GEA

95 Avenue Road
London
NW8 6HY

Ground Investigation &
Basement Impact Assessment

95 Avenue Road (Freehold) Limited

February 2023

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Ground investigation | Geotechnical consultancy | Contaminated land assessment

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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 95 Avenue Road (Freehold) Limited, with respect to the partial demolition of the existing garages and construction of a pair of semi-detached two-storey houses, the lower level of which will effectively form a single level basement, extending to approximately 3.00 m. The purpose of the investigation has been to determine the ground conditions and hydrogeology, to provide a preliminary assessment of the presence of contamination and to provide information to assist with the design of the basement structure and suitable foundations. The report also includes information required to comply with London Borough of Camden Planning Guidance (CPG) Basements, relating to the requirement for a Basement Impact Assessment (BIA), including a ground movement analysis (GMA).

Desk study findings

The earliest map studied, a historical town plan dated 1850, provides little detail but indicates that some of the existing road network, including Avenue Road (then known as Upper Avenue Road), Finchley Road, St John's Wood Park and Adelaide Road (then known as Tunnel Road) had been established. A tunnel, which is known as the Primrose Hill Tunnel' is shown running from a tunnel portal approximately 250 m to the west, eastwards beneath Tunnel Road, passing approximately 20 m north of the site. Online information indicates that the tunnel was the first major railway tunnel to be constructed in London and was opened in 1838. The next available map, dated 1871, provides a greater level of detail and indicates that the site was occupied by two plots, each developed with a detached house and associated gardens. The surrounding area was also extensively developed with similar residential properties at that time. By 1895, the tunnel portal to the west had been widened to incorporate a second tunnel to the south of the original line, which runs below the centre of the site. A further two tunnels were bored to the north of the original tunnel by 1912. The site remained essentially unchanged until the 1960s, when the existing residential apartment block and associated structures were constructed.

Ground conditions

The investigation generally encountered the expected ground conditions, in that below a surface covering of concrete or topsoil, and a generally moderate but locally significant thickness of made ground, the London Clay Formation extended to the full depth of the investigation. The made ground generally comprised a matrix of brown sandy gravelly clay and gravelly sand with fragments of brick, concrete and clinker, with localised roots and rootlets. This extended to maximum depths of 1.50 m (49.60 m OD) and 1.20 m (49.65 m OD) in Borehole Nos 1 and 2 respectively, and to a depth of 2.20 m (49.23 m OD) in Borehole No 3, whereupon further made ground comprising brown gravelly sand and gravelly clay with fragments of timber was encountered to a depth of 3.00 m (48.43 m OD).The underlying London Clay comprised an initial naturally reworked horizon comprising firm becoming stiff brown and orange-brown mottled grey silty slightly sandy slightly gravelly clay. The initial horizon extended to depths of between 3.10 m (48.00 m OD) and 3.50 m (47.93 m OD), whereupon stiff becoming very stiff medium strength to high strength fissured brown mottled grey silty clay with mica and occasional fine partings of fine sand was proved to the full depth investigated, of 10.00 m (41.10 m OD).

Groundwater was encountered as seepage from a granular pocket in Borehole No 3 only at a depth of 3.50 m (47.93 m OD). Subsequent groundwater monitoring however recorded the standpipes to be dry.

Contamination testing has identified elevated concentrations of lead in addition to fibres of amosite and crocidolite asbestos in a sample of the made ground. Subsequent quantification testing found the fibres to comprise 0.455 % of the sample.

Recommendations

Formation level for the basement is likely to be within the stiff clay of the London Clay at depths of between 2.40 m and 3.00 m. The London Clay is of low permeability, which will not typically support a continuous "water table" or significant groundwater flow. Therefore, significant groundwater inflows are not expected to be encountered in the basement excavation. Any relatively minor perched water inflows or seepages should be adequately dealt with through sump pumping, although it would be prudent for the chosen contractor to have a contingency plan in place to deal with more significant or prolonged inflows as a precautionary measure. In the absence of significant groundwater inflows and the underlying clay soils, the use of underpinning in a traditional hit and miss approach is considered to be a suitable option of forming the basement retaining walls.

New spread foundations bearing in the stiff clay of the London Clay below basement level may be designed to apply a net allowable bearing pressure of around 150 kN/m^2.

Site workers should adopt suitable precautions when handling soil, particularly with respect to the presence of asbestos; however further investigation, sampling and screening will be required across proposed and remaining landscaped areas.

Basement Impact Assessment

The BIA has not indicated any concerns with regard to the effects of the proposed basement on the site and surrounding area. It has been concluded that the impacts identified can be mitigated by appropriate design and standard construction practice.

The ground movement analysis and building damage assessment has indicated that the basement is not expected to cause unacceptable movements or levels of damage to surrounding sensitive structures, including the London Overground railway tunnel below the site.

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.

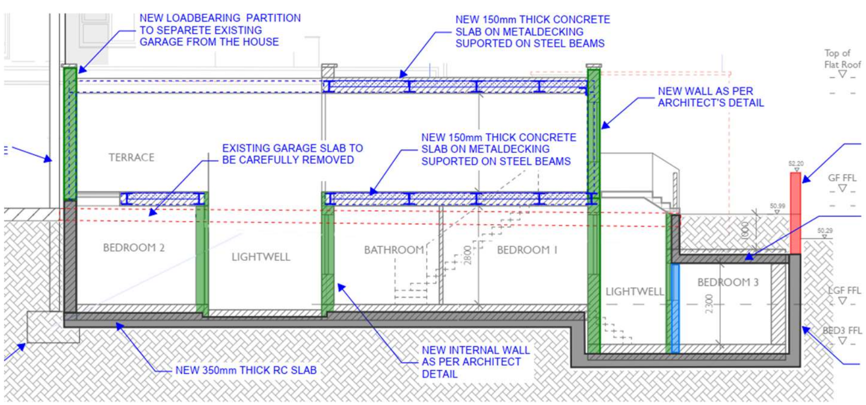
1.0 Introduction

Geotechnical and Environmental Associates Limited (GEA) has been commissioned by 95 Avenue Road (Freehold) Limited to carry out a desk study and ground investigation at 95 Avenue Road, London NW8 6HY. Michael Barclay Partnership are the consulting structural engineers for the project.

This report also forms part of a Basement Impact Assessment (BIA), which has been carried out in accordance with guidelines from the London Borough of Camden (LBC) in support of a planning application.

1.1 Proposed Development

It is understood that it is proposed to demolish part of the existing garage building along the southern boundary of the site and subsequently construct a pair of two-storey semi-detached houses, with the lower level effectively forming a single level basement that will have a general formation level of approximately 2.50 m below ground level, with a deepened front lightwell that will be excavated to approximately 3.00 m, as shown by the cross-section below.



This report is specific to the proposed development and the advice herein should be reviewed if the development 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 with respect to previous contaminative uses;
- to provide an assessment of the risk of encountering UXO;
- to determine the ground conditions and their engineering properties;
- to use the above information to provide recommendations with respect to the design of suitable foundations and retaining walls;
- to assess the impact of the proposed basement on the local hydrogeology, hydrology and stability of the surrounding natural and build environment;
- 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 historical Ordnance Survey (OS) maps and environmental searches sourced from the Envirocheck database;
- a review of readily available geology maps;
- the commissioning of a preliminary and detailed UXO risk assessment from 1st Line Defence, a UXO specialist, and
- a walkover survey of the site carried out in conjunction with the fieldwork.

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

- a single borehole advanced to a depth of 10 m using a cable percussion drilling rig;
- two further additional boreholes advanced to a depth of 5.45 m using an opendrive sampling rig;
- standard penetration tests (SPTs) carried out at regular intervals within the boreholes to provide quantitative data on the strength of the soils;
- the installation of groundwater monitoring standpipes in two of the boreholes to depths of 4.00 m and 5.00 m and a single monitoring visit undertaken to date;
- testing of selected soil samples for contamination and geotechnical purposes; and
- provision of a report presenting and interpreting the above data, together with our advice and recommendations with respect to the proposed development.

This report includes a contaminated land assessment which has been undertaken by a suitably qualified and competent professional in accordance with the methodology presented by the Environment Agency in their Land contamination risk assessment (LCRM)[1] published 19 April 2021. This 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. Risk management is divided into three stages; Risk Assessment, Options Appraisal and Remediation, and each stage comprises three tiers. The Risk Assessment stage includes preliminary risk assessment (PRA), generic quantitative risk assessment (GQRA) and detailed quantitative risk assessment (DQRA)and this report includes the PRA and GQRA.

The exploratory methods adopted in this investigation have been selected on the basis of the constraints of the site including but not limited to access and space limitations, together with any budgetary or timing constraints. Where it has not been possible to reasonably use an EC7 compliant investigation technique a practical alternative has been adopted to obtain indicative soil parameters and any interpretation is based upon engineering experience, local precedent where applicable and relevant published information.

1.3.1 Basement Impact Assessment

The work carried out includes a Hydrological and Hydrogeological Assessment and Land Stability Assessment (also referred to as Slope Stability Assessment). These assessments form part of the BIA procedure specified in the London Borough of Camden (LBC) Planning Guidance CPG[2] and their Guidance for Subterranean Development[3] prepared by Arup (the "Arup report") in accordance with Policy A5 of the Camden Local Plan 2017. The aim of the work is to provide information on surface water, groundwater and land stability and in particular to assess whether the development will affect neighbouring properties or groundwater movements and whether any identified impacts can be appropriately mitigated by the design of the development.

