2022 Annual Performance Report

Aberthaw Quarry Ash Disposal Site

Permit Number: BP3339BH

March 2023

RWE
The energy to lead

Summary

This document gives details on the performance of Aberthaw Quarry Ash Disposal Site over 2022, as required by condition 4.2.1 of the site's Environmental Permit (EP), BP3339BH.

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1. Operational Update

Aberthaw Quarry Ash Disposal Site was designed to be constructed and filled with Pulverised Fuel Ash (PFA) in four distinct phases (see Appendix A).

- Phase 1 was constructed in 2008, filled between Quarter 4 2008 to Quarter 4 2010 and then capped and hydroseeded in Spring 2011.
- Phase 2 was constructed in 2009/10 with filling commencing from Quarter 4 2010. Phase 2 East was filled until Quarter 3 2013 before being capped and hydroseeded whilst Phase 2 West was filled until Quarter 4 2014 before being capped and hydroseeded.
- Phase 3A (east) was constructed in 2012/13 with filling commencing in Quarter 3 2013 and remained the working phase throughout 2014 to 2015. The construction of Phase 3B (west) was completed in 2014 with filling commencing in Quarter 2 2015. These phases continued to be worked until the formal closure of Aberthaw Power Station.

Aberthaw Power Station formally closed in March 2020. The main coal-fired generating units ceased generation in December 2019 after which only the gas turbines remained available during Quarter 1 of 2020 before eventual full site closure. Ash disposal routes remained open throughout the station decommissioning period, however, the last time PFA was deposited at Aberthaw Quarry was Quarter 3 2019.

2. Review of Results for Emission Monitoring

Four groundwater monitoring visits were undertaken by a specialist contractor during 2022:

- 23rd February 2022 (Q1 Visit)
- 28th April 2022 (Q2 Visit)
- 21st July 2022 (Q3 Visit)
- 13th October 2022 (Q4 Visit)

Please note that Boreholes E06/04 and E06/05 were not sampled during Q4 as the sampling contractor reported that they were unable to gain safe access with their sampling equipment. It is unclear why this was the case as the setting of these boreholes has not changed. SW12 was also not sampled during Q4 for the same reason. A complaint was raised directly with the sampling contractor when the Q4 issue became known, significantly after the fact, by RWE in late January 2023.

Please also note that upgradient borehole 06_02B was only successfully sampled during Q1 of 2022 due to a blockage – this borehole has now been successfully unblocked by RWE and sampling resumed in Q1 2023.

2.1. Hydrogeological Risk Assessment HRA Review

In accordance with the BP3339BH Permit requirement the last 6-yearly review of the HRA was undertaken during late 2017/early 2018 by an external specialist consultant.

Due to the early closure of Aberthaw Power Station, the final restoration plans for the Quarry are currently under review by RWE. Predominantly this is because the approved filling levels and profiles can no longer be achieved due to the cessation of ash deposition from Aberthaw Power Station. Various site assessments, including a review of the site HRA, are currently being undertaken by external consultants and a formal application to modify the approved site restoration plan is expected to be made later this year. Once the consultant reports are finalised, and the reprofiling plans known, copies will be submitted to NRW for discussion. Ultimately the primary purpose of the revised restoration plan is to improve the surface water shedding of the site (especially within Phases 3a & 3b) preventing surface/ash erosion and return the landform to agricultural end use in line with previous approved plans.

2.2. Groundwater Quality Review

Monitoring Objective

To carry out routine monitoring of groundwater to monitor the performance of the ash disposal site by measurement of absolute levels and concentrations and trends relative to relevant criteria including background levels and concentrations, control levels and compliance limits.

Number and Location of Monitoring Points

A summary of the monitoring boreholes is provided in Table 1 below and the locations are shown in Appendix A. Historically, in January 2015, borehole improvement works were completed to improve water sampling. E05-03 and E06-01 were re-drilled and the top hat cover was replaced on E06-05. In addition, a new borehole was installed above Phase 3B, E15/1 to improve the understanding of groundwater quality potentially flowing into the site from the south-east. In total, there are 12 monitored boreholes in natural ground, all completed in the Porthkerry Member limestone.

Groundwater flow beneath the ash disposal site is directed towards the cement work lagoons and the River Thaw to the west. Hence, monitoring boreholes, E09-01A, E09-01B, E09-02A and E09-02B on the north-eastern site boundary (approximately 200m apart) are upgradient. Borehole E15/1 on the south site boundary is also classed as upgradient.

Monitoring boreholes along the western site boundary (E05-03, E05-04 and E06-01) with an average spacing of 100m are downgradient of the Pulverised Fuel Ash (PFA) disposal area (Phase 1 and 2). Along the south-western site boundary, two of the monitoring boreholes with an average spacing of 100m (E06-02 and E06-03) are downgradient of the last active PFA disposal area (Phase 3A & 3B) and the non-utilised area (Phase 4). Whilst the two remaining boreholes (E06-04 and E06-05) with an average spacing of 100m are located downgradient of the unworked Phase 4.

Table 1: Summary of Monitoring Boreholes

Monitoring Borehole	Formation Sampled	Lithology Type – Natural (N)	Response Zone Depth (m b GL)	Designation
E09-01A	Limestone	N	18-24	Upgradient
E09-01B	Limestone	N	24-30	Upgradient
E09-02A	Limestone	N	21-27	Upgradient
E09-02B	Limestone	N	27-33	Upgradient
E15-1	Limestone	N	17-29	Upgradient
E05-03	Limestone	N	3 - 15	Downgradient Phase 1&2 Active Area
E05-04	Limestone	N	2.5 - 20	Downgradient Phase 1&2 Active Area
E06-01	Limestone	N	3 - 15	Downgradient Phase 1&2 Active Area
E06-02	Limestone	N	2 - 10	Downgradient Phase 3A & 3B Active Area
E06-03	Limestone	N	2 - 10	Downgradient Phase 3A & 3B Active Area
E06-04	Limestone	N	2 - 10	Downgradient Unutilised Phase 4
E06-05	Limestone	N	2 – 8	Downgradient Unutilised Phase 4

m b GL – metres below ground level

Monitoring Measurements

The groundwater monitoring analytical suite contains a range of parameters which are monitored in accordance with the Environmental Permit on a quarterly basis, along with the groundwater level and standard field measurements. An independent external contractor is responsible for the sampling of the groundwater boreholes, and they utilise an independent external accredited laboratory for analysis of the samples.

Figure 1 shows the recorded groundwater elevations for the previous 17 years which vary between +17 (E05-03) to +35m OD (E09-02B). Upgradient groundwater elevations are characterised by larger amplitude seasonal water level fluctuations with annual winter influxes of rainfall recharge. Downgradient groundwater elevations fluctuate only slightly due to the effect of dewatering from the Quarry which maintains groundwater at near-constant elevations.

Figure 1: Groundwater Hydrograph

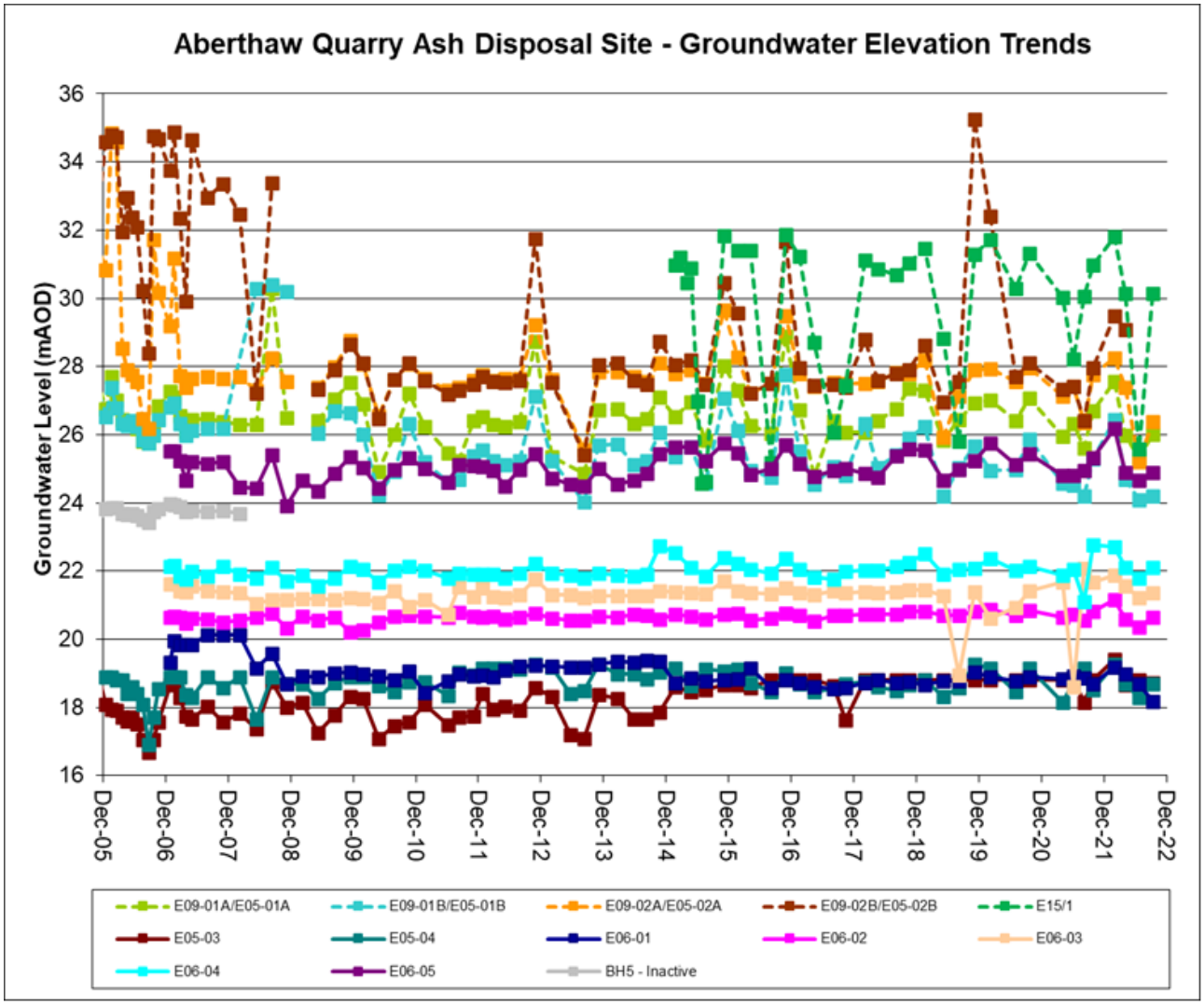
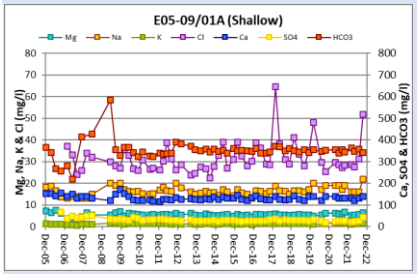


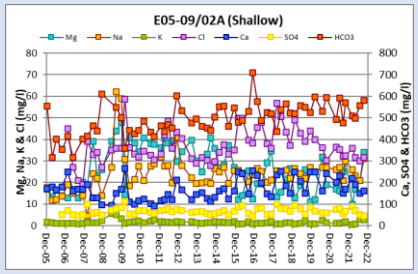
Figure 2 shows the general groundwater quality for the major ions in each of the site's boreholes. Natural groundwater quality varies between upgradient and downgradient locations. Calcium is depleted in some of the downgradient boreholes and correlated with elevated sodium, suggesting ion exchange reactions are occurring along the groundwater flow path. Whilst in other downgradient boreholes major ion chemistry is distinctly different with elevation of calcium, magnesium and sulphate, suggesting a natural geological or quarry-related source in or upgradient of this area.

Figure 2: General Groundwater Quality Charts

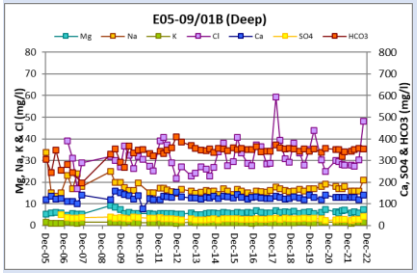
Upgradient Boreholes



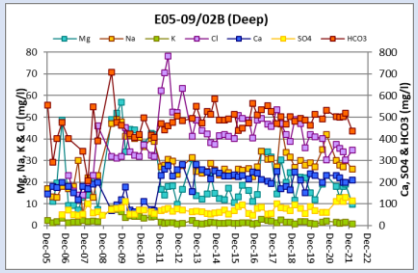
All analytes low and concentrations remain relatively steady



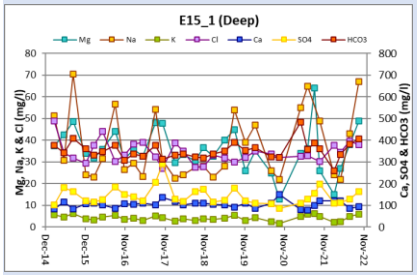
All analytes low but fluctuating.



All analytes low and concentrations remain relatively steady

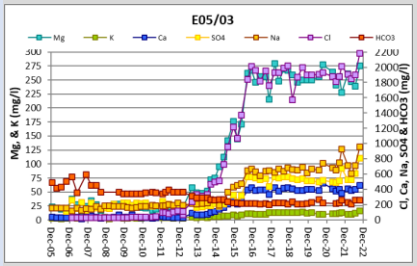


All analytes low but fluctuating.

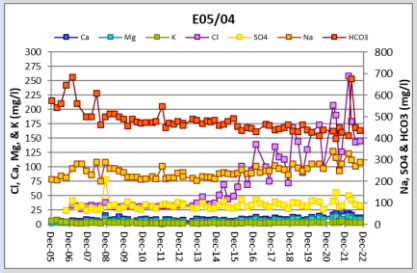


All analytes low and concentrations remain relatively steady

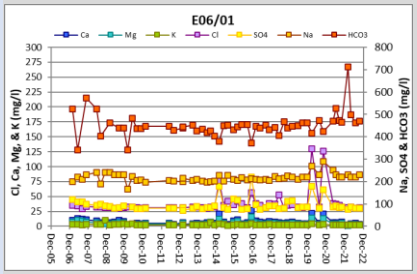
Downgradient Boreholes Phase 1/2



All analytes relatively steady since mid-2015

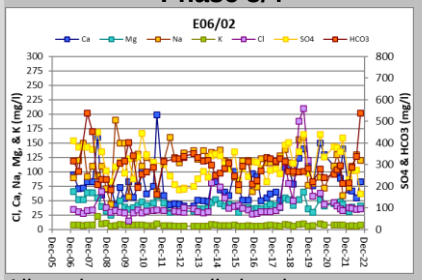


All analytes relatively steady, although Cl showing a gradual upwards trend since 2013.

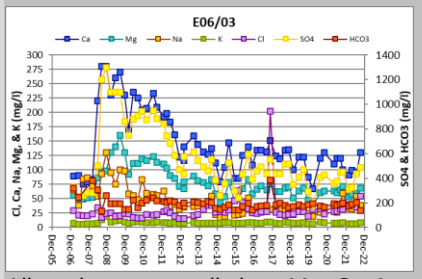


All analytes realtively steady.

Downgradient Boreholes Phase 3/4

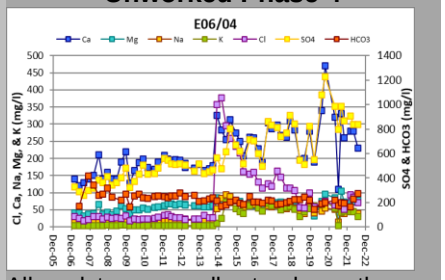


All analytes generally low but fluctuating.

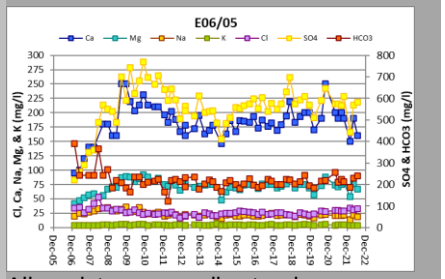


All analytes generally low, Mg, Ca & SO_4 showing a gradually decreasing trend.

Downgradient Boreholes Unworked Phase 4



All analytes generally steady, an the gradual upwards trend of Ca & SO4 has shown a reduction.



All analytes generally steady.

