

Groundwater Monitoring Report

**Clarendon Road Phase 3
Mary Neuner Road
Wood Green
N22 6TZ
London**

St William Homes LLP

June 2022

Keltbray Ltd,
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1 Introduction

Keltbray was instructed by St William Homes LLP (St William), the Client, to undertake groundwater monitoring (and provide the results as factual information) alongside the primary task of delivering the enabling and remediation works at Clarendon Road Phase 3, Mary Neuner Road, Wood Green, N22 6TZ, London (referred to hereafter as 'site'). Site location and layout drawings, including monitoring locations are included in **Appendix A**.

The groundwater monitoring was required for a period 12 months following the casting of the ground floor slabs of Blocks D1 and D2. The primary purpose of the groundwater monitoring was to demonstrate that the enabling, remediation and piling works had no adverse effect on the groundwater quality residing in the bedrock aquifers located below the London Clay. The quality of groundwater perched within the Made Ground and water within Moselle Brook was also monitored to ensure no deterioration in quality. The Client's consultant, Atkins produced a Foundation Works Risk Assessment (FWRA) which provided the specification for the groundwater monitoring:

- Phase 3, Clarendon Road, Hornsey – Foundation Works Risk Assessment. Atkins. Doc Ref: 5192204_P3_FWRA Rev 4.0, dated 01st June 2021.

This report has been produced to accompany the Verification Report issued previously by Keltbray:

- Verification Report – Clarendon Road Phase 3. Keltbray. Doc Ref: RE6075-VR-AH-November2020-03-Phase 3, Rev 3, dated May 2022.

The Verification Report provides details of the enabling and remediation works undertaken. This report should be referred to for further context and details pertaining to the project.

This report will be issued in conjunction with the Verification Report for approval/comment to London Borough of Haringey and the Environment Agency (EA) as statutory planning consultees and to Atkins Ltd. (Atkins) as the Client's appointed environmental consultant. It is anticipated that this will permit the discharge of the pertinent contaminated land-related conditions of planning permission reference HGY/2017/3117 for the relevant building phases.

1.1 Site and Environmental Setting

The Phase 3 development area is approximately 1.5 ha and includes the northern part of the former gasworks site which was reportedly active between c. 1857 and 1973. The site area is presented in drawing *CR3-KRE-X-000-XX-M2-CE-1025_P01*, **Appendix A**.

The site is bounded by Mary Neuner Road to the west, the Olympia trading estate to the north and residential properties on Hornsey Park Road to the east. The proposed development includes four ground bearing residential blocks, as well as a large basement structure which covers approximately 50% of the site. Multiple residential blocks are scheduled within Phase 3 of up to 13 storeys, and referred to as Blocks D1, D2, D3, D4, E1, E2, E3 and F1. The remainder of the site area will comprise soft landscaping, and hard pedestrian and vehicle access routes.

At the time of Keltbray's initial occupation the site was vacant and comprised of two redundant gasholders. Gasholder No.1 (GH1) in the southwest of the site, with a largely intact clay dumphing at the base and

Gasholder No. 3 (GH3) a redundant, partially infilled, below ground level gasholder to the north-east. The remainder of the site was uncovered ground with hardstanding in the north-western section and a brick wall running north to south down the centre adjacent to GH3, separating the higher ground level to the east of the wall from the west.

The ground conditions on site comprised Made Ground soils overlying London Clay (approximately 25m thick) which was underlain by Lambeth Group, Thanet Sand Formation and Chalk. The EA classifies the Lambeth Group and the Thanet Sand Formation as Secondary (A) Aquifers and the Chalk as a Principal Aquifer.

A culverted watercourse, the Moselle Brook, runs west to northeast along the southern and eastern site boundaries. The EA classifies the Moselle Brook as a main river.

