

Verification Report

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

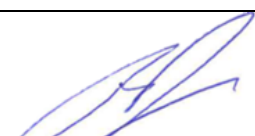
St William Homes LLP

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1 Introduction

Keltbray Remediation (KR) were instructed by St William Homes LLP (St William), the client, to complete a package of enabling 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 environmental monitoring locations and general area, are included in **Appendix A**.

This report is aimed to provide a detailed summary of the works completed by KR between 3rd June 2020 and 16th October 2020 and demonstrate compliance against the remediation objectives.

This document will be issued 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.

1.1 Background and Key Design Information

The Phase 3 development area is approximately 1.5 ha and includes the northern part of the former gasworks site. 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 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.

At time of KR's 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 dumping 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 comprise Made Ground soils overlying London Clay (approximately 25m thick) which is underlain by Lambeth Group, Thanet Sands and Chalk. The EA classifies the Lambeth Group as a Secondary A Aquifer and the Thanet Sands and Chalk as Principal Aquifers.

A culverted watercourse, the Moselle Brook, runs west to north east along the southern and eastern boundary. The EA classifies the Moselle Brook as a main river.

The site has been subject to past demolition and civilisation works, completed by National Grid Property Holdings (NGPH) under planning condition *HGY/2009/0503* and varied by *HGY/2013/2455*, *HGY/2016/0026* and *HGY/2016/166*. In 2017, GH1 and GH3 were demolished with GH3 partially infilled.

In 2020 Atkins were commissioned by St William to undertake additional assessment of the site and produce an appropriate remediation strategy and method statement. Subsequently Atkins produced:

- Geotechnical Site Assessment Report (5192204_P3_GE_R001/2.0 February 2020);
- Human Health Detailed Quantitative Risk Assessment (5192201_P3_HHDQRA_Rev2, February 2020);
- Controlled Water Detailed Quantitative Risk Assessment (5192204_P3_CWDQRA_Rev03, May 2020);
- Remediation Strategy (5192204_P3_RemStrat_Rev4, May 2020);
- Remediation Method Statement (5192204_P3_RMS_Rev4, May 2020); and
- Foundation Work Risk Assessment (5192204_P3_FWRA_Rev3, May 2020)

Following the acceptance of these documents and the site specific assessment criteria (SSAC) by the regulators KR produced the Remediation Implementation Plan (RIP) (KREM-6066-RIP-001-CRP3) setting out the proposed works for the site.

In addition to this, the previously conducted stabilisation / solidification (S/S) trials were reassessed to ensure that the existing proposed mix designs remained effective for the proposed SSAC. This was reported in CE Geochem report A190707 *Hornsey Gasworks Stabilisation Trials – Addendum Report*. This report is included in **Appendix M**.

1.1.1 Conceptual Site Model

The potential contaminant linkages as identified by Atkins, as presenting a potentially unacceptable risk to human health and environmental receptors under the site's future use are summarised in **Table 1**.

Table 1: Potential Contaminant linkages and Qualitative Risk Assessment

Source	Pathway	Receptor	Consequence	Likelihood	Risk Category
Residual contamination in Made Ground across the site associated with former Hornsey Gasworks	Ingestion / dermal contact / inhalation of contaminated soil / dust.	Future site users (commercial / residential)	Medium	Unlikely	Low
		Off-site workers and residents	Medium	Unlikely	Low
	Migration of organic contaminants through drinking water pipes.	Future site users (commercial / residential)	Medium	Unlikely	Low
	Accumulation and / or ignition of ground gas into buildings.	Future site users (commercial / residential)	Medium	Likely	Moderate
		Off-site residents	Medium	Unlikely	Low
	Migration and build-up of volatile vapours within structures followed by inhalation.	Future site users (commercial / residential)	Medium	Likely	Moderate
		Off-site residents	Medium	Unlikely	Low
	Migration and build-up of ground gas (CO ₂ and CH ₄) within structures.	Future site users (commercial / residential)	Medium	Unlikely	Low
	Leaching / Dissolution followed by Migration of NAPL/ contaminated perched water followed by chemical attack of materials.	Future on-site property (buildings / structures / services)	Medium	Unlikely	Low
	Leaching / dissolution of contaminants from contaminated soil / NAPL	Surface water (Moselle Brook)	Medium	Unlikely	LOW (moderate for ammonium, sulphate, and NAPL)
	Leaching / dissolution of contaminants from contaminated soil / NAPL followed by lateral migration within groundwater water.	Surface water (Moselle Brook)	Medium	Unlikely	LOW (moderate for ammonium, sulphate and NAPL)
	Man-made pathway developed during building works, e.g. foundation construction or drainage	Surface water (Moselle Brook)	Medium	Unlikely	Low

Source	Pathway	Receptor	Consequence	Likelihood	Risk Category
Localised asbestos contamination in Made Ground	Inhalation of contaminated soil/dust	Future site users (commercial / residential)	Severe	Unlikely	Moderate/Low
		Off-site works and residents	Severe	Unlikely	Moderate/Low
Residual contamination within the upper horizons of the London Clay.	Migration and build-up of volatile vapours within structures	Future site users (commercial/residential)	Mild	Unlikely	Very Low
		Off-site works and residents	Mild	Unlikely	Very Low
	Migration of organic contaminants through drinking water pipes.	Future site users (commercial/residential)	Medium	Unlikely	Low
	Leaching / dissolution from contaminated soil / NAPL	Surface Water (Moselle Brook)	Medium	Unlikely	LOW (moderate for ammonium, sulphate, and NAPL)
	Leaching / dissolution from contaminated soil / NAPL followed by migration within the groundwater.	Surface Water (Moselle Brook)	Medium	Unlikely	LOW (moderate for ammonium, sulphate, and NAPL)
		Secondary A Aquifer and Principal Aquifer within the Lambeth Group Thanet Sands and Chalk.	Medium	Unlikely	Low
	Migration of NAPL / contaminated perched water followed by chemical attack of materials	Future on-site property (buildings / structures / services)	Medium	Unlikely	Low
Contamination in groundwater above the London Clay.	Leaching / dissolution of contaminants from contaminated soil followed by lateral migration within water.	Surface water (Moselle Brook)	Medium	Unlikely	LOW (moderate for ammonium, sulphate, and NAPL)
		Secondary A Aquifer and Principal Aquifer within the Lambeth Group Thanet Sands and Chalk	Medium	Unlikely	Low
Site won soils placed within gas holder bases including those processed using solidification / stabilisation methodology	Inhalation of soil derived vapours	Future site users (commercial/residential)	Severe	Unlikely	Low
	Leaching / dissolution from contaminated soil / NAPL	Surface water (Moselle Brook)	Medium	Unlikely	LOW (moderate for ammonium, sulphate, and NAPL)
	Leaching / dissolution of contaminants from contaminated soil followed by lateral migration within groundwater.	Surface water (Moselle Brook)	Medium	Unlikely	LOW (moderate for ammonium, sulphate, and NAPL)
		Secondary A Aquifer and Principal Aquifer within the Lambeth Group Thanet Sands and Chalk	Medium	Unlikely	Low

Source	Pathway	Receptor	Consequence	Likelihood	Risk Category
Mobile free phase NAPL	Migration of free phase NAPL	Surface water (Moselle Brook)	Severe	Unlikely	Moderate/Low
Off-site contamination in perched groundwater associated with historical gasworks uses, railway sidings, and light industrial land uses.	Lateral migration in perched water followed by vapour inhalation.	Future site users (commercial/residential)	Medium	Unlikely	Low
	Leaching and dissolution from impacted soil and / followed by migration in groundwater	Surface water within the Moselle Brook culvert Secondary A Aquifer and Principal Aquifer within the Lambeth Group Thanet Sands and Chalk	Medium	Likely	Moderate
	Migration in groundwater	Surface within the Moselle Brook culvert	Medium	Unlikely	Moderate
		Secondary A Aquifer and Principal Aquifer within the Lambeth Group Thanet Sands and Chalk	Medium	Unlikely	Moderate

1.1.2 Scope of works

To address the identified pollution linkages the following scope of works for the remediation were identified:

- Environmental monitoring for key factors including air quality, dust, noise and vibration;
- Removal of redundant hardstanding, foundations, services and any potentially contaminative structures including below ground tanks;
- Excavation and investigation of Made Ground across the site;
- Identification and removal of visible asbestos containing material (ACM) and removal of known asbestos contaminated areas during earthworks activities;
- Inspection and validation of excavation extents against Site Specific Assessment Criteria (SSAC);
- Segregation and screening of generated arisings;
- Crushing of segregated brick and concrete including oversized screened from arisings;
- Assessment and sampling of stockpiles prior to reuse;
- Stabilisation / Solidification (S/S) and verification of material exceeding the SSAC; and
- Import and sampling of compliant fill to achieve required levels and make up.

N.B In addition to these a Volatile Organic Compound (VOC) vapour and gas resistant membrane is also required, however this is to be installed by other contractors and is not detailed in this verification report.

