E-014

Minimum 0	Maximum 1.8246E-013	
Mean 2.80178E-015	Std. Dev. 8.41797E-015	Variance 7.08623E-029

Phase: Phase 2 and 3

Concentration of Mecoprop at base of Clay Liner [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 0.0014273
05% of values less than 0.00199262
10% of values less than 0.00267716
50% of values less than 0.00629866
90% of values less than 0.0124722
95% of values less than 0.0147513
99% of values less than 0.019992

Minimum 0.000849772	Maximum 0.0246463	
Mean 0.00705603	Std. Dev. 0.00398017	Variance 1.58418E-005

At 300 years

01% of values less than 0.000685378
05% of values less than 0.00115544
10% of values less than 0.00164225
50% of values less than 0.00471148
90% of values less than 0.00994441
95% of values less than 0.0120032
99% of values less than 0.01615

Minimum 0.00035535	Maximum 0.0213562	
Mean 0.00535484	Std. Dev. 0.00340139	Variance 1.15694E-005

At 1000 years

01% of values less than 0
05% of values less than 6.40802E-009
10% of values less than 7.35373E-008
50% of values less than 9.88514E-005
90% of values less than 0.000635299
95% of values less than 0.000889332
99% of values less than 0.00154952

Minimum 0	Maximum 0.00217089	
Mean 0.000233076	Std. Dev. 0.000325895	Variance 1.06208E-007

Phase: Phase 2 and 3

Concentration of Mecoprop at base of Clay Liner [mg/l]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0 Maximum 4.63525E-018
Mean 1.07923E-020 Std. Dev. 1.76497E-019 Variance 3.11513E-038

Phase: Phase 2 and 3

Concentration of Naphthalene at base of Clay Liner [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 3.85385E-006
05% of values less than 1.07732E-005
10% of values less than 1.74429E-005
50% of values less than 7.0136E-005
90% of values less than 0.000220223
95% of values less than 0.000282336
99% of values less than 0.000366775

Minimum 3.03374E-007	Maximum 0.000568208	
Mean 9.72751E-005	Std. Dev. 8.49755E-005	Variance 7.22084E-009

At 300 years

01% of values less than 2.96132E-010
05% of values less than 1.00289E-009
10% of values less than 2.30914E-009
50% of values less than 3.41221E-007
90% of values less than 2.47105E-006
95% of values less than 3.73319E-006
99% of values less than 7.27605E-006

Minimum 1.4549E-010	Maximum 1.25252E-005	
Mean 9.21533E-007	Std. Dev. 1.4731E-006	Variance 2.17003E-012

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 6.80991E-015
90% of values less than 4.72182E-012
95% of values less than 1.76206E-011
99% of values less than 2.05278E-010

Minimum 0	Maximum 7.35883E-009	
Mean 2.3041E-011	Std. Dev. 2.97627E-010	Variance 8.85816E-020

Phase: Phase 2 and 3

Concentration of Naphthalene at base of Clay Liner [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Concentration of Nickel at base of Clay Liner [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 0
05% of values less than 1.3953E-015
10% of values less than 1.87073E-015
50% of values less than 4.98524E-015
90% of values less than 9.68023E-015
95% of values less than 1.08042E-014
99% of values less than 1.35265E-014

Minimum 0	Maximum 1.71823E-014	
Mean 5.39305E-015	Std. Dev. 3.00907E-015	Variance 9.05453E-030

At 300 years

01% of values less than 3.31035E-015
05% of values less than 7.10979E-014
10% of values less than 2.4736E-013
50% of values less than 1.76687E-011
90% of values less than 2.00027E-010
95% of values less than 2.98142E-010
99% of values less than 4.9999E-010

Minimum 1.3275E-015	Maximum 7.77615E-010	
Mean 6.60384E-011	Std. Dev. 1.07804E-010	Variance 1.16217E-020

At 1000 years

01% of values less than 2.27369E-005
05% of values less than 0.0002865
10% of values less than 0.000448173
50% of values less than 0.00127261
90% of values less than 0.00277482
95% of values less than 0.00320652
99% of values less than 0.00415291

Minimum 5.54764E-006	Maximum 0.00563451	
Mean 0.0014729	Std. Dev. 0.000923016	Variance 8.51959E-007

