SITE INVESTIGATION & BASEMENT IMPACT ASSESSMENT REPORT

42Caversham Road
London
NW5 2DS

Client: Dexbay Properties Limited

Engineer: Gurney Consulting Engineers

J14023

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Geotechnical & Environmental Associates

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EXECUTIVE SUMMARY

This executive summary contains an overview of the key findings and conclusions. No reliance should be placed on any part of the executive summary until the whole of the report has been read. Other sections of the report may contain information that puts into context the findings that are summarised in the executive summary.

BRIEF

This report describes the findings of a site investigation carried out by Geotechnical and Environmental Associates Limited (GEA), on the instructions of Gurney Consulting Engineers, on behalf of Dexbay Properties Ltd, with respect to the proposed demolition of the existing building and construction new a five-storey concrete framed building with basement to include 17 apartments. The purpose of the investigation has been to research the history of the site with respect to possible contaminative uses, to determine the ground conditions and hydrogeology, to investigate the existing foundations, to assess the extent of any contamination and to provide information to assist with the design of suitable foundations and retaining walls. The report also includes information that follows the London Borough of Camden (LBC) Planning Guidance CPG4, relating to the requirement for a Basement Impact Assessment (BIA).

DESK STUDY FINDINGS

The earliest Ordnance Survey (OS) map studied, dated 1875, shows the site to be undeveloped and adjacent to semi-detached houses to the west and the existing railway line to the east passing through Kentish Town Train Station 115 m to the northeast. By 1896 a single small building had been built on the western boundary and was subsequently extended northwards at some point between 1938 and 1946. Within a 55 m radius of the site to the northwest, northeast, east and southeast adjacent to the railway line, stonemasons, timber yards and builder's yard were built by 1953. By the same year, the residential estate 60 m to the north was being redeveloped into a playground, blocks of flats and communal gardens and was completed by 1969. The 1968 map shows the site to be covered by the existing building surrounded by builder's yards and labels it as a mosaics works, with the stonemasons to the northwest no longer present. The site and surrounding area have remained unchanged since this time.

GROUND CONDITIONS

Beneath a moderate thickness of made ground, London Clay was encountered and proved to the maximum depth investigated of 5.45 m. The made ground generally comprised dark brown, grey and brown slightly sandy silty clay with gravel of flint, brick, tile, ash and clinker and occasional roots, with horizons of black ash gravel and orange-brown coarse sand, and extended to a depth of 1.40 m. in Borehole No 2 and the maximum depth investigated in Trial Pit No 1 of 1.50 m. The London Clay comprised firm fissured grey and brown mottled clay with occasional selenite crystals and decomposing roots, frequent black clay pockets and rare black flint gravel, becoming brown mottled blue-grey with depth, and extended to the maximum depth investigated of 5.45 m. In the western section of the site frontage beneath a maximum 300 mm thickness of reinforced concrete, Borehole Nos 1 and 1A encountered made ground comprised of dark brown slightly sandy silty clay with gravel of brick, flint and ash was encountered, and extended to depths of 0.50 m and 0.65 m, wherein a concrete slab was encountered. The concrete slab is approximately 0.85 m below street level and it is unknown what this may represent. It was not possible to extend Borehole Nos 1 and 1A beyond this depth.

Groundwater was not encountered during drilling of the boreholes, but subsequent monitoring of the standpipe installed to a depth of 5.00 m recorded groundwater at a depth of 1.15 m four weeks after installation. Contamination testing has revealed elevated concentrations of lead and total PAH, including elevated concentrations of benzo(a)pyrene, within four samples of made ground.

RECOMMENDATIONS

Formation level for the new basement is assumed to be at a depth of 4 m, within the London Clay. Based on the findings of the ground investigation, moderately sized spread foundations may be designed to apply a net allowable bearing pressure of about 130 kN/m² at that depth. However, loads for the proposed development are understood to be 800 kN and the resultant large pad sizes could lead to excessive settlement. Consideration may therefore need to be given to the use of piled foundations

On the basis of the results of the ground investigation, it is not considered that the proposed basement will result in a significant change to the groundwater flow regime in the vicinity of the proposal or on the amount of annual recharge into the London Clay. The proposed development will include a retaining wall that will be designed to maintain stability of the surrounding ground, thus protecting the adjacent road and infrastructure beyond.

Part 1: INVESTIGATION REPORT

This section of the report details the objectives of the investigation, the work that has been carried out to meet these objectives and the results of the investigation. Interpretation of the findings is presented in Part 2.

1.0 INTRODUCTION

Geotechnical and Environmental Associates (GEA) has been commissioned by Gurney Consulting Engineers, on behalf of Dexbay Properties Limited, to carry out a desk study and ground investigation at 42 Caversham Road, London, NW5 2DS. This report also includes a Basement Impact Assessment (BIA), which has been carried out in support of a planning application.

1.1 Proposed Development

It is understood consideration is being given to the demolition of the existing building and construction of a new five-storey concrete framed apartment block with single level basement.

This report is specific to the proposed development and the advice herein should be reviewed if the proposals are amended.

1.2 Purpose of Work

The principal technical objectives of the work carried out were as follows:

- to check the history of the site and surrounding areas with respect to previous contaminative uses;
- to determine the ground conditions and their engineering properties;
- to assess the possible impact of the proposed development on the local hydrogeology;
- to provide advice with respect to the design of shallow foundations and retaining walls;
- to provide an indication of the degree of soil contamination present; and
- to assess the risk that any such contamination may pose to the proposed development, its users or the wider environment.

1.3 Scope of Work

In order to meet the above objectives, a desk study was carried out, followed by a ground investigation. The desk study comprised:

- a review of readily available geological and hydrogeological maps;
- a review of historical Ordnance Survey (OS) maps and environmental searches sourced from the Envirocheck database;

- a review of archive information held by GEA and a review of online borehole records held by the British Geological Survey (BGS); and
- a walkover survey of the site carried out in conjunction with the fieldwork.

In light of the desk study, an intrusive ground investigation was carried out which comprised, in summary, the following activities:

- three boreholes, advanced to maximum depth of 5.45 m by means of an open-drive lined percussive sampler;
- standard penetration tests (SPTs), carried out at regular intervals in the borehole, to provide quantitative data on the strength of the soils;
- the installation of a single groundwater monitoring standpipe and a single monitoring visit four weeks following installation;
- laboratory testing of selected soil samples for geotechnical purposes and for the presence of contamination; and
- provision of a report presenting and interpreting the above data, together with our advice and recommendations with respect to the proposed development.