As well as completing the above in line with the Remediation Strategy and Remediation Method Statement (RMS) Keltbray were also instructed to undertake the following work on site:

- Construction of additional temporary car parking. This variation resulted in a reduced dig area to account for an extended welfare and parking area and additional import of material to the required levels. The area under the extended welfare in the northwest corner was not remediated.
- A central haul road was instructed to run through the centre of the site, enable a new access point off Brook's road to the north of the site. Additional 6F5 was imported to form the base of the concreted haul road.
- The pocket park package of works included excavation and scrape south and east of GH1. Materials generated were reused on site in GH1.
- Groundwater monitoring and reporting on a biweekly basis during the remediation works and weekly during the piling works as specified in the FWRA. This was reduced to a monthly basis for 12 months following completion of piling works.

Keltbray Piling were contracted to complete the piling works as part of a separate works package. This included the installation of CFA piles for the foundation of Blocks D1 & D2. Pile arisings from these activities were reused on site under a revision to the site Material Management Plan (MMP).

1.1.3 Key Stakeholders and Roles

The following stakeholders were involved in overseeing the works.

Table 2: Project Stakeholders and Roles

Role	Project Stakeholders	Contact
Client	St William Homes LLP	Timothy Collinson
Environmental Consultant for St William	Atkins Ltd	Anna Nash
Regulator (Controlled Waters)	Environment Agency	Themis Kantara
Regulator (Human Health)	London Borough of Haringey	Kenny Abere
Sewage Undertaker	Thames Water Utilities Ltd	Nick Gorham
Contractor	Keltbray Ltd	Joe Darcy

1.1.4 Remediation Strategy and Methodology

The RMS objectives were designed to mitigate identified risks and eliminate the identified pollution linkages. The strategy focused on removing sources of contamination such that residual ground conditions conform to the SSAC.

As per the RMS all soils were screened, stockpiled and assessed for reuse based on visual and olfactory evidence of contamination in addition to the SSAC's. The definitions of Visual and Olfactory evidence are summarised in **Table 3**. The SSAC are presented below in **Table 4**.

Table 3: Visual and olfactory indicators of contamination

Contaminant / Indicator	Criteria
Free cyanide	Visual: Blue oxide staining
PAHs and coal tar	Visual: Black liquid or semi-solid tar in veins or zone. Black/dark stained or coated surfaces Olfactory: strong hydrocarbon odour
TPH	Visual: Liquid oil, oil saturated solids in veins or zones. Black/dark stained or coated surfaces. Olfactory: strong hydrocarbon odour
Asbestos	Visual: ACM clearly observed as fragments or large fibre bundles within the soil

Table 4: Site Specific Assessment Criteria

Determinants	Soils SSAC	Leachate SSAC (mg/L)
Asbestos	<0.1% w/w*	N/A
Sulphate	18,000 mg/kg	2,900
Total Ammonium	21.6 mg/kg	10.3

*Concentrations exceeding 0.1% suitable for placement at depth within the gas holders.

In addition to the above, reused material was required to achieve < 50 ppm on a PID headspace assessment. Headspace readings were conducted at the same 250m³ rate on the same sample material.

As the site will be capped with buildings, hardstanding and capping in soft landscaped area, all material passing the leachate criteria only were considered suitable for reuse (as long as they also pass the visual and olfactory assessment and PID assessment).

1.1.5 Stabilisation / Solidification

Materials failing the leachate SSAC's were stabilised prior to reuse on site. Depending on the ammonium concentration of the failing material one of two mix designs were used.

Table 5: S/S mix designs

Ammonium Concentration (mg/kg)	Mix design
≤21.6	N/A - suitable for reuse
>21.6 – 325	5% wt. CEM1
>325	5% wt. CEM1 + 10% GGBS

1.2 Verification Strategy and Methodology

The RMS established the following verification requirements as presented in **Table 6**.

Table 6: Verification Strategy

Verification Strategy	Methodology
Validation of excavation base	Visual and olfactory inspection to confirm absence of gross contamination
	Validation testing to demonstrate compliance against SSAC's every 10m ²
Verification of placed site won material	Visual and olfactory inspection to confirm absence of gross contamination
	Verification testing to demonstrate compliance against SSAC's (1 sample per 250m ³).
Verification of imported material	Verification testing to demonstrate compliance against Target Import Criteria on a frequency of 1 sample per 250m ³ .

In addition to the above material reused on site was also tested for the determinands presented in the Generic Assessment Criteria (GACs) for human health > 1 m suite. These results were for information only.

2 Detailed Descriptions of Works

As part of the contracted works the following activities were completed. Various licenses and consents were acquired to facilitate the site wide remediation works, details of which are provided below.

2.1 Pre-Mobilisation Works

2.1.1 Mobile Treatment Permit

To treat the material onsite a deployment (reference CB3902KF/W0026) was approved by the regulators against KR's SR2008 No 27: mobile plant for treatment of soils and contaminated material, substances or products (more commonly refer to as a Mobile Treatment Permit or MTP). The approved deployment period commenced on 2nd February 2020 and was valid for 52 weeks.

A full copy of the MTP and a copy of the EA deployment letter CB3902KF/W0026 are included in **Appendix B**. Relevant correspondence between KR and the EA is summarised in **Section 2.1.5**.

2.1.2 Materials Management Plan

To allow for the reuse of site won material under the *CL:AIRE Definition of Waste: Development Industry code of Practice* (DoWCoP) a Materials Management Plan (MMP) was prepared and issued to a qualified person for declaration. **Appendix B** contains the MMP and confirmation of its declaration (MMP ref: 27/04/2020 17:05:14).

To allow for the additional reuse of pile arisings material the MMP was revised to include an additional 1380m³ of suitable pile arisings. As the volume change was <10% of the originally declared volume this was not considered a significant change and therefore no further declaration was required.

2.1.3 Discharge Consents

During the works two applications were submitted and approved by Thames Water allowing discharge of water from the site under Discharge Consents TDEE0CO5 and TDEE0CP2. The locations of the on-site permitted discharge locations are shown in drawing *CR3-KRE-X-000-XX-M2-CE-1025_P01* included in **Appendix A**. Although two locations were permitted, water was only discharged at one location under consent TDEE0CP2.

Copies of the consents and associated compliance limits are included within **Appendix B**. Further information of the subsequent testing and treatment of groundwater are described in **Section 4**.

2.1.4 Notification of Non-Licensed Work with Asbestos

Two known exceedance of the asbestos SSAC were identified during previous investigation works. To facilitate the works in these areas KR completed an 'ASB>NNLW1 - Notification of non-licensed work with asbestos'. This was submitted to the Health and Safety Executive (HSE) on 5th June 2020 ahead of works starting on 10th July 2020. The decision to notify was informed by the *CL:AIRE Decision Support Tool for the Categorisation of Work Activities Involving Asbestos in Soil and Construction & Demolition Materials in accordance with the Control of Asbestos Regulations 2012; v2* (CL:AIRE JIWG DST). The notification can be found in **Appendix B** with further information detailing the excavation and reuse of these areas discussed in **Section 2.5.1.1**.

2.1.5 Key Correspondence

Table 7 summarises the correspondence between KR and the relevant authorities throughout the duration of the project.

Table 7: Correspondence with Regulators and Relevant Parties

Date	Summary	Correspondents
25/02/2020	MTP CB3902KF/W0026 Deployment issue letter	Environment Agency / KR
24/04/2020	Discharge consent (TDEE0CO5) granted	Thames Water / KR
28/04/2020	MMP Declaration confirmation	CL:AIRE / KR
05/07/2020	ASB NNLW1 Notification	HSE / KR
06/07/2020	Discharge consent (TDEE0CP2) granted	Thames Water / KR

2.2 Site Establishment

KR mobilised to site and established a site compound on 3rd June 2020. Excavation works and breaking of hard standing began on the 5th June 2020.

2.2.1 Site Services

All live underground and aboveground services were removed by third parties contracted by the client prior to KR taking occupation of the site. No live services were present when KR mobilised to site.

2.3 Water Management

Upon mobilising to site both GH1 and GH3 contained significant volumes of rainwater. This water was tested to confirm compliance against the discharge criteria ('GH1' & 'GH3') and then discharged under consent to sewer via a laminal flow settlement tank.

In addition to water removed from the gasholders, rainwater ponding in open excavations was tested and discharged under consent to sewer (Sample 'water discharge'). In total 844m³ of water was discharged under consent to sewer.

Contaminated perched water not suitable to be discharged under consent to sewer was disposed of offsite separately via 8 No. tankers as detailed in **Section 2.8**. No other perched water or free phase liquid was encountered.

2.4 Borehole Decommissioning

11 No. groundwater monitoring wells had been installed on site prior to the KR enabling works. WS510, BH511 and WS511 were not able to be found upon KR's mobilisation to site. Efforts were made to locate these with GPS coordinates and localised excavation as recent ground level changes appeared to have

buried the wells. During bulk excavation in these areas an additional watching brief was carried out however none of the wells were found.

Wells (WS506, WS508, BH510, BH513 and BH514) were retained strategically, as specified within the Foundation Work Risk Assessment (FWRA) to allow continued monitoring of groundwater. A total of 3 No. boreholes were decommissioned in July 2020 to facilitate the on-going excavation works and following confirmation received by the client.

