SOUTH SIDE QUEENSWAY WASTE MANAGEMENT SITE, LLANWERN STEELWORKS

2020 Annual Review of Environmental Monitoring

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The landfill area has been an area of industrial waste disposal for many years having initially been developed in the 1970's to accept wastes from the Llanwern Steel Works. The landfill was one of two landfill sites operated at the Llanwern site, the other being the East Waste Management Site (EWMS). The landfill accepted industrial wastes from the steel making activity whilst the EWMS accepted general wastes, refuse, biodegradable wastes as well as industrial waste.

The 89 Ha occupied by the site was developed in a series of cells, historically termed lagoons. Lagoon 12 was constructed first on the west by raising four large bunds on top of the stabilising slag layer placed over the majority of the 89 Ha. Fine metallic dust (50% iron, 3% zinc) washed from the flues of the BOS plant was suspended in water and pumped from the steel works into Lagoon 12. There it settled and hardened to form the waste deposit seen today. Infilling in Lagoon 12 was completed by the mid 1980's with Lagoon 25 coming on stream as a replacement. Lagoon 25 was also constructed by developing slag bunds onto the stabilising slag layer, with the metallic fines pumped into the Lagoon. Infilling in Lagoon 25 was completed in 2002 with the demise of the steel making plant. There are no lining systems for either the base or side slopes of either Lagoon 12 or 25.

Throughout the duration of disposal activities, steel and iron slag was deposited to the north and east of Lagoons 12 and 25. Deposits of coarse granular slag of up to 7m thickness covered parts of the areas but today approximately 1m remains as the slag has been commercially worked and recovered. Apart from the lagoons, the entire area now occupied by SSQ Non-Hazardous Landfill has largely reduced to a 1m thick slag stabilising layer.

Groundwater and surface water sampling around the perimeter of the site reveals that groundwater within the upper layer of made ground is dominated by an elevated pH and alkalinity due to slaking of lime. Some parameters are sometimes detected at increased concentrations, although these are not typically persistent. The elevated pH and alkalinity is likely limiting the mobility of several potential contaminants. Visible oil has been noted on groundwater recovered from BH16. This is not a new occurrence but requires further evaluation.

Deeper groundwater within the alluvial sequence also has low concentrations of most non-hazardous pollutants and hazardous substances but has a pH of approximately 8. As this pH is very different from the pH in the overlying made ground there would appear to be little hydraulic connectivity between the groundwater bodies encountered. This is not unexpected due to the sequence of low permeability sediments present.

There is scope for rationalising the monitoring programme, but Tata should first consider the potential impact of any development proposals in the area. NRW should be consulted and agree to any changes to the monitoring programme. Routine vegetation clearance is required to ensure safe, reliable access to all monitoring points.

1 INTRODUCTION

The Environment Agency (now Natural Resources Wales) issued a Closure Notice (No. GR/EM4/01) for Llanwern Landfill, South Side of Queensway (SSQ) which specified that the landfill must cease accepting waste for disposal as of 25 February 2008 and that it must be maintained, monitored and controlled as required by the conditions of the authorisation numbered 024/79. In response, Tata commissioned Geotechnology to prepare a Closure Report and Aftercare Monitoring Plan (see Geotechnology Report 664.1/0/0708).

One of the requirements of the Aftercare monitoring period is the production of annual interpretive reports that evaluate the most recent environmental monitoring results. This report reviews the data collected up to December 2020.

2 SITE SETTING

2.1 Site Location and Extent

The Llanwern Landfill is in an area referred to as South Side of Queensway (SSQ) which lies immediately to the south of Llanwern Steelworks to the east of Newport. The centre of the landfill site is at Ordnance Survey Grid Reference ST375 858, as shown on the site location plan (Figure 1). Access to the site is only possible through the steelworks off Queensway Road which runs east to west through the plant, north of the landfill.

Until recently, Queensway was a road entirely within the works boundary, but the road has become a public road as the steelworks boundary has shrunk following closure of the "heavy end", where iron and steel was produced. The parcel of land to the south of Queensway (known as South Side Queensway or SSQ for short) is now separated from the secure part of the works. Parts of the site can be accessed by members of the public directly from this road.

In the 1970's, Newport Borough Council, issued a COPA licence for the disposal of waste materials from the works within SSQ. The licence was never surrendered or rescinded and the licence transferred into the Waste Management regime. Various parts of the SSQ Waste Management site were subsequently taken into the IPPC permit for the steelworks, but this permit ceased with the cessation of steelmaking in 2002. Subsequently, several parts of the SSQ Site were taken into the existing steelworks PPC Permit (Permit BS3905). A Non-Hazardous landfill has also been permitted under the PPC regime within SSQ (PPC Permit GP 3331SV). This PPC landfill is referred to as South Side Queensway Non-Hazardous Landfill (SSQNHL) and its location is shown on Figure 2. This landfill has yet to be constructed and has not yet entered its pre-operational phase.

Due to the different waste management activities and changes in regulatory regime, the boundary positions of the currently applicable regulatory regime are complex. To assist with understanding the current situation the position of all relevant boundaries are shown in Figures 2 and 3. The position of key surface water collection ditches within the site boundary are also shown on Figure 3. These ditches collect surface run-off from SSQ which is diverted to the main works treatment plant prior to discharge in accordance with the current discharge consent. The regulatory boundaries shown on Figure 2 are:

- Current Waste Management Licence Boundary No. 024/79
- Boundary of SSQNHL PPC Permit GP 3331SV
- Relevant boundaries of Llanwern Steelworks PPC Permit BS3905

In the context of the areas of SSQ which have now been definitively closed and which are of most relevance to this report, these are distinguished from the other site areas as coloured blocks on Figure 3. On Figure 3, the area which has been definitively closed is outlined with a black dashed line with key sub-areas shaded. The closure plan, therefore, only referred to the areas within the dashed closure boundary and no other areas. The areas bound by the closure plan are:

- Slag Area W
- Slag Area E
- Lagoons 25 and 12 comprising slurry from the BOS and Blast Furnace plants
- Powerline Valley

There are also small areas outside of these distinguished areas although these have not been impacted by waste activities.

2.2 Site Setting

The site lies within an existing industrial area. The northern area of land within SSQ is occupied by Newport Galvanizers Ltd. and Air Products Ltd. North of Queensway road is the steel plant itself. To the west of the site lies an area currently occupied by Multiserv. To the east of the site lies the works effluent treatment reed beds. The steel plant boundary lies some 57m to the south of the site with the land ownership boundary lying further to the south again. Land to the south of Tata's ownership comprises Bowleaze Common which is part of the Wentloog levels, an area of ecological interest benefiting from statutory protection with a SSSI (Site of Special Scientific Interest) designation. This land comprises flat, low lying, sparsely populated and reclaimed grazing land.

2.3 Ground Conditions

The geology of the site has been determined from published information and several phases of site investigations.

The site is located on a Holocene sequence of low permeability sediments that overlie Mercia Mudstone. The mudstones, exposed to the north of the site, show a shallow dip to the SSW.

2.3.1 Holocene sediments

A Holocene sequence of clays and peat overlie bedrock at the site. This sequence of clays and peats are typically 10 to 15 meters thick across the Gwent levels and were formed within the last 10,000 years or so. At the site, these sediments have been found to be locally up to 17 meters thick and to comprise an upper and lower clay layer separated by a peat horizon.

The upper clay layer varies in thickness from 3.1m (borehole 18) and 7m (borehole 21) across the site and has been found in all site investigation boreholes. Laboratory testing of 4 undisturbed samples of the upper clay layer have established permeabilities in the range 1.4 x 10^{-10} and 9.2 x 10^{-10} ms^{-1}.

A peat layer has been encountered, below the upper clay, in all the boreholes at the site and has been found to be between 1 and 2 m thick. Six variable head permeability tests have been undertaken in boreholes completed within the peat which have established a range of permeabilities between 4.8 x 10^{-7} ms^{-1} and 7.2 x 10^{-6} ms^{-1}. The peat, in relative terms, is the "most permeable" unit within the Holocene sediments beneath the site.

The lower clay layer has been found to vary in thickness between 1 metre (borehole 21) and 8.9 metres (borehole 23) and once again has been identified in all the site investigation boreholes. Whilst no sampling and testing for permeability has been undertaken from this unit, lithologically it is closely related to the upper clay unit and, as such, it would be expected to have a permeability of 5 x 10^{-10} ms^{-1}.

There is some evidence that limited thin lenses of gravel occur between the lower clay and the weathered Mercia Mudstone.

2.3.2 Bedrock

The bedrock found below the Holocene sediments at the site is Mercia Mudstone (formally known as Keuper Marl). The Mercia Mudstones of the area are documented to consist of red or chocolate fine silty mudstones with conchoidal fractures.

From site investigation boreholes, the Mercia Mudstone has been found to have a weathered surface of approximately 1 to 2 meters in thickness. Falling head tests have been carried out in four piezometers completed within this weathered horizon. Borehole 23 on site, as well as 3 boreholes adjacent to the site, have established permeabilities of around 1 x 10^{-5} ms^{-1}.

The un-weathered Mercia Mudstone, which has very low matrix permeability and extremely limited secondary fracture permeability, is an important unit in terms of groundwater flow at the site, in that it is considered to provide the impermeable base to the groundwater "flow" system within the overlying Holocene sediments.

Rockhead below the Holocene sediments of the Gwent Levels is between -5m and -7.5 m below OD.

2.3.3 Made Ground

The area is currently covered with a blanket of fill materials comprising mainly steelmaking BOS slag (steel slag) which was deposited under the terms of a COPA licence in the 1970's. This layer is approximately 1m thick.

2.4 Hydrogeology

2.4.1 Aquifer Characteristics

There are no Source Protection Zones (SPZ) near the site, the nearest SPZ is that for the Great Spring which at its nearest point is more than 5km away from the site and is hydraulically isolated from the site by the intervening geology.

The strata below and near the site is considered by Natural Resources Wales as a non-aquifer (as shown on published Vulnerability Maps). Both the Holocene sediments and the underlying Mercia Mudstone are of low to extremely low permeability, which supports the classification of the area as a Non-Aquifer. There is no known licensed or unlicensed groundwater abstraction from strata underlying the Caldicot Levels.

The upper clay, with proven permeabilities in the range of 4 x 10^{-10} and 9.2 x 10^{-10} ms^{-1} and with a thickness of between 3.1 meters (borehole 18) and 7 meters (borehole 21) is a natural geological barrier that prevents vertical flow from the ground surface to the water table. Both the smaller drainage ditches around the site and the larger reens such as Hundred Perch Reen are founded within and do not pass through the upper clay layer.

Permeability values for the upper clay were acquired from testing undisturbed samples (U100's) in the laboratory and can, therefore, be relied upon to reflect field conditions. Uncertainty in the quality of the permeability results is reduced when all samples are considered, thus giving a narrow range and the fact that one of the results comes from testing during the Site Investigation carried out by Enviros in 2002.

The lower clay, having a thickness across the site of between 1 meter (borehole 21) and 8.9 meters (borehole 23) has the same lithological and sedimentological characteristics as the upper clay. Whilst its permeability has not been directly tested, it is considered to have permeabilities in a narrow range centred around 5 x 10^{-10} ms^{-1}, similar to that of the upper clay. As such the lower clay, like the upper clay, likely presents a significant barrier to vertical flow.

The peat horizon that has been identified across the site has permeabilities in the range of 4.8 x 10^{-7} ms^{-1} and 7.2 x 10^{-6} ms^{-1} and a thickness varying between 1 and 2 meters. It can be considered permeable in a relative sense, when compared to the upper and lower clays. Its position below the site, sandwiched between two layers of low permeability clay results in it becoming a credible route for the horizontal movement of limited volumes of groundwater. This is not because the peat is particularly permeable, or that it represents an aquifer but simply that it represents a "permeability contrast" when considering its location between two very low permeability clays. No significant amount of groundwater can be extracted from the peat.

There are possible localised lenses of gravels between the lower clay and the weathered Mercia Mudstone. The evidence for these gravels comes from samples taken at the depth of the weathered mudstone and there is a potential for some confusion between the two. However, with respect to groundwater flow, were there gravels in such circumstances, they would have a permeability like that attributed to the weathered mudstone which is considered contiguous across the site, so in hydrogeological terms their presence or absence is irrelevant.

The weathered layer of Mercia Mudstone located below the lower clay and above the un-weathered Mercia Mudstone has similar hydrogeological significance as the peat layer, in that its permeability, as established from variable head tests, is of the order of 1 x 10^{-5} ms^{-1}**.** As with the peat layer, this provides opportunity for horizontal movement of groundwater.

The significance of the underlying un-weathered Mercia Mudstone is that it is the impermeable base above which the limited groundwater movement occurring in this geological setting, takes place.

The absence of any groundwater abstractions from this hydrogeological setting, in an area where mains supply requires significant investment in infrastructure, supports the assertion that groundwater is not a viable resource in this low permeability setting.

2.4.2 Groundwater Flow

Historical hydrographs developed from the collection of groundwater level data show a variation between summer and winter groundwater levels of less than 0.5 meters. The small variation in groundwater levels over a 12-month period demonstrates that the amounts of recharge reaching the groundwater system within the peat and weathered mudstone horizon are very limited, particularly when considering the low specific yield of each formation.

Groundwater below the site has been encountered within the made ground, peat and weathered mudstone (bedrock) layers. Rest groundwater levels within the peat and bedrock units are observed as being almost identical suggesting that the peat and weathered mudstone horizons are in hydraulic continuity with one another. There is no lithological evidence for linkage between these two units directly below the site as all boreholes demonstrate the presence of the lower clay layer.

The historical groundwater gradient within the low permeability Holocene sediments has been previously found to be approximately 0.0033 towards the east-southeast, that is

Hundred Perch Reen. Groundwater gradients are very shallow, reflecting extremely low rates of recharge to the peat due to the overlying low permeability upper clay layer and the frequency of reens which groundwater within the peat discharges to.

2.5 Hydrology

The site is located close to the boundary of the Caldicot Levels which are part of the larger Gwent Levels. The Gwent Levels are an important and extensive low-lying area of estuarine alluvium located on the north side of the Severn estuary in Southeast Wales between Cardiff and the River Rhymney in the west and Chepstow on the River Wye in the east.

The Levels were created through the enclosing and draining of tidal saltmarshes and their continued existence requires the ongoing management of seawalls which prevent their frequent inundation by the sea. To manage runoff from the low permeability sediments that make up the levels and to transport runoff from adjacent areas of higher ground a complex system of channels has been constructed. The channels make up a hierarchical network, smaller ditches discharging into larger water courses known as reens, which in turn discharge into the sea via pumps and tidal gates. This network is the key feature of the Levels, both in terms of their ecological importance and the historic landscape. The minor ditches around the site are completed above the water table whilst the deeper reens around the site are completed within the Upper Clay, just below the water table. The drainage network and flows within it are managed by the Caldicot and Wentloog Drainage Board (an IDB).

Almost all the annual recharge falling on the site leaves via surface runoff due to the low permeability nature of the sites soils and the underlying low permeability Holocene sediments.

The closest water courses to the site which are not part of the sites own drainage infrastructure, are the Elver Pill Reen and the Hundred Perches Reen, some 359 meters to the ESE of the site. Due to their managed nature, flows within the reens can be variable and flow data is limited. Previous spot gauging of Hundred Perches Reen taken at the point where Queensway crosses the reen to the north of the site, shows flows to be in the order of 78 litres per second.

The Caldicot Levels are a SSSI, primarily as they are representative of a grazing marsh/reen habitat and also due to their invertebrate assemblages, plant species, otters, water voles and breeding birds. The nearest SAC to the site is the River Usk some 4 kilometres to the west of the site. There is no hydraulic connection between the site and the River Usk with all surface water from the levels draining directly into the Severn Estuary.

2.6 Conceptual Site Model

To enable the risks posed to groundwater and surface water to be evaluated, a conceptual hydrogeological model was developed as part of the closure process. The diagrammatic representation of the model is provided in Figure 4.

3 LAND USE AND CLOSURE PLANNING

3.1 Overview

The landfill area has been an area of industrial waste disposal for many years, initially developing in the 1970's to accept wastes from the Llanwern Steel Works. The landfill was one of two landfill sites operated at the Llanwern site, the other being the East Waste Management Site (EWMS). The landfill accepted industrial wastes from the steel making activity whilst the EWMS accepted general wastes, refuse, biodegradable wastes as well as industrial waste.

The 89 Ha occupied by the site was developed in a series of cells, historically termed lagoons. Lagoon 12 was constructed first on the west by raising four large bunds on top of the stabilising slag layer placed over the majority of the 89 Ha. Fine metallic dust (50% iron, 3% zinc) washed from the flues of the BOS plant was suspended in water and pumped from the steel works into Lagoon 12. There it settled and hardened to form the waste deposit seen today. Infilling in Lagoon 12 was completed by the mid 1980's with Lagoon 25 coming on stream as a replacement. Lagoon 25 was also constructed by developing slag bunds onto the stabilising slag layer, with the metallic fines pumped into the Lagoon. Infilling in Lagoon 25 was completed in 2002 with the demise of the steel making plant. There are no lining systems for either the base or side slopes of either Lagoon 12 or 25.

Throughout the duration of disposal activities, steel and iron slag was deposited to the north and east of Lagoons 12 and 25. Deposits of coarse granular slag of up to 7m thickness covered the areas indicated on Figure 3 as Slag Area W, Slag Area E and the SSQ Non-Hazardous Landfill. Since its deposition, both steel slag and blast furnace slag have become commercially viable for a variety of applications and most of the deposit has now been removed. The entire area now occupied by SSQ Non-Hazardous Landfill has, therefore, been reduced to a 1m thick slag stabilising layer.

Lagoon 27 is divided into four equal quarters and has accepted wastes from the Hot Mill under an IPC and now an Environmental Permit. This area lay outside the scope of the closure report for the areas in SSQ. Similarly, the water treatment lagoons in the NE of the site now fall under the works PPC Permit and therefore did not form part of the closure report.

Some of the activities in these areas have been carried out by Tata and its predecessors (Corus and British Steel) whilst some have been carried out by contractors (such as Harsco and Multiserv) and others by third parties (such as Air Products, Newport Galvanisers, and Tarmac).

3.2 Areas Comprising Slag

These areas have been re-worked by Multiserv and Tarmac. Multiserv first recovered the steel from the material to enable excavation of secondary aggregate by Tarmac. This recovery operation went on for several years but is now largely complete. The recovery process worked from east to west, from the area of SSQNHL towards Slag Area W. To enable the continued tracking of vehicles, a foundation layer of weathered slag approximately 1m thick is all that remains following removal of the workable slag.

3.3 Lagoons 12 and 25

Lagoons 12 and 25 are very similar in terms of their site position, construction and deposit. Lagoon 12, however, is approximately 20 years old whilst Lagoon 25 is 10 years old. The current condition of the surface of Lagoon 12 is shown in Plate 3-1.

Plate 3-1 Surface of Lagoon 12 in 2020

Plate 3-2 Surface of Lagoon 25 in 2020

Assessments completed as part of the closure report demonstrated that the lagoons were not likely to pose a significant risk to controlled waters due to the chemical stability of the stored material, the lack of sensitivity of the hydrogeological setting and the collection of surface run-off by the sites' surface water drainage system. Further, the stability assessment demonstrated that there were no concerns over their long-term stability.

As the lagoons are predicted to pose no significant risk to the aquatic environment and have been shown to be geotechnically stable, the restoration plan focussed on preventing the release of dust during dry conditions, improving the overall site aesthetics and ensuring that the surface water collection ditches are regularly maintained. As can be seen from Plates 3-1 and 3-2, both lagoons are currently partially naturally vegetated, with the vegetation at Lagoon 12 more advanced than Lagoon 25. Consequently, there have been no recorded issues regarding dust blow events. Therefore, there is no intention to disturb this habitat currently. Rather, the occurrence of dust release at both lagoons will be monitored and only, if necessary, will additional soil cover be placed. Such an approach will also benefit the appraisal of recovery operations, which is ongoing.

3.4 Powerline Valley

No specific restoration plans were planned for this area as no waste activities have occurred within the area.

3.5 Other Areas

No specific restoration plans were planned for these areas at this stage as no waste activities have occurred within these areas.

4 MONITORING PROGRAMME

The current available monitoring network is illustrated in Figure 5.

4.1 Groundwater and Surface Water

The AMP set out the determinants to be examined in groundwater and surface water. During 2014 and 2015, Tata commissioned more frequent monitoring than required by the AMP and implemented most of the characterisation suite. Following the completion of the first 12 months of monitoring, the AMP suggested that the analytical data should be reviewed to identify parameters from the characterisation suite that should be included in the indicator suite. This review was presented in the 2014 Annual Monitoring Report and the monitoring programme, summarised in Tables 4-1 and 4-2 started to be implemented during 2016.

Table 4-1 New Monitoring Schedule

Monitoring Parameter	Monitoring Location	Frequency	Type of Monitoring Point
Groundwater	BH13 to BH19, BH24, BH201 to BH205	Quarterly	50mm diameter piezometer wells
Surface water	SW1, SW2 and SW3	Quarterly	Surface water body comprising reens
Leachate	Lagoon 12 and 25 embankments	Six Monthly	Visual observation and physical measurement
Dust and Particulates	As required	As required	Dust gauges as required
Odour	As required	As required	Subjective assessment area
Stability	Lagoon 12 embankment	Annual	Visual observation and physical measurement

Table 4-2 Current Analytical Programme

Measurement	**Groundwater and Surface Water Suite**	
Monitoring Positions	All surface water and groundwater locations	
Frequency	Annually	All other times
Suite Reference	Characterisation Suite	Indicator Suite
Water Level	•	•
Temperature	•	•
pH	•	•
Electrical Conductivity	•	•
Ammoniacal Nitrogen	•	•
Total Oxidised Nitrogen	•	
Total Suspended Solids	• (surface water only)	• (surface water only)
BOD	•	
COD	•	
Total Organic Carbon	•	
Aluminium	•	
Arsenic	•	
Antimony	•	•
Boron	•	
Cadmium	•	•
Chromium	•	•
Chromium (vi)	•	
Copper	•	•
Iron	•	
Lead	•	•
Manganese	•	
Mercury	•	
Molybdenum	•	
Nickel	•	
Phosphate	•	•
Silica	•	
Titanium	•	
Tin	•	
Vanadium	•	
Zinc	•	
Calcium	•	•
Magnesium	•	
Nitrate	•	
Nitrite	•	
Sodium	•	•
Potassium	•	
Selenium	•	
Sulphate	•	
Total Alkalinity	•	•
Chloride	•	•
Total hydrocarbons	•	
Polyaromatic hydrocarbons	•	
VOC and SVOC compounds	•	

The monitoring network is, overall, performing as designed. There are, however, several aspects that require consideration and improvement:

- Samples cannot always be collected from the surface water sample monitoring locations due to dense vegetation growth. This was a particular problem during 2019 and during 2020 efforts have been made to maintain access.
- Buddleia growth along the southern boundary sometimes limits access and monitoring, particularly during the summer months.
- In 2019, no sample was collected from BH24 as the headworks were found to have been destroyed. During 2020, further investigations located the well and a sample was collected, although the headworks remain damaged and require repair. Other headworks also require maintenance and repair.

Plate 4-1 Overgrown buddleia at BH24
Note headworks on ground in left of picture

The reader should also be aware that the laboratory is currently reporting pH values above 12 as >12 pH units as they do not have the capability to accurately define pH values above this level.

4.2 Dust

The AMP details the dust monitoring programme to be implemented.

4.3 Waste Stability

The previous assessment of the stability of the waste mass, its containment bunds and the surrounding ground did not reveal the possibility of slope failure with even the most pessimistic model parameters. Waste settlement is not expected as the site has not received biodegradable wastes, simply hydraulically placed industrial wastes that are now becoming consolidated and partly cemented by mineral precipitation. Accordingly, waste settlement monitoring and waste/ bund stability monitoring is not required by the AMP.

However, in recognising that there is a possibility that part of the eastern bund of Lagoon 12 is not cemented and could have an inadequate Factor of Safety (though failure is not indicated) there should be an annual walk-over each springtime to look for evidence of shallow translational slips.

During the 2020 walkover, the embankment was found to be stable with no signs of instability.

4.4 Leachate Breakout

The AMP suggested leachate breakout monitoring should comprise six monthly site walkovers, particularly around the embankments of Lagoons 12 and 25. These areas are not always readily accessible.

During 2020, there were no signs of leachate breakout.

4.5 Analytical Testwork

All aspects of the analytical and monitoring programme are directly managed by Tata Environment Department. Under the direction of the Environment Department, Geotechnology and TDC undertake several aspects of the sampling and analysis. These include surface water and groundwater laboratory analysis and measurement of groundwater levels. Tata Environmental Department undertakes all other monitoring aspects when required. All analysis is undertaken by TDC based at the Engineering Centre for Manufacturing and Materials (ECM) in Margam, adjacent to the Port Talbot steelworks.

4.6 Actions required

- Safe access to the surface water sampling points needs to be improved. Given that vegetation growth is inevitable, routine maintenance and signage would be beneficial. Alternate sample positions could be considered and agreed with NRW, if necessary.
- Several of the headworks are open and not secure. The headworks at monitoring positions BH205, BH16, BH17, BH18, BH19, BH24 and BH201 need particular attention due to inadvertent damage over the years.
- Buddleia growth along the southern boundary is limiting access and monitoring. The vehicular access route and monitoring positions should be routinely maintained.

5 GROUNDWATER LEVEL AND QUALITY

5.1 Groundwater Flow

Piezometric plans in Appendix 1 present groundwater levels encountered in the shallow made ground and peat layer during 2019 and 2020. These plans have been developed from measurements of water level at the piezometers summarised in Table 5-1, where accessible.

Table 5-1 Groundwater Monitoring Wells

ID	Monitoring Interval
BH13S	Made Ground
BH16S	Made Ground
BH18S	Made Ground
BH201S	Made Ground
BH203S	Made Ground
BH13D	Peat
BH16D	Peat
BH17	Peat
BH18D	Peat
BH19	Peat
BH201D	Peat
BH202D	Peat
BH203D	Peat
BH205D	Peat

5.2 Groundwater Chemistry

Appendix 1 contains a summary of the groundwater chemistry data gathered to date. The data is presented as a series of hydrochemical contour plans and time series charts. To help understand some of the main differences in groundwater chemistry between the shallow made ground, peat and underlying bedrock a series of scatter plots are presented below.

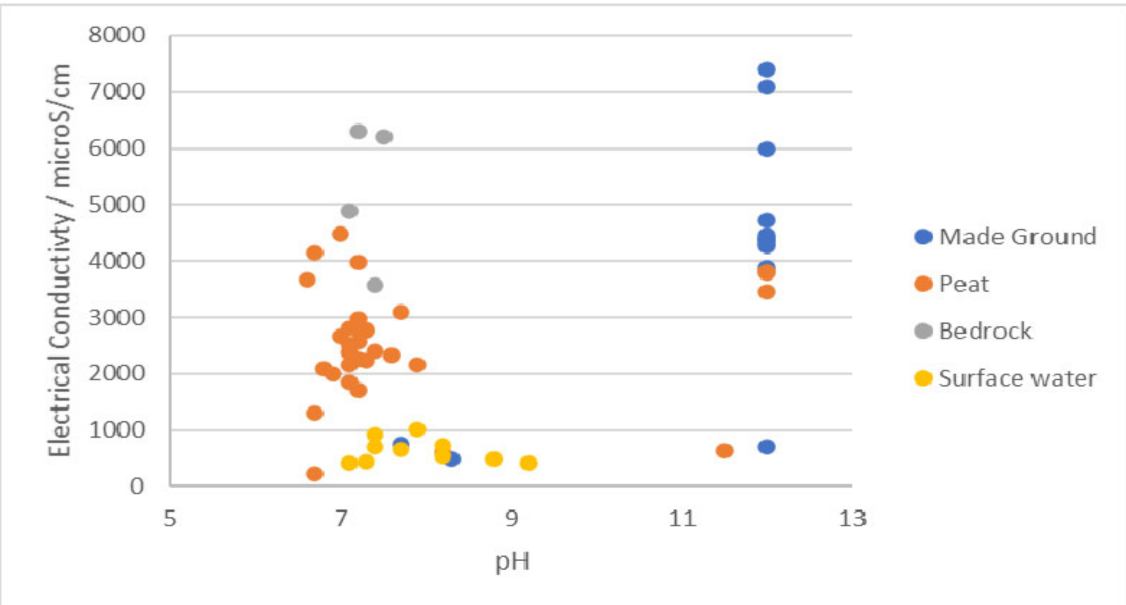


Plate 5-1 Differences in pH and Electrical Conductivity during 2020

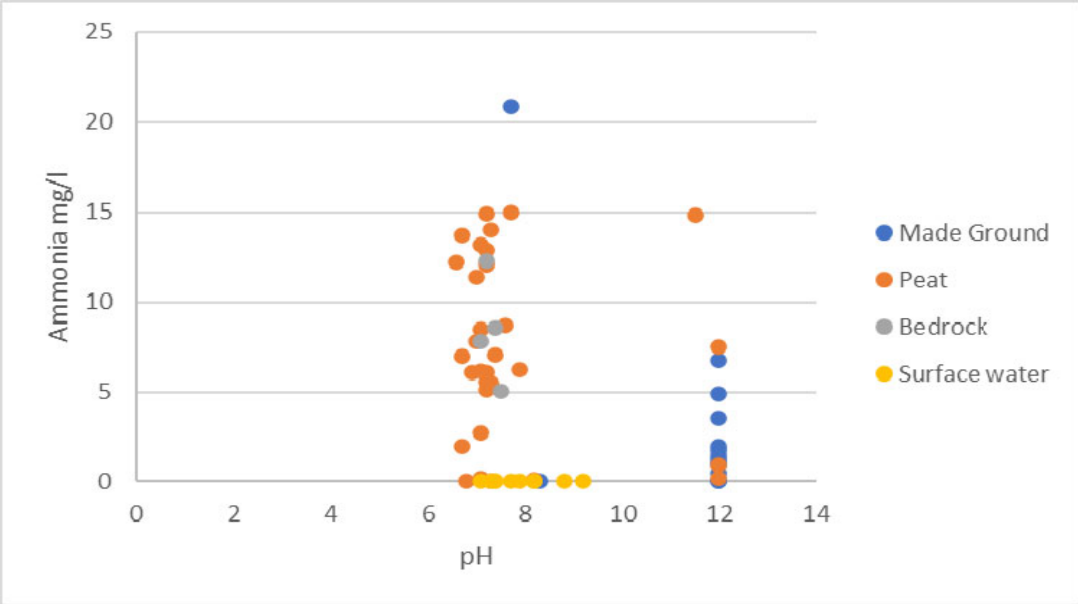


Plate 5-2 Differences in ammonia concentrations during 2020

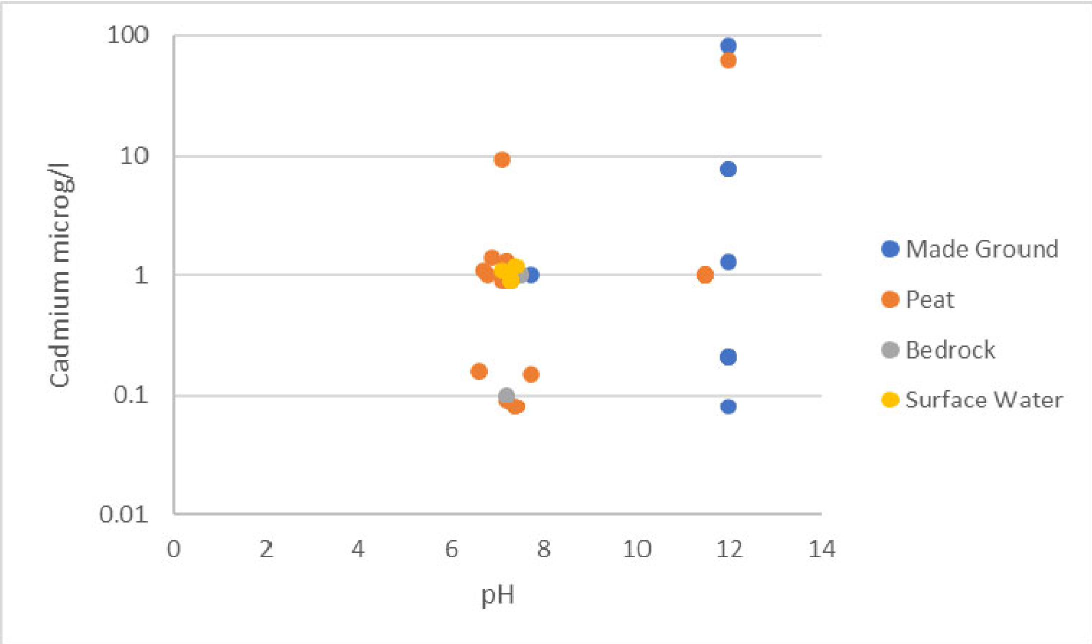


Plate 5-3 Differences in cadmium concentration during 2020

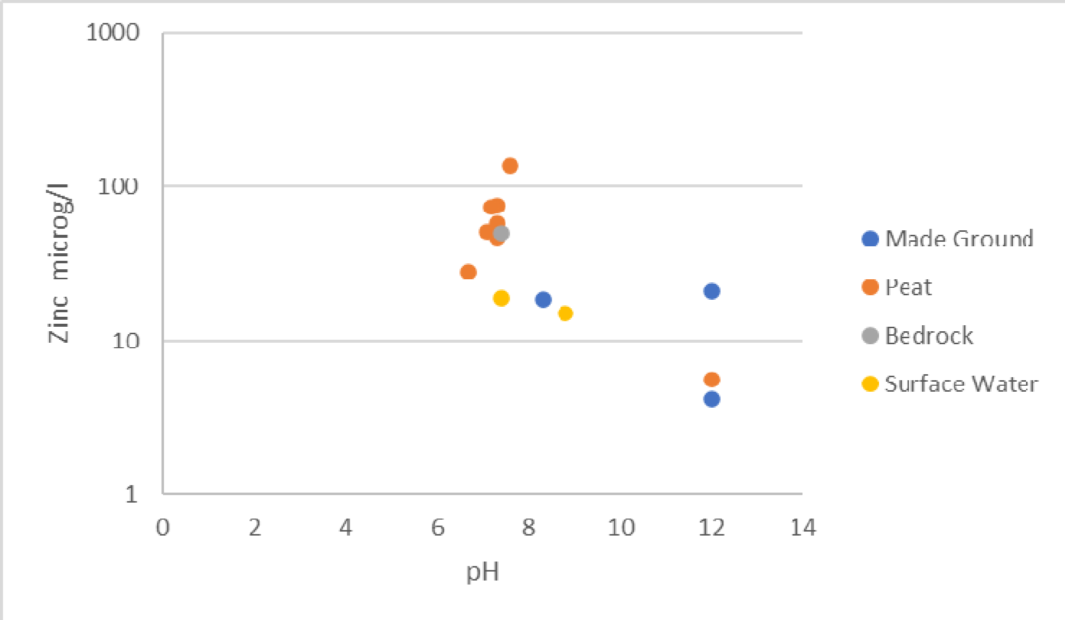


Plate 5-4 Differences in Zinc concentration during 2020

The data indicates that groundwater within the shallow made ground is distinct and characterised by elevated pH (typically > pH 11). This is principally because some of the made ground comprises steel slag that leaches lime with a strong alkaline pH. In comparison, the groundwater in the peat is circumneutral (pH 6 – 8) although there is potential evidence of potential interconnection between the made ground and peat at BH202, as the pH is persistently elevated at this point. Groundwater chemistry tends to become more dilute from north to south.

Because of the highly alkaline pH, many non-hazardous and hazardous substances are sometimes below detection limits or at low concentrations in the groundwater recovered from the made ground. In recent years, hazardous substance cadmium has been detected on several occasions, and sometimes at elevated concentration. Chromium, copper, lead (and other metals) have also been found above their freshwater Environmental Quality Standards (EQS). In 2019, cadmium was only detected once, within the peat at BH18D, at 0.001 mg/l. In 2020, Cadmium was detected on several occasions, including within the made ground and peat groundwater, as illustrated in Plate 5-3. Some of the levels detected were above freshwater Environmental Quality Standards (EQS), as summarised in Table 5-2. Mercury was not detected in 2020 but lead and nickel, also hazardous substances were detected above their respective EQSs.

As with many other substances, the temporal variation of several trace metals, including lead, could be described as 'spikey' with no clear trends. This variation may be a consequence of the low analytical detection limits (that sometimes appears to change) and potentially suggests that there is no widespread persistent deterioration in groundwater quality. Rather, the shallow perched groundwater chemistry is suspected to be influenced by antecedent rainfall and leaching / flushing of primary and secondary precipitates within the made ground. Previously, long-term increases in mineralisation were evident at several positions (e.g. BH17, BH19, BH201) but these trends are less distinct in 2020.

Although the concentration of several parameters sometimes significantly exceed their EQSs in groundwater within the made ground there does not appear to be any distinct widespread long-term deterioration in the perched water within the made ground. Some parameters were lower in 2020 than in other years. The key contaminants of potential concern in the made ground groundwater are identified in the last row of Table 5-2 with an average concentration / EQS ratio greater than unity. These are Cd, Cu, Cr and Pb The reader should note that exceedances of the EQS also occur in the underlying groundwaters sampled from the peat and bedrock horizons.

Ammonia is also sometimes present in groundwater sampled from the made ground, peat and bedrock. The comparative concentrations are summarised in Table 5-2. This indicates that ammonia is sometimes present in the shallow made ground, but persistent occurrence of elevated concentrations is not typical. At the high prevalent pH the ammonia would be expected to be dominated by un-ionised ammonia, the most toxic form. Within the underlying peat, the less toxic ammonium ion would be expected to dominate as the pH is lower.

Table 5-2 Comparison of selected data with EQS

	pH	**EC**	**Alkalinity**	**NH3-N**	**Chloride**	**Phosphate**	**Sulphate**	**Cd**	**Hardness**	**Hg**
		µS/cm	mg/l as $CaCo^3$	mg/l	mg/l	mg/l	mg/L	µg/l	mg/l	µg/l
EQS	6-9				250		400	0.25 / 1,5		0.07
Max (2020)										
Made ground	12	7400	1800	20.9	28.26	1.21	36.8	82.4	1527.57	<0.1
Peat	12	4480	1900	15	748	9.81	135	61.8	1222.47	<0.1
Bedrock	7.5	6300	3300	12.3	1090	12.63	98.5	1	593.3	<0.1
Average (2020)										
Made ground	11.38462	4065.846	1047.692	4.407	15.55615	0.836667	30.34	15.44833	945.6567	<0.1
Peat	7.783871	2539.387	914.7419	7.850344828	245.3537	5.186	55.49	6.089231	602.8875	<0.1
Bedrock	7.3	5237.5	1900	8.42	736.75	8.726667	98.5	0.55	593.3	<0.1
Made ground										
Average / EQS ratio					0.062225		0.07585	61.79333		
	As	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**V**	**Zn**	**B**
	µg/l	µg/l	µg/l	mg/l	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l
EQS	50	4.7 / 32	1	1	0.123 (bio)	4 / 34 (BIO)	1.2 / 14	20	10.9	2000
Max (2020)										
Made ground	1.488225	61.1	61.1	0	0.20862	11.4005	82.3	18.93157	20.88915	126.6994
Peat	12.41287	43.2	43.2	10.3	0.653838	7.577752	46.2	8.453672	137.7264	1433.005
Bedrock	2.110359	4	4	0.6	0.49559	2.177112	1.8	6.390276	49.63983	811.3442
Average (2020)										
Made ground	1.123596	10.25166	10.25166	<0.10	0.072125	4.142805	12.02111	7.369979	14.59184	91.91875
Peat	4.774738	5.644829	5.644829	5.3	0.470827	1.63567	4.015365	3.083317	59.57664	731.1401
Bedrock	2.110359	2.485736	2.485736	0.6	0.49559	2.177112	1.351666	6.390276	49.63983	811.3442
Made ground										
Average/ EQS ratio	0.022472	2.181204	10.25166	<<1	0.586382	1.035701	10.01759	0.368499	1.338701	0.045959

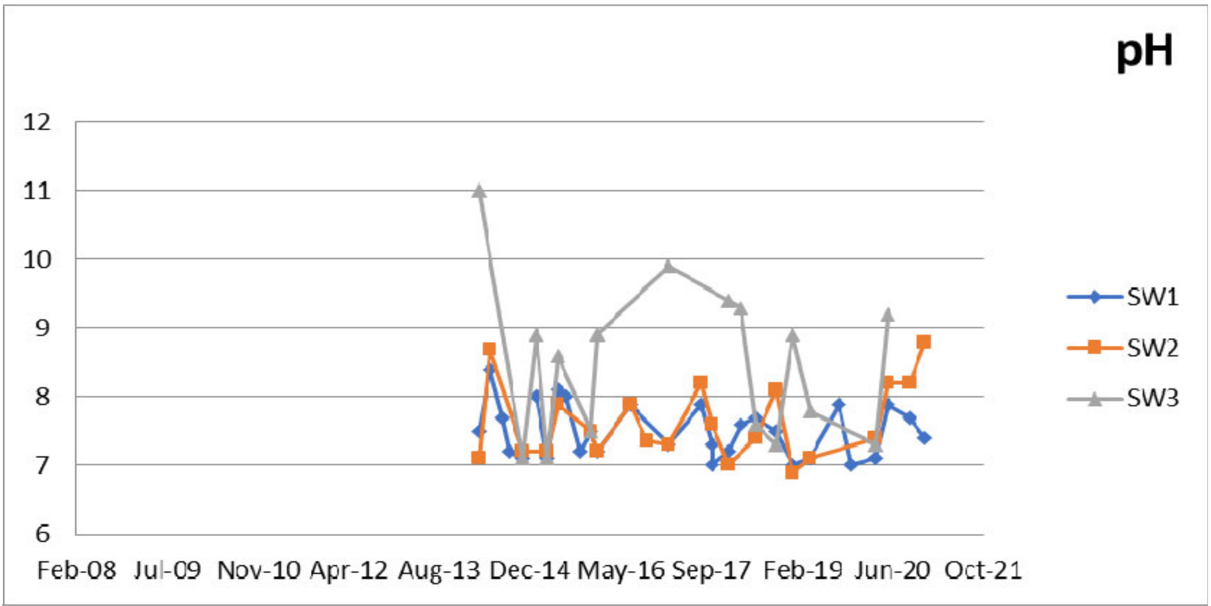
At BH16, an oil sheen was noted on the sample retrieved from the made ground in December 2016. Unfortunately, samples could not be collected from this position during 2018 and 2019 but following further excavation, the headworks (although damaged) were accessed again in 2020 and samples collected. An oil sheen was once again observed in 2020. Despite oil being observed, no organic hazardous substances were detected in the VOC or SVOC scans performed by the laboratory in Q4. This analysis included the screening of the samples for BTEX compounds and speciated PAHs with an analytical detection limit of 0.01microg/l. This situation should be further reviewed during 2021.

Interestingly, the groundwater within the peat is as mineralised as the perched groundwater within the shallow made ground. This is not considered to be due to infiltration of groundwater from the made ground through the intervening clay as several parameters are at higher concentration in the peat (e.g. chloride, sodium, chromium) and pH is significantly lower. The cause of the increased mineralisation is suspected to be due to processes within and possibly below the peat, including the potential influence of sub-artesian groundwater in the underlying bedrock and a potential saline contribution. There are variations in the hydrochemistry in the peat, but these are not considered to be related to the passage of groundwater from the overlying made ground.

Groundwater in the Mercia mudstone is only monitored at BH24, to the south of Lagoon 25. Like the groundwater found in the peat, the groundwater in the bedrock has a circumneutral pH and elevated electrical conductivity (4000-6000 microS/cm in 2017). During 2017, the mineralisation was increasing due, in part, to sustained increases in chloride and ammonia. Since this time, the mineralisation has stabilised within the range of previous observed values but can be spikey between sampling rounds. Some of the variations may be influenced by the significantly damaged headworks.

6 SURFACE WATER

The results of the surface water monitoring are presented in Appendix 2. The data gathered during the past 12 months is similar to that collected several years ago suggesting a large degree of stability in the water chemistry. Some of thee variations are illustrated in
Plate 6-1.