1.2 Pertinent Information from the Foundation Works Risk Assessment

- The London Clay acts as an aquiclude and hence the shallow and deep aquifers are not in hydraulic continuity;
- A Detailed Quantitative Risk Assessment (DQRA) concluded that the Site did not pose an unacceptable risk to the deep aquifers residing below the London Clay (based on contaminant travel time);
- The variation in the lithology (and hence permeability) of the Lambeth Group gives rise to variable groundwater levels within the stratum; and
- The deep piles were designed to terminate within 5m of the base of the London Clay (19-24m in length) to minimise the potential for pile-related impacts on the Lambeth Group aquifer

2 Groundwater Monitoring Specification (FWRA Section 6)

Monitoring was required during earthworks, remediation and piling and up to twelve months after the completion of the ground floor slabs. Monitoring was to be undertaken as follows:

Shallow Boreholes – targeting perched water in Made Ground

- I. Fortnightly dipping, monitoring and sampling from WS506, WS507 and WS511 during all remediation and earthworks activities;
- II. Increasing to weekly during piling activities; and
- III. Monthly for 12 month post completion of basement slabs.

Deep Boreholes – targeting the groundwater residing in the Lambeth Group

- Fortnightly dipping, monitoring and sampling from BH510, BH513 and BH514A during all remediation and earthworks activities;
- Increasing to weekly during piling activities; and
- Monthly for 12 month post completion of basement slabs.

Moselle Brook

The Moselle Brook was sampled every two weeks during the remediation works and piling works and then monthly for 3 months following completion of the phase 3 enabling and piling works. Samples were numbered for MD.22 onwards as a continuation of the monitoring completed for Phase 2.

Table 1: Field Testing Parameters in Deep Boreholes – Stability to be Achieved Prior to Sampling (3-minute intervals)

Parameter	Units	Continuity Threshold
Dissolved oxygen	%	+/- 10
Electrical conductivity	µs/cm	+/- 3
Groundwater depth	mm	+/- 10
NAPL presence / thickness	mm	N/A
pH	-	+/- 0.1
Redox potential	mV	+/- 10
Temperature	°C	+/- 10
Turbidity	%	+/- 10

Table 2: Groundwater Analytical Testing Suite

Determinand	
Ammonia	Phenols - total
BTEX	Sulphate
Cyanide - total	Sulphide
Cyanide - free	Total Suspended Solids
Metals (As, Cd, Cr (III), Cr (VI), Cu, Ni, Pb, Zn, Hg, Se)	TPHCWG
Polycyclic Aromatic Hydrocarbons (Suite of 16)	Turbidity

Action or 'trigger' levels were determined with reference to the baseline conditions which encompassed 6 No. sampling rounds from BH501, BH511, BH512, BH513 and BH514A. Following review of the data, the contractor was required to highlight any exceedances of the action levels and/or two consecutive increases in any determinand concentration(s) to the Client and consultant. No action levels were assigned to the shallow boreholes primarily due to a lack of baseline data as wells were dry on the majority of occasions.

Table 3: Groundwater Action or 'Trigger' Levels [µg/l]

Determinand	Action Level (+10% of baseline maximum)	Determinand	Action Level (+10% of baseline maximum)
Hydrocarbons		Heavy Metals Cont...	
BTEX	1 ¹	Nickel	21
PAH (16)	0.16 ¹	Selenium	26.4
TPHCWG	10 ¹	Zinc	47.3
Heavy Metals		General Inorganics	
Arsenic	3.92	Ammonia	2,420
Cadmium	0.08	Cyanide - free	2.2
Chromium (III)	2.75	Cyanide - total	38.5
Chromium (VI)	5 ¹	Phenols - total	10 ¹
Copper	7	Sulphate	4,477,000
Lead	6	Sulphide	5 ¹
Mercury	0.66		

¹ action level set at laboratory limit of detection (LOD)

Actions levels were also stipulated for field (physiochemical) parameters as follows:

Table 3B: Actions Levels for Field Parameters*

Parameter	Units	Continuity threshold	Max	Action Level (+10 %)
Dissolved oxygen	%	± 10%	126 ^a	139
pH	-	± 0.1	8.4 ^d	8.6 [#]
Temperature	°C	± 10°C	18.7 ^c	20.6
Electrical conductivity	µS/cm	±3	9999 ^d	N/A
Redox potential	mV	± 10mV	527 ^c	580
Turbidity	NTU	± 10%	80 ^e	88
Groundwater depth	mm	± 10mm*	N/A	N/A
NAPL presence / thickness	mm	detection	0	detection

^a taken from BH511 ^b taken from BH513 ^c taken from BH510 ^d taken from BH514 ^e no data – value taken from BH508, Phase 2.