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 appropriate infill material with permeability properties similar to the original geological strata. The status of the wells across site is listed in **Table 8** below and shown in drawing *CR3-KRE-X-000-XX-M2-CE-1027_P01*, in **Appendix A**. Photographs documenting decommissioning are included within **Appendix C**.

Table 8: Well Condition Summary

Well ID	Installed by	Status
WS506	KR	Retained
WS507	KR	Decommissioned
WS508	KR	Retained
WS509A	KR	Decommissioned
WS510	KR	Retained
WS511	KR	Not Found
BH510	KR	Retained
BH511	KR	Not Found
BH512	KR	Decommissioned
BH513	KR	Retained
BH514	KR	Retained

Bulk excavation works will have removed at least the top 2m of well 3 No. well installations 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 and are considered not 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 limited (Note: No perched water was encountered in the Made Ground or on the London Clay in the area of BH511).

2.5 Excavation Works

Remedial excavation works were progressed across site, from the north western corner towards GH1 between 3rd June 2020 and 16th October 2020.

To ensure that excavation validation samples were collected at the required frequency the site it was divided into a 10m by 10m grid, A1 to T13 and later extended to include A0 to T-2 to include the pocket park area. Due to the irregular shape of site not all of these grid square fall within the Phase 3 area, drawing *CR3-KRE-X-000-XX-DR-CE-2005_P03* in **Appendix A** shows the validation grid and ammonium leachate

results from across the site. Due to temporary works requirements grid locations G10 and H10 were unable to be excavated.

All obstruction within 2m of existing ground level were removed. The walls of both gasholders were broken down to at least 2m from existing level with the remaining depth left in situ. To support the culvert of the Moselle Brook the gasholder walls within 6m of this were fully left in at their original height. Final Obstruction Plan (CR3-KRE-X-000-XX-M2-CE-1033, **Appendix A**) details this, with final site level shown in drawing CR3-KRE-X-000-XX-M2-CE-1032.

2.5.1 Known and Unexpected Exceedance Excavations

During all remedial works a continuous visual assessment of the excavation faces along with soil arisings was undertaken looking for any potential unexpected contamination. In accordance with the RIP a full watching brief was conducted to identify any areas of previously undocumented gross contamination. Field grid validation sheets were completed during the excavation works and are included in **Appendix D**.

There were 3 No. occurrences where unexpected conditions were encountered, in addition to 2 No. known asbestos exceedances. These were all encountered during remediation works and no unexpected contamination was encountered during piling for Blocks D1 and D2.

2.5.1.1 Known Exceedances

Previous investigation works identified 2 No. asbestos exceedances. These were concentrations of 0.189 & 6.6% at 0.55m below ground level (bgl) and 1.35m bgl, (exceeding the SSAC of 0.1%) within previous trial pits TP424 and TP419 (Drawing CR3-KRE-X-000-XX-M2-CE-1026, **Appendix A**).

Both of these known exceedances were located in close proximity to each other along the western site boundary, north of GH1. Their previously recorded locations were marked out by an engineer and they were excavated under controlled working conditions. Both locations were over excavated with a 5m by 5m excavation to 0.5m below the previously recorded exceedance.

Validation samples were taken from each face of the completed excavations and compared to the 0.1% asbestos SSAC. All validation samples passed, except sample VS-TP419-W from the western face of the excavation around TP419. This face of excavation was then further excavated and an additional validation sample collected. This sample was reported below the 0.1% asbestos criteria and both voids were temporary backfilled until this area was further remediated as part of the main excavation works.

Excavated material was removed and stockpiled as SP-Asbestos, before being placed at depth within GH1 as detailed **Section 2.6.2**. Photographs documenting this work are included within **Appendix C**.

2.5.1.2 Unexpected Exceedances

3 No. unexpected exceedances were encountered;

- 1 No. Brick Tank;
- 1 No. Fibreglass Interceptor; and
- 1 No. Concrete Trench.

During excavation works in the south of the site in grid square Q-2, a brick tank structure was encountered. The tank was 1m by 2m and constructed from yellow brick. It was filled with the same Made Ground that had been encountered across the area and contained not liquid. It was carefully broken out to expose its full extent. Following removal the exposed surrounding soils were validated and no gross contamination

was identified, samples 'Q2', 'Q2-East' and 'Q2-West' were taken for comparison to the SSAC's. These sample passed and no further excavation was undertaken. Hardcore from the tank was added to stockpile SP-005 and crushed prior to being reused onsite. Excavated Made Ground was added to SP-017 screened, stockpiled and sampled against the validation criteria. Further information on the chemical results for reuse can be found in **Section 3.2**.

While breaking out the concrete hardstanding in grid square L12 a small 0.5m by 1m fibreglass interceptor was uncovered. The interceptor contained oily water which was pumped and stored in an IBC, prior to disposal offsite via tanker, further detail is provided in **Section 4**. The interceptor was in good condition with no sign of contamination to the surrounding Made Ground or hardstanding once removed. The surrounding concrete and pipework showed no signs of contamination and was removed and crushed being added to the site won crushed concrete stockpile SP-022. The fibreglass was removed offsite via general waste and the excavation in this area was extended to achieve the required formation levels. Following this the grid square was validated and sample taken for comparison to the SSAC's.

During the reduced level excavation in the northern portion of site KR encountered a concrete trench, roughly 2.5m wide by 1m deep, between grids square J13 and J6. The trench contained a significant quantity of blackish water and was filled with black stained Made Ground mostly consisting of whole bricks. The water within this trench was sampled and reported ammonia concentrations of 150 mg/L and 130 mg/L. Approximately 96,000 L of contaminated water was removed from this excavation via tanker and disposed offsite at an appropriately licensed facility (**Section 2.8**).

The black stained Made Ground was excavated, stockpiled in a bunded area, and processed/treated onsite. The concrete surround was broken out and removed for onsite processing, exposing competent natural London Clay on the underside of the trench (Note: The 'fines' generated from the processing of this material was stabilised and the 'hard' material added to the stockpile for crushing). The location of this trench is shown on CR3-KRE-X-000-XX-M2-CE-1026 in **Appendix A**, photographs of its removal are included in **Appendix C**. Following removal validation samples were collected and grid validation inspections completed. The results of these validation samples are discussed in **Section 3.1.2**.

No further gross contamination was encountered.

2.5.1.3 Japanese Knotweed Excavation

During previous works Japanese knotweed had been identified along the eastern boundary of site. KR engaged Phlorum Ltd to produce and oversee a Japanese knotweed management plan for the identified knotweed growth and provide an insurance guarantee for the removal works.

The affected areas were excavated under the supervision of Phlorum, ensuring all knotweed roots and rhizomes were fully excavated. To ensure no regrowth from offsite areas, a root barrier membrane was installed along the length of the affected area, this is shown in CR3-KRE-X-000-XX-M2-CE-1026 **Appendix A**.

Soil excavated was placed in a line skip for offsite disposal. Details of material disposal are included in **Section 4**. **Appendix E** contains a record of completed works and associated insurance backed guarantee. No other ecological issues were identified on site.

2.6 Material Reuse

In total 14,633m³ of material was excavated and reused on site. This includes 701m³ of pile arisings reused.

All material reused was screened and stockpiled prior to verification against the SSAC's to prove suitability for reuse. A total of 43 stockpiles were created throughout the works, these are detailed in **Table 9**. Drawings showing the location of reused stockpiles are included in **Appendix A**, stockpile verification forms confirming suitability for reuse against visual, olfactory and PID assessment are included in **Appendix F**.

Material from stockpiles SP-006, SP-016, SP-020, SP-023, SP-029, SP-032, SP-037, SP-037.3 and SP-Sludge failed the ammonium reuse criteria. This material was subject to onward S/S prior to reuse. All other material passed the validation criteria and was reused on site, material reuse verification is detailed in **Section 3.2**.