The report includes a contaminated land assessment which has been undertaken in accordance with the methodology presented in Contaminated Land Report (CLR) 11[1] and involves identifying, making decisions on, and taking appropriate action to deal with, land contamination in a way that is consistent with government policies and legislation within the United Kingdom. The risk assessment is thus divided into three stages comprising Preliminary Risk Assessment, Generic Quantitative Risk Assessment, and Site-Specific Risk Assessment.

1.3.1 Basement Impact Assessment (BIA)

The work carried out also includes a Hydrological and Hydrogeological Assessment and Land Stability Assessment (also referred to as Slope Stability Assessment), all of which form part of the BIA procedure specified in the London Borough of Camden (LBC) Planning Guidance CPG4 and their Guidance for Subterranean Development[2] prepared by Arup. Camden's approach has been adopted as it is now widely known and is considered to provide a robust approach to the issues of concern. The aim of this work is to provide information on the groundwater conditions specific to this site and land stability, in particular to assess whether the development will affect the stability of neighbouring properties and whether any identified impacts can be appropriately mitigated.

1.4 Qualifications

The Basement Impact Assessment (BIA) has been carried out by Martin Cooper, a BEng in Civil Engineering, a chartered engineer (CEng), member of the Institution of Civil Engineers (MICE), and Fellow of the Geological Society (FGS) who has over 20 years specialist experience in ground engineering and Steve Branch, a BSc in Engineering Geology and Geotechnics, MSc in Geotechnical Engineering, a chartered geologist (CGeol) and Fellow of the Geological Society (FGS) with 25 years' experience in geotechnical engineering,

1 *Model Procedures for the Management of Land Contamination* issued jointly by the Environment Agency and the Department for Environment, Food and Rural Affairs (DEFRA) Sept 2004

2 Ove Arup & Partners (2010) *Camden geological, hydrogeological and hydrological study. Guidance for Subterranean Development.* For London Borough of Camden November 2010

engineering geology and hydrogeology. Both assessors meet the Geotechnical Adviser criteria of the Site Investigation Steering Group and satisfy the qualification requirements of the Council guidance.

The surface water and flooding element of the BIA is provided for guidance only and should be confirmed by a suitably qualified engineer experienced in carrying out surface water assessments.

1.5 Limitations

The conclusions and recommendations made in this report are limited to those that can be made on the basis of the investigation. The results of the work should be viewed in the context of the range of data sources consulted, the number of locations where the ground was sampled and the number of soil, gas or groundwater samples tested; no liability can be accepted for information in other data sources or conditions not revealed by the sampling or testing. Any comments made on the basis of information obtained from the client or other third parties are given in good faith on the assumption that the information is accurate; no independent validation of such information has been made by GEA.

2.0 THE SITE

2.1 Site Description

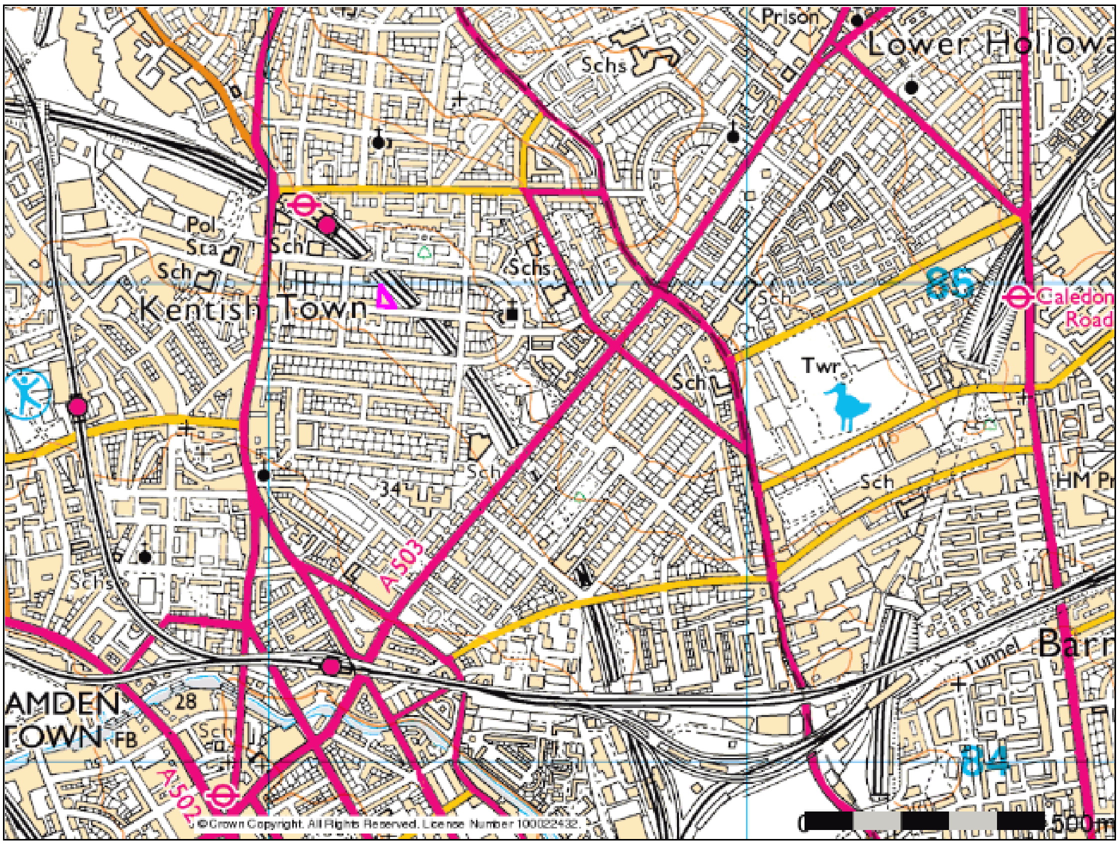
The site is located in Kentish Town within the London Borough of Camden, approximately 235 m to the west of St Luke’s Church, 295 m southeast of Kentish Town London Underground station, and 745 m north of Camden Town railway station.

The site forms a triangular shape with maximum dimensions of approximately 35 m east-west by 40 m north-south and is occupied by a mixed use single storey to three-storey building fronting onto Caversham Road to the south. At the time of the investigation the building was used as a Family Services and Social Work Centre and in view of the continued occupancy of the site the fieldwork was limited to the site frontage only.

