22 Thurlow Road

Basement Impact Assessment

REP-GEO 001

Rev. 1 | 10 July 2014

Job number 234937

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Contents

Appendix I

Envirocheck data (extract from ARH Associates Ltd Desk Study, July 2011)

Executive Summary

This report presents the findings of a Basement Impact Assessment carried out for a proposed extension to the existing basement/lower ground floor at 22 Thurlow Rd, London NW3 5PP.

This executive summary is an overview of the key findings of the report and forms the non-technical summary of the BIA required under Camden guidance CPG4. The full body of the report should also be consulted for further detail and to give appropriate context.

This report was commissioned by Mr Csaba Barta and is intended to accompany a Planning Application by Barnaby Gunning Architects and is to be read in conjunction with their architectural drawings.

The report relies on the factual data given in the Ground Investigation report prepared by GEA in 2011 provided for a previous application. The data was gathered by others and Arup have not been party to it. The recommendations made in this report will therefore need to be validated through a further GI, and this report is written on the basis of that expectation.

The report follows the approach laid out in Camden Planning Guidance Basements and Lightwells' CPG4 (April 2011, [8]) in assessment of the impact of the basement development.

This report includes assessment of the following:

- Surface flow and flooding;
- Groundwater flow; and
- Ground stability and ground movements.

These are assessed in accordance with the Camden Planning Guidance for relevance to the proposed development and potential impacts that the development may cause.

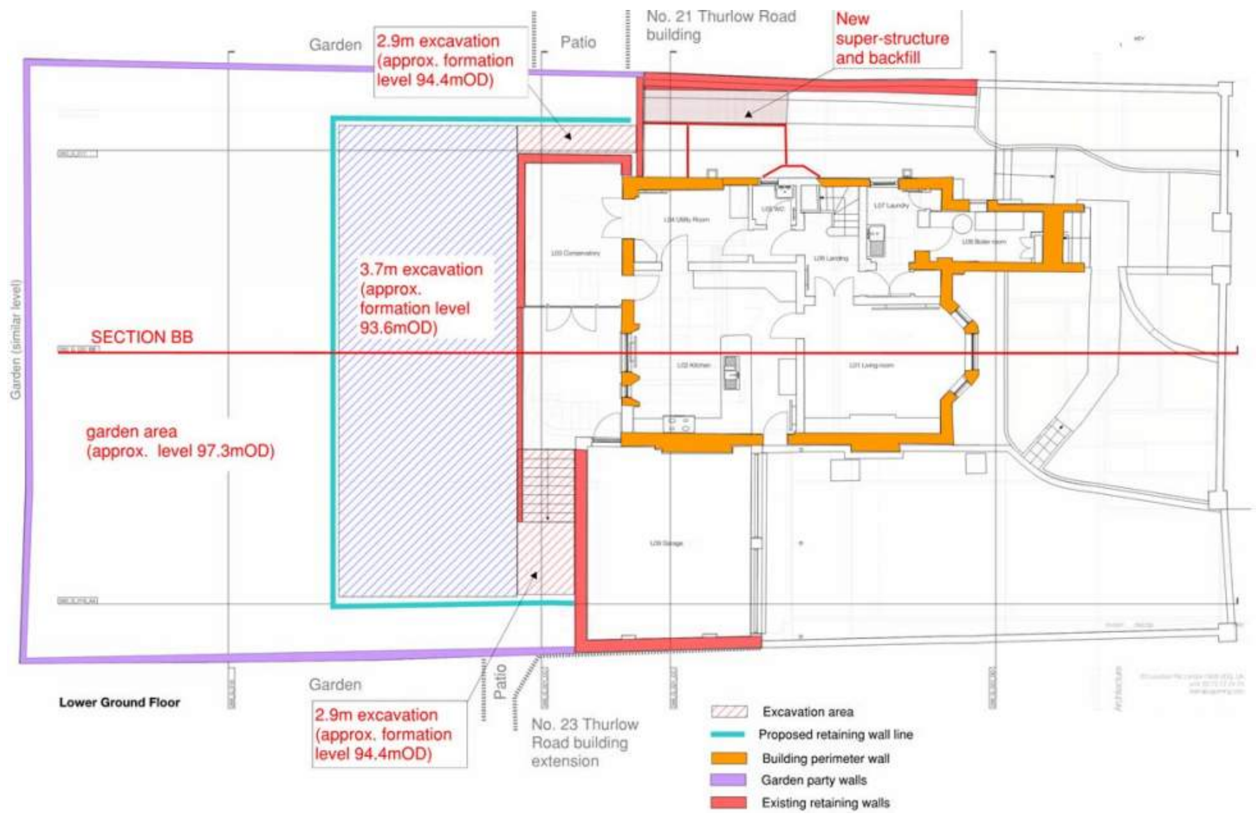
Project Description

22 Thurlow Road is a 4 storey detached Victorian property constructed circa1896. The proposed works involve:

- the extension of the existing basement/lower ground floor under part of the rear garden at a similar level to the existing construction. The basement extension requires a maximum dig of up to 3.7m within the raised garden area of the current house.
- the demolition and re-construction of existing garage building to the east to allow for an additional level of accommodation above.
- the reconstruction of the internal floors of the building to provide greater internal flexibility and to improve the thermal performance of the spaces
- A small side extension

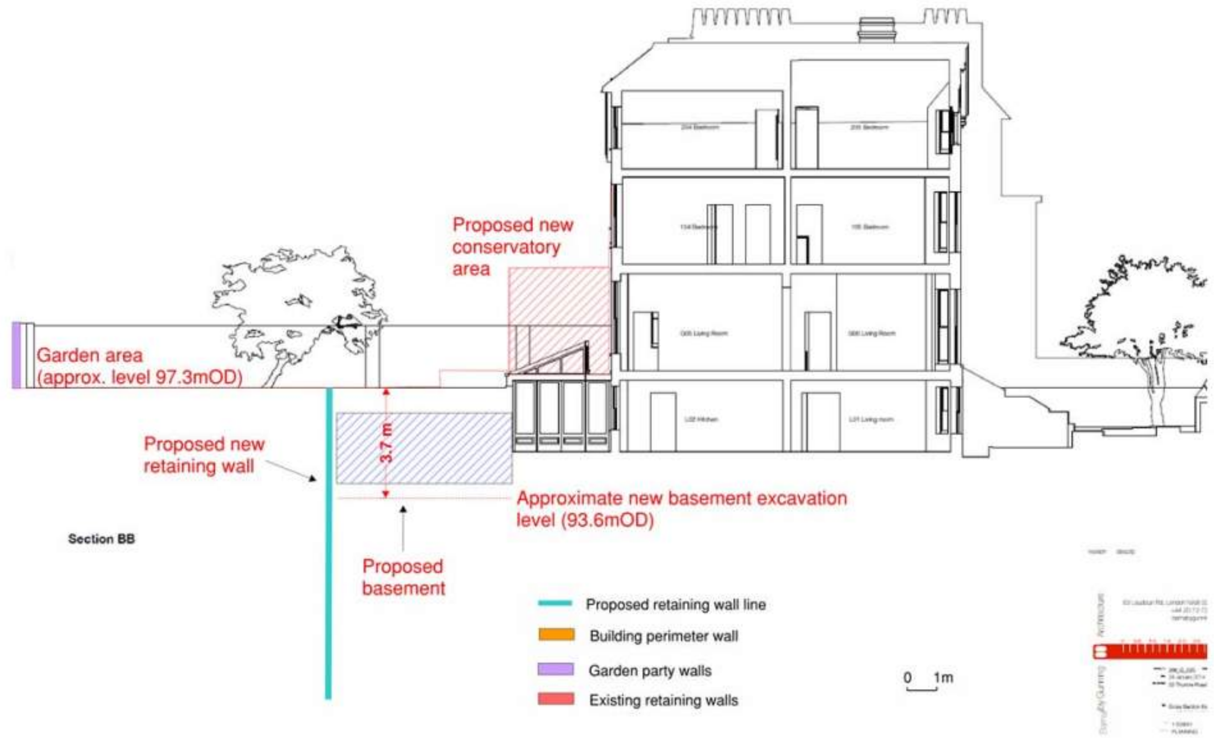
The excavation for the proposed basement extension is illustrated in the following figures:

Existing layout



Proposed layout

Existing section



Proposed section

Neighbouring Properties

As seen in the above figures, No 21 Thurlow Rd and No 23 Thurlow Rd are located either side of No. 22 Thurlow Rd. The rear faces of these properties are close to the corners of the proposed basement extension, where ground movements due to excavation will be much smaller than at mid-span along the basement.

Garden walls run adjacent to the sides of the new basement.

Basement Construction Methodology

The proposed basement retaining system has been developed to limit ground movements during basement excavation and to ensure that potential damage to adjacent structures remains within Category 1, “Very Slight”.

The proposal is to construct a contiguous piled wall around the perimeter of the proposed basement from garden level. Initial analyses indicate that piles of 350mm or 450mm diameter at 500mm or 600mm spacing respectively and length 10.5m below the garden level would be appropriate, with the wall propped in the temporary condition during excavation of the basement. Construction of the basement structure would then proceed bottom-up within the piled walls.

BIA Stages 1 and 2 - Screening and Scoping

A screening exercise was carried out in accordance with the recommendations of CPG4 in respect of groundwater flow; land stability and surface flow/flooding. Reference was made to the Camden Geological Hydrogeological and Hydrological Study and other data sources.

The screening exercise is carried out to identify those issues which need to be taken forward in the BIA. Those issues for which the screening is negative are not considered further in the process.

Scoping identifies the potential impacts and considers how these will be addressed.

Groundwater flow

Groundwater Flow screening chart - Figure 1 in CPG4

No.	Screening Question	Impact
1a.	Is the site located directly above an aquifer?	Yes
1b.	Will the proposed basement extend beneath the water table surface?	No, but the contiguous piled wall would extend below the water table
2.	Is the site within 100m of a watercourse, well (open/disused) or potential spring line?	No
3	Is the site within the catchment of the pond chains on Hampstead Heath?	No
4	Will the proposed basement development result in a change in the proportion of hard-surfaced/paved areas?	Not significantly
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 soak-away and/or SUDS)?	No
6	Is the lowest point of the 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

In respect of groundwater flow, the potential impacts, which need to be assessed were found to be:

- Whether the basement works will impact on the groundwater level locally and whether this will impact neighbouring properties, structures and services.

Surface flow and flooding

Surface Flow and flooding screening chart - Figure 3 in CPG4.

No.	Screening Question	Impact
1.	Is the site within the catchment of the pond chains on Hampstead Heath?	No
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?	Possible
3	Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?	Yes
4	Will the proposed basement result in changes to the profile of the inflows (instantaneous & long-term) of surface water being received by adjacent properties or downstream water-courses?	No
5	Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream water courses?	No
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 King's Cross, or is it at risk from flooding, for example because the proposed basement is below the static water level of a nearby surface water feature?	No

With regard to surface flow and flooding, the potential impacts which need to be considered were:

- Whether the increase in impermeable area will impact on the rate of surface water received by the combined sewer.

Ground stability screening

Ground stability screening chart - figure 2 in CPG4.

No.	Screening Question	Impact
1.	Does the existing site include slopes, natural or manmade, greater than 7^o? (approximately 1 in 8)	No
2.	Will the proposed re-profiling of landscaping at site change slopes at the property boundary to more than 7^o? (approximately 1 in 8)	No
3.	Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7^o? (approximately 1 in 8)	No
4.	Is the site within a wider hillside setting in which the general slope is greater than 7^o? (approximately 1 in 8)	No
5.	Is the London Clay the shallowest strata at the site?	No
6.	Will any tree/s 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? (Note that consent is required from LB Camden to undertake work to any tree/s protected by a Tree Protection Order or to tree/s in a Conservation Area if the tree is over certain dimensions).	Yes
7.	Is there a history of seasonal shrink-swell subsidence in the local area (Claygate Beds), and/or evidence of such effects at the site?	No
8.	Is the site within 100m of a watercourse or a potential spring line?	No
9.	Is the site within an area of previously worked ground?	No
10.	Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?	Yes
11.	Is the site within 50m of the Hampstead Heath ponds?	No
12.	Is the site within 5m of a highway or pedestrian right of way?	No
13.	Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Yes
14.	Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	Yes

In considering ground stability, the potential impacts which were found to need assessment were:

- The potential for damage to neighbouring properties due to the differential depth of foundations.
- Whether the basement works will impact on the tunnel below Thurlow Road. A Network railway runs east-west in a tunnel below the property.
- Whether the basement works will impact on the aquifer and affect the groundwater flow regime.
- The potential for damage to trees and their roots.

Based on the earlier arboriculture report prepared for a previous planning application the basement will affect two trees to the rear garden and it is proposed to remove these and plant replacement trees -although not necessarily on the same type). The report also provided guidance on the protection of remaining trees which will be followed in the current proposal.

Basement Impact Assessment

Groundwater Flow

The use of free draining soft landscaping over the basement box has been adopted to minimise the impact on the surface water flows.

As identified in the initial screening and scoping stages the only potential impact, which will need to be considered is whether the basement works will impact on the groundwater level locally and whether this will impact neighbouring properties structures and services. This is because the site is located on a secondary aquifer and secant piled walls extend below the water table and so will provide a constraint to groundwater flow

The additional site investigation and data review has enabled an assessment of nature and extent of likely impacts.

The Claygate Beds underlying the site are able to transmit small quantities of groundwater. Recharge would be by leakage and vertical infiltration across the aquifer outcrop area. Ground water gradients will follow the local topography and flows will generally be from north to south across the site.

Groundwater levels have been measured on a number of occasions between 2011 and 2014 which spans both wet and dry periods allowing a good understanding of typical fluctuations. Groundwater is encountered at approximately 9m below ground (+88.3mOD) and fluctuates by about 1.0m over time. The maximum recorded groundwater level was found at 7.9mbgl, i.e. at +89.4mOD in June 2014.

The proposed basement has a final formation elevation of approximately 93.6mOD well above the zone of water table fluctuation and will therefore not create any impacts.

A piled wall will be constructed around the perimeter of the proposed basement from garden level. Initial analyses indicate that piles of 350mm diameter at 500 spacing and length 10.5m below the garden level would be appropriate. As there will be some limited penetration of the piles below the water table, there is a possibility that the pile wall may act as a barrier to flow. However it should be noted that the pile wall will not be continuous but will contain regularly spaced gaps which will allow groundwater to flow through it. In addition the wall has a limited depth of penetration and frontage. The potential impact of the pile wall on local groundwater levels or flows will be minimal – certainly well within the range of natural (annual) fluctuation.

Surface Water flow assessment

As identified in the initial screening and scoping stages the existing surface water drainage system will modified as part of the proposal. There will be a small change in the area of hard surfacing and as a result total surface water flows may increase. An assessment was made of whether this increase in impermeable area will impact on the rate of surface water received by the combined sewer.

Review of the proposals shows that the surface permeability will be affected with a slight increase in the footprint of the building and a small decrease in the amount of paved surface in relation to the total site – the total change will be a decrease in hard standing of 1.6%.

Overall it is concluded that the surface water flows will not materially change in response to the small reduction in hard standing. On completion of the development the surface water flows will be routed in a similar way to the existing condition, with rainwater run-off collected in a surface water drainage system and discharged to a combined sewer.

It will not be necessary to consider additional mitigation measures such as SUDS or soft landscaping over to reduce the rate of any surface water run-off.

Ground stability and ground movement assessment

Ground movement assessments have been carried out to understand potential ground movements around the basement excavation.

Ground movements will occur due to the following:

- installation of the contiguous piled retaining wall,
- retaining wall movements as the basement is excavated in front
- potential heave of the ground within the excavation due to unloading may affect the existing basement at No. 22 Thurlow Rd
- a small increase in loading on the ground due to the increased height of garage

Maximum ground movements are predicted to occur behind the middle of the sides of the basement and are a maximum of 11mm vertical movement and 8mm horizontal movement.

The impact on the house and adjacent properties and walls has been assessed. In all cases potential damage falls within Category 1, “Very Slight”, fine cracks less than 1mm.

Movement of the Network Rail tunnel below the site is predicted to be negligible (less than 1mm) provided that the tunnel is at the depth assumed (about 35m below ground level). NR will be contacted to confirm the details of the tunnel.

1 Introduction

Ove Arup and Partners have been appointed to provide structural engineering services for the proposed extensions and modification to the existing house at 22 Thurlow Road, London NW3 5PP including carrying out a Structural Basement Impact Assessment (BIA) to support the Planning Application.

The existing property is a detached house of traditional construction, dating from the 1890s with an attached garage building, of recent construction. The house comprises living areas and the garage at lower ground floor, reception rooms to the ground floor and bedroom accommodation at the first and second floor levels. The external walls are constructed from solid masonry and the internal walls are a combination of solid and load bearing timber stud walls. Upper floors and the roof are of timber construction. The site slopes up from north to south so that the garden is approximately 2.5m higher than the street level.

The proposed works involve the extension of the existing lower ground floor under part of the rear garden, so forming a new basement area. As part of the works the existing garage will be demolished and replaced with a new garage building, incorporating new accommodation above the garage which will require new foundations.

The new structure in the garage area and the existing lower ground floor will remain at the existing levels. The proposed extension to the rear extends 6m out into the garden and has a Finished Floor Level only 700mm deeper than the existing ground floor levels

There will be a small area of side extension and some external stairs to the west side of the building which will cut into the existing sloped walkway.

The existing property is in the Fitzjohns Netherhall Conservation Area.

The existing property is not understood to be listed.

