Chelmer
Consultancy Services
'Groundbreaking Services'

Basement Impact Assessment

Site 11 Cannon Lane
London
NW3 1EL

Client Greenway Architects
Date December 2014
Our Ref BIA/4938

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Report Status: **FINAL**		
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Foreword

This report has been prepared in accordance with the scope and terms agreed with the Client, and the resources available, using all reasonable professional skill and care. The report is for the exclusive use of the Client and shall not be relied upon by any third party without explicit written agreement from Chelmer Site Investigation Laboratories Ltd.

This report is specific to the proposed site use or development, as appropriate, and as described in the report; Chelmer Site Investigation Laboratories Ltd accept no liability for any use of the report or its contents for any purpose other than the development or proposed site use described herein.

This assessment has involved consideration, using normal professional skill and care, of the findings of ground investigation data obtained from the Client and other sources. Ground investigations involve sampling a very small proportion of the ground of interest as a result of which it is inevitable that variations in ground conditions, including groundwater, will remain unrecorded around and between the exploratory hole locations; groundwater levels/pressures will also vary seasonally and with other man-induced influences; no liability can be accepted for any adverse consequences of such variations.

This report must be read in its entirety in order to obtain a full understanding of our recommendations and conclusions.

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1.0 INTRODUCTION

1.1 This Basement Impact Assessment has been prepared in support of a planning application to be submitted to the London Borough of Camden (LBC) for the demolition of the existing house within the listed perimeter wall, bulk excavations to lower the ground levels and the construction of a new 3-storey building, with a single storey basement under its full footprint. Further details of the proposed re-development and basement are given in Section 3. The assessment is in accordance with the requirements of the London Borough of Camden (LBC) Development Policy DP27 in relation to basement construction, and follows the requirements set out in LBC's guidance document CPG4 'Basements and Lightwells' (September 2013).

1.2 This assessment has been prepared by Keith Gabriel, a Chartered Geologist with an MSc degree in Engineering Geology, and Mike Summersgill, a Chartered Civil Engineer and Chartered Water and Environmental Manager with an MSc degree in Soil Mechanics. Both authors have previously undertaken assessments of basements in several London Boroughs.

1.3 A preliminary site inspection (walk-over survey) of the house was undertaken on Tuesday 30th October 2014. Photos from that visit are presented in Appendix A. Desk study data have been collected from various sources including borehole records (Appendix B) and geological data, environmental data and historic maps from GroundSure which are presented in Appendices D, E and F. Relevant information from the desk study and site inspections is presented in Sections 2–6, followed by the basement impact assessment in accordance with CPG4 Stages 1–4 in Sections 7–10 respectively.

1.4 The following site-specific documents in relation to the proposed basement and planning application have been considered:

Greenway architects:

Existing

- Drg No's EP-101 & EP-102 — Basement and Ground Floor Plans
- Drg No. ES-101 — Section A-A
- Drg No's EE-102 & EE-103 — Front and Rear Elevations

Proposed

- Drg No's AE-101 – AE-103 — Side, Front and Rear Elevations
- Drg No. AP-101 to AP-104 — Floor Plans: Basement to First Floor
- Drg No. AS-001 — Context Section
- Drg No's AS-101 – AS-104 — Sections A-A, B-B, C-C and D-D

Chelmer Site Investigations (CSI):

Factual Report on Site Investigation, Ref: FACT/4938 (November 2014).

No structural engineering drawings were available at the time of writing. This report should be read in conjunction with all the documents and drawings listed above.

1.5 Instructions to prepare this Basement Impact Assessment (BIA) were sent by email on the 5th November 2014.

2.0 THE PROPERTY AND TOPOGRAPHIC SETTING

2.1 No.11 Cannon Lane is a large, multi-level, single/two-storey house, situated within the Hampstead conservation area in the London Borough of Camden. Cannon Lane is located west of East Heath Road, and can be accessed at its southern and eastern ends where it joins Well Road and East Heath Road respectively, and to the north-west where it shares a junction with Squires Mount. No. 11 is located on the west side of Cannon Lane, adjacent to its junction with Well Road. The site is bounded by the adjoining No.24 Well Road to the west, by the rear garden of Cannon Hall (No.14 Cannon Place) to the north, and by Well Road and Cannon Lane to the south and east respectively, as shown in Figure 1. The house is of 1970's origin, however it is located behind a listed wall which includes a 'Parish Lock Up' near the north-east corner of the site (see cover photo and Photo 1 in Appendix A) that is thought to date back to 1730.

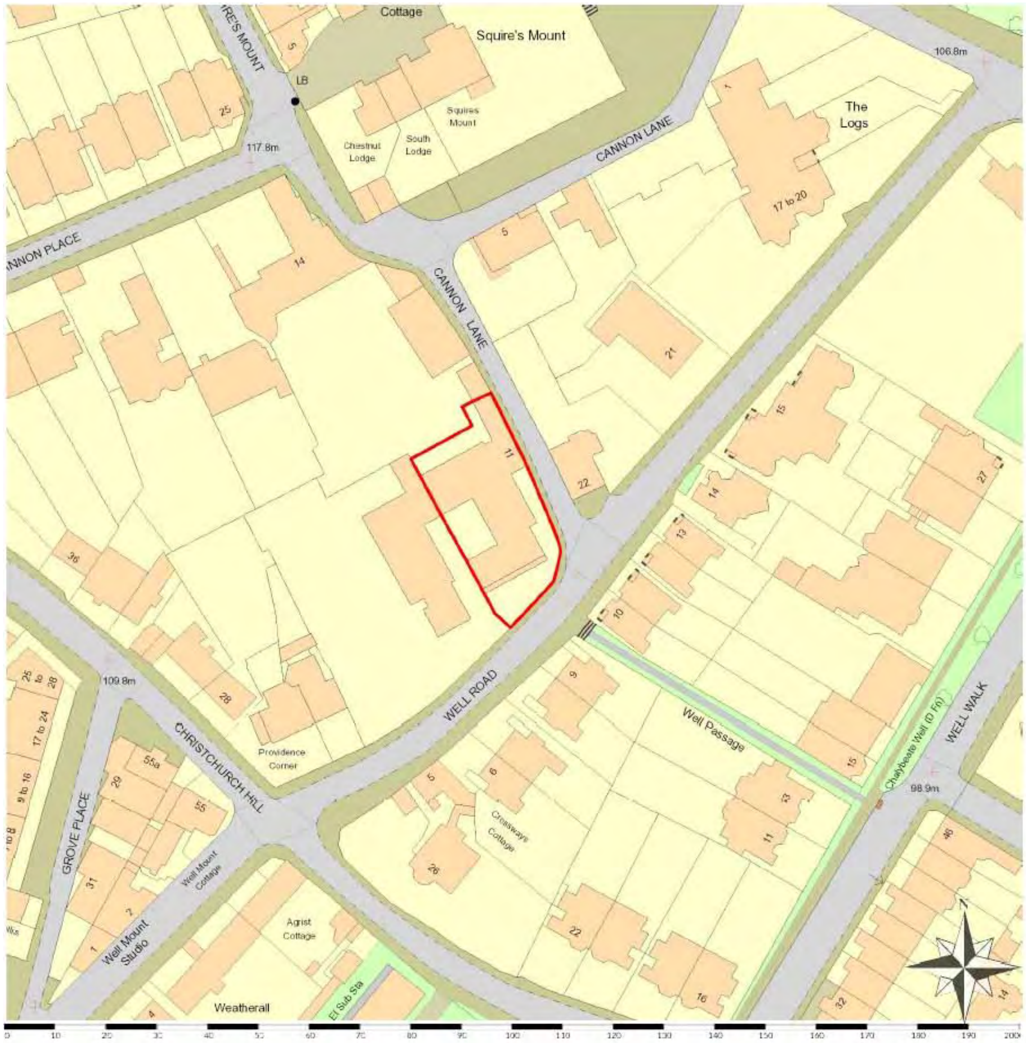


Figure 1: Extract from 1:1,250 OS map (not to scale) with the site outlined in red

2.2 Reference to the 1870 historic Ordnance Survey (OS) maps (see Appendix F) confirmed that the 'Parish Lock-Up' and brick boundary wall were constructed prior to that date, as was the road network in the surrounding area, and several properties close to the site, including those on the south side of Cannon Place (labelled as Cannonhall Road until the 1893 OS map). Behind the brick boundary wall, the site of No.11 Cannon Lane is shown by the 1870 OS map to include a well in the centre of the plot, situated within park land, with the lock-up and a greenhouse alongside the east boundary wall. Significant redevelopment of the surrounding area occurred prior to publication of the 1893 OS map, including the construction of houses both to the north and south of No.11, on the north side of Cannon Place and the south side of Well Road respectively. Development also occurred to the east of the site, including the construction of a property directly opposite No.11, as well as various others. Few changes can be seen between the 1893 and 1974 OS maps, however by the time the next available OS map was published (1991) a number of significant changes can be seen, including the construction of No.11, and the adjoining No.24 Well Road.

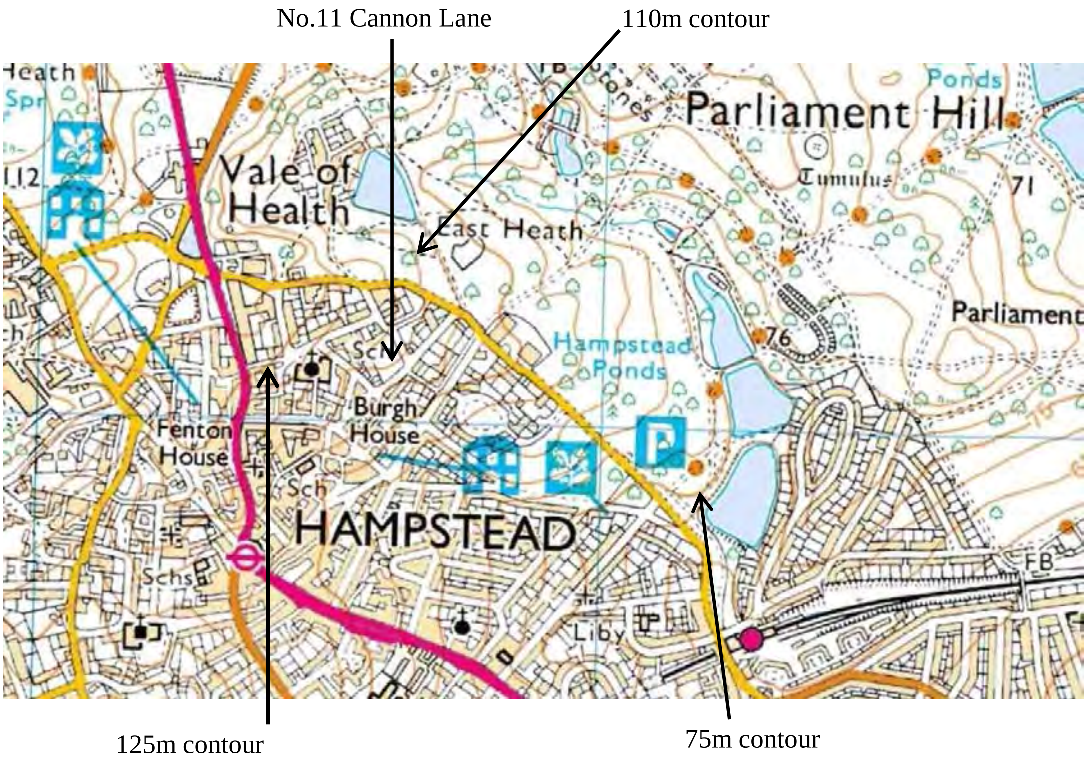


Figure 2: Enlarged extract from 1:25,000 Ordnance Survey map showing site location.

2.3 No.11 Cannon Lane is situated on a south-east facing slope, on the side of a weakly developed valley which eventually leads down to the former alignment of the river Fleet (reaching it just below Hampstead Ponds). Christchurch Hill follows this valley to the west of Cannon Lane, as illustrated by the contours on Figure 2.

The contours on the 1:25,000 scale Ordnance Survey (OS) map indicate an overall slope angle within the immediate vicinity of the site of approximately 5.5° (measured between the 110m contour, which crosses the site, and 115m contour). Considerable variation in the slope angle can be found both above and below the site, with measured slope angles ranging from 3.4° (between the 115m and 120m contours) to approximately 7° (between both the 120m/125m, and 100m/105m contours). However, Figure 16 of the Camden GHHS

(Camden Geological, Hydrogeological and Hydrological Study by Arup, November 2010) shows that there are no slopes >7° in the vicinity of the site – see extract presented in Figure 3.

2.4 The bomb map for Hampstead shows that the closest recorded hit to the property was a high explosive or incendiary bomb, which landed on the eastern side of Christchurch Hill, approximately 50m to the north-west of No.11. The OS maps do not show any major changes to the pattern of housing after WWII in the area concerned.

2.5 To the west of the site, outside of the brick boundary wall to No.11, there is a shared driveway which slopes gently up from the entrance gate/archway off Well Road (Photos 2 & 3) to a pedestrian entrance gate located close to the south-west corner of the plot, as well as a flight of stairs which leads up from the footway (Photo 4).

