2023 Annual Performance Report

Aberthaw Quarry Ash Disposal Site

Permit Number: BP3339BH

February 2024

RWE
The energy to lead

Summary

This document gives details on the performance of Aberthaw Quarry Ash Disposal Site over 2023, as required by condition 4.2.1 of the site's Environmental Permit (EP), BP3339BH.

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1. Operational Update

Aberthaw Ash Disposal Site is a mono-fill landfill site solely utilised for the disposal of surplus Pulverised Fuel Ash (PFA) from Aberthaw Power Station. It was designed and constructed over 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.
- Phase 4, although consented, has never been developed or utilised for PFA disposal.

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.

Due to the early closure of Aberthaw Power Station, the final restoration plans for the Quarry have been reviewed by RWE. Predominantly this is because the approved filling levels and profiles can no longer be achieved due to the cessation of ash disposal at the site. A S73 application to the Planning Authority is expected to be made later this year. In line with the information received from NRW a permit variation will also be submitted to incorporate the proposed changes to the original pre-settlement contours and final landform.

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. Review of Results for Emission Monitoring

Four groundwater monitoring visits were undertaken by a specialist contractor during 2023:

- 13th March 2023 (Q1 Visit)
- 13th June 2023 (Q2 Visit)
- 19th August 2023 (Q3 Visit)
- 8th November 2023 (Q4 Visit)

Please note that Borehole E06/04 was unable to be sampled during 2023 due it being damaged by one of Tarmac's Heavy Vehicles during 2022. This borehole was replaced by E23/04 in late September 2023, and sampled for the first time in Q4 2023.

E05/03 (deemed unrepresentative by the latest HRA review) was also replaced in September 2023 (E23/03) and sampled for the first time in Q4 2023. The original E05/03 is being retained for comparison purposes (until it is decommissioned during the Phase 2 borehole replacement works in line with the Aberthaw Quarry CQA Plan) but for compliance reporting E23/03 is now being utilised.

2.1. Hydrogeological Risk Assessment HRA Review

A HRA review for the Aberthaw Quarry Site was undertaken by an external Specialist and submitted to NRW in October 2023. At the time of writing, the HRA is being reviewed with regard to the NRW comments received via CAR_NRW0043316

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. In total, there are 12 monitored borehole locations 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 (E23-03, 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 (E23-04 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
E23-03	Limestone	N	3 - 15	Downgradient Phase 1&2 Restored Area
E05-04	Limestone	N	2.5 - 20	Downgradient Phase 1&2 Restored Area
E06-01	Limestone	N	3 - 15	Downgradient Phase 1&2 Restored 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
E24-04	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 UKAS accredited laboratory for analysis of the samples.

Figure 1 shows the recorded groundwater elevations for the previous 18 years which vary between +17 (E05-03) to +35m OD (E09-02B). Upgradient groundwater elevations (dashed lines) are characterised by larger amplitude seasonal water level fluctuations with annual winter influxes of rainfall recharge. Downgradient groundwater elevations (solid lines) fluctuate only slightly due to the effect of dewatering from the Quarry which maintains groundwater at near-constant elevations.

Figure 1: Groundwater Hydrograph

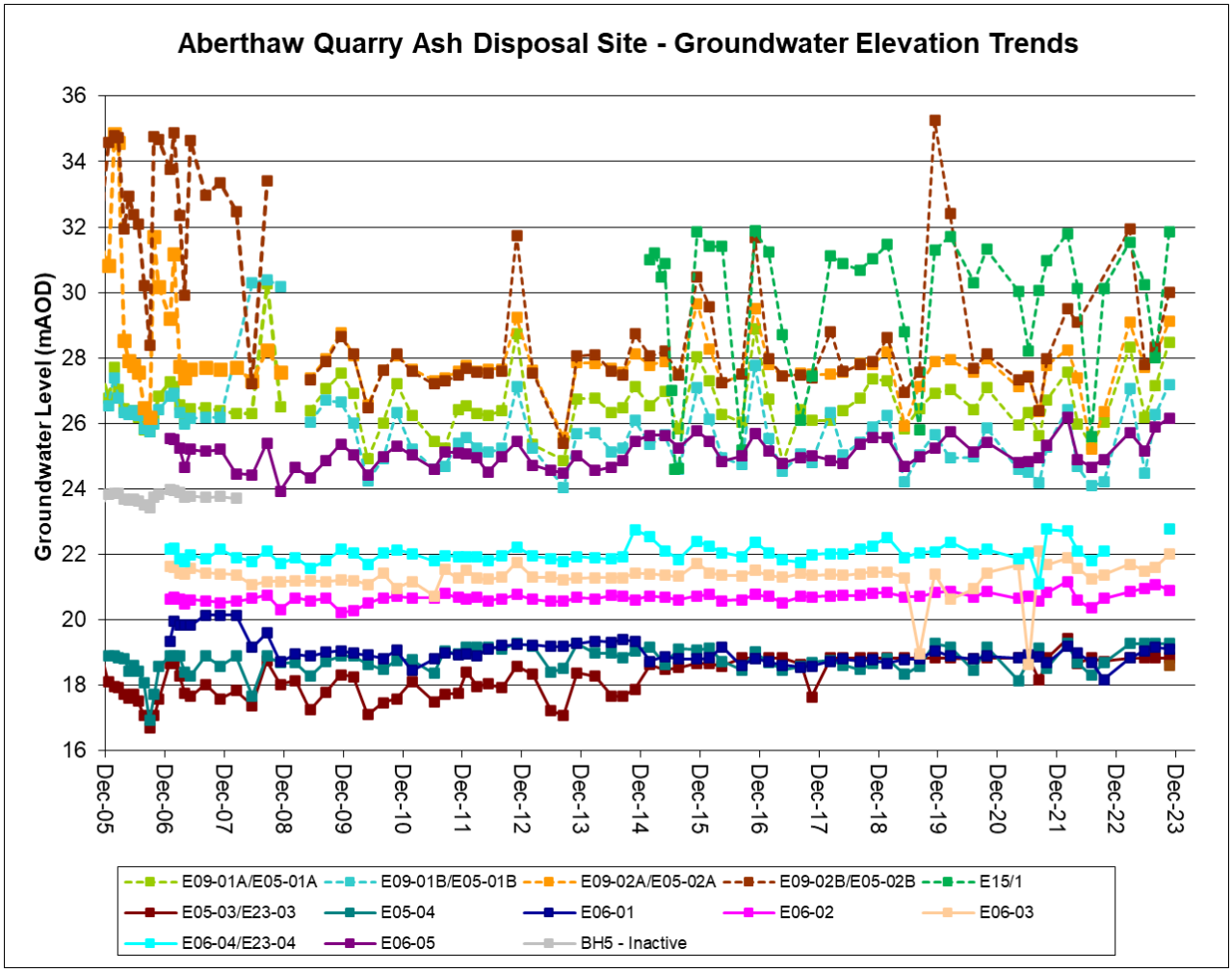
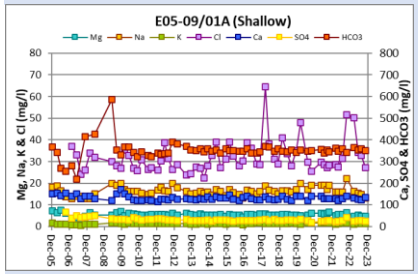


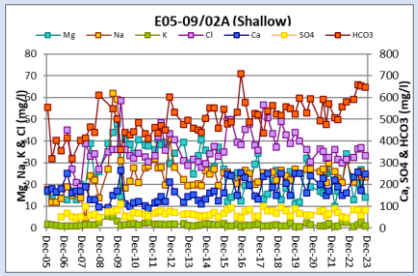
Figure 2 shows the general groundwater quality for the major ions in each of the site's boreholes. Natural groundwater quality varies between upgradient and downgradient locations. Calcium is depleted in some of the downgradient boreholes and correlates with elevated sodium, suggesting ion exchange reactions 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

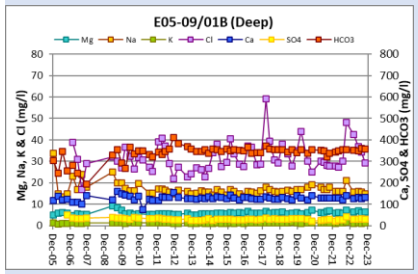
Upgradient Boreholes



All analytes low and concentrations remain relatively steady.



All analytes low but fluctuating.



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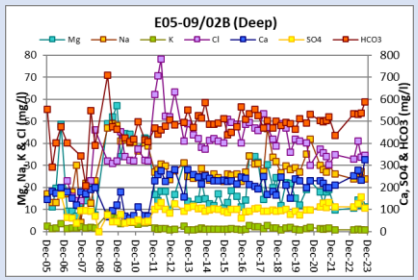
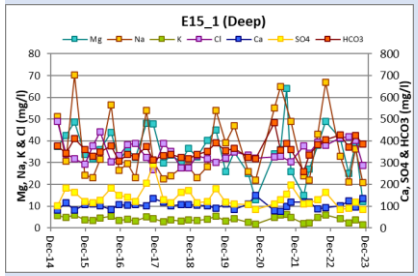
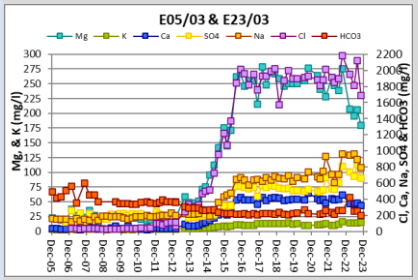


All analytes low but fluctuating.

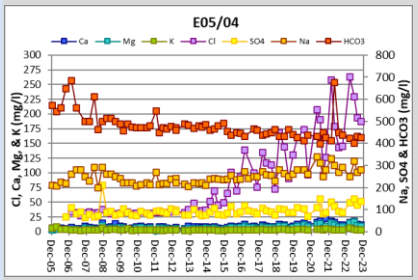


All analytes low but fluctuating.

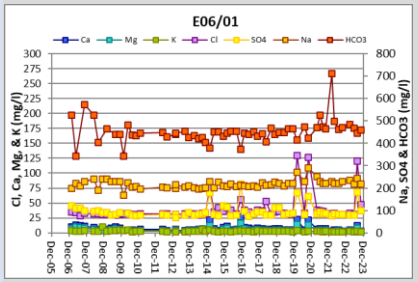
Downgradient Boreholes Phase 1/2



All analytes relatively steady since mid-2015. General drop in Mg & Cl during 2023.

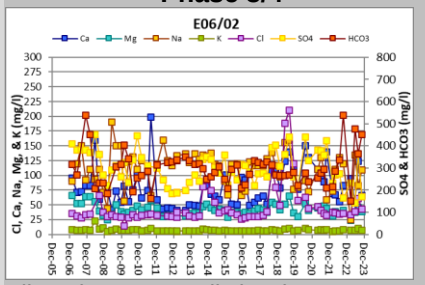


All analytes relatively steady, although Cl showing a gradual upwards trend since 2013.

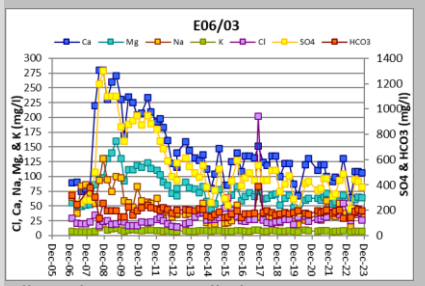


All analytes realtively steady.

Downgradient Boreholes Phase 3/4

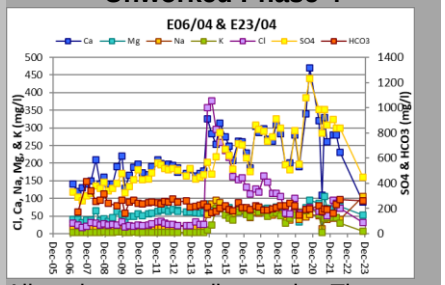


All analytes generally low but fluctuating.

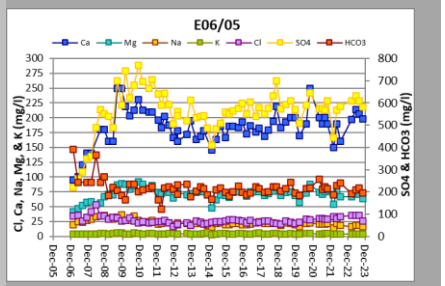


All analytes generally low, Mg, Ca & SO_4 showing a gradually decreasing trend.

Downgradient Boreholes Unworked Phase 4



All analytes generally steady. The gradual upwards trend of Ca & SO_4 has shown a recent 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/E23-03, 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 for information within Figure 3.