The majority of properties along Thurlow Road are semi-detached houses and appear to be of similar age and construction. Many of the nearby properties also have lower ground floors, but with reference to Figure 25 of the Camden Geological, Hydrogeological and Hydrological Study and of Camden Planning Applications, it is not thought that the adjoining properties have applied for new or extended basements since June 2005.

A tree survey was carried out as part of the preparation for the proposals of the 2011 planning submission and as with that submission it is intended that two trees at the rear of the property will be removed.

A series of preliminary structural drawings have been prepared to show the proposed layouts and elevations. These are included in Appendix A. The architects drawings, prepared by Barnaby Gunning Architects (BGA), are included separately in the planning application.

This document provides a summary of the proposed basement structure and includes an Outline Method Statement for the construction of the Works, which will be developed in detail by the appointed Contractor.

The main objective of the BIA is to assess the potential impact of the development and basement construction on the local surface water and groundwater environment and of possible impacts on structural stability of the building and its neighbours. The BIA is a process of assessing a combination of surface and groundwater conditions, with geotechnical analysis, into a comprehensive review.

As recommended by the Guidance for Subterranean Development (ref [8]) the BIA methodology comprises the following steps:

1. Initial **Screening** to identify whether there are matters of concern;
2. **Scoping** to further define the matters of concern identified in the screening stage and devise an approach to evaluate the potential impacts;
3. **Site investigation and study** to establish baseline conditions;
4. **Assessment** of the information to determine the impact of the proposed basement on baseline conditions.

The information contained within this BIA has been produced to meet the requirements of a BIA as set out by Camden Planning Guidance – Basements and Lightwells (CPG4) including Camden Development Policies DP27 – Basements and Lightwells (ref. [8]) in order to assist LBC with their decision making process.

Arup were not commissioned to undertake or supervise the ground investigations at the site. All the factual ground investigation information has been collected by others and it is assumed to be sufficiently reliable, representative and suitable for the purpose of this assessment. The recommendations made in this report will need to be validated through a further GI, and this report is written on the basis of that expectation.

2 Site context

2.1 Location

The site is located at 22 Thurlow Rd London NW3 5PP in the London Borough of Camden.

The location is south west of the bottom end of Hampstead Heath, about 500m south of Hampstead tube station (see Figure 1).

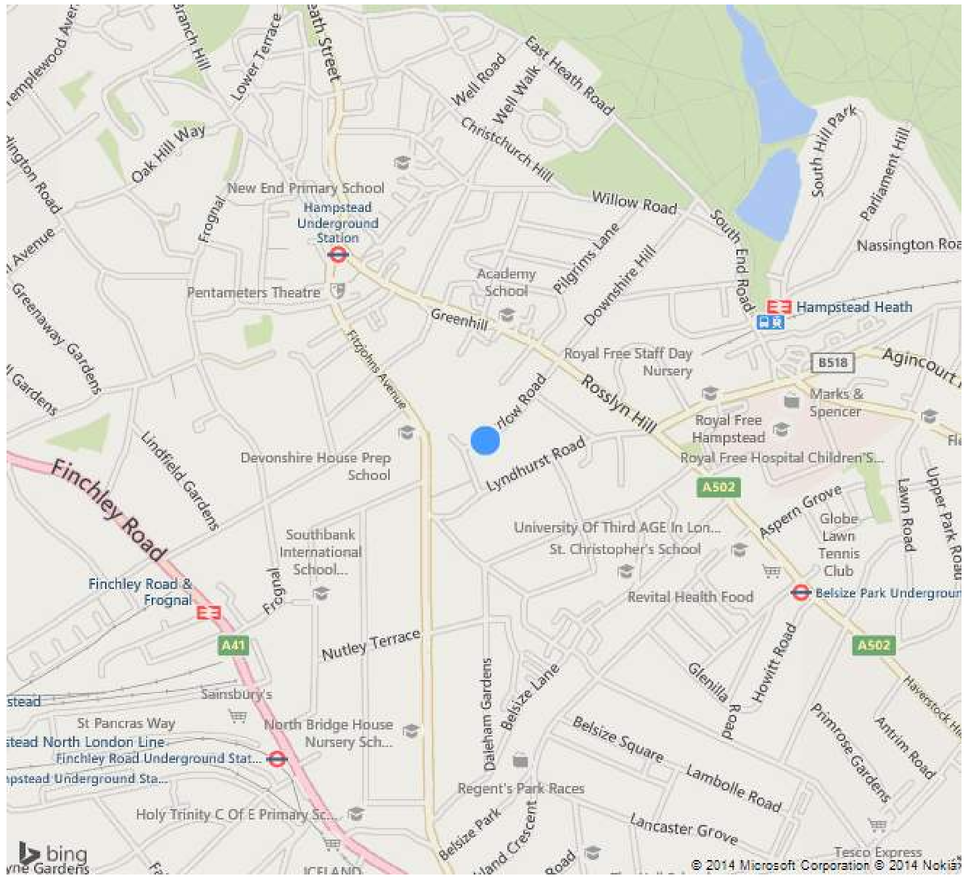


Figure 1 Site location

2.2 Site history

The site history has been researched by reference to historical Ordnance Survey (OS) maps sourced from the Envirocheck database (Appendix I).

At the time of the earliest Ordnance Survey (OS) map, dated 1879, Thurlow Road had already been constructed, although the site itself was undeveloped. By the time of the next map, dated 1896, a rectangular building had been constructed on site and the majority of Thurlow Road had been developed. Further study of subsequent maps would suggest that the building shown in 1896 is the existing house. On the map dated 1954, a railway tunnel is shown running west to east below the site, which information available online suggests was constructed by 1879 and had first been used by the then London and Birmingham Railway. A small outbuilding, presumably a garage, is shown to the east of the house on the 1954 map; this building was demolished some time between 1974 and 1979 and the site has remained unaltered until construction of the existing double garage within the last ten years.

2.3 Topography

Information from available OS maps and site-specific level survey (see Appendix A) gives the information on ground levels in the general area of 22 Thurlow Rd as shown in Figure 2.

Figure 2 Levels at and around the site

The general area around the Site slopes in South-East direction with approximate slope of 1/16 to 1/30 based on the available OS Maps and Figure 10 of the Camden Geological, Hydrogeological and Hydrological Study, Arup 2010 (ref. [3]). A series of terraces along the slope are present due to private gardens and public streets. Approximate Ordnance Datum elevation of the Site is 95.1mOD at the north end of the site (at the front of the house) and +97.3mOD at the south end of the site (the garden of the house).

Based on the site survey information (Appendix A), topography from OS maps and information available on the Camden Planning Portal for the house to the south on Lyndhurst Rd, an approximate cross-section showing the variation of ground level going north to south across the site between Thurlow Rd and Lyndhurst Rd is shown in Figure 3. This shows the garden area of 22 Thurlow Rd to be raised up by about 2.3m above the level of Thurlow Rd to the north and about 5.3m above the level of Lyndhurst Rd to the south.

Figure 3 Approximate cross section of ground elevation going north to south though the site.

2.4 Existing site structures

The existing property is a detached house of traditional construction, dating from the 1890s with an attached garage building, of recent construction. The house comprises living areas and the garage at lower ground floor, reception rooms to the ground floor and bedroom accommodation at the first and second floor levels. The external walls are constructed from solid masonry and the internal walls are a combination of solid and load bearing timber stud walls. Upper floors and the roof are of timber construction. The site slopes up from north to south so that the garden is approximately 2.5m higher than the street level.

2.5 Geology

The Site is located in North London, just to the South of Hampstead Heath. The Geological Map (England and Wales Sheet 256, North London, 1:50,000 series, published by BGS in 2006) shows the Site to be underlain by:

- *Claygate Beds*. The Claygate Beds are classed as a member of the London Clay formation and are described as silt and fine-grained sand and has an average thickness of about 16m in the London area. Since the Site appears to be close to half way in plan between the upper junction with the Bagshot Beds and its lower junction with the underlying London Clay, it is expected that not more than about 7.5 to 10m of Claygate Beds lies beneath the site.
- *London Clay*. Main stratum of the London Clay formation, this is described as clay, silty in part. At the Site location its thickness is likely to be between 70 and 100m. In the close vicinity of the Site (at about 100m), the London Clay is mapped to be covered by Quaternary head deposits.

Deeper strata are not of interest for the present study.

2.5.1 Previous ground investigations

The present study is based on the review of the following documentation and information:

1. *Desk study and Ground Investigation Report produced by GEA (July 2011, ref. [1])*. It presents the results of a ground site-specific investigation carried out in February 2011 to support the proposed development at that time.
2. *Supplementary Ground Investigation Report produced by GEA (October 2011, ref. [2])*. It presents the results of an additional ground site-specific investigation carried out in September 2011.
3. *Further Groundwater monitoring*. On the 12th of June 2014 Arup carried out the monitoring of the groundwater level in the available standpipes on site (BH1, BH7, BH8, BH9).
4. *Existing records of historical BGS boreholes* (online data available at www.bgs.ac.uk). Records of no.5 boreholes located at about 250m from the site are available.

2.6 Hydrology

2.6.1 Rainfall and runoff

Rainfall in the area averages about 610 mm (ref. [10]) significantly less than the national annual average of about 900 mm. Rainfall in London is split almost equally over the seasons, with the winter months experiencing only marginally higher rainfall than summer months. However, the rainfall in summer months will often occur in a smaller number of intense rainfall events leading to peaks which can lead to flash flooding and overloading of sewer systems. Climate change predictions indicate that future winters may be wetter and summers drier, but that rainfall patterns may become more intense and the summer storms will become more frequent. Over time the standard of protection of existing sewers is likely to reduce leading to an increase in localised flooding incidents.

Evapotranspiration is typically about 450 mm/yr resulting in about 160 mm per year as “hydrologically effective” rainfall which is available to infiltrate into the ground or runoff as surface water flow.

The site lies at the top of the catchment of the River Tyburn, which rises at the Shepard’s Well near Fitzjohns Street just to the south of Thurlow Road to flow southwards underground through Primrose Hill and Regents Park to discharge into the River Thames at Whitehall.

The area around the site, in central London, is highly developed with more than 80% of the surface covered with hard standing. Most of the rainfall in the area will runoff hard surface areas and be collected by the local sewer network.

2.6.2 Drainage

Surface drainage from the site is assumed to be directed to drains flowing downhill east to west along Thurlow Rd. This needs to be confirmed in detailed design.

2.6.3 Flood risk

Although Camden missed the serious national floods of 2007 & 2012 it is known that Camden is at risk of flooding because of the significant floods in 1975 and 2002 (ref. [7]).

The lead local flood authority (LLFA) and local planning authority is the London Borough of Camden (LBC). The recommendations from the LBC Preliminary Flood Risk Assessment (PFRA) have been reviewed in undertaking this assessment. The LBC Local Flood risk Management Strategy (LFRMS) was approved in June 2013 (ref. [9]). LBC has also produced a strategic flood risk assessment (SFRA) in conjunction with a number of surrounding local planning authorities (ref. [11]).

Review of these documents show that potential flooding risks in LBC are primarily from surface water flooding, when the intensity of rainfall can overwhelm sewers and drainage systems. There is also a small risk of groundwater flooding, which occurs when the water table rises to ground level. The impact of the basement on each of these types of flooding is considered in the surface flow and flooding scoping section of the BIA.

2.6.3.1 River or tidal flooding

Because the site is elevated well above the flood plain of the River Thames at about 28.0mOD, it is shown as being outside Flood Zone as defined on the Environment Agency Flood Zone maps (ref. [5]).

2.6.3.2 Surface water flooding

Surface water runoff from the area is assumed to drain to drains flowing downhill east to west along Thurlow Rd. The site is not located near any of the areas with the potential to be at risk of surface flooding or on any road that were flooded in 1975 or 2002 as shown in Figure 5.1 of the LFRMS ([9]). The risks of surface water flooding at the site are therefore considered low.

2.6.3.3 Sewer flooding

Most of Camden is served by combined sewers which receive foul water, water from roofs, hard standing and sometimes highways. Thames Water holds details of incidents of sewer flooding for individual properties in a Sewer Flood database. This database has not been interrogated as part of this assessment but it is understood that very few properties have experienced flooding from sewers in the N1 post code area.

The London Regional Flood Risk Appraisal (2009) advises that foul sewer flooding is most likely to occur where properties are connected to the sewer system at a level below the hydraulic level of the sewage flow, which in general are often basement flats or premises in low lying areas. There is no record of sewer flooding having occurred at 22 Thurlow Rd. The proposed basement extension is only about 0.8m deeper than the existing lower ground floor and therefore the risk of sewer flooding is considered low.

2.6.3.4 Groundwater flooding

As described in 3.3, the garden area of 22 Thurlow Rd is raised up by about 2.3m above the level of Thurlow Rd to the north and about 5.3m above the level of Lyndhurst Rd to the south, so that there could be no significant groundwater flow over much of the depth of the basement. In addition, the groundwater table has been found at about 8m below the garden level. Therefore the risk of groundwater flooding due to the proposed development is considered negligible.

2.7 Hydrogeology

Typically in central London, there is a ‘shallow’ aquifer usually consisting of varied deposits ofl River Terrace Deposits, River Alluvium or recent Made Ground and a ‘deeper’ aquifer contained within the Thanet Sand and Upper Chalk Formations. The two aquifers are separated by the impermeable London Clay which acts as an aquiclude and which is classed as a non-aquifer by the Environment Agency.

Referring to the deep aquifer, information obtained from the Environment Agency in 2010 suggests that the piezometric level is at approximately -32mOD. Investigations and foundations for the proposed structure are not expected to penetrate through the London Clay aquiclude into the deep aquifer at this location. Because deeper Chalk aquifer is fully confined in this area and isolated from activities near surface the influence of and risks of this proposal are not considered further as part of this impact assessment.

The desk study and previous investigations in the vicinity of the site have indicated that a thin layer of Soil and Made Ground (0.1-0.75m) directly overlies the silty sandy clay Claygate Beds which range up to 8.0m in thickness. The Claygate Beds are permeable, are capable of storing and transmitting groundwater and are considered to be an aquifer. The uppermost soils and made ground appear to be dry

Groundwater levels within the Claygate Beds and across the site have been monitored during several site investigations and are summarized in Section 8.7 below. Generally groundwater is only encountered at a depth of 8.0 to 9.0m below ground level.

3 The proposed development

3.1 Description

The proposed works involve the extension of the existing lower ground floor under part of the rear garden, so forming a new basement area. As part of the works the existing garage will be demolished and replaced with a new garage building, incorporating new accommodation above the garage which will require new foundations.

The new structure in the garage area and the existing lower ground floor will remain at the existing levels. The proposed extension to the rear extends 6m out into the garden and has a FFL only 800mm deeper than the existing ground floor levels.

There will be a small area of side extension and some external stairs to the west side of the building which will cut into the existing sloped walkway.

The details of the existing building and proposals for the basement and upper floors are shown on Barnaby Gunning Architect's (BGA) drawings, included separately in this planning application. Outline structural drawings have been prepared in response by Arup, which are included in Appendix B. These will be subject to further review and development during the detailed design process.

Plans of the existing layout and the proposed main ground works are given in Figure 4 and in Figure 5. Indicative sections representing existing structures and proposed main ground works are shown in Figure 6 and Figure 7.

The original masonry 1890s facades will generally remain unchanged. It is intended that the internal floors are replaced with a long span timber and steel structure to provide a more open plan arrangement. The scheme for the internal works will be developed through detailed design and presented to Building Control. The loads on the existing external walls will be balanced against the existing loads (keeping potential load increase on existing foundations to within about 10% of existing load) to ensure that the foundations do not require strengthening. The existing garage building will be demolished and reconstructed.

Generally the new basement is not significantly deeper than the existing basement /lower ground floor and we do not envisage that the new structure will undermine the existing foundations and so underpinning of the existing foundations is not envisaged. This will need to be further confirmed on site with preliminary trial digs/pits to confirm all founding levels. Underpinning if required will be relatively shallow.

The proposal is to construct a contiguous piled wall around the perimeter of the proposed basement from garden level. Initial analyses indicate that piles of 350mm or 450mm diameter at 500mm or 600mm spacing respectively and length 10.5m below the garden level would be appropriate, with the wall propped in the temporary condition during excavation of the basement. Construction of the basement structure would then proceed bottom-up within the piled walls.