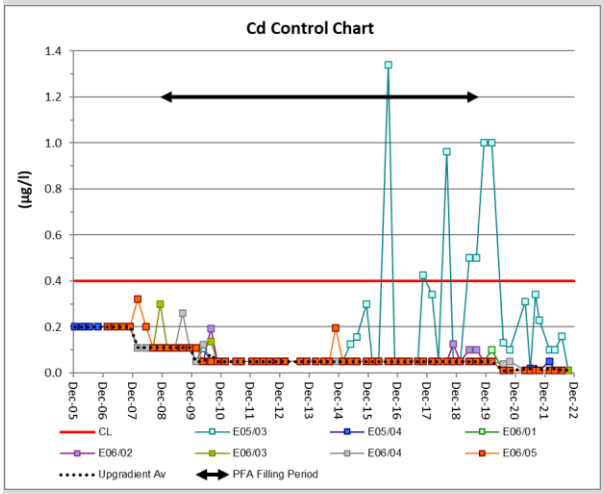
Figure 3 shows the groundwater control charts with concentrations of all downgradient boreholes plotted as well as the average upgradient concentration (representing concentrations in boreholes E09-01A, E09-01B, E09-02A, E09-02B and E15/1, i.e. background groundwater quality). It should be noted that the compliance limits apply to boreholes E05-03, E05-04 and E06-01 whilst the control levels (where defined) apply to all downgradient boreholes. An exceedance is defined as a result above the compliance limit or control level for 3 consecutive sampling events. Quarry Phase average trends are also included within Figure 3.

Please note that to prevent skewing of the parameter trends the dataset has continued to be managed in line with that previously set out in the 2021 Annual Report. All values reported by the accredited laboratory as less than the limit of detection (<LOD) have been substituted with values of half the reported LOD value applicable at the time of analysis.

In 2022 there was a continued exceedance of the compliance limit and control level for Molybdenum at borehole E05-03, however the upward trend initially observed from 2012 peaked at 1880 ug/l in November 2016 and, although still high, was generally reducing until recently. Molybdenum was also elevated in borehole E05/04 during 2022 (with two results greater than the control limit and two above the Compliance Limit). E06/01 has remained below both limits during 2002 and the elevated values observed in 2020 have not been repeated.

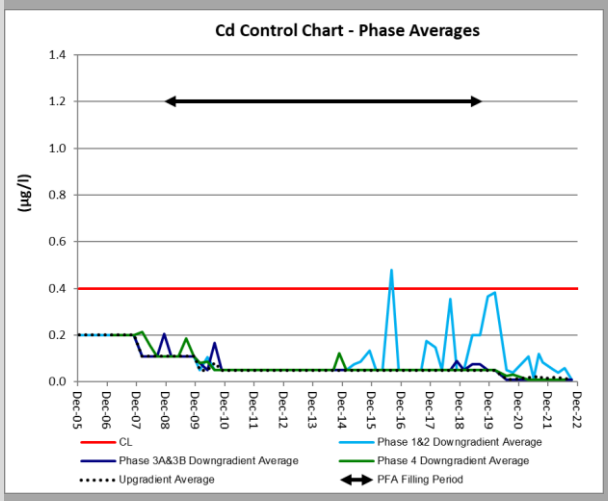
Figure 3: Control charts & Phase Averages for Down-gradient Groundwater boreholes
(CL – Compliance Limit, CON – Control Level)

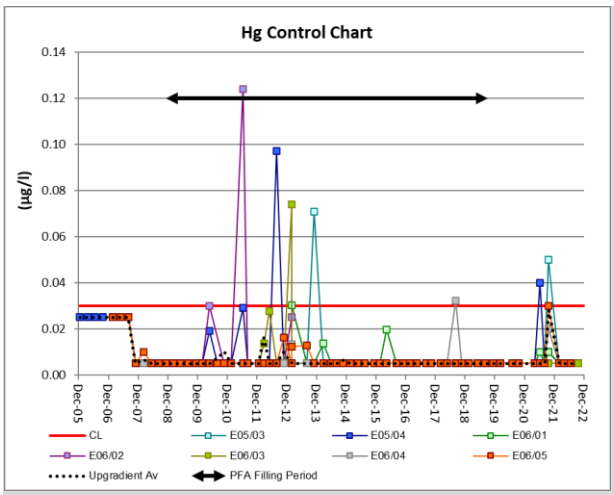
Down-gradient Boreholes against Average Up-gradient

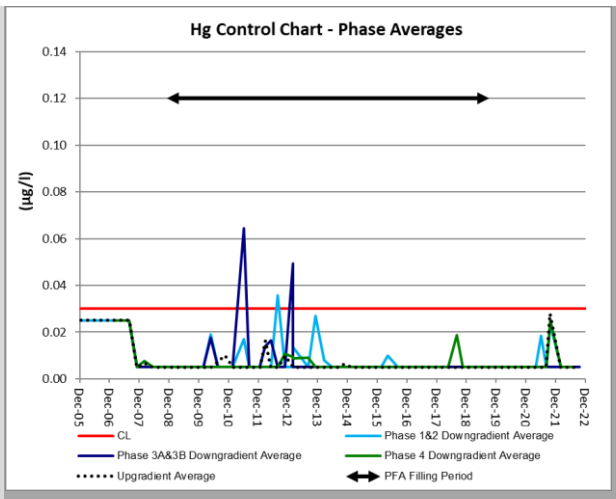


All results within the Control Limit over the last year.

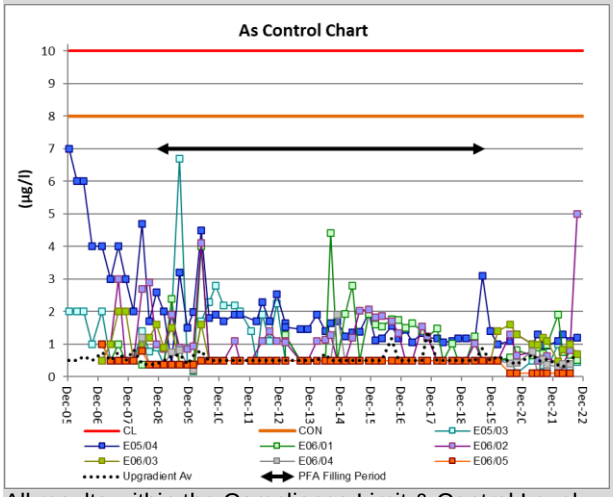
Down-gradient Site Phase averages

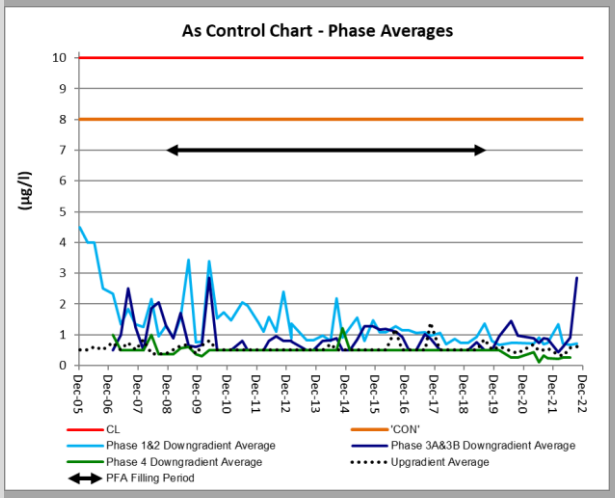




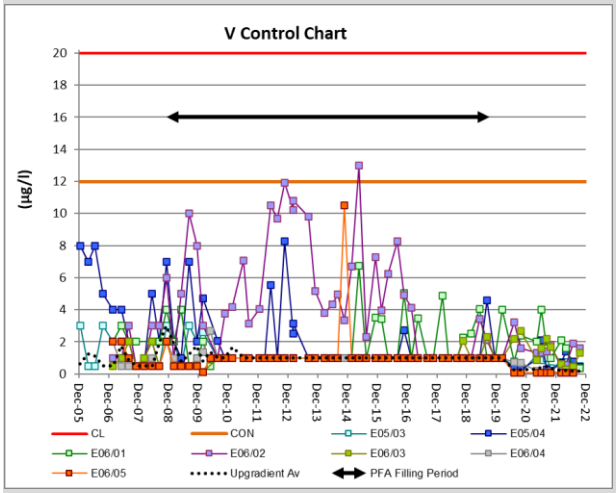


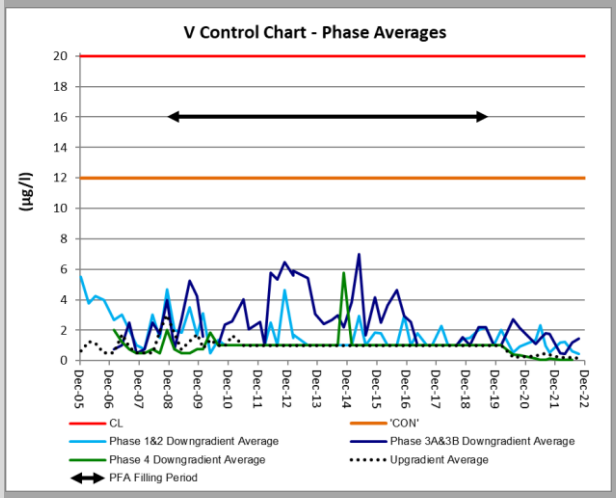
All results within the Compliance Limit over the last year.



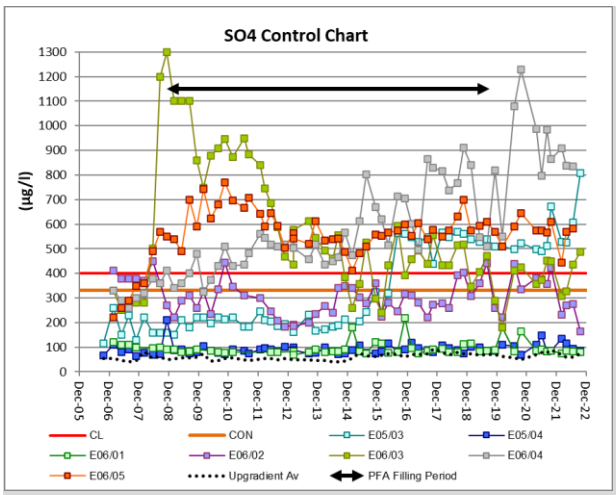


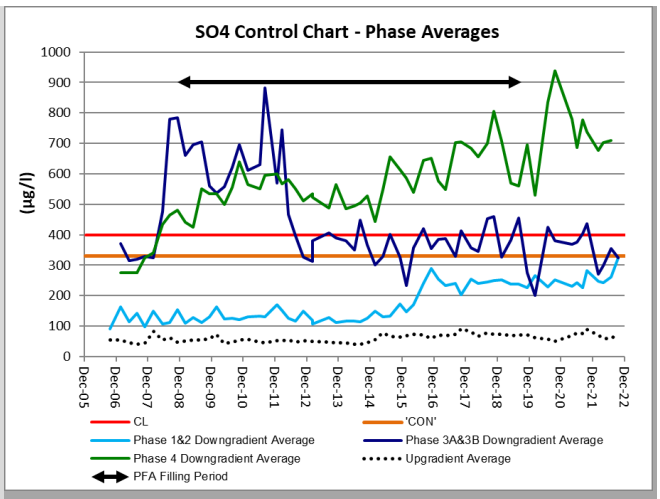
All results within the Compliance Limit & Control Level over the last year.



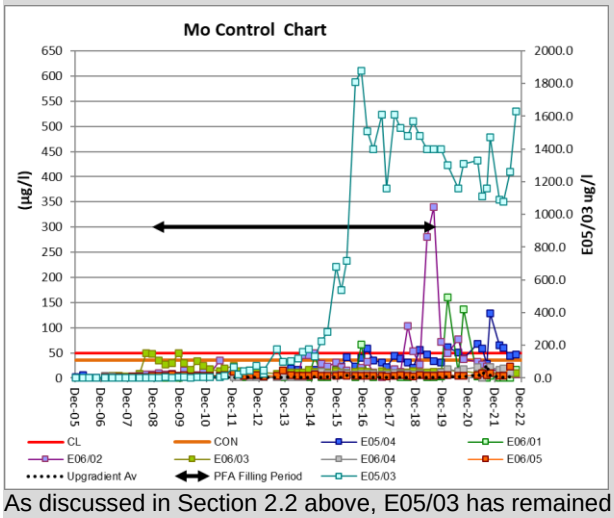


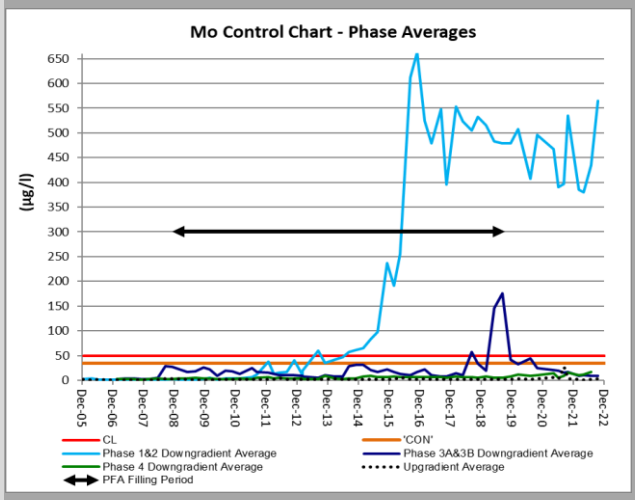
All results within the Compliance Limit & Control Level over the last year.



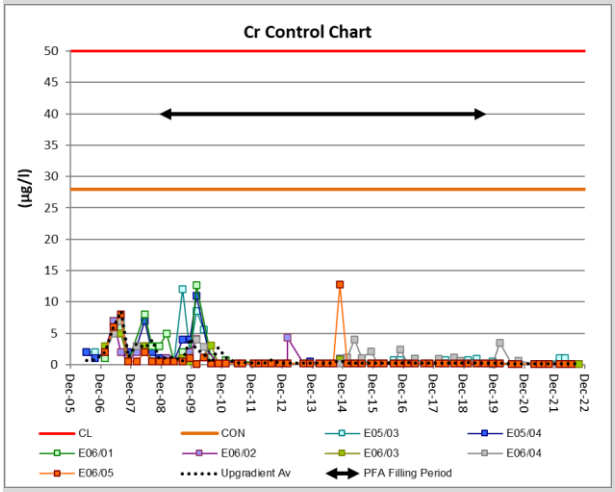


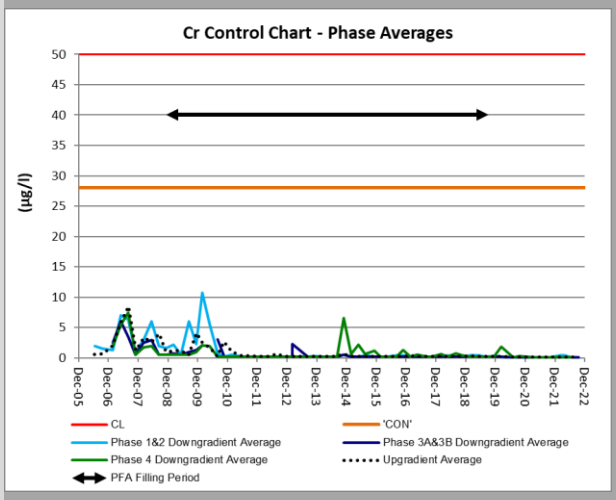
All trends generally steady, although E05/03 is consistently above the Compliance Limit.



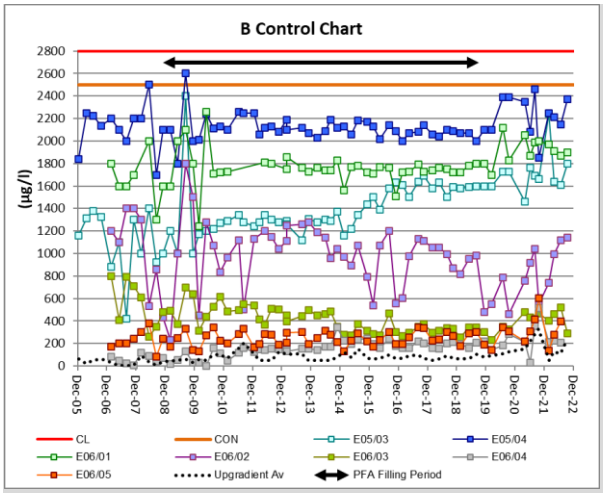


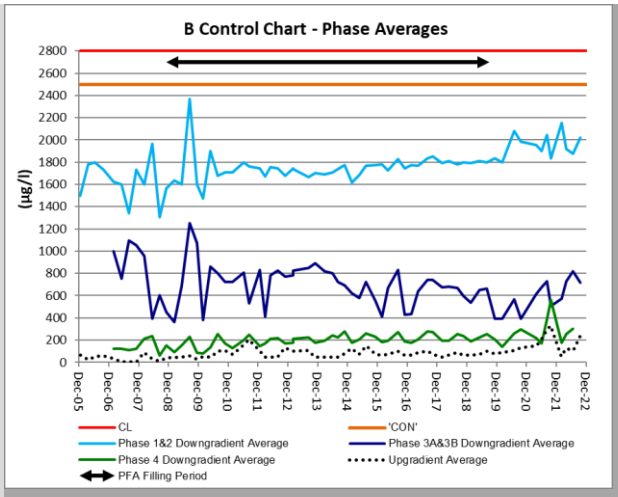
As discussed in Section 2.2 above, E05/03 has remained over the Control Limit but was gradually decreasing until recently. E05/04 has had some results above the Control & Compliance limits in 2022. Other locations remain consistently low.