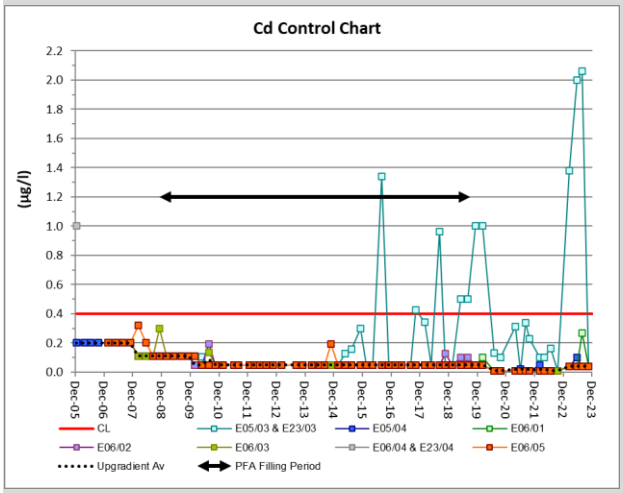
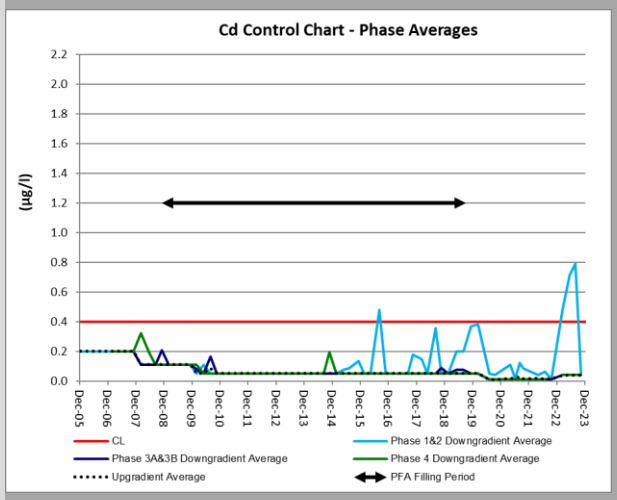
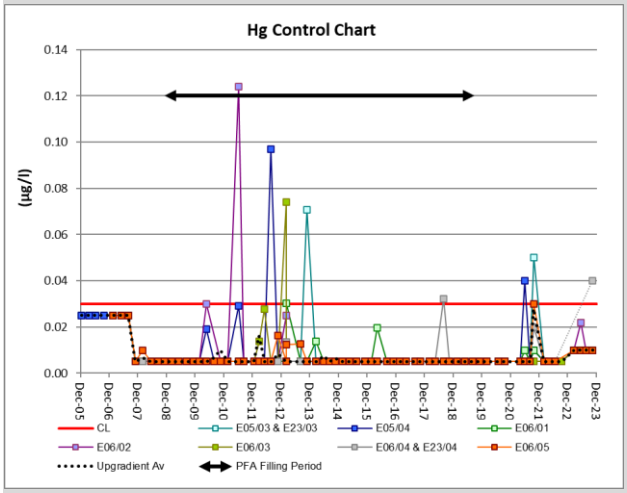
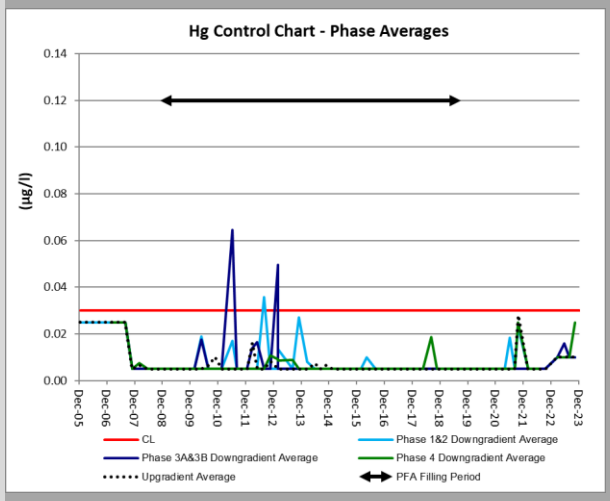
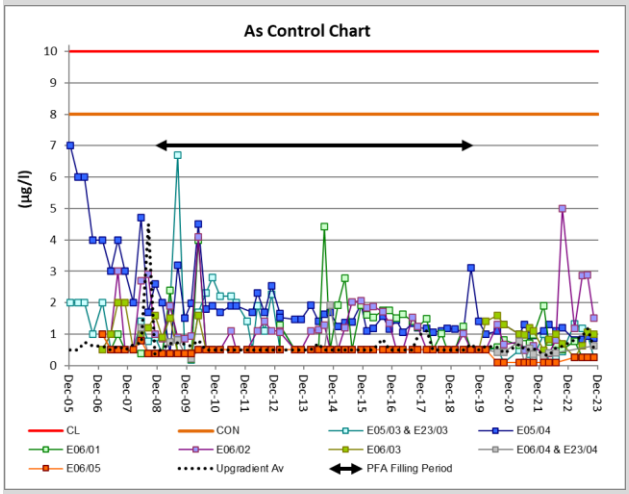
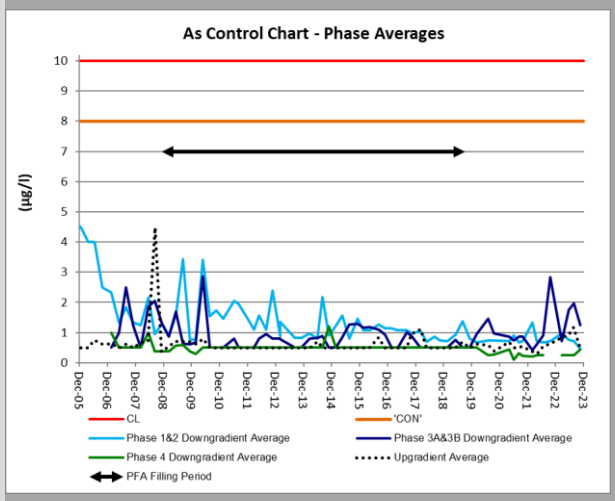
Please note that to prevent skewing of the parameter trends the dataset has continued to be managed in line with that previously set out in the 2021 Annual Report. All values reported by the accredited laboratory as less than the limit of detection (<LOD) have been substituted with values of half the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

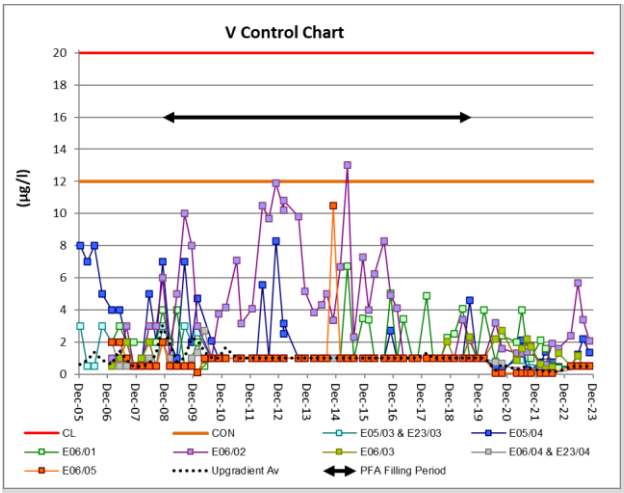
In 2023 the following should be noted:

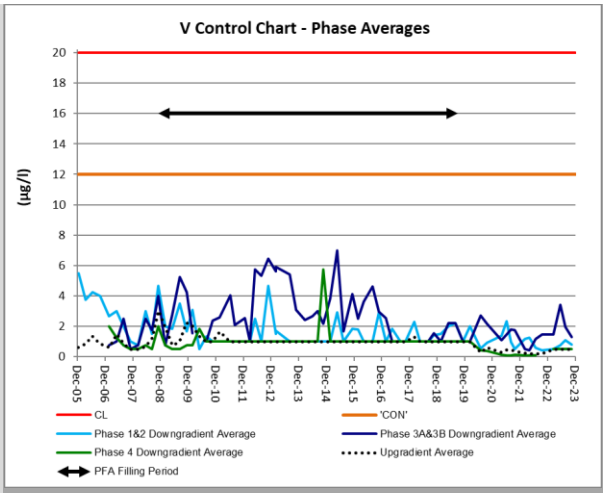
- Exceedance noted for E05-03 as three consecutive Cd results were received. Q4 result (for replacement borehole E23-03) was <LOD.
- There was a continued exceedance of the compliance limit and control level for Sulphate at borehole E05/03 and its replacement E23/03. The boreholes downgradient of the phase 4 area also consistently record elevated sodium.
- There was a continued exceedance of the compliance limit and control level for Molybdenum at borehole E05-03/E23-03. Borehole E05-04 also recorded all four rounds above the control limit, although the last two round were lower than those at the start of the year. E06-01 was below both limits during 2023 with the exception of the Q3 monitoring round where an elevated value of 216ug/l was recorded.
- A spurious Q2 Aluminium result for E06/02 (493ug/l) has been removed from the dataset as non-representative. The sampling contractor reported that the groundwater was significantly turbid following purging and that they were unable to filter the sample onsite at the time of sampling. They had highlighted that the external laboratory would need to filter the sample prior to testing, however this does not appear to have been undertaken. This was the only sample not filtered and the only one to record an elevated result an order of magnitude higher than historical values for its location. All other 2023 sampling rounds recorded values of <LOD (i.e. <10ug/l) for this location.

Figure 3: Control charts & Phase Averages for Down-gradient Groundwater boreholes

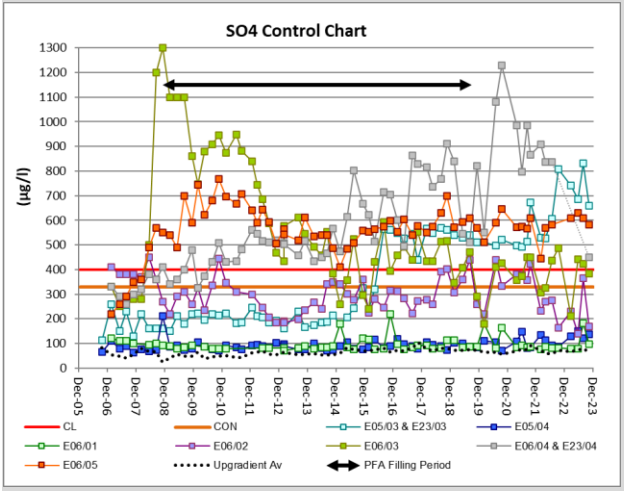
(CL – Compliance Limit, CON – Control Level)

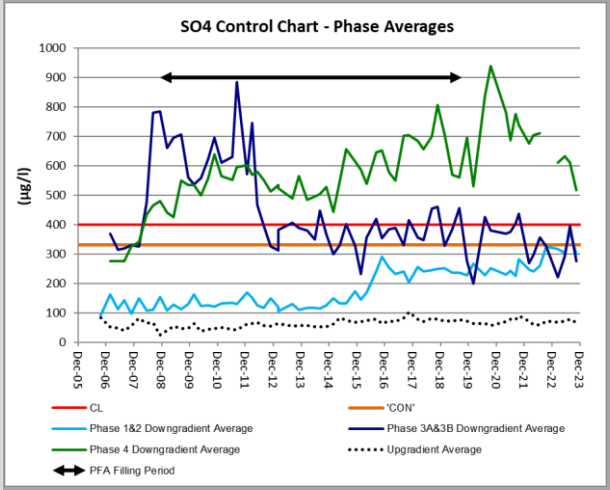
Down-gradient Boreholes against Up-gradient Average	*Down-gradient Site Phase averages*
	
Exceedance for E05-03 during 2023 as three consecutive results were recorded above the Cd compliance limit. All other locations within the Compliance Limit for the last year.	
	
All results within the Compliance Limit over the last year, with the exception of the E23/04 Q4 sample.	
	
All results within both the Compliance Limit & Control Level over the last year.	



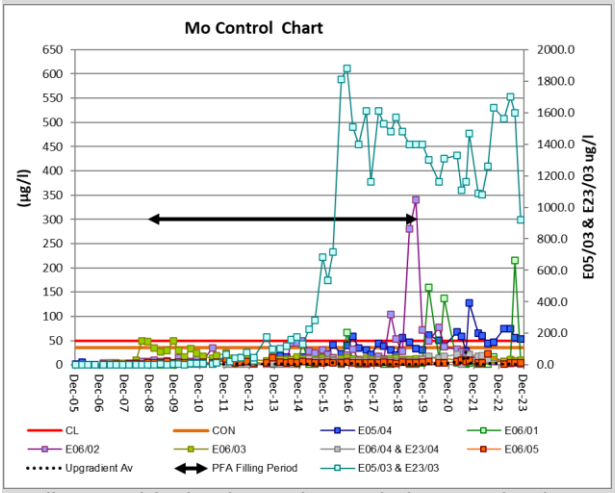


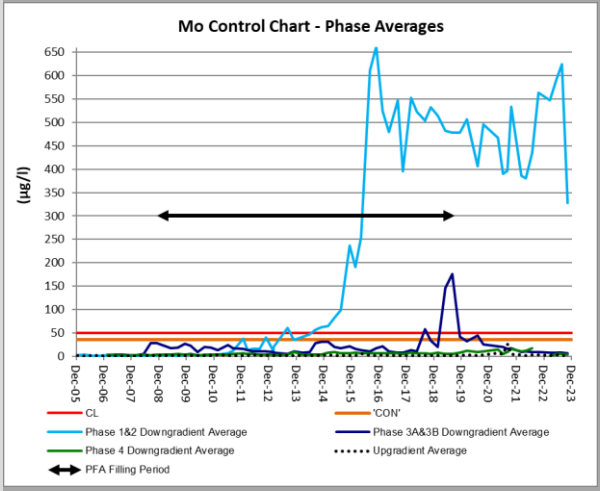
All results within both the Compliance Limit & Control Level over the last year.



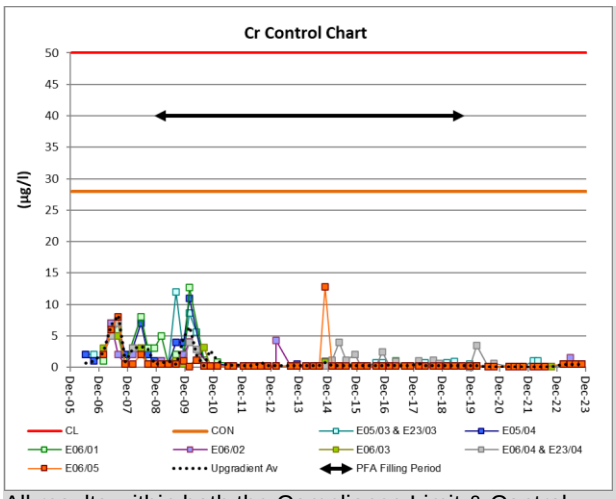


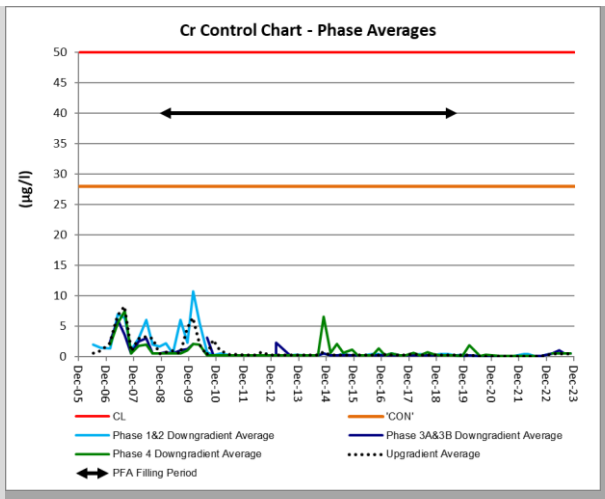
All trends generally steady, although E05/03 (& E23/03) remain consistently above the Compliance Limit. E06/03 and E06/05 also recorded results above the Control Level.



