# 7 The Grove
# London
# N6 6JU

## Ground Investigation & Basement Impact Assessment Report

Mr. Nicholas Thomlinson

February 2023

J22393
Rev 0

**Report prepared by**

Alex Taylor BSc MSc FGS
Senior Geotechnical Engineer

**With input from**

Martin Cooper BEng CEng MICE FGS
Technical Director

Rupert Evans
MSc CEnv CWEM MCIWEM AIEMA
Consultant Hydrologist

Nick Mannix
MSc FGS CGeol
Consultant Hydrogeologist

**Report checked and approved for issue by**

Steve Branch BSc MSc CGeol FGS FRGS
Managing Director

| Rev No | Status | Revision Details | Date | Approved for Issue |
|---|---|---|---|---|
| 0 | Final | | 22 February 2023 | |

*This report has been issued by the GEA office indicated below. Any enquiries regarding the report should be directed to the report project engineer at the office indicated or to Steve Branch in our main Herts office.*

| | | |
|---|---|---|
| ✓ | Hertfordshire | tel 01727 824666 |
| | Nottinghamshire | tel 01509 674888 |
| | Manchester | tel 0161 209 3032 |



# Contents

# 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 Mr Nicholas Thomlinson, with respect to the redevelopment of the site through the construction of a new swimming pool within the rear garden. The purpose of the investigation has been to determine the ground conditions and hydrogeology, to carry out an assessment of ground movements resulting from excavation of the proposed basement, to assess the extent of any contamination and to provide information to assist with the design of the basement structure and suitable foundations. The report also includes information required to comply with London Borough of Camden Planning Guidance (CPG) Basements, relating to the requirement for a Basement Impact Assessment (BIA).

## Site history

Details on the Grade II listing of the building indicates the structure to have been constructed in 1832. The earliest map studied, dated 1870, shows the site to have been developed in its existing configuration, with much of the surrounding existing road network and buildings also shown to have been constructed. The area to the southwest and west of the site is shown as open ground labelled 'Fitzroy Park' with a large building labelled as 'Parkfield' located approximately 150 m to the south. By the time of the map dated 1935 Parkfield had been demolished and redeveloped with the existing Witanhurst mansion. Some time between 1974 and 1991 Highfield Grove and the existing properties fronting onto it were constructed and a tennis court and pond are labelled in the grounds of Witanhurst, to the west of the site. Both the site and the surrounding area have since remained essentially unchanged.

## Ground conditions

The investigation has generally confirmed the expected ground conditions in that, beneath a moderate thickness of made ground, the Bagshot Formation was encountered and extended to the full depth of the investigation. The made ground generally comprised dark brown clayey silty sand with gravel and occasional brick, ash and concrete fragments and extended to depths of between 1.00 m and 1.30 m below ground level. The Bagshot Formation generally comprised firm to stiff orange-brown mottled pale grey very sandy clay extending to the full depth of the investigation of 4.00 m. However, an upper layer of firm to stiff orange-brown mottled pale grey very sandy clay with occasional fine to medium subangular to subrounded gravel was present in Borehole No 3, extending to a depth of 2.00 m below ground level.

Groundwater was not encountered during the investigation and the three standpipes have been found to be dry during a single monitoring visit.

The results of the chemical analyses have indicated all of the samples tested to contain elevated concentrations of lead while one of the samples also contained an elevated concentration of arsenic.

## Recommendations

The proposed swimming pool will extend to a depth of approximately 2.50 m below existing ground level in the garden, such that formation level is expected to be within the Bagshot Formation. Groundwater is unlikely to be encountered within the excavation and the use of shallow spread foundations should be feasible to support the loads of the development.

Remedial measures are not considered to be required with respect to contamination.

## Basement Impact Assessment

It has been concluded that the majority of the impacts identified can be mitigated by appropriate design and standard construction practice. Groundwater is unlikely to be present within the excavation and will still be able to flow around and beneath the pool following construction. As the new pool does not close a pathway or create a cut-off, it is considered that the groundwater will follow a pathway around and beneath the proposed pool and will not build up significantly behind it. The swimming pool excavation should not, therefore, have any noticeable effect on groundwater flow.

# 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 Mr Nicholas Thomlinson to carry out a desk study, ground investigation and ground movement assessment at 7 The Grove, London N6 6JU. The consulting engineers for the project are Engineers HRW.

GEA has previously carried out a basement impact assessment and ground investigation report for the adjacent site to the south, the findings of which are referred to where appropriate.

### 1.1 Proposed Development

It is understood that it is proposed to construct a new swimming pool and a new single storey pool house in part of the rear garden.

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

### 1.2 Purpose of Work

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

- to check the history of the site with respect to previous contaminative uses;
- to provide an assessment of the risk of encountering UXO;
- to determine the ground conditions and their engineering properties;
- to use the above information to provide recommendations for shallow foundations and retaining walls;
- to assess the impact of the proposed basement on the local hydrogeology, hydrology and stability of the surrounding natural and build environment;
- to provide an indication of the degree of soil contamination present; and
- to assess the risk that any such contamination may pose to the proposed development, its users or the wider environment.

### 1.3 Scope of Work

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

- a review of historical Ordnance Survey (OS) maps and environmental searches sourced from the Envirocheck database;
- a review of readily available geology maps;
- a walkover survey of the site carried out in conjunction with the fieldwork; and
- a review of the previous GEA basement impact assessment and ground investigation report prepared for the adjacent site (ref J20060 Issue 3, dated March 2021).

