# Basement Impact Assessment - 1B St John's Wood Park, London NW8 6QS

**Hydrogeology and Land Stability**

17 August 2015

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# Document Control Sheet

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# Contents

# 1 Introduction

## 1.1 Terms of Reference

Maund Geo-Consulting Ltd was instructed on 8 July 2015 by Chris Tomlin of Croft Structural Engineers Ltd to undertake the hydrogeology and geology sections of a Basement Impact Assessment (BIA) at 1B St John's Wood Park in connection with a proposal to construct a house with a basement at the site.

## 1.2 Scope and Objective

This report has been written in general accordance with 'Camden geological, hydrogeological and hydrological study - Guidance for subterranean development' produced for the London Borough of Camden (LBC) by Arup (November 2010), hereafter referred to as the 'Arup Report'. The guidance sets out the methodology for a risk-based impact assessment to be undertaken with regard to hydrology, hydrogeology and land stability in support of planning policy DP27. The BIA comprises stages in which information is obtained to enable LBC to make a decision on the impact of the development for the planning application. The LBC Guidance CPG4 (September 2013) requires a BIA to be undertaken for new basements in 5 stages:

1. Screening
2. Scoping
3. Site investigation
4. Impact assessment
5. Review and decision making (By LBC)

This report includes stages 1 to 4 and has been undertaken by Dr Julian Maund, director of Maund Geo Consulting Ltd, who is a chartered engineer and geologist with 30 years' experience.

As a site investigation has already been undertaken as part of the BIA for 1B St John's Wood Park on 1/7/2015 the screening part of the assessment has been assessed on the basis of existing information including the site investigation, so the project has been completed in the following sequence:

1. Background information
2. Site Investigation
3. Screening
4. Scoping
5. Impact Assessment

This report considers the hydrogeological and land stability elements of the BIA only. Hydrology is considered in a separate report by Croft Structural Engineers Ltd.

# 2 Background Information on the Site

## 2.1 Information Sources

Background information has been derived from a Groundsure report obtained on 16/07/15 for the site (Appendix A). Geological information has been derived from on-line BGS sources (Geology of Britain Viewer) and the Arup Report. Mapping and aerial photography have been obtained from Streetmap and GoogleEarth. Information is also derived from a recent site investigation, reported by Ground and Water Ltd (July 2015).

## 2.2 Location

The site is located on the west side of St John's Wood Park, at approximate National Grid Reference TQ26782674 and Post Code NW8 6QS, in Swiss Cottage, London Borough of Camden (Figure1).

## 2.3 Description

The site comprises an access road to a row of garages and six of the garages at the eastern end of the row. The access road is secured by a steel tube gate from St John's Wood Park road. Between the eastern end of the garages and St John's Wood Park is an area enclosed by a wooden panel fence to the south and a brick wall to the east and north. The enclosed area is partially obscurred by vegetation and a tree. Immedaitely to the south of the site is a row of substantial two storey brick houses.

## 2.4 Present use

The site appears to be used as an access road for a row of garages, and six garages.

## 2.5 Proposed use

The proposed development relevant to this BIA is understood to comprise the construction of a new house with a basement approximately 24 m long west to east and 12 m wide north to south. The proposed house has an area of approximately 12 m by 12 m, with three storeys above the basement.

## 2.6 Topography, geomorphology and drainage

The site is level at approximately 52 m AOD. The land around in the vicinity of the site has a slight fall in level to the south east.

There are no discernible geomorphological features in the vicinity of the site. There are no open watercourses within at least 100 m of the site.

## 2.7 Geology

Geological information obtained from the Figure 4 of the Arup Report at 1: 10 000 and the BGS website geological mapping at 1 50 000 scale shows the site to be underlain by the London Clay Formation. There are no superficial deposits within 0.5 km radius of the site.

## 2.8 Hydrogeology/groundwater

The property is located on the London Clay Formation. London Clay is classified as 'unproductive strata'. The Camden Aquifer designation map (Figure 8 of the Arup Report) confirms the property is located on unproductive strata.

The site lies within the outer source protection zone of Barrow Hill Pumping Station. The Barrow Hill Pumping Station is located 939 m to the east of the site.