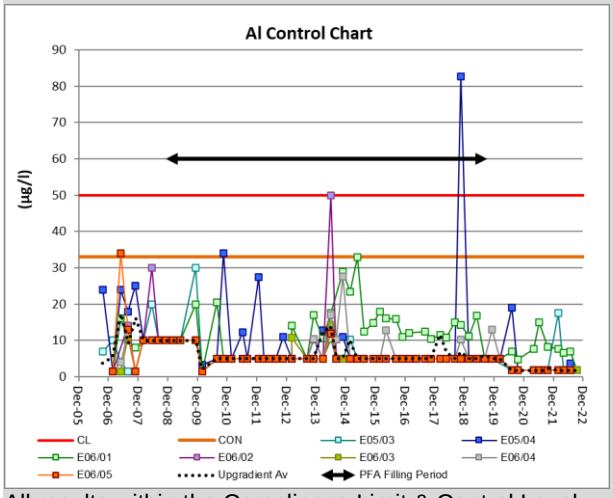


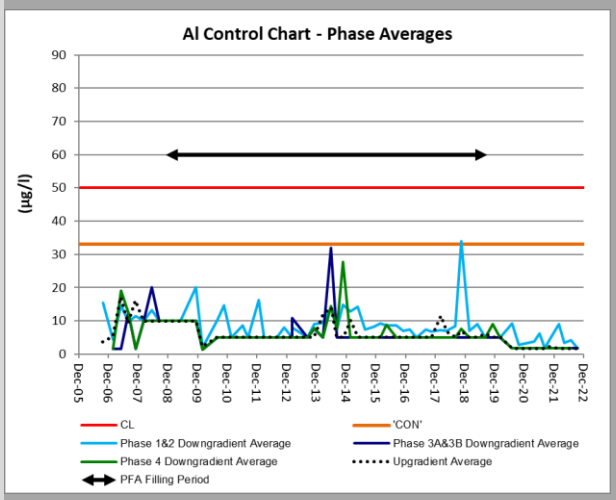
All results within the Compliance Limit & Control Level over the last year.



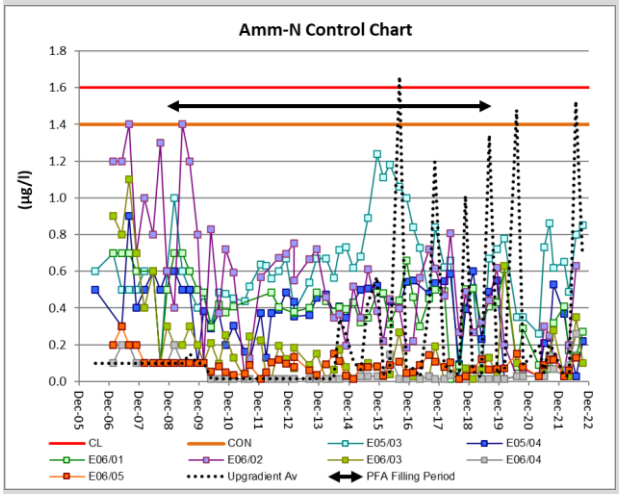


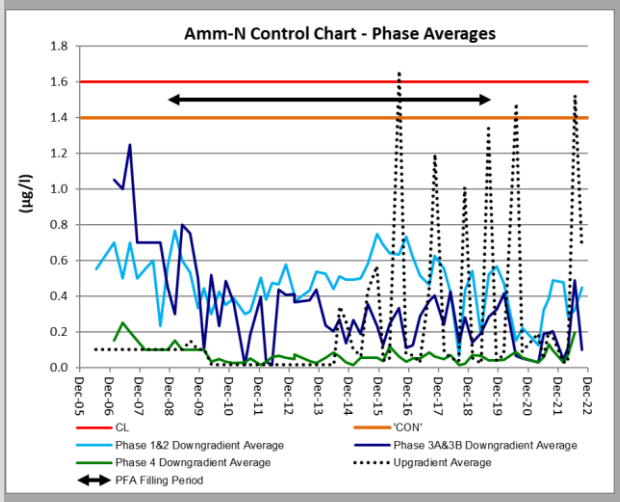
All results within the Compliance Limit & Control Level over the last year.





All results within the Compliance Limit & Control Level over the last year.

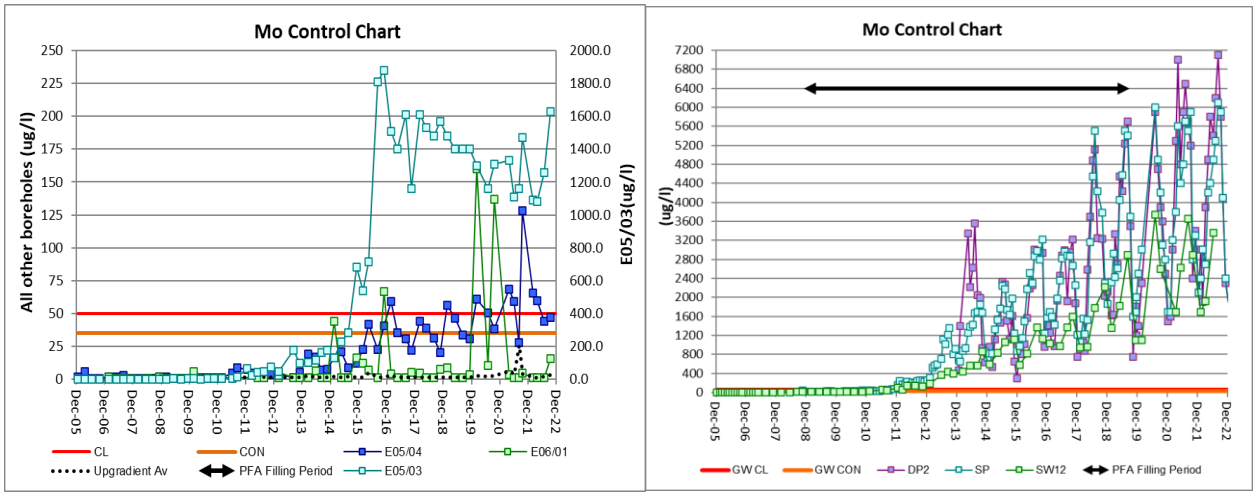




All results within the Compliance Limit & Control Level over the last year. n/b a spurious result was removed for E06/02 (2.81ug/l Dec-22) as it was believed non-representative due to the surrounding area flooding into the borehole.

Figure 4 shows the control chart for molybdenum for E05-03 and the two other boreholes located closest to it, E05-04 and E06-01, as well as the surface water monitoring points for the Quarry site (note there are no surface water compliance limits or control levels for molybdenum). The boreholes are located to the west of and adjacent to Phase 1 and are downgradient of the PFA fill. Natural background concentrations of molybdenum in the Porthkerry Formation are <3µg/l and the average pre-filling concentration for the cement works lagoon (SW12) is around 4µg/l.

Figure 4: Molybdenum concentrations



Molybdenum concentrations in E05-03 initially increased from around January 2012, about a year after Phase 1 was completed. After reviewing the subsequent data it appears there is a co-association of increasing concentrations in other indicative PFA leachate parameters; boron, sulphate and ammoniacal-nitrogen, suggesting PFA was the source of contamination. During site investigations in 2014, three possible sources were identified; discharges from the wheel wash pipe into an unlined ditch close to the borehole; surface water discharges of eroded PFA areas around the wheel wash pipe into the unlined ditch; and/or; leakage from adjacent cement works lagoon. In 2015, the wheel wash discharge pipe was re-routed into Settlement Pond 1, the unlined ditch cleaned out and the eroded areas smoothed. Since the improvements, molybdenum concentrations continued to increase until Q1 2017 when the results started to show a decrease. Boron, Ammoniacal Nitrogen and Sulphate have remained relatively consistent across the boreholes and stable within borehole E05-03 (where boron remains consistently below the Compliance Limit).

In borehole E05-04, molybdenum concentrations were approximately double the natural background concentrations until March 2014. Since then concentrations have slowly increased up to an unexpected peak of 128µg/l in October 2021. The trend appears seasonal with higher results in the winter months. Prior to 2015, the molybdenum concentrations in E06-01 consistently reflected the natural background concentrations, since February 2015, results have been sporadically above the natural background concentrations. The elevated concentrations observed during 2020 have not been repeated, and E06-01 has appeared to return back to reflecting background concentration. E06-02 has also continued to come down since its Mo peak of 340µg/l in 2019, and all four Mo results recorded in 2022 were below the control limit.

As in E05-03, molybdenum concentrations in the settlement ponds (SP) have been increasing since January 2012, however, since 2013, concentrations have been characterised by large amplitude seasonal fluctuations, with the highest concentrations in the summer and the lowest in the winter. This seasonal fluctuation is also reflected in DP2 which collects surface water and potentially under-drainage flows from the site. The water from the settlement ponds is discharged periodically into the cement works lagoon (SW12) where molybdenum concentrations have also been rising steadily since January 2012. The close proximity of SW12 to E05-03 and E05-04 is noted and the HRA review, currently being undertaken by external specialists, has questioned whether E05/03 can be classed as representative of groundwater.

A summary of the average groundwater quality for all monitoring parameters between 2006 and 2022 is provided in Appendix B with a comparison of pre- and post-fill concentrations. The key trends in the data have been discussed above, however, it can be summarised that there may be some elevation of some identified parameters potentially due to surface water contact with PFA surfaces.

The external contractor reported that the duplicate samples collected during 2022 showed good repeatability and were within the expected laboratory error levels.

2.3. Surface Water Quality Review

Monitoring Objective

To carry out routine monitoring of surface water to;

- monitor the performance of the ash disposal site by measurement of absolute levels and concentrations and trends relative to relevant criteria including background concentrations and control levels; and;
- identify and quantify effects on surface water receptors.

Number and Location of Monitoring Points

A summary of the surface water monitoring points is provided in Table 3 below and the locations are shown in Appendix A. As detailed in a letter to NRW dated 13th June 2014 a new surface water monitoring point, DP2, was added to monitor the composition of water from the under-drainage. Routine monitoring of DP2 began in May 2014.

Table 3: Summary of Surface water monitoring points

Monitoring Point	Description	Direction from site	Designation
SW12	East shore of cement works lagoon in NW area	West	Surface water Receptor
Settlement Ponds (SP)	Two concrete ponds collecting groundwater and surface water	South-west	
DP2	Surface water and groundwater drainage channel at base of Phase 1 and 2	West within site	

A proportion of the upstream and underlying groundwater will be collected in the groundwater drainage layer and directed towards the two settlement ponds along with any water that has infiltrated through the PFA and the barrier/attenuation layer. Surface water from runoff is also directed into the two settlement ponds via a series of perimeter ditches and toe drains. The settlement ponds are constructed on the quarry floor, contained by concrete and butyl lined 3m high bunds, and are designed to allow suspended solids to settle out before the water is discharged through penstocks into the nearby cement works lagoon (SW12).

Monitoring Measurements

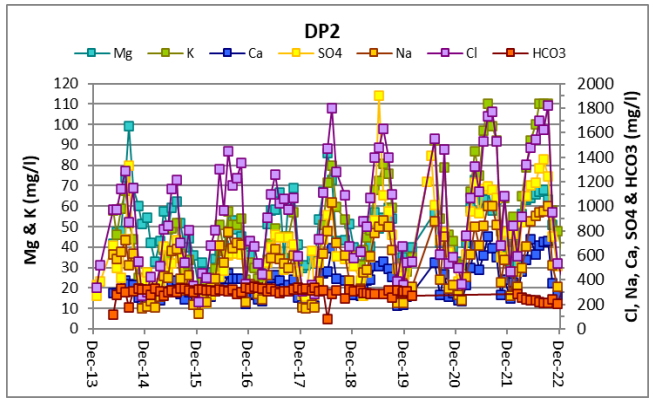
The surface water monitoring analytical suite contains a range of parameters which are monitored in accordance with the Environmental Permit on a quarterly basis for SW12 and a monthly basis for the SP and DP2. Trained in-house operatives are responsible for the sampling of the SP and DP2 and an independent external contractor is responsible for the sampling of SW12 (undertaken during the wider groundwater monitoring rounds). An independent external accredited laboratory is responsible for the analysis of the samples (usually ALS).

Figure 5 shows the general surface water quality for the major ions. Calcium, magnesium and sulphate concentrations appear naturally elevated in the cement works lagoon and the settlement ponds (i.e. prior to any PFA deposition). Concentrations appear to be seasonably variable in the settlement ponds and the cement works lagoon with highs in July to December and lows in February to June except for HCO_3 with lows in July to December and highs in February to June. When routine monitoring began in DP2 in May 2014 this seasonal pattern in concentrations was also evident. The seasonal pattern is much more marked in 2013-2022 with much higher chloride concentrations than seen previously.

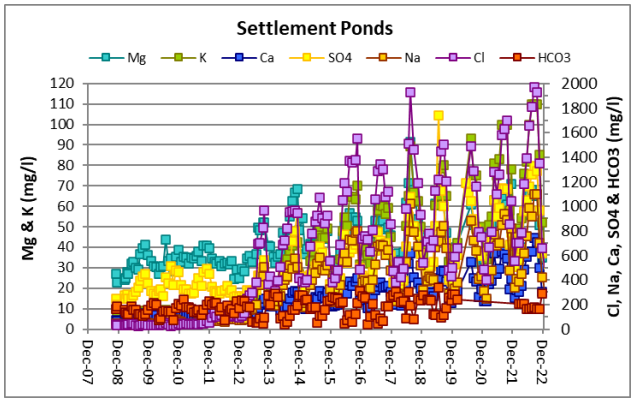
Please note that RWE have had discussions with ALS (the external accredited laboratory who undertake the monthly analysis for DP2 & Settlement Ponds) as it became apparent that there was an issue with the Total Alkalinity analysis for these locations (when they superseded NLS as the contracted accredited laboratory for the site in the summer 2020[1]). It was suspected, and the lab confirmed, that they were not titrating the samples to the required pH target value due to an incorrect classification of the sample matrix. This has resulted in a significant step change to lower alkalinity values which ultimately impacted the HCO_3 calculations for these locations (Jul-20 to Feb-22). The laboratory matrix/analysis method specified for the Quarry has now been corrected by ALS (from Mar-22) and RWE are not expecting to have any further issues going forwards. The unrepresentative HCO_3 figures have now been removed from the dataset/trends for that time period.

[1] Due to restricted working/operation under the coronavirus pandemic NLS were unable to meet the analysis requirements for the site.

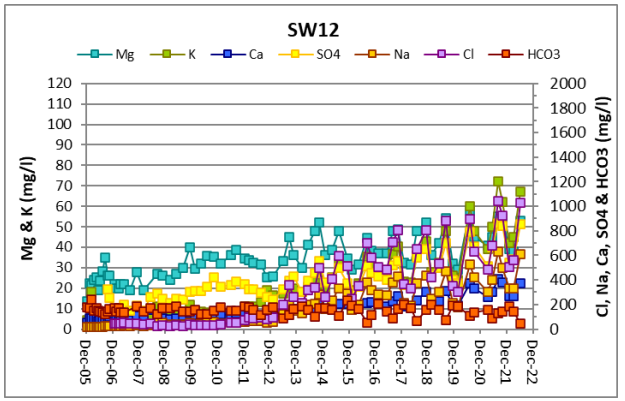
Figure 5: General Surface Water Quality Charts



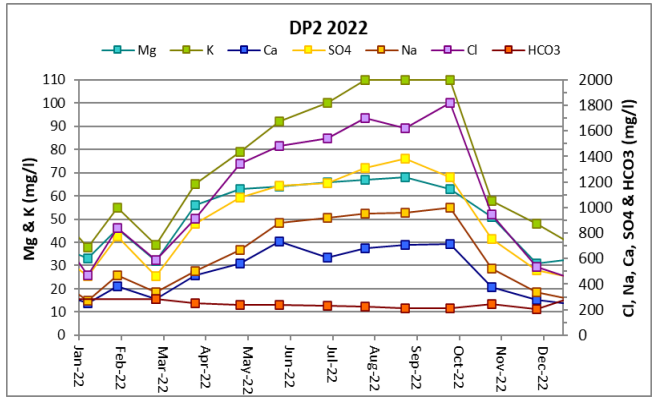
Fluctuations in SO4, Na & Cl with high concentrations in summer and low concentrations in winter.