The building occupies the majority of the site, with a narrow alleyway along the western boundary, a small garden and areas of hardstanding with delivery bays along the frontage. The garden has maximum dimensions of approximately 7 m by 10 m and is laid to lawn with 3 m tall semi-mature deciduous trees around the perimeter. A ramp leads down to a delivery door approximately 0.50 m below street level.

The site is bordered by three-storey houses with semi-basements to the south and west, a builder’s yard to the east and a railway line to the north. The site is essentially level and the local topography slopes down towards the west.

The site may be additionally located by National Grid Reference 529249, 184960 and is shown on the map below.



2.2 Site History

The history of the site and surrounding area has been researched by reference to historical Ordnance Survey (OS) maps sourced from the Envirocheck database.

The earliest Ordnance Survey (OS) map studied, dated 1875, shows the site to be undeveloped and adjacent to semi-detached houses to the west and the existing railway line to the east passing through Kentish Town station 115 m to the northeast. By 1896 a small building had been built on the western boundary and was subsequently extended northwards at some point between 1938 and 1946. By 1953, within a 55 m radius of the site to the northwest, northeast, east and southeast, adjacent to the railway line, a number of businesses including stonemasons, timber yards and builder’s yard had been developed. By the same year, the residential estate 60 m to the north was being redeveloped with blocks of flats, a playground and communal gardens, and was completed by 1969.

The 1968 map shows the site to be covered by the existing building and labelled as a mosaic works, surrounded by builder’s yards, with the stonemason to the northwest no longer present. The site and surrounding area have remained essentially unchanged since this time, with a Works still labelled on the site on the map dated 1991. However, the existing building was refurbished as a Family Services and Social Work Centre between 1991 and 2014.

2.3 Other Information

A search of public registers and databases has been made via the Envirocheck database and relevant extracts from the search are appended. Full results of the search can be provided if required.

The desk study research has indicated that there are no registered landfills, historic landfills, registered waste transfer sites or waste management facilities within 500 m of the site and there have been no pollution incidents to controlled waters within 500 m of the site. There are no controlled processes operating within 250 m of the site.

The site is not located within a nitrate vulnerable zone or any other sensitive land use.

The search has indicated that the site is located in an area where less than 1% of homes are affected by radon emissions; which is the lowest classification given by the Health Protection Agency (HPA) and therefore no radon protective measures will be necessary. The site is not located within a nitrate vulnerable zone or any other sensitive land use.

A search of historical planning applications on Camden Council's planning portal obtained few significant results for the site and the surrounding houses. However, the site walkover indicated that the houses surrounding No 42 have semi-basements which extend below street level by approximately 2.00 m.

2.4 Geology

Reference to digital mapping of the area provided by the British Geological Survey (BGS) indicates the site to be underlain by London Clay.

A search of borehole records held by the British Geological Survey (BGS) has indicated that the London Clay was found beneath a moderate thickness of made ground, at a distance of 100 m to the southwest of the site. Another borehole, drilled 450 m to the south indicated the base of the London Clay to be at a depth of 52 m, approximately -22 m OD.

2.5 Hydrology and Hydrogeology

The London Clay is classified as an 'Unproductive Stratum', which are as defined by the Environment Agency (EA) as rock or drift deposits with low permeability that have negligible significance for water supply or river base flow. Published data for the permeability of the London Clay indicates the horizontal permeability to range between 1×10^{-10} m/s and 1×10^{-8} m/s, with an even lower vertical permeability.

There are no surface water features within the vicinity of the site. The River Thames is approximately 5.6 km to the southeast and flows in an easterly direction. The direction of groundwater flow within the London Clay beneath the site is likely to be controlled by the local topography and therefore is likely to be in a southerly and southwesterly direction.

Reference to the Lost Rivers of London[3] indicates that the River Fleet flowed in a southeasterly direction approximately 590 m east of the site and into the River Thames approximately 5.6 km to the southeast of the site. The River Fleet was culverted[4] by 1769 in response to its unnavigable condition and the numerous fatalities occurring from drowning in the river.

There are no listed water abstractions within 250 m of the site and the site is not located within a Groundwater Source Protection Zone, as defined by the Environment Agency.

[3] Barton, N (1992) *The Lost Rivers of London* Historical Publications Ltd
[4] P. Talling (2011) *London's Lost Rivers*. Random House Books.

The site is not at risk of flooding from rivers or sea, as defined by the Environment Agency and there are no Environment Agency designated Source Protection Zones (SPZs) on the site.

2.6 Preliminary Risk Assessment

Part IIA of the Environmental Protection Act 1990, which was inserted into that Act by Section 57 of the Environment Act 1995, provides the main regulatory regime for the identification and remediation of contaminated land. The determination of contaminated sites is based on a "suitable for use" approach which involves managing the risks posed by contaminated land by making risk-based decisions. This risk assessment is carried out on the basis of a source-pathway-receptor approach.

2.6.1 Source

The historical usage of the site as a mosaics works and subsequently an unidentified works may have resulted in the localised contamination of the ground resulting from the spillage or leakage of paint, dye or hydrocarbon fuels. The surrounding land uses have also included timber yards and builders yards, which are potential sources of contamination.

There are no historical or existing landfill sites within 500 m of the site and therefore there is not a risk to the site from landfill gas.

2.6.2 Receptor

The site will to have a residential end use following the construction of the new five-storey residential block of flats and is considered to have a high sensitivity end-use. However, no areas of soft landscaping are proposed.

Buried services are likely to come into contact with any contaminants present within the soils through which they pass and site workers are likely to come into direct contact with any contaminants present in the soil and through inhalation of vapours during basement excavation and construction. Being underlain by London Clay, an Unproductive Stratum, groundwater is not considered to be a sensitive target.

2.6.3 Pathway

Within the site, end users will be isolated from direct contact with any contaminants present within the near surface soils by the presence of the building and the surrounding areas of hardstanding, thus limiting potential contaminant exposure pathways. In addition the shallow soils will be removed by the excavation of the new basement and no new pathways will be introduced for end users to come into contact with the soil.

There will be a limited potential for contaminants to move onto or off the site, except horizontally within any made ground or topsoil layer or upon the interface with the London Clay Formation, in association with perched groundwater movements, this pathway is also already in existence.