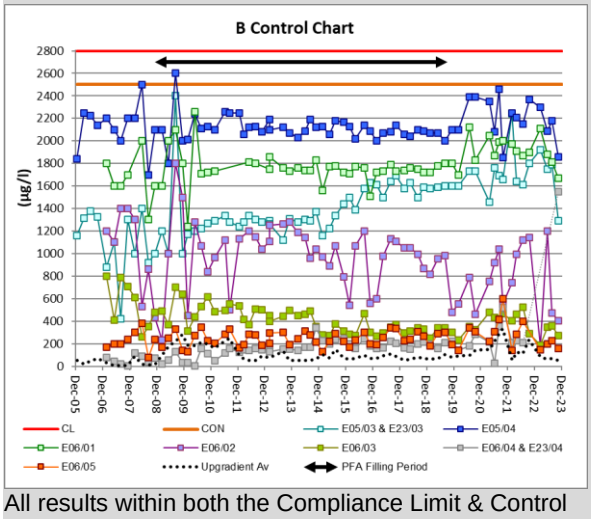


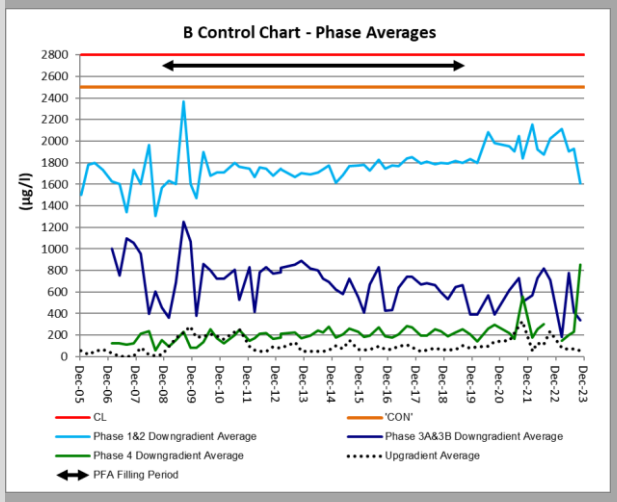
As discussed further in Section 2.2 below, E05/03 (& E23/03) have remained consistently over the Compliance Limit. E05/04 has also recorded results above the Control Level for all four quarters. Other locations remain consistently low.



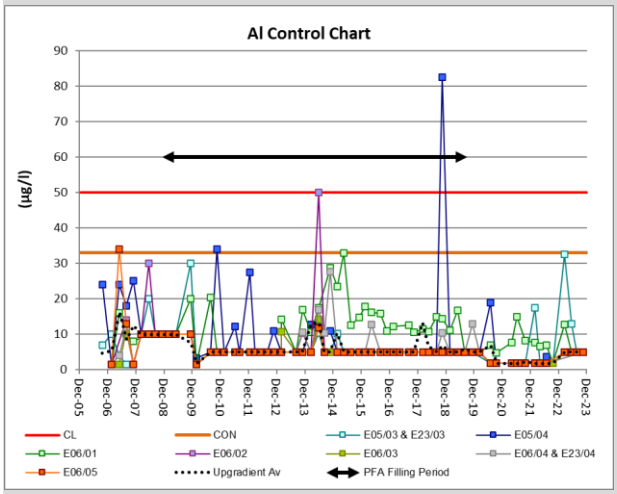


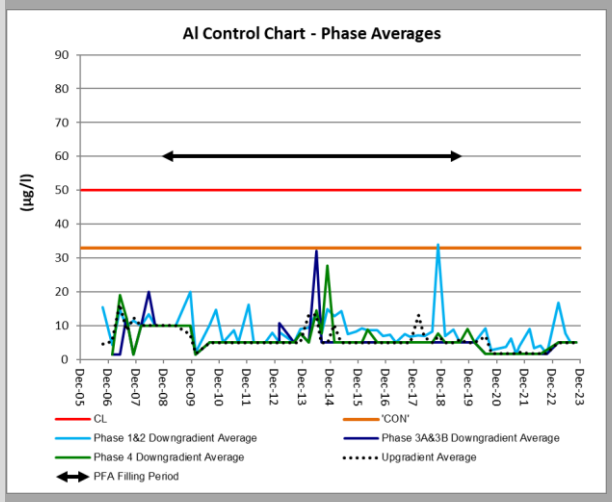
All results within both the Compliance Limit & Control Level over the last year.



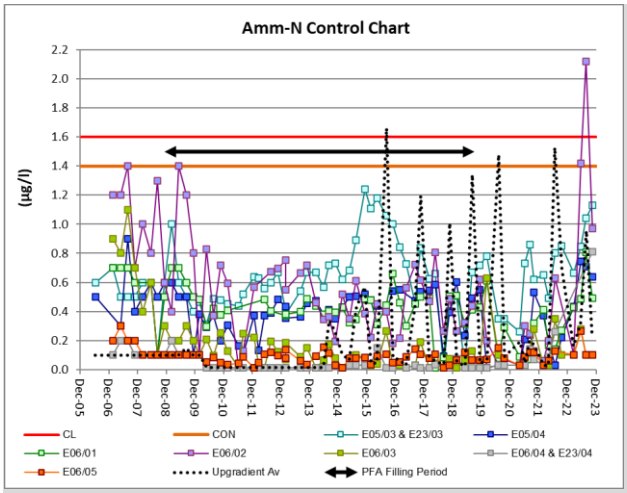


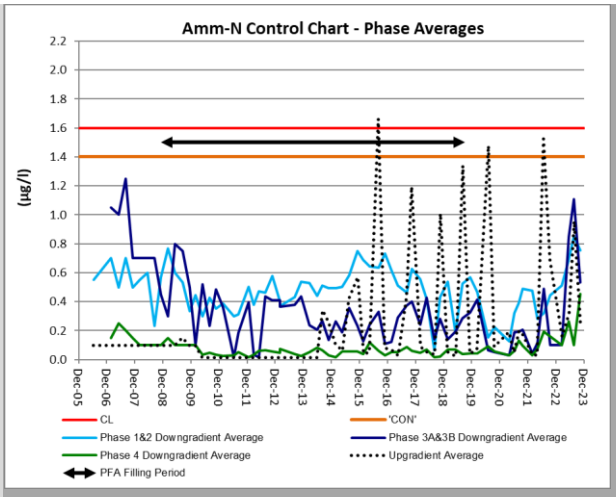
All results within both the Compliance Limit & Control Level over the last year.





All results within the Compliance Limit & Control Level over the last year. Q2 2023 spurious result for E06/02 (493ug/l) removed as non-representative.

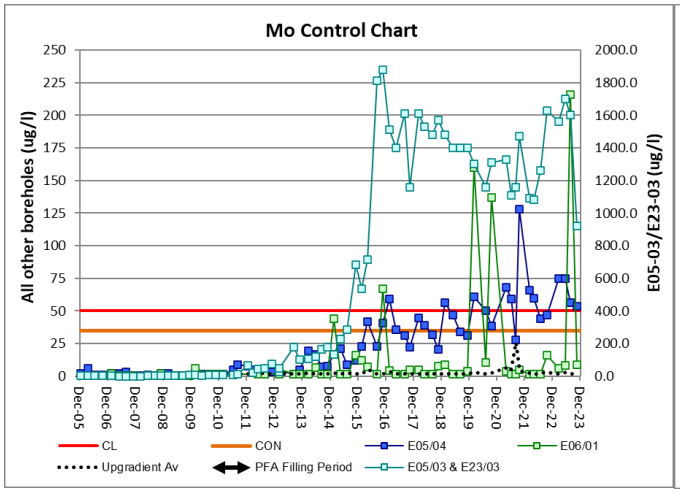


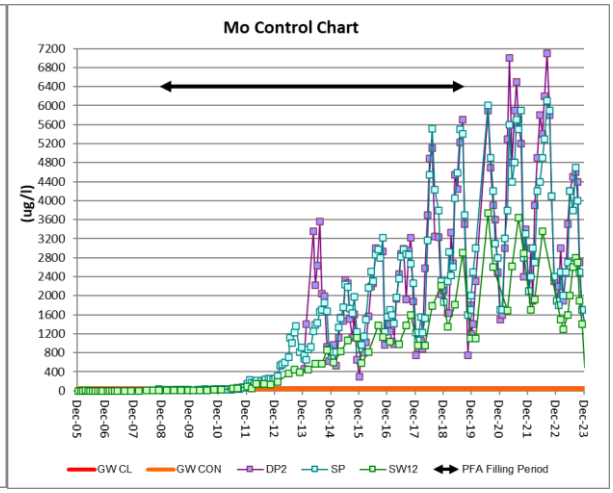


All results within the Compliance Limit & Control Level over the last year with the exception of E06/02.

Figure 4 shows the control chart for molybdenum for E05-03/E23-03 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 (n/b 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 site reviewed the subsequent data it appeared there was 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.

Despite the improvements, molybdenum concentrations continued to increase from the site, the biggest step change occurring from 2015 onwards, when Phase 3 was being actively filled. 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. Prior to 2015, the molybdenum concentrations in E06-01 consistently reflected the natural background concentrations, but since February 2015, results have been sporadically above this.

As in E05-03, molybdenum concentrations in the settlement ponds (SP) have been generally 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/E23-03 and E05-04 is noted.

A summary of the average groundwater quality for all monitoring parameters between 2006 and 2023 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 is some elevation of some key identified parameters potentially due to surface water contact with PFA surfaces.

The external contractor reported that the duplicate samples collected during 2023 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 (outside permit boundary)
Settlement Ponds (SP)	Final discharge from two concrete ponds collecting groundwater and surface water from the site.	South-west	Actual surface water discharge from the permitted area.
DP2	Surface water and groundwater drainage channel at base of Phase 1 and 2	West (within site)	Surface water sample within the site.

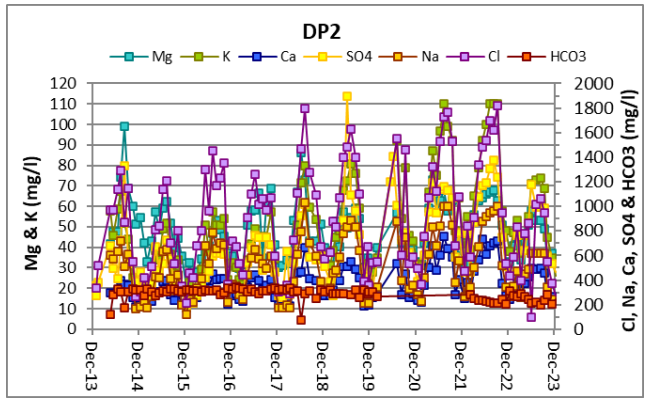
A proportion of the upstream and underlying groundwater will be collected by the site under-drainage layer and directed towards the two settlement ponds along with any water that, however unlikely, may have infiltrated through the PFA and the barrier/attenuation layer. Surface water from runoff is also 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

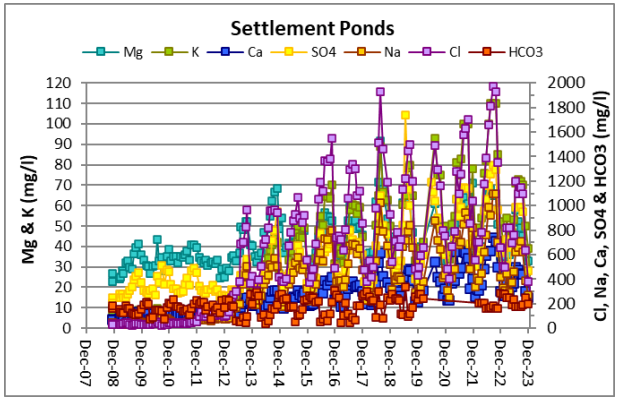
The surface water monitoring analytical suite contains a range of parameters which are reported in accordance with the Environmental Permit - a quarterly basis for SW12 and a monthly basis for the SP and DP2. Surface water samples are taken by trained in-house operatives and an independent external UKAS accredited laboratory is contracted 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 the five years preceding 2023.

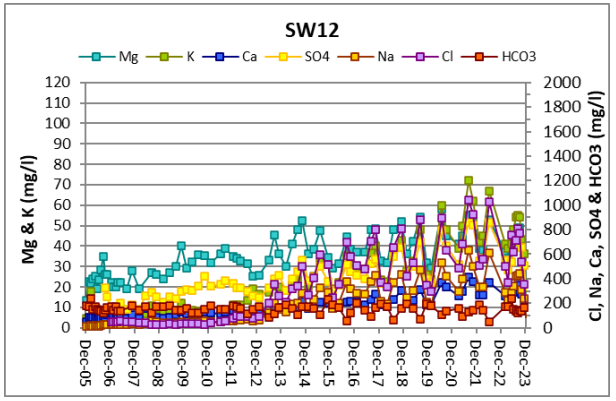
Figure 5: General Surface Water Quality Charts



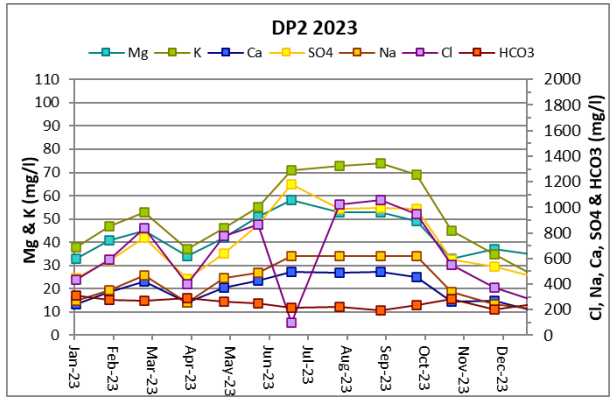
Fluctuations in SO4, Na & Cl with high concentrations in summer and low concentrations in winter.