Figure 4 Existing layout

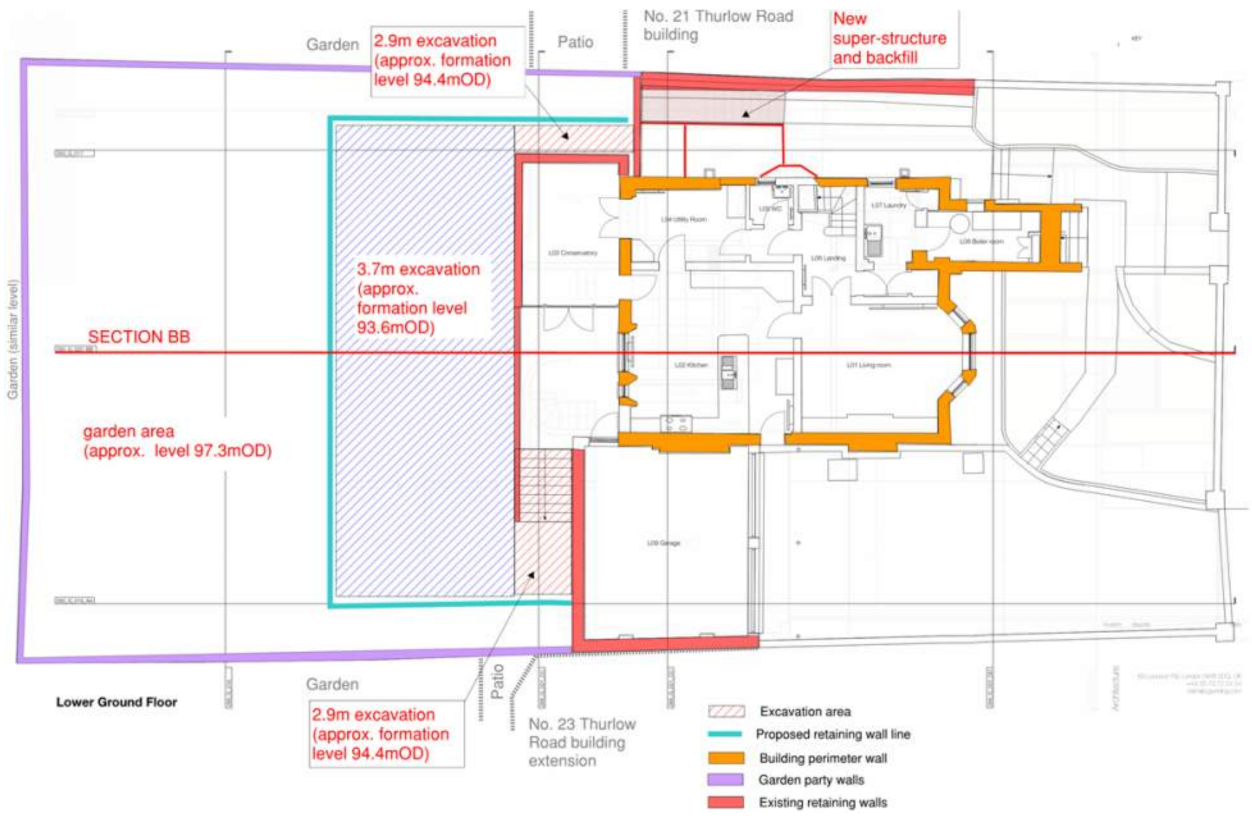


Figure 5 Proposed layout

Figure 6 Existing section

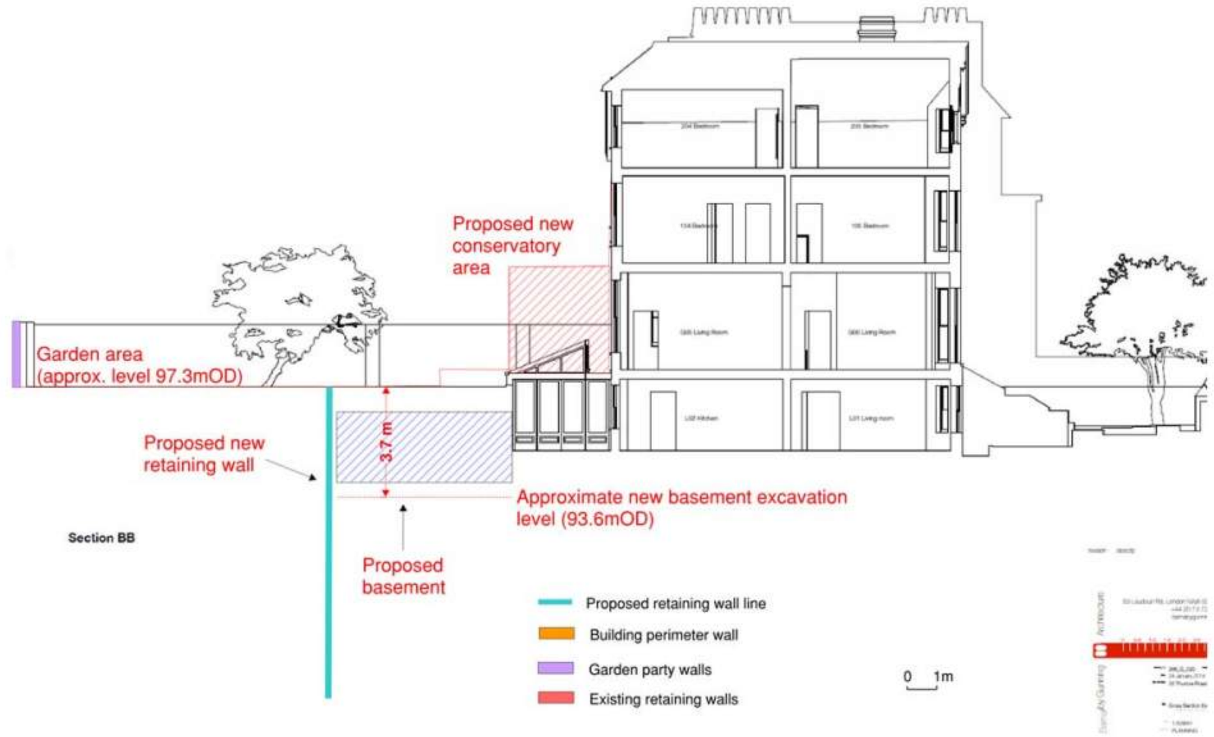


Figure 7 Proposed section

The basement slab may be designed for the potential effects of heave due to unloading of the ground, involving the potential use of tension piles and tension resistance from the embedded piled retaining wall. Alternatively use of a heave void with heave board is also being considered. This will be developed during detailed design and is not considered further in this report.

Additional foundations such as piles or pads may be required beneath the load bearing walls within the basement. Requirements for any internal foundations will be considered during detailed design and are not considered further here.

The design and construction of the building structure shall be in accordance with current Building Regulations, British Standards, Codes of Practice, Health and Safety requirements and good building practice.

The basement will be designed to Grade 3 in accordance with BS8102 2009. It is likely that an admixture will be used in the concrete, to improve the water resistance of the reinforced concrete basement box, with an internal drained cavity system for the floors and walls.

3.2 Construction methodology

The construction methodology will be developed and finalised at later stages of design by the Main Contractor and any other temporary consultants. A preliminary construction sequence is here described according to the present level of design (refer to Appendix H for the relevant illustrations):

- **Prior to works**. A condition survey of the adjoining properties and boundary features shall be undertaken. Monitoring targets will be installed and base-line surveys will be carried out.
- **Stage 1**. The existing garage will be demolished to ground slab level and a temporary ramp will be installed to allow free access to the site. The existing wall towards no.23 Thurlow Road will be retained and supported if required. If rubble/backfill material will be used for the ramp, care shall be used to not apply new load on the building wall or to the retained garage wall. Temporary platforms will be installed in the conservatory and patio area to allow piling rig operations (full backfill should be avoided unless measures will be applied to prevent loading the building walls)
- **Stage 2**. Guide walls will be installed at the two sides of the wall line. Piling rig (i.e. Klemm 708 or similar) will access the site and install the piles to the required depth. Any bearing/tension piles to internal walls and slab will be installed if required at later stages of design.
- **Stage 3.** A capping beam will be installed along the whole wall line to connect the piles. A first level of excavation of 1.0m will be undertaken and temporary props will be installed. The existing retaining walls (if assessed to be suitable for such scope) could be used to improve the system. Temporary props layout sketched in the Appendix is indicative only and will be revised by the Main Contractor.
- **Stage 4.** Full excavation (about 3.7m below garden level and 2.9m adjacent to the garage) will be undertaken and blinding will be immediately put in place to prevent eventual water ingress. A battered slope will be adopted between existing conservatory level and new formation level. Temporary platforms for piling rig operations will be removed.

- **Stage 5**. Demolish existing conservatory walls and slab and cast new base slab in the whole excavation area. Any new pad/strip foundations to support the internal walls will be installed if required at later stages of design.
- **Stage 6**. Perimeter RC lining and internal walls will be constructed and the top slab will be then casted. The garage superstructure will be completed. On the West side the existing retaining wall will be partially demolished to allow the construction of the utility room RC box. The space between this room and the existing boundary wall will be backfilled to allow the construction of the external steps.
- **Stage 7**. Once the concrete of the top slab has reached target strength, temporary props shall be removed.
- **Stage 8.** Top soil will be put over the top slab and the garden area will be restored. External elements of the superstructure above garden level shall be finally constructed.

4 Subterranean (groundwater) flow

4.1 Stage 1: Initial screening

The first stage in assessing the impact of any proposed basement development is to recognise what issues are relevant to the proposed site and to identify the matters of concern which should be investigated further. This is done by using the screening flowchart and guidance found in Appendix E of the Arup guidance for Subterranean Development [3] and in the Camden Planning Guidance – Basements and Lightwells (CPG4) including Camden Development Policies DP27 – Basements and Lightwells [8]. The impact of the proposed development on groundwater flows and levels is considered here.

4.1.1 Subterranean (groundwater) flow screening flowchart

The references are to the screening chart in Figure 1 in CPG4.

(Q1a) Is the site above a secondary aquifer

With reference to the Camden Geological, Hydrogeological and Hydrological Study (see Figure 8) the site is above a Secondary "A" Aquifer as designated as by the Environment Agency. A Secondary "A" aquifer consists of 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 and streams. These are generally aquifers that were formerly classified as minor aquifers.

Figure 8 Aquifer designation

(Q1b): Will the proposed basement extend beneath the water table surface

As part of the GEA ground investigations, the level of water strikes were recorded where they were encountered in window sampler boreholes and in the cable percussion boreholes. Groundwater was encountered as seepages in the cable percussion boreholes at depths of between 8m and 12.4m. Four standpipes were installed, one to a depth of 6m and three to depths of 11m. Repeat monitoring visits were made to check stabilised levels in August and September 2011. Groundwater was encountered at approximately 9m below ground in the standpipes in the 2011 monitoring, i.e. at about +88.3mOD.

Arup measured the groundwater level in the 4 existing standpipes in June 2014. Groundwater levels in all standpipes had increased since 2011 by up to 1.2m. The maximum groundwater level was found at 7.9mbgl, i.e. at +89.4mOD.

The proposed basement retaining system includes contiguous piled walls with a toe level at +86.8mOD. Preliminary analysis indicates a wall consisting of 350mm diameter piles at 500mm spacing is most likely to be a solution. The piles may extend a maximum of 3.0m below the water table and therefore there may be some impedance to groundwater flow.

(Q2) Is the site within 100m of a watercourse, well (used/disused) or a potential spring line.

With reference to the Camden Geological, Hydrogeological and Hydrological Study, (refer Figure 9), the closest subsurface water courses, run along the approximate line of Fitzjohn's Avenue, to the south west; this is greater than 100metres from site.

The nearest recorded spring location is the former "Shepherd's well" which Stanfords 1868 map records as having been located to due south of Spring path, possibly on the south side of Lyndhurst Road (see Figure 10). The course of this portion of Lyndhurst road may have changed however the distance to the site is between 125m and 130m

The nearest surface water is the Hampstead Heath ponds, which are located approximately 850metres from the site. The local geology suggests that spring lines are present at the interface of the Bagshot Beds and the Claygate Member, but the site is remote from the stratigraphic boundary. From the British Geological Society 'Geoindex' the nearest water well is adjacent to Hampstead High Street, north of Thurlow Road approximately 300metres from the site.

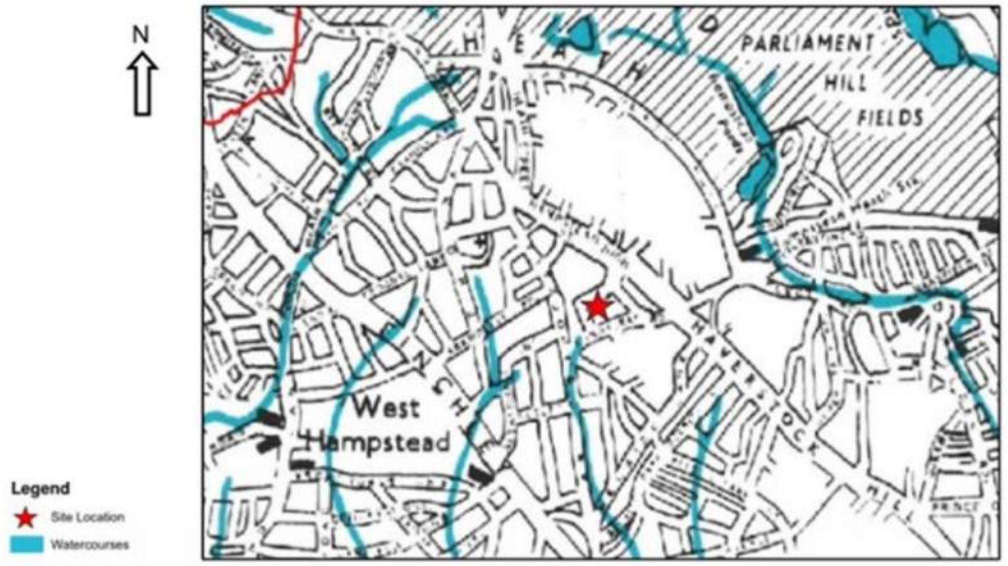


Figure 9 Watercourses (Extract from Fig 11 of Camden Geological, Hydrogeological and Hydrological Study)

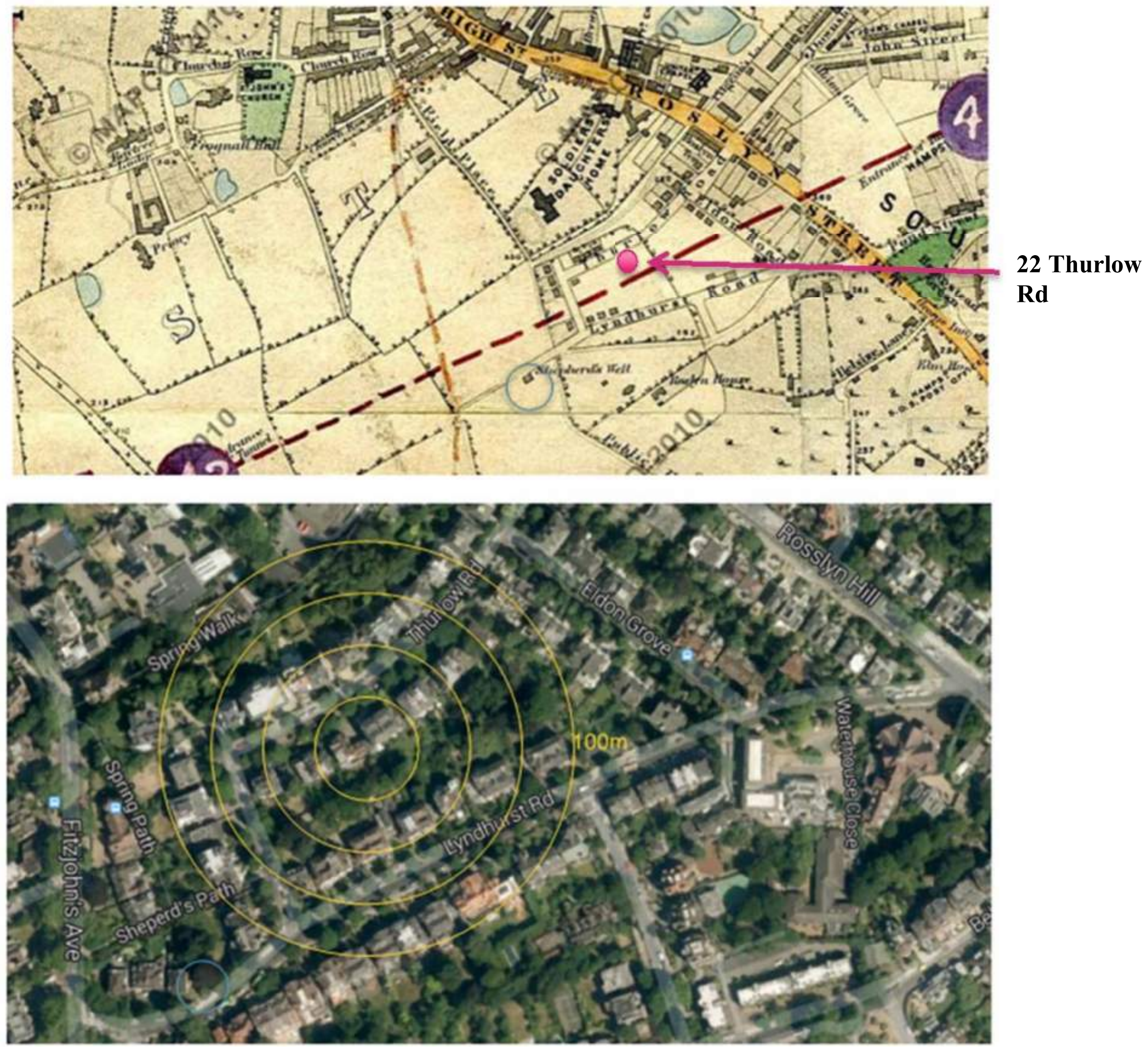


Figure 10 Former location of Shepherds Well 125m approx. from 22 Thurlow Rd

(Q3) Is the site within the catchment of the pond chains of Hampstead Heath

With reference to the Camden Geological, Hydrogeological and Hydrological Study, the site is not within the catchment of the pond chains on Hampstead, nor the Golder’s Hill Chain (see Figure 11).