2.6 Within No.11's site, there is a front amenity area/garden which is mostly paved (Photo 5), as well as a small rear garden, which is part-paved and part soft landscaping (Photo 6). In addition to the front and rear gardens, there is a narrow side garden between the brick boundary wall and the eastern flank wall of the property which incorporates an ornamental pond (dry at the time of our visit). As was mentioned in paragraph 2.1, the listed brick boundary wall surrounds the southern and eastern sides of the plot; a more modern wall defines west boundary of the plot whereas retaining walls of varying age mark the northern boundary. The difference in levels between the front and rear gardens, as indicated by Greenway architects' Existing Section AA (Drg No. ES-101), is 4.17m. A number of trees, some large, were present in the neighbouring garden to the north of No.11's rear garden. Within No.11's garden the only trees of note were a few 8-10m high conifers alongside the east boundary wall.

2.7 A search of planning applications on LBC's planning website found a small number of applications for the construction of basements beneath houses or the construction of new houses with basements in the vicinity of No.11, including:

- **No.24 Well Road**: Application (2009/1090/P) involving the "*Erection of part one part two storey side extension adjoining the east boundary wall, 1st floor rear extension of existing garage, and excavation for a new basement floor under whole house and part of side garden, with front and side lightwells, to provide additional accommodation for the existing dwelling/house*" was granted planning permission (subject to a Section 106 legal agreement) on 21st July 2009. No documents relating to the ground conditions beneath the site were found.
- **No.5 Cannon Lane:** Application (2012/6658/P) involving "*amendments to planning permission ref: 2008/4242/P granted on 03/06/2009 (as amended by 2010/2557/P, 2011/6453/P, and 2009/3632/P) allowing for the erection of a new single family dwelling with two basement levels following demolition of existing house with increased height of rear dormer window and roof ridge, further excavation at lower garden level to create lightwells and patios with access to garden, and various changes to all elevations and boundary structures with further amendments to include the addition of a rooflight to the side roofslope*" was granted planning permission (subject to Section 106 legal agreement) on 21st March 2013. Documents relating to a ground investigation, which included 2 boreholes, were found.

3.0 PROPOSED BASEMENT

3.1 The proposed 3-storey building with basement for which planning permission will be sought, as shown in Greenway Architects' drawings, will require a general reduction of ground levels within most of the site. The main aspects comprise:

- Basement beneath the full footprint of the lower ground floor, including a swimming pool, gym and wine cellar. The basement's finished floor level (FFL) will generally be 10.77m above an arbitrary site datum (ASD), whereas the pool floor will be at 9.27m ASD.
- A lower ground floor with FFL at 14.72m ASD, with the rear garden excavated (by 5.83m) down to the same level across the full width of this floor. Owing to the topographic setting of the site, the level of this lower ground floor FFL will be similar to the level of the carriageway (Well Road) at the front of the property.
- An upper ground floor with a FFL at 21.12m ASD, which is approximately the same level as the parish lock-up. An external terrace with bike store will be created at this level in the north-east corner of the site.
- Staff quarters will be created above the parish lock-up and bike store; this will infill the small courtyard alongside the existing annex shown in Photo 8.

3.2 The footprint of the proposed building is smaller than that of the existing building, thus allowing for a larger garden, and a parking area inside of the brick boundary wall. Access to this parking area will be created by increasing the size of the existing entrance gate in the south-west corner of the plot. The parking area will remain at the existing ground level, whereas most of the front garden and the southern part of the side garden will be excavated by at least 1.2m to 15.17m ASD.

3.3 The basement's FFL will be approximately 4.4m below the level of the front garden, and 9.78m below the level of the existing rear garden. The floor of the pool is shown as 1.5m below the basement FFL. With an allowance of 0.5m for the thickness of the basement slab, insulation and floor finishes, the founding levels for the basement and the swimming pool will be approximately 4.9m and 6.4m respectively below the external ground level at the front of the house, and 10.3m and 11.8m respectively below the existing level of the rear garden.

4.0 GEOLOGICAL SETTING

4.1 Mapping by the British Geological Survey (BGS) indicates that the site is located just south of the boundary between the Bagshot Formation (to the north-west), and the Claygate Member which underlies the site. Figure 3 shows an extract from Figure 4 of the Camden GHHS (Camden Geological, Hydrogeological and Hydrological Study by Arup, November 2010) which illustrates the site geology of the north-west Hampstead area.

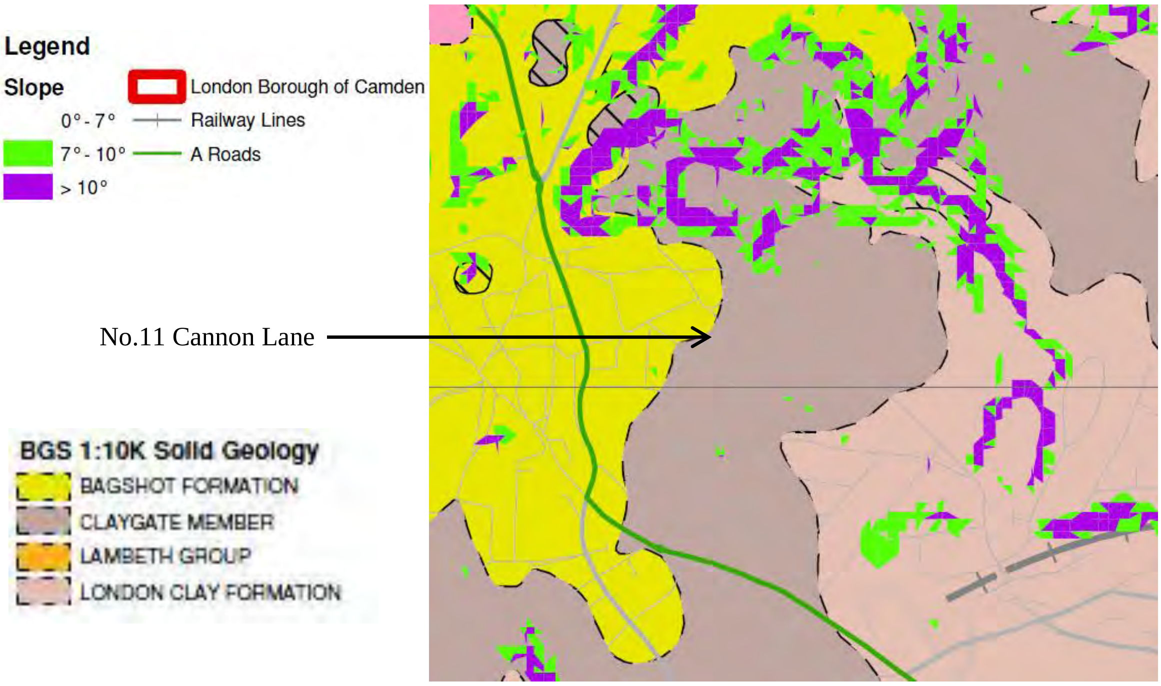


Figure 3: Extract from Figure 16 of the Camden GHHS (Arup, 2010) showing geology and slope angles >7° and >10°.

4.2 In urban parts of London, these natural strata are typically overlain by Made Ground. A thin superficial layer of natural, locally-derived re-worked soils called Head deposits may also be present (because these are not mapped by the British Geological Survey where they are expected to be less than 1.0m thick). In the areas which have been excavated, some or all of these deposits may have been removed.

4.3 The Claygate Member forms the uppermost unit of the London Clay Formation and is described in the relevant BGS memoir (Ellison et al, 2004) as "*alternating beds of clayey silt, very silty clay, sandy silt and glauconitic silty fine sand. Beds are generally 1 to 5m thick, although the boundaries are generally diffuse as a result of bioturbation*". The Claygate Member was 16.0m thick in the Hampstead Heath borehole (located to the NW of the site of present interest, near the top of the Heath) where the Claygate Member occurred between the levels of 93.71m and 109.71m AOD).

4.4 The London Clay beneath the Claygate Member is well documented as being a firm to very stiff over-consolidated clay which is typically of high or very high plasticity and high volume change potential. As a result it undergoes considerable volume changes in response to variations in its natural moisture content (the clay shrinks on drying and swells on subsequent rehydration). These changes can occur seasonally, in response to normal climatic variations, to depths of up to 1.50m and to much greater depths in the presence of the trees whose roots abstract moisture from the clay. The clay will also swell when unloaded by excavations such as those required for the construction of basements. The more silty and sandy clays of the Claygate Member generally have somewhat lower plasticities.

4.5 The Bagshot Formation which crops out to the north of the site is described by the BGS as "*pale yellow-brown to pale grey or white, locally orange or crimson, fine- to coarse-grained sand that is frequently micaceous and locally clayey, with sparse glauconite and sparse seams of gravel*". The base of the Bagshot Formation is marked by an erosional surface, with a basal fine gravelly sand developed in places.

4.6 The results of the BGS classifications of six natural ground subsidence/stability hazards are presented in the GroundSure GeoInsight report (see Appendix D, Section 4); all indicated "Negligible" or "Very low" hazard ratings with the exception of 'Shrink – Swell Clay' for which a 'Moderate' hazard rating was given, which reflects the outcrop of the Claygate Member at surface. Although the hazard rating for 'Running Sand' was indicated as "Very low" on site, it was given a "Low" hazard rating just 6m to the north-west of the site, reflecting the outcrop of the Bagshot Formation at surface.

4.7 A search of the BGS borehole database was undertaken for information on previous ground investigations and any wells in the vicinity of the site. Three relevant boreholes were identified, the locations of which are shown on the plan in Appendix B. BH TQ28NE/98 (originally known as OF11) was on Well Road by the former Old White Bear pub, south-west of the site. BH TQ28NE/97 (originally OF10) was at a slightly lower level on Well Walk to the south-east of the site, by the Chalybeate spring (see paragraph 4.4.5), while BH TQ28NE/96 (originally OF9) was further upslope near Cannon Hall. These boreholes are summarised in Table 1, with a tentative correlation between them. Reference should be made to the logs in Appendix B for full strata descriptions. Also included within Table 1 is a summary of the two borehole logs gleaned from the planning search, drilled at No.5 Cannon Lane during a ground investigation for the recently completed new house with double basement (see paragraph 2.7).

Table 1: Summary of BGS and other Boreholes - Depths/levels to base of strata							
Strata (abbreviated descriptions)	**BH TQ28NE/96 OF9**		**BH2 TQ28NE/97 OF10**		**BH21 TQ28NE/98 OF11**		**BH1 & BH2 (No.5 Cannon Lane)**
Approx GL (ft AOD)	Depth (ft)	**Level 385.50**	Depth (ft)	**Level 326.87**	Depth (ft)	**Level 354.09**	Depth (m)
Made Ground	3.0	**382.5**	4.0	**322.9**	1.0	**353.1**	1.10/0.60
Sand with silt and gravel (Head?)							-/2.20
CLAY with sand and gravel (Head?)							1.70/3.80
Sandy GRAVEL (Bagshot Fm?)	9.0	**376.5**	-	**-**	-	**-**	
Silty fine SAND (Claygate Mbr?)	28.0	**354.5**	-	**-**	-	**-**	6.70/6.90
Stiff CLAY & fine sand 'mixture' (Claygate Mbr)	>40.0	(345.5)	-	**-**	12.0	**342.1**	14.60/12.20
Silty, fine SAND	-	**-**	-	**-**	17.0	**337.1**	-/15.10
Firm, grey/red, silty CLAY and fine sand	-	**-**	-	**-**	22.0	**322.1**	
Dark grey, silty, sandy CLAY	-	**-**	-	**-**	25.0	**319.1**	>20.00
OF10: Fine SAND & softish clay. OF11: Silty SAND & CLAY	-	**-**	9.0	**317.9**	35.0	**309.1**	
Soft/firm, dark grey, silty sandy CLAY	-	**-**	15.0	**311.9**	-	**-**	
Firm/stiff or Stiff, dark grey silty CLAY (London Clay Fm?)	-	**-**	35.0	**291.9**	>40.0		
Silty SAND, to base of BH at:	-	**-**	>40.0		-	**-**	

4.8 The sandy GRAVEL in BH OF9 is tentatively taken as the base of the Bagshot Formation, because the geological memoir (Ellison et al, 2004) describes the basal unit in this Hampstead Heath outlier as "coarse grit with small well-rounded flint pebbles".

5.0 HYDROLOGICAL SETTING (SURFACE WATER)

No.11 Cannon Lane

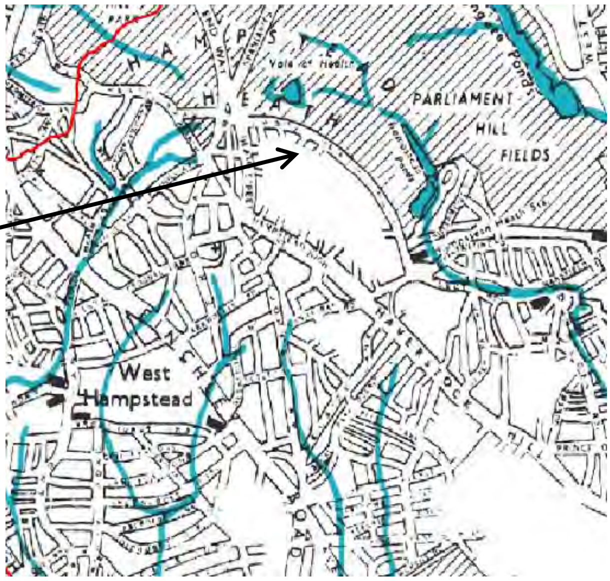


Figure 4: Extract from Figure 11 of the Camden GHHS (Arup, 2010) showing former watercourses, based on Barton (1992).

5.1 As shown in Figure 4, none of the 'lost' rivers of London, most of which now run in dedicated culverts or the sewer system, are illustrated as flowing close to the property. The nearest former watercourse to the property is the river Fleet, which is located at the base of the south-east facing slope on which the property is situated. The topographic map of the area appeared to reveal a weakly developed valley, which leads down to the former alignment of the river Fleet, broadly following the alignment of Christchurch Hill to the west of the property; however a former watercourse is not shown in this location in Figure 4.