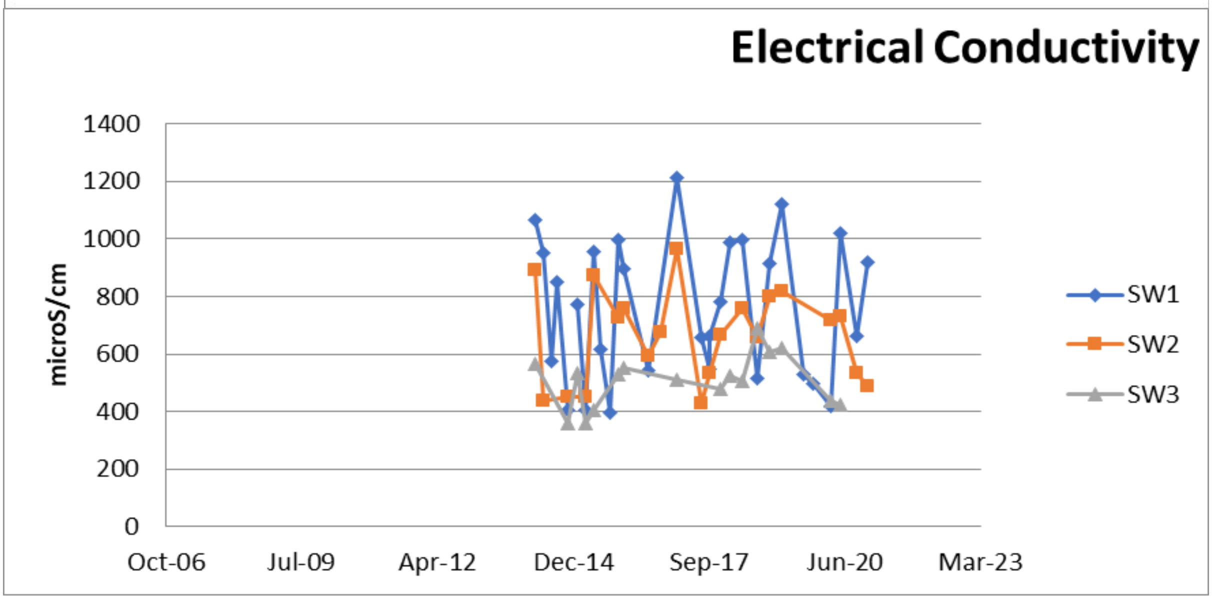


Plate 6-1 Variations in surface water chemistry

Surface water is typically circumneutral, moderately mineralised with low levels of non-hazardous and hazardous substances. As surface water progresses from east to west, the mineralisation decreases from ~ 800 microS/cm to less than 600 microS/cm. The main reason for this change is decreasing alkalinity although most parameters are lower downgradient of SW1.

Apart from a few short-term breaches, all data is typically within Environmental Quality Standards (EQS), as summarised in Table 6-1. The analysis presented in Table 613 does however indicate that Cd and Cu are above freshwater EQS in surface water in 2020.

Table 6-1 Comparison of surface water chemistry with EQS

	pH	EC	NH3-N	TSS	Chloride	Phosphate	Sulphate	Cd	Hardness	Hg
		µS/cm	mg/l	mg/l	mg/l	mg/l	mg/L	µg/l	mg/l	µg/l
EQS	06-Sep				250		400	0.15 / 0.25		0.07
Maximum	9.2	1020.0	0.0	88.0	54.7	0.7	87.5	1.2	654.4	<0.1
Average	7.9	634.7	#DIV/0!	43.3	31.2	0.7	62.8	1.1	401.5	<0.1
Average/EQS					0.1		0.2	4.3		
	As	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn	B
	µg/l	µg/l	µg/l	mg/l	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l
EQS	50.0	4.7 / 32	1.0	1.0	0.123 (bio)	4 / 34 (BIO)	1.2 / 14	20.0	10.9	2000.0
Maximum	1.8	1.8	182.0	<0.1	0.6	0.6	1.1	0.3	19.0	241.3
Average	1.4	1.1	32.5	<0.1	0.3	0.5	0.9	0.3	17.0	175.9
Average / EQS	0.0	0.2	32.5		2.6	0.1	0.8	0.0	1.6	0.1

As shown in Plate 6-1, sample positions SW2 and SW3 were not always accessible in 2019 and 2020 due to dense vegetation growth. This should be routinely cleared or new sample points established with agreement from NRW.

Plate 6-2 Example of dense vegetation approximately 2m high along access route to SW3

7 AMENITY ISSUES

There have been no requirements for any dust, noise or odour monitoring or investigations.

8 SUMMARY AND RECOMMENDATIONS

8.1 Evaluation and Summary

Monitoring of groundwater and surface water has revealed conditions like those previously observed. Shallow groundwater chemistry is dominated by the leaching of slag-based wastes with elevated pH and alkalinity. Such chemistry is not widely evident in the underlying peat as the made ground and peat are separated by low permeability clays. Mineralised groundwater within the peat is not considered to be a consequence of downwards percolation from the overlying made ground.

Shallow groundwater in the made ground is perched on the underlying clay surface. This groundwater has been found to contain several trace metals at concentrations that exceed Environmental Quality Standards by several orders of magnitude. The occurrence is not always persistent and the concentrations of several parameters were lower in 2020 compared to previous years.

Free oil has once again been observed at BH16.

Like the groundwater in the peat, surface water on the southern, downgradient edge of the site is circumneutral. The concentration of non-hazardous and hazardous substances tend to be lower in surface water, with more parameters meeting Environmental Quality Standards. This surface water drains to the works treatment system.

8.2 Monitoring Programme

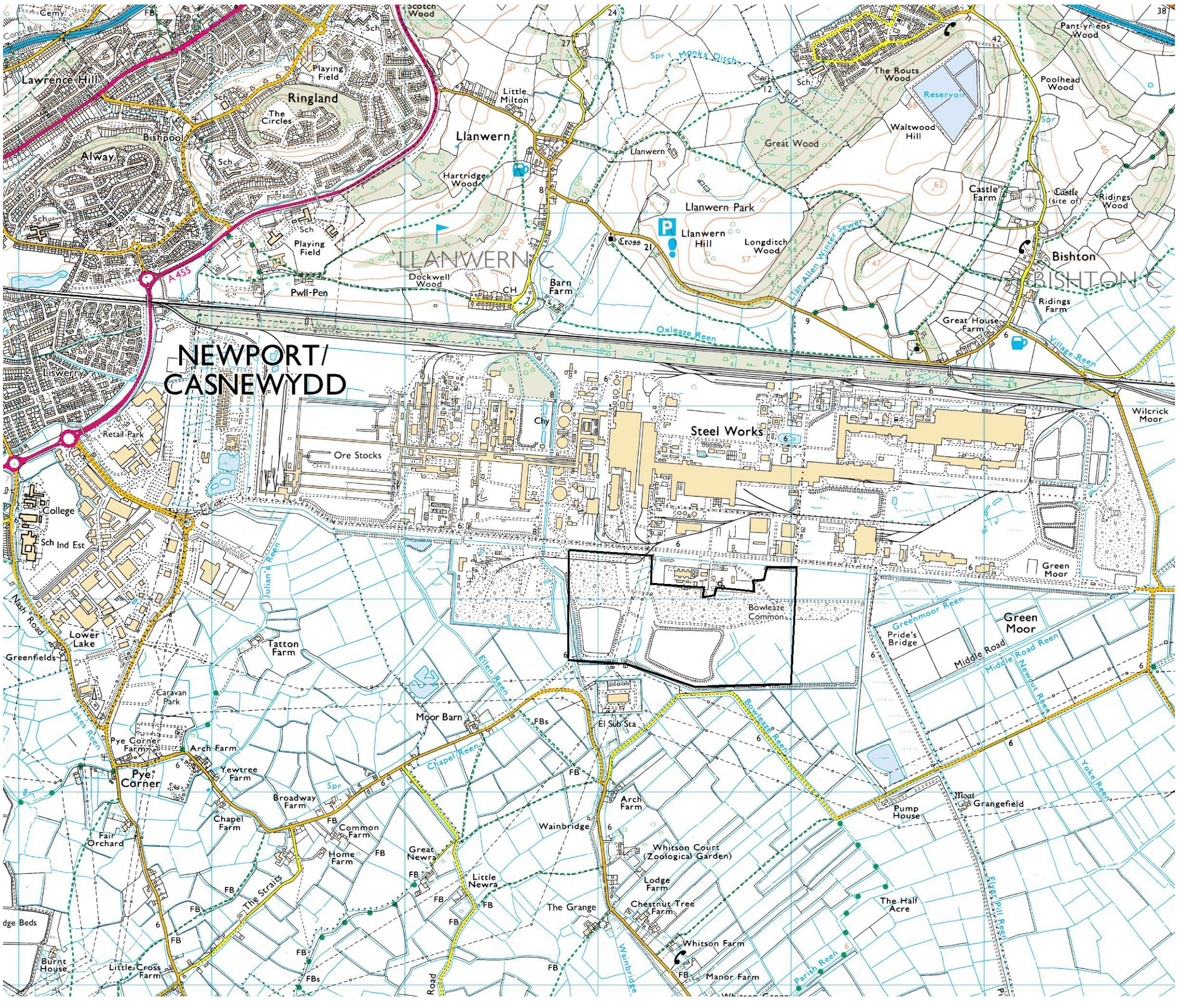
As noted previously, the monitoring programme could be rationalised as the current datasets reveal that groundwater gradients are low, and conditions are relatively stable. For instance, the frequency of groundwater monitoring could be reduced to six monthly and monitoring at BH203, BH16 and BH24 stopped. This latter suggestion is on the basis that BH203 is close to BH13, BH16 (which has been buried) is close to BH18 and BH24 monitors the bedrock.

Before requesting NRW to evaluate this suggestion, Geotechnology suggests that Tata first considers the potential impact of any development proposed for the site and immediate area and the potential benefit of the current monitoring programme. Consideration could also be given to utilising information and infrastructure from the boreholes drilled by others along the southern part of the site to inform the M4 relief road design. It is unclear if these boreholes contain groundwater wells that could be utilised.

8.3 Actions Required

- Check integrity of the site boundary to ensure members of the public cannot gain access.
- Conduct six monthly walkovers around embankments of Lagoons 12 and 25 to check for leachate breakout.
- Conduct annual walk-over each springtime to look for evidence of shallow translational slips along the embankment of Lagoon 12.
- Improve year-round access to the surface water monitoring positions.
- Locate and expose BH16 and BH18 to assess condition of headworks.
- Manage buddleia growth along the southern boundary as it is limiting access and monitoring.
- Investigate damage to BH24 and take appropriate actions.

Figure 1 Site Location Plan



Reproduced from the Ordnance Survey Land Ranger Map
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Figure 2 Site Plan Showing Permit Boundaries

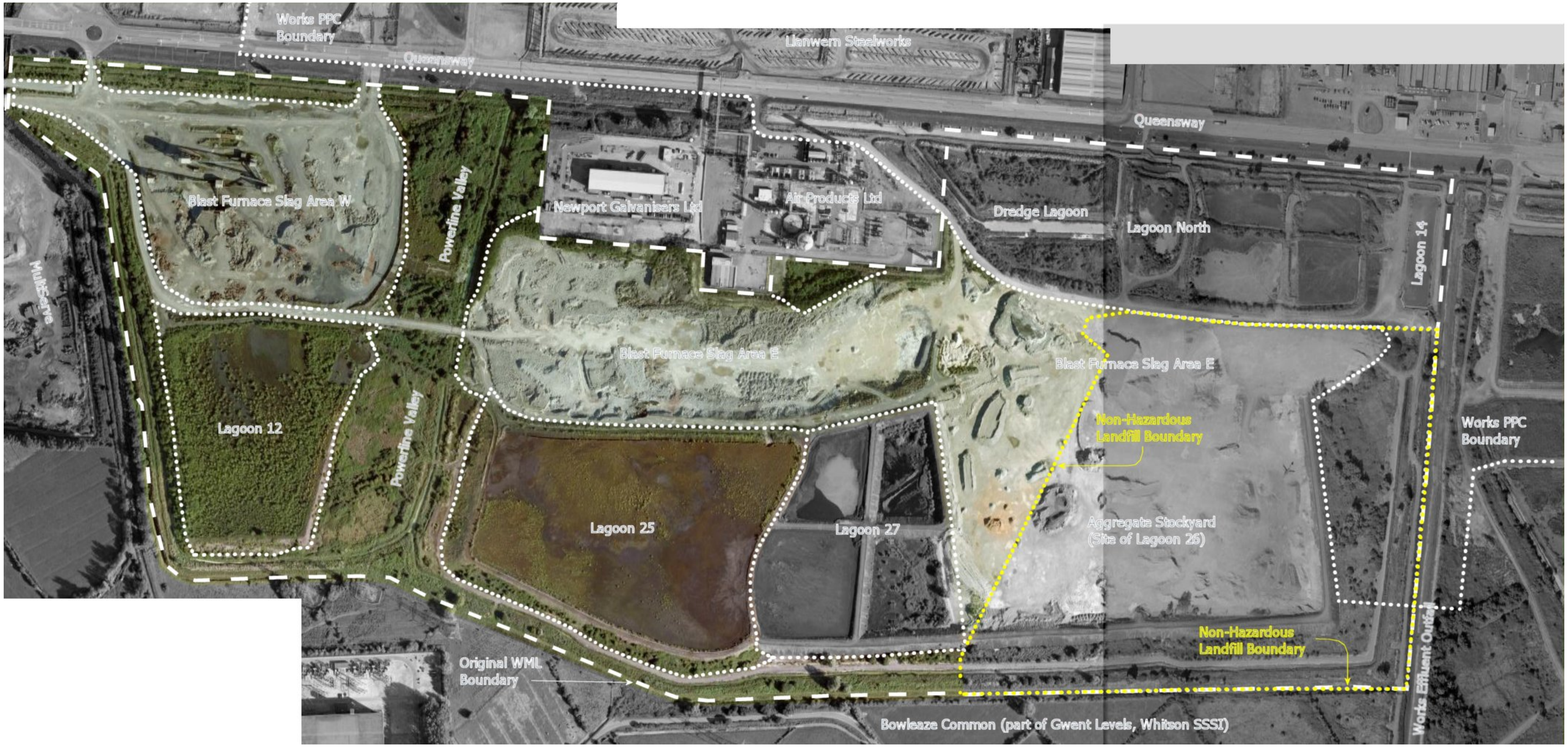


Figure 3 Areas of Site Included in Closure Plan

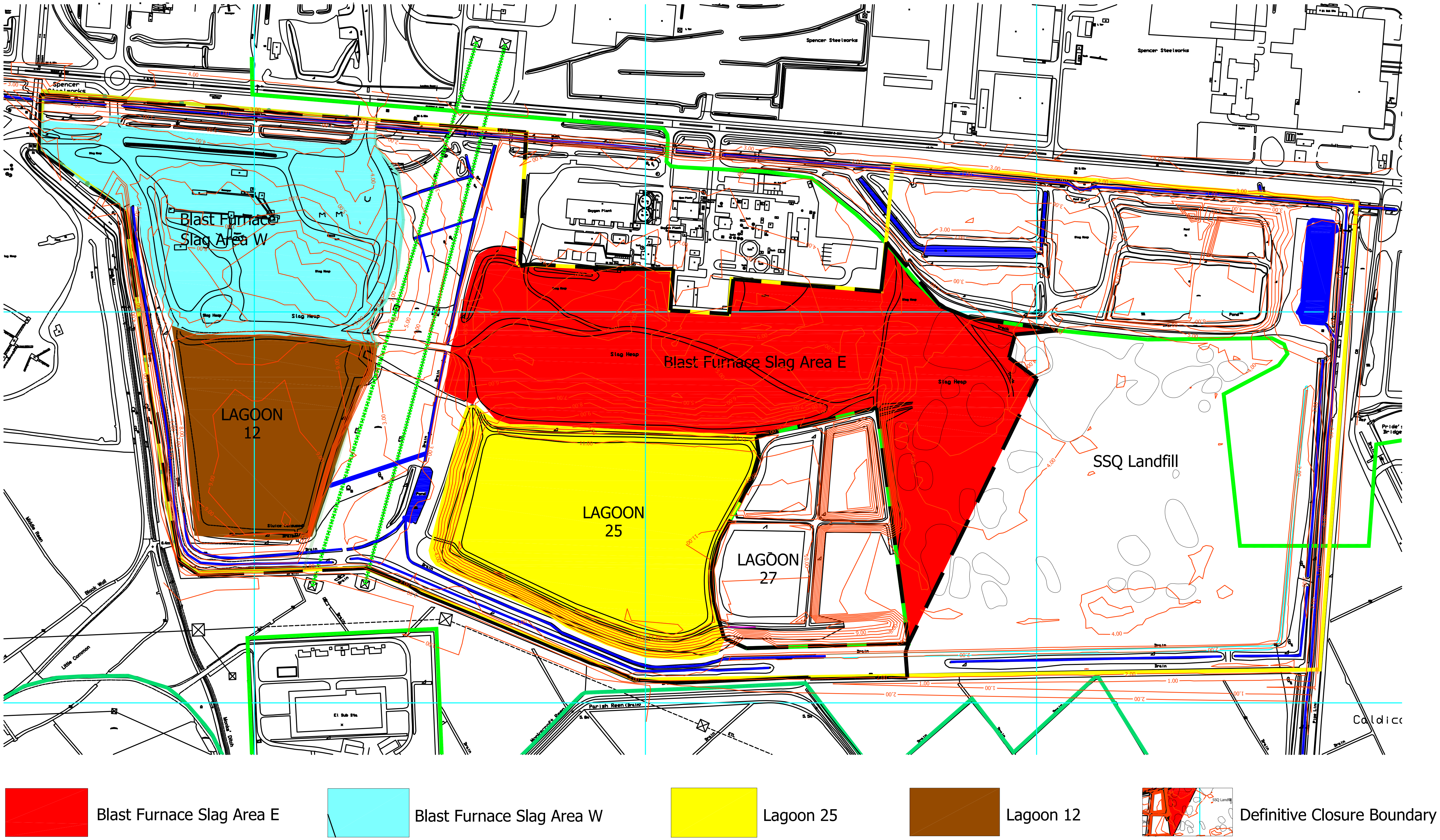


Figure 4 Conceptual Site Model

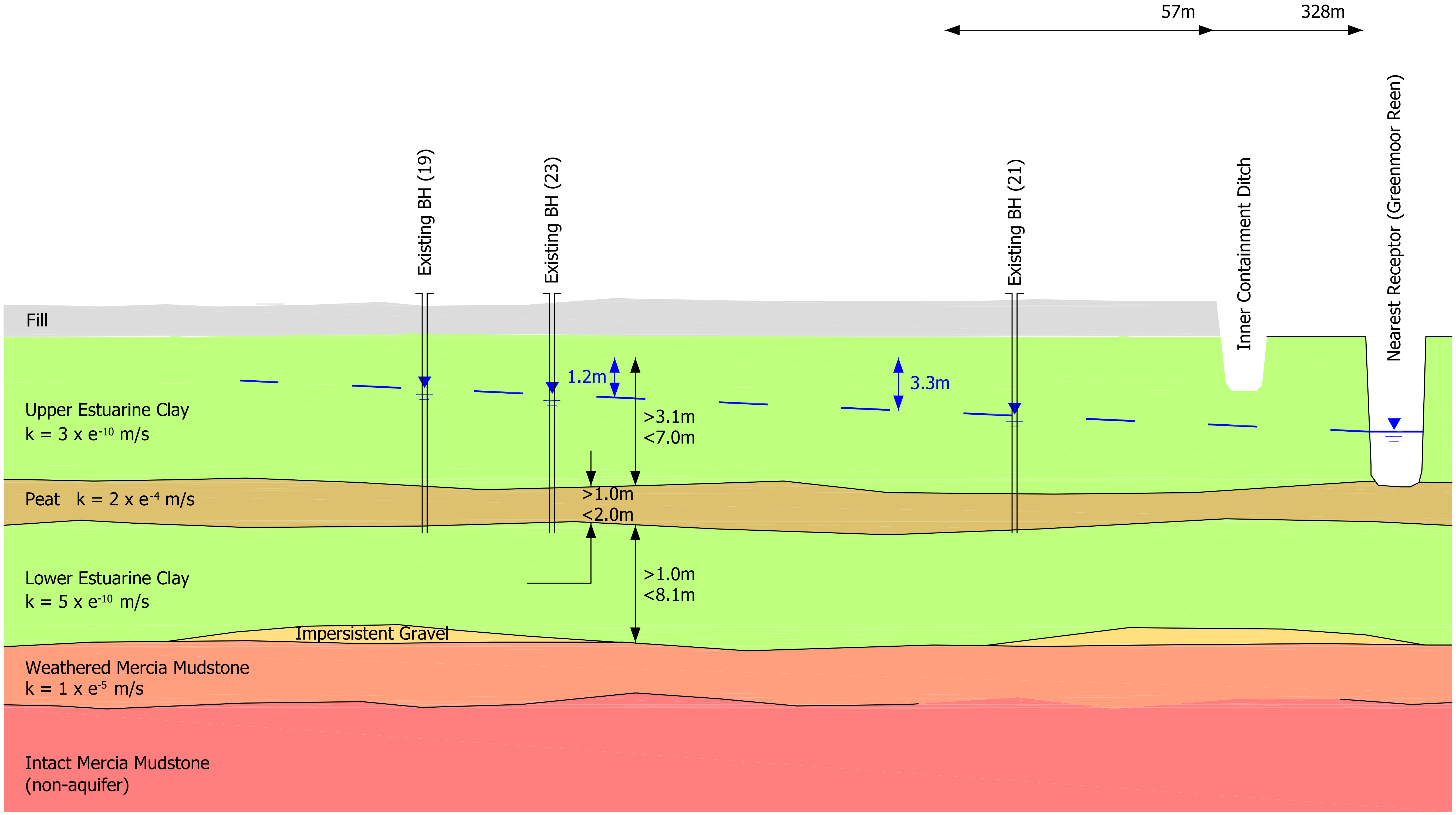
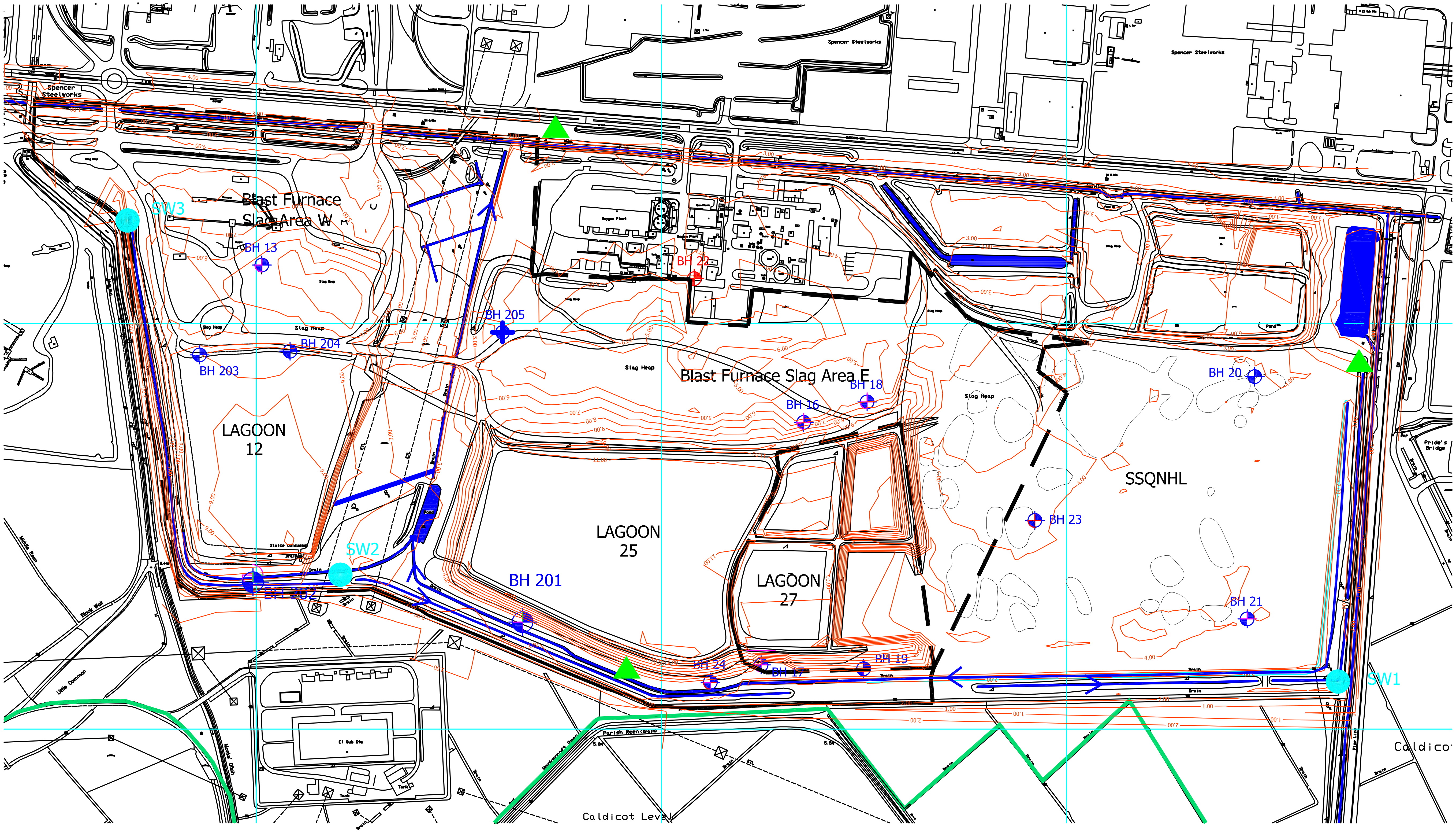
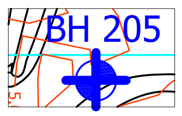
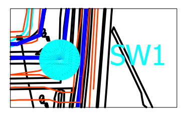


Figure 5 Available Monitoring Network





Monitoring Position to be replaced

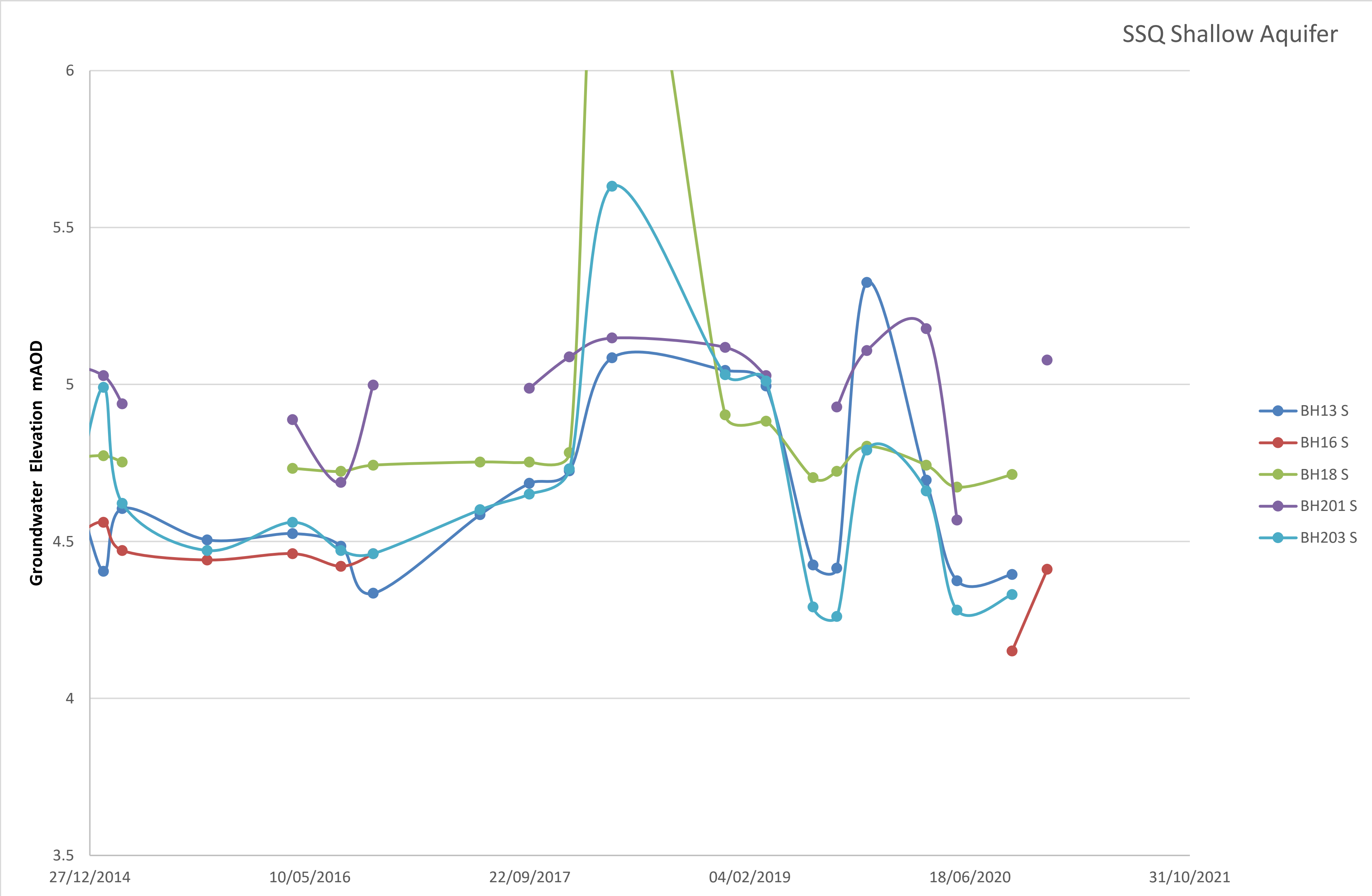


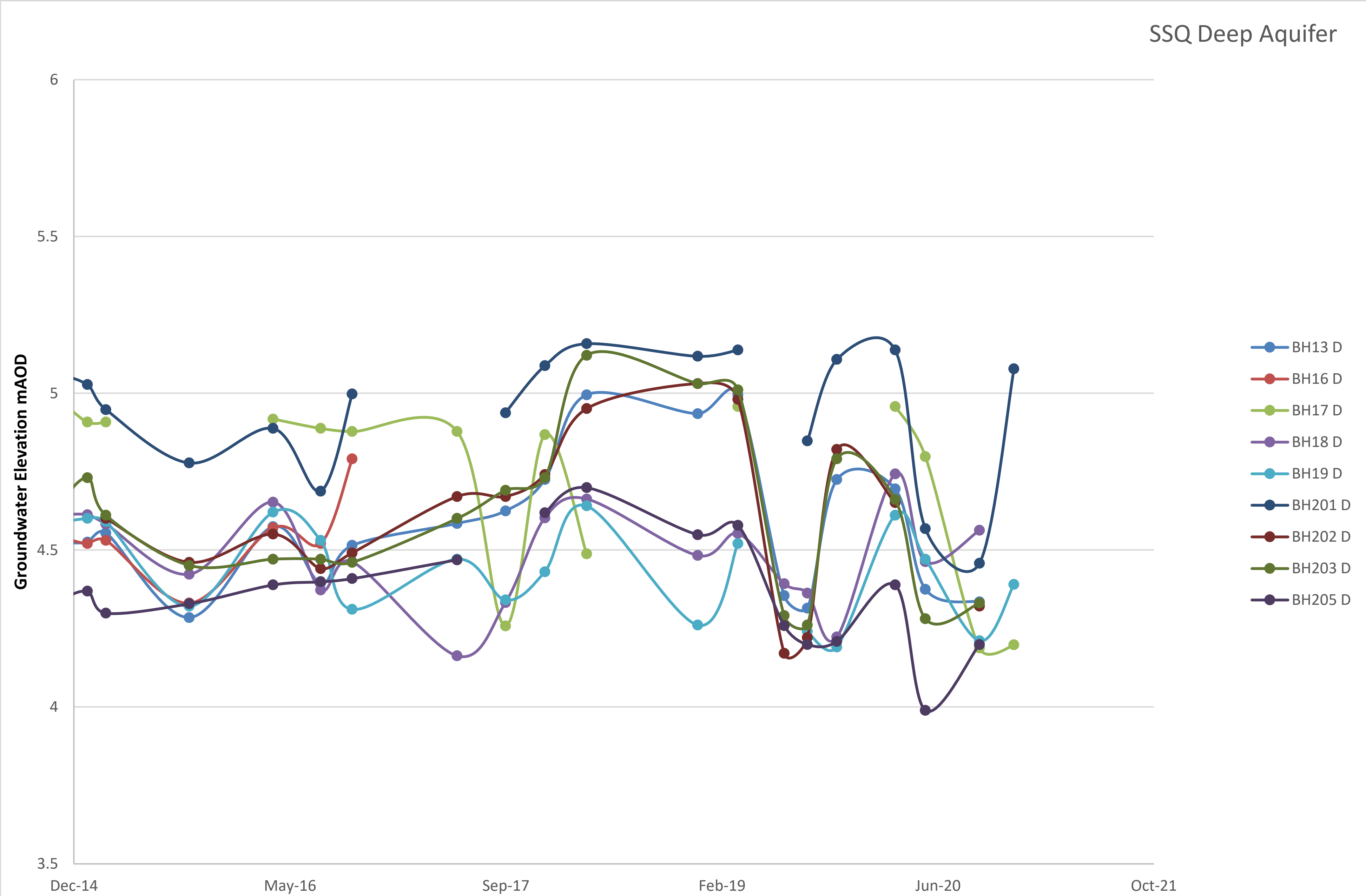
Surface Water and Leachate Monitoring Position

SOUTH SIDE QUEENSWAY WASTE MANAGEMENT SITE, LLANWERN STEELWORKS

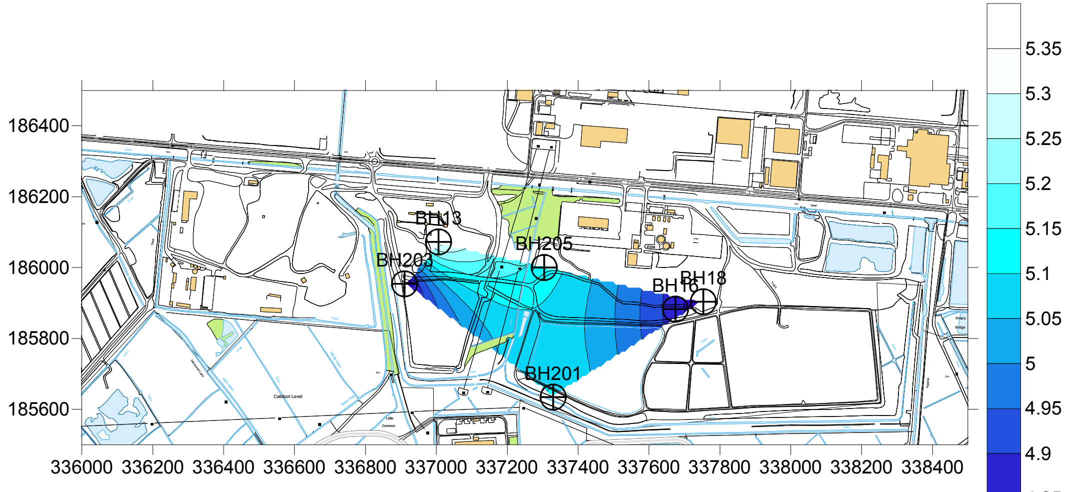
2020 Annual Review of Environmental Monitoring

Appendix 1
Groundwater Level and Chemistry Analysis
Report Number 2116r2v1d0221

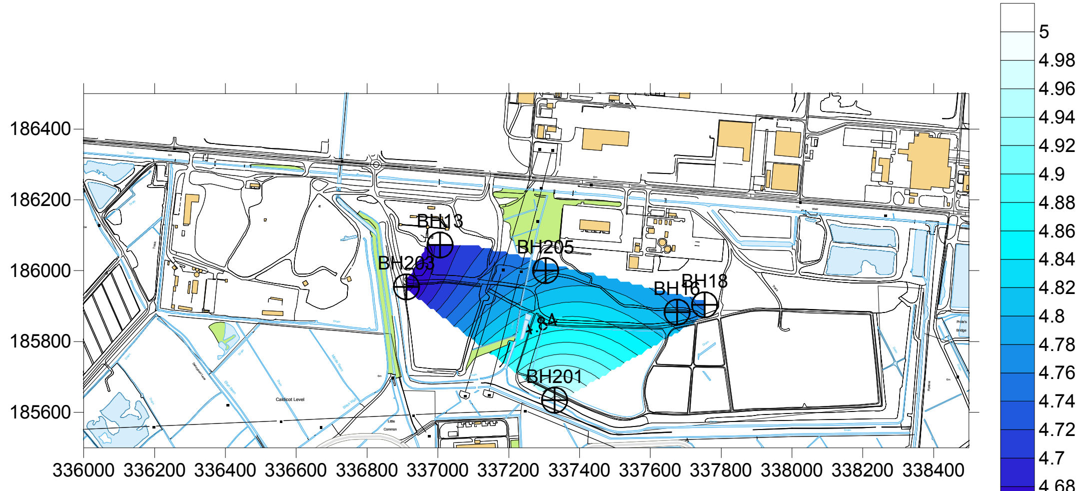

SSQ Shallow Aquifer
Groundwater Elevation mAOD
6
5.5
5
4.5
4
3.5
27/12/2014
10/05/2016
22/09/2017
04/02/2019
18/06/2020
31/10/2021
BH13 S
BH16 S
BH18 S
BH201 S
BH203 S


SSQ Deep Aquifer
Groundwater Elevation mAOD
6
5.5
5
4.5
4
3.5
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
BH13 D
BH16 D
BH17 D
BH18 D
BH19 D
BH201 D
BH202 D
BH203 D
BH205 D

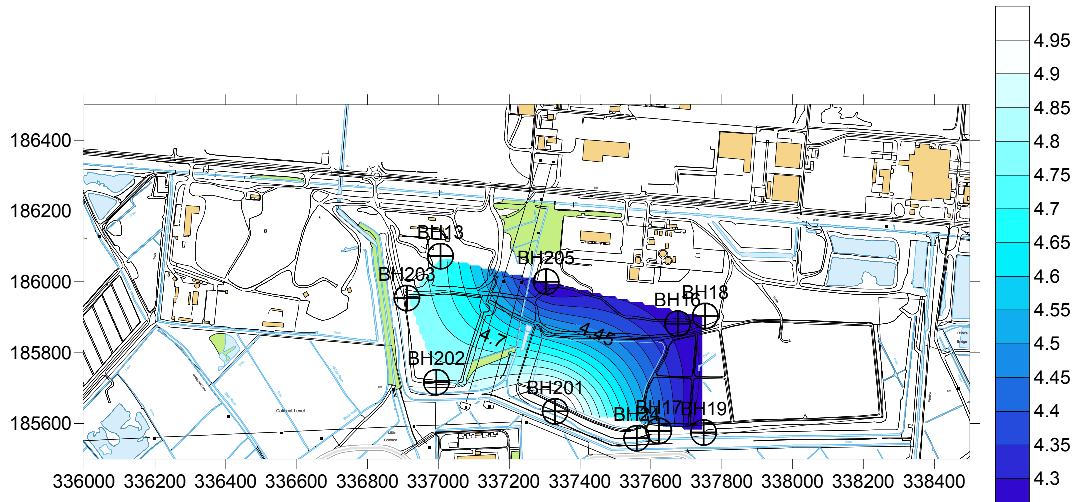
Groundwater Contours 2017 and 2019



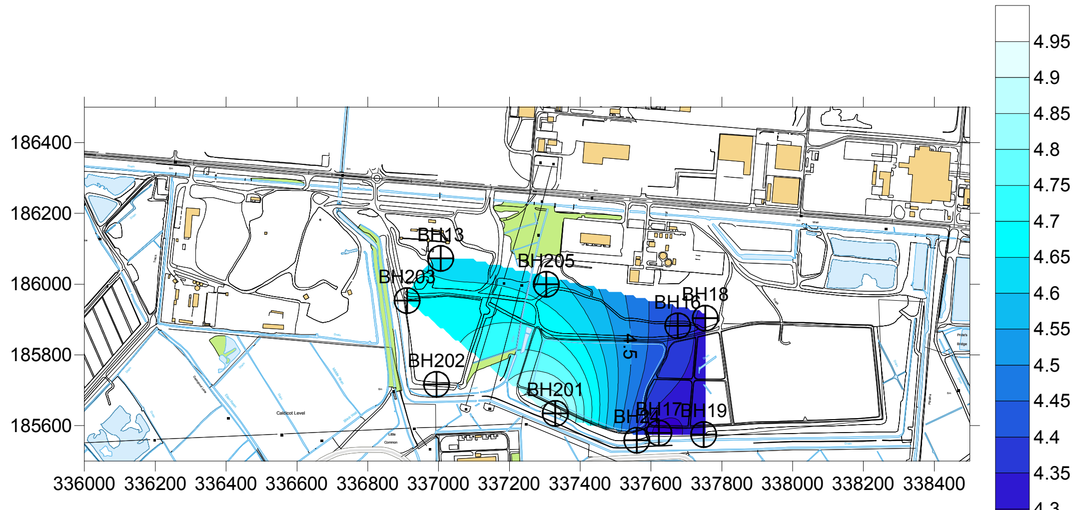
December 2019 Shallow



September 2017 Shallow

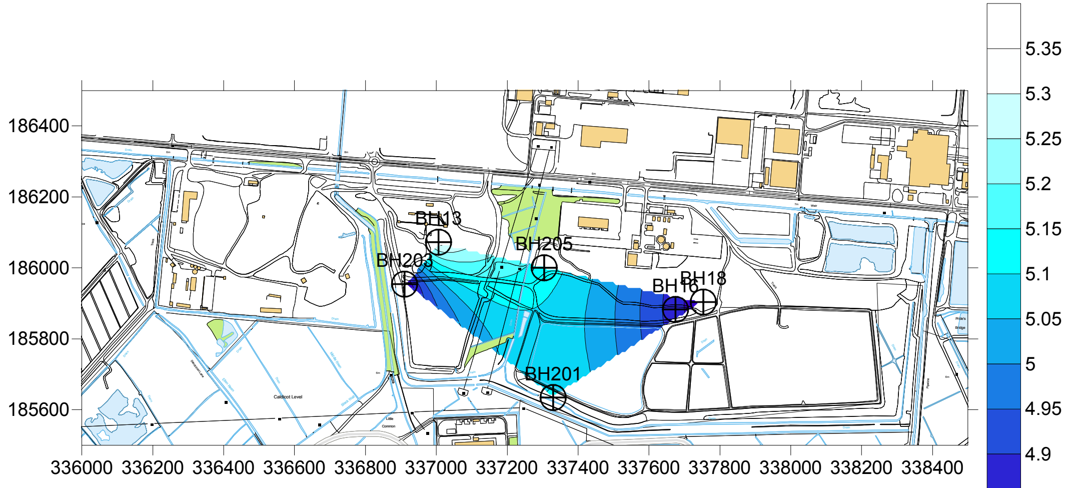


December 2019 Deep

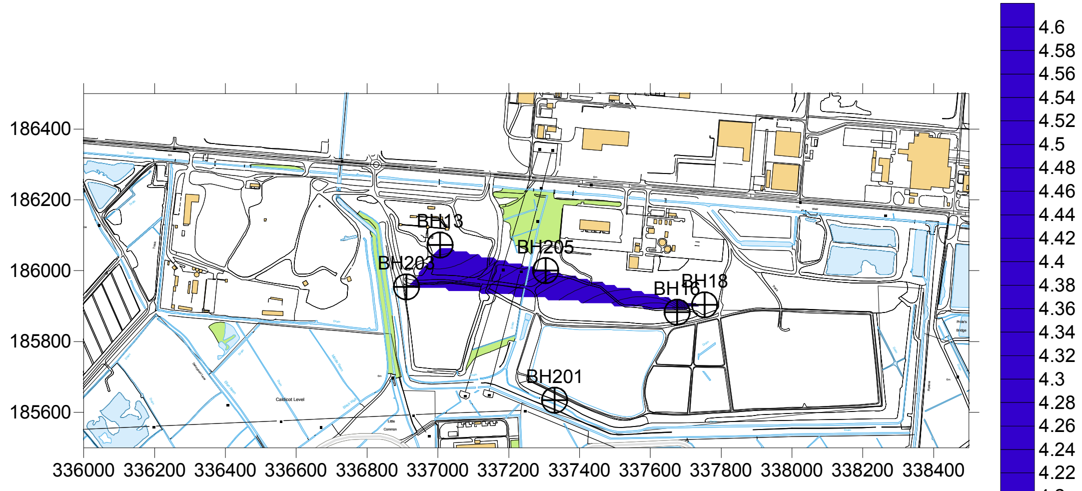


September 2017 Deep

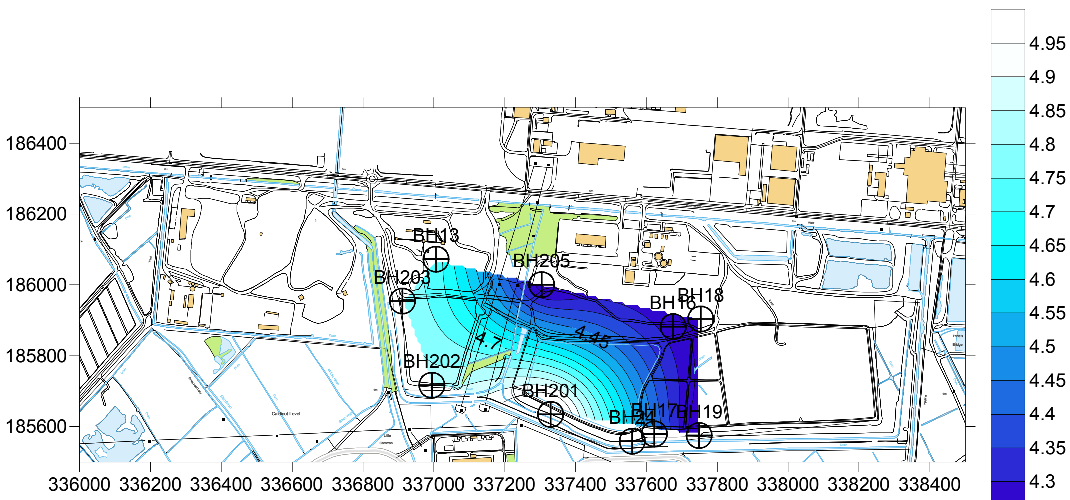
Groundwater Contours 2019 and 2020



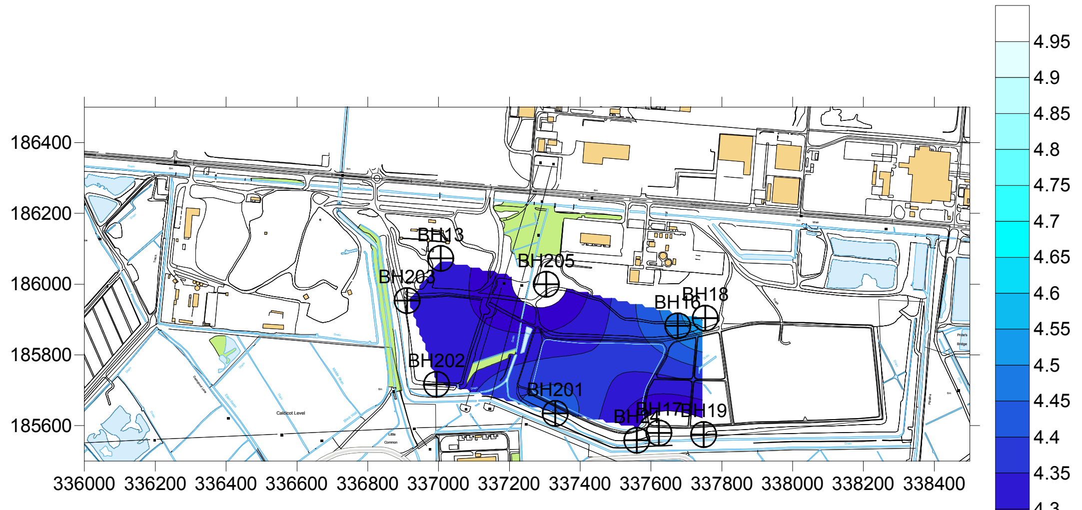
October 2019 Shallow



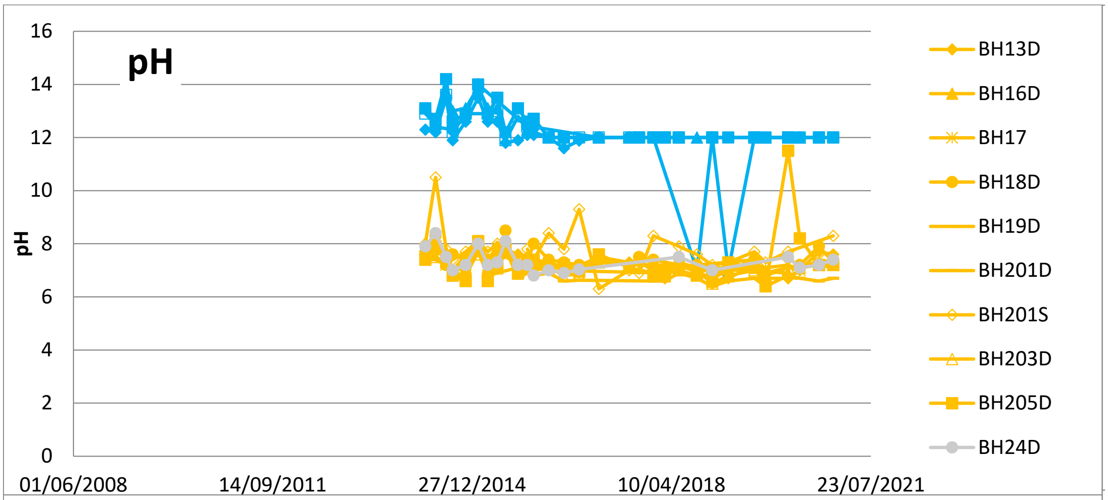
September 2020 Shallow



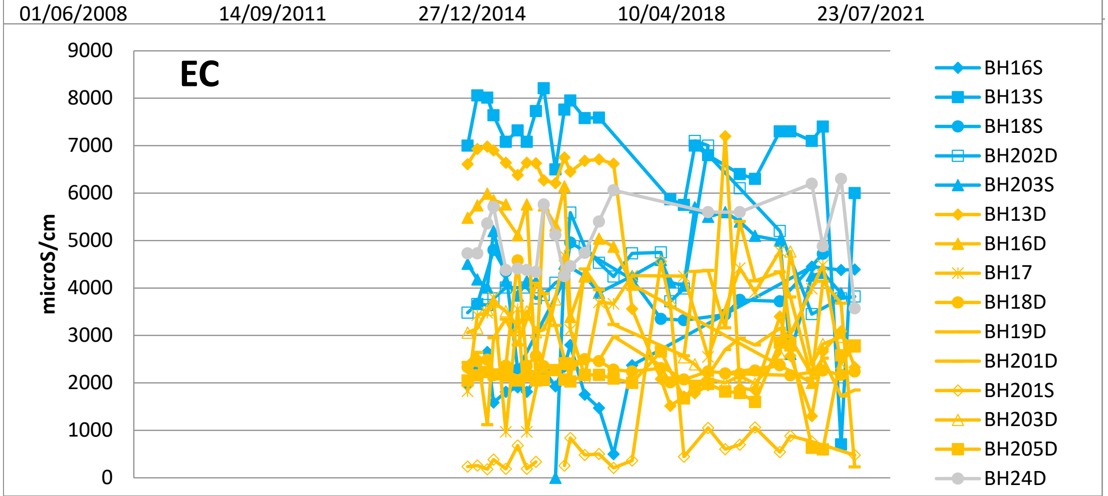
October 2019 Deep



September 2020 Deep



pH
16
14
12
10
8
6
4
2
0
pH
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH13D
BH16D
BH17
BH18D
BH19D
BH201D
BH201S
BH203D
BH205D
BH24D