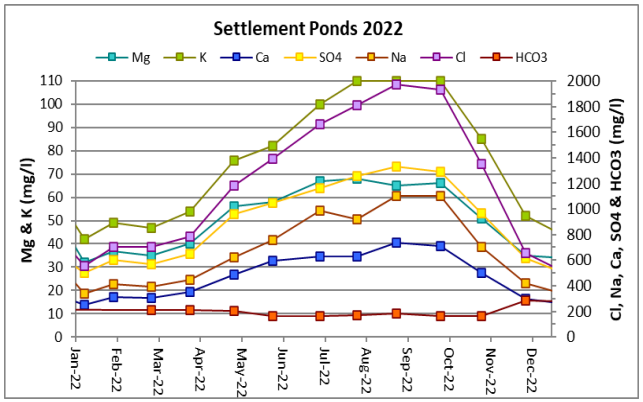


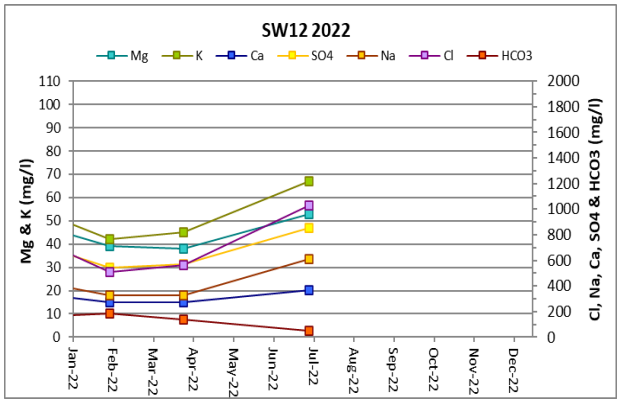
From 2013 fluctuations in Mg, K, Ca, SO4, Na & Cl with high concentrations in summer and low concentrations in winter.



From 2013 fluctuations in Mg, K, SO4, Na & Cl with high concentrations in summer and low concentrations in winter.







Please ref. HCO3 discussion in Section 2.3 above.

Figure 6 shows the surface water control charts. It should be noted that the compliance limits apply to the discharge from the settlement ponds whilst the control levels (where defined) apply to both the discharge from the settlement ponds and SW12. An exceedance is defined as a result above the compliance limit or control level for 3 consecutive sampling events.

In 2022, there were no exceedances of the compliance limit or control level for any critical parameter, except for:

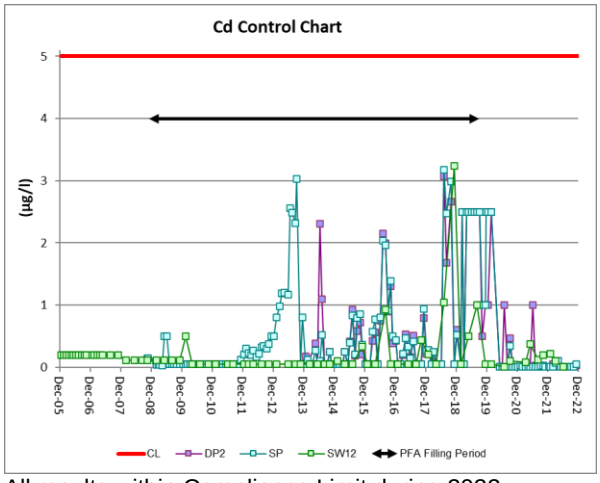
- Boron – the majority of results have been recorded above the Control Level for all three locations during 2022, and the general upwards trend appears to be continuing across all three locations. DP2 and the Settlement Ponds also recorded a few results above the Compliance Limit (x6 and x3 respectively) with corresponding max results of 2300ug/l and 2200ug/l respectively. As per the previous year the trend appears seasonal with results reducing during winter. However 2022 peak within SW12 (1,510ug/l) is lower than the peak recorded in 2020 (1,790ug/l).
- Chromium – briefly spiked twice in DP2, at and slightly above the Control Level, during 2022 (Mar & Aug) measuring 28ug/l and 30ug/l respectively. All other results during 2022 remained within the Compliance Limit.
- Sulphate – all analysis results record during 2022 for all three surface water locations were recorded above the Compliance Limit of 400mg/l. A temporary approval of the elevated discharge is in place with NRW on the basis of no environmental impact and the understanding that the elevated concentrations are being caused by drainage into the site from the south-east. This has also been suggested by the HRA conducted in 2018.
- Ammonia – is also consistently above the Compliance Level for both the Settlement Ponds and DP2, although sufficient oxidation or stripping appears to take place by the time the discharge passes to the cement works lagoon (SW12) as concentrations are low, within target limits and not increasing. Ammonia was injected into the Power Station flue gas stream to increase the efficiency of the Electrostatic Precipitators, this will have resulted in the deposited Ash being slightly Ammoniated. This may be the source of the elevated Ammonia levels observed at DP2.

In general, Figure 6 shows that there are no increasing trends in critical parameter concentrations except for sulphate, boron and ammoniated nitrogen, as discussed above. It is hoped that post restoration/reprofiling site works (when approved) that the surface water shedding of the site will improve, limiting the erosion of ash surfaces and the associated mobilisation of parameters of concern. Surface water trends should begin to drop and the associated compliance borehole trends also improve if they are, as suspected, being impacted by SW12.

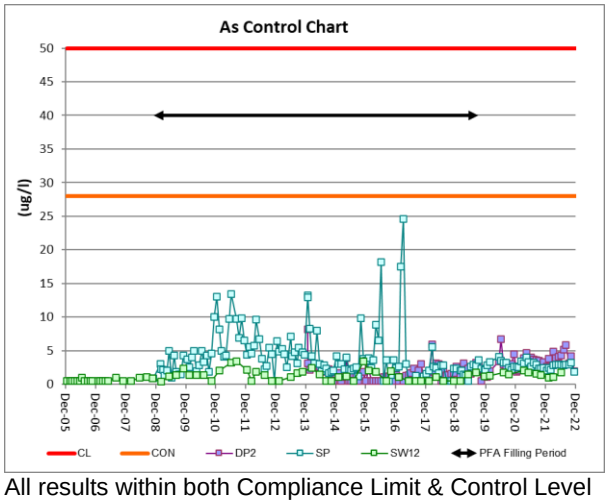
A summary of the average surface water quality between 2006 and 2022 is provided in Appendix B with a comparison of pre- and post-fill concentrations. The key trends in the data have been discussed above, however, it can be summarised that there may be some low-level contamination from surface water contact with PFA, which is considered to have not significantly impacted the surface water receptors.

Figure 6: Surface Water Control Charts

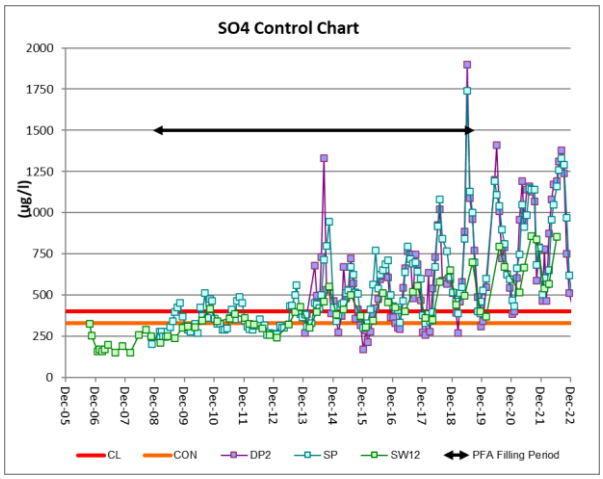
(CL – Compliance Limit, CON – Control Level)



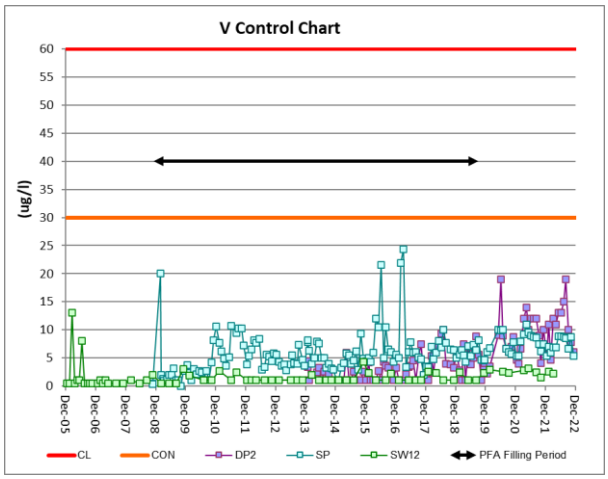
All results within Compliance Limit during 2022.



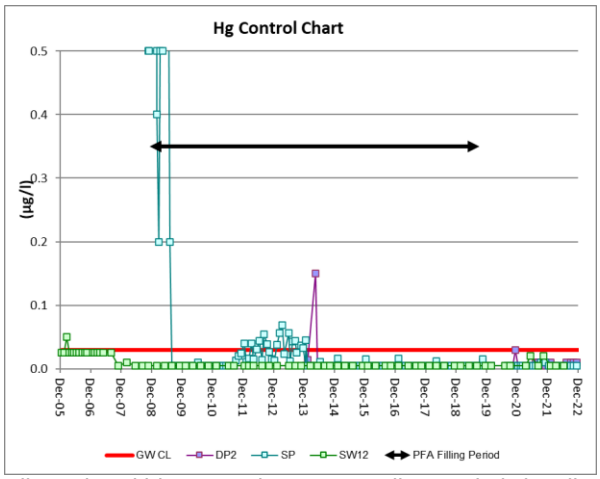
All results within both Compliance Limit & Control Level during 2022.



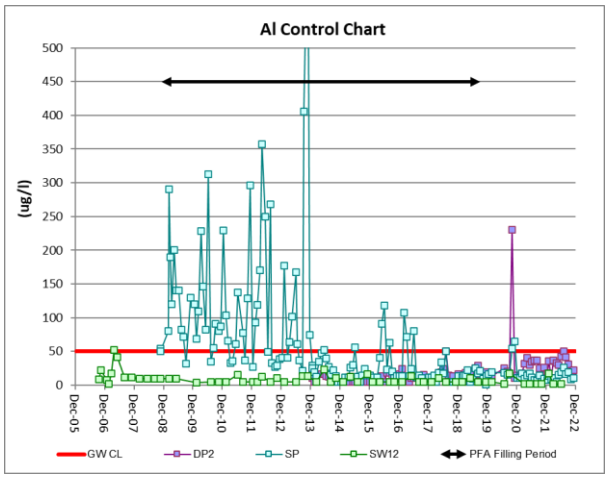
Generally increasing (seasonal) trends across all three locations. SO_4 continues to consistently exceed both target limits during 2022.



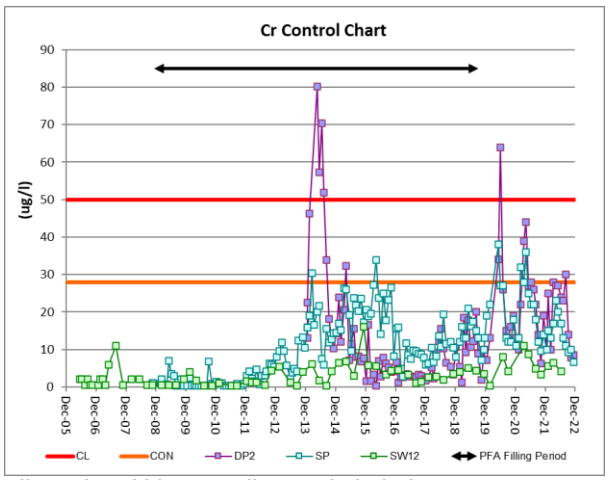
All results within both Compliance Limit & Control Level during 2022.



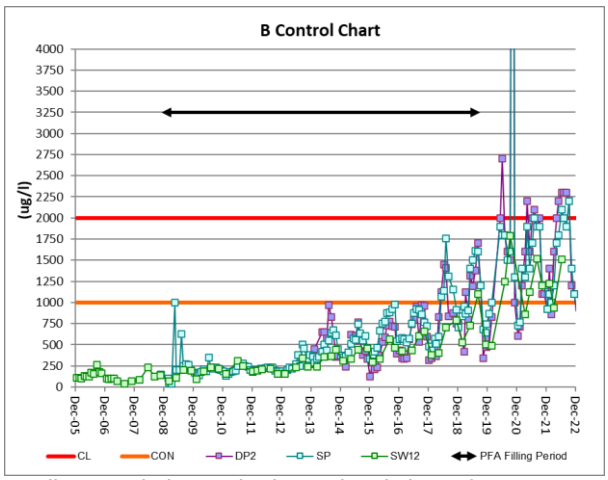
All results within Groundwater Compliance Limit (applied for comparison) during 2022.



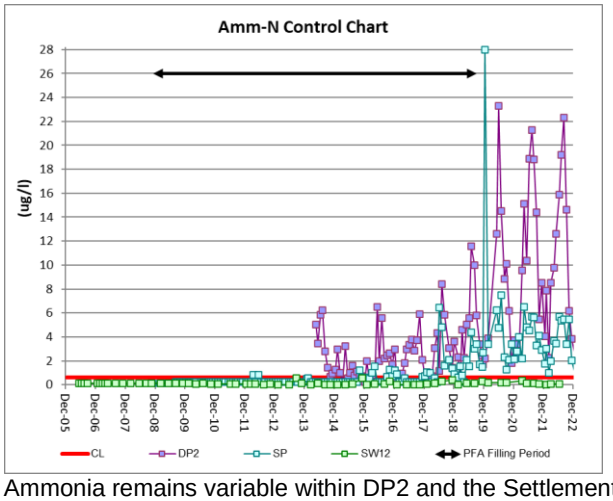
All results within Groundwater Compliance Limit (applied for comparison) during 2022 (SP above scale Nov-13 peak = 736 ug/l).



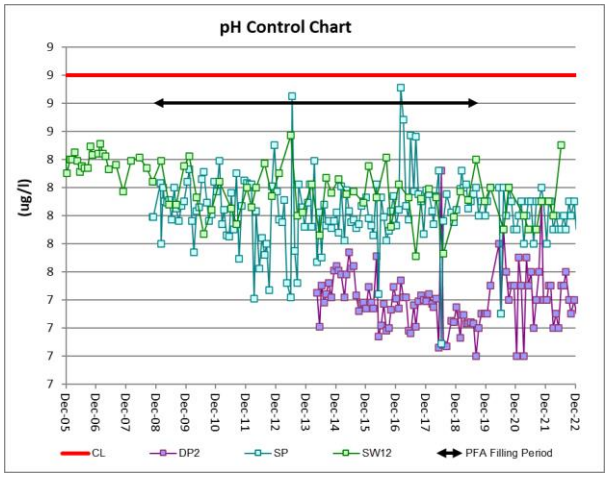
All results within Compliance Limit during 2022. SW12 and SP are also within the Control Level through the year. DP2 clipped the Control Level during March (28ug/l) and August (30ug/l).



As discussed above, the boron levels in surface water appear to be continuing to exhibit a general upwards trend. (DP2 & SP above scale Nov-2020 peaks = 13000 & 10000 ug/l respectively).



Ammonia remains variable within DP2 and the Settlement Ponds and consistently above the Compliance Level for both locations (whilst SW12 remains within target).



pH levels have remained generally consistent across the three surface water locations.

3. Annual Production/Treatment Data

Table 5: Annual Production/Treatment Data(Table S5.2 EP)

Parameter	Value	Unit
Surface water disposed off site	0	m^3/yr
Groundwater disposed off site	0	m^3/yr

4. Contamination/Decontamination of Site

There have been no incidents or emissions which may have caused any site contamination during 2022, and, therefore, no requirement to decontaminate the site during 2022.

5. Topographical Survey

The last topographical survey to ordnance datum was carried out in July 2018 which is shown in Appendix C. Further topographical surveys of the site are currently being undertaken to support the revised restoration plan/works to be agreed in the future.

