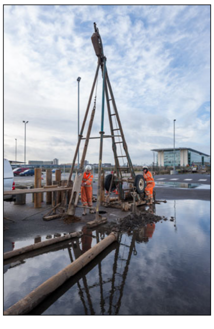
GROUND INVESTIGATION AND BASEMENT IMPACT ASSESSMENT REPORT

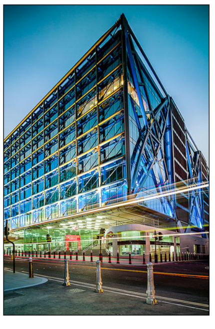
45 Highgate West Hill
London
N6 6DB

Client: Tim and Ciara Rowe

J19183

August 2019



GEA

Document Control

Project title	45 Highgate West Hill, London N6 6DB	**Project ref**	J19183
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Part 3: GROUND MOVEMENT ASSESSMENT

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 Momentum, on behalf of Mr Tim & Mrs Ciara Rowe, with respect to the demolition of the existing single-storey side extension and subsequent construction of a new two-storey side extension with a single level basement section. The purpose of the investigation has been to determine the ground conditions and hydrogeology, to carry out an assessment of ground movements resulting from excavation of the proposed basement, to assess the extent of any 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 (LBC) Planning Guidance Basements, relating to the requirement for a Basement Impact Assessment (BIA).

GROUND CONDITIONS

The investigation has confirmed the expected ground conditions in that, below a nominal to moderate thickness of made ground, the Bagshot Formation was encountered overlying the Claygate Member, which extended to the full depth of the investigation, of 15.00 m. The made ground generally comprised dark brown clayey sand with gravel and variable amounts of brick, ash, concrete and paving fragments and extended to depths of between 1.05 m and 2.40 m. The Bagshot Formation encountered interbedded layers of orange-brown and occasionally orange-brown mottled pale brown clayey sand and sandy clay and extended to a depth of 13.40 m (114.90 m OD). The Claygate Member comprised stiff fissured dark grey very sandy clay and extended to the full depth of the investigation, of 15.00 m (113.30 m OD).

Groundwater was not encountered during drilling. The standpipe installed in Borehole No 1 has been found to be dry during the single monitoring visit carried out to date.

The contamination testing has indicated two of the samples tested to contain elevated concentrations of lead.

RECOMMENDATIONS

Formation level of the basement will be within the medium dense slightly clayey sand of the Bagshot Formation at a depth of 3.20 m below ground level. Groundwater was not encountered during drilling and the standpipe installed in Borehole No 1 was found to be dry during a single monitoring visit, suggesting that groundwater will not be encountered within the basement excavation. The consulting engineer has provided a preferred structural scheme which includes the use of contiguous bored piled walls to form the retaining walls, which should be appropriate. Spread foundations formed beneath the basement formation level may be designed to apply a net allowable bearing pressure of 120 kN/m^2 in the medium dense clayey sand of the Bagshot Formation.

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 have indicated that ground movements of up to 12 mm (Vertical) and 13 mm (horizontal) are anticipated and if this is the case the building damage to surrounding properties and the listed elements of the existing building on the site will remain within acceptable limits.

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 and an assessment of the ground movements associated with the basement excavation are included in Part 3.

1.0 INTRODUCTION

Geotechnical and Environmental Associates Limited (GEA) has been commissioned by Momentum Consulting Engineers, on behalf of Tim and Ciara Rowe, to carry out a desk study, ground investigation and ground movement assessment at 45 Highgate West Hill, London N6 6DB. 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 the existing single storey side extension to the main building and subsequently construct a two-storey extension with a single level basement section beneath part of the new extension.

The new basement section will have a finished floor level about 2.80 m below existing ground level resulting in an excavation of approximately 3.20 m depth with formation level at approximately 125.30 m OD.

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

1.2 Purpose of Work

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

- to check the history of the site with respect to previous contaminative uses;
- to provide information on the level of Unexploded Ordnance (UXO) risk;
- to determine the ground conditions and their engineering properties;
- to provide advice and information 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 walkover survey of the site carried out in conjunction with the fieldwork;
- commissioning of 1st Line Defence to undertake a preliminary UXO risk assessment;

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

- a single cable percussion borehole advanced to a depth of 15.00 m;
- standard penetration tests (SPTs), carried out at regular intervals in the cable percussion boreholes to provide quantitative data on the strength of the soils;
- two drive-in window sampler boreholes advanced to a depth of 5.00 m;
- installation of three groundwater monitoring standpipes, to a maximum depth of 6.0 m;
- two hand excavated trial pits advanced to a maximum depth of 1.06 m;
- testing of selected soil samples for contamination and geotechnical purposes;
- provision of a report presenting and interpreting the above data, together with our advice and recommendations with respect to the proposed development.

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

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), all of which form part of the BIA procedure specified in the London Borough of Camden (LBC) Planning Guidance

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

Basements[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 John Evans, 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

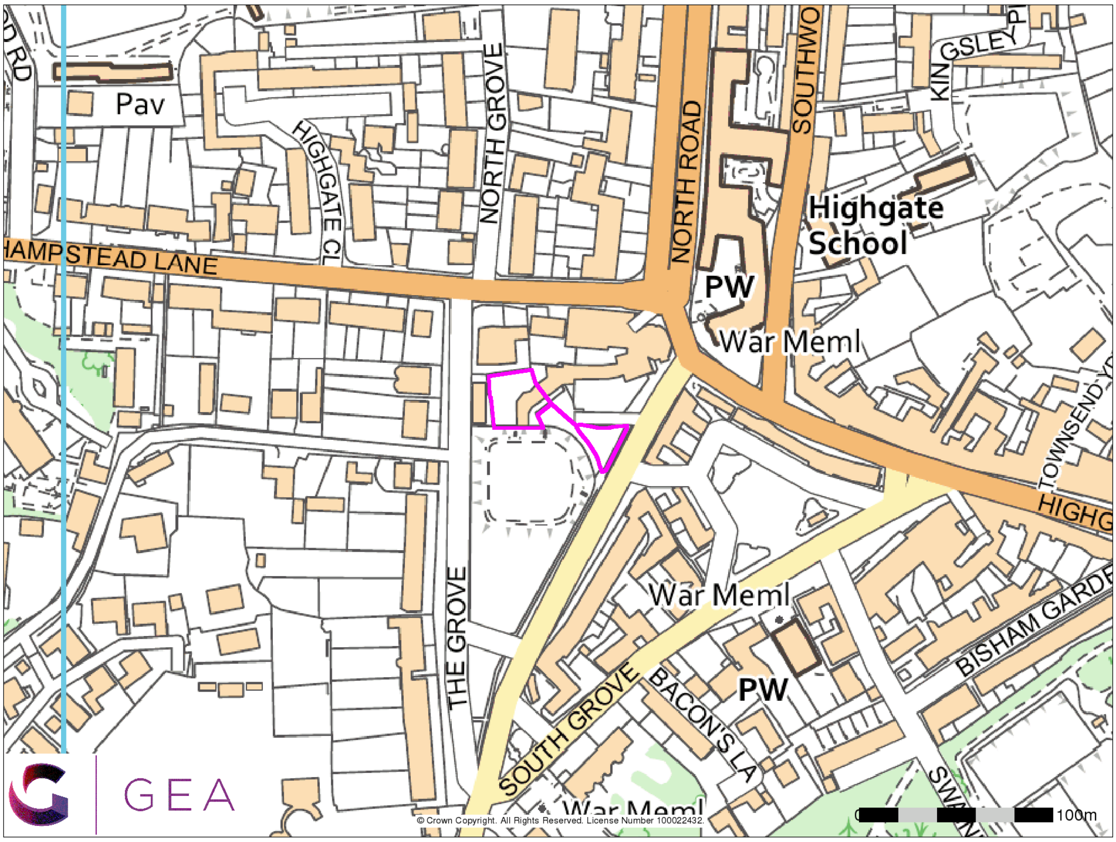
The conclusions and recommendations made in this report are limited to those that can be made on the basis of the investigation. The results of the work should be viewed in the context of the range of data sources consulted, the number of locations where the ground was sampled and the number of soil,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

2.0 THE SITE

2.1 Site Description

The site is located in Highgate village in the London Borough of Camden, roughly 775 m southwest of Highgate London Underground Station. It is irregular in shape, measuring approximately 24 m north-south by 24 m east-west, in maximum dimensions. The site fronts onto Highgate West Hill via a shared access way to the east and is bounded by residential properties to the northeast, north and west, and by a covered reservoir to the south. The site may additionally be located by National Grid Reference 528260, 187445 and is shown on the map extract overleaf.

2 London Borough of Camden Planning Guidance (March 2018) *CPG Basements*
3 Ove Arup & Partners (2010) *Camden geological, hydrogeological and hydrological study. Guidance for Subterranean Development.* For London Borough of Camden November 2010



The site is occupied by a four-storey Grade II* listed house with two storey and single storey extensions in the south and an associated garden in the north and west of the site. The rear garden is largely soft landscaped comprising a central lawn with planted beds around the perimeter and a paved area in the southeast of the garden. There are a number of mature to mature coniferous and deciduous trees in the rear garden. The property has planted beds along the front façade of the building and beyond this the shared access area comprises hardstanding in the form of a gravel double driveway while an area vegetation comprising shrubs and trees is present close to the roadway.

2.2 Site History

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

The earliest map studied, dated 1870, shows the shared access part of the site to have been in its existing configuration, comprising an area of vegetation between two access ways. The north-western part of the site is shown to have been occupied by the existing house, which is reported to have been built in 1729, in its existing position in the east of the site fronting onto the shared access driveway. The remainder of the site appears to be soft landscaped and the majority of the existing road network and building in the surrounding area are also shown to have already been constructed by this time while the existing covered waterworks is labelled immediately to the south of the site.

By the time of the map dated 1915 a number of trees had been removed from the rear garden of the site and an outbuilding had been constructed in the central part of the south of the site. Between 1915 and 1935 the existing house was extended to the southwest and by 1952 another outbuilding had been constructed along the western boundary of the rear garden.

Between 1974 and 1991 the house was further extended to the south to be joined to the outbuilding in the south of the site and the outbuilding itself had been extended to the southern boundary. The site and surrounding area have subsequently remained essentially unchanged.

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 1 km of the site. A single area of potentially infilled land is present within 500 m of the site, located 498 m to the northeast of the site. There have been no pollution incidents to controlled waters within 250 m of the site.

The search has indicated that the site is located in an area where less than 1% of homes are affected by radon emissions; which is the lowest classification given by the Health Protection Agency (HPA) and therefore no radon protective measures will be necessary.

