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 Vabel London, on behalf of Zoe Fox, to carry out a desk study, ground investigation and ground movement assessment at 25 Oakhill Avenue, London NW3 7RD. 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 ("Camden") in support of a planning application.

Conisbee are the structural engineers for the project.

1.1 Proposed Development

It is understood that following demolition of the existing garage, it is proposed to construct a new two-storey property on the north-western part of the site, which will be cut into the existing slope, as shown on the drawing extract below.

Proposed formation level for the development is understood to be at about 98.5 m OD. Therefore, whilst proposed lower ground floor level will be at a similar elevation to the adjoining street on the southern part of the site, it will extend to a depth of about 4.5 m to 5.0 m beneath the level of the adjoining garden on the northern part of the site.

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 unexploded ordnance (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;
- a preliminary UXO risk assessment completed by 1st Line Defence (report ref PA16908-00, dated November 2022); 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 25.0 m deep borehole, drilled to the front of the existing garage at the top of the sloped driveway, by means of a Premier 110 rotary-percussive rig;
- standard Penetration Tests (SPTs) carried out at regular intervals within this borehole in order to provide additional quantitative data on the strength of the soils;
- two window sampler boreholes, advanced to depths of 4.0 and 5.0 m, to provide additional coverage of the site;
- three hand-dug trial pits to provide information on the boundary wall conditions;
- the installation of three groundwater monitoring standpipes and two subsequent monitoring visits;
- 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 8 October 2020. 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 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 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

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.

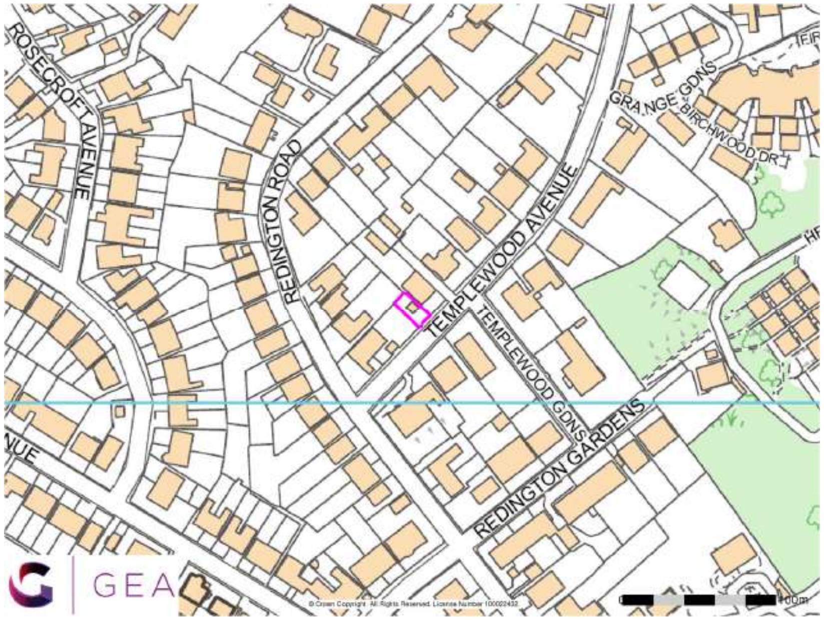
1.4 Limitations

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 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 London Borough of Camden, approximately 325 m to the south of Hampstead Heath and 725 m to the west-northwest of Hampstead London Underground station. It fronts onto Templewood Avenue to the southeast and is bounded by the existing garden of No 1 Templewood Avenue to the southwest, the garden of No 46 Reddington Road to the northwest and No 3 Templewood Avenue, a three-storey detached property, to the northeast. The site may be additionally located by National Grid Reference 525690, 186060 and is shown on the map extract below.



A walkover of the site was carried out by a geotechnical engineer from GEA at the time of the fieldwork.

The site is rectangular in shape and measures approximately 11 m southwest-northeast by 22 m northwest-southeast. It presently forms part of the garden of No 1 Templewood Avenue and is occupied by a garage, which is accessed via a sloping driveway (approx. 10°) from Templewood Avenue. A wooden shed and remains of a small outbuilding are also present on the upper part of the site, to the rear of the existing garage.

The site is located in an area where the ground slopes down towards the south / southwest, with a survey drawing (ref 220779/Rev 0, dated September 2022) showing that the ground level across the site reduces from a level of approximately 104 m OD on the north-eastern part of the site, to a level of approximately 99 m OD, where the driveway meets with the public pavement of Templewood Avenue. However, whilst the main part of the driveway slopes down at of approximately 10°, the rest of the site does not include any unsupported slopes with angles in excess of 7°.

Brick retaining walls are present along the south-western boundary of the site with Templewood Avenue and along the sides of the driveway, with the adjoining garden areas approximately 1.5 m above that of the adjoining street. A retaining structure is also present along part of the boundary with No 3 Templewood Avenue, separating the garden area of the north-eastern part of the site, with a side passageway providing access to the lower ground floor level of this adjoining structure.

At the time of the investigation, a number of mature trees of mixed deciduous and evergreen species, including a mature oak and a 15 m to 20 m acacia, which appeared to have died and was covered in climbers, were located in the raised arrear adjacent to the driveway on the southern part of the site. A large 25 m to 30 m tall oak is also present within the rear garden of No 46 Reddington Road, approximately 4 m beyond the north-eastern boundary of the site.

2.1.1 Adjoining Structures

No 3 Templewood Avenue, the adjacent property to the northeast of the site, is cut into the existing slope and whilst the lower ground floor level is not visible along the boundary with the site, it can clearly be seen along the access road that runs along the north-eastern elevation of this building.

2.2 Site History

The site history has been researched by reference to internet sources and historical Ordnance Survey (OS) maps obtained from the Envirocheck database.

The earliest maps studied, dated 1871 to 1879, show the site and immediate surrounding area to be undeveloped, comprising open fields, with a number of small streams, understood to comprise tributaries of the River Westbourne, approximately 125 m to the west, 60 m to the east and 125 m to the southeast.

The site is shown as unchanged on the 1895 map. However, Reddington Road had been established by this time and a covered reservoir is shown approximately 300 m to the southwest. The former tributaries of the River Westbourne are no longer shown on this and subsequent maps. However, a large pond had been established within the grounds of a large house, approximately 200 m to the east, although it is not shown after 1896, so appears to have been a very short-lived feature.