EC
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
microS/cm
BH16S
BH13S
BH18S
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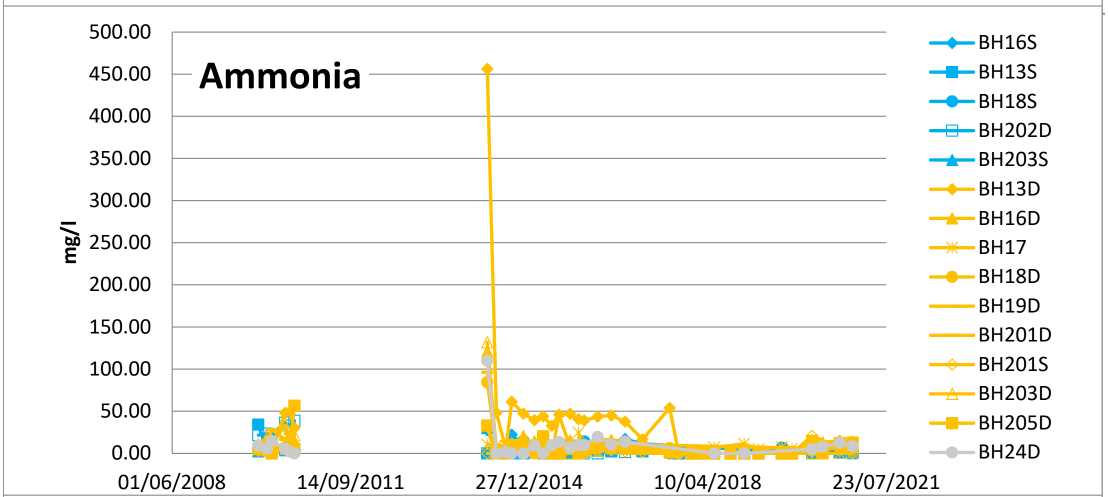
BH203D
BH205D
BH24D



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450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
mg/l
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH16S
BH13S
BH18S
BH202D
BH203S
BH13D
BH16D
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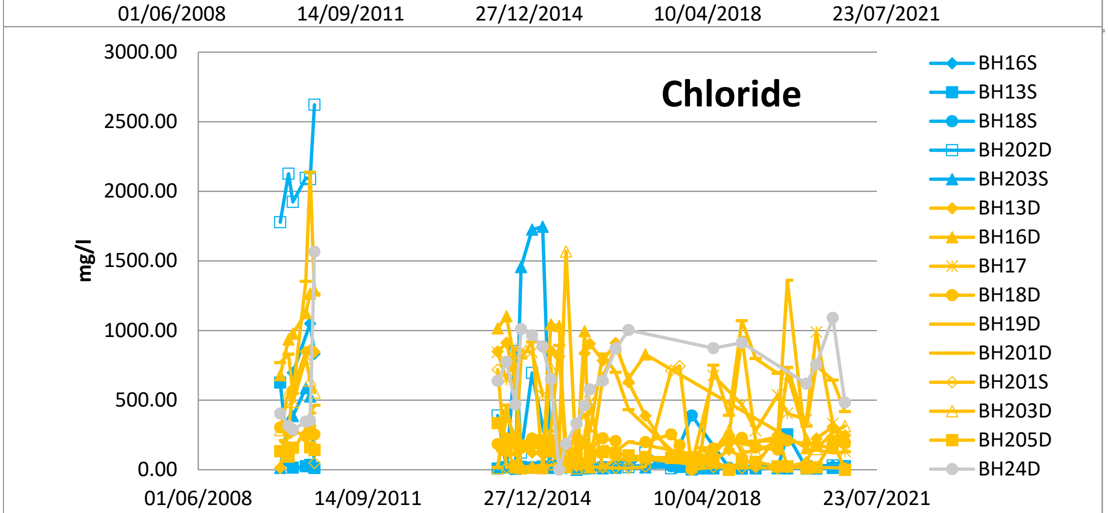
BH203D
BH205D
BH24D



Chloride
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2000.00
1500.00
1000.00
500.00
0.00
mg/l
01/06/2008
14/09/2011
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10/04/2018
23/07/2021
BH16S
BH13S
BH18S
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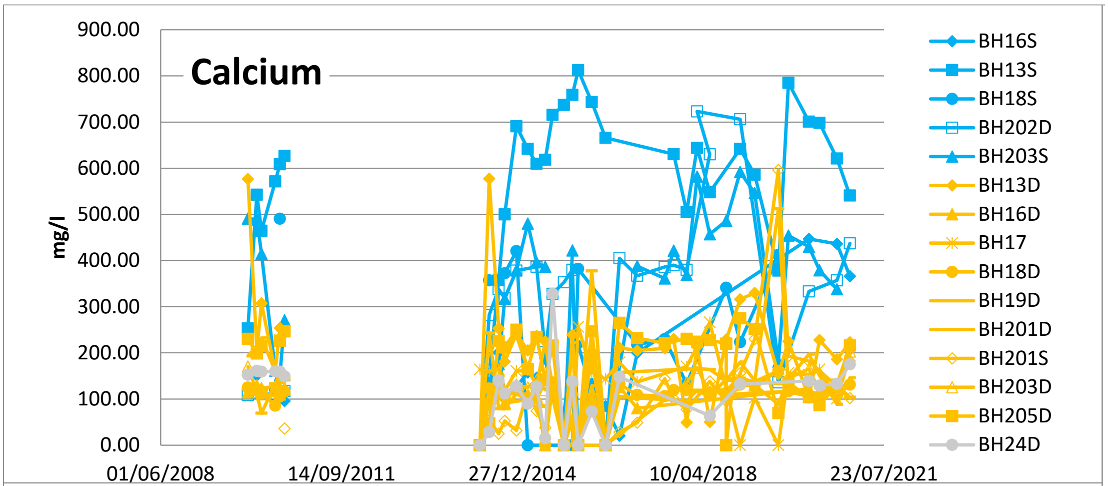
BH203D
BH205D
BH24D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mg/l
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800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
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14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH16S
BH13S
BH18S
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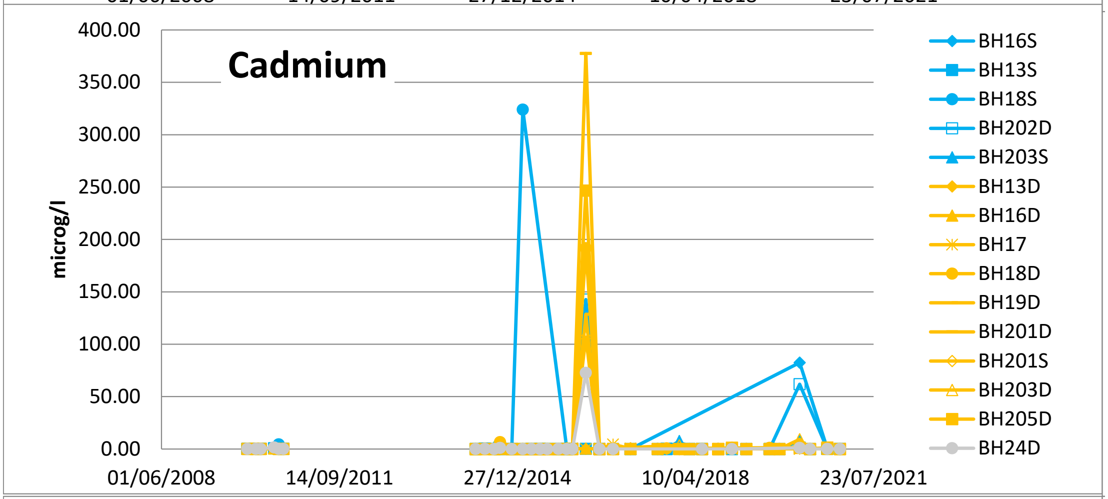
BH203D
BH205D
BH24D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300.00
250.00
200.00
150.00
100.00
50.00
0.00
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14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH16S
BH13S
BH18S
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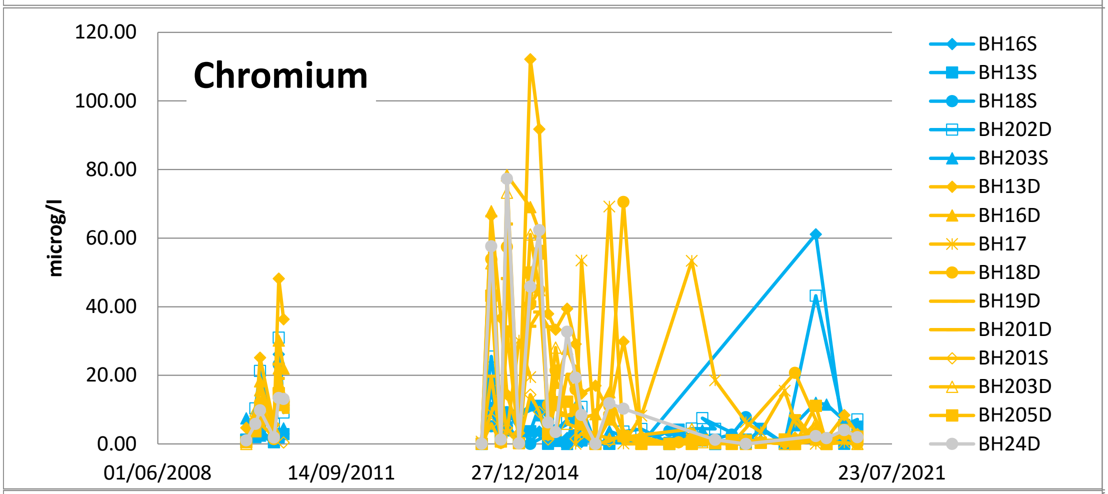
BH203D
BH205D
BH24D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microg/l
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60.00
40.00
20.00
0.00
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14/09/2011
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10/04/2018
23/07/2021
BH16S
BH13S
BH18S
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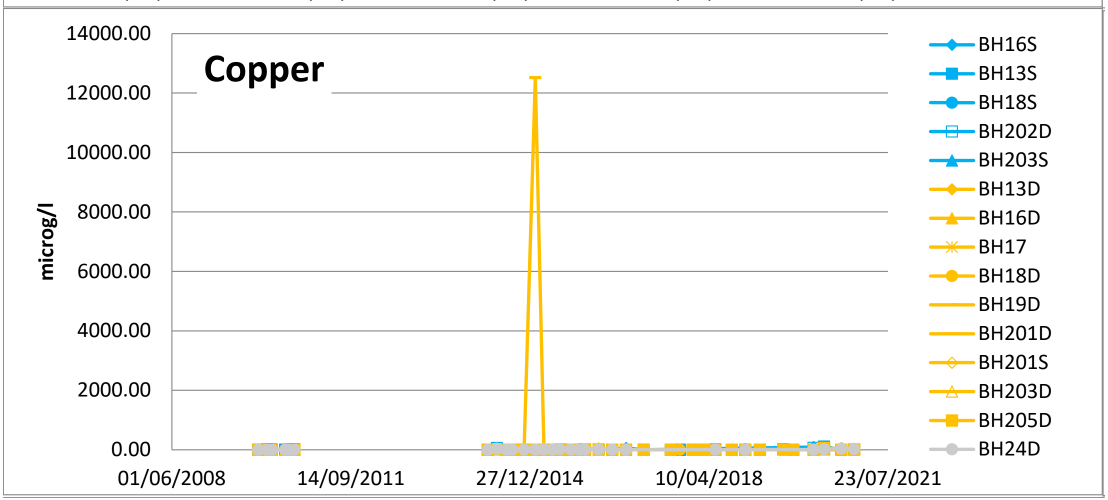
BH203D
BH205D
BH24D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microg/l
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12000.00
10000.00
8000.00
6000.00
4000.00
2000.00
0.00
01/06/2008
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27/12/2014
10/04/2018
23/07/2021
BH16S
BH13S
BH18S
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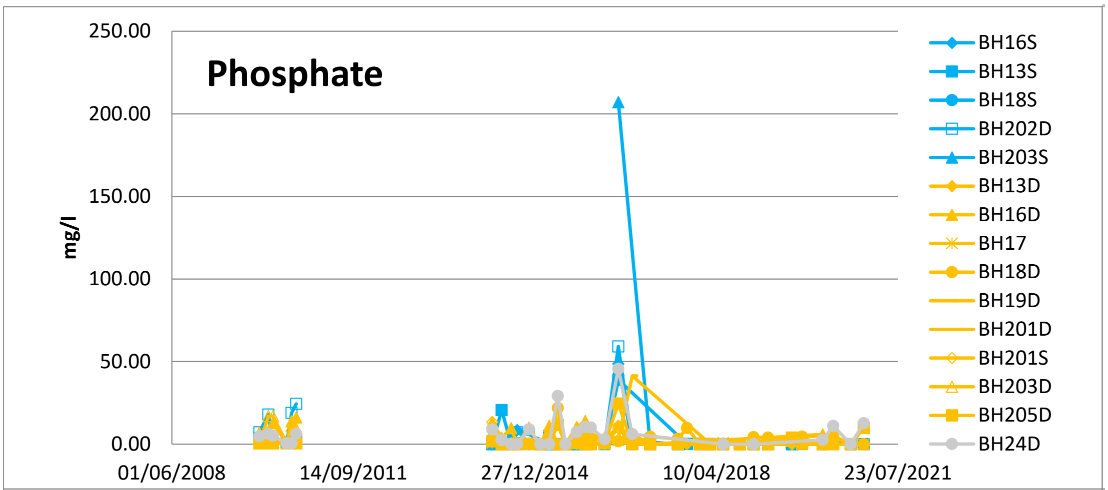
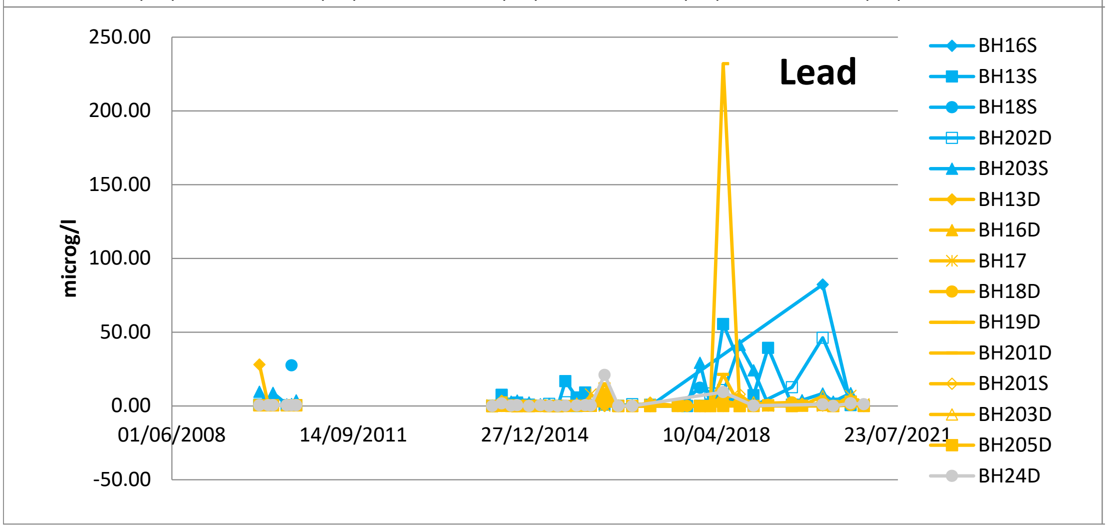
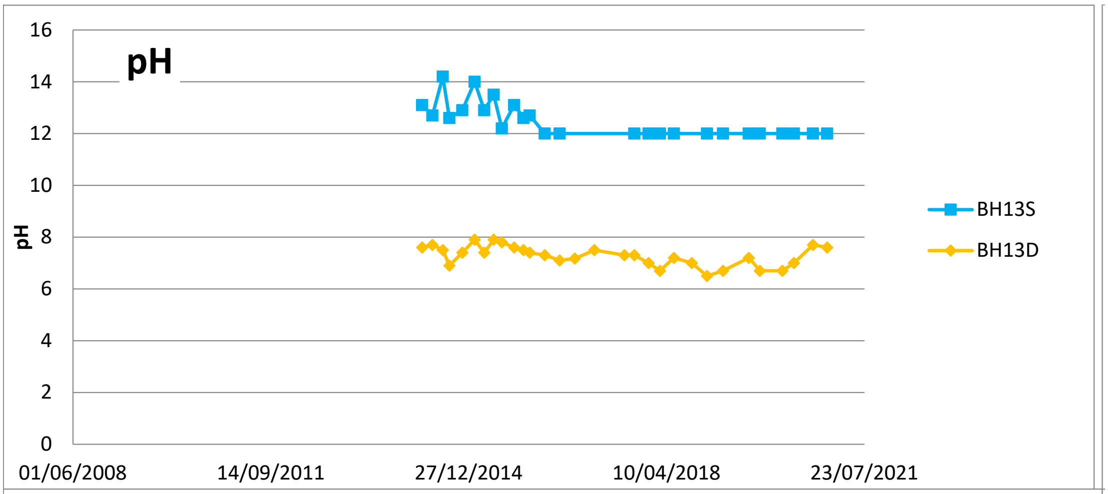
BH203D
BH205D
BH24D


Phosphate
mg/l
250.00
200.00
150.00
100.00
50.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH16S
BH13S
BH18S
BH202D
BH203S
BH13D
BH16D
BH17
BH18D
BH19D
BH201D
BH201S
BH203D
BH205D
BH24D


Lead
microg/l
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH16S
BH13S
BH18S
BH202D
BH203S
BH13D
BH16D
BH17
BH18D
BH19D
BH201D
BH201S
BH203D
BH205D
BH24D


pH
pH
16
14
12
10
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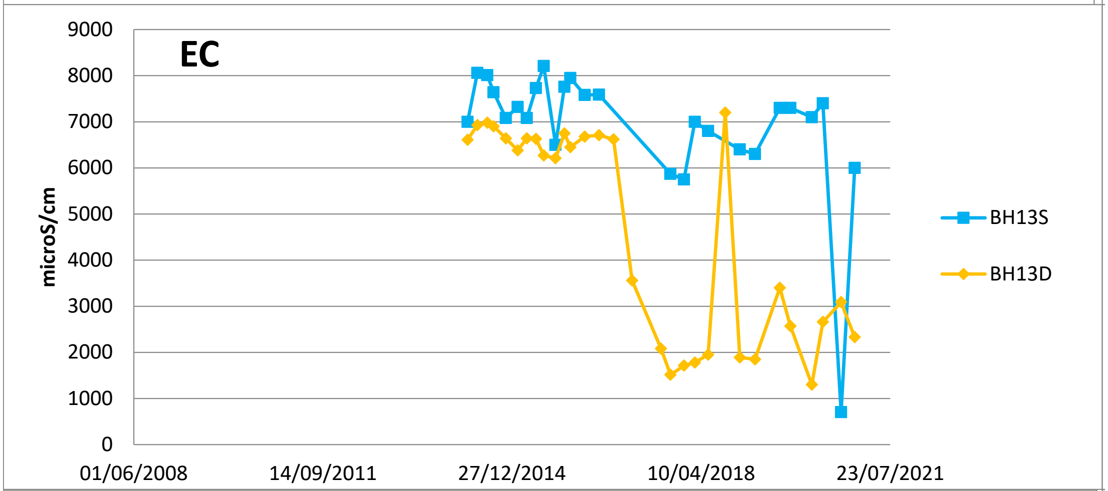
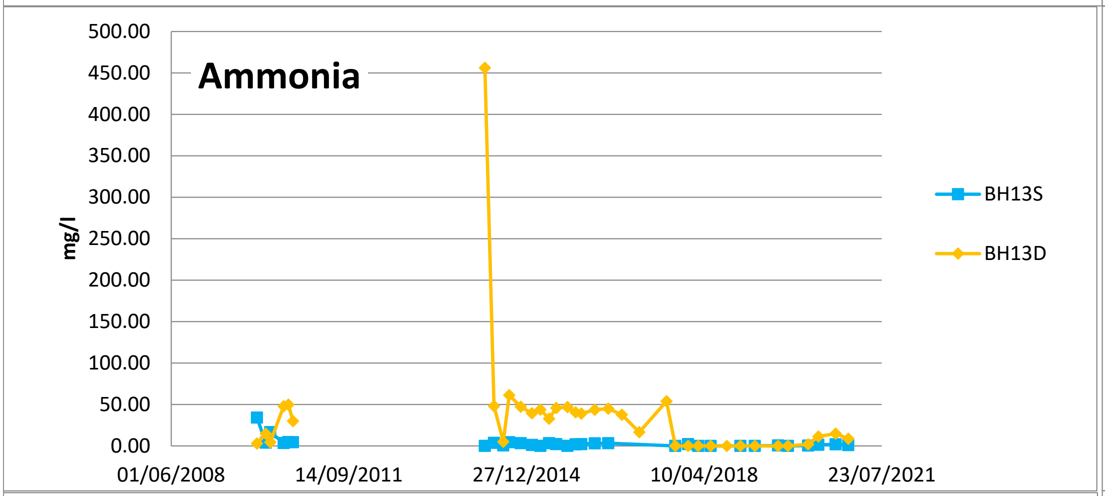
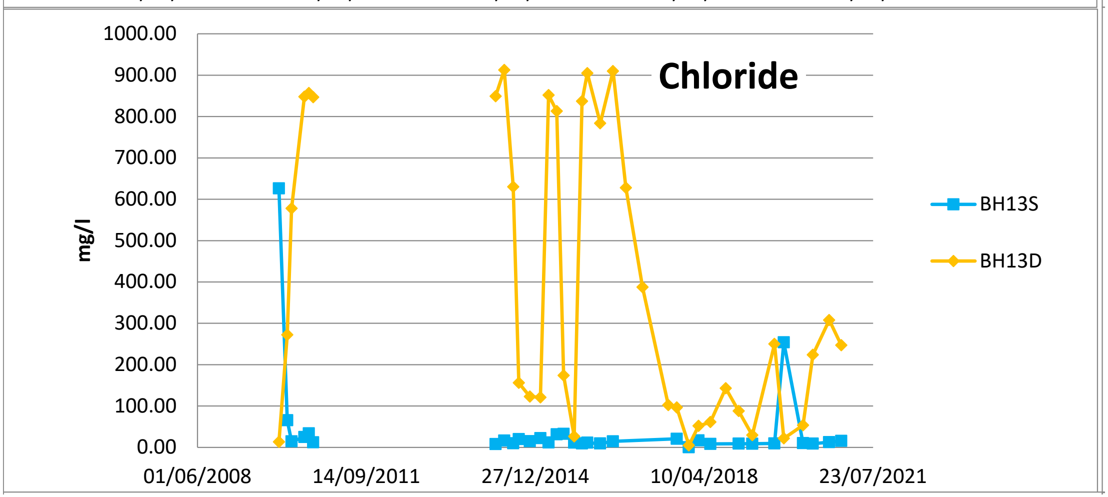
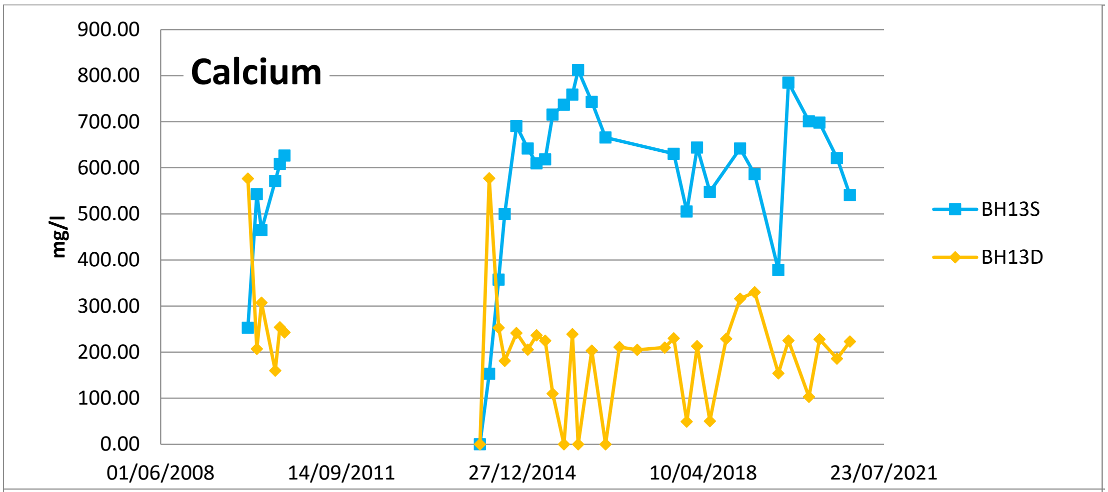
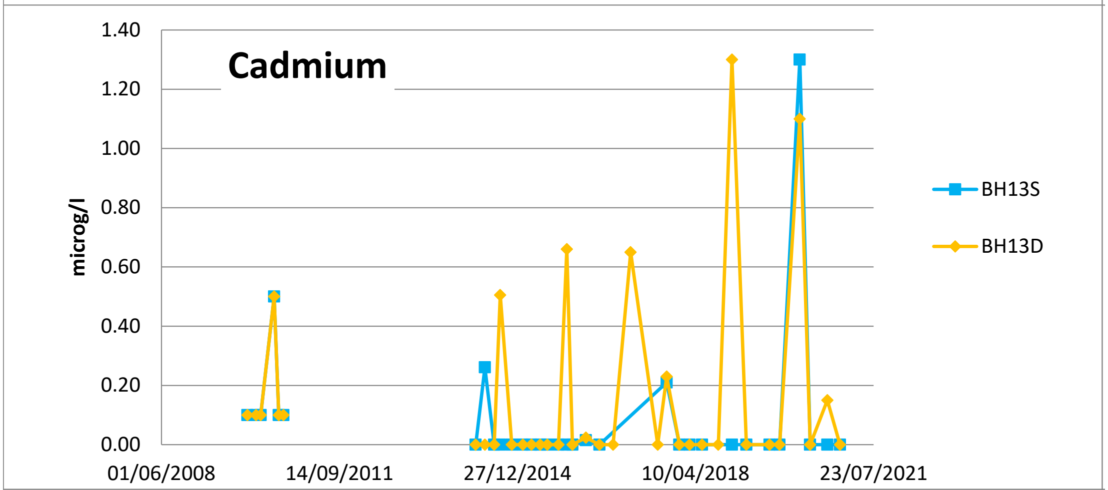
0
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH13S
BH13D

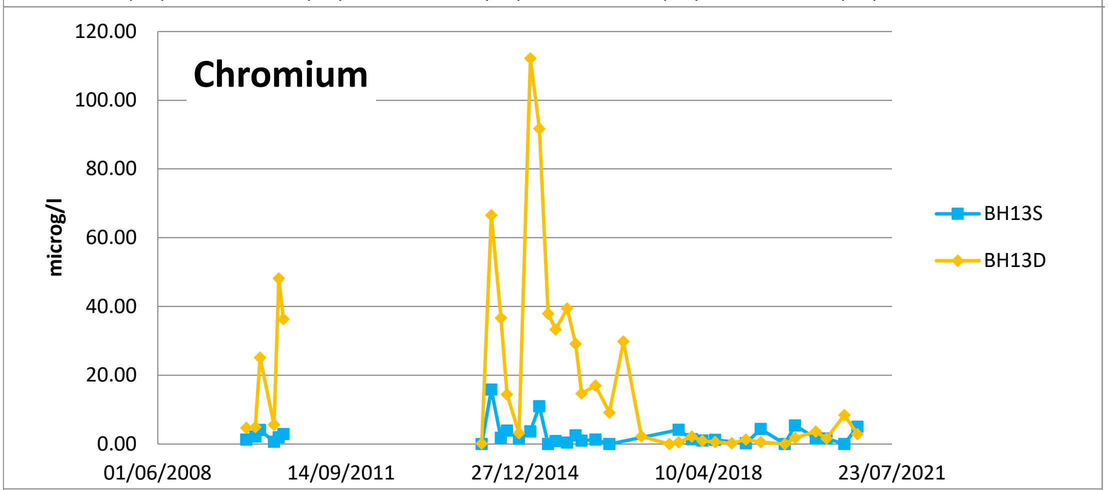

EC
microS/cm
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH13S
BH13D

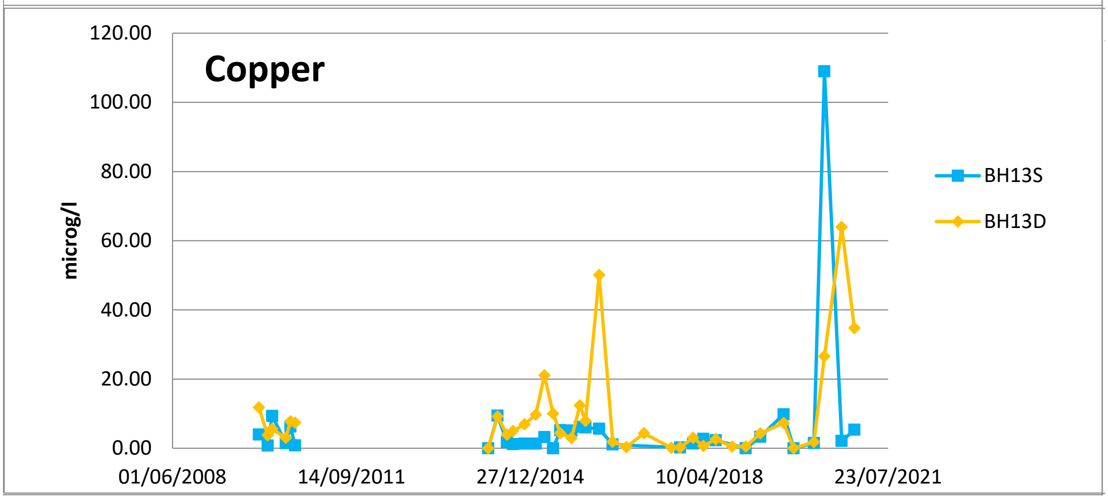

Ammonia
mg/l
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH13S
BH13D


Chloride
mg/l
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH13S
BH13D


Calcium
mg/l
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH13S
BH13D


Cadmium
microg/l
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH13S
BH13D


Chromium
microg/l
120.00
100.00
80.00
60.00
40.00
20.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH13S
BH13D


Copper
microg/l
120.00
100.00
80.00
60.00
40.00
20.00
0.00
01/06/2008
14/09/2011
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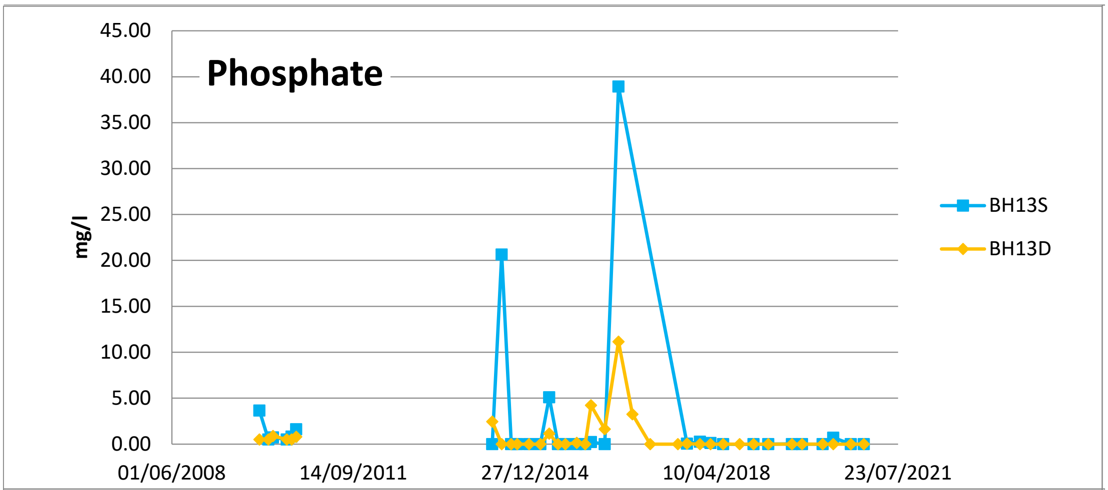
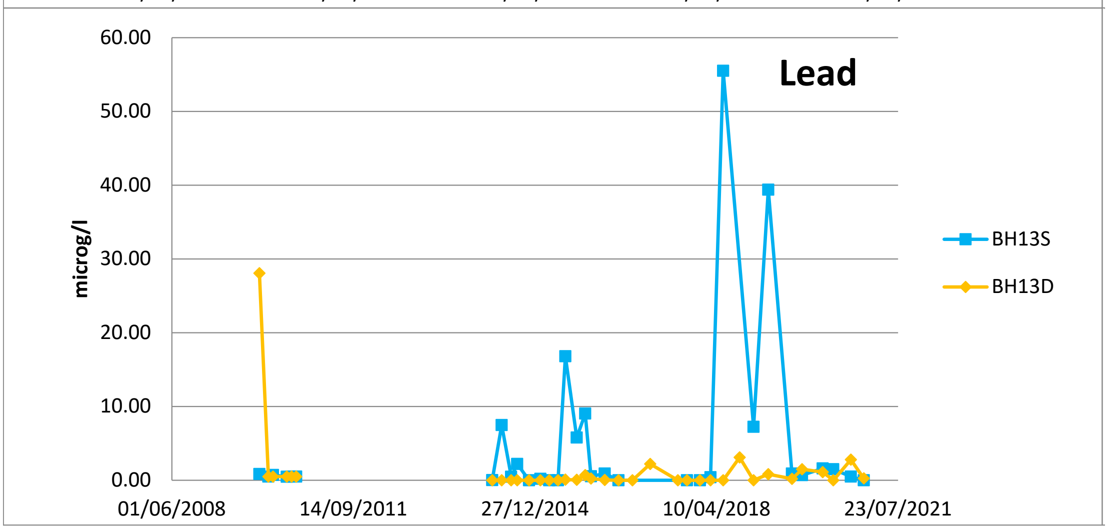
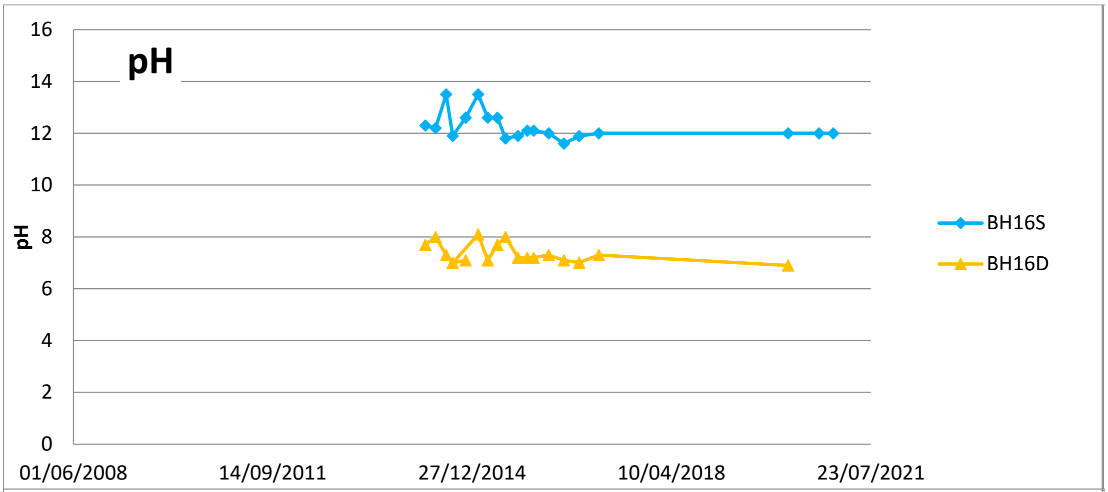
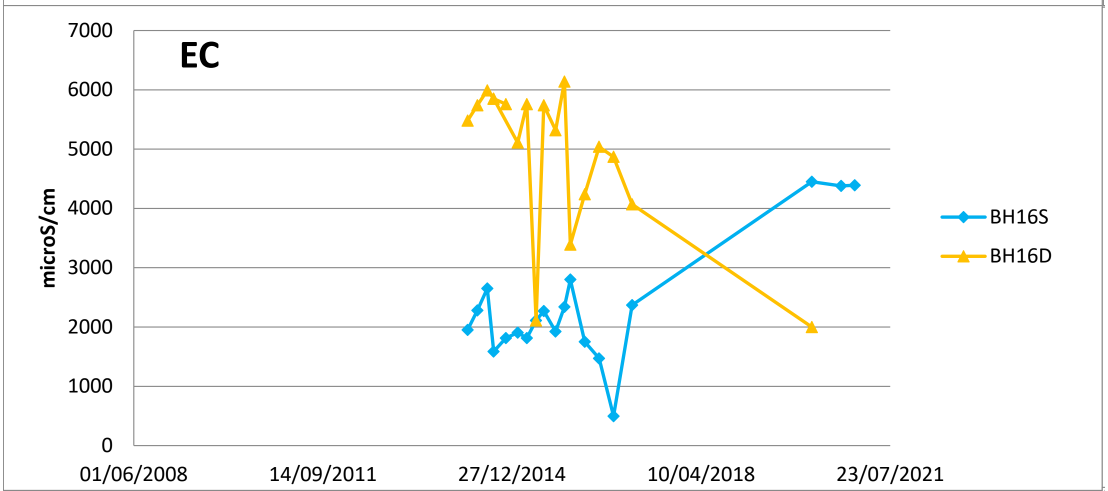
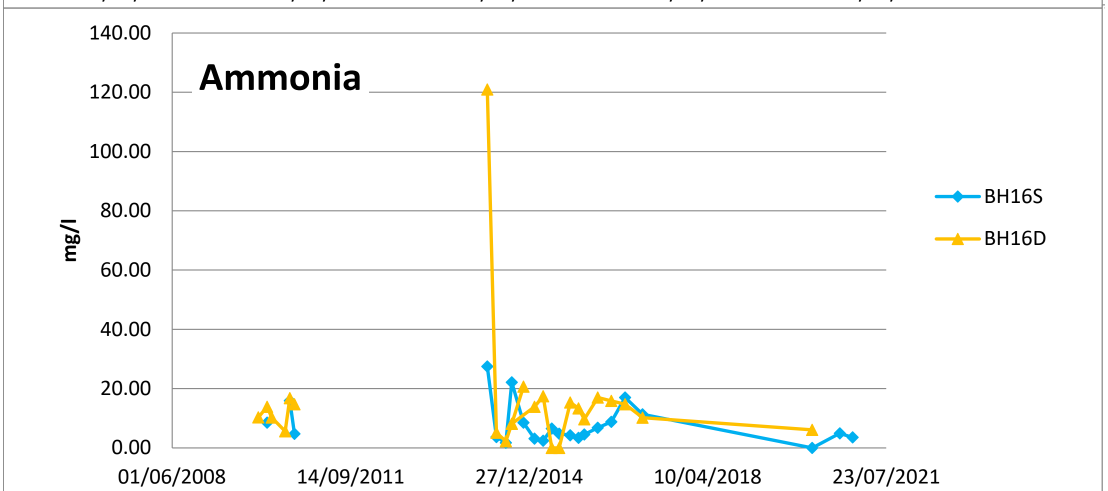
10/04/2018
23/07/2021
BH13S
BH13D