5.2 Figure 14 of the Camden GHHS (Arup, 2010) shows that the site is not within the catchment of any of the Hampstead Heath Pond Chains, of which the Hampstead Chain is the nearest.

5.3 The front and side gardens to No.11 are bounded by high brick walls or by the house on all sides, as was described in paragraphs 2.5 and 2.6. Thus, the surface water catchment for this area is restricted to direct rainfall. The front garden, and the side garden up to the pond and adjacent flower bed, are predominantly surfaced with 'granite setts', so infiltration will be limited or nil in most of this area, although infiltration is likely to occur in the adjacent flower beds (see Photo 5). Any surface water run-off which reaches the entrance doorway near the south-west corner of the site would then flow away from the property, down the driveway or steps to Well Road.

5.4 The rear garden to No.11 is also bounded by high brick boundary walls, therefore the surface water catchment for the rear garden is also restricted to direct rainfall, and there will be no run-off from or to neighbouring gardens. Part of the rear garden to No.11 was surfaced with tiles so infiltration will be limited or nil in that area, whereas infiltration is likely to occur in the adjacent soft landscaped part of the rear garden (Photo 6).

5.5 Figure 5 shows that Cannon Lane did not flood during either the 1975 or the 2002 flood events. The closest road to the property which flooded in either of these events is Vale of Health to the north of the site, which flooded in 1975.

No.11 Cannon Lane

Figure 5: Extract from Figure 15 of the Camden GHHS (Arup, 2010) showing roads which flooded in 1975 (light blue), in 2002 (dark blue), and 'Areas with potential to be at risk of surface water flooding' (wide light blue bands).

5.6 Maps on the website of the Environment Agency (EA) show that the site lies within Flood Zone 1, which is defined as areas where flooding from rivers and the sea is very unlikely, with less than a 0.1 per cent (1 in 1000) chance of such flooding occurring each year. The EA's website also shows that this area does not fall within an area at risk of flooding from reservoirs.

5.7 The following hydrological data for the site has been obtained from the GroundSure EnviroInsight report (see Appendix E), including:

- The closest river (or more specifically "Detailed River Network entries") is the Tertiary grade upper waters of the river Fleet at 301-400m north and north-east of the property. This feeds into the Hampstead Pond Chain. The only other river feature within 500m is one of the Hampstead ponds centred at 433m north-east of the property (App.E, Section 5.10).
- The closest surface water feature is a pond centred 227m to the north of the site (see App.E, Section 5.11).
- There are no surface water abstraction licences within 2000m of the site (App.E, Section 5.4).
- There are no flood defences, no areas benefitting from flood defences and no flood storage areas within 250m of the site (App.E, Sections 6.3, 6.4 & 6.5).

5.8 Recently, further modelling of surface water flooding has been undertaken by the Environment Agency and was published on its website in January 2014; an extract from their model is presented in Figure 6. While this map identifies four levels of risk (high, medium, low and very low) it is understood that it is based at least in part on depths of flooding. This modelling shows a 'Very Low' risk of flooding (the lowest category for the national background level of risk) for No.11 and the surrounding area.

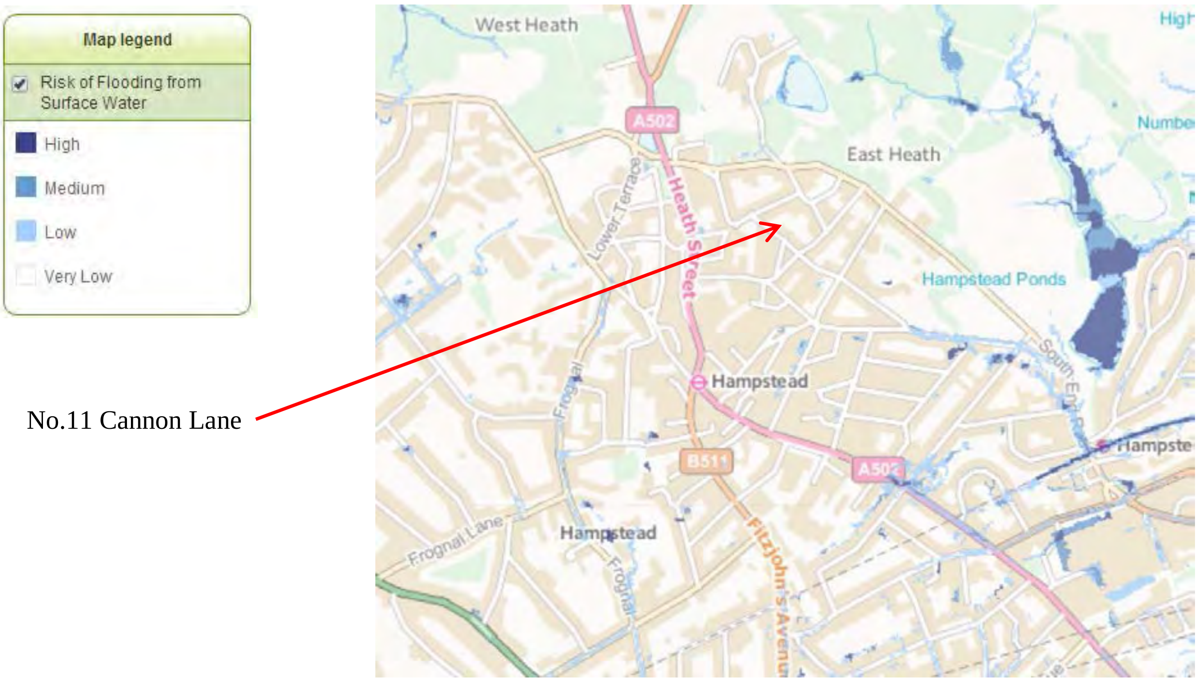


Figure 6: Extract from the Environment Agency's 'Risk of Flooding from Surface Water'.

5.8 The implications from these flood models are discussed in Section 10.7.

6.0 HYDROGEOLOGICAL SETTING (GROUNDWATER)

6.1 The Claygate Member and the overlying Bagshot Formation are both classified by the Environment Agency as a superficial 'Secondary A Aquifer', whereas the underlying London Clay is an 'Unproductive Stratum' as indicated by Figure 7.

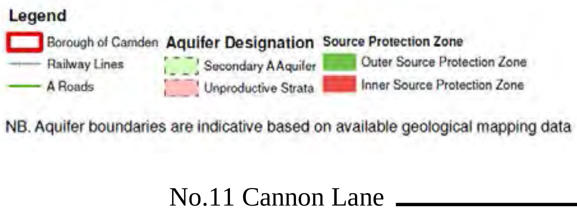
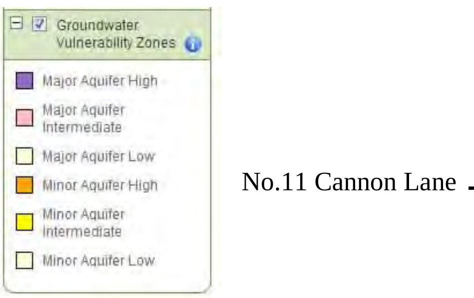


Figure 7: Extract from Figure 8 of the Camden GHHS (Arup, 2010) showing aquifer designations.

6.2 The Chalk Principal Aquifer which occurs at depth beneath the London Clay is not considered relevant to the proposed basement so is not considered further.

6.3 Under the old groundwater vulnerability classification scheme, which now applies only to superficial soils, the site is classed as 'Minor Aquifer High' groundwater vulnerability, as shown in Figure 8.



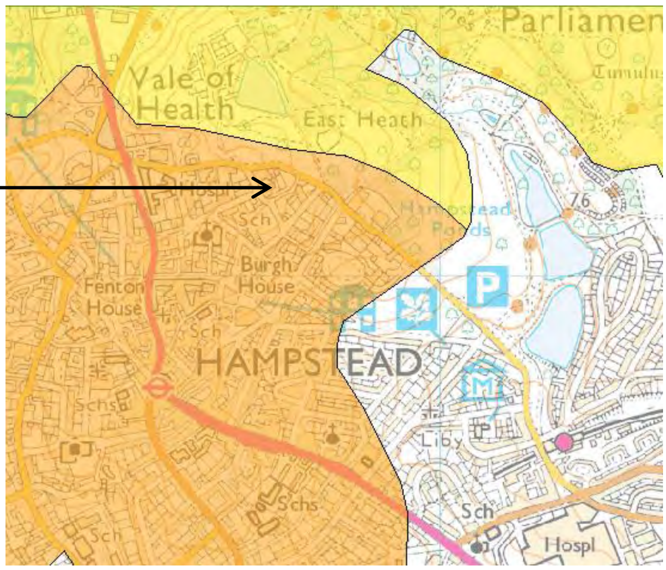


Figure 8: Extract from Environment Agency's map of Groundwater Vulnerability Zones and SPZs
(Red = Zone I, Green = Zone II).

6.4 The beds of silty sand and sandy silt within the Claygate Member would generally be expected to be water-bearing and where these are laterally continuous they can give rise to moderate water entries into excavations. The clay and silty clay beds would also be expected to be saturated, with water pressures controlled by the water levels/ pressures in adjacent silt/sand beds, by tree root activity, or by the influence of man-made changes such as utility trenches (which can act either land drains or as sources of water and high groundwater pressures). Boreholes drilled through low permeability layers can also homogenise groundwater pressures between permeable layers if they are not adequately sealed. Natural groundwater flow rates, if any, in the silt/sand horizons within the Claygate Member are typically low. Variations in groundwater levels and pressures will occur seasonally and with other man-induced influences.

6.5 Local perched groundwater may occur near surface in Made Ground, and possibly also in any Head deposits which overlie the Claygate Member, in at least the winter and early spring seasons.

6.6 While the London Clay Formation is classified as an 'Unproductive Stratum', it can still be water-bearing. In this case however, the London Clay is likely to be sufficiently deep to be of limited relevance.

6.7 The presence of interbedded sands, silts and clays of the Claygate Member give rise to various springs in the headwater valleys of the river Fleet. The lack of springs recorded within Hampstead village on the historic Ordnance Survey maps in Appendix F probably reflects their having been collected and channelled into drains/culverts long before the first OS map was published. A spring line is also often found at the interface between the Bagshot Formation, which is predominantly composed of sands, and the top of the Claygate Member. However, this is less likely to occur in this area, where the upper part of the Claygate Member also consists of sands.

6.8 The historic maps in Appendix D show a Chalybeate spring on Well Walk, at the lower end of Well Passage, approximately 85m downslope of the site to the south-east (see Figure 1). Chalybeate springs are particularly iron-rich, as well as having high levels of some other minerals, and were claimed to have a variety of health-giving properties. From the 1915 map onwards it is referred to as a well, rather than a spring. The 1871 map gives a spot height of 329.3 feet (100.4m) AOD on the path immediately above the well; the current map gives a spot height of 98.9m AOD on Well Walk, just east of the Chalybeate well, which is more than 10m below No.11's site. BGS BH OF10 was drilled at the junction of Well Walk and Gainsborough Gardens, close to the east of this spring/well (see paragraph 4.7 and Table 1).

6.9 The historic OS maps show several wells in this part of Hampstead, including the well located within the site of No.11 Cannon Lane. These exploited either the Bagshot Formation or the sand layers within the Claygate Member.

6.10 No groundwater entry was recorded in BGS BH OF9, although the sands at 5.3-8.5m bgl were 'extremely wet and running'. The log for BH OF10 records 'Water first met at 20.0', in the stiff silty CLAY below the near-surface sands. In BH OF11 water was 'first met' at 17'.0" which is the base level of the 'extremely wet' silty fine SAND in that borehole. Piezometers were installed in these boreholes, but no readings from them were included in the records on the BGS website.

6.11 The groundwater catchment areas upslope of No.11 are likely to differ for each of the main stratigraphic units:

- Made Ground: The catchment for any perched groundwater in the Made Ground is probably limited to No.11's own front and rear gardens, except where the trenches for drains and other services provide greater interconnection.
- Claygate Member and London Clay Formation: The catchment for the underlying in-situ strata will comprise recharge from the overlying soils in the vicinity of the site plus a much wider area determined by the lateral degree of interconnection between the sand horizons in the Claygate Member and the overlying Bagshot Formation.

6.12 Other hydrogeological data obtained from the GroundSure EnviroInsight report (Appendix E) include:

- The nearest groundwater abstraction licence is 1816m to the south of the site at the Swiss Cottage Open Space Borehole (TQ28SE1769) (see Appendix E, Section 5.3), so is irrelevant to the proposed basement.
- There are no abstraction licences for potable water within 2000m of the site (App.E, Section 5.5).
- There are no Source Protection Zones (SPZ) within 500m of the site (App.E, Section 5.6). The nearest is over 1km to the south of the site, so is irrelevant to the current issue.
- For an area within 50m of No.11, the BGS has classified the susceptibility to groundwater flooding as '**Limited Potential**', at a 'Low' confidence level (App.E, Sections 6.6 and 6.7). Such groundwater flooding is defined as "*the emergence of groundwater at the ground surface or the rising of groundwater into man-made ground under conditions where the normal range of groundwater levels is exceeded*".

6.13 Details of what was found by the site-specific ground investigation in November 2014 are presented in Section 9.

7.0 STAGE 1 - SCREENING

7.1 The screening has been undertaken in accordance with the three screening flowcharts presented in LBC's CPG4 guidance document. Information to assist with answering these screening questions has been obtained from various sources including the site-specific ground investigation, the Camden geological, hydrogeological and hydrological study (Arup, 2010), historic maps and data obtained from GroundSure (see Appendices D, E & F) and other sources as referenced.