Templewood Avenue and the majority of the nearby properties, including the adjoining property of No 3 Templewood Avenue to the northeast, was established between 1896 and 1915, with the site shown to comprise part of the garden on No 1 Templewood Avenue.

The site remined essentially unaltered until some time between 1969 and 1972, when the existing garage was established on the central part of the site, with a driveway providing access to Templewood Avenue. The site and surrounding area have remained essentially unchanged from this time.

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 search has revealed that there are no landfills, waste management, transfer, treatment or disposal sites within 500 m of the site and that there are no areas of potentially infilled land within 250 m.

There have been no pollution incidents to controlled waters within 500 m of the site and there are no pollution prevent and controls, enforcements or contaminated land register entries within 500 m of the site. The site is not located within a nitrate vulnerable zone or any other sensitive land use. There are no contemporary trade directory entries or fuel station entries within 250 m of the site.

Information on Urban Soil Chemistry provided by the BGS indicates that background concentrations for lead in the vicinity of the site are likely to range between 600 mg/kg and 900 mg/kg. Therefore, whilst relatively high concentrations of lead may be encountered within any near surface soils present on the site, a significant proportion of the measured concentration is likely to be the result of residual airborne sources, and this will need to be taken into account in any subsequent risk assessment.

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 are not deemed to be necessary.

2.4 Preliminary UXO Risk Assessment

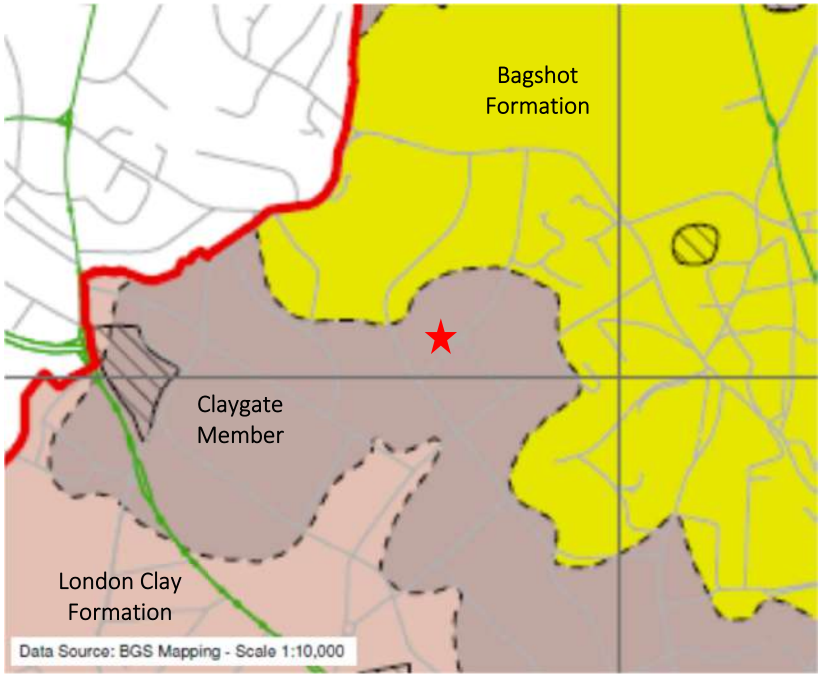
A Preliminary UXO Risk Assessment has been completed by 1st Line Defence (report ref PA16908-00, dated November 2022), and the report is included in the appendix. The risk assessment has been carried out in accordance with the guidelines provided by CIRIA[4], which state that the likelihood of encountering 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 World War II (WWII), the site was located within the Metropolitan Borough of Hampstead, which sustained a very high bomb density. However, no high explosive bombs are recorded on the site, nor is the site or immediate area shown to have suffered any damage.

It is also considered likely that the site and much of the surrounding area would have remained occupied and subject to regular post-raid checks for signs of UXO and therefore a minimal risk of encountering unexploded ordnance has been identified for the site and no further action is recommended in this respect.

2.5 Geology

The British Geological Survey (BGS) map of the area (sheet 256) indicates that the site is underlain by the Claygate Member over the London Clay Formation, as shown on the map extract below, with the overlying Bagshot Member shown to be present on the upper part of Reddington Road, approximately 60 m to the northwest .



The Claygate Member forms the uppermost unit of the London Clay Formation and is described in the geological memoir as typically comprising interbedded fine-grained sand, silt and clay, becoming more cohesive in nature with increasing depth, whilst the underlying London Clay is homogenous, slightly calcareous silty clay to very silty clay, with some beds of clayey silt grading to silty fine-grained sand.

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

The boundary between the Claygate Member and underlying London Clay is often difficult to distinguish due to its transitional nature.

The geology in this area is generally horizontally bedded such that the boundary between the geological formations roughly follows the ground surface contour lines. A borehole drilled by the BGS about 2 km to the northeast of the site on Hampstead Lane, generally referred to as the Hampstead Heath borehole, found the Bagshot Formation to extend to a level of about 110 m OD. Below this, the Claygate Member was found to extend to a level of about 94 m OD, with the underlying London Clay encountered to the full extent of the borehole, to a level of about 62 m OD.

The Arup document contains a map showing the slope angles within the borough (Fig No 16) and the site is not shown to include any slopes with an angle greater than 7° so is not deemed on that basis to be at risk of general slope failure.

2.6 Hydrology and Hydrogeology

The Claygate Member is classified as a Secondary ‘A’ Aquifer, which refers to strata that contain permeable layers capable of supporting water supply at a local level and in some cases, may form an important source of base flow for local rivers, as defined by the Environment Agency (EA). However, in the absence of significant sand horizons, the Claygate Member is not capable of storing and transmitting water in usable amounts and receives very low levels of annual recharge due to very low permeability.

The underlying London Clay is classified as a Non-Aquifer and Unproductive Strata, which refers to a soil or rock with low permeability that has a negligible effect on local water supply or river base flow. In this respect, published data for the permeability of the London Clay indicates the horizontal permeability to generally range between 1×10^{-10} m/s and 1×10^{-8} m/s, with an even lower vertical permeability.