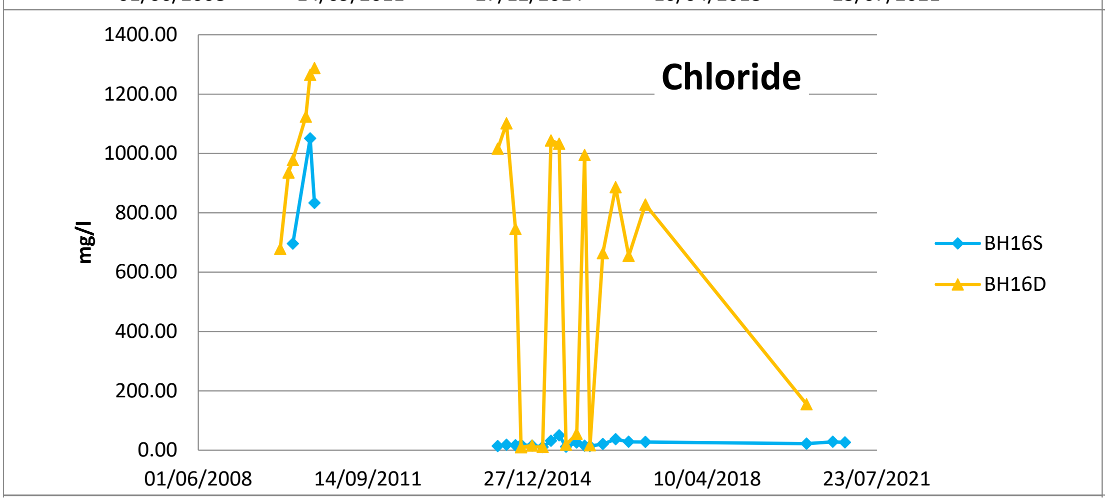

Phosphate
mg/l
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH13S
BH13D

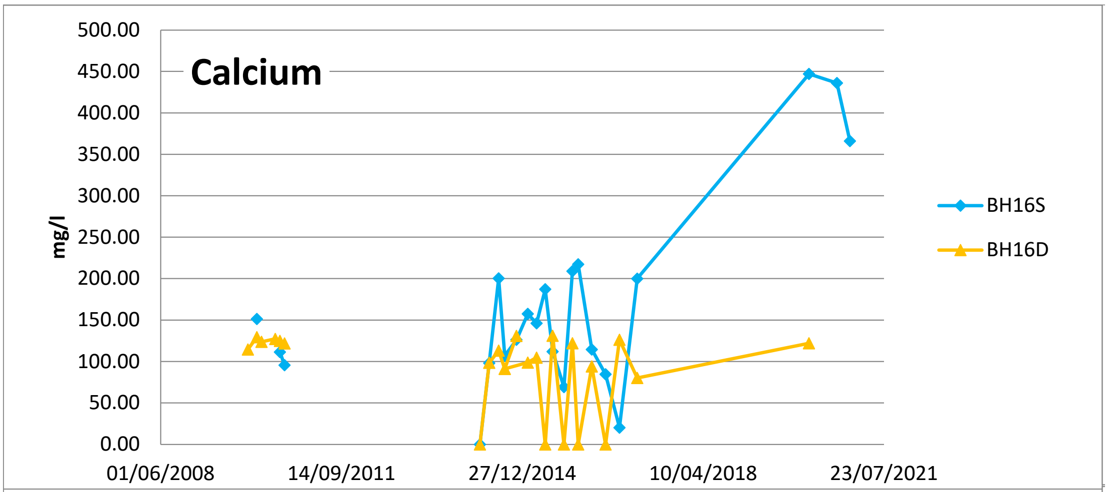

Lead
microg/l
60.00
50.00
40.00
30.00
20.00
10.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH13S
BH13D


pH
pH
16
14
12
10
8
6
4
2
0
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH16S
BH16D


EC
microS/cm
7000
6000
5000
4000
3000
2000
1000
0
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH16S
BH16D


Ammonia
mg/l
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH16S
BH16D


Chloride
mg/l
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH16S
BH16D


Calcium
mg/l
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
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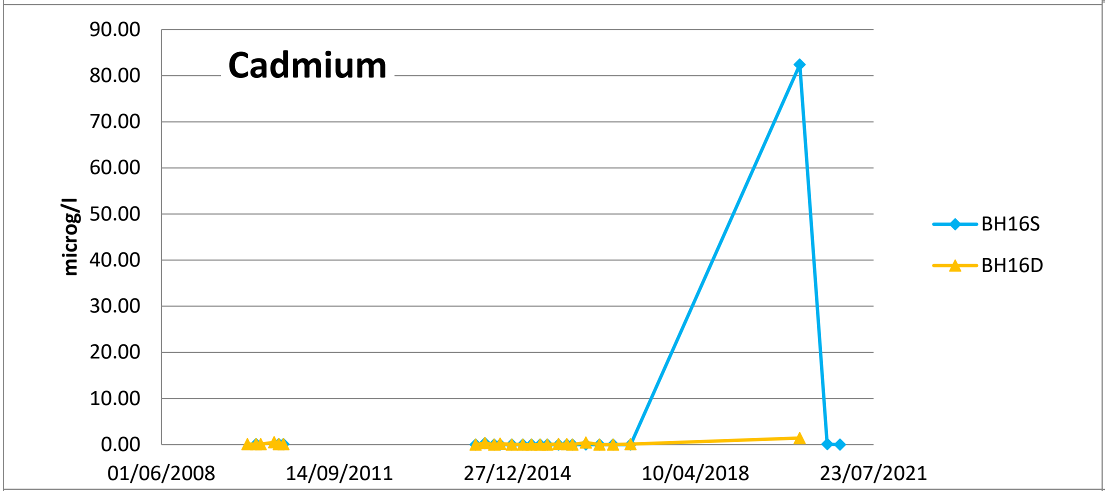
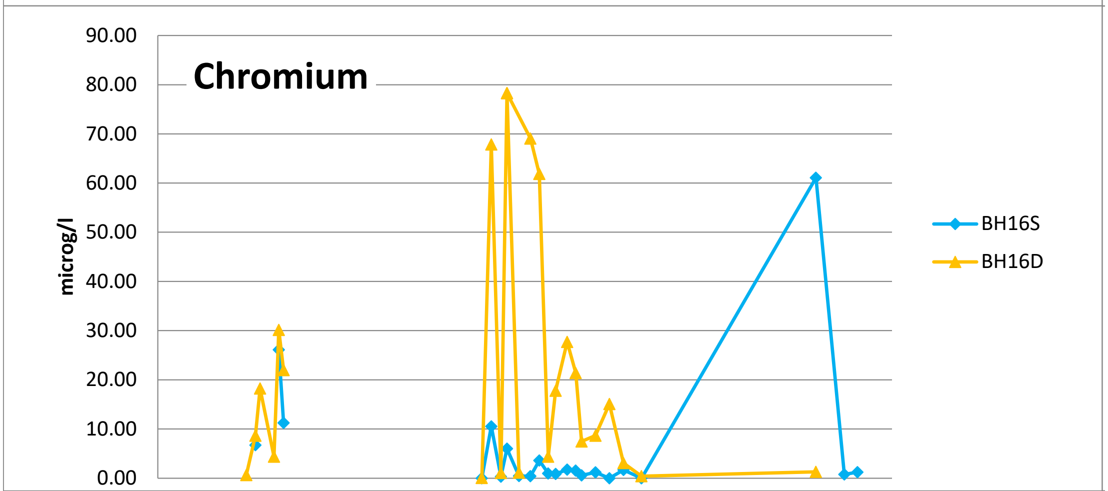
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH16S
BH16D


Cadmium
microg/l
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH16S
BH16D


Chromium
microg/l
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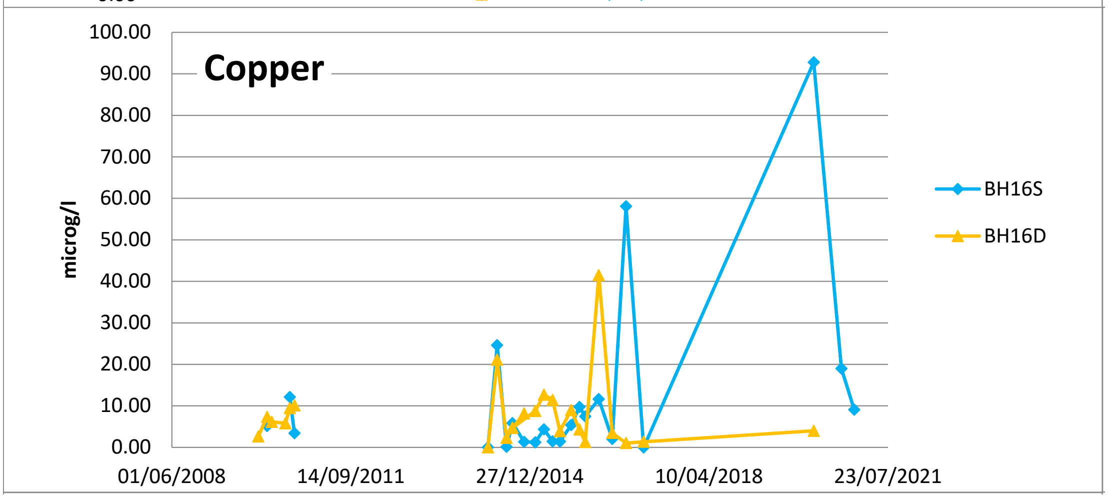
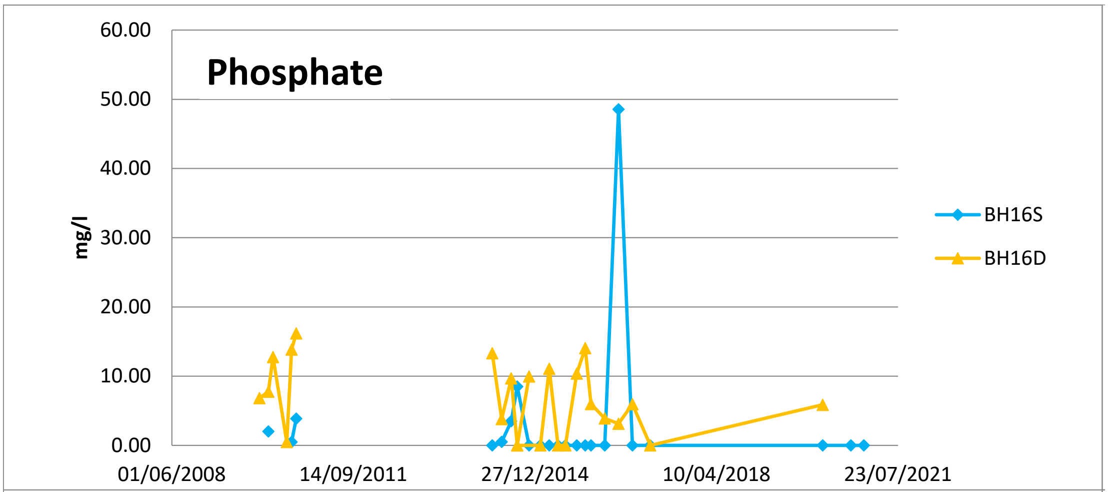
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
BH16S
BH16D


Copper
microg/l
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH16S
BH16D


Phosphate
mg/l
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50.00
40.00
30.00
20.00
10.00
0.00
01/06/2008
14/09/2011
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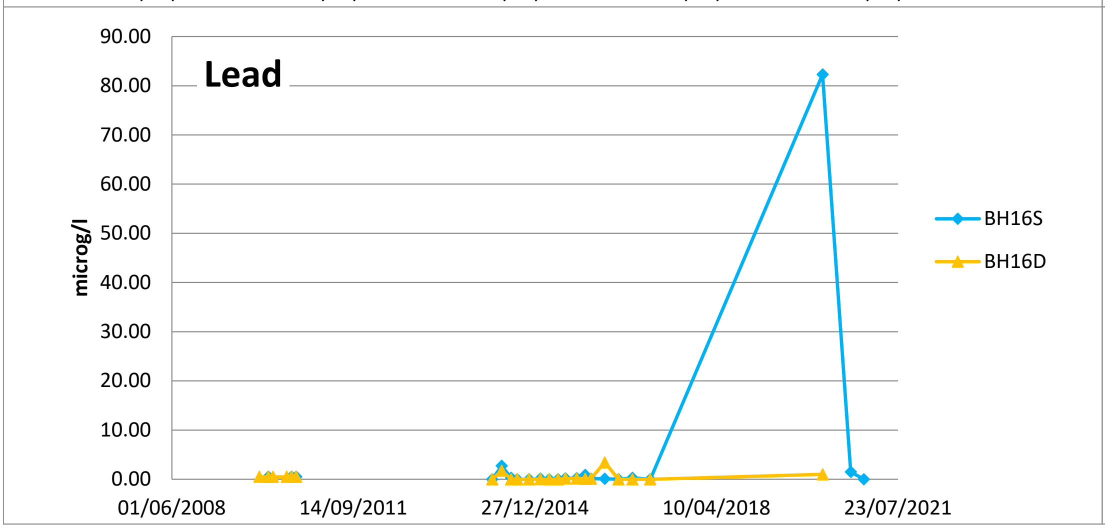
23/07/2021
BH16S
BH16D


Lead
microg/l
90.00
80.00
70.00
60.00
50.00
40.00
30.00
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10.00
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01/06/2008
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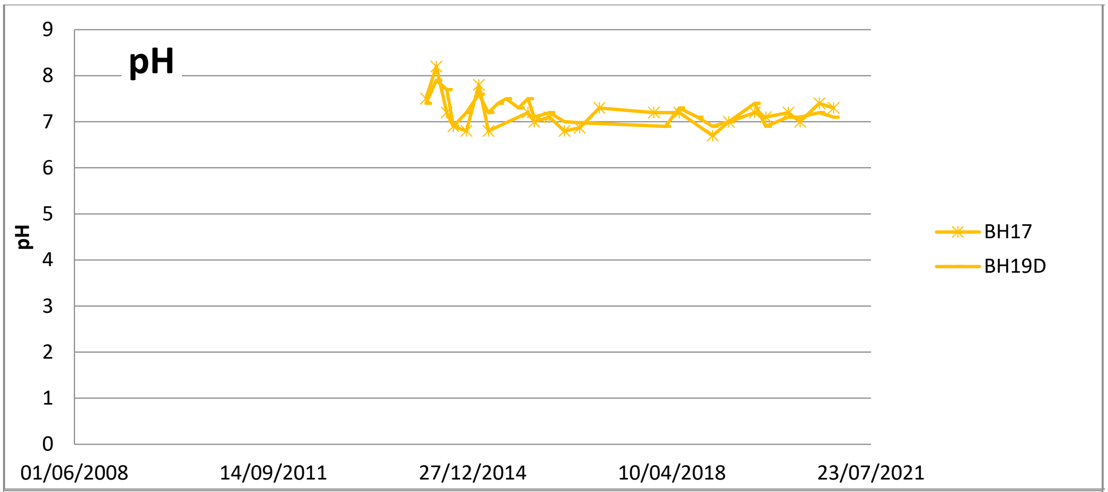
27/12/2014
10/04/2018
23/07/2021
BH16S
BH16D


pH
9
8
7
6
5
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2
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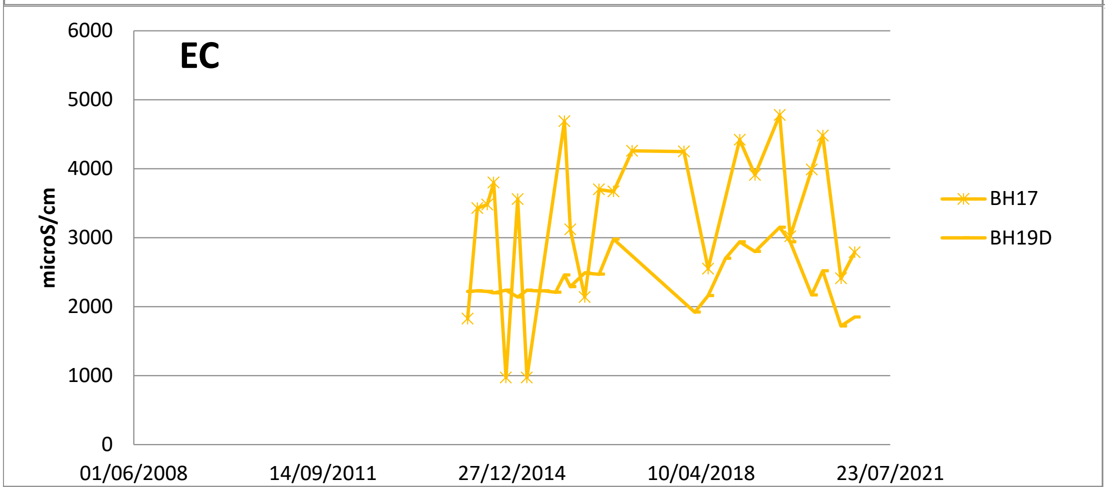
0
pH
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH17
BH19D


EC
6000
5000
4000
3000
2000
1000
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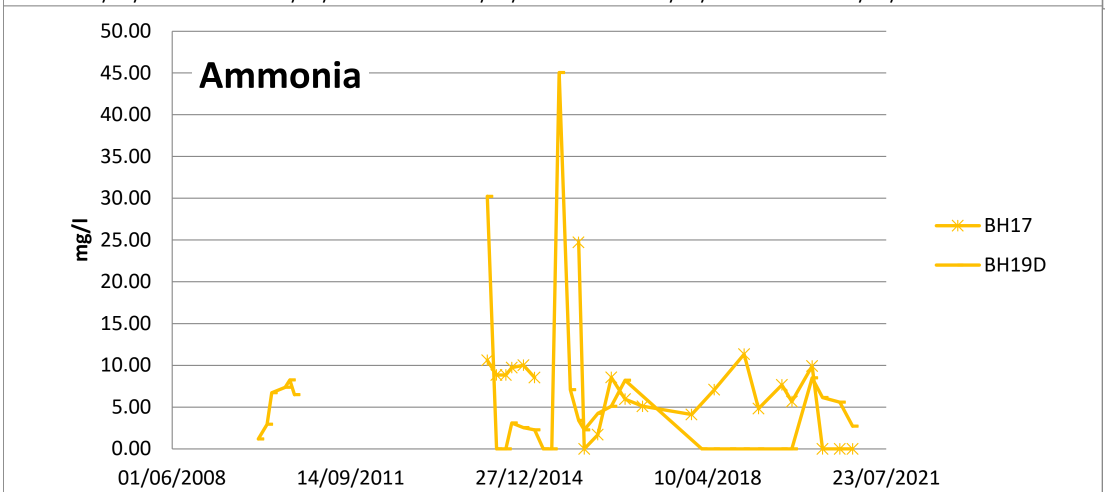
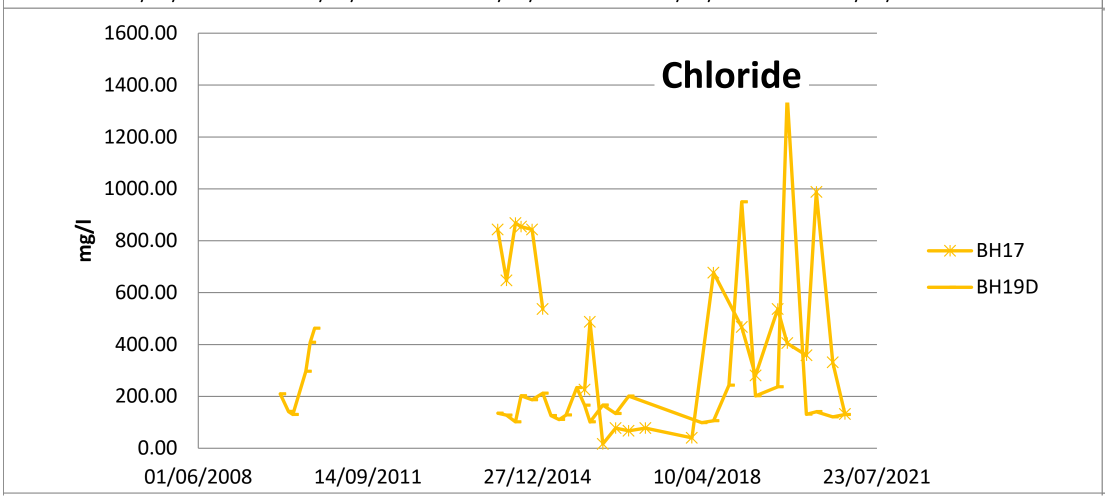
microS/cm
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH17
BH19D


Ammonia
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
mg/l
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH17
BH19D


Chloride
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
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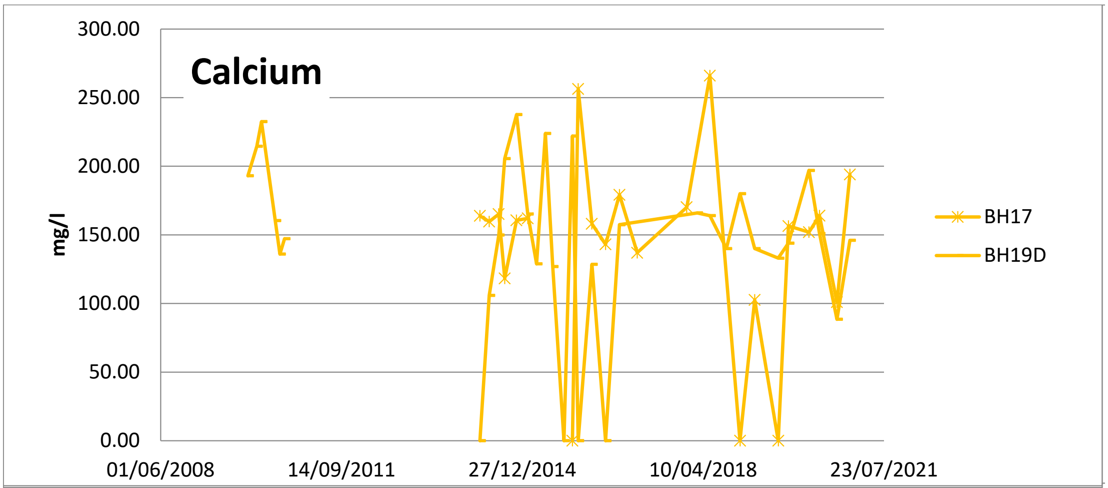
mg/l
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH17
BH19D


Calcium
mg/l
300.00
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200.00
150.00
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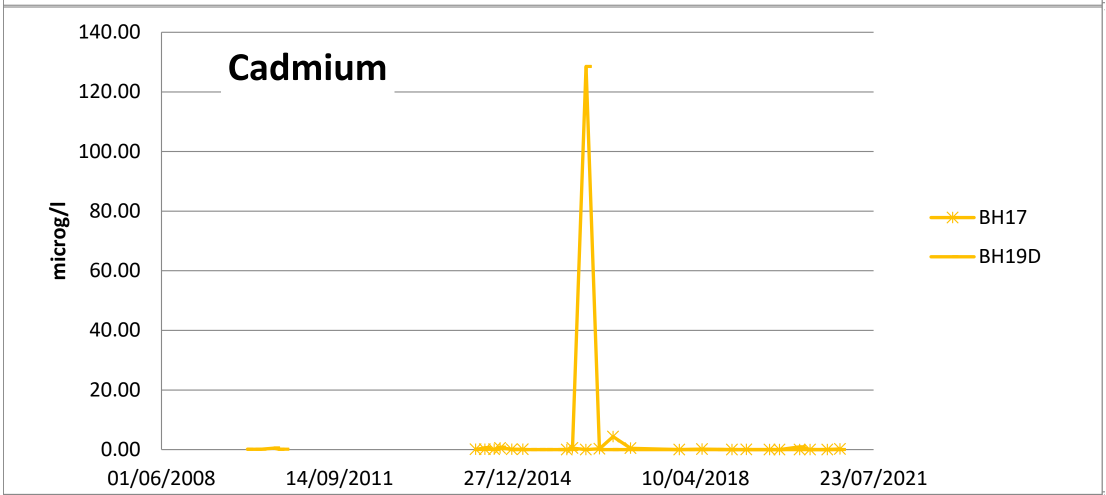
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH17
BH19D


Cadmium
microg/l
140.00
120.00
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60.00
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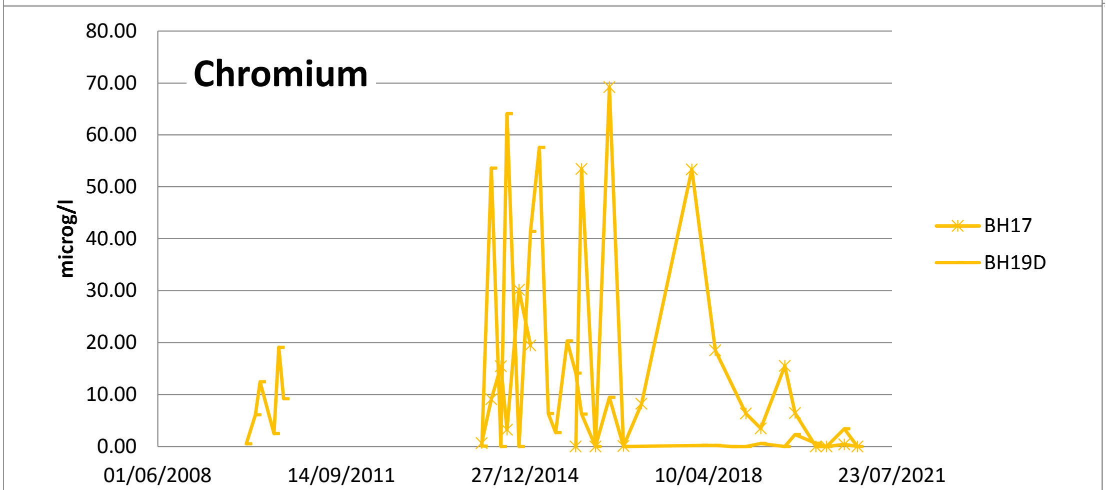
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH17
BH19D


Chromium
microg/l
80.00
70.00
60.00
50.00
40.00
30.00
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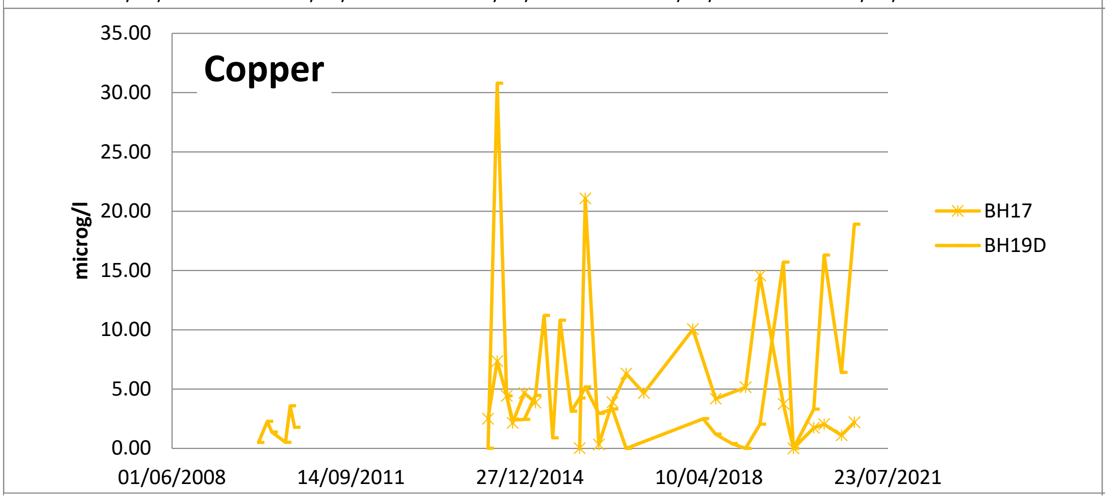
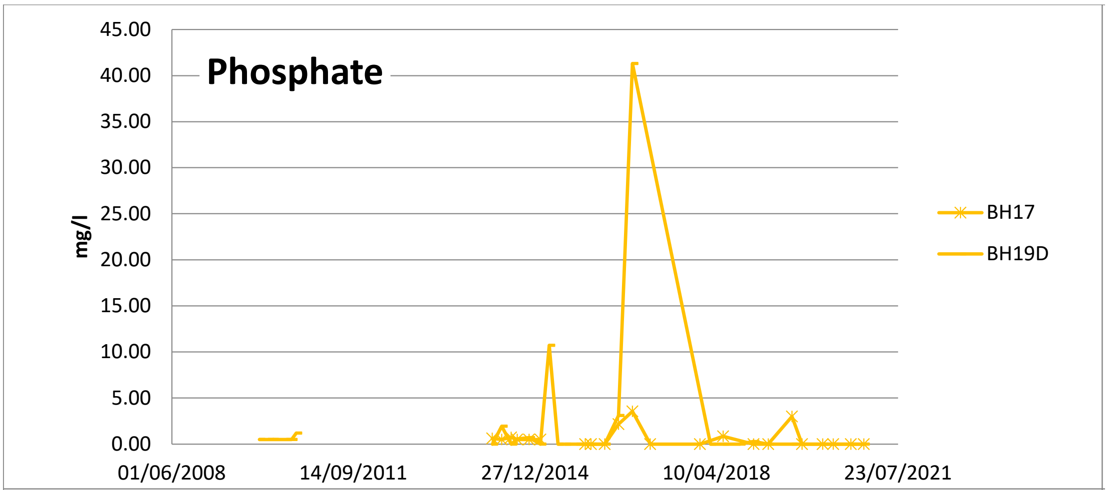
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH17
BH19D


Copper
microg/l
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH17
BH19D


Phosphate
mg/l
45.00
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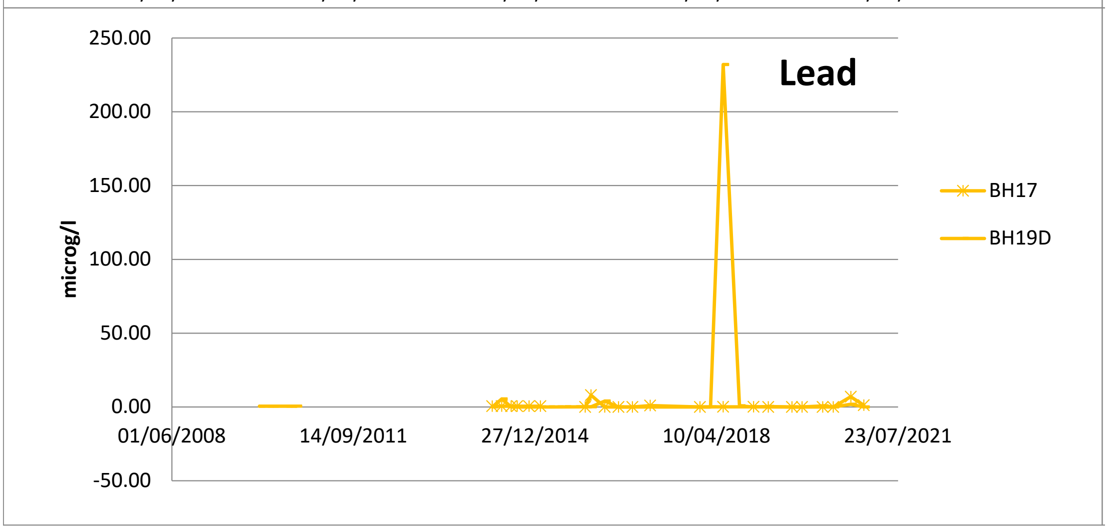
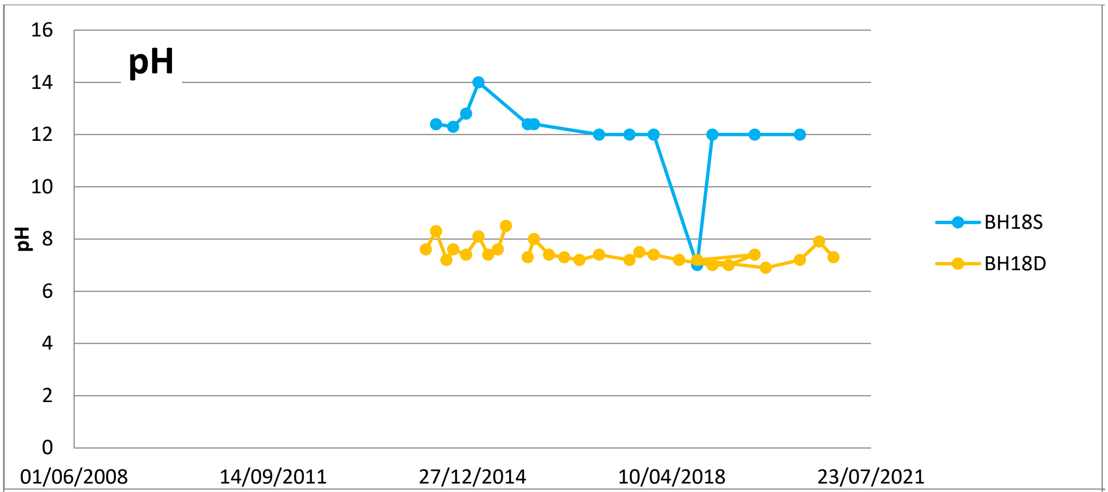
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH17
BH19D


Lead
microg/l
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH17
BH19D


pH
16
14
12
10
8
6
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2
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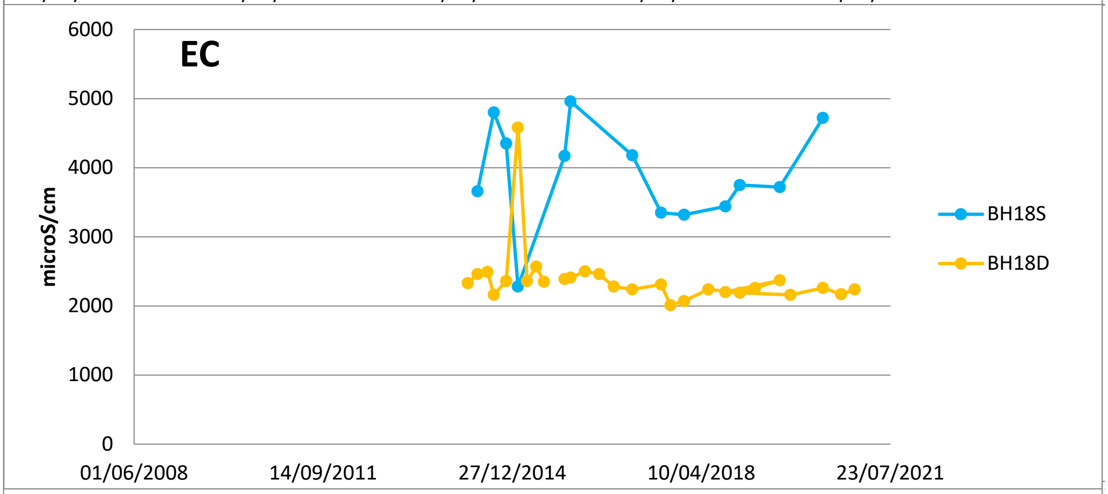
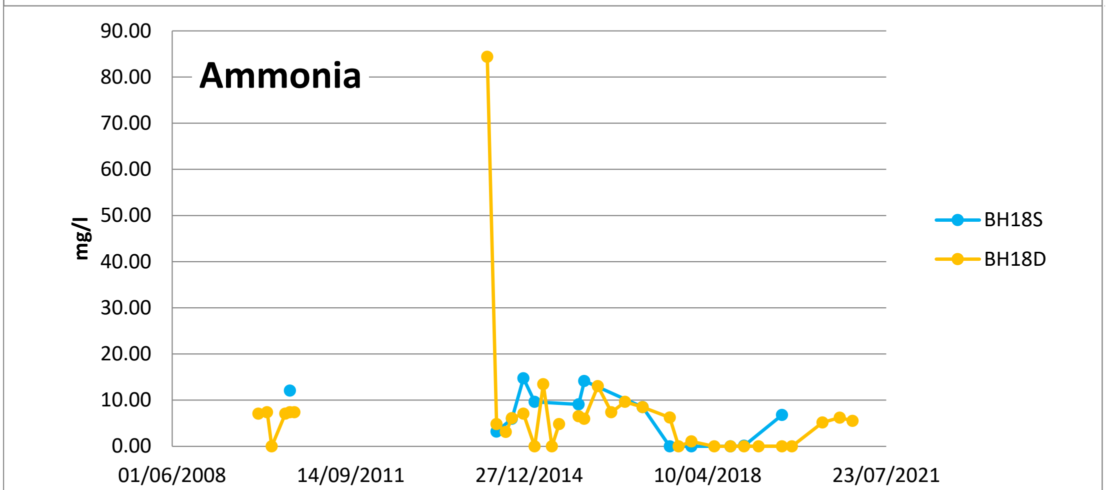
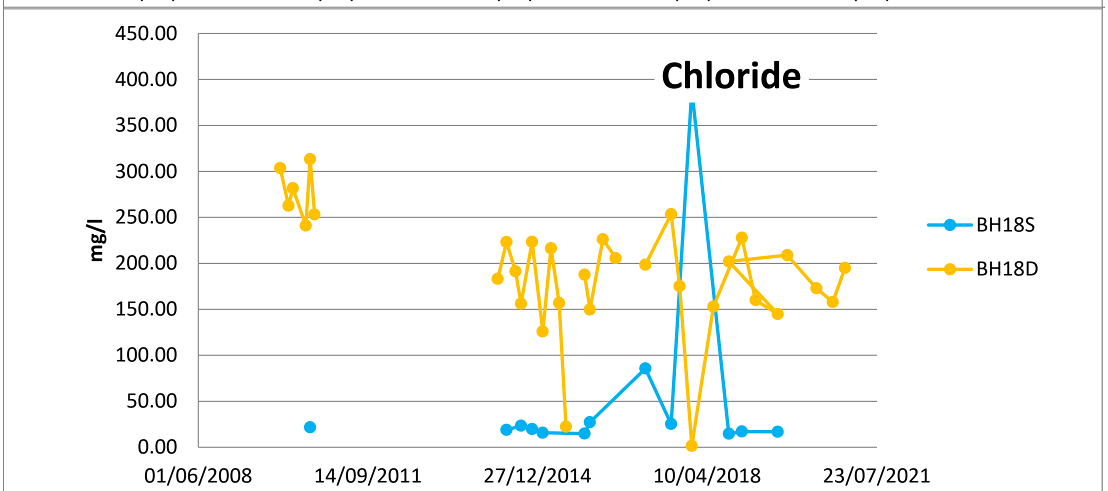
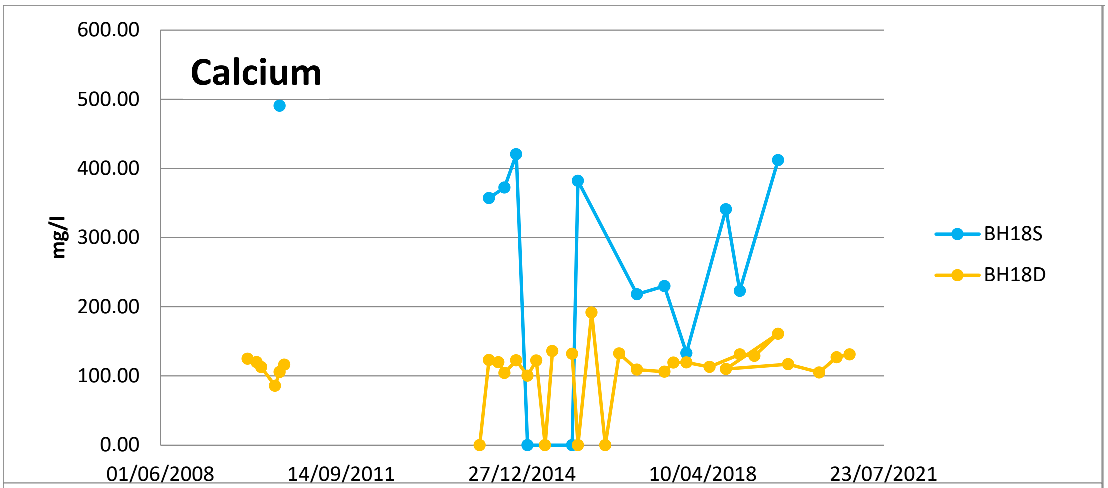
pH
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH18S
BH18D


EC
6000
5000
4000
3000
2000
1000
0
microS/cm
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH18S
BH18D


Ammonia
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
mg/l
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH18S
BH18D


Chloride
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
mg/l
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH18S
BH18D


Calcium
mg/l
600.00
500.00
400.00
300.00
200.00
100.00
0.00
01/06/2008
14/09/2011
27/12/2014
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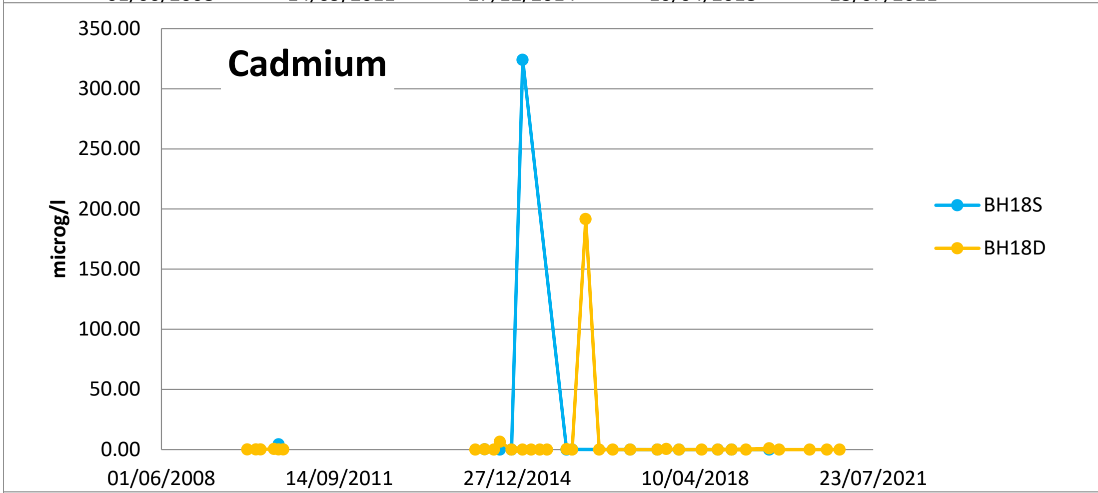
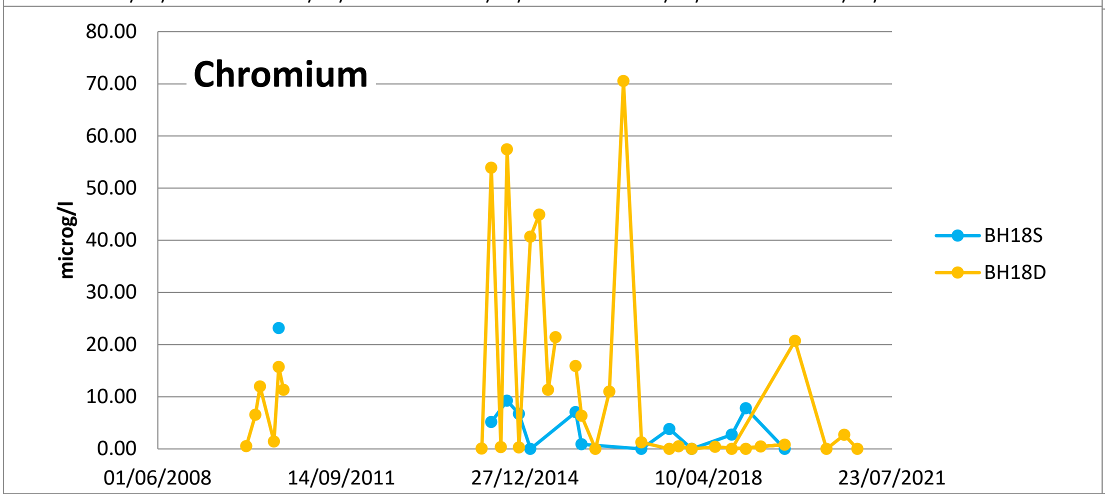
23/07/2021
BH18S
BH18D


Cadmium
microg/l
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH18S
BH18D


Chromium
microg/l
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
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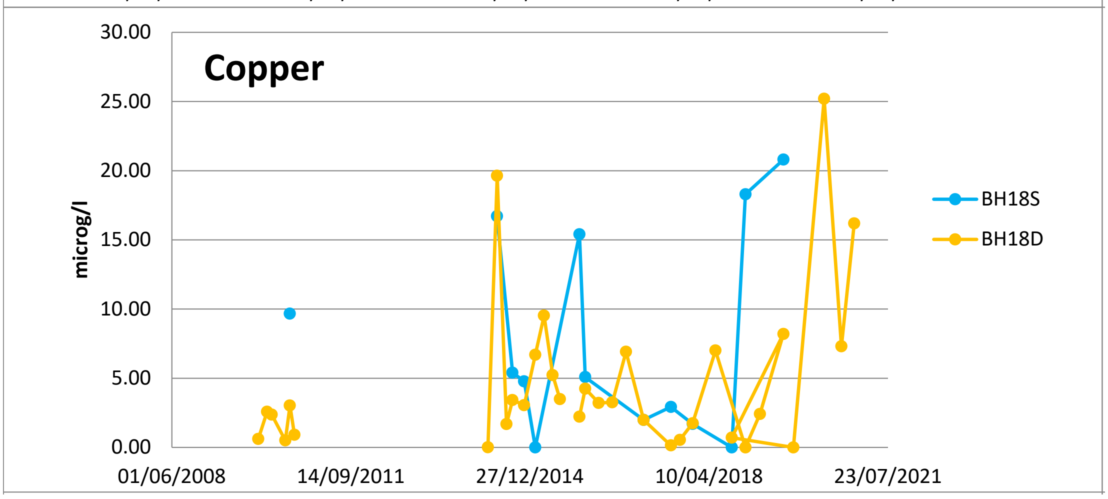
23/07/2021
BH18S
BH18D