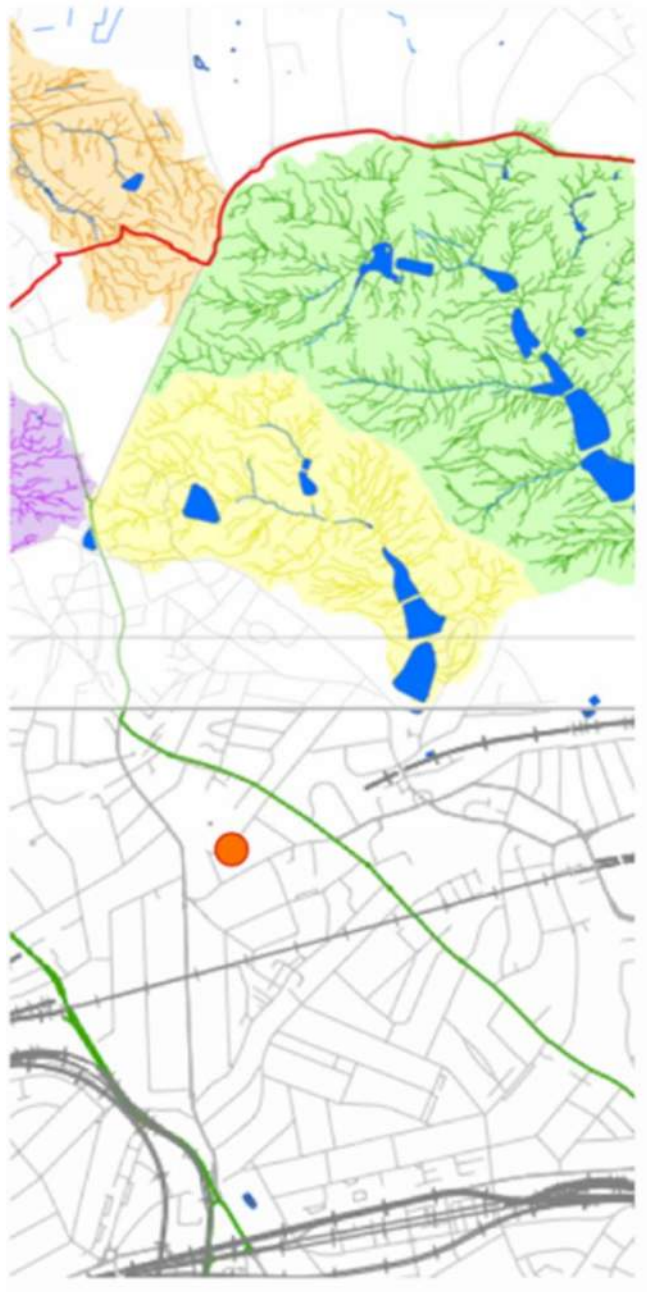


Figure 11 Catchment of Hampstead ponds (extract)

(Q4) Will the proposed basement development result in a change in the proportion of hard surface/paved areas?

No, the proposed change in the proportion hard surface/paved areas is too small to create any significant change in surface water runoff (see Figure 12). The surface permeability will be affected with a slight increase in the footprint of the building and a small decrease in the amount of paved surface in relation to the total site.

	Site Area [m2]	Hard Surfaces [m2]	Proportion [%]
	788		
Existing		176	22.3%
Proposed		163	20.7%
change		**-13**	**-1.6%**

Figure 12 Change in hard surface

(Q5) 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)?

Soakaways are not considered appropriate to the site, due to the sub-soil conditions, and therefore no surface water will be discharged to ground as part of the site drainage.

(Q6) 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 (not just the pond chains on Hampstead Heath) or spring line?

No, there are no ponds in the vicinity of the site. The nearest existing surface water features are the Hampstead Ponds located approximately 850m to the north east of the site.

4.1.2 Summary of Screening Stage

No.	Screening Question	Impact
1a.	Is the site located directly above an aquifer?	Yes
1b.	Will the proposed basement extend beneath the water table surface?	No, but the contiguous piled wall would extend below the water table
2.	Is the site within 100m of a watercourse, well (open/disused) or potential spring line?	No
3	Is the site within the catchment of the pond chains on Hampstead Heath?	No
4	Will the proposed basement development result in a change in the proportion of hard-surfaced/paved areas?	Not significantly
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 soak-away and/or SUDS)?	No
6	Is the lowest point of the 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

4.2 Subterranean flow, matters to be carried forward

On the basis of items in section 4.1 above, and with reference to Figure 1 of CPG4, the aspects carried forward to the scoping stage in respect of ground water are:

- The site being above a secondary aquifer (Q1a)
- Secant piled walls extend below the water table and so will provide a constraint to groundwater flow.

It is not considered necessary to consider further the other issues raised in the screening stage where a negative response was given.

4.3 Stage 2 Scoping

The potential impacts, which will need to be considered will include:

• Whether the basement works will impact on the groundwater level locally and whether this will impact neighbouring properties, structures and services.

5 Surface flow and flooding

The impact of the proposed development on the surface water environment and need for flood risk assessment is considered here.

5.1 Stage 1: Initial screening

The impact of the proposed development on the surface water environment and need for additional flood risk assessment is considered here.

5.1.1 Surface Flow and Flooding screening flowchart

The references are to the screening chart in Figure 3 in CPG4.

(Q1) Is the site within the catchment of the pond chains on Hampstead Heath?

With reference to the Camden Geological, Hydrogeological and Hydrological Study, the site is not within the catchment of the pond chains on Hampstead, nor the Golder's Hill Chain.

(Q2) 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?

Possibly, although the surface water flows will not materially change. On completion of the development the surface water flows will be routed similarly to the existing condition, with rainwater run-off collected in a surface water drainage system and discharged to a combined sewer. SUDS measures that will be considered are as follows:

- the use of a lined permeable paving system to new external hard landscaped areas to reduce the rate of surface water run off (or alternative methods of attenuation)
- where the basement extends beyond the ground floor footprint, the use of soft landscaping over to reduce the rate of any surface water run-off.

(Q3) Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?

Yes, there will be a small change in the area of hard surfacing. The surface permeability will be affected with a slight increase in the footprint of the building and a small decrease in the amount of paved surface in relation to the total site. In addition the basement will be constructed under the rear garden, which will effect surface infiltration in this area although a significant area of soil will be included above this area.

(Q4) Will the proposed basement result in changes to the profile of the inflows (instantaneous & long-term) of surface water being received by adjacent properties or downstream water-courses?

All surface water for the site will be contained within the site boundaries and collected as described above; hence there will be no change from the development on the quantity or quality of surface water being received by adjoining sites.

(Q5) Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream water courses?

The surface water quality will not be affected by the development, as in the permanent condition collected surface water will be generally be from roofs, domestic hard landscaping or collected from beneath the landscaping layer over the basement. Yes, there will be a small change in the area of hard surfacing.

(Q6) Is the site in an area known to be at risk from surface water flooding, such as South Hampstead, West Hampstead, Gospel Oak and King's Cross, or is it at risk from flooding, for example because the proposed basement is below the static water level of a nearby surface water feature?

The site is not on one of the streets noted within the Camden Planning Guidance CPG 4 (April 2011) as a street "at risk of surface water flooding" (refer Figure 13). The site is not at risk of static flooding.

Figure 13 Flood Map (Extract from Figure 15 of Camden Geological, Hydrogeological and Hydrological Study)

From reference to the EA Rivers and Sea Flood Map, the site is not located within a flood risk zone (see Figure 14). The EA Reservoir flood map shows that the site is not at risk of flooding from reservoirs (see Figure 15).

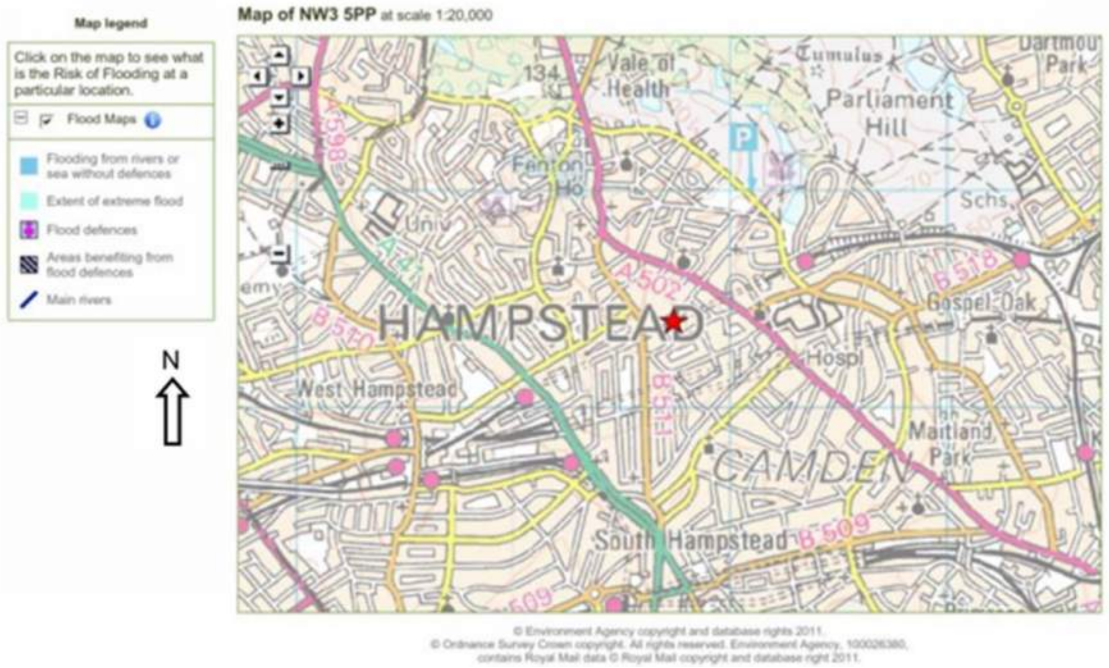


Figure 14 Areas at Risk of Flooding from Rivers or Sea (Extract from Environment Agency flood map)

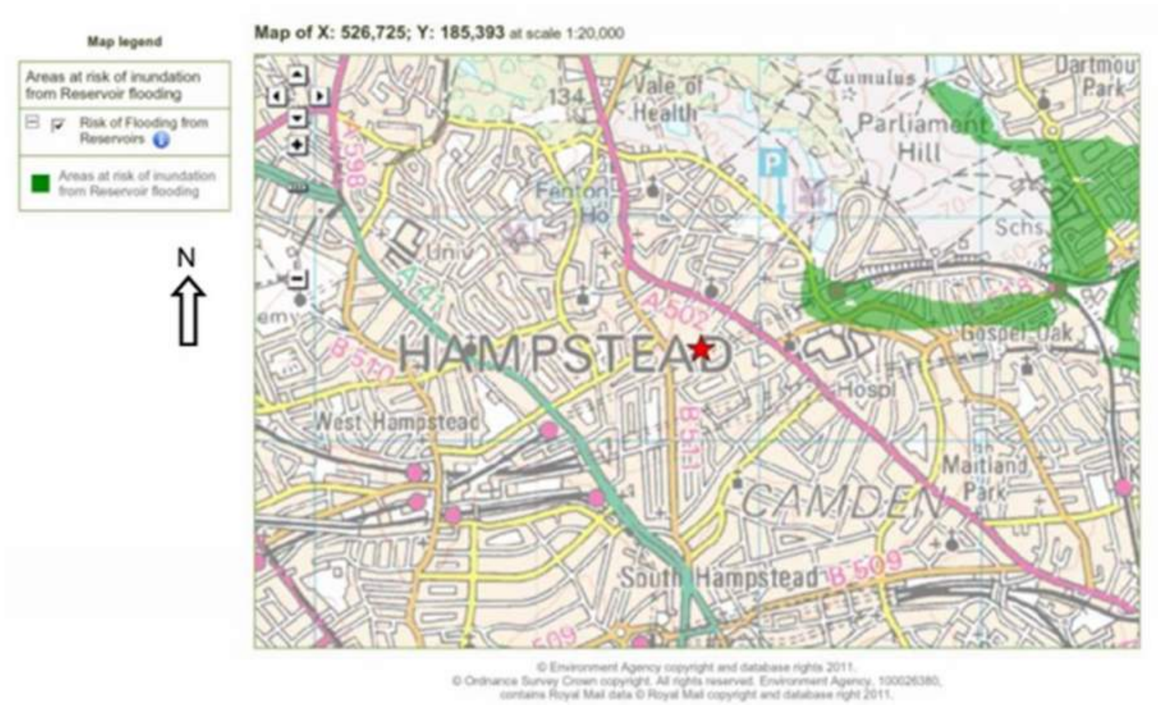


Figure 15 Areas at Risk of Flooding from Reservoirs (Extract from Environment Agency flood map)

On the basis of the above and in accordance with the figure 3 in Camden Planning Guidance CPG 4 (April 2011), a flood risk assessment is not required.

5.1.2 Summary of Screening Stage

No.	Screening Question	Impact
1.	Is the site within the catchment of the pond chains on Hampstead Heath?	No
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?	Possible
3	Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?	Yes
4	Will the proposed basement result in changes to the profile of the inflows (instantaneous & long-term) of surface water being received by adjacent properties or downstream water-courses?	No
5	Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream water courses?	No
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 King's Cross, or is it at risk from flooding, for example because the proposed basement is below the static water level of a nearby surface water feature?	No

5.2 Surface flow and flooding, matters to be carried forward

On the basis of the above, with reference to figure 3 in CPG4, it is considered appropriate to carry forward the potential impact of the increase in impermeable area to the scoping stage. It is not considered necessary to consider further the other impacts of the works in respect of surface flow and flooding, due to the negative responses above.

The following impacts have been identified during screening:

- The existing surface water drainage system will need to be modified as part of the proposal;
- The proposal may increase total surface water flows, as a result of a possible increase in hard landscaping across the site.

5.3 Stage 2 Scoping

The potential impacts which will need to be considered will include:

- Whether the increase in impermeable area will impact on the rate of surface water received by the combined sewer.

The above impacts will be considered by calculating whether the surface permeability of the site will be significantly affected by the works, and considering what measures can be used to mitigate impact of this.

6 Ground stability

6.1 Stage 1: Initial screening

6.1.1 Slope stability screening flowchart

The impact of the proposed development on land stability is considered here as outlined in Camden Planning Guidance CPG 4 (April 2011). The references are to the screening chart figure 2 in CPG4.

(Q1) Does the existing site include slopes greater than 7 deg?

There is a difference of 2.3metres in height between the front and rear gardens, but the existing site is generally flat within the front and rear gardens. All slopes are at less than 7 degrees.

Figure 16 Existing Section through site

(Q2) Will the proposed re profiling of landscape at the site change slopes at the boundary to more than 7 degrees?

The surrounding land will generally remain at existing slopes in the permanent condition.

(Q3) **Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7^{o}? (approximately 1 in 8)**

With reference to the Camden Geological, Hydrogeological and Hydrological Study, (refer Figure 17), the neighbouring properties also have slopes less than 7 degrees.

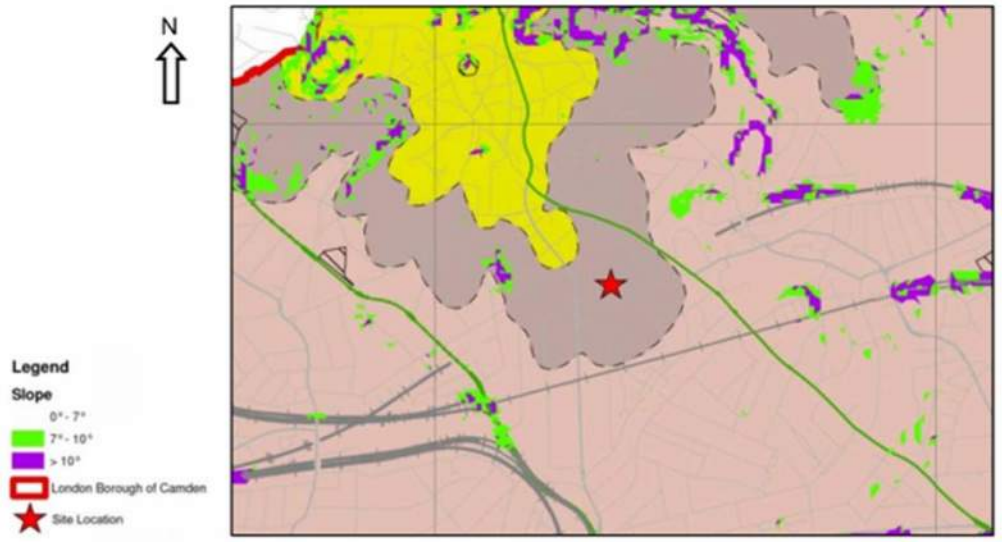


Figure 17 Slope Angle Map (Extract from Figure 16 of Camden Geological, Hydrogeological and Hydrological Study)

(Q4) Is the site within a wider hillside setting in which the general slopes are greater than 7 degrees ?

The surrounding areas slope towards the south and east of the site. Figure 17 above shows the site to be located in an area with slopes less than 7 degrees. With reference to Figure 10 in the Camden Geological, Hydrogeological and Hydrological Study, the hillside falls by approximately 10metres over approximately a 160m distance, suggesting an overall slope of around 4 degrees. The level data from available OS maps shown in Figure 2 suggests a fall in level of about 9m over 300m local to the site, giving a slope of about 2 degrees. It is concluded that the slope is less than 7 degrees overall.

(Q5) Is the London Clay the shallowest strata at the site?

The underlying soil strata is Claygate Member as confirmed by the 2011 geotechnical investigation. With reference to Camden Geological, Hydrogeological and Hydrological Study the stratigraphic boundary is approximately 250m away to the east; therefore the site is not considered close to a stratigraphic boundary.