The Claygate Member is predominantly cohesive in nature and therefore groundwater flow is likely to be relatively slow, although horizons of sandier soils are sometimes present, resulting in the permeability ranging from “very low” to “high”. Any groundwater flow in the area will be restricted to these sandier horizons and will generally follow the local topography with a flow direction to the south/southwest.

As the Claygate Member and underlying London Clay are likely to comprise predominantly clay soils, they cannot support groundwater flow over any significant distance, nor can they be considered to support a “water table” such as would be found within a porous and permeable saturated stratum, such as the overlying Bagshot Beds. 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.

Spring lines are present at the interface of the Bagshot Beds and the Claygate Member and reflect the presence of groundwater within the predominantly granular deposits of the Bagshot Beds, which cover the areas of higher ground to the north and northeast of the site. These springs have been the major source of a number of London’s “lost” rivers, notably the Fleet, Westbourne and Tyburn, which generally all rose on Hampstead Heath.

Perched water is likely to be present within the Claygate Member, or other superficial deposits, and other investigations carried out around the area of Hampstead indicate that spring lines, reflecting the presence of perched groundwater, are present at the interface between the Claygate Member and the underlying essentially impermeable London Clay. These spring lines are generally less significant than those associated with the overlying Bagshot Beds.

The site lies outside the catchment of the Hampstead Heath chain of ponds, with the nearest surface water feature comprises a private swimming pool located approximately 405 m to the southwest. However, Figure 11 of the Arup report and reference to the Lost Rivers of London[5] indicates that two former tributaries of the River Westbourne, flowed approximately 60 m to the west and 125 m to the southeast, along the present lines of Reddington Road and Reddington Gardens, before meeting at the present junction of these two roads and flowing in a south-westerly direction along Heath Drive, as shown on the map extract overleaf. These former water courses are not shown after 1895, by which time Reddington Road was established and like many of London’s Lost Rivers are likely to have been incorporated into local sewer system and will not therefore be impacted by, or impact upon, the proposed development.

The site is not located within an EA designated Source Protection Zone (SPZs) and there are no listed water abstraction points within 1 km of the site.

5 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 relative to the site.

The site is not located in an area at risk of flooding from rivers or sea, as defined by the EA, but is identified on the BGS map, as being within an area with a limited potential for groundwater flooding.

Templewood Avenue is not listed within the London Borough of Camden report[6] as having suffered from surface water flooding in 1975 but is referenced has having been affected during the 2002 flooding event. However, the site is shown on Figure 15 of the Arup report, and the EA surface water flood maps, as having a very low risk from surface water flooding.

With the exception of the footprint of the existing garage and associated driveway, the site is almost entirely covered by soft landscaping and as such, infiltration of rainwater is largely unimpeded in this area. However, the underlying clay will limit infiltration, therefore resulting in a high proportion of runoff.

Information provided by the architect, Vabel London, indicates that the proposed development will result in a loss of about 50% of the existing soft landscaping. However, it is understood that mitigation measures, such as the inclusion of green roofs to the main structure and storage areas on the lower part of the site, will reduce the overall loss of soft landscaping to about 5 m^2, therefore limiting any potential impact.

As the development does not result in a significant change to the present conditions, for example through the loss of large areas of highly permeable soils, there is unlikely to be a significant increase in runoff rate or volume into the existing sewer system, or that could have a potentially adverse impact on the surrounding area.

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

2.6 Nearby Investigations

GEA has previously carried out a number of ground investigations within 100 m of the site, the findings of which are summarised in the table below.

Location	Report Ref	Distance from site (m) and direction	Details
50 Redington Road	J12045 May 2014	30 to the NW	Base of made ground 0.30 m to 1.50 m (107.40 m OD to 104.60 m OD); Base of Bagshot Formation (NE corner of site only) 0.85 m (106.35 m OD) to 1.25 m (105.95 m OD) Base of Claygate Member 4.00 m to 10.50 m (100.40 m OD to 96.90 m OD); London Clay to full depth of investigation at 25.00 m (82.40 m OD). Groundwater monitored at levels of between 97.52 m OD and 106.88 m OD.
58a Redington Road	J18142 April 2019	90 to the N	Base of made ground 0.35 m to 1.00 m; Base of Claygate 4.60 m to 9.00 m (102.90 m OD to 101.2 m OD); London Clay to the full depth of the investigation, of 15.45 m (90.94 m OD). Groundwater monitored at between 104.80 m OD and 100.57 m OD.
38 Redington Road	J12204 August 2012	80 m to the S	Base of made ground 0.70 m to 1.20 m (93.8 m OD to 92.5 m OD); Base of Claygate 2.00 m to 2.70 m (90.50 m OD to 9.1.80 m OD); London Clay proved 20.00 m (74.50 m OD). Groundwater monitored at 1.55 m (92.95 m OD).
24 to 26 Redington Gardens	J18223 March 2019	80 m to the SE	Base of made ground to 1.20 m to 1.50 m (approx. 93.8 m OD to 93.5 m OD); Alluvium 3.00 m to 3.40 m (92.00 m OD to 91.60 m OD) BASe of Claygate 4.80 m to 5.50 m (90.50 m OD to 89.50 m OD); London Clay to 20.00 m (75.00 m OD). Groundwater was encountered within the Alluvium during drilling at a depths of 2.40 m (approx. 92.60 m OD) and 3.00 m (approx. 9.2.50 m OD) and at the base of the Claygate ember in a single locations, at a depth of 4.80 m (approx. 90.20 m OD).

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 findings indicate that the site does not have a potentially contaminative history as it has been developed with a house for its entire developed history.

As with any developed site, there is the potential for localised spillages and leakages, but this is not considered to represent a significant source of contamination.

No sources of soil gas have been identified on site or in the surrounding area.

2.7.2 Receptor

The occupants of the proposed house will represent relatively high sensitivity receptors. Buried services are likely to come into contact with any contaminants present within the soils through which they pass, and site workers are likely to come into contact with any contaminants present during construction works.

Perched water may be present in the made ground or Claygate Member, particularly in the vicinity of existing foundations, although such pockets of water are likely to be localised and unlikely to form part of a general water table.