A pathway for ground workers to come into contact with any contamination will exist during construction work and services will come into contact with any contamination within the soils in which they are laid.

2.6.4 Preliminary Risk Appraisal

On the basis of the above it is considered that there is a LOW risk of there being a significant contaminant linkage at this site which would result in a requirement for major remediation work. Furthermore as there is no evidence of filled ground within the vicinity of the site, there is no potential for hazardous soil gas to be present on or migrating towards the site: there should thus be no need to consider landfill gas exclusion systems.

3.0 SCREENING

The LBC guidance suggests that any development proposal that includes a subterranean basement should be screened to determine whether or not a full BIA is required.

3.1 Screening Assessment

A number of screening tools are included in the Arup document and for the purposes of this report reference has been made to Appendix E which includes a series of questions within a screening flowchart for three categories; groundwater flow, land stability, and surface water flow. Responses to the questions are tabulated below.

3.1.1 Subterranean (groundwater) Screening Assessment

Question	Response for 42 Caversham Road
1a. Is the site located directly above an aquifer?	No. The site is underlain by the London Clay Formation which is designated as an Unproductive Stratum by the Environment Agency.
1b. Will the proposed basement extend beneath the water table surface?	Possibly. The basement is anticipated to extend to 4.00 m.
2. Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line?	No. There are no surface water features in the vicinity of the site.
3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No
4. As part of the site drainage, will more surface water (e.g. rainfall and run-off) than at present be discharged to the ground (e.g. via soakaways and/or SUDS)?	No
5. Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to or lower than, the mean water level in any local pond or spring line?	No. There are no local ponds or spring lines present within 100 m of the Site.

The screening exercise has identified the following potential issues which should be assessed:

Q1b The basement may extend below the groundwater level.

3.1.2 Stability Screening Assessment

Question	Response for 42 Caversham Road
1. Does the existing site include slopes, natural or manmade, greater than 7°?	No
2. Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7°?	No
3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	No
4. Is the site within a wider hillside setting in which the general slope is greater than 7°?	No
5. Is the London Clay the shallowest strata at the site?	Yes

Question	Response for 42 Caversham Road
6. Will any trees be felled as part of the proposed development and / or are any works proposed within any tree protection zones where trees are to be retained?	Yes.
7. Is there a history of seasonal shrink-swell subsidence in the local area and / or evidence of such effects at the site?	No, but London Clay is known to have a high volume change potential.
8. Is the site within 100 m of a watercourse or potential spring line?	No
9. Is the site within an area of previously worked ground?	No
10. Is the site within an aquifer?	No. The site is underlain by the London Clay Formation which is designated as an Unproductive Stratum by the Environment Agency.
11. Is the site within 50 m of Hampstead Heath ponds?	No
12. Is the site within 5 m of a highway or pedestrian right of way?	Yes. The site fronts onto a public road.
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Possibly. The adjacent buildings are understood to have semi-basements
14. Is the site over (or within the exclusion zone of) any tunnels, eg railway lines?	No

The above assessment has identified the following potential issues that need to be assessed:
Q5 London Clay is the shallowest strata on the site.
Q7 The site is possibly in an area of seasonal shrink-swell.
Q12 The site is within 5 m of a public highway on one side.

3.1.3 Surface Flow and Flooding Screening Assessment

This element of the BIA is provided for guidance only and should be confirmed by a suitably qualified engineer experienced in carrying out surface water assessments.

Question	Response for 42 Caversham Road
1. Is the site within the catchment of the pond chains on Hampstead Heath?	No
2. As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route?	No
3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No
4. Will the proposed basement development result in changes to the profile of the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses?	No
5. Will the proposed basement result in changes to the quantity of surface water being received by adjacent properties or downstream watercourses?	No
6. Is the site in an area known to be at risk from surface water flooding such as South Hampstead, West Hampstead, Gospel Oak and Kings Cross, or is it at risk of flooding because the proposed basement is below the static water level of a nearby surface water feature?	No

No potential issues have been identified that need to be assessed.

4.0 SCOPING AND SITE INVESTIGATION

The purpose of scoping is to assess in more detail the factors to be investigated in the impact assessment. Potential consequences are assessed for each of the identified potential impact factors.

4.1 Potential Impacts

The following potential impacts have been identified.

Potential Impact	Possible Consequence
The London Clay Formation, which is the shallowest strata on the site, is prone to seasonal shrink / swell (subsidence and heave)	Shrinkage and swelling of the underlying soil may result in structural damage of the buildings.
Site within 5 m of a highway or pedestrian right of way	Excavation of a basement could lead to damage
The basement may extend below the groundwater table	This may affect the groundwater flow regime

These potential impacts have been further assessed through the ground investigation, as detailed below.

4.2 Exploratory Work

The ground investigation was limited to the frontage of No 42 Caversham Road. In order to meet the objectives described in Section 1.2, it was initially proposed to drill three boreholes to 5 m using an opendrive lined percussive sampling rig. However, the presence of a concrete obstruction at depths of 0.50 m and 0.65 m in Borehole No 1 and No 1A, prevented progress at those locations and only Borehole No 2 was advanced to a maximum depth of 5.45 m.

Standard Penetration Tests (SPTs) were carried out at regular intervals to provide quantitative data on the strength of soils encountered.

A single groundwater monitoring standpipe was installed in a borehole to a depth of 5.00 m, and has been monitored on a single occasion three and half weeks following installation.

All of the work described above was carried out under the supervision of a geotechnical engineer from GEA. In addition, a single trial pit was hand excavated by others, in the small garden at the front of the site on the eastern boundary and this was logged by GEA while on site.

A selection of the disturbed and undisturbed samples recovered from the boreholes and trial pits was submitted to a soil mechanics laboratory for a programme of geotechnical testing and an analytical laboratory for a programme of contamination testing.

The borehole records and results of the laboratory analyses are appended, together with a site plan indicating the exploratory positions.

4.3 Sampling Strategy

The scope of the works was specified by the consulting engineers, with input from GEA. The borehole locations were specified by the consulting engineers and adjusted on site by GEA to suit limitations, including inaccessible areas.

Four samples of the made ground were subjected to analysis for a range of common industrial contaminants and contamination indicative parameters. For this investigation the analytical suite for the soil included a range of metals, speciation of total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), total cyanide and monohydric phenols. The soil samples were selected to provide a general view of the chemical conditions of the soils that are likely to be involved in a human exposure or groundwater pathway and to provide advice in respect of re-use or for waste disposal classification.