Copper
microg/l
30.00
25.00
20.00
15.00
10.00
5.00
0.00
01/06/2008
14/09/2011
27/12/2014
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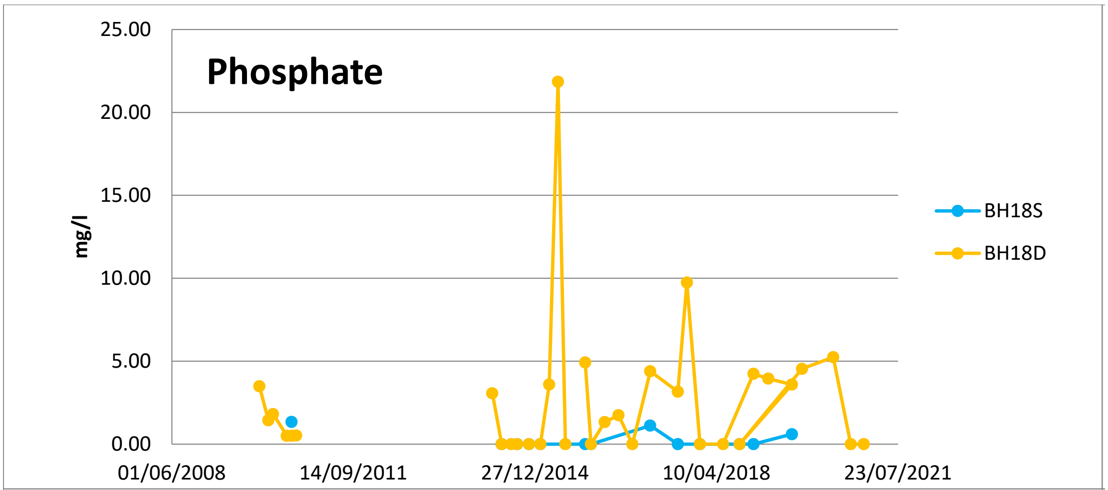
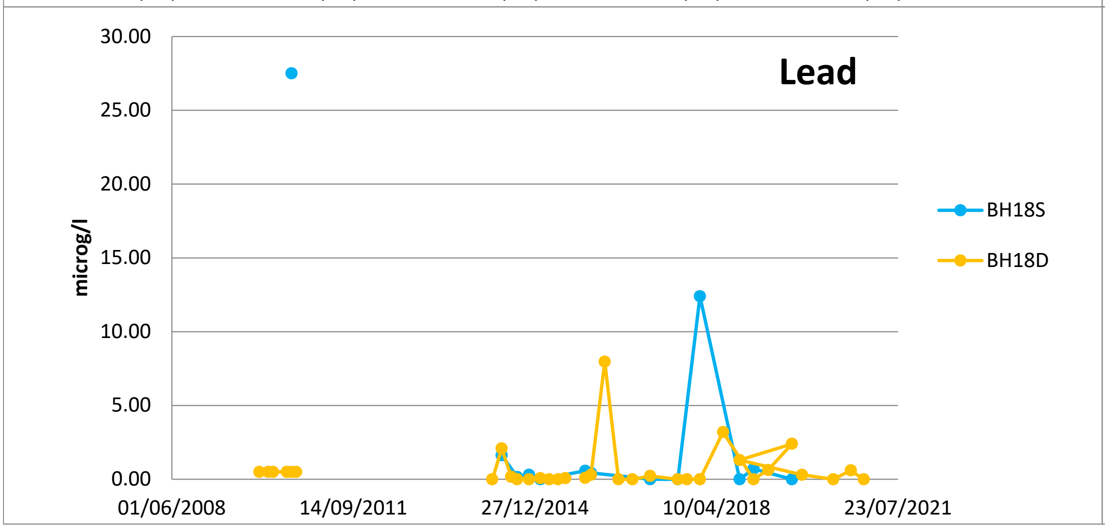
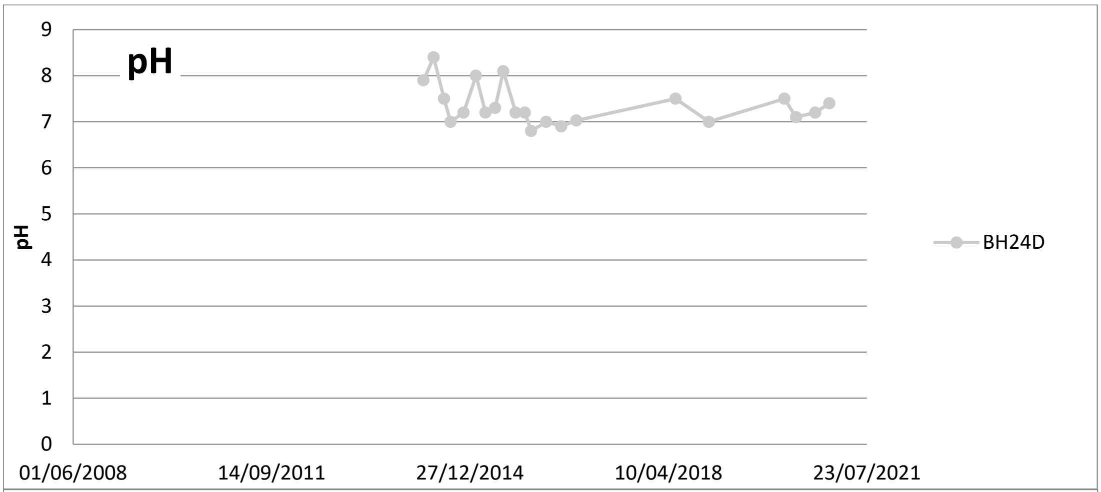
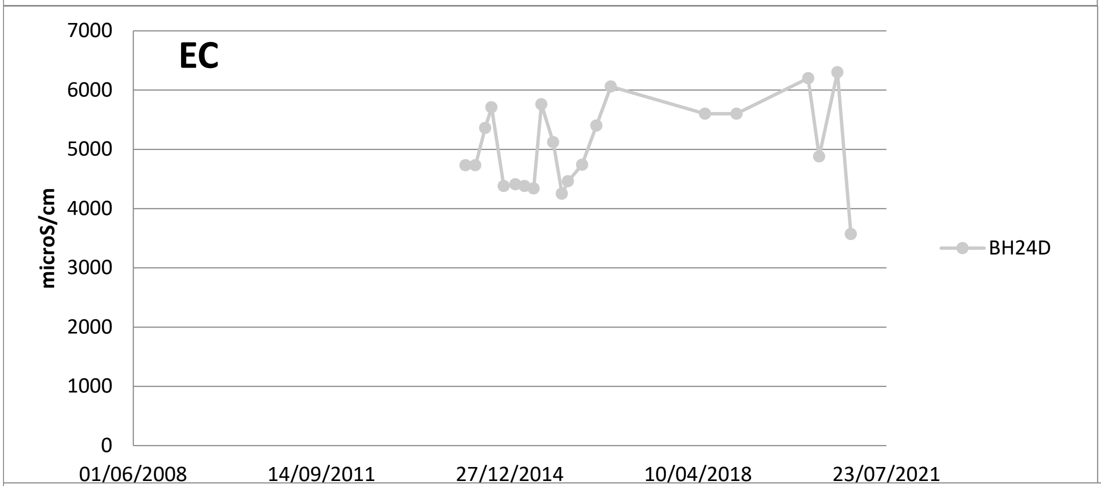
23/07/2021
BH18S
BH18D

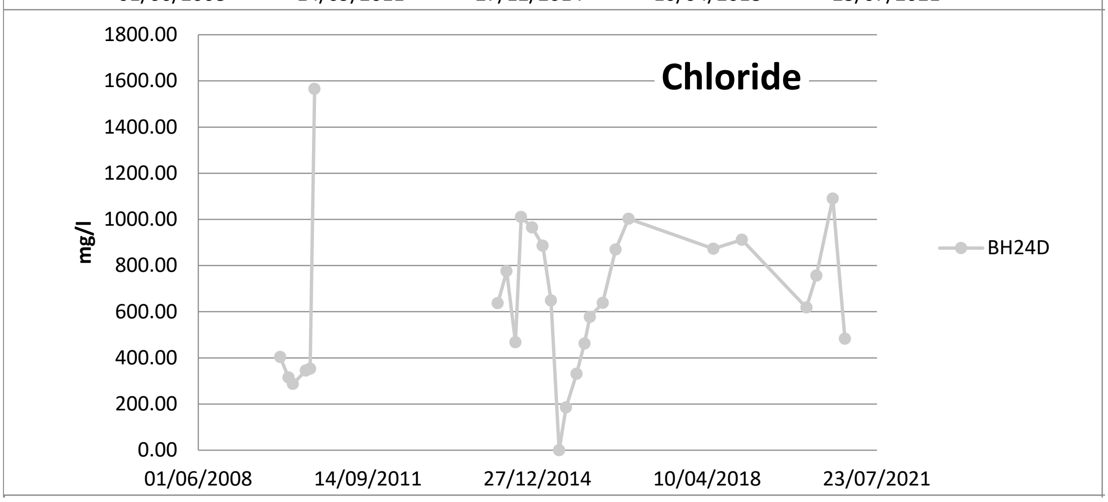

Phosphate
mg/l
25.00
20.00
15.00
10.00
5.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH18S
BH18D

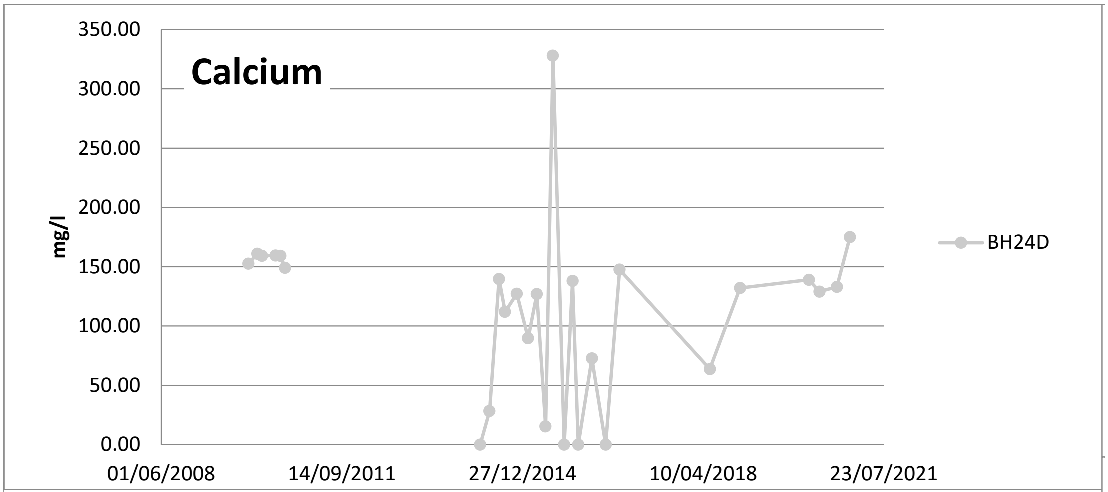

Lead
microg/l
30.00
25.00
20.00
15.00
10.00
5.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH18S
BH18D

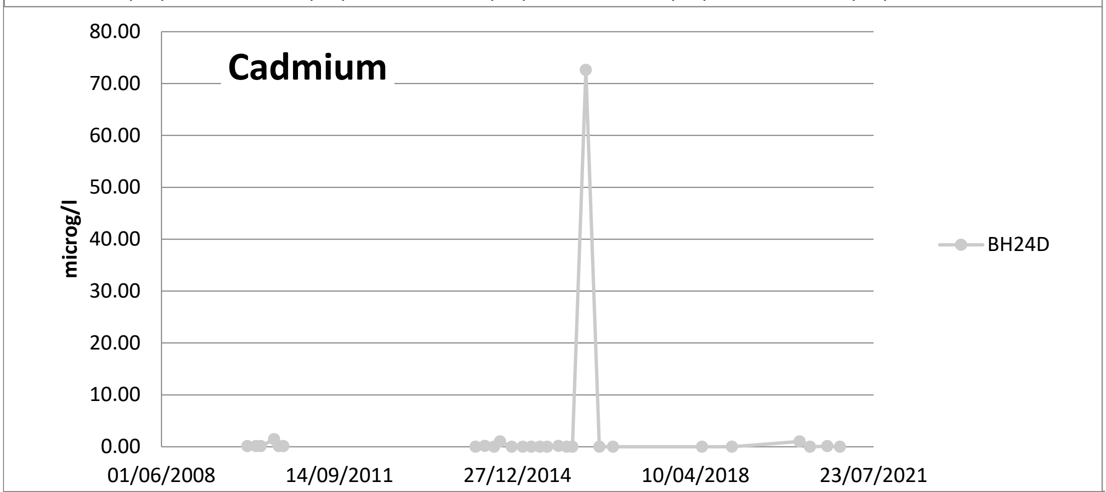

pH
9
8
7
6
5
4
3
2
1
0
pH
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH24D

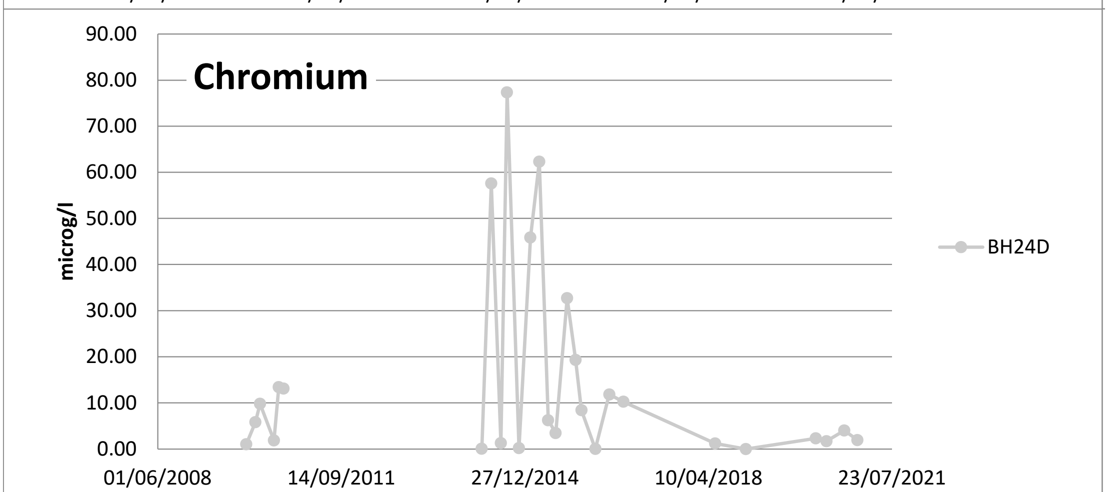

EC
7000
6000
5000
4000
3000
2000
1000
0
microS/cm
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH24D

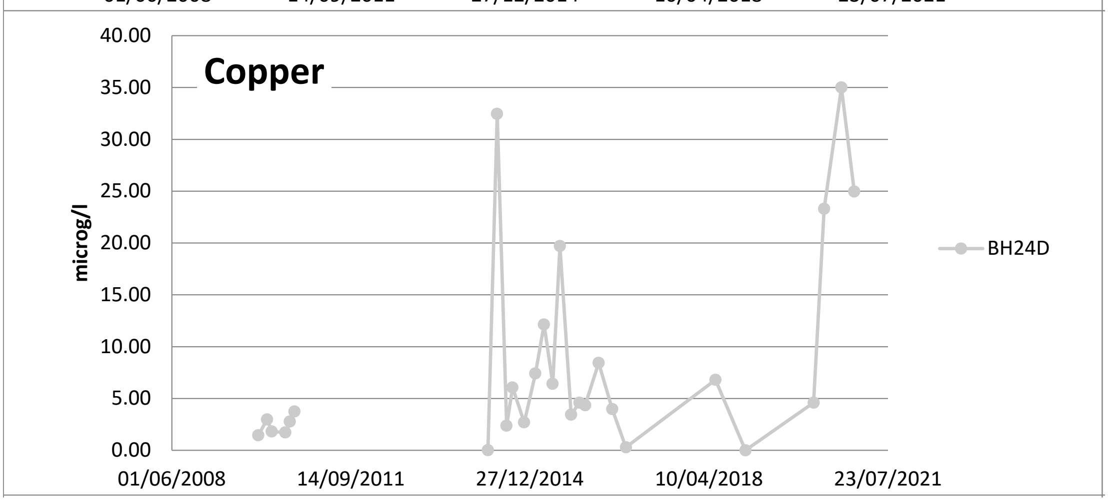

Ammonia
120.00
100.00
80.00
60.00
40.00
20.00
0.00
mg/l
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH24D

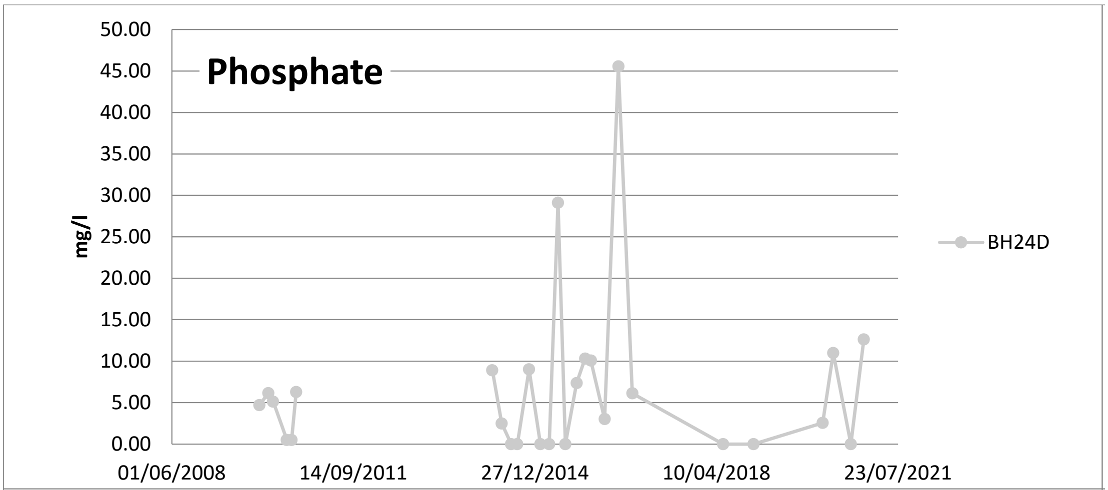

Chloride
1800.00
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
mg/l
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH24D

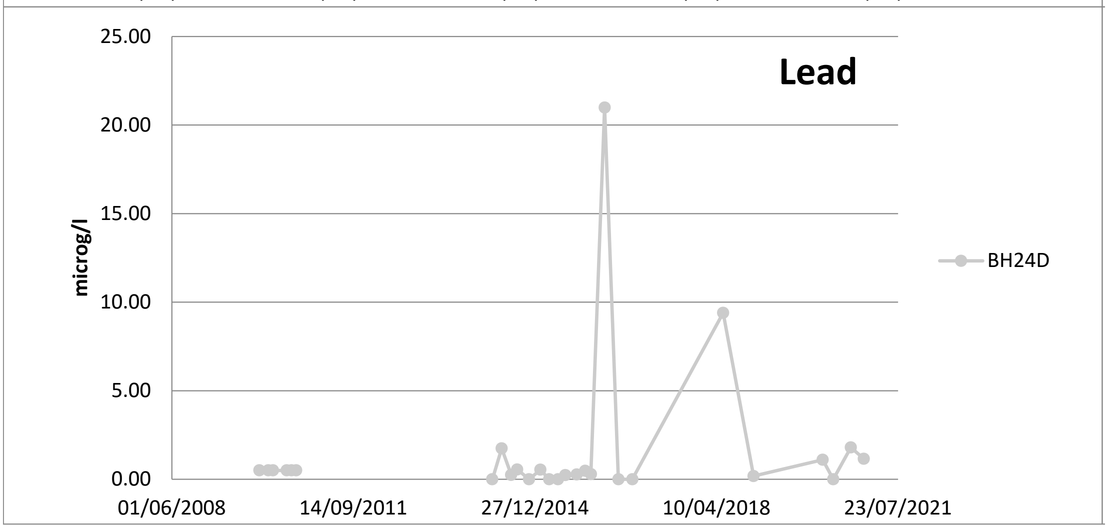

Calcium
mg/l
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH24D

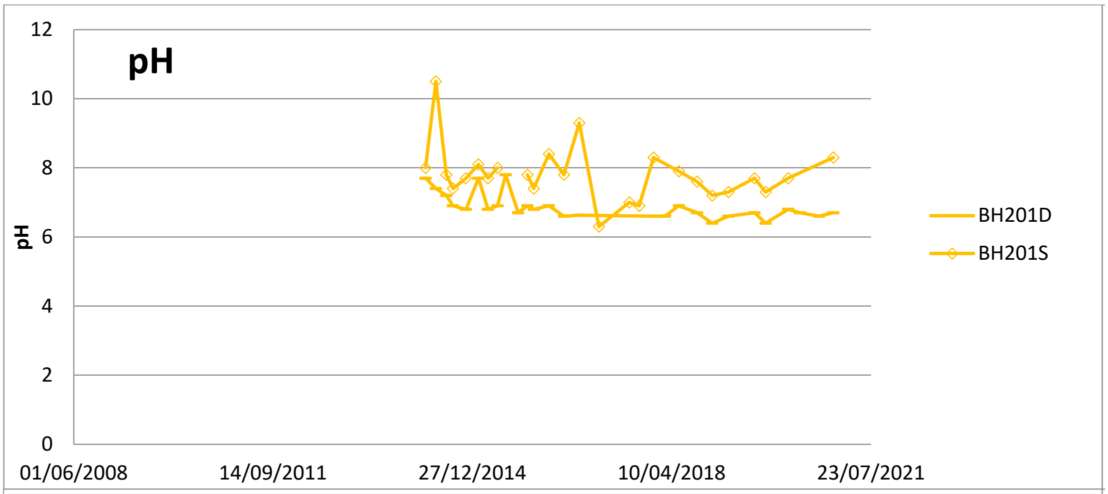

Cadmium
microg/l
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH24D

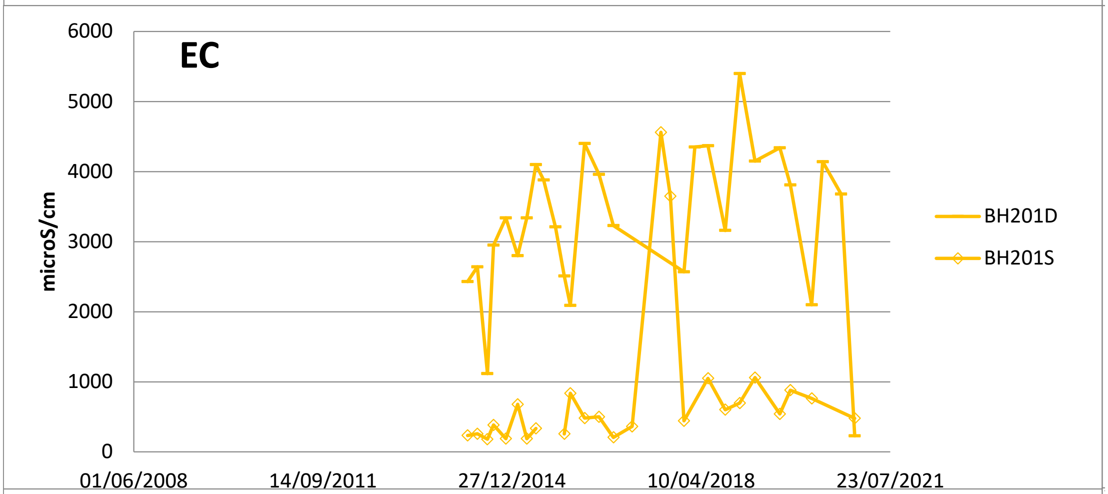

Chromium
microg/l
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH24D

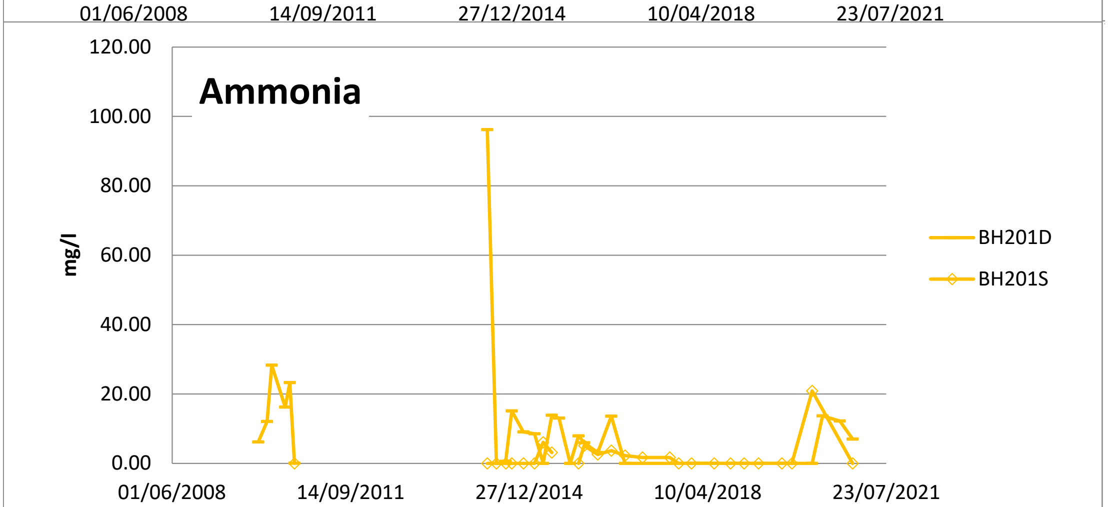

Copper
microg/l
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH24D

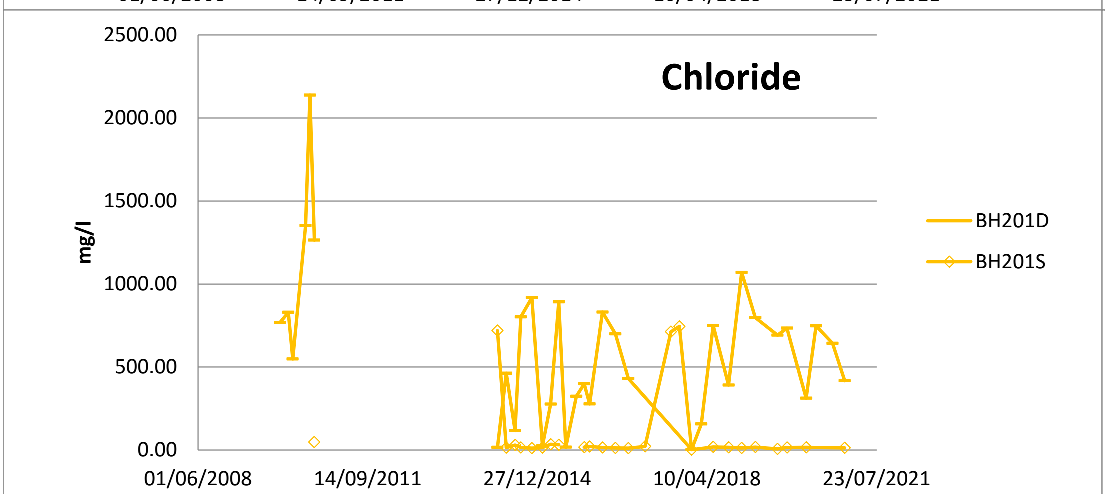

Phosphate
mg/l
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH24D

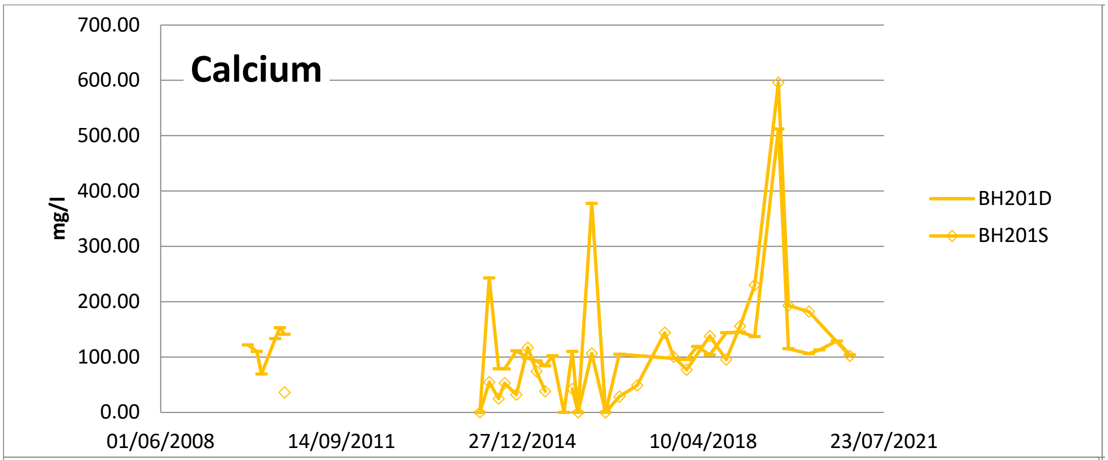

Lead
microg/l
25.00
20.00
15.00
10.00
5.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH24D

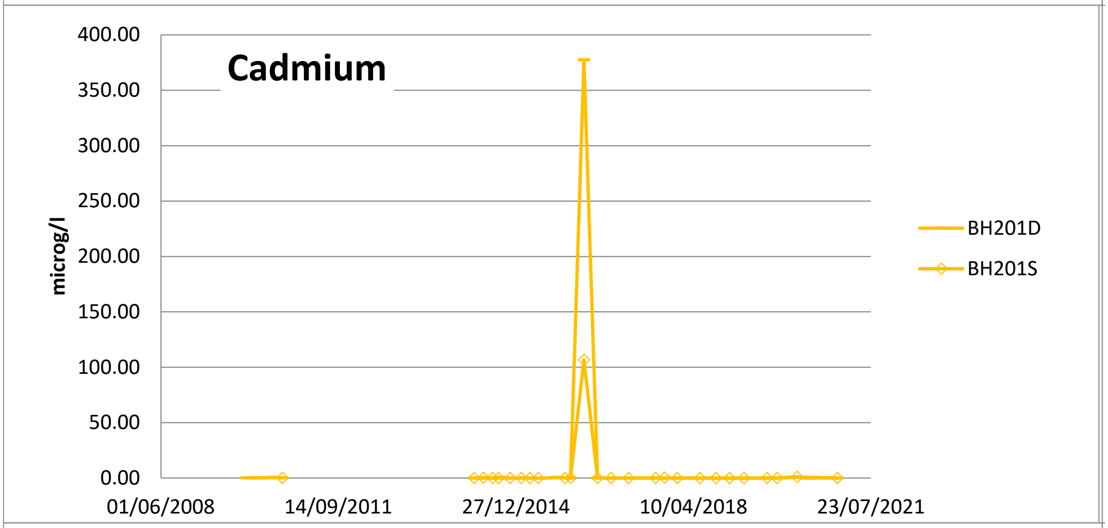

pH
pH
12
10
8
6
4
2
0
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH201D
BH201S

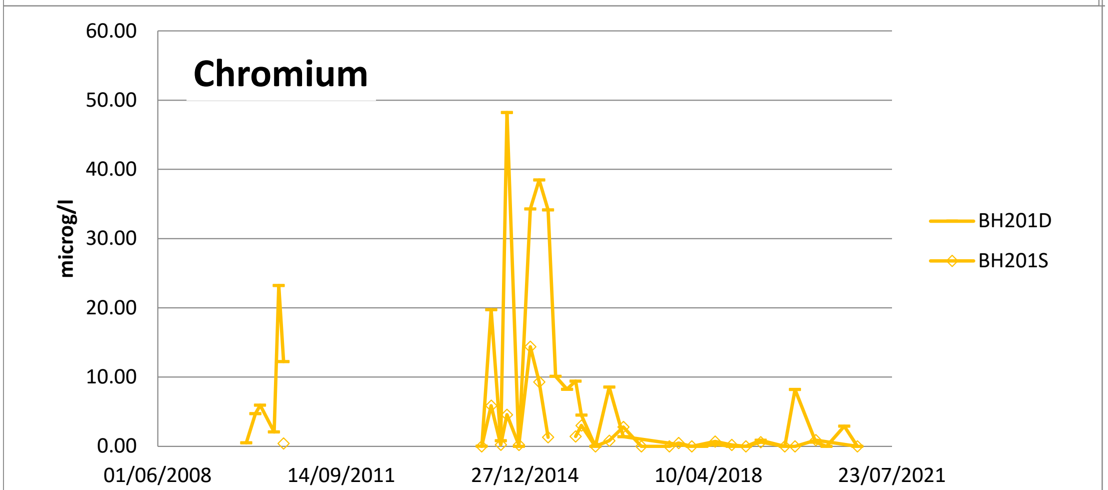

EC
microS/cm
6000
5000
4000
3000
2000
1000
0
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH201D
BH201S

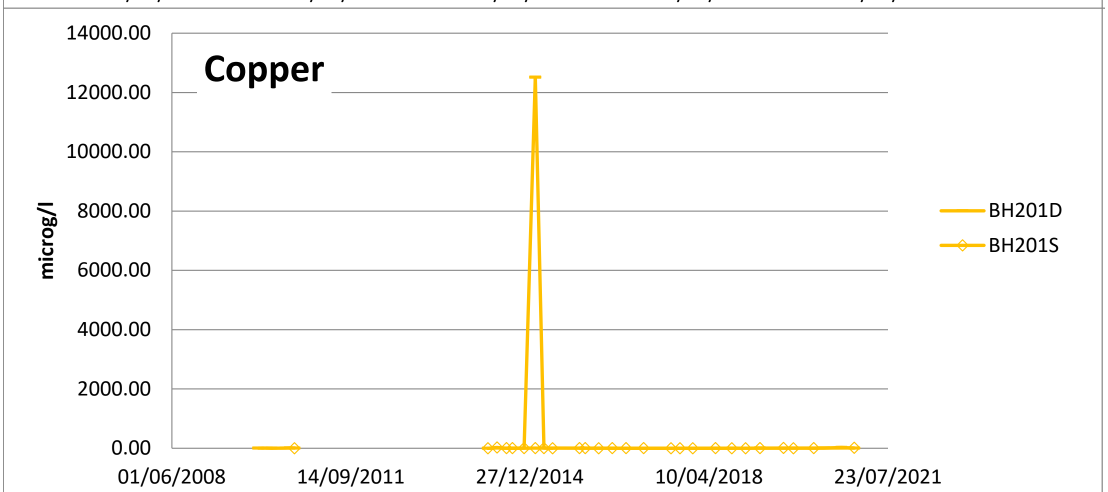

Ammonia
mg/l
120.00
100.00
80.00
60.00
40.00
20.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH201D
BH201S

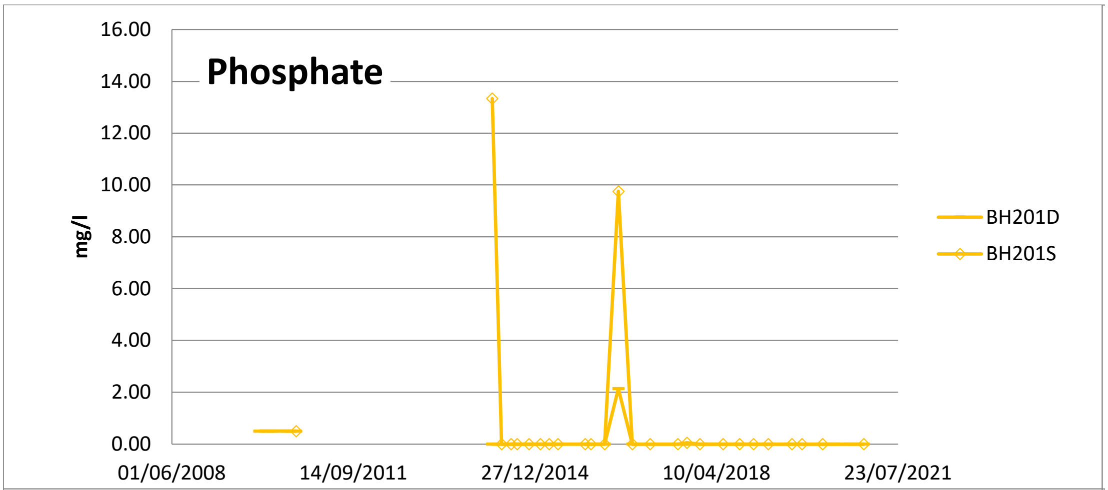

Chloride
mg/l
2500.00
2000.00
1500.00
1000.00
500.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH201D
BH201S

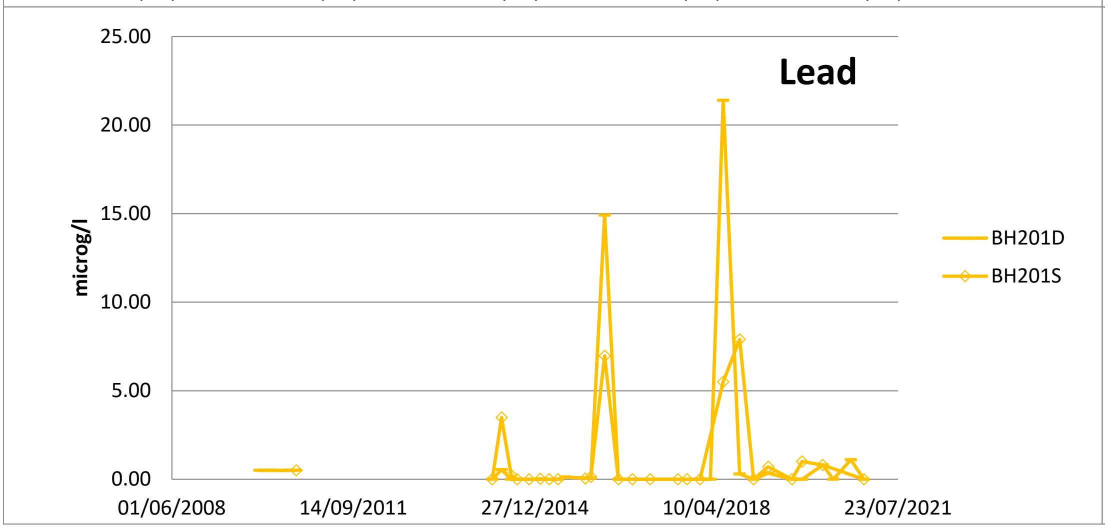

Calcium
mg/l
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH201D
BH201S

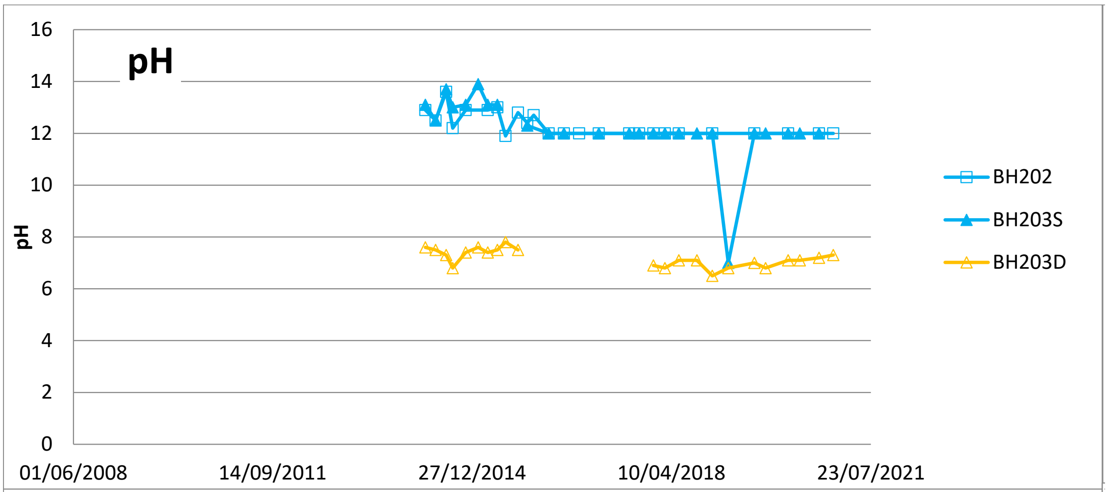

Cadmium
microg/l
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH201D
BH201S

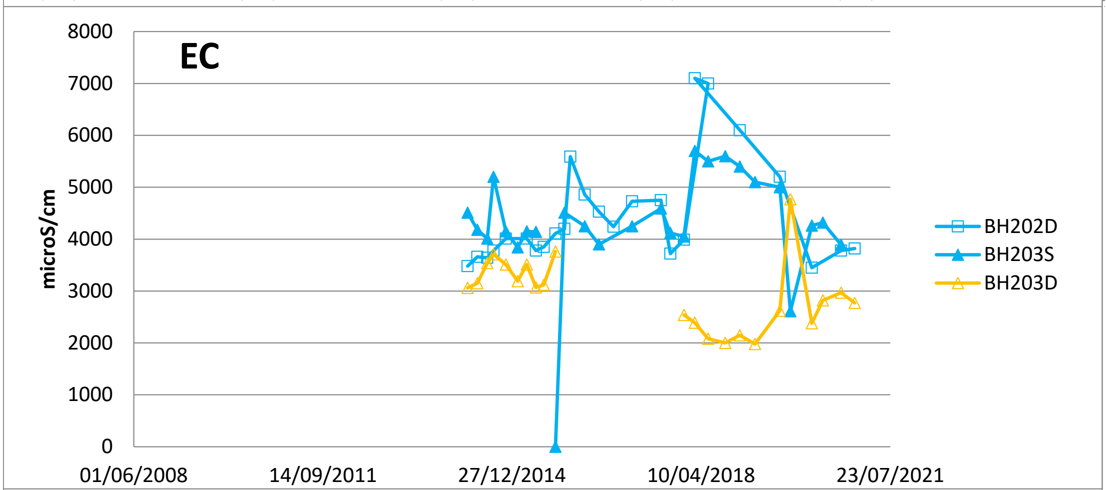

Chromium
microg/l
60.00
50.00
40.00
30.00
20.00
10.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH201D
BH201S

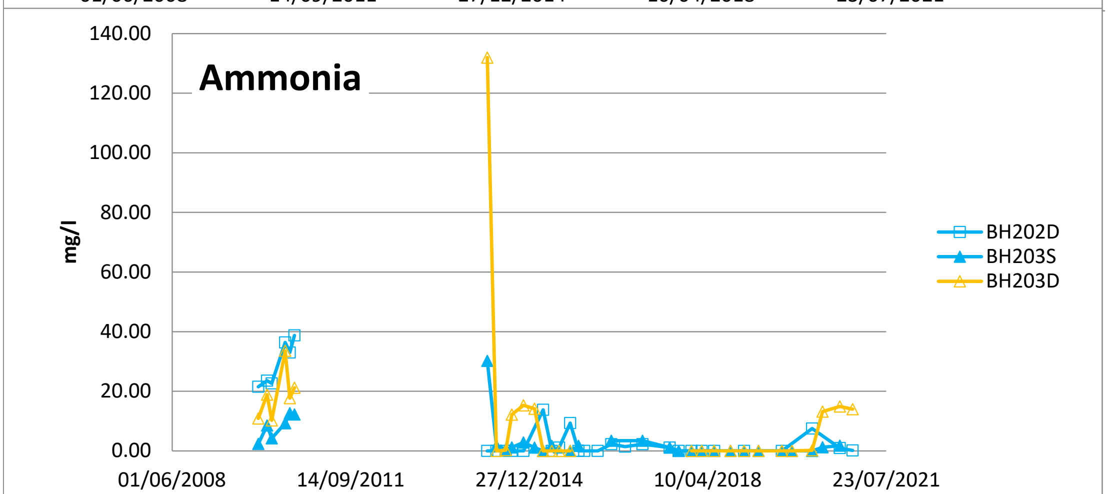

Copper
microg/l
14000.00
12000.00
10000.00
8000.00
6000.00
4000.00
2000.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH201D
BH201S