Phase: Phase 2 and 3

Concentration of Nickel at base of Clay Liner [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Concentration of Phenols at base of Clay Liner [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years

01% of values less than 0.0183594
05% of values less than 0.0326696
10% of values less than 0.0480122
50% of values less than 0.131533
90% of values less than 0.284203
95% of values less than 0.357131
99% of values less than 0.482329
Minimum 0.011243 Maximum 0.619177
Mean 0.154732 Std. Dev. 0.101261 Variance 0.0102537

At 300 years

01% of values less than 2.93896E-008
05% of values less than 5.29513E-008
10% of values less than 7.19689E-008
50% of values less than 1.99874E-007
90% of values less than 4.35624E-007
95% of values less than 5.31266E-007
99% of values less than 6.9972E-007
Minimum 1.53427E-008 Maximum 8.18784E-007
Mean 2.32926E-007 Std. Dev. 1.50298E-007 Variance 2.25896E-014

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Concentration of Phenols at base of Clay Liner [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 2.03182E-018

95% of values less than 4.06552E-018

99% of values less than 1.28992E-017

Minimum 0 Maximum 5.96563E-017

Mean 7.47521E-019 Std. Dev. 3.08771E-018 Variance 9.53397E-036

Phase: Phase 2 and 3

Concentration of Xylene at base of Clay Liner [mg/l]

At 30 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years
01% of values less than 5.62777E-006
05% of values less than 2.31346E-005
10% of values less than 4.34214E-005
50% of values less than 0.000289207
90% of values less than 0.00134318
95% of values less than 0.00175579
99% of values less than 0.00265261
Minimum 2.05273E-007 Maximum 0.00443348
Mean 0.000524412 Std. Dev. 0.000591785 Variance 3.5021E-007

At 300 years
01% of values less than 7.02439E-009
05% of values less than 3.34763E-008
10% of values less than 9.60425E-008
50% of values less than 5.69753E-006
90% of values less than 3.55209E-005
95% of values less than 4.74196E-005
99% of values less than 7.31093E-005
Minimum 2.86475E-009 Maximum 0.000153998
Mean 1.26514E-005 Std. Dev. 1.78782E-005 Variance 3.1963E-010

At 1000 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 9.03897E-013
90% of values less than 4.54316E-010
95% of values less than 1.69482E-009
99% of values less than 1.24851E-008
Minimum 0 Maximum 4.59334E-007
Mean 1.28532E-009 Std. Dev. 1.63608E-008 Variance 2.67677E-016

Phase: Phase 2 and 3

Concentration of Xylene at base of Clay Liner [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Concentration of Ammoniacal_N at base of Unsaturated Zone [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 1.89855
05% of values less than 5.61089
10% of values less than 9.49596
50% of values less than 40.222
90% of values less than 126.14
95% of values less than 167.43
99% of values less than 249.209

Minimum 0.445613	Maximum 352.263	
Mean 57.0657	Std. Dev. 52.8945	Variance 2797.82

At 300 years

01% of values less than 6.81142
05% of values less than 13.7605
10% of values less than 19.8798
50% of values less than 59.2402
90% of values less than 151.802
95% of values less than 184.716
99% of values less than 262.43

Minimum 2.29929	Maximum 344.815	
Mean 74.632	Std. Dev. 55.9435	Variance 3129.67

At 1000 years

01% of values less than 0.0959017
05% of values less than 0.569929
10% of values less than 1.66563
50% of values less than 20.7636
90% of values less than 70.2227
95% of values less than 90.9191
99% of values less than 143.061

Minimum 0.0106406	Maximum 216.01	
Mean 30.0119	Std. Dev. 31.036	Variance 963.234

Phase: Phase 2 and 3

Concentration of Ammoniacal_N at base of Unsaturated Zone [mg/l]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 2.89718E-014
90% of values less than 5.14207E-013
95% of values less than 1.85012E-012
99% of values less than 9.18735E-012

Minimum 0 Maximum 2.67969E-011
Mean 4.30458E-013 Std. Dev. 1.84697E-012 Variance 3.41128E-024