[#] pH revised as per Environment Agency recommendations for Phase 2 works (email dated 25 July 2019)

* table extracted from Atkins Foundation Works Risk Assessment Table 7-1 Ref: 5192204_P3_FWRA Rev 3.0, dated 13th May 2020

3 Sampling Methodology

A bladder pump was utilised to take the samples from the deep boreholes as this is the only low-flow (minimal disturbance) methodology suitable for obtaining samples in instances where the depth to groundwater

exceeds that where a peristaltic pump may be utilised (c. 10 m bgl). The shallow wells were sampled (if/where groundwater was present) using a peristaltic pump.

Wells were dipped to groundwater and to base using an interface probe so that the presence of any Non-Aqueous Phase Liquid (NAPL) could be detected.

Once the field parameters reached a compliant stability, samples were collected in laboratory-supplied containers suitable for the testing suite. Samples were placed in cool boxes with ice packs and dispatched to i2 laboratories (an MCERTS and UKAS accredited laboratory with a facility based in Watford) for testing.

3.1 Timeline

Fortnightly monitoring began on the 11th June 2020 after remediation works began on the 5th of June, increasing to weekly during deep level piling works for blocks D1 and D2 between the 14th September and the 15th October.

Noteworthy occurrences throughout the monitoring period were as follows:

- WS511 could not be located;
- Remedial excavation works were progressed across site, from the north western corner towards GH1 between 3rd June 2020 and 16th October 2020;
- WS507 was decommissioned in July 2020 (see **Appendix D**) and WS508 was monitored from thereon as a replacement but remained dry throughout; and
- BH514A became blocked between 10th and 19th November 2021. It was cleared prior to sampling on 26th November. Samples from 10th December 2021 needed to be bailed as the bladder pump could not pass down the standpipe due to a kink or other defect. Physiochemical parameters were analysed thereafter from samples taken from this standpipe by the laboratory.

4 Results

As the remediation commenced in early June 2020 and the ground floor slabs in Blocks D1 and D2 were completed in February 2021, monitoring data has been provided for the period April 2020 – February 2022. In case of the deep boreholes, this equates to 40 No. monitoring rounds. The full dataset is provided in **Appendix B** and laboratory certificates are provided in **Appendix C**.

4.1 Presence of NAPL

No measurable NAPL was recorded in any well on any monitoring or sampling occasion.

4.2 Shallow Wells

The wells proved to be dry for the majority of the monitoring period. Two samples were collected from WS507 in May and July 2020. Low level elevations of total cyanide (280-570 ug/l) were recorded along with some significantly elevated concentrations of ammonia (c. 500,000 ug/l). Metal concentrations were low. Phenol, PAH and BTEX were all below the laboratory limit of detection (LOD). 180 ug/l of TPH was recorded in July 2020. Samples were able to be recovered from WS506 from late June 2021. Low level elevations of total

cyanide (up to 140 ug/l) were recorded along with elevations of ammonia up to 4,700 ug/l. Low level elevations of heavy metals were also recorded. Phenol was detected on 4 occasions at concentrations up to 58 ug/l. TPH, BTEX and PAH concentrations remained below the laboratory LOD throughout the monitoring period.

4.3 Moselle Brook

Low level elevations of total cyanide (up to 110 ug/l) were recorded along with elevations of ammonia up to 24,000 ug/l. Low level elevations of heavy metals were also recorded. Phenol was detected on 3 occasions at concentrations up to 39 ug/l. TPH, BTEX and PAH concentrations remained below the laboratory LOD throughout the monitoring period on all but one occasion, September 2021 where 11 ug/l of PAH, 8 ug/l of BTEX and 18 ug/l of TPH were recorded.

4.4 Field Parameters (Deep Boreholes)

Table 4 summarises the field (physiochemical) parameters measured throughout the monitoring period.

