

Groundwater Technical Note

Project:	Phase 3 – Stage 2 Remediation Works, Clarendon Road, Hornsey		
Subject:	Supplementary Information to Keltbray Phase 3 Groundwater Monitoring Report		
Date:	14 December 2022	Project No.:	5196431
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Document history

Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
P1	For issue	JE	MC	KB	NK	14/12/2022

Client signoff

Client	St William Homes LLP
Project	Phase 3 – Stage 2 Remediation Works, Clarendon Road, Hornsey
Project No.	5196431

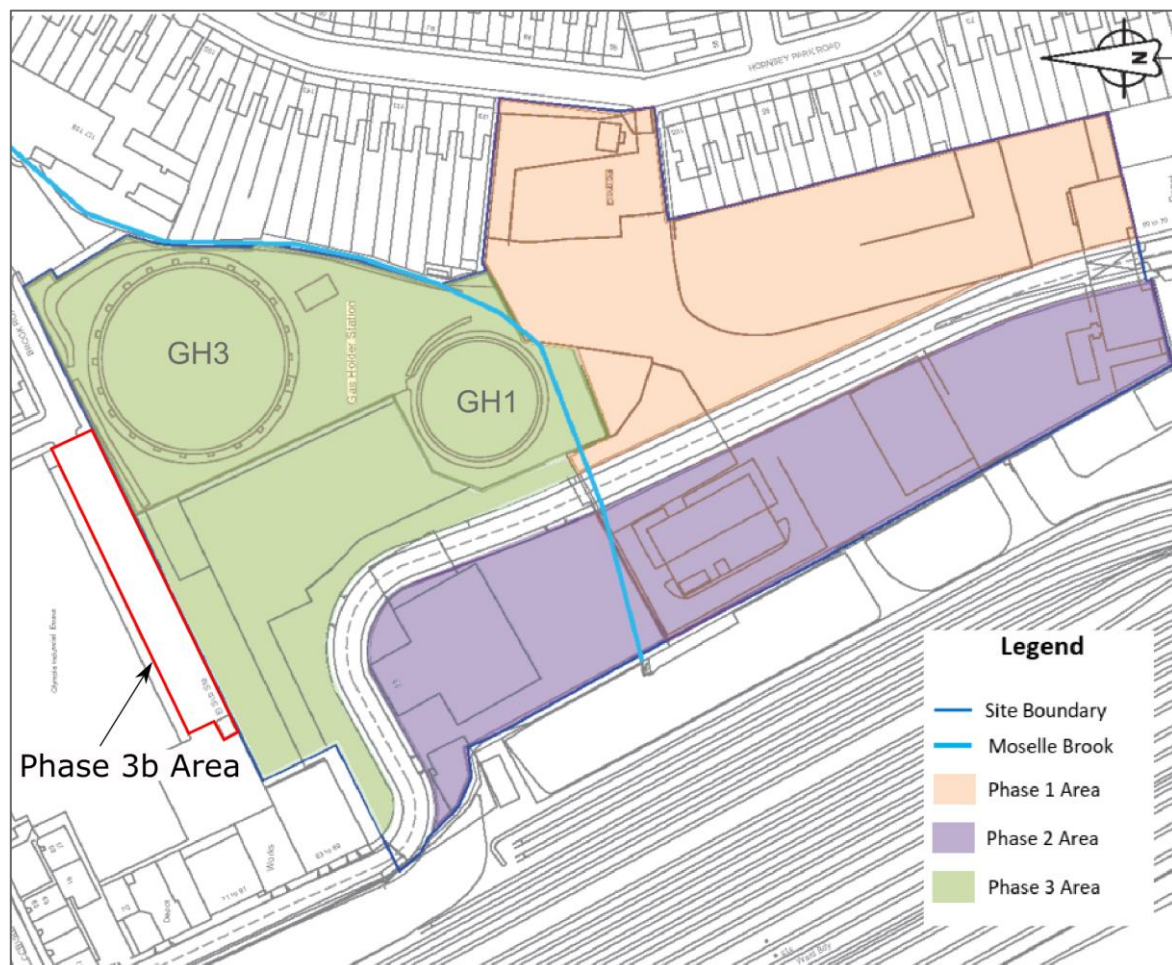
1. Introduction

Atkins Limited (Atkins) was commissioned by St William Homes LLP (the client) to complete an interpretation of data presented in *Keltbray Groundwater Monitoring Report* (Document reference: *RE6075-GWMMR-PA-June 2022-Phase 3*, dated June 2022). This report includes data collected between 23 April 2020 and 23 February 2022.

The Keltbray report summarises groundwater and surface water monitoring undertaken alongside two stages of development within Phase 3. The first stage (Phase 3, Stage 1) comprises the Main Remediation Works and were completed during 2020 and 2021; the second stage (Phase 3, Stage 2) comprises further excavation to establish the Block E basement. Between the Stage 1 and Stage 2 site works, an additional area was incorporated into Phase 3, identified as Phase 3B.

The location of Phase 3 and 3b is shown in Figure 1-1.

Figure 1-1 – Location of Phase areas at the site, showing Phase 3 and 3b in the north



1.1. Objectives

The objectives of this report are as follows:

- Provide a high-level summary of groundwater data collected during the Phase 3 works, between April 2020 and February 2022;
- Comparison of chemical groundwater data to action level screening criteria as detailed in the approved Foundation Works Risk Assessment (FWRA);
- Trend analysis of groundwater chemical data to identify any potential impact generated by site works as part of the Phase 3 development activities.

1.2. Site Works

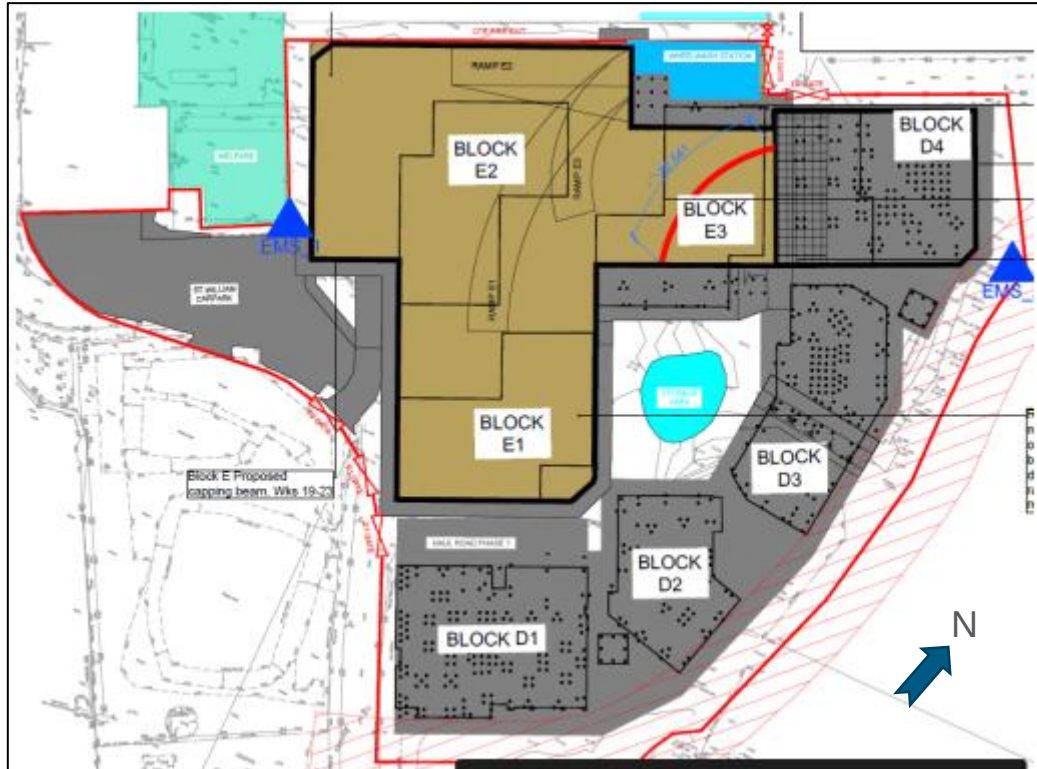
During the monitoring period, remediation, excavation and piling works were undertaken on-site for the construction of the proposed residential blocks D1–D4 and E1. Additional work for further residential blocks (E2 and E3) was also undertaken at the site, however, this occurred post the period covered by this monitoring and is therefore outside the monitored period.

The following works were undertaken on site during the monitoring period;

- Phase 1 Main Remediation works; 03 June to 16 October 2020;
- Piling for the proposed residential blocks D1 and D2, 14 September to 06 November 2020;
- Phase 2 Excavation for residential blocks D3 and D4; 11 October to 11 November 2021;
- Piling for residential blocks D3 and D4; 08 November 2021 to 16 February 2022; and
- Phase 2 excavation for residential block E1; 24 January to 18 February 2022.

The location of each residential block within the Phase 3 and 3b boundary is shown in Figure 1-2.

Figure 1-2 – Location of proposed residential blocks inside the Phase 3 and 3b boundary. (Taken from Keltbray Phase 3b Remediation Implementation Plan: KREM-6089-RIP-001-CRP3b).



1.2.1. Phase 1 Remediation Works

The Phase 1 remediation works are described in Keltbray's Remediation Implement Plan (RIP) dated 13 July 2020 (*Document reference: KREM-6066-RIP-001-CRP3*). The RIP included the following scope:

- Removal of above ground structures and pipework;
- Removal and treatment of any perched water,
- Filling of Gas Holders 1 and 3 using site won material;
- Installation of piling mat to D1 and D2 required levels;
- Removal of below ground features likely to contain sources of contamination. Any below ground obstructions were removed to a depth of 2 m;
- Excavation and removal of Made Ground across the site; and
- Installation of a low permeability clay buffer, along the easement to the Moselle Brook culvert to reduce the potential for leachable contaminants.

2. Groundwater Monitoring

Keltbray collected groundwater samples between April 2020 and February 2022. A summary of the various monitoring rounds undertaken for Phase 3 and Phase 3B are included in Table B.1 (Appendix B).

