



UNIVERSAL DESTINATIONS & EXPERIENCES UK PROJECT

Former Kempston Hardwick Brickworks
and adjoining land, Bedford

Environmental Statement Volume 3

Appendix 11.2 - Ground Investigation Technical Note

Report reference: 4.11.2.0

Revision number: 00

Date: June 2025



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1. INTRODUCTION

1.1. TERMS OF REFERENCE

- 1.1.1. This appendix has been prepared in support of the planning proposal for the Proposed Development as described in **Chapter 2: Description of the Proposed Development (Volume 1)** of the Environmental Statement. This technical note summarises the available ground investigation records relevant to the Site.
- 1.1.2. It should be noted that a Preliminary Risk Assessment Report (**Appendix 11.1: Contaminated Land Preliminary Risk Assessment (Volume 3)**) for this development has also been prepared by WSP separately. This technical note supplements information/detail to that presented within **Appendix 11.1: Contaminated Land Preliminary Risk Assessment (Volume 3)**.

1.2. SITE DESCRIPTION AND HISTORICAL LAND USE

- 1.2.1. The Site location and current layout (including Zones) are presented in **Annex 1: Figures of Appendix 11.1: Contaminated Land Preliminary Risk Assessment (Volume 3)**.
- 1.2.2. A description of the Site is provided in **Chapter 1: Introduction and Site Description (Volume 1)** and a description of the Proposed Development in **Chapter 2: Description of the Proposed Development (Volume 1)**.
- 1.2.3. As detailed within **Appendix 11.1: Contaminated Land Preliminary Risk Assessment (Volume 3)**, the Site is known to have historically been occupied in part by the Kempston Brickworks and associated clay pits. Many of the existing clay pits are believed to comprise the present-day lakes surrounding the Site and some are understood to have been subjected to infilling with waste materials.

SOURCES OF INFORMATION

- 1.2.4. The following third-party ground investigation reports were reviewed in the preparation of this technical note:
- SLR Global Environmental Solutions, Former Kempston Brick Works, Bedfordshire – Factual Geotechnical Investigation Report (ref: 403.00027.00436), October 2016¹; and
 - Arcadis, Project 320 - Kempston Hardwick - Phase 2 Preliminary Geo-Environmental Ground Investigation Interpretive Report (30174974-ARC-P01-XX-TR-GE-00001), May 2023².

¹ SLR Consulting (2016) *Former Kempston Brickworks Factual Geotechnical Investigation Report (Appendix E)*. Available at: <https://edrms.bedford.gov.uk/OpenDocument.aspx?id=U9VG7%2b1rh2kecUK9r4og5g%3d%3d&name=18+02940+EIA+V OL+3+P3-P4+Appendix+11+GROUND+CONDITIONS.pdf> [Accessed: 09 June 2025].

² Arcadis (2023) *Project 320 - Kempston Hardwick - Phase 2 Preliminary Geo-Environmental Ground Investigation Interpretive Report*.

2. SUMMARY OF EXISTING INFORMATION

2.1.1. The following section of this technical note aims to summarise key findings from previous phases of intrusive ground investigation carried out across the Site historically.

2.2. FORMER KEMPSTON BRICK WORKS, BEDFORDSHIRE – FACTUAL GEOTECHNICAL INVESTIGATION REPORT (SLR GLOBAL ENVIRONMENTAL SOLUTIONS, 2016)

2.2.1. It should be noted that this phase of investigation was restricted to just the very southern extents of the present-day Lake Zone of the Site as defined above. At the time, this area of land (formerly occupied by Kempston Brickworks) was proposed for residential redevelopment. An intrusive investigation was undertaken at the former brickworks site and provided general coverage and targeted former tanks (CP2, WS6 – WS8, WS10, WS11) landfill areas (CP4, WS1, WS2, WS5 and TP1) and comprised the following:

- Five cable percussion boreholes (CP1 – CP5) drilled to depths between 17.25m 19.55m below ground level (bgl), terminating on limestone bedrock of the Cornbrash Formation;
- 19 No. trial pits (TP1 to TP19) excavated to depths of between 1.80m and 4.0m bgl;
- 11 No. window sample boreholes (WS1 – WS11) drilled between 4.80m and 6.0m bgl;
- Collection of soil samples for a suite of environmental laboratory testing;
- Installation of monitoring wells within all cable percussion boreholes (CP1 – CP5) and within select window sample borehole locations (WS1, WS5, WS8, WS9 and WS10):
 - CP2 was installed with a response zone that targeted 2.00 – 6.00m bgl; and
 - All other monitoring wells were installed to full depth with surface seals ranging in thickness between 0.50m and 2.0m in thickness (i.e., crossing several strata boundaries);
- Completion of two return visits to complete groundwater level monitoring on one occasion and gas monitoring on two occasions (August 2016); and
- Collection of a total of 11 No. groundwater samples for laboratory analysis.