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

- three boreholes advanced to a depth of 4.00 m by window sampling techniques;
- two trial pits advanced to a depth of 1.30 m;
- the installation of three groundwater monitoring standpipes to a depth of 4.00 m and a single subsequent monitoring visit;
- testing of selected soil samples for contamination and geotechnical purposes; and
- provision of a report presenting and interpreting the above data, together with our advice and recommendations with respect to the proposed development.

This report includes a contaminated land assessment which has been undertaken by a suitably qualified and competent professional in accordance with the methodology

presented by the Environment Agency in their Land contamination risk assessment (LCRM)[1] published 19 April 2021. This involves identifying, making decisions on, and taking appropriate action to deal with, land contamination in a way that is consistent with government policies and legislation within the United Kingdom. Risk management is divided into three stages; Risk Assessment, Options Appraisal and Remediation, and each stage comprises three tiers. The Risk Assessment stage includes preliminary risk assessment (PRA), generic quantitative risk assessment (GQRA) and detailed quantitative risk assessment (DQRA)and this report includes the PRA and GQRA.

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

### 1.3.1 Basement Impact Assessment

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

### 1.3.2 Qualifications

The land stability element of the Basement Impact Assessment (BIA) has been carried out by Martin Cooper, a BEng in Civil Engineering, a chartered engineer (CEng), member of the Institution of Civil Engineers (MICE), and Fellow of the Geological Society (FGS) who has over 20 years' specialist experience in ground engineering. The subterranean (groundwater) flow assessment has been carried out by Nick Mannix, MSc in Hydrogeology, Chartered Geologist (CGeol) and Fellow of the Geological Society of London (FGS). The surface water and flooding assessment has been carried out by Rupert Evans, a hydrologist with more than ten years consultancy experience in flood risk assessment, surface water drainage schemes and hydrology / hydraulic modelling. Rupert Evans is a Chartered Environmentalist, Chartered Water and Environmental Manager and a Member of CIWEM.

The assessments have been made in conjunction with Steve Branch, a BSc in Engineering Geology and Geotechnics, MSc in Geotechnical Engineering, a Chartered Geologist (CGeol) and Fellow of the Geological Society (FGS) with some 30 years' experience in geotechnical engineering and engineering geology.

All assessors meet the qualification requirements of the Council guidance.

## 1.4 Limitations

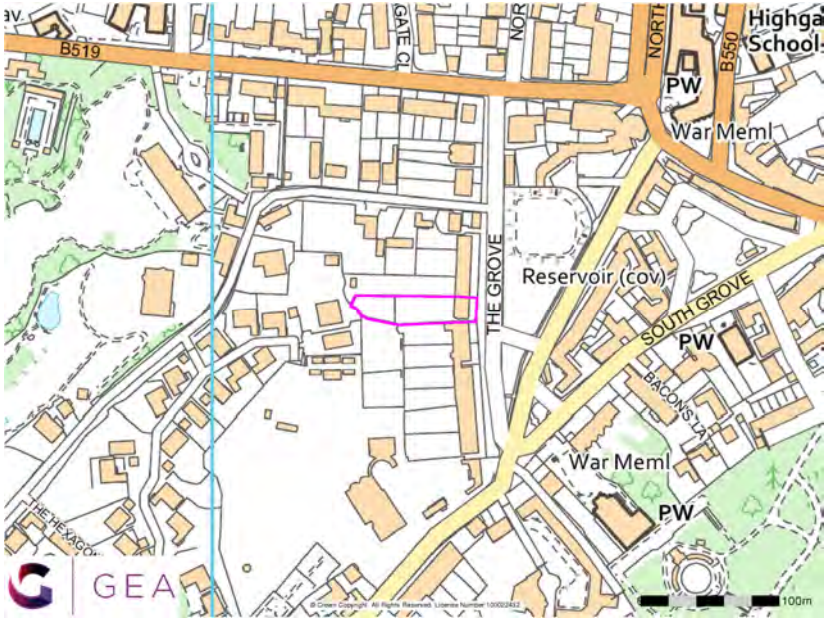
The conclusions and recommendations made in this report are limited to those that can be made on the basis of the investigation. The results of the work should be viewed in the context of the range of data sources consulted, the number of locations where the ground was sampled and the number of soil,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

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

# 2.0 The Site

## 2.1 Site Description

The site is located within the London Borough of Camden, to the east of Hampstead Heath, approximately 850 m southwest of Highgate London Underground Station and 1.3 km northwest of Archway London Underground Station. It fronts onto The Grove to the east and is bordered to the north by an adjoined three-storey house with associated areas of hardstanding and soft landscaping and to the south by a three-storey terraced house with associated areas of hardstanding and soft landscaping. The rear of the property is bounded by the grounds of two properties fronting onto Highfields Grove. The properties to the rear have a ground level about 8 m below the site level. The site may be additionally located by National Grid Reference 528177, 187307 and is shown on the map extract below.