Table 9: Stockpile Reuse Summary Table

Stockpile ID	Description	SSAC / Stabilisation mix	Placed Volume (m ³)
SP-Knotweed	Knotweed contaminated soils	Exported	N/A (15)
SP-000	Broken concrete and oversize	pass	400
SP-001 (combined SP1, 2 & 3)	Existing stockpiles on site (SP1, SP2, and SP3) combined to SP001	pass	231
SP-004	MG, pink granite gravel ('Type 1') from car park excavation.	pass	480
SP-005	Crushed concrete	pass	320
SP-006	Ashy, gravelly, clayey MG	5% wt. CEM1	233
SP-007	Made Ground, pink granite gravel ('Type 1') from pocket park area	pass	246
SP-008	Brown clay scrape from car park area.	pass	134
SP-009	Slightly ashy MG with high organic content from pocket park	pass	550
SP-010	Brown slightly sandy topsoil from north west corner behind GH3	pass	495
SP-011	Natural brown clay from 0.5-3m bgl north west corner behind GH3	pass	612
SP-012	Mottled black/brown reworked clay	pass	217
SP014	Crushed concrete (6F2)	pass	220 (added to SP-022)
SP-015	Dark grey gravelly MG	pass	86
SP-016	MG, gravelly clayey material	5% wt. CEM1	243
SP-017	Ashy black, granular MG from tank in Q -2	pass	10

Stockpile ID	Description	SSAC / Stabilisation mix	Placed Volume (m³)
SP-018	Brown gravelly MG with brick and flint from pocket park area	pass	203
SP-019	GH1 wall, crushed and added to SP-022	pass	315 (added to SP-022)
SP-020	Black stained gravelly clay. Moderate Gasworks odour.	5% wt. CEM1	293
SP-021	MG, pink granite gravel ('Type 1') from northern of site	pass	178
SP-022	Crushed concrete (6F2)	pass	3361
SP-023	Black wet granular material with wood and brick boulders.	5% wt. CEM1	225
SP-024	Black granular MG with bricks and flint gravels	pass	407
SP-025	Stiff brown sandy clay from east of GH1 1.50 - 4.00mbgl	pass	182
SP-026	Brown gravelly sandy MG from east of GH1 1.50-4.00mbgl	pass	404
SP-027	Greyish brown gravelly clayey MG	pass	68
SP-028	Brown sandy clayey MG	pass	686
SP-029	Black stained bricky MG from trench hotspot	5% wt. CEM1	151
SP-030	Screened granular MG from west of GH1.	pass	200
SP-031	Clay MG from south west of GH3	pass	156
SP-032	Brown gravelly clay from north of GH1.	5% wt. CEM1 +	157
SP-033	MG, pink granite gravel ('Type 1') from north of GH1	pass	124
SP-034	Clay from north of GH1	pass	219
SP-035	Dark brown granular material from north of GH1	pass	146
SP-036	Brown gravelly sandy MG	pass	143
SP-037	Mottled black and brown clayey MG – split due to exceedances	5% wt. CEM1	218
SP-037.2		Pass	185
SP-037.3		5% wt. CEM1 + 10% GGBS	126
SP-038	Imported recycled crush (6F5)	pass	1677

Stockpile ID	Description	SSAC / Stabilisation mix	Placed Volume (m ³)
SP-039	Brown stiff clay - Pile arisings	pass	701
SP-040	Brown stiff clay – Pile arisings	pass	171 (Added to SP39)
SP-Sludge	Black gravelly sludge from trench dig in trench	5% wt. CEM1	144
SP-Asbestos	Brown granular, sandy MG from previous exceedances	Pass (excluding known asbestos)	22

2.6.1 Stabilisation / Solidification

Of the 9 stockpiles subject to S/S seven were stabilised using the 5% wt. CEM1 mix design with the other two stabilised with the 5% wt. CEM1 and 10% wt. GGBS mix. All S/S works were conducted as specified in the Stabilisation Methodology (*KREM_T6455_TEC_SM_001_02*). Stabilisation tracking forms were completed for each batch stabilised and monolith, UCS, and CBR swell validation samples were collected by CE Geochem for analysis. S/S tracking forms are included in **Appendix G**.

Stabilised material was immediately backfilled and the location recorded, reuse locations are shown on the material reuse drawings in **Appendix A**. Stabilised material reused in GH3 was placed at least 14 days prior to piling works starting in this area. Verification results of all stabilised material is discussed in **Section 3.2.1**, and fully reported in **Appendix M**.

Table 10: Stabilisation / Solidification summary table

S/S Stockpile	Volume (m ³)	Mix design
SP-006	233	5% wt. CEM1
SP-016	243	5% wt. CEM1
SP-020	293	5% wt. CEM1
SP-023	225	5% wt. CEM1
SP-029	151	5% wt. CEM1
SP-032	157	5% wt. CEM1 + 10% wt. GGBS
SP-037	218	5% wt. CEM1
SP-037.3	126	5% wt. CEM1 + 10% wt. GGBS
SP-Sludge	144	5% wt. CEM1

2.6.2 Asbestos Material Reuse

22m³ of material excavated from the 2 No. known asbestos exceedances, stockpiled as SP-Asbestos, were encapsulated and reused at depth in GH1. The reuse location was confirmed as being outside any future excavation areas or piles by St William and the material was placed 4m below proposed finish levels. It was encased in an orange marker layer.

Photographs documenting this activity are included within **Appendix C**. The location is marked out on drawing *CR3-KRE-X-000-XX-M2-CE-1029 _P01* in **Appendix A** and reuse verification samples are included in **Section 3.2**.

2.7 Imported Material

In addition to the use of site generated 6F2 recycled aggregate, 6F5 was imported to site to achieve the required levels as well as for construction purposes. An estimated 1,677m³ of 6F5 (129 loads) was imported.

All imported material was from SRC Aggregates' Barking Recycling facility. **Appendix H** contains the WRAP quality protocol for this site and a log of the imported loads. Imported material was stockpiled as SP-038 and sampled to ensure compliance against the specified import criteria. These results are discussed in **Section 3.3**.

Table 11: Imported material summary table

Import Source	Number of loads	Volume (m ³)
SRC Barking	129	1,677

2.8 Off Site Disposal

A total of 36 loads of waste were removed from, 1 load of Japanese knotweed contaminated soils, 21 loads of mixed metals, 6 loads of mixed construction and demolition wastes, 1 load of recovered oily water and 7 loads of contaminated groundwater.

The different waste streams and corresponding disposal facilities are summarised in **Table 12**. The receiving facility permits and waste carrier licenses can be found in **Appendix I**. Waste transfer and consignment notes were completed for each load removed, a full copy of the export log is included in **Appendix J**. Waste characterisation sampling is discussed in **Section 4**.

Table 12: Summary of EWC Codes and Disposal Facilities

Material Description	EWC Code	Final Destination	Permit Number	Total No. of Loads
Non-hazardous soil and stones	17 05 04	Springfield Farm, Broad Lane, Beaconsfield, Bucks HP9 1XD	JP3891NX/A001	1
Mixed Metals	17 04 07	EMR, Albert Works, Kenninghall lane, Edmonton, N18 2PD	HB3604TQ	6

Material Description	EWC Code	Final Destination	Permit Number	Total No. of Loads
		EMR, 29 Bidder Street, Canning Town, London, E16 4SZ	QP3796NY	15
Mixed construction and demolition wastes	17 09 04	Powerday Willesden Recovery Centre, Old Oak Sidings, Scrub Lane, NW10 6RJ	PP3093EE	1
		Powerday Enfield, Unit 2, 115 Jeffreys Road, Enfield, EN3 7UA	AP3391NF	5
Recovered oily water	13 02 05	RWR (Commercial) Ltd., 12 Barber Road Facility, Stratford, London, E15 2PH	JP3596NH	1
Non-hazardous liquid wastes from groundwater remediation	19 13 08			7

3 Verification

KR undertook verification sampling throughout the duration of the site works as per the requirements of the RMS. The subcontracted UKAS and MCERTS accredited laboratories used for all chemical and geotechnical testing are listed below.

Table 13: Analytical Laboratories Used

External Testing	Laboratory
Passive VOC analysis	Chemtest
Soil, leachate and water analysis	i2 Analytical
S/S validation analysis	CE Geochem (Chemtest)
Geotechnical analysis	CET
Hydraulic conductivity analysis	Socotec

To provide reassurance of removal of all gross contamination as required, validation inspection forms were completed for each grid square and stockpile validated for reuse. All grid validation inspection forms can be found in **Appendix D**.

3.1 Excavation Validation

Validation of the remedial excavation was completed on a 10m x 10m grid with an initial visual and olfactory assessment to confirm removal of any residual contamination that may have been present. All samples were then tested for headspace VOCs analysis on site and samples dispatched for analysis against the SSAC's.

A total of 227 validation soil samples were submitted for testing. 215 of these were analysed for the full SSAC suite, with an additional 12 samples from the asbestos exceedances around TP424 and TP419 analysed for asbestos only. A summary of the results is presented in **Table 14**.

Of the 215 samples analysed for total sulphate, no samples reported exceedances. The one reported VOC exceedance was re-visited, excavated further and resampled, this resample recorded a passing VOC reading and was dispatched for testing. 59 samples exceeded the criteria for total ammonium. All samples were also submitted for leachate analysis. A summary of the leachate results is presented in **Table 15**.

Table 14: Summary of Excavation Validation Totals Results

Determinand	Units	SSAC's	Total No. of Samples	Minimum	Maximum	No. of exceedances	Location of exceedances (Sample ID)
Sulphate as SO ₄	mg/kg	18,000	215	0.02	7,100	0	N/A
Ammonium as NH ₄	mg/kg	21.6	215	0.03	1,300	56	VSG12, VSG11-S, VSG11W, VSH11, VSH11-S, VSH12, VSH13, VSH13-N, VSI11, VSI12, VSI13, VSI5, VSI5-W, VSI6, VSI6-W, VSI7, VSI9, VSI9-W, VSJ10, VSJ11, VSJ12, VSJ13, VSJ5, VSJ6, VSJ7, VSJ8, VSJ9, VSK10, VSK11, VSK12, VSK13, VSK6, VSK7, VSK8,
VOC headspace analysis	ppm	50	216	0.0	250**	0**	N/A
Asbestos	%	0.1	227	Not detected	0.38*	1*	TP419-west*
* Excavation extended and resampled resulting in <0.001%.							
** Excavation extended to remove exceeding material and resampled.							