ENCOUNTERED GROUND CONDITIONS

2.2.2. Made Ground was found to vary in thickness between 0.60m and 10.80m across the Site. A greater proven thickness of Made Ground was identified towards the east of the Site. Made Ground was generally found to comprise of brick rubble overlying reworked sandy/silty clay containing various artificial inclusions such as asphalt, clinker, wood, metal, plastic, concrete and suspected asbestos tiles. The following evidence of contamination was noted during the ground investigation:

- Elevated Photo Ionisation Detector (PID) headspace test results up to 31ppm recorded within CP1 (1.50m bgl);
- Frequent faint to strong organic odours noted within Made Ground recovered from trial pits (typically 1.00 to 2.50m bgl) and a faint chemical/organic odour noted within TP3 (1.70 to 2.40m bgl);
- Oily sheen noted on surface of groundwater encountered within:

- TP3 (1.50m bgl); and
- TP12 (2.60m bgl).
- Rare inclusions of possible asbestos tiles within TP14 (0.10 to 0.80m bgl);
- Identification of suspected asbestos within CP4 (7.80m bgl) resulting in abandonment of this location; and
- CP4 was dampened down and re-instated with bentonite. CP4A was instead progressed approximately 10m further north.

2.2.3. The Made Ground was underlain by deposits of the Oxford Clay Formation (Peterborough Member) to a proven depth of 14.4m bgl. These deposits were recorded as firm to stiff dark grey, thinly laminated silty clays with frequent shells/fragments.

2.2.4. An approximately 5.0 to 5.5m thick layer of clay and sand members of the Kellaway's Formation, was encountered beneath the Oxford Clay Formation, prior to encountering an interface of strong grey limestone of the Cornbrash Formation, between 17.25m and 19.55m bgl.

GROUNDWATER CONDITIONS

2.2.5. Groundwater strikes encountered within the window sample holes were not recorded during the ground investigation (i.e., levels on logs equate to post investigation monitored levels). Water strikes recorded within the trial pits indicated the presence of a shallow water table between 1.30m bgl (TP5) to 3.20m bgl (TP10) (approximately 30 to 32.5m Above Ordnance Datum (AOD)). Groundwater was observed to be in hydraulic connection with Made Ground and underlying natural deposits. A deeper groundwater strike was also observed between 12m and 13m bgl (20.5 to 21.5m AOD), thus within the Oxford Clay Formation, during the drilling of all cable percussion boreholes, with the exception of CP04A.

SOIL LABORATORY ANALYSIS

- 2.2.6. A total of 63 No. soil samples were submitted for chemical analysis for pH, asbestos, Total Organic Carbon (TOC), metals, hydrocarbons (including Polycyclic Aromatic Hydrocarbons (PAHs) and Total Petroleum Hydrocarbons (TPHs), Benzene, Toluene, Ethylbenzene and Xylenes (BTEX compounds)).
- 2.2.7. No asbestos was detected within the sample of suspected Asbestos Containing Materials collected at 0.30m within TP14.

MONITORING AND ASSESSMENT OF CONTROLLED WATERS

2.2.8. A total of 10 groundwater samples were collected from installed monitoring wells on the 3 August 2016 and an eleventh was also obtained from TP05 during the ground investigation. Samples were collected by use of disposable bailers. Groundwater samples were scheduled for analysis of heavy metals, PAHs, TPHs, BTEX compounds and Methyl Tert-Butyl Ether, Volatile Organic Compounds and pH.