A walkover of the site was carried out by a geotechnical engineer from GEA at the time of the fieldwork. The site is irregular in shape and measures approximately 80 m east-west by 15 m north-south in maximum dimensions. It is occupied by a four-storey building, including a single level basement. The site is essentially level and is almost entirely occupied by the existing building in the east and a large rear garden comprising an initial area of lawn at the rear of the house with planted beds around the borders of the site and an area of trees and planted beds in the far west of the site. The site is very heavily vegetated, particularly in the west of the site which includes numerous mature trees.

## 2.2 Site History

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

Details of the Grade II listing of the property indicates the building was constructed in 1832. The earliest map studied, dated 1870, shows the site to have been developed in its existing configuration, with much of the surrounding existing road network and buildings also shown to have been constructed. The area to the southwest and west of the site is shown as open ground labelled 'Fitzroy Park' with a large building labelled as 'Parkfield' located approximately 150 m to the south.

By the time of the map dated 1935 Parkfield had been demolished and redeveloped with the existing Witanhurst mansion. Some time between 1974 and 1991 Highfield Grove and the existing properties fronting onto it were constructed and a tennis court and pond are labelled in the grounds of Witanhurst, to the west of the site. Both the site and the surrounding area have since remained essentially unchanged.

## 2.3 Other Information

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

The Envirocheck report has indicated no landfill sites, waste management or waste transfer sites located within 1 km of the site and additionally, there are no areas of infilled land listed within 500 m of the site.

No pollution incidents to controlled waters have been recorded within 250 m of the site.

The site is not within an area shown by the Environment Agency to be at risk from flooding from rivers or the sea and does not lie within any known areas of sensitive land use.

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.

## 2.4 Geology

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

GEA has previously carried out a ground investigation at No 5 The Grove, located immediately to the south of the site, which encountered a nominal to moderate thickness of made ground, overlying the Bagshot Formation which was underlain by the Claygate Member, extending to the full depth of the investigation, of 20.00 m. The made ground generally comprised dark brown clayey sand with gravel and variable amounts of brick, ash, and glass fragments and extended to depths of between 0.80 m (127.70 m OD) below street level and 2.00 m (119.50 m OD) below the lower rear garden level. The Bagshot Formation predominantly comprised layers of firm orange-brown and grey sandy clay with lenses of fine sand, interbedded with layers of medium dense becoming dense orange-brown and brown sandy with variable clay content and extended to a depth of 15.00 m (113.50 m OD) below street level. The Claygate Member comprised stiff grey sandy clay with layers of fine sand and extended to the full depth of the investigation, of 20.00 m (108.50 m OD) below street level.

A borehole drilled by the BGS on Hampstead Lane to the north of the site, generally referred to as the 'Hampstead Heath borehole', was advanced to a depth of 66.74 m (61.97 m OD) at National Grid Reference 526455, 186890. The borehole records indicate that the Bagshot Formation extends to a level of 109.71 m OD, which would equate to about 15 m below ground level at The Grove, and penetrated the full thickness of the Claygate Member, which was found to extend to a level of 93.71 m OD.

## 2.5 Hydrology and Hydrogeology

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

The Claygate Member is classified as a Secondary 'A' Aquifer, which refers to permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. In the absence of significant sand horizons, the Claygate Member is not capable of storing and transmitting water in usable amounts and receives very low levels of annual recharge due to very low permeability. The underlying London Clay Formation is classified by the EA as Unproductive Strata, referring to rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

The nearest surface water feature is a private pond located approximately 211 m to the west of the site.

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

The nearby previous GEA investigation encountered groundwater at a depth of 6.00 m (118.00 m OD and 115.50 m OD).

## 2.6 Preliminary UXO Risk Assessment

A Preliminary UXO Risk Assessment has been completed by 1st Line Defence (report ref PA17108-00, dated 20th December 2022), and the report is included in the appendix. The risk assessment has been carried out in accordance with the guidelines provided by CIRIA[4], which state that the likelihood of encountering and detonating UXO below a site should be assessed along with establishing the consequences that may arise. The first phase comprises a preliminary risk assessment, which should be undertaken at an early stage of the development planning. If such an assessment identifies a high level of risk then a detailed risk assessment should be carried out by a UXO specialist, which will identify an appropriate course of action with regard to risk mitigation.

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

The report indicates that, during World War II (WWII), the site was located within the Metropolitan Borough of St. Pancras, which sustained a very high bomb density. The site was occupied by the existing residential property throughout the War. This property does not appear to have been directly affected by bombing and is not labelled as significantly damaged on available damage mapping. It is considered likely that the properties would have remained occupied and subject to regular post-raid checks for signs of UXO and therefore a minimal risk of encountering unexploded ordnance has been identified for the site and no further action is recommend in this respect.

## 2.7 Preliminary Risk Assessment

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

### 2.7.1 Source

The desk study findings indicate that the site does not have a potentially contaminative history as it has apparently been developed with the existing house since prior to 1870.

No sources of ground gas have been identified.

### 2.7.2 Receptor

The site will remain in residential use following the redevelopment and therefore end users will continue to represent relatively high sensitivity receptors and as the site is underlain by a Secondary 'A' Aquifer, adjacent sites are considered to be a moderately sensitive receptors. Shallow groundwater is also considered to be a moderately sensitive receptor, while the chalk aquifer at depth is considered to be a particularly sensitive receptor. Buried services are likely to come into contact with any contaminants present within the soils through which they pass and site workers are likely to come into contact with any contaminants present in the soils during construction works.