2.1. Monitoring Scheme

As outlined in Section 1.2, a monitoring programme was developed following the FWRA. However, as a result of site constraints, not all boreholes were monitored in every round and certain boreholes were decommissioned ahead of the original schedule as the work progressed. A summary of the final monitoring scheme and on-site issues is summarised below:

- Perched water monitoring was proposed to be undertaken at three locations across the site monthly. WS507 was decommissioned in July 2020 and was replaced by WS508 in December 2020. However, borehole WS508 could not be sampled due to the absence of water as it was routinely dry following its installation. Monitoring was therefore undertaken on shallow boreholes WS506, WS507 and WS508, screened in Made Ground deposits and deep boreholes BH510, BH513 and BH514A, screened in the Lambeth Group;
- The Phase 3B boreholes (BH21-01, BH21-02, and BH21-03) and historical borehole WS07 are present to the north of Phase 3. Monitoring of these locations was completed by Keltbray from the start of Phase 3, Stage 2 Basement Excavation scope in November 2021. Monitoring recorded that BH21-01 and WS07 were dry throughout this period with BH21-02 only recording brown sludge.
- Surface water samples were collected from the Moselle Brook during construction works up to the completion of the D1 – D2 ground floor slab, then monthly for three months following completion of the ground floor slab.
- Exploratory locations WS510, WS511 and BH511, drilled to the north and east of the southern gas holder (Gas Holder 1), were not located upon Keltbray's mobilisation to site in 2020 and recorded as lost;
- BH512 was decommissioned during remediation works. The justification for decommissioning from Keltbray is detailed within their verification report (*Document reference; RE6075-CR-AH-November2020-03-Phase 3*). WS507 was decommissioned in July 2020; and
- BH21-01, BH21-02, and BH21-03 were decommissioned on 30 November 2021.

The current status of the monitoring locations at the site are summarised in Table 2-1 below. The monitoring points referenced within this report can be identified in Figure 2-1 and Figure 2-2.

Table 2-1 – Current Status of Groundwater Monitoring Locations (February 2022)

Location	Monitoring Status	Area
BH510	Active	Phase 3
BH511	Could not be located	
BH512	Decommissioned	
BH513, BH514A	Active	
WS506	Active	
WS507	Decommissioned	
WS508	Active (Dry)	
WS509	Decommissioned	
WS510-11	Could not be located	
BH21-01	Decommissioned	Phase 3b
BH21-02	Decommissioned	
BH21-03	Decommissioned	
WS07*	Decommissioned	

* Historical window sample – not associated with Phase 3 installations.

KEY TO PLAN

- Site boundary
- Window sample location
- Borehole location

DECOMMISSIONING KEY

- Retained
- Decommissioned
- Not located

Drawing Control
This drawing is based on the following source information

Component	Company	Drawn/Model Ref.	Date/Issue
Site Investigation survey	Kellyway Remediation	CS3-KRE-X-000-XX-M2-CE-11.08.2012/PRI	08/10

Safety, Health and Environmental Information
This drawing is for information only.

Clarendon Road Gas Works Phase 3
BOREHOLE DECOMMISSIONING PLAN

Legend

- NTS
- X - SUBCONTRACTOR
- S2 - FOR INFORMATION

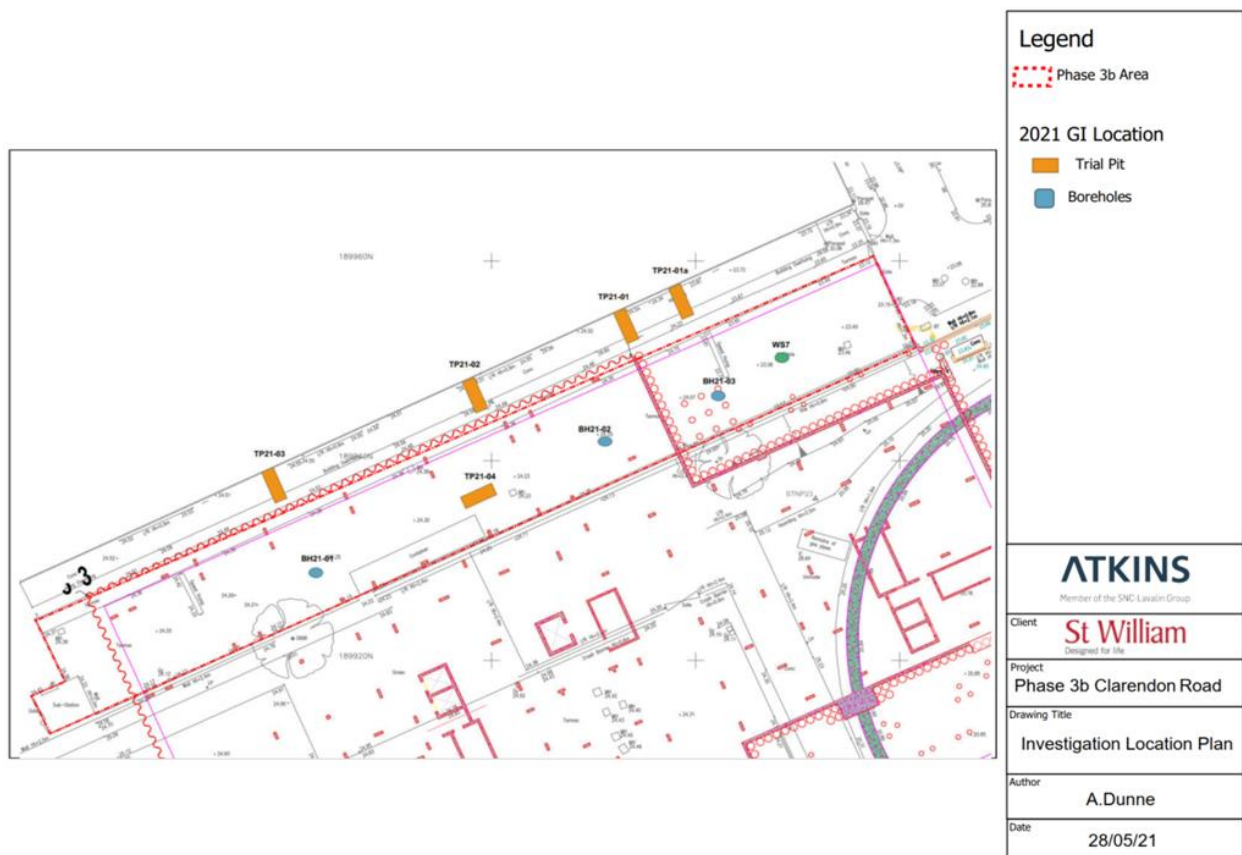
Scale
6075

North Arrow

Notes

- This drawing is to be read in conjunction with all relevant engineering drawings, specifications and other documents.
- The setting and information, refer to the relevant conditions drawing.
- Drawings issued after the date of issue shall be subject to the conditions of issue.
- All drawings are to be read in conjunction with the conditions of issue.
- The user shall be responsible for the design, build and temporary works.
- The user shall be responsible for the design, build and temporary works.
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- The user shall be responsible for the design, build and temporary works.

Figure 2-2 – Groundwater Monitoring Locations Phase 3B Groundwater Monitoring Locations



2.1.1. Sampling Methodology

The sampling methodology undertaken by Keltbray is detailed in their groundwater monitoring report, however, a summary is provided below:

- Field data and groundwater samples were collected using low flow pumping where possible;
- Shallow perched water samples were collected using a peristaltic pump in boreholes WS506, WS507 and WS508, however it was not always possible to collect a perched water sample from boreholes WS506 and WS508. Borehole WS508 was consistently dry whilst WS506 could not recharge fast enough to keep up with the low pumping rate and was therefore pumped dry;
- A bladder pump was used where groundwater was encountered at greater depth in BH510 and BH513;
- A bailer was used to collect groundwater samples from BH514A;
- Groundwater samples were analysed at an MCERTS and UKAS accredited laboratory (i2 Analytical); and
- Keltbray state that samples were collected in containers provided by the laboratory, stored in a cool box with ice packs on-site and sent to the laboratory for external testing. The testing schedule is summarised in Appendix A.

Field data is absent for BH514A between 15 May and 25 November 2020 as a bailer was used to collect groundwater samples between these dates. Low flow pumping was attempted prior to using a bailer; however, Keltbray highlight it was impractical due to damage to the bladder pump caused by a high volume of fines ingress. After November 2020, the groundwater samples collected from BH514A were submitted to the laboratory for measurement of parameters usually collected in the field (DO, pH, Electrical Conductivity, Redox and Turbidity), but as this is a different method to historical sampling, any interpretation of the data will take into consideration the methodology of the sampling process and appropriate comparisons made. On 19 November 2021, BH14A was blocked and a groundwater sample could not be collected. To clear the blockage the ground surrounding the borehole was excavated to expose the borehole pipework. A sample was successfully collected during the following sampling round (26 November 2021).