7.2 Subterranean (groundwater) flow screening flowchart:

Question		Response, with justification of 'No' answers	Clauses where considered further
1a	Is the site located directly above an aquifer?	Yes	Carried forward to Scoping: 8.2, Section 10.2
1b	Will the proposed basement extend beneath the water table surface?	Yes	Carried forward to Scoping: 8.2, Sections 10.2 & 10.3
2	Is the site within 100m of a watercourse?	No – The nearest surface water feature is a pond centred 227m to the north of the site.	5.1 & 5.6
3	Is the site within the catchment of the pond chains on Hampstead Heath?	No – As shown on Figure 14 of the Camden GHHS.	
4	Will the proposed basement development result in a change in the proportion of hard surfaced/ paved areas?	Yes (probably) - reduced hard cover because of the smaller footprint of proposed house and larger area of garden.	Carried forward to Scoping: 8.2, Section 10.2
5	As part of the site drainage, will more surface water (eg: rainfall and run-off) than at present be discharged to the ground (eg: via soakaways and/or SUDS)?	Yes (possibly) as Q4 above.	Carried forward to Scoping: 8.2, Section 10.2
6	Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to, or lower than, the mean water level in any local pond (not just the pond chains on Hampstead Heath) or spring line?	No – There are no surface water features within 200m of the site. The main (Chalybeate) spring in the vicinity is 85m downslope from the site, and has been described as a 'well' on OS maps since 1915, which suggests a long-term decline in groundwater levels.	6.8

7.3 Slope/ground stability screening flowchart:

Question		Response, with justification of 'No' answers	Clauses where considered further
1	Does the existing site include slopes, natural or man-made, greater than 7°? (approximately 1 in 8)	No – Gradients within the site are gentle (between steps/ retaining walls). See Fig 3.	2.3
2	Will the proposed re-profiling of landscaping at site change slopes at the property boundary to more than 7°?	No – Re-profiling will be within bored pile retaining walls.	
3	Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	No – There are no slopes >7° in the vicinity of the site. See Figure 3.	2.3
4	Is the site in a wider hillside setting in which the general slope is greater than 7°?	No – As Q3 above	2.3
5	Is the London Clay the shallowest strata at the site?	No – Site is underlain by Claygate Member.	4.1
6	Will any tree/s be felled as part of the proposed development and/or are any works proposed within any tree root protection zones where trees are to be retained?	No. The existing trees will remain in an area of soft landscaping, so it is assumed that they will be retained, and the new house will be further from them than the existing house.	
7	Is there a history of seasonal shrink/swell subsidence in the local area, and/or evidence of such effects at the site?	No – no evidence seen.	
8	Is the site within 100m of a watercourse or potential spring line?	Yes – The Chalybeate spring is approx 85m downslope.	Carried forward to Scoping: 8.3, Section 10.4
9	Is the site within an area of previously worked ground?	No – See BGS map extract (Figure 3 herein) and maps on pages 8 & 15 of the GeoInsight report (in Appendix D).	4.1
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 and Yes	Carried forward to Scoping: 8.3, Section 10.4
11	Is the site within 50m of the Hampstead Heath ponds?	No – Site is approx 540m from nearest Hampstead Pond Chain (No.3) and 227m from pond to north of site.	5.6
12	Is the site within 5m of a highway or a pedestrian right of way?	Yes	Carried forward to Scoping: 8.3, Section 10.4
13	Will the proposed basement substantially increase the differential depth of foundations relative to neighbouring properties?	Yes	Carried forward to Scoping: 8.3, Section 10.4
14	Is the site over or within the exclusion zone of any tunnels, eg railway lines.	No – Re railway tunnels. Unknown re other tunnels.	Carried forward to Scoping: 8.3, 10.1.3

7.4 Surface flow and flooding screening flowchart:

Question		Response, with justification of 'No' answers	Clauses where considered further
1	Is the site within the catchment of the pond chains on Hampstead Heath?	No – As shown on Figure 14 of the Camden GHHS.	
2	As part of the proposed site drainage, will surface water flows (eg volume of rainfall and peak run-off) be materially changed from the existing route?	Unknown	Carried forward to Scoping: 8.4 & Section 10.7
3	Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?	Yes (probably) because of the smaller footprint of the proposed house and larger area of garden.	3.1 Carried forward to Scoping: 8.4 & Section 10.7
4	Will the proposed basement result in changes to the profile of the inflows (instantaneous and long-term) of surface water being received by the adjacent properties or downstream watercourses?	No – There is no run-off to adjacent properties (the only possible run-off is down the shared drive which, if anything, will reduce because of the proposed excavation of the front garden). The historic natural watercourse downslope of the property has been culverted since the 1800's.	5.3, 5.4
5	Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No – There will be no run-off to adjacent properties. None of the (minimal) surface run-off from this property reaches a nearby watercourse.	5.3, 5.4
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 – Neither Cannon Lane nor Well Road flooded in either 1975 or 2002, and surface water flood modelling by the Environment Agency indicated a 'Very Low' flood risk (the lowest) for this property and the surrounding area.	5.5 & Figure 5.

7.5 Non-technical Summary – Stage 1:

The screening exercise in accordance with CPG4 has identified eleven issues which need to be taken forward to Scoping (Stage 2); four related to groundwater, five are related to ground stability and two are related to flooding potential.

8.0 STAGE 2 - SCOPING

8.1 The scoping stage is required to identify the potential impacts from the aspects of the proposed basement which have been shown by the screening process to need further investigation. A conceptual ground model is usually compiled at the scoping stage however, because the ground investigation has already been undertaken for this project, the conceptual ground model including the findings of the ground investigation is described under Stage 4 (see Section 10.1).

8.2 Subterranean (groundwater) flow scoping:

Issue (= Screening Question)		**Potential impact and actions**
1a	Is the site located directly above an aquifer?	**Potential impact**: Infiltration could be reduced. **Action:** Ground investigation required, then review.
1b	Will the proposed basement extend beneath the water table surface?	The anticipated groundwater regime is described in Section 6, Hydrogeological Setting. **Potential impact**: Local restriction of groundwater flows (perched groundwater or below groundwater table). **Action:** Ground investigation required, then review.
4	Will the proposed basement development result in a change in the proportion of hard surfaced/ paved areas?	**Potential impact:** Increased hard surfacing would decrease infiltration of surface water into the ground. Reduced hard surfacing above an aquifer, while generally beneficial in promoting recharge, might lead to local groundwater flooding elsewhere. **Action:** Review potential impacts of proposed changes, including appropriate types of SuDS for use as site-specific mitigation when relevant.
5	As part of the site drainage, will more surface water (eg: rainfall and run-off) than at present be discharged to the ground (eg: via soakaways and/or SUDS)?	**Potential impact:** Increased discharge of surface water above an aquifer, while generally beneficial in promoting recharge, might lead to local groundwater flooding elsewhere. **Action:** Review potential impacts of proposed increased discharge, including appropriate site-specific mitigation when relevant.

8.3 Slope/ground stability scoping:

Issue (= Screening Question)		Potential impact and actions
8	Is the site within 100m of a watercourse or potential spring line?	**Potential impact:** For watercourse(s) or spring(s) downslope of the proposed basement, as applies here, construction of the basement might block or divert the flow of groundwater, thereby increasing groundwater pressures and reducing the stability of slopes and/or retaining structures in the vicinity. **Action:** Review hydrogeology of the site and undertake a ground investigation.
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?	**Potential impact:** Inadequate provision of dewatering can lead to collapse of excavations. Inappropriate dewatering can cause removal of fines and/or unacceptable increases ineffective stress, both of which can cause ground structures to settle. . **Action:** Ground investigation required in order to enable a proper assessment of the appropriate forms of groundwater control.
12	Is the site within 5m of a highway or a pedestrian right of way?	**Potential impact:** Excavation of basement causes loss of support to footway/highway and damage to the services beneath them. **Action:** Ensure adequate temporary and permanent support by use of best practice working methods.
13	Will the proposed basement substantially increase the differential depth of foundations relative to neighbouring properties?	**Potential impact:** Loss of support to the ground beneath the foundations to No.24 if basement excavations are inadequately supported. **Action:** Ensure adequate temporary and permanent support by use of best practice underpinning methods. Consider the need for transition underpinning.
14	Is the site over or within the exclusion zone of any tunnels, eg railway lines.	**Potential impact:** Stress changes on any tunnel lining. **Action:** Undertake services search to check that there are no tunnels/services in the vicinity.

8.4 Surface flow and flooding scoping:

Issue (= Screening Question)		Potential impact and actions
2	As part of the proposed site drainage, will surface water flows (eg volume of rainfall and peak run-off) be materially changed from the existing route?	**Potential impact:** Changes to drainage route can alter the discharge hydrograph and potentially result in increased flooding elsewhere. **Action:** Investigate existing drainage system, and provide appropriate flood resistance and mitigation measures as appropriate**.**
3	Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?	**Potential impact:** May increase flow rates to sewer, and thus increase the risk of flooding (locally or elsewhere). **Action:** Assess net change in hard surfaced/paved areas and, if required, recommend appropriate types of SuDS for use as site-specific mitigation.

8.5 Non-technical Summary – Stage 2:

The scoping exercise has reviewed the potential impacts for each of the items carried forward from Stage 1 screening, and has identified the following actions to be undertaken:

- A ground investigation is required (which has already been undertaken).
- Review of site's hydrogeology and groundwater control requirements.
- Assess the net change in area of hard surfacing and the potential for change in discharge to the ground.
- Investigate existing drainage system.
- Review need to implement appropriate types of Sustainable Drainage System (SuDS) in order to offset (mitigate) any potential increase in discharge to mains sewer.
- Ensure adequate temporary and permanent support by use of best practice working methods.
- Consider the need for transition underpinning to mitigate differential foundation depths.
- Undertake a services search to ensure there are no deep tunnels/services.
- Review flood risk and include appropriate flood resistance and mitigation measures in the scheme's design.

All these actions are covered in Stage 4, or Stage 3 for the ground investigation.

9.0 STAGE 3 – GROUND INVESTIGATION

9.1 A site-specific ground investigation was undertaken by Chelmer Site Investigations (CSI) on 13th November 2014, and included three continuous flight auger boreholes (BH1, BH2 & BH3) drilled to depths of 8-15m below ground level, and three hand dug trial pits (TP1, TP2 & TP3). The factual findings from the investigation are presented in Appendix C, including a site plan, trial pit logs, borehole logs, groundwater monitoring and laboratory test results.

9.2 The three trial pits were excavated in order to expose the foundations of the brick retaining walls located to the rear of the property (see site plan for locations).

- TP1 was excavated in the north-west corner of the site, exposing both the foundations of the western boundary wall, and the rear retaining wall in sections A & B respectively. TP1 section A revealed brickwork to a depth of 0.4m below ground level (bgl), resting on a 0.4m thick concrete slab which projected 0.3m from the face of the wall. Section B revealed 0.55m of brickwork bgl with two brick corbels at its base, each projecting 75mm from the face of the wall, resting on a 0.25m thick brick and concrete slab which projected a further 150mm. This brick and concrete slab was described as "in poor condition" in all the trial pits in which it was found.
- TP2 was excavated at the eastern end of the rear retaining wall, the foundations of which were exposed in TP1 section B. As a result, TP2 revealed the same foundations as were described in TP1 section B, with the exception of the founding depths, which were recorded to be 0.1m below those recorded in TP1.
- TP3 was excavated in the north-east part of the rear garden, at the intersection between south and east facing sections of the rear retaining wall (see location plan). Section A (east facing part of retaining wall) revealed the same foundations as were described in TP1 section B and TP2, however were founded at a greater depth, with the base of the brickwork and concrete slab at depths of 0.95m and 1.2m bgl respectively. In section B (south facing part of retaining wall), the base of the brickwork was found at ground level, below which was a 0.28m thick concrete slab which extended southwards beyond the area investigated by the trial pit.

9.3 In all three trial pits, a 0.28-0.38m thick reinforced concrete slab was found directly overlying Made Ground, which was described as "medium compact, dark brown, (slightly gravelly in TP1), silty, fine to medium **sand**, with brick fragments". This Made Ground was proved to depths of 0.8-1.2m bgl, below which, "medium dense, light brown–brown, very silty SAND with occasional fine gravel" was described.

9.4 The site's geology as found by the boreholes may be summarised as:

- Made Ground: Intercepted beneath the topsoil within BH1 only, the Made Ground was described as "medium compact, dark brown, slightly sandy silt with occasional brick fragments and fine gravel", with a maximum depth of 1.35m below ground level (bgl).
- Claygate Member: Immediately beneath the Made Ground/Topsoil, BH1 and BH3 recorded "medium dense, light brown-brown, slightly-very silty fine SAND" (with the addition of "occasional gravels" to the description in BH3), to depths of 2.8 and 6.5m bgl respectively. These sands were also described in BH2 to a depth of 3.6m bgl, however were encountered beneath a 1.0m thick horizon of "firm, greyish brown, slightly silty sandy CLAY with occasional fine gravel". In BH3 only, "Medium dense to dense, wet, mid brown, clayey very silty fine and medium SAND" was then described below 6.5m, to a depth of 14.5m bgl.