1.3.2 Qualifications

The land stability element of 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. The subterranean (groundwater) flow assessment has been carried out by Nick Mannix, MSc in Hydrogeology, Chartered Geologist (CGeol) and Fellow of the Geological Society of London (FGS). The surface water and flooding assessment has been carried out by Rupert Evans, a hydrologist with more than ten years consultancy experience in flood risk assessment, surface water drainage schemes and hydrology / hydraulic modelling. Rupert Evans is a Chartered Environmentalist, Chartered Water and Environmental Manager and a Member of CIWEM.

The assessments have been made in conjunction with 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 some 30 years' experience in geotechnical engineering and engineering geology.

All assessors meet the qualification requirements of the Council guidance.

1.4 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 ground water samples tested. No liability can

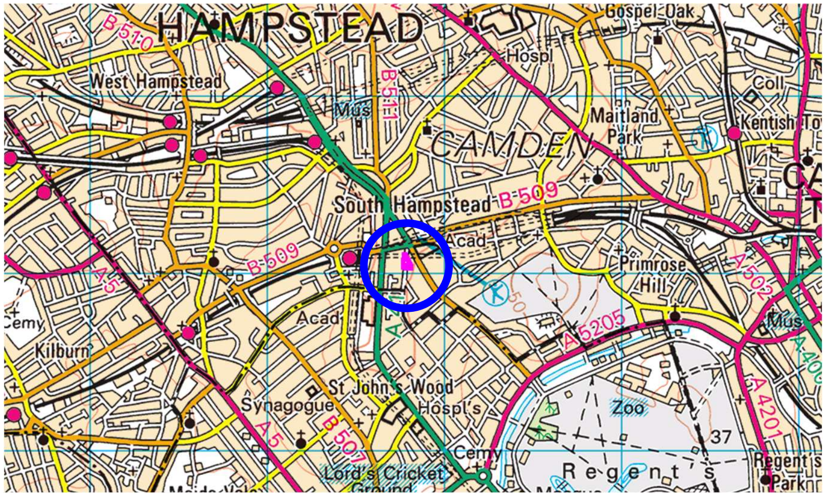
1 https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm
2 London Borough of Camden Planning Guidance CPG (January 2021) *Basements*
3 Ove Arup & Partners (2010) *Camden geological, hydrogeological and hydrological study. Guidance for Subterranean Development.* For London Borough of Camden November 2010

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 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 the London Borough of Camden, approximately 225 m southeast of Swiss Cottage London Underground station and 380 m east of South Hampstead train station. It fronts onto and is accessed from Avenue Road to the northeast and is bounded by St John's Wood Park to the west and by two four-storey apartment blocks to the south. The site may be additionally located by National Grid Reference 526780,184060 and is shown on the location plan below.



A site walkover was undertaken at the time of the fieldwork by a geotechnical engineer from GEA. The site is roughly triangular shaped and is occupied by an eight-storey apartment building that includes a single level basement. A row of lock up garages adjoins the building to the south. Paved driveways are located to the east and west of the building while a communal garden area covers the northern corner of the site. The site slopes down towards the southeast, which is in keeping with the surrounding topography. Numerous deciduous trees of up to 20 m in height, line the northeastern and western boundaries of the site. Notable species include London plane and Lime. No potential sources of contamination were identified during the site walkover.

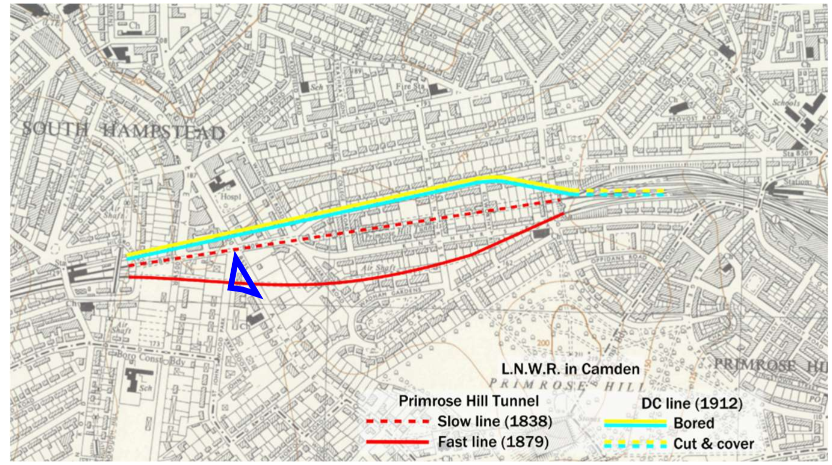
2.1.1 Adjoining Structures

The site is bounded to the south by four-storey apartment blocks known as Avenue Lodge and Park Lodge. Observations of the buildings suggest that they do not include basement or lower ground floor levels.

2.2 Site History

The earliest map studied, a historical town plan dated 1850, provides little detail but indicates that some of the existing road network, including Avenue Road (then known as Upper Avenue Road), Finchley Road, St John's Wood Park and Adelaide Road (then known as Tunnel Road) had been established. A tunnel, which is known as the Primrose Hill Tunnel is shown running from a tunnel portal approximately 250 m to the west, eastwards beneath Tunnel Road, passing approximately 20 m north of the site. Online information[4] indicates that the tunnel was the first major railway tunnel to be constructed in London and was opened in 1838.

The next available map, dated 1871, provides a greater level of detail and indicates that the site was occupied by two plots, each developed with a detached house and associated gardens. The surrounding area was also extensively developed with similar residential properties at that time. By 1895, the house across the northern half of the site and been extended along the had been extended to the north while a conservatory had been added to the southern façade. The tunnel portal to the west had been widened to incorporate a second tunnel to the south of the original line, which runs below the centre of the site. The aforementioned online information indicates that this tunnel had been constructed by 1879. A further two tunnels are shown to have been added to the north of the original tunnel on the map dated 1935 and these are understood to have been completed by 1912. The tunnel alignments and construction dates are shown on the plan opposite, with the site outlined in blue.



By 1935, the property across the northern half of the site had either been demolished and re-built or extended to form a different layout and the existing Avenue Lodge and Park Lodge had been constructed to the south of the site.

On the map dated 1954, the buildings on site and a number of the buildings surrounding the site are labelled as "Ruin", suggesting that they had sustained bomb damage during World War II (WWII). However, reference to the UXO risk assessments carried out by 1st Line Defence, as discussed further in Section 2.4, indicates that this labelling is in error as there are no records of the properties occupying the site having sustained any bomb damage. By 1962, the previous properties had been demolished and the existing buildings constructed, with a number of other former detached and semi-detached properties surrounding the site demolished to make way for apartment blocks, a school, swimming baths and a library amongst others during the 1960s. The site and surrounding area have since remained essentially unchanged.

4 https://camdenist.com/history/primrose-hill-portal/

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 Envirocheck report indicates that there are no existing or historical landfill sites, waste management, transfer, treatment of disposal sites within 250 m of the site. There are no registered contaminated land sites within 1 km of the site and there have been no recorded pollution incidents to controlled waters within 250 m of the site. Two Local Authority Pollution Prevention and Controls are in place for sites in use as dry cleaners 205 m north and 217 m to the northwest. These are considered to be at a sufficient distance from the site as to not be considered a potential risk to the site.

Reference to records compiled by the Health Protection Agency (formerly the National Radiological Protection Board) indicates that the site falls within an area where less than 1% of homes are affected by radon emissions and therefore radon protective measures will not be necessary.

The railway tunnel below the site is operated by London Overground, although it has not been possible to acquire any further information on the tunnel at this stage. From lidar data, track level at the tunnel portal to the west of the site is approximately 33 m OD, which would equate to approximately 17 m below the level of the site. Assuming an approximately 6 m to 7 m tunnel diameter, a crown level of 39 m OD has been adopted, equating to 11 m below the level of the site.

2.4 UXO Risk Assessment

A Preliminary UXO Risk Assessment has been completed by 1st Line Defence (report ref PA15426-00, dated March 2022), and the report is included in the appendix. The risk assessment has been carried out in accordance with the guidelines provided by CIRIA[5], which state that the likelihood of encountering and detonating UXO below a site should be assessed along with establishing the consequences that may arise. The first phase comprises a preliminary risk assessment, which should be undertaken at an early stage of the development planning. If such an assessment identifies a high level of risk then a detailed risk assessment should be carried out by a UXO specialist, which will identify an appropriate course of action with regard to risk mitigation.

The report indicates that, during WWII, the site was located within the Municipal Borough of Hampstead, which sustained an overall very high density of bombing. London bomb census mapping indicates that the site was subject two incendiary showers in 1940, with closest high explosive (HE) bomb strike recorded 80 m to the north of the site. Although no immediate records of bomb damage on the site was determined, annotation on post-war historical maps indicate that buildings occupying the site at the time were ruined. It was therefore recommended that further research in the form of a detailed UXO risk assessment was carried out, in order to acquire and review further historical records.