GAS MONITORING AND ASSESSMENT

- 2.2.9. Both rounds of gas monitoring completed at the Site were undertaken during periods of high atmospheric pressure (1004mbar, round 1 – 03 August 2016 and 1019mbar, round 2 – 31 August 2016). Elevated concentrations of carbon dioxide (CO₂), relative to atmospheric conditions, were noted predominantly within deeper monitoring wells advanced by cable percussive drilling (CP1, CP3, CP4A and CP5) and WS10. Readings ranged between:
- 3.1%v/v (CP5) and 8.3%v/v (WS10), round 1; and
 - 3.6%v/v (CP5) and 10.9%v/v (WS10), round 2.
- 2.2.10. Depleted oxygen levels (minimum of 0.3%v/v, WS10, round 2) were also observed alongside the elevated CO₂ readings. Consistent readings of 2ppm of carbon monoxide (CO) were observed at all locations with the exception of WS5 (16ppm observed for round 1). Marginal and inconsistent detections of hydrogen sulphide (H₂S) were also recorded at a few locations (1ppm was consistently noted at CP2, CP5, WS1, WS8 and WS10). Methane (CH₄) was not detected within any of the monitoring wells across both rounds. PID readings were only recorded during round 1 with a maximum of 7.3ppm observed within WS109. All gas flows recorded were negative (-0.1 to 0.3l/hr). There were no comments attached to the monitoring records.
- 2.2.11. It should be noted that based on the groundwater levels recorded (only during round 1), all wells were partially flooded with the exception of WS09 which was entirely flooded by groundwater on this occasion. When flooded, ground gas can become trapped in the monitoring well's air space, resulting in anomalous concentrations that are not necessarily representative of the Site's ground gas levels.

2.3. PHASE 2 PRELIMINARY GEO-ENVIRONMENTAL GROUND INVESTIGATION INTERPRETIVE REPORT (ARCADIS, 2023)

- 2.3.1. This report covers the Lake Zone and Core Zone (referred to as Areas A1 to A3 and B within the Arcadis report, respectively). At this time, the Site was being promoted for a theme park and resort.
- 2.3.2. The intrusive investigation was undertaken between 20 March to 21 April 2023 and consisted of the following:
- Machine excavation of 36 No. trial pits (TP01 to TP38) to depths between 1.7m and 4.0m bgl;
 - Progression of 16 No. cable percussion boreholes (CP01 to CP16) to depths between 13.1m and 21.0m bgl:
 - Four of which were advanced to greater depths (30 to 30.85m bgl) with rotary drilling techniques (CP04, CP07, CP10 and CP14) with the aim of characterising the upper boundary of the Rutland Formation.
 - Collection of soil samples for laboratory analysis;
 - Installation of gas and groundwater monitoring wells within all boreholes:
 - Dual installations targeting both shallow Made Ground for gas monitoring purposes and deeper installs within natural strata to assess groundwater conditions.
 - Completion of six return visits between 27 April 2023 and 29 May 2023 to complete groundwater level and gas monitoring;

- Completion of groundwater quality monitoring (by determination of in-situ water quality parameters) on five occasions following an initial round of well development;
- Proposed collection of groundwater samples from each installed monitoring well on two occasions (i.e., 16 No. groundwater samples in total)³; and
- Proposed collection of surface water samples from eight locations (SW1 – SW8) on two occasions (i.e., total of 16 No. surface water samples)³.

2.3.3. The exploratory holes were positioned to both provide good spatial coverage in addition to specifically targeting:

- The footprint of a former river channel (TP02, TP04 and TP06);
- The edges of former clay pits (current-day lakes) (TP09 -TP11, TP13 and TP15);
- The contents of a terraced spoil heap identified north of the former brickworks (CP04, TP12A and TP16);
- A former structure (TP37); and
- The spatial distribution of Alluvium at the Site (in relation to British Geological Survey (BGS) map records).

2.3.4. It is worth noting that a number of trial pit locations (TP07, TP08 and TP12) proposed along the edges of the existing lakes (i.e., within Arcadis' Area A3) were abandoned due to access and ecological constraints. Furthermore, a number of stockpiles of demolition rubble were noted within the footprint of the former brickworks (Arcadis Zone A2) which were not sampled due to ecological constraints. These stockpiles are considered by WSP to be separate to the terraced spoil heap referred to in the above list.

ENCOUNTERED GROUND CONDITIONS

Made Ground

2.3.5. Made Ground up to 3.00m in thickness was only encountered locally within exploratory holes positioned within the undeveloped fields within the Lake Zone (TP02, TP05 and TP06). Organic rich soils (black) and accompanying organic odours were noted within positions targeting the former river channel. Topsoil (0.20m to 0.40m) overlying natural deposits was more typically encountered in this area of the Site.

2.3.6. Although exploratory holes positioned within Arcadis' Zone A3 mostly sit outside the current boundary of interest (i.e., to the east of the Lake Zone), it is worth noting that similar recovered thicknesses of Made Ground were noted in this area (2.80m – 3.00m).