  In BH1 and BH2, variations of CLAYS were then described from the base of the overlying SAND, to the base of the boreholes at 8 and 10m bgl respectively. These clays were generally stiff, brown in colour, and varied from "silty, sandy CLAYS" to "sandy, very silty CLAYS", commonly with partings of brown/orange silt and fine sand. The clay was also described as "becoming very stiff" from 7.4m and 6.8m bgl in BH1 and BH2 respectively. Clay was also encountered in BH3, from the base of the overlying sand to the base of the borehole at 15m bgl, but was described as "very stiff, mid grey silty CLAY with partings of grey silt and fine sand and crystals".

9.5 Roots of live and dead appearance were described to depths of 0.25 and 0.20m bgl in BH1 and BH2 respectively, and to a depth of 1m in TP2.

9.6 Both groundwater seepage and groundwater strikes were recorded during drilling, the results of which are summarised in Table 2 below. Standpipes were installed to the base of all three boreholes, enabling the groundwater levels to be monitored. The groundwater levels recorded over the subsequent short period of monitoring are also included within Table 2. In general the results of the groundwater monitoring show a slight rise in the groundwater levels over time, with the exception of BH3, in which a significant rise in the groundwater level was recorded, from below 15m (dry) to 6.8m bgl.

Table 2: Summary of groundwater records from CSI's boreholes

Location	Seepage (m bgl)	Strike (m bgl)	Borehole condition on completion	Depth to water (m bgl)	
				20/11/2014	08/12/1014
BH1	7.40	-	Wet at base and open-	6.67	6.36
BH2	3.60	8.20	Wet and collapsing at 4.0m	6.69	6.38
BH3	-	6.50	Wet and collapsing at 10.0m	dry	6.80

9.7 Laboratory Testing:

Laboratory tests were carried out by Chelmer Geotechnical Laboratories and others on samples recovered from the three boreholes. The tests undertaken included classification tests (moisture content and plasticity), particle size distribution gradings, and chemical testing in accordance with BRE Special Digest 1 (2005) to assess the potential for acid or sulphate attack on buried concrete (by QTS Environmental Ltd). The results are presented in CGL's Geotechnical Testing report.

9.8 Plasticity tests were performed on samples of the clayey strata, including two samples recovered from BH1 at 3.5 and 5.0m bgl, two samples recovered from BH2 at 1.0 and 10.0m bgl, and one sample recovered from the base of BH3 at 15.0m bgl. With the exception of the upper sample recovered from BH2, all of the samples were found to be of Intermediate Plasticity, as classified by BS5930 (1999, 2010), and Medium volume change potential, as defined by the NHBC (NHBC Standards, 2013, Chapter 4.2, Building near Trees). The sample recovered from 1.0m bgl in BH2 was found to be of Low Plasticity, and Low volume change potential; however it should also be noted that the majority of the samples were close to the boundary between Low and Medium volume change potential.

9.9 The moisture contents of the five samples tested were found to vary between 21% and 37%, with the overall trend showing an increase with depth (see plotted profiles against depth in CGL's report). As only a maximum of two samples were taken from each of the boreholes, there could be significant variation between the samples, and therefore further data would be required to confirm this trend.

9.10 The grading analyses were carried out on four samples of the sand from the Claygate Member by wet sieving, including one sample recovered from BH1 at 2.0m bgl, one sample recovered from BH2 at 3.0m bgl, and two samples recovered from BH3 at 5.0 and 9.0m bgl. The results were very consistent, with all four samples consisting of silty/clayey fine SAND.

9.11 The chemical tests were undertaken on a total of five samples, recovered at various depths from BH1, BH2 and BH3, in order to assess the potential for acid or sulphate attack on buried concrete and recorded the following ranges of results:

pH value:	5.6 – 8.0
Water-soluble sulphate:	20 – 50 mg/l
Total Sulphur:	<200 – 424 mg/kg
Total Sulphate	220 – 1282 mg/kg
Oxidisable sulphides	DS1

9.12 Non-technical Summary – Stage 3:

9.12.1 The ground investigation found an unexpected thickness of sand, attributed to the top of the Claygate Member, within the northern part of the site. These sands were also recorded in the southern part of the site, however with a significantly reduced thickness. Clays, also attributed to the Claygate Member, were found underlying the sand to the maximum depths investigated. The grey silty clay at the base of borehole BH3 might represent the top of the main London Clay deposit, of might be a less sandy clay within the Claygate Member.

9.12.2 Groundwater seepage and strikes were recorded in the boreholes during drilling, and water levels in installed standpipes rose slightly during the short period of monitoring in late Autumn (and all three were reading at a significant depth below ground level, though within the depth of excavation for the proposed basement).

9.12.3 The laboratory testing has shown that almost all of the clay specimens from the Claygate Member were of Intermediate plasticity and Medium volume change potential. Grading analyses of the samples of sand from the Claygate Member revealed them all to consist of silt/clayey fine sand, with very little difference between the samples.

10.0 STAGE 4 – BASEMENT IMPACT ASSESSMENT

10.1 Conceptual Ground Model

10.1.1 The desk study evidence together with the ground investigation findings suggest a conceptual ground model for the site characterised by:

- Made Ground: found sporadically across the site, Made Ground was recorded to a maximum depth of 1.4m below ground level (bgl) (including overlying topsoil). In the northern part of the site the Made Ground was described as "medium compact, dark brown, slightly gravelly, silty, fine to medium **sand**, with brick fragments", whereas at the other end of the site the Made Ground was described as "medium compact, dark brown, slightly sandy **silt** with occasional brick fragments and fine gravel". Made Ground is inherently variable, therefore other materials and different thicknesses are likely to be found across the site.

  Perched groundwater may occur locally within this Made Ground, supported on horizons of lower permeability; such perched groundwater may only be present during the wetter winter and spring seasons.

- 'Head' Deposits?: The uppermost parts of the Claygate Member described within both the boreholes and the trial pits may consist of Head Deposits (see section 4.2). These locally-derived re-worked soils typically consist of material that has been washed down from upslope (Bagshot Formation and upper part of Claygate Member). 'Occasional gravels' were described within the near-surface clays and sands in the northern part of the site, and gravel was described within the Made Ground encountered in the southern part of the site. These gravels may originate from the gravel horizon described near the top of borehole OF9 (located upslope of the site), which are thought to form the basal bed to the Bagshot Formation, which overlies the Claygate Member (see section 4.1 and CSI's Factual Report). Further investigation would be required to confirm the presence of Head Deposits on site, however, as it is also possible that the gravels originate from the Claygate Member.
  Perched groundwater sufficient to give at least small to moderate water entries into excavations may be found in these suspected Head deposits, even though no such groundwater was recorded in the boreholes.

- Bagshot Formation: Predominantly fine sands which cap Hampstead Heath and are mapped as extending to with 6m of the site's northern boundary, so possibly present behind the retaining wall on that boundary. The BGS Memoir notes that the lowest bed in this 'outlier' is a "coarse grit with small well rounded flint pebbles". The gravel at the top of BGS BH OF9 has tentatively been correlated with that basal bed (see geological section in Appendix C).
- Claygate Member (part of the London Clay Formation): SANDS and CLAYS of the Claygate Member were described directly beneath the Made Ground/Top soil (or possible Head deposits) to the maximum depths excavated. The classification of these deposits as part of the Claygate Member is based both on BGS mapping of the area, and the interpretation of the overlying gravel in borehole OF9 (see Appendix B) as being the basal bed of the Bagshot Formation. Tentative correlations between the boreholes drilled on site and BGS BH OF9 are shown on the geological section which is presented in Appendix C.

With the exception of a 1.0 thick CLAY horizon at the top of BH2, silty fine SAND was generally recorded overlying silty CLAYS. As shown in Appendix C, SAND was described in the northern part of the site to a depth of 14.5m bgl, significantly below the recorded base of the sand in any of the other available boreholes in the vicinity. A possible explanation for this could be the presence of an in-filled river channel or scour feature in the area around BH3. Another possible explanation is the presence of faults, both to the north and south of BH3, in-between OF9 and BH2 respectively. Any such faults would have to be paired, to create a small 'graben' structure. The absence of the gravels, as described in BH OF9, from BH3 suggests that the presence of an in-filled river channel seems the more likely explanation, however based on the thickness of the sand, the scour channel would have to have been deep. The lateral extent of this possible river channel also remains unknown (see Appendix C)

- The groundwater pressures may be close to fully hydrostatic (which means that the water pressure increases linearly with depth), or may be hydrostatic modified locally by seepage/flow pressures and/or under-drainage (via permeable layers which are drained further down the valley). Groundwater flow will generally be limited to seepage through any of the silt/sand partings which are sufficiently interconnected.
- The change of designation of the Chalybeate spring, downslope of No.11, to a well suggests that there has been a long-term decline in groundwater levels (or pressures and/or the phreatic surface).
- The hydrogeology may be complicated further by the backfill in service trenches and granular pipe bedding (where present) forming preferential groundwater flow pathways, within the strata they pass through.

10.1.2 The hydrogeological regime outlined above will be affected by long-term climatic variations as well as seasonal fluctuations, all of which must be taken into account when selecting a design water level for the permanent works. No multi-seasonal monitoring data are available, so a conservative approach will be needed, in accordance with current geotechnical design standards which require use of 'worst credible' groundwater levels/pressures. See paragraph 10.2.5 for the recommended provisional design groundwater level.

10.1.3 No railway tunnels are known to pass below or close to the site. Other infrastructure (including tunnels), for sewers, cables or communications might be present within the zone of influence of the proposed basement, so an appropriate services search should be undertaken. If any such infrastructure is identified, then its potential influence on the proposed basement must be assessed. These searches will not identify any private services.

10.2 Subterranean (Groundwater) Flow – Permanent Works

10.2.1 The Made Ground comprised predominantly granular silts and sands which would facilitate flow of groundwater, but may be too permeable to support perched groundwater. No groundwater entries were recorded in the trial pits. Flow through the Made Ground may also occur where service trenches or granular pipe bedding facilitates channelled flow.

10.2.2 The seepage into borehole BH2 at 3.6m showed that there is some groundwater in the sands above the clays, as would be expected. The groundwater standing level in BH3 during the monitoring period (max. 6.80m) was slightly below the water strike (6.5m) and is slightly below the level of the seepage into BH2. The response zones of the standpipes in BHs 1 & 2 are believed to be sealed into the clays, so the water levels recorded by monitoring in those BHs may not reflect the unconfined groundwater in the overlying sands.

10.2.3 The proposed founding depths for this basement and swimming pool are approximately 4.9m and 6.4m respectively below the proposed external ground level at the front of the house, and 10.3m and 11.8m respectively below the existing level of the rear garden. Thus, the basement and pool are expected to be founded in the Claygate Member clays over the southern part of the new building's footprint, and in the sands as recorded in BH3 over the northern part of the footprint. If the deeper sands in BH3 are laterally extensive, then any natural flow of groundwater in these sands would be able to continue to flow around the new basement. This behaviour is acknowledged in the Camden GHHS which noted that even extensive excavations for basements in the City of London have not caused any serious problems in 'damming' groundwater flow, with groundwater simply finding an alternative route (Arup, 2010, paragraph 205).

10.2.4 'Blowing sands' were recorded in one of the boreholes at No.5 Cannon Lane. Secant bored pile walls will be required for all parts of the basement constructed within the sands below the groundwater table, in order to support the substantial depths of excavation and to minimise groundwater ingress into the excavations. These piles must be extended deep enough to achieve a hydraulic seal into the clays, recorded below 14.5m in BH3. Use of a full secant piled basement 'box' is recommended because groundwater strikes were also recorded from more permeable horizons within the clays.

10.2.5 The highest groundwater level readings from the standpipes during the limited monitoring period were 6.3m to 6.8m bgl. The water levels were still rising so these were probably still in the process of reaching equilibrium with water pressures in the surrounding ground. The groundwater monitoring must therefore be continued through the current winter and during the detailed design stage, in order to gain a greater understanding of the current range of fluctuations in the water table.

10.2.6 Current geotechnical design standards require use of a 'worst credible' approach to selection of groundwater pressures. The seepage at 3.6m in BH2 was at a very similar depth to the seepages at 3.7m bgl in both the boreholes at No.5 Cannon Lane. As a result, use of a provisional design groundwater level equal to 3.0m below ground level is recommended, subject to a further review once additional groundwater monitoring results are available to assess whether a higher level should be selected. For the upslope walls of the rear garden, the relevant ground level will be the level in the adjoining garden to Cannon Hall.

10.2.7 The basement structure must be designed to resist the buoyant uplift pressures which could be generated by groundwater at design level eventually selected. The variable depth of the proposed basement means that the uplift pressures will also vary along its length, from approximately 105kPa at the upslope rear wall to 20kPa at the front of the building away from the swimming pool (both un-factored). Use of tension piles will be required to resist these uplift forces.

10.2.8 The proposed basement will need to be fully waterproofed in order to provide adequate long-term control of moisture ingress from the groundwater. Detailed recommendations for the waterproofing system are beyond the scope of this report although it is noted that, as a minimum, it would be prudent for the system to be designed in compliance with the requirements of BS8102:2009.

10.3 Subterranean (Groundwater) Flow – Temporary Works

10.3.1 Provided that the secant bored pile walls proposed above are adequately sealed into both the clay recorded at the base of BH3 and the clays at basement level in BH2, then groundwater control should be limited to pumping to remove the 'trapped' groundwater within the bored pile wall 'box' (together with surface water). An appropriate discharge location must be identified for the water removed from the excavations.

10.3.2 A careful watch should be maintained to check that there is no leakage into the box between piles, which might result in removal of fines from the adjoining ground; if any such leakage, with or without erosion/removal of fines is noticed, then the advice of a suitably experienced and competent ground engineer should be sought.