Phase: Phase 2 and 3

Concentration of Cadmium at base of Unsaturated Zone [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Concentration of Cadmium at base of Unsaturated Zone [mg/l]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 2.44068E-008
95% of values less than 3.78181E-007
99% of values less than 2.75863E-005

Minimum 0	Maximum 0.000117766	
Mean 7.92404E-007	Std. Dev. 6.79446E-006	Variance 4.61647E-011

Phase: Phase 2 and 3

Concentration of Chloride at base of Unsaturated Zone [mg/l]

At 30 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years
01% of values less than 110.971
05% of values less than 173.758
10% of values less than 210.713
50% of values less than 386.829
90% of values less than 628.333
95% of values less than 703.778
99% of values less than 875.424
Minimum 78.5922 Maximum 998.956
Mean 407.527 Std. Dev. 163.24 Variance 26647.5

At 300 years
01% of values less than 60.0907
05% of values less than 111.448
10% of values less than 149.261
50% of values less than 315.65
90% of values less than 537.168
95% of values less than 590.651
99% of values less than 734.754
Minimum 35.0129 Maximum 892.122
Mean 332.008 Std. Dev. 152.041 Variance 23116.3

At 1000 years
01% of values less than 0.174005
05% of values less than 1.29754
10% of values less than 4.85172
50% of values less than 80.1271
90% of values less than 200.84
95% of values less than 230.8
99% of values less than 300.048
Minimum 0.0397255 Maximum 383.864
Mean 93.8798 Std. Dev. 75.8305 Variance 5750.27

Phase: Phase 2 and 3

Concentration of Chloride at base of Unsaturated Zone [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 1.16665E-013

90% of values less than 8.24466E-013

95% of values less than 1.30389E-012

99% of values less than 3.79811E-012

Minimum 0	Maximum 1.47607E-011	
Mean 3.51419E-013	Std. Dev. 8.70248E-013	Variance 7.57331E-025

Phase: Phase 2 and 3

Concentration of Mecoprop at base of Unsaturated Zone [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 1.18658E-014
05% of values less than 1.22846E-012
10% of values less than 2.10166E-011
50% of values less than 2.34276E-007
90% of values less than 7.70785E-006
95% of values less than 1.28015E-005
99% of values less than 3.05946E-005

Minimum 0	Maximum 5.9592E-005	
Mean 2.66135E-006	Std. Dev. 6.23561E-006	Variance 3.88828E-011

At 300 years

01% of values less than 7.05857E-015
05% of values less than 1.0706E-012
10% of values less than 1.90832E-011
50% of values less than 1.75499E-007
90% of values less than 6.54962E-006
95% of values less than 1.1153E-005
99% of values less than 2.47941E-005

Minimum 0	Maximum 5.39419E-005	
Mean 2.24192E-006	Std. Dev. 5.31325E-006	Variance 2.82306E-011

At 1000 years

01% of values less than 9.68489E-016
05% of values less than 1.16125E-013
10% of values less than 4.15719E-012
50% of values less than 3.45133E-008
90% of values less than 2.30264E-006
95% of values less than 3.92322E-006
99% of values less than 1.00065E-005

Minimum 0	Maximum 2.53743E-005	
Mean 7.5193E-007	Std. Dev. 2.0311E-006	Variance 4.12538E-012

Phase: Phase 2 and 3

Concentration of Mecoprop at base of Unsaturated Zone [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 8.96101E-018

Mean 1.35385E-020 Std. Dev. 3.01968E-019 Variance 9.11848E-038

Phase: Phase 2 and 3

Concentration of Naphthalene at base of Unsaturated Zone [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 1.5752E-014
95% of values less than 9.78668E-014
99% of values less than 1.57213E-012

Minimum 0	Maximum 2.20832E-011	
Mean 9.21063E-014	Std. Dev. 8.47081E-013	Variance 7.17545E-025

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 9.37653E-015
95% of values less than 4.7025E-014
99% of values less than 4.19433E-013

Minimum 0	Maximum 2.98275E-012	
Mean 1.89796E-014	Std. Dev. 1.38979E-013	Variance 1.93151E-026

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 4.4422E-017

Minimum 0	Maximum 8.43776E-016	
Mean 3.42605E-018	Std. Dev. 4.04489E-017	Variance 1.63612E-033