In light of the findings and recommendations of the preliminary assessment, a detailed UXO risk assessment was undertaken by 1st Line Defence (report ref DA15426-00, dated April 2022) and the report is included in the appendix. The report confirms the findings of the preliminary risk assessment and through a review of further aerial imagery and written air raid records, it was concluded that the annotation included on historical mapping is in error and the risk of encountering UXO was deemed to be low.

2.5 Geology

The British Geological Survey (BGS) map of the area (Sheet 256) indicates the site is directly underlain by the London Clay. According to the BGS memoir, the London Clay is homogenous, slightly calcareous silty clay to very silty clay, with some beds of clayey silt grading to silty fine-grained sand. The London Clay overlies a downwards sequence of Lambeth Group (sandy clays) overlying Thanet Sand (fine grained sands), which in turn overlies the Cretaceous Chalk. A review of archive records or boreholes held by BGS indicates that the London Clay extends to a depth of 80 m.

Previous ground investigations in the area have encountered a covering of reworked London Clay or head deposits, comprising layers of gravelly clay and granular soils.

5 CIRIA C681 (2009) *Unexploded ordnance (UXO) A guide for the construction industry*

2.6 Hydrology and Hydrogeology

The London Clay Formation is classified as Unproductive Strata, referring to rock layers or drift deposits with low permeability and that have negligible significance for water supply or river base flow.

As the London Clay is likely to comprise predominantly clay soils, it cannot support groundwater flow over any significant distance, nor can it be considered to support a "water table" or continuous piezometric surface. Boreholes constructed within clays do fill with water, due to the often high water content of shallow clays draining into the standpipe or by the collection of surface water drainage, which is unable to drain through the clay; however, this is not reflective of the type of groundwater flow that would occur in a porous and permeable saturated stratum.

The permeability of the weathered London Clay will be predominantly secondary, through fissures in the clay. Published data indicates the horizontal permeability of the London Clay to generally range between 1×10^{-11} m/s and 1×10^{-9} m/s. Any reworked surface layers will be expected to have a higher permeability, but the granular soils have not typically been encountered as continuous layers, such that the overall permeability will be governed by the permeability of the surrounding clay.

The nearest surface water feature is located 309 m to the southeast of the site, which is believed to relate to an ornamental water feature in the Swiss Cottage Open Space. The site is not located within an area at risk of flooding from rivers or sea, as defined by the Environment Agency, and College Crescent has not been identified as a street at risk of surface water flooding within the London Borough of Camden.

The site lies outside the catchment of the Hampstead Heath chain of ponds.

The site is located within a groundwater Source Protection Zone (SPZ) (Zone II – outer protection zone), classified as either 25% of the source area or a 400-day travel time, whichever is greater. The SPZ is likely to be associated with a public water supply from the Chalk Aquifer, which is confined by the London Clay at a depth greater than 50 m. There is no hydraulic continuity between the London Clay and the Chalk aquifer at depth. The abstraction point associated with the SPZ is indicated to be around 900 m to the southeast.

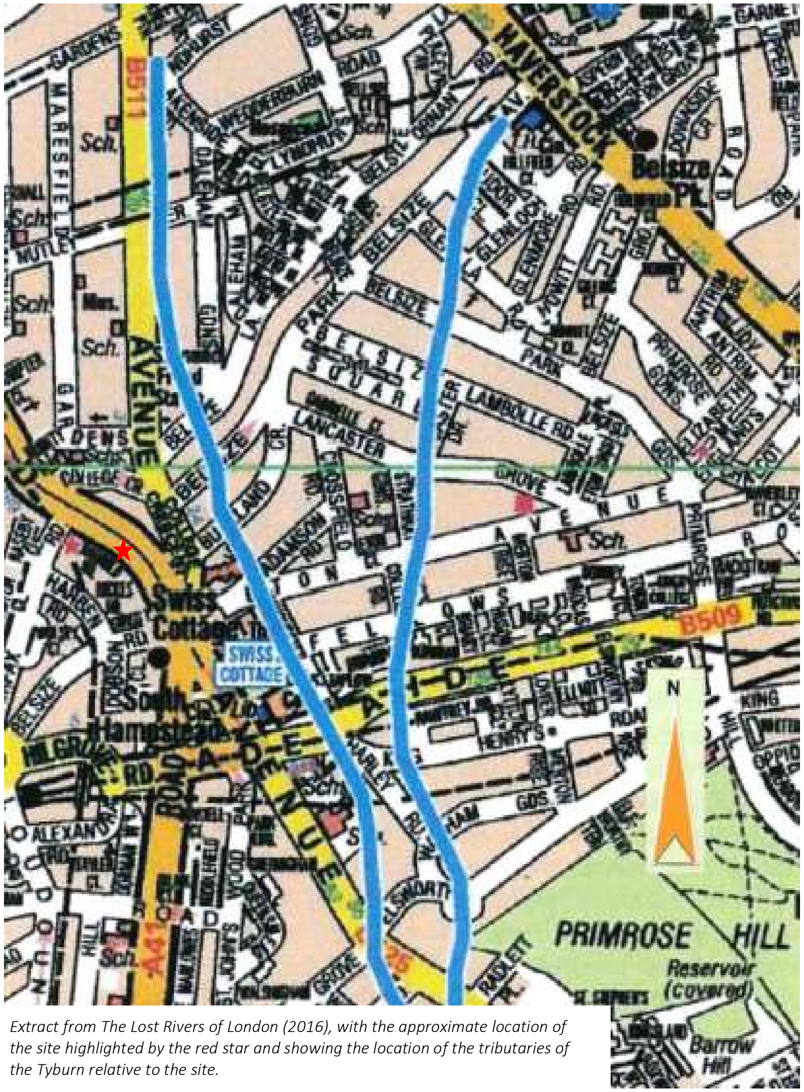
The site is not listed within the London Borough of Camden report[6] as having suffered from surface water flooding in the 1975 flooding event. However, the report indicates that Avenue Road did suffer surface water flooding at the site during the 2002 event.

Spring lines are present at the interface of the Bagshot Beds and the Claygate Member in the area of Hampstead Heath and, to a lesser extent, near the boundary between the Claygate Member and the underlying lowly permeable London Clay. These springs have been the source of a number of London's lost rivers, including the Tyburn and Westbourne. Figure 11 of the Arup report and reference to the Lost Rivers of London[7] indicates that a tributary of the River Tyburn formerly flowed southwards approximately 150 m to the east of the site, from where it flowed through St John's Wood and Regents Park, where it flowed southwards through Mayfair and Westminster, where two tributaries issued into the River Thames close to Westminster Bridge and Lambeth Bridge. The former river course is shown on the map extract overleaf, and now flows through culverts and sewers.

The site is largely covered by the existing buildings and hardstanding and therefore infiltration of rainwater into the ground beneath the site is limited to localised areas of soft landscaping. The majority of surface runoff is therefore likely to drain into combined sewers in the road. The proposed development will not increase the ratio of hardstanding with the basement footprint extending below the existing garage building footprint. There will therefore not be an increase in runoff rate or volume into the existing sewer system, or that could have a potentially adverse impact on the surrounding area. There should not, therefore, be any requirement for any mitigation measures.

6 London Borough of Camden (2003) *Floods in Camden, Report of the Floods Scrutiny Panel*

7 Barton, N, & Meyers, S (2016) *The Lost Rivers of London (revised and extended edition with colour maps).* Historical Publications Ltd.



Extract from The Lost Rivers of London (2016), with the approximate location of the site highlighted by the red star and showing the location of the tributaries of the Tyburn relative to the site.

2.7 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.

2.7.1 Source

The desk study has indicated that the site does not have a contaminative history as it has been occupied by residential properties prior to the existing apartment block since the 1960s. As such no potential sources of contamination were identified, although given that the building was constructed in the 1960s, there is the potential for asbestos containing materials to be present on site. The immediate surrounding area has also been predominantly occupied by residential streets and as such no off-site sources of contamination have been identified by the desk study. No potential sources of landfill or hazardous soil gases have been identified either.

2.7.2 Receptor

Following the proposed redevelopment, the site will continue to have a residential end use, such that end users will represent highly sensitive receptors. Neighbouring sites are potentially sensitive receptors, although as the site is underlain by the non-aquifer of the London Clay, groundwater is not a sensitive receptor. Site workers during groundworks and construction works are sensitive receptors, as are new buried services and buried concrete.

2.7.3 Pathway

It is understood that the site will continue to have communal garden areas, with areas of soft landscaping forming a pathway by which end users could come into contact with any contaminants in the shallow soils. These areas of soft landscaping also form a pathway for the infiltration of rain and surface water. Any made ground will theoretically form a pathway for any perched groundwater inflows to flow onto and off of site The groundworks and construction works form a pathway by which construction workers, new buried services and buried concrete may be exposed to any contaminants present within the shallow soils.

2.7.4 Preliminary Risk Appraisal

It is considered that there is a LOW risk of there being a contaminant linkage at this site that could result in a requirement for major remediation work.

3.0 Screening

The Camden planning guidance suggests that any development proposal that includes a 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 Appendices E1, E2 and E3 which include a series of questions within screening flowcharts for surface flow and flooding, subterranean (groundwater) flow and land stability. The flowchart questions and responses to these questions are tabulated below.