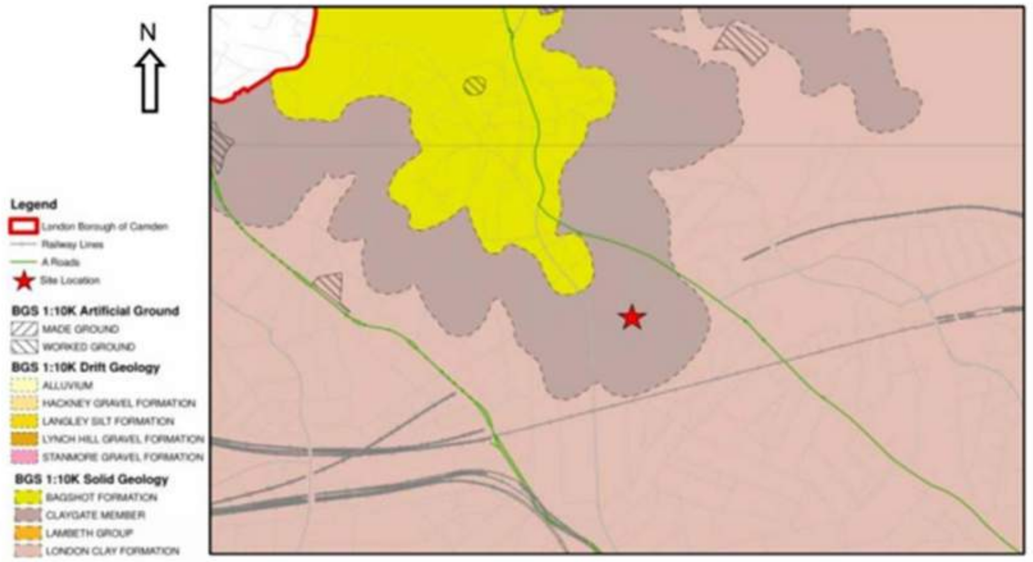


Figure 18 Geological Map Extract from Fig 4 of Camden Geological, Hydrogeological and Hydrological Study)

(Q6) Will any tress be felled as part of the proposed development

With reference to Arborcultural Solutions LLP report dated April 2011, tree T6 and T7 are to be removed with 12 trees to be retained.

(Q7) Is there a history of seasonal shrink-swell subsidence in the local area (Claygate Beds), and/or evidence of such effects at the site?

The Claygate Beds at the site contain significant sand layers and significant shrink – swell is not expected. There is no evidence of subsidence having previously affected 22 Thurlow Road.

(Q8), (Q11) is the site within 100m of a watercourse or a potential spring line?

With reference to the Camden Geological, Hydrogeological and Hydrological Study (see Figure 10) the closest subsurface water courses run along the approximate line of Fitzjohn's Avenue to the south west which is greater than 100 meters from the site. The nearest surface water is the Hampstead Heath ponds, which is also greater than 100m from the site. The local geology suggests that the closest spring lines are present approximately 250m away from the site along Haverstock Hill at the interface of the Claygate Member and the London Clay.

(Q9) Is the site within an area of previously worked ground?

The site is not in the vicinity of any recorded areas of worked ground, the nearest recorded on the geological map are close to Finchley Road and to the south of West Heath Road.

(Q10) Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?

With reference to the Camden Geological, Hydrogeological and Hydrological Study (see Figure 8 of this report) the site is above a secondary aquifer. The construction of the basement will be about 4 metres higher than the recorded ground water level at +89.4mOD and therefore dewatering should not be required.

(Q12) Is the site within 5m of a highway or pedestrian right of way?

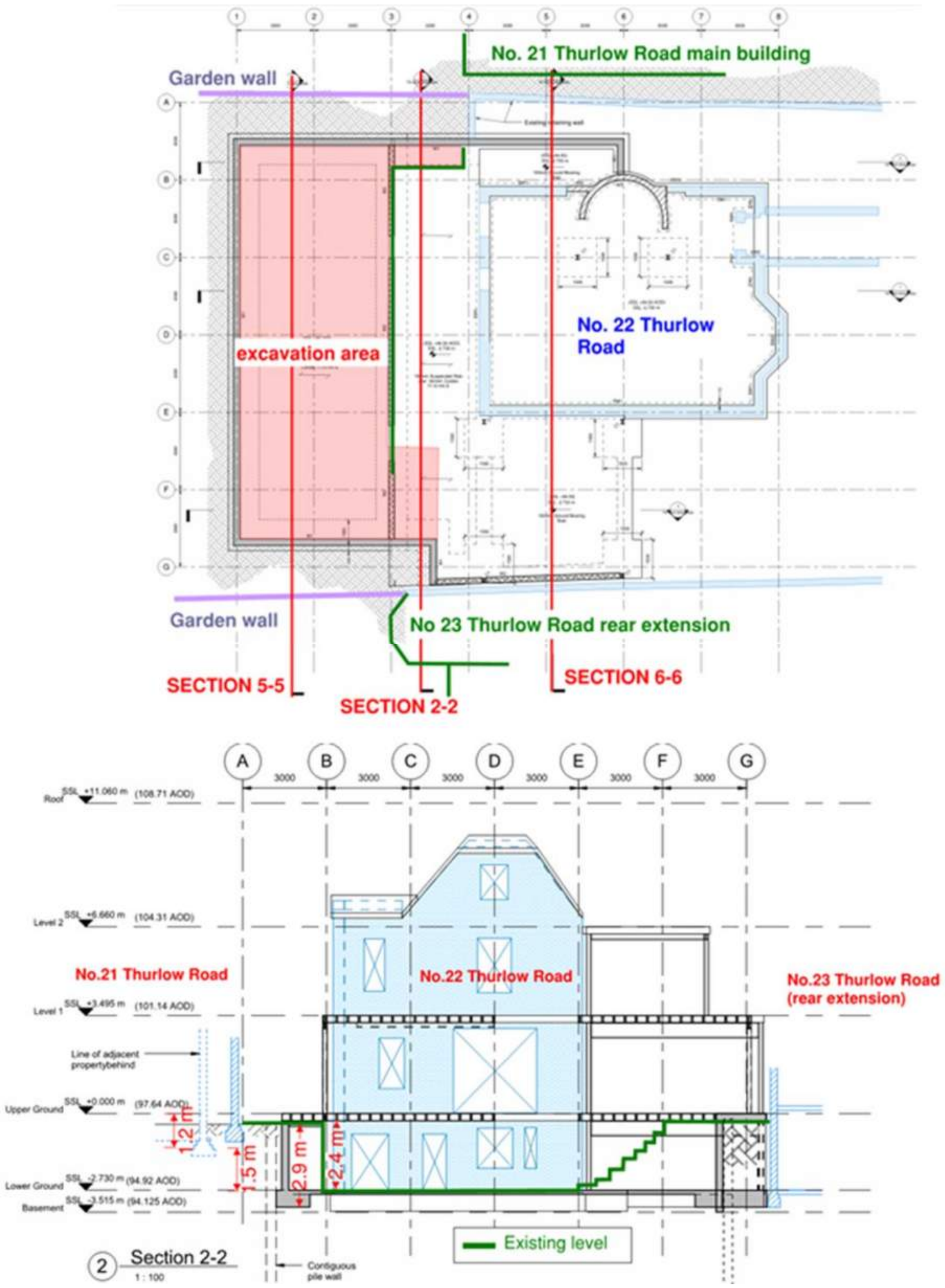
The house is located approximately 9metres away from the public pavement and therefore the works shall not affect the public highway.

(Q13) Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?

The two adjacent properties are residential houses at No.21 and No.23 Thurlow Road, respectively to the West and East of the site.

Drawings of the assumed levels of the adjacent structures and the proposed works at No 22 Thurlow Rd, shown relative to the level of the rear garden, are shown in Figure 19. It can be seen that:

- The extents of the main buildings of both adjoining properties are generally in line with the main building of No.22 Thurlow Road, so adjacent only to the corners of the excavation, where ground movements will be small;
- The proposed dig close to No 21 will extend to approximately 2.7m below the floor level of No. 21. Despite the observation that the excavation does not extend past No. 21, consideration of potential ground movements has been carried forward to later stages of this BIA.
- The rear extension of No.23 Thurlow Road slightly extends towards the garden area and it is about 2m distance from the excavation area. There is likely to only be about 0.4m between the formation level of the proposed basement and the extension at No. 23. Although the differential depth of founding is not significant, consideration of potential ground movements has been carried forward to later stages of this BIA
- The lower level of the proposed new garage building is similar to the current garage level and is considered to be not lower than No.23 Thurlow Road extension level. Temporary localised extra-dig will be required for the installation of the new garage foundations and it is recommended that assessment of potential movements will be carried through to the later stages of this BIA.



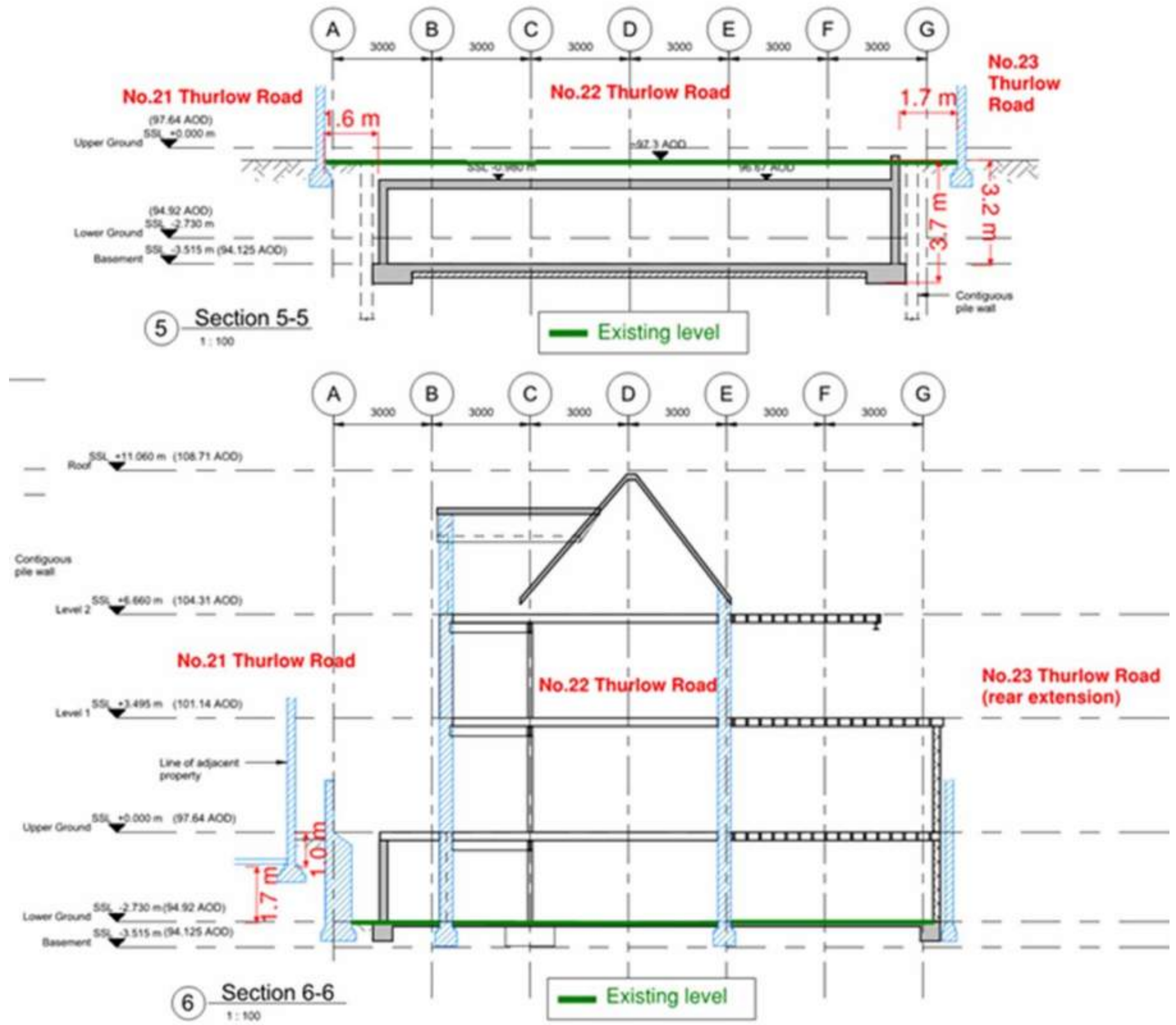


Figure 19 Assumed levels of the adjacent structure at No. 21 and No. 23 Thurlow Rd and the proposed works at No 22 Thurlow Rd

(Q14) Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?

The Network Rail tunnel connecting *Hampsted Heath* and *Finchley Road & Frognal* overground stations was constructed in 1879 and run at some depth below no. 22 Thurlow Road (see Figure 20). Elevation of the tunnel is not confirmed by factual data but the Basement Impact Assessment presented in October 2011 by Michael Alexander Consulting Engineers for the previous proposed development at site stated that the tunnel '*was found to be around 35m below existing ground level at site*'. A preliminary check on topography of the area seems to confirm such statement. However, no factual data are currently available about the actual tunnel elevation and NR shall be contacted to confirm the feasibility of the currently proposed development.

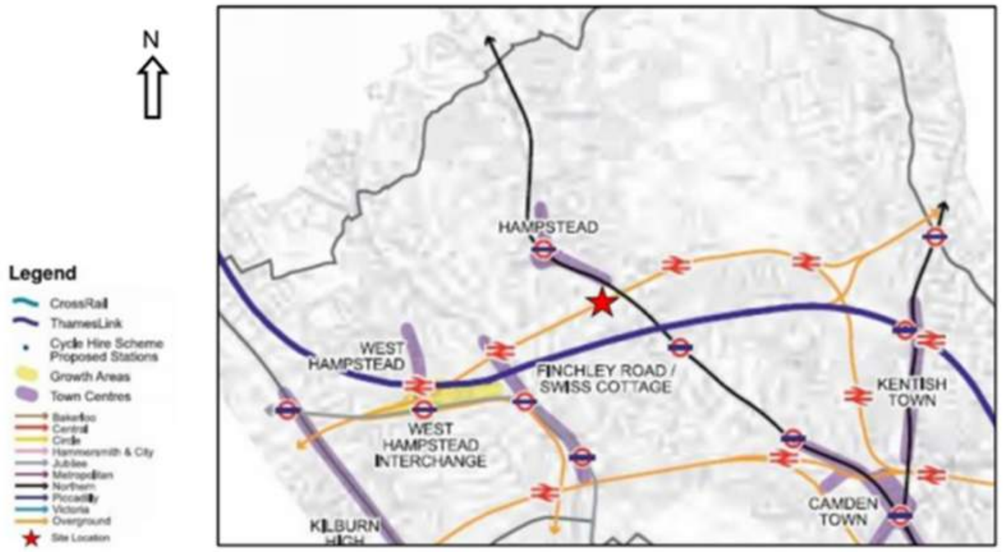


Figure 20 Map of underground infrastructure (Extract from Fig 18 of Camden Geological, Hydrogeological and Hydrological Study)

6.1.2 Summary of Screening Stage

No.	Screening Question	Impact
1.	Does the existing site include slopes, natural or manmade, greater than 7°? (approximately 1 in 8)	No
2.	Will the proposed re-profiling of landscaping at site change slopes at the property boundary to more than 7°? (approximately 1 in 8)	No
3.	Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°? (approximately 1 in 8)	No
4.	Is the site within a wider hillside setting in which the general slope is greater than 7°? (approximately 1 in 8)	No
5.	Is the London Clay the shallowest strata at the site?	No
6.	Will any tree/s 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? (Note that consent is required from LB Camden to undertake work to any tree/s protected by a Tree Protection Order or to tree/s in a Conservation Area if the tree is over certain dimensions).	Yes
7.	Is there a history of seasonal shrink-swell subsidence in the local area (Claygate Beds), and/or evidence of such effects at the site?	No
8.	Is the site within 100m of a watercourse or a potential spring line?	No
9.	Is the site within an area of previously worked ground?	No
10.	Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?	Yes
11.	Is the site within 50m of the Hampstead Heath ponds?	No
12.	Is the site within 5m of a highway or pedestrian right of way?	No
13.	Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Yes
14.	Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	Yes

6.2 Slope stability, matters to be carried forward

On the basis of the scoping queries noted above and in reference to Figure 2 of CPG4, the aspects carried forward to the scoping stage in respect of land stability are:

- The impact of the proposals on tree retention (Q6).
- The impact of site above a secondary aquifer (Q10).
- The increase in differential depth of foundation relative to neighbouring properties (Q13)
- The impact of the works upon the railway tunnel below Thurlow Road (Q14)

It is not considered necessary to consider further the other issues, raised in the screening stage.

6.3 Scoping

The potential impacts which will need to be considered will include:

- The potential for damage to neighbouring properties due to the differential depth of foundations.
- Whether the basement works will impact on the tunnel below Thurlow Road.
- Whether the basement works will impact on the aquifer and affect the groundwater flow regime.
- The potential for damage to trees and their roots.

7 Stage 3: Site Investigation

Arup's interpretation of the available ground investigation data at 22 Thurlow Rd for the preliminary design of the proposed basement is given in Appendix C.

The following is a summary provided for clarity of the main part of this BIA report.

The data was gathered by others and Arup have not been party to it. In particular, a full understanding of the nature of the Claygate Beds at this location is not possible based on the available data. The recommendations made in this report will therefore need to be validated through a further GI, and this report is written on the basis of that expectation.