2.7.3 Pathway

Within the site, end users will be isolated from direct contact with any contaminants present within the made ground by the extent of the proposed house and surrounding hard surfacing, thus no potential contaminant exposure pathways will exist with respect to end users. Only in areas of proposed soft landscaping will end users potentially come into contact with contaminants, although such pathways are already in existence.

There will be a potential for contaminants to move onto or off the site horizontally within the made ground, although these pathways are already in existence. A pathway for ground workers to come into contact with any contamination will exist during construction work and services will come into contact with any contamination within the soils in which they are laid.

There is thus considered to be a low potential for a contaminant pathway to be present between any potential contaminant source and a target for the particular contaminant.

2.7.4 Preliminary Risk Appraisal

On the basis of the above it is considered that there is a LOW risk of there being a significant contaminant linkage at this site which would result in a requirement for major remediation work. Furthermore, as there is no evidence of filled ground within the vicinity of the site and no landfill sites, there is not considered to be a significant potential for hazardous soil gas to be present on or migrating towards the site.

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 Templewood Avenue
1a. Is the site located directly above an aquifer?	*Yes. The site is located above a Secondary 'A' Aquifer as designated by the EA. However, as the Claygate Member is understood from previous experience of adjacent and nearby sites, to comprise predominantly clay, it is likely it will have the characteristics of Unproductive Strata, similar to that of the London Clay.*
1b. Will the proposed basement extend beneath the water table surface?	*Unlikely. Perched groundwater may be encountered within the Claygate Member and the proposed excavations may therefore extend below local monitored groundwater levels. However, the predominantly clay soils likely to be present beneath the site cannot store or transmit groundwater under normal hydraulic conditions and therefore cannot support a water table, such as would be found within a porous and permeable saturated stratum with a predominantly granular soil matrix. It is therefore considered that significant inflows are unlikely to be encountered, although this does not eliminate a requirement for potential mitigation measures during basement construction.*
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 within 100 m of a former tributary of the River Westbourne this feature is no longer present at surface, having been diverted to form part of the local surface water sewer system.

Question	Response for Templewood Avenue
3. Is the site within the catchment of the pond chains on Hampstead Heath?	No. As shown by Figure 14 of the Arup Report.
4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	*Yes. The proposed development will result in an increase in the proportion of hard surface / paved areas However, the low permeability of the underlying clay soils would result in a low recharge in any case and consequently there would be little or no effect on groundwater.*
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 sewers. 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.

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

Q1a. The site is located directly above the Claygate Member, which is classified as a Secondary 'A' Aquifer.

Q1b. There is a possibility that the proposed excavations may encounter local and perched groundwater.

Q4. The development will result in a change in the proportion of hard surface / paved areas.

3.1.2 Stability Screening Assessment

Question	Response for Templewood Avenue
1. Does the existing site include slopes, natural or manmade, greater than 7°?	*Yes. Part of the existing driveway slopes at an angle greater than 7°. However, this feature is entirely covered by concrete hardstanding and bounded by existing retaining structures.*
2. Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7°?	No. The development of the site will not introduce any new slopes and will result in the removal of the existing driveway mentioned above, with new retaining structures proposed along the frontage with Templewood Avenue.
3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	No. Topographical maps and Figures 16 and 17 of the Arup report confirm this.
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?	No. The site is indicated as being underlain by the Claygate Member.
6. Will any trees be felled as part of the proposed development and / or are any works proposed within any tree protection zones where trees are to be retained?	*Yes. A number of trees are likely to be felled as part of the proposed development, although it is understood that the majority of the existing trees around the permitter of the site will be retained.*
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 clay soils. However, there is no evidence of any potential movement on the existing and / or surrounding structures.*
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 within 100 m of a former tributary of the River Westbourne 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?	*Yes. The site is located above a Secondary 'A' Aquifer as designated by the EA. However, as the Claygate Member comprises predominantly clay beneath this and adjacent sites, it is likely it will have the characteristics of Unproductive Strata, similar to that of the London Clay.*
10b. Will the proposed basement extend beneath the water table such that dewatering may be required during construction?	*Unlikely. Groundwater may be encountered within the Claygate Member and the proposed excavations may therefore extend below local monitored groundwater levels. However, the predominantly clay soils likely to be present beneath the site cannot store or transmit groundwater under normal hydraulic conditions and therefore cannot support a water table, such as would be found within a porous and permeable saturated stratum with a predominantly granular soil matrix. It is therefore considered that significant inflows are unlikely to be encountered, although this does not eliminate a requirement for potential mitigation measures during construction.*
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.

Question	Response for Templewood Avenue
12. Is the site within 5 m of a highway or pedestrian right of way?	*Yes. Although the site fronts on to Templewood Avenue, the proposed structure is located over 5 m away from the public footway and roads.*
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	*Unlikely. The depth of adjacent foundations is unknown, but it is unlikely that the development will increase the foundation depths relative to the neighbouring properties to a relatively significant extent, as formation level of the proposed new building is at a similar level the existing lower ground floor level of the nearby property. However, a ground movement analysis has been completed as part of this investigation to predict the likely movements as a result of the excavation, the findings of which are included in Part 3.0 of this report.*
14. Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	No. An online search for London Underground Tunnels and railway tunnels did not indicate any in the proximity of the site. This is confirmed with reference to ARUPs Transport Infrastructure map, Figure 18. 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:

- Q1 The site includes a man-made slope with an angle greater than 7°.
- Q6 A number of trees are to be felled as part of the development.
- Q7 The site is in an area that has the potential to be affected by seasonal shrink-swell.
- Q10a The site is located above a Secondary 'A' Aquifer as designated by the EA.
- Q10b There is a possibility that the proposed excavations may encounter local and perched groundwater.
- Q12 The site is within 5 m of both a footpath and carriageway.
- Q14 The proposed basement may increase the differential depth of foundations relative to neighbouring properties.