The contamination analyses were carried out at an MCERTs accredited laboratory with the majority of the testing suite accredited to MCERTS standards. Details of the MCERTs accreditation and test methods are included in the Appendix together with the analytical results.

5.0 GROUND CONDITIONS

The investigation has confirmed the expected ground conditions in that, below a moderate thickness of made ground, the London Clay Formation was encountered, and proved to the maximum depth investigated of 5.45 m.

5.1 Made Ground

Borehole Nos 1 and 1A were located on the access ramp to the delivery bay in the building on site. Beneath a maximum 300 mm thickness of reinforced concrete, the made ground comprised dark brown and brown slightly sandy silty clay with gravel of brick, flint and ash, locally with clinker and concrete, and extended to depths of 0.50 m and 0.65 m, whereupon a concrete slab was encountered. The boreholes were terminated at these depths.

In the southeastern corner of the site, the made ground generally comprised dark brown, grey and brown slightly sandy silty clay with gravel of flint, brick, tile, ash and clinker and occasional roots, with horizons of black ash gravel and orange-brown coarse sand, and extended to depths of 1.40 m in Borehole No 2 and the maximum depth investigated in Trial Pit No 1, 1.50 m.

No visual or olfactory evidence of contamination was noted in the made ground, apart from the presence of extraneous material such as charcoal and ash fragments, which can commonly contain elevated concentrations of PAH, including benzo(a)pyrene. Four samples of the made ground have tested for a range of contaminants as a precautionary measure and the results are presented in Section 5.5.

5.2 London Clay

The London Clay was encountered in Borehole No 2 only and comprised firm fissured grey and brown mottled clay with occasional selenite crystals and decomposing roots, frequent black clay pockets and rare black flint gravel, becoming brown mottled blue-grey with depth, and extended to the maximum depth investigated of 5.45 m. In-situ pocket penetrometer readings indicate that the soil is not desiccated.

Laboratory plasticity index tests have indicated the clay to generally be high shrinkability with plasticity indices between 40% and 44%.

These soils were observed to be free of any visual or olfactory evidence of soil contamination.

5.3 Groundwater

Groundwater was not encountered during drilling of the boreholes. Monitoring of the standpipe recorded groundwater at a depth of 1.15 m, three and a half weeks after installation. It is suspected that this water represents water from the made ground that has collected in the standpipe. The water was purged from the standpipe to a depth of 5.00 m and the rate at which the water recharged the standpipe was recorded; after 45 minutes, a rate of 1.62×10^{-8} m/sec was determined. Standing groundwater was also observed in the trial pit on the eastern boundary.

5.4 Soil Contamination

The table below sets out the values measured within four samples of made ground analysed. All concentrations are in mg/kg unless otherwise stated.

Determinant	BH1 0.35m	BH2 0.10m	BH2 0.90m	TP1 0.10m
pH	9.5	7.9	8.5	7.7
Arsenic	28	21	23	20
Cadmium	<0.10	0.46	0.15	0.59
Chromium	33	20	25	17
Lead	**500**	**610**	**640**	**510**
Mercury	2.3	1.5	3.7	2.2
Selenium	0.30	0.53	0.32	0.41
Copper	87	90	1000	93
Nickel	21	16	21	15
Zinc	190	300	650	290
Total Cyanide	<0.50	0.50	<0.50	<0.50
Total Phenols	<0.3	<0.3	<0.3	<0.3
Total organic carbon %	2.6	2.5	2.6	1.8
TPH	<10	79	<10	83
Benzo(a)pyrene	**1.2**	**4.5**	**9.8**	**4.2**
Naphthalene	<0.1	0.24	0.49	0.19
PAH	**13**	**49**	**150**	**48**
Sulphide	1.3	1.6	1.3	1.8

Note: Figure in bold indicates concentration in excess of risk-based soil guideline values, as discussed in Part 2 of this report

5.4.1 Generic Quantitative Risk Assessment

The use of a risk-based approach has been adopted to provide an initial screening of the test results to assess the need for subsequent site-specific risk assessments. To this end contaminants of concern are those that have values in excess of a generic human health risk based guideline values which are either that of the CLEA[5] Soil Guideline Value where available, or is a Generic Guideline Value calculated using the CLEA UK Version 1.06 software assuming a residential end use. The key generic assumptions for this end use are as follows:

- that groundwater will not be a critical risk receptor;
- that the critical receptor for human health will be young female children aged zero to six years old;
- that the exposure duration will be six years;
- that the critical exposure pathways will be direct soil and indoor dust ingestion, consumption of homegrown produce, consumption of soil adhering to homegrown produce, skin contact with soils and indoor dust, and inhalation of indoor and outdoor dust and vapours; and
- that the building type equates to a two-storey small terraced house.

It is considered that these assumptions are acceptable for this generic assessment of this site. The tables of generic screening values derived by GEA and an explanation of how each value has been derived are included in the Appendix.

Where contaminant concentrations are measured at concentrations below the generic screening value it is considered that they pose an acceptable level of risk and thus further consideration of these contaminant concentrations is not required. However, where concentrations are measured in excess of these generic screening values there is considered to be a potential that they could pose an unacceptable risk and thus further action will be required which could include;

- additional testing to zone the extent of the contaminated material and thus reduce the uncertainty with regard to its potential risk;
- site specific risk assessment to refine the assessment criteria and allow an assessment to be made as to whether the concentration present would pose an unacceptable risk at this site; or
- soil remediation or risk management to mitigate the risk posed by the contaminant to a degree that it poses an acceptable risk.

This assessment is based upon the potential for risk to human health, which at this site is considered to be the critical risk receptor.

The results of the contamination testing generally indicate low concentrations of the contaminants tested. However, elevated concentrations of lead and total PAH were measured

5 *Updated Technical Background to the CLEA Model (Science Report SC050021/SR3) Jan 2009* and Soil Guideline Value reports for specific contaminants; all DEFRA and Environment Agency.

in four samples of made ground. Speciation testing has indicated that a number of the PAH compounds, including benzo(a)pyrene, are elevated above their respective generic guideline value. No elevated concentrations of any other contaminants were measured in excess of the generic risk based screening values for a residential end-use with plant uptake.

The significance of these results is considered further in Part 2 of the report.