Table 4: Summary of Deep Groundwater Field Parameter Results

Parameter	Units	Total samples	Minimum	Maximum	Average
GW depth	m bgl	118	31.39	39.12	34.66
NAPL present?	mm	118	Not present	Not present	Not present
DO	%	102	1.80	42.80	11.78
pH	pH Units	103	6.34	9.08	7.62
Temp	°C	102	4.80	25.00	11.44
EC	µS/cm	103	465	9,725	4,650
Redox	mV	103	-161	319	64
Turbidity (TDS)	mg/L	101	8.90	38,000	3,488

Data includes physiochemical data from laboratory results for bailed samples from BH514A

Notable Field Parameter Action Level Exceedances

An elevated pH result of 9.08 was recorded in BH513 (on 27th May 2020), however, this result is inconsistent with other groundwater parameters and is therefore thought to be either sampling or instrument error. Two high temperature readings were recorded both in BH513 (23 degrees in June 2020 and 25 degrees in September 2020). These results were clearly outliers and are considered to be either engineer or instrument error. The remaining parameters were, predictably, quite variable across a long period of time on a brownfield site.

4.5 Action Level Exceedances (Deep Boreholes – Chemical Criteria)

Table 5 summarises instances where exceedances of the action levels were recorded. These exceedances were reported to the Client and the Client's consultant.

Table 5: Exceedances of Action Levels

Borehole ID	Determinand	No. Exceedances / 40	Action Level [µg/l]	Notes
BH510	Heavy Metals			
	Arsenic	15	3.92	Max 10.3 µg/l Sept 2020
	Cadmium	12	0.08	Max 0.39 µg/l Dec 2021 & Jan 2022
	Chromium (III)	18	2.75	Max 8.3 µg/l Jan 2022
	Copper	23	7	Max 24 µg/l Feb 2022
	General Inorganics			
	Cyanide - free	2	2.2	Max 8 µg/l in May 2020
	Cyanide - total	5	38.5	Max 170 µg/l in Feb 2022
	Phenol - total	2	10	Max 31 µg/l in Dec 2020
	Sulphate	10	4,477,000	Max 1,230,000 mg/l in Oct 2020 All exceedances occurred in the early phase of the monitoring. No exceedances were recorded post Oct 2020
BH513	Hydrocarbons			
	PAH (16)	1	0.16	Max 1.19 µg/l in Mar 2021
	TPHCWG	1	10	Max 530 µg/l in Jan 2021
	Heavy Metals			
	Arsenic	2	3.92	Max 8.77 µg/l Sept 2020
	Chromium (III)	17	2.75	Max 9.4 µg/l in Feb 2021
	Copper	14	7	Max 21 µg/l Sept 2020
	General Inorganics			
	Sulphate	2	4,477,000	Max 1,310,000 mg/l in Oct 2020
BH514A	Hydrocarbons			
	PAH (16)	1	0.16	Max 3.12 µg/l in Feb 2022
	TPHCWG	2	10	Max 440 µg/l Sept 2020
	Heavy Metals			
	Arsenic	8	3.92	Max 19.5 µg/l in Feb 2022
	Cadmium	1	0.08	Max 0.18 µg/l in Feb 2022
	Chromium (III)	7	2.75	Max 5.9 µg/l in Dec 2020

Borehole ID	Determinand	No. Exceedances / 40	Action Level [µg/l]	Notes
	Copper	5	7	Max 28 µg/l in Sept 2020
	Nickel	1	21	Max 58 µg/l in Feb 2022
	General Inorganics			
	Ammonia	15	2,420	Max 91,000 µg/l in Feb 2022
	Cyanide - free	11	2.2	Max 69 µg/l in Feb 2022
	Cyanide - total	24	38.5	Max 19,000 µg/l in Feb 2022
	Phenol - total	3	10	Max 430 µg/l in Feb 2022
	Sulphate	1	4,477,000	Max 192,000 mg/l in Oct 2020
	Sulphide	1	5	250 µg/l in Feb 2022

From the data summarised above, it is evident that some increases in determinand concentrations were recorded in BH514A towards the end of the monitoring period in February 2022. Cyanide and ammonia elevations were the most notable. Assessment of these findings was complicated somewhat by the fact that works (and hence monitoring) are continuing at the time of writing for Phase 3B. These data (and that collected subsequently) have been scrutinised in more detail in a Technical Note produced for the Client, and the Client's consultant. Because much of the assessment is not directly applicable to Phase 3, the Technical Note is contained within **Appendix E**. 3 No. samples from the round of the 1st October 2020 all produced exceptionally high sulphate results (approximately 3 orders of magnitude higher than previous). All three samples in this round exceeded the trigger value by several orders of magnitude. However, the results in the subsequent monitoring rounds returned to what are considered the 'normal range' reported across Keltbray's works. The laboratory was contacted at the time and they concluded no testing or transcription errors. The results appear to be anomalous and the cause was unclear.