### 2.7.3 Pathway

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

### 2.7.4 Preliminary Risk Appraisal

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

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

# 3.0 Screening

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

## 3.1 Screening Assessment

A number of screening tools are included in the Arup document and for the purposes of this report reference has been made to Appendices E1, E2 and E3 which include a series of questions within screening flowcharts for surface flow and flooding, subterranean (groundwater) flow and land stability. The flowchart questions and responses to these questions are tabulated below.

### 3.1.1 Subterranean (groundwater) Screening Assessment

| Question | Response for 7 The Grove |
|---|---|
| 1a. Is the site located directly above an aquifer? | Yes. The site is underlain by the Bagshot Formation which are designated a Secondary Aquifer by the Environment Agency, capable of supporting flow to watercourses and private abstractions. Aquifer designation maps acquired from the Environment Agency as part of the desk study and Figures 3, 4 and 8 of the Arup report confirm this. |
| 1b. Will the proposed basement extend beneath the water table surface? | Unlikely. The proposed swimming pool will extend to a depth of 2.0 m below ground level. The previous nearby investigation performed by GEA indicated groundwater to be absent to a depth of 6.00 m below ground level which is well below the maximum excavation depth for the pool, as such that groundwater should not be encountered within the basement excavation. |
| 2. Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line? | No. Topographical maps acquired as part of the desk study and Figures 11 and 12 of the Arup report confirm this. |
| 3. Is the site within the catchment of the pond chains on Hampstead Heath? | No. The site lies outside of the catchment area for the Golders Hill pond chains as shown on Figures 14 of the Arup report. |
| 4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas? | Yes.<br>Any additional hardstanding or decking around the new swimming pool will be permeable to ensure the surface water flow regime will be unchanged. |
| 5. As part of the site drainage, will more surface water (e.g. rainfall and run-off) than at present be discharged to the ground (e.g. via soakaways and/or SUDS)? | No. 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. Topographical maps acquired as part of the desk study and Figures 11 and 12 of the Arup report confirm this. |

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

Q1 The site is located directly above an aquifer.
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 7 The Grove |
|---|---|
| 1. Does the existing site include slopes, natural or manmade, greater than 7°? | No. Fig 16 of the Arup report does not show the site to be in an area with slopes greater than 7°. Ordnance survey maps show the site and immediate surrounding area to be relatively level. |
| 2. Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7°? | No. The site is not to be significantly re-profiled as part of the development. |
| 3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°? | No. As indicated on the Slope Angle Map Fig 16 of the Arup report. |
| 4. Is the site within a wider hillside setting in which the general slope is greater than 7°? | No. As indicated on the Slope Angle Map Fig 16 of the Arup report. |
| 5. Is the London Clay the shallowest strata at the site? | No. Not according to Figure 2 of the Arup report or the BGS map of the area. |
| 6. Will any trees be felled as part of the proposed development and / or are any works proposed within | Yes. A number of trees are to be removed as part of the redevelopment (see arboricultural report for details) |

| Question | Response for 7 The Grove |
|---|---|
| any tree protection zones where trees are to be retained? | |
| .7. Is there a history of seasonal shrink-swell subsidence in the local area and / or evidence of such effects at the site? | No. The Bagshot Sands are predominantly granular and are not capable of shrink swell. Also, information derived from the Envirocheck report indicates the site is not in an area susceptible to ground shrink swell stability hazards. |
| 8. Is the site within 100 m of a watercourse or potential spring line? | No. Not according to Figure 12 of the Arup report, extracts from the Envirocheck report and Ordnance Survey maps. |
| 9. Is the site within an area of previously worked ground? | No. The geological map of the area and Figures 3, 4 and 8 of the Arup report do not indicate any worked ground. |
| 10a. Is the site within an aquifer? | Yes. The site is underlain by the Bagshot Formation which is classified as a Secondary 'A' Aquifer by the Environment Agency (EA). |
| 10b. Will the proposed basement extend beneath the water table such that dewatering may be required during construction? | No. |
| 11. Is the site within 50 m of Hampstead Heath ponds? | No. Not According to Figure 14 of the Arup report. |
| 12. Is the site within 5 m of a highway or pedestrian right of way? | No. The site boundary is within 5 m of a pedestrian right of way, but the proposed swimming pool is not. |
| 13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties? | No, There are no structures located within 6 m of the swimming pool excavation and therefore neighbouring structures will be unaffected. |
| 14. Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines? | No. Not according to Figure 18 of the Arup report. |

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

Q6 Trees are to be felled as part of the development.
Q10a The site is within an aquifer.