The Envirocheck report indicates a very low risk of potential landslide instability on site.

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

A search of the London Borough of Camden Planning Portal has been carried out for planning applications relating to the properties surrounding the site to provide an indication of the presence of basement beneath the properties. The results of the search are detailed in the table below.

Property	Planning Portal Findings	Comments
No 46 Highgate West Hill	No planning entries related to basements	The section of the building constructed in the 1700s is considered likely to have a single basement similar to that beneath the portion of the existing building on the subject site constructed during the same period
No 46A Highgate West Hill	No planning entries related to basements	Assumed to not have a basement level
No 47 Highgate West Hill	Planning portal drawings indicate basement to extend to a depth of 1.90 m below ground level	Basement level taken to be 1.90 m below ground level across footprint of building
Nos 1-5 The Grove	Planning portal drawings indicate basement to extend to a depth of 2.60 m below ground level	Basement level taken to be 2.60 m below ground level across footprint of building
Fitzroy House	No planning entries related to basements	Assumed to not have a basement level
Three Bells House, 3B Hampstead Lane	No planning entries related to basements	Assumed to not have a basement level
3A Hampstead Lane	Reference to single level basement within planning entry for the construction of the existing building but no drawings available detailing extent and depth	Assume single level basement extending to a depth of 3.00 m beneath the footprint
1-3 Hampstead Lane	No planning entries related to basements	Assumed to not have a basement level

There are no London Underground or Network Rail Tunnels within 250 m of the site.

2.4 Geology

The British Geological Survey (BGS) map of the area (Sheet 256) indicates the site to be underlain by the Bagshot Formation overlying the Claygate Member of the London Clay.

GEA has previously carried out a ground investigation at a property on The Grove about 120 m to the southwest of the site, which encountered a significant thickness of made ground overlying the Bagshot Formation, which was underlain by the Claygate Member. The Made Ground extended to depths of between 1.80 m and 3.40 m. The Bagshot Formation generally comprised an initial horizon of soft to firm pale brown mottled orange-brown sandy clay, extending to depths of between 8.20 m and 4.10 m, whereupon medium dense pale brown mottled orange-brown clayey fine to medium sand was encountered, and extended to a depth of 14.90 m. The Claygate Member comprised stiff grey silty clay and extended to the full depth of the investigation, of 15.00 m.

A borehole drilled by the BGS on Hampstead Lane to the north of the site, generally referred to as the 'Hampstead Heath borehole', was advanced to a depth of 66.74 m (61.97 m OD) at National Grid Reference 526455, 186890. The borehole records indicate that the Bagshot Formation extends to a level of 109.71 m OD, which would equate to about 18.5 m below ground level at Highgate West Hill, and penetrated the full thickness of the Claygate Member, which was found to extend to a level of 93.71 m OD.

2.5 Hydrology and Hydrogeology

The Bagshot Formation is classified by the Environment Agency (EA) as a Secondary 'A' Aquifer, which refers to permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.

The Claygate Member is classified by the Environment Agency as a Secondary 'A' Aquifer, which refers to permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. 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 Formation is classified by the EA as an Unproductive Stratum, referring to rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow

During the previous GEA investigation detailed in the previous section, groundwater was encountered at a depth of 12.70 m during drilling, and rose to a depth of 12.30 m after 20 minutes. Three standpipes were installed to a maximum depth of 6.00 m and where found to be dry during two subsequent monitoring visits.

There are no EA designated Source Protection Zones (SPZs) on the site. The Envirocheck report indicates a pond in the garden of a property fronting onto Fitzroy Park is the nearest surface water feature to the site and is located 365 m west of the site. The site is not located in an area at risk of flooding from rivers or sea and surface water, as defined by the EA.

Reference to the Lost Rivers of London[4] indicates that none of London's Lost Rivers were present within 500 m of the site.

4 Nicholas Barton and Stephen Myers (2016) *London's Lost Rivers. Revised Edition.* Historical Publications Ltd

2.6 Preliminary Risk Assessment

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

2.6.1 Source

The desk study research has indicated that the site has only had a residential end use since the the early part of the 18th Century when the main part of the existing house was constructed and is therefore not considered to have had a contaminative history. No sources of soil gas have been identified on site or in the surrounding area.

2.6.2 Receptor

The site will remain in residential use following the redevelopment and therefore end users will continue to represent relatively high sensitivity receptors and as the site is underlain by a Secondary 'A' Aquifer, adjacent sites are considered to be a moderately sensitive receptors. Shallow groundwater is also considered to be a moderately sensitive receptor, while the chalk aquifer at depth is considered to be a particularly sensitive receptor. 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 in the soils during construction works.

2.6.3 Pathway

The presence of the permeable Bagshot Formation would allow the migration of contaminated groundwater through the shallow soils to surrounding sites, although the impermeable layers in the Claygate Member and impermeable London Clay create a barrier to the major Chalk aquifer. In the east of site, end users will be isolated from direct contact with any contaminants present within the made ground by the presence of the building and hardstanding. However, to the rear of the site, existing areas of soft landscaping will remain and will continue to provide a pathway for contaminants to end users. Buried services may be exposed to any contaminants present within the soil through direct contact and site workers will come into contact with the soils during construction works. 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.

2.6.4 Preliminary Risk Appraisal

On the basis of the above it is considered that there is a low risk of there being a significant contaminant linkage at this site, which would result in a requirement for major remediation work.

There is no evidence of filled ground within the vicinity and so there is not considered to be a significant potential for hazardous soil gas to be present on or migrating towards the site; there should thus be no need to consider soil gas exclusion systems.

2.7 UXO Risk Assessment

A Preliminary UXO Risk Assessment has been completed by 1st Line Defence (report ref EP9006-00, dated 5th June 2019), and the report is included in the appendix. The risk assessment has been carried out in accordance with the guidelines provided by CIRIA, 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 Paddington, which sustained a very high density of bombing. However, the site and immediate vicinity are not recorded as being impacted by bombing according to the London bomb census mapping records. As a result, the risk level associated with encountering UXO at the site is low, such that no further consideration of UXO risk is required.

3.0 SCREENING

The LBC 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 45 Highgate West Hill
1a. Is the site located directly above an aquifer?	*Yes. The site is underlain by the Bagshot Formation sands which are designated a Secondary Aquifer by the Environment Agency, capable of supporting flow to watercourses and private abstractions. Aquifer designation maps acquired from the Environment Agency as part of the desk study and Figures 3, 4 and 8 of the Arup report confirm this.*
1b. Will the proposed basement extend beneath the water table surface?	Unlikely. The proposed basement will extend to a depth of 3.2 m below ground level. The previous nearby investigation performed by GEA indicated groundwater to be absent to a depth of 12.7 m below ground level such that groundwater should not be encountered within the basement excavation.
2. Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line?	No. Topographical maps acquired as part of the desk study and Figures 11 and 12 of the Arup report confirm this.
3. Is the site within the catchment of the pond chains on Hampstead Heath?	No. The site lies outside of the catchment area for the Golders Hill pond chains as shown on Figures 14 of the Arup report.
4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No. The basement development will include a single level basement beneath an area that is already occupied by an existing extension to the house and an area of rear paving such that the proportion of hardstanding will remain unchanged.
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. 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?	No. Topographical maps acquired as part of the desk study and Figures 11 and 12 of the Arup report confirm this.

Q1 The site is underlain by the Bagshot Formation which is classified a Secondary 'A' Aquifer.

The above assessment has not identified any potential issues that need to be further assessed:

3.1.2 Stability Screening Assessment

Question	Response for 45 Highgate West Hill
1. Does the existing site include slopes, natural or manmade, greater than 7°?	No. Fig 16 of the Arup report does not show the site to be in an area with slopes greater than 7°. Ordnance survey maps show the site and immediate surrounding area to be relatively level at approximately 125 m OD.
2. Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7°?	No, not according to proposed drawings supplied by the consulting engineer.
3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	No. Not according to Figure 16 of the Arup report.
4. Is the site within a wider hillside setting in which the general slope is greater than 7°?	No. Figure 16 of the Arup report shows the site to be a significant distance from areas containing sustained slopes of greater than 7°.
5. Is the London Clay the shallowest strata at the site?	No. Not according to Figure 2 of the Arup report or the BGS map of the area.
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. The arboricultural report for the development has indicated that two small weeping birch and hawthorn trees will be removed from the rear garden.*
7. Is there a history of seasonal shrink-swell subsidence in the local area and / or evidence of such effects at the site?	No. The Bagshot Sands are predominantly granular and are not capable of shrink swell. Also, information derived from the Envirocheck report indicates the site is not in an area susceptible to ground shrink swell stability hazards.
8. Is the site within 100 m of a watercourse or potential spring line?	No. Not according to Figure 12 of the Arup report, extracts from the Envirocheck report and Ordnance Survey maps.
9. Is the site within an area of previously worked ground?	No. Not according to Figure 3 of the Arup report.
10. Is the site within an aquifer?	*Yes. The site is underlain by the Bagshot Formation which is classified as a Secondary 'A' Aquifer by the Environment Agency (EA).*
11. Is the site within 50 m of Hampstead Heath ponds?	No. Not According to Figure 14 of the Arup report.
12. Is the site within 5 m of a highway or pedestrian right of way?	No. The site boundary is within 5 m of a pedestrian right of way, but the proposed basement is not.
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	*Yes. According to the Camden Planning Portal, not all neighbouring properties have basement levels. It is therefore assumed that foundation level of neighbouring buildings is generally relatively shallow and thus the proposed scheme will deepen foundations relative to some of the neighbouring properties.*
14. Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	No. Not according to Figure 18 of the Arup report.

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

Q6 The Arboriculturist report for the site indicates that two trees will be removed from the rear garden

Q10 The site is underlain by a Secondary 'A' Aquifer, as defined by the EA

Q13 The proposed development will extend foundations deeper relative to some neighbouring properties

3.1.3 Surface Flow and Flooding Screening Assessment

Question	Response for 45 Highgate West Hill
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 generated from an increased impermeable area will be attenuated to ensure they are not increased or altered. The basement will entirely 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 2018 does not apply.
3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No. The proposed hard surfacing/roof will not increase beyond the extent of the existing building and hardstanding.
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 generated from an increased impermeable area will be attenuated to ensure they are not increased or altered. The basement will entirely 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 2018 does not apply.
5. Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No. The proposed basement 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 3iii, 4e, 5a and 5b of the SFRA dated 2014, in addition to the Environment Agency online flood maps show that the site has a low flooding risk from surface water, groundwater, sewers, reservoirs (and other artificial sources), and fluvial/tidal watercourses. In accordance with paragraph 6.16 of the CPG a positive pumped device and non-return valve will be installed in the basement in order to further protect the site from sewer flooding.