3.1.3 Surface Flow and Flooding Screening Assessment

Question	Response for Templewood Avenue
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 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 new lower ground floor level will be beneath the footprint of the building, therefore the 1 m distance between the roof of the basement and ground surface as recommended by the Arup report and para 3.2 of the CPG (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?	*Yes. The proposed development will cover a larger proportion of the site, which is currently partially permeable. However, SUDS attenuation, such as the proposed green roof, prior to discharge into the sewers will reduce the impact to acceptable levels.*
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 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 new lower ground floor level will be beneath the footprint of the building, therefore the 1 m distance between the roof of the basement and ground surface as recommended by the Arup report and para 3.2 of the CPG (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?	No. The findings of this BIA together with the Camden Flood Risk Management Strategy dated 2013 and Figures 3iv, 4e, 5a and 5b of the SFRA dated 2014, in addition to the Environment Agency online flood maps show that the site has a very low flooding risk from surface water, sewers, reservoirs (and other artificial sources), groundwater and fluvial/tidal watercourses. It is possible that the basement will be constructed within pockets of perched water and the recommendations outlined in the BIA with regard to waterproofing 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 assessed:

Q3 The development will result in a change in the proportion of hard surfaced / paved areas.

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
The site is located above a Secondary 'A' Aquifer as designated by the EA.	There is the potential for the hydrogeological setting to be affected by a basement development.
There is a possibility that the proposed excavations may encounter local and perched groundwater.	It is possible the proposed excavations could encounter local an perched groundwater. Should this happen, the proposed structure is capable of diverting groundwater flow such that groundwater level is affected on both the up slope and down slope side of the sub-terranean structure. This in turn has the potential to affect the local hydrogeology and any adjacent structures.
The site includes a man-made slope with an angle in excess of 7°.	The presence of a slope may cause local instability within the site.
The site is within an area likely to be affected by seasonal shrink-swell	If a new foundations are not dug to below the depth likely to be affected by tree roots this could lead to damaging differential movement between the subject site and adjoining properties.
A number of trees will be felled as part of the development.	Whilst shrinkable soils are present at shallow depth, there are no critical slope angles that are dependent on the existing trees to aid long term stability.
Increase in the proportion of hard standing.	Less soft covering for surface water infiltration. However, the Claygate Member is of relatively low permeability so will not make much difference.
The development is located within 5 m of the public highway	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.
The development may increase the differential depth of foundations relative to neighbouring properties.	Excavation of a sub-terranean structure may result in structural damage to neighbouring properties if there is a significant differential depth between adjacent foundations.

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

4.2 Exploratory Work

In view of the access restrictions and in order to meet the objectives described in Section 1.2, a single borehole was advanced to a depth of 25.0 m (7.5.5 m OD) to the front of the existing garage, using a Premier 110 tracked rotary-percussive rig, with a continuous flight auger attachment. During boring, disturbed and undisturbed samples were obtained from the boreholes for subsequent laboratory examination and testing.

Additionally, two further boreholes were advanced to depths of 4.0 m (99.0 m OD) and 5.0 m (97.0 m OD) using hand-held window sampling equipment to provide coverage across the rest of the site. Three trial pits were also dug by hand to depths of between 0.3 m and 0.9 m to provide information on the boundary wall conditions.

Groundwater monitoring standpipes have been installed to depths of 10.0 m (90.5 m OD), 5.0 (97.0 m OD) and 4.0 m (99.0 m OD) in Borehole Nos 1, 2 and 3, respectively, to facilitate groundwater monitoring, which has been carried out on two occasions since installation.

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 have been interpolated from a site survey drawing (drawing ref 220779/Rev 0, dated September 2022) provided by Conisbee.

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.

Four samples of the 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 polycyclic aromatic hydrocarbons (PAH), banded total petroleum hydrocarbons (TPH), 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 ground investigation generally encountered the expected ground conditions, in that beneath a variable, but generally limited, thickness of made ground, the Claygate Member was encountered overlying the London Clay, which extended to the full depth of the investigation, of 25.0 m (75.5 m OD).

5.1 Made Ground

Made ground was encountered to depths of between 0.18 m (102.82 m OD) and 0.90 m (102.60 m OD) and typically comprised brown silty sandy clay to clayey sand with roots and rootlets and variable amounts of extraneous material, such as brick, ash, concrete and charcoal.

Apart from the presence of fragments of extraneous material noted above, no visual or olfactory evidence of contamination was observed during the fieldwork. Three samples of the made ground have however been analysed for a range of contaminants as a precautionary measure and the results are detailed within Section 4.4.

5.2 Claygate Member

The Claygate Member was encountered beneath the made ground and generally comprised firm becoming stiff pale orange-brown mottled grey silty slightly sandy to sandy clay, with occasional partings or pockets of yellowish brown to orange-brown silt or very fine sand, which extended to the base of the two window sampler boreholes, at depths of 4.00 m (99.00 m OD) and 5.00 m (97.00 m OD), but was proved in the deeper borehole to a depth of 4.90 m (95.60 m OD).

The results of plasticity index tests indicate the clay to be of medium volume change potential, whilst the results of laboratory undrained triaxial compression tests indicate the clay to be of high to very high strength.

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

5.3 London Clay

The London Clay initially comprised stiff becoming very stiff fissured dark brownish grey to dark grey silty sandy clay with occasional shell fragments and partings of very fine sand, which extended to a depth of 10.50 m (90.00 m OD). This upper layer may comprise the lowest part of the Claygate Member, although the appearance and consistency of the samples recovered from the boreholes was more akin to typical soils of the upper London Clay.

Below this, the London Clay comprised very stiff fissured dark grey initially sandy clay, which was proved to the full depth of the investigation, of 25.00 m (75.5 m OD).

The London Clay is likely to be of high volume change potential, whilst the results of laboratory undrained triaxial compression tests indicate the clay to be of high strength to very high strength, becoming extremely high strength. The triaxial sample from a depth of 18.5 m was noted to have failed along a large fissure plane, whilst the sample from 21.5 m showed signs of sample disturbance, such that these results are not considered to accurately reflect the true in-situ strength.

5.4 Groundwater

Groundwater was not encountered within any of the trial pit or the two window sampler boreholes. However, a seepage was observed within the upper part of the London Clay in Borehole No 1 at a depth of 6.5 m (94.0 m OD), rising to a depth of about 5.9 m (94.6 m OD) after a period of 20 minutes.

Standpipes were installed in Borehole Nos 1 to 3 and the findings of groundwater monitoring undertaken to date are presented in the table below.