3. Lambeth Group Groundwater Level

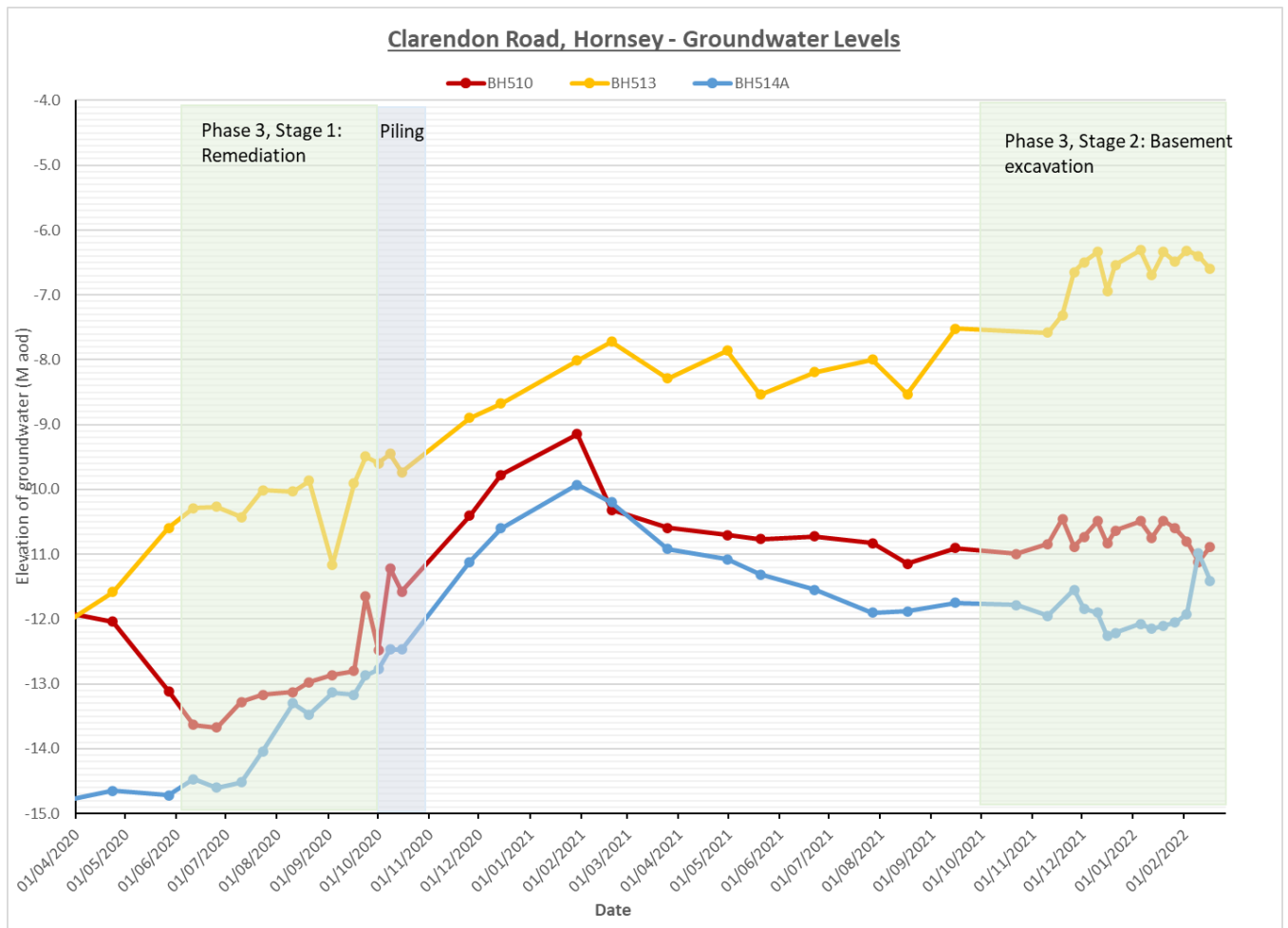
Figure 3-1 presents Lambeth Group groundwater levels recorded pre, during and post remediation and piling works at the site. Monitoring has been undertaken from April 2020 to February 2022.

Figure 3-1 indicates that groundwater levels at the site are broadly fluctuating seasonally. The groundwater level in BH510 and BH514 increases following winter and into spring (October 2020 to February 2021) before decreasing into summer between April to August 2021. Groundwater levels are not observed to recharge during the 2021-2022 winter period, this is considered concurrent with water levels across the south east where winter recharge that year was limited.

The groundwater level in BH513 is continuously rising over the monitored period in two distinct phases. The first phase of groundwater rise was observed between April 2020 and February 2021, where the groundwater elevation rises from -12 to -7.7 m AOD. After February 2021 the groundwater level is stable before rising in a second phase in December 2022, followed by a relatively stable groundwater level for the remainder of the monitored period. The final groundwater level measurement for the monitored period was -6.6 m AOD.

The change in groundwater level is unlikely to be generated by on-site activity. The groundwater level rise observed earlier in the monitoring period is seen pre, during and post remediation and piling work and is similar to the general trend observed in BH510 and BH514 (i.e. rising post October 2020 and slightly decreasing between April and August 2021). Furthermore, borehole BH513 is in the west of the site, outside the areas of development as detailed in Figure 1-2.

Figure 3-1 – Groundwater level within the Lambeth Group



4. Groundwater Quality

4.1. Groundwater Quality within the Lambeth Group

Keltbray have provided Atkins with the groundwater data obtained from the Lower Lambeth Group from locations BH510, BH513 and BH514A. As mentioned in Section 2.1, BH511 and BH512 (screened in the Upper Lambeth Group) were not monitored as they were decommissioned. Therefore, no groundwater samples were collected from the Upper Lambeth Group.

4.1.1. Screening Exercise

Atkins have subsequently reviewed the chemical data provided by Keltbray and have undertaken an independent screening exercise using action levels presented in the FWRA.

The action levels are summarised in **Table 4-1** and a summary of screening is presented in Table 4-2 below.

Table 4-1 – Action levels for contaminants of concern determined by the FWRA

Determinand	Units	Action Level
TPH CWG*	mg/l	0.01 [#]
PAH16*	mg/l	0.00016 [#]
BTEX	mg/l	0.001 [#]
Ammonia as NH ₄	mg/l	2.42
Arsenic	mg/l	0.00392
Cadmium	mg/l	0.00008
Chromium (III)***	mg/l	0.00275
Chromium (IV)	mg/l	0.005
Copper	mg/l	0.007
Lead	mg/l	0.006
Mercury	mg/l	0.00066
Nickel	mg/l	0.021
Selenium	mg/l	0.0264
Zinc	mg/l	0.0473
Free cyanide	mg/l	0.0022
Total Cyanide	mg/l	0.0385
Phenols (total)	mg/l	0.01 [#]
Sulphate**	mg/l	4477
Sulphide	mg/l	0.005 [#]

* Excludes previous PAH and TPH detections in BH513.

** Excludes outlier result of 26,000 mg/l in BH514A

*** Maximum concentration for total chromium used

[#] Limit of detection used

Table 4-2 – Exceedances for each determinand from the screening exercise

Determinand	Units	Action Level	Min	Max	No. of exceedances / number of samples	Average Baseline Concentration (Pre-work commencement)
Total Cyanide	µg/l	38.5	1.1	19,000 ^{a #}	29 / 89	22.2
Free Cyanide	µg/l	2.2	1	69 ^a	13 / 24	1.3
Inorganics						
Sulphate as SO ₄	mg/l	4,477	135	1,310,000 [~]	13 / 112	1453
Sulphide	mg/l	0.005	0.005	0.005	1 / 1	<0.005
Ammonia as NH ₄	mg/l	2.42	0.06	96.39 ^a	15 / 116	0.87
Metals / Metalloids						
Arsenic	µg/l	3.92	0.15	19.5 ^a	25 / 109	6.4
Cadmium	µg/l	0.08	0.02	0.91 ^b	16 / 59	0.05
Chromium (III)	µg/l	2.75 [*]	1.1	9.4 ^b	58 [*] / 58	0.7 (Total Cr)
Copper	µg/l	7	0.7	28 ^a	43 / 105	28
Lead	µg/l	6	0.2	2	0 / 29	65.4
Mercury	µg/l	0.66	0.05	0.09	0 / 29	0.1
Nickel	µg/l	21	0.6	58 ^b	1 / 111	97.1
Selenium	µg/l	26.4	0.6	23	0 / 109	271
Zinc	µg/l	47.3	0.6	33	0 / 109	129.2
Organics						
TPH-CWG – Aliphatic >C12 - C16	µg/l	10	10	49 ^b	1 / 117	<10
TPH-CWG – Aliphatic >C16 - C21	µg/l	10	10	280 ^b	1 / 117	<10
TPH-CWG – Aliphatic >C21 - C35	µg/l	10	10	440 ^a	2 / 117	<10
TPH-CWG – Aliphatic (C5 - C35)	µg/l	10	10	530 ^b	2 / 117	<10
TPH-CWG – Aromatic >C10 - C12	µg/l	10	10	48 ^a	1 / 117	<10
TPH-CWG – Aromatic >C12 - C16	µg/l	10	10	65 ^a	1 / 117	<10
TPH-CWG – Aromatic >C16 - C21	µg/l	10	10	38 ^a	1 / 117	<10
TPH-CWG – Aromatic >C21 - C35	µg/l	10	10	150 ^a	1 / 117	<10
Total Phenols	µg/l	10	10	83 ^{# a}	3 / 117	<10
Total EPA-16 PAHs	µg/l	0.16	0.16	3.12 ^a	2 / 117	<0.16

Maximum concentration / value identified in: ^a BH514A; ^b BH513; ^c BH510

* LOD of Chromium (III) changed from 1 µg/l to 5 µg/l in November 2021, resulting in exceedance occurring. Concentrations measured as below the 5 µg/l have been included as exceedances. Discounting these values results in 42 exceedances rather than 58.

~ Deviating Sample

#Concentration measured following removal of blockage in BH514A

Following review of the monitoring data it is clear that some of the adopted action levels were set at too stringent concentrations for certain determinands. For some determinands the action level is lower than the average baseline concentration (e.g. copper and cadmium), which has led to a high proportion of exceedances.

Copper, is naturally ubiquitous in the Lambeth Group, as shown by an average concentration of 0.028 mg/l, but due to the low action level (0.007 mg/l) most samples are returned as exceedances. In this instance, a high number of exceedances suggest that work may have impacted groundwater, yet the baseline dataset highlights copper is naturally elevated prior to work commencing. As such, care will be taken when drawing conclusions from any exceedances with stringent action levels.

As shown in Table 4-2 there are several exceedances in groundwater samples collected across the site for turbidity, total cyanide, free cyanide, ammonia as NH_4 , arsenic, cadmium, chromium (III) and copper with maximum concentrations consistently identified in BH514A, and to a lesser extent BH513.

Graphs of concentrations of key contaminants over time (ammonia as NH_4 , total cyanide, free cyanide, sulphate, arsenic, copper and chromium (III)) that have been recorded in BH510, BH513, and BH514A are presented in Appendix C (Figures C.1-C.8).

A discussion on groundwater quality monitored during the works and the action levels is presented below.

4.1.2. Inorganics

Sulphate

Sulphate was identified to be elevated in all samples collected on 01 October 2021 compared to the rest of the monitoring period. Sulphate concentrations were identified above 1.23×10^6 mg/l in BH510, BH513 and BH514A on one occasion, whereas in other monitoring rounds sulphate was much lower (generally 200 mg/l to 5,000 mg/l). This elevated sample was labelled as deviating by the laboratory as no sample date was provided, as such the result is not deemed reliable.

The second highest sulphate concentration was 6,590 mg/l in BH510 on 10 July 2020, during the Phase 1 Remediation works, which exceeds the action level of 4,477 mg/l. This is likely to reflect natural variations of sulphate in groundwater, noting the pre-works concentration of 6,000 mg/l in BH510 on 28 May 2020.

The concentration of sulphate decreases in all boreholes post-Phase 1 Remediation and remains below the action level in all locations for the remainder of the monitored period. In total, there were thirteen exceedances for sulphate out of 112 samples, indicating an overall low concentration (i.e. below action levels) in the Lambeth Group.