7.1 Ground investigation information

The present study is based on the review of the following documentation and information:

1. *Desk study and Ground Investigation Report produced by GEA (July 2011, ref. [1]).* It presents the results of a ground site-specific investigation carried out in February 2011 to support the proposed development at that time. It included:
   a. No.1 cable percussion borehole to a depth of 15.0m (BH1) with collection of soil samples and SPT;
   b. Installation of a groundwater monitoring standpipe to a depth of 6.0m in BH1 and groundwater monitoring;
   c. No.5 window sample boreholes to a depth of 5.0m;
   d. Laboratory testing for geotechnical and environmental purposes.
2. *Supplementary Ground Investigation Report produced by GEA (October 2011, ref. [2]).* It presents the results of an additional ground site-specific investigation carried out in September 2011. It included:
   a. No.3 cable percussion boreholes to a depth of 15.0m (BH7, BH8, BH9) with collection of soil samples and SPT;
   b. Installation of a groundwater monitoring standpipe to a depth of 11.0m in the three boreholes and groundwater monitoring;
   c. Laboratory testing for geotechnical purposes.
3. *Further Groundwater monitoring.* On the 12th of June 2014 Arup carried out the monitoring of the groundwater level in the available standpipes on site (BH1, BH7, BH8, BH9).
4. *Existing records of historical BGS boreholes* (online data available at www.bgs.ac.uk). Records of no.5 boreholes located at about 250m from the site are available.

The locations of the investigations are shown in Figure 21. Boreholes BH3, BH5, BH7 and BH8 are within the proposed excavation area.

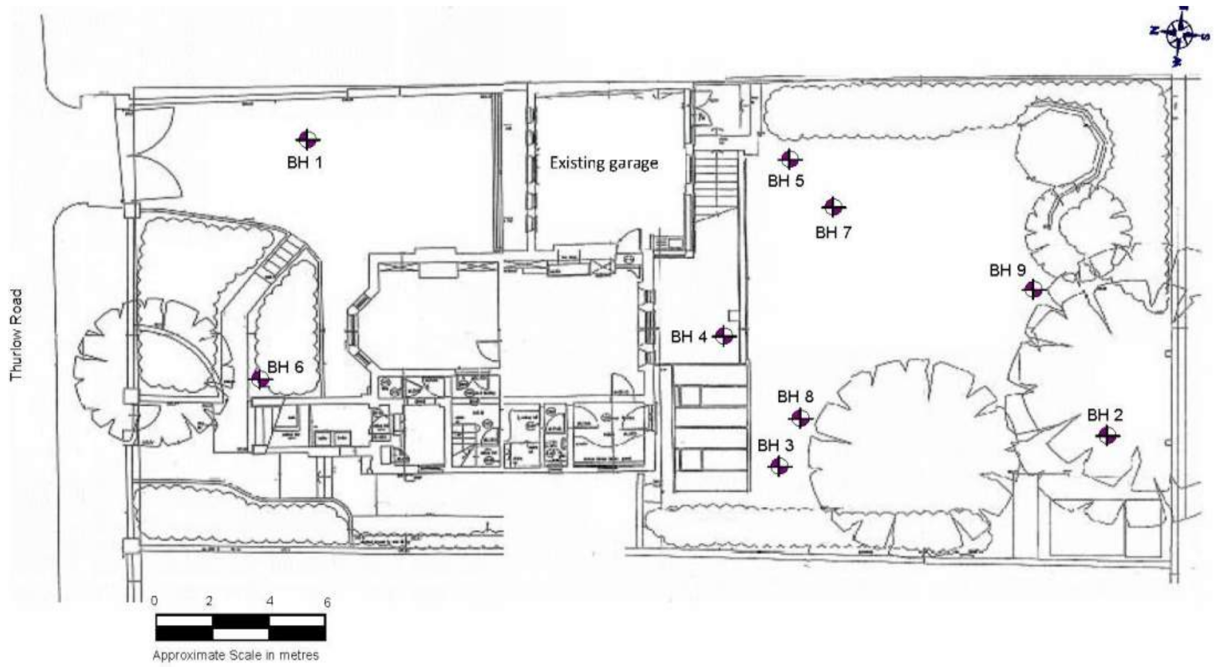


Figure 21 Plan of GEA GI

7.2 Elevations of Existing GI

It should be noted that the existing GI was referenced to an arbitrary datum considered to be more or less at the location of borehole 1 and assigned 100mTBM. Based on the current site survey it is considered that the mTBM levels adopted in the existing GI are approximately 5.3m higher than mOD levels.

In the present assessment, the elevations of the data given in mTBM have been corrected by 5.3m to give elevations in mOD.

7.3 Ground conditions

Geological sections through the site interpreted from the available borehole data are shown in the N-S and E-W directions in Figure 23 and Figure 24.

The generalised stratigraphy is given in the table below.

Stratum	**Top level (mOD)**
Made Ground	+97.3
Claygate Beds - drained	+96.8
London Clay -drained	+88.7

7.4 Top Soil/Made Ground

This layer consists mostly of clayey silt with gravel, root and rootlets, fine brick and charcoal fragments. Concrete top is present at BH1 location only which corresponds to the entrance of the garage. Thickness varies between 0.10 and 0.75m.

7.5 Claygate Beds

The Claygate Beds at the site consist mainly of a either *silty sandy Clay* or *clayey silty Sand*. Pockets of clay and sparse coarse rounded gravel are also locally present. At the location of the proposed excavation area the following succession of mixtures is generally described in the borehole logs:

- *silty sandy Clay* directly below the Made Ground (1.0 to 1.6m thick);
- *clayey silty Sand* with lenses of layers of silty clay (4.3 to 5.7m thick);
- *silty sandy Clay* on top of the London Clay (0.5 to 2.0m).

There is only one Particle Size Distribution test (in BH2) to identify the soil classification of slightly clayey silty Sand, although even in this test the relative proportions of clay and silt were not tested. Very little other test data exists to examine the nature of the material described as clayey silty Sand:

- In BH7 and BH9, samples for undrained shear strength testing were identified as clayey silty fine sand, though the material was clearly sufficiently clayey to carry out an undrained shear strength test.
- In BH8 a sample for undrained shear strength testing, presumably taken from a layer of clay described within the Sand horizon, is described as a very sandy Clay.

It is noted that in BH1 which is located 12m away from the excavation area, the clayey silty Sand layer was apparently not encountered.

The Claygate Beds are characterised by brown or orange-brown colouring.

Due to the clayey nature of the material, it is considered likely that in short-term dry conditions a high proportion of the material would show an undrained behaviour. About 15 U100 samples have been collected during the 2011 investigations and this recognizes the cohesive response of the soil.

On this basis, and given the water table well below the level of the basement excavation (refer to 8.7), it is considered that a contiguous piled wall will provide sufficient support to the ground during basement excavation and that there will not be a risk of significant quantities of sand flowing through the small gaps in the contiguous piled wall.

For retaining wall analysis drained parameters have been adopted as this is a worst case for design of the wall and predicted ground movements.

7.6 London Clay

The top of the London Clay has been interpreted though the change in description on the borehole logs to a stiff grey silty clay. It is acknowledged that, based on the available test data, the boundary between the Claygate Beds and London Clay is not readily distinguished.

In boreholes BH7, BH8 and BH9, samples tested for undrained shear strength at the top of the London Clay describe the clay as silty very sandy clay.

7.7 Groundwater conditions

As part of the GEA ground investigations, the level of water strikes were recorded where they were encountered in window sampler boreholes and in the cable percussion boreholes.

Groundwater was encountered as seepages in the cable percussion boreholes at depths of between 8m and 12.4m. Four standpipes were installed, one to a depth of 6m (in BH1 – length of slotted zone not specified) and three to depths of 11m (in BHs 7, 8 and 9 – slotted zone from 1m to 10m below ground level). Repeat monitoring visits were made to check stabilised levels in August and September 2011.

Groundwater was encountered at approximately 9m below ground in the standpipes in the 2011 monitoring, i.e. at about +88.3mOD.

Arup measured the GW level in the 4 existing standpipes in June 2014. Groundwater levels in all standpipes had increased since 2011 by up to 1.2m. The maximum groundwater level was found at 7.9mbgl, i.e. at +89.4mOD. A graph showing the measured groundwater levels with time is given in Figure 22(BH1 was dry).

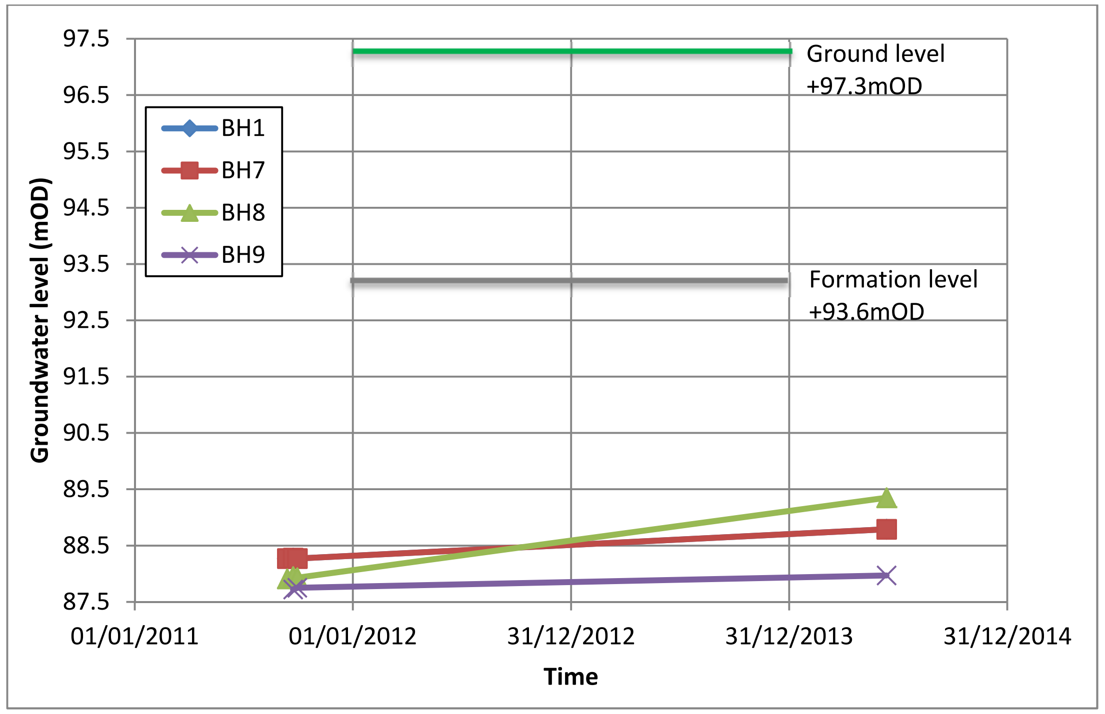


Figure 22 Measured Groundwater Levels

The significant differences in groundwater level between standpipes, together with the rise since 2011, do raise questions over the data. The installations of the standpipes were not witnessed by Arup so the quality of construction is not known. During the further GI some additional standpipes will be installed to confirm the data.

Based on the site survey information, topography from OS maps and information available on the Camden Planning Portal for the house to the south on Lyndhurst Rd, an approximate cross-section showing the variation of ground level going north to south across the site between Thurlow Rd and Lyndhurst Rd is shown in Figure 3. This shows the garden area of 22 Thurlow Rd to be raised up by about 2.3m above the level of Thurlow Rd to the north and about 5.3m above the level of Lyndhurst Rd to the south. This indicates that for the first few metres of ground in the garden area, a groundwater table as groundwater would not rise between the roads. In addition, the existing garden retaining wall is in good condition and shows no signs of water seepage.

It is therefore considered that over the 4m depth of the proposed basement (to formation level) the only potential sources of groundwater would be rainfall or accidental supply, such as a leaking hose pipe.

The recommended design water pressure profile is therefore to adopt a groundwater table at depth at +90mOD, but to allow for a potential localised temporary build-up of hydrostatic water pressure from 1m below ground level over the depth of the basement, i.e. above +93.3mOD.

In the long term it is recommended that allowable is made for a rise in the groundwater table at depth by 1m.

7.8 Ground model

The ground parameters summarised in the following table are recommended to be used for geotechnical analyses.

Stratum	Top level (m OD)	Thickness (m)	Unit weight (kN/m3)	Su (kPa)	Phi (º)	E (MPa)	ν (-)	K0 (-)
Made Ground	+97.3	0.5	20.0	-	28	10MPa	0.2	0.5
Claygate Beds - undrained	+96.8	9.0	20.0	50	-	400cu (heave)	0.5	0.5
Claygate Beds - drained	+96.8	9.0	20.0	-	27	27MPa (retaining wall) 320cu (heave) 220cu (shallow foundations)	0.2	0.5
London Clay - undrained	+88.7	-	20.0	45+5z	-	1000cu (retaining wall) 400cu (heave)	0.5	1.0
London Clay - drained	+88.7	-	20.0	-	23	750cu (retaining wall) 320cu (heave)	0.2	1.0

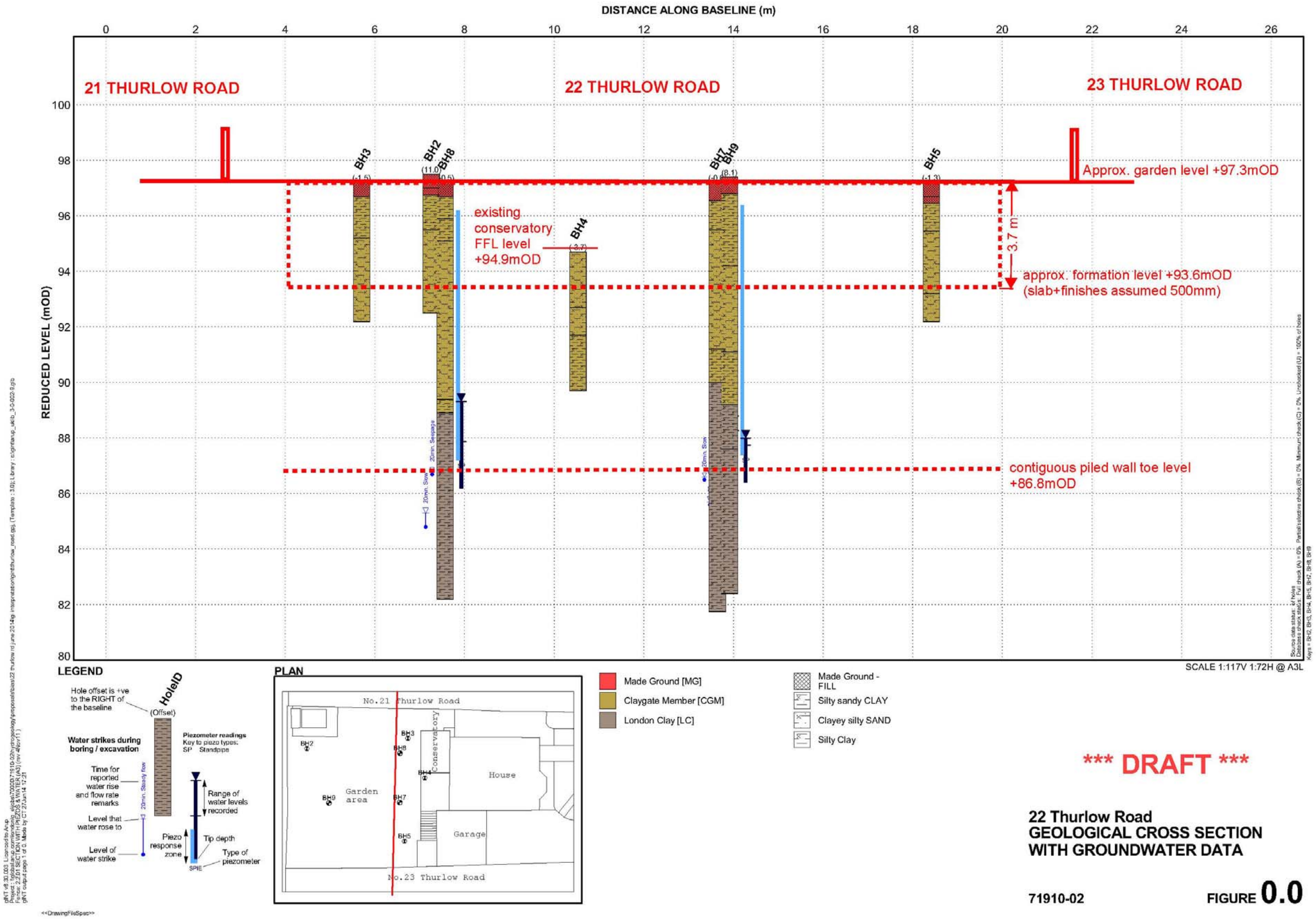


Figure 23 Geological section through the site interpreted from the available borehole data in the E-W direction