Table 15: Summary of Excavation Validation Leachate Results

Determinand	Units	SSAC's	Total No. of Samples	Minimum	Maximum	No. of exceedances	Location of exceedances (Sample ID)
Sulphate as SO ₄	mg/L	2,900	215	0.1	1,810	0	N/A
Ammonium as NH ₄	mg/L	10.3	215	0.5	160,000	38	VS12N , VS18, VSH11, VSH12, VSH13, VSI11, VSI12, VSI13, VSI5, VSI5-W, VSI6-W, VSI7, VSI9, VSI9-W, VSJ10, VSJ11, VSJ12, VSJ13, VSJ5, VSJ7, VSJ8, VSJ9, VSK12, VSK13, VSK7, VSL10,VSL11, VSL12, VSL13, J9-W, J13-W, J12-W, J10-E, J10-W, VS-J8-E, VS-J8-B, VS-J7 Base, VS-J7- East

None of the 215 excavation validation leachate results exceeded the sulphate SSAC of 2.9 mg/L, however, 38 samples reported ammonium concentrations above the ammonium criteria of 10.3 mg/L.

All ammonium exceedances were reported in the north west portion of site, associated with the removed flooded concrete trench. Drawing *CR3-KRE-X-000-XX-DR-CE-2005_P03* in **Appendix A** shows the reported exceedances of the grid validation samples along with the location of the removed trench. Full copies of the verification analytical results are presented within **Appendix K**.

All validation samples in this north west area were taken in the London Clay following removal of the overlying Made Ground and obstructions, at approximately 22.85m AOD. Ammonium exceedances in the clay were unexpected, with no record or observations within previous intrusive works of contamination of this strata. Additionally there were no visual or olfactory indicators of contamination within what appeared to be naturally occurring and undisturbed London Clay. Failing samples were left in-situ pending further assessment.

3.1.1 Additional Investigation

To delineate the vertical and lateral extent of these exceedances, KR undertook two separate sampling exercises. An initial trial pitting exercise was completed consisting of 4 trial pits within grid locations H12, I12, I11 and H11. Samples were collected at 0.25m intervals, from the base of remedial excavation (22.85m AOD) down to a depth of 1.25 m (21.6m AOD). Concentrations of leachable ammonium from these trial pits ranged from 13-43mg/L. Competent London Clay with minimal staining or odour were observed throughout the depth of all 4 trial pits.

Given that ammonium exceedances were still being reported at depth, further investigations were undertaken to recover deeper samples of the London Clay. This consisted of 4 No. window samples (WS01-WS04). Samples were collected at 0.5m intervals to a depth of 7m below the base of excavation (15.85m AOD) and were analysed for both total and leachable ammonium concentrations. These locations were completed by a third party drilling contractor under the supervision of a field engineer.

The analytical data demonstrated that in WS01 and WS03, leachable concentrations of ammonium were orders of magnitude below the SSAC by a depth of 1.5m below the base of the excavation (21.35m AOD). With samples from WS02 identifying only a marginal leachable concentration of ammonium above the SSAC in the shallowest sample (0.5m). In WS04, the leachable ammonium was reported to a depth of 2.0m (20.85m AOD) above the SSAC (maximum concentration 47mg/L) but by 2.5m below the base of excavation concentrations were reported well below the SSAC. **Table 16** summarises all results from the window samples.

Table 16: Summary of window samples ammonium leachate results against depth, exceedances highlighted

Depth Below base of remedial excavation (m)	Ammonium leachate results (mg/L)			
	WS01	WS02	WS03	WS04
0.50	9	17	16	41
1.00	5	4.7	8.7	47
1.50	0.38	0.44	0.87	27
2.00	0.5	0.79	0.29	13
2.50	0.057	0.55	0.47	1.7
3.00	0.037	0.23	0.72	1.1
3.50	0.079	0.078	0.058	0.32
4.00	0.1	0.18	0.087	0.12
4.50	0.16	0.14	0.068	0.1
5.00	0.16	0.098	0.082	0.12
5.50	0.26	0.14	0.089	0.12
6.00	0.22	0.043	0.48	0.075
6.50	0.28	0.38	0.2	0.26
7.00	0.49	0.3	0.22	0.1

The borehole logs for the four window sample locations (**Appendix L**) confirm that the geology at the base of the remedial excavation comprised a mixture of the upper weathered surface of the London Clay (e.g. “soft brown silty CLAY”), present in WS01 and WS02, and more competent London Clay in WS03 and WS04 (“Firm brown mottled dark grey silty CLAY”). By a depth of 3.5m below the base of the excavation, the geology in all locations has been described as “firm” or “stiff” CLAY indicating that competent London Clay is present.

Falling head tests were carried out in all 4 location within the clay, these are included in **Appendix L**. Results from these showed that there was insufficient infiltration to accurately calculate permeability in all four wells i.e. the introduced water / head did not measurably dissipate throughout the test. Indicating that the London Clay strata at the base of the remedial excavation has a very low permeability.

3.1.2 Assessment of Residual Ammonium Risk

As per industry guidance Land Contamination: Risk Management (LCRM - formally CLR11) the conceptual site model (CSM) is considered “live” for remediation implementation and verification, and should be updated as new information becomes available. In light of the ammonium concentrations encountered in the London Clay, and the additional SI, KR consider it appropriate to review and update the CSM.

Previous work for the site identified contamination within the Made Ground as the source, with the Moselle Brook and deep bedrock aquifer as the two controlled waters receptors of concern:

- For the assessment of risk to the Moselle Brook, Atkins identified groundwater migrating through the Made Ground as the primary transport route of concern and developed Remediation Criteria accordingly.

- For the assessment of risk to the deeper aquifer (Lambeth Group and underlying units), Atkins identified piling activities as the potential transport route for contamination to by-pass the London Clay unproductive strata. They undertook indicative modelling using the Remedial Targets Worksheets assuming that contamination was dragged down through the London Clay to the depth of the piles (the source) with the pathway being the migration of contamination through the final 2.5m of clay to the Lambeth Group.

Atkins derived Remediation Criteria for soils and soil leachate, focused on the first pathway as per guidance from the EA (i.e. lateral migration of groundwater into the Moselle Brook). This modelled the Made Ground as the source medium. Remediation Criteria (RC) were then developed for ammonium (amongst other constituents) for groundwater based on an 8m compliance point. This assumes that contamination is present as a source right up to the boundary of the easement zone (8m) for Moselle Brook.

Based on observations noted during the additional validation works / validation sampling, we believe that sufficient qualitative evidence has been collected to update the modelled source medium to reflect the additional source of ammonium detected in the low permeability deposits i.e. the London Clay. Furthermore, we have also observed that the source of the ammonium is localised within the N. Western portion of the site, some 50m from the compliance point. On this basis we do not consider the transport of contaminants through the (unproductive) London Clay a viable pathway - i.e. the London Clay is acting as an aquitard, on which the Made Ground groundwater unit is “perching”, so the potential for groundwater flow through the London Clay is unlikely to be occurring at any notable rate.

Similarly, based on the CSM presented by Atkins, the Moselle Brook is characterised as being culverted within the Made Ground deposits above the London Clay. Therefore, given the fact that the identified potential source of elevated ammonium is in the Clay, KR would suggest that it would be highly unlikely for the contaminants within the London Clay to interact with a receptor in an overlying unit.

3.1.3 Summary

From review of the additional site investigation data and the DQRA (and specifically the CSM which underpins the development of the Remediation Criteria), KR note the following:

1. It is clear that there are differences between what was conceptualised as “source” requiring treatment within the DQRA and the material identified as containing leachable ammonium;
2. The elevated concentrations of leachable ammonium as are present within the upper section of the London Clay, and typically reduce significantly within the upper 1.5m of the base of the remediation excavation – albeit in one location evidence for deeper penetration of up to 2.5m was identified;
3. The elevated leachable ammonium concentrations are located some 50m from the Moselle Brook, with data collected in the weathered London Clay along the 50m pathway which does not have the same elevated concentrations of leachable ammonium.

In summary we do not believe there is any viable pathway for leachable concentrations of ammonium in the weathered London Clay to reach the Moselle Brook in an overlying unit. Accordingly, we do not consider there to be any residual risk to controlled waters and recommend no affirmative remedial action is taken to address the identified exceedances.

Furthermore, as per LCRM and SuRF UK guidance, the sustainability element of any alternative must also be considered. If exceedances across the impacted area averaged a depth of 1.5m it would represent

25,500m³ or 45,900 tonnes of clay. Due to the cohesive nature of the clay there are no suitable treatment options. Therefore the only other route for remediation of this material would be excavation and disposal to landfill. To make up the required ground level the equivalent quantity of material would be required to be imported, resulting in a significant number of lorry movements into and out of site. Keltbray considering the landfilling of large volumes of material that pose no risk to either controlled waters or human health to be unsustainable and against industry guidance and best practice.