The above assessment has identified no potential issues that need to be assessed.

4.0 SCOPING AND SITE INVESTIGATION

The purpose of scoping is to assess in more detail the factors to be investigated in the impact assessment. Potential 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 underlain by a Secondary 'A' Aquifer, as defined by the EA	Groundwater present within the aquifer may enter the proposed excavation and cause structural instability and damage. There is potential for the contamination of groundwater.
Trees will be felled as a result of the basement development	The soil moisture deficit associated with the felled trees will gradually recover and in high plasticity soils this can lead to swelling of the ground. Additionally, It could reduce the strength of the soil affecting slope stability, as could the loss of the binding effect of tree roots in soil.
The proposed basement will significantly increase differential depth of foundations to neighbouring properties	Ground movements associated with significantly changing the differential depth of foundations to neighbouring properties could result in structural damage.

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

4.2 Exploratory Work

Access to the site, and in particular to the rear of the house, was restricted by the existing buildings. In order to meet the objectives described in Section 1.2 as far as possible within these restrictions, a single borehole was advanced to a depth of 15.00 m using a cable percussion rig in the shared access area at the front of the site. In addition, two window sampler boreholes were advanced to a depth of 5.00 m in the rear garden to provide further coverage of the site.

During boring, disturbed and undisturbed samples were obtained from the boreholes for subsequent laboratory examination and testing. Standard Penetration Tests (SPTs) were carried out at regular intervals within the cable percussion borehole to provide additional quantitative data on the strength of soils encountered.

Groundwater monitoring standpipes were installed in all of the boreholes, to a maximum depth of 6.0 m, and have subsequently been monitored on a single occasion to date.

Two trial pits were hand excavated to a maximum depth of 1.06 m in order to determine the configuration of the existing foundations of the main house.

A selection of the disturbed 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 work was carried out under the supervision of a geotechnical engineer from GEA. The borehole records are appended, together with the results of the laboratory testing and a site plan indicating the borehole locations. Ordnance Datum (OD) levels have been based on a single spot height for the site shown on a series of unreferenced drawings provided by the architect, Chris Dyson Architects.

4.2.1 Sampling Strategy

The boreholes and trial pits were positioned on site by an engineer from GEA in accessible areas, with due regard to the proposed development and the locations of known buried services.

Three samples of the shallow soil and were subjected to analysis for a range of common industrial contaminants and contamination indicative parameters. For this investigation the analytical suite for the soil and water included a range of metals, total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), total cyanide and monohydric phenols.

The soil samples were selected to provide a general view of the chemical conditions of the soils that are likely to be involved in a human exposure or groundwater pathway and to provide advice in respect of re-use or for waste disposal classification. The contamination analyses were carried out at a MCERTs accredited laboratory with the majority of the testing suite accredited to MCERTS standards.

A number of the disturbed and undisturbed samples of natural soil were submitted to a geotechnical testing laboratory and were subject to a number of material property tests, including four-point Atterberg Limit, moisture content tests and particle size distribution tests (PSD).

5.0 GROUND CONDITIONS

The investigation has confirmed the expected ground conditions in that, below a nominal to moderate thickness of made ground, the Bagshot Formation was encountered overlying the Claygate Member, which extended to the full depth of the investigation, of 15.00 m.

5.1 Made Ground

The made ground generally comprised dark brown clayey sand with gravel and variable amounts of brick, ash, concrete and paving fragments and extended to depths of between 1.05 m and 2.40 m.

No evidence of significant contamination was identified during the fieldwork. As a precaution three samples of the made ground were tested for the presence of contamination and the results are presented in Section 6.5.

5.2 Bagshot Formation

The Bagshot Formation predominantly comprised orange-brown and occasionally orange-brown mottled pale brown clayey sand with occasional layers of sandy clay and extended to a depth of 13.40 m (114.90 m OD).

Atterberg results show the clay layers to be of medium shrinkability while the results of quick undrained triaxial compression tests have indicated the clay to be high strength.

No evidence of contamination was noted in these soils.

5.3 Claygate Member

The Claygate Member comprised stiff fissured dark grey very sandy clay and extended to the full depth of the investigation, of 15.00 m (113.30 m OD). The results of laboratory undrained triaxial compression tests have indicated the clay to be medium strength.

No evidence of contamination was noted in these soils.

5.4 Groundwater

Groundwater was not encountered during drilling. The standpipe installed in Borehole No 1 was found to be dry during the single visit carried out to date. Access was not possible to the standpipes installed at the rear of the site during this visit.

5.5 Soil Contamination

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

Determinant	BH2 0.40 m	BH3 0.40 m	BH2 2.00 m
Asbestos	Not-detected	Not-detected	Not-detected
pH	8.0	8.1	8.1
Arsenic	20	16	11
Cadmium	<0.2	<0.2	<0.2
Chromium	<4.0	<4.0	<4.0
Copper	84	50	81
Mercury	1.6	0.6	<0.3
Nickel	16	13	8.7
Lead	**780**	**460**	54
Selenium	<1.0	<1.0	<1.0
Zinc	120	110	30
Total Cyanide	<1	<1	<1
Total Phenols	<1.0	<1.0	<1.0
Sulphide	6.3	2.4	3.0
Total TPH	40	200	<10
Naphthalene	<0.05	0.28	<0.05
Benzo(a)pyrene	0.28	2.5	<0.05
Total PAH	2.61	38.9	<0.80
Total organic carbon %	1.8	1.4	0.6

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. To this end contaminants of concern are those that have values in excess of a generic human health risk based guideline values which are either that of the CLEA[5] Soil Guideline Value where available, or is a Generic Guideline Value calculated using the CLEA UK Version 1.06 software assuming a residential with plant uptake end use. The key generic assumptions for this end use are as follows:

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

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

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

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

The contamination testing has indicated two of the samples tested to contain elevated concentrations of lead. No other elevated concentrations of contaminants were encountered within the samples tested and the significance of which is discussed further in Part 2.

The results are discussed in detail in Section 2 of this report.

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

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	Rear Façade	Mass concrete strip / trenchfill Top 630 mm Base 790 mm Lateral projection 620 mm	Made Ground (dark brown slightly clayey sand with gravel, and fragments of brick and ceramic)
2	Rear Façade	Mass concrete strip / trenchfill Top 465 mm Base 965 mm Lateral projection 235 mm	Made Ground (dark brown slightly clayey sand with gravel, and brick fragments)

Part 2: DESIGN BASIS REPORT

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

6.0 INTRODUCTION

It is understood that it is proposed to demolish the existing single storey side extension to the main building and subsequently construct a two storey extension with a single level basement section beneath part of the new extension.

The new basement section will have a finished floor level about 2.80 m below existing ground level resulting in an excavation of approximately 3.20 m depth with formation level being approximately 125.30 m OD.

The loads from the proposed new basement will be supported by piled foundations with a lightly loaded ground bearing basement floor slab.

7.0 GROUND MODEL

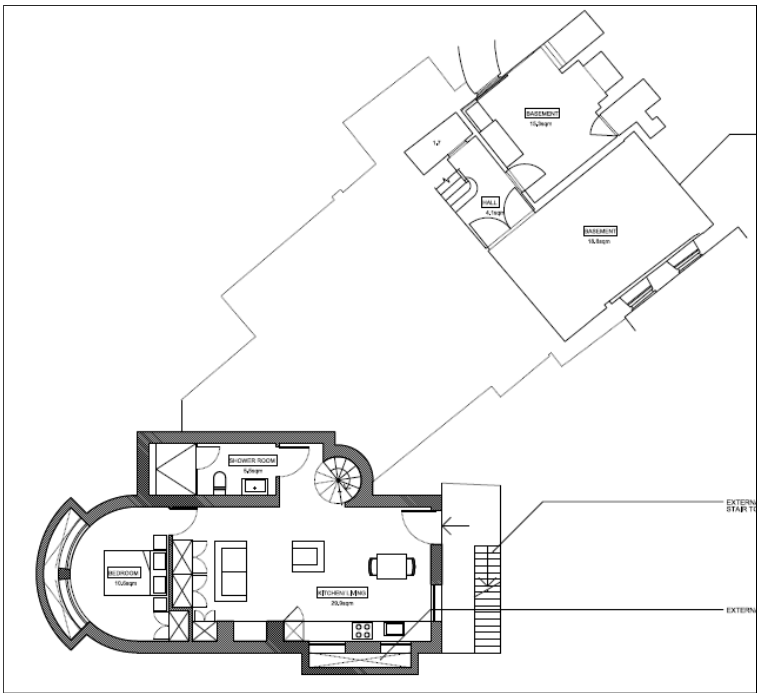
The desk study research indicates that the site has not had a potentially contaminative history, having had a residential use for its entire developed history. On the basis of the fieldwork, the ground conditions at this site can be characterised as follows:

- below a nominal to moderate thickness of made ground, the Bagshot Formation is present and underlain by the Claygate Member which was proved to the maximum depth investigated of 15.00 m (113.30 m OD);
- the made ground generally comprises dark brown clayey sand with gravel and variable amounts of brick, ash, concrete and paving fragments and extends to depths of between 1.05 m and 2.40 m;
- the Bagshot Formation predominantly comprises medium dense orange-brown medium to fine grained sand with variable clay and silt content, with occasional layers orange-brown sandy clay and extends to a depth of 13.40 m (114.90 m OD).
- the Claygate Member generally comprises stiff fissured dark grey very sandy clay extending to the maximum depth investigated, of 15.00 m (113.30 m OD);
- groundwater was not encountered during the investigation; and,
- the contamination testing has measured two of the three samples tested to contain elevated concentrations lead.

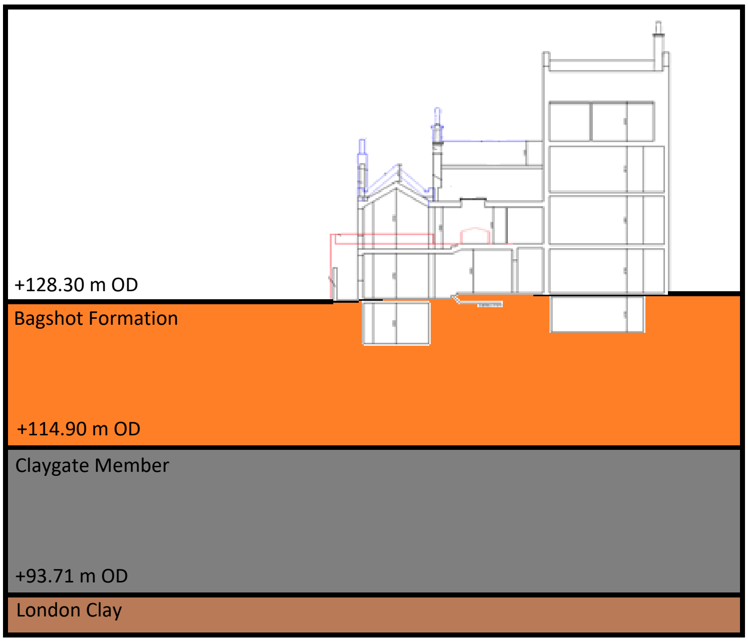
7.1 Conceptual Site Model

A section through the proposed scheme with the above ground model is shown below.