Phase: Phase 2 and 3

Concentration of Naphthalene at base of Unsaturated Zone [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Concentration of Nickel at base of Unsaturated Zone [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 1000 years

01% of values less than 3.24788E-012
05% of values less than 5.03188E-010
10% of values less than 1.18756E-009
50% of values less than 1.18282E-008
90% of values less than 5.75336E-008
95% of values less than 8.46443E-008
99% of values less than 1.36415E-007
Minimum 2.14707E-013 Maximum 2.05837E-007
Mean 2.28079E-008 Std. Dev. 2.91677E-008 Variance 8.50757E-016

Phase: Phase 2 and 3

Concentration of Nickel at base of Unsaturated Zone [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 1.94747E-014

50% of values less than 1.51092E-012

90% of values less than 3.94026E-011

95% of values less than 8.5085E-011

99% of values less than 3.93861E-010

Minimum 0 Maximum 6.93532E-009

Mean 3.09558E-011 Std. Dev. 2.55398E-010 Variance 6.52281E-020

Phase: Phase 2 and 3

Concentration of Phenols at base of Unsaturated Zone [mg/l]

At 30 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years
01% of values less than 3.47894E-006
05% of values less than 7.68228E-005
10% of values less than 0.000230829
50% of values less than 0.0110426
90% of values less than 0.0823946
95% of values less than 0.11661
99% of values less than 0.200058
Minimum 6.0499E-008 Maximum 0.323137
Mean 0.0286747 Std. Dev. 0.0420213 Variance 0.00176579

At 300 years
01% of values less than 1.02535E-009
05% of values less than 2.34776E-008
10% of values less than 6.58222E-008
50% of values less than 3.35577E-006
90% of values less than 2.47563E-005
95% of values less than 3.44843E-005
99% of values less than 5.39552E-005
Minimum 1.75395E-011 Maximum 9.71346E-005
Mean 8.48992E-006 Std. Dev. 1.23363E-005 Variance 1.52185E-010

At 1000 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 4.51356E-013
90% of values less than 5.91238E-012
95% of values less than 8.91655E-012
99% of values less than 1.86374E-011
Minimum 0 Maximum 9.44288E-011
Mean 2.09549E-012 Std. Dev. 4.94883E-012 Variance 2.44909E-023

Phase: Phase 2 and 3

Concentration of Phenols at base of Unsaturated Zone [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 1.62482E-017

95% of values less than 3.37548E-017

99% of values less than 1.23398E-016

Minimum 0 Maximum 6.73629E-016

Mean 7.27407E-018 Std. Dev. 3.1111E-017 Variance 9.67897E-034

Phase: Phase 2 and 3

Concentration of Xylene at base of Unsaturated Zone [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 1.67908E-013
95% of values less than 1.1255E-012
99% of values less than 3.81944E-011

Minimum 0	Maximum 1.59523E-010	
Mean 1.23433E-012	Std. Dev. 8.97048E-012	Variance 8.04694E-023

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 2.53498E-016
90% of values less than 5.46189E-013
95% of values less than 1.757E-012
99% of values less than 1.83821E-011

Minimum 0	Maximum 7.93546E-011	
Mean 6.7227E-013	Std. Dev. 4.37464E-012	Variance 1.91374E-023

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 1.21167E-016
95% of values less than 6.37584E-016
99% of values less than 1.40974E-014

Minimum 0	Maximum 7.90565E-014	
Mean 5.17378E-016	Std. Dev. 4.09836E-015	Variance 1.67966E-029

Phase: Phase 2 and 3

Concentration of Xylene at base of Unsaturated Zone [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Approx. time to Peak Conc. Ammoniacal_N at Base of Unsaturated Zone [years]

01% of values less than 100
05% of values less than 105
10% of values less than 116
50% of values less than 210
90% of values less than 344
95% of values less than 380
99% of values less than 420

Minimum 86	Maximum 420	
Mean 202.347	Std. Dev. 82.7995	Variance 6855.75

Approx. time to Peak Conc. Cadmium at Base of Unsaturated Zone [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 20000
95% of values less than 20000
99% of values less than 20000