### 3.1.3 Surface Flow and Flooding Screening Assessment

| Question | Response for 7 The Grove |
|---|---|
| 1. Is the site within the catchment of the pond chains on Hampstead Heath? | No. Figure 14 of Arup report confirms that the site is not located within this catchment area. |
| 2. As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route? | No. Any additional hardstanding or decking around the new swimming pool will be permeable to ensure the surface water flow regime will be unchanged. |
| 3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas? | Yes.<br>Any additional hardstanding or decking around the new swimming pool will be permeable to ensure the surface water flow regime will be unchanged. |
| 4. Will the proposed basement development result in changes to the profile of the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses? | No. Any additional hardstanding or decking around the new swimming pool will be permeable to ensure the surface water flow regime will be unchanged. |
| 5. Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses? | No. The proposed development 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 . |
| 6. Is the site in an area identified to have surface water flood risk according to either the Local Flood Risk Management Strategy or the Strategic Flood Risk Assessment or is it at risk of flooding, for example because the proposed basement is below the static water level of nearby surface water feature? | No<br>The findings of this BIA together with the Camden Flood Risk Management Strategy dated 2013 and Figures 3iii, 4e, 5a and 5b of the SFRA dated 2014, in addition to the Environment Agency online flood maps show that the site has a very low flooding risk from surface water, groundwater, sewers, reservoirs (and other artificial sources), and fluvial/tidal watercourses. |

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

# 4.0 Scoping and Site Investigation

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

## 4.1 Potential Impacts

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

| Potential Impact | Consequence |
|---|---|
| The site is underlain by a Secondary 'A' Aquifer, as defined by the EA | Groundwater present within the aquifer may enter the proposed excavation and cause structural instability and damage. There is potential for the contamination of groundwater. |
| Trees are to be felled as part of the development | Removal of the trees could result in swelling of the soil and the removal of part of the existing root network which could affect slope stability on the site. However, the site does not contain any significant slopes so any impact will be minimal. |

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

## 4.2 Sampling Strategy

In order to meet the objectives described in Section 1.2, three boreholes were advanced to a depth of 4.00 m using hand held window sampling equipment. Additionally, two trial pits were hand excavated to a depth of 1.30 m to provide access to the existing foundations of the archway structure in the garden.

Three groundwater monitoring standpipes have been installed to a depth of 4.00 m to facilitate groundwater monitoring, which has been carried out on a single occasion to date, approximately two weeks after installation.
During boring, disturbed samples were obtained from the boreholes for subsequent laboratory examination and testing. A selection of the samples recovered from the boreholes was submitted to a soil mechanics laboratory for a programme of geotechnical testing and an analytical laboratory for a programme of contamination testing.

All of the above work was carried out under the supervision of a geotechnical engineer from GEA. The borehole and trial pit records are appended, together with a site plan indicating the exploratory positions.

## 4.3 Sampling Strategy

The trial pit and borehole locations were agreed with the consulting engineers, Engineers HRW, prior to the site work.

Three samples of the made ground have been tested for the presence of contamination. The analytical suite of testing was selected to identify hydrocarbon contamination resulting from the former use of the site and a range of typical industrial contaminants for the purposes of general coverage. The analytical suite for the soil included a range of metals, total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), total cyanide and monohydric phenols. The analyses were carried out at an MCERTs accredited laboratory with the majority of the testing suite accredited to MCERTS standards. A summary of the MCERTs accreditation and test methods are included with the attached results and further details are available upon request.

# 5.0 Ground Conditions

The investigation has generally confirmed the expected ground conditions in that, beneath a moderate thickness of made ground, the Bagshot Formation was encountered to the full depth of the investigation.

## 5.1 Made Ground

The made ground generally comprised dark brown clayey silty sand with gravel and occasional brick, ash and concrete fragments and extended to depths of between 1.00 m and 1.30 m below ground level.

No evidence of significant contamination was identified during the fieldwork. As a precaution three samples of the made ground were tested for the presence of contamination and the results are presented in Section 5.4.

## 5.2 Bagshot Formation

The Bagshot Formation generally comprised firm to stiff orange-brown mottled pale grey very sandy clay extending to the full depth of the investigation of 4.00 m. However, an upper layer of firm to stiff orange-brown mottled pale grey very sandy clay with occasional fine to medium subangular to subrounded gravel was present in Borehole No 3, extending to a depth of 2.00 m below ground level.

Atterberg results show the clay to be of low to medium shrinkability.

No evidence of contamination was noted in these soils.

## 5.3 Groundwater

Groundwater was not encountered during the investigation and the three standpipes have been found to be dry during a single monitoring visit.

## 5.4 Soil Contamination

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

| Determinant | TP2 0.20 m | BH1 0.40 m | BH2 0.50 m |
|---|---|---|---|
| pH | 7.4 | 7.6 | 7.3 |
| Asbestos Screen | Not Detected | Not Detected | Not Detected |
| Arsenic | **39** | 21 | 25 |
| Cadmium | <0.20 | <0.20 | <0.20 |
| Chromium | 25 | 22 | 20 |
| Lead | **510** | **440** | **830** |
| Mercury | 0.8 | 1.6 | 1.5 |
| Selenium | <1.0 | <1.0 | <1.0 |
| Copper | 57 | 54 | 71 |
| Nickel | 23 | 14 | 16 |
| Zinc | 200 | 180 | 210 |
| Total Cyanide | <1.0 | <1.0 | <1.0 |
| Total Phenols | <1.0 | <1.0 | <1.0 |
| Total PAH | 8.1 | 2.98 | 8.6 |
| Sulphide | 3.5 | 4.3 | 2.8 |
| Benzo(a)pyrene | 0.79 | 0.28 | 0.72 |
| Naphthalene | <0.05 | <0.05 | 0.11 |
| TPH | 33 | 17 | 16 |
| Total Organic Carbon % | 3.0 | 2.2 | 2.8 |

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

### 5.4.1 Generic Quantitative Risk Assessment

The use of a risk-based approach has been adopted to provide an initial screening of the test results to assess the need for subsequent site-specific risk assessments. Contaminants of concern are those that have values in excess of generic human health risk-based guideline values, which are either the CLEA[5] Soil Guideline Values where available, the Suitable 4 Use Values[6] (S4UL) produced by LQM/CIEH calculated using the CLEA UK Version 1.07[7] software, or the DEFRA Category 4 Screening values[8], assuming a residential end use with plant uptake. The key generic assumptions for this end use are as follows:

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

It is considered that these assumptions are acceptable for this generic. The tables of generic screening values derived by are included in the Appendix.