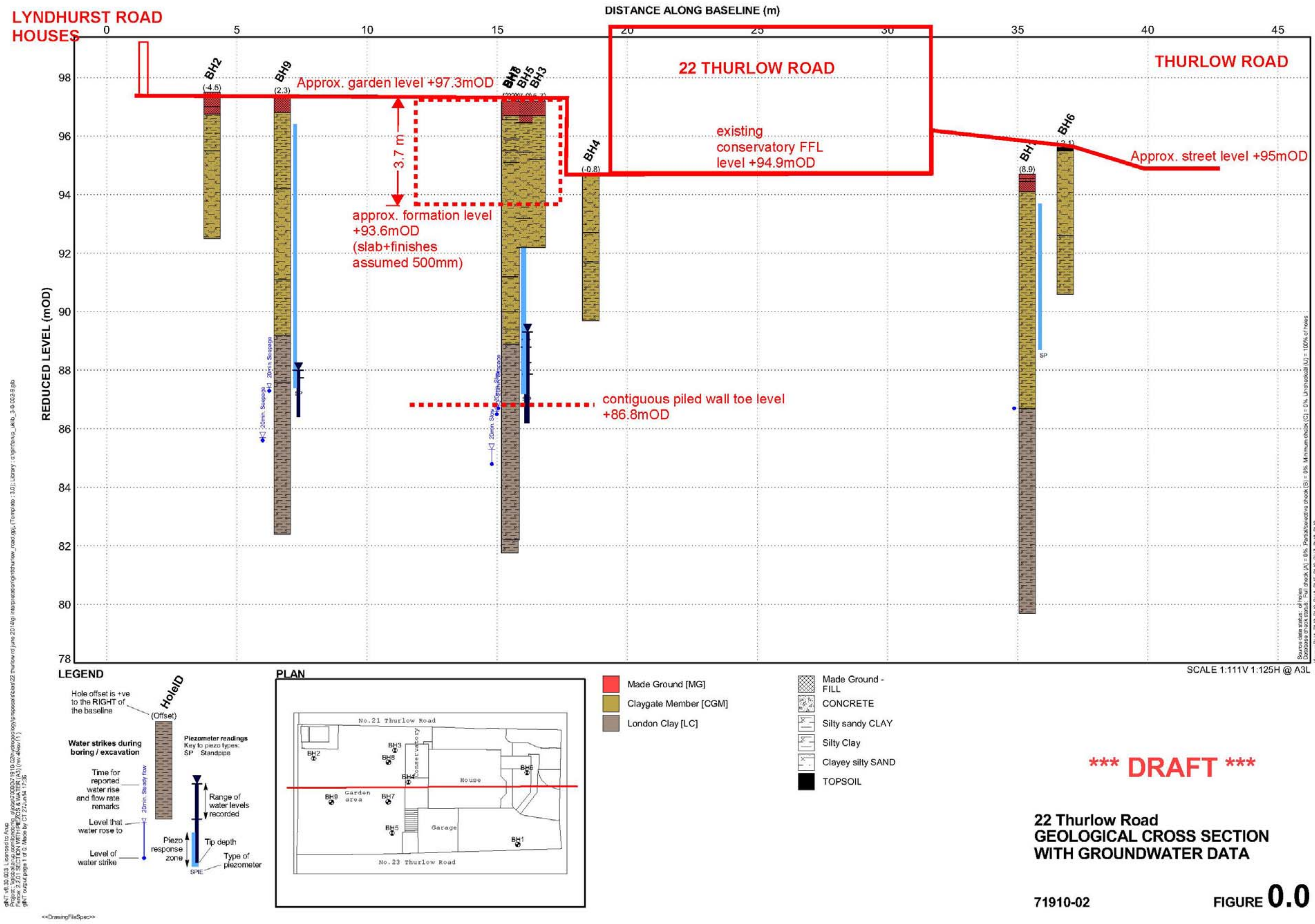


Figure 24 Geological section through the site interpreted from the available borehole data in the N-S direction

8 Stage 4: Impact Assessment

As outlined in Arup 2010 Guidance for Subterranean development, a BIA describes the impacts of the proposed project on the environment by comparing the present situation (the baseline) with the situation as it would be with the basement in place (i.e. constructed).

8.1 Groundwater flow assessment

As identified in the initial screening and scoping stages the only potential impact, which will need to be considered is whether the basement works will impact on the groundwater level locally and whether this will impact neighbouring properties structures and services. This is because the site is located on a secondary aquifer and secant piled walls extend below the water table and so will provide a constraint to groundwater flow

The additional site investigation and data review has enabled an assessment of nature and extent of likely impacts.

The Claygate Beds underlying the site are able to transmit small quantities of groundwater, recharge would be by leakage and vertical infiltration across the aquifer outcrop area. Ground water gradients will follow the local topography and flows will generally be from north to south across the site. The groundwater will eventually discharge from the aquifer at a series of small springs and wells located to the edge of its outcrop area some distance to the south, for example at the Shepherd's Well.

Groundwater levels have been measured on a number of occasions between 2011 and 2014 which spans both wet and dry periods allowing a good understanding of typical fluctuations. Groundwater is encountered at approximately 9m below ground (+88.3mOD) and fluctuates by about 1.0m over time. The maximum recorded groundwater level was found at 7.9mbgl, i.e. at +89.4mOD in June 2014.

The proposed basement has a final formation elevation of approximate 93.8mOD well above the zone of water table fluctuation and will therefore not create any impacts.

A piled wall will be constructed around the perimeter of the proposed basement from garden level. Initial analyses indicate that piles of 350mm diameter at 500 spacing and length 10.5m below the garden level would be appropriate. As there will be some limited penetration of the piles below the water table, there is a possibility that the pile wall may act as a barrier to flow. However it should be noted that the pile wall will not be continuous but will contain regularly spaced gaps which will allow groundwater to flow through it. In addition the wall has a limited depth of penetration and frontage. The potential impact of the pile wall on local groundwater levels or flows will be minimal – certainly well within the range of natural (annual) fluctuation.

8.2 Surface Water flow assessment

As identified in the initial screening and scoping stages the existing surface water drainage system will modified as part of the proposal. There will be a small change in the area of hard surfacing and as a result total surface water flows may increase. An assessment has been made of whether this increase in impermeable area will impact on the rate of surface water received by the combined sewer.

Review of the proposals shows that the surface permeability will be affected with a slight increase in the footprint of the building and a small decrease in the amount of paved surface in relation to the total site – the total change will be a decrease in hard standing of 1.6%.

Overall it is concluded that the surface water flows will not materially change in response to the small reduction in hard standing. On completion of the development the surface water flows will be routed in a similar way to the existing condition, with rainwater run-off collected in a surface water drainage system and discharged to a combined sewer.

It will not be necessary to consider additional mitigation measures such as SUDS or soft landscaping over to reduce the rate of any surface water run-off.

8.3 Stability of basement and adjacent structures

8.3.1 Retaining wall analysis

A preliminary design of the retaining wall was carried out for this site in order to understand potential movements and impact on adjacent structures.

A contiguous piled wall with 350mm or 450mm diameter piles at 500mm or 600mm centres respectively centre has been considered as a potential solution. A preliminary design has been carried out based on a 350mm diameter piled wall for a conservative excavation depth of 4.0m.

Due to the clayey nature of the material, it is considered likely that in short-term dry conditions a high proportion of the material would show an undrained behaviour. On this basis, and given the water table well below the level of the basement excavation (refer to 8.7), it is considered that a contiguous piled wall will provide sufficient support to the ground during basement excavation and that there will not be a risk of significant quantities of sand flowing through the small gaps in the contiguous piled wall. However, provision of grouting shall be made in case of evidence of such mechanism of ground loss. Piles are likely to be auger-bored.

The small diameter of the piles allows the use of small piling rigs on site which minimises problems of access, reduces the operational space and plant required room and provides an improved flexibility for pile installation.

The Oasys software FREW has been used to model a typical section of the retaining wall during different stages of the excavation. Details of the analysis are given in Appendix D and the basic features of the piled wall analysed are presented in the following table.

Pile diameter	Pile spacing	Pile top	Pile toe	Pile length
350mm	500mm	97.3mOD	86.8mOD	10.5m

At this stage, the retaining wall is assumed to provide permanent support. An RC lining wall will be cast up against it, so that if it is beneficial during detailed design, the retaining wall need only be designed for the temporary condition if the RC lining is designed for the long-term conditions of soil retention. A maximum bending moment of 75kNm has been predicted to occur for each pile (ULS case) and it is considered to be reasonably accommodated by a 350mm pile with typical reinforcement. Maximum wall deflection is anticipated to be 13mm and to occur at about formation level. The top of the wall is predicted to move by about 4mm due to the restraint offered by the temporary prop and, at a later stage, by the permanent top slab.

The preliminary design has been carried out to understand potential ground movements and to ensure that potential damage to adjacent structures is minimal. At design stage this solution could be optimised or revised, provided that resulting ground movements are not significantly more than concluded here. This could include considering other types of walls or the possibility to avoid the use of props during construction except at locations close to buildings. Additional ground investigations will be carried out. These further investigations and/or additional analyses could justify such solutions.

8.4 Prediction of ground movements and damage assessment

8.4.1 Predicted ground movement

CIRIA report C580 ‘Embedded retaining walls guidance for economic design’ ([6]) gives empirical profiles of ground movements behind retaining walls due to wall installation and excavation in front. These profiles are based on numerous case histories and are widely adopted in the prediction of ground movements behind retaining walls.

Following the guidance of CIRIA C580, profiles of ground movement behind the piled retaining walls have been calculated. In particular:

- Movements due to wall installation
    - Vertical movements have been derived from database plots shown in CIRIAC580 - Figure 2.8b;
    - Horizontal movements have been derived from database plots shown in CIRIAC580 - Figure 2.8a;
- Movements due to wall deflection
    - Vertical movements have been derived from the results of retaining wall analyses with FREW applying relationship given in CIRIA C580 Figure 2.16
    - Horizontal movements have been derived from database plots shown in CIRIAC580 - Figure 2.11a

The results are shown in Figure 25 and Figure 26.

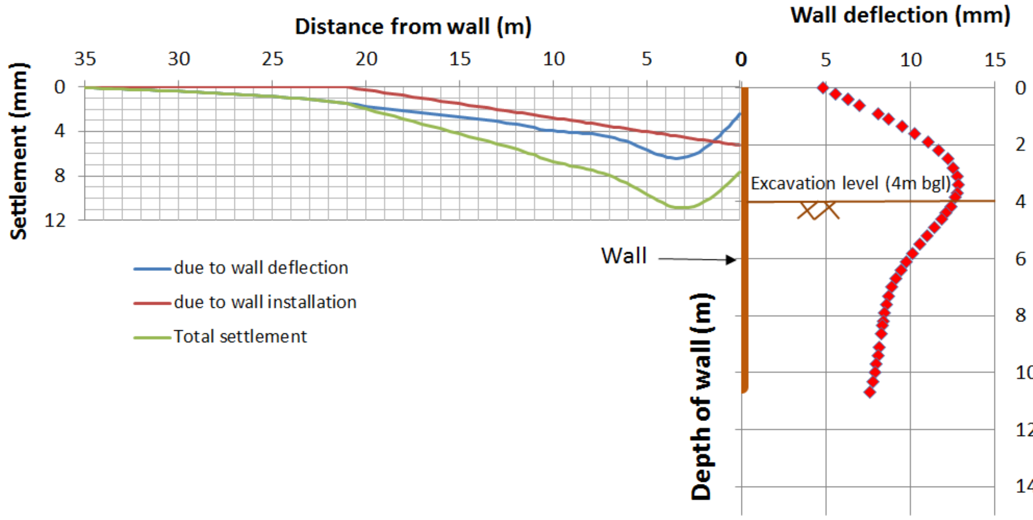


Figure 25 Predicted *vertical* movements at ground level due to installation and deflection of retaining wall

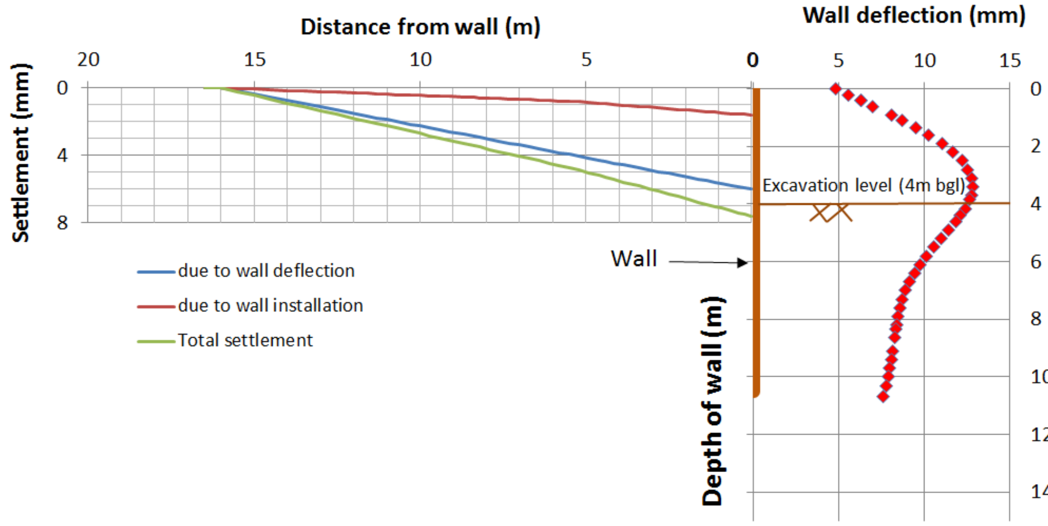


Figure 26 Predicted *horizontal* movements at ground level due to installation and deflection of retaining wall

Ground movements due to heave effects have been also considered to understand potential movements of No. 22 Thurlow Rd itself due to the extension of the lower ground floor area, movements of the NR tunnel at depth (see 8.4.3) and for potential use in preliminary design of the basement slab and any tensile restraint. For the neighbouring structures, outside the basement, the proposed piled wall restricts the heave movements that would otherwise occur. The governing case for the assessment of ground movements for the neighbouring structures has been found to be the calculations of ground movement using the empirical guidance of CIRIA C580 based on case history data (8.4.2).

8.4.2 Damage assessment

The predicted ground movements described in the previous section were used to carry out an assessment of the potential impact of the predicted ground movements on neighbouring structures.

The damage is assessed based on a categorisation, where 0 is least effect and 5 is the greatest effect. The target is to keep the damage within Category 1, which can be summarised as:

- Very slight' damage consisting of 'Fine cracks that can easily be treated during normal decoration'.
- Perhaps isolated slight fracture in building.
- Cracks in external brickwork visible on inspection'.
- The approximate crack width is less than 1mm.

Figure 27shows the relationship between damage category, deflection ratio and horizontal tensile strain (from CIRIA C580).

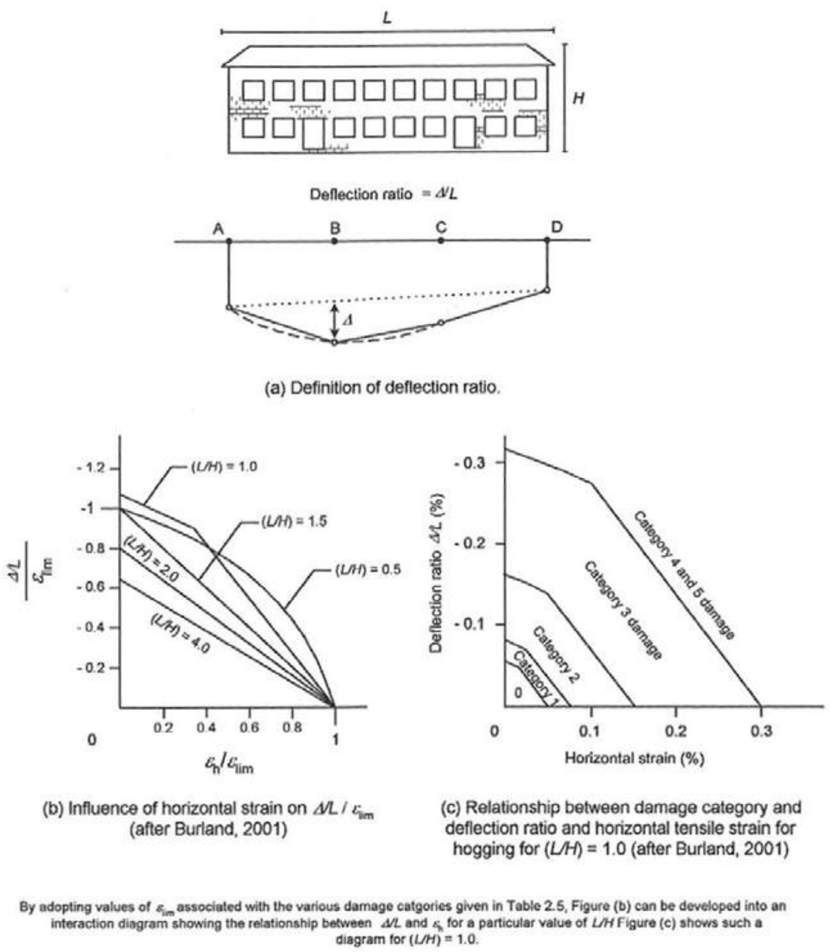


Figure 27 Relationship between damage category, deflection ratio and horizontal tensile strain (from CIRIA C580)

Such analysis has been carried out for selected structures upon which the proposed works may have some impact. The stiffness of the structure is conservatively neglected in these analyses. The results are described as follows.

8.4.2.1 Garden walls

The predicted ground movement profiles perpendicular to the walls in the horizontal and vertical directions have been applied throughout the length of the garden walls to the South of the excavation (length=10m, height=2m). The beneficial effects of the wall corner and lateral distance from excavation have conservatively not been considered.

Predicted damage is within Category 1 "very slight".