Minimum 0	Maximum 20000	
Mean 8978.86	Std. Dev. 9883.43	Variance 9.76822E+007

Approx. time to Peak Conc. Chloride at Base of Unsaturated Zone [years]

01% of values less than 64
05% of values less than 64
10% of values less than 64
50% of values less than 64
90% of values less than 70
95% of values less than 70
99% of values less than 70

Minimum 57	Maximum 86	
Mean 64.7722	Std. Dev. 2.49721	Variance 6.23607

Approx. time to Peak Conc. Mecoprop at Base of Unsaturated Zone [years]

01% of values less than 64
05% of values less than 64
10% of values less than 64
50% of values less than 70
90% of values less than 70
95% of values less than 78
99% of values less than 86

Minimum 0	Maximum 256	
Mean 69.6513	Std. Dev. 11.4804	Variance 131.799

Approx. time to Peak Conc. Naphthalene at Base of Unsaturated Zone [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 210
95% of values less than 232
99% of values less than 232

Phase: Phase 2 and 3

Approx. time to Peak Conc. Naphthalene at Base of Unsaturated Zone [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 210
95% of values less than 232
99% of values less than 232
Minimum 0 | Maximum 256
Mean 78.986 | Std. Dev. 93.7771 | Variance 8794.15

Approx. time to Peak Conc. Nickel at Base of Unsaturated Zone [years]

01% of values less than 3046
05% of values less than 3363
10% of values less than 3363
50% of values less than 3714
90% of values less than 4100
95% of values less than 4100
99% of values less than 4527
Minimum 3046 | Maximum 4999
Mean 3638.54 | Std. Dev. 315.923 | Variance 99807.4

Approx. time to Peak Conc. Phenols at Base of Unsaturated Zone [years]

01% of values less than 64
05% of values less than 64
10% of values less than 64
50% of values less than 64
90% of values less than 70
95% of values less than 70
99% of values less than 78
Minimum 64 | Maximum 78
Mean 65.2328 | Std. Dev. 2.66735 | Variance 7.11477

Approx. time to Peak Conc. Xylene at Base of Unsaturated Zone [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 172
90% of values less than 232
95% of values less than 232
99% of values less than 232
Minimum 0 | Maximum 420
Mean 124.948 | Std. Dev. 99.7915 | Variance 9958.35

Phase: Phase 2 and 3

Concentration of Ammoniacal_N at Phase Monitor Well [mg/l]

At 30 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years
01% of values less than 1.48094E-010
05% of values less than 1.05449E-007
10% of values less than 1.19397E-006
50% of values less than 0.000425489
90% of values less than 0.0126221
95% of values less than 0.0257406
99% of values less than 0.0775591
Minimum 3.37359E-018 Maximum 0.252649
Mean 0.00548924 Std. Dev. 0.017487 Variance 0.000305794

At 300 years
01% of values less than 0.00030867
05% of values less than 0.00121734
10% of values less than 0.00293038
50% of values less than 0.0345651
90% of values less than 0.281145
95% of values less than 0.461604
99% of values less than 0.980624
Minimum 8.08176E-005 Maximum 1.72798
Mean 0.107023 Std. Dev. 0.201359 Variance 0.0405455

At 1000 years
01% of values less than 0.00018375
05% of values less than 0.0011587
10% of values less than 0.00217569
50% of values less than 0.0390957
90% of values less than 0.293675
95% of values less than 0.533474
99% of values less than 1.04619
Minimum 2.77217E-005 Maximum 3.06299
Mean 0.123152 Std. Dev. 0.237002 Variance 0.0561699

Phase: Phase 2 and 3

Concentration of Ammoniacal_N at Phase Monitor Well [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 5.27853E-015

Mean 5.71557E-018 Std. Dev. 1.67398E-016 Variance 2.80223E-032

Phase: Phase 2 and 3

Concentration of Cadmium at Phase Monitor Well [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Concentration of Cadmium at Phase Monitor Well [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 1.3147E-014

Minimum 0 Maximum 4.42897E-009

Mean 9.28146E-012 Std. Dev. 1.89752E-010 Variance 3.60059E-020

Phase: Phase 2 and 3

Concentration of Chloride at Phase Monitor Well [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