## 2.9 Natural Hazards

The Groundsure report (Appendix A) findings on natural hazards are summarised in table 2.1

Table 2.1 Natural Hazards

| Natural Hazard | Risk (Stated by BGS in Groundsure report) | Comment |
|---|---|---|
| Shrink Swell | Moderate | The site is on a clay soil, subject to shrinkage and swell from desiccation. Desiccation due to seasonal factors could be up to 1.0 m below ground level in London Clay which has a high volume change potential (NHBC) |
| Landslides | Very Low | Not applicable to the topography of the site |
| Soluble Rocks | Negligible | Not applicable to the site geology |
| Compressible Ground | Negligible | Clay soil is subject to consolidation from additional imposed loads, which are limited by appropriate foundation design |
| Collapsible Rocks | Very Low | Not applicable to the site geology |
| Running sand | Negligible | Not applicable to the site geology |
| Radon | No protection required | |

## 2.10 History of site

The Groundsure report in Appendix A includes historical mapping surveys from 1871 to 1995.

The site was developed from the earliest survey of 1871 with two semi-detached houses. The houses were demolished between the 1953 and 1960 surveys.

The map surveys indicate the existing properties lying immediately south of the site were constructed between 1965 and 1969. The garages were constructed between the 1953 and 1960 surveys. The site has remained largely unchanged since then to the present day.

## 2.11 Underground features

There are no underground features (basements or tunnels) at the site. The closest tunnels run east west at 49 m to the north (London Overground Railway). The GroundSure report (Appendix A) has not identified any mining, underground workings or natural cavities within at least 500 m of the site.

## 2.12 Other factors e.g. contamination and archaeology

The GroundSure report (Appendix A) has not identified any 'Environmental Permits, Incidents and Registers' or 'Landfill and Other Waste Sites' within at least 100 m of the site boundary.

No specific archaeological investigation has been undertaken. The 'GroundSure' survey has not identified any known 'Environmentally Designated Sensitive Sites' within 250 m of the site (Appendix II).

## 2.13 Flooding

The GroundSure report (Appendix II) has not identified any flooding issues within 250 m of the site.

# 3 Site Investigation

A ground investigation was undertaken by Ground and Water Ltd on 1st July 2015. A ground investigation report of the ground investigation comprising exploratory hole records and laboratory testing is included in Appendix B.

The ground investigation comprised:

- One Premier Windowless Sampler Borehole to a depth of 12.50 m,
- Two hand excavated trial pit (TP1 and TP2) to determine the nature of the foundation to the garages.
- The in-situ strengths of the subsoil encountered were assessed by means of standard penetrations tests,
- Disturbed soil samples were obtained from both exploratory holes for laboratory geotechnical testing and further examination.
- A sealed 63 mm diameter combined bio-gas and groundwater monitoring well was installed at a depth of 5.0 m in the borehole BH1.

The approximate locations of the above exploratory holes together with the exploratory hole records and laboratory test results are shown in Appendix B.

## 3.1 Details of laboratory tests

Laboratory tests to determine the geotechnical properties of the soil (London Clay only) was scheduled by Ground and Water Ltd were carried out by K4 Soils Laboratory generally in accordance with BS1377:1990 and BRE Special Digest 1 2005. The tests included:

3 Moisture Content

4 Atterberg Limits

2 Sulphate and pH determinations

1 Undrained triaxial test

1 Swelling test

In addition 2 samples of Made Ground BH1 @ 0.3 m and TP/FE1 @ 0.3 m depth were analysed for a suit of contamination tests by QTS Enviromental Ltd which included:

Semi and Heavy Metals

Asbestos Screen

Organic compounds (PAHs, Fuels Oils and BTEX)

The results of the laboratory tests are included in Appendix B.

# 4 Ground Conditions

## 4.1 Stratigraphy

The ground conditions encountered in BH1 are summarised in Table 4.1 below:-

Table 4.1

| Stratum | General description of Stratum | Thickness of Strata (m bgl) | Undrained Cohesion (KN/m$^2$)/ STP |
|---|---|---|---|
| MADE GROUND | Tarmac over crushed brickwork | G.L. to 1.1 | n/a |
| HEAD DEPOSITS | Brown and orange mottled grey gravelly silty CLAY (in TP/FE1 only) | 1.1 to 1.5 (proven) | |
| WEATHERED LONDON CLAY FORMATION | Soft to firm orange brown silty CLAY | 0.50 to 3.60 | 18 to 50 (4 to 11) |
| LONDON CLAY FORMATION | Stiff to very stiff brown silty CLAY | 3.60 to 9.00 | 67 to 122 (15 to 27) |
| LONDON CLAY FORMATION | Very stiff silty CLAY | 9.00 to 12.50 proven | 130 to 171 (29 to 38) |

Note – No groundwater was encountered in boreholes or trail pits

The undrained cohesion of the London Clay formation is based on a correlation of SPT to undrained correlation of 4.5 assuming a plasticity index of >30% after Stroud and Butler (1975).