3.1.1 Subterranean (groundwater) Screening Assessment

Question	Response for 95 Avenue Road
1a. Is the site located directly above an aquifer?	No. The site is underlain by the London Clay which is designated as Unproductive Strata by the Environment Agency and cannot store and transmit water in sufficient quantities to support groundwater abstractions or watercourses.
1b. Will the proposed basement extend beneath the water table surface?	No. The London Clay and clay dominated Head Deposits, if present, cannot support groundwater flow and cannot therefore support a water table consistent with a permeable water bearing strata.
2. Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line?	No. Whilst the Lost Rivers of London and Figure 11 of the Arup Report show the site to be approximately 100 m of a former tributary of the River Tyburn, this feature is no longer present at surface, having been diverted to form part of the local surface water sewer system.
3. Is the site within the catchment of the pond chains on Hampstead Heath?	No. Topographical maps acquired as part of the desk study and Figures 12 and 14 of the Arup report confirms that the site is not located within this catchment area
4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No. The basement footprint extends below the footprint of an existing building.
5. 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. Given that the site is underlain by clay soils and is unlikely to be suitable for a soakaway or similar SUDS based system, the site drainage will therefore be directed to public sewer. Site drainage will therefore be designed to generally maintain the existing situation.
6. 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 groundwater dependent ponds or spring lines present within 500 m of the site. The flow of the former Tyburn watercourse was perched on the London Clay.

The above assessment has not identified any potential issues with regard to groundwater flow and therefore further assessment beyond the screening stage is not required.

3.1.2 Stability Screening Assessment

Question	Response for 95 Avenue Road
1. Does the existing site include slopes, natural or manmade, greater than 7°?	No, as indicated on the Slope Angle Map Fig 16 of the Arup report.
2. Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7°?	No. The site is not to be significantly re-profiled as part of the development.
3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	No. As indicated on the Slope Angle Map Fig 16 of the Arup report.
4. Is the site within a wider hillside setting in which the general slope is greater than 7°?	No. As indicated on the Slope Angle Map Fig 16 of the Arup report.
5. Is the London Clay the shallowest strata at the site?	*Yes. As indicated on the geological map and Figures 3, 5 and 8 of the Arup report*
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?	No. The site does not include any trees and the three semi-mature deciduous trees present on neighbouring land to the northwest are expected to be retained. Care should be taken whilst excavating close to any roots not to damage them.
7. Is there a history of seasonal shrink-swell subsidence in the local area and / or evidence of such effects at the site?	*Yes. The area is prone to these effects as a result of the presence of shrinkable London Clay.*

Question	Response for 95 Avenue Road
8. Is the site within 100 m of a watercourse or potential spring line?	No. Whilst the Lost Rivers of London and Figure 11 of the Arup Report show the site to be approximately 150 m of a former tributary of the River Tyburn, this feature is no longer present at surface, having been diverted to form part of the local surface water sewer system.
9. Is the site within an area of previously worked ground?	No. The geological map of the area and Figures 3, 4 and 8 of the Arup report do not indicate any worked ground.
10a. Is the site within an aquifer?	No. The site is underlain by the London Clay which is designated as Unproductive Strata by the Environment Agency and cannot store and transmit usable amounts of water.
10b. Will the proposed basement extend beneath the water table such that dewatering may be required during construction?	No. The London Clay cannot support a continuous water table.
11. Is the site within 50 m of Hampstead Heath ponds?	No. Figure 14 of the Arup report confirms that the site is not located within 50 m of the Hampstead Heath ponds.
12. Is the site within 5 m of a highway or pedestrian right of way?	*Yes. The site fronts on to Avenue Road to the east*
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	No. The proposed basement does not share a party wall with any neighbouring properties.
14. Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	*Yes. One of the Primrose Hill Tunnels operated by London Overground is located below the site. This is confirmed with reference to Figure 18 of the ARUP report.* *Thames Water has been contacted and their plans indicate no deep sewers or tunnels under or in close proximity of the site.*

The above assessment has identified the following potential issues that need to be assessed:

Q5 The London Clay is the shallowest strata beneath the site.
Q7 The site is in an area likely to be affected by seasonal shrink-swell.
Q12 The site is located within 5 m of a public highway.
Q14 A London Overground railway tunnel is present beneath the site.

3.1.3 Surface Flow and Flooding Screening Assessment

Question	Response for 95 Avenue Road
1. Is the site within the catchment of the pond chains on Hampstead Heath?	No. Figure 14 of Arup report confirms that the site is not located within this catchment area.
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. Any additional surface water from the marginal increase in hardstanding area will be attenuated and discharged into the Thames Water sewers to ensure the surface water flow regime will be unchanged. The basement will mainly be beneath the footprint of the building and existing hardstanding areas, and the 1m distance between the roof of the basement and ground surface as recommended by section 3.2 of the CPG Basements 2021 does not apply across these areas.
3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No. The basement footprint extends below the footprint of an existing building.
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. Any additional surface water from the marginal increase in hardstanding area will be attenuated and discharged into the Thames Water sewers to ensure the surface water flow regime will be unchanged. The basement will be beneath the footprint of the building, and the 1m distance between the roof of the basement and ground surface as recommended by section 3.2 of the CPG Basements 2021 does not apply across these areas.
5. Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No. The proposal is very unlikely to result in any changes to the quality of surface water being received by adjacent properties or downstream watercourses as the surface water drainage regime will be unchanged and the land uses will remain the same.
6. Is the site in an area identified to have surface water flood risk according to either the Local Flood Risk Management Strategy or the Strategic Flood Risk Assessment or is it at risk of flooding, for example because the proposed basement is below the static water level of nearby surface water feature?	*Yes. The Camden Flood Risk Management Strategy dated 2013, together with Figures 3v, 4e, 5a and 5b of the SFRA dated 2014, and Environment Agency online flood maps show that the site has a very low flooding risk from sewers, reservoirs (and other artificial sources), groundwater and fluvial/tidal watercourses.* *The Environment Agency online flood maps and Figure 3v of the SFRA show that the site has a very low to low flooding risk from surface water. The flood depth is shown to be <0.3m during the low risk event.*

Question	Response for 95 Avenue Road
	It is possible that the basement will be constructed within pockets of perched water and the recommendations outlined in the BIA with regards to water-proofing and tanking of the basement will reduce the risk to acceptable levels. *In accordance with paragraph 5.11 of the CPG, a positive pumped device will be installed in the basement in order to further protect the site from sewer flooding.*

The above assessment has identified the following potential issues that need to be further assessed:

Q6 The site is at a low risk of surface water flooding. Whilst it is shown to be in an area at risk of surface water flooding, it is classified as a very low to low risk and as such it is not considered necessary to take it forward to the scoping stage.

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 impacts are assessed for each of the identified potential impact factors.

4.1 Potential Impacts

The following potential impacts have been identified by the screening process.

Potential Impact	Consequence
London Clay is the shallowest stratum at the site.	The London Clay is prone to seasonal shrink-swell (subsidence and heave).
Seasonal shrink-swell can result in foundation movements.	Multiple potential impacts depending on the specific setting of the basement development. For example, the implications of a deepened basement/foundation system on neighbouring properties should be considered.
The site is within 5 m of Finchley Road and the adjoining footpath.	Should the design of retaining walls and foundations not take into account the presence of nearby infrastructure, it may lead to the structural damage of footways, highways and associated buried services.
A London Overground tunnel is present below the site.	The majority of the site extends into the zone of influence and movements associated with the basement construction and excavation may potentially lead to unacceptable movements and increase in strain to the tunnel structures

These potential impacts have been investigated through the site investigation, as detailed in Section 13.0.

4.2 Exploratory Work

In order to meet the objectives described in Section 1.2, a single borehole was advanced, to a depth of 10.00 m using a cable percussion rig, with the depth of borehole limited due to the presence of the railway tunnel below the site. The deep borehole was supplemented by two further boreholes advanced to a depth of 5.45 m using a tracked opendrive sampler. Standard Penetration Tests (SPTs) were carried out at regular intervals in the boreholes to provide additional quantitative data on the strength of soils encountered and disturbed and undisturbed samples were obtained from the boreholes for subsequent laboratory examination and testing.

Groundwater monitoring standpipes were installed in two of the boreholes to depths of 4.00 m and 5.00 m to facilitate future groundwater monitoring, with a single monitoring visit undertaken to date.

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

All of the above work was carried out under the supervision of a geotechnical engineer from GEA. The borehole records are appended, together with a site plan indicating the exploratory positions. The Ordnance Datum (OD) levels shown on the borehole records have been interpolated from spot heights shown on a site survey drawing (ref: 1289-EX-002, dated January 2021), which was provided by Michael Barclay Partnership.

4.3 Sampling Strategy

The boreholes were positioned on site by a geotechnical engineer from GEA in accessible areas, with due regard to the proposed development and the locations of known buried services, including the railway tunnel alignment.

Five samples of made ground have been tested for the presence of contamination. The analytical suite of testing was selected to identify a range of typical industrial contaminants for the purposes of general coverage. 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 samples were also screened for the presence of asbestos. The contamination analyses were carried out at an MCERTs accredited laboratory with the majority of the testing suite accredited to MCERTS standards. A summary of the MCERTs accreditation and test methods are included with the attached results and further details are available upon request.

5.0 Ground Conditions

The investigation generally encountered the expected ground conditions, in that below a surface covering of concrete or topsoil, and a generally moderate but locally significant thickness of made ground, the London Clay Formation extended to the full depth of the investigation, of 10.00 m (41.10 m OD).