³ Based on the version of the report WSP has been provided to review (ref: 30174974-ARC-P01-XX-TR-GE-00001) the dataset available was incomplete (i.e., only one round of groundwater and surface water sampling and the first five rounds of gas monitoring available).

- 2.3.7. A thicker and more spatially continuous layer of Made Ground (1.70m to 5.00m) was encountered within exploratory holes positioned about the location off the former brickworks (Arcadis Area A2). Frequent inclusions of brick/concrete cobbles and gravel were generally noted within Made Ground recovered in this part of the Site. An infilled basement structure was also encountered at TP23 (1.00m – 2.50m bgl).
- 2.3.8. Very limited recovery of Made Ground was recorded across the Core Zone (Arcadis Area B), varying in thickness between 0.20m (TP37) and 0.60m (CP08) across only two exploratory hole locations.

Evidence of Contamination

- 2.3.9. Visual evidence of contamination was limited to the observation of ash within Made Ground arisings recovered from trial pits TP18 to TP20; all of which were located towards the south of the Lake Zone (i.e., footprint of the former brickworks). Organic odours were also noted within areas of thick Made Ground associated with either the infilled river channel (TP02) or at a number of exploratory holes located in close proximity to/within the footprint of the former brickworks. In-situ head space testing of environmental soil samples was undertaken. A maximum reading of 0.7ppm was recorded within CP06 (4.00m bgl) and the majority of all other readings did not exceed the instrument's limit of detection (i.e., <0.1ppm).

Natural Ground

- 2.3.10. In general, the ground investigation encountered a similar sequence of strata to those characterised within the Lake Zone exclusively by the 2016 SLR Ground Investigation¹ detailed above.
- 2.3.11. Made Ground or topsoil was encountered at the surface overlying either superficial deposits of Alluvium or Head Deposits (where present). Alluvium was encountered in general accordance with the footprint of BGS mapped exposures. The subsequent Peterborough Member (Oxford Clay Formation) was noted to initially comprise an upper weathered zone, overlying a non-weathered deposit. The Kellaway's Formation, present beneath the Oxford Clay Formation, comprised both sand and clay members, the latter of which was noted to be absent locally.
- 2.3.12. The strata underlying the Kellaways Formations was only encountered within the rotary follow-on boreholes (CP04, CP07, CP10 and CP14) and comprised the Cornbrash Formation, the Forest Marble Formation, the Blisworth Formation (divided into the Blisworth Clay Member and the underlying Blisworth Limestone Member) and the Rutland Formation. The Forest Marble Formation was generally described to comprise a very stiff dark grey fissured clay with frequent to absent fossilised shells. The Blisworth Clay Formation was described as a very stiff yellow to black fissured clay with fossilised shells and as an extremely weak dark grey mudstone (CP14 only). The underlying Blisworth Limestone Formation was described as a strong light grey limestone. The Rutland Formation was encountered in all rotary follow-on boreholes (except CP04) underlying the Blisworth Limestone Formation and was generally described as a very stiff dark grey fissured clay with pockets of organic matter and peat.

Groundwater Conditions

- 2.3.13. Groundwater strikes encountered during the ground investigation indicated the presence of:
- A shallow groundwater table between 1.0 to 2.0m bgl within the superficial Alluvium and Head Deposits or in continuity with the Made Ground;

- A deeper aquifer within the Peterborough Member (Oxford Clay Formation) was encountered in seven boreholes between 3.9m bgl (TP30) and 12.9m bgl (CP11); and
- A confined groundwater body within the Kellaways Sand Member (i.e., significant rises noted after 20 minutes of up to 5.5m within CP07).

2.3.14. It was noted that similar conditions were anticipated within the deeper limestone strata, but it was not possible to confirm this during the ground investigation due to the masking of groundwater strikes with the addition of rotary flush water.