5.5 Existing Boundary Conditions

A single trial pit was manually excavated prior to GEA attending site, to investigate the existing boundary conditions on the eastern boundary of the site. The trial pit excavation was carried out by a contractor arranged by Gurney Consulting Engineers.

The eastern boundary of the site was delineated by a wooden fence which separates the site from the adjacent builder’s yard. The trial pit indicated the wooden fence was bearing in the made ground. A 130 mm diameter pipe was encountered at a depth of 0.32 m and was orientated parallel to the line of the fencing, which is on a northwest-southeast bearing. Two 30 mm diameter pipes were encountered at depths of 0.45 m and 0.50 m; the lowest of these pipes was orientated parallel to the line of the fence, whilst the other was found to be orientated east-west.

The trial pit record and photographs are included in the Appendix.

Part 2: DESIGN BASIS REPORT

This section of the report provides an interpretation of the findings detailed in Part 1, in the form of a ground model, and then provides advice and recommendations with respect to foundation options and contamination issues.

6.0 INTRODUCTION

It is understood consideration is being given to the demolition of the existing building and construction of new a five-storey concrete framed building with single level basement to comprise residential flats. No soft landscaping is proposed. It is assumed that the basement will extend 4.00 m below ground level and the proposed maximum column load is understood to be 800 kN.

7.0 GROUND MODEL

The desk study has revealed that the site was formerly occupied by a works building until at least the 1990s. On the basis of the fieldwork, the ground conditions at this site can be characterised as follows.

- Below a moderate thickness of made ground, London Clay is present, which was proved to the full depth investigated of 5.45 m;
- the made ground generally comprises dark brown, grey and brown slightly sandy silty clay with gravel of flint, brick, tile, ash and clinker and occasional roots, with horizons of black ash gravel and orange-brown coarse sand, and extended to depths of 1.40 m in Borehole No 2 and the maximum depth investigated in Trial Pit No 1 of 1.50 m;
- the London Clay comprised firm fissured grey and brown mottled clay with occasional selenite crystals and decomposing roots, frequent black clay pockets and rare black flint gravel, becoming brown mottled blue-grey with depth, and extended to the maximum depth investigated of 5.45 m;
- groundwater monitoring has measured groundwater at a depth of 1.15 m; and
- the chemical analyses have revealed elevated concentrations of lead and total PAH, including elevated concentrations of benzo(a)pyrene, within four samples of made ground.

8.0 ADVICE AND RECOMMENDATIONS

Formation level for the proposed basement will be within the London Clay. Groundwater has been measured close to the base of the proposed basement and it may not be possible to construct the basement without some form of groundwater control.

Excavations for the proposed basement will require temporary support to maintain stability of the excavation and surrounding structures at all times.

8.1 Basement Construction

8.1.1 Basement Excavation

The proposed basement will extend beneath the entire footprint of the new five-storey building, and is assumed to extend to a depth of up to 4.00 m below ground level, such that formation level will be within the London Clay.

Groundwater has been measured at a depth of 1.15 m in the standpipe. It is possible that the measured water reflects perched groundwater within the made ground rather than a general "water table" within the London Clay. However, on the basis of the monitoring to date, it is apparent that groundwater is likely to be encountered within the basement excavation, although it is not possible to assess the quantity and persistence of groundwater entering the excavation. It is therefore recommended that further monitoring of the standpipe is carried out to establish equilibrium levels and determine the extent of any seasonal fluctuations.

It is important to bear in mind that shallow inflows of perched water may also be encountered from within the made ground, particularly within the vicinity of existing foundations. In general it would be expected that such groundwater inflows will be of limited volume and groundwater inflows from within the London Clay should be relatively slow such that inflows should be controllable with sump pumping. In light of the rate of recharge determined from the rising head test in the standpipe, it should be possible to control groundwater inflows through sump pumping, although it would be prudent to confirm this through trial excavations.

There are a number of methods by which the sides of the basement excavation could be supported in the temporary and permanent conditions. The choice of wall may be governed to a large extent by the requirement to prevent groundwater inflows and whether it is to be incorporated into the permanent works and have a load bearing function. The final choice will depend to a large extent on the need to protect nearby structures from movements, and the required overall stiffness of the support system. Traditional mass concrete underpinning may be suitable to provide support for the single basement excavation, provided that groundwater inflows can be suitably controlled. Alternatively, a contiguous bored pile wall could be considered and would have the benefit of providing some load-bearing capability in the permanent condition.

The ground movements associated with the basement excavation will depend on the method of excavation and support and the overall stiffness of the basement structure in the temporary condition. Thus, a suitable amount of propping will be required to provide the necessary rigidity. In this respect the timing of the provision of support to the wall will have an important effect on movements. The stability of the adjacent foundations will need to be ensured at all times and the retaining walls will need to be designed to accommodate the loads from these foundations unless they are underpinned.

Careful control of pumping will be required to ensure that it does not lead to undermining and settlement of the adjacent buildings. If the adopted method of temporary support during excavations is not watertight, it would be prudent for the chosen contractor to have a contingency plan in place to deal with more significant inflows as a precautionary measure.

8.1.2 Basement Retaining Walls

The following parameters are suggested for the design of the new retaining walls.

Stratum	Bulk Density (kg/m^3)	Effective Cohesion (c' – kN/m^2)	Effective Friction Angle (□degrees)
Made Ground	1850	Zero	20
London Clay	1950	Zero	23

Groundwater has been measured at a depth of 1.15 m to date and is likely to be encountered during excavation of the basement. Monitoring should be continued to determine an appropriate design groundwater level. Consideration will need to be given to the possibility of groundwater collecting within any disturbed zone behind the retaining walls and it may be prudent to design for a groundwater level of two-thirds the retained height in this respect.

Reference should be made to BS8102:2009[6] with regard to requirements for waterproofing and design with respect to groundwater pressures.

8.1.3 Basement Heave

The proposed construction of a 4 m deep basement will result in an approximate unloading of roughly 65 kN/m^2, which will result in elastic heave and long term swelling of the London Clay. The effects of the longer term swelling movement will be mitigated to some extent by the load applied by the new foundations. An assessment of the movement is to be carried out and will be reported separately.

8.2 Spread Foundations

Groundwater has been measured above formation level and it may not be possible to form spread foundations without groundwater control, although this will ideally be confirmed through continued monitoring and trial excavations.