6. Landfill Capacity

Table 6 below details the amount of PFA deposited at Aberthaw Quarry Ash Disposal Site during 2022 as reported to Natural Resources Wales via the Waste Return Form. With the closure of Aberthaw Power Station the site will no longer be utilised for the disposal of PFA.

Table 6: PFA Deposited

Reporting Period	PFA Deposited (tonnes)
1st January – 31st December 2022	Nil

7. Waste Acceptance Compliance Testing

Aberthaw Quarry Ash Disposal Site is a mono-landfill site which is under the direct operational control of Aberthaw Power Station. All the ash was transported directly from the Power Station to the Quarry using lorries.

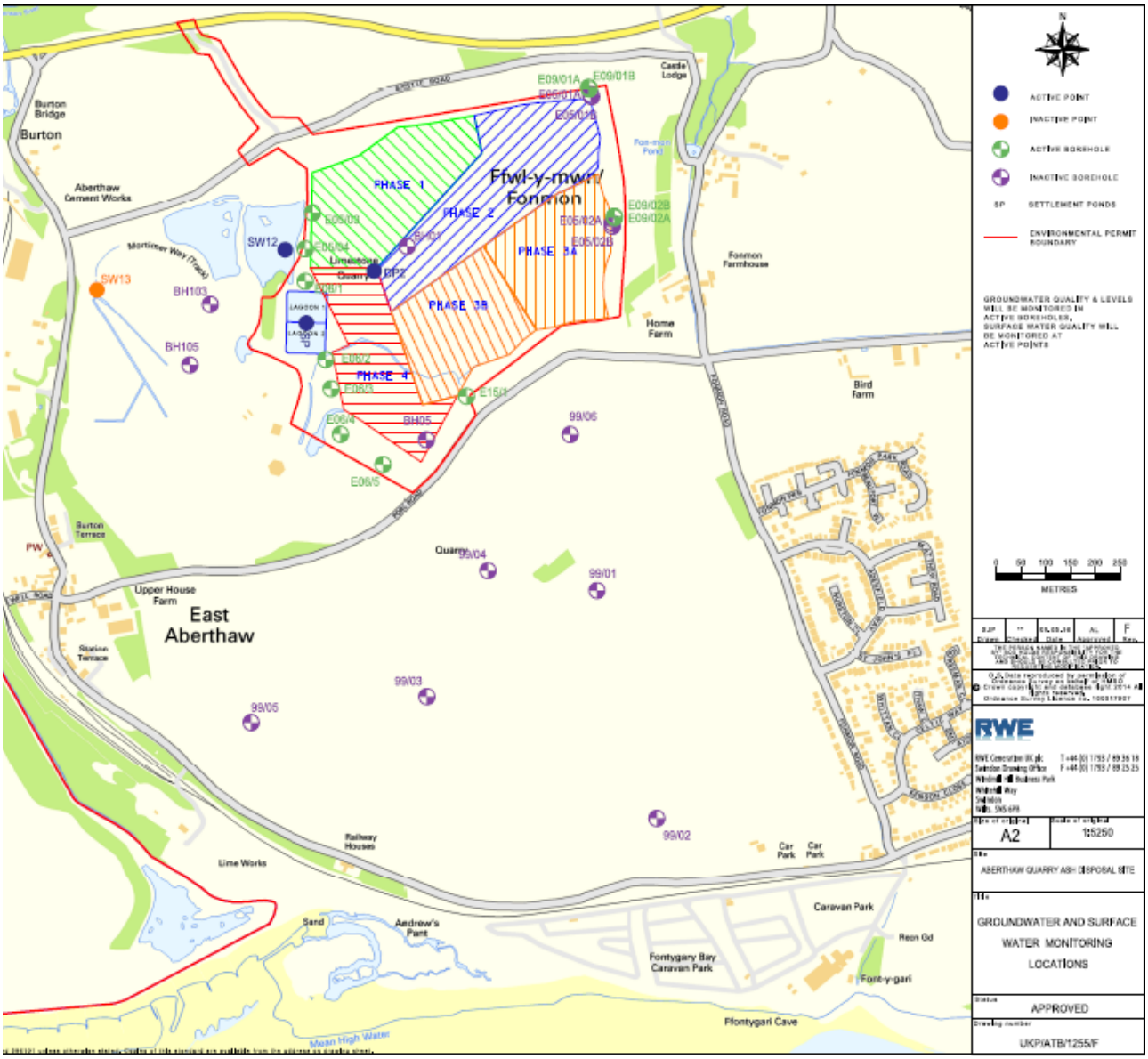
The exact composition of PFA was dependent upon the composition of the fuel utilised by Aberthaw Power Station. RWE has well established procedures which control the quality of fuel supplied to its stations.

Table 7 summarises the analytical data obtained for historic leachate tests performed on composite samples of conditioned PFA from Aberthaw Power Station between 2012 and 2017. The CEN two-stage method for leachate analysis was used (BS EN 12457-3:2002 Characterisation of waste – Leaching – Compliance test for leaching of granular waste materials and sludges of which Part 3).

Table 7: Summary of 10:1 Leachate Calculated Results (mg/kg)

Period	Jan-17	Apr-12 to Jan-17			
Analyte:	Latest Result	Minimum	Mean	Maximum	Number of results
Aluminium as Al (Dissolved)	8.1	2.4	21.9	75.4	15
Ammoniacal Nitrogen as N	156.6	4.2	83.5	158.1	15
Antimony as Sb (Dissolved)	0.192	0.020	0.163	0.256	15
Arsenic as As (Dissolved)	2.449	0.077	1.907	3.313	15
Barium as Ba (Dissolved)	1.4	0.1	2.5	5.9	15
Boron as B (Dissolved)	12.1	0.7	12.8	17.7	15
Bromide as Br	36.3	0.6	71.5	293.5	15
Cadmium as Cd (Dissolved)	0.0010	0.0004	0.002	0.0056	15
Chromium as Cr (Dissolved)	0.19	0.01	0.3	1.03	15
Copper as Cu (Dissolved)	0.010	0.004	0.015	0.028	15
Cyanide (Total) as CN	0.5	0.2	0.3	0.5	15
Dissolved Organic Carbon	25.5	2.2	22.6	43.3	15
Fluoride as F	21.7	2.3	23.5	45.1	15
Iron as Fe (Dissolved)	1.16	0.52	1.03	1.52	15
Lead as Pb (Dissolved)	0.043	0.013	0.034	0.083	15
Manganese as Mn (Dissolved)	0.025	0.006	0.066	0.174	15
Mercury as Hg (Dissolved)	0.0019	0.0004	0.0057	0.0132	15
Molybdenum as Mo (Dissolved)	8.1	0.7	9.4	17.8	15
Nickel as Ni (Dissolved)	0.040	0.003	0.028	0.062	15
Nitrate as N	4.6	2.3	3.1	4.6	15
Selenium as Se (Dissolved)	2.8	0.2	2.1	3.5	15
Sodium as Na (Dissolved)	327	9	821	2696	15
Total Dissolved Solids	6787	350	8888	21800	15
Total Nitrogen as N	162.7	5.0	92.1	166.0	15
Total Sulphur as SO4 (Dissolved)	3745	170	3422	4271	15
Vanadium as V (Dissolved)	3.59	0.40	2.39	3.59	15
Zinc as Zn (Dissolved)	0.17	0.01	0.14	0.57	15

Appendix A Groundwater and Surface Water Monitoring Locations



Appendix B. Groundwater and Surface Water Quality 2006-2022

	Aquifer	Response Zone Interval [1] m b GL	Al µg/l		Sb µg/l		As µg/l		B µg/l		Cd µg/l		Ca mg/l		Cr µg/l		Cu µg/l	
Background - Limestone [2]			5.9		1.0		0.6		87		0.07		149		0.9		2.8	
Background - Seawater [3]			256		<10		2		4166		0.07				1.1		12	
GW EQS/DWL			200		5		10		2000		5.0		250		50		2000	
GW MRV							1				1.0							
Groundwater CL			50				10		2800		0.4				50			
Surface Water CL							50		2000		5.0				50			
Upstream Groundwater			Average		Average		Average		Average		Average		Average		Average		Average	
E05-09_01A	Limestone	18-24	5.5		0.9		0.5		55.5		0.1		132.6		0.9		2.1	
E05-09_01B		24-30	6.4		0.8		0.4		54.3		0.1		128.3		0.7		1.4	
E05-09_02A		21-27	5.5		1.1		0.6		93.4		0.1		169.5		0.9		4.1	
E05-09_02B		27-33	5.7		1.0		0.6		82.1		0.1		193.3		0.9		5.0	
E15_1		17-29	4.8		0.6		0.7		241.9		0.0		104.4		0.2		1.6	
Downstream Utilised Areas			Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill
E05_03 - COMPLIANCE LOCATION	Limestone	3-15	8.0	5.6	2.1	0.9	1.2	0.9	1109	1452	0.18	0.18	37	223	2.8	0.8	6.5	1.7
E05_04 - COMPLIANCE LOCATION		2.5-20	15.3	8.2	3.9	1.0	4.1	1.6	2123	2136	0.18	0.05	6	9	3.7	0.6	4.5	1.0
E06_01 - COMPLIANCE LOCATION		3-15	9.3	11.5	2.9	0.9	0.6	1.1	1667	1792	0.17	0.05	10	7	4.3	0.7	0.8	1.0
E06_02		2-10	11.2	5.7	4.1	0.7	1.6	1.0	1113	947	0.16	0.05	89	77	2.4	0.4	4.8	1.2
Downstream Phase 4 (unfilled)			Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill
E06_03	Limestone	2-10	6.5	5.0	2.0	1.2	1.2	0.7	561	405	0.2	0.1	131	147	2.9	0.3	1.8	1.6
E06_04		2-10	7.0	6.0	1.8	0.7	0.7	0.5	57	170	0.2	0.1	147	229	2.9	0.7	5.1	2.6
E06_05		2-8	11.4	4.9	3.1	0.6	0.6	0.4	224	256	0.2	0.1	129	189	2.8	0.5	1.5	1.8
Downstream Surface Water			Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill
DP2 Phase 2 West				17.6		0.6		2.2		1046		0.5		365		15.3		2.8
Settlement Ponds			120.8	54.6	0.7	0.8	2.2	4.0	256	782	0.1	0.5	83	267	1.7	12.0	2.0	2.6
SW12 Lafarge Lagoon			15.7	7.1	2.1	0.5	0.7	1.4	124	535	0.2	0.2	86	200	1.8	3.7	1.4	2.3

1 Response zone interval for latest well where time series data are compiled from the original and replacement monitor well

2 Background - Limestone is mean of upstream boreholes (E05-09/1A,E05-09/1B, E05-09/2A, E05-09/2B)

3 Background - Seawater is mean of Aberthaw Power Station CW Inlet data collected 2011-12

Over Compliance Limit

Above DWS / EQS

Above Background by >25% (GW)

	Aquifer	Response Zone Interval [1] m b GL	Fe µg/l		Mg mg/l		Mn µg/l		Hg µg/l		Mo µg/l		Ni µg/l		K mg/l		Se µg/l	
Background - Limestone [2]			46		17.5		21.6		0.008		2.3		2.7		1.9		0.8	
Background - Seawater [3]			<100				<20		0.02		<30		9		380		<1	
GW EQS/DWL			1000		50		50		0.07		70		20		12		10	
GW MRV									0.10									
Groundwater CL									0.03		50							
Surface Water CL																		
Upstream Groundwater			Average		Average		Average		Average		Average		Average		Average		Average	
E05-09_01A	Limestone	18-24	22		6		5		0.007		1.4		1.4		1.3		0.6	
E05-09_01B		24-30	26		6		5		0.009		1.6		1.1		1.3		0.7	
E05-09_02A		21-27	102		26		43		0.008		1.7		3.6		1.7		0.9	
E05-09_02B		27-33	51		22		24		0.008		2.1		4.9		2.0		0.9	
E15_1		17-29	16		36		43		0.006		7.7		1.4		4.2		0.6	
Downstream Utilised Areas			Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill
E05_03 - COMPLIANCE LOCATION	Limestone	3-15	38	25	24	143	11	39	0.018	0.007	1.1	696	2.2	1.6	3.5	8.0	0.9	0.5
E05_04 - COMPLIANCE LOCATION		2.5-20	42	17	4	7	6	5	0.018	0.008	1.8	25.0	2.3	0.7	3.7	3.0	1.3	0.8
E06_01 - COMPLIANCE LOCATION		3-15	53	15	7	5	1	8	0.015	0.006	0.8	11.4	0.8	0.8	3.2	2.9	1.0	0.6
E06_02		2-10	89	17	56	40	18	7	0.014	0.008	2.9	31.4	4.3	1.5	9.9	7.0	1.6	0.7
Downstream Phase 4 (unfilled)			Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill
E06_03	Limestone	2-10	77	15	62	79	10	9	0.014	0.007	10.9	15.7	4.9	2.5	7.3	8.2	4.9	1.4
E06_04		2-10	59	21	42	64	5	24	0.014	0.006	2.5	6.9	4.2	3.5	3.7	30.1	2.3	0.6
E06_05		2-8	41	15	52	74	6	10	0.014	0.006	2.0	5.8	3.8	2.0	4.0	4.5	1.4	0.5
Downstream Surface Water			Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill
DP2 Phase 2 West				15		48		41		0.007		2721		14.4		48.9		17.7
Settlement Ponds			20	34	30	44	3	10	0.392	0.010	19.8	1904	8.5	9.8	7.4	37.9	7.4	12.3
SW12 Lafarge Lagoon			33	17	24	39	2	10	0.020	0.006	4.0	1086	2.2	4.4	6.1	27.9	1.5	1.7

1 Response zone interval for latest well where time series data are compiled from the original and replacement monitor well

2 Background - Limestone is mean of upstream boreholes (E05-09/1A,E05-09/1B, E05-09/2A, E05-09/2B)

3 Background - Seawater is mean of Aberthaw Power Station CW Inlet data collected 2011-12

Over Compliance Limit

Above DWS / EQS

Above Background by >25% (GW)

	Aquifer	Response Zone Interval [1] m b GL	Na mg/l		V µg/l		pH		EC µS/cm		Bicarbonate mg/l		Sulphate mg/l		Ammoniacal Nitrogen as N mg/l		Total Oxidised Nitrogen as N mg/l	
Background - Limestone [2]			23		0.9		7.4		822		409		61		0.23		9.8	
Background - Seawater [3]					<20		7.9				97		2396					
GW EQS/DWL			200		60				2500				400		0.5			
GW MRV																		
Groundwater CL					20								400		1.6			
Surface Water CL					60		9.00						400		0.6			
Upstream Groundwater			Average		Average		Average		Average		Average		Average		Average		Average	
E05-09_01A	Limestone	18-24	16		0.9		7.4		669		350		32		0.0		5.2	
E05-09_01B		24-30	17		0.8		7.4		659		338		31		0.0		4.8	
E05-09_02A		21-27	24		0.9		7.3		927		494		68		0.5		10.9	
E05-09_02B		27-33	29		1.0		7.2		1054		478		72		0.4		23.8	
E15_1		17-29	37		0.8		7.6		818		353		143		0.2		2.4	
Downstream Utilised Areas			Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill
E05_03 - COMPLIANCE LOCATION	Limestone	3-15	149	432	1.5	1.1	8.5	7.6	977	3706	462	274	178	359	0.51	0.63	0.2	0.8
E05_04 - COMPLIANCE LOCATION		2.5-20	241	248	4.2	1.7	8.8	8.5	1010	1043	564	465	79	93	0.53	0.36	0.3	0.2
E06_01 - COMPLIANCE LOCATION		3-15	215	218	2.2	1.9	8.7	8.6	923	892	473	449	106	94	0.57	0.38	0.5	0.4
E06_02		2-10	109	113	1.7	4.2	8.4	7.8	1214	1038	336	286	390	294	1.09	0.45	0.8	0.7
Downstream Phase 4 (unfilled)			Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill
E06_03	Limestone	2-10	70	42	1.1	1.1	8.2	7.8	1224	1211	276	189	443	566	0.7	0.1	2.3	0.7
E06_04		2-10	17	40	0.8	0.9	8.0	7.6	930	1495	290	221	320	626	0.1	0.0	0.2	0.9
E06_05		2-8	27	23	1.0	1.0	8.1	7.6	1063	1242	289	208	363	583	0.2	0.1	0.4	0.2
Downstream Surface Water			Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill
DP2 Phase 2 West				508		5.0		7.4		3998		292		646		5.2		28.6
Settlement Ponds			43	382	2.9	6.2	8.1	8.0	864	3039	144	177	292	561	0.1	1.5	1.7	17.4
SW12 Lafarge Lagoon			26	239	1.4	1.6	8.4	8.1	710	2159	161	146	214	457	0.1	0.1	1.2	6.4