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

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

The results of the chemical analyses have indicated all of the samples tested to contain elevated concentrations of lead while one of the samples also contained an elevated concentration of arsenic.

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

## 5.5 Existing Foundations

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

| Trial Pit No | Structure | Structure | Foundation detail | Bearing Stratum |
|---|---|---|---|---|
| 1 | B-B' | Garden Archway | Brick Footing<br>Top 0.50 m<br>Base 1.20m<br>Lateral projection 120mm | Made Ground (brown clayey sand with gravel and rare concrete fragments) |
| | A-A' | Archway Support Pier | Concrete Footing<br>Top 0.20 m<br>Base 0.35 m<br>Lateral projection 200mm | Made Ground (dark brown clayey sand with gravel and occasional brick and ash fragments) |
| 2 | A-A' | Garden Archway | Brick Footing<br>Top 0.50 m<br>Base 1.20m<br>Lateral projection 120mm | Made Ground (brown clayey sand with gravel and rare concrete fragments) |

It should be noted that the extension of the trial pits between the archway columns indicated that the foundations for the archways extend between each column below ground level.

5 *Updated Technical Background to the CLEA Model (Science Report SC050021/SR3) Jan 2009* and Soil Guideline Value reports for specific contaminants; all DEFRA and Environment Agency.
6 *The LQM/CIEH S4Uls for Human Health Risk Assessment* S4UL3065 November 2014
7 Contaminated Land Exposure Assessment (CL|EA) Software Version 1.071 Environment Agency 2015
8 CL:AIRE (2013) *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination* Final Project Report SP1010 and DEFRA (2014) *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination* Policy Companion Document SP1010

# Part 2: Design Basis Report

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

## 6.0 Introduction

It is understood that it is proposed to construct a new swimming pool a new single storey pool house in part of the rear garden. The loads are not known but are anticipated to be moderate.

## 7.0 Ground Model

The desk study has revealed that the site has not had a potentially contaminative historical use as it has been developed as existing for its entire known developed history, and on the basis of the fieldwork, the ground conditions at this site can be characterised as follows:

- below a moderate thickness of made ground, the Bagshot Formation is present and extends to the full depth of the investigation, of 4.00 m;
- the made ground comprises dark brown clayey silty sand with gravel and occasional brick, ash and concrete fragments and extends to depths of between 1.00 m and 1.30 m below ground level;
- the Bagshot Formation generally comprises layers of firm to stiff orange-brown mottled pale grey very sandy clay and firm to stiff orange-brown mottled pale grey very sandy clay with occasional fine to medium subangular to subrounded gravel extending to the full depth of the investigation of 4.00 m;
- groundwater is not present below the site at shallow depths; and
- contamination testing has revealed the presence of locally elevated lead and arsenic contamination within the made ground.

## 8.0 Advice & Recommendations

It is proposed to form the swimming pool excavation within a sheet piled wall and to support the structure with either shallow spread foundations or a raft foundation. Groundwater is unlikely to be encountered within the excavation. The formation level for the pool will probably be at a depth of about 2.50 m below ground level and should therefore be within the sandy clay of the Bagshot Formation.

### 8.1 Swimming Pool Construction

The investigation has indicated that groundwater should not be encountered in the swimming pool excavation. However, the excavation will expose a greater volume of soil than has been investigated by the boreholes and it is possible that larger pockets or inter-connected layers of higher permeability soils could be encountered. Therefore, it is recommended that trial excavations are undertaken to as close to the full depth of the proposed swimming pool to confirm the nature of any possible groundwater inflows.

There are a number of methods by which the sides of the swimming pool excavation could be supported in the temporary and permanent conditions. The choice of wall will be governed, to a large extent, by whether it is to be incorporated into the permanent works and have a load bearing function and also by the limited available access. The final choice will depend on a number of factors, including the need to protect nearby structures from movements, the required overall stiffness of the support system and the potential need to control groundwater movement through the wall in the temporary condition.

It is understood that it is currently proposed to carry out the swimming pool excavation within a sheet piled wall. This should be generally feasible, although consideration should be given to the noise and vibrations associated with the installation of this type of wall and the disruption this may cause to other residents and structures.

There are no structures present within 15 m to the east and 36 m to the west of the swimming pool. Only an unlisted boundary wall is present within 25 m to the north, which is not classed as a sensitive structure in accordance with CIRIA C760, and to the south there is a listed boundary wall with the adjacent No 5 The Grove. The ground level of the adjacent site is at a maximum level of 124.50 m OD which is 2.50 m below the ground level of the subject site. It is anticipated that the wall will have a foundation extending below a level of 124.50 m OD, but access was not possible to confirm the extent of the footing. In any case, the swimming pool excavation of 2.50 m would be level with the ground level of the

adjacent site and it is therefore considered that the boundary wall will be unaffected by any ground movements resulting from the excavation. Additionally, as the wall is 6 m from the excavation, the foundations would need to extend to a depth of 6 m below the ground level of the site, which corresponds to about 3.50 m below the level of the adjacent site. This is considered to be extremely unlikely and therefore the proposed swimming pool will not apply any load to the boundary wall. A ground movement assessment is, therefore, not considered to be required for the development.