10.3.3 Where the formation level onto which the underpins and the basement slab will bear consists of clays, they must be protected from water, because they would soften rapidly if water gets onto these surfaces. Thus, the formation should be blinded with concrete immediately following excavation and inspection.

10.3.4 A leaking water supply pipe to the property could increase significantly the volume of water entries, so it would be prudent to ensure the isolation stopcock is both accessible and operational before the start of the works.

10.3.5 Irrigation systems in neighbouring gardens can also contribute significantly to water entries so, if such systems are present in the adjoining gardens, then the owners should be asked to avoid excessive use during the basement construction period.

10.4 Slope and Ground Stability

10.4.1 Slope Stability

With overall slope angles of approximately 5.5° in the vicinity of this property, the proposed basement excavation raises no concerns in relation to the overall stability of the slope. However, the retaining walls on the upslope boundary were already showing evidence of forward rotation at the time of our site inspection, so measures will be required to strengthen and stabilise these before the proposed basement is excavated.

10.4.2 The bored pile wall (or walls) on the upslope sides of the rear garden will not be propped by the floors in the house, so use of ground anchors is likely to be necessary. Wayleaves will need to be negotiated with the adjoining owners for these anchors.

10.4.3 Geotechnical Design

Design of the basement retaining walls must take into consideration:

- Earth pressures from the surrounding ground (see also paragraph 10.4.4 below);
- Dead and live loads from the proposed new house, including loads from the adjoining No.24 Well Road, the Parish Lock-up and the redeveloped annex above which are carried on the party walls;
- Imposed loads from all load-bearing walls in the adjoining structures which are within the potential zone of influence of active pressures acting on the basement walls, including the historic boundary wall, where relevant and the upslope retaining walls;
- A surcharge, or increased earth pressure coefficient, to allow for the slope upslope of the rear garden retaining wall, and normal surcharge allowances elsewhere;
- Swelling displacements/pressures from the underlying clays;
- A provisional design groundwater level at 3.0m below the adjoining ground level (see paragraph 10.2.6);
- Precautions to protect the concrete from sulphate attack.

10.4.4 The following geotechnical parameters should be used when calculating earth pressures:

Made Ground:	Unit weight, γ_b:	18.0 kN/m^3
(silts/sands)	Effective cohesion, c':	0 kPa
	Angle of internal friction, φ':	28°
Claygate Member:		
Sands:	Unit weight, γ_b:	18.0 kN/m^3
	Effective cohesion, c':	0 kPa
	Angle of internal friction, φ':	32°
Sandy Clays:	Unit weight, γ_b:	20.0 kN/m^3
	Effective cohesion, c':	0 kPa
	Angle of internal friction, φ':	25°
	Coefficient of earth pressure at rest, k_0:	1.5 after release of higher pressures in response to installation of piles.

These parameters should be used in conjunction with appropriate partial factors dependent upon the design method selected.

10.4.5 The formation level clays onto which the underpins and the basement slab will bear must be protected from water to prevent softening and loss of strength, as described in 10.3.3 above.

10.5 Settlement/Heave and Damage Category Assessment

Vertical Ground Movements beneath the Basement

10.5.1 Excavation of the basement will cause immediate elastic heave in response to the stress reduction, followed by long term plastic swelling as the clays take up groundwater. The amount of swelling in the clays will depend on several factors, including its condition when placed, the amount of compactive effort applied, and their subsequent access to water, so cannot be quantified without testing on good quality samples. The rate of plastic swelling in the in-situ clays will be determined largely by the availability of water and as a result, given the low permeability of the clays in the Claygate Member/London Clay Formation, can take decades to reach full equilibrium. The basement slab will need to be designed so as to enable it to accommodate the swelling displacements/pressures developed underneath it.

10.5.2 Quantitative analysis of potential heave in response to construction of the proposed basement using dedicated PDISP software have been commissioned and will be presented in a separate Ground Movement Assessment report.

Ground Movements alongside the Basement

10.5.3 Quantitative analyses of potential ground movements alongside the proposed retaining walls have been commissioned. These will be undertaken using dedicated retaining wall design software, WALLAP, and presented in the separate Ground Movement Assessment report.

Preliminary Damage Category Assessment

10.5.4 No damage category assessment will be warranted for the rear, up-slope retaining wall, because there is no adjoining or adjacent structure alongside that boundary.

10.5.5 A preliminary damage category assessment for the Parish Lock-up and the adjoining No.24 Well Road will be provided with the Ground Movement Assessment report.

10.6 Monitoring

10.6.1 Condition surveys should be undertaken of the neighbouring property (No.24 Well Road) before the works commence, in order to provide a factual record of any pre-existing damage. Such surveys are usually carried out while negotiating the Party Wall Award and are beneficial to all parties concerned.

10.6.2 Precise movement monitoring should be undertaken weekly throughout the period during which the basement walls and slab are constructed with initial readings taken before excavation of the basement starts. Readings may revert to fortnightly once all the perimeter walls and the basement slab have been completed. This monitoring should be undertaken with a total station instrument and targets attached at two levels at the following locations (as a minimum):

- at four equally spaced intervals along party wall with No.24, adjacent to the excavations;
- at three equally spaced intervals along the up-slope rear wall;
- along the listed boundary wall in any area where excavations will reduce the garden level by more than 0.5m.

10.6.3 If any undue movements are recorded, the frequency of readings should be increased as appropriate to the severity of the movement and consideration should be given to installing additional targets.

10.6.4 If any structural cracks appear in the main loadbearing walls, then those cracks should be monitored using the Demec system (or similar) on the same frequency as the target monitoring.

10.7 Surface Flow and Flooding

10.7.1 The evidence presented in Section 5 has shown that:

- the site lies within the Environment Agency's Flood Zone 1 which means that it is considered to be at negligible risk of fluvial flooding;
- the site is not at risk of flooding from reservoirs, as mapped by Environment Agency;
- Cannon Lane and Well Road were not affected by the surface water flooding events in either 1975 or 2002;
- there are no surface water features within 200m of the site;
- the nearest river is the Tertiary grade upper waters of the river Fleet at 301-400m north and north-east of the property;
- the latest flood modelling by the Environment Agency gives a 'Very Low' risk of surface water flooding (the lowest category, which represents the national background level of risk) for No.11 and all the surrounding area (see Figure 6).

10.7.2 While the nearest river to the site is one of the headwaters to the river Fleet which flows into the Hampstead Pond Chain, the site is not in the catchment of the pond chain. It is, however, in the catchment of the Fleet being close to the head of the weakly developed valley occupied by Christchurch Hill which leads down to the main Fleet valley below Hampstead No.1 Pond. A minor tributary to the Fleet probably created this valley and was culverted or diverted into a sewer when the area was developed. Whether the culvert remains connected hydraulically to the perennial surrounding groundwater is unknown.

Change in Paved Surfacing & Surface Water Run-off:

10.7.3 The smaller footprint of the proposed new house and the larger garden area gives the potential to increase beneficial infiltration and recharge direct to the aquifer. The 'Proposed Lower Ground Floor Plan' shows a large area of soft landscaping in the front garden. However, it is not known whether any of the existing surface water is discharged to soakaways. A quantitative analysis will be required, based on a survey of the drainage system including the roof water downpipes if records are not available, in order to establish the net changes to surface water run-off that will be generated by the proposed redevelopment scheme.

10.7.4 Shallow soakaways are unlikely to be an option as much of the upper sand unit will be removed by the proposed excavations, though infiltration rates should be good in the soft landscaped front garden (see geological section in Appendix C). Discharge to deep bored soakaways could be an option, subject to appropriate testing and Environment Agency approval. The testing should be undertaken once the existing house has been demolished and access is available for a larger drill rig.

10.7.5 If use of soakaways is not feasible then, in order to minimise surface water run-off from the site, if, then appropriate Sustainable Drainage System (SuDS) could be included in the scheme, such as:

- Installing a green (sedum) roof, although these offer no additional storage once they become fully saturated in a storm situation ;
- Intervention storage;
- Rainwater harvesting;
- Directing some roof water to rain gardens;
- Use of permeable paving.

Surface Water (Pluvial) Flooding:

10.7.6 In view of the 'Very Low' risk of flooding predicted by the Environment Agency and the site's total enclosure within perimeter walls, only basic flood resistance measures will be required to protect the basement from local surface water flooding, including:

1. Provision of an upstand or ramped paving around the area which is set down by three steps alongside the front and flank wall of the house;
2. Installation of raised thresholds, or lowering the external ground levels, relative to the floor level concerned at all entrances to the building.

Sewer Flooding:

10.7.7 No drainage system can be guaranteed to have adequate capacity for all storm eventualities and all drainage systems only work at full capacity when they are properly maintained, including emptying gullies and regular checks of the sewers themselves for condition and blockages. Maintenance of the adopted sewers is the responsibility of Thames Water, so is outside both the Applicant's and the Council's control.

10.7.7 Drainage systems are designed to operate under 'surcharge' at times of peak rainfall, which means that effluent levels in the sewer may rise to ground level. Non-return valves or above ground loop systems should be fitted on the drains serving the basement and all external areas where the ground level is below the ground level at the relevant sewer connection, in order to ensure that water from the mains sewer system cannot enter the basement or flood any part of the property when the sewers are operating under surcharge.

10.7.8 If non-return valves are used, then no surface water would be able to enter the sewer for most of the time that the surcharge in the main sewer is sufficient to close the valves. The basement could then be vulnerable to flooding while the surcharged flows continue. Sufficient temporary interception storage should therefore be provided if non-return valves are used, in order to hold temporarily the predicted maximum volume of surface water run-off from all sources (roof, low garden areas and foul) for the predicted duration of surcharged flows. The same interception storage would be required with above-ground loop systems unless the design can demonstrate that the increased hydraulic 'head' created is sufficient to accommodate the predicted flows. This temporary interception storage would require formal design to ensure satisfactory performance.

10.8 Mitigation

10.8.1 The following mitigation measures have been recommended in Sections 10.2-10.7:

- tension piles will be required to resist the hydraulic uplift forces (10.2.7);
- the retaining walls on the upslope boundary were already showing evidence of forward rotation, so measures will be required to strengthen and stabilize these before the proposed basement is excavated (10.4.1).
- condition surveys should be undertaken of neighbouring properties before the works start (10.6.1);
- if further testing shows that use of soakaways would not be viable, then use of appropriate SuDS system(s) for management of surface water (10.7.4 & 10.7.5).
- Provision of upstands or ramped paving around the recessed areas alongside the new house and raised thresholds or floor levels to protect all entrances to the house (10.7.6).
- Provision of non-return valves or above ground loop systems and temporary interception storage (10.7.7 & 10.7.8).

11.0 NON-TECHNICAL SUMMARY – STAGE 4

11.1 This summary considers only the primary findings of this assessment; the whole report should be read to obtain a full understanding of the matters considered.

11.2 A services search should be undertaken (10.1.3).

11.3 The proposed basement will require the use of secant bored piles to create a 'box', sealed into the underlying clays, in order to control groundwater and minimise ground movements around the 4.9-11.8m deep excavations for this basement and swimming pool. No adverse impact is anticipated from the construction of this basement box as groundwater flow would be able to continue around it where permeable materials are present (10.2.1 to 10.2.4).

11.4 Water levels in the standpipes were still rising, so probably did not reflect the water pressures in the surrounding ground; the monitoring must therefore be continued (10.2.5). A provisional design groundwater level at 3.0m below the relevant external ground level is proposed, subject to review based on the monitoring readings. This means that the basement must be able to resist buoyant uplift pressures (un-factored) which vary along its length 50kPa to about 120kPa, for which tension piles will be required (10.2.6, 10.2.7). The basement will need to be fully waterproofed (10.2.8).

11.5 Once the bored pile walls have been sealed into the underlying clay, groundwater control should be limited to pumping to remove the groundwater trapped inside the into the basement excavations (10.3.1). The clays onto which the basement slab will bear must be blinded with concrete immediately following excavation and inspection (10.3.3).

11.6 There are no concerns regarding the overall stability of the slope, although the damaged retaining walls on the upslope side of the excavation must be repaired before the excavations start (10.4.1). Ground anchors, with appropriate wayleaves, will be required for the retaining wall on the up-slope side of the excavation (10.4.2).

11.7 Various guidance is provided in relation to the geotechnical design and construction of the basement's perimeter walls (10.4.3 to 10.4.5).

11.8 A separate Ground Movement Assessment report will be prepared with analyses of vertical ground movements beneath the basement, ground movements alongside the basement and a preliminary damage category assessment (Section 10.5).

11.9 Condition surveys of the neighbouring properties should be commissioned and a programme of monitoring the adjoining structures should be established before the works start (Section 10.6).

11.10 The new house will have a smaller footprint and a much larger soft landscaped area than presently exists, which will result in increased infiltration and recharge to the aquifer. A quantitative analysis of the existing drainage system will be required in order to assess the net change in surface water run-off. Deep bored soakaways might be an acceptable option subject to testing and approval (10.7.3, 10.7.4).

11.11 Only basic flood resistance measures will be required in view of the 'Very Low' risk of surface water flooding; general guidance is given (10.7.6).

11.12 Non-return valves or above ground loop systems should be fitted to the drains serving the basement and gullies in the lightwells (10.7.8). Temporary interception storage should be provided for the predicted maximum volume of discharges (from all sources) via the protected outfall pipe(s), for the duration of the predicted surcharged flows in the sewer; formal design will be required (10.7.9)

11.13 The mitigation measures recommended in various parts of Sections 10.2 to 10.7 have been summarised in Section 10.8.