## 4.2 Groundwater

Groundwater was not encountered in BH1 during the drilling of the borehole on 01/07/2015. A monitoring well installed to a depth of 5.40 m. A measurement of groundwater on 04/08/15 showed a level of 0.49m bgl. Due to the apparent discrepancy between the borehole at the end of drilling and the subsequent groundwater level in the well, which might have been caused by surface water inundation, the well was bailed on 05/08/15 to a depth of 4.84 m and subsequently re-measured. The results of the monitoring of the well are shown in table 4.2 below:

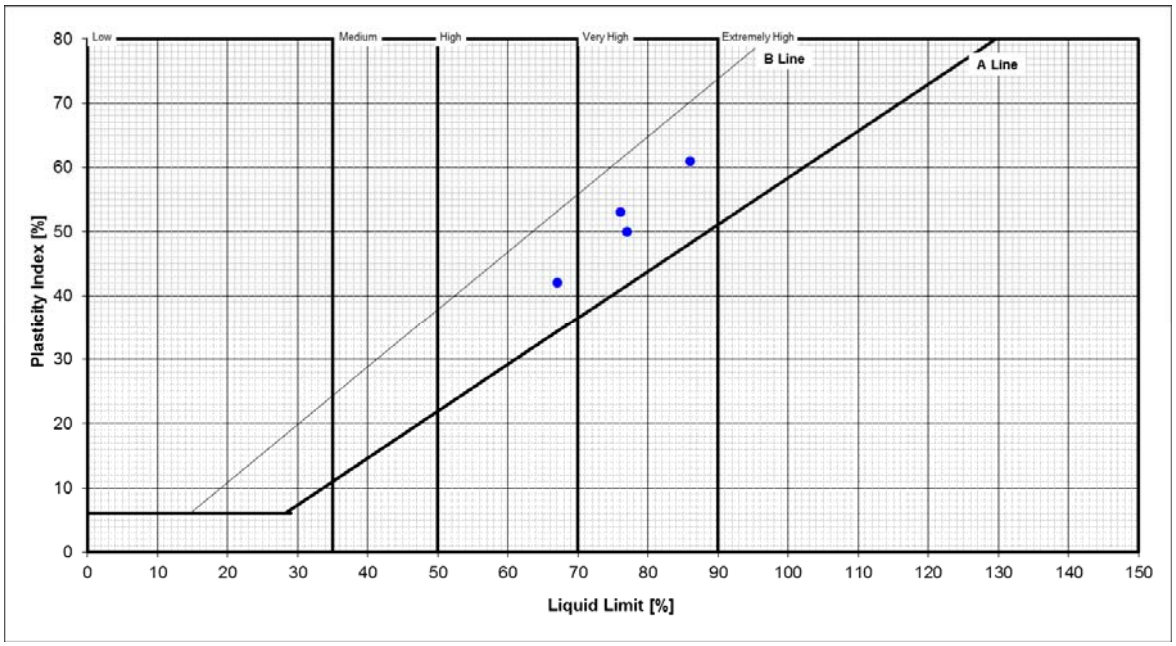
Table 4.2 Groundwater monitoring in BH 1

| Date of monitoring | Groundwater Depth (metres below ground level – Approximately 52 m AOD) |
|---|---|
| 04/08/15 | 0.49 |
| 05/08/15 | 0.54 prior to bailing well |
| 05/08/15 | 4.23 after bailing well |
| 10/08/15 | 1.63 |
| 13/08/15<br><br>17/08/15 | 0.74<br><br>0.57 |

### 4.3 Plasticity

From the laboratory testing the London Clay has a Plasticity Index ranging from 42 to 61% and a Liquid Limit ranging from 67 to 86%, as shown in the Atterberg Chart in Figure 4.1 below, characterising the material as having a high to very high plasticity.