Plan



Section



8.0 ADVICE AND RECOMMENDATIONS

The consulting structural engineer has provided a preferred construction scheme with respect to the basement construction and founding options. It is proposed to form the basement within contiguous bored piled walls which will also be used to support the loads of the building. Given that groundwater is unlikely to be encountered within the basement excavations, the use of contiguous walls is likely to be appropriate for the proposed scheme.

The formation level for the basement will be at a depth of 3.20 m below ground level (125.30 m OD) and should therefore be within the slightly clayey sand of the Bagshot Formation.

8.1 Basement Excavation

8.1.1 Basement Construction

The investigation has indicated that groundwater should not be encountered in the basement excavation. However, given the variable nature of the ground conditions and the potential for perched water to be present in the more permeable layers of the Bagshot Formation, it would be prudent, once access is available, to carry out a number of trial excavations, to depths as close to the full basement depth as possible, to provide an indication of the likely groundwater conditions. The basement excavation will expose a greater volume of soil than has been investigated by the boreholes and it is possible that larger pockets or inter-connected layers of higher permeability soils could be encountered. Therefore, it is also recommended that monitoring of the standpipes is continued.

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 will be governed, to a large extent, by whether it is to be incorporated into the permanent works and have a load bearing function and also by the limited available access. The final choice will depend on a number of factors, including the need to protect nearby structures from movements, the required overall stiffness of the support system and the potential need to control groundwater movement through the wall in the temporary condition. In this respect the stability of the adjacent buildings will be paramount.

It is proposed to utilise contiguous bored pile walls to support the basement excavation. On the basis of the monitoring to date, the use of contiguous bored pile walls is feasible.

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 Basements guidance and is presented in Part 3 below.

8.1.2 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	20
Bagshot Formation (Sands)	1900	Zero	31
Bagshot Formation (Clay)	1900	Zero	24
Claygate Member	1900	Zero	26

Significant inflows of groundwater are unlikely to be encountered within the basement excavation, although monitoring of the standpipes should be continued in order to establish equilibrium levels. Consideration should however be given to the risk of surface water building up behind the retaining walls and unless adequate drainage can be incorporated to prevent such build-up, it is recommended that a water level of three-quarters of the retained height be adopted in the design of new retaining walls. Reference should be made to BS8102:2009[6] with regard to requirements for waterproofing.

8.1.3 Basement Heave

The 3.20 m deep basement excavation will result in a net unloading of up to approximately 60 kN/m². The proposed excavations will result in elastic heave and long term swelling of the clay layers within the Bagshot Formation and underlying Claygate Member. The effects of the longer term swelling movement will to a certain extent be counteracted by the applied loads from the development and the granular deposits found in both stratum. Further consideration is given to heave movements in the Ground Movement Assessment report which is presented in Part 3 of this report.

8.2 Spread Foundations

It should be possible to adopt spread foundations provided that proposed loads are relatively light. Given the basement excavation depth of 3.20 m all new foundations should bypass any potentially desiccated soils and there should not be a need for further deepening to take account for the presence of possible tree root effects.

Spread foundations bearing beneath basement formation level in the medium dense clayey sand of the Bagshot Formation may be designed to apply a net allowable bearing pressure of 120 kN/m². The requirement for compressible material alongside foundations should be determined by reference to the NHBC guidelines.

If the proposed loads are too high or the required founding depths become uneconomic piled foundations would provide a suitable alternative foundation option.

8.3 Piled Foundations

Given the ground conditions at this site a conventional rotary augered pile may be appropriate but consideration will need to be given to the possible instability and water ingress in the Bagshot Formation and Claygate Formation from within any silty or sandy zones. The use of bored piles installed using continuous flight auger (cfa) techniques may therefore be the most appropriate.

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

The following table of ultimate coefficients may be used for the preliminary design of bored piles, based on the SPT / elevation graph in the appendix and a water table of 13.0 m depth (98.72 m OD).

Stratum	Depth (m) [m OD]	kN / m^2
Ultimate Skin Friction		
Basement	G.L to 3.2 m [128.3 to 125.1]	Ignore
Bagshot Formation	3.2 to 13.4 [125.1 to 114.9]	69
Claygate Member	13.4 to 15.0 [114.9 to 113.3]	Increasing linearly from 20 to 25
Ultimate End Bearing		
Bagshot Formation	10.00 to 12.00 [118.3 to 116.3]	Increasing linearly from 575 to 705

In the absence of pile testing a factor of safety of 3.0 should be applied to the above coefficients in the computation of safe theoretical working loads.

On the basis of the above coefficients and a factor of safety of 3.0, the following pile capacitiy has been estimated for a 350 mm diameter pile as suggested by the consulting engineers.

Pile Diameter mm	Effective Pile length	Pile Toe Depth	Safe Working Load kN
350	6.8	10	365

The above examples 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 an appropriate piling scheme and their attention should be drawn to potential groundwater inflows within the made ground and from within silt and sand partings within the Bagshot Formation and Claygate Member.

8.4 Basement Floor Slabs

Following the excavation of the single level basement, a lightly loaded ground bearing floor slab is to be adopted for the development, which is considered feasible.

8.5 Shallow Excavations

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

Significant inflows of groundwater into shallow excavations are not generally anticipated, although seepages may be encountered from localised perched water tables within the made ground or from within more silty and sandy horizons from within the Bagshot Formation and Claygate Member, although such inflows should be suitably controlled by sump pumping.

If deeper excavations are considered it is recommended that provision be made for 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.

8.6 Effect of Sulphates

Chemical analyses have generally 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), while the measured pH values of the samples show that an ACES class of AC-1 would be appropriate for the site. This assumes a mobile water condition at the site. The guidelines contained in the above digest should be followed in the design of foundation concrete.

8.7 Site Specific Risk Assessment

The desk study research has indicated that the site has only had a residential end use since the 1700s when the main part of the existing house was constructed and as a result the site is not considered to have had a potentially contaminative history. Furthermore, the results of the contamination testing have indicated two of the three samples of made ground tested to contain an elevated concentration of lead, with all other contaminants being present at low levels.

The source of the lead contamination is not known, although the made ground was noted as containing fragments of extraneous material and it is possible that these fragments, possibly lead based paint or coal, could be the source of the lead contamination. In addition, reference to the Envirocheck report has indicated that the site lies within an area known to have a background concentration of lead of between 300 mg and 600 mg. Furthermore, a localised area known to have a background lead concentration of between 600 mg and 900 mg is known to have been present nearby to the north of the site. The development will not result in an increase in soft landscaping at the site, meaning exposure will remain as it has been throughout the history of the site. As a result, a requirement for remedial measures at the site is not considered to be required. However, measures will be required to protect site workers.

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[7] and CIRIA[8] and the requirements of the Local Authority Environmental Health Officer.

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

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

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

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[9] 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[10] 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 £91.35 per tonne (about £219 per m^3) or at the lower rate of £2.90 per tonne (roughly £6.95 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 upon 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	£91.35/tonne (Standard rate)
Natural Soils	Inert (17 05 05)	Should not be required but confirm with receiving landfill	£2.90 / 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[11] which states that in certain circumstances, segregation at source may be considered as pre-treatment and thus excavated material may not have to be treated prior to landfilling if the soils can be segregated onsite prior to excavation by sufficiently characterising the soils insitu prior to excavation.

The above opinion with regard to the classification of the excavated soils 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.

9 Environment Agency 2015. *Guidance on the classification and assessment of waste.* Technical Guidance WM3 First Edition
10 CL:AIRE March 2011. *The Definition of Waste: Development Industry Code of Practice* Version 2
11 Environment Agency 23 Oct 2007 *Regulatory Position Statement Treating non-hazardous waste for landfill - Enforcing the new requirement*

9.0 BASEMENT IMPACT ASSESSMENT

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

The table below summarises the previously identified potential impacts of the development and the following paragraphs detail the additional information that is now available from the site investigation and how this will effect each potential impact.

Potential Impact	Consequence
The site is underlain by a Secondary 'A' Aquifer, as defined by the EA	Groundwater present within the aquifer may enter the proposed excavation and cause structural instability and damage. There is potential for the contamination of groundwater.
Trees will be felled as a result of the basement development	The soil moisture deficit associated with the felled trees will gradually recover and in high plasticity soils this can lead to swelling of the ground. Additionally, It could reduce the strength of the soil affecting slope stability, as could the loss of the binding effect of tree roots in soil.
The proposed basement will significantly increase differential depth of foundations to neighbouring properties	Ground movements associated with significantly changing the differential depth of foundations to neighbouring properties could result in structural damage.

The proposed basement will significantly increase the differential depth of foundations relative to neighbouring properties

A search of the Camden Planning portal suggested some of the neighbouring properties do not have basements, while others do. To this extent and to remain conservative it has been assumed that where the presence of a basement has not been identified through the planning portal the surrounding houses are founded on shallow foundations at approximately 1.0 m depth. It is expected that the proposed scheme will be result in foundations extending a significantly greater depth relative to the existing foundations of the neighbouring properties.

A Ground Movement Analysis has been carried out to determine the effects of the basement development on the nearby buildings and the results are discussed in Part 3 below.

The site is underlain by a Secondary 'A' Aquifer

There is a potential for groundwater to be present within the Secondary 'A' Aquifer beneath the site, however, the findings of the investigation have indicated groundwater to not be present at shallow depths beneath the site such that significant inflows of groundwater are not anticipated. Trial excavations to as close to the full basement excavation depth as possible should be carried out to confirm this view when possible and in the interim monitoring of the standpipes should be continued. In addition, the samples of made ground tested from the site have been found to be free from elevated concentrations of soluble contaminants and the site is not considered to have had a potentially contaminative history. As a result a risk of contaminating the aquifer is not envisaged.