5.1 Made Ground

Where present, the existing concrete slab of the garage building was found to be of 200 mm and 300 mm in thickness and reinforced with a single layer of reinforcing. The underlying made ground generally comprised a matrix of brown sandy gravelly clay and gravelly sand with fragments of brick, concrete and clinker, with localised roots and rootlets. This extended to maximum depths of 1.50 m (49.60 m OD) and 1.20 m (49.65 m OD) in Borehole Nos 1 and 2 respectively, and to a depth of 2.20 m (49.23 m OD) in Borehole No 3, whereupon further made ground comprising brown gravelly sand and gravelly clay with fragments of timber was encountered to a depth of 3.00 m (48.43 m OD).

Borehole No 3 was advanced in the existing communal garden area in the north of the site and it is not apparent as to why an increased thickness of made ground would be present in that part of the site, whilst these soils were slightly stained black at a depth of 2.80 m (48.63 m OD) with a slight hydrocarbon odour noted. Additionally in this borehole a fragment of suspected asbestos was encountered at a depth of 1.00 m, which was recovered and sent for confirmatory analysis.

Elsewhere, with the exception to the presence of fragments of extraneous material, no other visual or olfactory evidence of contamination was observed during the fieldwork. A sample of the stained soil encountered in Borehole No 3 was recovered along with four other samples of made ground, which have been sent to a laboratory for a suite of analysis for a range of contaminants and the results are detailed within Section 4.4.

5.2 London Clay

The London Clay comprised an initial naturally reworked horizon comprising firm becoming stiff brown and orange-brown mottled grey silty slightly sandy slightly gravelly clay. The initial horizon extended to depths of between 3.10 m (48.00 m OD) and 3.50 m (47.93 m OD), whereupon stiff becoming very stiff medium strength to high strength fissured brown mottled grey silty clay with mica and occasional fine partings of fine sand was proved to the full depth investigated, of 10.00 m (41.10 m OD).

The results of plasticity index tests indicate the clay to be of medium to high-volume change potential, and the results of quick undrained triaxial tests undertaken on undisturbed samples of the clay indicate the clay to be of medium becoming high strength, with undrained shear strength increasing with depth from 67 kPa to 111 kPa.

5.3 Groundwater

Groundwater was encountered as seepage from a granular pocket in Borehole No 3 only at a depth of 3.50 m (47.93 m OD). This is thought to be associated with a high proportion of surface water infiltrating into the shallow soils through the communal garden, rather than being representative of a shallow ground water table. A single monitoring visit recorded the standpipes installed in Borehole Nos 1 and 2 to be dry.

5.4 Soil Contamination

The table below summarises the results of the contamination analyses carried out on the five samples of made ground; all concentrations are in mg/kg unless otherwise stated. A copy of the full results is included in the appendix.

Determinant	Minimum Concentration	Maximum Concentration	No. of Samples below Detection limit
pH	6.7	10.8	-
Arsenic	12	36	None
Chromium	19	45	None
Chromium (hexavalent)	<1.8	<1.8	All
Copper	15	150	None
Lead	85	**1100**	None
Mercury	<0.3	1.1	2
Nickel	15	36	None
Selenium	<1.0	<1.0	All
Zinc	78	150	None
Sulphide	1.4	**180**	None
Total Phenols	<1.0	<1.0	All
Cyanide	<1.0	8.8	4
Total PAH	<0.80	11.5	2
Naphthalene	<0.05	<0.05	All
Benzo(a)pyrene	<0.05	1.2	3
TPH	<10	33	1
Total Organic Carbon %	0.5	1.7	None

Note: Figures in bold indicate values in excess of the generic guideline screening values.

The results of the contamination testing have indicated elevated concentrations of lead in the samples of made ground recovered from Borehole Nos 1 and 2, whilst an elevated concentration of sulphide was recorded in the sample recovered from Borehole No 3 at a depth of 2.80 m, although this sample did not contain any elevated concentrations of hydrocarbons. No other elevated concentrations of the contaminants tested were encountered.

The sample of suspected ACM identified recovered from Borehole No 3 indicate the material to include fibres of amosite and crocidolite asbestos. Subsequent asbestos quantification revealed an asbestos concentration of 0.455 %.

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. Contaminants of concern are those that have values in excess of generic human health risk-based guideline values, which are either the CLEA[8] Soil Guideline Values where available, the Suitable 4 Use Values[9] (S4UL) produced by LQM/CIEH calculated using the CLEA UK Version 1.07[10] software, or the DEFRA Category 4 Screening values[11], assuming a residential end use without plant uptake. 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 less than six years old;
- that the exposure duration will be six years;
- that the critical exposure pathways will be direct soil and indoor dust ingestion, skin contact with soils and indoor dust, and inhalation of indoor and outdoor dust and vapours; and

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.

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

8 *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.

9 *The LQM/CIEH S4Uls for Human Health Risk Assessment* S4UL3065 November 2014

10 Contaminated Land Exposure Assessment (CL|EA) Software Version 1.071 Environment Agency 2015

11 CL:AIRE (2013) *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination* Final Project Report SP1010 and DEFRA (2014) *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination* Policy Companion Document SP1010

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 the proposed development.

6.0 Introduction

It is understood that it is proposed to demolish part of the existing garage building along the southern boundary of the site and subsequently construct a pair of two-storey semi-detached houses, with the lower level effectively forming a single level basement that will have a general formation level of approximately 2.50 m below ground level, with a deepened front lightwell that will be excavated to approximately 3.00 m.

7.0 Ground Model

The desk study has revealed that the site has not had a potentially contaminative historical use as it has only had a residential end use. On the basis of the fieldwork, the following ground model has been established:

Geological Formation	Depth to base (m) [Level m OD]	Thickness (m)
Made Ground	1.20 [49.65] to 3.00 [48.43]	1.20 to 3.00
Reworked London Clay	3.10 [48.00] to 3.50 [47.93]	0.50 to 1.90
Unweathered London Clay	Not proved at 10.00 [41.10]	Not proved

A continuous groundwater table is not present below the site. Contamination testing has indicated elevated concentrations of lead, sulphide and the presence of asbestos within the made ground.

8.0 Advice & Recommendations

Excavations for the proposed basement structure will require temporary support to maintain stability and to prevent any excessive ground movements. Formation level for the basement will be within the London Clay at a depths of about 2.40 m (48.50 m OD) and 3.00 m (47.80 m OD). On the basis of the investigation observations and the underlying ground conditions, significant groundwater inflows are not expected to be encountered within the basement excavation.

On the basis of the proposals and the contamination testing undertaken to date, there is not considered to be a requirement for remedial works, however consideration will need to be given to further investigation of the presence of asbestos.

8.1 Basement Construction

Formation level for the basement is likely to be within the stiff clay of the London Clay at depths of between 2.40 m and 3.00 m. The London Clay is of low permeability, which will not typically support a continuous "water table" or significant groundwater flow. Therefore, significant groundwater inflows are therefore not generally expected to be encountered in the basement excavation. The London Clay did, however, initially comprise a naturally reworked horizon, which was typically slightly sandy and slightly gravelly, which could potentially give rise to a slight increase in permeability, albeit negligibly. Minor and localised groundwater inflows may therefore be encountered, in addition to perched groundwater with the overlying made ground. Any such inflows or seepages should be adequately dealt with through sump pumping, although it would be prudent for the chosen contractor to have a contingency plan in place to deal with more significant or prolonged inflows as a precautionary measure.

The design of basement support in the temporary and permanent conditions needs to take account of the need to maintain the stability of the excavation and surrounding structures, and to protect against potential shallow groundwater inflows. 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 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, the required overall stiffness of the support system, and the need to control groundwater movement through the wall in the temporary condition. In this respect the stability of the existing and adjacent buildings will be paramount.

In the absence of significant groundwater inflows and the underlying clay soils, the use of underpinning in a traditional hit and miss approach is considered to be a suitable option of forming the basement retaining walls. Careful workmanship will be required to ensure that movement of the surrounding structures does not occur and the contractor should be required to provide details of how they intend to control groundwater and instability of excavations, should it arise.

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. Consideration will also need to be given to a retention system that maintains the stability at all times of the existing building, neighbouring properties and structures.

An assessment of the potential movements as a result of the proposed basement construction has been carried out as part of the Ground Movement Analysis, which is reported in Part 3.

8.1.1 Basement Retaining Walls

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

Stratum	Bulk Density (kg/m³)	Effective Cohesion (c′ – kN/m²)	Effective Friction Angle (ϕ′ – degrees)
Made ground	1700	Zero	27
London Clay	1950	Zero	23

Significant groundwater inflows are not anticipated within the basement excavation.

Provided that a fully effective drainage system can be ensured in order to prevent the build-up of groundwater behind the retaining walls, it should be possible to design the basement on the basis that water will not collect behind the walls. If an effective drainage system cannot be ensured, then a water level of two-thirds of the basement depth, subject to a minimum depth of 1.0 m, should be assumed. The advice in BS8102:2009[12] should be followed in this respect and with regard to the provision of suitable waterproofing.