References

Arup (November 2010) Camden geological, hydrogeological and hydrological study – Guidance for subterranean development. Issue 01. London.

Barton N (1992) The Lost Rivers of London. Historical Publications Ltd, London.

BS 1377-2 (1990) Methods of test for Soils for civil engineering purposes – Part 2: Classification Tests. British Standards Institution, London.

BS 5930 (1999, 2010) Code of practice for site investigations. Including Amendment No.2. British Standards Institution, London.

BS 8002 (1994) Code of Practice for Earth retaining structures. British Standards Institution.

BS 8102 (2009) Code of practice for protection of below ground structures against water from the ground. British Standards Institution, London.

BS EN 1997-1 (2004) Eurocode 7: Geotechnical Design – Part 1: General rules. British Standards Institution.

Ellison RA et al (2004) Geology of London. Special Memoir for 1:50,000 Geological sheets 256 (North London), 257 (Romford), 270 (South London) and 271 (Dartford) (England and Wales). British Geological Survey, Keyworth.

London Borough of Camden (2003) Floods in Camden, Report of the Floods Security Panel.

NHBC (2011) NHBC Standards, Chapter 4.2, Building Near Trees.

URS (2009) Camden Infrastructure Study: Utilities and Physical Infrastructure Needs Assessment.

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Project:

11 Cannon Lane, London, NW3 1EL

15375

Photo 1: Front elevation (street scene). Within the boundary wall of the site, in the north-east corner of the site, is a 'Parish Lock-Up' thought to date back to 1730. Note southwards fall of Cannon Lane.

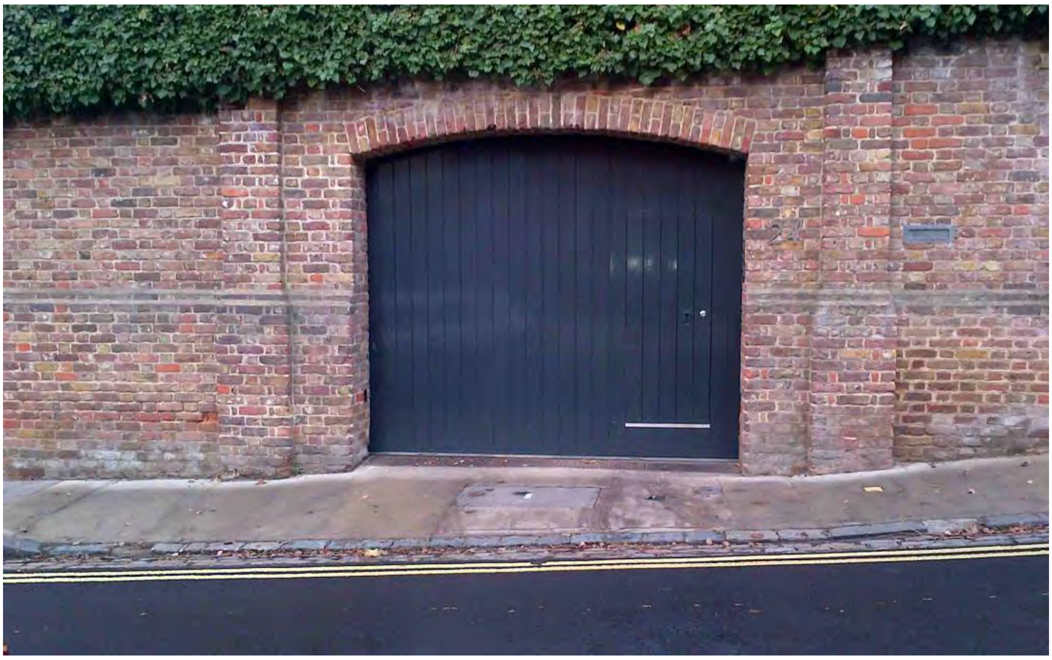

Photo 2: Driveway entrance shared with the adjoining No.24 Well Road. Note the south-westwards fall of Well Road, despite the general south-easterly facing orientation of the slope.

Title:	**Photographs - Sheet 1**					Sheet	**A1**
Date:	30 October 2014	Checked:	AG	Approved:	KRG	Scale :	NTS

Project:

11 Cannon Lane, London, NW3 1EL

15375

Photo 3: Shared driveway, leading up from the entrance arch (Photo 2) to the SW corner of the site.

Photo 4: Entrance doorway in the southern part of the western boundary wall. Note the adjacent flight of steps which lead up from the Well Road footway, and the more modern brickwork of the western boundary wall compared with the southern and eastern boundaries.

Title:	**Photographs - Sheet 2**					Sheet	**A2**
Date:	30 October 2014	Checked:	AG	Approved:	KRG	Scale :	NTS

Project:

11 Cannon Lane, London, NW3 1EL

15375

Photo 5: Front garden of No.11. Beneath the vegetation, the majority of the front garden is paved with granite setts, with the exception of a flower bed adjacent to the southern boundary wall.

Photo 6: Rear garden to No.11, the majority of which consists of a planting area. Note the brick retaining wall which forms the northern boundary to the site.

Title:	**Photographs - Sheet 3**					Sheet	**A3**
Date:	30 October 2014	Checked:	AG	Approved:	KRG	Scale :	NTS

Project:

11 Cannon Lane, London, NW3 1EL

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Photo 7: Rear retaining wall showing signs of damage (forward rotation, to right).

Photo 8: Eastern part of rear retaining wall. Note the more modern brickwork compared with the retaining wall to the west. During the Ground Investigation, TP3 revealed different foundations beneath this section of the retaining wall, compared with the foundations described beneath the rest of the rear retaining wall, indicating it was constructed at a later date. Annex on right.

Title:	**Photographs - Sheet 4**			Sheet	**A4**
Date:	30 October 2014	Checked: AG	Approved: KRG	Scale :	NTS

Project:

11 Cannon Lane, London NW3 1EL

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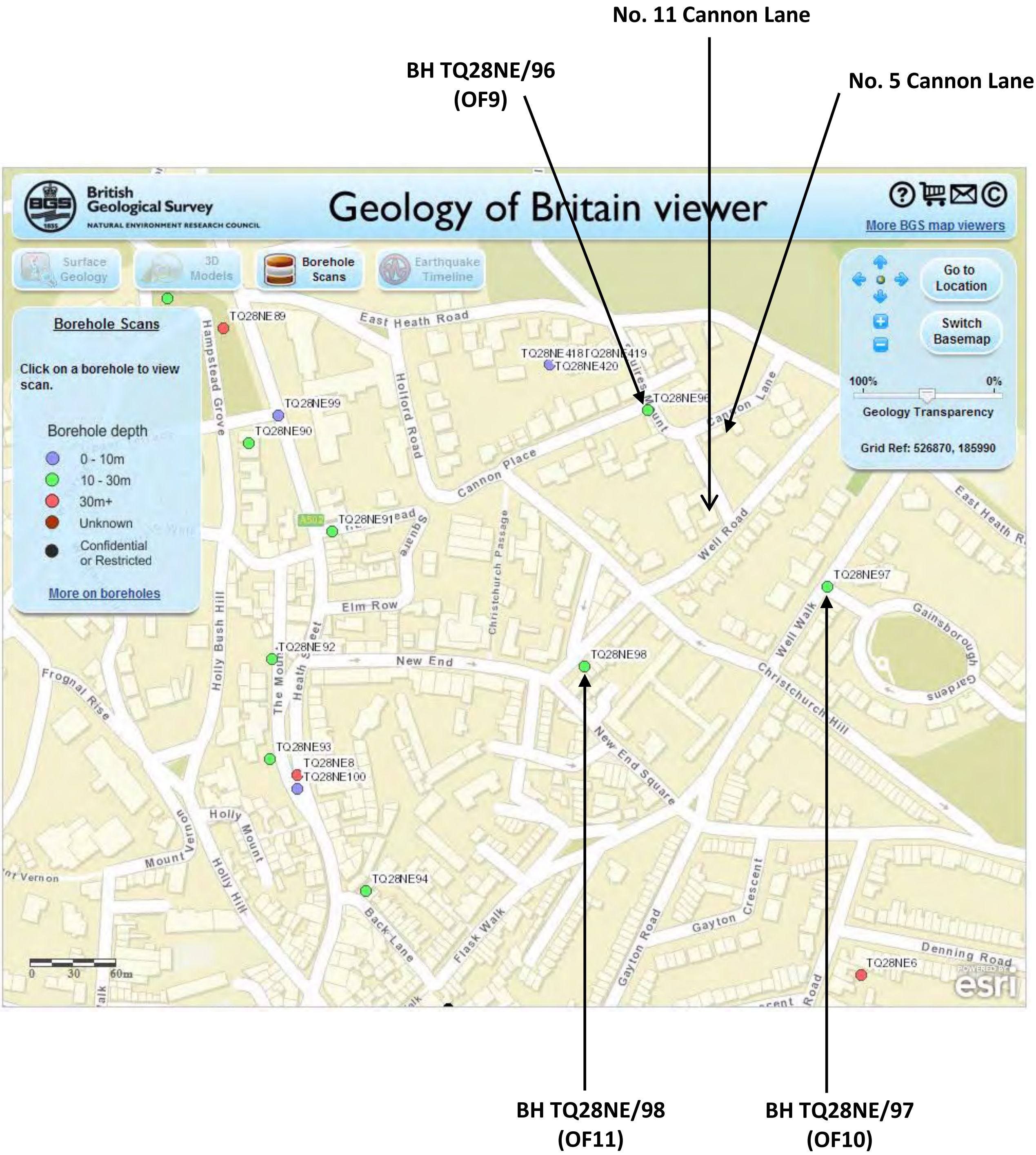
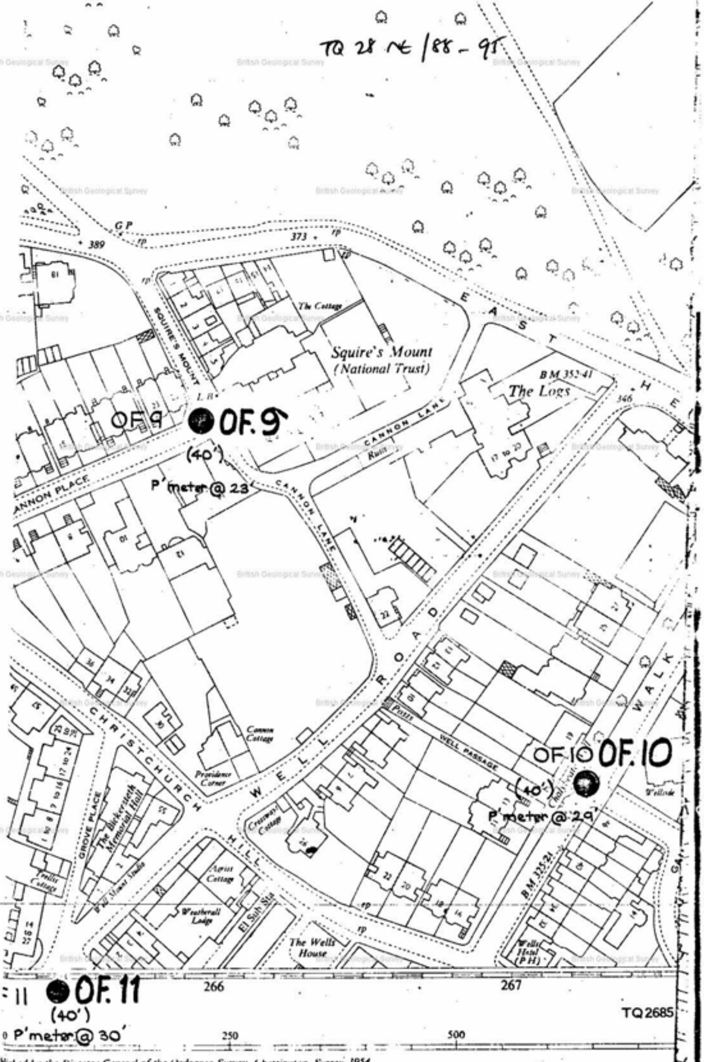


Title:	**Location Plan of BGS & Other Boreholes**					Sheet	**B1**
Date:	December 2014	Checked:	AG	Approved:	KRG	Scale :	NTS



...lished by the Director General of the Ordnance Survey, Chessington, Surrey. 1954.