Trees will be felled as part of the development

The removal of trees will result in the recovery of the associated moisture deficit in the soils ion the vicinity of these trees. However, the trees are relatively small and the basement depth is sufficiently deep as to bypass any soils that could potentially be affected. Furthermore, the

Bagshot Formation beneath the site has been found to be predominantly granular and as such has limited potential for significant shrink/swell movement. In addition, the site is essentially level such that any loss of strength resulting from the additional moisture or the removal of the root networks is unlikely to trigger any ground movement with respect to slope stability.

9.1 BIA Conclusion

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.

9.2 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.

9.2.1 Screening

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?	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 and existing plans of the site have confirmed that the proposed basement scheme will not increase the amount of hardstanding.
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?	As above.
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 SFRA dated 2014.

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?	Site investigation.
2. Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line?	Historical maps acquired as part of the desk study 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 that the basement development will only replace existing hardstanding areas.
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 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°?	Site survey drawing 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 and confirmed during a site walkover
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 Arboriculturist report prepared for the site and the existing and proposed ground floor drawings prove that two trees from the rear garden will be removed
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 and the Lost Rivers of London book.
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.

Question	Evidence
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.

9.2.2 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 and the engineering properties of the underlying soils to enable suitable design of the basement development. The findings of the investigation are discussed in Part 2 of this report and summarised in the Executive Summary.

9.2.3 Impact Assessment

Section 10.0 of this report summarises whether or not, 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 below.

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.

10.0 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 during underpinning 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.

10.1 Ground Movements

An assessment of ground movements within and surrounding the excavation has been undertaken using the X-Disp and P-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 analysis of potential ground movements within the excavation, as a result of unloading of the underlying soils, has been carried out using the Oasys P-Disp (Version 20.0 – Build 12) software package and is based on the assumption that the soils behave elastically, which provides a reasonable approximation to soil behaviour at small strains.

The X-Disp program (Version 20 - Build 14) has been used to predict ground movements likely to arise from the construction of the proposed basement. This includes the lateral movement of soil behind the proposed retaining walls (horizontal movement).

For the purpose of these analyses, the corners have been defined by x and y coordinates, with the x-direction roughly parallel with the orientation east-west, whilst the y-direction is parallel with the orientation of north-south. Vertical movement is in the z-direction. All walls have been modelled as a series of 1 m long structural elements.

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.

10.2. Construction Sequence

The following sequence of operations has been supplied by the consulting engineers and has been adopted to enable analysis of the ground movements around the proposed basement both during and after construction.

In general, the sequence of works for basement construction will comprise the following stages.

1. Demolish existing structures where necessary;

2. Grub out existing foundations and drainage;

3. Install contiguous bored pile walls from ground level;

4. Excavate and construct reinforced concrete capping beam just below ground floor level and prop capping beam across;

5. Excavate to formation level and cast blinding layer followed by 250 mm thick basement floor slab along with any drainage and waterproofing measures;

6. Install reinforced concrete lining walls; and,

7. Once slab is in place remove props then cast ground floor slab.

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 be cantilevered for a short period in between the removal of the props at ground floor level and casting of the ground floor slab.

The detail of the support provided to adjacent walls is beyond the scope of this report at this stage and the structural engineer will be best placed to agree a methodology with the piling contractor once appointed.

10.3 P-Disp Model

At this site, unloading of the underlying London Clay will take place as a result of the excavation of the basement, such that the reduction in vertical stress in the short term 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. The model is based on the assumption that the soils behave elastically, which provides a reasonable approximation to soil behaviour at small strains. Drained parameters have been used to provide an estimate of the total movement, which includes long term swelling that will continue for a number of years.

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 and we have used a well-established method to provide our estimates. This relates values of E_u and E', the undrained and drained stiffness respectively, to values of undrained cohesion, as described by published data[12] indicating stiffness values of 750 x Cu for the London Clay and a ratio of E' to Eu of 0.75, which is considered a sensible approach for this stage in the design. The profile of the underlying stratum have been interpolated from the results of the

12 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

ground investigation detailed in the previous sections of the report, with a design line being extended from the maximum depth investigated, of 15 m, to the base of the London Clay Formation. The base of the London Clay is considered to be at a depth of about 129 m below ground level, as indicated by an archived BGS borehole (reference TQ28NE446, located 200 m to the southwest).

The excavation of the proposed basement will extend to a depth of 3.20 m below ground level and will resulting in an approximate unloading of 60 kN/m^2, which could result in an elastic heave and long term swelling of the cohesive layers of the Bagshot Sand and Claygate Member.

The effects of the longer term swelling movement will be mitigated to some extent by the presence of layers of granular material interbedded with the cohesive layers, coupled with the load applied by the proposed building.

The loading arrangement has been modelled in accordance with information provided in the Structural Stability Report by Momentum (ref 4144_MOM_HGHW_ZZ_RPT_S_Structural Stability, dated 6 August 2019).

The soil parameters used in this assessment are tabulated below.

Stratum	Depth range (m below ground level) [m OD]	Eu (MPa)	E' (MPa)
Made Ground	GL to 1.4 [128.3 to 126.9]	10	10
Bagshot Formation	1.4 to 13.4 [126.9 to 114.9]	42	42
Claygate Member	13.4 to 34.6 [114.9 to 93.7]	30 to 97.5	22.5 to 73.1
London Clay	34.6 to 128.3 [93.7 to 0.0]	97.5 to 322.5	73.1 to 241.9

A rigid boundary for the analysis has been set at the base of the London Clay at roughly 129 m below ground level where a nearby BGS borehole indicate that the base of this formation is likely to be present.

10.3.1 Results

The P-Disp analysis indicates that, by the time the basement construction is complete, about 12 mm of heave is likely to have taken place at the centre of the basement excavation, reducing to between 5 mm and 10 mm of around the edge of the basement. The potential movements are shown in the following table and shown on contour plans in the appendix.

Location	Movement (mm) + = settlement / - = heave	
	Short-term	Total
Centre of Extension	-10 mm	-12 mm
Edge of excavation	-5 mm to -8 mm	-5 mm to -10 mm

10.4 Ground Movements – Surrounding the Basement

Settlement of the soil behind the new retaining wall may occur during installation due to the excavation in front of the wall causing the wall to deflect. For an underpinned wall this movement is likely to be small as the wall will be subject to a continued vertical loading from the structure above, which will also act as additional support at ground level. The magnitude of the settlement will be controlled to a large extent by the quality of workmanship of the underpins and by the existing building that is likely to provide additional rigidity.

The basement excavation will be supported by a contiguous bored pile walls. The ground movement curves for 'installation of a contiguous bored pile wall in stiff clay' have been adopted to model the movements occurring as a result of pile installation. These curves have been utilised as the curves in CIRIA 760 for an excavation in sand are not considered to be based on a sufficient number of case studies and predict no horizontal movement to occur. The use of the curves for stiff clay is considered to provide a conservative assessment with the movements resulting from an excavation in sand being likely to result in less movement. For the excavation phase the movement curves for 'excavation in front of a high stiffness wall in stiff clay' have been adopted.

It should be noted that the proposed basement footprint contains re-entrant corners. The inclusion of re-entrant corners may result in the amplification of movements where predicted movements from each wall overlap which will not be the case in practice. As a result the analysis is considered to provide conservative assessment.

10.4.1 Results

The movements predicted by X-Disp are summarised in the table below; and are presented to the degree of accuracy required to allow predicted variations in ground movements around the structure to be illustrated, but may not reflect the anticipated accuracy of the predictions.

Phase of Works	Movement (mm) + = settlement / - = heave	
	Vertical	Horizontal
Pile Installation	Up to 8 mm	Up to 6 mm
Combined Movements	Up to 12 mm	Up to 13 mm

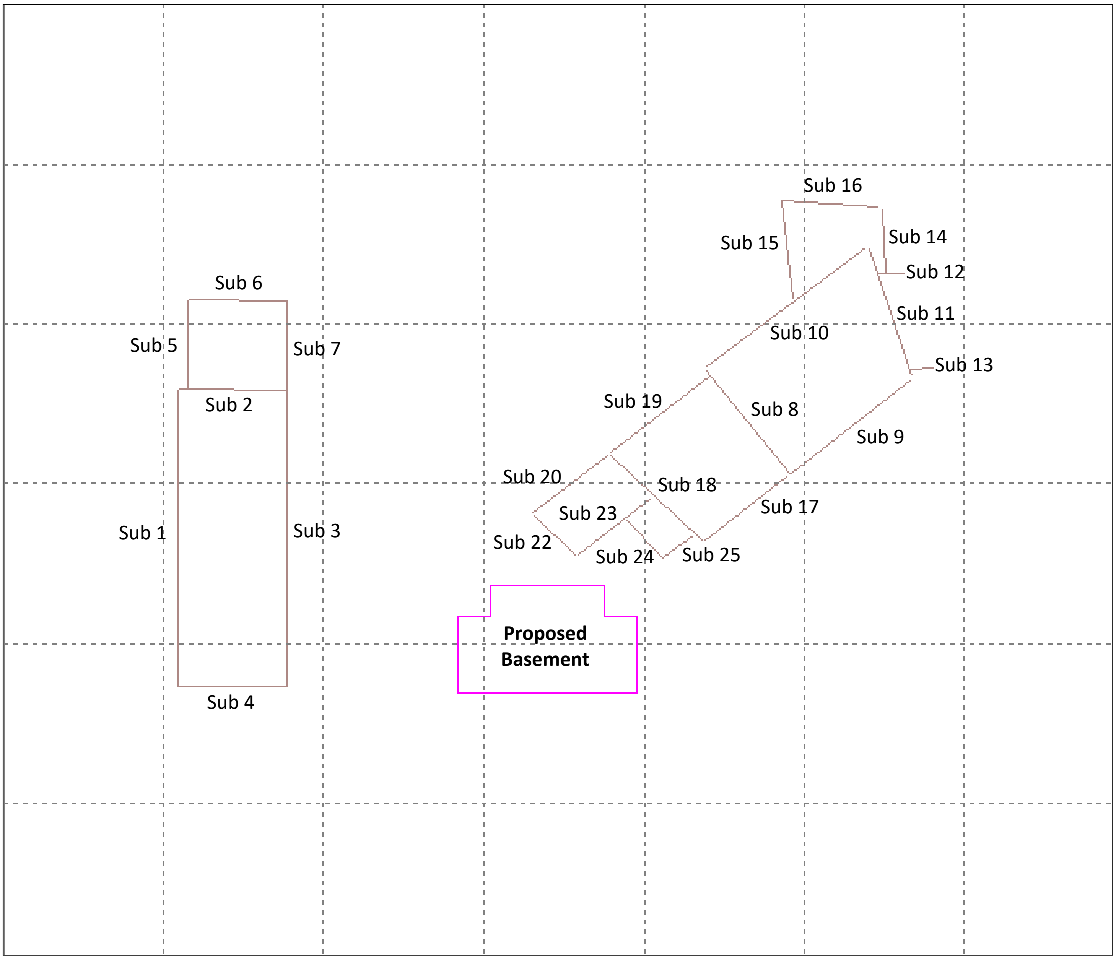
10.5 Damage Assessment

In addition to the above assessment of the likely movements that will result from the proposed development, the neighbouring buildings are considered to be sensitive structures, requiring Building Damage Assessments, on the basis of the classification given in Table 6.4 of C760[1]. These buildings are as follows:

- Nos 1 to 5 The Grove;
- No 45 Highgate West Hill; and,
- No 46 Highgate West Hill.