01% of values less than 0.0683755
05% of values less than 0.147839
10% of values less than 0.210924
50% of values less than 1.05671
90% of values less than 2.84975
95% of values less than 3.69233
99% of values less than 5.47872

Minimum 0.035113	Maximum 7.28135	
Mean 1.35256	Std. Dev. 1.16323	Variance 1.3531

At 300 years

01% of values less than 0.430037
05% of values less than 0.862233
10% of values less than 1.23527
50% of values less than 5.58219
90% of values less than 14.6068
95% of values less than 18.297
99% of values less than 23.4425

Minimum 0.116657	Maximum 30.6593	
Mean 6.90949	Std. Dev. 5.5083	Variance 30.3413

At 1000 years

01% of values less than 0.0181956
05% of values less than 0.0768218
10% of values less than 0.211192
50% of values less than 2.8884
90% of values less than 10.1791
95% of values less than 13.5957
99% of values less than 18.2324

Minimum 0.00292075	Maximum 27.8517	
Mean 4.17757	Std. Dev. 4.35662	Variance 18.9801

Phase: Phase 2 and 3

Concentration of Chloride at Phase Monitor Well [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 5.8829E-014

95% of values less than 1.21934E-013

99% of values less than 1.14047E-012

Minimum 0 Maximum 1.15825E-011

Mean 6.62945E-014 Std. Dev. 5.51081E-013 Variance 3.0369E-025

Phase: Phase 2 and 3

Concentration of Mecoprop at Phase Monitor Well [mg/l]

At 30 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 2.50003E-017
95% of values less than 1.87779E-016
99% of values less than 4.55326E-015
Minimum 0 Maximum 1.4292E-013
Mean 3.72278E-016 Std. Dev. 5.33435E-015 Variance 2.84552E-029

At 300 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 1.22332E-016
95% of values less than 1.02837E-015
99% of values less than 1.94203E-014
Minimum 0 Maximum 4.46294E-013
Mean 1.66474E-015 Std. Dev. 2.0561E-014 Variance 4.22753E-028

At 1000 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 6.43443E-017
95% of values less than 5.56224E-016
99% of values less than 1.47637E-014
Minimum 0 Maximum 1.92042E-013
Mean 7.43121E-016 Std. Dev. 7.41637E-015 Variance 5.50025E-029

Phase: Phase 2 and 3

Concentration of Mecoprop at Phase Monitor Well [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Concentration of Naphthalene at Phase Monitor Well [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Concentration of Naphthalene at Phase Monitor Well [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Concentration of Nickel at Phase Monitor Well [mg/l]

At 30 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 300 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 1000 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Concentration of Nickel at Phase Monitor Well [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 3.59072E-008

95% of values less than 2.04126E-007

99% of values less than 9.50668E-007

Minimum 0 Maximum 3.22571E-006

Mean 3.95459E-008 Std. Dev. 2.02872E-007 Variance 4.11572E-014

Phase: Phase 2 and 3

Concentration of Phenols at Phase Monitor Well [mg/l]

At 30 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 | Maximum 0
Mean 0 | Std. Dev. 0 | Variance 0

At 100 years
01% of values less than 0
05% of values less than 0
10% of values less than 1.05611E-018
50% of values less than 4.12615E-012
90% of values less than 4.28514E-009
95% of values less than 2.02083E-008
99% of values less than 1.36687E-007
Minimum 0 | Maximum 6.14591E-007
Mean 5.65055E-009 | Std. Dev. 3.47293E-008 | Variance 1.20612E-015

At 300 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 1.23929E-014
90% of values less than 1.20022E-011
95% of values less than 5.23718E-011
99% of values less than 3.2747E-010
Minimum 0 | Maximum 1.52849E-009
Mean 1.58536E-011 | Std. Dev. 9.4727E-011 | Variance 8.97321E-021

At 1000 years
01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 9.6976E-019
95% of values less than 7.58563E-018
99% of values less than 7.60679E-017
Minimum 0 | Maximum 6.37247E-016
Mean 3.82431E-018 | Std. Dev. 3.21398E-017 | Variance 1.03297E-033

Phase: Phase 2 and 3

Concentration of Phenols at Phase Monitor Well [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0 Maximum 0

Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Concentration of Xylene at Phase Monitor Well [mg/l]

At 30 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Concentration of Xylene at Phase Monitor Well [mg/l]

At infinity

01% of values less than 0

05% of values less than 0

10% of values less than 0

50% of values less than 0

90% of values less than 0

95% of values less than 0

99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase 2 and 3

Approx. time to Peak Conc. Ammoniacal_N at Phase Monitor Well [years]

01% of values less than 344
05% of values less than 344
10% of values less than 344
50% of values less than 420
90% of values less than 464
95% of values less than 512
99% of values less than 565

Minimum 312	Maximum 624	
Mean 407.601	Std. Dev. 47.6528	Variance 2270.79

Approx. time to Peak Conc. Cadmium at Phase Monitor Well [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 20000

Minimum 0	Maximum 20000	
Mean 799.201	Std. Dev. 3919.27	Variance 1.53606E+007

Approx. time to Peak Conc. Chloride at Phase Monitor Well [years]

01% of values less than 282
05% of values less than 282
10% of values less than 282
50% of values less than 344
90% of values less than 344
95% of values less than 344
99% of values less than 344

Minimum 282	Maximum 380	
Mean 333.255	Std. Dev. 22.3351	Variance 498.856

Approx. time to Peak Conc. Mecoprop at Phase Monitor Well [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 344
95% of values less than 344
99% of values less than 344

Minimum 0	Maximum 512	
Mean 80.3157	Std. Dev. 143.628	Variance 20628.9

Phase: Phase 2 and 3

Approx. time to Peak Conc. Naphthalene at Phase Monitor Well [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Approx. time to Peak Conc. Nickel at Phase Monitor Well [years]

01% of values less than 6728
05% of values less than 6728
10% of values less than 7428
50% of values less than 8202
90% of values less than 9056
95% of values less than 9999
99% of values less than 11039
Minimum 6094 Maximum 11039
Mean 8104.57 Std. Dev. 889.574 Variance 791342

Approx. time to Peak Conc. Phenols at Phase Monitor Well [years]

01% of values less than 0
05% of values less than 0
10% of values less than 70
50% of values less than 78
90% of values less than 86
95% of values less than 86
99% of values less than 95
Minimum 0 Maximum 95
Mean 69.6903 Std. Dev. 22.6088 Variance 511.16

Approx. time to Peak Conc. Xylene at Phase Monitor Well [years]

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

Phase: Phase 2 and 3

Flow to Leachate Treatment Plant [l/day]

At 30 years

01% of values less than 285022
05% of values less than 285022
10% of values less than 285022
50% of values less than 285022
90% of values less than 285022
95% of values less than 285022
99% of values less than 285022

Minimum 285022	Maximum 285022	
Mean 285022	Std. Dev. 0.0192455	Variance -0.000370387

At 100 years

01% of values less than 24069.6
05% of values less than 24288.8
10% of values less than 24416.8
50% of values less than 24842.4
90% of values less than 25166.2
95% of values less than 25215.2
99% of values less than 25250.5

Minimum 23873.4	Maximum 25276.9	
Mean 24811	Std. Dev. 288.802	Variance 83406.5

At 300 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase 2 and 3

Flow to Leachate Treatment Plant [l/day]

At infinity

01% of values less than 0
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
99% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

Phase: Phase 2 and 3

Head on EBS [m]
At 1000 years
01% of values less than 3
05% of values less than 3
10% of values less than 3
50% of values less than 3
90% of values less than 3
95% of values less than 3
99% of values less than 3

Minimum 3	Maximum 3	
Mean 3	Std. Dev. 3.6121E-008	Variance -1.30473E-015

At infinity
01% of values less than 3
05% of values less than 3
10% of values less than 3
50% of values less than 3
90% of values less than 3
95% of values less than 3
99% of values less than 3

Minimum 3	Maximum 3	
Mean 3	Std. Dev. 3.6121E-008	Variance -1.30473E-015

Phase: Phase 2 and 3

Surface Breakout [l/day]

At 300 years

01% of values less than 24532.7
05% of values less than 25107.5
10% of values less than 25517.3
50% of values less than 27728.9
90% of values less than 29810.9
95% of values less than 30076.9
99% of values less than 30306.1