3.2 Material Reuse Verification

To verify the 14,633m³ of material reuse on site a total of 108 soil verification samples were taken. This equates to one sample per 135m³ satisfying the required frequency of one sample per 250m³.

Material was sampled for verification following screening on a per stockpile basis. **Tables 17** and **18** summarise the results. All material reuse verification results are also included in **Appendix K**.

Stockpile validation inspection forms were completed on a stockpile basis, these forms are included in **Appendix F**.

Of the 108 reuse verification samples taken all passed the sulphate SSAC with 1 sample reporting greater than 0.1% asbestos. This sample, 'SP-022 2' reported asbestos at 0.303%. When queried at the laboratory this was confirmed to be a single bulk piece of asbestos containing material in the sample. The location from which this sample was taken was thoroughly inspected and no further identifiable pieces of asbestos were identified. All 13 other verification samples from SP022 reported either no asbestos identified or <0.001% detectable asbestos. As such all material in SP022 was considered suitable for reuse.

One sample from SP-Sludge reported a VOC headspace of >50 ppm. SP-Sludge was recovered from the flooded concrete trench following removal of contaminated groundwater. This VOC sample was prior to the material being subjected to S/S. All S/S verification analysis is discussed in **Section 3.2.1**.

Table 17: Summary of Material Reuse Verification Totals Results

Determinand	Units	SSAC's	Total Samples	Minimum	Maximum	No. of exceedances	Location of exceedances (Sample ID)
Asbestos	%	0.1	108	0	0.303	1	SP-022 2
Sulphate as SO ₄	mg/kg	18,000	108	0.018	9,900	0	N/A
Ammonium as NH ₄	mg/kg	21.6	108	0.5	850	31	SP-012 1, SP-012 2, SP-005, SP-020, SP-020, SP-023, SP-024(1), SP-024(2), SP-026 3, SP-026 4, SP-020 3, SP-020 4, SP-016, SP-024-3, SP-023-2, SP-027, SP-Sludge, SP-029, SP-022 3, SP-022 4, SP-032, SP-034, SP-035, SP-022, SP-036.2, SP-037, SP-037.2, SP-37.3, SP-22 7, SP-22 8, SP-39 3
VOC	ppm	50	105	0	854	1	SP-Sludge*
*SP-Sludge pre stabilisation.							

Table 18: Summary of Material Reuse Verification Leachate Results

Determinand	Units	SSAC's	Total Samples	Minimum	Maximum	No. of exceedances	Location of exceedances (Sample ID)
Sulphate as SO ₄	mg/L	2900	108	0.9	1,900	0	N/A
Ammonium as NH ₄	mg/L	10.3	108	16	47,000	11	SP006, SP020, SP-020 (3), SP-020 (4), SP023, SP016, SP-Sludge, SP-029, SP-032, SP037, SP-37.3

31 samples also reported exceedances of the ammonium totals SSAC. All these samples were also subjected to leachate analysis to assess their risk to controlled waters.

Off the 108 reuse verification leachate samples taken, all passed the sulphate criteria with 11 No. exceeded the ammonium reuse criteria of 10.3 mg/L. All material represented by these ammonium exceedances was stockpiled for onward S/S.

3.2.1 Stabilisation / Solidification

Following stabilisation by one of the two mix designs, verification samples were taken by CE Geochem on site. Stabilisation verification samples consisted of 11 semi-dynamic tank tests, in addition to geotechnical verification by CBR Swell and UCS testing. CE Geochem report *A190707 Hornsey Gas Works – Stabilisation Technology Verification* included in **Appendix M** details the verification all stabilisation samples.

Table 19: Summary of S/S samples

Stockpile	Mix Design Used	Volume (m ³)	S/S Verification sample reference
SP-006	5% CEM1	233	Val-001
SP-016	5% CEM1	243	Val-002
SP-020	5% CEM1	293	Val-003 Val-004
SP-023	5% CEM1	225	Val-006
SP-029	5% CEM1	151	Val-007
SP-032	5% CEM1 + 10% GGBS	157	Val-005
SP-037	5% CEM1	218	Val-008 Val-009
SP-037.3	5% CEM1 + 10% GGBS	126	Val-010
SP-Sludge	5% CEM1	144	Val-011

3.3 Imported Material Verification

To verify the 1,677m³ of 6F5 imported to site 7 import verification samples were taken and screened against the import criteria. This represents 1 sample per 240m³ satisfying the 1 per 250m³ requirement.

All samples passed the import criteria and the material was reuse on site. **Table 20** summarises the results, all import material verification reports are included in **Appendix K**.

Table 20: Summary of Import Verification Results

Determinand	Unit	Import Criteria	Total Samples	Min.	Max.	Number of Exceedances
General Inorganics						
Asbestos	%	0.10%	7	Not Detected	Not Detected	0
BTEX			7			0
Benzene	mg/kg	2.51	7	0.001	0.001	0
Toluene	mg/kg	315	7	0.001	0.001	0
Ethylbenzene	mg/kg	85.6	7	0.001	0.001	0
Xylenes	mg/kg	26.9	7	0.001	0.001	0
TPH Bands						0
TPH Aliphatic > C5-C6	mg/kg	42.9	7	0.001	0.001	0
TPH Aliphatic > C6-C8	mg/kg	99.6	7	0.001	0.001	0
TPH Aliphatic > C8-C10	mg/kg	13.9	7	0.001	0.001	0
TPH Aliphatic > C10-C12	mg/kg	141	7	1.0	1.0	0
TPH Aromatic > C5-C7	mg/kg	2.51	7	0.001	0.001	0
TPH Aromatic > C7-C8	mg/kg	315	7	0.001	0.001	0
TPH Aromatic > C8-C10	mg/kg	22.8	7	0.001	0.001	0
TPH Aromatic > C10-C12	mg/kg	141	7	1.0	4.4	0
PAHs						0
Naphthalene	mg/kg	5.68	7	0.05	2.7	0
Other Organics						0
1,1-Dichloroethane	mg/kg	1.19	7	0.001	0.001	0
1,2-Dichloroethane (1,2-DCA)	mg/kg	0.0089	7	0.001	0.001	0
cis-1,2-Dichloroethene	mg/kg	0.0574	7	0.001	0.001	0
trans-1,2-Dichloroethene	mg/kg	0.0966	7	0.001	0.001	0
1,1,1-Trichloroethane (1,1,1-TCA)	mg/kg	3.2	7	0.001	0.001	0
1,1,2-Trichloroethane (1,1,2-TCA)	mg/kg	0.431	7	0.001	0.001	0
1,1,1,2-Tetrachloroethane	mg/kg	1.89	7	0.001	0.001	0
1,1,2,2-Tetrachloroethane	mg/kg	4.75	7	0.001	0.001	0
Trichloroethene (TCE)	mg/kg	0.0016	7	0.001	0.001	0
Tetrachloroethene (PCE)	mg/kg	0.678	7	0.001	0.001	0
Trichloromethane	mg/kg	0.472	7	0.001	0.001	0
Carbon Tetrachloride /	mg/kg	0.147	7	0.001	0.001	0
Vinyl Chloride (VC)	mg/kg	0.0003	7	0.001	0.001	0
Phenol	mg/kg	621	7	0.2	0.2	0

3.4 Hydraulic Conductivity Verification

Material reused within 8m of the Moselle Brook and within the gasholders was required to have a hydraulic conductivity of less than 1.20×10^{-2} m/day. To achieve this 1,300m³ of cohesive soils were reused within these locations. 6 No. samples were collected and dispatched for hydraulic conductivity analysis. All samples reported results below the required level. Results for these samples are included in **Appendix N**.

3.5 Verification Sample Deviations

130 no. of the validation samples submitted for testing reported deviations following their analysis. These were chiefly due to either no date being supplied on the sample containers or incorrect containers being used.

Although the samples are noted as deviating, it is Keltbray's opinion that it is unlikely that lack of sample date resulted in any volatile holding times being exceeded as samples were dispatched to the laboratory either on the day of collection or following working day. With respect to the deviations associated to incorrect sample containers, these were principally due to only plastic tubs being used. Keltbray have confirmed with the laboratory (i2 Analytical) that the deviations would not have affected the results of the validation criteria, - ammonium and sulphate - total or leachate testing methods.

4 Waste Classification

2 No. waste streams disposed of from site required classification samples. These were soils excavated as part of the Japanese knotweed removal and contaminated groundwater encountered in the excavation in the north east of site. **Table 21** summarises the waste classification samples taken, all waste classification results are included in **Appendix K**.

Table 21: Summary of Waste Classification Samples

Waste Stream	Sample ID	EWC Classification
Japanese knotweed impacted soils	SP-Knotweed	17 05 04
Contaminated Groundwater	I10/11 GW, J5 WW	19 13 08

N.B Sample 'I10/11 GW' was taken from the flooded trench in J10/11 but incorrectly labelled.

In addition to the above, water encountered in the fibreglass interceptor removed from L12 contained a significant proportion of oily water. This was removed via tanker and classified under the absolute hazardous entry of 13 02 05.