The sensitive structures outlined above have been modelled as lines in the analysis and are the lines along which the damage assessment has been undertaken. The location of each of the buildings is detailed on the plan below.

For the analyses it has been assumed that the original sections of Nos 45 and 46 Highgate West have a basement level extending to a depth of 2.40 m below ground level and Nos 1-5 The Grove has a basement extending to a depth of 2.60 m below ground level, as detailed in the planning archive information. The remainder of the walls are assumed to have foundations extending to a depth of 1.00 m below ground level.



10.5.1 Damage to Neighbouring Structures

The combined movements resulting from both retaining wall installation and basement excavation calculated using the X-Disp modelling software have been used to carry out an assessment of the likely damage to adjacent properties. All structures were predicted as sustaining damage Category 1 (very slight) or less with the exception of the front façade of the original section of No 45 Highgate West Hill (Wall 23) which was found to move in three segments. One of those segments is predicted to sustain Category 0 (negligible) damage, while the other two are predicted to sustain Category 2 (slight) damage. However, in reality the wall will act as a more monolithic structure and the predicted differential movements are likely to be distributed across the entire length of the wall. As a result the two segments of predicted movements have been combined resulting in a predicted damage of Category 1 (Very Slight). On this basis, the damage that would inevitably occur as a result of basement construction would fall within the acceptable limits. The detailed tabular output can be seen in the Appendix.

10.6 Utilities and buried services

A search of all the local utilities and buried services was carried out prior to the site investigation. As all known services are outside the 1 mm contour and due to the topography of the site, it is deemed that none of the known services will be affected by the works. Furthermore, in accordance with the CMS, any private services on site that are to be affected by the works are to be redirected.

10.7 Ground Movement Assessment Conclusions

The analysis has concluded that the predicted damage to the neighbouring properties would generally be 'negligible to very slight', which is deemed to be acceptable.

The separate phases of work, including the installation of underpinned and piled retaining walls and subsequent excavation of the proposed basements, will in practice be separated by a number of weeks. This will provide an opportunity for the ground movements during and immediately after excavation 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.

11.0 OUTSTANDING RISKS AND ISSUES

This section of the report aims to highlight areas where further work is required as a result of limitations on the scope of this investigation, or where issues have been identified by this investigation that warrant further consideration. The scope of risks and issues discussed in this section is by no means exhaustive, but covers the main areas where additional work 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 would be prudent, once access is available, to carry out a number of trial excavations, to depths as close to the full basement depth as possible, to provide an indication of the likely groundwater conditions. Continued monitoring of the standpipes to establish any seasonal fluctuations and a groundwater design line is also recommended.

APPENDIX

Borehole Records

SPT vs Elevation Plot

Laboratory Geotechnical Results

Contamination Results

Generic Risk Based Screening Values

Envirocheck Report Extracts

Historical Maps

Preliminary UXO Risk Assessment

Ground Movement Analysis Results:

PDISP
Short term movement plot
Total movement plot

XDISP

Pile Installation Model Outputs:
Vertical settlements
Horizontal settlements

Combined Model Outputs:
Vertical settlements
Horizontal settlements
Building Damage Inputs and Outputs

Site Plan

GEA Geotechnical & Environmental Associates
Widbury Barn | Widbury Hill | Ware | SG12 7QE

Site	Borehole Number
45 Highgate West Hill, London N6 6DB	BH1

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	150 mm to 12.00 m	128.30	Mr Tim & Mrs Ciara Rowe	J19183
	Location	**Dates** 11/07/2019-12/07/2019	**Engineer** Momentum	**Sheet** 1/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description
							Made Ground (dark brown clayey sand with gravel and brick, concrete and paving fragments with pockets of clayey sand from 0.90 m)
0.50	D1					(1.40)	
0.90	D2						
1.20-1.65 1.20-1.65	SPT(C) N60=59 B3	1.20	DRY	5,8/10,12,15,18	126.90	1.40 (0.40)	Dense orange-brown slightly clayey fine to coarse SAND with sub-rounded fine to coarse gravel
1.80	D4				126.50	1.80	Medium dense brown slightly clayey fine to coarse SAND
2.00-2.45 2.00-2.45	SPT N60=21 D5	1.50	DRY	2,3/4,4,5,7			
2.80	D6					(1.90)	
3.00-3.45 3.00-3.45	SPT N60=23 D7	1.50	DRY	6,6/5,5,6,6			
3.70	D8				124.60	3.70 (0.30)	Firm orange-brown mottled pale brown slightly sandy slightly silty CLAY
4.00-4.45 4.00-4.45	SPT N60=9 D9	1.50	DRY	1,1/2,1,3,2	124.30	4.00 (0.90)	Orange-brown fine to medium SAND
4.80	D10				123.40	4.90	Firm orange-brown very sandy CLAY
5.00-5.45 5.00-5.45	SPT N60=18 D11	1.50	DRY	1,3/4,4,4,5		(1.10)	
6.00-6.45	U12				122.30	6.00	Dense brown slightly clayey fine to coarse SAND
6.50	D13						
7.50-7.95 7.50-7.95	SPT N60=32 D14	1.50	DRY	2,3/4,8,9,9		(4.00)	
9.00-9.45 9.00-9.45	SPT N60=39 D15	9.00	DRY	6,9/9,9,9,10			

Remarks
Groundwater monitoring standpipe installed to a depth of 6.00 m and found to be dry during monitoring visit on 26/07/19.
Groundwater not encountered,
Water added to assist drilling at depths of between 9.80 m and 12.90 m.
1 hr 30 mins spent excavating services pit.

Scale (approx)	Logged By
1:50	AT

Figure No. J19183.BH1

GEA — Geotechnical & Environmental Associates
Widbury Barn | Widbury Hill | Ware | SG12 7QE

Site	Borehole Number
45 Highgate West Hill, London N6 6DB	BH1

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	150 mm to 12.00 m	128.30	Mr Tim & Mrs Ciara Rowe	J19183

Location	Dates	Engineer	Sheet
	11/07/2019-12/07/2019	Momentum	2/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					118.30	10.00	Medium dense brown mottled orange-brown clayey fine to medium SAND		
10.50-10.95 10.50-10.95	SPT N60=28 D16	10.50	10.10	3,5/6,6,7,7					
						(2.00)			
12.00-12.45 12.00-12.45	SPT N60=31 D17	12.00	10.90	4,4/6,7,8,8	116.30	12.00	Dense pale orange-brown very clayey fine SAND		
						(1.40)			
13.50-13.95	U18				114.90	13.40	Stiff fissured dark grey very sandy CLAY		
14.00	D19								
						(1.60)			
14.50-14.95 14.50-14.95	SPT N60=42 D20	12.00	DRY	5,5/7,8,11,13					
					113.30	15.00	Complete at 15.00m		

Remarks	Scale (approx)	Logged By
	1:50	AT

Figure No. J19183.BH1

GEA — Geotechnical & Environmental Associates, Widbury Barn | Widbury Hill | Ware | SG12 7QE			Site: 45 Highgate West Hill, London N6 6DB	Number: **BH2**
Excavation Method Drive-in window sampler	**Dimensions**	**Ground Level (mOD)**	**Client** Mr Tim & Mrs Ciara Rowe	**Job Number** J19183
	Location	**Dates** 15/07/2019	**Engineer** Momentum	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.50)	Made Ground (dark brown clayey sand with gravel and rare brick fragments)		
0.40	D1				0.50			
					(0.55)	Made Ground (dark brown slightly silty slightly clayey sand with gravel and brick and ash fragments)		
					1.05			
					(0.55)	Orange-brown slightly clayey fine to coarse SAND		
					1.60			
1.80	D2				(0.70)	Orange-brown very clayey fine to coarse SAND with fine to coarse sub-rounded gravel. Gravel content decreases with depth.		
					2.30			
3.00	D3				(2.10)	Firm orange-brown mottled pale grey slightly silty sandy CLAY		
					4.40			
					(0.60)	Pale brown clayey fine SAND		
5.00	D4				5.00	Complete at 5.00m		

Remarks
Groundwater not encountered.
Groundwater monitoring standpipe installed to a depth of 4.90 m.

Scale (approx)	Logged By
1:50	AT

Figure No. J19183.BH2

Geotechnical & Environmental Associates
Widbury Barn | Widbury Hill | Ware | SG12 7QE

Site 45 Highgate West Hill, London N6 6DB				**Number** **BH3**
Excavation Method Drive-in window sampler	**Dimensions**	**Ground Level (mOD)**	**Client** Mr Tim & Mrs Ciara Rowe	**Job Number** J19183
	Location	**Dates** 15/07/2019	**Engineer** Momentum	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						Made Ground (dark brown clayey sand with gravel and ocasional brick and concrete fragments)		
0.40	D1							
					(1.80)			
					1.80	Made Ground (dark brown slightly silty slightly clayey sand with gravel and brick and ash fragments)		
2.00	D2				(0.60)			
					2.40	Orange-brown slightly clayey fine to coarse SAND with fine to coarse sub-angular gravel		
					(0.40)			
2.60	D3							
					2.80	Orange-brown very clayey fine to coarse SAND with fine to coarse sub-rounded gravel		
					(0.60)			
					3.40	Firm pale orange-brown sandy CLAY		
3.50	D4							
					(1.60)			
					5.00	Complete at 5.00m		

Remarks Groundwater not encountered. Groundwater monitoring standpipe installed to a depth of 3.00 m.	**Scale (approx)** 1:50	**Logged By** AT
	Figure No. J19183.BH2	

GEA

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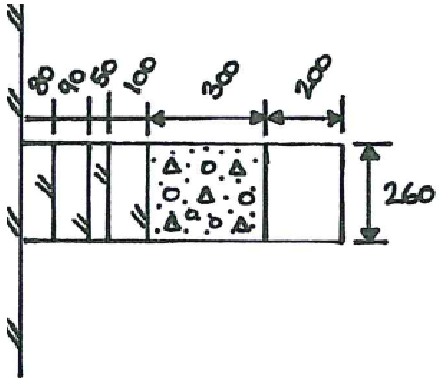
Herts | 01727 824666 Notts | 01509 674888