Provided that a dry excavation can be maintained, spread foundations excavated from basement level may be designed to apply a net allowable bearing pressure of about 130 kN/m^2 at a depth of 4.00 m within the London Clay. This value incorporates an adequate factor of safety against bearing capacity failure and should ensure that settlement remains within normal tolerable limits.

However, the anticipated maximum column load at foundation level is anticipated to be 800 kN and the resultant large pad sizes could lead to excessive settlement. Consideration may therefore need to be given to the use of piled foundations. Further investigation will be required, in the form of a deep borehole ideally to a depth of at least 15 m, to obtain information to assist with the pile design.

6 BS8102 (2009) *Code of practice for protection of below ground structures against water from the ground*

The requirement for compressible material alongside foundations should be determined by reference to the NHBC guidelines.

8.3 Piled Foundations

For the ground conditions at this site a driven or bored pile could be adopted, although the noise and vibrations typically associated with the installation of driven piles is likely to render their use unacceptable. The use of a bored pile retaining wall would have the advantage of providing support for structural loads. At this stage, and subject to further assessment of the groundwater conditions, it is considered likely that a contiguous bored pile wall in association with sump pumping or grouting may be sufficient to protect against groundwater inflows, although this should be confirmed by trial excavations at basement level. A secant pile wall will be suitable should groundwater control be unfeasible or the level of risk be deemed unacceptable.

If piled foundations are to be considered, it is recommended that a deeper borehole is carried out at the site to provide suitable design parameters.

8.4 Basement Floor Slab

Following the excavation of the new basement level, it should be possible to adopt a ground bearing basement floor slab bearing on the natural soils. It would be prudent to proof roll the stratum with any soft spots being removed and replaced with suitably compacted granular fill.

It is recommended that the basement slab is suitably reinforced to withstand heave and potential fluctuating groundwater pressures or that a void is incorporated below the slab to allow the movement to take place or a suitable compressible layer is provided. The rate of movement will of course depend on a number of site-specific factors such as the availability of water at formation level and if piles are used which may restrict heave movements. Further analysis should be carried out once the proposals have been finalised.

8.5 Shallow Excavations

On the basis of the borehole findings, it is considered that shallow excavations for foundations and services that extend through the made ground or London Clay should remain generally stable in the short term, although some instability may occur.

However, should deeper excavations be considered or if excavations are to remain open for prolonged periods it is recommended that provision be made for battered side slopes or lateral support. Where personnel are required to enter excavations, a risk assessment should be carried out and temporary lateral support or battering of the excavation sides considered in order to comply with normal safety requirements.

Groundwater inflows may be encountered within made ground, particularly within the vicinity of existing foundations. Any inflows of groundwater into excavations should be suitably controlled by sump pumping, although this should be confirmed by trial excavations to the full depth of the proposed basement.

8.6 Effect of Sulphates

Chemical analyses carried out on three samples have revealed concentrations of soluble sulphate and near-neutral pH in accordance with Class DS-5 conditions of Table C2 of BRE Special Digest 1 Part C (2005). The measured pH value of the samples shows that an ACEC class of AC-4s of Table C2 would be appropriate for the site. This assumes a static water condition at the site. The guidelines contained in the above digest should be followed in the design of foundation concrete.

8.7 Site Specific Risk Assessment

The desk study has indicated the site to have had a potentially contaminative history, having been occupied by a works building. The chemical analysis has revealed elevated concentrations of lead and total PAH, including benzo(a)pyrene, within four samples of made ground tested, no other elevated concentrations of contaminants were measured.

Although the source of this contamination has not been identified it is likely to be due to fragments of extraneous material within the made ground. Statistical analysis of the chrysene:benzo(a)anthracene and fluoranthene:pyrene ratios suggests that the source of the PAH contamination is coal-based tarmac.

The majority of the made ground is likely to be removed by the basement excavation and end users will in any case be effectively isolated from direct contact with the identified contaminants by the extent of the proposed building.

Consideration should however be given to the protection of site workers handling the soil and there may be a requirement for protection of new buried plastic services laid within the made ground at the front of the site.

8.7.1 Site Workers

Site workers should be made aware of the contamination and a programme of working should be identified to protect workers handling any soil. The method of site working should be in accordance with guidelines set out by HSE[7] and CIRIA[8] and the requirements of the Local Authority Environmental Health Officer.

8.7.3 Plastic Services

Consideration may need to be given to the protection of buried plastic services laid within the made ground. Details of the proposed protection measures for buried plastic services will in any case need to be approved by the EHO and the relevant service authority prior to the adoption of any scheme. It is possible that barrier pipe will be required or additional testing will need to be carried out.

8.8 Waste Disposal

Any spoil arising from excavations or landscaping works, which is not to be re-used in accordance with the CL:AIRE guidance[9], will need to be disposed of to a licensed tip. Under the European Waste Directive, waste is classified as being either Hazardous or Non-Hazardous and landfills receiving waste are classified as accepting hazardous or non-hazardous wastes or the non-hazardous sub-category of inert waste in accordance with the Waste Directive. Waste going to landfill is subject to landfill tax at either the standard rate of £82.60 per tonne (about £145 per m^3) or at the lower rate of £2.60 per tonne (roughly £5 per m^3). However, the classification for tax purposes is not the same as that for disposal purposes. Currently all made ground and topsoil is taxable at the ‘standard’ rate and only

7 HSE (1992) HS(G)66 *Protection of workers and the general public during the development of contaminated land* HMSO

8 CIRIA (1996) *A guide for safe working on contaminated sites* Report 132, Construction Industry Research and Information Association

9 CL:AIRE (2011) *The Definition of Waste: Development Industry Code of Practice* Version 2, March 2011

naturally occurring rocks and soils which are accurately described as such in terms of the 2011 Order[10] would qualify for the 'lower rate' of landfill tax.

Based upon on the technical guidance provided by the Environment Agency[11] it is considered likely that the made ground from this site, as represented by the three chemical analyses carried out, would be classified as a NON-HAZARDOUS waste under the waste code 17 05 04 (soils and stones not containing dangerous substances) and would be taxable at the standard rate. It is likely that the natural soils, if separated out, could be classified as an INERT waste also under the waste code 17 05 04. This material would be taxable at the lower rate, if accurately described as naturally occurring sand and gravel in terms of the 2011 Order on the waste transfer note. As this site has not had a contaminative history there should be no requirement for WAC leaching analyses to confirm that this material is suitable for landfilling, although this would require confirmation from the receiving site.