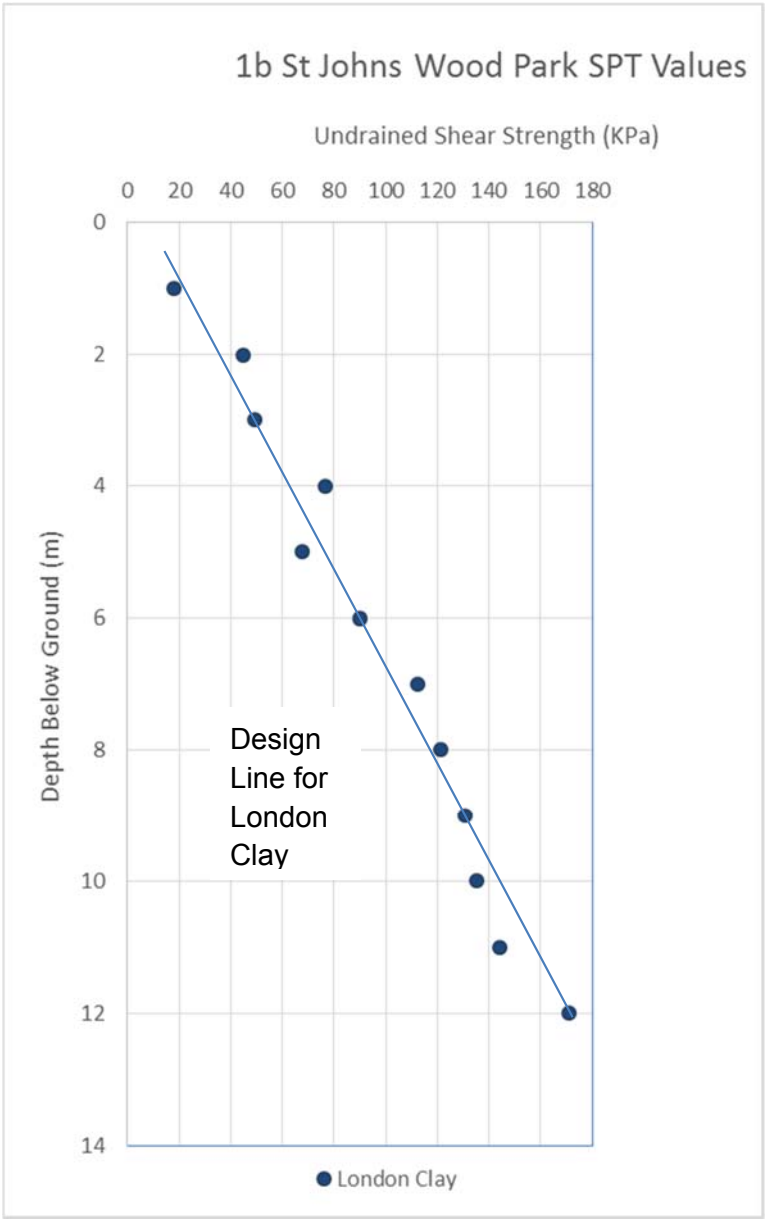
Figure 4.1 Atterberg Chart




## 4.4 Strength (Undrained Cohesion)

The undrained cohesion of the London Clay formation is based on a correlation of SPT to undrained correlation of 4.5 assuming a plasticity index of >30% after Stroud and Butler (1975). Based on the SPT / depth plot in Figure 4.2, the undrained cohesion shows a linear increase in depth from 18 kPa at 1m bgl to 171 kPa at 12 m bgl. This strength progression with depth is indicated by a design line for the London Clay strata at this location. A single triaxial test result at 4.00 m give a shear strength of 110 kPa, although it appears to be from a disturbed sample so it should not be considered a reliable test.

Figure 4.2 Undrained shear strength v Depth Plot




## 4.5 Sulphate and pH

Laboratory testing for sulphate ($SO_4$ in 2:1 water: soil) in accordance with BS 1377: Part 3 was carried out on 2 samples which range from 2.62 to 2.78 g/l. The range of pH was from 7.7 to 8.2 or slightly alkaline. The soluble sulphate concentrations will require a design sulphate class of DS3, with a classification of Aggressive chemical environment for concrete of AC3s.

### 4.6 Consideration of the individual strata in detail, with reference to any proposed foundations.

The anticipated formation level of the basement floor slab will be approximately 5.0 m below ground level at approximately a level of 47.0 m AOD. The undrained cohesion at the anticipated founding depth at 5.00 m is 80 kPa.