1 Response zone interval for latest well where time series data are compiled from the original and replacement monitor well
2 Background - Limestone is mean of upstream boreholes (E05-09/1A,E05-09/1B, E05-09/2A, E05-09/2B)
3 Background - Seawater is mean of Aberthaw Power Station CW Inlet data collected 2011-12

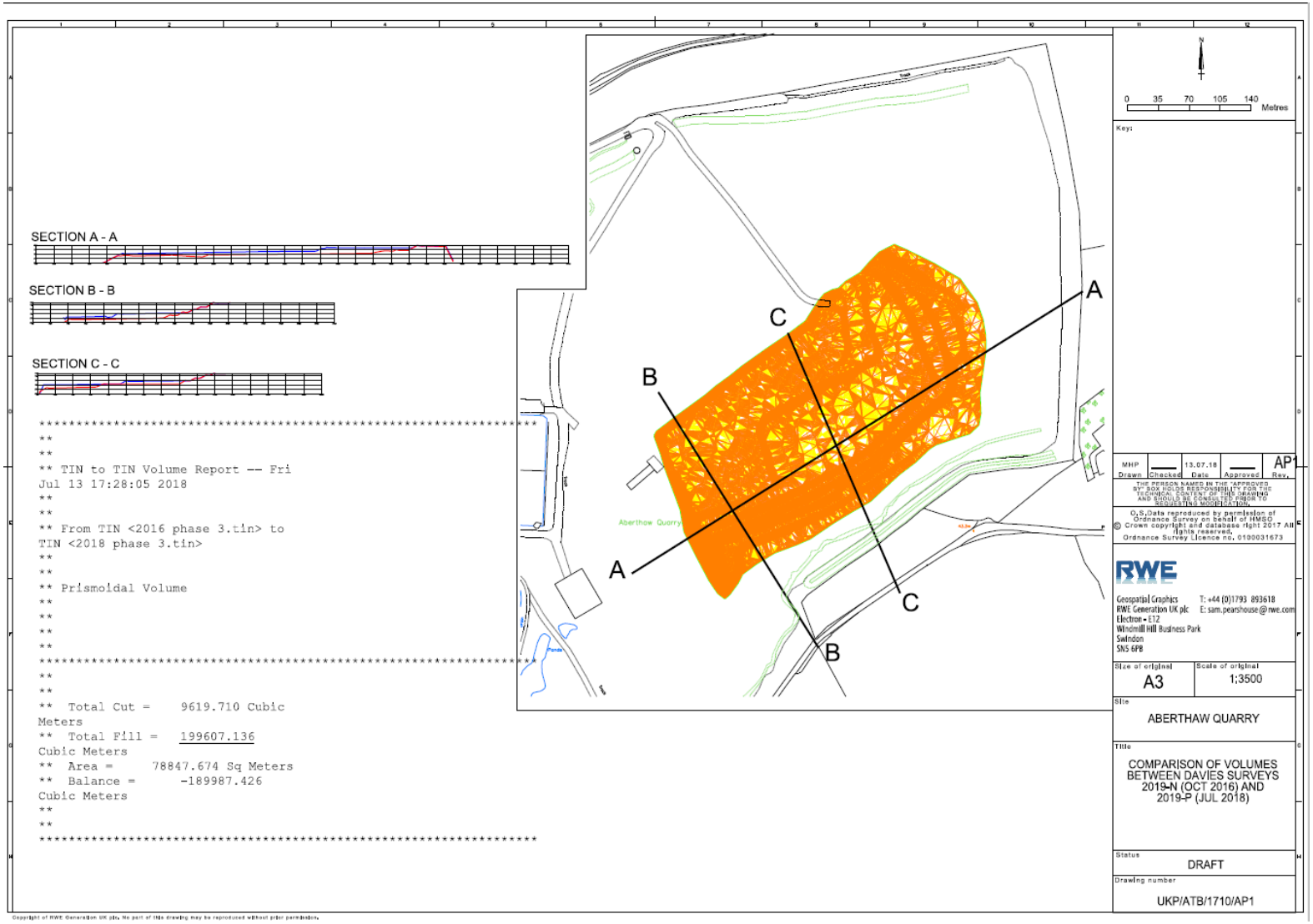
Over Compliance Limit
Above DWS / EQS
Above Background by >25% (GW)

	Aquifer	Response Zone Interval [1]	Nitrate		Chloride		Fluoride		Total Organic Carbon		Cr VI	
		m b GL	mg/l		mg/l		mg/l		mg/l		µg/l	
Background - Limestone [2]			10.5		35		0.2		4.2		0.2	
Background - Seawater [3]					16300		1.3					
GW EQS/DWL			50		250		1.5				3.4	
GW MRV												
Groundwater CL												
Surface Water CL												
Upstream Groundwater			Average		Average		Average		Average		Average	
E05-09_01A	Limestone	18-24	8.7		32		0.1		3.4		0.25	
E05-09_01B	Limestone	24-30	5.6		31		0.1		2.9		0.25	
E05-09_02A	Limestone	21-27	11.5		37		0.2		4.4		0.61	
E05-09_02B	Limestone	27-33	21.9		41		0.2		5.9		0.61	
E15_1	Limestone	17-29	2.2		34		0.3		1.8		0.25	
Downstream Utilised Areas			Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill
E05_03 - COMPLIANCE LOCATION	Limestone	3-15	0.3	0.9	33	1015	1.4	1.3	15.9	2.7		0.22
E05_04 - COMPLIANCE LOCATION	Limestone	2.5-20	0.8	0.2	31	81	6.4	5.4	18.6	3.0		0.22
E06_01 - COMPLIANCE LOCATION	Limestone	3-15	0.2	0.4	33	39	2.1	3.0	19.2	2.3		0.22
E06_02	Limestone	2-10	0.6	0.6	38	48	0.6	0.5	4.3	3.5		0.23
Downstream Phase 4 (unfilled)			Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill
E06_03	Limestone	2-10	1.6	0.2	23	31	0.4	0.4	3.8	2.5		0.22
E06_04	Limestone	2-10	0.5	0.6	26	89	0.3	0.4	11.3	3.1		0.25
E06_05	Limestone	2-8	3.3	0.2	37	26	0.3	0.4	8.3	1.2		0.24
Downstream Surface Water			Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill
DP2 Phase 2 West				17.7		903		0.2		1.4		
Settlement Ponds			0.6	10.8	35	675	0.6	0.2	8.1	3.0		
SW12 Lafarge Lagoon			5.0	4.2	40	404	0.3	0.3	8.4	3.7		0.52

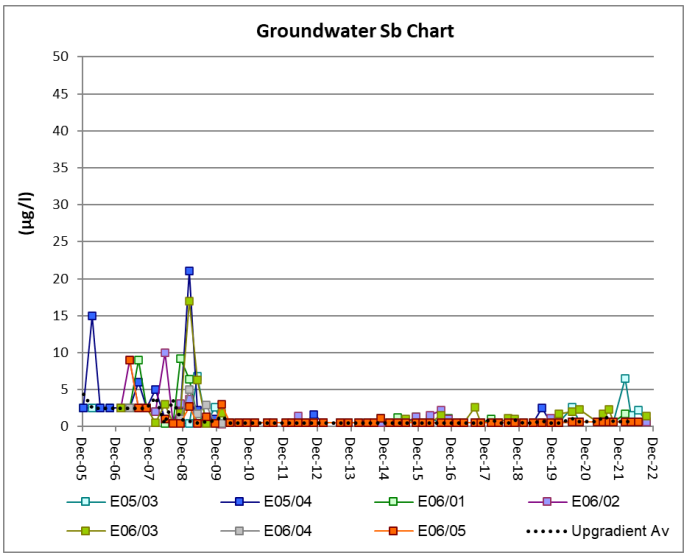
1 Response zone interval for latest well where time series data are compiled from the original and replacement monitor well
2 Background - Limestone is mean of upstream boreholes (E05-09/1A,E05-09/1B, E05-09/2A, E05-09/2B)
3 Background - Seawater is mean of Aberthaw Power Station CW Inlet data collected 2011-12

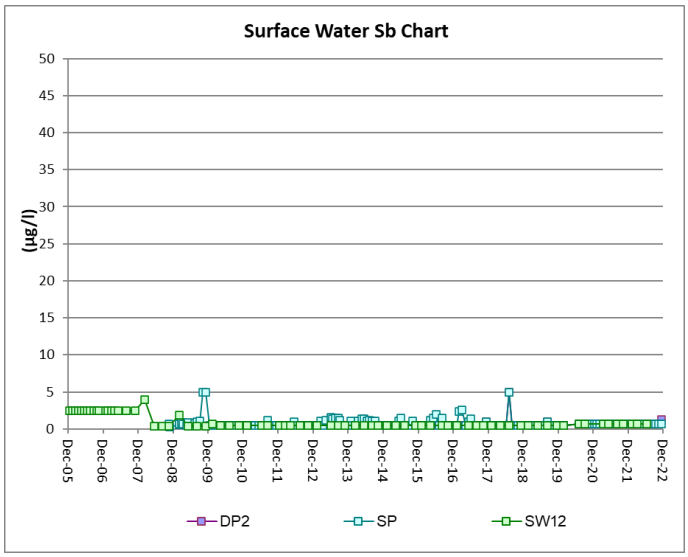
Over Compliance Limit
Above DWS / EQS
Above Background by >25% (GW)