Under the requirements of the European Waste Directive all waste needs to be pre-treated prior to disposal. The pre-treatment process must be physical, thermal, chemical or biological, including sorting. It must change the characteristics of the waste in order to reduce its volume, hazardous nature, facilitate handling or enhance recovery. The waste producer can carry out the treatment but they will need to provide documentation to prove that this has been carried out. Alternatively, the treatment can be carried out by an approved contractor. The Environment Agency has issued a position paper[12] which states that in certain circumstances, segregation at source may be considered as pre-treatment and thus excavated material may not have to be treated prior to landfilling if the soils can be segregated onsite prior to excavation by sufficiently characterising the soils insitu prior to excavation.
The above opinion with regard to the classification of the excavated soils and its likely landfill taxable rate is provided for guidance only and should be confirmed by the receiving landfill once the soils to be discarded have been identified.

The local waste regulation department of the Environment Agency should be contacted to obtain details of tips that are licensed to accept the soil represented by the test results. The tips will be able to provide costs for disposing of this material but may require further testing.

9.0 BASEMENT IMPACT ASSESSMENT

It is understood that consideration is being given to the demolition of the existing building and construction of a new five-storey concrete framed building with a single basement beneath the entire footprint. The basement is assumed to extend to a depth of 4.00 m below ground level, with formation level in the London Clay, which has been proved to the maximum depth investigated of 5.45 m.

Groundwater has been measured at a depth of 1.15 m to date and on this basis is likely to be encountered during excavation. However, it is suspected that this represents perched water and monitoring should be continued to determine an appropriate design groundwater level.

The London Clay is not capable of storing and transmitting water in usable amounts and receives very low levels of annual recharge due to its low permeability. The London Clay

10 *Landfill Tax (Qualifying Material) Order 2011*
11 Environment Agency (2013) *Hazardous Waste: Interpretation of the definition and classification of hazardous waste. Technical Guidance* WM2 Third Edition, August 2013
12 Regulatory Position Statement (2007) *Treating non-hazardous waste for landfill - Enforcing the new requirement* Environment Agency 23 Oct 2007

strata does not support flow to any ponds or watercourses within 100 m of the site. The proposed basement will not increase the area of existing hardstanding.

The screening identified a number of potential impacts. The desk study and ground investigation information has been used below to review the potential impacts, to assess the likelihood of them occurring and the scope for reasonable engineering mitigation.

The table below summarises the previously identified potential impacts and the additional information that is now available from the site investigation in consideration of each impact.

Potential Impact	Site Investigation Conclusions
The London Clay Formation, which is the shallowest strata on the site, is prone to seasonal shrink / swell - this can result in foundation movements	Plasticity index tests generally indicate the London Clay to be of high volume change potential at the site. Shrinkable clay is present within a depth that can be affected by tree roots and the soil is not currently desiccated.
Location of public highway – excavation of basement could lead to damage	The highway is located within 5 m of the site. The basement will be constructed beneath the footprint of the new building which will be within 5 m of the highway.
The basement may extend below the groundwater table	Groundwater has been recorded at a depth of 1.15 m, although this may represent perched water and there is not a general water table within the London Clay in view of its low permeability.

The results of the site investigation have been used below to review the remaining potential impacts, to assess the likelihood of them occurring and the scope for reasonable engineering mitigation.

Shrink / swell potential of London Clay

Shrinkable clay is present within a depth that can be affected by tree roots; however, the soil was not found to be desiccated. The proposed basement will be constructed from ground level and will be located over ground occupied by the existing building. The depth of founding should be checked to ensure that it provides sufficient protection against future tree root growth and it is recommended that the basement excavation is inspected by a qualified and experienced geotechnical engineer to ensure that no desiccation remains at formation level.

Location of public highway

The proposed basement excavation will be located beneath the footprint of the new building, which measures 5 m from the highway to the front door. Consequently, excavation will be within 5 m of the public highway. The proposed development will include retaining walls that will be designed to maintain the stability of the surrounding ground, thus protecting the adjacent road and associated infrastructure beyond. There is nothing unusual or exceptional in the proposed development or the findings of the investigation that give rise to any concerns with regard to stability over and above any development of this nature.

Proposed basement structure will extend below groundwater table

Groundwater is likely to be encountered within the 4.0 m deep basement excavation which will have a formation level within the London Clay. This soil is known to have very low permeability and cannot store or transmit significant quantities of groundwater. It receives very low levels of annual recharge due to its very low permeability nature and this stratum does not support flow to any ponds or watercourses within 100 m of the site. On the basis of the above, the proposed basement will not affect the amount of annual recharge into the London Clay, and it is not considered that the proposed basement would result in a significant change to the groundwater flow regime in the vicinity of the proposal.

10.0 OUTSTANDING RISKS AND ISSUES

This section of the report aims to highlight areas where further work is required as a result of limitations on the scope of this investigation, or where issues have been identified by this investigation that warrant further consideration. The scope of risks and issues discussed in this section is by no means exhaustive, but covers the main areas where additional work is considered to be required.

The ground is a heterogeneous natural material and variations will inevitably arise between the locations at which it is investigated. This report provides an assessment of the ground conditions based on the discrete points at which the ground was sampled, but the ground conditions should be subject to review as the work proceeds to ensure that any variations from the Ground Model are properly assessed by a suitably qualified person.

The anticipated maximum column load at foundation level is anticipated to be 800 kN such that spread foundations are unlikely to be a suitable foundation solution. A piled foundation solution will be a suitable alternative. Further investigation will be required, in the form of at least one deep borehole ideally to a depth of at least 15 m, to obtain information to assist with a pile design, should this be considered.

Further groundwater monitoring should be carried out to establish equilibrium levels and the extent of any seasonal fluctuations. It would be prudent to carry out a number of trial excavations, to depths as close to the full basement depth to provide an indication of the likely groundwater conditions.

A separate Ground Movement Analysis has been commissioned and will be reported separately.

Network Rail will need to be consulted with regards to the proposed development to ensure that their property will not be affected by the construction of the new development.

If during ground works any visual or olfactory evidence of contamination is identified it is recommended that further investigation be carried out and that the risk assessment is reviewed. These areas of doubt should be drawn to the attention of prospective contractors and further investigation will be required or sufficient contingency should be provided to cover the outstanding risk.