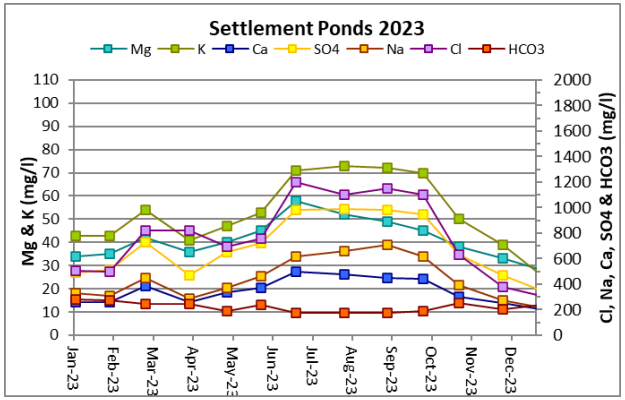


From 2013 fluctuations in Mg, K, Ca, SO4, Na & Cl with high concentrations in summer and low concentrations in winter.



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





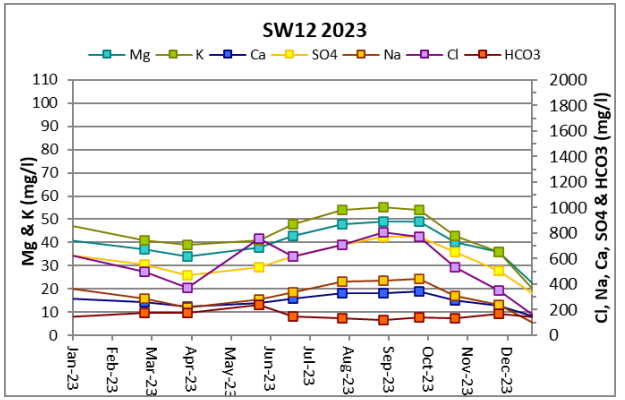


Figure 6 shows the surface water control charts. It should be noted that the compliance limits apply to the discharge from the settlement ponds whilst the control levels (where defined) apply to both the discharge from the settlement ponds and SW12. An exceedance is defined as a result above the compliance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

In 2023, there were no exceedances of the compliance limit or control level for any critical parameter, with the exception of:

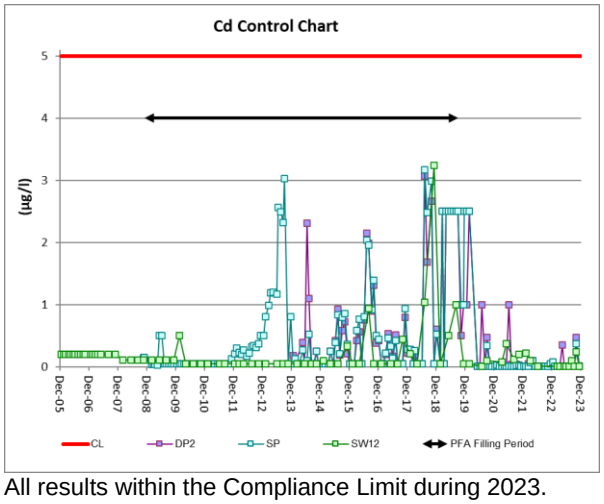
- Boron – All three locations recorded multiple results above the Control Level, however in terms of the DP Compliance Point only one result clipped the Compliance Limit (2,000ug/l in Q4). The DP2 peak (2,300ug/l) is consistent with last year, however the SW12 maximum has continued to reduce (1,200ug/l) compared to its peak (1,790ug/l) in 2020.
- Sulphate – all analysis results during 2023 for all three surface water locations were recorded above the Compliance Limit of 400mg/l.
- 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 lower, generally 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 PFA being slightly ammoniated. This may be the source of the elevated Ammonia levels observed at DP2 and SP.

In general, Figure 6 shows that there are no increasing trends in critical parameter concentrations except for sulphate, boron and ammoniated nitrogen, however all three parameters are showing a reduction when compared to 2022. 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.

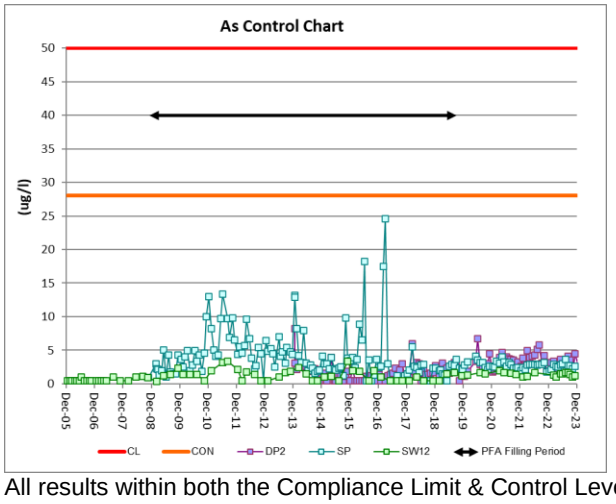
A summary of the average surface water quality between 2006 and 2023 is provided in Appendix B with a comparison of pre- and post-fill concentrations. The key trends in the data have been discussed above, however, it can be summarised that there may be some low-level contamination from surface water contact with PFA.

Figure 6: Surface Water Control Charts

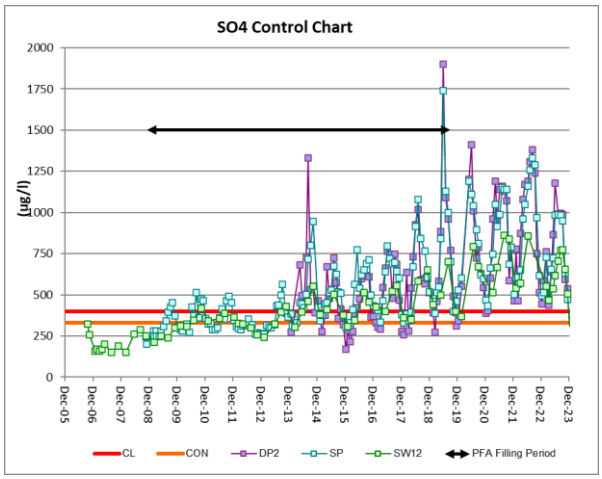
(CL – Compliance Limit, CON – Control Level)



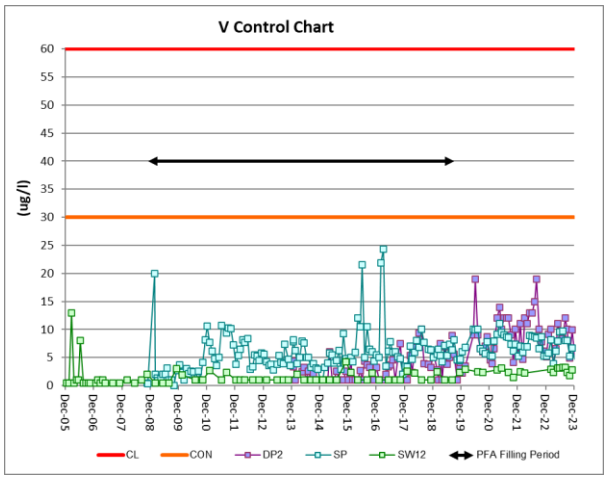
All results within the Compliance Limit during 2023.



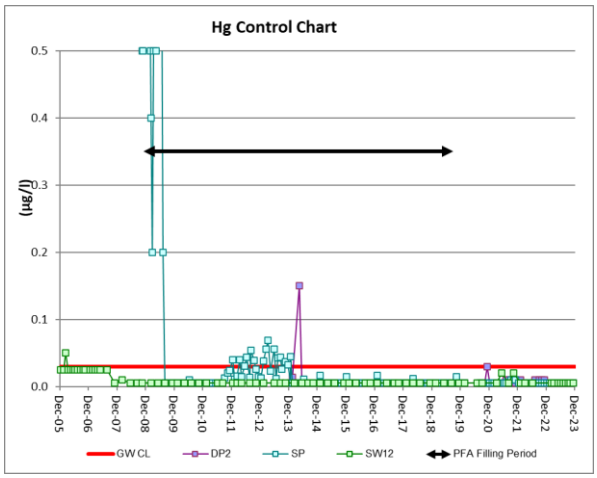
All results within both the Compliance Limit & Control Level during 2023.



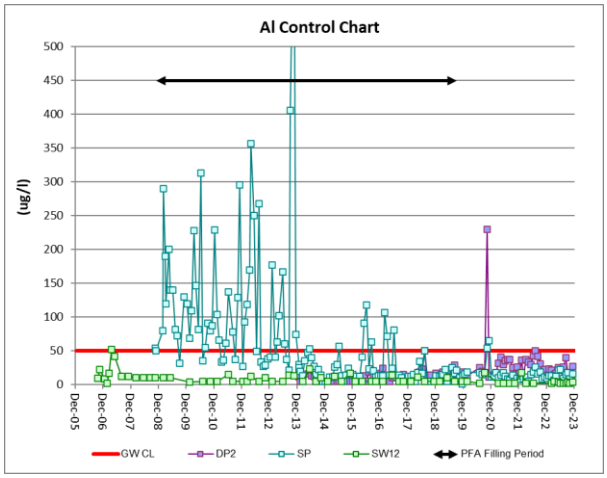
Elevated (seasonal) trends continue across all three locations consistently exceeding both target limits during 2023.



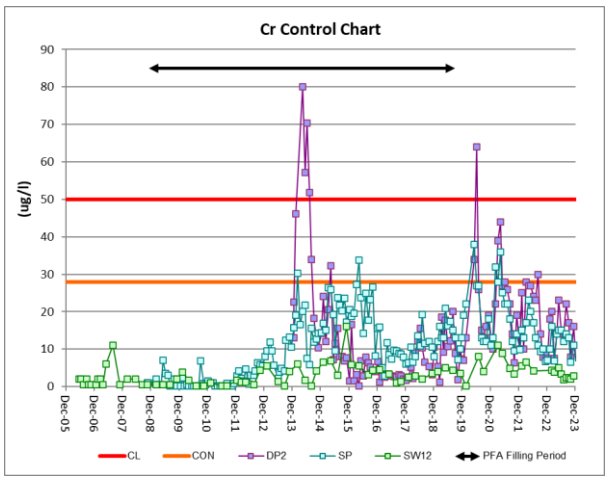
All results within both the Compliance Limit & Control Level during 2023.



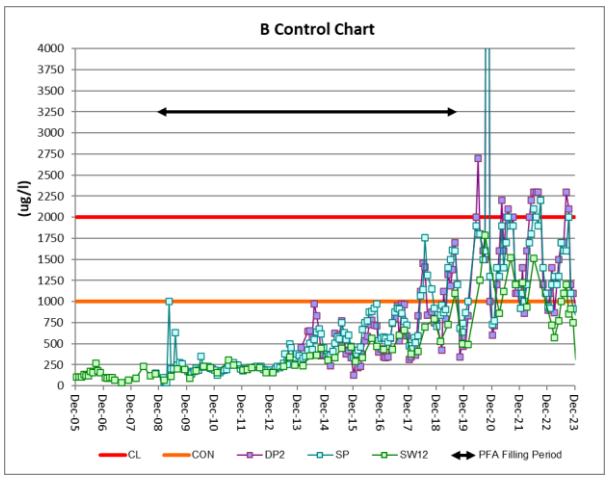
All results within the Groundwater Compliance Limit (applied for comparison) during 2023.



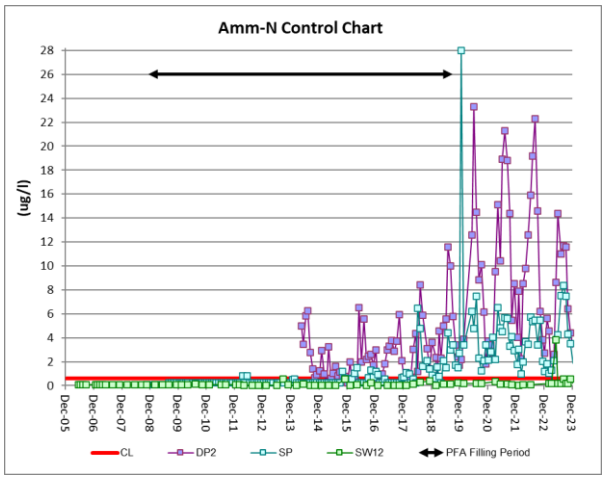
All results within Groundwater Compliance Limit (applied for comparison) during 2023 (n/b SP above scale Nov-13 peak = 736 ug/l).



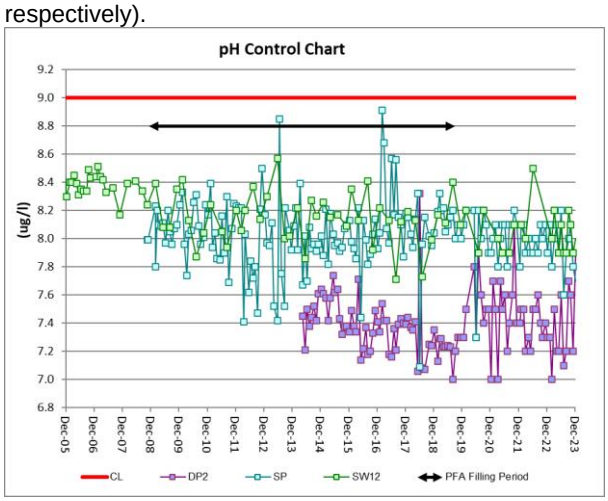
All results within both the Compliance Limit and Control Level during 2023.



SP Boron level clipped the Control Limit once during 2023. DP2 level consistent with previous year whilst SW12 has shown a reduction. (n/b DP2 & SP Nov-2020 peaks above scale = 13,000 & 10,000 ug/l respectively).