Trial Pit No 1	
Site 45 Highgate West Hill, London N6 6DB	**Job Number** J19183
Client Mr Tim & Mrs Ciara Rowe	**Sheet** 1/1
Engineer Momentum	**Dates** 15/07/2019

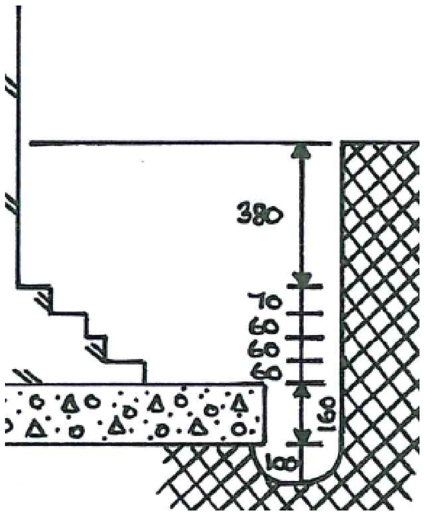
Excavation Method	**Dimensions**	**Ground Level (mOD)**	**Location**
Manual	260 x 820 x 890		Rear Façade

Plan:

Rear Facade Wall



Section A-A':



Made Ground (dark brown slightly clayey sand with gravel and brick and ceramic fragments)

Remarks:
All dimensions in millimetres
Sides of trial pit remained stable during excavation
Groundwater not encountered during excavation

Scale: 1:20

Logged by: AT

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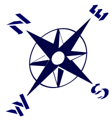
Herts | 01727 824666 Notts | 01509 674888

Trial Pit No 2

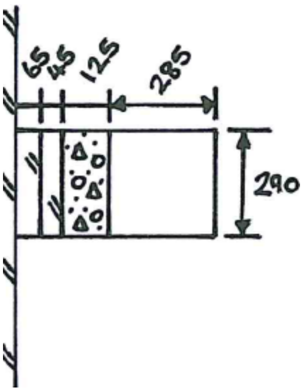
Site 45 Highgate West Hill, London N6 6DB	**Job Number** J19183
Client Mr Tim & Mrs Ciara Rowe	**Sheet** 1/1
Engineer Momentum	**Dates** 15/07/2019

Excavation Method	**Dimensions**	**Ground Level (mOD)**	**Location**
Manual	290 x 520 x 1065		Rear Façade

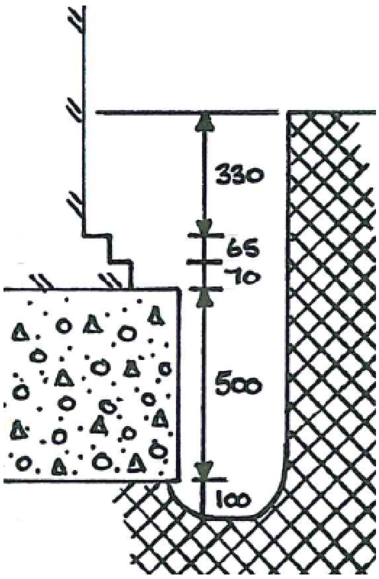
Plan:



Rear Facade Wall



Section A-A':



Made Ground (dark brown slightly clayey sand with gravel and brick fragments)

Remarks:	Scale: 1:20
All dimensions in millimetres	
Sides of trial pit remained stable during excavation - Wall found to be unstable	Logged by: AT
Groundwater not encountered during excavation	

SUMMARY OF GEOTECHNICAL TESTING

Sample details					Classification Tests					Density Tests		Undrained Triaxial Compression				Chemical Tests			Other tests and comments
Borehole / Trial Pit	Depth (m)	Sample Ref	Type	Description	WC (%)	LL (%)	PL (%)	PI (%)	<425 µm (%)	Bulk Mg/m³	Dry Mg/m³	Condition	Cell Pressure kPa	Deviator Stress kPa	Shear Stress kPa	pH	2:1 W/S SO4 (g/L)	W/S Mg (mg/L)	
BH1	2.80		D													8.0	0.03		
BH1	6.00		U	Firm friable light brown very sandy CLAY. Sand is yellow brown.	19.3					1.85	1.55	Undisturbed	120	275	137				
BH1	7.50		D	Yellow brown sandy silty CLAY lumps.															Particle Size Distribution
BH1	13.50		U	Stiff fissured dark brown sandy CLAY becoming fissured dark grey sandy CLAY. Sand is yellow brown.	29.6					1.94	1.50	Undisturbed	270	108	54				
BH1	14.00		D	Grey brown fine sandy silty CLAY with rare fine gravel.	26.5	67	26	41	99										
BH2	1.80		D	Brown clayey very gravelly SAND.															Particle Size Distribution
BH2	3.00		D	Orange brown and yellow brown fine sandy silty CLAY with rare fine gravel.	22.6	48	19	29	98							7.3	<0.01		
BH3	2.60		D	Brown clayey very gravelly SAND.															Particle Size Distribution
BH3	3.50		D	Orange brown and yellow brown fine sandy silty CLAY with rare fine gravel.	22.2	42	19	23	99							7.9	0.03		

Sample type: B (Bulk disturb.) BLK (Block) C (Core) D (Disturbed) LB (Large Bulk dist.) U (Undisturbed)

Checked and Approved by

S Burke

S Burke - Senior Technician
31/07/2019

Project Number:

GEO / 29581

Project Name:

45 Highgate West Hill, London N6 6DB
J19183

GEOLABS®

BS EN ISO 17892-4 : 2016

PARTICLE SIZE DISTRIBUTION

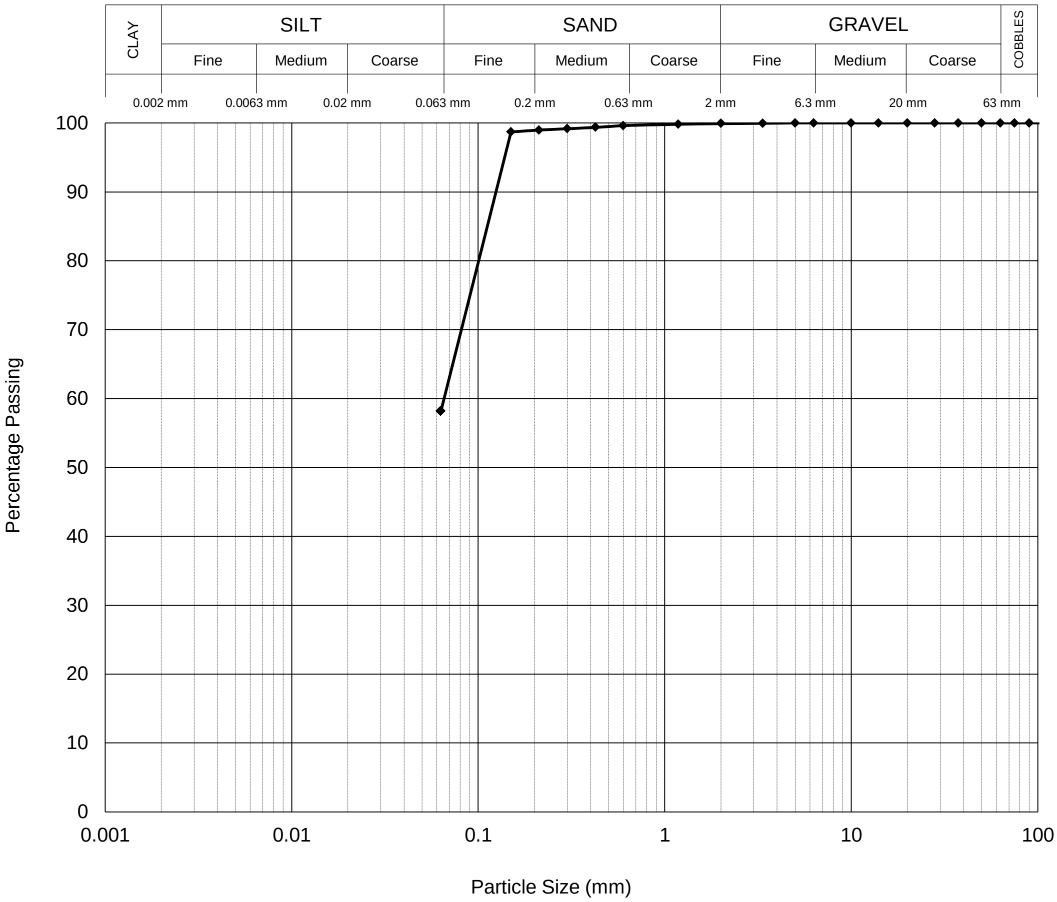
BH / TP No.	BH1
Depth (m)	7.50
Sample Type	D

Description

Yellow brown sandy silty CLAY lumps.

BS EN ISO 17892-4 : 2016 : Clause 5.2 - Wet Sieve

Sieve	
Size	% Pass
200.0 mm	100
125.0 mm	100
90.0 mm	100
75.0 mm	100
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	100
10.0 mm	100
6.30 mm	100
5.00 mm	100
3.35 mm	100
2.00 mm	100
1.18 mm	100
600 µm	100
425 µm	99
300 µm	99
212 µm	99
150 µm	99
63 µm	58



Particle Proportions	
Cobbles	0
Gravel	0
Sand	42
Silt & Clay	58

Checked and Approved by

S Burke

S Burke - Senior Technician
30/07/2019

Project Number:

GEO / 29581

Project Name:

45 Highgate West Hill, London N6 6DB
J19183

GEOLABS

UKAS TESTING 1982

Test Report By GEOLABS Limited Bucknalls Lane, Garston, Watford, Hertfordshire, WD25 9XX

Client : Geotechnical & Environmental Associates Limited, Widbury Barn, Widbury Hill, Ware, Hertfordshire, SG12 7QE

(Ref 1564501313)