Total Cyanide, Free Cyanide and Ammonia as NH_4

Total cyanide exceeded the action level in 29 samples with a maximum concentration of 19,000 $\mu\text{g/l}$ identified in BH514A on 09 February 2022, following the excavation for the block E1 basement. The reported concentrations of free cyanide were lower (13), mostly associated with BH514A. In other boreholes, free cyanide was lower and only marginally exceeded the action level with concentrations ranging from 2.0-2.8 $\mu\text{g/l}$ in BH510 and one exceedance in BH513 (2.2 $\mu\text{g/l}$, 26 November 2021, during the piling of residential blocks D3 and D4).

As shown in Figure C.2 and Figure C.3 total and free cyanide concentrations were generally stable during the monitored period with fluctuating sporadic peak concentrations. The fluctuating concentrations were also encountered during baseline monitoring in BH510 and BH514.

BH514A showed increased total and free cyanide and ammonia as NH_4 concentrations after November 2021. BH513 and BH510, however, did not identify ammonia as NH_4 above the respective action level of 2.42 mg/l. More details regarding the elevated concentrations of total and free cyanide and ammonium as NH_4 are provided in Section 4.1.2.1 below.

4.1.2.1. Decommissioning of BH514A

On 26 November 2021 a blockage was identified in BH514A, which required Keltbray to excavate the ground adjacent to the borehole on this date. Upon trying to clear the material within the standpipe, the blockage became loose and migrated down the well and into the groundwater within the well. It has been subsequently noted that elevated concentrations of cyanide and ammonium are present in groundwater within the well. It is believed the material that entered groundwater was from a Made Ground source and is likely responsible for the observed increase in total / free cyanide and ammonium in this borehole. Aromatic TPH was also identified in BH514 on the monitoring round following the removal of the blockage, having not been identified in BH514A prior to this date).

On 03 February 2020, Keltbray attempted to purge the well to remove any potential contamination source. The purging exercise was unsuccessful as only a minimal amount of water could be removed before the well was pumped dry. A subsequent sampling round on 09 February 2020 detected further elevated concentrations of cyanide and ammonia as NH_4 their respective action level and as result the decision was made to decommission BH514A and help contain the small volume of material within the well. The borehole was filled with bentonite:cement grout in line with Environment Agency guidance and a replacement well (BH514B) was drilled 3 m to the southeast on 22 February 2022. Further information regarding the decommissioning of BH514A is provided in Appendix E of Keltbray's groundwater monitoring report.

Seven rounds of groundwater monitoring were undertaken on the newly installed BH514B. The results are compared to the action levels associated with BH510, BH513, BH514A, which are considered valid for BH514B due to its proximity to BH514A.

The results show that PAH and total TPH were consistently identified below laboratory detection limits and ammonia as NH_4 below action levels. Total cyanide was identified above its respective action level, however the concentrations identified (49 – 200 $\mu\text{g/l}$) are similar to the majority of samples collected from the nearby BH514A (prior to the blockage being present). Free cyanide was identified above its action level on two occasions but showed a decrease in concentration in following sampling rounds. The final four samples did not identify free cyanide above the laboratory limit of detection and were therefore below the 2.2 $\mu\text{g/l}$ action level.

The analytical results for the groundwater samples collected at BH514B are shown in Table 4-3. Samples were collected from BH514B after the monitored period discussed in this report to assess the presence of elevated determinands previously identified in BH514A.

The concentrations identified across seven groundwater monitoring rounds at BH514B suggest that any potentially contaminative source at BH514A that formed the blockage is localised in the direct vicinity of the well. Concentrations of previously elevated contaminants in BH514A were not identified in BH514B. The concentrations in BH514B were within ranges seen during monitoring rounds prior to the blockage being present in BH514A and free cyanide was not identified in four consecutive samples (rounds 4 – 7). Elevated concentrations of free and total cyanide, ammonium, PAH or TPH were also not identified in the remaining boreholes at the site, as such, any impact is considered localised to BH514A.

Aliphatic TPH and PAH were identified on 29 January and 25 March 2021 in BH514A, respectively however this was not reciprocated in previous and subsequent rounds.

Table 4-3 – Results from filtered samples collected from BH514B ($\mu\text{g/l}$)

Determinand	Action Level	Round 1 13/04/22	Round 2 22/04/22	Round 3 27/04/22	Round 4 04/05/22	Round 5 11/05/22	Round 6 19/05/22	Round 7 25/05/22
Total Cyanide	38.5	200	190	110	86	63	67	49
Free Cyanide	2.2	1.6	5.9	5.2	<1.0	<1.0	<1.0	<1.0
PAH (16)	0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
TPH (Total)	10	<10	<10	<10	<10	<10	<10	<10
Ammonia as NH_3	2420	890	1300	1200	1200	1400	810	1200

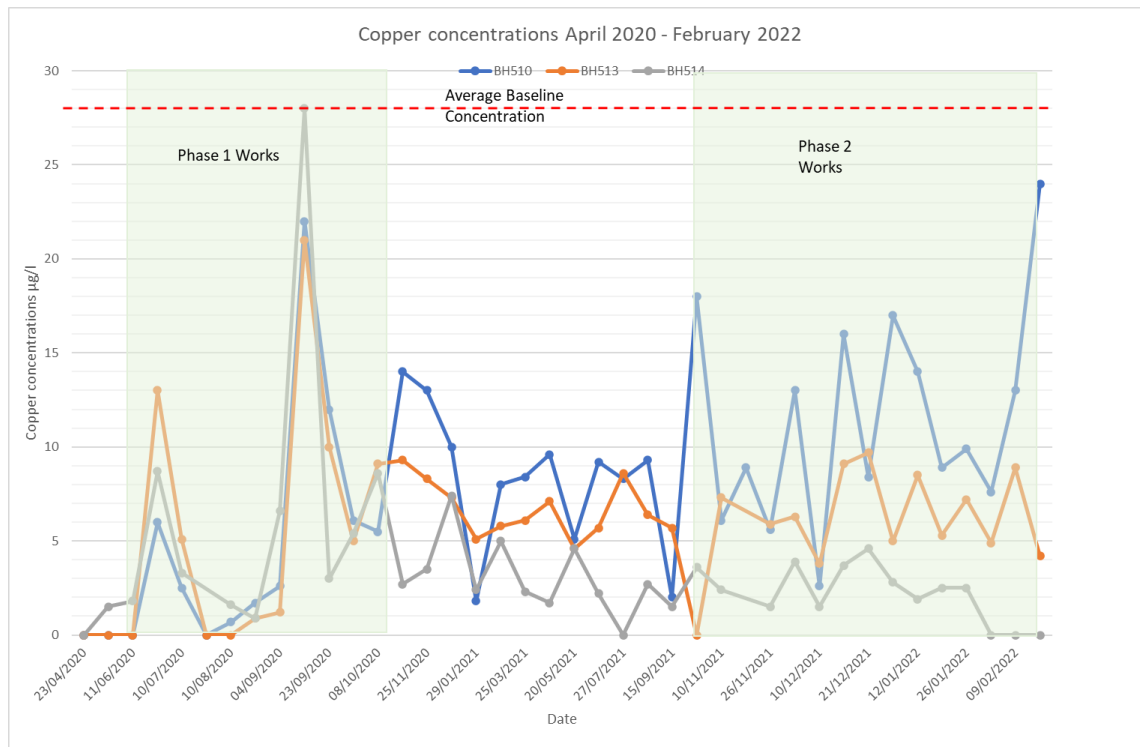
4.1.3. Metals / Metalloids

Recorded concentrations of a number of metal / metalloid determinands reported exceedances of action levels within the boreholes monitored. Chromium (III) (58 exceedances from 58 samples) and copper (43 / 105) reported the most exceedances with arsenic and cadmium reporting 25 / 109 and 16 / 59 respectively.

Copper was identified at a maximum concentration of 28 $\mu\text{g/l}$ in BH514A with the highest number of exceedances of the action level (7 $\mu\text{g/l}$). It should be noted that baseline monitoring reported an average

concentration of 28 µg/l, as such the action level exceedances of copper reported during the monitoring period are considered likely natural variation and are not as a consequence of intrusive works at the site.

Figure 4-1 – Copper concentrations over time. Average baseline concentration shown by red line



The concentration of chromium (III) was identified below action levels in BH513 across the monitored period. In BH510 and BH514 the concentration of chromium (III) fluctuates over time, with samples identified above and below the action level. As chromium (III) is fluctuating between concentrations rather than rising over time, it is likely this is a natural response of the groundwater in the Lambeth Group rather than an effect related to work on-site. Furthermore, chromium (III) concentrations decrease in both locations during the Phase 2 excavation and piling works, post-October 2021. Chromium (III) was generally identified below the laboratory detection limit of 5 µg/l.

It was noted that the laboratory used by Keltbray changed the limit of detection (LOD) in November 2021 from 1 µg/l to 5 µg/l for chromium (III). Keltbray received confirmation from the analytical laboratory that chromium (III) is calculated as the difference between total (dissolved) chromium and chromium (VI). Due to potential colour interferences on the chromium (VI) procedure the laboratory had to increase the reporting limit of chromium (III) to 5 µg/l to fall in line with that of chromium (VI). As such to highlight this issue, chromium (III) concentrations detected below the 5 µg/l detection limit have been plotted as 5 µg/l suggesting elevated concentrations of chromium in BH510 and BH513 in the final third of the monitored period. However, as lower concentrations of chromium were identified in the first half of the monitoring period, it is likely a concentration of 5 µg/l per sample is an overestimate. It is expected with a more stringent laboratory detection limit (i.e. 1 µg/l), lower concentrations of chromium would have been detected.

4.1.4. Quality Assurance

The laboratory reports included as Appendix C in Keltbray's Groundwater Monitoring report describe deviations for a select set of groundwater samples. Keltbray highlight that there were 91 deviations in total due to four samples with missing sample dates or as a result of logistical limitations that caused exceedances of holding times (13 occasions). Generally, however, most testing did not deviate and are therefore considered accurate.

Most deviating samples were associated with Ammonia as NH₃ and Ammoniacal Nitrogen as NH₃, or field parameters for BH514A (dissolved oxygen was the most common exceedance in this respect). One sampling round (02 December 2021) had additional deviations for most inorganic analysis suites in BH510, BH514,

BH514A and WS506. Although exceedances of holding times are more likely to affect the analysis of organic contaminants, care will be taken when discussing any deviating samples.