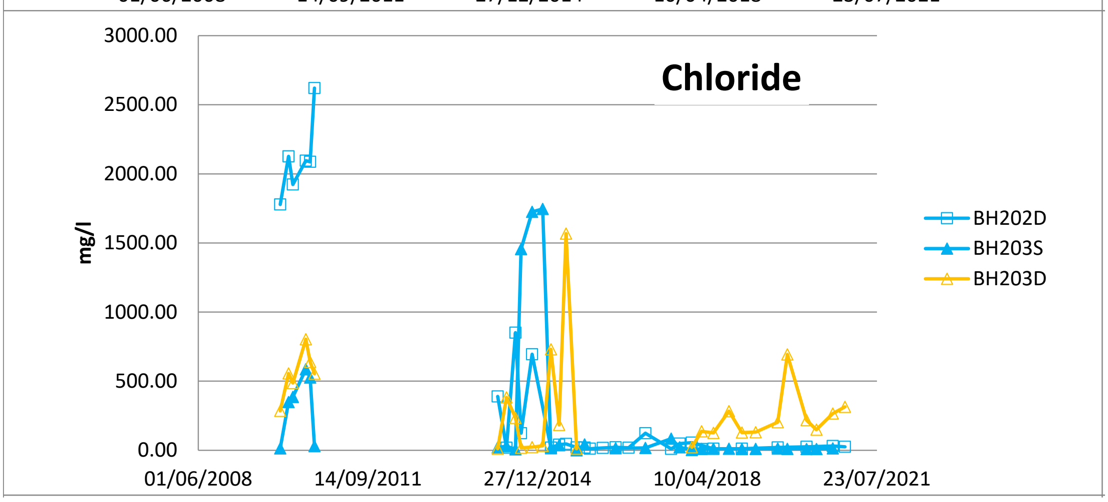

Phosphate
mg/l
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH201D
BH201S

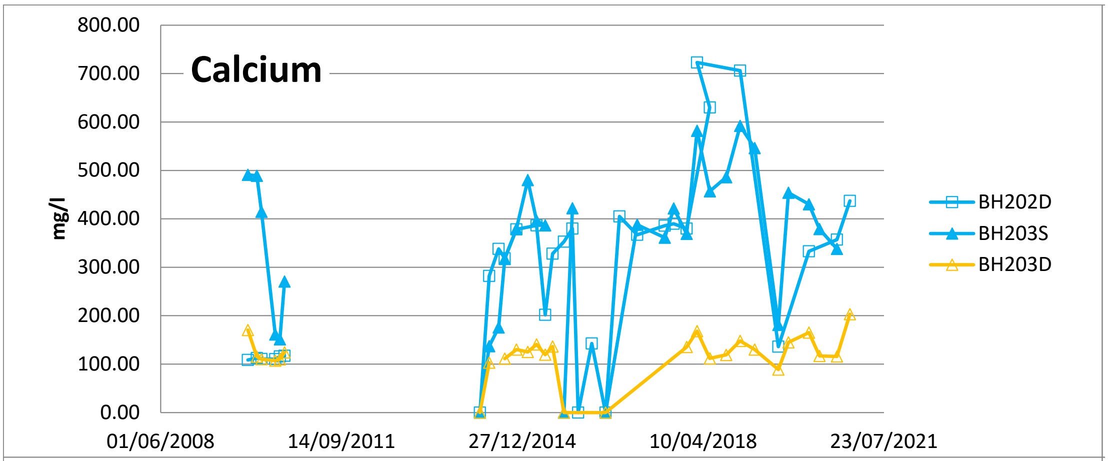

Lead
microg/l
25.00
20.00
15.00
10.00
5.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH201D
BH201S

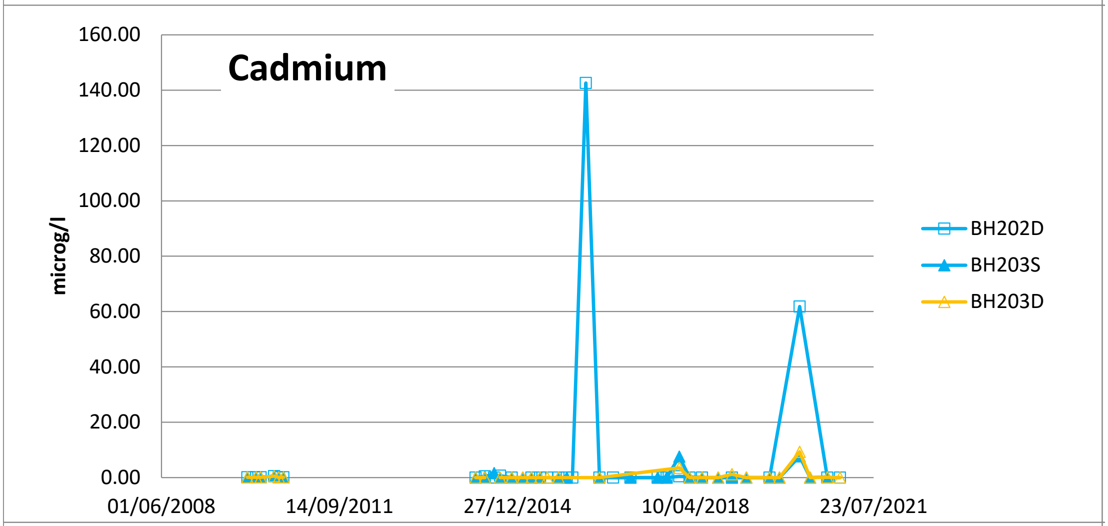

pH
16
14
12
10
8
6
4
2
0
pH
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH202
BH203S
BH203D

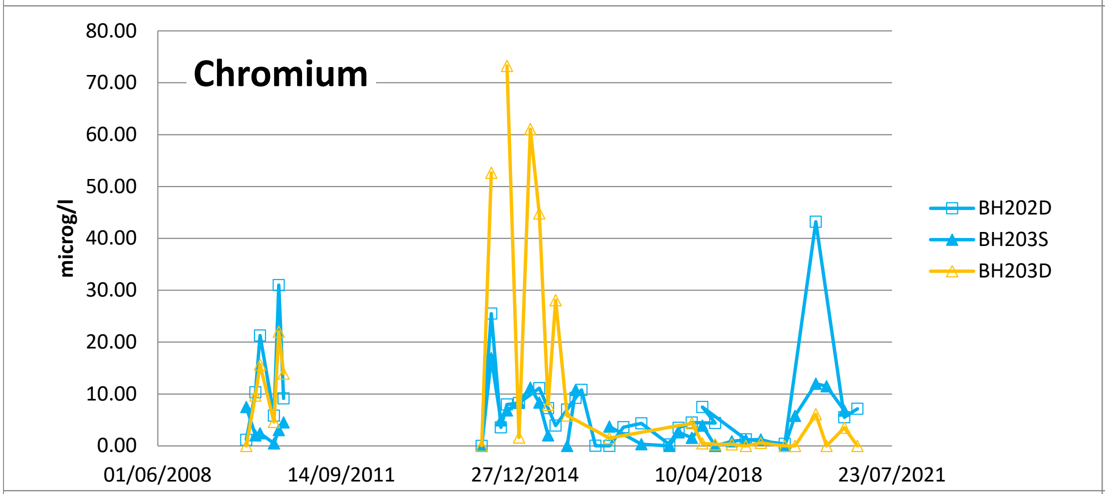

EC
8000
7000
6000
5000
4000
3000
2000
1000
0
microS/cm
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH202D
BH203S
BH203D

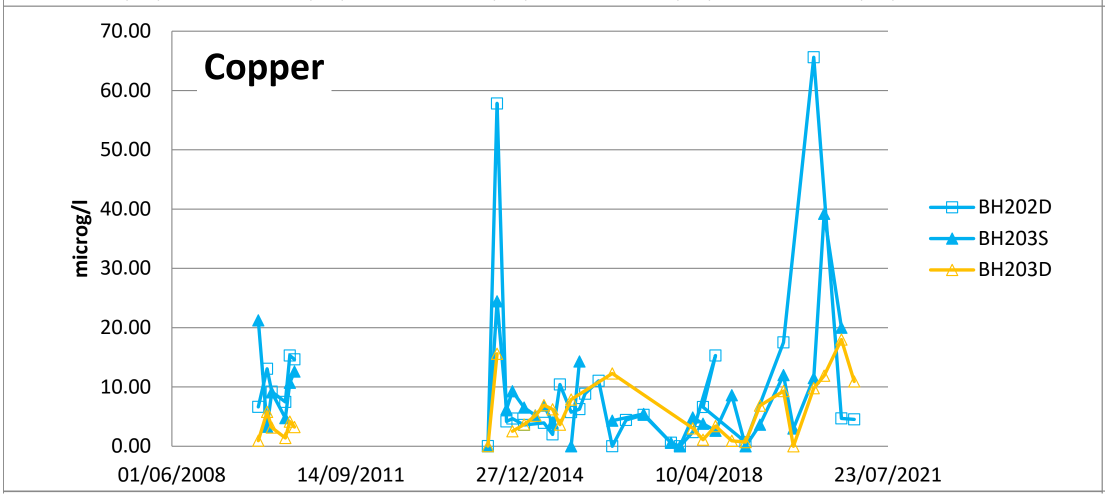

Ammonia
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
mg/l
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH202D
BH203S
BH203D

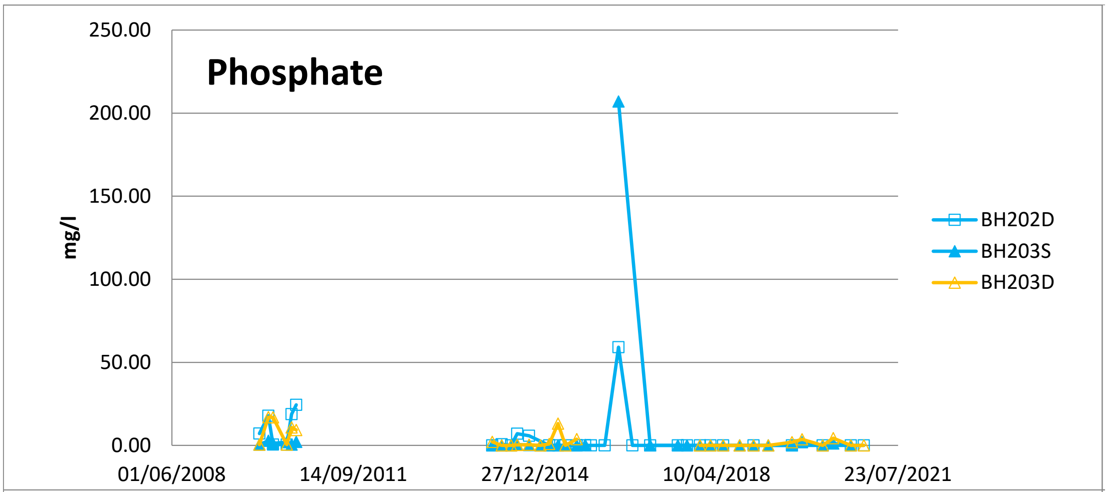

Chloride
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
mg/l
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH202D
BH203S
BH203D

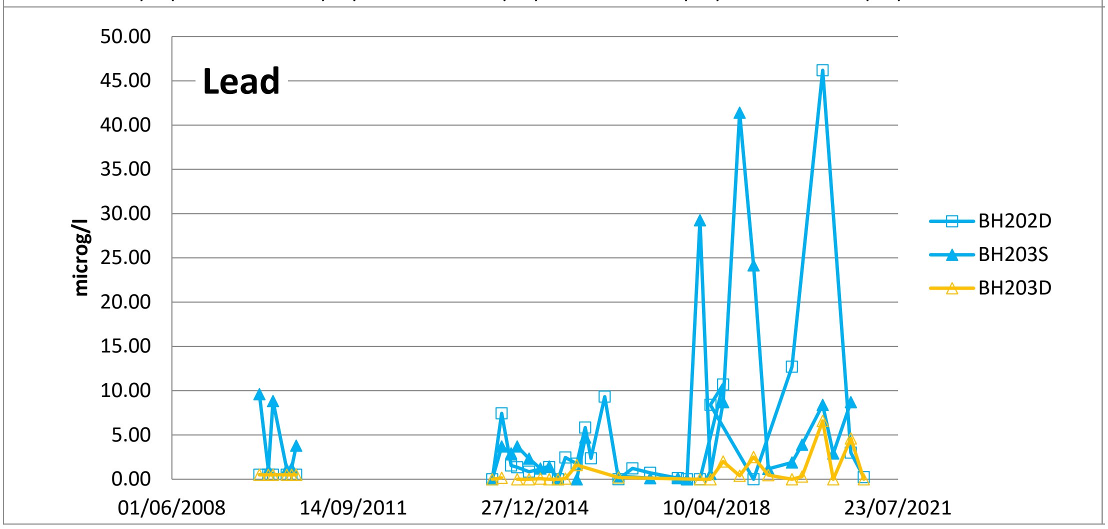

Calcium
mg/l
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH202D
BH203S
BH203D

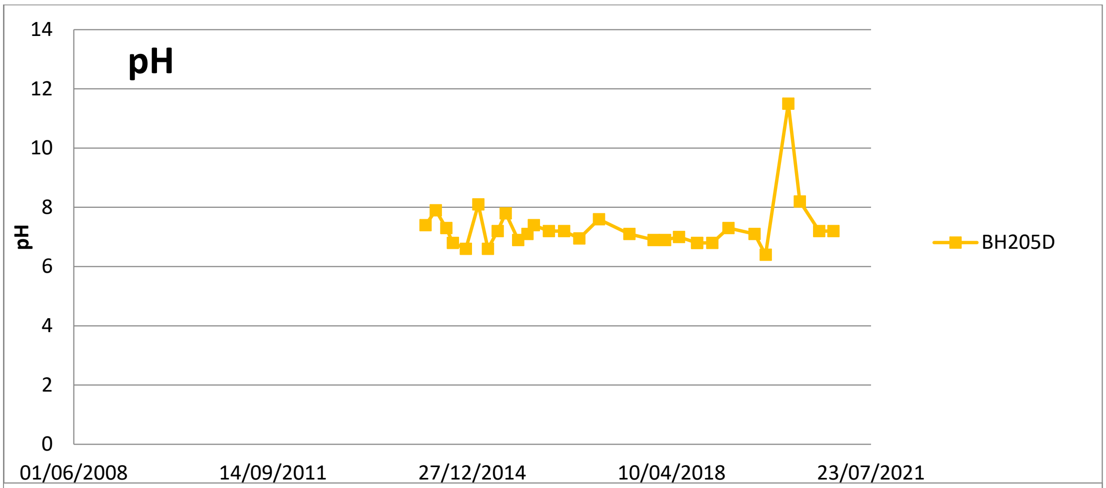

Cadmium
microg/l
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH202D
BH203S
BH203D

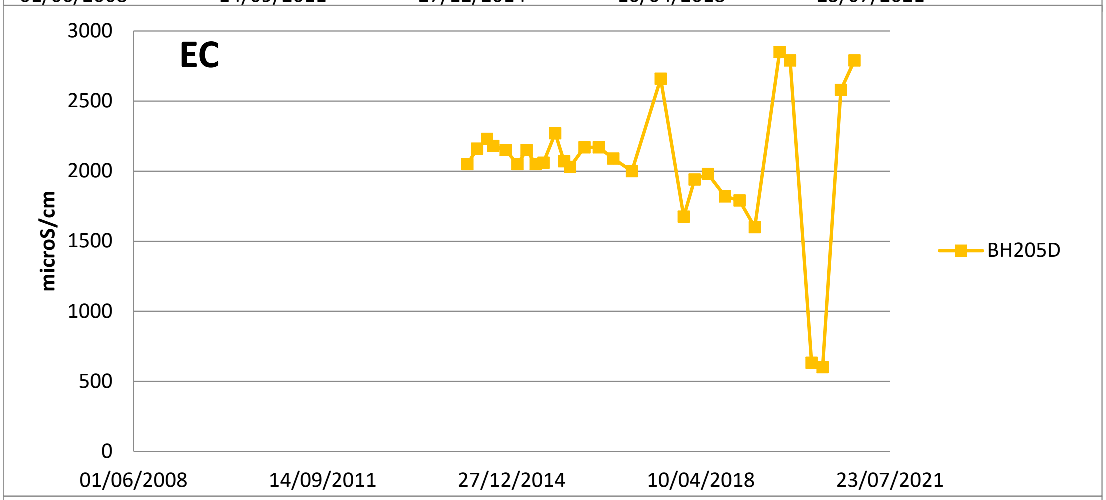

Chromium
microg/l
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH202D
BH203S
BH203D

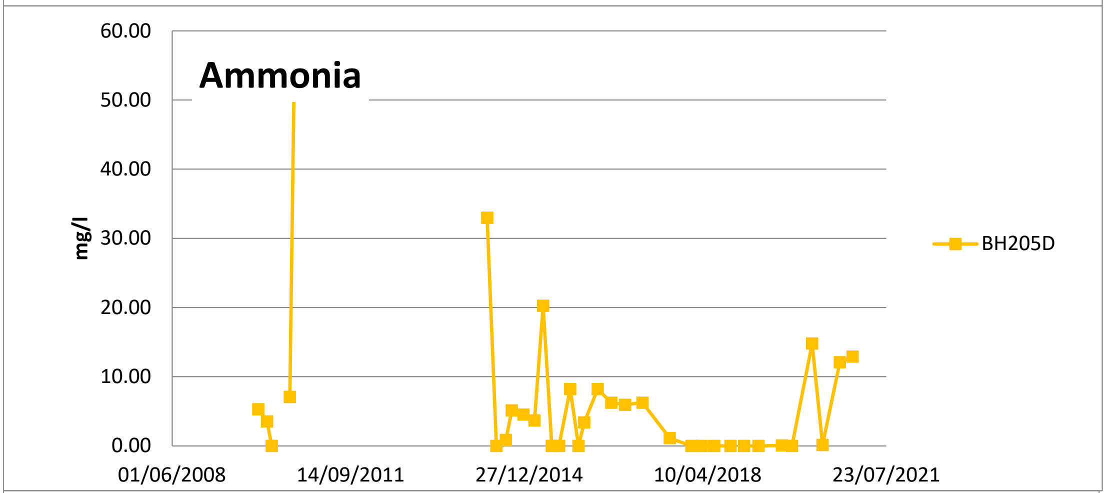

Copper
microg/l
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH202D
BH203S
BH203D

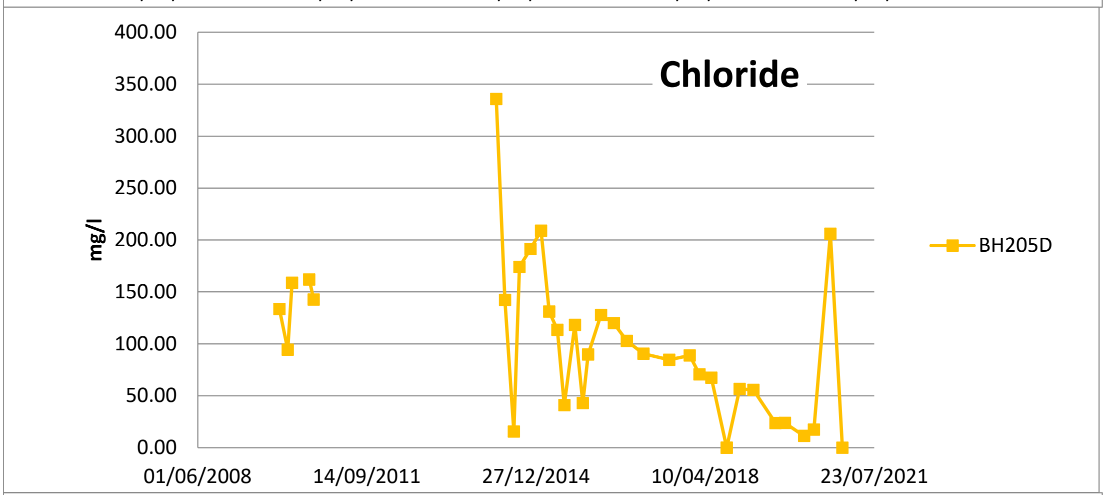

Phosphate
250.00
200.00
150.00
100.00
50.00
0.00
mg/l
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH202D
BH203S
BH203D

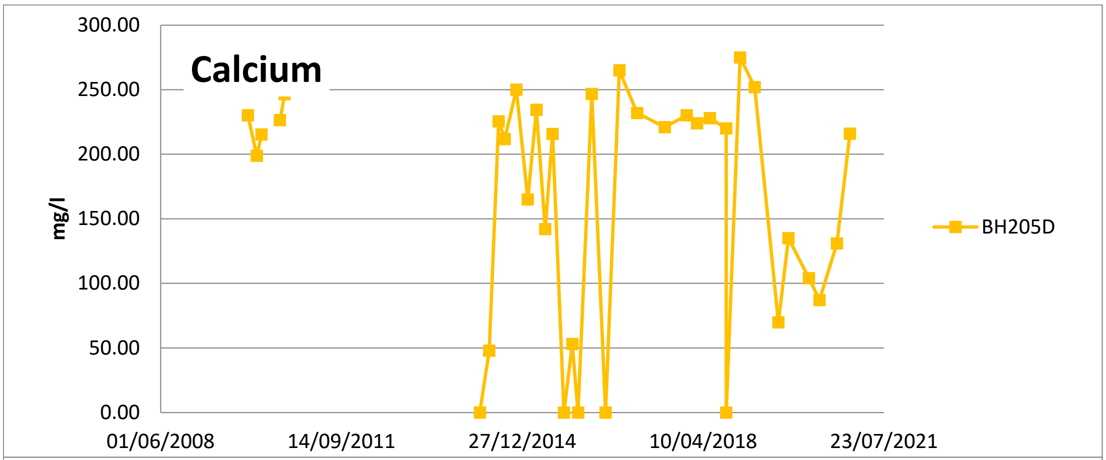

Lead
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
microg/l
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH202D
BH203S
BH203D

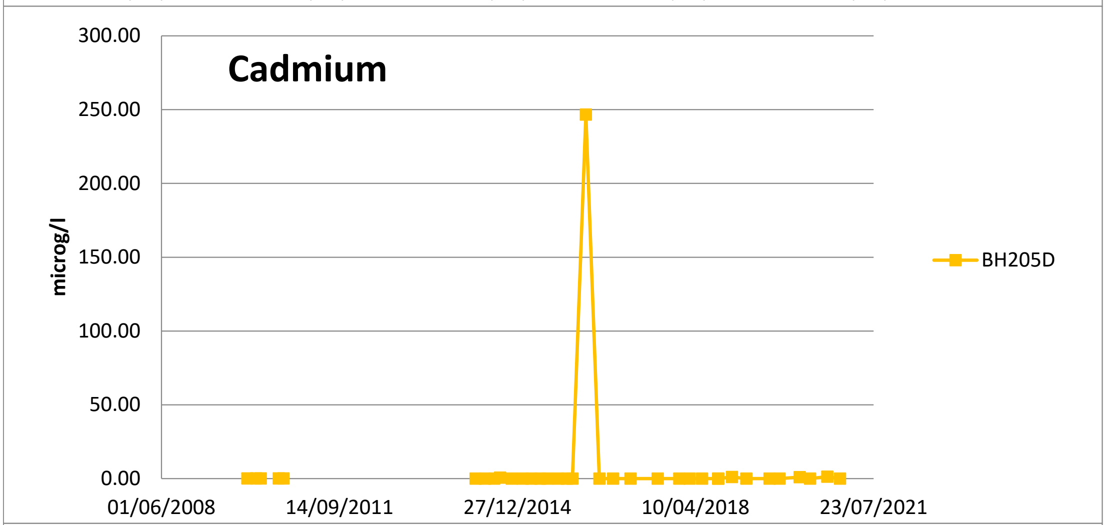

pH
pH
14
12
10
8
6
4
2
0
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH205D

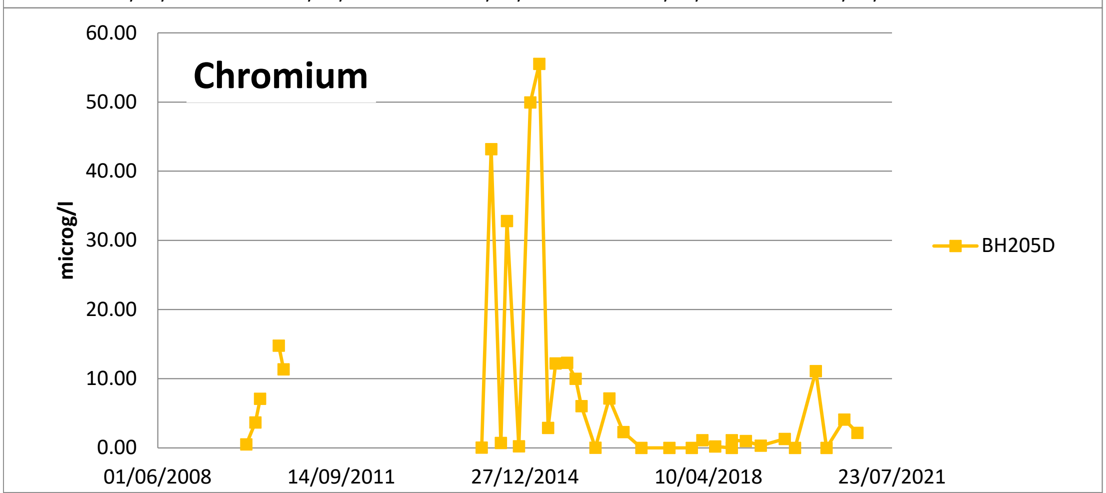

EC
microS/cm
3000
2500
2000
1500
1000
500
0
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH205D

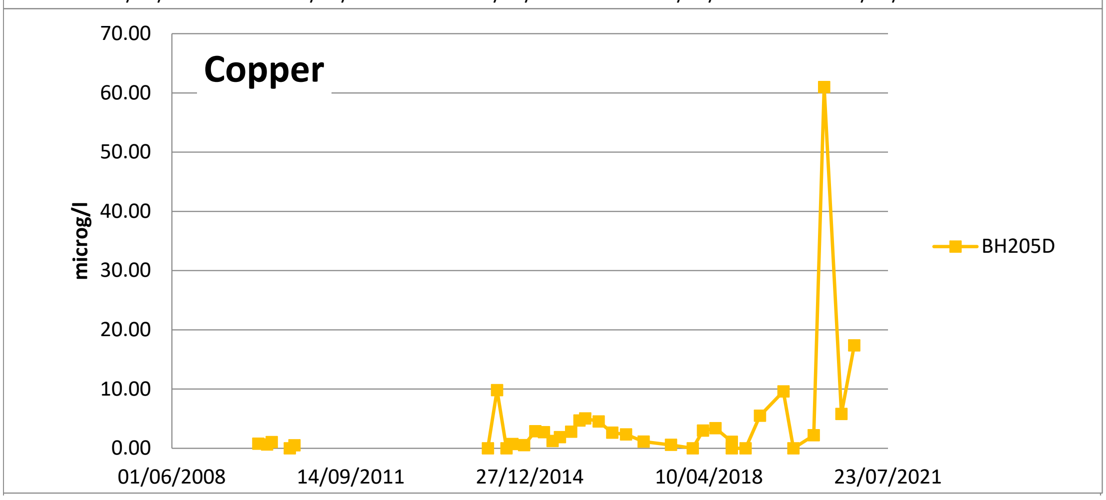

Ammonia
mg/l
60.00
50.00
40.00
30.00
20.00
10.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH205D

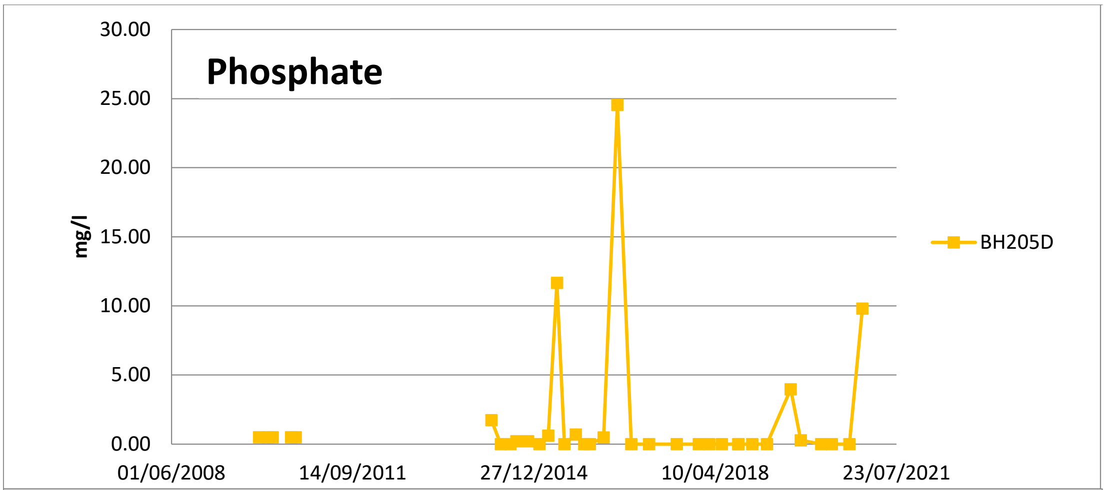

Chloride
mg/l
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH205D

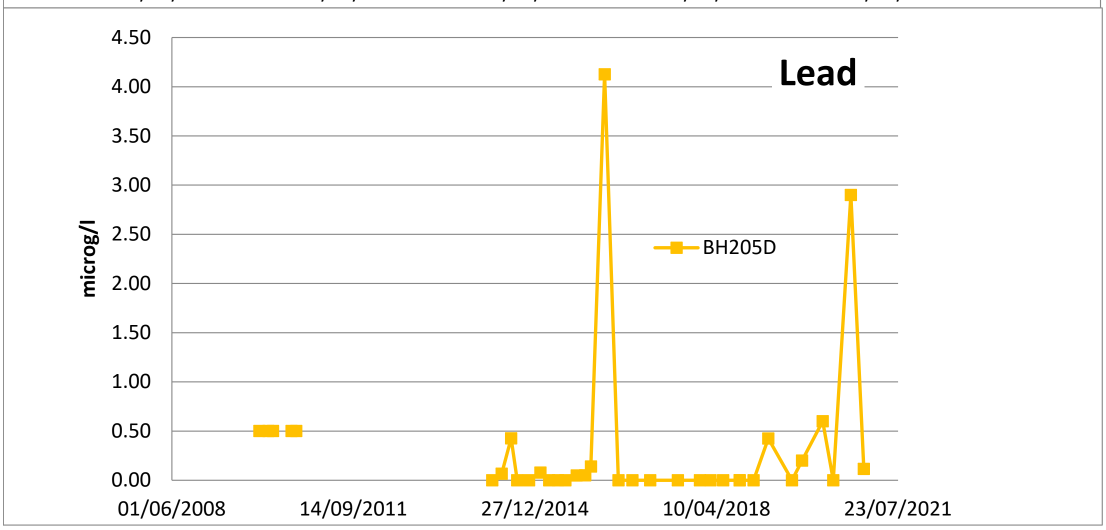

Calcium
mg/l
300.00
250.00
200.00
150.00
100.00
50.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH205D


Cadmium
microg/l
300.00
250.00
200.00
150.00
100.00
50.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH205D


Chromium
microg/l
60.00
50.00
40.00
30.00
20.00
10.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH205D


Copper
microg/l
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH205D


Phosphate
mg/l
30.00
25.00
20.00
15.00
10.00
5.00
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH205D


Lead
microg/l
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
01/06/2008
14/09/2011
27/12/2014
10/04/2018
23/07/2021
BH205D

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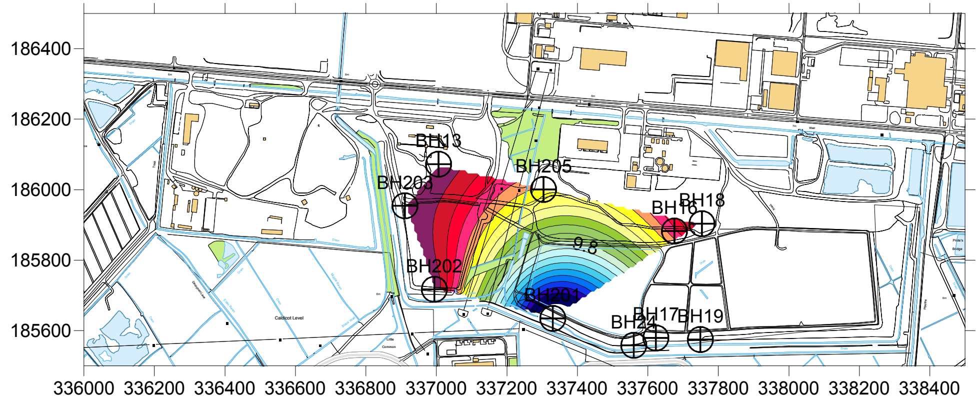
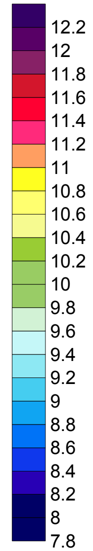
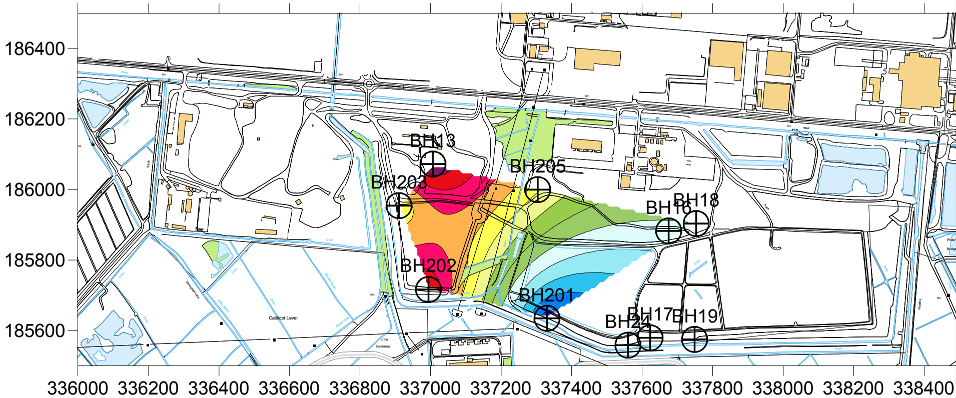
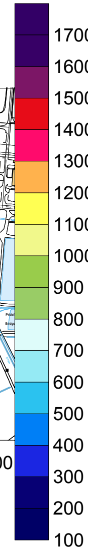


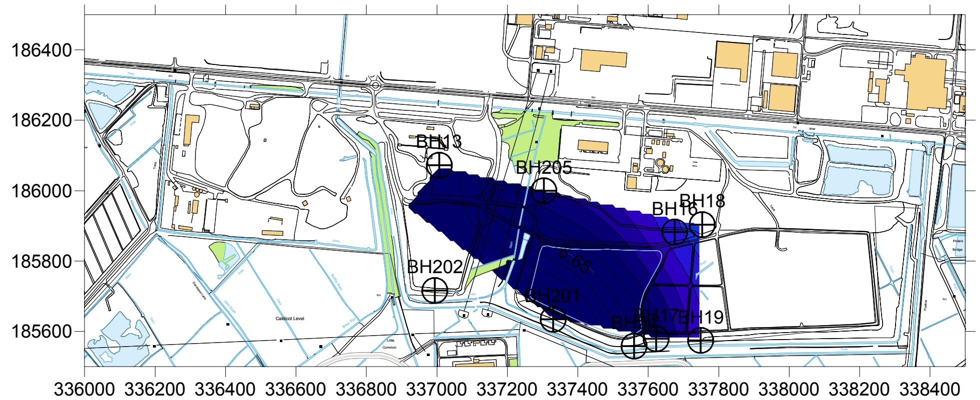


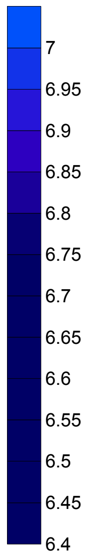
pH in Shallow Groundwater



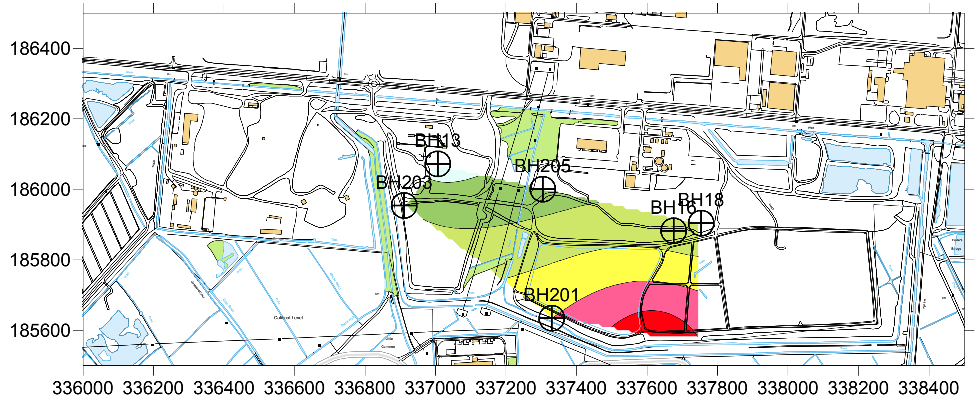


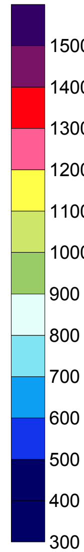
Alkalinity in Shallow Groundwater (mg/l $CaCO_3$)





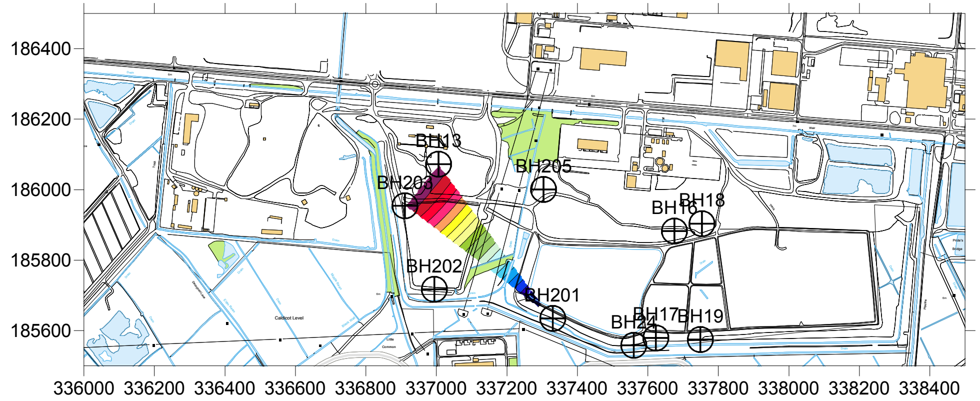
pH in Deep Groundwater

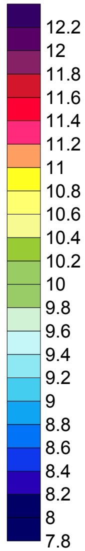




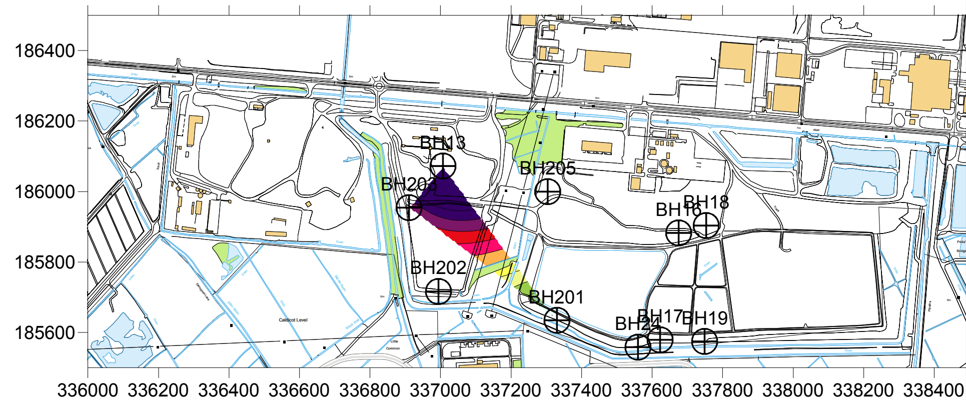
Alkalinity in in Deep Groundwater (mg/l $CaCO_3$)

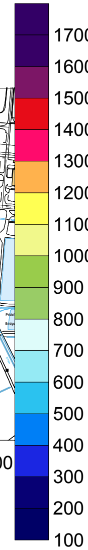
Groundwater Chemistry October 2019



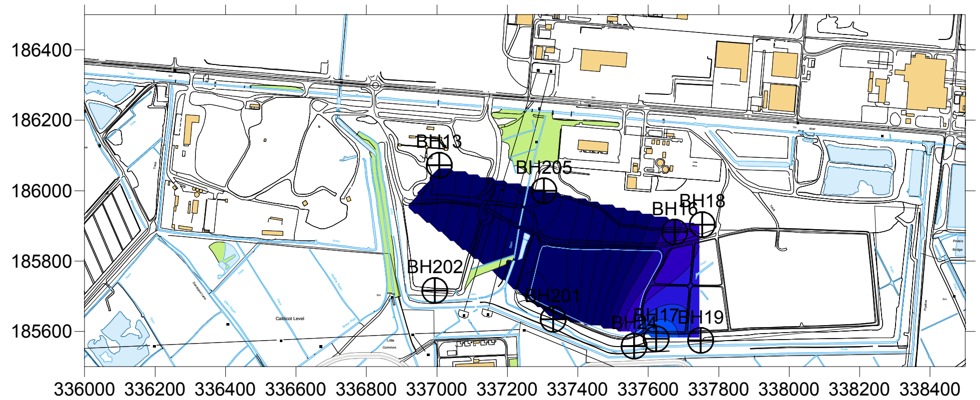


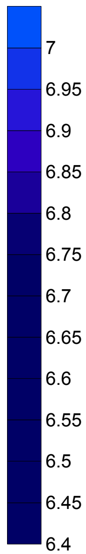
pH in Shallow Groundwater



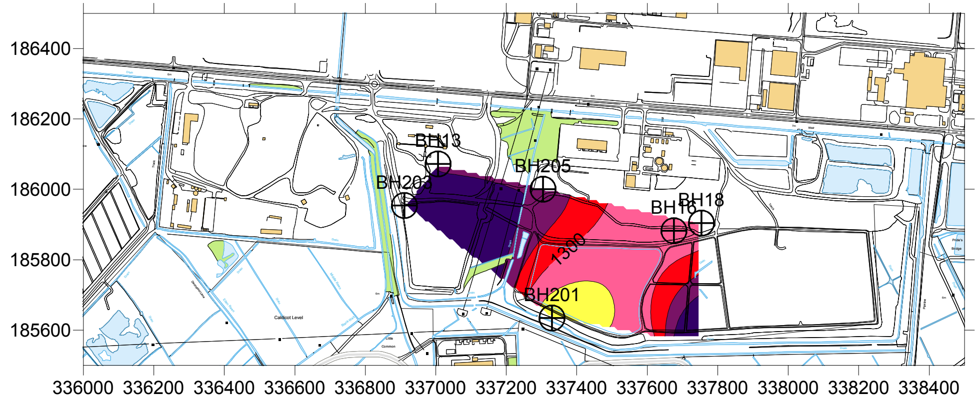


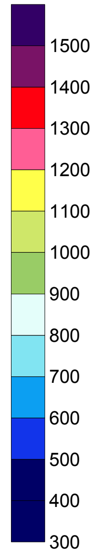
Alkalinity in Shallow Groundwater (mg/l $CaCO_3$)



