BASEMENT IMPACT AND GROUND MOVEMENT ASSESSMENT REPORT

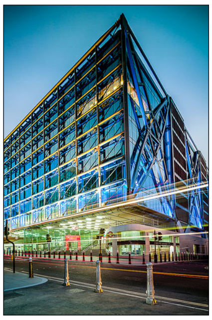
69 Avenue Road
London
NW8 6HP

Client: Mr Nick Goulandris

J19104

May 2020



GEA

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This report is intended as a Ground Investigation Report (GIR) as defined in BS EN1997-2, unless specifically noted otherwise. The report is not a Geotechnical Design Report (GDR) as defined in EN1997-2 and recommendations made within this report are for guidance only.

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Part 3: GROUND MOVEMENT ASSESSMENT

Part 4: BASEMENT IMPACT 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 HGH Planning Environment & Development Services (HGH), on behalf of Mr Nick Goulandris, with respect to the refurbishment of the existing house through the construction of a new rear extension, replacement of the existing north wing with a new single-storey extension and construction of a single-level basement, which will extend to a depth of approximately 4.0 m beneath the house and part of the new extension, with an additional 2.0 m of excavation in the area of the proposed swimming pool.

A ground investigation and basement impact assessment (BIA) has previously been carried out at the site by GEA (report ref J16224, dated December 2016). Based on this existing report, a revised BIA has now been prepared, in compliance with the London Borough of Camden (LBC) Planning Guidance CPG, for the finalised scheme. This work also includes a ground movement analysis and building damage assessment for the proposed basement construction.

DESK STUDY FINDINGS

The desk study research indicates that the site was occupied by two detached houses between 1850 and 1872. At some time between 1915 and 1935, the two detached houses were demolished and replaced by what appears to be the existing house. By 1954, an extension had been constructed to the northern wing of the house. The River Tyburn formerly flowed close to the present-day route of Avenue Road, and across the eastern half of the site.

GROUND CONDITIONS

The investigation has generally confirmed the expected ground conditions, in that, beneath a moderate thickness of made ground, Head Deposits were encountered over the London Clay, which was proved to the full depth of the investigation of 20.00 m. No soils associated with the River Tyburn were encountered. The made ground generally comprised brown gravelly clay with brick and ash and extended to depths of between 0.90 m and 2.00 m. The Head Deposits comprised an upper horizon of 'stiff' (desiccated) high strength orange-brown silty very sandy gravelly clay, which extended to depths of between 2.20 m and 2.70 m, overlying stiff high strength brown mottled grey silty clay with a reworked texture which extended to depths of between 5.50 m and 6.50 m. The London Clay comprised an upper weathered layer of stiff fissured high strength brown silty clay with bluish grey veins and selenite crystals, extending to depths of 8.80 m and 9.90 m, overlying stiff becoming very stiff fissured high strength becoming very high strength grey silty clay.

Seepages associated with claystones were encountered during drilling at depths of 9.50 m and 8.60 m, in Borehole Nos 1 and 2 respectively. Monitoring of the standpipes has measured groundwater at depths of between 1.70 m and 11.75 m.

Contamination testing has measured elevated concentrations of lead within the made ground, along with asbestos fibres, and consideration will need to be given to protecting site workers and end users of the site.

RECOMMENDATIONS

Formation level for the proposed basement is likely to be within the stiff silty sandy clay of the Head Deposits or underlying London Clay, at depths of between 4.0 m and 6.0 m, either of which should provide an eminently suitable bearing stratum for spread foundations. Excavations for the proposed basement structure will require temporary support to maintain stability and to prevent any excessive ground movements. Perched water is likely to be encountered within the proposed excavations, such that some form of groundwater control is likely to be required. However, significant groundwater inflows are not anticipated.

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 has indicated movements of sensitive structures to fall well 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.

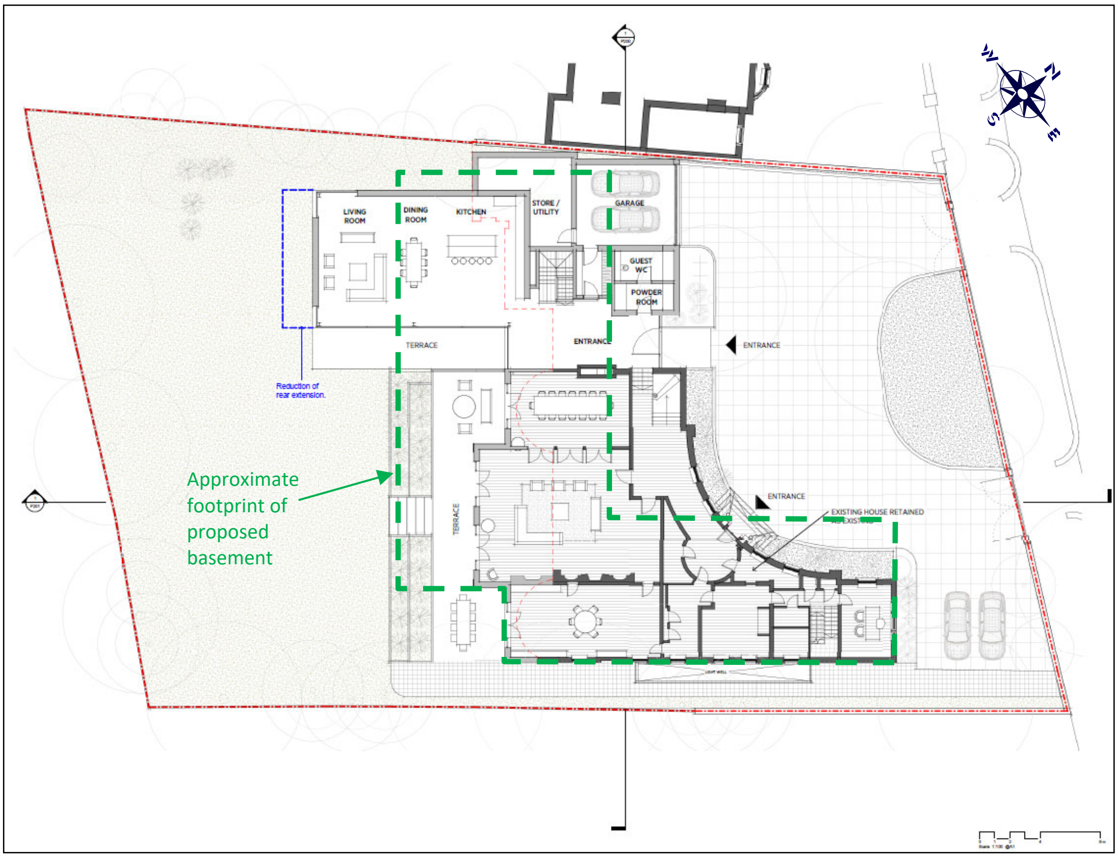
1.0 INTRODUCTION

Geotechnical and Environmental Associates Limited (GEA) has been commissioned by HGH Planning Environment & Development Services (HGH), on behalf of Mr Nick Goulandris, to revise a previous desk study and ground investigation report (ref J16224, dated December 2016) for the proposed development at 69 Avenue Road, London, NW8 6HP.

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).

1.1 Proposed Development

It is understood that it is proposed to refurbish the existing house through the construction of a new rear extension, replacement of the existing north wing with a new single-storey extension and construction of a single-level basement beneath the house and part of the new extension, as shown on the drawing below.



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 determine the ground conditions and their engineering properties;
- to determine the configuration of existing foundations;
- 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 geological and hydrogeological maps; and
- a walkover survey of the site carried out prior to the fieldwork.

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

- two cable percussion boreholes, advanced to depths of 15 m and 20 m on the front driveway;
- three open-drive sampler boreholes advanced to a maximum depth of 8.45 m in the rear garden;
- a total of nine hand-dug trial pits manually excavated to a maximum depth of 1.85 m to expose the existing foundations and determine the party wall conditions;
- installation of four groundwater monitoring standpipes, to a maximum depth of 12.00 m;
- laboratory testing of selected soil samples for geotechnical purposes and for the presence of contamination;
- provision of a report presenting and interpreting the above data, together with our advice and recommendations with respect to the proposed development.

This report includes a contaminated land assessment which has been undertaken by a suitably qualified and competent professional in accordance with the methodology presented by the Environment Agency in their report, Land contamination: risk management (June 2019). This involves identifying, making decisions on, and taking appropriate action to deal with, land contamination in a way that is consistent with government policies and legislation within the United Kingdom. Risk management is divided into three stages; Risk Assessment, Options Appraisal and Remediation, and each stage comprises three tiers. The Risk Assessment stage includes ppreliminary risk assessment (PRA), generic quantitative risk assessment (GQRA) and detailed quantitative risk assessment (DQRA)and this report includes the PRA and GQRA.

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

1.3.1 Basement Impact Assessment

The work carried out includes a Hydrological and Hydrogeological Assessment and Land Stability Assessment (also referred to as Slope Stability Assessment). These assessments form part of the BIA procedure specified in the London Borough of Camden Planning Guidance CPG[1] and their Guidance for Subterranean Development[2] 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 completed 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 of London (FGS) who has over 25 years' specialist experience in ground engineering. The subterranean (groundwater) flow assessment has been completed 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 undertaken by Water Environment Ltd, as part of the separate Flood Risk Assessment (report ref 18024, dated February 2020) for the site, the findings of which have been reviewed within this report 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 London Borough of Camden Planning Guidance CPG (March 2018) *Basements*
2 Ove Arup & Partners (2010) *Camden geological, hydrogeological and hydrological study. Guidance for Subterranean Development.* For London Borough of Camden November 2010

1.4 Limitations

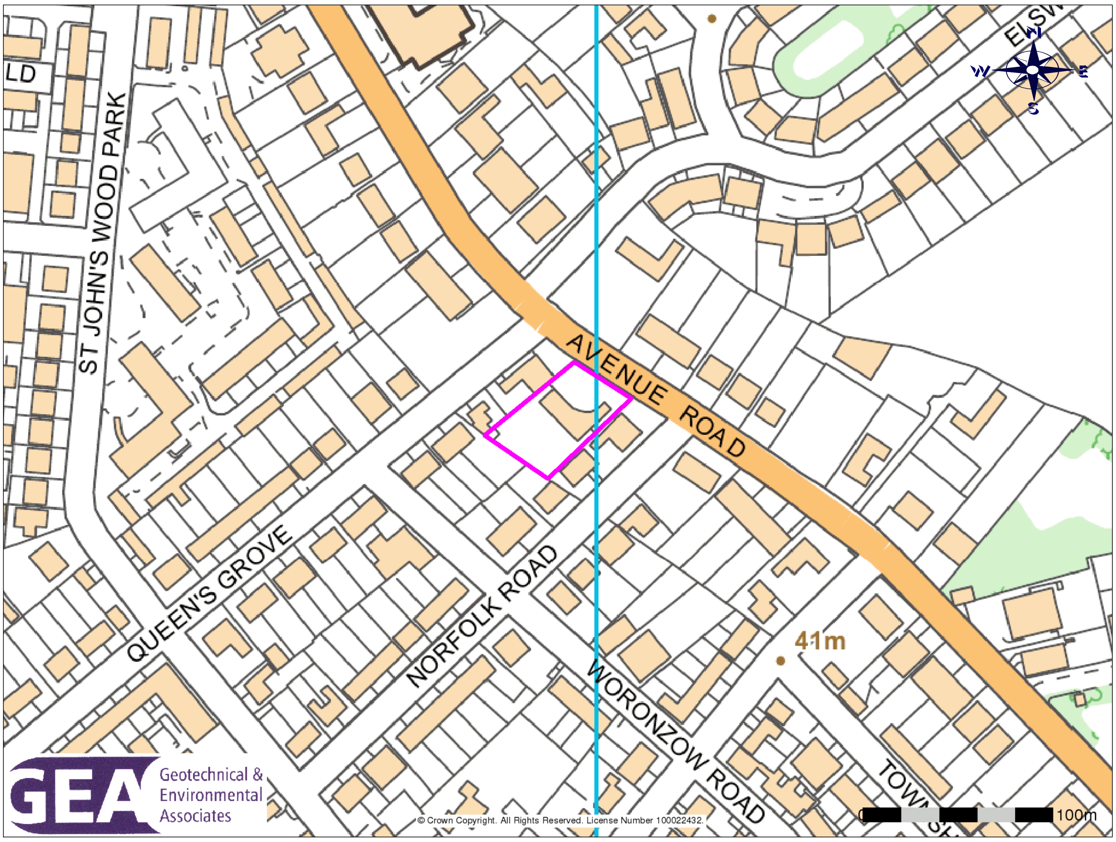
The conclusions and recommendations made in this report are limited to those that can be made on the basis of the investigation. The results of the work should be viewed in the context of the range of data sources consulted, the number of locations where the ground was sampled and the number of soil, 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 the London Borough of Camden, 400 m to the southeast of Swiss Cottage London Underground station. It fronts onto Avenue Road to the east and is bounded to the north by No 71 Avenue Road and to the south by No 65 Avenue Road, both of which comprise detached houses. A review of local planning information by the consultant engineers, Croft Structural Engineers, indicates that neither of these properties includes an existing basement. The site is bordered to the west by the rear gardens of houses fronting onto Norfolk Road.

The site may be additionally located by National Grid Reference 526980, 183770 and is shown on the map extract below.



A walk-over of the site was undertaken at the time of the fieldwork and selected photographs are shown overleaf.


Rear of house


Front driveway

The site is currently occupied by a detached two-storey L-shaped house with an adjoining single storey side extension along the northern elevation, attached to a garage that adjoins the boundary wall shared with No 71 Avenue Road. A single level basement is present beneath part of the single storey side extension. The house is set back from the road and a carriage driveway is present at the front of the house, with a semi-circular planted area with an ornamental well and planted borders around the edges. Brick walls form the boundary of the site.

A passageway is present along the southern elevation of the house which is paved with concrete slabs with planted borders along the southern edge. A gate leads into the rear garden. A raised patio area is present along the full breadth of the western elevation with steps leading down to a central lawn, with planted borders. In the southwestern corner of the lawn a raised mound was noted, possibly indicating that a tree has been removed from the area and heave of the ground has occurred.


Mound in lawn


Rear garden

Wisteria is growing up the rear facade of the house and there are numerous hydrangeas planted in the flower beds.

Numerous trees are present on site, particularly along the perimeters of the site. In the front garden, including a 'Tree of Heaven', which is protected under a tree preservation order, which is a mature tree, 23 m in height, located at the front of a single storey extension. No visual signs of damage was noted to the wall adjacent to the 'Tree of Heaven'. However, the tarmac driveway is cracked and damaged in places.

Tree of heaven causing heave movement to ground

Photo taken from rear garden looking towards Tree of heaven

Cracking to driveway

At the rear of the site, the construction of a new building including double level basement is currently underway at No 1 Norfolk Road and the piling rig was on site at the time of this investigation. A site visit to the adjoining site indicated that during installation of the piles London Clay was encountered and the bores had been found to be dry.

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 1850, shows the site fronting onto Upper Avenue Road, although no buildings are depicted on this map. The next map studied, dated 1872, shows the site to be occupied by two detached houses with two ponds, shown roughly 175 m to the northeast of the site. On the 1894 map, the ponds are not shown, and had presumably been infilled. By the time of the 1896 map, Upper Avenue Road was renamed Avenue Road. At some time between 1915 and 1935, the two detached houses were demolished and replaced by what appears to be the existing house and by 1954, the existing extension had been constructed to the northern wing of the house.

Reference to London bomb damage map (Sheet 37), held at the London Metropolitan Archives, indicates minor blast damage to the existing house, with total clearance areas to the north of the site. It would be prudent to commission a preliminary UXO risk assessment, prior to any excavation works.

A search of the Camden online planning portal indicates that a planning application (reference 2016/5260/T) was submitted to the council on 28 September 2016 to fell the protected Tree of Heaven, although the application was refused by the council on 2 December 2016.

2.3 Other Information

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

The desk study research indicated that there are no registered landfills, historic landfills, registered waste transfer sites, waste management facilities or recorded pollution incidents within 500 m of the site. In addition, there has been no recorded pollution incidents within 500 m of the site.

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

The site is not located within a Nitrate Vulnerable Zone or any other sensitive land uses.

There are no listed fuel stations within 500 m of the site or contemporary trade directory entries within 250 m of the site.

Information on Urban Soil Chemistry provided by the BGS also indicates that background concentrations for lead across the majority of the site are likely to be between 300 mg/kg and 600 mg/kg, whilst the north-eastern corner of the site extends into an area with background concentrations in excess of 900 mg/kg. Therefore, whilst relatively high concentrations of lead may be encountered within any near surface soils present on the site, a significant proportion of the measured concentration is likely to be the result of residual airborne sources and this will need to be taken account of in any subsequent risk assessment.

Information obtained on buried services has not identified any potentially sensitive infrastructure beneath Avenue Road likely to be affected by the proposed development. There are also no London Underground Tunnels or Network Rail tunnels located within 50 m of the site. The service search information is included within the appendix.

2.4 Geology

The British Geological Survey (BGS) map (Sheet 256), dated 2006 indicates that the site is directly underlain by the London Clay Formation and is located between two areas of Head propensity.

The London Clay Formation is homogenous, slightly calcareous silty clay to very silty clay, with some beds of clayey silt grading to silty fine-grained sand.

According to the BGS map, dated 2006, the Head propensity is based on the geotechnical properties of the London Clay and Head may occur close to the Claygate Member / London Clay boundary. Head propensity is shown on the BGS map as areas denoted as most likely to be covered by Quaternary Head Deposits as interpreted from digital slope analysis and confirmed by borehole data.

A ground investigation has previously been carried out by GEA on a nearby site at Nos 73-75 Avenue Road to the north. The ground conditions comprised a moderate to significant thickness of made ground, overlying brown mottled silty sandy gravelly clay, extending to depths of up to 4.30 m. This was in turn underlain by firm becoming stiff brown mottled grey silty fissured clay with traces of selenite crystals which extended to depths of 8.20 m and 9.40 m. Below these depths, stiff becoming very stiff dark brownish grey and grey silty fissured clay, with traces of pyrites, which was proved to the full depth investigated of 25.45 m.

GEA also undertook an investigation in 2013 at No 28 Norfolk Road, located 50 m to the south-southwest. The soils encountered also comprised sandy gravelly clay in the upper horizon, extending to depths of between 1.80 m and 2.60 m, in turn overlying London Clay, proved to the maximum depth investigated of 6.00 m.