8.1.2 Basement Heave

The 2.40 m to 3.00 m deep excavation will result in an unloading of around 45 kN/m² to 55 kN/m², which will result in heave of the underlying London Clay. This will comprise immediate elastic movement, which will account for approximately 40 % of the total movement and be expected to be complete during the construction period, and long-term movements, which will theoretically take many years to complete. These movements will, to some extent, be mitigated by the loads applied by the proposed development, however the ground movements associated with the proposed basement excavation and construction have been considered in more detail in Part 3 of this report.

8.3 Spread Foundations

Spread foundations bearing beneath the proposed basement in the stiff clay of the London Clay may be designed to apply a net allowable bearing pressure of around 150 kN/m².

The above values incorporate an adequate factor of safety against bearing capacity failure and should ensure that settlements remain within normal tolerable limits.

8.4 Shallow Excavations

On the basis of the borehole findings, it is considered that it will be generally feasible to form relatively shallow excavations terminating within the London Clay without the requirement for lateral support, although localised instabilities may occur where more granular material or groundwater is encountered.

Significant inflows of groundwater into shallow excavations are not generally anticipated, although seepages may be encountered from perched water tables within the made ground, particularly within the vicinity of existing foundations, although such inflows should be suitably controlled by sump pumping.

If deeper excavations are 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

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

carried out and temporary lateral support or battering of the excavation sides considered in order to comply with normal safety requirements.

8.5 Basement Floor Slab

Following excavation of the basement, the floor slab will need to be suspended over a void or a layer of compressible material to accommodate the anticipated heave and any potential uplift forces from groundwater pressures, unless the slab can be suitably reinforced to cope with these movements. Further information on the detailed movements is provided in the ground movement assessment in Part 3.

8.6 Effect of Sulphates

Chemical analyses have revealed relatively low concentrations of soluble sulphate and near-neutral pH in accordance with Class DS-1 conditions of Table C2 of BRE Special Digest 1:SD Third Edition (2005). The measured pH values of the samples show that an ACEC class of AC-1s would be appropriate for the site. This assumes a static water condition at the site. The guidelines contained in the digest should be followed in the design of foundation concrete.

8.7 Contamination Risk Assessment

The desk study findings indicate that the site does not have a potentially contaminative history as it has only been developed with residential properties. Furthermore, there are no potential offsite sources of contamination that are considered to pose a risk to the site. The contamination testing has however indicated elevated concentrations of lead and sulphide in samples of made ground, with no other elevated concentrations identified by the contamination testing, which generally revealed low concentrations of the contaminants tested.

The lead concentrations were encountered in samples of made ground that will be excavated and removed from site as part of the basement excavation, whilst the elevated concentration recovered from the existing communal garden area is not considered to pose a risk to end users. However, a piece of suspected ACM was recovered from the communal garden area at a depth of 1.00 m during the site work, which was found contained amosite and crocidolite asbestos fibres at a concentration of 0.455 %.

As asbestos is insoluble it is not considered to pose any meaningful risk to groundwater, the development or to neighbouring sites through migration in the ground. It is however potentially hazardous to human health as airborne fibres and could thus pose a risk through inhalation during construction works and to end users through direct contact pathways. Although the asbestos was found to be present at a concentration of 0.455 %, the asbestos was encountered in damp soil at a depth of 1.00 m and as a result there is a negligible risk of fibres dusting into the air with respect to end users[13]. However, it would be prudent to provide suitable protection to site workers during the groundworks.

All work being carried out within asbestos containing soils should be carried out in accordance with the Control of Asbestos Regulations, including toolbox talks for all workers and having the correct PPE in place. During the excavation and movement of any soils, an asbestos specialist should be appointed and will need to hand pick and suitably bag any asbestos containing material and also monitor dust levels using air monitoring equipment. Any asbestos containing soil will need to be covered, either by a cover system, or by hardstanding in order to protect end users from exposure to fibres dusting from the shallow soil during activities on site.

The local authority and / or HSE should be consulted prior to commencement of any excavations. The local authority will also be able to provide information on the nearest suitable waste disposal facility licensed to accept asbestos. The measured concentration of 0.455 % will mean that the affected soil is likely to be classified as hazardous waste although the landfill may require further testing to confirm this view.

As the site is underlain by the London Clay Formation, classified as Unproductive Stratum, groundwater is a not a sensitive receptor. In any case, given that the observed contamination is relatively immobile and unlikely to be in a soluble form and is considered to be non-volatile or of a low volatility, the contamination does not present a significant risk to groundwater through leaching, migration to adjacent sites or vapour risk.

13 *The Release of Dispersed Asbestos Fibres from Soils, Addison et. al., 1988 http://www.iom-world.org/pubs/IOM_TM8814.pdf*

8.7.1 Protection of Site Workers

Site workers should be made aware of the potential 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[14] and CIRIA[15] and the requirements of the Local Authority Environmental Health Officer.

A watching brief should be maintained during the site works and if any suspicious soil is encountered, it should be inspected by a suitably qualified engineer and further testing carried out if required.

8.8 Waste Disposal

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 classification is a staged process and this investigation represents the preliminary sampling exercise of that process. Once the extent and location of the waste that is to be removed has been defined, further sampling and testing may be necessary. The results from this ground investigation should be used to help define the sampling plan for such further testing, which could include WAC leaching tests where the totals analysis indicates the soil to be a hazardous waste or inert waste from a contaminated site. It should however be noted that the Environment Agency guidance WM3[16] states that landfill WAC analysis, specifically leaching test results, must not be used for waste classification purposes.

Any spoil arising from excavations or landscaping works, which is not to be re-used in accordance with the CL:AIRE[17] guidance, will need to be disposed of to a licensed tip. Waste going to landfill is subject to landfill tax at either the standard rate of £98.60 per tonne (about £185 per m^3) or at the lower rate of £3.15 per tonne (roughly £5.85 per m^3). However, the classifications for tax purposes and disposal purposes differ and currently all made ground and topsoil is taxable at the 'standard' rate and only naturally occurring soil and stones, which are accurately described as such in terms of the 2011 Order, would qualify for the 'lower rate' of landfill tax.

Based on the technical guidance provided by the EA it is considered likely that the soils encountered during this ground investigation, as represented by the chemical analyses carried out, would be generally classified as follows.

Soil Type	Waste Classification (Waste Code)	WAC Testing Required Prior to Landfill Disposal?	Current applicable rate of Landfill Tax
Made ground	Non-hazardous (17 05 04)	No	£98.60 / tonne (Standard rate)
Made ground (containing asbestos concentration of 0.291 %)	HAZARDOUS (17 05 03)	Check with receiving landfill	£98.60 / tonne plus gate fee and hazardous waste landfill tax
Natural Soils	Inert non-hazardous (17 05 04)	Should not be required but confirm with receiving landfill	£3.15 / tonne (Reduced rate for uncontaminated naturally occurring rocks and soils)

Any soil containing asbestos materials will be classified as hazardous waste, as well as soil containing concentrations of asbestos fibres of over 0.1 %. It would be prudent to screen the made ground for asbestos before exporting off-site, with the hand picking out any asbestos material but suitably qualified contractors.

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[18] which states that in certain circumstances, segregation at source may be considered as pre-treatment so excavated material may not have to be treated prior to landfilling if it 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 is provided for guidance only and should be confirmed by the receiving landfill once the soils to be discarded have been identified.

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

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

16 Environment Agency 2015. *Guidance on the classification and assessment of waste.* Technical Guidance WM3 First Edition

17 CL:AIRE March 2011. *The Definition of Waste: Development Industry Code of Practice* Version 2

18 Environment Agency 23 Oct 2007 *Regulatory Position Statement Treating non-hazardous waste for landfill - Enforcing the new requirement*

The local waste regulation department of the Environment Agency (EA) 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.

Part 3: Ground Movement Analysis

This section of the report comprises an analysis of the ground movements arising from the proposed basement and foundation scheme discussed in Part 2 and the information obtained from the investigation, presented in Part 1 of the report.

9.0 Introduction

The sides of an excavation will move to some extent regardless of how they are supported. The movement will typically be both horizontal and vertical and will be influenced by the engineering properties of the ground, groundwater level and flow, the efficiency of the various support systems employed and the efficiency or stiffness of any support structures used.

An analysis has been carried out of the likely movements arising from the proposed excavation and the results of this analysis have been used to predict the effect of these movements on surrounding structures.

10.0 Basis of Ground Movement Assessment

10.1 Nearby Sensitive Structures

Sensitive structures relevant to this assessment include the retained garage building and the main apartment building of 95 Avenue Road, and the neighbouring buildings of Avenue Lodge and Park Lodge to the south of the site. In addition to the above structures, the footway of Avenue Road is present directly along the site frontage to the east with a London Overground Tunnel passing below the centre of the site in an east-west orientation.

The formation levels for the retained buildings within the site have been determined though on-site surveys and trial pitting works, whilst conservative assumptions have been made on the neighbouring properties to the south of the site from on site observations.
It has not been possible to acquire information on the London Overground railway tunnel, however lidar data indicates that the track level at South Hampstead station to the west of the site, and to where the tunnel leads to, is circa 33 m OD. Assuming a tunnel diameter of around 7.5 m, a crown level of around 39 m OD has been adopted, equating to circa 11 m below the level of the site. This is likely to be a relatively conservative assumption.

The heights and foundation levels of each of the neighbouring buildings are summarised in the table below.