### 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 ($\phi'$ – degrees) |
|---|---|---|---|
| Made ground | 1700 | Zero | 20 |
| Bagshot Formation (clay) | 1900 | Zero | 24 |
| Claygate Member | 1900 | Zero | 26 |

Monitoring of the standpipe should be continued to assess the design water level but at this stage it would appear that groundwater may be assumed to be below basement level; the advice in BS8102:2009[9] should also be followed in this respect.

### 8.1.2 Swimming Pool Excavation Heave

The 2.50 m deep swimming pool excavation will result in a net unloading of up to approximately 48 $kN/m^2$. The proposed excavations will result in elastic heave and long term swelling of the clay layers within the Bagshot Formation and underlying Claygate Member. The effects of the longer term swelling movement will to a certain extent be counteracted by the applied loads from the development and the granular deposits found in both stratum.

## 8.2 Spread Foundations

It should be possible to adopt spread foundations provided that proposed loads are relatively light. Given the swimming pool excavation depth of 2.50 m all new foundations should bypass any potentially desiccated soils and there should not be a need for further deepening to take account for the presence of possible tree root effects.

Spread foundations bearing beneath the formation level of the swimming pool in the firm sandy clay of the Bagshot Formation may be designed to apply a net allowable bearing pressure of 100 $kN/m^2$. The requirement for compressible material alongside foundations should be determined by reference to the NHBC guidelines.

If the proposed loads are too high or the required founding depths become uneconomic mini-piled foundations would provide a suitable alternative foundation option. Foundations will need to be nominally reinforced where they span granular and cohesive soils to minimise differential movements.

A check has been made with respect to the surrounding structures which are outside of a line drawn at a 45 degree angle from the base of the swimming pool excavation which indicates that the loads of the swimming pool will not impact any nearby foundations.

## 8.3 Raft Foundation

Depending on the loads and whether they can be relatively uniformly distributed, it may be feasible to adopt a raft foundation for the new swimming pool. The loads of the swimming pool are not know at this stage. If a raft is to be considered, once the loads and levels have been finalised a settlement analysis should be carried out to confirm the suitability of the use of a raft foundation as this will be controlled largely by the predicted settlements to be expected.

## 8.4 Shallow Excavations

On the basis of the borehole findings it is considered that shallow excavations for foundations and services that extend through the made ground should remain generally stable in the short term, although some instability may occur. Where personnel are required to enter excavations, a risk assessment should be carried out and temporary

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

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

Significant inflows of groundwater into shallow excavations are not generally anticipated, although seepages may be encountered from localised perched water tables within the made ground or from within more silty and sandy horizons from within the Bagshot Formation, although such inflows should be suitably controlled by sump pumping.
If deeper excavations are considered it is recommended that provision be made for lateral support. Where personnel are required to enter excavations, a risk assessment should be carried out and temporary lateral support or battering of the excavation sides considered in order to comply with normal safety requirements.

## 8.5 Basement Floor Slab

Following the excavation of the swimming pool, if a raft foundation is not adopted, a lightly loaded ground bearing floor slab should be utilised. The slab will need to be designed to resist heave movements, or it could be constructed as a rigid box tied into the walls. A check should be made on potential movements once final levels have been determined.

## 8.6 Effect of Sulphates

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

## 8.7 Contamination Risk Assessment

The desk study research has indicated that the site has been occupied by the existing building for its entire known developed history. The results of the chemical analyses have indicated all of the samples tested to contain elevated concentrations of lead while one of the samples also contained an elevated concentration of arsenic.

The source of the lead and arsenic contamination is not known, although the made ground was noted as containing fragments of extraneous material and it is possible that these fragments, possibly lead based paint or coal, could be the source of the lead contamination. Lead and arsenic may also be associated with the historical use of lead arsenate pesticides in the garden. In addition, reference to the Envirocheck report has indicated that the site lies within an area known to have a background concentration of arsenic of between 15 mg/kg and 25 mg/kg and concentrations of lead of between 300 mg and 600 mg. Only one of the concentrations of lead and the single elevated concentration of arsenic was found to be elevated above these background levels. Additionally, a localised area nearby to the north is known to have a background lead concentration of between 600 mg and 900 mg, the upper limit of which is above the maximum lead value found during the investigation. The development will not result in an increase in soft landscaping at the site, meaning exposure will remain as it has been throughout the history of the site. As a result, a requirement for remedial measures at the site is not envisaged. However, measures will be required to protect site workers, which is discussed further below.

### 8.7.1 Site Workers

Apart from the physical hazards represented by the fill materials, concentrations of potentially carcinogenic lead have been measured in the shallow soils in the southwest of the site. Site workers should be made aware of the contamination and a programme of working should be identified to protect workers handling any soil. The method of site working should be in accordance with guidelines set out by HSE[10] and CIRIA[11] and the requirements of the Local Authority Environmental Health Officer.