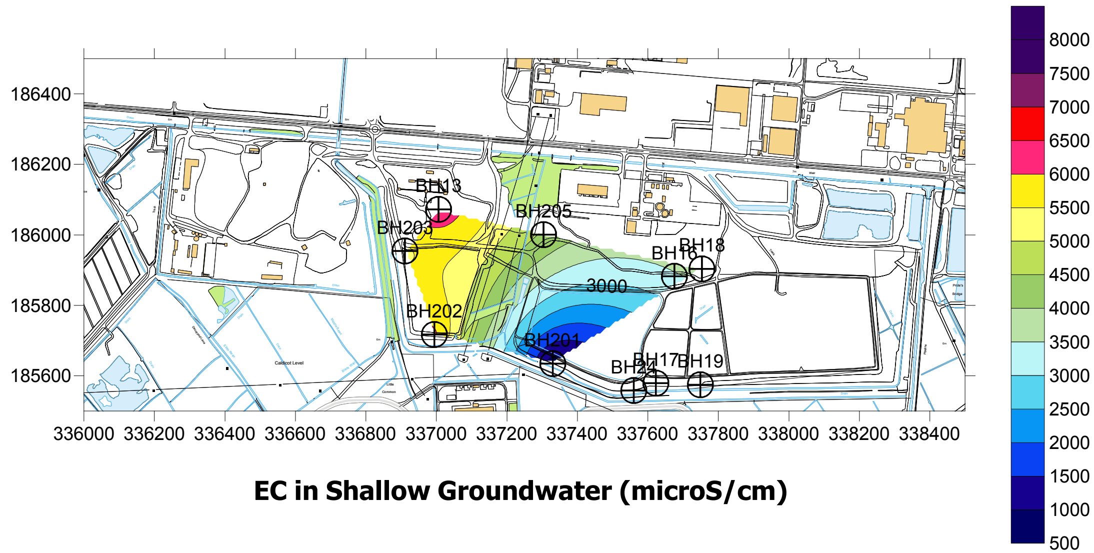


pH in Deep Groundwater

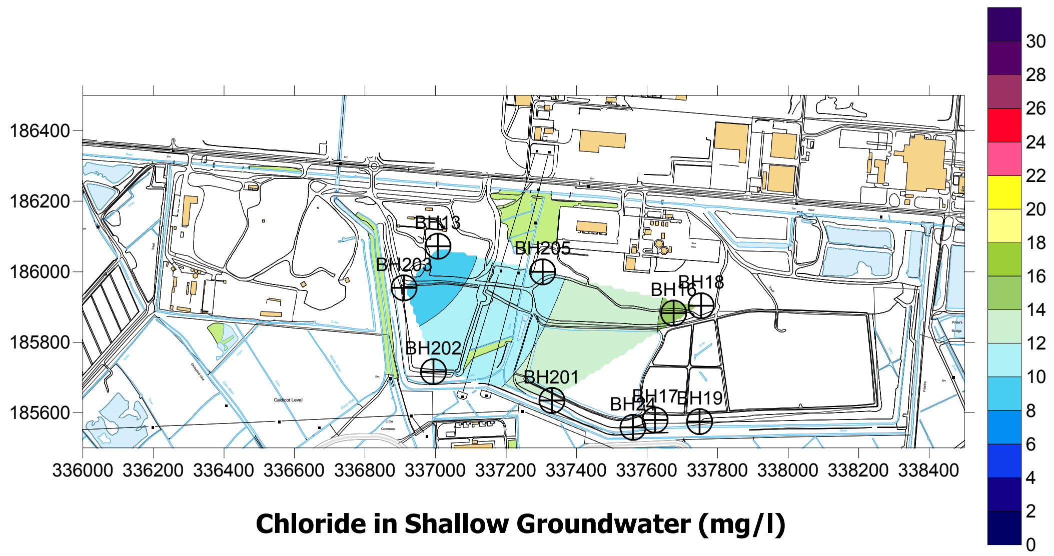




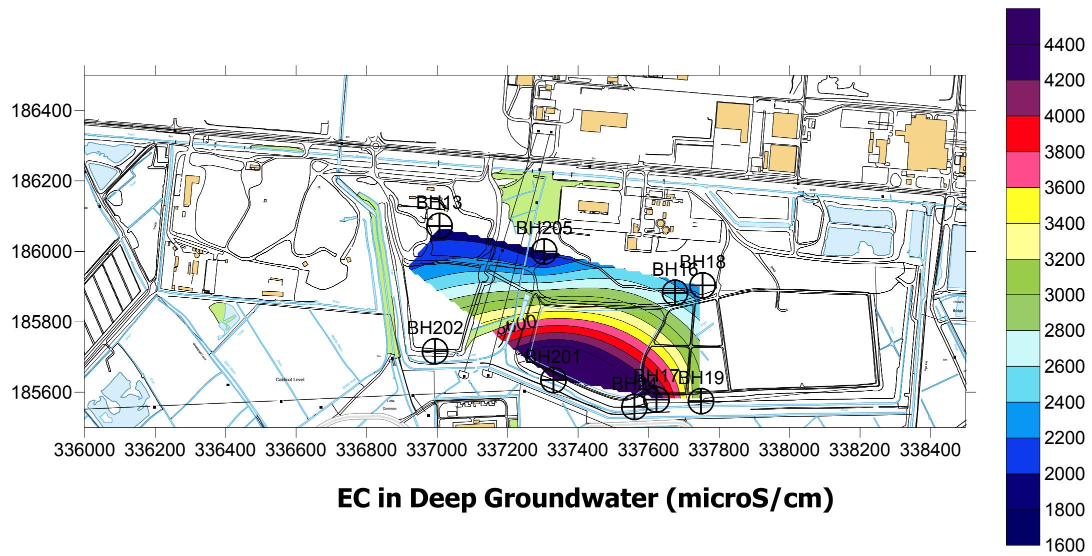
Alkalinity in in Deep Groundwater (mg/l $CaCO_3$)



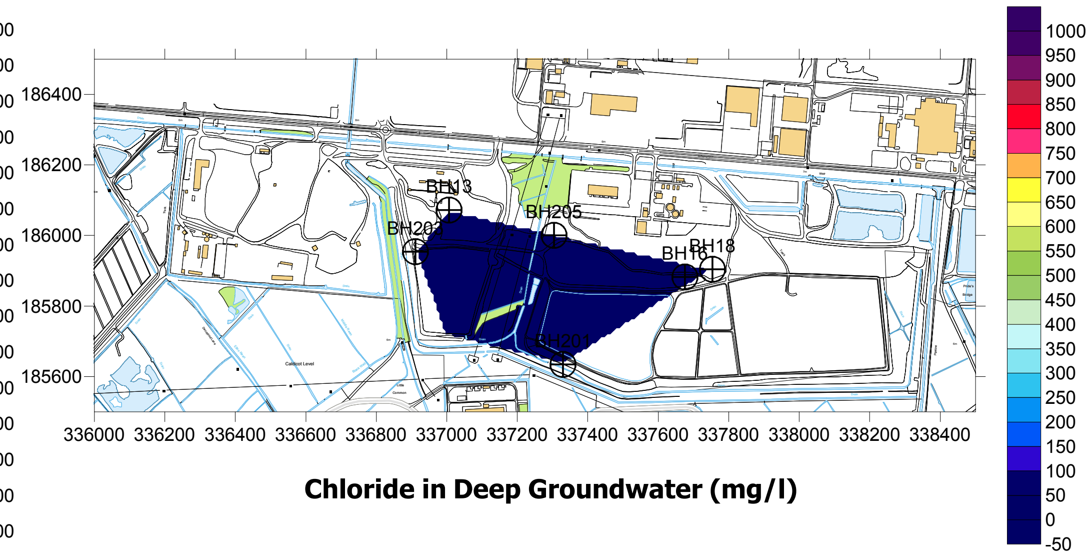
EC in Shallow Groundwater (microS/cm)



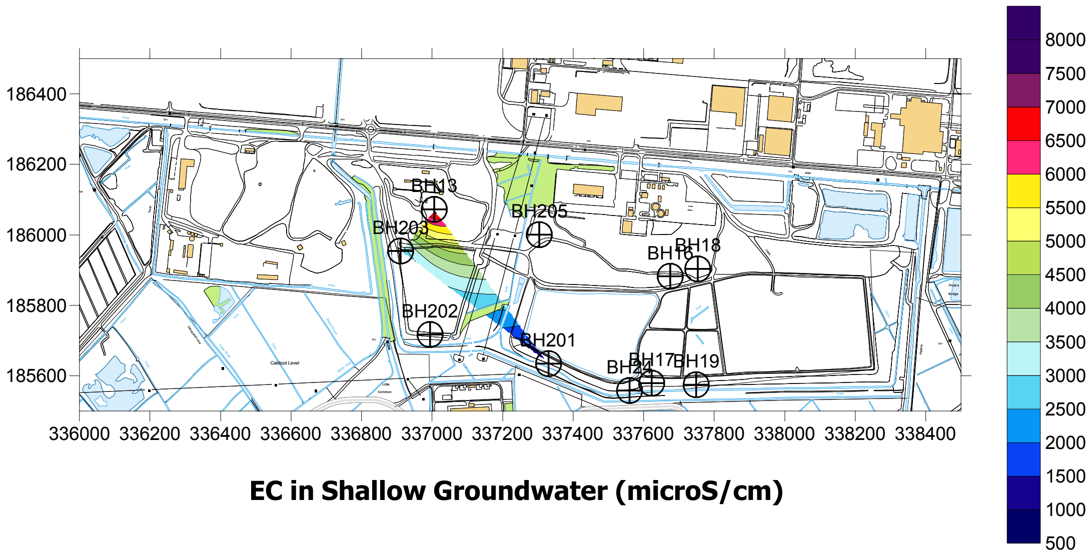
Chloride in Shallow Groundwater (mg/l)



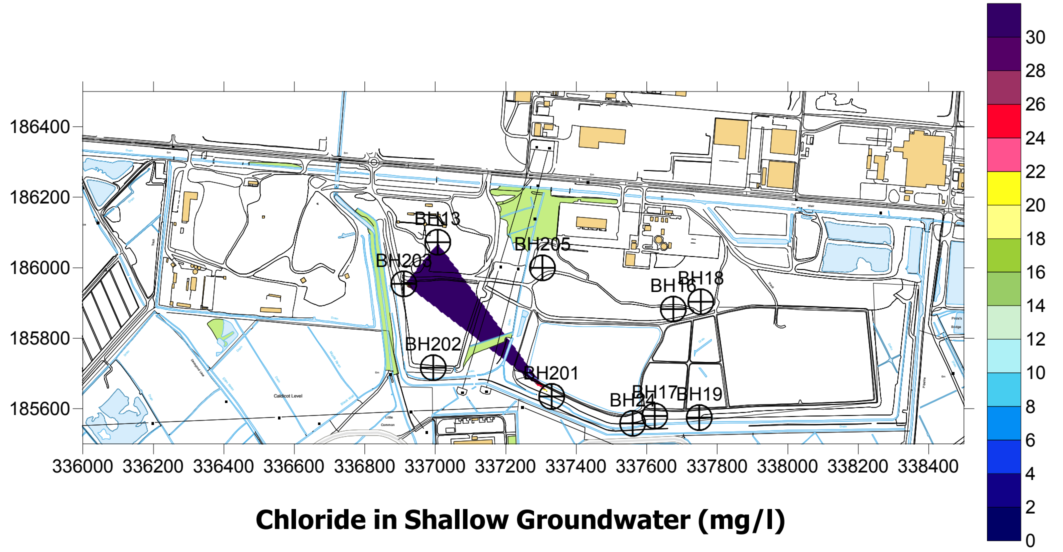
EC in Deep Groundwater (microS/cm)



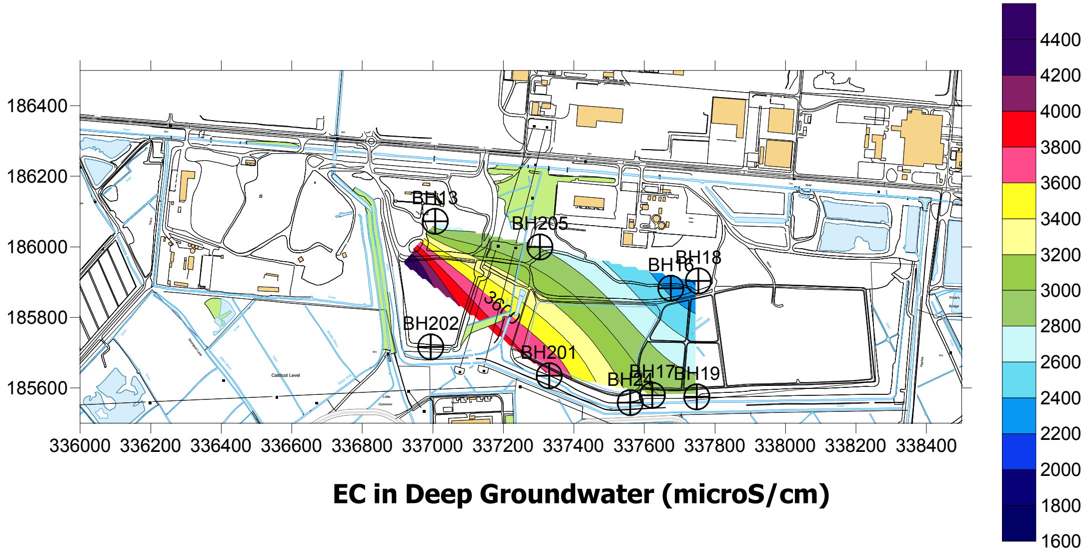
Chloride in Deep Groundwater (mg/l)



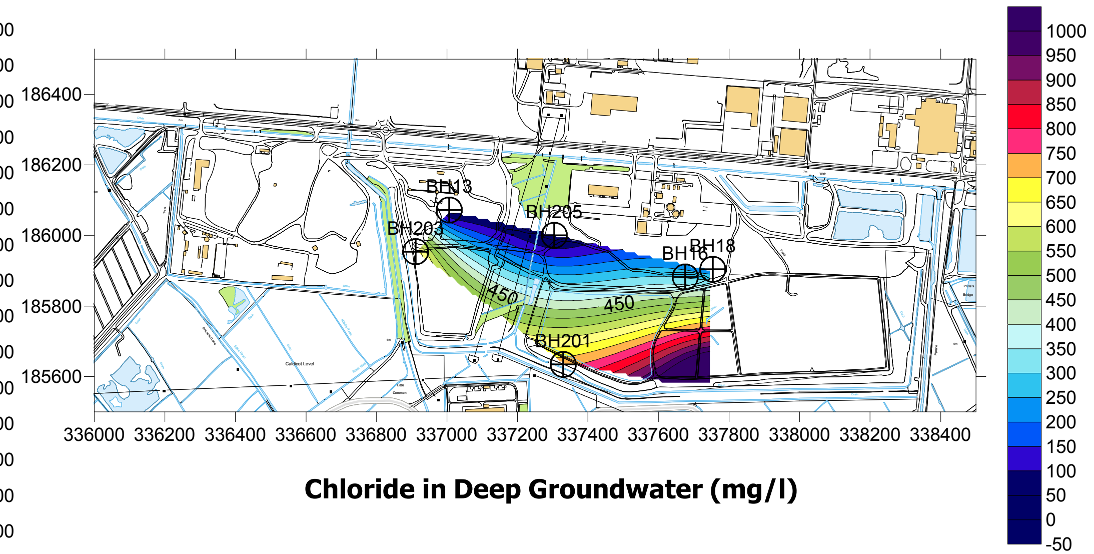
EC in Shallow Groundwater (microS/cm)



Chloride in Shallow Groundwater (mg/l)

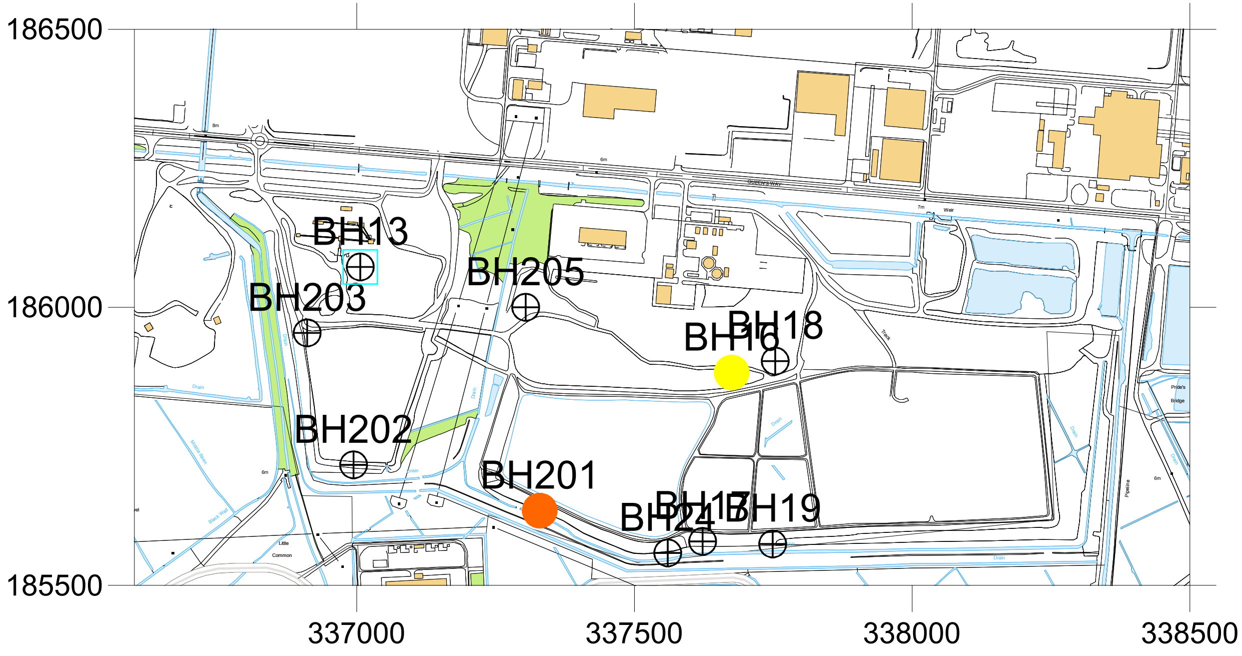


EC in Deep Groundwater (microS/cm)



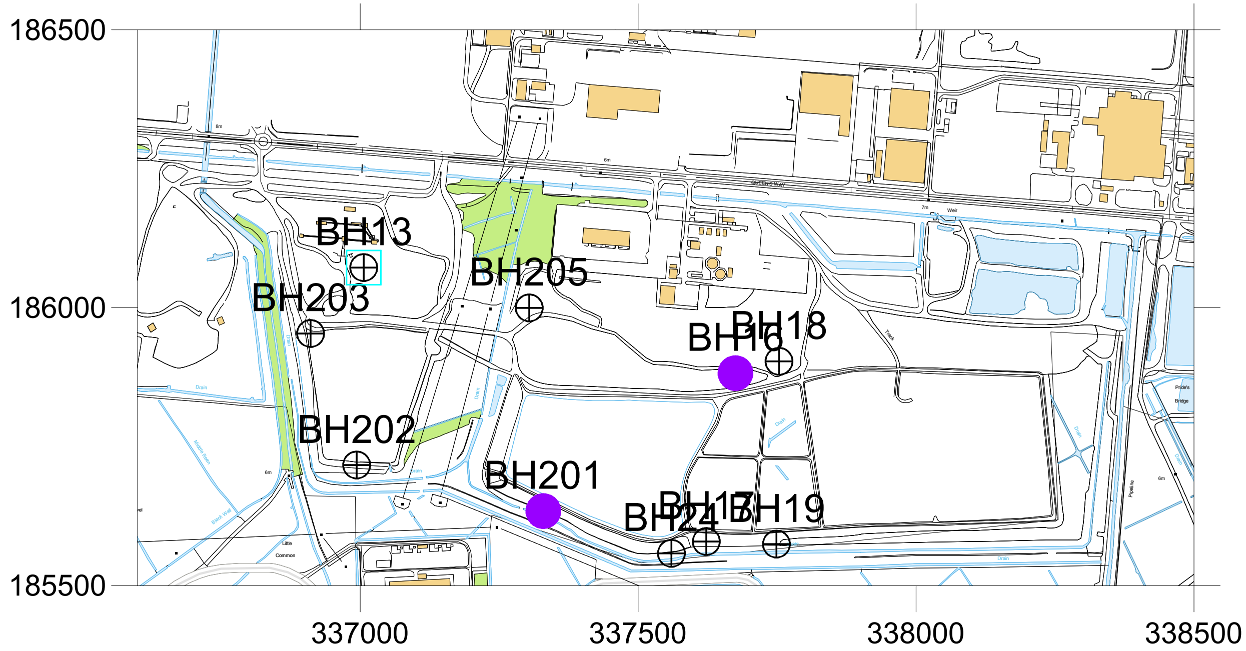
Chloride in Deep Groundwater (mg/l)

Groundwater Chemistry December 2020 (microg/l)



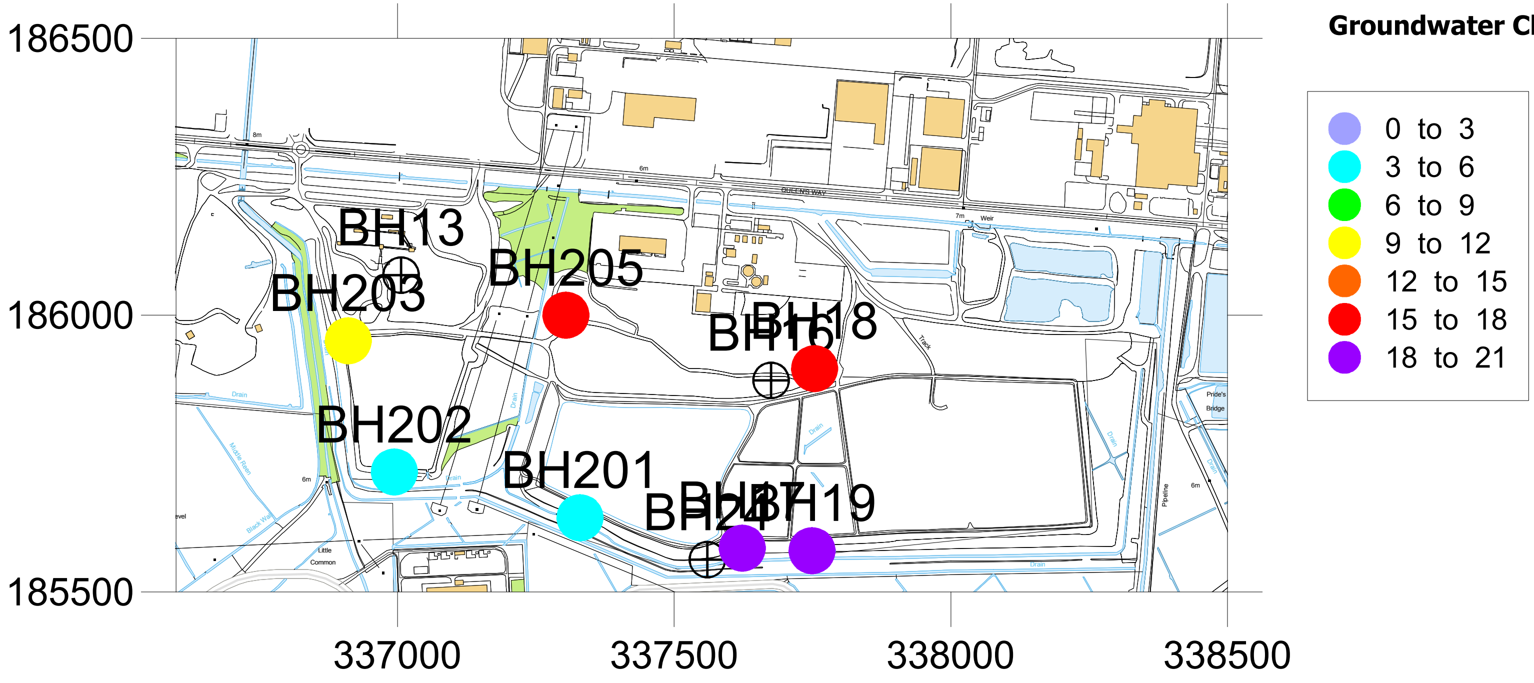
●	0 to 3
□	3 to 6
●	6 to 9
●	9 to 12
●	12 to 15
△	15 to 18
●	18 to 21

Copper in Shallow Groundwater

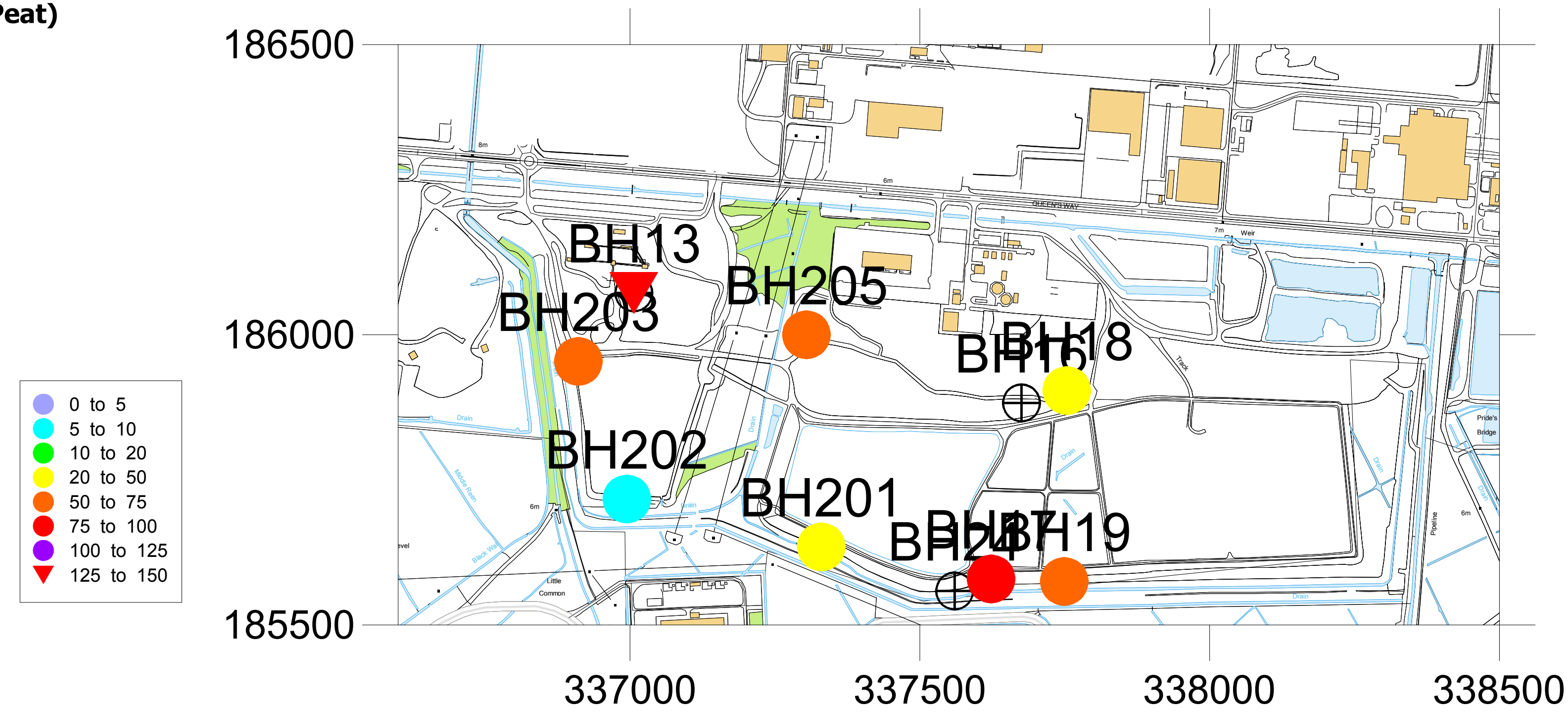


Zinc in Shallow Groundwater

Groundwater Chemistry in Peat - December 2020 (microg/l)



Copper in Deep Groundwater (Peat)



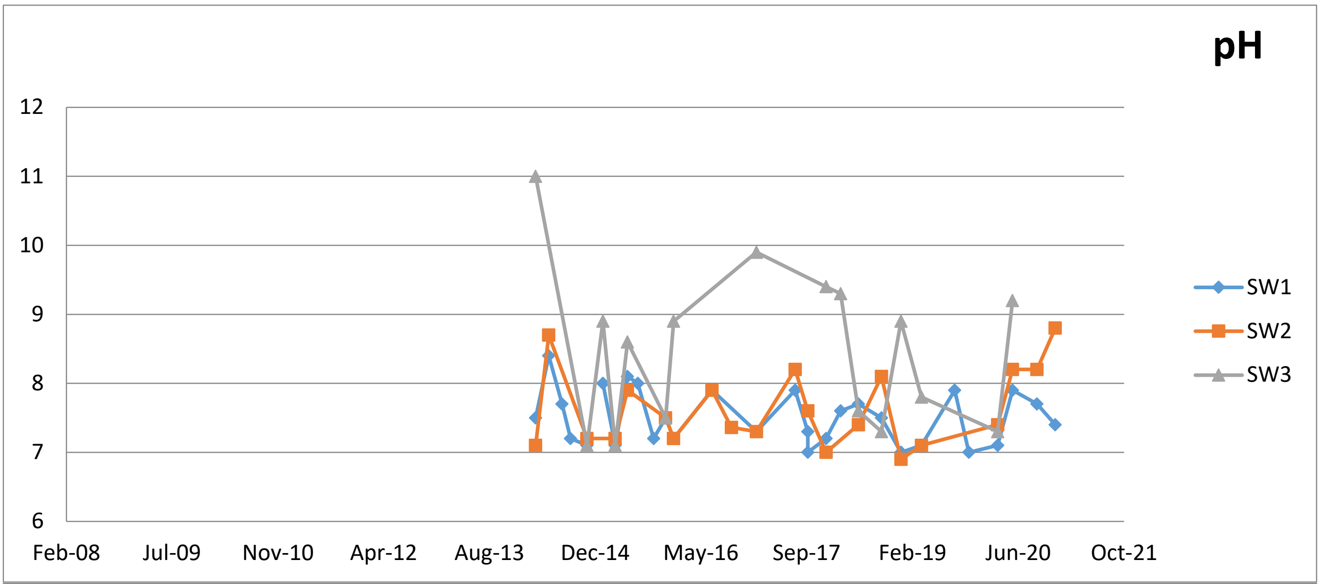
Zinc in Deep Groundwater (peat)

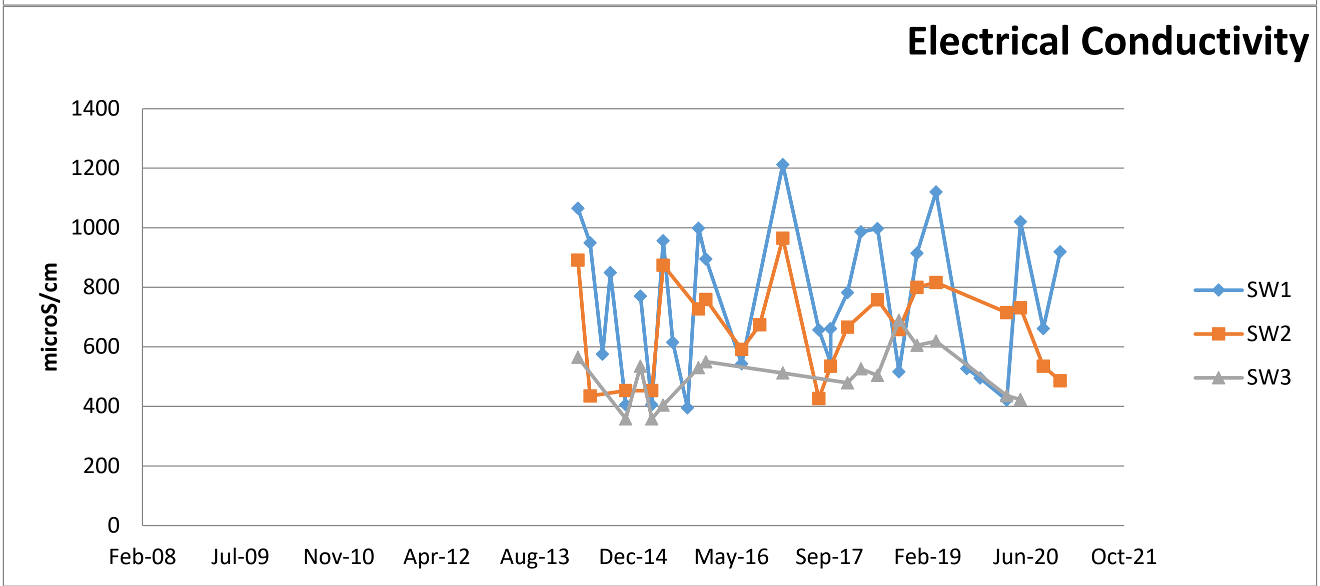
SOUTH SIDE QUEENSWAY WASTE MANAGEMENT SITE, LLANWERN STEELWORKS

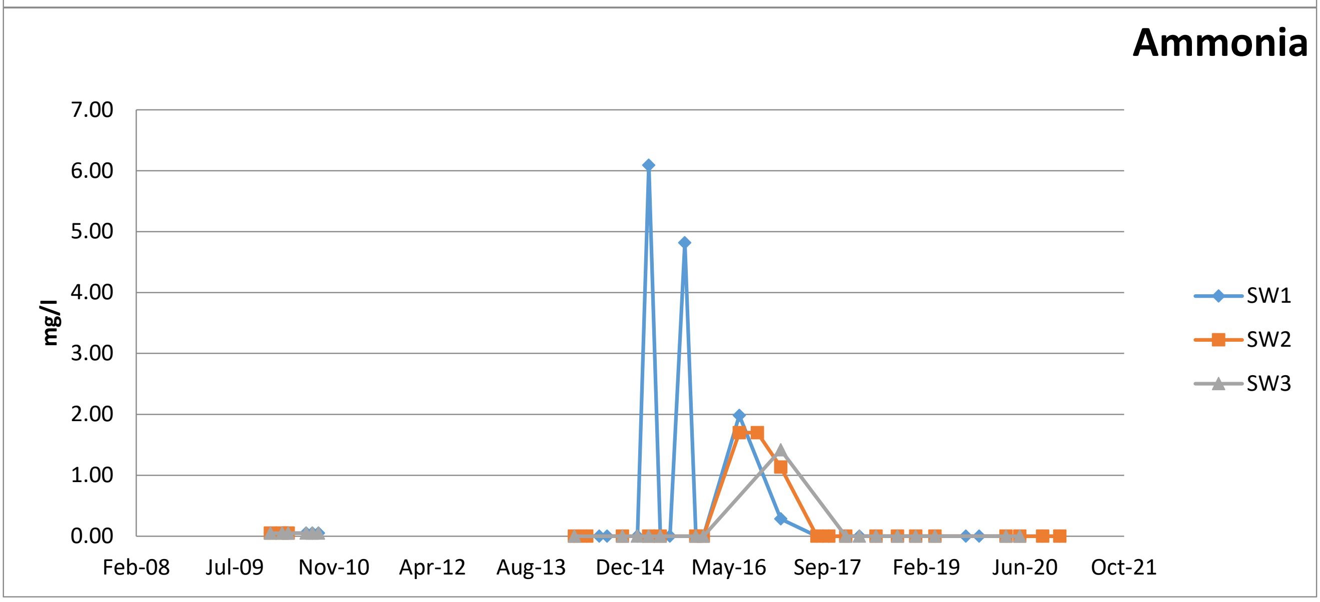
2020 Annual Review of Environmental Monitoring

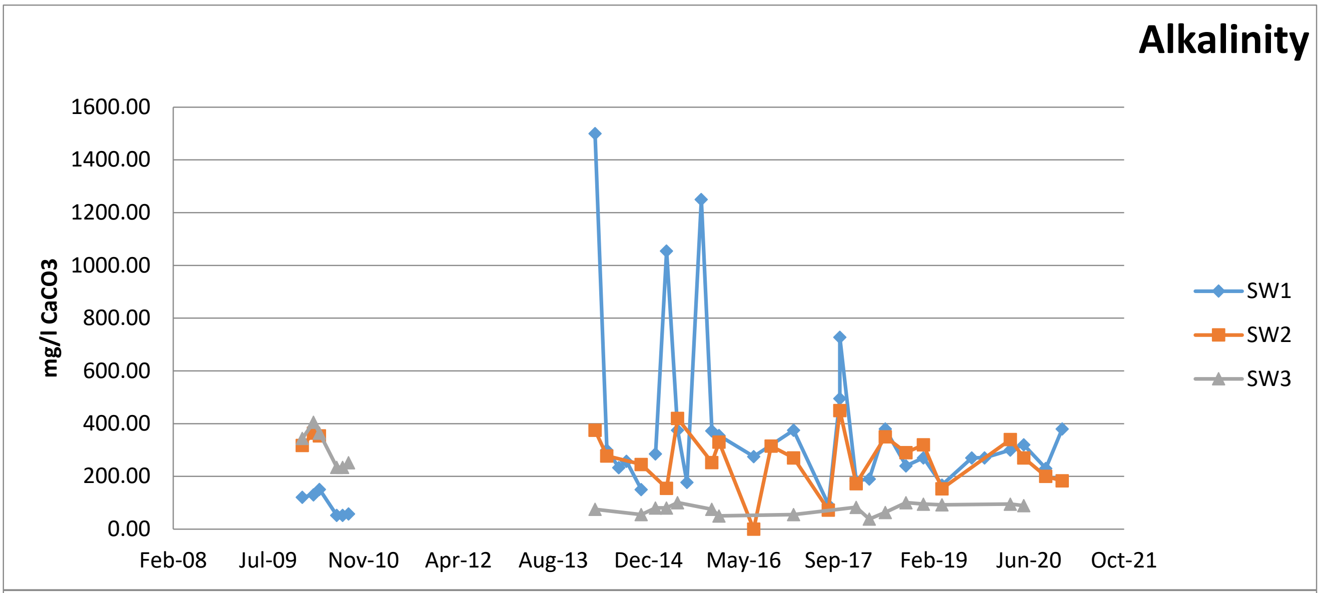
Appendix 2
Surface Water Chemistry Analysis

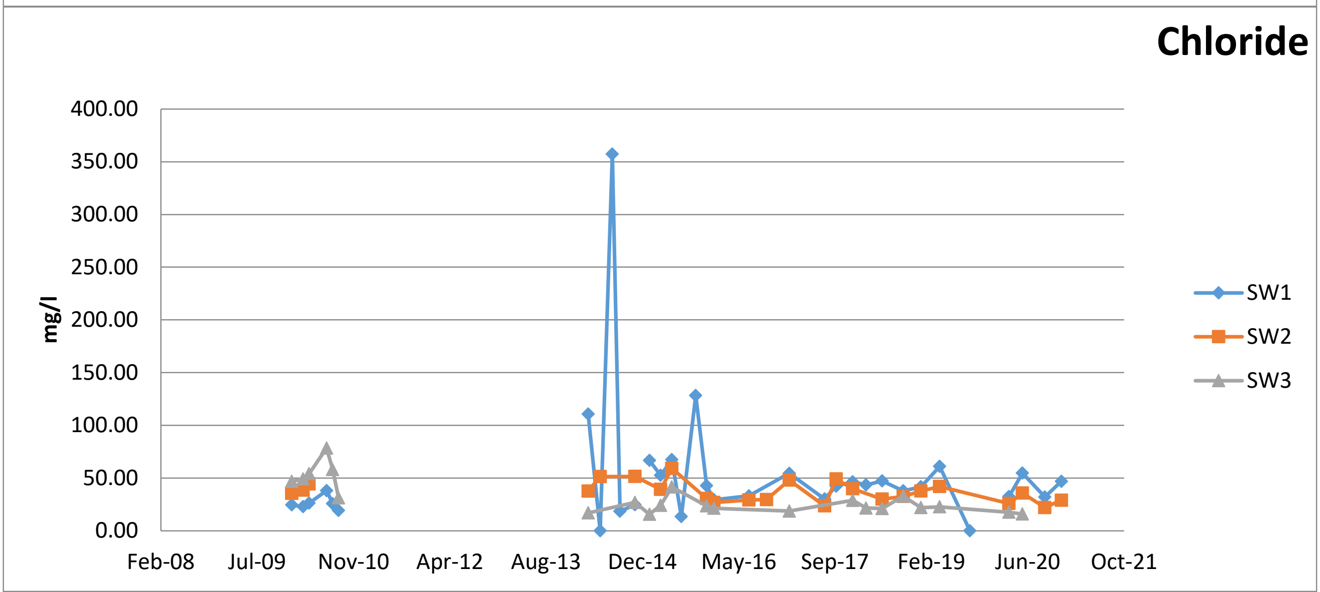
Report Number 2116r2v1d0221

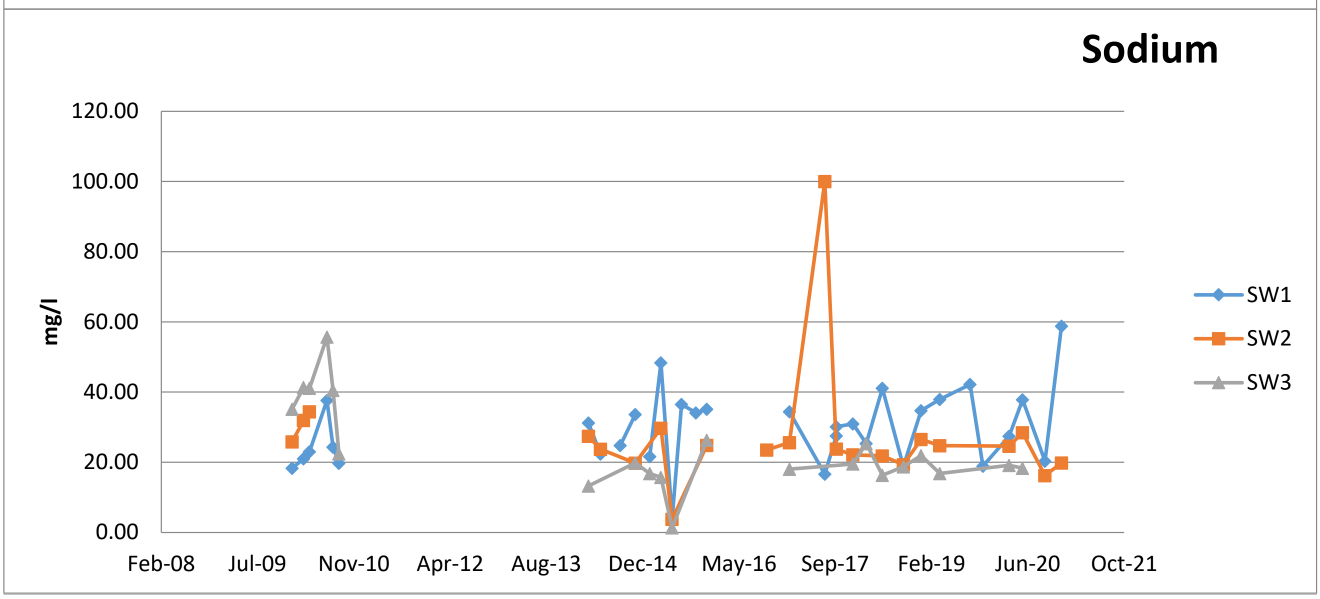

pH
12
11
10
9
8
7
6
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

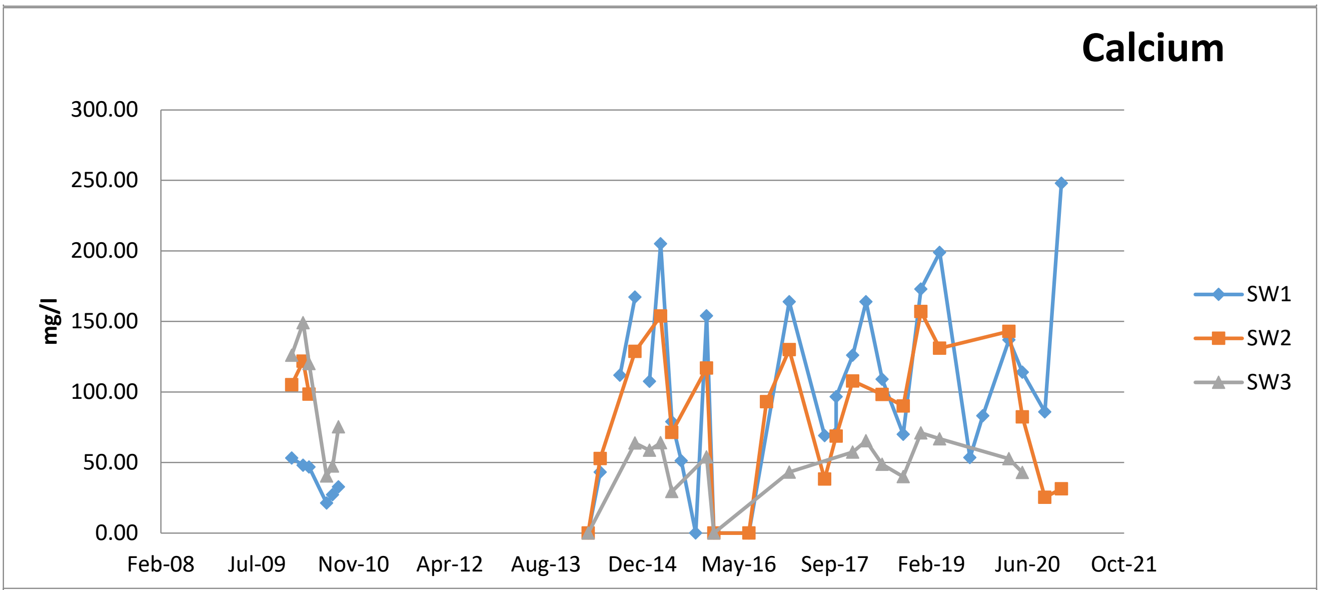

Electrical Conductivity
microS/cm
1400
1200
1000
800
600
400
200
0
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