Structure	Structure Reference	Foundation Depth (m) [level m OD]	Height of building above foundation level (m)
Garage structure	G-A to G-C	1.00 [49.9]	5
	G-D	2.50 [48.5]	22
95 Avenue Road	95A & 95-J to 95-L	2.50 [48.5]	22
	95-B to 95-I		25
Park Lodge	PL=A to PL-F	1.00 [48.90]	15
Avenue Lodge	AL-A to AL-C	1.00 [48.90]	15

It is possible that the apartment blocks are supported on piled foundations, but in the absence of archive information, conservative assumptions have been made. A plan indicating the locations of each of the sensitive structures, including the underground tunnels, and the positions of the individual elevations are shown on the GMA plan included in the appendix.

10.2 Construction Sequence

In general, the sequence of works for excavation and construction, are assumed to comprise the following stages.

1. Carry out underpinning works to the existing foundations using a ‘hit and miss’ method of panel widths no more than 1 m, in order to form the basement retaining walls;

2. demolish the superstructure;

3. install top level props;
4. excavate down to formation level and install lower level props;
5. install internal load bearing walls and foundations at basement level
6. cast the basement floor slab;
7. construction up to ground floor level and cast ground floor slab;
8. removal of props once concrete sufficiently cured; and
9. continue with superstructure.

The underpins will be adequately laterally propped and sufficiently dowelled together, and the concrete will be cast and adequately cured prior to excavation of the basement and removal of the formwork and supports. It is assumed that the corners of the excavation will be locally stiffened by cross-bracing or similar and that the new retaining walls will not be cantilevered at any stage during the construction process. It is assumed that adequate temporary propping of the new retaining walls, particularly at the top level, will occur at all times prior to the construction of permanent concrete floor slabs.

11.0 Ground Movements

An assessment of ground movements within and surrounding the excavation has been undertaken using the P-Disp and X-Disp computer programs licensed from the OASYS suite of geotechnical modelling software from Arup. These programs are commonly used within the ground engineering industry and are considered to be appropriate tools for this analysis.

The X-Disp and P-Disp programs have been used to predict ground movements likely to arise from the excavation and construction of the proposed basement. This includes the heave / settlement of the ground (vertical movement) and the lateral movement of soil behind the proposed retaining walls (horizontal movement). Both the P-Disp and X-Disp programs are commonly used within the ground engineering industry and are considered to be appropriate tools for the purpose of this analysis.

For the purpose of these analyses, the corners have been defined by x and y coordinates, with the x-direction approximately parallel with the orientation north-south, whilst the y-direction is approximately parallel with the orientation of east-west. Vertical movement is in the z-direction. Wall lengths of less than 10 m have been modelled as 1 m long structural elements, while walls greater than 10 m in length have been modelled as 2 m elements to reflect their greater stiffness.

The basement structure has been modelled as a polygon, which will be formed through the underpinning of existing foundations. Formation levels of 47.75 m OD and 48.50 m OD are proposed for the basement, requiring a depth of underpinning of about 2.50 m and 3.00 m.

It is assumed that suitable propping will be provided during the construction of the basement and in the permanent condition, such that the walls can be considered to be stiff for the purpose of the ground movement modelling.

The full outputs of all the analyses can be provided on request but samples of the output movement contour plots are included within the appendix.

11.1 Ground Movements – Surrounding the Basement

11.1.1 Model Used

For the X-Disp analysis, the soil movement relationships used for the embedded retaining walls are the default values within CIRIA report C760[19], which were derived from a number of historic case studies.

Published data for ground movements associated with underpinned retaining walls and the subsequent excavation of a new basement is limited compared to other types of retaining wall. It is widely accepted that movements associated with underpinning are generally influenced by the quality of the workmanship. It is also generally accepted that horizontal movements would be expected to fall within the order of 5 mm to 10 mm. A movement curve that produces a minimum of 5 mm of both vertical and horizontal movement for a maximum of 3 m retained height has therefore been produced and adopted for modelling the movements associated with the construction of the underpins and the subsequent mass excavation.

The analysis has indicated that the maximum vertical settlement and horizontal movements that will result from the installation of the underpins will be in the region of 5 mm and 6.00 mm.

11.2 Ground Movements – Resulting from Excavation

11.2.1 Model Used

Unloading of the London Clay will take place as a result of the excavation of the proposed basements and the reduction in vertical stress will cause heave to take place. Undrained soil parameters have been used to estimate the potential short-term movements, which include the “immediate” or elastic movements as a result of the basement excavation. Drained parameters have been used to provide an estimate of the total long-term movement.

The elastic analysis requires values of soil stiffness at various levels to calculate displacements. Values of stiffness for the soils at this site are readily available from published data[20] and a well-established method has been used to provide estimated values.

Relationships of $E_u = 500\ C_u$ and $E' = 300\ C_u$ for the cohesive soils have been used to obtain values of Young’s modulus.

The 2.50 m to 3.00 m deep excavation of the basement will result in an unloading of between around 47 kN/m^2 and 57 kN/m^2, which will result in heave of the underlying London Clay.

The soil parameters used in this analysis and tabulated below have been primarily derived from the data from the aforementioned previous GEA investigation directly to the north of the site.

A rigid boundary for the analysis has been set within the London Clay at a depth of 50 m below ground level. Below this depth the London Clay is not considered to be impacted by the proposed development and comprise essentially incompressible soils.

Stratum	Depth Range (m) [level m OD]	Eu (MPa)	E'(MPa)
Made Ground	GL to 1.00 [49.90]	10	6
London Clay	GL to 20.0	25 to 200	15 to 120

11.2.2 Results

The predicted movements are summarised in the table below; the results are presented below and in subsequent tables to the degree of accuracy required to allow predicted variations in ground movements around the structure(s) to be illustrated, but may not reflect the anticipated accuracy of the predictions. In the table below, heave movements are shown as negative.

Location	Movement (mm)	
	Short-term	Total
Centre of the excavation	6-7	15-17
Edges of the excavation	3-4	9-11
5 m from the basement	<2	<5

19 Gaba, A, Hardy, S, Powrie, W, Doughty, L and Selemetas, D (2017) *Embedded retaining walls – guidance for economic design* CIRIA Report C760

20 Burland JB, Standing, JR, and Jardine, FM (2001) *Building response to tunnelling, case studies from construction of the Jubilee Line Extension.* CIRIA Special Publication 200

The P-Disp analysis indicates short-term undrained heave movements of the order of 6 mm and 7 mm are expected to occur at the center of the excavation, whilst total heave movements of between 15 mm and 17 mm have been indicated by the analysis. However, it is considered that these movements will not be fully realised due to the loads to be applied from the proposed building. The analysis has indicated negligible movements outside of the basement excavation, which is to be expected, and as such these movements are not considered to impact the surrounding structures, with movements of less than 2 mm indicated along the London Overground tunnel alignment.

If a compressible material is used beneath the slab, it will need to be designed to be able to resist the potential uplift forces generated by the ground movements. In this respect, potential heave pressures are typically taken to equate to around 40% of the total unloading pressure.

12.0 Damage Assessment

In addition to the above assessment of the likely movements that will result from the proposed development, any neighbouring buildings within the zone of influence of the excavations are considered to be sensitive structures, requiring Building Damage Assessments, on the basis of the classification given in Table 6.4 of CIRIA report C760.

The sensitive structures outlined previously have been modelled as displacement lines in the analysis along which the damage assessment has been undertaken.

12.1 Damage to Neighbouring Structures

The ground movements resulting from the piling, underpinning and basement excavation phases have been calculated using X-Disp modelling software to carry out an assessment of the likely damage to adjacent properties and the results are discussed below.

The building damage reports for sensitive structures previous discussed are included in the appendix and indicate that predominantly the damage to the adjoining and nearby structures due to basement construction are expected to fall within Category 0 'Negligible, with the exception of two sensitive structures predicted as Category 1 'Very Slight'. A summary of the predicted building damage categories for the individual structures is shown in the table below, with the structures suffering damage exceeding category 'Negligible (0)' highlighted in bold.

Structure	Elevation	Category*
Garage Building	All elevations	Negligible (0)
95 Avenue Road	95-A, 95-B & 95-D to 95-L	Negligible (0)
	95-C	**Very Slight (1)**
Park Lodge	PL-A, PL-B & PL-d to PL-F	Negligible (0)
	PL-C	**Very Slight (1)**
Avenue Lodge	All elevations	Negligible (0)

The results discussed above are based on individual building lines, or walls, that in some instances, have been further divided up within the analysis into a series of segments that are assumed to be able to move independently of one another, with the most critical segment determining the result for the entire wall. In reality, this is unlikely to be the case as the walls will behave as single stiff elements that are also joined continuously with the rest of the structure.

The results therefore provide a conservative estimate of the behaviour of each of the sensitive structures and overestimate the degree of damage, although they provide a useful indication of the most critical structures within the adjoining properties that may require further assessment, as detailed below.

The GMA has indicated that negligible movements of less than 5 mm are expected to occur along the footway of Avenue Road. The London Overground tunnel; is at a depth that will not be impacted by the movements associated with then basement.

11.2 Monitoring of Ground Movements

The predictions of ground movement based on the ground movement analysis should be checked by monitoring of the adjacent properties and structures. The structures to be monitored during the construction stages should include the existing property and the neighbouring structure assessed above. Condition surveys of the above existing structures should be carried out before and after the proposed works.