Ammonia remains variable and consistently above the Compliance Level within both the DP2 and the SP locations. SW12 remains within target with the exception of a single result in May 2023).



pH levels have remained generally consistent across all 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 2023.

5. Topographical Survey

The last site topographical survey was undertaken during 2020 to support the revised restoration profiles for the site. The 2020 topography of the site can be seen in Appendix C. However, due to the level of detail involved the plan is also provided as a separate file alongside this annual report for information. The 2020 levels were confirmed in 2023 by RPS.

6. Landfill Capacity

Table 6 below details the amount of PFA deposited at Aberthaw Quarry Ash Disposal Site during 2023 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 2023	Nil

7. Waste Acceptance Compliance Testing

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

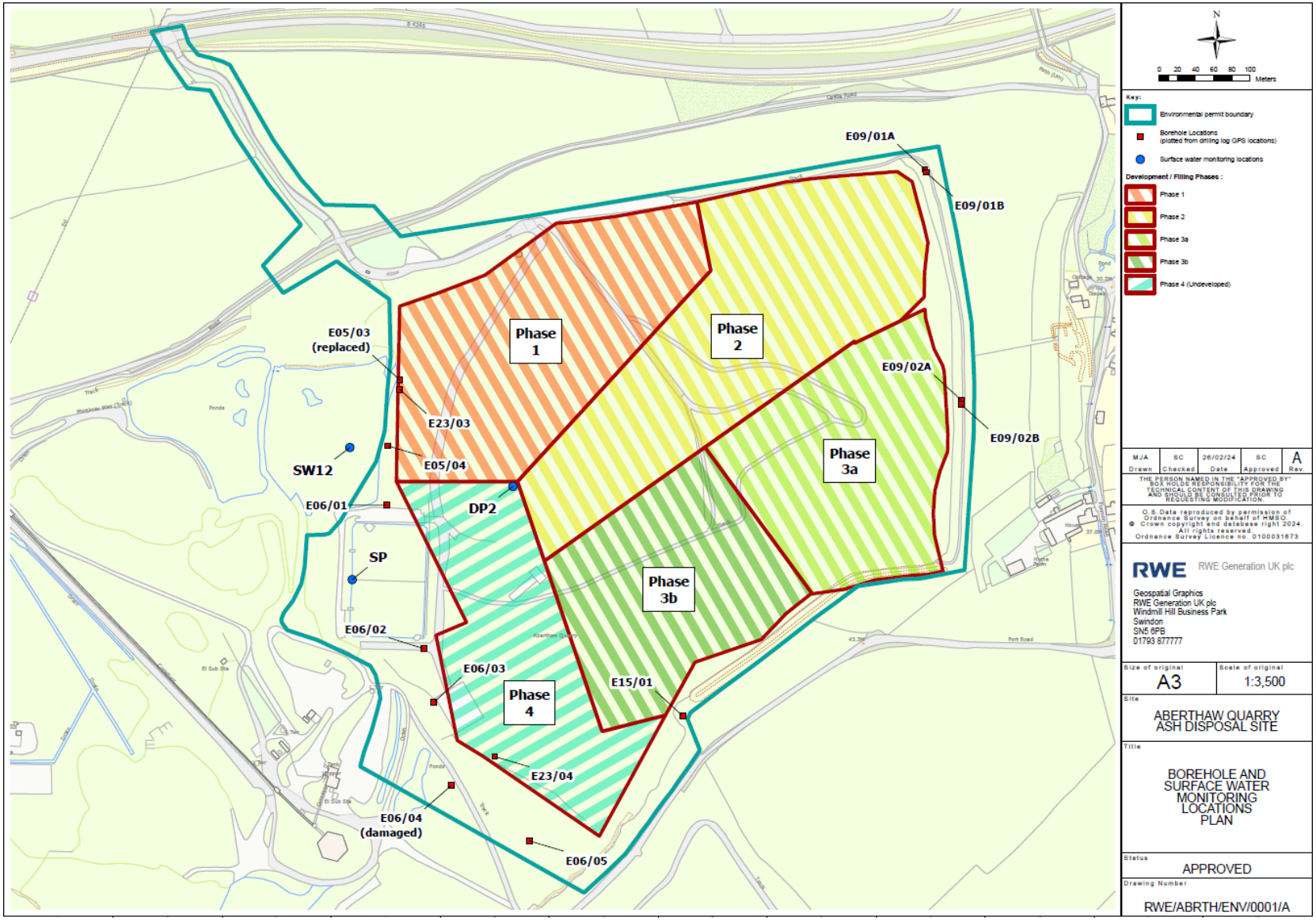
The exact composition of PFA was dependent upon the composition of the fuel utilised by Aberthaw Power Station. RWE has well established procedures which control the quality of fuel supplied to its stations.

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 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 2006-2023

	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]			5.8		0.9		0.6		102		0.07		151		0.9		2.7	
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			
Upgradient Groundwater			Average		Average		Average		Average		Average		Average		Average		Average	
E05-09_01A	Limestone	18-24	5.5		0.8		0.4		54.6		0.07		132.3		0.8		2.0	
E05-09_01B		24-30	6.3		0.8		0.4		53.1		0.06		128.3		0.7		1.3	
E05-09_02A		21-27	5.5		1.0		0.7		93.8		0.07		172.9		0.9		4.0	
E05-09_02B		27-33	5.4		1.0		0.7		140.2		0.07		198.2		1.2		4.7	
E15_1		17-29	4.8		0.6		0.9		226.6		0.04		105.6		0.2		1.5	
Downgradient Utilised Areas			Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill
E05_03 / E23_03	Limestone	3-15	8.0	6.2	2.1	0.8	1.2	0.9	1109	1468	0.18	0.26	37	231	2.8	0.8	6.5	1.6
E05_04		2.5-20	15.3	8.0	3.9	1.0	4.1	1.5	2123	2134	0.18	0.05	6	10	3.7	0.6	4.5	1.0
E06_01		3-15	9.3	11.1	2.9	0.9	0.6	1.0	1667	1797	0.17	0.05	10	7	4.3	0.7	0.8	1.0
E06_02		2-10	11.2	5.6	4.1	0.7	1.6	1.1	1113	921	0.16	0.05	89	78	2.4	0.5	4.8	1.3
Downgradient 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	398	0.16	0.05	131	143	2.9	0.3	1.8	1.5
E06_04 / E23_04		2-10	7.0	6.0	1.8	0.7	0.7	0.5	57	195	0.16	0.05	147	227	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	251	0.20	0.05	129	190	2.8	0.5	1.5	1.7
Downstream Surface Water			Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill	Prefill	Postfill
DP2 Phase 2 West				18.1		0.7		2.3		1086		0.47		367		15.4		2.9
Settlement Ponds			120.8	51.9	0.7	0.8	2.2	3.9	256	819	0.14	0.47	83	273	1.7	12.0	2.0	2.6
SW12 (Lafarge Lagoon)			15.7	6.4	2.1	0.6	0.7	1.4	124	586	0.18	0.19	86	212	1.8	3.6	1.4	2.6

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)

Compliance Location

	Aquifer	Response Zone Interval [1]	Fe		Mg		Mn		Hg		Mo		Ni		K		Se	
		m b GL	µg/l		mg/l		µg/l		µg/l		µg/l		µg/l		mg/l		µg/l	
Background - Limestone [2]			50		17.3		25.7		0.008		2.2		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																		
Upgradient Groundwater			Average		Average		Average		Average		Average		Average		Average		Average	
E05-09_01A	Limestone	18-24	22		6		5		0.008		1.4		1.4		1.3		0.6	
E05-09_01B	Limestone	24-30	25		6		5		0.009		1.6		1.1		1.3		0.7	
E05-09_02A	Limestone	21-27	114		26		43		0.008		1.7		3.6		1.7		0.9	
E05-09_02B	Limestone	27-33	49		21		23		0.008		1.8		5.0		2.0		0.9	
E15_1	Limestone	17-29	41		35		86		0.007		7.1		1.3		4.0		0.6	
Downgradient Utilised Areas			**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**
E05_03 / E23_03	Limestone	3-15	38	68	24	147	11	45	0.018	0.007	1.1	746	2.2	1.7	3.5	8.5	0.9	0.5
E05_04	Limestone	2.5-20	42	17	4	7	6	5	0.018	0.008	1.8	27.7	2.3	0.7	3.7	3.1	1.3	0.8
E06_01	Limestone	3-15	53	15	7	5	1	8	0.015	0.006	0.8	15.0	0.8	0.7	3.2	2.8	1.0	0.6
E06_02	Limestone	2-10	89	28	56	40	18	8	0.014	0.008	2.9	29.6	4.3	1.5	9.9	7.1	1.6	0.7
Downgradient 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	17	62	77	10	11	0.014	0.007	10.9	15.3	4.9	2.5	7.3	8.1	4.9	1.4
E06_04 / E23_04	Limestone	2-10	59	21	42	63	5	25	0.014	0.007	2.5	6.9	4.2	4.2	3.7	29.7	2.3	0.6
E06_05	Limestone	2-8	41	21	52	74	6	11	0.014	0.006	2.0	5.7	3.8	1.9	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				14		47		41		0.007		2767		13.8		49.5		20.2
Settlement Ponds			20	32	30	44	3	11	0.392	0.010	19.8	1973	8.5	9.7	7.4	39.1	7.4	14.0
SW12 (Lafarge Lagoon)			33	16	24	40	2	9	0.020	0.006	4.0	1220	2.2	4.5	6.1	30.6	1.5	5.2

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)

Compliance Location

	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		827		412		64		0.24		10.1	
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			
Upgradient Groundwater			Average		Average		Average		Average		Average		Average		Average		Average	
E05-09_01A	Limestone	18-24	16		0.8		7.4		669		351		32		0.04		5.4	
E05-09_01B	Limestone	24-30	17		0.8		7.4		660		340		31		0.04		4.9	
E05-09_02A	Limestone	21-27	24		0.9		7.2		942		503		68		0.56		11.6	
E05-09_02B	Limestone	27-33	29		1.1		7.2		1067		482		91		0.38		24.8	
E15_1	Limestone	17-29	36		0.8		7.6		815		358		138		0.22		2.2	
Downgradient Utilised Areas			**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**
E05_03 / E23_03	Limestone	3-15	149	463	1.5	1.0	8.5	7.6	977	3886	462	275	178	384	0.51	0.65	0.2	0.7
E05_04	Limestone	2.5-20	241	251	4.2	1.7	8.8	8.5	1010	1072	564	462	79	96	0.53	0.38	0.3	0.2
E06_01	Limestone	3-15	215	219	2.2	1.8	8.7	8.6	923	900	473	450	106	95	0.57	0.40	0.5	0.4
E06_02	Limestone	2-10	109	112	1.7	4.2	8.4	7.8	1214	1035	336	291	390	290	1.09	0.50	0.8	0.6
Downgradient 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	41	1.1	1.1	8.2	7.8	1224	1193	276	189	443	552	0.66	0.12	2.3	0.7
E06_04 / E23_04	Limestone	2-10	17	41	0.8	0.9	8.0	7.6	930	1490	290	222	320	623	0.13	0.06	0.2	0.9
E06_05	Limestone	2-8	27	23	1.0	1.0	8.1	7.6	1063	1246	289	208	363	585	0.17	0.08	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				504		5.4		7.4		3984		287		658		5.44		29.0
Settlement Ponds			43	388	2.9	6.2	8.1	8.0	864	3089	144	179	292	573	0.13	1.66	1.7	18.1
SW12 (Lafarge Lagoon)			26	252	1.4	1.8	8.4	8.1	710	2285	161	148	214	481	0.10	0.20	1.2	7.0

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)

Compliance Location

	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]			10.9		35		0.2		4.1		0.18	
Background - Seawater [3]					16300		1.3					
GW EQS/DWL			50		250		1.5				3.4	
GW MRV												
Groundwater CL												
Surface Water CL												
Upgradient Groundwater			**Average**		**Average**		**Average**		**Average**		**Average**	
E05-09_01A	Limestone	18-24	8.6		32		0.1		3.2		0.18	
E05-09_01B	Limestone	24-30	5.6		32		0.1		2.7		0.18	
E05-09_02A	Limestone	21-27	12.5		37		0.2		4.5		0.18	
E05-09_02B	Limestone	27-33	23.5		40		0.2		5.9		0.20	
E15_1	Limestone	17-29	2.0		35		0.3		2.1		0.10	
Downgradient Utilised Areas			**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**
E05_03 / E23_03	Limestone	3-15	0.3	0.8	33	1074	1.4	1.3	15.9	2.6		0.17
E05_04	Limestone	2.5-20	0.8	0.2	31	90	6.4	5.3	18.6	2.9		0.17
E06_01	Limestone	3-15	0.2	0.4	33	40	2.1	3.0	19.2	2.2		0.17
E06_02	Limestone	2-10	0.6	0.6	38	48	0.6	0.5	4.3	3.4		0.18
Downgradient 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	2.4		0.17
E06_04 / E23_04	Limestone	2-10	0.5	0.6	26	88	0.3	0.4	11.3	3.2		0.23
E06_05	Limestone	2-8	3.3	0.2	37	26	0.3	0.4	8.3	1.2		0.20
Downstream Surface Water			**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**
DP2 Phase 2 West				19.1		882		0.2		1.4		0.01
Settlement Ponds			0.6	11.9	35	685	0.6	0.2	2.0	2.9		0.01
SW12 (Lafarge Lagoon)			5.0	5.4	40	433	0.3	0.3	6.1	3.7		0.28