Due to logistical limitations over the monitored period certain samples were returned as deviating by the laboratory, mainly associated with ammoniacal nitrogen as NH_3 and field parameters for BH514A. Any anomalous result generated by a deviating sample, such as a significantly elevated concentration, has been discussed and in some cases discounted. The conclusions presented throughout the report are therefore based on data that is considered accurate. An MCERTS and UKAS accredited laboratory was selected for each analysis suite and Keltbray implemented essential quality assurance procedures on site, such as storing groundwater samples in a cool box containing ice packs.

4.1.5. Summary of groundwater quality in the Lambeth Group

Apart from chromium (Figure C.8) arsenic (Figure C.6), free cyanide (Figure C.3) and samples collected from BH514A after November 2021, the data show concentrations of contaminants between April 2020 and February 2022 are relatively stable, albeit with the observed short-term peaks in 2020 and 2021 previously mentioned. Copper was identified at a slightly higher concentration towards the end of the monitored period in BH510. However, the concentration of copper in all samples did not exceed the average baseline concentration of 28 $\mu\text{g/l}$. Generally, the screened determinands fluctuate in concentration over the monitored period, which is likely a reflection of natural conditions in the Lambeth Group.

4.2. Groundwater Quality within the Perched Water

Perched water samples were collected from boreholes WS506, WS507 and WS508 where possible. As discussed in Section 2.1, samples could not be collected from WS508 as it was consistently dry, and occasionally, WS506 was pumped dry before a sample could be collected. In total, 19 perched water samples were collected as follows:

- 17 samples from WS506; 22 June 2021 – 16 February 2022; and
- Two samples from WS507; 27 May and 10 July 2021.

As action levels for the site are associated with the Lambeth Group and not the perched water, a screening exercise was not undertaken on perched water samples. Instead, the chemical data from the laboratory are summarised below. It is noted that ammoniacal nitrogen as NH_3 was monitored in perched water, variations in concentrations are discussed to provide an indication of relative ammonium concentrations in perched water samples.

The perched water samples collected from WS506 returned slightly elevated concentrations of determinands. For example, total cyanide had an 68 $\mu\text{g/l}$ from 17 samples. However, most samples identified free cyanide below the laboratory limit of detection, suggesting minimal impact to surface water receptors in respect to cyanide.

Ammoniacal nitrogen as NH_3 was identified at relatively high concentrations (maximum concentration, 4,700 $\mu\text{g/l}$), although concentrations decreased over time as shown by the final two samples for ammoniacal nitrogen as NH_3 in WS506 (530 and 440 $\mu\text{g/l}$, respectively). The general decreasing trend likely highlights source removal generated by the Phase 1 remediation works or general excavation (i.e Made Ground removal) to facilitate the residential development. It is expected concentrations to continue to improve over time.

The general decreasing trend for ammoniacal nitrogen as NH_3 is shown in Figure 4-2.

The field parameters have been omitted from discussion due to their failure to stabilise during each monitoring round.

A summary of perched water quality in the sampled boreholes is given in Table 4-4.

Figure 4-2 – Concentration of Ammoniacal Nitrogen as NH_3 in samples collected from WS506. An approximate trendline is plotted showing a decrease in contaminant concentrations over time.

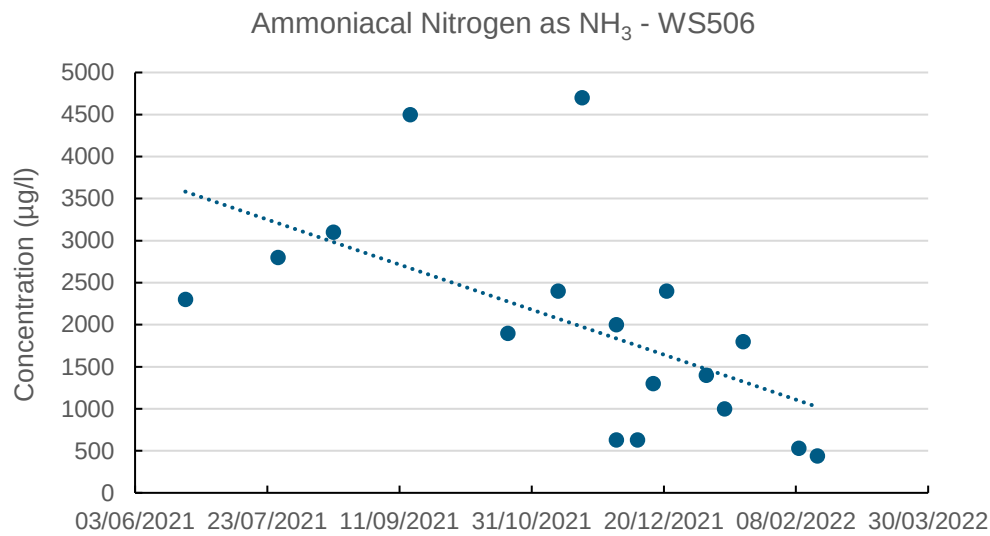


Table 4-4 – Summary of water chemistry in perched water monitoring locations

Determinand	Units	WS506 (17 samples)			WS507 (2 samples)		
		Min	Max	average	Min	Max	average
Arsenic	µg/l	2.4	22.5	10.8	1	6.3	3.65
Chromium	µg/l	7	49	24.9	<5	<5	<5
Copper	µg/l	7	35	18.8	0.8	7.4	4.1
Sulphate	µg/l	27.5	182	105	2720	4180	3450
Total Cyanide	µg/l	17	130	68	280	570	425
Free Cyanide	µg/l	1.1	2.2	1.5	12	12	12
Ammoniacal Nitrogen as NH_3	µg/l	440	4700	1990	510,000	570,000	54,000

5. Surface Water Monitoring

Surface water sampling was undertaken on the Moselle Brook. In total 20 samples were collected between 11 June 2020 and 23 February 2022. One sample was collected from the Moselle Brook on each sampling occasion.

5.1. Surface Water Quality

The surface water samples identified low levels of target analytes. As action levels are not required for the Moselle Brook, a screening exercise was not undertaken. A summary of the surface water sampling is provided below.

5.1.1. Total Cyanide, Free Cyanide and Ammonia as NH_3

Total cyanide was generally identified at concentrations less than 10 $\mu\text{g/l}$ and free cyanide was typically below laboratory detection limits.

Ammonia as NH_3 was identified above detection limits in most samples with a range of similar concentrations across the monitored period.

5.1.2. Sulphate

Sulphate was not identified at elevated concentrations except in one sample collected on 1 October 2020. However, this sample should be discounted as it was returned as deviating by the laboratory.

5.1.3. Dissolved Metals

Arsenic and chromium were identified at low concentrations. The maximum concentration for each dissolved determinand was 5.47 $\mu\text{g/l}$ and 7 $\mu\text{g/l}$, respectively. However, the concentration of chromium was generally below 3.0 $\mu\text{g/l}$ or the laboratory detection limit (5 $\mu\text{g/l}$). Copper was identified at a slightly higher concentration ranging from 1.1 to 29 $\mu\text{g/l}$.

5.1.4. Summary of Surface Water Quality

The data shows that the contaminants of concern associated with the former use of the site have not adversely affected the nearby Moselle Brook. While concentrations of total cyanide, arsenic, chromium and copper were identified, their impact is not widespread as they are significantly outweighed by the number of remaining samples identified at low concentrations. Concentrations of ammonia as NH_3 were detected in samples collected from the Moselle Brook, although this is likely to be as a result of urban nature of the brook with multiple potential off-site sources, as concentrations are consistent with historical sampling undertaken over previous phases of works. No correlation has been identified between the Phase 3 earthworks and remediation activities and the variation of contaminant concentrations in the Moselle Brook.

The presence of TPH, BTEX and PAH was also not identified, with the exception of one sample (15 September 2021) that identified minimal concentrations of benzene, toluene and p & m-xylene. Phenol was also identified in three samples. However, most samples did not identify organic contaminants suggesting any potential impact is negligible.

Given the minimal volume of perched water at the site (as shown by lack of water in WS locations, Section 4.2), the potential discharge to the Moselle Brook is considered to be nominal, as presented in the controlled waters DQRA.

6. Conclusions

Summaries of the key conclusions for key controlled waters are provided below.

6.1. Lambeth Group

The groundwater monitoring results suggest that groundwater present in the Lambeth Group has not been significantly affected by the site's former use as a gas works or by current development activities. The presence of the overlying London Clay (aquitard) is thought to have been effective at restricting vertical migration of historical contamination in the Made Ground and perched water flow deeper into the subsurface, whilst piling on-site has not created a new contaminant pathway. Overall (discounting BH514A), most contaminants were shown to be fluctuating at the site and did not present any correlation with the Phase 3 piling or basement excavation. In addition, groundwater levels within BH510, BH513 and BH514A have been unaffected by the works. As such, the concentrations of determinands identified is thought to be associated with natural variations in groundwater chemistry in the Lambeth Group.

Localised contamination has been highlighted in BH514A as a result of potentially impacted Made Ground entering the well. This issue led to BH514A being decommissioned and the installation of a new borehole nearby (BH514B). Seven rounds of groundwater monitoring were undertaken on BH514B that concluded the contaminants of concern were mostly below action levels, especially for free cyanide. As such, the presence of contamination associated with BH514A is therefore localised in the immediate vicinity of the well and has not adversely affected groundwater quality in the wider site.

6.2. Perched Water

The perched water samples collected from WS506 identified slightly elevated concentrations of determinands including total cyanide, ammoniacal nitrogen as NH_3 , arsenic, chromium and copper. However, free cyanide was mostly identified below laboratory detection limits. The concentration of ammoniacal nitrogen as NH_3 also decreased over the monitored period.

6.3. Surface Water

Generally, determinands were not identified at elevated concentrations in samples collected from the Moselle Brook. Occasionally, peak concentrations of determinands were identified, however given the minimal volumes of perched water at the site, any discharge to the Moselle Brook is considered nominal. As such, it is unlikely that works at the site have adversely impacted nearby surface water quality. Additional off-site sources may also be affecting the Moselle Brook.