4.1 Thames Water Discharge

To ensure discharge water was compliant with the Thames Water discharge consent 2 discharge samples were collected and dispatched for analysis. Both discharge samples passed the relevant criteria. 2 samples were also taken of surface water within the gasholder on mobilisation to site, these samples passed the discharge criteria and this water was pumped via the laminal flow settlement tank to discharge. Full copies of the analytical results are included in **Appendix O**.

Table 22: Summary of Discharge Water Samples

Type of sample	No. of samples	Sample IDs
Pre-treatment	2	'GH1' & 'GH3'
Post-treatment discharge	2	'Water discharge' and 'Discharge SW'

3 no. discharge samples submitted for testing reported deviations following their analysis. These were all due to holding times being exceeded prior to analysis.

Although the samples are noted as deviating, after discussions with the laboratory it is Keltbray's opinion that it is unlikely that these minor exceedances of holding times would have affected the reported results significantly enough to breach the discharge criteria.

5 Environmental Controls and Monitoring

To ensure that the works had a minimal impact on surrounding receptors environmental controls and monitoring were undertaken throughout KR's time on site. Monitoring schedules and trigger levels for the different parameters as set out in previous documentation are detailed in **Table 23**, below.

KR installed two continuous environmental monitoring stations (EMS) equipped with quantitative noise, dust and VOC monitors. These were located along the site boundary at sensitive locations to continually assess the impact of the works. The location of these is shown in drawing *CR3-KRE-X-000-XX-M2-CE-1025_P01*, included in **Appendix A**.

Similarly, quantitative vibration monitoring was completed using separate mobile vibration monitors placed adjacent to sensitive receptors. Both these systems included telemetry which allowed the upload of live data to monitoring site and included trigger values to notify the project team of any elevated readings above the agreed trigger values.

Table 23: Environmental Monitoring schedule

Monitoring Locations	Parameter	Frequency	Trigger Values
2 No. environmental monitoring stations (EM1 and EM2)	Noise	Continuous quantitative	+5dB(A) above pre-construction
	Dust	Continuous quantitative	3 mg/m ³
	Odour/VOCs	Continuous quantitative and biweekly diffusion tubes	PID - 1 ppm TENAX >0.1 mg/m ³
Vibration monitoring completed adjacent to works.	Vibration	Continuous quantitative	40mm/s

Daily qualitative monitoring of environmental impacts were assessed using a numerical scale from 1 to 5, which then implemented the corresponding control measures required on site. The adopted scale and corresponding actions are detailed in **Table 24**.

Table 24: Qualitative monitoring assessment and action levels

Level	Qualitative Assessment	Action
1	No Noticeable Issue	No Action Required
2	Minor Issue	To be Monitored
3	Obvious Issue	Preventative Action to be Planned
4	Significant Issue	Working Methods to be Adjusted
5	Major Issue	Works Cease Immediately and Not Recommence Until Solution Implemented

Full copies of the daily qualitative environmental monitoring data is included in **Appendix P**. Data from the full time continuous environmental monitoring stations for dust, VOC, and noise is included **Appendix Q**.

5.1 Odours / Volatile Organic Compounds

Given the known contaminants present within the site boundary, qualitative and quantitative odour and VOC monitoring was completed. Qualitative monitoring was completed daily at the 2 locations in the form of 'sniff tests'. A trigger value of 3 was adopted to ensure that activities did not emit any unpleasant odours and appropriate control measures were put in place to mitigate any nuisance caused.

All qualitative odour assessment at the boundary monitoring points were reported as 1 'no noticeable issue'. Any odorous material encountered during the excavation works were subject to odour management at source, with mobile de-odourise units being deployed wherever needed. The amount of odorous material exposed or processed at one time was limited as far as possible, and screening and stabilisation activities were carefully managed to minimise odour release.

In addition to the mobile odour suppression units used on site a boundary misting unit was deployed along the downwind eastern boundary to further mitigate nuisance to the adjacent residential units.

Quantitative monitoring and spot checks were completed daily using a handheld PID at any point sources and across the works area to monitor VOC release. The two EMS at the site boundary continuously recorded VOC concentrations to monitor VOC release, issuing alert should any exceedances above the 1 ppm trigger value be detected.

Table 25: Summary of VOC EMS monitoring data

Station Number ID	VOC (ppm)	
	EMS1	EMS2
Station Location	Offices	Houses
Minimum	0.0	0.0
Maximum	3	52*
Average	0.0	0.0
* 52ppm and 5ppm exceedances on 11/06/20 during monitor maintenance, for a total of 2 seconds.		

In support of the PID field monitoring, TENAX diffusion tubes were installed alongside the continuous monitoring stations at EMS1 and EMS2. Sampling was carried out from 29th May 2020 on biweekly passive sampling periods. Results reported concentrations below the laboratory limit of detection for the majority of determinants with the exception of 4 detects of naphthalene, with a maximum of 0.6 µg/m³. The full analytical VOC reports are included in **Appendix R**.

5.2 Dust

All daily qualitative dust results were recorded as 1 'no noticeable issue' and therefore no further actions or mitigation was required. To reduce the risk of windblown dust during dry spells and high winds, jet washes and dust atomisers were deployed. These were operated on site during potential dusty activities such as S/S, screening and crushing.

Quantitative dust monitoring was completed as part of the continuous monitoring at EMS1 and EMS2, measuring PM₁₀. Results were compared against the trigger value of 3 mg/m³. All results reported below the site specific trigger value. Dust results are summarised in **Table 26** below.

Table 26: Summary of quantitative dust monitoring data

Station Number ID	PM10 (mg/m ³)	
	EMS1	EMS2
Station Location	Offices	Houses
Minimum	0.001	0.00
Maximum	1.622	1.3830
Average	0.010362	0.0074

5.3 Noise

Continuous quantitative noise monitoring was completed as part of the monitoring at both EMS1 and EMS2. Sound Pressure Level (SPL) readings were taken continuously and reported to the online monitoring system. **Table 27** summarises these results.

In addition to this, qualitative monitoring was undertaken to assess to impact of noisy work on surrounding receptors, this was completed daily at both boundary EMS locations. All qualitative results reported no noticeable issue.

Table 27: Summary of noise results

Station Number ID	SPL (dB)	
	EMS1	EMS2
Station Location	Offices	Houses
Minimum	45.8	45
Maximum	77.1	77.1
Average	63.7	63.5

5.4 Vibration

Real-time vibration monitoring was carried out at using two vibration monitors located adjacent to sensitive receptors. One was located at EMS2 adjacent to the residential properties along Hornsey Park Road and the second was located along the southern boundary to monitor vibration impact to the medium pressure gas easement running along the southern boundary of site.

During the piling works the gas easement monitor was moved to coincide with the piling locations and placed on the remaining southern wall of GH1 to best capture the on-going activities. No vibration in excess of the trigger value were encountered during the works other than when the monitors were accidentally disturbed.

The full results of the vibration monitoring are reported in **Appendix S**.

5.5 Surface Water Monitoring of Moselle Brook

The Moselle Brook was sampled every two weeks during the remediation works and piling works and will continue to be monitored 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.

These samples are summarised in **Table 28**, below. Chemical results of the water samples are summarised in **Table 29**. Full analytical results are included within **Appendix T**.

Table 28: Summary of Surface Water Samples

Type of testing	No. of samples	Sample IDs
Surface water	9	MB.22, MB.23, MB24, MB25, MB26, MB27, MB28, MB29, MB30 and MB31

Table 29: Summary of Surface Water Results

Determinand	Units	Total samples	Minimum Concentration	Maximum Concentration	Average Concentration
TPH CWG	µg/L	9	<10	<10	<10
PAH 16	µg/L	9	<0.16	<0.16	<0.16
BTEX	µg/L	9	<1.0	<1.0	<1.0
Ammonia	µg/L	9	4,300	17,000	9,933.3
Arsenic (dissolved)	µg/L	9	1.73	3.28	2.52
Cadmium (dissolved)	µg/L	9	0.02	2.53	0.87
Chromium (hexavalent)	µg/L	9	0.03	0.03	0.03
Chromium (III)	µg/L	9	2.4	7	4
Chromium (dissolved)	µg/L	9	0.3	7	2.51
Copper (dissolved)	µg/L	9	1.1	29	8.37
Lead (dissolved)	µg/L	9	0.4	1.5	0.76
Mercury (dissolved)	µg/L	9	0	0	<0.05
Nickel (dissolved)	µg/L	9	1.6	4	2.59
Selenium (dissolved)	µg/L	9	1.1	3	1.51
Zinc (dissolved)	µg/L	9	4.8	34	16.68
Free cyanide	µg/L	9	1	2	1.5
Total Cyanide	µg/L	9	1.5	96	23.26
Thiocyanate	µg/L	9	230	750	436.67
Phenols (total)	µg/L	9	<10	14	11.5
Sulphate	µg/L	9	90	84,300	9,464.06
Sulphide	µg/L	9	300	300	300

5.6 Groundwater Monitoring

As per the requirements of the FWRA groundwater monitoring was completed every two weeks during the remediation works, weekly during the piling works and will be completed monthly thereafter for 12 months.