The Ground Investigation Report (Appendix B) indicates that a maximum preliminary safe bearing pressure at 5 m depth should be taken as 180 kPa, which is in broad agreement by calculation (e.g. Brinch Hansen 1961) with the design line indicated in Figure 4.2.

### 4.7 A review and summary of the derived values of geotechnical parameters.

The geotechnical parameters assessed on the basis of the data obtained from the ground investigation (AppendixB) have been summarised in Table 4.2 as follows:

Table 4.2 Geotechnical Parameters

| | Plasticity | | | | Class-classification | Undrained Cohesion | Effective cohesion | Effective angle of friction | Bulk unit weight | Concrete Class |
|---|---|---|---|---|---|---|---|---|---|---|
| Strata | LL (%) | PL (%) | PI (%) | MC (%) | | Cu (kPa) | C' (kPa) | Φ' | kN/m$^3$ | DC |
| Made Ground | n/a | n/a | n/a | n/a | n/a | n/a | 0* | 13* | 15* | DC-3 AC-3s |
| Head Material | n/a | n/a | n/a | n/a | n/a | n/a | 0** | 13** | 15** | DC-3 AC-3s |
| Weathered London Clay | 67-86 | 23-27 | 42-61 | 25-33 | CH /CV | 18 to 171 | 0* | 24* | 20-22* | DC-3 AC-3s |

*Values derived by Ground and Water Ltd.

** Assume the same as made ground for design purposes

# 5 Screening

## 5.1 Introduction

Screening is undertaken as outlined in Section 6.2 of the Arup study recommendations. It identifies if there are hydrogeological and land stability issues associated with the proposed development that requires detailed analysis and investigation. If there are no significant issues identified in the screening stage, then further stages are not required. The report follows the flow charts set out in CPG4, and makes reference to the Arup Report.

## 5.2 Subterranean (Groundwater) flow

This section answers questions in Figure 1 of CPG4:

The source of information for the assessment of subterranean flow is from the Arup Report and a site specific Groundsure Environmental Insight Report obtained in July 2015 for 1B St John' Wood Park (Appendix A).

***Table 5.1: Responses to Figure 1, CPG4***

| Question | Response | Action required |
|---|---|---|
| *1a.* Is the site located directly above an aquifer | No.<br>The site is located in the London Clay, a non-aquifer. The London clay extends to a depth of 84.2 m at a borehole at Swiss Cottage 300 m north (BGS ref. TQ28SE1769) and 87 m at a borehole at Waverley Place 500 m to the south (BGS ref. TQ28SE 1566). | None |
| *1b.* Will the proposed basement extend beneath the water table surface. | Yes<br><br>The borehole drilled on 1 /7/2015 at the site indicated that no groundwater was encountered to a depth of 12.50 m bgl. Borehole TQ28SE1769 at Swiss Cottage indicated a rest water level of 90m bgl. Subsequent monitoring from a well installed to 5.40 m bgl indicated water at 0.49 to 1.63 m bgl. This was considered to represent perched water level as it was not consistent with regional groundwater records, however any design of the basement will allow for groundwater to surface level. | Mitigate the potential groundwater height to ground level by appropriate design and construction methods |
| *2.* Is the site within 100m of a watercourse, well, or potential spring line. | None.<br><br>There are no known wells or spring-lines within 100 m of the site[b,c]. | None |
| *3.* Is the site within the catchment of the pond chains on Hampstead Heath | No.<br><br>The site is not within the catchment of the ponds[b] | None |

| Question | Response | Action required |
|---|---|---|
| *4.* Will the proposed basement development result in a change in the proportion of hard surfaced/paved areas. | No<br>The existing area has pavement cover and buildings. The proposed development will have a building over the entire site. | None |
| *5.* As part of site drainage, will more surface water than at present be discharged to ground (e.g. via soakaways and/or SUDS). | No.<br><br>The London Clay is relatively impermeable and as unlikely to be suitable for soakaway or SUDS drainage. | None |
| *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 lines. | No.<br><br>There are no recorded local ponds or spring lines within 250 m of the site | None |

a. *Camden Geological, Hydrogeological, and Hydrological Study, Arup, 2010. (Fig. 8).*

b. *Camden Geological, Hydrogeological, and Hydrological Study, Arup, 2010. (Fig. 11).*

c. *Camden Geological, Hydrogeological, and Hydrological Study, Arup, 2010. (Fig. 14).*

In summary, the site is located within the London Clay. A borehole drilled at the site to a depth of 12.5 m indicated that from subsequent monitoring of a well in the boreholes groundwater was present between 0.49 and 1.63 m below ground level. For further details refer to section 4 of this report.