BS EN ISO 17892-4 : 2016

PARTICLE SIZE DISTRIBUTION

BH / TP No. BH2
Depth (m) 1.80
Sample Type D

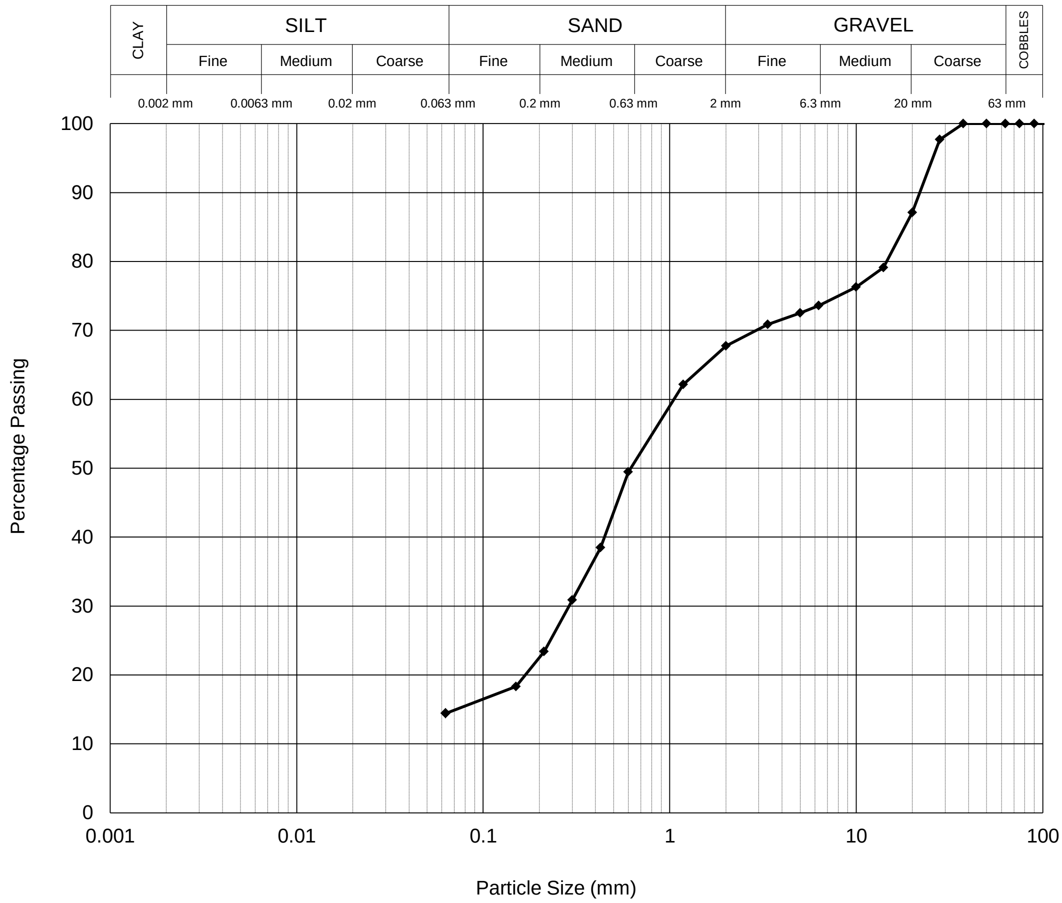
Description

Brown clayey very gravelly SAND.

Remarks Insuffcient sample supplied to comply with BS EN ISO 17892-4 : 2016 minimum mass requirements

BS EN ISO 17892-4 : 2016 : Clause 5.2 - Wet Sieve

Sieve	
Size	% Pass
200.0 mm	100
125.0 mm	100
90.0 mm	100
75.0 mm	100
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	98
20.0 mm	87
14.0 mm	79
10.0 mm	76
6.30 mm	74
5.00 mm	73
3.35 mm	71
2.00 mm	68
1.18 mm	62
600 µm	49
425 µm	38
300 µm	31
212 µm	23
150 µm	18
63 µm	14



Particle Proportions	
Cobbles	0
Gravel	32
Sand	53
Silt & Clay	15

Checked and Approved by

S Burke

S Burke - Senior Technician
30/07/2019

Project Number:

GEO / 29581

Project Name:

45 Highgate West Hill, London N6 6DB
J19183

GEOLABS

UKAS TESTING 1982

Test Report By GEOLABS Limited Bucknalls Lane, Garston, Watford, Hertfordshire, WD25 9XX

Client : Geotechnical & Environmental Associates Limited, Widbury Barn, Widbury Hill, Ware, Hertfordshire, SG12 7QE

(Ref 1564501316)

BS EN ISO 17892-4 : 2016

PARTICLE SIZE DISTRIBUTION

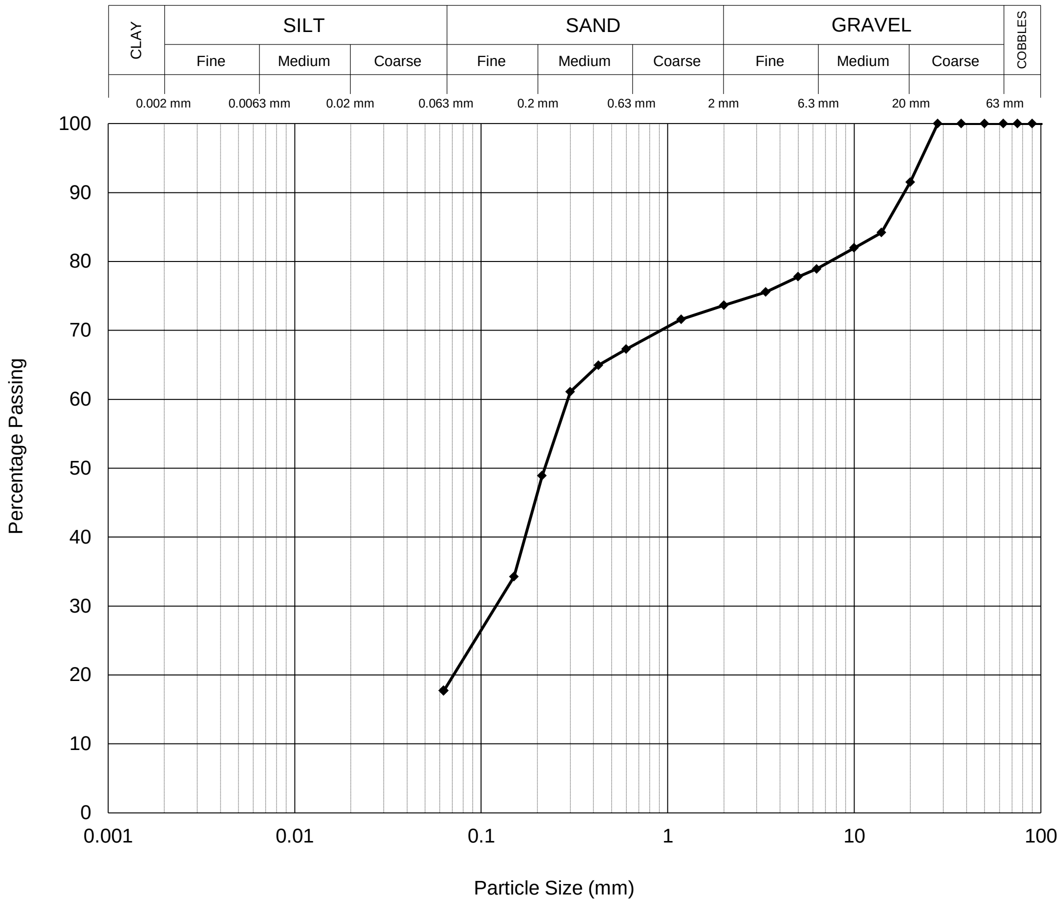
BH / TP No.	BH3
Depth (m)	2.60
Sample Type	D

Description

Brown clayey very gravelly SAND.

BS EN ISO 17892-4 : 2016 : Clause 5.2 - Wet Sieve

Sieve	
Size	% Pass
200.0 mm	100
125.0 mm	100
90.0 mm	100
75.0 mm	100
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	92
14.0 mm	84
10.0 mm	82
6.30 mm	79
5.00 mm	78
3.35 mm	76
2.00 mm	74
1.18 mm	72
600 µm	67
425 µm	65
300 µm	61
212 µm	49
150 µm	34
63 µm	18



Particle Proportions	
Cobbles	0
Gravel	26
Sand	56
Silt & Clay	18

Checked and Approved by

S Burke

S Burke - Senior Technician
30/07/2019

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Test Report By GEOLABS Limited Bucknalls Lane, Garston, Watford, Hertfordshire, WD25 9XX

Client : Geotechnical & Environmental Associates Limited, Widbury Barn, Widbury Hill, Ware, Hertfordshire, SG12 7QE

(Ref 1564501320)

1731 - UUTXL BH1 06.00 U Test 01 - 29581-332983.XLSM

BS EN ISO 17892-8 : 2018

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION

BH/TP No BH1
Depth (m) 6.00
Sample Type U

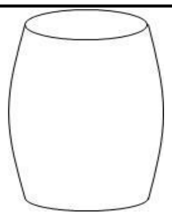
Description:

Stiff friable light brown very sandy CLAY. Sand is yellow brown.

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	202.1
Diameter	(mm)	102.6
Moisture content	(%)	19.3
Bulk density	(Mg/m³)	1.85
Dry density	(Mg/m³)	1.55
Test Details		
Latex membrane thickness	(mm)	0.3
Specimen height prior to shearing	(mm)	201.4
Membrane correction	(kPa)	0.6
Mean rate of shear	(%/min)	1.0
Cell pressure	(kPa)	120
Strain at failure	(%)	7.9
Maximum deviator stress	(kPa)	275
Shear Stress Cu	(kPa)	137

Mode of failure



Orientation of the sample	Vertical
Distance from top of tube mm	85

Version 1.79 - 03/04/2019

Processed by DD
Checked and Approved by

S Burke - Senior Technician
30/07/2019

Project Number:

GEO / 29581

Project Name:

45 Highgate West Hill, London N6 6DB
J19183

BS EN ISO 17892-8 : 2018

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION

BH/TP No	BH1
Depth (m)	13.50
Sample Type	U

Description:

Stiff fissured dark brown very sandy CLAY becoming stiff fissured dark grey sandy CLAY. Sand is yellow brown.

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	201.6
Diameter	(mm)	102.6
Moisture content	(%)	29.6
Bulk density	(Mg/m^3)	1.94
Dry density	(Mg/m^3)	1.50
Test Details		
Latex membrane thickness	(mm)	0.3
Specimen height prior to shearing	(mm)	201.6
Membrane correction	(kPa)	1.1
Mean rate of shear	(%/min)	1.0
Cell pressure	(kPa)	270
Strain at failure	(%)	19.8
Maximum deviator stress	(kPa)	108
Shear Stress Cu	(kPa)	54

Mode of failure

Orientation of the sample	Vertical
Distance from top of tube mm	140

Processed by DD
Checked and Approved by

S Burke

S Burke - Senior Technician
30/07/2019

Project Number:

GEO / 29581

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