4.6 QA/QC

In total, 91 deviations were recorded on laboratory certificates over the monitoring period. These were due to either no date being supplied on the sample containers (4 occasions) or holding times being exceeded prior to analysis for either, or a combination of; ammonia, dissolved oxygen, electrical conductivity, redox, turbidity and pH (13 occasions). In the majority of instances, the holding time exceedances were due to delays in transit caused by bank holidays and third-party couriers. Although the samples were noted as deviating, after discussions with the laboratory it is Keltbray's opinion that it is unlikely that minor exceedances of holding times would have resulted in any significant under reporting of volatile/unstable determinands.

5 Conclusions

Whilst a significant number of exceedances of the baseline concentrations were recorded during the monitoring period it was concluded (following detailed discussions with the Client and the Client's consultant) that the exceedances were not of significant magnitude and/or longevity to be of concern and necessitate further action. Short-term increases showed no apparent correlation to works being undertaken at the Site, no environmental incidents occurred during the works and the baseline data clearly indicated that the deep

aquifer was impacted with total cyanide and, in particular, ammonia prior to the commencement of the works. Furthermore, there was no evidence of soils attributable to the Lambeth Group within the pile arisings.

Further monitoring and assessment will continue to be undertaken throughout the Phase 3B works. These data will be reported under separate cover twelve months after the installation of the basement slab in subsequent blocks. The Groundwater Monitoring Report for Phase 3B will also detail the decommissioning of all remaining monitoring installations.

Appendix A Drawings

- I. Site Location - CG3-KRE-X-000-XX-M2-CE-0011
- II. Site Layout Plan - CR3-KRE-X-000-XX-M2-CE-1025_P01
- III. Borehole Decommissioning Plan - CR3-KRE-X-000-XX-M2-CE-1027_P01

Appendix B Data Summary Tables

Appendix C Laboratory Certificates

Appendix D Well Decommissioning Information

Three boreholes, WS507, WS509A and BH512 were decommissioned in July 2020 to facilitate the on-going excavation works and following confirmation received by the client. BH514A was decommissioned on 22nd February 2022.

All decommissioning works were completed in accordance to the EA 'Good Practice for Decommissioning Redundant Boreholes and Wells' and Section 6.5 of the FWRA. Boreholes were filled using cement bentonite grout. The current status of the wells across site (at the time of writing) is listed in **Table D1** below and shown in drawing CR3-KRE-X-000-XX-M2-CE-1027_P01, in **Appendix A**.

Table D1: Well Condition Summary

Well ID	Installed by	Status
WS506	Keltbray	Retained
WS507	Keltbray	Decommissioned
WS508	Keltbray	Retained
WS509A	Keltbray	Decommissioned
WS510	Keltbray	Retained
WS511	Keltbray	Not Found
BH510	Keltbray	Retained
BH511	Keltbray	Not Found
BH512	Keltbray	Decommissioned
BH513	Keltbray	Retained
BH514A	Keltbray	Decommissioned; replaced with BH514B
BH514B	Keltbray	Retained

Bulk excavation works will have removed at least the top 2m of the 3 No. well installations which Keltbray were unable to locate (Note: despite a watching brief during the excavation works no well or well materials were noted during the excavation works). The 2 No. (WS510 and WS511) boreholes terminated within the Made Ground are not considered to represent any additional risk to the underlying aquifer or Moselle Brook. The single deep borehole (BH511) is located under the footprint of a future building, therefore future infiltration in this area will be negligible (Note: No perched water was encountered in the Made Ground or on the London Clay in the area of BH511).

Appendix E Technical Note