## 5.3 Slope / Land Stability

This section answers questions posed by Figure 2 in CPG4.

***Table 5.2: Responses to Figure 2, CPG4***

| Question | Response | Action required |
|---|---|---|
| *1.* Does the site include slopes, natural or man made, greater than about 1 in 8? | No The site is on level ground at approximately 52.0 m AOD. | None |
| *2.* Will the proposed re-profiling of the landscaping at site change slopes at the property boundary to greater than about 1 in 8? | No. | None |
| *3.* Does the development neighbour land including railway cuttings and the like with a slope greater than about 1 in 8? | No. | None |
| *4.* Is the site within a wider hillside setting in which the general slope is greater than about 1 in 8? | No. | None |
| *5.* Is the London Clay the shallowest stratum on site? | No. London Clay is overlain by 0.5 m of made ground and / or approximately 1.5 m of head desposits . | Soil properties to be taken into account in design |
| *6.* Will any tress 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? | Unknown -Mature trees with an estimated height of 10 m occur with a tree protection zone of the site. | Engineering and arboricultural assessment of the influence of the foundations and retaining wall on the trees |

| Question | Response | Action required |
|---|---|---|
| *7.* Is there a history of shrink/swell subsidence in the local area and/or evidence of such at the site. | No records.<br><br>The London Clay is susceptible to seasonal shrink/swell movements and it is likely that these will occur, which is normal. The BGS define the risk of shrink / swell as 'moderate.<br>There is no evidence or records of subsidence in the vicinity of the site. | The foundation will be below the influence of shrink swell from seasonal fluctuations therefore no specific additional action is required. |
| *8.* Is the site within 100 m of a watercourse or a potential spring line? | No[a,b]. | None |
| *9.* Is the site within an area of previously worked ground? | No.<br><br>Borehole and trial pit records for the site show made ground extends to 0.5 m bgl. It is assumed this relates to a sub base for the access road and foundations associated with the garages present on the site and potentially earlier houses which were present on the site from before 1871 to when they were demolished between 1953 and 1960. There is no historical evidence of any working of the ground | None |
| *10.* Is the site within an aquifer? | No.[a,b]<br><br>(See also Table 5.1) | None |
| *11.* Is the site within 50m of the Hampstead Heath Ponds? | No. | None |
| *12.* Is the site within 5 m of a highway or pedestrian right of way? | Yes.<br><br>The site is immediately adjacent to St John's Wood Park road. | Impact assessment |
| *13.* Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties? | Yes<br>New foundations will be significantly deeper than those of neighbouring properties which do not have basements. This risk will be mitigated by outline design in accordance with relevant design standards. | Impact assessment |

| Question | Response | Action required |
|---|---|---|
| *14.* Is the site over (or within the exclusion zone of) any tunnels? | No[d]. | None |

a. *Camden Geological, Hydrogeological, and Hydrological Study, Arup, 2010. (Fig. 8).*

b. *Camden Geological, Hydrogeological, and Hydrological Study, Arup, 2010. (Fig. 11).*

c. *Camden Geological, Hydrogeological, and Hydrological Study, Arup, 2010. (Fig. 14).*

*d. Groundsure Report July 2015*

In summary, the site is located on level ground over the London Clay Formation. A layer of made ground and possibly head up to 1.5 m thick proven, encountered in the borehole and trial pit is considered to be a subbase for the existing access road and foundations for the existing garages and former houses which were demolished between 1953 and 1960.

Foundation levels will be lower with respect to adjacent properties which will require mitigation measures in the foundation / retaining wall design.