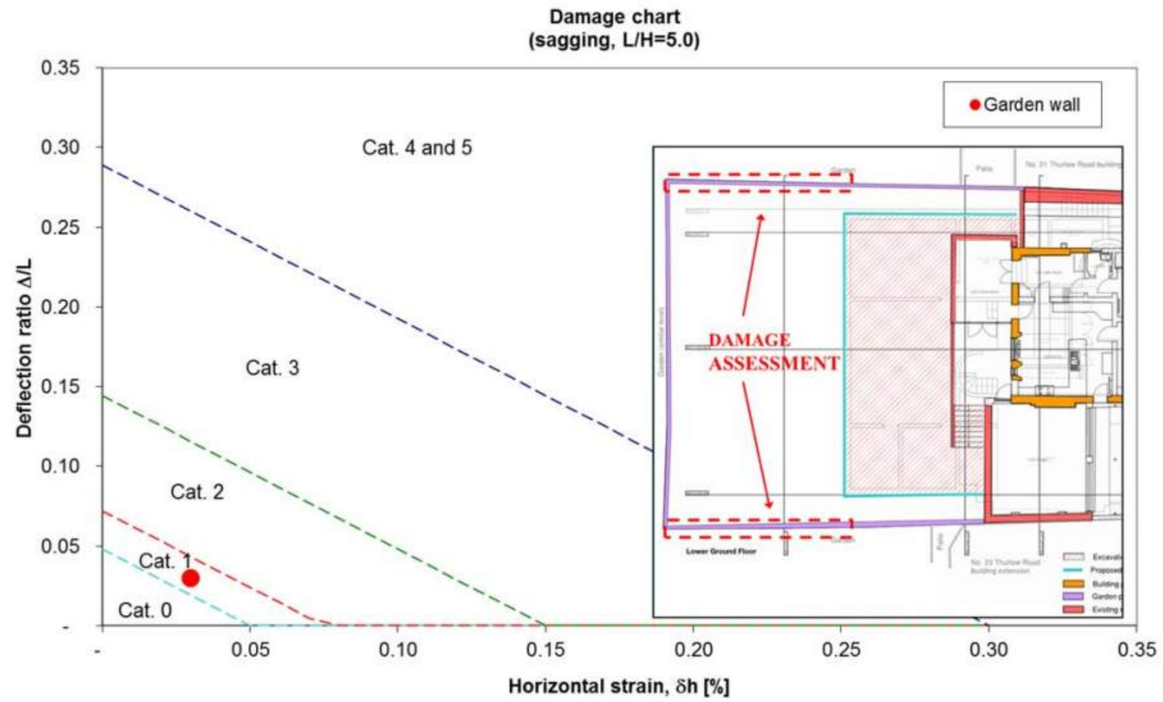


Figure 28 Garden wall damage assessment

Induced movements on the garden walls where they are situated parallel to the proposed retaining wall line have been also considered. The maximum predicted settlement deduced from the predicted settlement trough perpendicular to the walls at mid-span is 10mm. Based on Burland (1997, ref [12]), settlement perpendicular to a retaining wall at the corner of an excavation is approximately 67% of the settlement mid-span, i.e. 6.7mm at the basement corners for the present study. For the 7.5m and 9m lengths of garden wall parallel to the basement, this results in a relative deflection of the wall at mid-span of 3.3mm and a maximum deflection ratio 3.3/7500 = 0.044%. No significant horizontal strains are predicted to occur along this length of garden wall.

With reference to Figure 28 (allowing for a small reduction on the y intercept for the lower Δ/L), predicted damage is therefore within Category 1 "very slight".

8.4.2.2 No. 21 Thurlow Road

The rear façades of the main buildings at no. 21 and no. 22 Thurlow Road are approximately in line with each other. Since the proposed excavation is located in the garden area, it is considered that the detrimental effects on the main building at no.21 Thurlow Road are minimal. However, applying the predicted ground movements perpendicular to the basement walls at the building location, the damage category is 0 (negligible), as shown in the figure below.

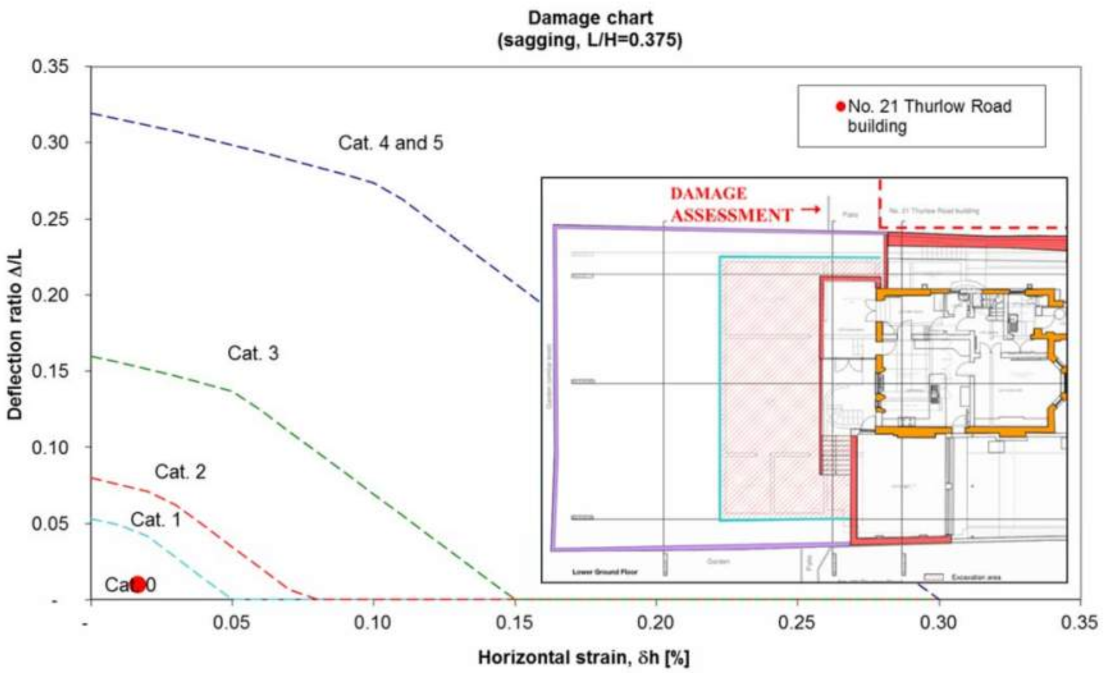


Figure 29 No. 21 Thurlow Road damage assessment

8.4.2.3 No. 23 Thurlow Road

The ground movements predicted to occur behind the proposed retaining wall have been applied to the property at no.23 Thurlow Road. The rear extension is the closest structure to the excavation site and it appears to be founded at a level similar to the proposed excavation. The approximate dimensions are 3m in width and 8m in height. The predicted ground movements at the surface have been conservatively adopted at foundation level to calculate the anticipated class of damage. The following figure shows that the damage is limited to Category 1.

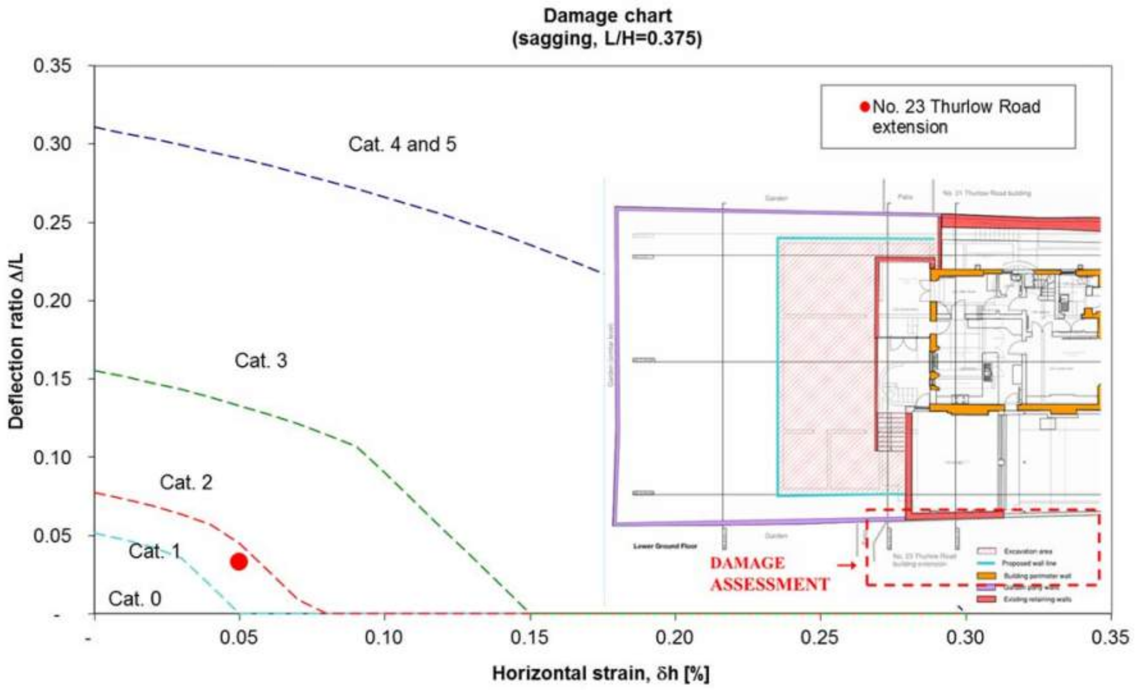


Figure 30 No. 23 Thurlow Road extension damage assessment

With regard to the main building at no.23 Thurlow Road, this is situated close to the corner of the proposed basement and therefore movement will be significantly less than predicted for plane strain conditions behind the middle section of the basement walls. Nevertheless, taking the building to start approximately 5m distance behind the new basement, Figure 25 shows a maximum deflection of 10mm and a slope of 1 in 1875 (8mm over 15m). These criteria are considered to lead to negligible damage, with no further studies required, in accordance with the preliminary assessment methodology described by Burland (1995).

Predicted damage is therefore within Category 1 “very slight”.

8.4.2.4 No.22 Thurlow Road – main building

No excavation is proposed in the current building and conservatory area and the proposed excavation is not adjacent to the existing building footings. Some small heave effects due to the extension of the lower ground floor area are anticipated (see calculations in Appendix E). Anticipated upwards ground movement in free-field conditions at the main building footing location is about 5mm. Considering the weight and stiffness of the structures (not considered in the analysis) and the small movement anticipated (5mm), the effects of the heave is considered negligible.

The damage expected to the main building is considered negligible.

8.4.2.5 New garage building effects

In the garage area an additional part storey is proposed. The existing garage wall at the boundary with No 23 Thurlow Rd will either be retained or demolished, depending on whether it helps to support the neighbour’s floors. If it is retained, it will be stabilised during construction, but no new loads will be added.

The existing garage floor and roof will be demolished. A new ground bearing RC floor slab will be constructed. New load from the newly constructed garage superstructure will be taken on four columns which sit on new pads. The proposed pads are offset from the columns to avoid the adjacent footings from No 22 and No 23 Thurlow Rd. Ground beams will link across the garage to balance the loads. Any new garage walls will not be load bearing and will sit on a thickened edge to the ground slab.

The loads on the columns are approximately 200kN maximum. For this load, square pads 1.3m x 1.3m are calculated to be appropriate, giving a FOS = 2.5 on ultimate bearing capacity. This calculation checks undrained and drained bearing capacity based on an undrained shear strength *cu* of 50kPa or an angle of friction of 27º in the Claygate Beds. The pads are assumed to be about 0.5m deep, or deeper if required to avoid load transfer to the adjacent footings assuming a 45º load spread. The bearing capacity calculations are given in Appendix F.

The excavations for the 1.3m square pads will be localised and will not have a significant impact on the bearing capacity of the adjacent foundations.

A settlement calculation has been carried out in PDISP for the ground loaded by the footing. This takes a drained stiffness E' = 220 cu for shallow foundations on the Claygate Beds, giving E' = 11,000kPa, and assumes a uniformly loaded flexible footing. The predicted settlements are shown in Figure 31. Given that the footing is rigid, settlement of the footing is calculated as approximately 0.8x the settlement at the centre of a flexible footing, giving a settlement of the footing of 10mm.

The nearest edges of the adjacent footings for No 22 and No 23 Thurlow Rd are assumed to be located about 1m from the centre of the new pads. Therefore resulting settlement of the adjacent footings is predicted to be about 4mm.

Localised settlements of the adjacent footings of 4mm in the vicinity of the new garage pads are not considered to have any significant impact on the adjacent structures.

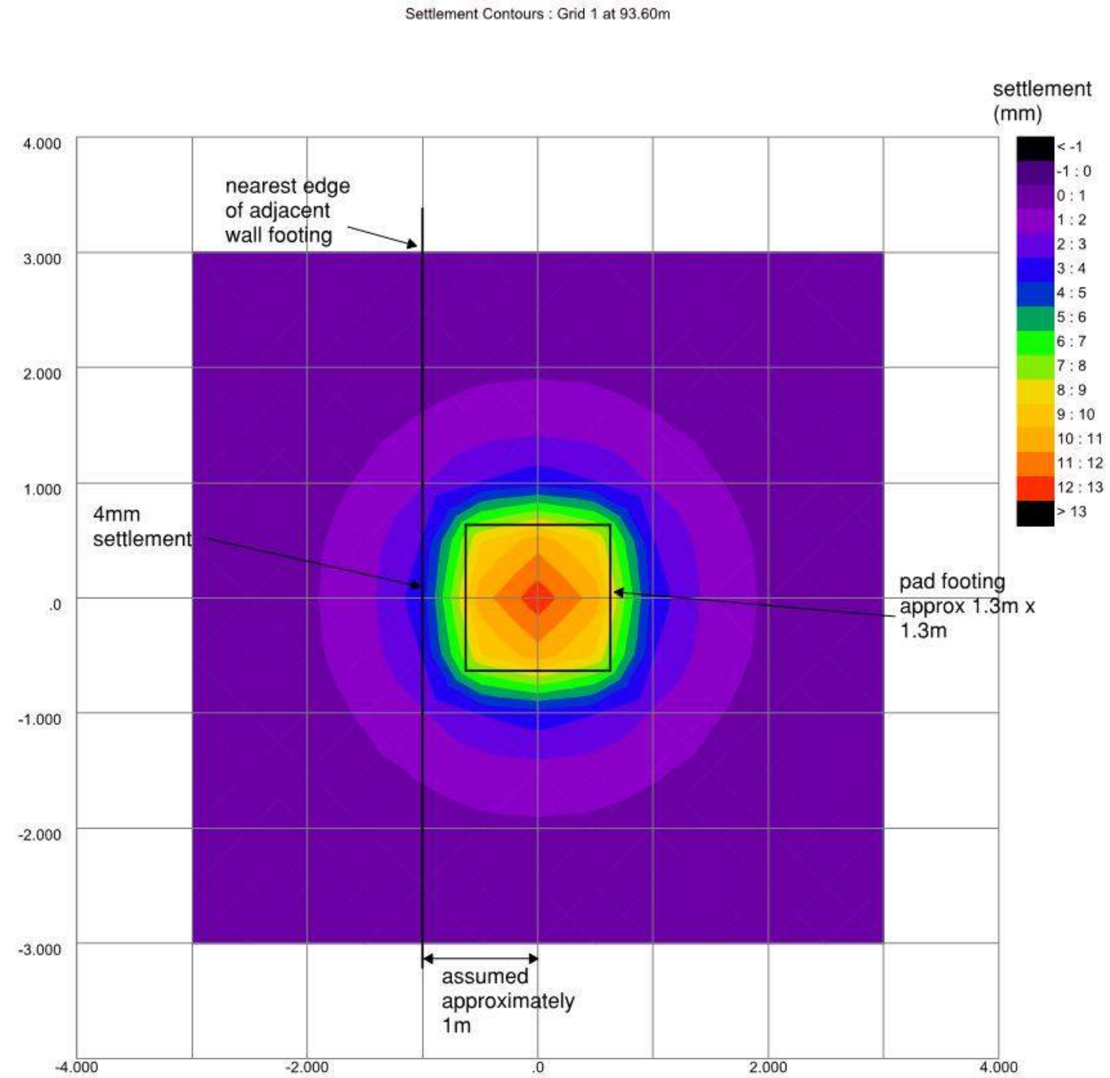


Figure 31 Anticipated settlement of the new garage foundation pads

8.4.3 Network Rail

The Network Rail tunnel connecting *Hampsted Heath* and *Finchley Road&Frognal* overground stations run at some depth below no. 22 Thurlow Road. Elevation of the tunnel is not confirmed by factual data but the Basement Impact Assessment presented in October 2011 by Michael Alexander Consulting Engineers for the previous proposed development at site stated that the tunnel '*was found to be around 35m below existing ground level at site*'. In the same report they said that a meeting was held with Network Rail Asset Management representatives which anticipated the impact of the development proposed at that time to be negligible. The current proposed development is significantly smaller than the previous one which should imply that a even smaller impact is anticipated on the NR asset. A simple analysis has been carried out in order to investigate the effect of the proposed basement excavation on the Network Rail tunnel underneath. The heave generated by the excavation decreases with depth and the corresponding ground movement has been predicted to be less than 1mm at tunnel elevation, hence negligible for the tunnel stability. More details on the undertaken analysis are given in Appendix E.

However, no factual data are available about the actual tunnel elevation and NR shall be contacted to confirm the feasibility of the currently proposed development.

8.5 Monitoring

A monitoring plan will be set out at design stage and will include a monitoring strategy, instrumentation and monitoring plan and action plan. Trigger levels on movements will be defined. Precise levelling (*Hilti* nail type precise levelling pins or *BRE* type levelling sockets) or reflective survey targets (retro reflective or 3D prisms) shall be installed at the garden walls and neighbouring buildings. Monitoring is proposed to take place in advance of the proposed works as a base-line survey, during the works and for a period time following the completion of the works, to understand the longer-term effects.

9 References

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