Minimum 23539	Maximum 30378.4	
Mean 27729.2	Std. Dev. 1593.87	Variance 2.54043E+006

At 1000 years

01% of values less than 208029
05% of values less than 208962
10% of values less than 209628
50% of values less than 213221
90% of values less than 216603
95% of values less than 217035
99% of values less than 217408

Minimum 206414	Maximum 217525	
Mean 213221	Std. Dev. 2589.25	Variance 6.70422E+006

At infinity

01% of values less than 134548
05% of values less than 134548
10% of values less than 134548
50% of values less than 134548
90% of values less than 134548
95% of values less than 134548
99% of values less than 134548

Minimum 134548	Maximum 134549	
Mean 134548	Std. Dev. 0.0580591	Variance 0.00337086

Phase: Phase 2 and 3

Leakage through EBS [l/day]

At 100 years

01% of values less than 47.29
05% of values less than 82.6363
10% of values less than 131.605
50% of values less than 455.346
90% of values less than 880.974
95% of values less than 1008.99
99% of values less than 1228.15

Minimum 20.8448	Maximum 1424.35	
Mean 486.816	Std. Dev. 288.802	Variance 83406.5

At 300 years

01% of values less than 343.835
05% of values less than 573.144
10% of values less than 839.338
50% of values less than 2922.76
90% of values less than 5135.96
95% of values less than 5546.06
99% of values less than 6121.24

Minimum 271.432	Maximum 7115.57	
Mean 2922.51	Std. Dev. 1594.98	Variance 2.54395E+006

At 1000 years

01% of values less than 558.561
05% of values less than 931.075
10% of values less than 1363.51
50% of values less than 4748.03
90% of values less than 8343.38
95% of values less than 9009.6
99% of values less than 9943.98

Minimum 440.943	Maximum 11559.3	
Mean 4747.63	Std. Dev. 2591.05	Variance 6.71352E+006

At infinity

01% of values less than 91445.8
05% of values less than 91445.8
10% of values less than 91445.8
50% of values less than 91445.8
90% of values less than 91445.8
95% of values less than 91445.8
99% of values less than 91445.8

Minimum 91445.8	Maximum 91445.8	
Mean 91445.8	Std. Dev. 0.0106647	Variance -0.000113737

Phase: Phase 2 and 3

Aquifer Flow [m³/year]

At 30 years

01% of values less than 30882.6
05% of values less than 32399.7
10% of values less than 33704.3
50% of values less than 38485
90% of values less than 43946
95% of values less than 45332.2
99% of values less than 48516.9

Minimum 0	Maximum 54745.9	
Mean 38686.2	Std. Dev. 4125.01	Variance 1.70157E+007

At 100 years

01% of values less than 30882.6
05% of values less than 32399.7
10% of values less than 33704.3
50% of values less than 38485
90% of values less than 43946
95% of values less than 45332.2
99% of values less than 48516.9

Minimum 0	Maximum 54745.9	
Mean 38686.2	Std. Dev. 4125.01	Variance 1.70157E+007

At 300 years

01% of values less than 30882.6
05% of values less than 32399.7
10% of values less than 33704.3
50% of values less than 38485
90% of values less than 43946
95% of values less than 45332.2
99% of values less than 48516.9

Minimum 0	Maximum 54745.9	
Mean 38686.2	Std. Dev. 4125.01	Variance 1.70157E+007

At 1000 years

01% of values less than 31004.5
05% of values less than 32445.8
10% of values less than 33872.4
50% of values less than 38516.9
90% of values less than 43946
95% of values less than 45332.2
99% of values less than 48516.9

Minimum 0	Maximum 54745.9	
Mean 38729.4	Std. Dev. 4095.86	Variance 1.67761E+007

Phase: Phase 2 and 3

Aquifer Flow [m³/year]

At infinity

01% of values less than 64283.2

05% of values less than 65800.3

10% of values less than 67104.8

50% of values less than 71885.6

90% of values less than 77346.6

95% of values less than 78732.8

99% of values less than 81917.4

Minimum 0	Maximum 88146.5	
Mean 72053.4	Std. Dev. 4551.31	Variance 2.07144E+007

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