A search of the BGS records has identified records of a deep borehole that was drilled roughly 1 km to the southeast of the site, which found the London Clay to extend to a depth of at least 120 m.

2.5 Hydrology and Hydrogeology

The London Clay is classified by the Environment Agency as unproductive strata, which refers to deposits that have low permeability and negligible significance for water supply or river base flow.

Head Deposits are typically defined as a Secondary Undifferentiated Aquifer, which describes soils that have previously been designated as both minor and non-aquifers in different locations due to their variable characteristics, which is typically determined by the source material. If superficial Head Deposits are present, then the potential for significant groundwater inflows from these materials is generally considered to be low due to their predominantly cohesive nature.

Published data for the permeability of the London Clay indicates the horizontal permeability to generally range between 1 x 10^{-10} m/s and 1 x 10^{-8} m/s, with an even lower vertical permeability.

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

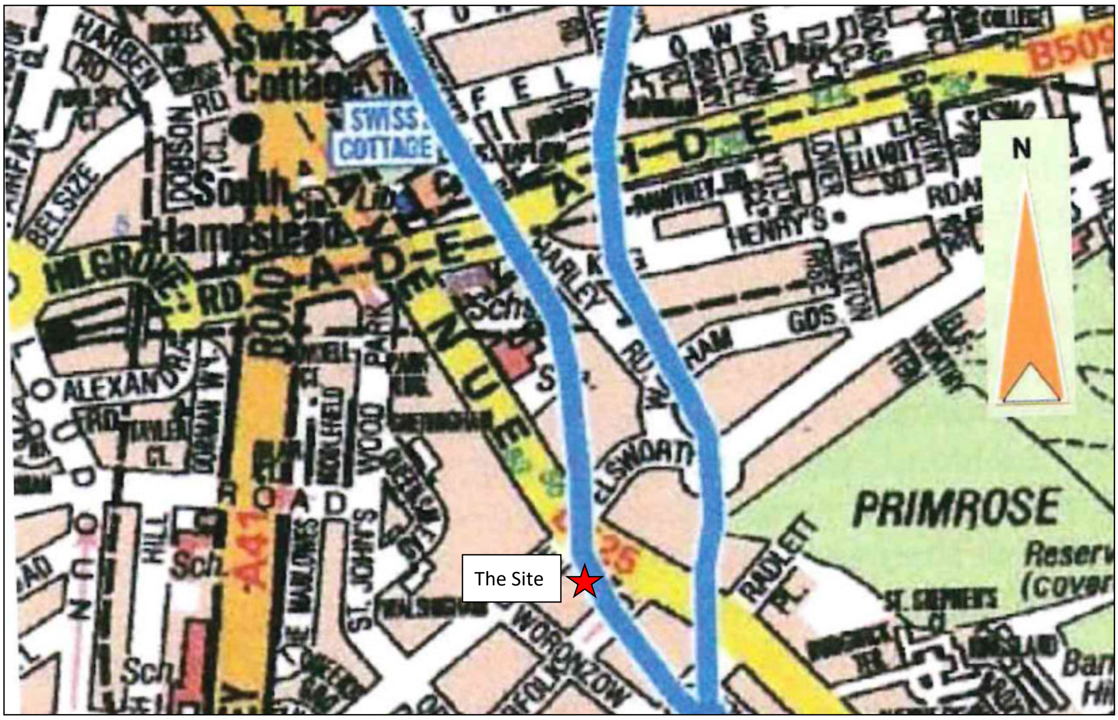
The aforementioned GEA investigations at 73–75 Avenue Road and 28 Norfolk Road, encountered groundwater from within the gravelly layer during drilling.

The site lies outside the catchment of the Hampstead Heath chain of ponds, with the nearest surface water feature comprising a small pond, located 527 m north of the site.

Reference to the Lost Rivers of London[3] indicates that a tributary of the River Tyburn formerly flowed close to the present-day route of Avenue Road, and across the eastern half of the site. The former course of the Tyburn, which would have been perched on top of the London Clay, is shown on an extract overleaf taken from the Lost Rivers of London.

The springs in Hampstead are located at about 90 m OD and the source of the tributary located in the eastern half of the site is Shepherd’s Well, located at the junction of Fitzjohn’s Avenue and Akenside Road in Hampstead. This tributary of the Tyburn initially flowed in a south-south-east direction and then headed in a southerly direction along Fitzjohn’s Avenue towards Swiss Cottage, crossing Avenue Road near the junction of Norfolk Road and Woronzow Road. It flowed close across the eastern half of the site, before merging with the second branch of the River Tyburn, as shown on the map extract overleaf.

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



The service plans obtained from Thames Water indicate that a Combined Sewer Main runs along the centre of Avenue Road. It is known that many of the lost rivers have become part of London's sewer system, so it is considered likely that the River Tyburn and its tributary are now captured in the sewer system.

The site is located within a Groundwater Source Protection Zone (SPZ) (Zone II – outer protection zone), classified as either 25% of the source area or a 400-day travel time, whichever is greater. The SPZ is likely to be associated with a public water supply from the Chalk Aquifer which is confined by the London Clay at a depth greater than 50 m. There are no listed water abstraction points within 500 m of the site.

The site is not located in an area at risk of flooding from rivers or sea, as defined by the EA, nor is it identified on the BGS map, as being within an area with a potential for groundwater flooding. It is also not shown on Figure 15 of the Arup report[4], or the EA surface water flood maps, as being in an area with the potential to be at high risk from surface water flooding. However, Avenue Road is listed within a London Borough of Camden report[5] as having suffered from surface water flooding in a 2002 flood event.

The eastern part of the site is occupied by the existing house, whilst the rear garden is predominantly laid to lawn. Infiltration of rainwater into the ground beneath the site is therefore limited to the rear garden and infiltration rates are expected to be low and run-off rates high, due to the high clay content of the soils.

A separate flood risk assessment, undertaken by Water Environment Ltd (report ref 18024, dated February 2020), has also confirmed that there is a potential risk of surface water flooding across the site. The assessment concluded that whilst impermeable areas across the site were likely to increase as a result of the development, the implementation of suitable mitigation measures would ensure that surface water rates would not increase post-development.

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

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

As a precaution, any potential risk from sewer flooding should be mitigated by introducing a non-return valve to the pumped system.

The site is located within Flood Zone 1 and therefore all uses of land are appropriate.

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 was developed between 1850 and 1872 with two detached houses. At some time between 1915 and 1935, the site was redeveloped, and the existing house was constructed. It is believed that there was some minor damage to the house during World War II and the house was extended to the north between 1935 and 1954. The site is not considered to have had a contaminative history, having been occupied by residential properties. However, as with any previously developed site, localised areas of contamination may be present.

Demolition of the two houses previously present on the site is likely to have resulted in the presence of a moderate thickness of made ground. This would mostly be inert rubble but is likely to include small quantities of contaminants such as lead, present in paintwork, and other metals.

There are no historical or existing landfill sites within 500 m of the site and made ground associated with demolition of the house previously present on the site is likely to be predominantly inert demolition rubble. The former ponds, located 175 m to the northeast of the site, were presumably infilled over 120 years ago, and on the basis of the above information, no potential sources of soil gas have, therefore, been identified.

2.6.2 Receptor

The continued use of the site for residential purposes represents a relatively high sensitivity end-use and end users are considered to be sensitive receptors. The site is underlain by unproductive strata and therefore groundwater is not considered to be a potential receptor. Site workers will come into contact with underlying soils during the construction phase, as will new buried services and both are therefore considered to be sensitive receptors. Neighbouring sites would also be considered to be moderately sensitive receptors.

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

2.6.3 Pathway

The site is likely to be directly underlain by low permeability London Clay and there is a limited pathway for the migration of potential contaminants on or off-site, except through made ground. The proposed development will result in the removal of any made ground from within the footprint of the proposed basement. However, made ground will still be present in the rear garden and existing pathways will remain.

The negligible permeability of the underlying London Clay Formation will limit the potential for groundwater percolation into the underlying chalk, and thus a pathway is not considered likely to exist to the Principal Aquifer. The construction phase is considered to be a pathway by which site workers and new buried services may come in contact with any contamination.

There is thus considered to be limited potential for a significant contaminant pathway to be present between any potential contaminant source and a target for the particular contaminant beneath the new basement.

2.6.4 Preliminary Risk Appraisal

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

3.0 SCREENING

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

3.1 Screening Assessment

A number of screening tools are included in the Arup document and for the purposes of this report reference has been made to 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 69 Avenue Road
1a. Is the site located directly above an aquifer?	No. The Site is underlain by the London Clay which is designated as Unproductive Strata by the Environment Agency and cannot store and transmit water in sufficient quantities to support groundwater abstractions or watercourses.
1b. Will the proposed basement extend beneath the water table surface?	Unlikely. The London Clay and Head Deposits, if present, cannot support groundwater flow and do not therefore have a water table consistent with a permeable water bearing strata.
2. Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line?	*Yes. The site is located close to or over a former tributary of the River Tyburn. However, this tributary is no longer present at surface, having been diverted to form part of the local surface water sewer system.*
3. Is the site within the catchment of the pond chains on Hampstead Heath?	No. Topographical maps acquired as part of the desk study and Figures 12 and 14 of the Arup report confirms that the site is not located within this catchment area
4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	*Yes. The basement may cover a larger proportion of the site, which is currently garden. However, the low permeability of the underlying London Clay would result in a low recharge in any case and consequently there would be little or no effect on groundwater.*

Question	Response for 69 Avenue Road
5. As part of the site drainage, will more surface water (e.g. rainfall and run-off) than at present be discharged to the ground (e.g. via soakaways and/or SUDS)?	No. Given that the site is underlain by clay soils and is unlikely to be suitable for a soakaway or similar SUDS based system, the site drainage will therefore be directed to public sewer. Site drainage will therefore be designed to generally maintain the existing situation.
6. Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to or lower than, the mean water level in any local pond or spring line?	No. There are no groundwater dependent ponds or spring lines present within 500 m of the site. The flow of the former Tyburn watercourse was perched on the London Clay.

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

Q2 The site is within 100 m of the former course of the culverted Tyburn stream.
Q4 The development will result in a change in the proportion of hard surface / paved areas.

3.1.2 Stability Screening Assessment

Question	Response for 69 Avenue Road
1. Does the existing site include slopes, natural or manmade, greater than 7°?	No. Topographical maps, Figures 16 and 17 of the Arup report and the site walkover confirm this.
2. Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7°?	No. 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°?	No. Topographical maps, Figures 16 and 17 of the Arup report and the site walkover confirm this.
4. Is the site within a wider hillside setting in which the general slope is greater than 7°?	No. Topographical maps, Figures 16 and 17 of the Arup report and the site walkover confirm this.
5. Is the London Clay the shallowest strata at the site?	*Yes. Geological maps show the site to be underlain by London Clay.*
6. Will any trees be felled as part of the proposed development and / or are any works proposed within any tree protection zones where trees are to be retained?	No.
7. Is there a history of seasonal shrink-swell subsidence in the local area and / or evidence of such effects at the site?	*Yes. There is a moderate potential for shrinking or swelling clay ground stability hazards.*
8. Is the site within 100 m of a watercourse or potential spring line?	*Yes. The River Tyburn historically flowed along the eastern of the site. This watercourse is not present at surface and has been culverted to form part of the local surface water sewer.*
9. Is the site within an area of previously worked ground?	No. The geological map of the area and Figures 3, 4 and 8 of the Arup report do not indicate any worked ground.
10. Is the site within an aquifer?	No. The site is underlain by the London Clay which is designated as Unproductive Strata by the Environment Agency and cannot store and transmit usable amounts of water.
11. Is the site within 50 m of Hampstead Heath ponds?	No.
12. Is the site within 5 m of a highway or pedestrian right of way?	No. Although the site fronts on to Avenue Road, the proposed basement is located over 5 m to the west of the public footway.
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	*Yes. The depth of adjacent foundations is unknown, but it is likely that the development will increase the foundation depths relative to the neighbouring properties to a relatively significant extent.*

Question	Response for 69 Avenue Road
14. Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	No. An online search for London Underground Tunnels and railway tunnels did not indicate any in the proximity of the site. This is confirmed with reference to ARUPs Transport Infrastructure map, Figure 18. Thames Water has been contacted and their plans indicate no deep sewers or tunnels under or in proximity of the site

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

Q5 The London Clay is the shallowest strata beneath the site.
Q7 The site is in an area likely to be affected by seasonal shrink-swell.
Q8 The site is within 100 m of London's "lost river", the River Tyburn.
Q13 The development may increase the foundation depths relative to the neighbouring properties to a relatively significant extent.

3.1.3 Surface Flow and Flooding Screening Assessment

The surface water and flooding assessment has been undertaken by Water Environment Ltd, as part of the separate Flood Risk Assessment (report ref 18024, dated February 2020) for the site, the findings of which are summarised in the table below.

Question	Response for 69 Avenue Road
1. Is the site within the catchment of the pond chains on Hampstead Heath?	No. Figure 14 of Arup report confirms that the site is not located within this catchment area.
2. As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route?	No. The FRA confirms that any additional surface water from the increase hardstanding area will be attenuated and discharged into the Thames Water sewers to ensure the surface water flow regime will be unchanged. The basement will mainly be beneath the footprint of the building and existing hardstanding areas, and the 1m distance between the roof of the basement and ground surface as recommended by section 3.2 of the CPG Basements 2018 does not apply across these areas. Where the basement and development extend into parts of the site which are currently permeable, these parts (namely the rear garden) will have a distance between the roof/floor slab of the basement and ground surface of less than 1m. However, it is considered that the use of SUDS attenuation, as specified by the FRA, will mitigate any impact by not meeting the 1m requirement.
3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	*Yes. The FRA indicates that basement and new extension will cover a larger proportion of the site, which is currently permeable (namely across the rear garden). However, SUDS attenuation prior to discharge into the sewers will reduce the impact to acceptable levels.*
4. Will the proposed basement development result in changes to the profile of the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses?	No. The FRA recommends the use of SUDS attenuation to control how water is stored from additional hardstanding areas. The proposed attenuation size is based upon peak surface water flows and discharge rates.
5. Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No. The FRA confirms that 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	Yes. The FRA confirms that there is a potential risk of surface water flooding across the site. It is possible that the basement will be constructed within

Question	Response for 69 Avenue Road
the proposed basement is below the static water level of nearby surface water feature?	pockets of perched water and the recommendations outlined in the BIA with regards to waterproofing and tanking of the basement will reduce the risk to acceptable levels. In accordance with paragraph 5.11 of the CPG, a positive pumped device will be installed in the basement in order to further protect the site from sewer flooding.

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

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

Q6 Avenue Road is at risk from surface water flooding.

4.0 SCOPING AND SITE INVESTIGATION

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

4.1 Potential Impacts

The following potential impacts have been identified by the screening process

Potential Impact	Consequence
London Clay is the shallowest stratum at the site.	The London Clay is prone to seasonal shrink-swell (subsidence and heave).
Seasonal shrink-swell can result in foundation movements.	If a new basement is not dug to below the depth likely to be affected by tree roots this could lead to damaging differential movement between the subject site and adjoining properties.
Is the site within 100 m of a former watercourse.	The basement may alter the groundwater flow regime to former watercourse.
The development is likely to increase the differential depth of foundations relative to neighbouring properties.	Excavation of a basement may result in structural damage to neighbouring properties if there is a significant differential depth between adjacent foundations.
Increase in proportion of hard-standing and paved areas.	Less soft covering for surface water infiltration. However, the London Clay is of relatively low permeability so will not make much difference.
The site has been identified as having a risk from surface water flooding.	It is possible that the basement will be constructed within perched groundwater.

These majority of these potential impacts, relating to the groundwater and stability screening assessments, have been investigated through the site investigation, as detailed below.

The potential impacts highlighted by the surface water and flooding screening assessment have been addressed in detail within the FRA, undertaken by Water Environment Ltd, although a discussion of the conclusions is included within Section 4.0 of this report.

4.2 Exploratory Work

In order to meet the objectives described in Section 1.2, as far as possible within the access limitations presented by the presence of the existing building, two cable percussion boreholes were advanced, to depths of 15.0 m and 20.0 m, by means of a standard cable percussion drilling rig on the front driveway. In addition, a further three boreholes were drilled to depths of 1.5 m, 5.0 m and 8.0 m, using an open-drive percussive sampler to provide additional coverage of the site. Standard Penetration Tests (SPTs) were carried out at regular intervals in the boreholes to provide quantitative data on the strength of soils encountered.

Groundwater monitoring standpipes were installed in four boreholes to depths of up to 12.00 m and have been monitored on three occasions to date.

A total of nine trial pits were hand dug to a maximum depth of 1.85 m to provide information on the existing foundations of the house, single storey extension, garage and garden boundary walls.

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 and trial pit records are appended, together with the results of the laboratory testing and a site plan indicating the borehole locations.

4.3 Sampling Strategy

The scope of the works was specified by GEA. The locations of the cable percussion boreholes and trial pits were specified by the previous consulting engineer, Fluid Structures, and positioned on site by GEA with due regard to the proposed development, whilst avoiding the areas of known services. The open-drive sampler boreholes were positioned by GEA to provide additional coverage of the site.

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

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

A number of samples recovered from the boreholes were submitted to a geotechnical laboratory for a programme of testing that included moisture content and Atterberg limit tests, undrained triaxial compression tests and soluble sulphate and pH level analysis.

5.0 GROUND CONDITIONS

The investigation has generally confirmed the expected ground conditions, in that, beneath a moderate thickness of made ground, Head Deposits were encountered, overlying London Clay, which was proved to the full depth of the investigation.

5.1 Made Ground

The made ground extended to depths of between 0.90 m and 2.00 m and generally comprised brown gravelly clay with brick and ash. With the exception of occasional fragments of extraneous material, no visual or olfactory evidence of significant contamination was observed within the made ground. However, four samples of the made ground have been subject to contamination testing as a precautionary measure and the results are presented in Section 5.4.

The base of the made ground was not proved in Borehole No 3, after encountering a concrete obstruction at a depth of 1.30 m. This borehole was terminated and relocated.