SOIL LABORATORY ANALYSIS

- 2.3.15. A total of 73 No. soil samples were collected during the ground investigation, of which 51 No. were scheduled for chemical laboratory testing. The general suite of testing included metals, PAHs, TPHs, inorganics and TOC. Select samples of Made Ground and topsoil were also subject to asbestos screening. A total of three soil samples collected from the undeveloped field to the north of the Lake Zone were also subjected to a suite of acid herbicide and pesticide testing.
- 2.3.16. The laboratory results were screened against Generic Assessment Criteria (GAC) protective of a number of different end use scenarios including public open space, commercial/industrial use and residential land use (with consumption of homegrown produce). No exceedances of GAC protective of commercial and public open space end use scenarios were identified across the Arcadis study site (i.e., across both the Lake Zone and Core Zone). Limited exceedances of metals (arsenic and lead) and PAH compounds (dibenz(a,h)anthracene, benzo(b)fluoranthene and benzo(a)pyrene) relative to the applied residential GAC were noted. All residential human health soil GAC exceedances were recorded within Made Ground with the exception of elevated arsenic detected within superficial deposits within CP02 (0.50m bgl). All exceedances noted fell within the Lake Zone. Contaminant concentrations were recorded within the same order of magnitude as that of the GAC.
- 2.3.17. Asbestos was not recorded in any of the 45 No. samples subjected to laboratory analysis. Similarly, no detections of pesticide and herbicide compounds were identified within the three samples subjected to analysis (i.e., concentrations fell below the laboratory limit of detection).

MONITORING AND ASSESSMENT OF CONTROLLED WATERS

- 2.3.18. A total of eight No. groundwater and eight No. surface water samples were collected and scheduled for laboratory testing. The report states that no visual or olfactory evidence of hydrocarbon contamination was identified. No measurable Light Non-Aqueous Phase Liquid was recorded and there was no sheen mentioned on any of the groundwater encountered.
- 2.3.19. Groundwater and surface water laboratory results were principally screened against Environmental Quality Standards (EQS) on the basis that groundwater beneath the Site is of limited sensitivity/is of limited future resource potential (unproductive aquifer).
- 2.3.20. Marginal exceedances of metals (nickel, copper and zinc) were identified within both groundwater and surface water samples recovered from both the Lake Zone and the Core Zone. Concentrations recorded within groundwater and surface water samples were comparable, indicating hydraulic connection.

- 2.3.21. An exceedance of mercury EQS (0.07µg/l) was also identified within SW01 (0.24µg/l), located in the very northwestern corner of the Site (within the Lake Zone). Elevated concentrations of long chain aromatic hydrocarbon compounds were also noted at this location (TPH>C21-C35, 300µg/l). This may indicate the presence of an off-Site source.
- 2.3.22. Various inorganic compounds have been recorded at elevated concentrations relative to EQS GAC (ammonia, chloride, sulphate, boron), which were recorded predominantly within groundwater samples. Elevated surface water concentrations of ammonia were only recorded within SW09, located in the southeastern corner of the Core Zone (i.e., within an undeveloped field in agricultural use).
- 2.3.23. Arcadis concluded that no unacceptable risk to human health or controlled waters receptors had been identified in light of the Proposed Development being considered.

GAS MONITORING AND ASSESSMENT

- 2.3.24. Gas monitoring was undertaken within all installed boreholes across five monitoring rounds between 26 April and 24 May 2023. It should be noted that all five rounds of gas monitoring were undertaken during periods of relatively high atmospheric pressure (1006 - 1027mbar). A summary of the gas monitoring results is presented below:
- CH₄ detections across the Site varied between <0.1% and 0.2%;
 - CO₂ detections were noted to vary between 0.1% v/v and 2.9% v/v (CP05S);
 - H₂S generally remained undetected across the majority of the Site; and,
 - CO levels were consistently noted to fluctuate typically between 2% v/v and 36% v/v.
- 2.3.25. The majority of monitoring wells were identified as flooded for the duration of the monitoring period and many were recorded to be missing bungs and/or gas taps by rounds 4 and 5. As such, it is unlikely that the data recorded at these locations and during those periods was representative of the actual ground gas regime.
- 2.3.26. Positive peak and steady flow readings were recorded within a number of monitoring wells distributed across both the Lake and Core Zones on more than one occasion (CP02, CP03S, CP08S and CP08D). The report does highlight the potential for some of these readings to have been erroneous/anomalous.
- 2.3.27. Based on a review of the desk-based information and reliance on the data collected from solely unflooded monitoring well locations (rounds 1 – 4), the risks posed from ground gas were low to very low across both the Lake and Core Zones. Arcadis classified the Lake Zone (Arcadis Areas A1 to A3) as representative of Characteristic Situation 1 conditions (CS1 – very low risk). The Core Zone (Arcadis Area B) was classified as representative of Characteristic Situation 2 (CS2 - low risk).



70 Chancery Lane
London
WC2A 1AF

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