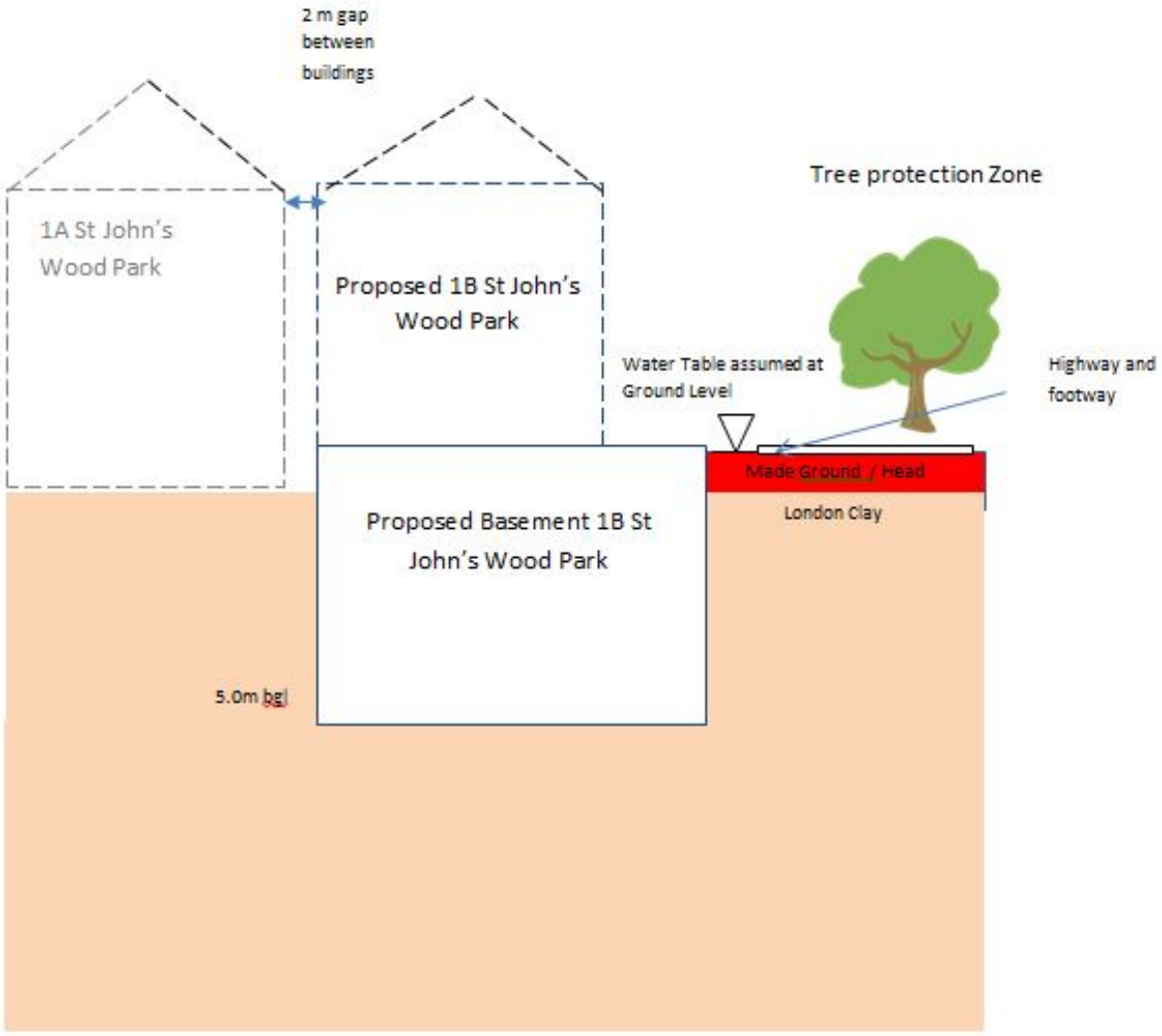
# 6 Scoping

## 6.1 Introduction

This section considers the output from the screening survey where further actions are required. It considers the scope of information required in addressing these actions and what the potential impacts are of the basement construction. The potential impacts of the development of a basement on the site can be summarised in a conceptual model.

## 6.2 Conceptual Model

**Figure 6.1 Conceptual Site Model**



Note this is conceptual model shows the house close to the existing property at 1A St John's Wood Park and the proximity of the basement to the highway and tree protection zone  in a combined section.

## Summary of Scoping Requirements

| Screening questions of concern - Hydrogeology | Potential Impact | Mitigation |
|---|---|---|
| 1b Groundwater | Groundwater level above basement formation level | To be mitigated by design |

| Screening questions of concern – Land Stability | Potential Impact | Mitigation |
|---|---|---|
| 5/ 7- Geology / shrink swell | Settlement or heave | To be mitigated by design |
| 6 Presence of trees | Impact of trees | To be mitigated by design |
| 12 - within 5 m of highway | Stability of Adjacent Highway | To be mitigated by design |
| 13 - differential foundation depth to adjacent property | Stability of Adjacent Property | To be mitigated by design |

# 7 Impact Assessment

## 7.1 Groundwater

The screening process has highlighted specific concern in relation to groundwater. The borehole drilled on 01/07/2015 indicated there was no groundwater to a depth of 12.5 m. Subsequent monitoring however indicated a maximum height of groundwater at 0.49 m below ground level (bgl). Although it is considered that the high groundwater level relates to perched water and does not reflect the true groundwater level which has been shown to be regionally at depth of 90 m (Borehole TQ28SE1769 at Swiss Cottage indicated a rest water level of 90m bgl) allowance will need to be made on the basement design for groundwater up to ground level.