5.2 Head Deposits

This stratum generally comprised an upper horizon of 'stiff' (desiccated) or firm high strength orange-brown silty very sandy clay with abundant carbonaceous material, becoming gravelly with depth, extending to depths of between 2.20 m and 2.70 m. The flint gravel was noted to be fine to coarse subangular to well rounded. The gravelly clay was notably absent in Borehole No 1, where a greater thickness of made ground was encountered.

Below these depths, the Head Deposits generally comprised stiff high strength brown mottled grey silty clay with occasional partings of orange-brown fine sand and silt and selenite crystals. This clay horizon was noted to have a reworked texture, extending to depths of between 5.50 m and 6.50 m. The thickness of the Head Deposits was not proved in Borehole No 4, which extended to a depth of 5.00 m.

Dead roots were noted in the boreholes to a maximum depth of 5.00 m. In-situ pocket penetrometer readings indicate that the clay was desiccated to a depth of about 3.00 m in Borehole No 3A.

Laboratory plasticity index tests on soils of the Head Deposits indicate the clay to be of moderate volume to high volume change potential.

No visual or olfactory evidence of contamination was noted within these soils.

5.3 London Clay

This formation was found to comprise an upper weathered layer of stiff fissured high strength brown silty clay with bluish grey veins, occasional partings of orange-brown fine sand and silt and selenite crystals, extending to depths of 8.80 m and 9.90 m. Below this depth, stiff becoming very stiff fissured high strength becoming very high strength grey silty clay was encountered and proved to the maximum depth investigated of 20.00 m.

These soils were found to be free from evidence of contamination and of high volume change potential.

5.4 Groundwater

Groundwater was encountered during drilling, associated with claystones at a depth of 9.50 m in Borehole No 1, rising to 9.20 m, after 20 minutes and in Borehole No 2 at a depth of 8.60 m.

Monitoring of the standpipes installed in four of the boreholes has been carried out on three occasions to date, approximately one week, four weeks and approximately 3 years after installation, and the results are shown in the table below.

Borehole No	Depth to water (m)		
	Dates		
	17/10/2016	09/11/2016	05/02/2020
1	11.75	7.92	1.90
2	DRY	DRY	1.70
3A	6.84	2.85	Unable to locate (re-turfed)
4	Not monitored as not able to lift paving slab		

The water levels observed in the standpipes are likely to have resulted from entry of surface and near surface water inflows following periods of heavy rain, as water that has slowly entered the pipe from the saturated zone within the underlying clay soils, which is then unable to drain away due to the low permeability of these soils.

The above findings are therefore considered to be consistent with the conclusions drawn in the screening and scoping stages of this assessment and the subsequent interpretation of the hydrogeological characteristics and indicate that that the soils underlying the site comprise predominantly low permeability clay soils and that the observed conditions are indicative of the presence of poorly connected and / or discrete bodies of water within the superficial deposits.

5.5 Soil Contamination

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

Determinant	TP2: 0.50 m	TP4: 0.50 m	TP6: 1.00 m	BH3: 0.70 m
pH	9.4	7.6	8.2	8.2
Arsenic	21	20	24	18
Cadmium	<0.2	0.5	<0.2	<0.2
Chromium	25	30	32	37
Copper	44	120	47	51
Mercury	0.6	<0.3	<0.3	1.2
Nickel	22	22	24	25
Lead	**1300**	**1200**	**570**	**380**
Selenium	<1.0	<1.0	<1.0	<1.0
Zinc	130	330	150	120
Total Cyanide	<1.0	<1.0	<1.0	<1.0
Total Phenols	<1.0	<1.0	<1.0	<1.0

Determinant	TP2: 0.50 m	TP4: 0.50 m	TP6: 1.00 m	BH3: 0.70 m
Sulphide	1.5	<1.0	<1.0	<1.0
Total PAH	8.75	11.0	6.62	4.87
Benzo(a)pyrene	0.93	1.1	0.64	0.58
Naphthalene	<0.05	<0.05	<0.05	<0.05
TPH C8-C10	<0.1	<0.1	<0.1	<0.1
TPH C10-C12	<2.0	<2.0	<2.0	<2.0
TPH C12-C16	<4.0	<4.0	<4.0	<4.0
TPH C16-C21	5.7	11	7.9	8.8
TPH C21-C35	13	34	9.1	6.1
Total organic carbon %	0.7	2.7	0.8	0.8
Asbestos	Detected	Detected	Not detected	Not detected
Note: Figures in bold exceed screening values.				

5.5.1 Generic Quantitative Risk Assessment

The use of a risk-based approach has been adopted to provide an initial screening of the test results to assess the need for subsequent site-specific risk assessments. Contaminants of concern are those that have values in excess of generic human health risk-based guideline values, which are either the CLEA[6] Soil Guideline Values where available, the Suitable 4 Use Values[7] (S4UL) produced by LQM/CIEH calculated using the CLEA UK Version 1.06[8] software, or the DEFRA Category 4 Screening values[9], assuming a residential end use with plant uptake. The key generic assumptions for this end use are as follows:

- that groundwater will not be a critical risk receptor;
- that the critical receptor for human health will be a young female aged 0 to 6 years old;
- that the exposure duration will be six years;
- that the building type equates to a terraced house; and
- that the critical exposure pathways will be direct soil and indoor dust ingestion, consumption of homegrown produce, consumption of soil adhering to home grown produce, skin contact with soils and dust, and inhalation of dust and vapours.

It is considered that these assumptions are acceptable for this generic assessment of this site, with the exception of the groundwater risk, which will be discussed in Part 2. The tables of generic screening values derived by GEA and an explanation of how each value has been derived are included in the Appendix.

6 *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.
7 *The LQM/CIEH S4Uls for Human Health Risk Assessment* S4UL3065 November 2014
8 Contaminated Land Exposure Assessment (CL|EA) Software Version 1.06 Environment Agency 2009
9 CL:AIRE (2013) *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination* Final Project Report SP1010 and DEFRA (2014) *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination* Policy Companion Document SP1010

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. 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 results of the contamination testing have revealed elevated concentrations of lead within all four samples of made ground tested above the generic screening values for a residential end use with plant uptake. In addition, asbestos was detected within two samples of the made ground as loose fibres. All of the other contaminants were found to be below their respective generic guideline value and of generally low concentrations.

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

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

5.6 Existing Foundations

A total of nine trial pits were excavated to expose the foundations of the existing buildings and the findings are summarised in the table below. Trial pit records and photographs are included within the appendix.

Trial Pit No	Structure	Foundation detail	Bearing Stratum
1	Main house	Footing not encountered Top – Not encountered Base of footing not proved, extends to a depth in excess of 1.74 m No lateral projection	Not proved
2	Main house	Footing not encountered Top – Not encountered Base of footing not proved, extends to a depth in excess of 1.70 m No lateral projection	Not proved
3	Southern boundary garden wall	Brick Wall Top – Not present Base 1.05 m No lateral projection	Made Ground
4	Bay window of main house	Three brick corbels over concrete Top 1.16 m Base 1.85 m Lateral projection 350 mm	Not proved

Trial Pit No	Structure	Foundation detail	Bearing Stratum
5	Main house – Section A-A'	Footing not encountered Top – Not encountered Base of footing not proved, extends to a depth in excess of 1.00 m No lateral projection	Not proved
5	Bay window – Section B-B'	Brick over brick corbel Top 0.95 m Base of footing not proved, extends to a depth of at least 1.05 m Lateral projection 180 mm	Not proved
6	Single storey extension	Brick over concrete Top 0.2 m Base 1.21 m Lateral projection 230 mm	MADE GROUND
7	Garage	Concrete over brick over concrete Top 0.59 m Base 0.90 m Lateral projection 190 mm	MADE GROUND
7A	Northern boundary garden wall – Section A-A'	Brick over concrete Top 0.63 m Base 0.85 m Lateral projection 140 mm	MADE GROUND
7A	Garage – Section B-B'	Brick over concrete Top 0.45 m Base 0.80 m Lateral projection 210 mm	MADE GROUND

Part 2: DESIGN BASIS REPORT

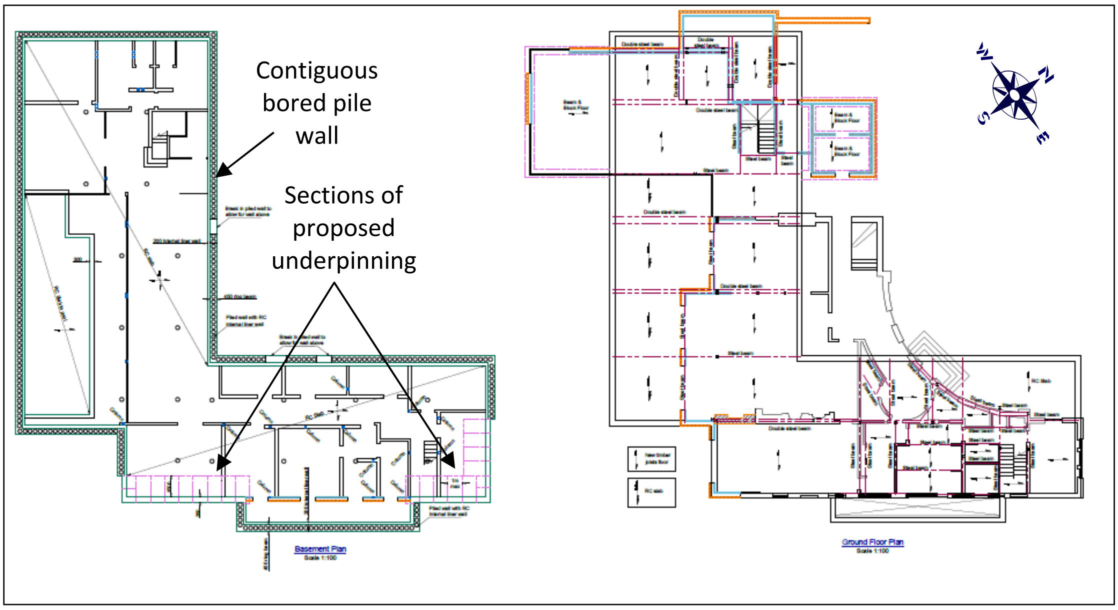
This section of the report provides an interpretation of the findings detailed in Part 1, in the form of a ground model, and then provides advice and recommendations with respect to foundation options and contamination issues.

6.0 INTRODUCTION

It is understood that it is proposed to refurbish the existing house through the construction of a new rear extension, replacement of the existing north wing with a new single-storey extension and construction of a single-level basement beneath the house and part of the new extension.

Excavations for the proposed basement are expected to extend to a depth of approximately 4.0 m, with an additional 2.0 m of excavation in the area of the proposed pool.

Information provided by the engineers indicates that the majority of the basement will be formed by contiguous piling, with limited sections of underpinning where the basement extends below part of the existing house, as shown on the plan drawing below.



7.0 GROUND MODEL

The desk study has indicated that the site was originally developed with two detached houses prior to being redeveloped with the existing house at some time between 1915 and 1935. On the basis of the fieldwork, the ground conditions at this site can be characterised as follows:

- below a moderate thickness of made ground, Head Deposits were encountered, overlying London Clay, which was proved to the full depth of the investigation;
- the made ground generally comprises brown gravelly clay with brick and ash and extends to depths of between 0.90 m and 2.00 m;

- the Head Deposits extend to depths of between 5.50 m and 6.50 m and generally comprise an upper horizon of 'stiff' or firm high strength orange-brown silty very sandy clay with abundant carbonaceous material, becoming gravelly with depth, overlying stiff high strength brown mottled grey silty clay with a reworked texture;

- the London Clay comprised an upper weathered layer of stiff fissured high strength brown silty clay with bluish grey veins, occasional partings of orange-brown fine sand and silt and selenite crystals, extending to depths of 8.80 m and 9.90 m.

- below this depth, stiff becoming very stiff fissured high strength becoming very high strength grey silty clay was encountered and proved to the maximum depth investigated of 20.00 m;

- desiccated clay soils were encountered within the vicinity of existing trees to a depth of approximately 3.00 m;

- groundwater was encountered during drilling around claystones;

- monitoring of the standpipes has measured groundwater at depths of between 1.70 m and 11.75 m;

- the contamination results have measured elevated lead within all four sample of made ground tested; and

- asbestos fibres were noted within two samples of made ground, identified as Chrysotile and Crocidolite.

7.1 Recommended Parameters

The table below summarises the vertical soil parameters to be used in any subsequent analysis and is based on the findings of the investigation. Values of stiffness for the soils at this site are readily available from published data[10, 11, 12 & 13] and a well-established method has been used to provide the estimated values. All depths are given relative to existing ground level.

Stratum	Base of Stratum (m bg.l)	Bulk Unit Weight (kN/m³)	Effective Friction Angle (φ' °)	Undrained Cohesion (C_u - kN/m²)	Undrained Young's Modulus* (E_u - kN/m²)	Drained Young's Modulus* (E'- kN/m²)
Made Ground	1.5 (varies)	17.5	27	-	-	10,000
Head Deposits	6.0	19.0	24	60 to 90	45,000 to 67,500	33,750 to 50,625
London Clay	20.0⁺	19.5	23	90 to 180	67,500 to 135,000	50,625 to 101,250

⁺Maximum depth of investigation: BGS records indicate that the London Clay extends to a depth of 120 m and an increase in cohesion of 7.5 kN/m² per metre increase in depth has been adopted to provide a conservative estimate of the likely strength profile below the depth of the investigation.

*Values based on a relationship of $E_u = 750\ C_u$ and $E' = 0.75\ E_u$ from Burland and Standing[11].

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

8.0 ADVICE AND RECOMMENDATIONS

Excavations for the proposed basement structure will require temporary support to maintain stability and to prevent any excessive ground movements.

Formation level for the proposed development is likely to be within the Head Deposits, or underlying London Clay, at a depth of between 4.0 m and 6.0 m, either of which should provide an eminently suitable bearing stratum for spread foundations excavated from basement level.

Some form of groundwater control is likely to be locally required to construct the basement, as perched water inflows should be expected from within the Head Deposits. However, given the results of the groundwater monitoring any inflows are anticipated to be localised and of limited volume.

8.1 Basement Excavation

Formation level for a single level basement is likely to be within the stiff silty sandy clay of the Head Deposits at a depth of 4.0 m, whilst deeper excavation for the proposed swimming pool, are likely to extend on the underlying London Clay, which was encountered at a depth of 6.0 m.

Inflows of perched water should be anticipated from within the made ground, particularly in the vicinity of existing structures, and from any more granular pockets within the Head Deposits. However, any such inflows are likely to be relatively minor in nature and should be adequately dealt with through sump pumping, although it would be prudent for the chosen contractor to have a contingency plan in place to deal with more significant or prolonged inflows as a precautionary measure.

The design of basement support in the temporary and permanent conditions needs to take account of the need to maintain the stability of the excavation and surrounding structures, and to protect against groundwater inflows.

It is understood that it is proposed to adopt a contiguous bored pile wall to support the majority of the proposed basement excavations, which will have the advantage of being incorporated into the permanent works and being able to provide support for structural loads. Localised grouting and / or sump pumping is likely to be necessary where perched water inflows are encountered.

Where the proposed basement extends beneath the existing house, it is understood that some limited sections of the proposed basement will formed by underpinning of the existing foundations, using a traditional ‘hit and miss’ approach, which should be feasible on the basis of the groundwater monitoring results to date, although it would be prudent to undertake trial excavations to confirm the likely groundwater conditions. Good workmanship will be required to ensure that movement of the surrounding structures does not arise during underpinning of the existing foundations, but this method will have the benefit of minimising the plant required and maximising usable space in the new basement.

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. A Ground Movement Analysis has been carried out in accordance with the requirements of CPG and is presented in Part 3 below.

8.1.1 Retaining Walls

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

Stratum	Bulk Density (kg/m^3)	Effective Cohesion (c' – kN/m^2)	Effective Friction Angle (Φ' – degrees)
Made ground	1800	Zero	27
Head Deposits	1950	Zero	24
London Clay	2000	Zero	23

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

Provided that a fully effective drainage system can be ensured in order to prevent the build-up of groundwater behind the retaining walls, it should be possible to design the basement on the basis that water will not collect behind the walls. If an effective drainage system cannot be ensured, then a water level of two-thirds of the basement depth, subject to a minimum depth of 1.0 m, should be assumed. The advice in BS8102:2009[14] should be followed in this respect and with regard to the provision of suitable waterproofing.

8.1.2 Basement Heave

The 4.0 m deep excavations to form the proposed basements will result in a net unloading of up to approximately 75 kN/m^2, increasing to 110 kN/m^2 in the area of the proposed swimming pool.

This unloading will result in elastic heave and long term swelling of the underlying clay soils, although these movements will to a certain extent be counteracted by the applied loads from the proposed development.

Further consideration is given to potential heave movements in Part 3 of this report.

8.2 Spread Foundations

Spread foundations, including underpinned foundations, bearing beneath basement formation level in the stiff silty sandy clay of the Head Deposits, or underlying London Clay, may be designed to apply a net allowable bearing pressure of 150 kN/m^2.

This value incorporates an adequate factor of safety against bearing capacity failure and should ensure that settlement remains within normal tolerable limits.

The depth of the basement excavation is expected to be such that foundations will be placed below the depth of actual or potential desiccation, but this should be checked once the proposals have been finalised, with the survey drawing showing former and existing trees.

Notwithstanding NHBC guidelines, all foundations should extend beyond the zone of desiccation. In this respect, it would be prudent to have all foundation excavations inspected by a suitably experienced engineer. Due allowance should be made for future growth of existing / proposed trees.

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

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

8.3 Basement Raft Foundation

The suitability of a raft foundation will be governed by the net load of the new development, taking into consideration the weight of soil removed by the basement excavation. On this site, in view of the depth of the proposed excavation and the estimated heave it is anticipated that the gross load on the raft will not be sufficient to balance the weight of soil removed and the raft may need to be anchored into the ground by piles to resist movements. The raft could be constructed so that it forms a rigid box with the retaining walls such that differential movements are minimised.

8.4 Piled Foundations

For the ground conditions at this site some form of bored pile is likely to be the most appropriate type. A conventional rotary augered pile may be appropriate, with temporary casing installed to maintain stability and prevent groundwater inflows, or alternatively the use of bored piles installed using continuous flight auger (cfa) techniques, which would not require the provision of casing, would also be appropriate.

The following table of ultimate coefficients may be used for the preliminary design of bored piles, based on the SPT & Cohesion / depth graph in the appendix.