Bi-weekly monitoring began on the 11th June 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.

Throughout the 14 No. monitoring rounds groundwater recovery from the shallower boreholes installed within the Made Ground was limited. These monitoring wells were frequently found to run dry prior to stabilisation of field parameters with insufficient sample volumes recovered for laboratory analysis.

Groundwater samples were more successfully recovered from the deeper boreholes, BH510, BH513 & BH514. All samples were recovered using low flow monitoring equipment except BH514. Low flow sampling equipment could not be advanced beyond 25m bgl within BH514, due to a kink or other defect. To avoid blocking the well it was discussed and agreed with the project team that BH514 was sampled with micro-bailers in all further sampling events, to avoid equipment become wedged within the well, as such no flow cell field parameter were collected for this location.

Recovered samples were scheduled and tested against the specified suite of determinands. These results are summarised in **Table 30**. Field parameter for the low flow sampled boreholes are detailed in **Table 31**. Full copies of the analytical results and water quality parameter are included in **Appendices T and U** respectively. Wells not required for the monitoring were decommissioned as reported in **Section 2.4**.

Table 30: Summary of Deep Groundwater Results

Parameter	Units	Total samples	Action level	Minimum Concentration	Maximum Concentration	Average Concentration
TPH CWG	µg/L	37	10	<10	440	20.49
PAH 16	µg/L	37	0.16	<0.16	<0.16	<0.16
BTEX	µg/L	37	1.0	<1.0	<1.0	<1.0
Ammonia	µg/L	37	2420	140	8,800	1,502
Arsenic (dissolved)	µg/L	37	3.92	0.53	10.3	2.07
Cadmium (dissolved)	µg/L	37	0.08	0.02	0.91	0.07
Chromium (hexavalent)	µg/L	37	5.0	2.7	5.0	4.64
Chromium (III)	µg/L	37	2.75	2.6	5.9	1.49
Copper (dissolved)	µg/L	37	7.0	0.7	28	5.43
Lead (dissolved)	µg/L	37	6.0	0.2	2.0	0.35
Mercury (dissolved)	µg/L	37	0.66	0.05	0.09	0.05
Nickel (dissolved)	µg/L	37	21	0.7	21	5.58
Selenium (dissolved)	µg/L	37	26.4	0.7	22	4.00
Zinc (dissolved)	µg/L	37	47.3	0.7	26	5.19
Free cyanide	µg/L	37	2.2	1	17	2.05
Total Cyanide	µg/L	37	38.5	1.1	220	26.94
Phenols (total)	µg/L	37	10	10	13	10.07
Sulphate	µg/L	37	4477	200	1,310,000	73,838
Sulphide	µg/L	37	5.0	<5.0	<5.0	<5.0

Table 31: Summary of Deep Groundwater Field Parameter Results

Parameter	Units	Total samples	Minimum	Maximum	Average
GW depth	m	42*	34.31	39.12	36.25
NAPL present?	mm	42*	0	0	0
DO	%	28	3.9	42.8	16.9
pH	pH Units	28	6.34	9.08	7.67
Temp	°c	28	12.6	25.0	15.5
EC	µS/cm	28	464.9	9709	6645
Redox	mV	28	-160.9	212.5	3.09
Turbidity (TDS)	mg/L	28	2119	24563	5065
*Includes dips from bailing of BH514					

Sample results exceeded the trigger values in the FRWA on several occasions. A single TPH result from BH514 detected above the limit of detection at 440 µg/L. This is thought to be an anomalous result as all subsequent results (3 No. at the time of writing this report) were reported below the limit of detection.

Four ammonia results were elevated above the 2,420 µg/L trigger value in BH514 and BH513. These were recorded in May and June and have no apparent correlation to relate to KR works on site. All 10 No. subsequent sample rounds from July onwards recorded ammonia below the trigger level.

Arsenic, cadmium, chromium (III), and copper concentrations were reported above the FWRA trigger values, these results did not show a clear trend or appear to correlate with each other. With the exception of 2 No. results for arsenic on 16th September 2020 (10.3 and 8.77 µg/L in BH510 and BH513) all results were below the groundwater drinking water standard (Schedule 5 of the WFD) of 7.5 µg/L, 3.75 µg/L, and 1,500 µg/L for arsenic, cadmium, chromium and copper respectively. Illustrating the low levels detected and conservative nature of the trigger values.

Cyanide and free cyanide were both detected above the trigger values in BH514. This occurred prior to the start of works in May 2020 and sporadically throughout the monitoring. Results showed no correlation with the remediation or piling activities. Further data gathering will continue to monitor cyanide concentrations.

One phenol result from BH510 was reported above the trigger value at 13 µg/L (note: the laboratory limit is detection of 10 µg/L). All subsequent samples recorded less than the limit of detection.

All sulphate results passed the trigger values in all rounds except the 3 No. samples from the round of the 1st October 2020. All three samples in this round exceeded the trigger value by several orders of magnitude. However, the results in the subsequent monitoring rounds (2 No. at the time of writing this

report) returned to what are considered the 'normal range' reported across KR works. It is unclear if the results are a 'spike' or a result of sampling error. Ongoing monitoring will continue to assess this.

Water quality parameters measured during monitoring showed consistent results throughout the works. 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 sampling error. Temperature readings were relatively consistent, however, hot and sunny weather did cause some elevated readings not likely representative of the aquifer below. Turbidity was consistent across the well network from round to round except for a single recording of 24,563 mg/L on 11th June, this again is thought to be an error as the EC for the same monitoring round recorded only 3,792 μ S/cm.

Further data will continue to be obtained and analysed as the ongoing monitoring is completed and any trends or issues acted upon. This will be reported fully following completion of the monitoring programme.

16 no. of the water monitoring samples submitted for testing reported deviations following their analysis. These were due to either no date being supplied on the sample containers or holding times being exceeded prior to analysis.

Although the samples are 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 determinands.

5.6.1 Ongoing Monitoring

As per the requirement of the FWRA and RMS, groundwater monitoring will continue for 12 months following completion of piles for Blocks D1 & D2. These piling works were finished in October 2020 and so groundwater monitoring will continue to be carried out monthly until October 2021.

Following decommissioning of redundant wells, boreholes BH510, BH513 and BH514 screened below the London Clay will continue to be monitored. As shown in drawing *CR3-KRE-X-000-XX-M2-CE-1027_P01*, **Appendix A**, these wells and shallow wells WS506 and WS508 remain on site. This monitoring will be undertaken by KR and shared amongst the project team, the full groundwater monitoring results will be reported following completion of this (estimated November 2021).

6 Completed Works Status

Contractual remedial works (excluding on going groundwater monitoring) have been completed in Phase 3 in accordance to the Scope of Works as detailed in the Remediation Method Statement.

As identified during the works residual ammonium contamination reported within a portion of the north west of the site. However, no viable pathway has been identified for leachable concentrations of this ammonium in the weathered London Clay to reach the Moselle Brook in the overlying unit and therefore is not considered to pose a risk to controlled waters.

Completion of these works has rendered the Phase 3 construction boundary suitable for onward development in accordance with planning Condition 31 and associated documentation.

6.1 Remaining Remedial Actions

Notwithstanding the above completion the following requirements of the RMS are still outstanding:

- Placement of cover systems including marker layers and human health compliant fill including capillary break layer, sub-soil, top-soil and MOT Type 1 in areas of soft landscaping as required;
- Construction of a managed drainage system;
- Gas and vapour mitigation as required by the Remediation Strategy;
- Appropriate classification and management of any arisings; and
- Remediation of the extended welfare area in the north west corner.

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. Remedial Dig Plan - CR3-KRE-X-000-XX-M2-CE-1026_P01
- IV. Ammonium Validation Grid Plan - CR3-KRE-X-000-XX-DR-CE-2005_P03
- V. Borehole Decommissioning Plan - CR3-KRE-X-000-XX-M2-CE-1027_P01
- VI. GH1 Backfill Locations - CR3-KRE-X-000-XX-M2-CE-1028 _P01 & CR3-KRE-X-000-XX-M2-CE-1029
- VII. GH3 Backfill Locations - CR3-KRE-X-000-XX-M2-CE-1030 _P01
- VIII. Final Site Levels - CR3-KRE-X-000-XX-M2-CE-1032
- IX. Final Obstruction Plan - CR3-KRE-X-000-XX-M2-CE-1033

Appendix B Permit and Licences

Appendix C Photographs

Appendix D Grid Validation Forms

Appendix E Japanese Knotweed Documentation

Appendix F Stockpile Verification Forms

Appendix G Stabilisation Tracking Forms

Appendix H WRAP Documents

Appendix I Facility Permit and Carrier Licences

Appendix J Export Log

Appendix K Verification Sampling Results

Appendix L Additional Investigation

Appendix M Stabilisation Reports

Appendix N Hydraulic Conductivity Results

Appendix O Discharge Sample Results

Appendix P Daily Environmental Monitoring Sheets

Appendix Q EMS data

Appendix R Diffusion Monitoring Results

Appendix S Vibration Monitoring Data

Appendix T Water Monitoring Sample Results

Appendix U Water Field Parameter Data