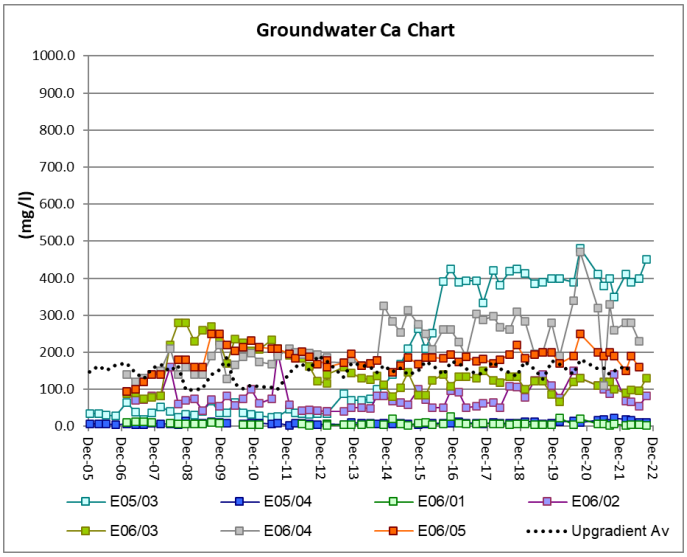
Appendix C. Topographical Survey

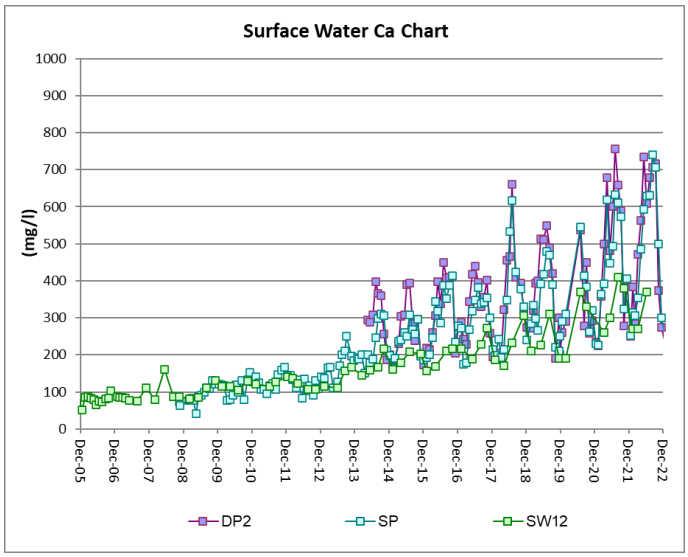


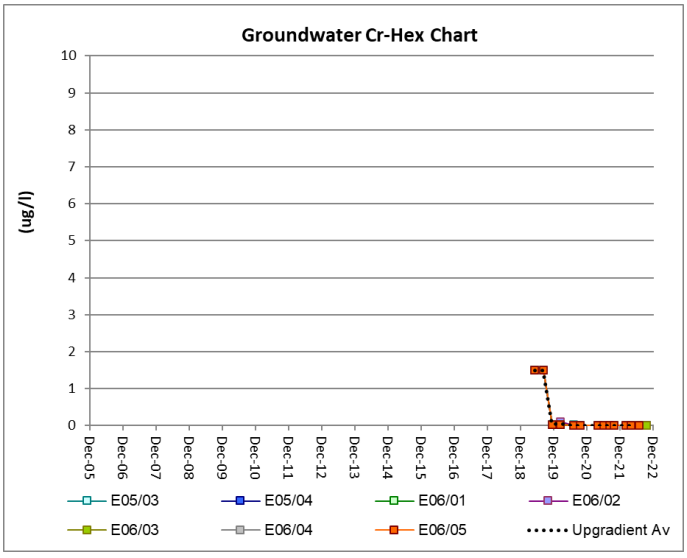
Appendix D. Other monitored parameters

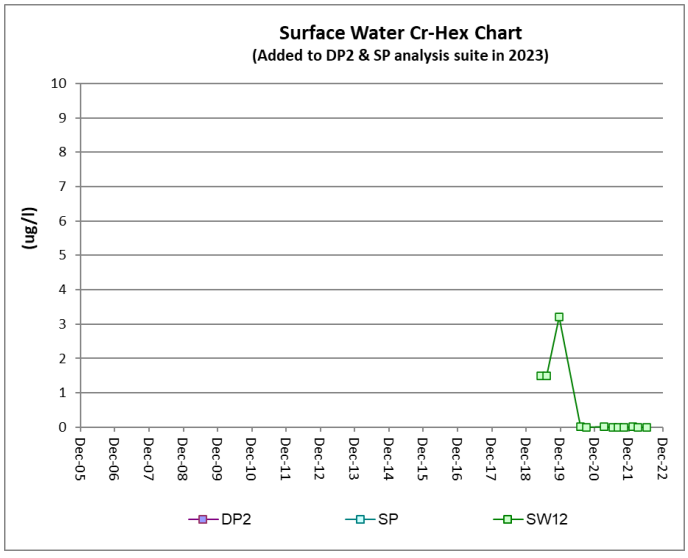


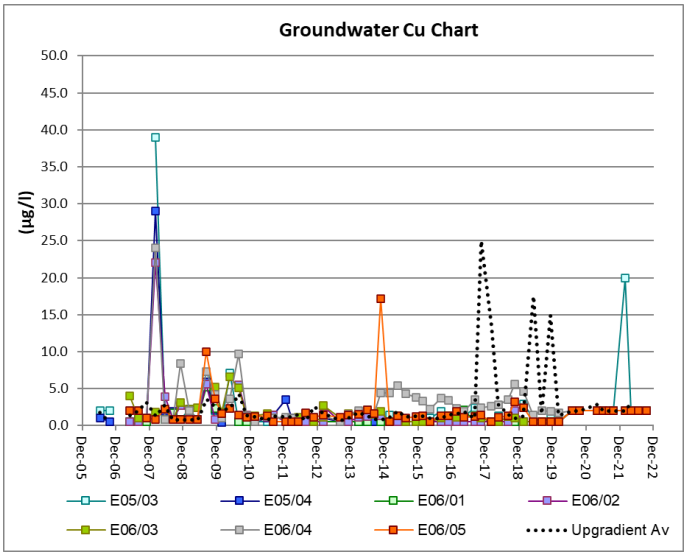


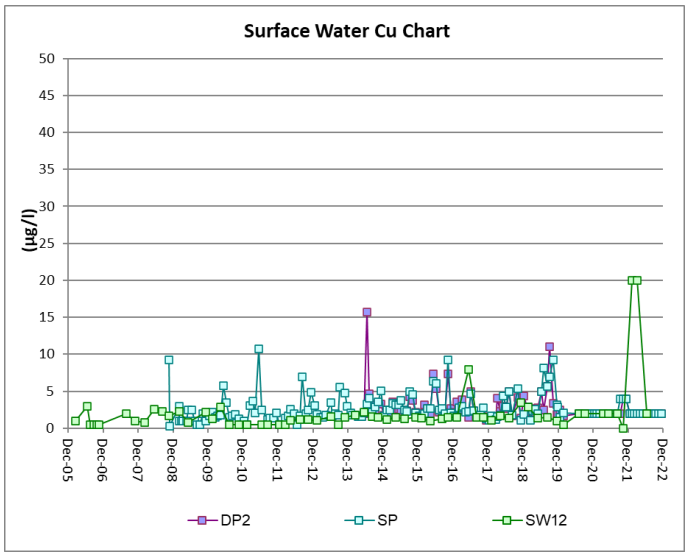


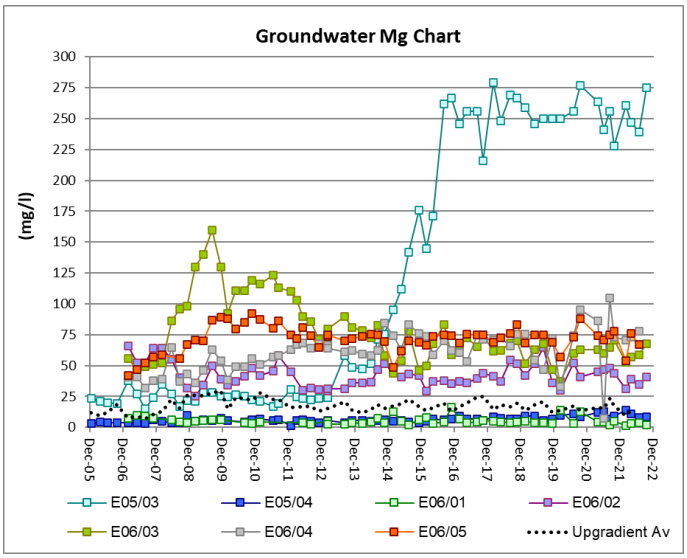


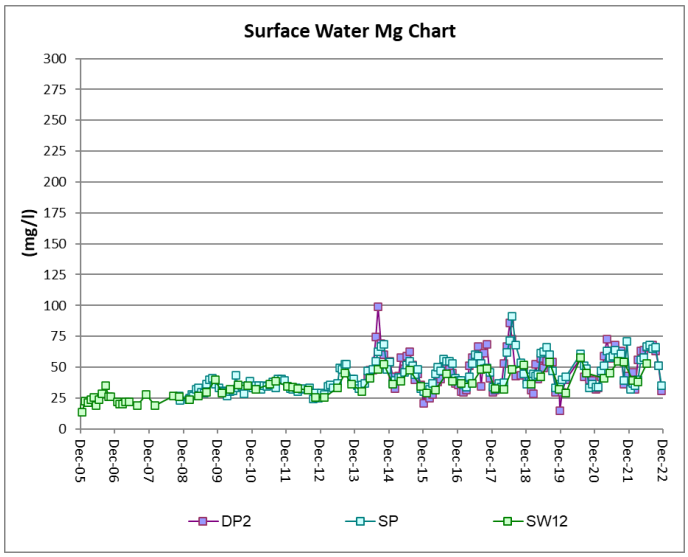


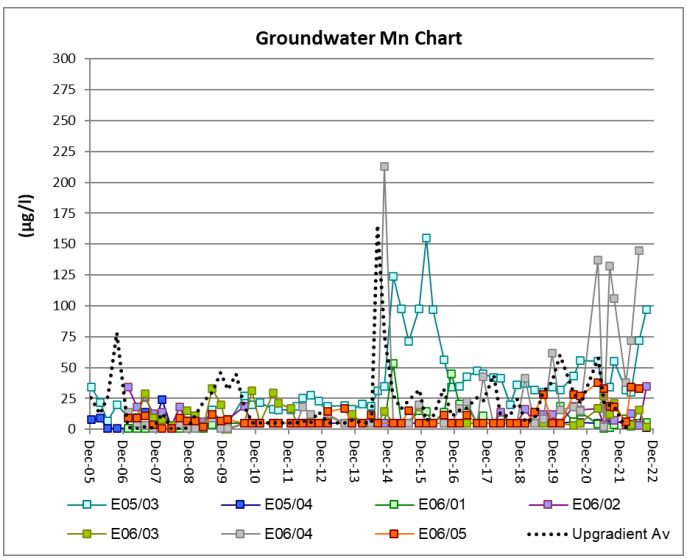


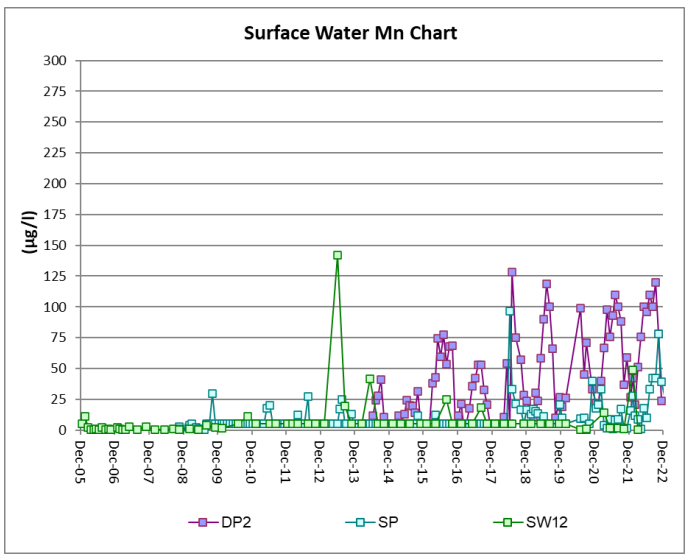

Groundwater Cu Chart
(µg/l)
E05/03
E05/04
E06/01
E06/02
E06/03
E06/04
E06/05
Upgradient Av

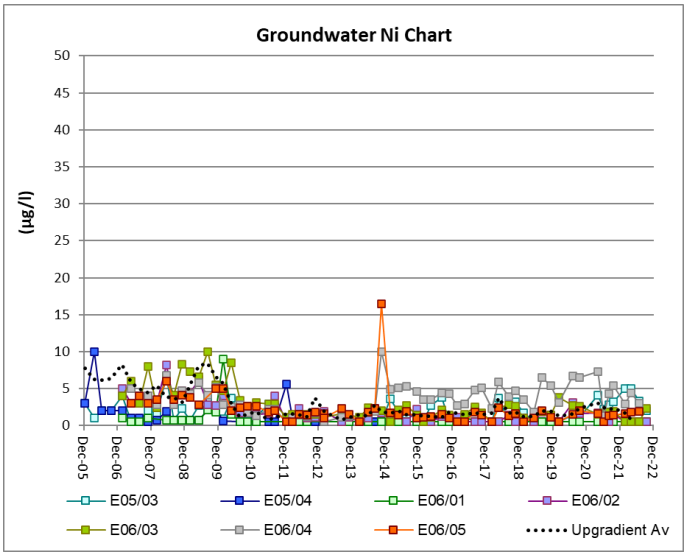

Surface Water Cu Chart
(µg/l)
DP2
SP
SW12

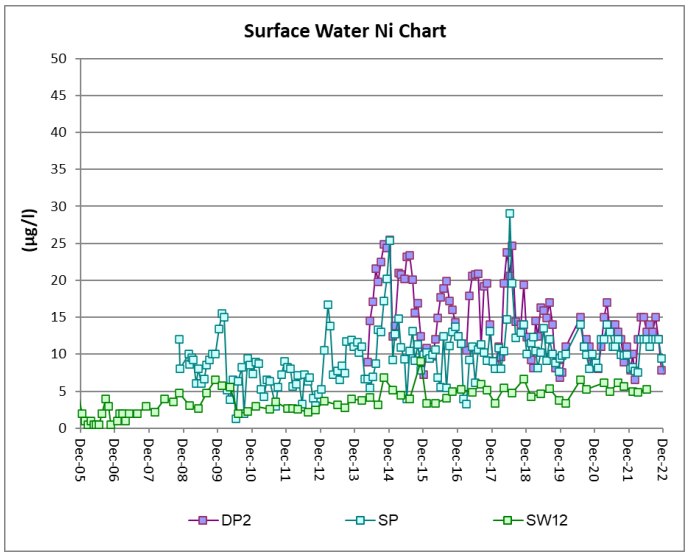

Groundwater Mg Chart
(mg/l)
E05/03
E05/04
E06/01
E06/02
E06/03
E06/04
E06/05
Upgradient Av

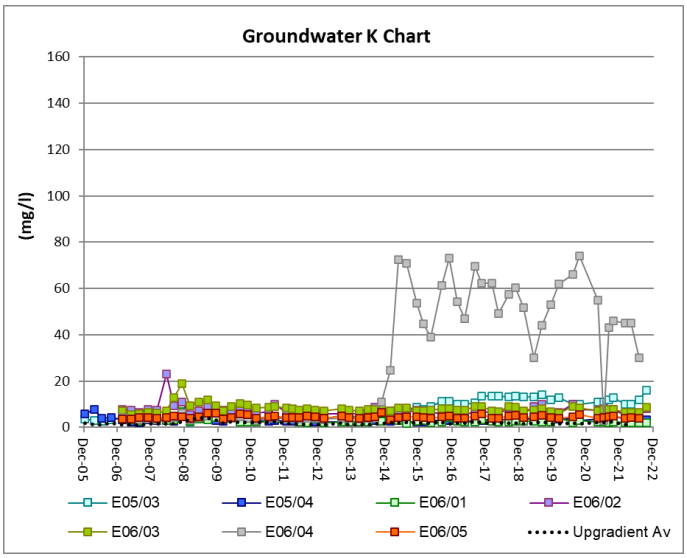

Surface Water Mg Chart
(mg/l)
DP2
SP
SW12

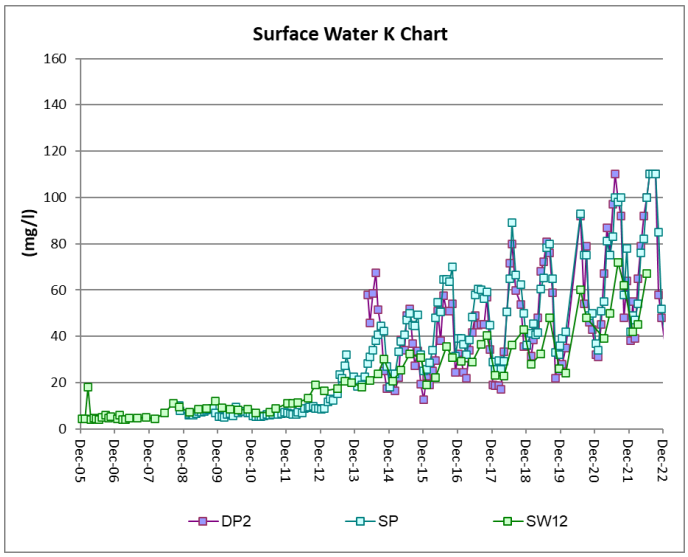

Groundwater Mn Chart
(µg/l)
E05/03
E05/04
E06/01
E06/02
E06/03
E06/04
E06/05
Upgradient Av

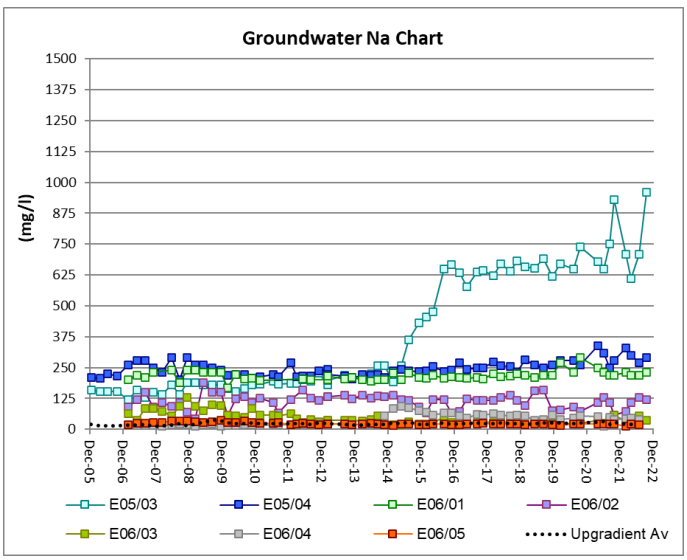

Surface Water Mn Chart
(µg/l)
DP2
SP
SW12

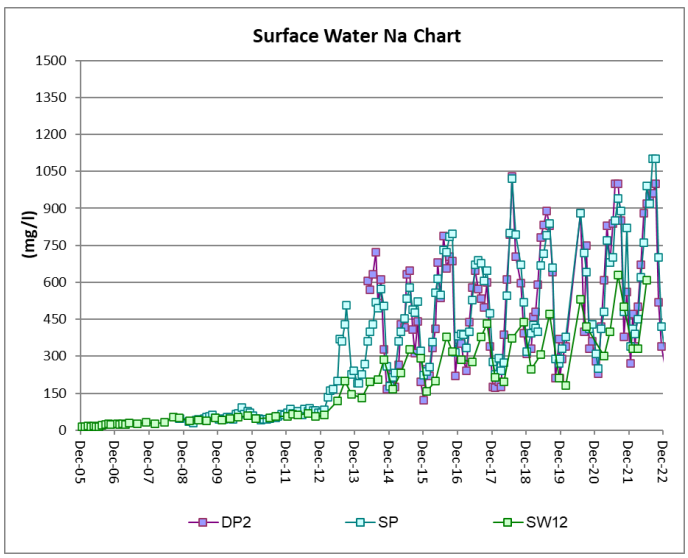

Groundwater Ni Chart
(µg/l)
E05/03
E05/04
E06/01
E06/02
E06/03
E06/04
E06/05
Upgradient Av

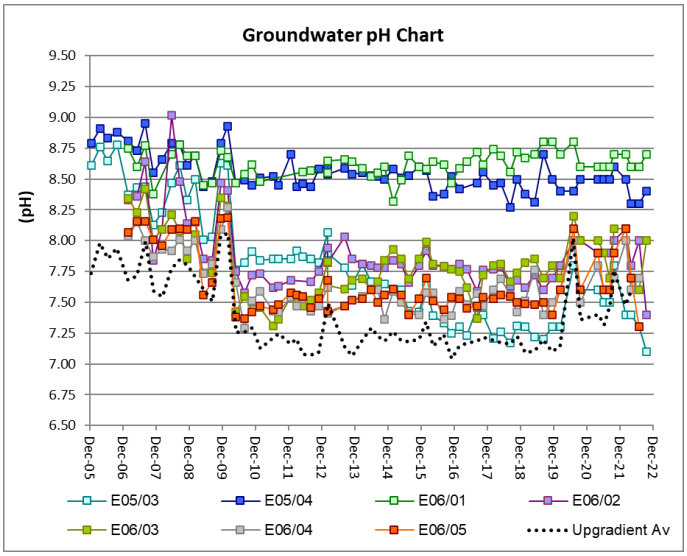

Surface Water Ni Chart
(µg/l)
DP2
SP
SW12

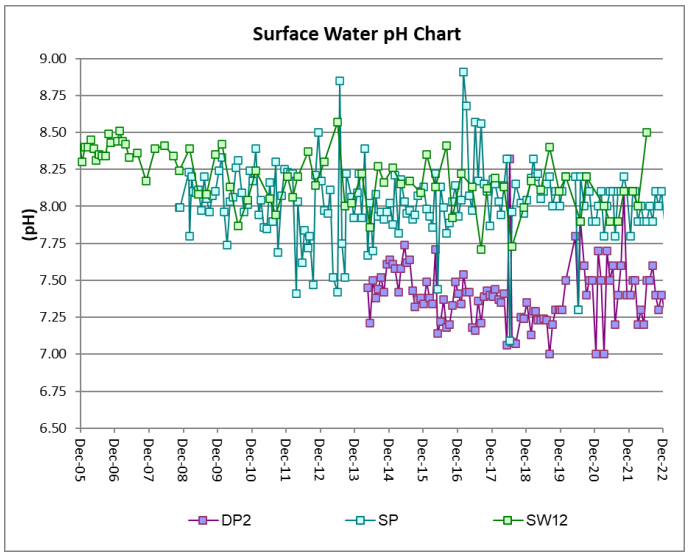

Groundwater K Chart
(mg/l)
E05/03
E05/04
E06/01
E06/02
E06/03
E06/04
E06/05
Upgradient Av