Borehole No	Date	Depth to water (m) [m OD]
1	30/11/2022*	3.85 [96.65]
	06/01/2023	3.48 [97.02]
	03/02/2023	3.79 [96.71]
2	06/01/2023	Dry

Borehole No	Date	Depth to water (m) [m OD]
	03/02/2023	Dry
3	06/01/2023	Dry
	03/02/2023	Dry
*Initial visit carried out during completion of window sampling works, approximately one week after installation		

5.5 Soil Contamination

The table below sets out the values measured within the three samples analysed; all concentrations are in mg/kg unless otherwise stated.

Determinant	BH1 0.25 m	BH2 0.30 m	BH2 0.70 m	BH3 0.15 m
pH	8	8.1	8	7.2
Arsenic	21	17	17	16
Cadmium	<0.2	<0.2	<0.2	<0.2
Chromium	48	45	54	37
Lead	63	68	46	160
Mercury	<0.3	<0.3	<0.3	0.4
Selenium	<1	<1	<1	<1
Copper	95	21	18	28
Nickel	26	20	24	18
Zinc	110	67	72	74
Total Cyanide	<1	<1	<1	<1
Total Phenols	<1	<1	<1	<1
Total PAH	9.9	2.2	<0.8	1.0
Sulphide	2.9	4.3	3.3	6.6
Benzo(a)pyrene	0.3	0.2	0.1	0.1
Naphthalene	0.8	<0.05	<0.05	0.1
TPH	82	<10	<10	<10
Total Organic Carbon %	0.4	0.8	0.5	1.7
Figure in bold indicates concentration in excess of risk-based soil guideline values, as discussed in Part 2 of this report				

In addition, all four samples of the made ground have been screened for the presence of asbestos and none was detected.

5.5.1 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[7] Soil Guideline Values where available, the Suitable 4 Use Values[8] (S4UL) produced by LQM/CIEH calculated using the CLEA UK Version 1.07[9] software, or the DEFRA Category 4 Screening values[10], assuming a residential end use with 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, consumption of home grown produce, consumption of soil adhering to home grown produce, skin contact with soils and dust, and inhalation of dust and vapours; and

7 *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.
8 *The LQM/CIEH S4Uls for Human Health Risk Assessment* S4UL3065 November 2014
9 Contaminated Land Exposure Assessment (CL|EA) Software Version 1.071 Environment Agency 2015
10 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

- that the building type equates to a terraced house.

It is considered that these assumptions are acceptable for this generic assessment of this site, albeit conservative given the actual nature of the development. 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.

Chemical analyses have not measured any elevated concentrations of contamination within the samples of made ground tested when compared to screening values for a residential end use with plant uptake. Additionally, asbestos was not detected within any of the samples tested.

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

5.6 Existing Foundations

The findings of the trial pits are summarised in the table below. Sketches and photographs of each pit are included in the Appendix.

Trial Pit No	Structure	Foundation detail	Bearing Stratum
1	Former outbuilding	Brick footing Top: 0.08 m Base: 0.18 m. Lateral projection: 50 mm to 70 mm	Firm pale orange-brown silty slightly sandy CLAY with occasional rootlets
2	Garden wall	Mass concrete strip / footing Top: 0.08 m Base: 0.33 m. Lateral projection: 300 mm	Firm pale orange-brown silty slightly sandy CLAY with occasional rootlets
3	Boundary wall with No 3 Templewood Avenue	Concrete retaining wall Top: N/A Base: Not proved Lateral projection: N/A	Not proved.

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 construct a new two-storey property within the garden of No 1 Templewood Avenue, which will be cut into the existing slope of the site to a maximum depth of approximately 4.5 m to 5.0 m.

It is understood from information provided by Conisbee, that the majority of excavations for the new structure will be supported by a contiguous bored pile wall, with new RC retaining structures proposed on the southern part of the site to replace the existing brick structures.

Anticipated loads are not known at this stage, but are expected to be light to moderate and thus typical of this type of development.

7.0 Ground Model

The desk study has revealed that the site has not had a potentially contaminative history, having had a residential end use, and on the basis of the fieldwork, the ground conditions at this site can be characterised as follows:

- beneath a variable, but generally limited thickness of made ground, the Claygate Member was encountered overlying the London Clay, which was proved to the full depth of the investigation, of 25.00 m (75.00 m OD);
- the made ground comprises brown silty sandy clay to clayey sand with roots and rootlets and variable amounts of brick, ash, concrete and charcoal, and extends to depths of between 0.18 m (102.82 m OD) and 0.90 m (102.60 m OD);
- the Claygate Member comprises firm becoming stiff high strength to very high strength pale orange-brown mottled grey silty slightly sandy to sandy clay, with occasional partings or pockets of yellowish brown to orange-brown silt or very fine sand, which extended to the base of the window sampler boreholes, but was proved in the rotary-percussive borehole to a depth of 4.90 m (95.60 m OD);
- the uppermost part of the underlying London Clay comprised a transitional zone of stiff becoming very stiff fissured high strength to very high strength dark brownish grey to dark grey silty sandy clay with occasional shell fragments and partings of very fine sand, which extended to a depth of 10.50 m (90.00 m OD);
- below this, the London Clay comprised very stiff fissured very high strength becoming extremely high strength dark grey initially sandy clay, which was proved to the full depth of the investigation, of 25.00 m (75.50 m OD);
- groundwater has been encountered with the Claygate Member and underlying transition layer of the underlying London Clay and has subsequently been monitored at a level of about 97.00 m OD; and
- contamination testing has not indicated any elevated concentrations of contamination or asbestos within the made ground.

7.1 Recommended Parameters

The table overleaf summarises the vertical soil parameters to be used in any subsequent analysis and is based on the findings of the investigation.

Values of stiffness for the soils at this site are readily available from published data[11, 12, 13 & 14] and a well-established method has been used to provide the estimated values.