Stratum	Depth m	kN / m^2
Ultimate Skin Friction		
Made Ground	All soil above 4.0	Ignore - basement excavation
Head Deposits	4.00 to 6. 0	Increasing linearly from 37.5 to 45
London Clay	6.0 to 20.0	Increasing linearly from 45 to 90
Ultimate End Bearing		
London Clay	10.0 to 20.0	Increasing linearly from 1035 to 1620

In the absence of pile tests, guidance from the London District Surveyors Association (LDSA)[15] suggests that a factor of safety of 2.6 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 2.6, the following safe working loads have been estimated.

Pile diameter mm	Depth Below Ground Level m	Pile length m	Safe Working Load kN
450	12	8	295
	15	11	420
	18	14	560
600	12	8	425
	15	11	595
	18	14	790

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

The above examples are not intended to constitute any form of recommendation regarding the pile size or type, but merely serve to illustrate the use of the above coefficients. Specialist piling contractors should be consulted about the design of an appropriate piling scheme and their attention should be drawn to potential groundwater inflows within the made ground and underlying Head Deposits, and the potential presence of claystones within the London Clay.

In the design of piled foundations, the effect of potential future shrinkage and swelling of the clay should be taken into account. In designing for compressive loads, it should be assumed that further desiccation, and hence shrinkage of the clay, could continue where trees are to remain. Pile shaft adhesion within the theoretical maximum future desiccated thickness should therefore be ignored.

8.5 Basement Floor Slab

Unless a raft is adopted, it is likely that the floor slab for the proposed basement will need to be suspended over a void or a layer of compressible material to accommodate the anticipated heave and any potential uplift forces from groundwater pressures, unless the slab can be suitably reinforced to cope with these movements.

Further consideration is given to heave movements in Part 3 of this report.

8.6 Shallow Excavations

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

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

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

8.7 Effect of Sulphates

Chemical analyses of selected soil samples have revealed low concentrations of soluble sulphate, corresponding to Class DS-1 and AC-1 of Table C2 of BRE Special Digest 1:2005. The guidelines contained in the above digest should be followed in the design of any new foundation concrete.

8.8 Site Specific Risk Assessment

The desk study has indicated that the site has not had a contaminative history, having been occupied by residential properties throughout its developed history and in a residential area, such that, no sources of contamination have been identified. However, the results of the contamination testing have identified elevated concentrations of lead within all four samples of made ground tested.

The exact source of the contamination is unknown. However, the made ground was noted as containing variable amounts of extraneous material and it is therefore possible that a fragment of such material was present within the samples tested, accounting for the elevated concentration. In addition, information on Urban Soil Chemistry provided by the BGS also indicates that background concentrations for lead in the vicinity of the site are on average 572 mg/kg, with a higher average of 2419 mg/kg immediately to the east, such that a significant proportion of the measured concentrations could be the result of residual airborne sources.

Lead compounds are relatively immobile and unlikely to be in a soluble form and are considered to be non-volatile or of a low volatility. The contamination does not therefore present a significant vapour risk or a significant risk of leaching and migration within any perched groundwater within the made ground. As the site is underlain by the London Clay, classified as Unproductive Strata, a risk to groundwater has not been identified.

End users will be effectively isolated from direct contact with the identified contaminants by the building and areas of external hardstanding. The contamination is likely to be removed as part of the basement excavation and only in proposed garden areas could end users conceivably come into direct contact with the contaminated soils, although this pathway is already in existence.

As only a limited number of samples have been tested, it would be prudent to carry out contamination testing on additional samples of made ground / topsoil recovered from the areas of the site that are to remain as soft landscaped gardens, in order to ensure the absence of any significant contamination.

Site workers will be protected from the lead contamination through adherence to normal high standards of site safety, as outline in more detail in Section 8.7.1 below.

Contamination testing has also detected asbestos within the two samples of made ground screened from Trial Pit Nos 2 and 4, although asbestos was not noted during logging of recovered samples on site. Loose fibres were detected as Chrysotile within both samples and Crocidolite was also identified in Trial Pit No 2.

It is recommended that asbestos quantification tests are undertaken for the made ground to be removed from the site as a precautionary measure, as a concentration greater than 0.1 % will lead to a hazardous waste classification. If suspected asbestos is encountered within the soil during groundworks, the suspect material should be double bagged and disposed of appropriately. Within areas of proposed soft landscaping, a marker layer should be installed prior to the importation of clean topsoil to ensure no mixing of the soils that may contain asbestos.

8.8.1 Protection of Site Workers

Site workers should be made aware of the contamination and asbestos fibres within the soils 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[16] and CIRIA[17] and the requirements of the Local Authority Environmental Health Officer.

8.9 Waste Disposal

Under the European Waste Directive, waste is classified as being either Hazardous or Non-Hazardous and landfills receiving waste are classified as accepting hazardous or non-hazardous wastes or the non-hazardous sub-category of inert waste in accordance with the Waste Directive. Waste classification is a staged process and this investigation represents the preliminary sampling exercise of that process. Once the extent and location of the waste that is to be removed has been defined, further sampling and testing may be necessary. The results from this ground investigation should be used to help define the sampling plan for such further testing, which could include WAC leaching tests where the totals analysis indicates the soil to be a hazardous waste or inert waste from a contaminated site. It should however be noted that the Environment Agency guidance WM3[18] 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[19] 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 £94.15 per tonne (about £175 per m^3) or at the lower rate of £3.00 per tonne (roughly £5.50 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 Environment Agency it is considered likely that the soils encountered during this ground investigation, as represented by the four chemical analyses carried out, would be generally classified as follows;

Soil Type	Waste Classification (Waste Code)	WAC Testing Required Prior to Landfill Disposal?
Made ground	Non-hazardous (17 05 04)	No
Made ground	Hazardous (17 05 04)	Yes, for any made ground containing asbestos over 0.1%
Natural soils	Inert (17 05 04)	Should not be required but confirm with receiving landfill

It is recommended that asbestos quantification tests are undertaken for any made ground to be removed from the site as a precautionary measure, as a concentration greater than 0.1 % will lead to a hazardous waste classification.

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,

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

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

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

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

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[20] 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.

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

Part 3: GROUND MOVEMENT ANALYSIS

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

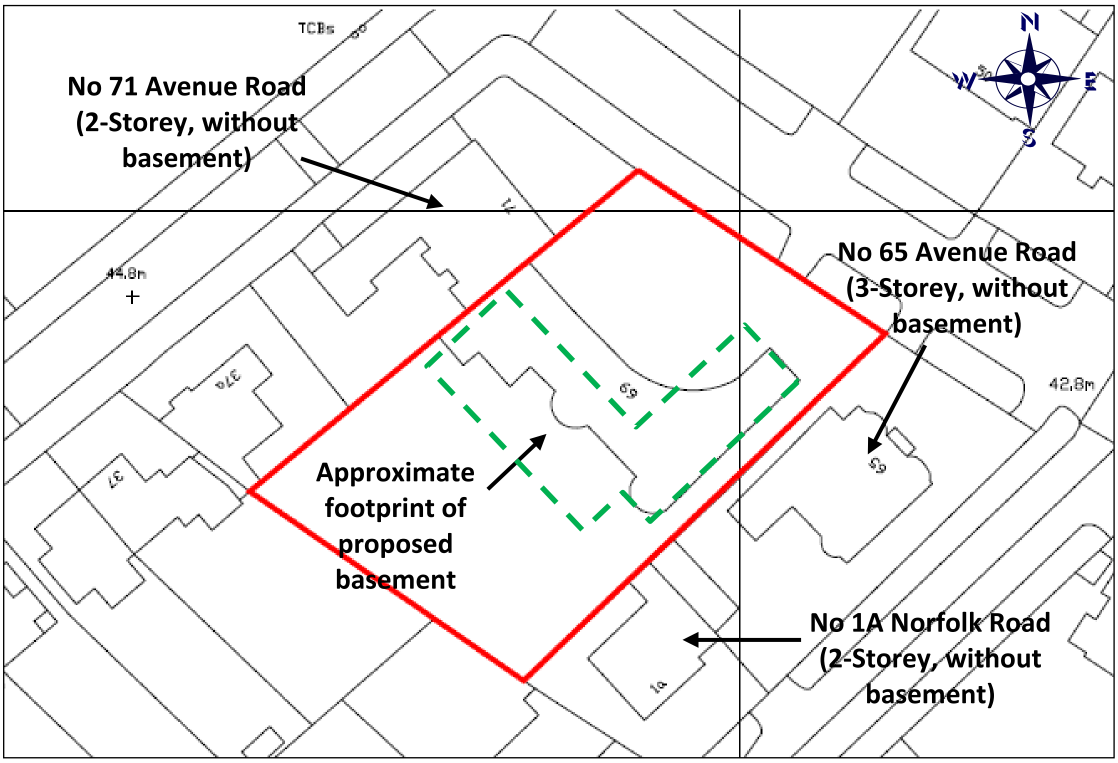
9.0 INTRODUCTION

The sides of an excavation will move to some extent regardless of how they are supported. The movement will typically be both horizontal and vertical and will be influenced by the engineering properties of the ground, groundwater level and flow 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.

9.1 Nearby Sensitive Structures

A plan showing the nearby sensitive structures is shown below.



Sensitive structures relevant to this assessment include the adjoining properties of Nos 65 and 71 Avenue Road, to the southeast and northwest respectively, as well as No 1A Norfolk Road to the south of the site. All other nearby structures have been found to be at sufficient distance as not to be affected by the proposed development and have not therefore been included within the analysis.

The nature of the foundations of the adjoining structures is not known and a cautious approach has therefore been adopted with the assumption that the buildings are supported on relatively shallow spread foundations, bearing within the Head Deposits at a depth of at least 1.00 m.

9.2 Construction Sequence

Consideration is being given to the redevelopment of the site, which will include the construction of a single level basement that will extend to a depth of 4.0 m beneath the existing house and rear patio / extension, with an additional 2.0 m of excavation in the area of the proposed swimming pool.

It is currently understood that a contiguous bored pile wall will be installed to support the majority of the basement excavations, whilst limited sections of underpinning will be employed on the southern part of the site, where the basement is coincident with the foundations of the existing building.

The following sequence of operations has been derived to enable analysis of the ground movements around the basement, both during and after construction, and is based on information provided by the consulting engineer, Croft Structural Engineers, in their own Basement Impact Assessment (report ref 200203, dated April 2020).

Essentially the sequence may be considered as two groups of activities, the first comprising the short-term temporary works, whilst the second represents the construction of the permanent works.

The detail of the support provided to adjacent walls is beyond the scope of this report and the structural engineer will be best placed to agree the methodology with the chosen contractor(s) once appointed.

9.2.1 Temporary Support to Piled Walls

Following the installation of the contiguous bored pile wall and associated capping beams, temporary props will be installed, and the basement excavation will proceed. The detail of section sizes and spacings will be finalised by the contractor but it is anticipated that the general philosophy adopted will be for diagonal braces to be used across the corners or returns of the basement walls whilst props will be positioned at regular intervals along the long walls of the basement.

Where horizontal restraint cannot be provided by other parts of the piled wall the prop forces can be provided by so-called ‘flying shores’ where the reaction to horizontal forces is provided by pile caps, gravity blocks or basement thickenings in the centre of the excavation.

It is anticipated that steel temporary props will be used with strut forces spread along the wall by steel waling beams fixed to the piles. Although the detail of the propping is to be finalised there is the option to use hydraulic ‘active’ props where the propping force is applied prior to excavation in order to minimise movement at critical locations.

9.2.2 Temporary Support to Underpinned Walls

It is understood that underpinning of two sections of the existing foundations on the southern part of the site will take place in a ‘hit and miss’ sequence, in stages to be agreed with the temporary works engineer and under party wall agreement.

Underpinning is to be undertaken in short sections not exceeding 1.0 m in length, with no adjacent pin to be excavated until a minimum of 48 hours after the adjacent pin has been cast and dry-packed placed, with the sides of the excavation adequately shored and propped.

9.2.3 Bulk Excavation

Excavation will proceed in stages and in broad terms the order of operations will be install capping beam props, excavate to a suitable depth below the next propping level, install props and then repeat the operation until the final excavation level has been reached.

9.2.4 Permanent Works

When the final excavation depths have been reached the permanent works will be formed which, from the information provided, are understood to comprise reinforced concrete walls with a drained cavity lining discharging to a sump pit. Reinforced concrete will be used for the proposed basement floor slab.

It is anticipated that the floor slabs, which will act as permanent props, will be constructed lowest level first and when each floor has achieved adequate strength, the temporary props will be removed, and the subsequent walls and floors cast until the structure is complete.

10.0 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 X-Disp program has been used to predict ground movements likely to arise from the construction of the proposed basement. This includes the settlement of the ground (vertical movement) and the lateral movement of soil behind the proposed retaining walls (horizontal movement).

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 software package and is based on the assumption that the soils behave elastically, which provides a reasonable approximation of soil behaviour at small strains.

For the purpose of these analyses, the corners have been defined by x and y coordinates, with the x-direction parallel with the site boundaries with the adjoining properties (approx. northeast-southwest), whilst the y-direction is parallel with the orientation of Avenue Road (approx. northwest-southeast). Vertical movement is in the z-direction.

For this movement analysis, the basement has been modelled as an approximately L-shaped polygon, with maximum dimensions of 34.0 m by 32.0 m, which will extend to a depth of 4.0 m, with an additional 2.0 m of excavation in the vicinity of the proposed swimming pool.

Wall lengths of less than 10 m have been modelled as 1 m long structural elements, while greater than 10 m wall lengths have been modelled as 2 m elements. Based on the findings of the investigation, the foundations of the adjoining structures have been assumed to extend to a depth of at least 1.0 m below existing ground level.

Based on information provided by the consulting engineer, a toe depth of approximately 10 m below existing ground level has been assumed to calculate ground movements as a result of pile installation, increasing to a depth of approximately 12.0 m in the vicinity of the proposed swimming pool.

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

It should be noted that the proposed basement footprint contains several re-entrant corners, which, due to limitations within the software, causes a doubling up of movements, creating an issue for any analysis, particularly along short walls, as in reality the opposite is likely to be the case, with an overall reduction in ground movements in these areas due to the increased stiffness of the structure at these points. Where it has not been possible simplify the shape of the basement to remove these features, a reduction factor of 50% has been applied to the ground movement curves applied to the walls forming part of a re-entrant corner to mitigate these effects and provide a more realistic model that can be used in the subsequent damage assessment.

The full inputs of all the analyses, along with selected movement contour plots and tabular outputs are included within the appendix.

10.1 Ground Model for Analysis (P-Disp)

At this site, unloading of the Head Deposits and underlying London Clay will take place as a result of the basement excavation and the reduction in vertical stress will cause heave to take place. Undrained soil parameters have been used to estimate the potential short-term movements, which include the "immediate" or elastic movements as a result of the basement excavation. Drained parameters have been used to provide an estimate of the total movement, from which the post-construction or long-term movements can be calculated.

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[21] and we have used a well-established method to provide our estimates. Relationships of $E_u = 750\ C_u$ and E' = 0.75, have been used to obtain values of Young's modulus for the clay soils, which are considered appropriate based on the size and depth of the proposed basement.

The soil parameters used in this assessment are summarised in the table below and are based on those presented in Section 7.1.

Stratum	Base of Stratum (m bg.l)	Cohesion (KPa)	Eu (KPa)	E'(KPa)
Made Ground	1.5 (varies)	-	-	10,000
Head Deposits	6.0	60 to 90	45,000 to 67,500	33,750 to 50,625
London Clay	20.0^{+}	90 to 180	67,500 to 135,000	50,625 to 101,250

$^{+}$Maximum depth of investigation. BGS records indicate that the London Clay extends to a depth of 120 m and an increase in cohesion of 7.5 kN/m^2 per metre increase in depth has been adopted to provide a conservative estimate of the likely strength profile below the depth of the investigation.

A rigid boundary for the analysis has been set within the London Clay at a depth of 50 m below ground level, at which point the degree of stress change and any associated movements due to the proposed basement effectively reduce to zero.

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

The excavation of approximately 4.0 m thickness of soil for the proposed basement will result in a net unloading of 75 kN/m^2, increasing to 110 kN/m² in the area of the proposed swimming pool.

Information provided by the consulting engineer indicates that the loads on the proposed underpinning will result in a bearing pressure of 92.5 kN/m^2 and an assessment of the potential behaviour of these foundations has been included within the analysis.

10.2 Ground Movements – Surrounding the Excavation

10.2.1 X-Disp Model

For the X-Disp analysis, the soil movement relationships used for the embedded retaining walls are the default values within CIRIA report C760[22], which were derived from a number of historic case studies.

Piled retaining walls:
Table 6.1 of CIRIA C760 gives the normalised horizontal movement for a contiguous wall of 0.04% of the installed pile length. However, monitoring of wall movements reported by Ball, Langdon and Creighton[23] of a contiguous bored pile wall in central London that represents, in scale and currency of data, a reasonable representation to this site, indicated measured wall installation movements normalised to between 0.006% and 0.012% of pile length. The paper then suggests that a normalised relationship of 0.02%, i.e. half of the C760 movements, could be appropriate for a contiguous wall whilst remaining relatively conservative and subject to careful control of installation. On the understanding that equally tight controls of pile installation are maintained it follows that there is no reason why a similar relationship cannot be adopted for this site.

An amended ground movement curve for the 'installation of a contiguous pile wall', with a normalised relationship of 0.02% has therefore been adopted to represent the effects of the installation of the piled walls that will form the proposed basement structure.

Proposed Underpinning:
On this site it is assumed that the mass concrete underpinning, to form the side walls of the new basement, will be supported or propped in the temporary condition to maintain stability during the excavation and that reinforced concrete retaining walls will be cast at a later stage in the appropriate areas.

Whilst it might appear reasonable to adopt the ground movement curves for 'no horizontal and vertical movement' for this analysis, in practice there will always be a potential for some movement to take place.

The installation curves for the panel-like planar diaphragm wall have therefore been adopted as most appropriate for the soil movement relationship for walls installed by underpinning techniques.

In order to fully assess the proposed underpinning, the vertical movements obtained from the P-Disp analysis of the installation phase of structures has also been imported into X-Disp to enable a damage assessment to be undertaken of all the potential movements.