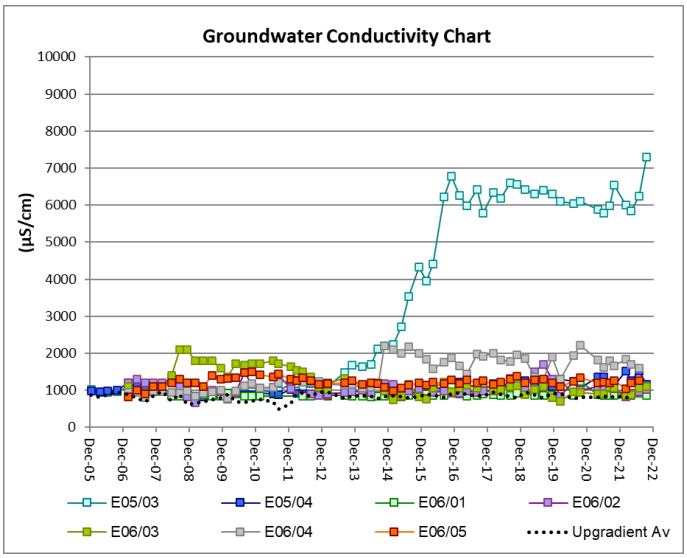

Surface Water K Chart
(mg/l)
DP2
SP
SW12

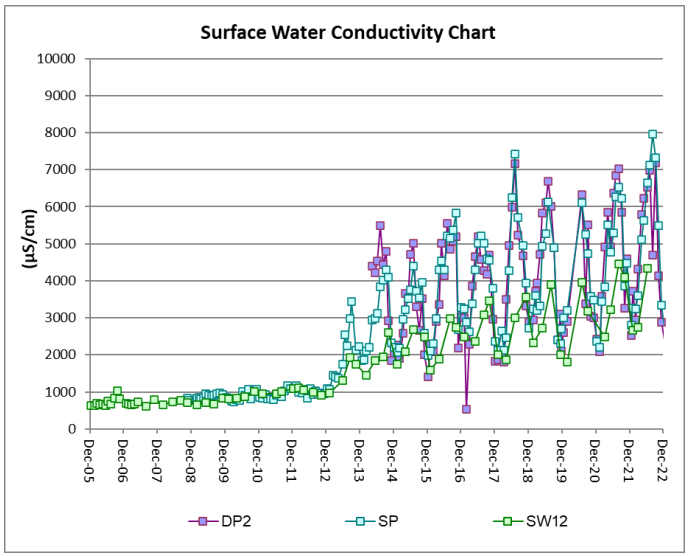

Groundwater Na Chart
(mg/l)
E05/03
E05/04
E06/01
E06/02
E06/03
E06/04
E06/05
Upgradient Av

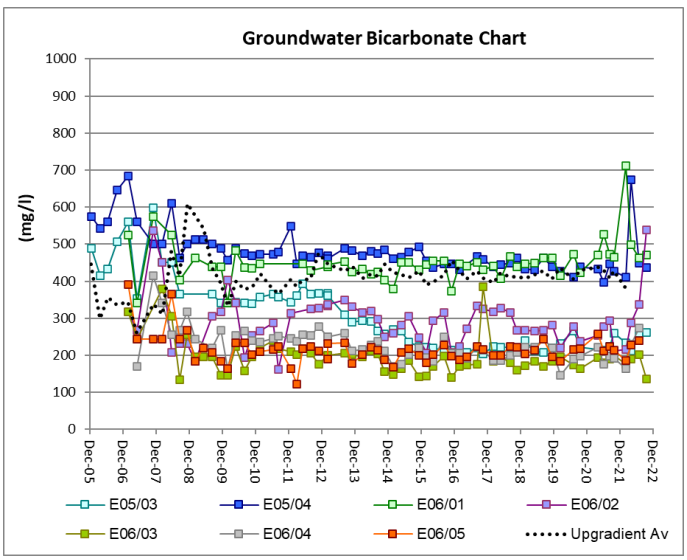

Surface Water Na Chart
(mg/l)
DP2
SP
SW12

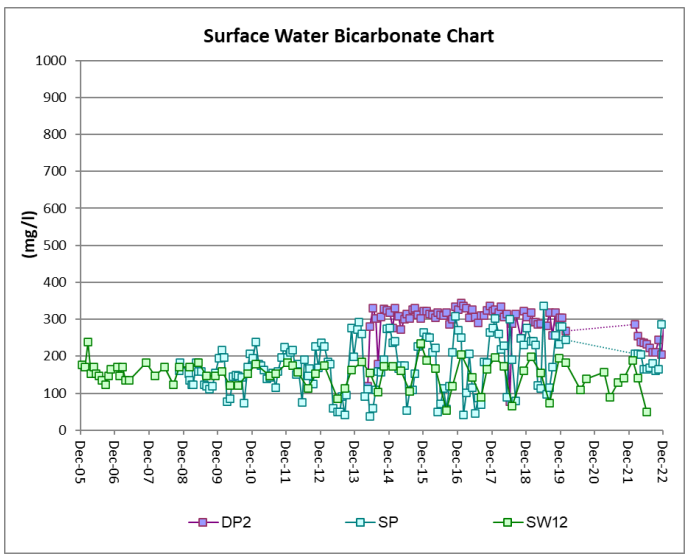

Groundwater pH Chart
(pH)
E05/03
E05/04
E06/01
E06/02
E06/03
E06/04
E06/05
Upgradient Av

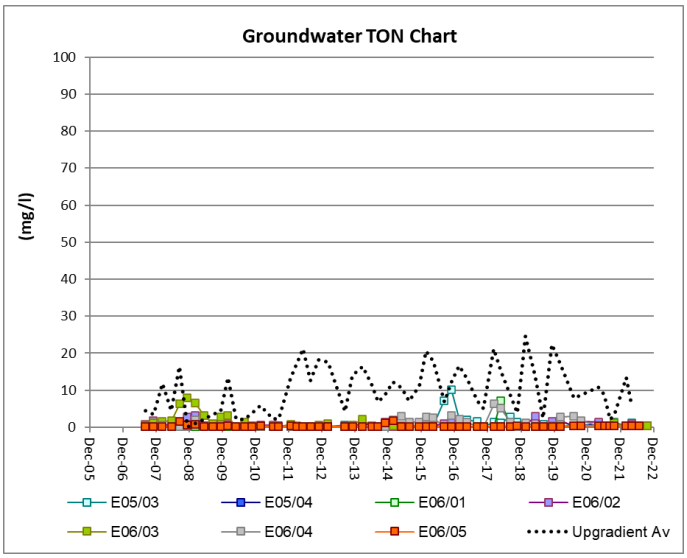

Surface Water pH Chart
(pH)
DP2
SP
SW12

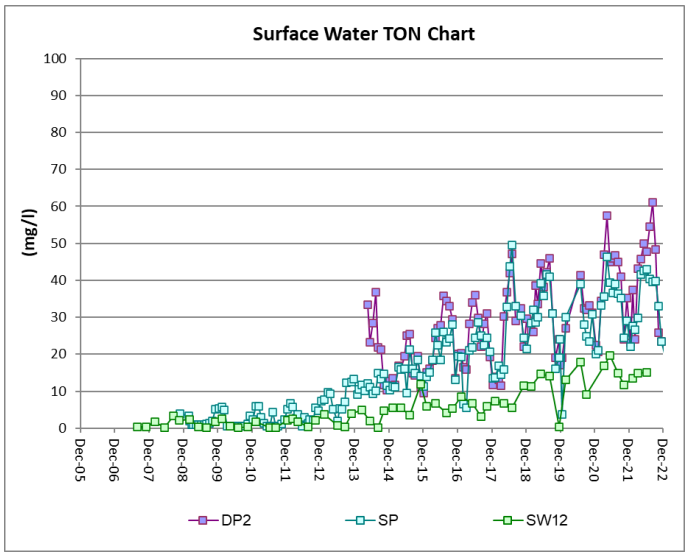

Groundwater Conductivity Chart
(µS/cm)
E05/03
E05/04
E06/01
E06/02
E06/03
E06/04
E06/05
Upgradient Av

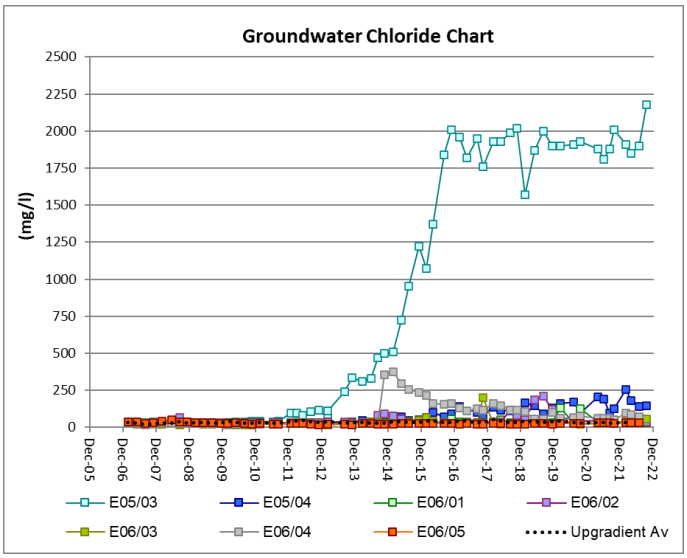

Surface Water Conductivity Chart
(µS/cm)
DP2
SP
SW12

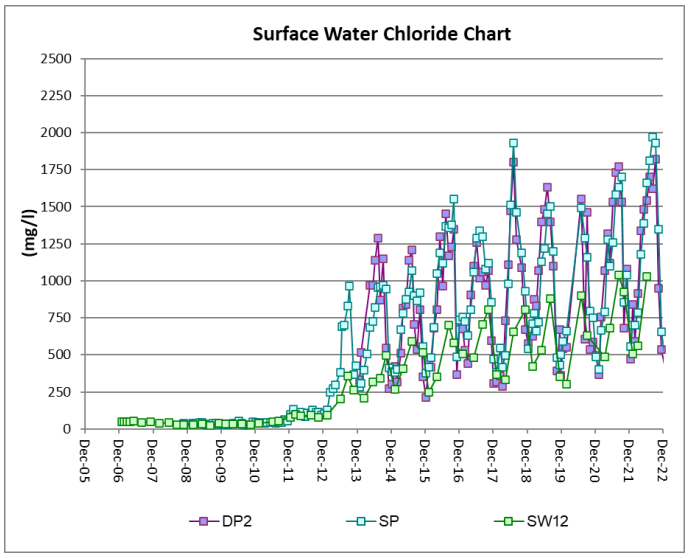

Groundwater Bicarbonate Chart
(mg/l)
E05/03
E05/04
E06/01
E06/02
E06/03
E06/04
E06/05
Upgradient Av

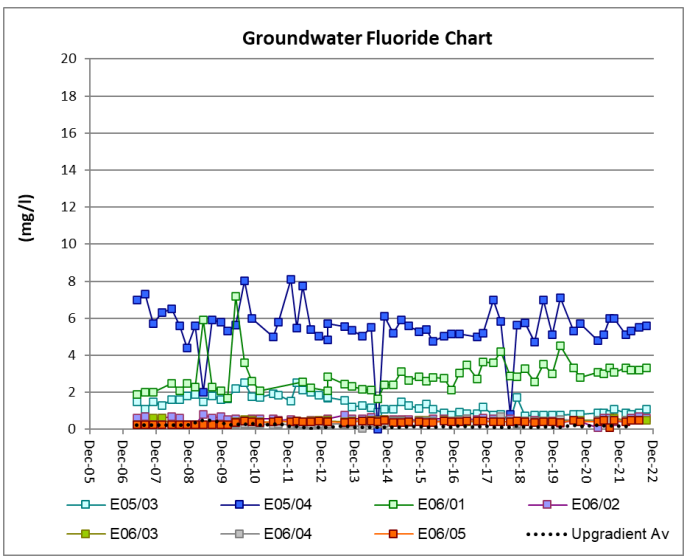

Surface Water Bicarbonate Chart
(mg/l)
DP2
SP
SW12

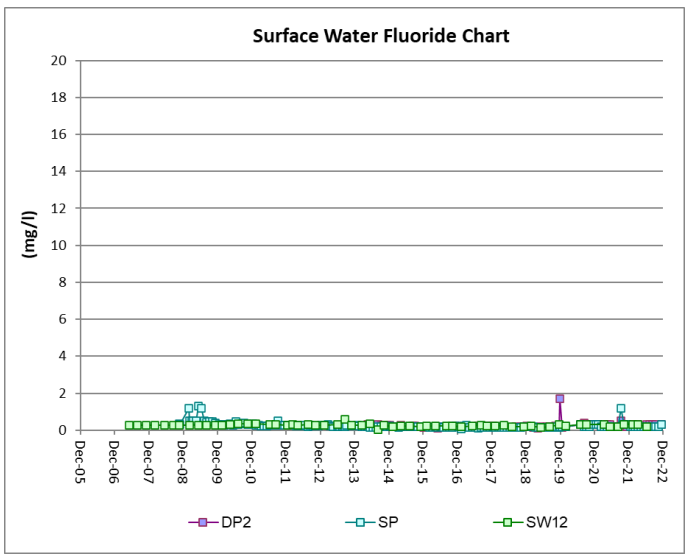

Groundwater TON Chart
(mg/l)
E05/03
E05/04
E06/01
E06/02
E06/03
E06/04
E06/05
Upgradient Av

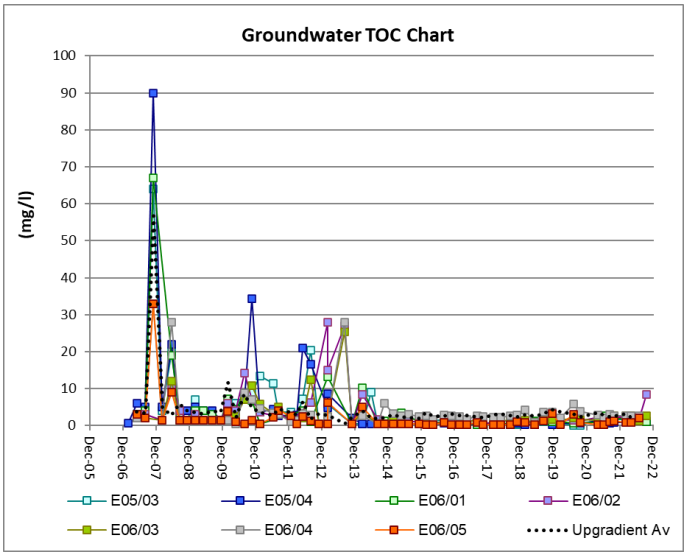

Surface Water TON Chart
(mg/l)
DP2
SP
SW12

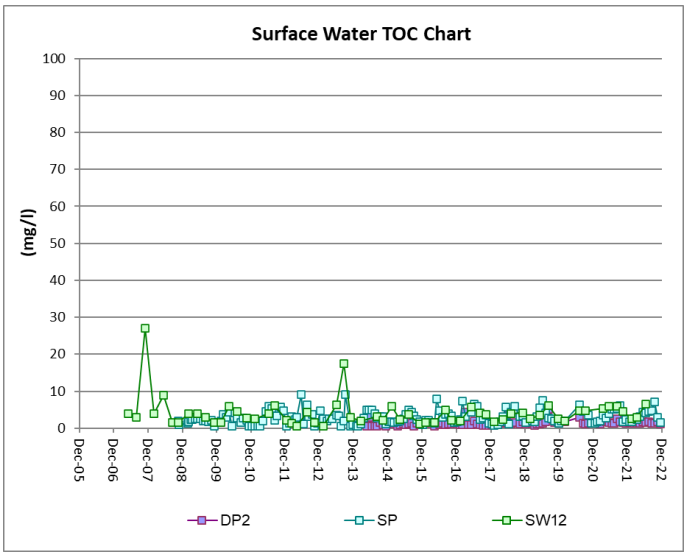

Groundwater Chloride Chart
(mg/l)
E05/03
E05/04
E06/01
E06/02
E06/03
E06/04
E06/05
Upgradient Av


Surface Water Chloride Chart
(mg/l)
DP2
SP
SW12


Groundwater Fluoride Chart
(mg/l)
E05/03
E05/04
E06/01
E06/02
E06/03
E06/04
E06/05
Upgradient Av


Surface Water Fluoride Chart
(mg/l)
DP2
SP
SW12


Groundwater TOC Chart
(mg/l)
100
90
80
70
60
50
40
30
20
10
0
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11
Dec-12
Dec-13
Dec-14
Dec-15
Dec-16
Dec-17
Dec-18
Dec-19
Dec-20
Dec-21
Dec-22
E05/03
E05/04
E06/01
E06/02
E06/03
E06/04
E06/05
Upgradient Av


Surface Water TOC Chart
(mg/l)
100
90
80
70
60
50
40
30
20
10
0
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11
Dec-12
Dec-13
Dec-14
Dec-15
Dec-16
Dec-17
Dec-18
Dec-19
Dec-20
Dec-21
Dec-22
DP2
SP
SW12