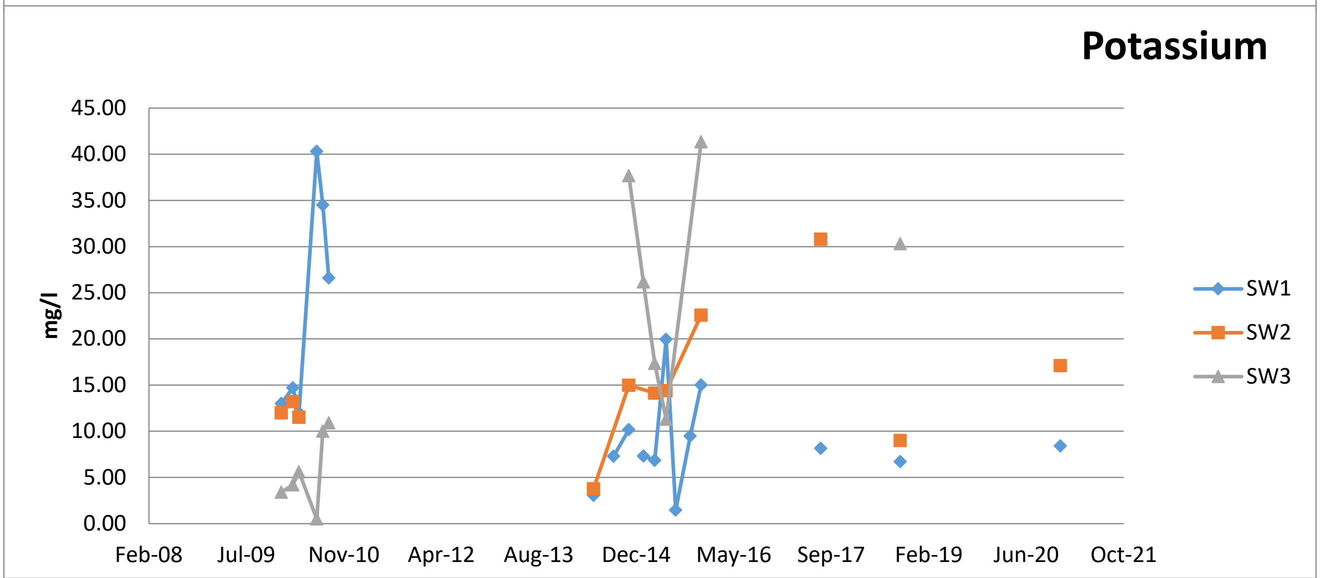

Ammonia
mg/l
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

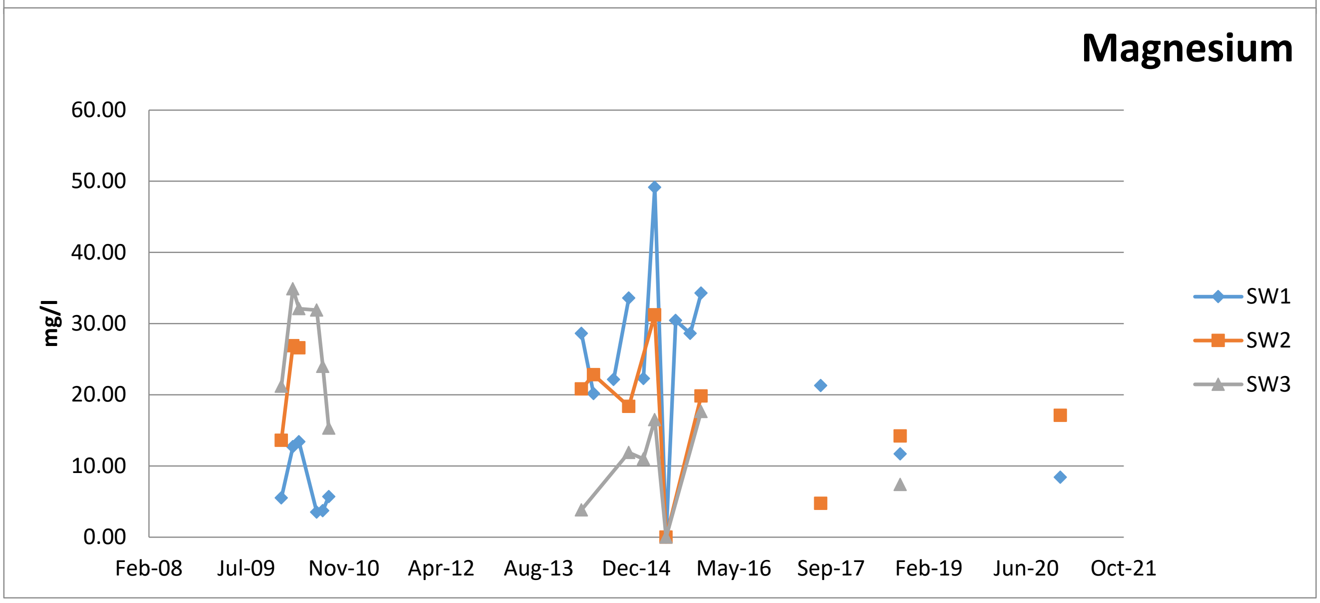

Alkalinity
mg/l CaCO3
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

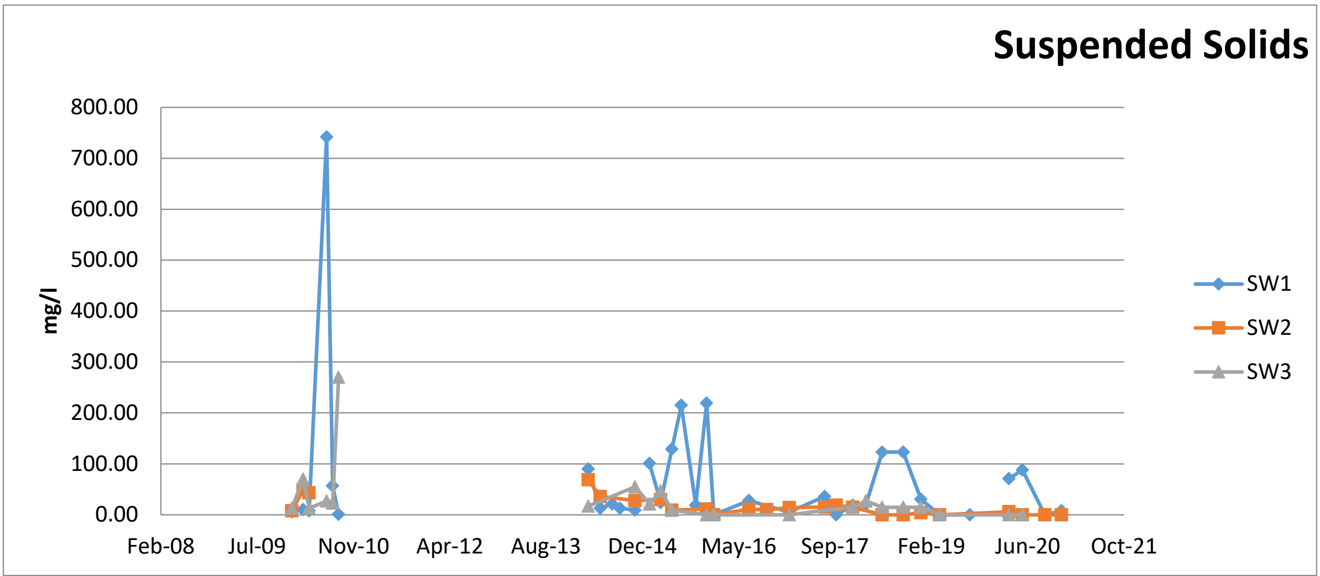

Chloride
mg/l
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

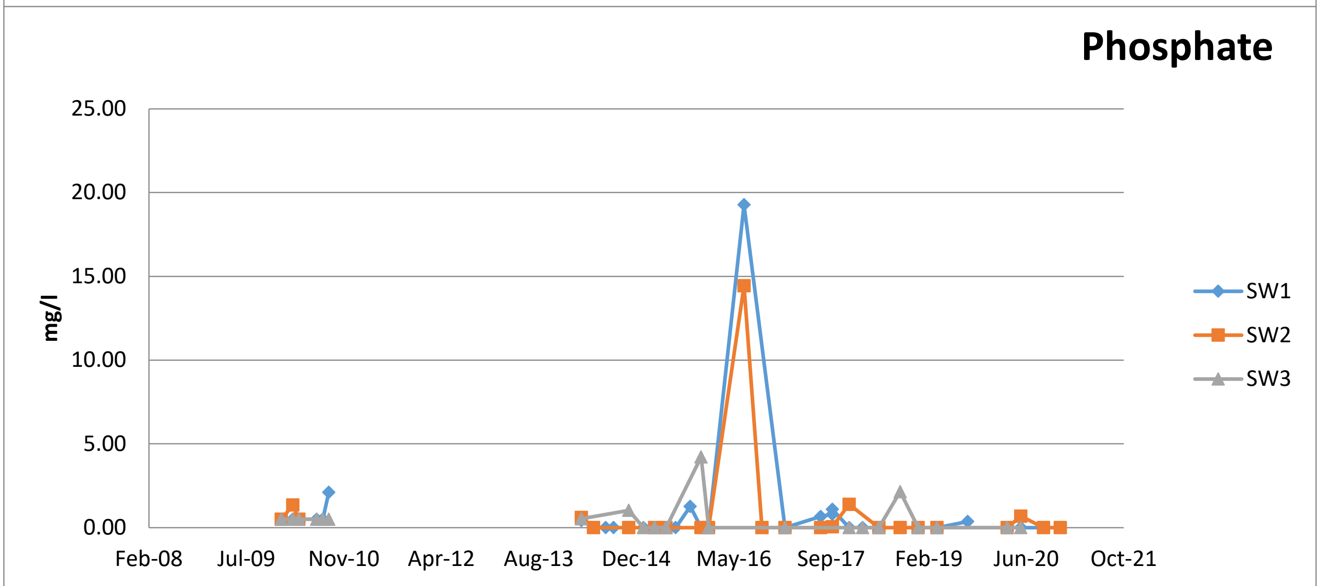

Sodium
mg/l
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

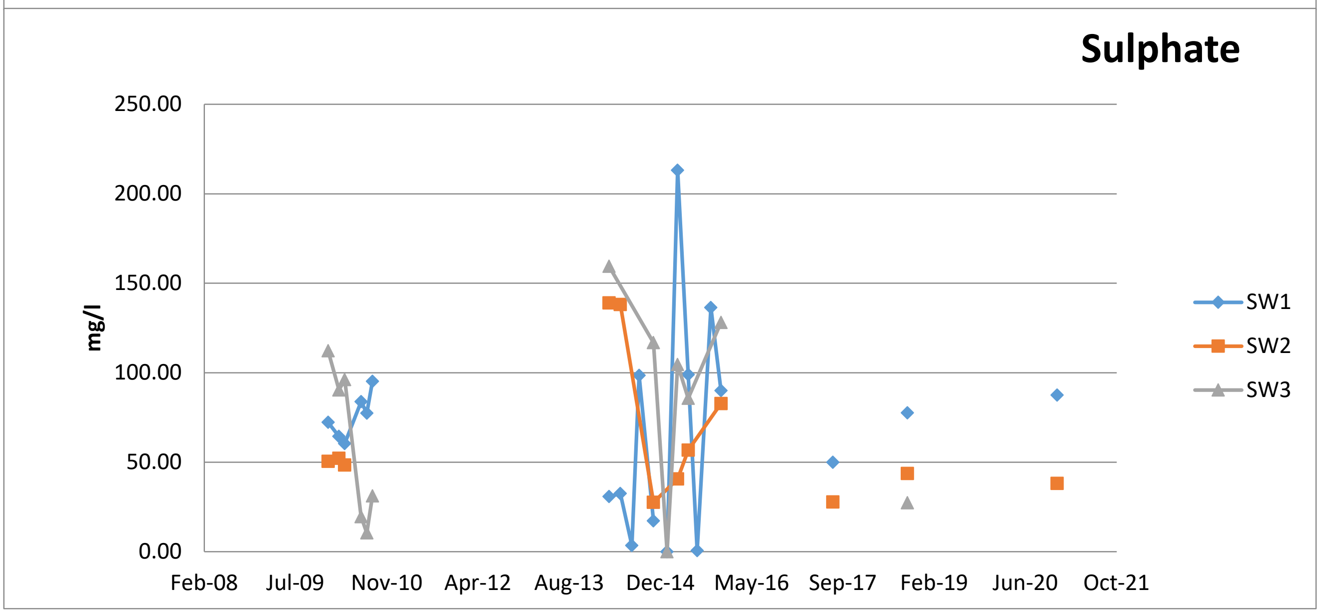

Calcium
300.00
250.00
200.00
150.00
100.00
50.00
0.00
mg/l
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

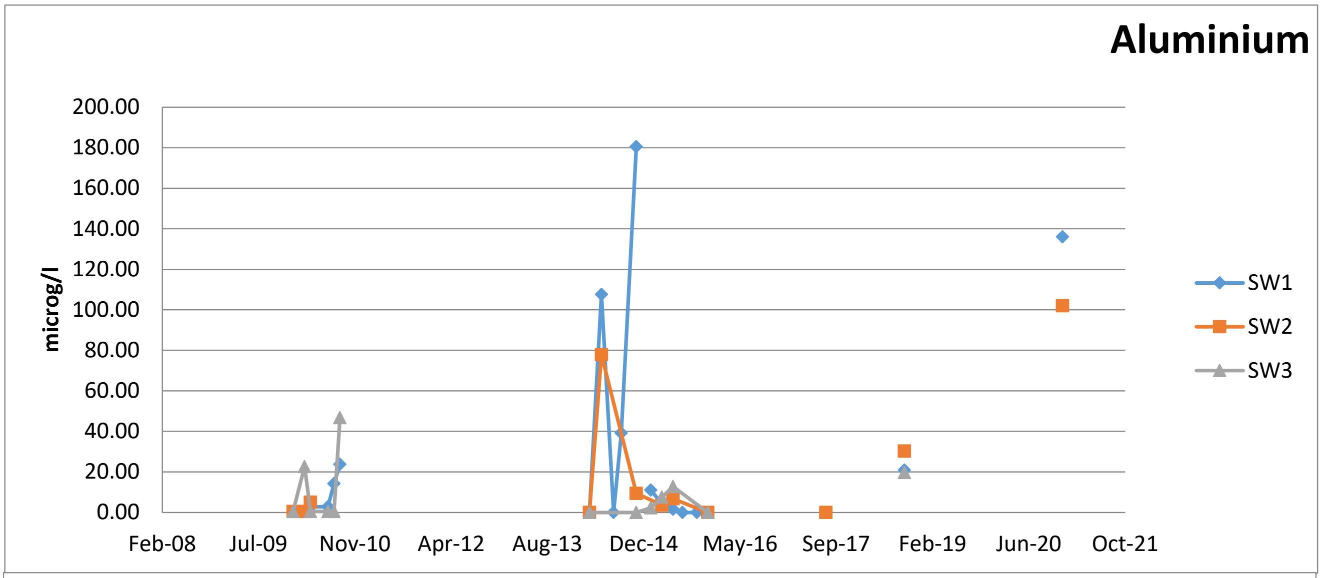

Potassium
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
mg/l
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

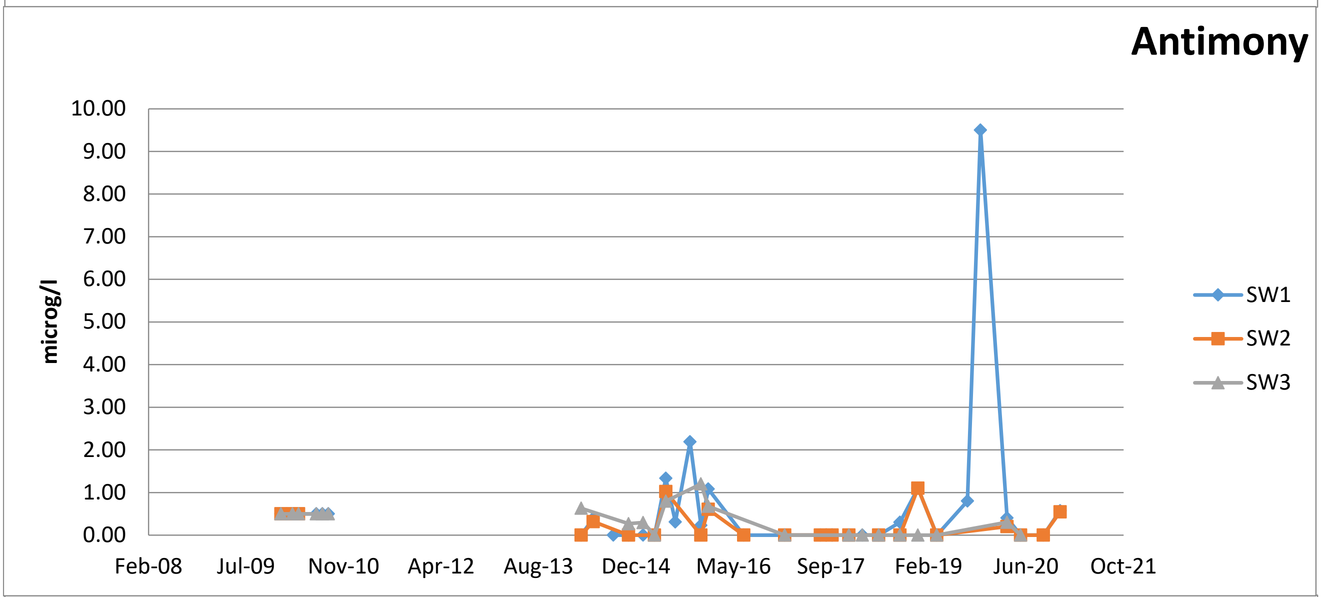

Magnesium
60.00
50.00
40.00
30.00
20.00
10.00
0.00
mg/l
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

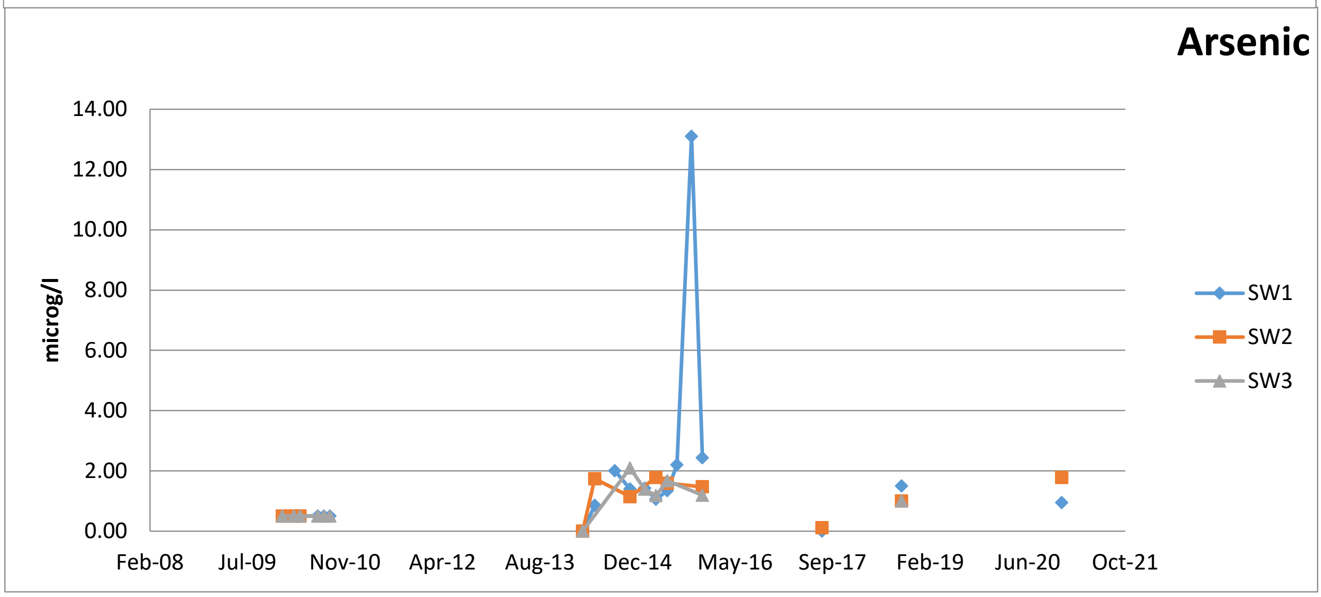

Suspended Solids
mg/l
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

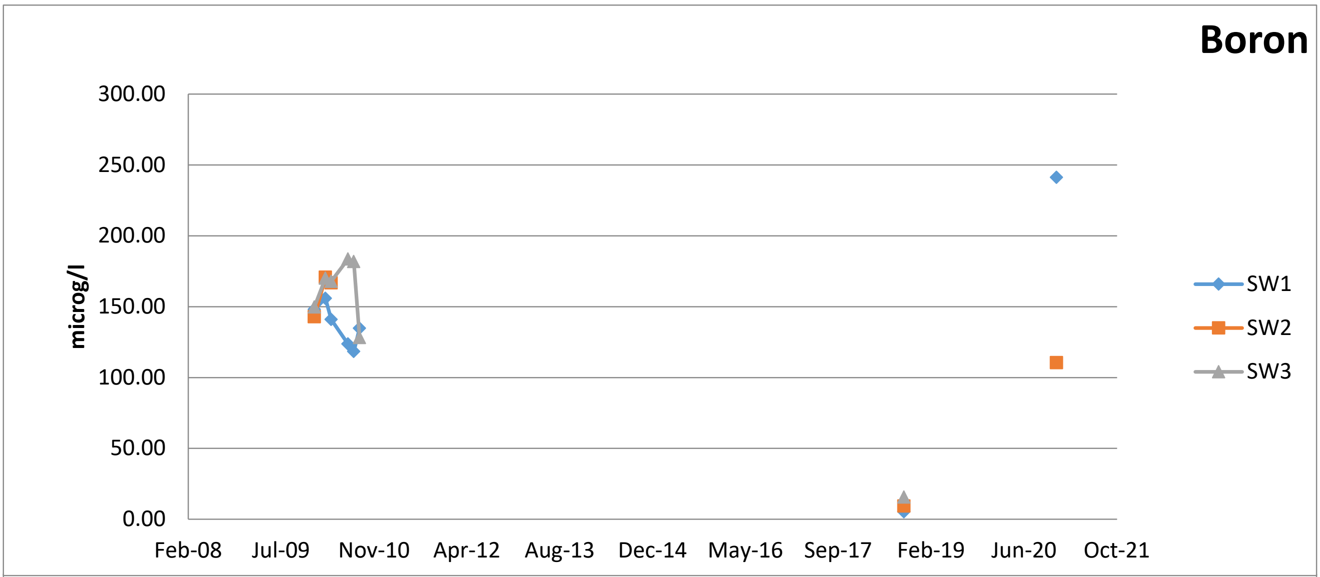

Phosphate
mg/l
25.00
20.00
15.00
10.00
5.00
0.00
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

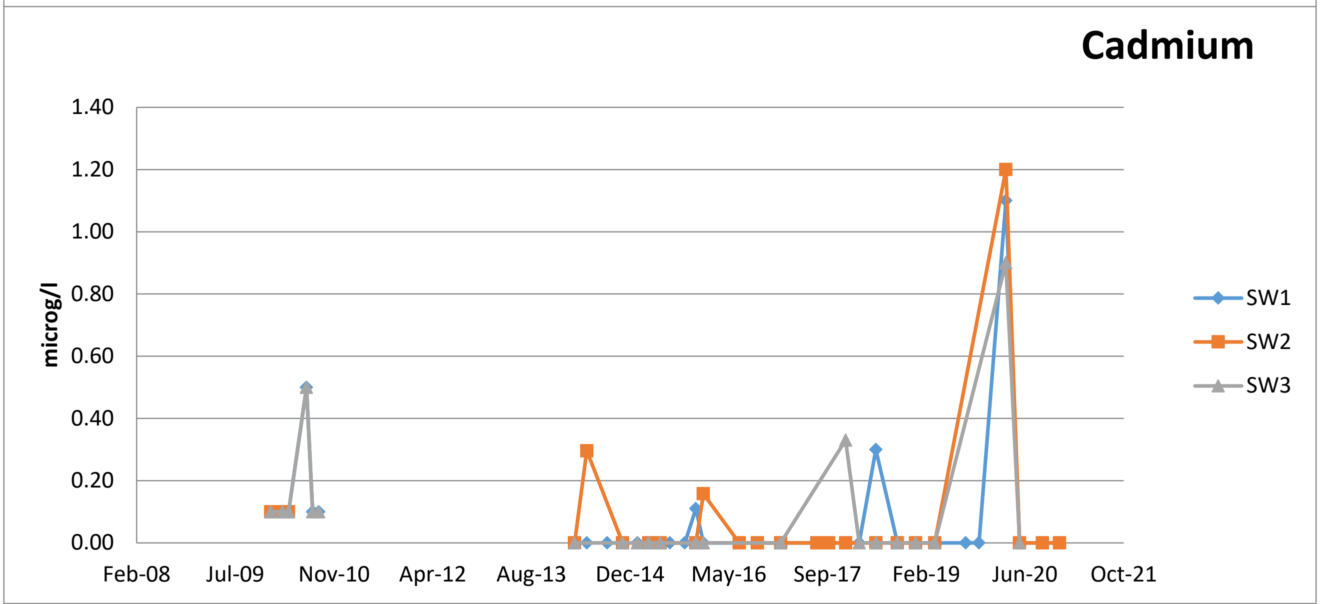

Sulphate
mg/l
250.00
200.00
150.00
100.00
50.00
0.00
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

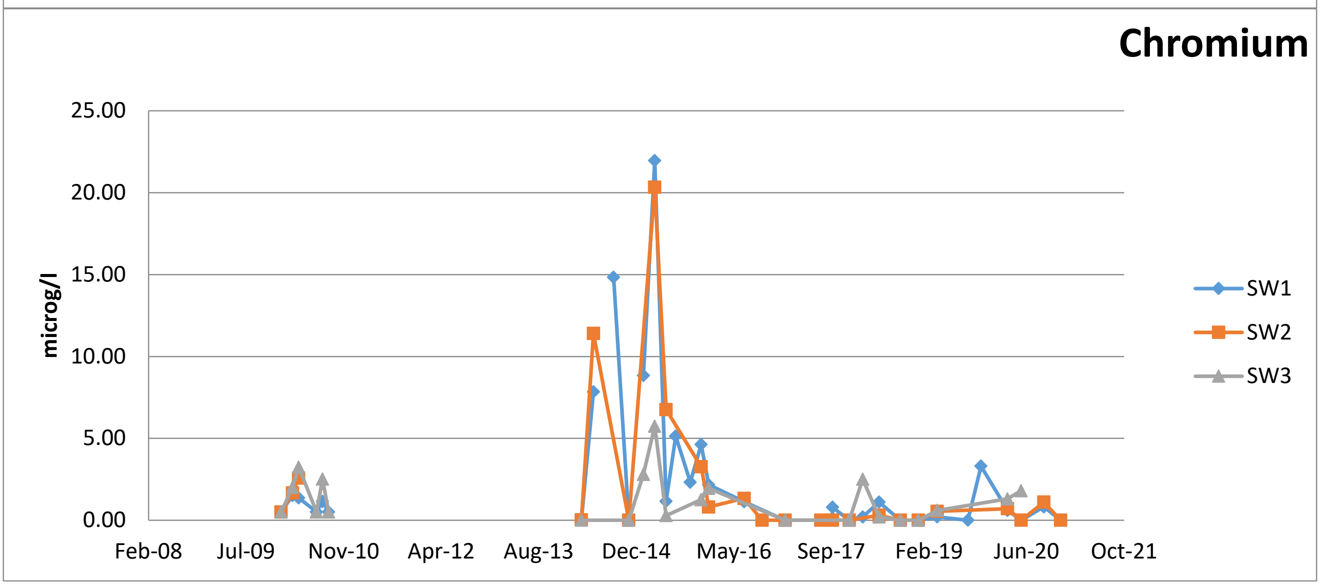

Aluminium
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
microg/l
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

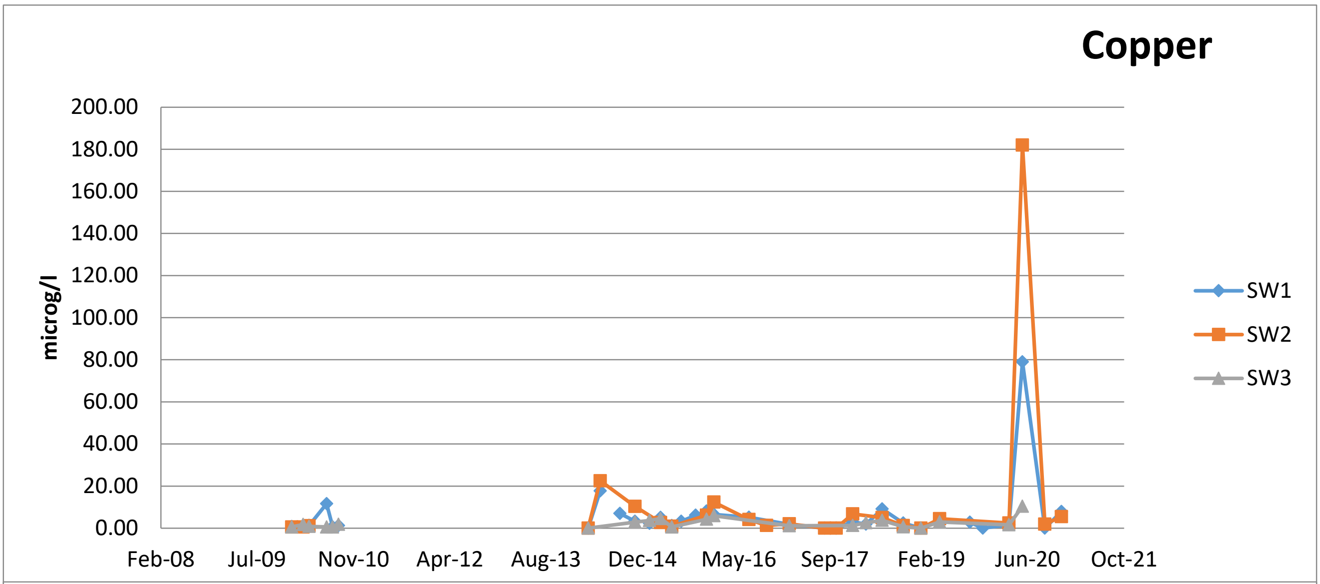

Antimony
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
microg/l
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

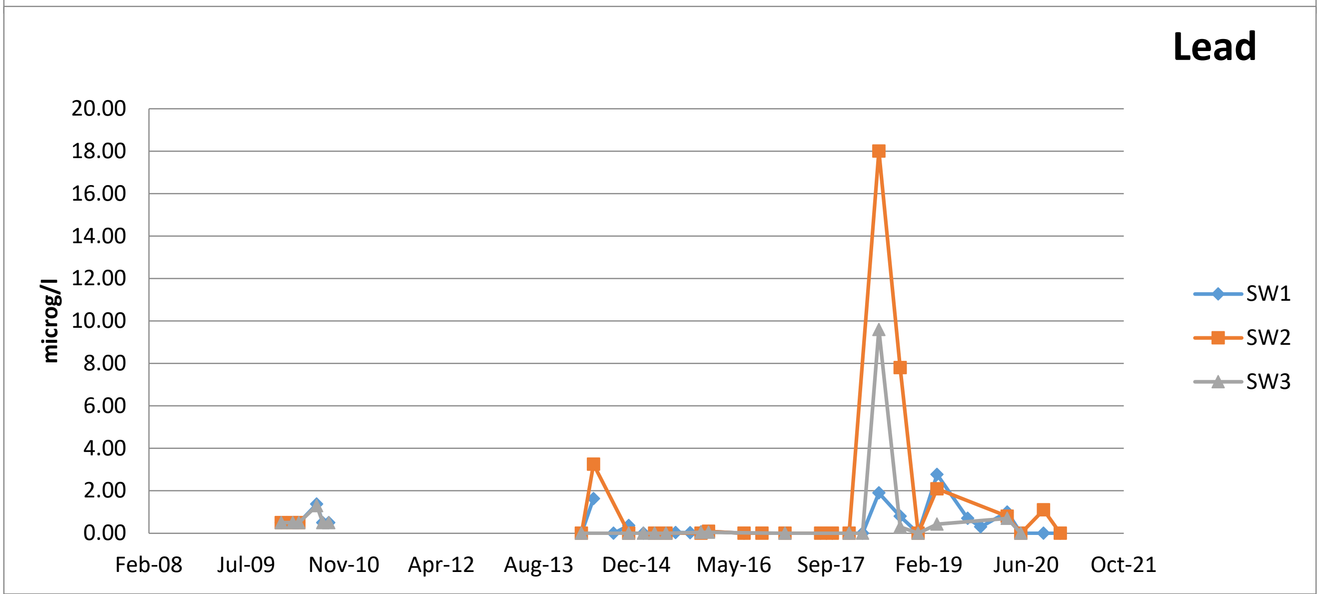

Arsenic
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
microg/l
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

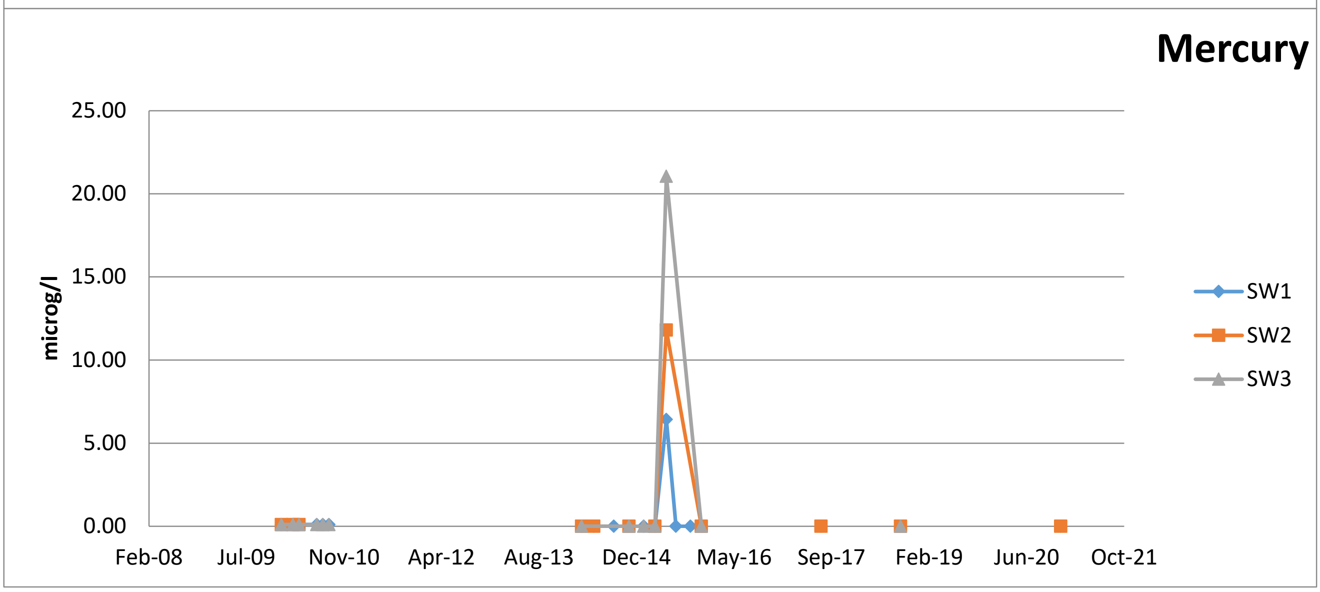

Boron
300.00
250.00
200.00
150.00
100.00
50.00
0.00
microg/l
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

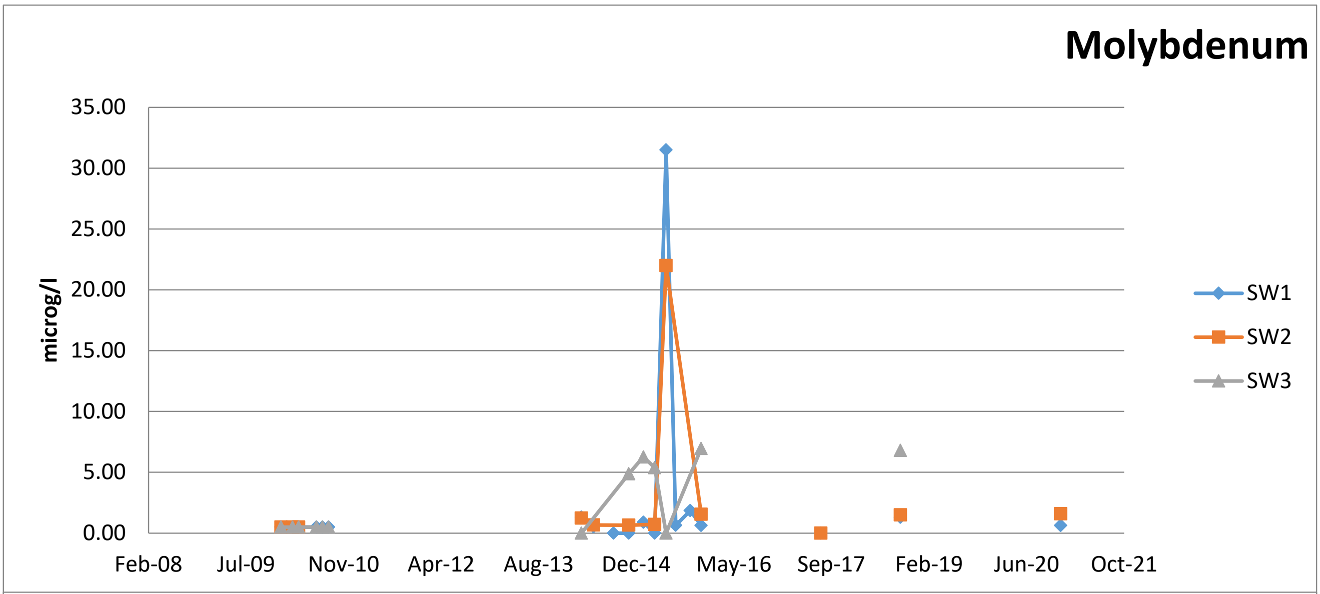

Cadmium
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
microg/l
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

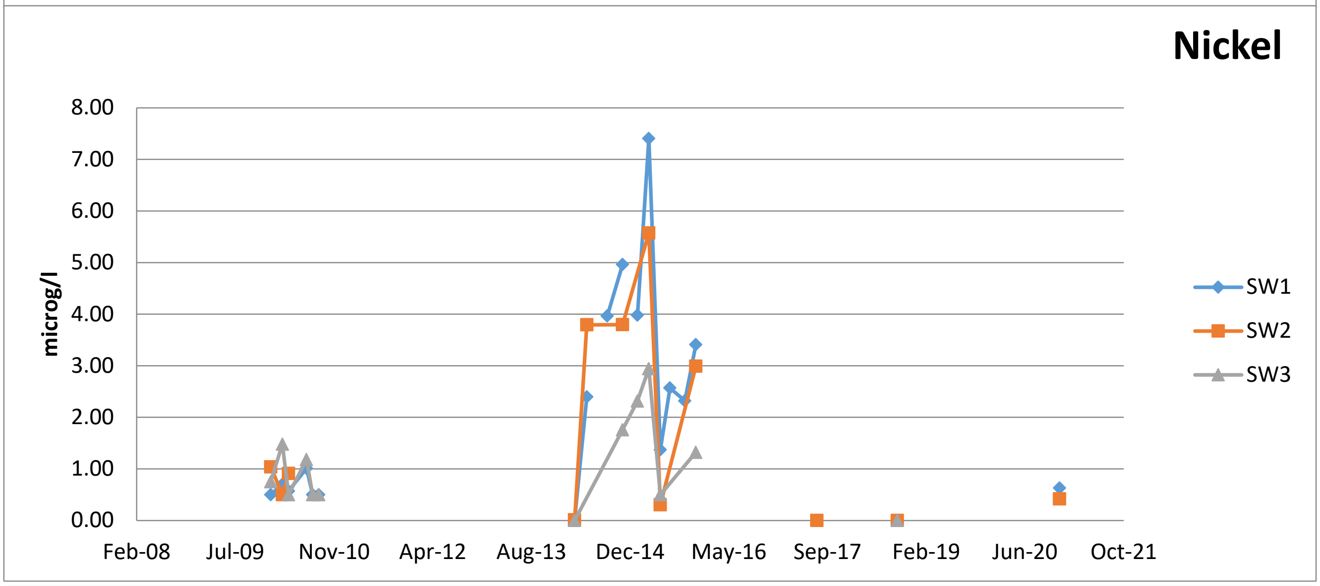

Chromium
25.00
20.00
15.00
10.00
5.00
0.00
microg/l
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

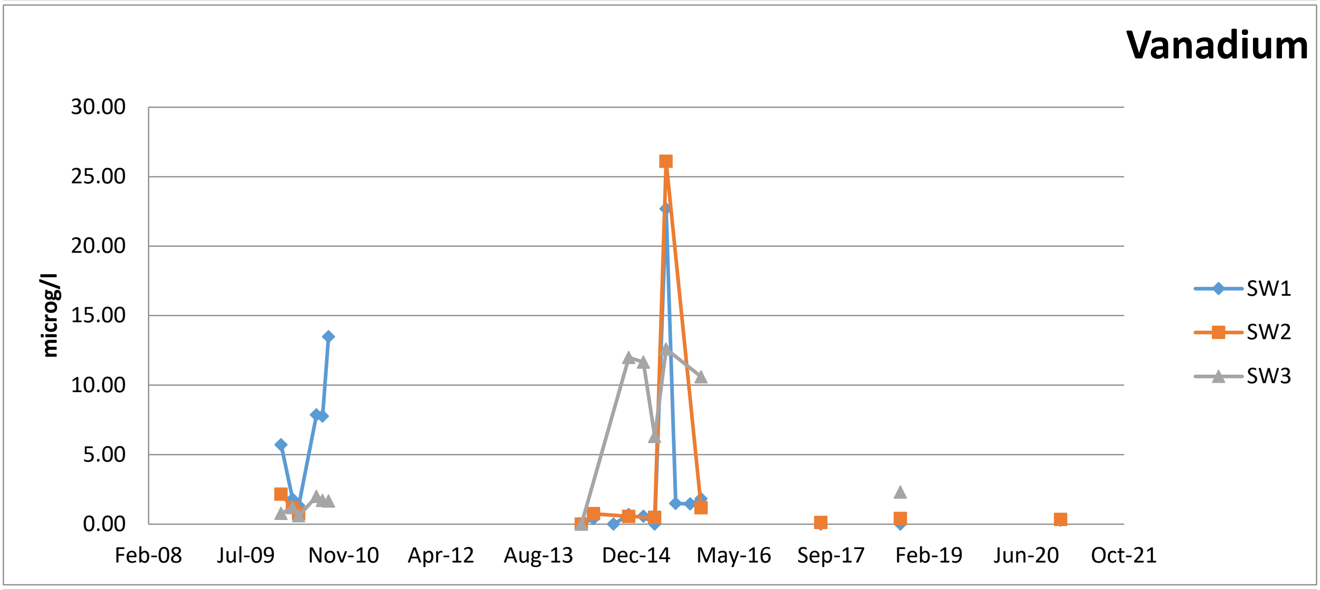

Copper
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
microg/l
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

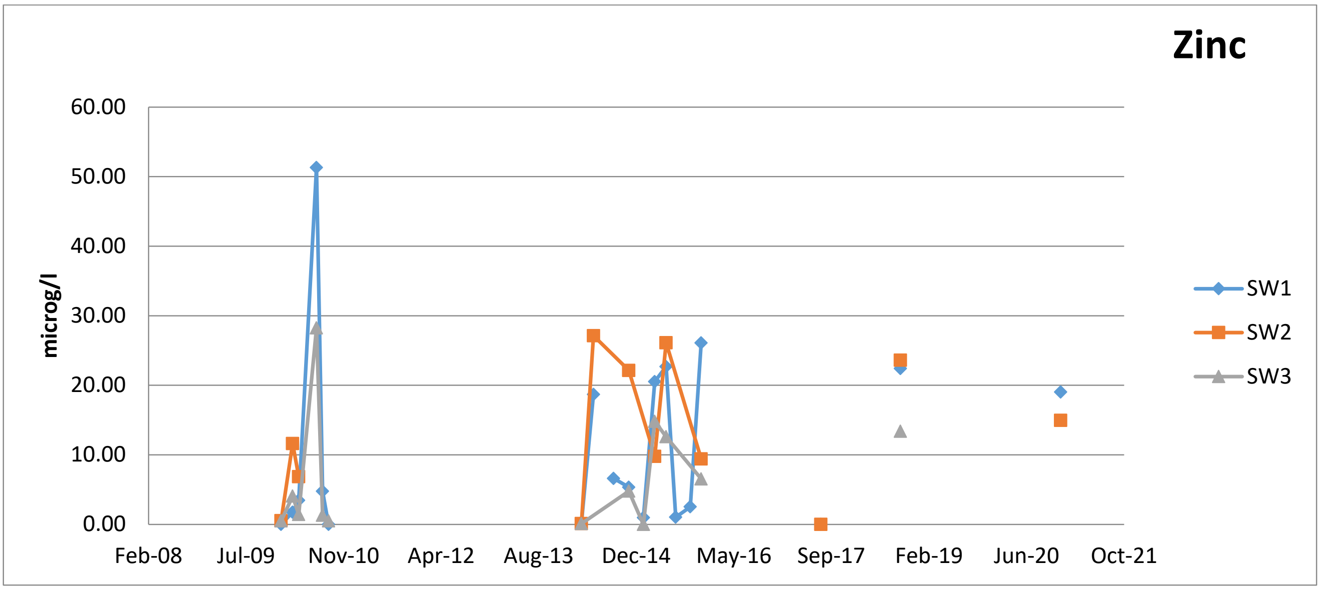

Lead
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
microg/l
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3


Mercury
25.00
20.00
15.00
10.00
5.00
0.00
microg/l
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3


Molybdenum
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
microg/l
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3


Nickel
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
microg/l
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3


Vanadium
30.00
25.00
20.00
15.00
10.00
5.00
0.00
microg/l
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3


Zinc
microg/l
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
SW1
SW2
SW3

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