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

23 Ball, R, Langdon, N, and Creighton, M (2014) Prediction of party wall movements using CIRIA report C580. *GE Technical Paper*

Excavation Phase:
The ground movement curves for 'excavations in front of a stiff wall in stiff clay' have been adopted for the subsequent excavation phase, as this provides a conservative assessment of the likely vertical and horizontal movements.

10.2.2 Results

The results are presented to the degree of accuracy required to allow predicted variations in ground movements around the structure(s) to be illustrated but may not reflect the anticipated accuracy of the predictions.

Phase of Works	Maximum Movements due to Wall Deflection (mm)	
	Vertical Settlement	Horizontal Movement
Wall installation (including vertical settlement due to loading on proposed underpins form P-Disp)	1 to 4	1.5 to 2.5
Combined movements from wall installation and excavation	4 to 8	6 to 10

The analysis has indicated that the maximum vertical and horizontal settlements that will result from the retaining wall installation are less than or equal to 4 mm and 2.5 mm respectively, while the movements arising from the combined wall installation and excavation phases are likely to range between 4 mm to 8 mm of vertical settlement and 6 mm to 10 mm of horizontal movement.

The movements set out in the table and discussed above are the maximum movements and the analysis has indicated that they occur immediately or just outside the line of the retaining walls.

10.3 Ground Movements within the Excavation (Heave)

10.3.1 Results

The potential movements are summarised in the table overleaf.

Location	Ground Movement (mm) Heave is -ve and Settlement +ve)			
	Short-term (Underpinning)	Short-term (Bulk Excavation)	Long-term (post construction)	Total Heave
Centre of excavations	<1.0	6 to 9	8 to 9	14 to 18
Edge of excavations	-<1.0	3 to 5	4 to 5	7 to 10
Proposed Underpinning	2 to 4	0 to 2	1	1 to 3

The P-Disp analysis indicates that, by the time the basement construction is complete, up to 6 mm to 9 mm of heave is likely to have taken place at the centre of the proposed excavations, reducing to between 3 mm and 5 mm at the edges. In the long term, following completion of the basement construction, a further 8 mm to 9 mm of heave is estimated as a result of long term swelling of the underlying clay soils.

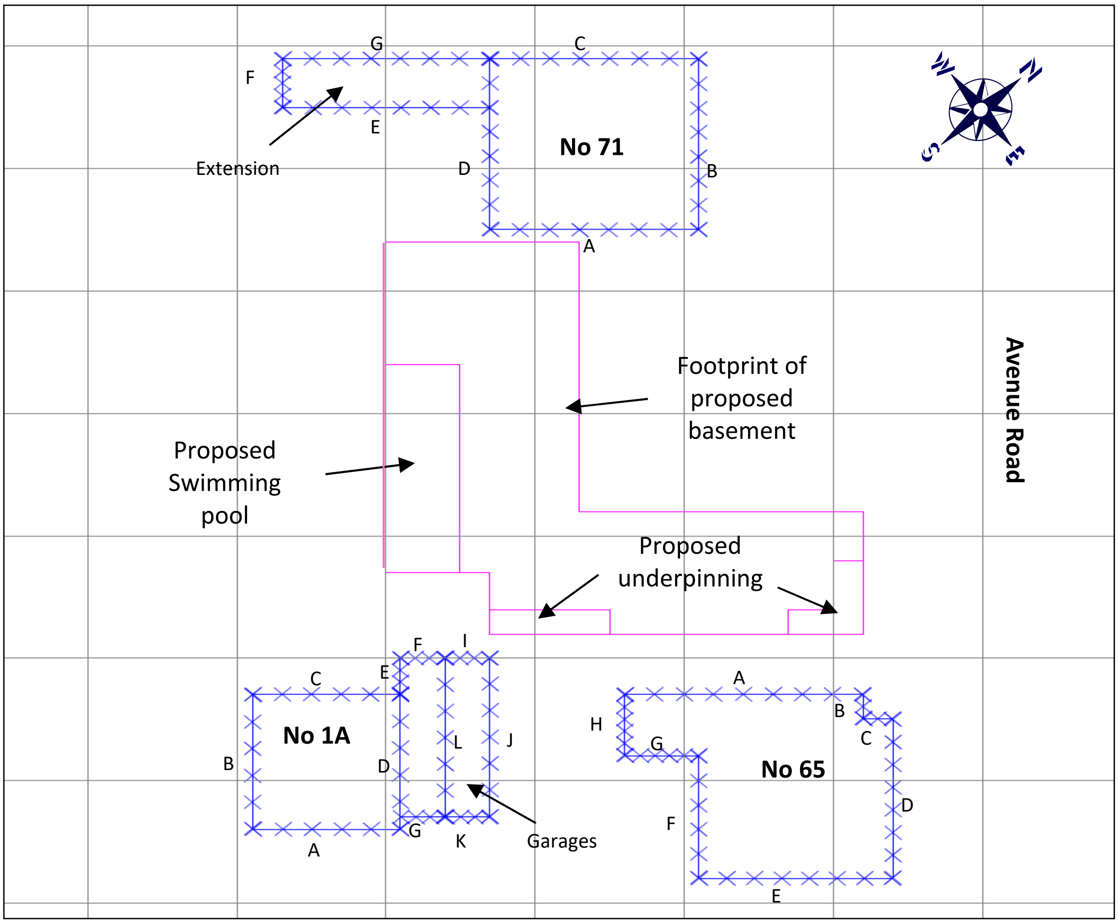
It is important to bear in mind that the results of the P-Disp analysis, which is based on an unrestrained excavation, does not take account of the mitigating effect of the existing structures, the stiffness of the proposed floor slabs, underpinning and the contiguous pile walls, which in reality will combine to restrict potential heave movements within the basement excavation. The movements predicted by the model at or just beyond the site boundaries are unlikely to be fully realised and should not therefore have a detrimental impact upon any nearby structures.

In order to mitigate the effects of heave on the new building, the basement could be designed to transmit heave forces into the wall piles or onto tension piles within the basement.

If a compressible material is used beneath the slab, it will need to be designed to be able to resist the potential uplift forces generated by the ground movements. In this respect potential heave pressures are typically taken to equate to around 50 % of the total unloading pressure, assuming a linear relationship between heave movement and the pressure applied to the underside of the slab, which in this case is taken to be inflexible. However, if there is some flexibility in the slab, this value would reduce as the slab deflects and it would be reasonable to assume that the heave pressure would reduce to around 35 % of the unloading pressure.

11.0 DAMAGE ASSESSMENT

In addition to the assessment of the likely movements that will result from the proposed development, some of the neighbouring structures have been set as sensitive structures, requiring Building Damage Assessments, on the basis of the classification given in Table 6.4 of C760.



The sensitive structures of No 65 Avenue Road, No 1A Norfolk Road and No 71 Avenue Road, previously identified in Section 9.1 have been modelled as a series of displacement lines in the analysis, as detailed on the plan above, along which the damage assessment has been undertaken.

As per the comments in Section 9.1, a foundation depth of approximately 1.0 m below existing ground level has been assumed for the purpose of the analysis.

The heights of neighbouring buildings have been estimated from observations made during the investigation and information provided by the consulting engineers.

11.1 Damage to Neighbouring Structures

The combined movements resulting from underpinning and excavation of the proposed basement, calculated using the X-Disp and P-Disp modelling software have been used to carry out an assessment of the likely damage to adjacent properties and the results are summarised in the table below.

Sensitive Structure	Ref No / Elevation	Max Tensile Strain (%)	Category of Damage*
No 65 Avenue Road	A	0.01	Category 0 - Negligible
	B	0.03	Category 0 - Negligible
	C	<0.01	Category 0 - Negligible
	D	0.02	Category 0 - Negligible
	E	Less than limit of sensitivity	
	F	0.02	Category 0 - Negligible
	G	<0.01	Category 0 - Negligible
	H	0.05	Category 1 – Very Slight-
No 65 Avenue Road (Garage)	I	<0.01	Category 0 - Negligible
	J	0.06	Category 1 – Very Slight-
	K	Less than limit of sensitivity	
No 65 Avenue Road /	L	0.04	Category 0 - Negligible
No 1A Norfolk Road	A	Less than limit of sensitivity	
	B	<0.01	Category 0 - Negligible
	C	<0.01	Category 0 - Negligible
	D	0.03	Category 0 - Negligible
No 1A Norfolk Road (Garage)	E	0.03	Category 0 - Negligible
	F	<0.01	Category 0 - Negligible
	G	<0.01	Category 0 - Negligible
No 71 Avenue Road	A	0.03	Category 0 - Negligible
	B	<0.01	Category 0 - Negligible
	C	<0.01	Category 0 - Negligible
	D	0.06	Category 1 – Very Slight-
No 71 Avenue Road (Extension)	E	<0.01	Category 0 - Negligible
	F	<0.01	Category 0 - Negligible
	G	<0.01	Category 0 - Negligible

*From Table 6.4 of C760: Classification of visible damage to walls.

The building damage reports for sensitive structures highlighted in the above table predict that the damage to the adjoining and nearby structures would generally be Category 0 (negligible), with a number of limited sections of Category 1 (Very Slight) damage to Nos 65 and 71 Avenue Road.

The results discussed above are based on individual building lines, or walls, that have been further divided up into a series of 1.0 m to 2.0 m segments that can move independently of one another. In reality, this is unlikely to be the case as the walls will behave as single elements that are also joined continuously with the rest of the structure. The above results therefore provide a conservative estimate of the behaviour of each of the sensitive structures and are likely to overestimate the degree of damage, although they provide a useful indication of the most critical structures within the adjoining properties.

11.2 Monitoring of Ground Movements

The predictions of ground movement based on the ground movement analysis should be checked by monitoring of adjacent properties and structures.

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

12.0 GROUND MOVEMENT CONCLUSIONS

The analysis has concluded that the predicted damage to the neighbouring properties from the construction of the basement retaining walls and excavation would be generally ‘Negligible’ to ‘Very Slight’. On this basis, the damage that has been predicted to occur as a result of the construction of the proposed basement falls within the acceptable limits, although careful construction, including the careful control of the proposed underpinning, will be required to ensure that no excessive movements occur that would lead to damage in excess of these limits.

Whilst it is recommended that movement monitoring is carried out on all structures prior to and during the proposed excavation and construction, it is unlikely that specification of these works will be required as part of the planning conditions, but may be required in order to satisfy party wall awards.

Part 4: BASEMENT IMPACT ASSESSMENT

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

13.0 INTRODUCTION

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

13.1 Potential Impacts

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

Potential Impact	Site Investigation Conclusions
London Clay is the shallowest strata at the site	The investigation indicated that beneath of covering of made ground, Head Deposits are covering the majority of the site, in turn overlying the London Clay. The Head Deposits have been classified as mostly high volume change potential soils, which are prone to seasonal shrink-swell (settlement and heave) and desiccated clay soils were encountered to a depth of approximately 3 m.
Seasonal shrink-swell can result in foundation movements	The results of plasticity index testing have indicated a high volume change potential. Shrinkable clay is present within a depth that can be affected by tree roots. Desiccation was encountered during the fieldwork, in close proximity to existing trees. The proposed basement will extend to a general depth of about 4.00 m, such that new foundations would be expected to bypass any desiccated soils present.
The site is within 100 m of a watercourse, well (used/ disused) or potential spring line	The site investigation did not establish the presence of alluvial deposits beneath the site, which indicated any hydraulic continuity with saturated alluvial deposits associated with the Tyburn stream. Therefore, there is not considered to be an issue to the site or the proposed development and in any case a continuous groundwater level has not been encountered below the site.
The development is likely to increase the differential depth of foundations relative to neighbouring properties which may result in structural damage.	The proposed building will be detached from any neighbouring properties. The retention system will ensure the stability of the excavation and neighbouring properties at all times.
The development will result in a change in the proportion of hard surface / paved areas	The sealing of the ground surface to rainfall, by increasing the building area, would result in decreased recharge to the underlying ground, although the low permeability of the underlying London Clay would result in a low recharge in any case and consequently there would be little or no effect on groundwater. In addition, it is considered that the use of SUDS attenuation will mitigate any potential impact on surface water inflows and run-off.
Site at risk from surface flooding	A flood risk assessment (FEA) has been undertaken separately, which concludes that potential risks are reduced to acceptable levels through the implementation of proposed mitigation measures.

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

London Clay is the shallowest stratum

The investigation indicated that beneath a covering of made ground, Head Deposits are covering the majority of the site, in turn overlying the London Clay.

The Head Deposits have been classified as mostly high volume change potential soils, which are prone to seasonal shrink-swell (settlement and heave).

Shrink / swell potential of shallow soils

Shrinkable clay is present within a depth that can be affected by tree roots. Numerous trees are present on the site, and desiccation was noted at the exploratory locations investigated, located in close proximity to existing trees. The proposed single level basement is likely to extend below the potential depth of root action, but this should be confirmed once proposals have been finalised.

The site is located 100 m of a former river course

The River Tyburn has been culverted to form a drain and is, therefore, unlikely to have any impact on, or be influenced by, the surrounding groundwater. The proposed basement development does not therefore impact on the surrounding water environment.

Increase in the differential depth of neighbouring foundations

The stability of neighbouring properties and structures will be ensured at all times, through a suitable retention system. There is nothing unusual or exceptional in the proposed development or the findings of the investigation that give rise to any concerns with regard to stability over and above any development of this nature.

An analysis of the potential ground movements resulting from construction of the proposed basement is included in Part 3 of this report and has concluded that the predicted damage to the neighbouring properties would be Category 0 (Negligible) to Category 1 (Very Slight).

On this basis, the damage that would inevitably occur as a result of such an excavation would fall well within the acceptable limits although monitoring and mitigation measures will be required to ensure that no excessive movements occur that would lead to damage in excess of these limits.

Increase in hardstanding and paved areas

The proposed development for the site will marginally increase the amount of hard-standing and paved areas, but this will have little effect as the ground is of low permeability. The ground conditions will not be suitable for a soakaway or similar SUDS based system.

It is understood that the attenuation systems recommended in the FRA will mitigate any potential impact on surface water inflows and run-off.

The site has low flooding potential from surface water

The FRA for the site indicates that any potential risk of flooding is reduced to acceptable levels through the implementation of the mitigation measures recommended by this assessment.

It is possible that the basement will be constructed within perched groundwater and the recommendations outlined in the BIA with regards to waterproofing and tanking of the basement will reduce the risk to acceptable levels.

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

13.2 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.

13.3 Non-Technical Summary of Evidence

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

13.3.1 Screening

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

Question	Evidence
1a. Is the site located directly above an aquifer?	Aquifer designation maps acquired from the Environment Agency as part of the desk study and Figures 3, 5 and 8 of the Arup report.
1b. Will the proposed basement extend beneath the water table surface?	Previous nearby GEA investigations and BGS archive borehole records.
2. Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line?	Topographical maps acquired as part of the desk study, reference to the Lost Rivers of London and Figures 11 and 12 of the Arup report.
3. Is the site within the catchment of the pond chains on Hampstead Heath?	Topographical maps acquired as part of the desk study and Figures 12 and 14 of the Arup report
4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	A site walkover and existing plans of the site have confirmed the proportions of hardstanding and soft landscaping, which have been compared to the proposed drawings to determine the changes in the proportions.
5. As part of the site drainage, will more surface water (e.g. rainfall and run-off) than at present be discharged to the ground (e.g. via soakaways and/or SUDS)?	The details of the proposed development do not indicate the use of soakaway drainage.
6. Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to or lower than, the mean water level in any local pond or spring line?	Topographical maps acquired as part of the desk study and Figures 11 and 12 of the Arup report.

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

Question	Evidence
1. Does the existing site include slopes, natural or manmade, greater than 7°?	Topographical maps and Figures 16 and 17 of the Arup report and confirmed during a site walkover
2. Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7°?	The details of the proposed development provided do not include the re-profiling of the site to create new slopes
3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	Topographical maps and Figures 16 and 17 of the Arup report
4. Is the site within a wider hillside setting in which the general slope is greater than 7°?	
5. Is the London Clay the shallowest strata at the site?	Geological maps and Figures 3, 5 and 8 of the Arup report
6. Will any trees be felled as part of the proposed development and / or are any works proposed within any tree protection zones where trees are to be retained?	The details of the proposed development provided do not include the removal of any trees.
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 were used to assess this
8. Is the site within 100 m of a watercourse or potential spring line?	Topographical maps acquired as part of the desk study and Figures 11 and 12 of the Arup report
9. Is the site within an area of previously worked ground?	Geological maps and Figures 3, 5 and 8 of the Arup report
10. Is the site within an aquifer?	Aquifer designation maps acquired from the Environment Agency as part of the desk study and Figures 3, 5 and 8 of the Arup report.
11. Is the site within 50 m of Hampstead Heath ponds?	Topographical maps acquired as part of the desk study and Figures 12 and 14 of the Arup report
12. Is the site within 5 m of a highway or pedestrian right of way?	Site plans and the site walkover.
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Camden planning portal and the site walkover confirmed the position of the proposed basement relative the neighbouring properties.
14. Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	Maps and plans of infrastructure tunnels were reviewed.

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

Question	Evidence
1. Is the site within the catchment of the pond chains on Hampstead Heath?	Topographical maps acquired as part of the desk study and Figures 12 and 14 of the Arup report
2. As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route?	A site walkover confirmed the current site conditions and the details provided on the proposed development, including reference to the FRA for the site, indicate that this situation will remain once the development is complete.
3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	

Question	Evidence
4. Will the proposed basement development result in changes to the profile of the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses?	
5. Will the proposed basement result in changes to the quantity of surface water being received by adjacent properties or downstream watercourses?	
6. Is the site in an area known to be at risk from surface water flooding such as South Hampstead, West Hampstead, Gospel Oak and Kings Cross, or is it at risk of flooding because the proposed basement is below the static water level of a nearby surface water feature?	Flood risk maps acquired from the Environment Agency as part of the desk study, Figure 15 of the Arup report, the Camden Flood Risk Management Strategy dated 2013 and the North London Strategic Flood Risk Assessment dated 2008, and reference to the site specific FRA.

13.3.2 Scoping and Site Investigation

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

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

14.0 OUTSTANDING RISKS AND ISSUES

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

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

As discussed throughout the report, perched water is likely to be encountered during the basement excavation, although the finding of the investigation indicate that potential inflows are unlikely to be significant and should be adequately dealt with through sump pumping. However, groundwater monitoring should be continued, and trial excavations should be considered to assess the extent of inflows to be expected within the proposed basement excavations.