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

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

Over Compliance Limit

Above DWS / EQS

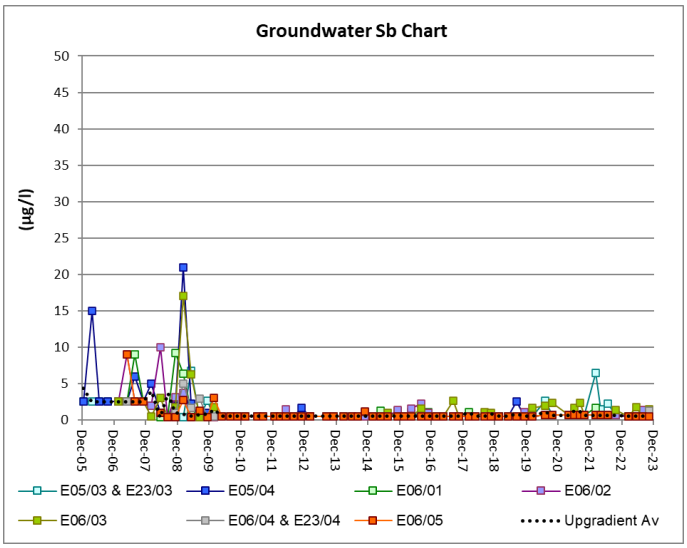
Above Background by >25% (GW)

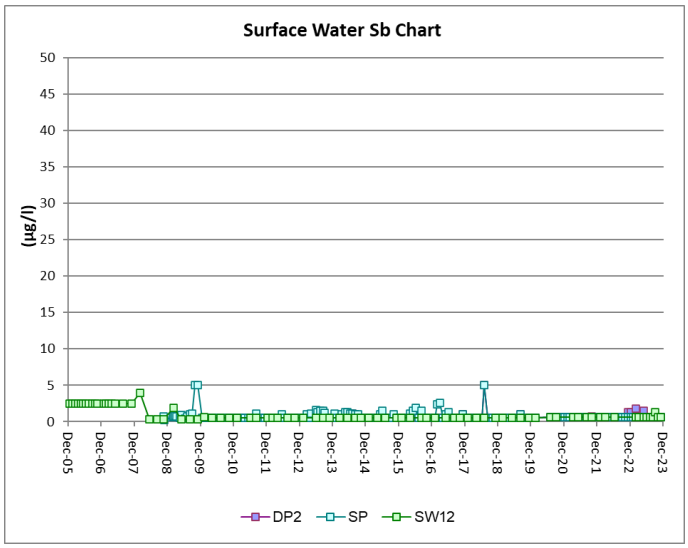
Compliance Location

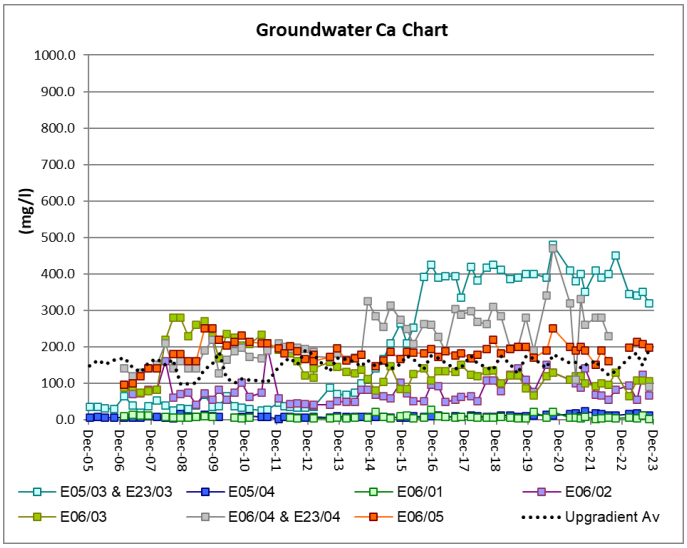
Appendix C. Topographical Survey 2023

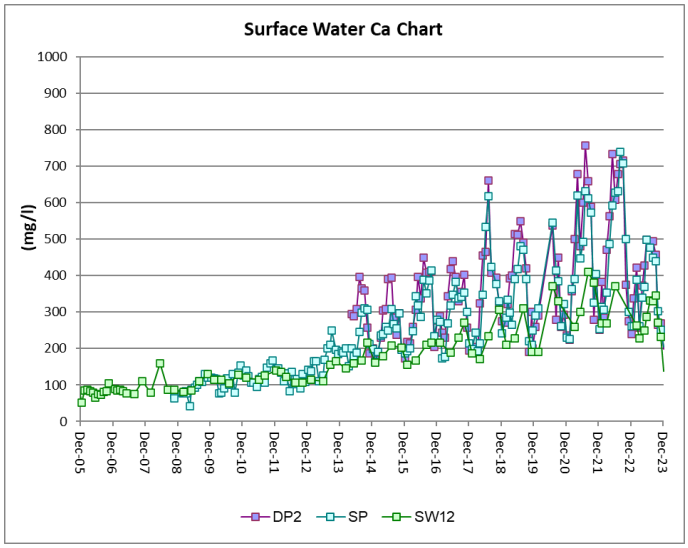
(Due to the size/detail of the topographical plan it has also been provided separately with the 2023 Annual Report).

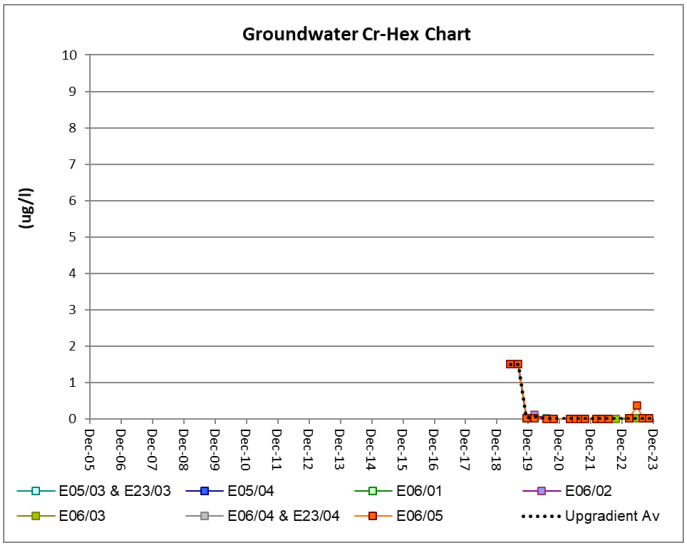
Appendix D. Other monitored parameters

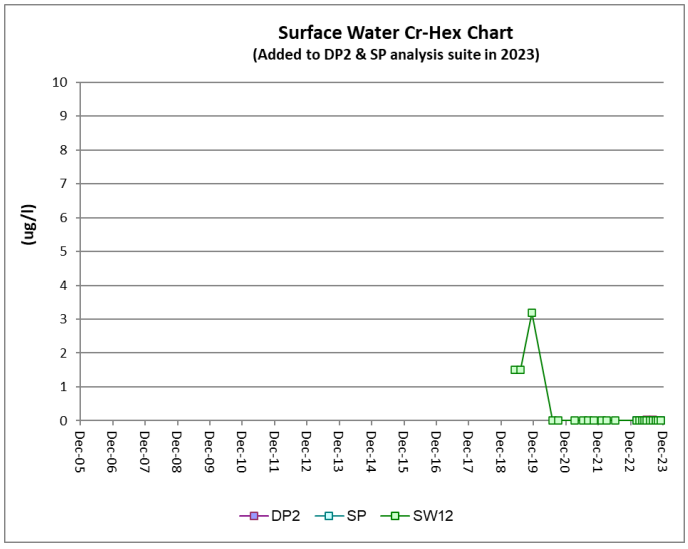


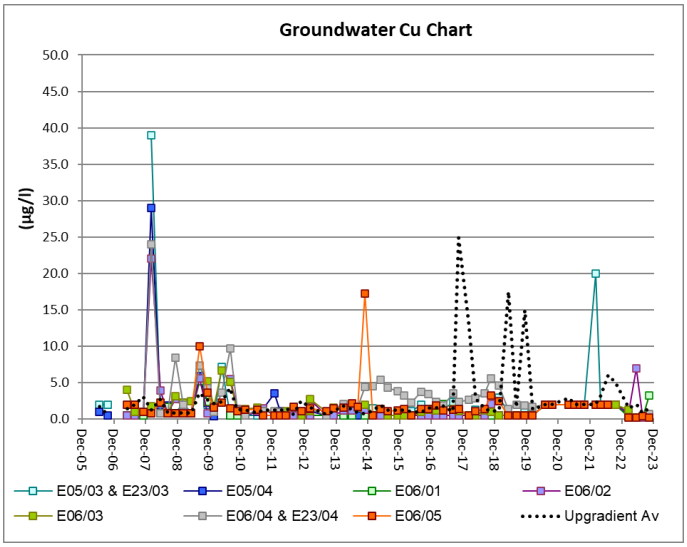


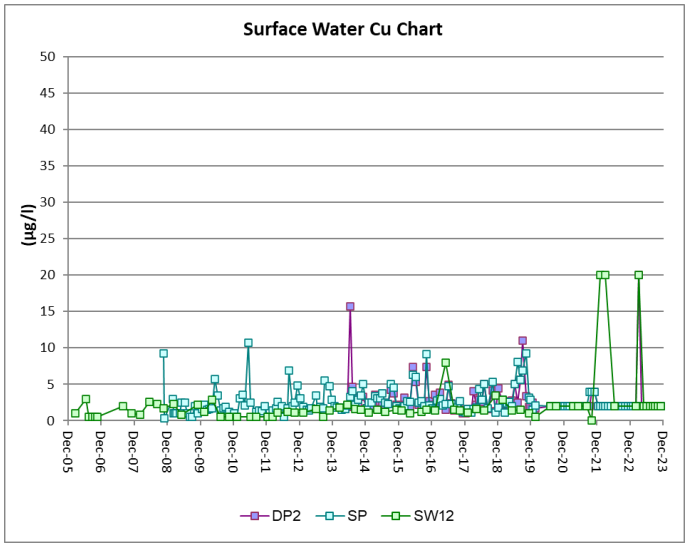


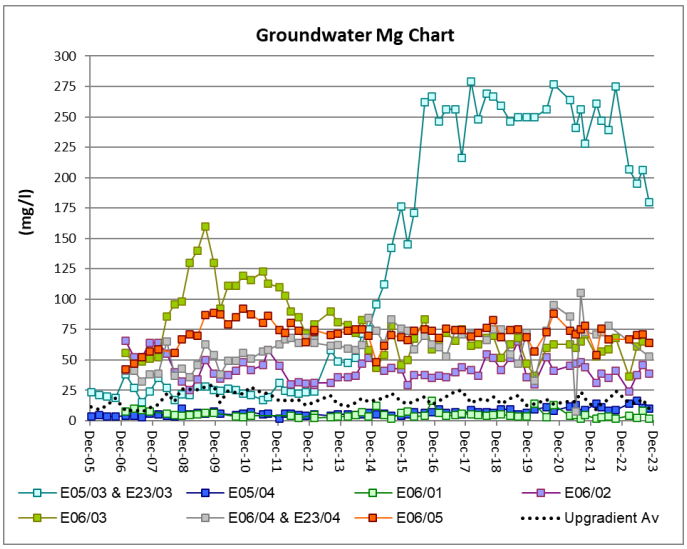


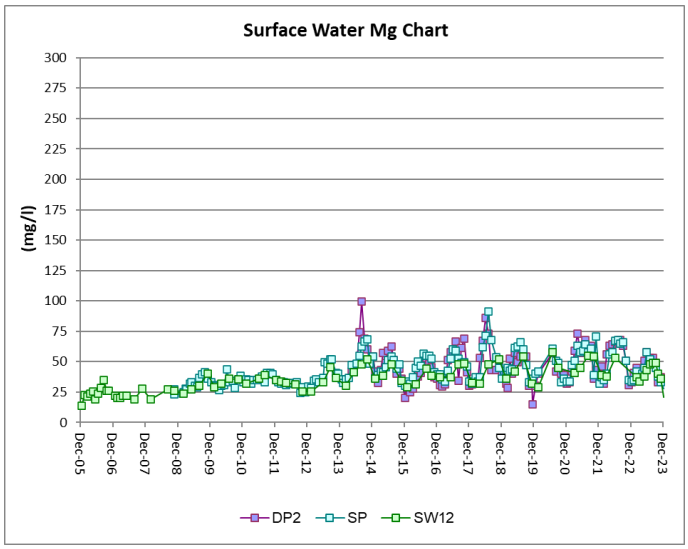


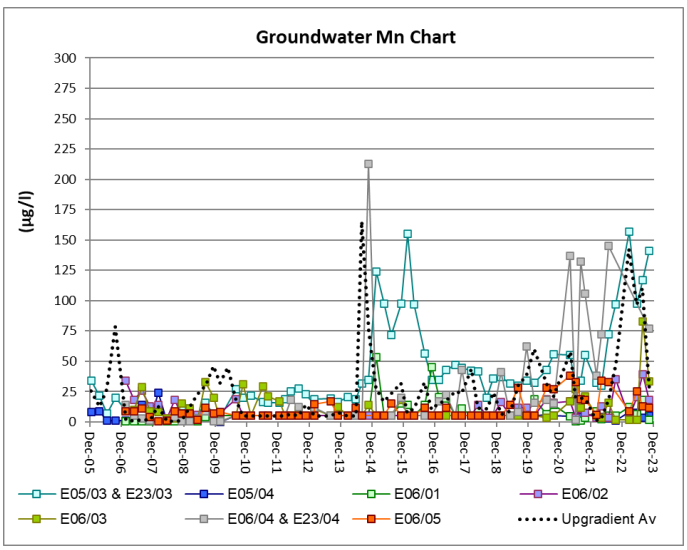


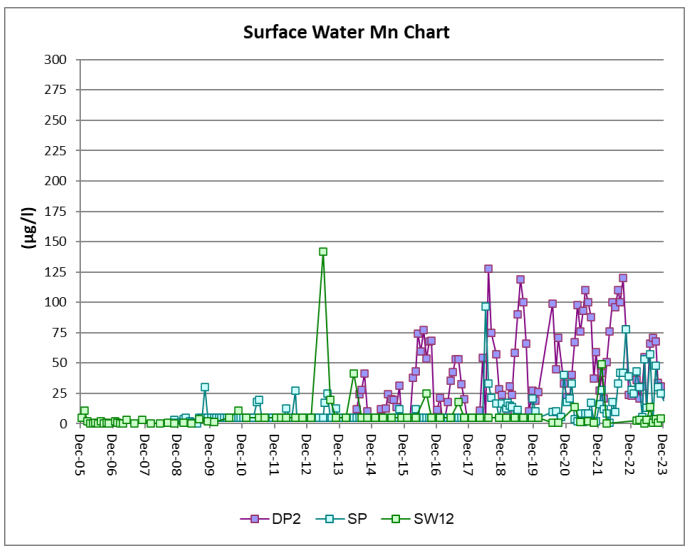

Groundwater Cu Chart
(µg/l)
E05/03 & E23/03
E05/04
E06/01
E06/02
E06/03
E06/04 & E23/04
E06/05
Upgradient Av