## 7.2 Land Stability

### *7.2.1 Shrink Swell of the soil and ground movements*

The foundation will be below the influence of shrink swell from seasonal fluctuations therefore no specific additional action is required. Ground movements settlement / heave resulting from the basement construction will be evaluated once the detailed design and design loads has been developed, using best practice in accordance with Building Regulations, CIRIA 580, BS8002 and BS EN 1997-1 Eurocode 7.

### *7.2.2 Presence of Trees*

Engineering and arboricultural assessment of the influence of the foundations and basement retaining wall on the trees will be required in accordance with best practice guidance by the NHBC (Chapter 4.2 Buildng near trees 2011) and Building Regulations.

### *7.2.3 Proximity to Highway Boundary*

Ground movements settlement / heave resulting from the basement construction in proximity to the highway (St John's Wood Park road) will be evaluated once the detailed design and design loads has been developed, using best practice in accordance with Building Regulations, CIRIA 580, BS8002 and BS EN 1997-1 Eurocode 7.

### *7.2.4 Proximity to adjacent buildings*

Ground movements settlement / heave resulting from the basement construction in proximity to the adjacent property (1A St John's Wood Park) will be evaluated once the detailed design and design loads has been developed, using best practice in accordance with Building Regulations, CIRIA 580, BS8002 and BS EN 1997-1 Eurocode 7.

### *7.2.5 Soil removal / Excavations*

The ground investigation indicates that the soil can be readily excavated using conventional plant appropriate for the access constraints imposed by the residential location of the property. The presence of Claystones is not anticipated to cause a significant obstacle to conventional plant as Claystones tend to occur as isolated

cobbles / boulders in the clay. It is presumed that the excavation for the basement will only be undertaken when the perimeter retaining wall construction is complete.

#### *7.2.6 Stability of Temporary Excavations*

It is understood that the basement retaining walls will be a contiguous piled wall. Therefore excavation for the basement will be protected from instability by the piled wall. Excavation of the basement area will need to comply with appropriate health and safety criteria in terms of height and width of excavation face.

#### *7.2.7 Groundwater Control*

The boreholes records have indicated the presence possible perched groundwater to a depth of 0.49 m bgl. However if groundwater is recorded during the construction works it anticipated that any inflow will be very modest, on the basis of the ground conditions encountered. The groundwater would be controlled by pumping to a tank prior to disposal by tanker to an approved facility. Alternatively discharge of the groundwater could be made to the sewer subject to an agreement from the local water company in terms of water quality, flow rate and quantity.

### 7.3 Monitoring of groundwater and ground movements

Groundwater levels should be continued to be monitored before, during and after construction. Monitoring of adjacent structures and the highway should be carried out before, during and after construction.

# References


Camden Development Policy DP27 – Basement development.

Camden Planning Guidance – Basements and Lightwells CPG4 September 2013

Camden geological, hydrogeological and hydrological study – Guidance for subterranean development. Arup November 2010

BS 1377:1990. *British Standard Methods of test for soils for Civil engineering purposes*. British Standards Institution.

BS 5930:1999. *Code of practice for Site Investigation.* British Standards Institution (amended in 2010 to comply with requirements of BS ENO 14688 Parts 1 and 2).

BS EN 1997-1 Eurocode 7 Geotech Design Part1 General Rules- inc. corrigendum Feb 2009

BS EN 1997-2 Eurocode 7 Geotechnical Design Part 2 Ground Investigation and Testing – inc. corrigendum 2010

BRE Special Digest 1. *Concrete in aggressive ground.* Building Research Establishment. August 2005.

BS 8002: 1994 Earth Retaining Structures

Building Regulations 2010 HM Government.

NHBC Chapter 4.2 Building near Trees 2011.

CIRIA C580 2003 Embedded retaining walls – guidance for economic design.