Appendix A – Analytical Suite Accreditation

Analysis Suite	Determinands	Units	Limit of Detection	Accreditation
Dissolved metals in water by Inductively coupled mass spectrometry (ICP-MS)	As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Zn	µg/l	0.02 – 0.6	ISO 17025
Hexavalent Chromium in water	Cr (hexavalent) Cr(III)	µg/l	5	ISO 17025 None (Cr (III))
BTEX and MTBE in water	Benzene, Toluene, Ethylbenzene and Xylenes Methyl tert-butyl ether	µg/l	1	ISO 17025
Total Petroleum Hydrocarbons (TPH) Criteria Working Group (CWG) series	TPH Aliphatic >C5 - >C35 TPH Aromatic >C5 - >C35	µg/l	1 – 10	ISO 17025 None (TPH Aliphatic >C10) None (TPH Aromatic >C10)
Polycyclic Aromatic Hydrocarbons (PAH)	Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene	µg/l	0.01	ISO 17025
Monohydric phenols in water	Total Phenols	µg/l	10	ISO 17025
Ammoniacal Nitrogen as NH ₃	Ammonia (NH ₃)	µg/l	15	ISO 17025
Sulphate in water	SO ₄	mg/l	0.045	ISO 17025
Sulphide in water	S	µg/l	5	None
Thiocyanate in water	Thiocyanate as SCN	µg/l	200	ISO 17025
Low level total cyanide in water	Total Cyanide Free Cyanide	µg/l	1	ISO 17025
Field Parameters	DO, pH, ORP, Electrical Conductivity, Temperature and Turbidity	Various	Various	ISO 17025 (Electrical Conductivity, pH) None (remaining)

Appendix B Timeline

Table B.1 Timeline of groundwater monitoring events

Stage of works	Site Work Activities				Date
	Environmental Monitoring for Phase 3, Stage 1 (Remediation)		Environmental Monitoring for Phase 3, Stage 2 (Basement Excavation)		
	Groundwater Sampling	Surface Water Sampling	Groundwater Sampling	Surface Water Sampling	
Pre-Remediation	Baseline Environmental Monitoring	-	-	-	07/11/2019 to 28/05/2020
Phase 3, Stage 1: Keltbray Remediation on site					29/05/2020
During remediation	Week 1	Week 1	-	-	11/06/2020
	Week 3	Week 3	-	-	25/06/2020
	Week 5	Week 5	-	-	10/07/2020
	Week 7	Week 7	-	-	23/07/2020
	Week 8	Week 8	-	-	10/08/2020
	Week 11	Week 11	-	-	20/08/2020
	Week 13	Week 13	-	-	03/09/2020
Piling started (D1 and D2 only)					14/09/2020
During remediation	Week 15	Week 15	-	-	16/09/2020
	Week 16	Week 16	-	-	23/09/2020
	Week 17	Week 17	-	-	01/10/2020
	Week 18	Week 18	-	-	08/10/2020
Remediation completed					08/10/2020
Piling ended					13/10/2020
Post-remediation monitoring	Visit 1	Round 1	-	-	15/10/2020
	Visit 2	Round 2	-	-	25/11/2020
	Visit 3	-	-	-	14/12/2020
	Visit 4	-	-	-	29/01/2021
	Visit 5	-	-	-	19/02/2021
D1 and D2 Ground floor slab completed					24/02/2021
	Round 0	-	-	-	25/03/2021

Stage of works	Site Work Activities				Date
	Environmental Monitoring for Phase 3, Stage 1 (Remediation)		Environmental Monitoring for Phase 3, Stage 2 (Basement Excavation)		
	Groundwater Sampling	Surface Water Sampling	Groundwater Sampling	Surface Water Sampling	
Long-term post-ground floor slab monitoring	Round 1	-	-	-	30/04/2021
	Round 2	-	-	-	20/05/2021
	Round 3	-	-	-	22/06/2021
	Round 4	-	-	-	27/07/2021
	Round 5	-	-	-	17/08/2021
	Round 6	Round 3	-	-	15/09/2021
	Phase 3, Stage 2: Keltbray Basement Excavation (start on site)				
Phase 3, Stage 2: Keltbray Basement Excavation (main excavation commences)					11/10/2021
Post-remediation monitoring and during current remediation	Round 7	-	Week 3	Week 3	22/10/2021
	Round 8	-	Week 6	Week 6	10/11/2021
Piling started (D3 and D4)					16/11/2021
Post-remediation monitoring and during current remediation	-	-	Week 7	-	19/11/2021
	-	-	Week 8	Week 8	26/11/2021
	Round 9	-	Week 9	-	02/12/2021
	-	-	Week 10	Week 10	10/12/2021
	-	-	Week 11	-	16/12/2021
	-	-	Week 12	Week 12	21/12/2021
	Round 10	-	Week 14	-	05/01/2022
	-	-	Week 15	Week 15	12/01/2022
	-	-	Week 16	-	19/01/2022
	-	-	Week 17	Week 17	26/01/2022
	-	-	Week 18		02/02/22

Stage of works	Site Work Activities				Date
	Environmental Monitoring for Phase 3, Stage 1 (Remediation)		Environmental Monitoring for Phase 3, Stage 2 (Basement Excavation)		
	Groundwater Sampling	Surface Water Sampling	Groundwater Sampling	Surface Water Sampling	
	-	-	Week 19	Week 19	09/02/22
	-	-	Week 20		16/02/22
	-	-	-	Week 21	23/02/22

Appendix C Graphs

For all graphs, the FWRA trigger value is shown as a red dotted line and the green shading indicate periods of time where physical earthworks (piling and/or remediation) were being undertaken.

Figure C.1 Ammonia as NH₄. Note the maximum concentration identified in BH514 (96.39 µg/l) has been omitted to make the remaining concentrations clearer.

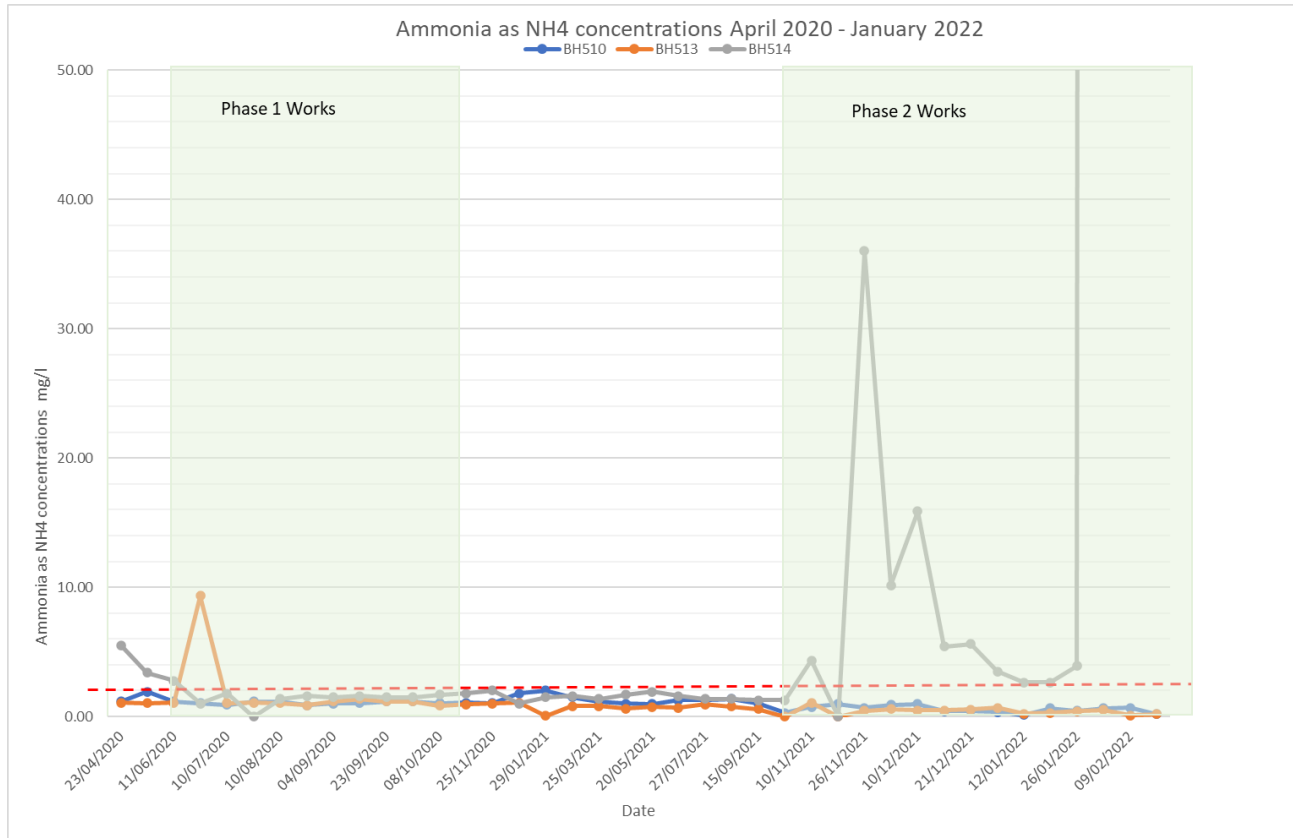


Figure C.2 Total Cyanide. Note the maximum concentration identified in BH514 (19,000 µg/l) has been omitted to make the remaining concentrations clearer.