## 8.8 Waste Disposal

Under the European Waste Directive, waste is classified as being either Hazardous or Non-Hazardous and landfills receiving waste are classified as accepting hazardous or non-hazardous wastes or the non-hazardous sub-category of inert waste in accordance with the Waste Directive. Waste classification is a staged process and this investigation represents the preliminary sampling exercise of that process. Once the extent and location of the waste that 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

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

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

WM3[12] 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[13] guidance, will need to be disposed of to a licensed tip. Waste going to landfill is subject to landfill tax at either the standard rate of £98.60 per tonne (about £185 per $m^3$) or at the lower rate of £3.15 per tonne (roughly £5.85 per $m^3$). However, the classifications for tax purposes and disposal purposes differ and currently all made ground and topsoil is taxable at the 'standard' rate and only naturally occurring soil and stones, which are accurately described as such in terms of the 2011 Order, would qualify for the 'lower rate' of landfill tax.

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

| Soil Type | Waste Classification (Waste Code) | WAC Testing Required Prior to Landfill Disposal? | Current applicable rate of Landfill Tax |
|---|---|---|---|
| Made ground | Non-hazardous (17 05 04) | No | £98.60/tonne (Standard rate) |
| Natural Soil | Inert non-hazardous (17 05 04) | Should not be required but confirm with receiving landfill | £3.15 / tonne (Reduced rate for uncontaminated naturally occurring rocks and soils) |

Under the requirements of the Waste Directive all waste needs to be pre-treated prior to disposal. The pre-treatment process must be physical, thermal, chemical or biological, including sorting. It must change the characteristics of the waste in order to reduce its volume, hazardous nature, facilitate handling or enhance recovery. The waste producer can carry out the treatment but they will need to provide documentation to prove that this has been carried out. Alternatively, the treatment can be carried out by an approved contractor. The Environment Agency has issued a position paper[14] 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.

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

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

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

# Part 3: 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.

## 9.0 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.

### 9.1 Potential Impacts

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

| Potential Impact | Consequence |
|---|---|
| The site is underlain by a Secondary 'A' Aquifer, as defined by the EA | Groundwater present within the aquifer may enter the proposed excavation and cause structural instability and damage. There is potential for the contamination of groundwater. |
| Trees are to be felled as part of the development | Removal of the trees could result in swelling of the soil and the removal of part of the existing root network which could affect slope stability on the site. However, the site does not contain any significant slopes so any impact will be minimal. |

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.

*A number of trees will be felled as part of the development, while a large deciduous tree in the western corner will be retained*

Whilst shrinkable soils are present at shallow depth, there are no critical slope angles that are dependent on the presence of the existing trees to aid long term stability.

Care will need to be taken to ensure the roots of the retained tree are not disturbed.

*The site is underlain by a Secondary 'A' Aquifer*

The investigation has found groundwater to not be present at shallow depths and the findings of a previous GEA on the adjacent site to the south indicate groundwater is present at a depth of about 8.50 m below ground level on the site. The excavation will only extend to a depth of 2.50 m and therefore significant groundwater inflows are unlikely to be encountered. However the contractor should have a plan in place to deal with potential localised inflows from permeable layers within the Bagshot Formation. The proposed use is not potentially contaminated and therefore the risk of groundwater contamination is minimal. Standard groundwater protections measures should be adopted by the contractor during the works, such as the use of drip trays when refilling petrol powered equipment etc.

### 9.2 BIA Conclusions

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

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

## 9.3 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.

### 9.3.1 Screening

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

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

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

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

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

| Question | Evidence |
|---|---|
| 1. Is the site within the catchment of the pond chains on Hampstead Heath? | Topographical maps acquired as part of the desk study and Figures 12 and 14 of the Arup report |
| 2. As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route? | A site walkover confirmed the current site conditions and the details provided on the proposed development, including reference to the FRA for the site. |
| 3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas? | |
| 4. Will the proposed basement development result in changes to the profile of the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses? | |
| 5. Will the proposed basement result in changes to the quantity of surface water being received by adjacent properties or downstream watercourses? | |
| 6. Is the site in an area known to be at risk from surface water flooding such as South Hampstead, West Hampstead, Gospel Oak and Kings Cross, or is it at risk of flooding because the proposed basement is below the static water level of a nearby surface water feature? | Flood risk maps acquired from the Environment Agency as part of the desk study, Figure 15 of the Arup report, the Camden Flood Risk Management Strategy dated 2013 and the North London Strategic Flood Risk Assessment dated 2008, and reference to the site specific FRA. |

### 9.3.2 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.

### 9.3.3 Impact Assessment

Section 9.1 of this report summarises whether, on the basis of the findings of the investigation, the potential impacts still need to be given consideration and identifies ongoing risks that will require suitable engineering mitigation. Section 8.0 of this report also provides recommendations for the design of the proposed development.

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

# 10.0 Outstanding Risks & Issues

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

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

Monitoring of the standpipe should be continued to determine equilibrium groundwater levels and to establish any seasonal fluctuations. Ideally, trial excavations extending to as close to the full depth of the proposed basement as possible should be carried out to determine likely groundwater inflows into the basement excavation.

If during ground works any visual or olfactory evidence of contamination is identified it is recommended that further investigation be carried out and that the risk assessment is reviewed.