PLAN TQ 2685 NE

TQ 28 NE/88-95

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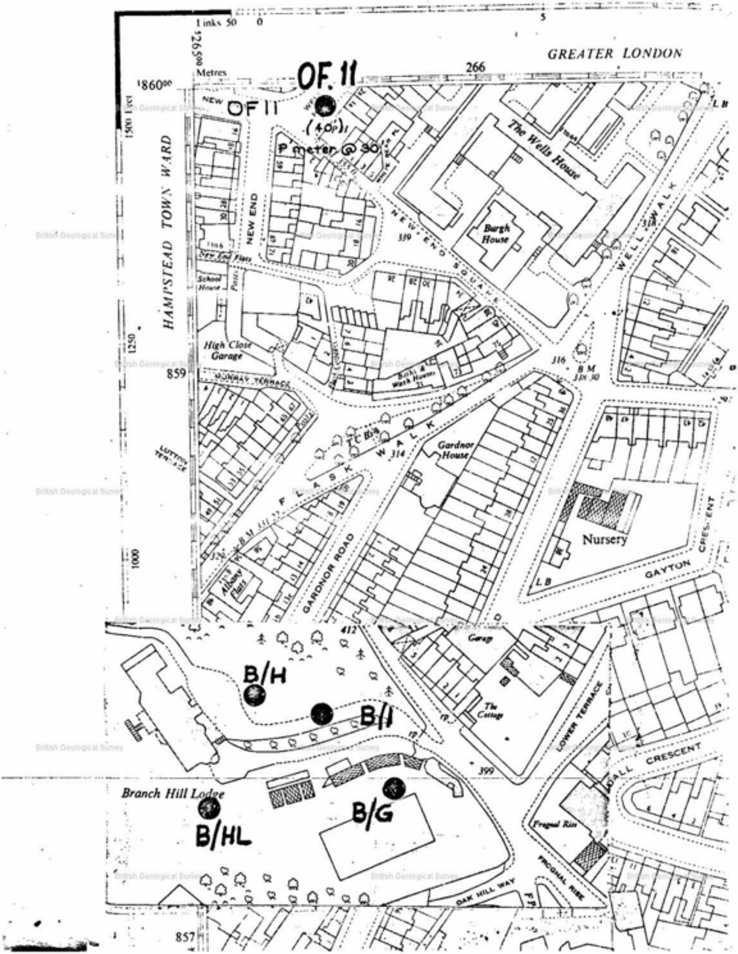

TQ/25NR/96
Q660. 8618

OF9

SQUIRES MOUNT, HAMPSTEAD HEATH

RECORD OF BOREHOLE No: OF9

...ct No. : 431
...ring : Shell + Auger
(started) : 21·5·'69

Borehole Dia : 6"
Casing : 6" to 30:0
Ground Level : 383·50'

Water Level	Samples Depth	Type	No.	Strata Depth	Thickness	Description of Strata
	2:6	D	1	3:0	3:0	MADE GROUND (loose dark brown gravelly sand & some clay)
	5:0 (N=31)	D	2			
	7:6	D	3	9:0	6:0	Compact sandy GRAVEL brown poorly sorted sand (up to 1/8" fragments) & some clay.
	10:0	U	4			
	12:6	D	5			
	15:0	U	6			
	17:6	D	7	17:6	8:6	Compact light brown fine silty SAND
	20:0	D	8			
	22:6	D	9			
	25:0 (N=6)	D	10			
	27:6	D	11	28:0	10:6	extremely wet and running compact light brown fine silty SAND
	30:0	U	12			
	32:6	D	13			
	35:0	U	14			
...30:0 DRY	37:6	D	15			
	40:0	U	16	40:0	12:0	Mixture orange/grey stiff CLAY, and fine sand.

Borehole dry.
U4 Failed at 20:0 (17 blows) very loose wet sand.
Piezometer installed at 23:0

Foundation Engineering Ltd.

TQ/28NE/97
2673. 8606. **OF.10**

RECORD OF BOREHOLE No: OF10

Site : WELL WALK,
:HAMPSTEAD HEATH
Contract No. : 431
Method of Boring : Shell + Auger
Date (started) : 21 · 5 · 69

Borehole Dia : 6"
Casing : 6" to 35:0
Ground Level : 326·87'

Casing	Water Level	Samples Depth	Samples Type	Samples No.	Strata Legend	Strata Depth	Strata Thickness	Description of Strata
		2:6	D	1		4:0	4:0	MADE GROUND + Topsoil (dark brown poorely sorted clayey sand and red brick rubble)
		5:0	U	2				Mottled brown + grey loose fine SAND and softish grey clay (= silty sandy clay)
		7:6	D	3		9:0	5:0	
		10:0	U	4				Dark grey soft/firm micaceous silty sandy CLAY
		12:6	D	5			6:0	
		15:0	U	6		15:0		
		17:6	D	7				
		20:0	U	8				Stiff dark grey micaceous silty CLAY
		22:6	D	9				
		25:0	U	10			20:0	
		27:6	D	11				
		30:0	U	12				
		32:6	D	13				
		35:0	U	14		35:0		Medium dense micaceous silty SAND
		37:6	D	15			5:0	
35:0	35:0	40:0	U	16		40:0		

Borehole Complete

Water first met at 20:0
Piezometer installed at 29:0

Foundation Engineering Ltd.

TQ/28NE/98

2656 . 8600.

OF. 11

RECORD OF BOREHOLE No: OF11

WELL ROAD
HAMPSTEAD HEATH

…No. : 431

…Boring : Shell + Auger

…(started) : 22. 5. '69

Borehole Dia : 6"

Casing : 6" to 35' 0"

Ground Level : 354·09'

Water Level	Samples Depth	Type	No.	Strata Legend	Strata Depth	Thickness	Description of Strata
					1' 0"	1' 0"	MADE GROUND Asphalt + brick rubble
	2' 6"	D	1				
	5' 0"	U	2		6' 0"	5' 0"	Dark orange / brown + grey loose micaceous silty sandy CLAY (mixture firm clay + loose sand)
	7' 6"	D	3				
	10' 0"	U	4		12' 0"	6' 0"	Cream / light grey firm micaceous silty CLAY, predominates over orange / brown fine sand
	12' 6" (N = 19)	D	5				
	15' 0"	D	6		17' 0"	5' 0"	extremely wet deep orange / brown fine micaceous silty SAND
	17' 6"	D	7				
	20' 0"	U	8		22' 0"	5' 0"	Mottled grey + brick red firm micaceous silty CLAY and light brown fine sand.
	22' 6"	D	9				
	25' 0"	U	10		25' 0"	3' 0"	Dark grey micaceous silty sandy CLAY
	27' 6"	D	11				
	30' 0"	U	12				
	32' 6"	D	13				
	35' 0"	U	14		35' 0"	10' 0"	Dark grey + brown mixture of silty SAND + CLAY
	37' 6"	D	15				
0" DRY	40' 0"	U	16		40' 0"	5' 0"	Dark grey firm / stiff micaceous silty CLAY

Borehole Complete

Water first met at 17' 0"
Piezometer instaled at 30' 0"

Foundation Engineering Ltd.

BOREHOLE LOG - M R H GEOTECHNICAL

HOLE NO. BH 1

CLIENT	SITE
Astwood Securities Ltd	5 Cannon Lane, London NW3 1SL

DATE OF FIELDWORK	SCALE	LEVEL/POSITION	OPERATOR	LOGGED BY	JOB NO.
23/04/09 - 23/04/09	1:50	GROUND / AS APPENDIX A	SB/PA	SB	291110

SAMPLE RECORD DEPTH	TYPE	SPT N (Cu:kN/m²)	DESCRIPTION OF STRATUM (thickness)	DEPTH
			Turf over topsoil (0.30)	
0.50	D1		Soft greyish brown topsoil with traces of rubble. MADE GROUND (0.80)	0.30
1.00	D2			
1.50	D3	(52)	Firm brown CLAY with partings of sand and rounded gravel (0.60)	1.10
2.00 - 2.30	D4	N=12	Medium dense brown SAND with laminations of silt (2.70)	1.70
2.50	D5			
3.00	D6			
3.50 - 3.80	D7	N=15		
			Water seepage at 3.70m	
4.00	D8			
4.50	D9		Medium dense brown SAND with laminations of silt and clay (2.30)	4.40
5.00 - 5.30	D10	N=14		
5.50	D11			
6.00	D12			
6.50 - 6.80	D13	N=16		
7.00	D14	(48)	Firm orange brown CLAY with laminations of silt and sand (2.80)	6.70
7.50	D15			
8.00	D16	(56)	Piezometer / gas monitoring well installed	
8.50	D17			
9.00	D18	(58)		
9.50	D19		Firm orange brown mottled grey CLAY with numerous partings of silt and sand (5.10)	9.50
10.00	D20		Borehole continues on Sheet 2	

GROUNDWATER AND CASING INFORMATION

DEPTH STRUCK	DEPTH CASED	ELAPSED TIME	WATER LEVEL	DEPTH SEALED	REMARKS ON GROUNDWATER AND CASING
3.70	-	-	-	-	Water seepage at 3.70m. Piezometer installed

BORING METHOD AND REMARKS

Mechanical auger
Piezometer / gas monitoring well installed

KEY: D = Disturbed Sample B = Bulk Sample
U = Undisturbed Sample W = Water Sample
All dimensions are in metres unless otherwise stated

BOREHOLE LOG - M R H GEOTECHNICAL

HOLE NO. BH 1
Sheet 2 of 2

CLIENT	SITE
Astwood Securities Ltd	5 Cannon Lane, London NW3 1EL

DATE OF FIELDWORK	SCALE	LEVEL/POSITION	OPERATOR	LOGGED BY	JOB NO.
23/04/09 - 23/04/09	1:50	GROUND / AS APPENDIX A	SB/PA	SB	291110

SAMPLE DEPTH	RECORD TYPE	SPT N (Cu-kN/m²)	Standp/ Piezo	DESCRIPTION OF STRATUM (thickness)	DEPTH
				Firm orange brown mottled grey CLAY with numerous partings of silt and sand	
11.00-11.30	D21	N=18			
12.00	D22	(62)			
13.00	D23	(66)			
14.00	D24	(60)			
					14.60
				Firm dark grey CLAY with occasional partings of silt and sand (5.40)	
15.00	D25	(68)			
16.00	D26	(62)			
17.00	D27	(74)			
18.00	D28	(74)			
19.00	D29	(68)			
20.00	D30	(70)		Borehole ends	20.00

GROUNDWATER AND CASING INFORMATION

DEPTH STRUCK	DEPTH CASED	ELAPSED TIME	WATER LEVEL	DEPTH SEALED	REMARKS ON GROUNDWATER AND CASING
3.70	-	-	-	-	Water seepage at 3.70m. Piezometer installed

BORING METHOD AND REMARKS

Mechanical auger
Piezometer / gas monitoring well installed

KEY: D = Disturbed Sample B = Bulk Sample
U = Undisturbed Sample W = Water Sample
All dimensions are in metres unless otherwise stated

BOREHOLE LOG - M R H GEOTECHNICAL

HOLE NO. BH 2
Sheet 1 of 2

CLIENT	SITE
Astwood Securities Ltd	5 Cannon Lane, London NW3 1EL

DATE OF FIELDWORK	SCALE	LEVEL/POSITION	OPERATOR	LOGGED BY	JOB NO.
24/04/09 - 24/04/09	1:50	GROUND / AS APPENDIX A	SB/PA	SB	291110

SAMPLE DEPTH	RECORD TYPE	SPT N (Cu-kN/m²)	Standp/ Piezo	DESCRIPTION OF STRATUM (thickness)	DEPTH
				Dark grey TOPSOIL (0.20)	0.20
0.50	D1			Soft dark grey topsoil with some rubble. MADE GROUND (0.40)	0.60
1.00 - 1.30	D2	N=16		Medium dense brown SAND with traces of silt and rounded gravel (1.60)	
1.50	D3				
2.00 - 2.30	D4	N=18			2.20
2.50	D5	(62)		Firm brown CLAY with partings of silt, sand and rounded gravel (1.60)	
3.00	D6	(58)			
3.50	D7	(58)		Water seepage at 3.70m	3.80
4.00 - 4.30	D8	N=12		Medium dense brown SAND with laminations of clay and silt (3.10)	
4.50	D9				
5.00	D10				
5.50 - 5.80	D11	N=21			
6.00	D12				
6.50	D13				
7.00 - 7.30	D14	N=19		Firm orange brown mottled grey CLAY with partings of silt and sand (5.30)	6.90
7.50	D15	(66)			
8.00	D16	(60)			
8.50	D17				
9.00	D18	(60)			
9.50	D19				
10.00	D20	(68)		Borehole continues on Sheet 2	

GROUNDWATER AND CASING INFORMATION

DEPTH STRUCK	DEPTH CASED	ELAPSED TIME	WATER LEVEL	DEPTH SEALED	REMARKS ON GROUNDWATER AND CASING
3.70	-	-	-	-	Water seepage at 3.70m

BORING METHOD AND REMARKS

Mechanical auger

KEY: D = Disturbed Sample B = Bulk Sample
U = Undisturbed Sample W = Water Sample
All dimensions are in metres unless otherwise stated

BOREHOLE LOG - M R H GEOTECHNICAL

HOLE NO	BH 2
Sheet	2 of 2

CLIENT	SITE
Astwood Securities Ltd	5 Cannon Lane, London NW3 1EL

DATE OF FIELDWORK	SCALE	LEVEL/POSITION	OPERATOR	LOGGED BY	JOB NO.
24/04/09 - 24/04/09	1:50	GROUND / AS APPENDIX A	SB/PA	SB	291110

SAMPLE DEPTH	RECORD TYPE	SPT N (Cu-kN/m²)	Standp/ Piezo	DESCRIPTION OF STRATUM (thickness)	DEPTH	LEGEND
				Firm orange brown mottled grey CLAY with partings of silt and sand		
11.00	D21	(72)				
12.00	D22	(70)				
				Medium dense brown SAND with laminations of silt and clay (2.90)	12.20	
13.00	D23					
14.00-14.30	D24	N=15				
15.00	D25					
				Firm dark grey CLAY with partings of silt and sand (4.90)	15.10	
16.00	D26	(74)				
17.00	D27	(72)				
18.00	D28	(66)				
19.00	D29	(66)				
20.00	D30	(74)		Borehole ends	20.00	

GROUNDWATER AND CASING INFORMATION

DEPTH STRUCK	DEPTH CASED	ELAPSED TIME	WATER LEVEL	DEPTH SEALED	REMARKS ON GROUNDWATER AND CASING
3.70	-	-	-	-	Water seepage at 3.70m

BORING METHOD AND REMARKS

Mechanical auger

KEY: D = Disturbed Sample; B = Bulk Sample; U = Undisturbed Sample; W = Water Sample

All dimensions are in metres unless otherwise stated