The investigation has not identified the presence of any significant contamination and as the majority of the made ground will be removed from this site through the excavation of the proposed basement, remedial measures should not be required, other than where areas of soft landscaping are to be formed. However, as with any site there is a potential for further areas of contamination to be present within the made ground beneath parts of the site not covered by the investigation it is recommended that a watching brief is maintained during any groundworks for the proposed new foundations and that if any suspicious soils are encountered that they are inspected by a geoenvironmental engineer and further assessment may be required.

The findings of the ground movement analysis and damage assessment should be reviewed once the design proposals have been finalised, particularly if any changes are made to the proposed basement construction.

It would be prudent to undertake a preliminary UXO assessment prior to any further work being conducted on site to assess the potential for UXO to be present and the requirement for further detailed assessment and / or on-site mitigation measures.

These items should be drawn to the attention of prospective contractors and further investigation will be required or sufficient contingency should be provided to cover the outstanding risk.

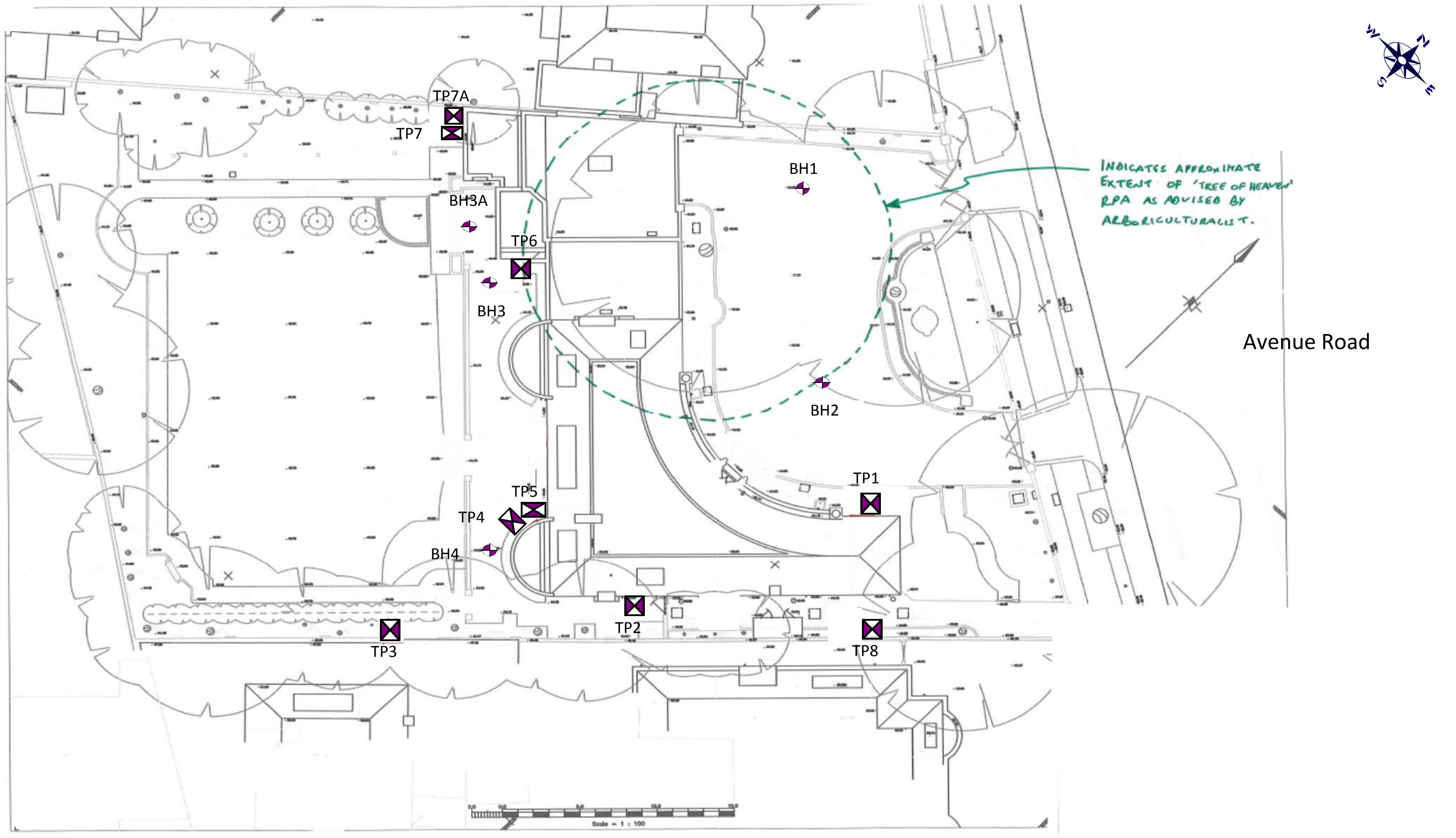
APPENDIX PART 1

Geotechnical & Environmental Associates

Widbury Barn
Widbury Hill
Ware
Herts SG12 7QE

Site Plan

Site	69 Avenue Road, London, NW8 6HP
Client	Mr Nicholas Goulandris
Engineer	Fluid Structures
Job Number	J16224
Sheet	1 / 1



GEA Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware,Herts SG12 7QE	**Site** 69 Avenue Road, London, NW8 6HP	**Borehole Number** **BH1**

Boring Method	**Casing Diameter**	**Ground Level (mOD)**	**Client**	**Job Number**
Cable Percussion	150 mm to 1.5 m		Mr Nick Goulandris	J16224
	Location	**Dates** 07/10/2016	**Engineer** Fluid Structures	**Sheet** 1/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records
0.30	D1			
0.70	D2			
1.00	D3			
1.20-1.65	U4			
1.70	D5			
1.90	D6			
2.00-2.45	SPT(C) N60=12	1.50	DRY	1,1/2,2,3,3
2.00	B7			
2.70	D8			
3.00-3.45	U9			
3.50	D10			
3.80	D11			
4.00-4.45	SPT N60=17	1.50	DRY	2,2/3,3,4,4
4.00	D12			
4.60	D13			
4.90	D14			
5.00-5.45	U15			
5.50	D16			
6.00-6.45	SPT N60=19	1.50	DRY	3,3/3,4,4,5
6.00	D17			
7.50-7.95	U18			
8.00	D19			
9.00-9.45	SPT N60=49	1.50	DRY	4,5/6,14,21
9.00	D20			
				Seepage(1) at 9.50m, rose to 9.20m in 20 mins.
9.90	B21			

Level (mOD)	Depth (m) (Thickness)	Description	Water
	0.10	TARMAC	
	(0.15) 0.25	CONCRETE	
	(1.75) 2.00	MADE GROUND ('stiff' brown mottled orange-brown and greenish grey silty sandy clay with medium to coarse subangular to rounded flint gravel, ash, burnt coal, carbonaceous material, fine brick and roots. Soil noted to be dry - possibly desiccated)	
	(1.00) 3.00	'Stiff' high strength brown mottled orange-brown and bluish grey silty CLAY with occasional partings of orange-brown fine sand and silt, selenite crystals, decayed roots and rootlets - possibly desiccated - reworked appearance	
	(1.50) 4.50	Firm medium strength becoming stiff at 4.00 m, brown mottled grey silty CLAY with abundant selenite crystals and specklings of mica. Claystone encountered at a depth of 5.50 m. Dead rootlets noted to a depth of 4.00 m - reworked appearance	
	(2.00) 6.50	Stiff high strength brown silty CLAY with abundant selenite crystals, specklings of mica and rare partings of light yellowish brown fine sand and silt - reworked appearance	
	(3.40) 9.90	Stiff fissured high strength brown silty CLAY with abundant selenite crystals, specklings of mica and rare partings of light yellowish brown fine sand and silt. Claystone encountered at a depth of 9.40 m	▼1 ∇1

Remarks
Hand-dug starter pit to a depth of 1.20 m (90 minutes)
Chiselling on claystone enocuntered at a depth of 9.40 m for 30 minutes
Standpipe installed to 12.0 m - response zone from 2.00 m to 12.00 m
Water measured in standpipe at a depth of 11.75 m on 17/10/2016 and 7.92 m on 09/11/2016

Scale (approx)	**Logged By**
1:50	HD

Figure No.
J16224.BH1

GEA Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware,Herts SG12 7QE	**Site** 69 Avenue Road, London, NW8 6HP	**Borehole Number** **BH1**

Boring Method	**Casing Diameter**	**Ground Level (mOD)**	**Client**	**Job Number**
Cable Percussion	150 mm to 1.5 m		Mr Nick Goulandris	J16224
	Location	**Dates** 07/10/2016	**Engineer** Fluid Structures	**Sheet** 2/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
							Stiff becoming very stiff fissured high strength dark grey silty CLAY with abundant specklings of mica, rare partings of grey fine sand and silt, grey burrrows, shells and fossils		
10.50-10.95	U22								
11.00	D23								
12.00-12.45 12.00	SPT N60=29 D24	1.50	DRY	4,5/5,6,6,7					
						(5.10)			
13.50-13.95	U25								
14.00	D26								
14.50-14.95 14.50	SPT N60=30 D27	1.50	DRY	5,5/5,6,7,7					
						15.00	Complete at 15.00m		

Remarks	**Scale (approx)**	**Logged By**
	1:50	HD
	Figure No. J16224.BH1	

Geotechnical & Environmental Associates

Widbury Barn
Widbury Hill
Ware,Herts
SG12 7QE

Site	Borehole Number
69 Avenue Road, London, NW8 6HP	BH2

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	150 mm to 1.5 m		Mr Nick Goulandris	J16224
	Location	**Dates** 10/10/2016	**Engineer** Fluid Structures	**Sheet** 1/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						0.10	TARMAC		
						0.20	CONCRETE		
0.50	D1					(0.70)	MADE GROUND ('stiff' brown mottled orange-brown and grey silty sandy gravelly clay with brick, ash and roots - possibly desiccated)		
0.90	D2					0.90	'Stiff' high strength yellowish brown and greyish brown silty CLAY with abundant fine to coarse subangular to subrounded flint gravel and occasional pockets of orange-brown fine sand and silt, roots and rootlets - possibly desiccated		
1.20-1.65	SPT(C)	1.20	DRY	2,2/2,2,3,4					
1.20	B3					(1.30)			
1.90	D4								
2.00-2.45	U5					2.20	Firm brown silty CLAY with occasional pockets of orange-brown fine sand and silt and rare claystones - reworked appearance		
2.50	D6								
2.80	D7								
3.00-3.45	SPT	1.50	DRY	2,2/3,3,4,4		(1.80)			
3.00	D8								
3.70	D9								
4.00-4.45	U10					4.00	Stiff high strength brown mottled bluish grey silty CLAY with abundant selenite crystals, occasional partings of light brown fine sand and silt. Decayed rootlets noted to a depth of 5.00 m - reworked appearance		
4.50	D11								
4.70	D12								
4.90	D13					(2.00)			
5.00-5.45	SPT	1.50	DRY	3,3/3,4,5,5					
5.00	D14								
6.00-6.45	U15					6.00	Stiff fissured high strength dark brown mottled orange-brown silty CLAY with frequent partings of orange-brown fine sand and silt. Claystone encountered at a depth of 8.60 m		
6.50	D16								
7.50-7.95	SPT	1.50	DRY	3,3/4,4,5,5		(2.80)			
7.50	D17								
				Seepage(1) at 8.60m, no rise after 20 mins.					▼1
						8.80	Stiff becoming very stiff fissured high strength becoming very high strength dark grey silty CLAY with abundant specklings of mica, grey sand burrows, fossils and rare grey burrows.		
9.00-9.45	U18								
9.50	D19								

Remarks
Hand-dug starter pit to a depth of 1.20 m (90 minutes)
Chiselling on a claystone encountered at a depth of 8.60 m for 15 minutes
Standpipe installled to a depth of 12.0 m - response zone from 1.00 m to 12.00 m
Standpipe recorded to be dry on 17/10/2016 and 09/11/2016
Chiselling from 0.00m to 1.20m for 1.5 hours. Chiselling from 8.60m to 8.80m for .25 hours.

Scale (approx)	Logged By
1:50	HD

Figure No. J16224.BH2

GEA Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware,Herts SG12 7QE	Site 69 Avenue Road, London, NW8 6HP	Borehole Number BH2
Boring Method: Cable Percussion	Casing Diameter: 150 mm to 1.5 m	Ground Level (mOD):	Client: Mr Nick Goulandris	Job Number: J16224
	Location:	Dates: 10/10/2016	Engineer: Fluid Structures	Sheet: 2/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
10.50-10.95 10.50	SPT D20	1.50	DRY	4,4/4,5,5,6					
12.00-12.45	U21								
12.50	D22								
13.50-13.95 13.50	SPT D23	1.50	DRY	4,4/5,6,7,7					
						(11.20)			
15.00-15.45	U24								
15.50	D25								
16.50-16.95 16.50	SPT D26	1.50	DRY	4,5/6,7,8,8					
18.00-18.45	U27								
18.50	D28								
19.50-19.95 19.50	SPT D29	1.50	DRY	4,5/7,7,8,9		20.00			

Remarks	Scale (approx)	Logged By
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	Figure No. J16224.BH2	

Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware,Herts SG12 7QE	Site 69 Avenue Road, London, NW8 6HP	Number **BH3**

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Open-drive sampler (Terrier)			Mr Nick Goulandris	J16224
	Location	**Dates**	**Engineer**	**Sheet**
		04/10/2016	Fluid Structures	1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					0.04	MADE GROUND (paving slab)		
					0.11	CONCRETE		
					(1.19)	MADE GROUND (brown sand with concrete rubble. Concrete obstruction encountered at a depth of 1.30 m)		
1.00-1.45	SPT(C) N60=40		1,1/2,7,14,17					
					1.30	Terminated at 1.30m		

Remarks
Groundwater not encountere during drilling
Borehole terminated at a depth of 1.30 m and relocated

Scale (approx)	Logged By
1:50	HD

Figure No.
J16224.BH5

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

Site	Number
69 Avenue Road, London, NW8 6HP	BH3A

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Open-drive sampler (Terrier)			Mr Nick Goulandris	J16224
	Location	**Dates**	**Engineer**	**Sheet**
		04/10/2016	Fluid Structures	1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records
0.70	D1		
1.00-1.45	SPT(C) N60=11		1,2/2,3,3,3
1.20	D2		PP = 3.00
1.50	D3		PP = 2.00
1.80	D4		PP = 2.75
2.00-2.45	SPT N60=9		3,4/2,2,3,2
2.10	D5		
2.40	D6		PP = 3.00
2.70	D7		PP = 3.40
3.00-3.45	SPT N60=21		2,4/4,5,6,6
3.00	D8		
3.30	D9		PP = 2.75
3.60	D10		PP = 3.25
3.90	D11		PP = 3.50
4.00-4.45	SPT N60=23		3,3/4,6,6,7
4.20	D12		PP = 3.50
4.50	D13		PP = 3.50
4.80	D14		PP = 3.50
5.00-5.45	SPT N60=23		3,3/5,5,6,7
5.10	D15		PP = 3.25
5.50	D16		
6.00-6.45	SPT N60=17		2,3/3,4,5,5
6.00	D17		
6.50	D18		
7.00-7.45	SPT N60=19		2,3/4,4,5,6
7.00	D19		
7.50	D20		
8.00-8.45	SPT N60=31		3,5/6,7,9,9
8.00	D21		

Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
	0.04	MADE GROUND (paving slab)		
	0.08 (0.56)	CONCRETE		
	0.64	MADE GROUND (brown sand with concrete rubble)		
	(0.25) 0.89	MADE GROUND (brown mottled grey and orange-brown silty clay with flint gravel, roots, fragments of brick and ash)		
	1.00	CONCRETE		
	(1.00) 2.00	Stiff orange-brown mottled grey silty sandy CLAY		
	(0.45) 2.45	Stiff brown mottled grey silty sandy gravelly CLAY. Gravel is fine to coarse subangular to rounded flint		
	(3.05) 5.50	Stiff brown mottled grey silty CLAY with occasional partings of orange-brown fine sand and silt and selenite crystals. Dead roots noted to a depth of 4.50 m - reworked appearance		
	(2.50) 8.00	Stiff brown silty fissured CLAY with occasional partings of orange-brown fine sand and silt and selenite crystals ...claystone encountered at a depth of 6.00 m		
		Complete at 8.00m		

Remarks
Groundwater not encountered during drilling
Standpipe installed to a depth of 8.00 m - response zone from a depth of 1.00 m to 8.00 m
Water measured in standpipe at a depth of 6.84 m on 17/10/2016 and 2.85 m on 09/11/2016
PP denotes pocket penetrometer reading

Scale (approx)	Logged By
1:50	HD

Figure No. J16224.BH3

Geotechnical & Environmental Associates

Widbury Barn
Widbury Hill
Ware,Herts
SG12 7QE

Site	Number
69 Avenue Road, London, NW8 6HP	BH4

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Open-drive sampler (Terrier)			Mr Nick Goulandris	J16224
	Location	**Dates**	**Engineer**	**Sheet**
		04/10/2016	Fluid Structures	1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					0.04	MADE GROUND (paving slab)		
					(0.20) 0.24	CONCRETE		
0.50	D1				(0.76)	MADE GROUND (greyish brown sand with flint gravel and whole and half bricks)		
					1.00	...occasional fragments of brick, ash and chalk		
1.20	D2				(0.50)	MADE GROUND (light brown silty clay with rare flint gravel, fragments of chalk, brick and ash)		
					1.50	Stiff orange-brown mottled pale grey silty sandy CLAY with roots.		
1.70	D3				(0.50)			
					2.00	Stiff orange-brown mottled pale grey sandy gravelly CLAY with abundant carbonaceous material. Gravel is fine to medium subangular to well-rounded flint		
					(0.70)			
2.50	D4							
					2.70	Stiff brown mottled bluish grey and orange-brown silty CLAY. Claystone encountered at a depth of 2.80 m - reworked appearance		
2.80	D5				(0.30)			
3.00	D6				3.00	Stiff brown mottled grey silty sandy CLAY with selenite crystals - reworked appearance		
3.50	D7							
4.00	D8				(2.00)			
4.50	D9					...abundant selenite crystals encountered at a depth of 4.50 m		
						...dead roots noted to a depth of 4.50 m		
5.00	D10				5.00	Complete at 5.00m		