The precise monitoring strategy will be developed at a later stage, and it will be subject to discussions and agreements with the owners of the adjacent properties and structures. Contingency measures will be implemented if movements of the adjacent structures exceed predefined trigger levels. Both contingency measures and trigger levels will need to be developed within a future monitoring specification for the works.

13.0 GMA Conclusions

The analysis has concluded that the predicted damage to the neighbouring properties from the construction of the proposed basements would be ‘Negligible’ to ‘Very Slight’. The adjacent footway structure, any below ground services and the London Underground tunnels are not expected to be impacted by the proposed development.

On this basis, the damage that has been predicted to occur as a result of the construction the proposed basement falls within the limits acceptable to the London Borough of Camden assuming that the careful control is taken during construction of the proposed excavations, and monitoring will be required to ensure that no excessive movements occur that would lead to damage in excess of these limits.

The separate phases of work, including underpinning and subsequent excavation of the proposed basement, will in practice be separated by a number of weeks. This will provide an opportunity for the ground movements during and immediately after installation of the retaining walls to be measured and the data acquired can be fed back into the design and compared with the predicted values. Such a comparison will allow the ground model to be reviewed and the predicted wall movements to be reassessed prior to the main excavation taking place so that propping arrangements can be adjusted if required.

Part 4: Basement Impact Assessment

This section of the report evaluates the direct and indirect implications of the proposed project, based on the findings of the previous screening and scoping, site investigation and ground movement assessment.

14.0 Introduction

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.

14.1 Potential Impacts

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

Potential Impact	Consequence
London Clay is the shallowest stratum at the site.	The London Clay is prone to seasonal shrink-swell (subsidence and heave).
Seasonal shrink-swell can result in foundation movements.	Multiple potential impacts depending on the specific setting of the basement development. For example, the implications of a deepened basement/foundation system on neighbouring properties should be considered.
The site is within 5 m of Avenue Road and the adjoining footpath.	Should the design of retaining walls and foundations not take into account the presence of nearby infrastructure, it may lead to the structural damage of footways, highways and associated buried services.
A London Underground tunnel is present beneath Finchley Road with an exclusion zone extending onto the site.	The proposed development is set back into the site such that it does not cross into the exclusion zone.

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

London Clay is the shallowest stratum / Seasonal Shrink-Swell
The investigation indicated that beneath a moderate thickness of made ground, the London Clay is present. The London Clay has been classified as being of high volume change potential, which are prone to seasonal shrink-swell (settlement and heave).

Shrinkable clay is present within a depth that can be affected by tree roots. Whilst there are a number of trees on site. The proposed basement is likely to extend below the potential depth of root action. Additionally, basement structures are already present on site and the addition of the proposed basement is not considered to pose a risk to neighbouring properties.

The site is within 5 m of Finchley Road and the adjoining footpath / A London Underground tunnel is present beneath Finchley Road with an exclusion zone extending onto the site
The analysis has indicated that negligible movements along the alignment of the adjacent footway and London Overground tunnels are expected to arise from the basement construction and excavation.

13.2 BIA Conclusions

A Basement Impact Assessment has been carried out following the information and guidance published by the London Borough of Camden.

It is concluded that the proposed development is unlikely to result in any specific land or slope stability issues.

13.3 Non-Technical Summary of Evidence

This section provides a short summary of the evidence acquired and used to form the conclusions made within the BIA.

13.3.1 Screening

The following table provides the evidence used to answer the subterranean (groundwater flow) screening questions.

Question	Evidence
1a. Is the site located directly above an aquifer?	Aquifer designation maps acquired from the Environment Agency as part of the desk study and Figures 3, 5 and 8 of the Arup report.
1b. Will the proposed basement extend beneath the water table surface?	Previous nearby GEA investigations and BGS archive borehole records.
2. Is the site within 100 m of a watercourse, well (used/disused) or potential spring line?	Topographical and historical maps acquired as part of the desk study, reference to the Lost Rivers of London and Figures 11 and 12 of the Arup report.
3. Is the site within the catchment of the pond chains on Hampstead Heath?	Figures 12 and 14 of the Arup report
4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	A site walkover and existing plans of the site have confirmed the proportions of hardstanding and soft landscaping, which have been compared to the proposed drawings to determine the changes in the proportions.
5. 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)?	The details of the proposed development do not indicate the use of soakaway drainage.
6. 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?	Topographical maps acquired as part of the desk study and Figures 11 and 12 of the Arup report.

The following table provides the evidence used to answer the slope stability screening questions.

Question	Evidence
1. Does the existing site include slopes, natural or manmade, greater than 7°?	Topographical maps and Figures 16 and 17 of the Arup report and confirmed during a site walkover
2. Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7°?	The details of the proposed development provided do not include the re-profiling of the site to create new slopes
3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	Topographical maps and Figures 16 and 17 of the Arup report
4. Is the site within a wider hillside setting in which the general slope is greater than 7°?	
5. Is the London Clay the shallowest strata at the site?	Geological maps and Figures 3, 5 and 8 of the Arup report
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?	The details of the proposed development.
7. Is there a history of seasonal shrink-swell subsidence in the local area and / or evidence of such effects at the site?	Knowledge on the ground conditions of the area and reference to NHBC guidelines were used to make an assessment of this, in addition to a visual inspection of the buildings carried out during the site walkover.
8. Is the site within 100 m of a watercourse or potential spring line?	Topographical maps acquired as part of the desk study and Figures 11 and 12 of the Arup report
9. Is the site within an area of previously worked ground?	Geological maps and Figures 3, 5 and 8 of the Arup report
10. Is the site within an aquifer?	Aquifer designation maps acquired from the Environment Agency as part of the desk study and Figures 3, 5 and 8 of the Arup report.
11. Is the site within 50 m of Hampstead Heath ponds?	Topographical maps acquired as part of the desk study and Figures 12 and 14 of the Arup report
12. Is the site within 5 m of a highway or pedestrian right of way?	Site plans and the site walkover.
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Camden planning portal and the site walkover confirmed the position of the proposed basement relative the neighbouring properties.
14. Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	Maps and plans of infrastructure tunnels were reviewed.

The following table provides the evidence used to answer the surface water flow and flooding screening questions.

Question	Evidence
1. Is the site within the catchment of the pond chains on Hampstead Heath?	Topographical maps acquired as part of the desk study and Figures 12 and 14 of the Arup report
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?	A site walkover confirmed the current site conditions and the details provided on the proposed development, including reference to the FRA for the site.
3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	
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?	
5. Will the proposed basement result in changes to the quantity of surface water being received by adjacent properties or downstream watercourses?	
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?	Flood risk maps acquired from the Environment Agency as part of the desk study, Figure 15 of the Arup report, the Camden Flood Risk Management Strategy dated 2013 and the North London Strategic Flood Risk Assessment dated 2008, and reference to the site specific FRA.

13.3.2 Scoping and Site Investigation

The questions in the screening stage that there were answered 'yes', were taken forward to a scoping stage and the potential impacts discussed in Section 4.0 of this report, with reference to the possible impacts outlined in the Arup report.

A ground investigation has been carried out, which has allowed an assessment of the potential impacts of the basement development on the various receptors identified from the screening and scoping stages. Principally the investigation aimed to establish the ground conditions, including the groundwater level, the engineering properties of the underlying soils to enable suitable design of the basement development and the configuration of existing party wall foundations. The findings of the investigation are discussed in Section 5.0 of this report and summarized in both Section 7.0 and the Executive Summary.

13.3.3 Impact Assessment

Section 14.0 of this report summarises whether, on the basis of the findings of the investigation, the potential impacts still need to be given consideration and identifies ongoing risks that will require suitable engineering mitigation. Section 9.0 of this report also provides recommendations for the design of the proposed development.

A ground movement analysis and building damage assessment has been carried out and its findings are presented in Part 3.

15.0 Outstanding Risks & 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 may 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.

It is recommended that further groundwater monitoring is undertaken in order to establish the presence of shallow inflows from within the made ground and the naturally reworked London Clay.

The investigation has not identified the presence of any significant contamination and as the vast majority of the made ground will be removed from this site through the excavation of the proposed basement and large areas are covered by hardstanding, remedial measures should not be required. However, as with any site there is a potential for further areas of contamination to be present within the made ground beneath parts of the site not covered by the investigation it is recommended that a watching brief is maintained during any groundworks for the proposed new foundations and that if any suspicious soils are encountered that they are inspected by a geoenvironmental engineer and further assessment may be required. Additionally, site workers should be made aware of the presence of asbestos and elevated concentrations of lead and total PAH within the made ground.

If during groundworks 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.

Appendix

a. Field Work

Site Plan
Borehole Records

b. Lab Testing

Geotechnical Test Results
Chemical Test Results
Generic Risk Based Screening Values

c. Desk Study

Envirocheck Summary
Historical Maps
Preliminary UXO Risk Assessment
Detailed UXO Risk Assessment

d. Ground Movement Analysis

GMA Reference Plan
XDisp Analysis – All Input Data
XDisp Analysis – Underpinning Movements
XDisp Analysis – Building Damage Assessment Results

PDisp Analysis – All Input Data
PDisp Analysis – Short Term Movements
PDisp Analysis – Total Movements