Stratum	Base of Stratum (m)	Bulk Unit Weight (kN/m³)	Effective Friction Angle (ϕ' °)	Undrained Cohesion (C_u - kN/m²)	Undrained Young's Modulus* (E' - kN/m²)	Drained Young's Modulus* (E_u - kN/m²)
Made Ground	102.5 to 100.0 (varies)	17.0	27	-	-	10,000
Claygate Member	95.5	18.5	25	50 to 100	25,000 to 50,000	15,000 to 30,000
London Clay	90.0	19.5	23	100 to 180	50,000 to 90,000	30,000 to 54,000
	75.5⁺			180 to 320	108,000 to 192,000	81,000 to 144,000
	>75.5**			320 +7.5	192,000 + 4500	144,000 + 3375

⁺Maximum depth of investigation. *Values based on the conservative relationship of E_u = 500 C_u and E' = 300 C_u for the Claygate Member and upper transitional zone of the London Clay and E_u = 600 C_u and E' = 0.75 E_u for the London Clay below a level of 90.00 m OD. **An increase in cohesion of 7.5 kN/m² per metre increase in depth has been adopted to provide a conservative estimate of the likely strength profile below the depth of the investigation.

The values in the above are unfactored and are considered to be moderately conservative 'characteristic' parameters suitable for routine calculations that require cautions, or lower bound, estimates of strength and stiffness, such as those required for piled foundation and embedded retaining wall design. The designer may therefore need to consider alternative characteristic values where an upper bound estimate is considered more appropriate, such as in the evaluation of structural forces within the proposed structures.

8.0 Advice & Recommendations

Excavations where the proposed structure cuts into the existing site will require temporary support to maintain stability and to prevent any excessive ground movements.

Formation level for the new structure will be within the Claygate Member at a level of about 98.5 m OD, which should provide an eminently suitable bearing stratum for spread foundations excavated from proposed ground floor level.

Shallow inflows of groundwater are unlikely to be encountered within the proposed excavations.

8.1 Lower Ground Floor Construction

It is understood that the proposed two-storey house is to be built into the existing slope, with a south-easterly facing frontage that will open out onto Templewood Avenue at the low side of the building. The formation level for the underside of the lower ground floor level slab is understood to be at approximately 98.5 m OD, such that excavations on the north-western part of the site are likely to extend to a depth of about 4.5 m to 5.0 m; formation level should therefore be within the stiff clay of the Claygate Member.

Whilst the investigation and subsequent monitoring suggest that groundwater inflows are unlikely to be encountered within the proposed excavations, localised inflows of perched water should be anticipated from within the made ground and granular pockets within the Claygate Member. However, any such inflows are likely to be relatively minor in nature and 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.

It would also be prudent to carry out a number of trial excavations, to depths as close to proposed formation level as possible, to provide an indication of the likely rate and volume of groundwater inflows, and to provide an indication of excavation stability.

11 Padfield CJ and Sharrock MJ (1983) *Settlement of structures on clay soils.* CIRIA Special Publication 27
12 Butler FG (1974) *Heavily over-consolidated clays: a state-of-the-art review.* Proc Conf Settlement of Structures, Cambridge, 531-578, Pentech Press, Lond.
13 O'Brien AS and Sharp P (2001) *Settlement and heave of over-consolidated clays - a simplified non-linear method.* Part Two, Ground Engineering, Nov 2001, 48-53
14 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

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.

It is understood that the excavations for the proposed new building, will be supported on three sides by a contiguous bored pile wall, which would have the advantage of being incorporated into the permanent works and provide support for structural loads. Reinforced concrete gravity retaining structures are then proposed as part of a second stage of works, which will be constructed in-situ with the ground built back up behind the walls to the finished levels to support the raised garden areas on the lower part of the site.

Whilst the proposed construction is set back from Templewood Avenue and the foundations of the adjoining structures, careful workmanship will still be required to ensure that movement of the surrounding structures does not arise. The contractor should also 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. The stability of the adjacent foundations will need to be ensured at all times and the existing foundations will need to be underpinned prior to construction of the proposed new basements or will need to be supported by new retaining walls. A Ground Movement Analysis has been carried out in accordance with the requirements of CPG and is presented in Part 3 below.

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	1750	Zero	27
Claygate Member	1900	Zero	25
London Clay	2000	Zero	23

Significant groundwater inflows are not anticipated within the basement, although monitoring of the standpipes should be continued to confirm this view, along with trial excavations.

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[15] should be followed in this respect and with regard to the provision of suitable waterproofing.

8.1.2 Excavation Heave

The excavations for the proposed structure will result in a net unloading of around 15 kN/m^2 to 85 kN/m^2, which will result in differential heave of the Claygate Member and 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.

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

8.2 Spread Foundations

On the basis that all foundations bypass any made ground then moderate width pad or strip foundations, bearing beneath proposed lower ground floor level within the stiff clay of the Claygate Member may be designed to apply a net allowable bearing pressure of 150 kN/m^2.

This value provides an adequate factor of safety against bearing capacity failure and should ensure that settlement remains within normal tolerable limits. The recommended bearing pressure takes account of the variable nature of the soils.

The depth of the lower ground floor excavations is expected to be such that foundations will be placed below the depth of any potential desiccation, but this should be checked once the proposals have been finalised, with the survey drawing showing former and existing trees. Notwithstanding NHBC guidelines, all foundations should extend beyond the zone of desiccation. In this respect, it would be prudent to have all foundation excavations inspected by a suitably experienced engineer. Due allowance should be made for future growth of existing / proposed trees. The requirement for compressible material alongside foundations should be determined by reference to the NHBC guidelines.

8.3 Piled Foundations

For the ground conditions at this site, bored pile or driven piles could be adopted, but the noise and vibrations associated with driven piles may be unacceptable. A conventional rotary augered pile could be utilised but consideration will need to be given to the possible instability and water ingress within the made ground and perched water inflows from within the Claygate Member and underlying London Clay. The use of bored piles installed using continuous flight auger (cfa) techniques may therefore be the most appropriate.

The following table of ultimate coefficients may be used for the preliminary design of bored piles, based on the SPT and cohesion / depth graph for Borehole No 1 in the appendix, with an approximate ground level of 100.5 m OD.