Remarks
Groundwater not encountered during drilling
Standpipe installed to a depth of 3.00 m - response zone from 1.50 m to 3.00 m
Standpipe not monitored as pipe under tight fitting paving slab

Scale (approx)	Logged By
1:50	HD

Figure No. J16224.BH4

Geotechnical & Environmental Associates

Widbury Barn
Widbury Hill
Ware,Herts
SG12 7QE

Standard Penetration Test Results

Site : 69 Avenue Road, London, NW8 6HP

Client : Mr Nick Goulandris

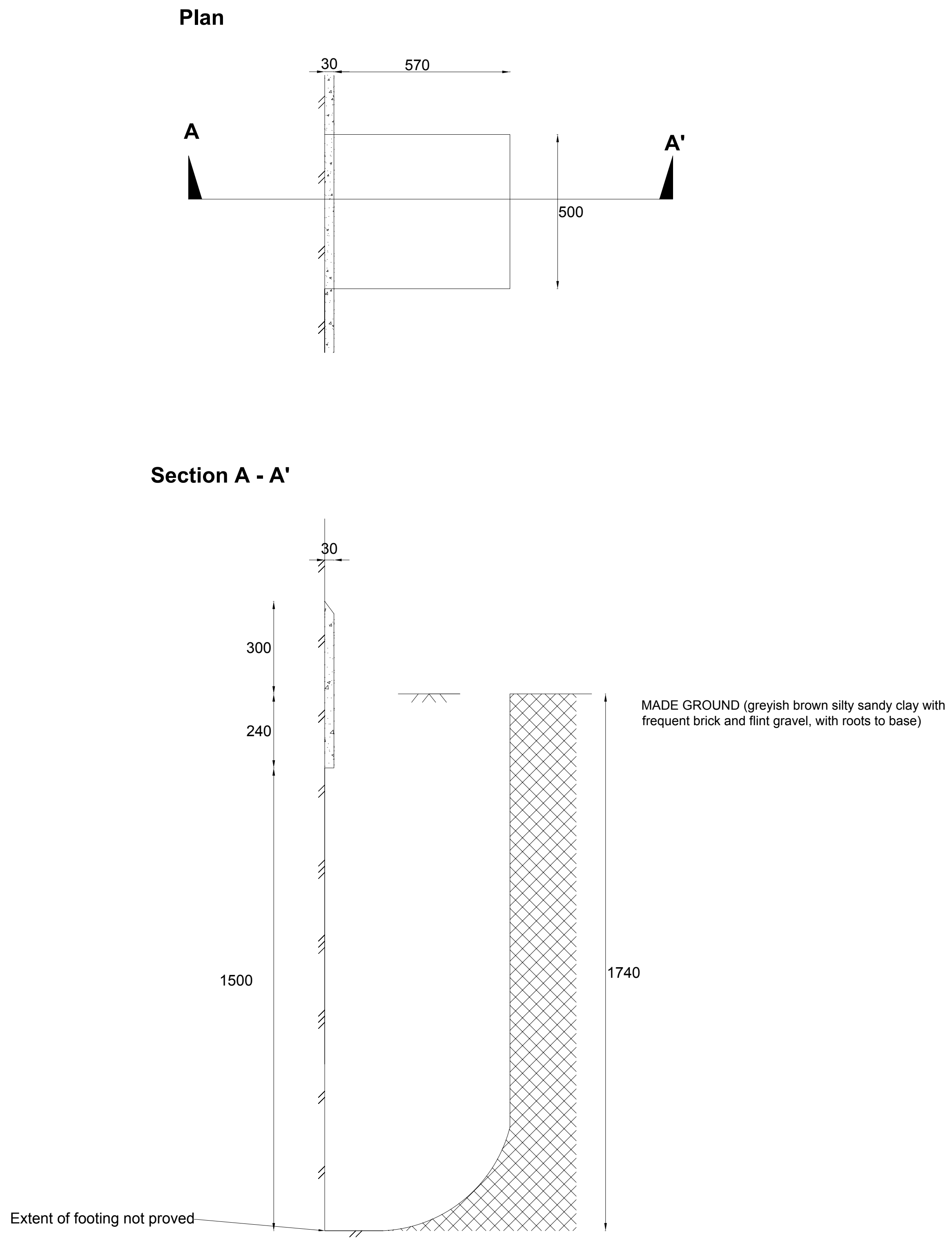
Engineer : Fluid Structures

Job Number J16224

Sheet 1 / 1

Borehole Number	Base of Borehole (m)	End of Seating Drive (m)	End of Test Drive (m)	Test Type	Seating Blows per 75mm		Blows for each 75mm penetration				Result	Comments
					1	2	1	2	3	4		
BH1	2.00	2.15	2.45	CPT	1	1	2	2	3	3	N60=12	
BH1	4.00	4.15	4.45	SPT	2	2	3	3	4	4	N60=17	
BH1	6.00	6.15	6.45	SPT	3	3	3	4	4	5	N60=19	
BH1	9.00	9.15	9.45	SPT	4	5	6	14	21		N60=49	Bouncing
BH1	12.00	12.15	12.45	SPT	4	5	5	6	6	7	N60=29	
BH1	14.50	14.65	14.95	SPT	5	5	5	6	7	7	N60=30	
BH2	1.20	1.35	1.65	CPT	2	2	2	2	3	4	N=11	
BH2	3.00	3.15	3.45	SPT	2	2	3	3	4	4	N=14	
BH2	5.00	5.15	5.45	SPT	3	3	3	4	5	5	N=17	
BH2	7.50	7.65	7.95	SPT	3	3	4	4	5	5	N=18	
BH2	10.50	10.65	10.95	SPT	4	4	4	5	5	6	N=20	
BH2	13.50	13.65	13.95	SPT	4	4	5	6	7	7	N=25	
BH2	16.50	16.65	16.95	SPT	4	5	6	7	8	8	N=29	
BH2	19.50	19.65	19.95	SPT	4	5	7	7	8	9	N=31	
BH3	1.00	1.15	1.45	CPT	1	1	2	7	14	17	N60=40	
BH3A	1.00	1.15	1.45	CPT	1	2	2	3	3	3	N60=11	
BH3A	2.00	2.15	2.45	SPT	3	4	2	2	3	2	N60=9	
BH3A	3.00	3.15	3.45	SPT	2	4	4	5	6	6	N60=21	
BH3A	4.00	4.15	4.45	SPT	3	3	4	6	6	7	N60=23	
BH3A	5.00	5.15	5.45	SPT	3	3	5	5	6	7	N60=23	
BH3A	6.00	6.15	6.45	SPT	2	3	3	4	5	5	N60=17	
BH3A	7.00	7.15	7.45	SPT	2	3	4	4	5	6	N60=19	
BH3A	8.00	8.15	8.45	SPT	3	5	6	7	9	9	N60=31	

GEA Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware Herts SG12 7QE	**Site** 69 Avenue Road , London NW8 6HP			**Trial Pit Number**
Excavation Method	**Dimensions**	**Ground Level (m OD)**	**Client**	**Job Number**	
Manual	600 x 500 x 1740 mm			J16224	**TP01**
	Location	**Date**	**Engineer**	**Sheet Number**	
	Along northwest facing wall of main house in front driveway	04/10/2016	Fluid Structures	1 of 1	



Notes:
Groundwater not encountered

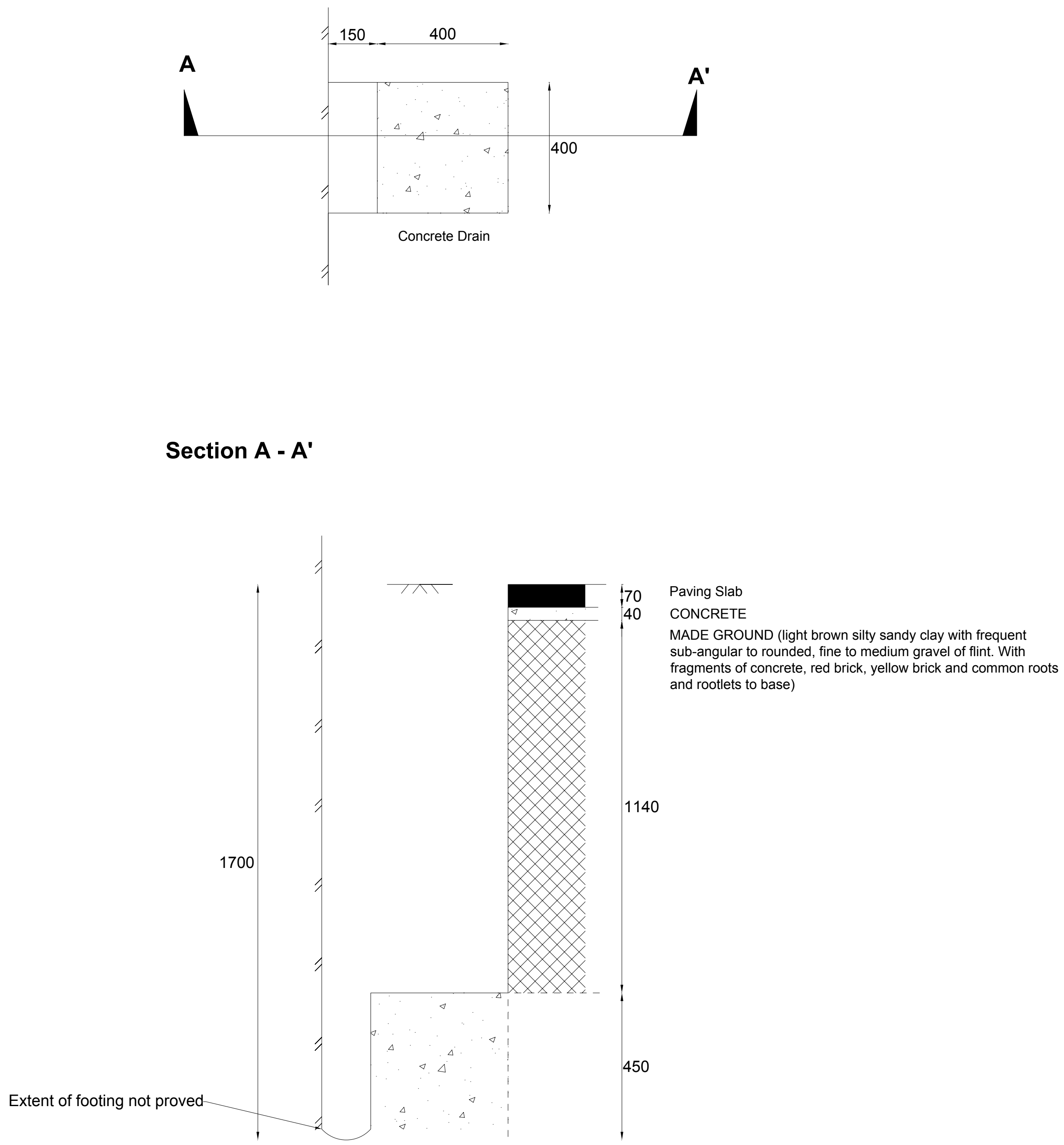
Scale	1 : 20
Logged By	HD

GEA Geotechnical & Environmental Associates	Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE	Site: 69 Avenue Road , London NW8 6HP		Trial Pit Number
Excavation Method Manual	**Dimensions** 550 x 400 x 1700 mm	**Ground Level (m OD)**	**Client**	**Job Number** J16224
	Location Along southeastern wall of main house	**Date** 04/10/2016	**Engineer** Fluid Structures	**Sheet Number** 1 of 1

Trial Pit Number: TP02

Plan

Section A - A'



Notes:
Groundwater not encountered

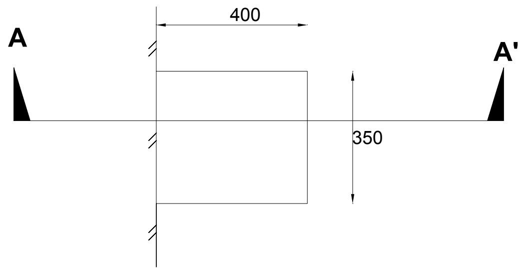
Scale 1 : 20

Logged By HD

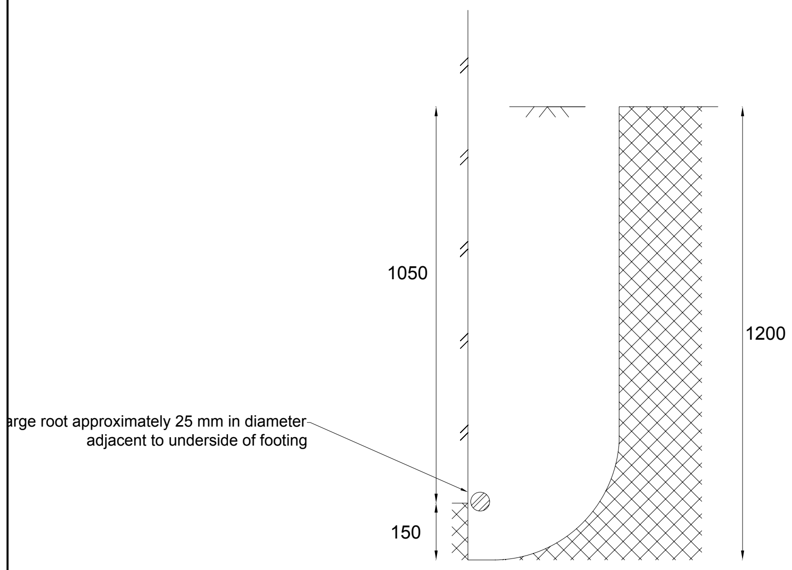
GEA Geotechnical & Environmental Associates — Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE		Site 69 Avenue Road , London NW8 6HP		Trial Pit Number
Excavation Method	**Dimensions**	**Ground Level (m OD)**	**Client**	**Job Number**
Manual	400 x 350 x 1200 mm			J16224
	Location	**Date**	**Engineer**	**Sheet Number**
	Along southeastern garden wall towards southwest of site	04/10/2016	Fluid Structures	1 of 1

Trial Pit Number: **TP03**

Plan



Section A - A'



MADE GROUND (brown clayey sand with frequent roots and rootlets; up to 25 mm in diameter. Frequent sub-angular to sub-rounded, fine to medium gravel of flint with occasional fragments of red brick, ceramic and fine to medium fragments of white chalk)

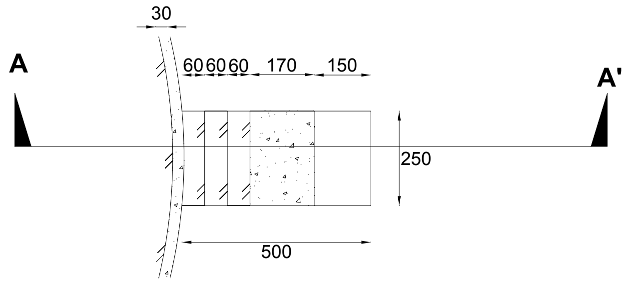
Notes:
Groundwater not encountered
Trees located to east and west of pit; 0.6 m west, 1.0 m east with hedge running approximately 0.5 m north, Both trees approximately 200 mm in diameter

Scale 1 : 20

Logged By HD

GEA Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware Herts SG12 7QE	**Site** 69 Avenue Road , London NW8 6HP			**Trial Pit Number** TP04
Excavation Method Manual	**Dimensions** 530 x 250 x 1850 mm	**Ground Level (m OD)**	**Client**	**Job Number** J16224	
	Location Along southeastern garage wall	**Date** 04/10/2016	**Engineer** Fluid Structures	**Sheet Number** 1 of 1	

Plan



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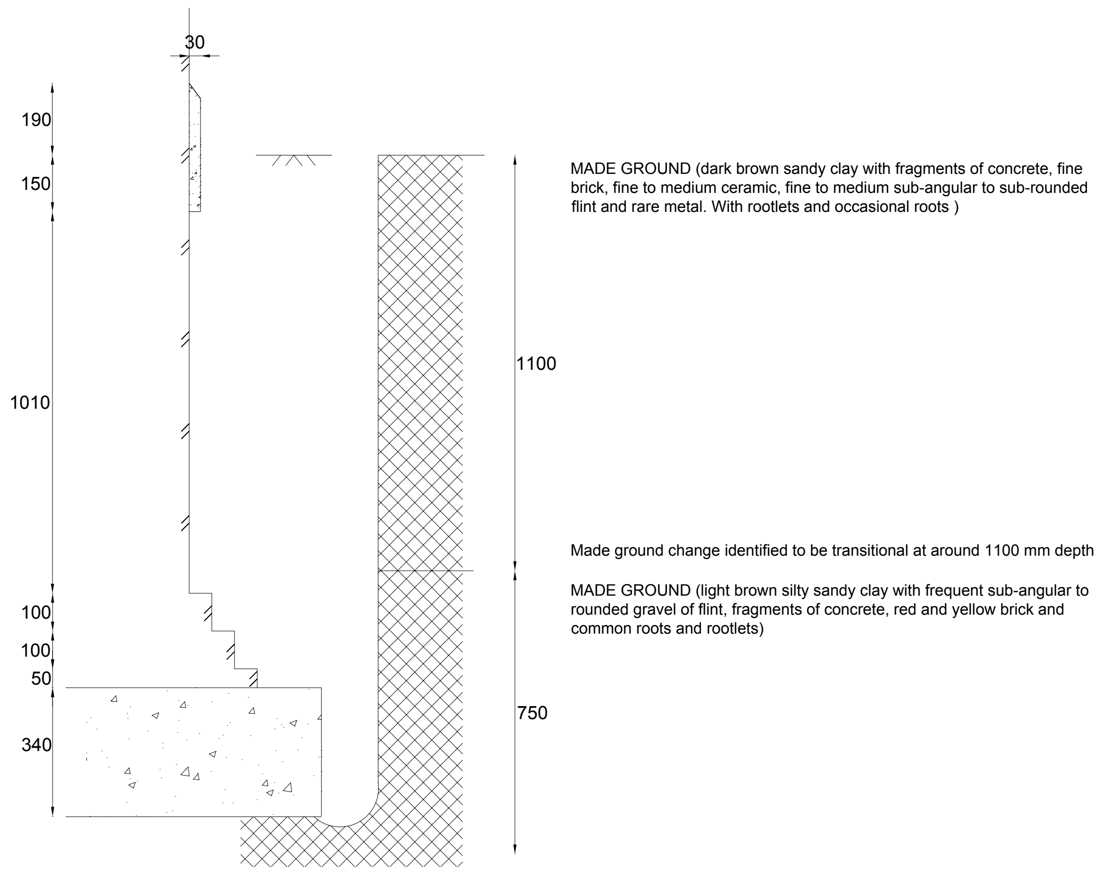