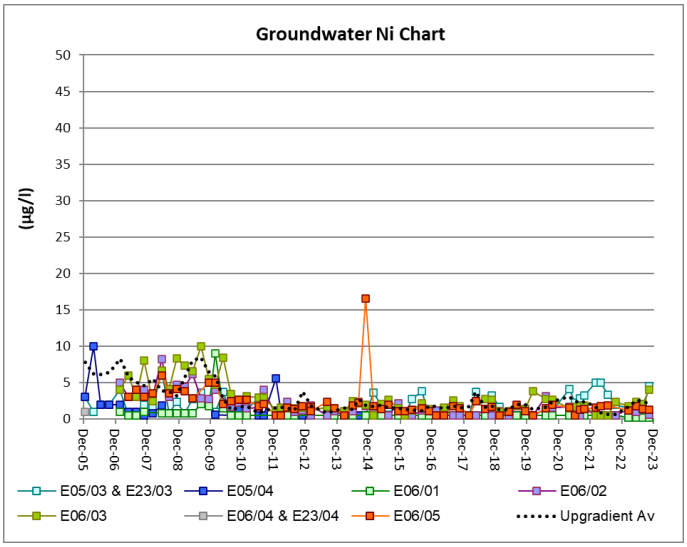

Surface Water Cu Chart
(µg/l)
DP2
SP
SW12

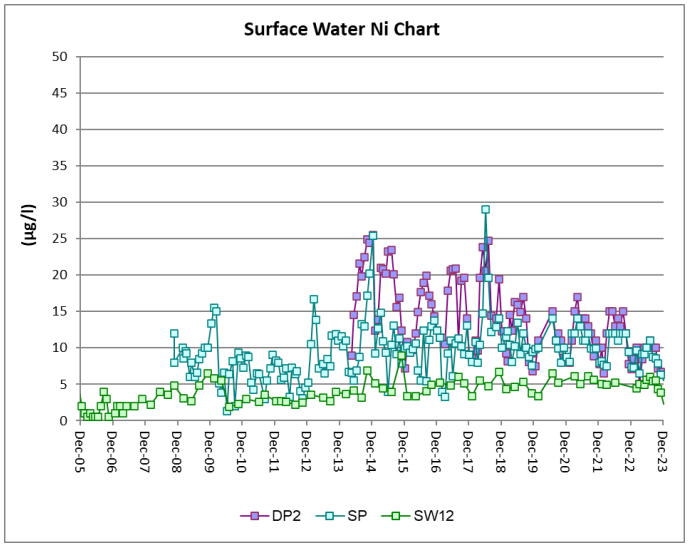

Groundwater Mg Chart
(mg/l)
E05/03 & E23/03
E05/04
E06/01
E06/02
E06/03
E06/04 & E23/04
E06/05
Upgradient Av

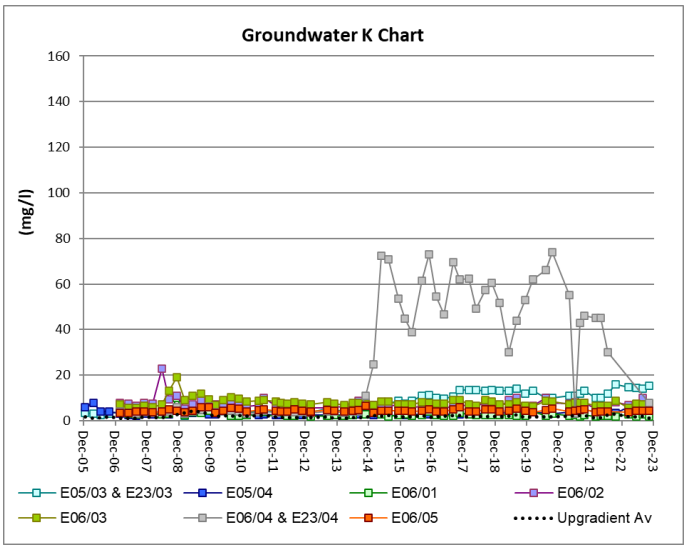

Surface Water Mg Chart
(mg/l)
DP2
SP
SW12

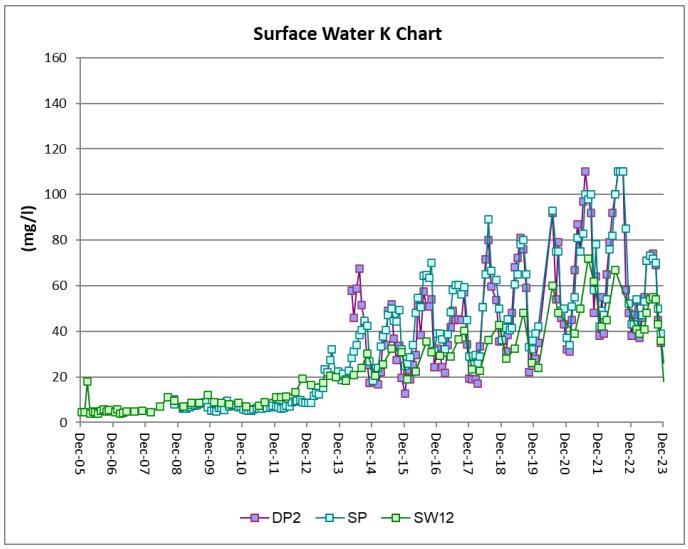

Groundwater Mn Chart
(µg/l)
E05/03 & E23/03
E05/04
E06/01
E06/02
E06/03
E06/04 & E23/04
E06/05
Upgradient Av

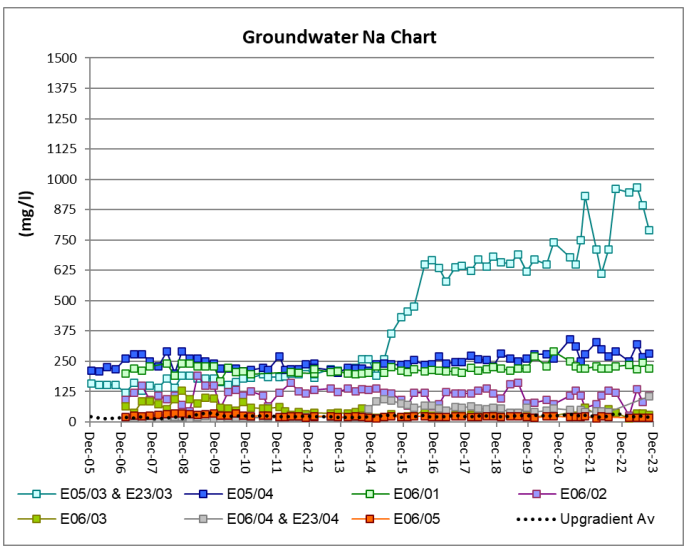

Surface Water Mn Chart
(µg/l)
DP2
SP
SW12

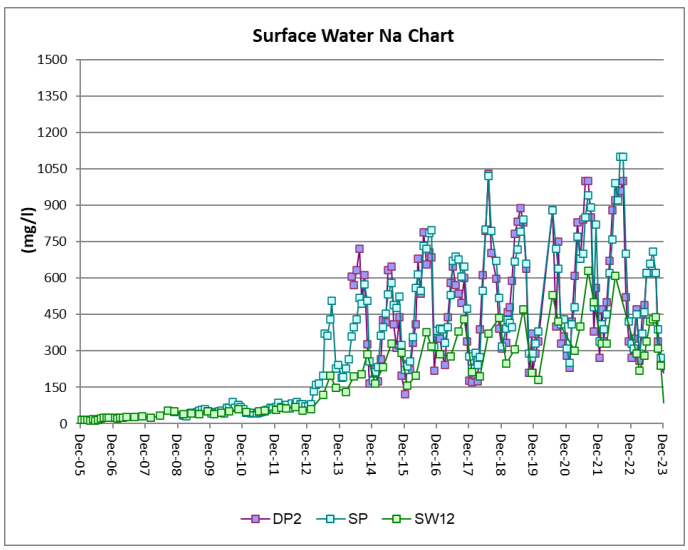

Groundwater Ni Chart
(µg/l)
E05/03 & E23/03
E05/04
E06/01
E06/02
E06/03
E06/04 & E23/04
E06/05
Upgradient Av

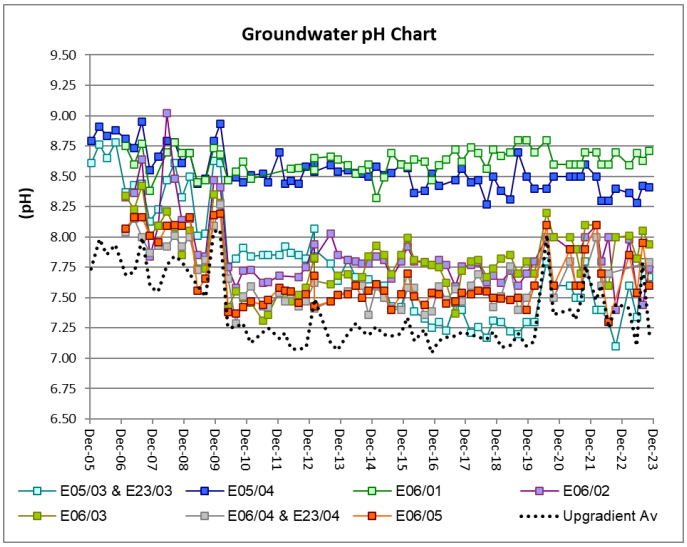

Surface Water Ni Chart
(µg/l)
DP2
SP
SW12

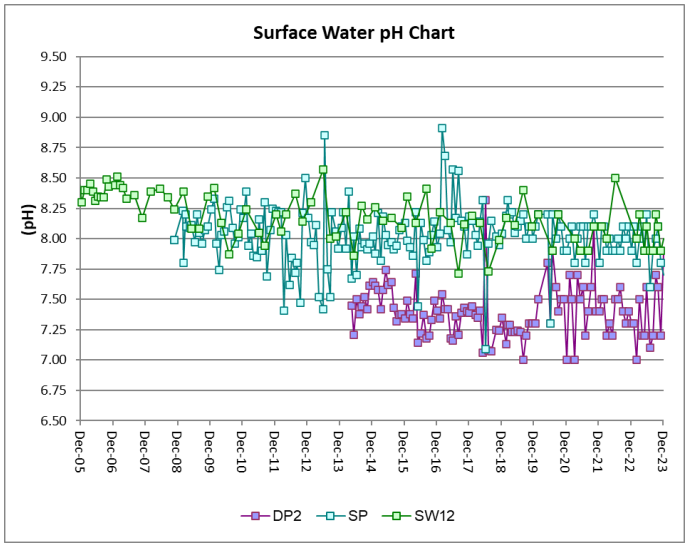

Groundwater K Chart
(mg/l)
E05/03 & E23/03
E05/04
E06/01
E06/02
E06/03
E06/04 & E23/04
E06/05
Upgradient Av

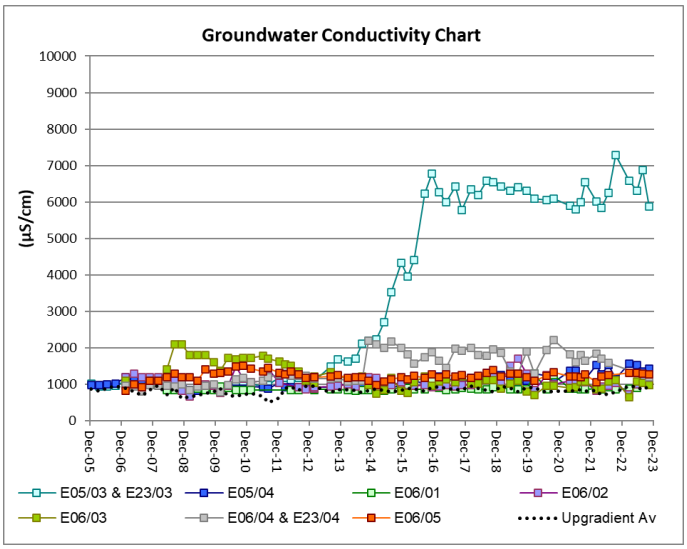

Surface Water K Chart
(mg/l)
DP2
SP
SW12

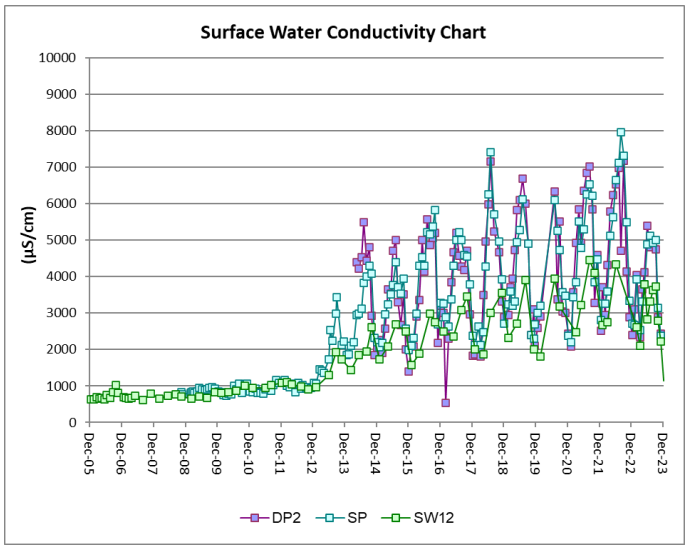

Groundwater Na Chart
(mg/l)
E05/03 & E23/03
E05/04
E06/01
E06/02
E06/03
E06/04 & E23/04
E06/05
Upgradient Av