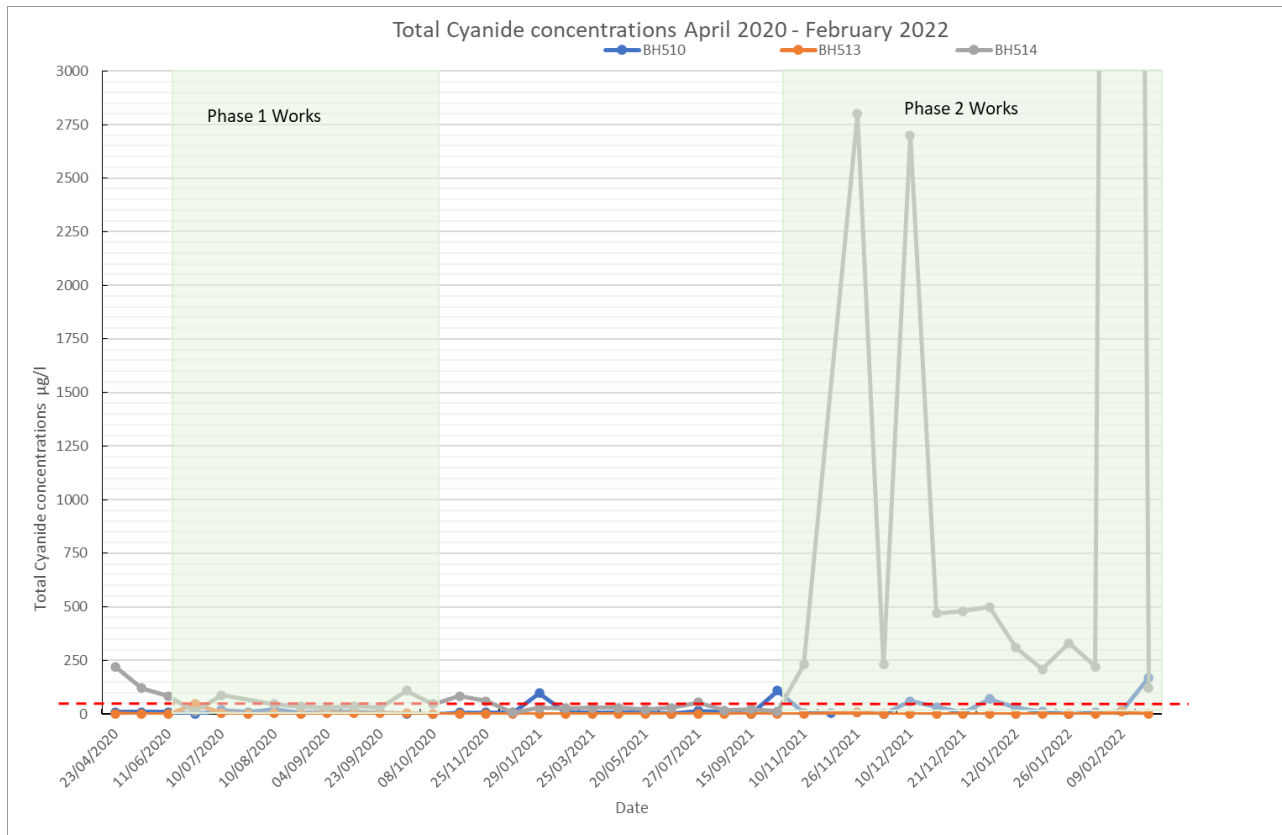


Figure C.3 Free Cyanide

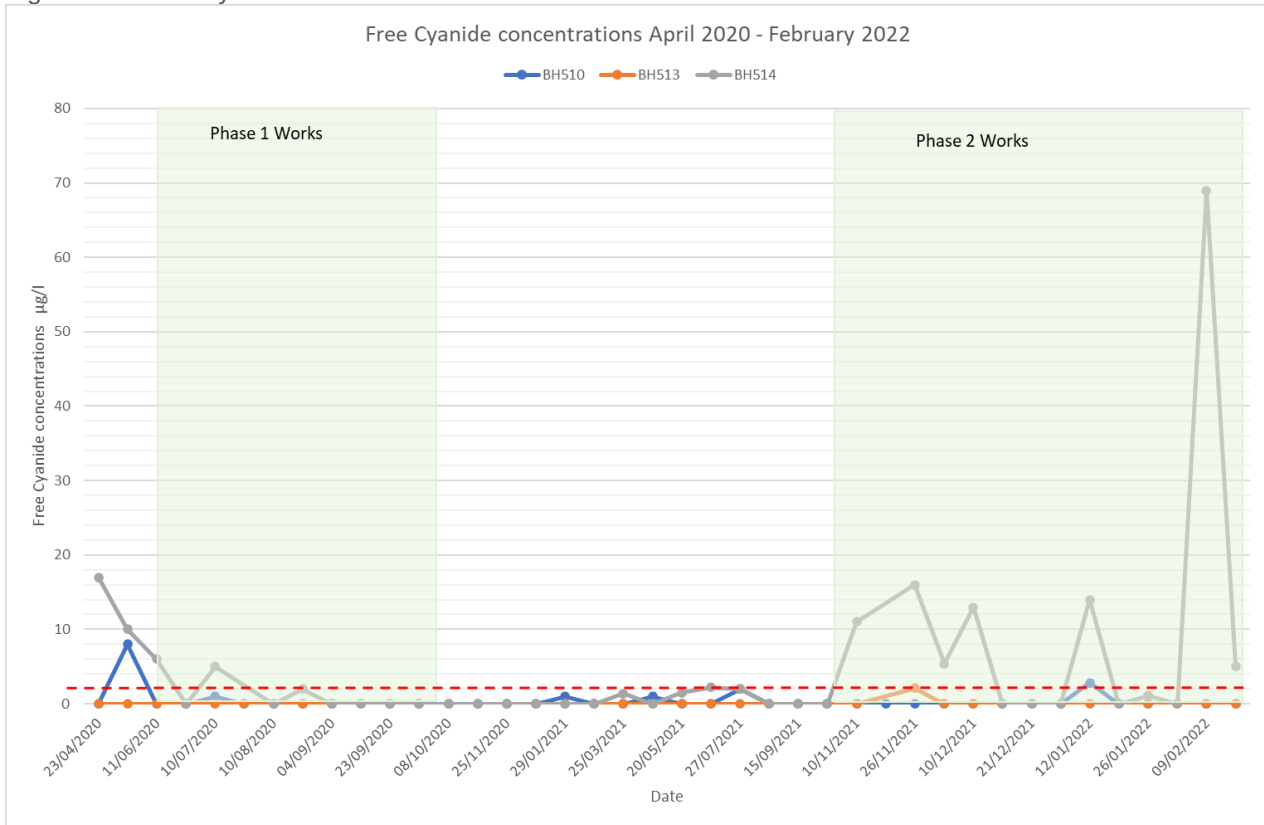


Figure C.4 Sulphate

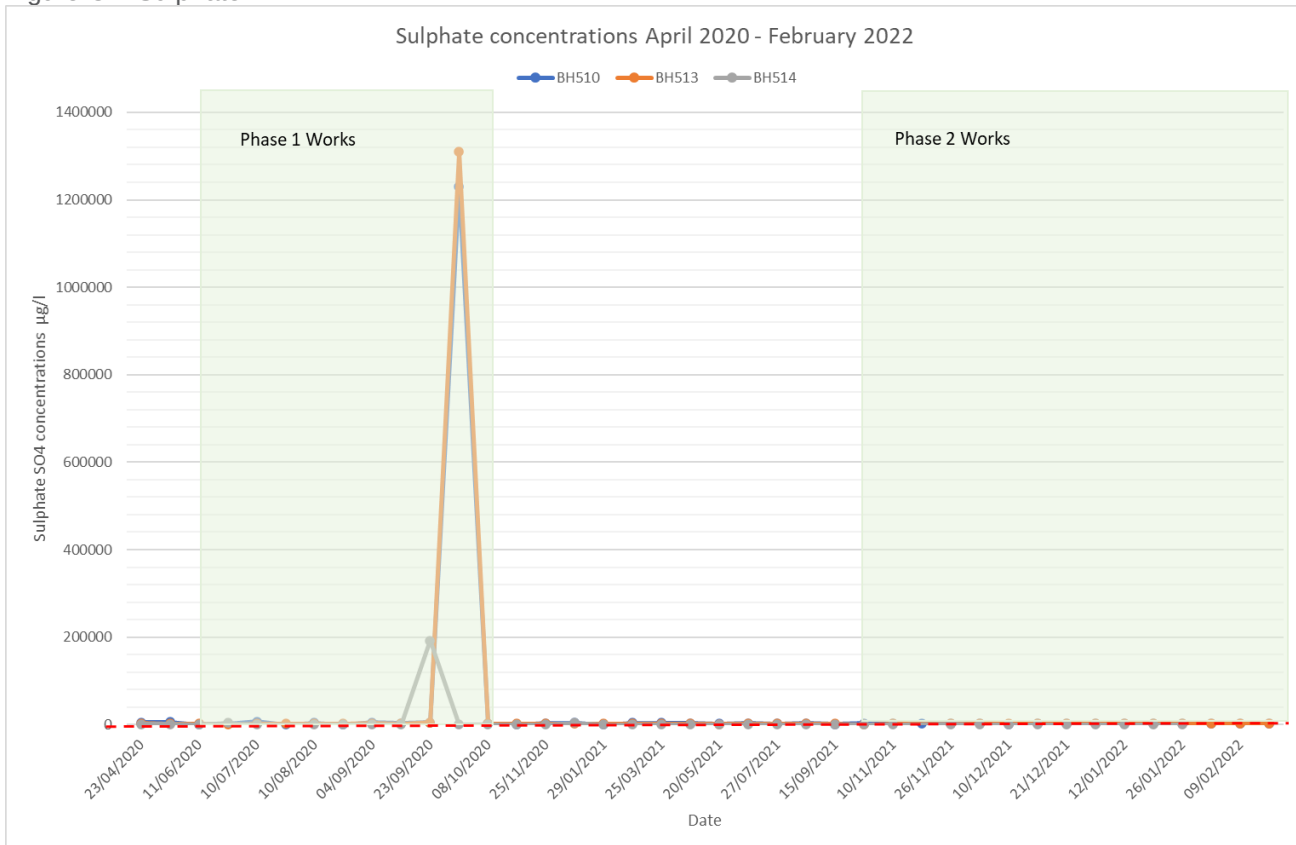


Figure C.5 Sulphate focused graph

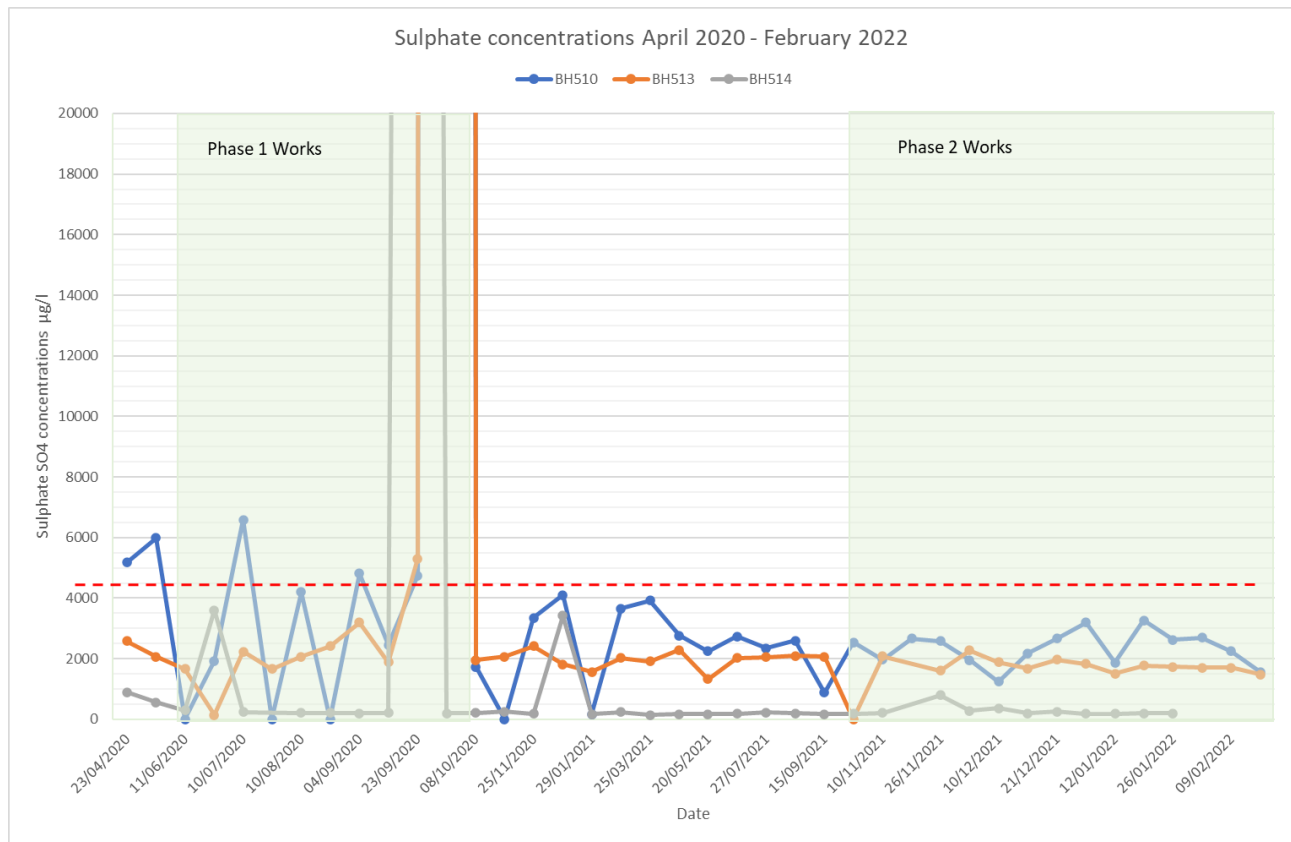


Figure C.6 Arsenic

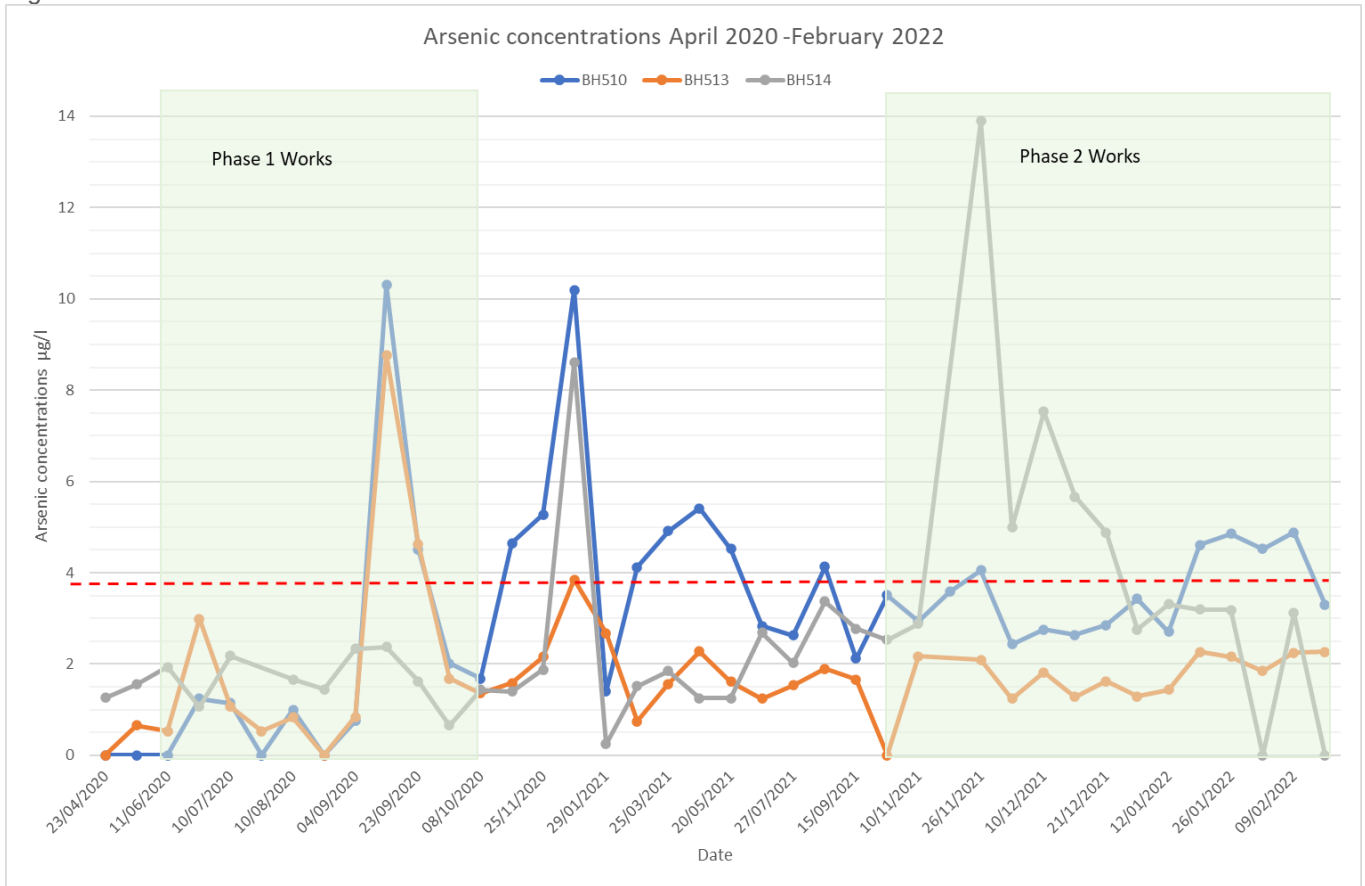


Figure C.7 Copper

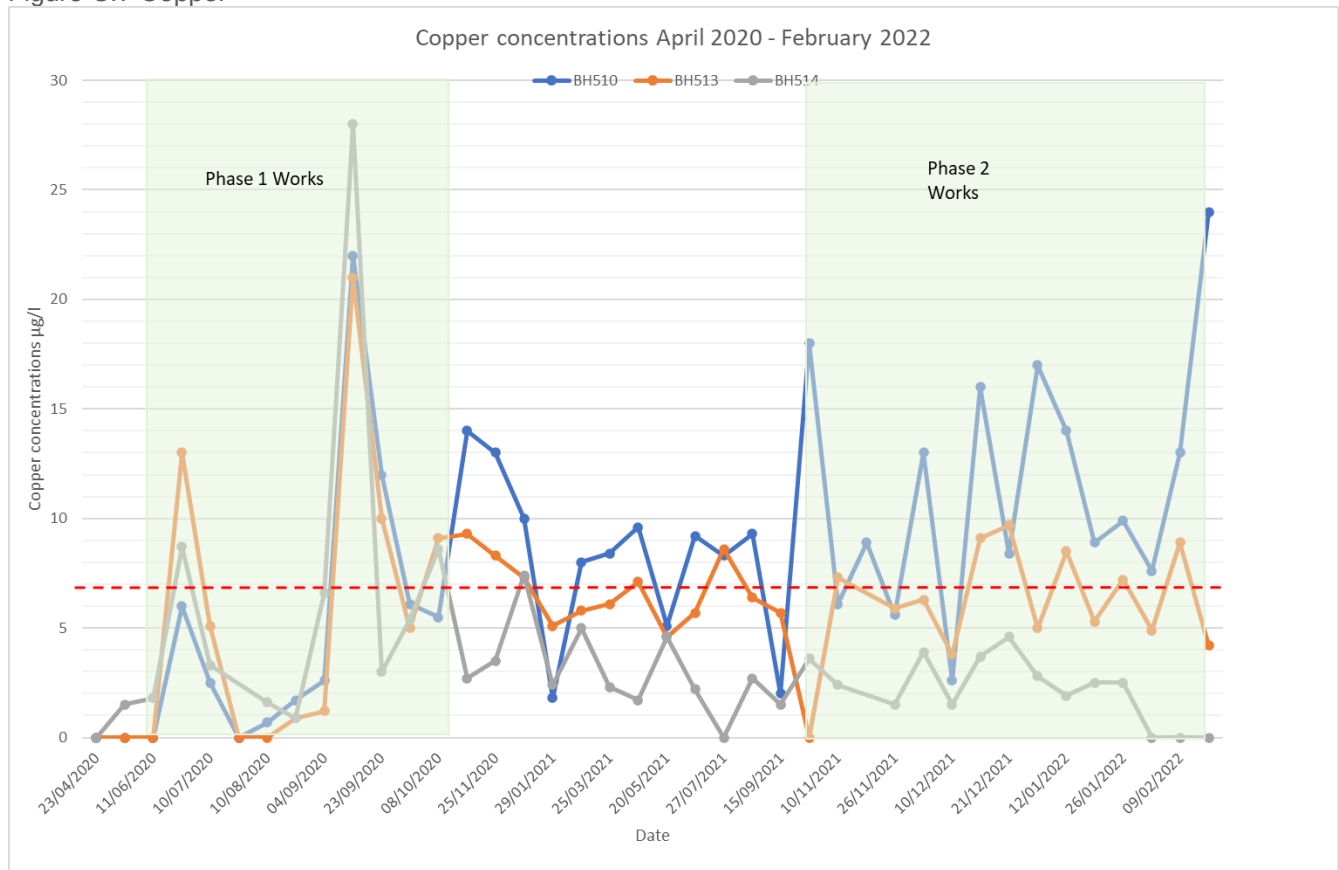


Figure C.8 Chromium (III). Note samples measured as below the <5 µg/l laboratory detection limit have been plotted as 5 µg/l, hence the high concentrations in the final third of the monitored period. Based on the much lower concentrations identified in the final set of samples, it is likely this is an overestimate of Chromium (III) concentrations in BH510 and BH514.