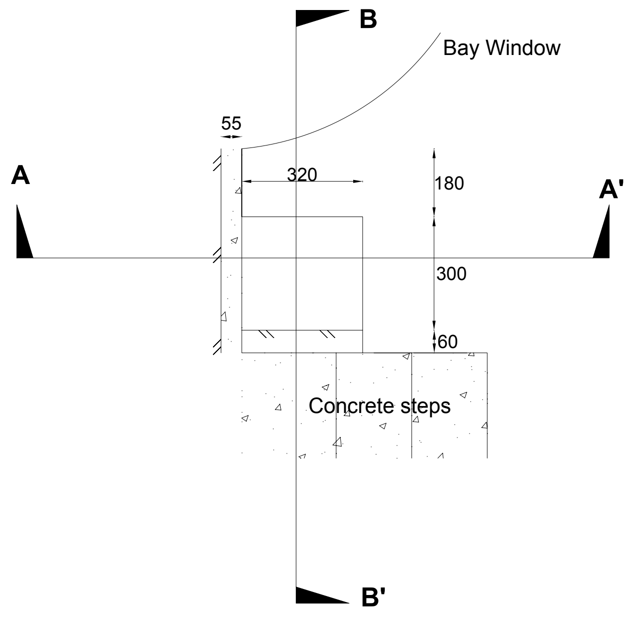
Notes:
Groundwater not encountered

Scale 1 : 20

Logged By HD

GEA Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware Herts SG12 7QE	**Site** 69 Avenue Road , London NW8 6HP		**Trial Pit Number** **TP05**
Excavation Method Manual	**Dimensions** 320 x 360 x 1050 mm	**Ground Level (m OD)**	**Client**	**Job Number** J16224
	Location Corner between rear of main house and southern bay window	**Date** 04/10/2016	**Engineer** Fluid Structures	**Sheet Number** 1 of 1

Plan



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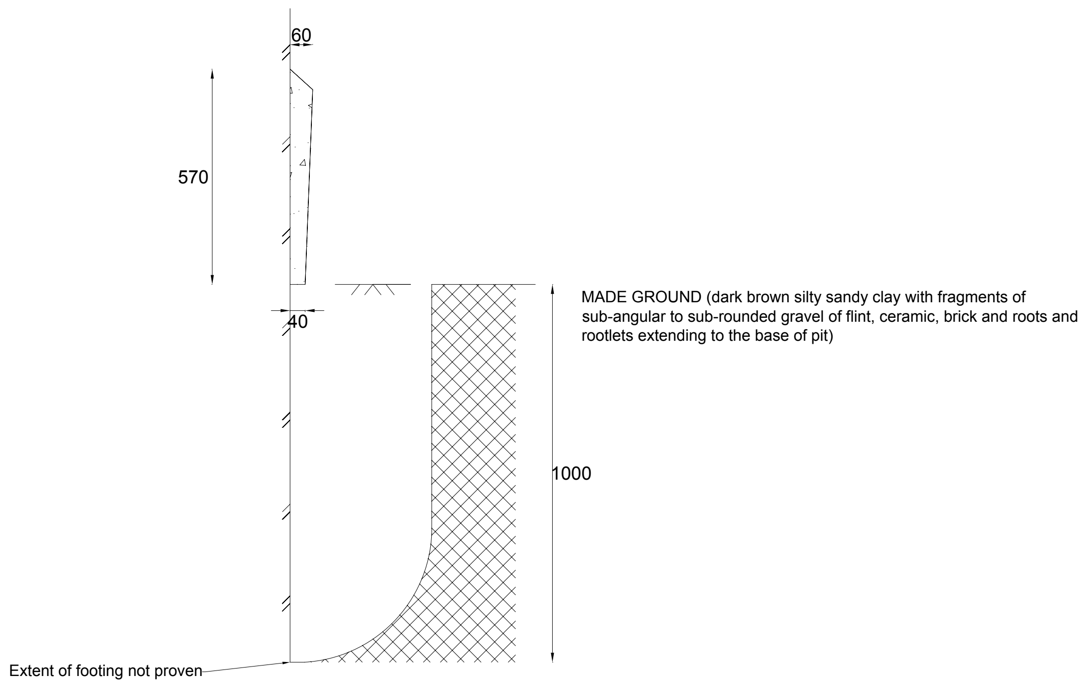
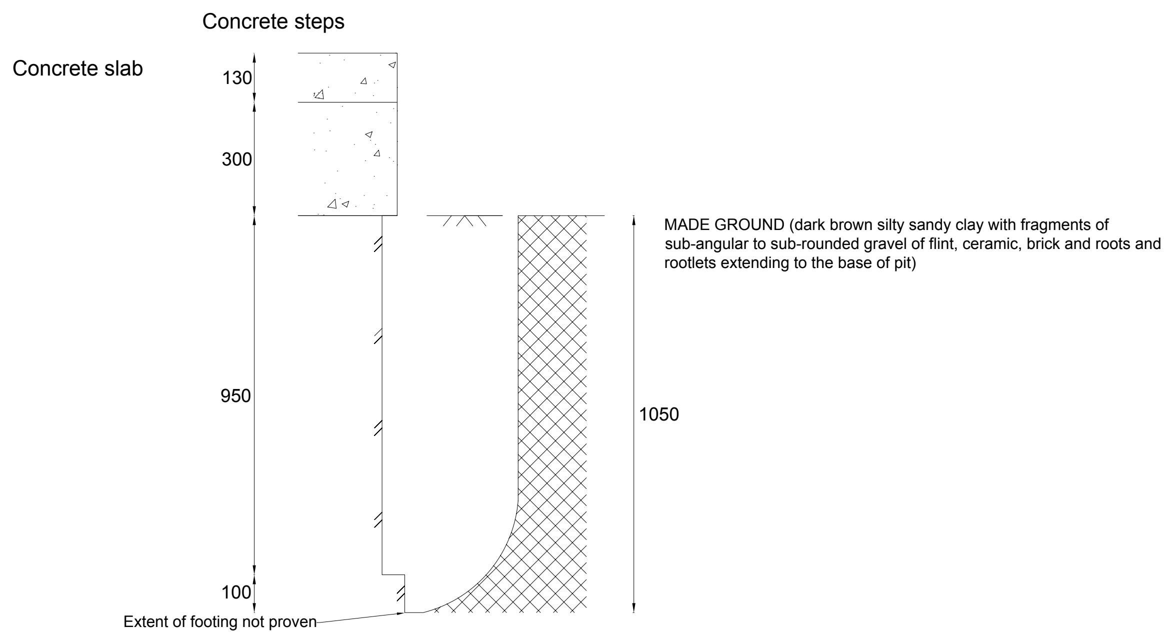


Section B - B'

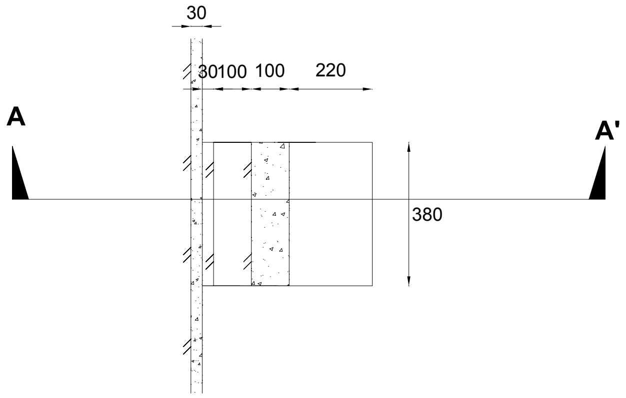


Notes:	Scale
Groundwater not encountered	1 : 20
	Logged By HD

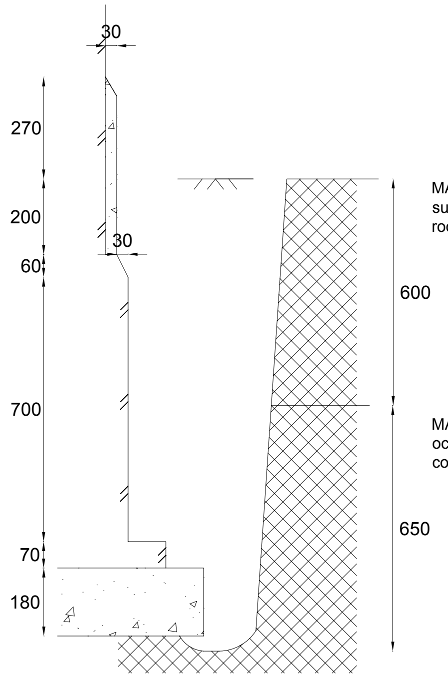
GEA Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware Herts SG12 7QE	**Site** 69 Avenue Road , London NW8 6HP		**Trial Pit Number**
Excavation Method Manual	**Dimensions** 480 x 380 x 1250 mm	**Ground Level (m OD)**	**Client**	**Job Number** J16224
	Location Along southeastern garage wall	**Date** 04/10/2016	**Engineer** Fluid Structures	**Sheet Number** 1 of 1

TP06

Plan



Section A - A'



MADE GROUND (dark brown silty sandy clay with fragments of sub-angular to sub-rounded gravel of flint, ceramic, brick and roots and rootlets extending to the base of pit)

MADE GROUND (brown silty sandy clay with frequent fragments of brick; occasional cobble and half brick, sub-angular to sub-rounded gravel of flint, concrete and frequent roots and rootlets extending to base of pit)

Two large roots located on western side of pit at a depth of 50 mm

Notes:
Groundwater not encountered

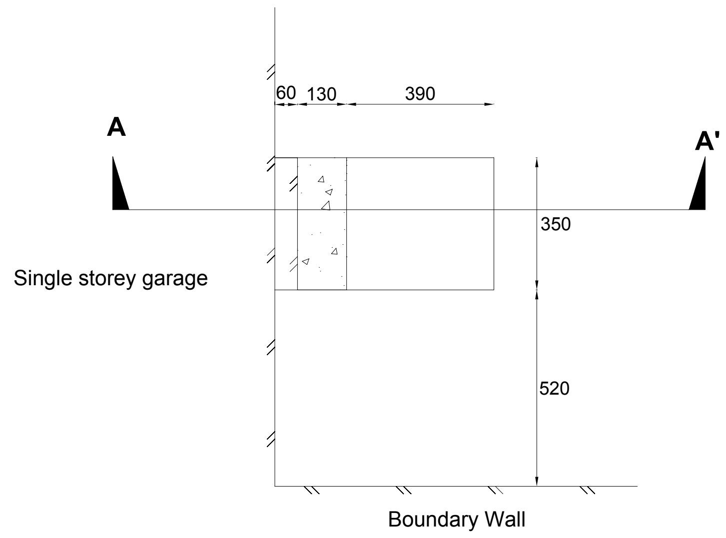
Scale
1 : 20

Logged By
HD

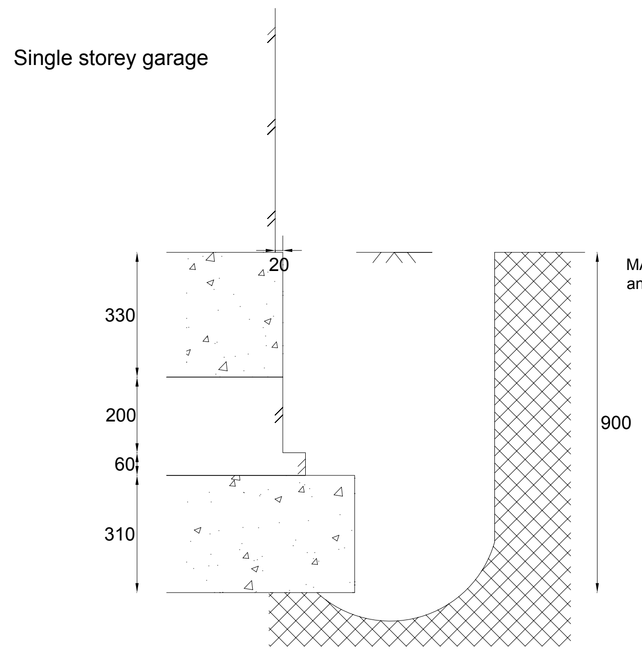
GEA Geotechnical & Environmental Associates — Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE		Site: 69 Avenue Road , London NW8 6HP		Trial Pit Number
Excavation Method	**Dimensions**	**Ground Level (m OD)**	**Client**	**Job Number**
Manual	580 x 350 x 900 mm			J16224
	Location	**Date**	**Engineer**	**Sheet Number**
	Along southwest facing garage wall	04/10/2016	Fluid Structures	1 of 1

Trial Pit Number: TP07

Plan



Section A - A'



MADE GROUND (greyish brown sandy clay with fragments of brick, roots and rare flint gravel. Old Ivy roots up to 30 mm across. Roots to base of pit)

Notes:
Groundwater not encountered

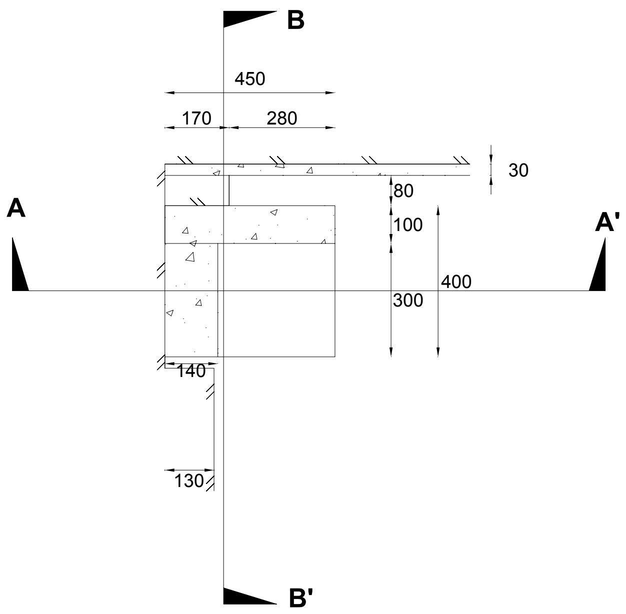
Scale	1 : 20
Logged By	HD

GEA Geotechnical & Environmental Associates — Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE		Site 69 Avenue Road , London NW8 6HP		Trial Pit Number
Excavation Method	**Dimensions**	**Ground Level (m OD)**	**Client**	**Job Number**
Manual	450 x 480 x 900 mm			J16224
	Location	**Date**	**Engineer**	**Sheet Number**
	Corner between southwest facing garage wall and northwest boundary wall	04/10/2016	Fluid Structures	1 of 1

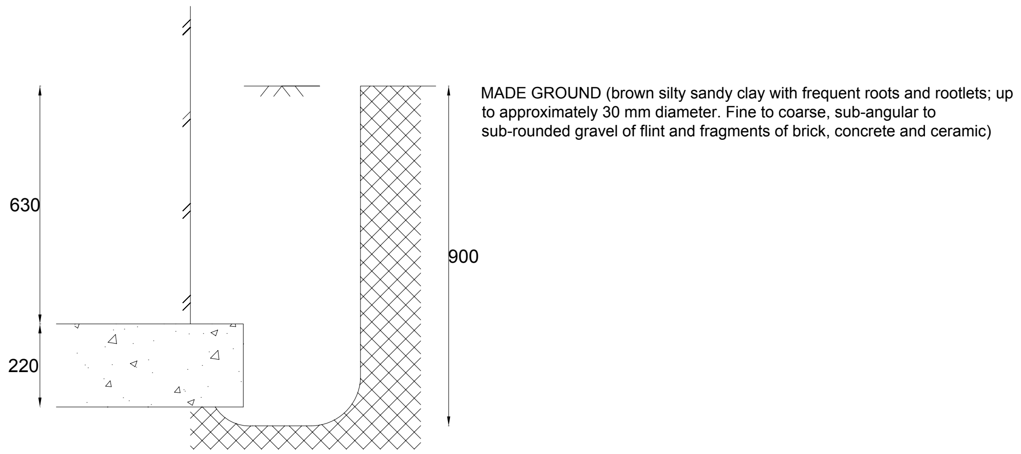
Trial Pit Number

TP07A

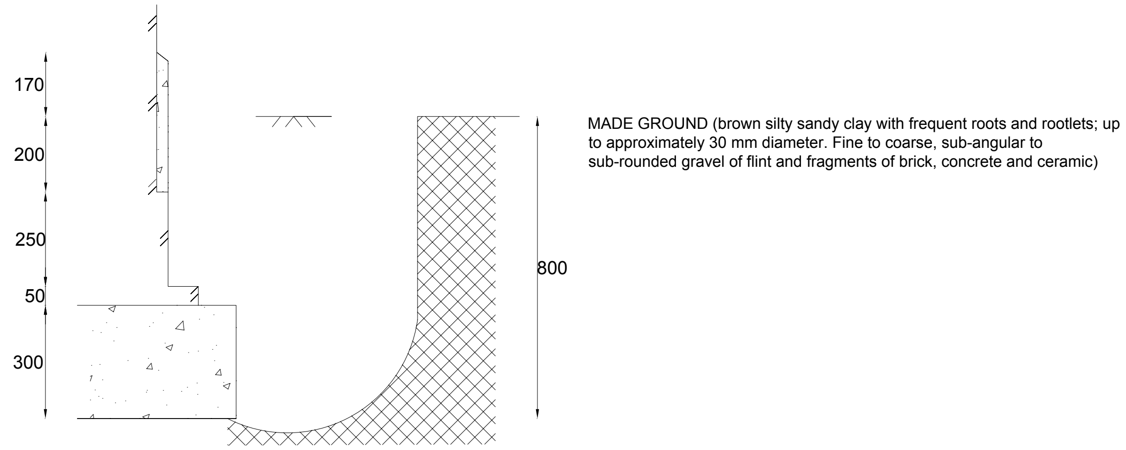
Plan



Section A - A'



Section B - B'



Notes:
Groundwater not encountered

Scale
1 : 20

Logged By
HD