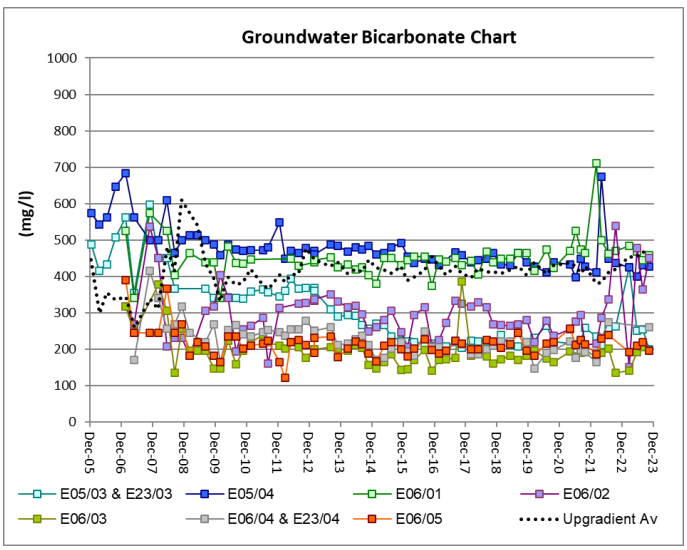

Surface Water Na Chart
(mg/l)
DP2
SP
SW12

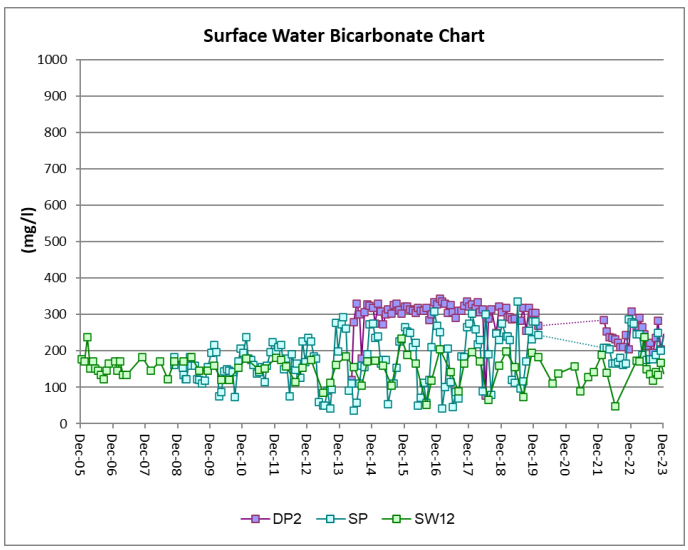

Groundwater pH Chart
(pH)
E05/03 & E23/03
E05/04
E06/01
E06/02
E06/03
E06/04 & E23/04
E06/05
Upgradient Av

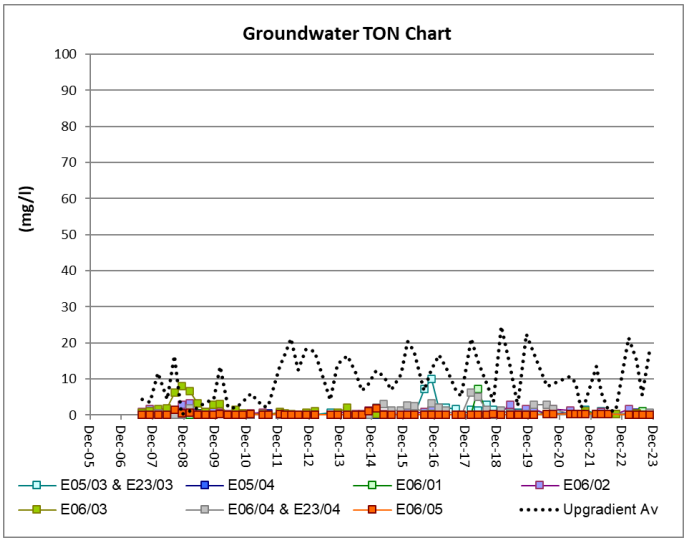

Surface Water pH Chart
(pH)
DP2
SP
SW12

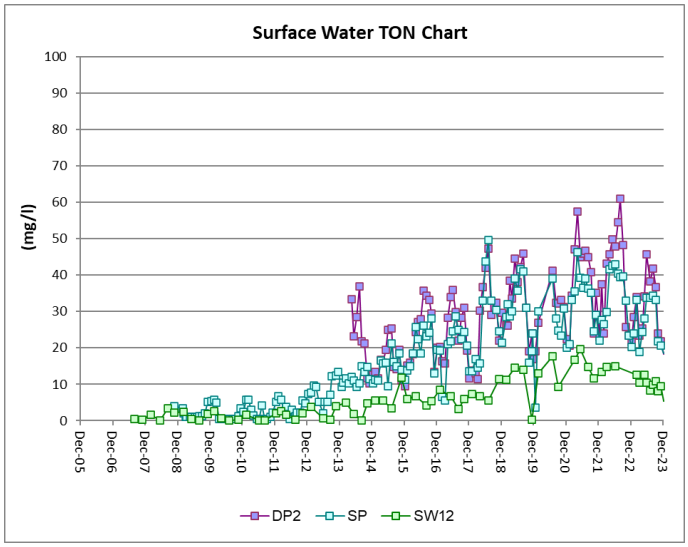

Groundwater Conductivity Chart
(µS/cm)
E05/03 & E23/03
E05/04
E06/01
E06/02
E06/03
E06/04 & E23/04
E06/05
Upgradient Av

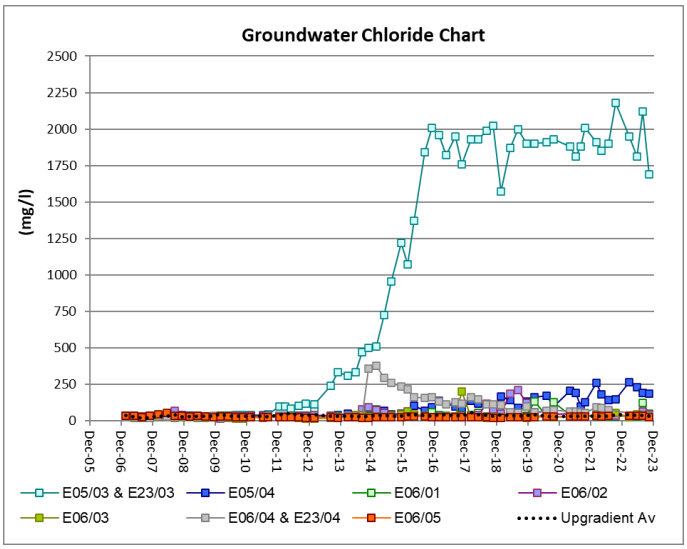

Surface Water Conductivity Chart
(µS/cm)
DP2
SP
SW12

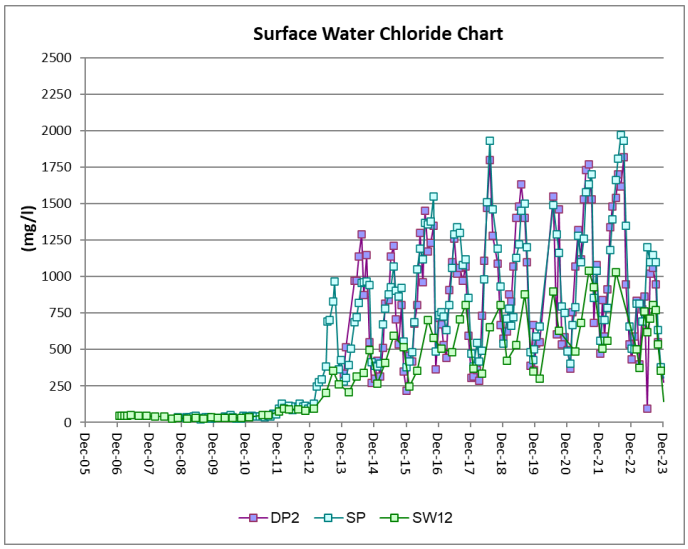

Groundwater Bicarbonate Chart
(mg/l)
E05/03 & E23/03
E05/04
E06/01
E06/02
E06/03
E06/04 & E23/04
E06/05
Upgradient Av

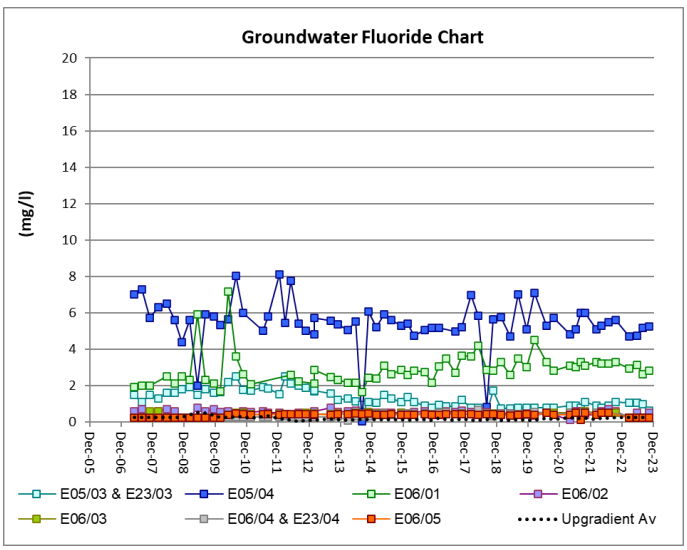

Surface Water Bicarbonate Chart
(mg/l)
DP2
SP
SW12

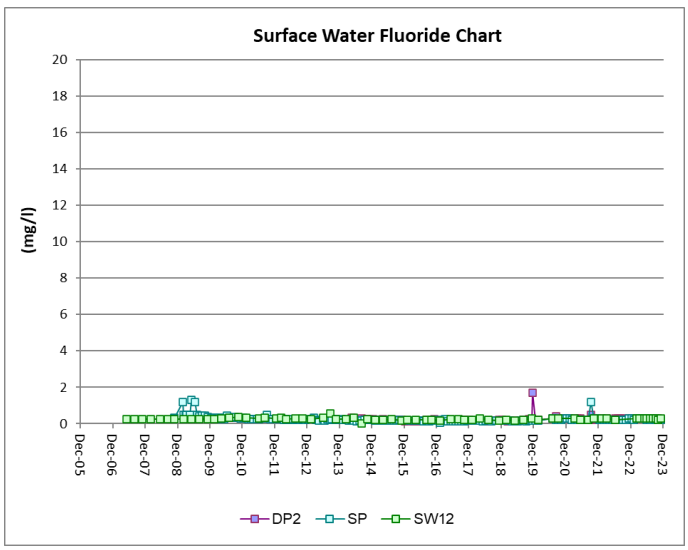

Groundwater TON Chart
(mg/l)
E05/03 & E23/03
E05/04
E06/01
E06/02
E06/03
E06/04 & E23/04
E06/05
Upgradient Av

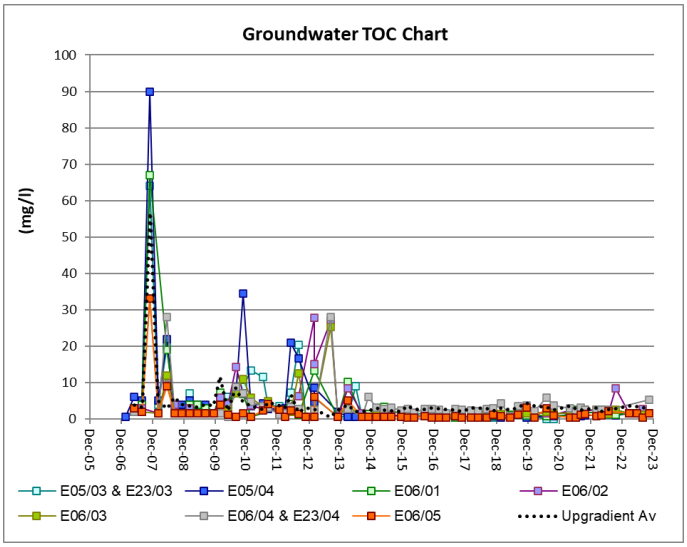

Surface Water TON Chart
(mg/l)
DP2
SP
SW12

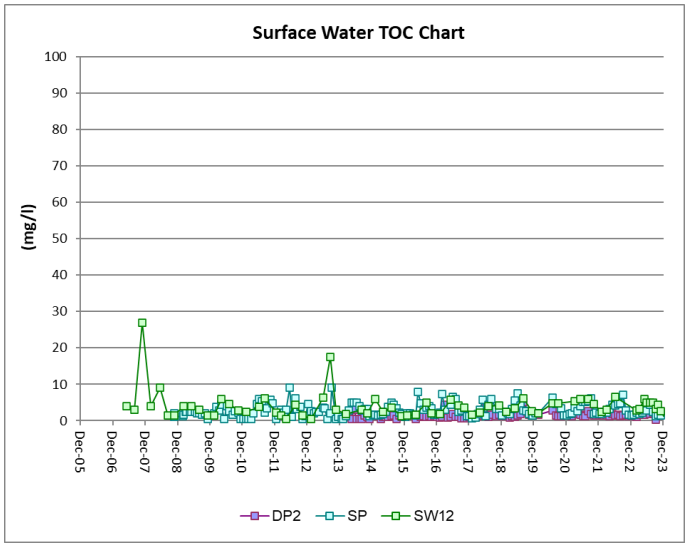

Groundwater Chloride Chart
(mg/l)
E05/03 & E23/03
E05/04
E06/01
E06/02
E06/03
E06/04 & E23/04
E06/05
Upgradient Av


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


Groundwater Fluoride Chart
(mg/l)
E05/03 & E23/03
E05/04
E06/01
E06/02
E06/03
E06/04 & E23/04
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
Dec-23
E05/03 & E23/03
E05/04
E06/01
E06/02
E06/03
E06/04 & E23/04
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
Dec-23
DP2
SP
SW12