Stratum	Level m OD	kN / m^2
Ultimate Skin Friction		
Made Ground	100.5 to 100.0	Ignore
Claygate Member	100.0 to 95.5	Increasing linearly from 25 to 50
London Clay	95.5 to 90.0	Increasing linearly from 50 to 90
	90.0 to 75.5	Increasing linearly from 90 to 160
Ultimate End Bearing		
London Clay	95.5 to 90.0	Increasing linearly from 900 to 1620
	90.0 to 75.5	Increasing linearly from 1620 to 2880

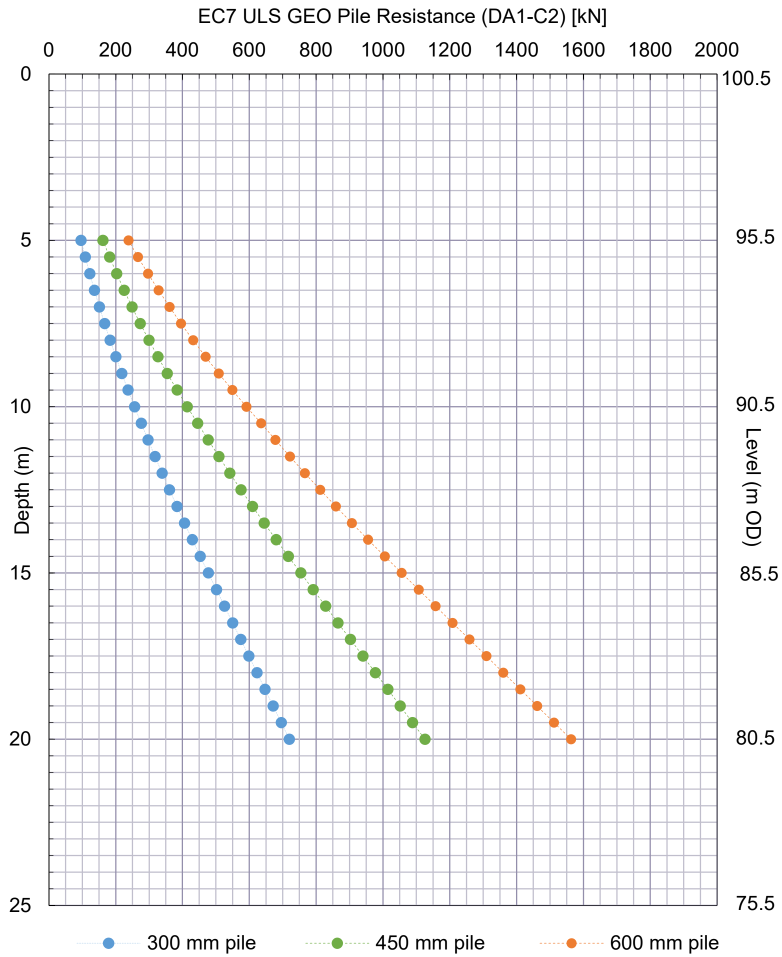
Average ultimate skin friction has been limited to 110 kN/m^2 and an adhesion factor of 0.5 has been adopted, in accordance with guidance from the London District Surveyors Association (LDSA)[16]. The maximum pile depth has also been limited to a depth of 20 m (approx 80.5 m OD).

On the basis of the above coefficients, the geotechnical resistances (R_d Geo) for a range of pile diameters and depths have been evaluated using the Method of Calculation, in accordance with Eurocode 7: Geotechnical Design, Part 1, General Rules, with the results presented in the graph overleaf.

The pile resistances provided have been determined in accordance with Design Approach 1 (DA1 – ULS GEO Combination 2: A2 + M1 + R4) of BS EN 1997 – 1:2004 (Eurocode 7), as prescribed in the UK National Annex of BS EN 1997–1 for partial factors *without pile testing, i.e., with partial factors of 1.6 and 2.0 on the shaft and base, respectively, combined with an additional model factor (MF) of 1.4*.

In order to determine the required pile lengths, the calculated pile resistances need to be compared with structural loads (actions) that have been appropriately factored to determine the design effect in the geotechnical ultimate limit state (ULS-GEO), in accordance with BS EN 1997-1:2004; Eurocode 7: Geotechnical Design Part 1. Pile

16 LDSA (2017) *Guidance notes for the design of straight shafted bored piles in London Clay*. LDSA



behaviour under loading and the design of reinforcement should be undertaken separately, using partial factors for the structural ultimate limit state (DA1 – ULS STR Combination 1).

The examples provided are not intended to constitute any form of recommendation with regard to pile size or type, but merely serve to illustrate the use of the above coefficients.

Specialist piling contractors should be consulted with regard to the design of a suitable piling scheme and their attention should be drawn to potential groundwater inflows and instability within the made ground and the presence of claystones within the London Clay.

8.3 Shallow Excavations

On the basis of the borehole and trial pit findings, it is considered that it will be generally feasible to form relatively shallow excavations terminating within the Claygate Member without the requirement for lateral support, although localised instabilities may occur where more granular material 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 carried out and temporary lateral support or battering of the excavation sides considered in order to comply with normal safety requirements.

8.4 Lower Ground Floor Slab

Following excavation to proposed formation level, it is likely that the lower ground floor slab will need to be suspended over a void or a layer of compressible material to accommodate the anticipated heave, unless the slab can be suitably reinforced to cope with these movements.

Further information on the likely movements that her lower ground floor slab will need to be designed to accommodate is provided in the ground movement assessment in Part 3.

8.5 Effect of Sulphates

Chemical analyses have revealed 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.

8.6 Contamination Risk Assessment

The desk study findings indicate that the site does not have a potentially contaminative history and the results of the contamination testing have not measured any elevated concentrations of contamination within the samples of made ground tested when compared to screening values for a residential end use with plant uptake. Additionally, asbestos was not observed within any of the samples tested.

Remedial measures to protect sensitive receptors, including end users, are not therefore deemed necessary. However, as with any development site, it would be prudent for ground workers to maintain a watching brief and if any suspicious or malodourous soils are encountered, further investigation may be required. Furthermore, 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 and CIRIA and the requirements of the Local Authority Environmental Health Officer.

8.7 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[17] 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[18] 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)
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)

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[19] which states that in certain circumstances, segregation at source may be considered as pre-treatment and thus excavated material may not have to be treated prior to landfilling if the soils can

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

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

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

be segregated onsite prior to excavation by sufficiently characterising the soils in-situ 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. 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.