Basement Impact Assessment:

33 South Hill Park
London
NW3 2ST

Report

Ecologia™
experts on the ground

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Prepared for: David Mikhail Architects

Reference:13.032.4

Date: 5th March 2014

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Basement Impact Assessment – 33 South Hill Park, London, NW3 2ST

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Contents

Appendix

1. Introduction

1.1 Background

Ecologia were instructed by David Mikhail Architects (Architects to the property owners) to undertake a Basement Impact Assessment (BIA) at the property: 33 South Hill Park (SHP), London, NW3 2ST. The scope of works undertaken is based on the Ecologia proposal dated 23rd January 2013, which addresses the need for a BIA to accompany a forthcoming Planning Application. An updated proposal was sent on 21st October by Ecologia, to include site-specific investigations following feedback from Council planners.

1.2 Regulatory Context

This assessment has been undertaken in accordance with guidance provided in the following documents:

- Camden Planning Guidance for Basements and Lightwells, ref. CPG4 (as revised September 2013)
- Camden Geological, Hydrogeological and Hydrological Study (ref: CGHHS). ARUP Consultants, November 2010

This guidance applies to all developments in the London Borough of Camden (LBC) that propose a new basement or an extension to a basement, where planning permission is required. As defined by the guidance, a BIA provides a method or determining whether a basement will cause, or will not cause, harm to the built or natural environment.

In accordance with the guidance, any BIA should involve the following sequence of steps:

1. Screening – identification of potential geological, hydrogeological or ground stability risk that might necessitate further assessment.
2. Scoping – defines further assessment procedures based on identification of risk at the screening stage.
3. Site Investigation and study – baseline conditions are established using existing or newly acquired information.
4. Impact assessment – determination of the potential impact that a basement will have on baseline conditions, and any mitigation measures that may then be proposed.
5. Review and Decision making – Undertaken by L.B.Camden, involves an audit of the data and ultimately decision on the acceptability of the basement development.

1.3 Scope of Works

The scope of works undertaken as part of this BIA is based on the completion of steps 1 - 4 listed in Section 1.2. Step 5, with the determination and the decision making to be completed by London Borough of Camden. This Reporting is chiefly undertaken by a Chartered Civil Engineer (MICE, C.Eng) & Chartered Water and Environment Manager (FCIWEM, C.WEM) with both hydrological and geotechnical expertise, and supplemented/reviewed by a Chartered Geologist (CGeol, FGS) with hydrogeological expertise. The principal author is also a registered Specialist in Land Condition (SiLC).

The screening and scoping exercises (Steps 1 - 2) are based on the assessment of specific parameters applicable to hydrogeology, hydrology and ground stability as defined within the ARUP 2010 Guidance (CGHHS). These parameters have been assessed using freely available literature and by completing a site walkover visit completed on 29th January 2013.

Step 3 is a site investigation, typically involving a desk study review of ground information and/or collection of new soil and groundwater data, in order to establish baseline conditions. An intrusive investigation took place in November 2013, combined with work at No. 35 SHP.

Step 4 (impact assessment) involves a comparison between the present situation (as defined by Steps 1-3) with an assessment of the future situation assuming the basement construction goes ahead. This Report contains that Assessment, and also uses Screening Flowcharts within it, for easy reference of the relevant locational risks as defined in the 2010 Guidance document CPG4.

2. Site Setting

2.1 Geographical Setting

The site is located at O.S. Grid Reference TQ 273858, approximately 200 metres north-east of Hampstead Heath Station. Located within the South Hill Park Conservation Area, the area is characterised by Victorian-era residential properties, at the periphery of parkland to the north. Figures in Appendix I show the property location and historical street mapping.

The Hampstead Ponds are situated some 45-50 metres to the west of the property, which is sited on the east side of South Hill Park, just south of the loop of South Hill Park Gardens.

The immediate site vicinity dips towards the west and also to the south. The property is sited at just below 80m above Ordnance Datum (AOD) contour, whilst Hampstead No. 1 Pond is situated to the west just below the 70m contour (ref. CGHHS Figure 10). There is a distinct 'high spot' or watershed in the natural ground levels trending north-south in the rear garden boundaries, between South Hill Park and Parliament Hill, at this location; a catchment 'divide' along South Hill Park road is also clearly shown on CGHHS Figure 14.

2.2 Site Description

The historical setting is that the existing property is a four-storey semi-detached dwelling located on the south-east side of South Hill Park, within the South Hill Park Conservation Area (Sub-area 1). South Hill Park is predominantly a residential street developed by Thomas Rhodes from 1871 onwards, consisting mainly of substantial semi-detached villas. There are also several examples of post-war housing within the Conservation Area (including the adjacent No.31/29, built by Michael Brawne in 1959); these examples create a diverse architectural character along the street.

The property is typical of the area, constructed out of yellow faced brick with white render detailing around the windows, main entrance and architectural horizontal banding. The dwelling also features a three-storey bay window to the front and dormer windows in the roof, to both the front and rear. The dwelling also has a two-storey closet wing to the rear which was at least partially re-built about 15 years ago.

Due to the steepness of the natural ground levels from front to rear, the main entrance to the dwelling is raised up significantly (2.1m) from the SHP pavement and is accessed via external steps. The ground floor continues through the kitchen extension (built about 15 years ago) to a small rear patio. The rear garden behind the closet wing is 2.6m higher than this sunken patio, accessed via a flight of steps with brick-faced retaining walls. A few further steps lead up to the rear lawn.

The adjacent semi-detached property, No.35, has a lower ground floor area on the original footprint and a first-floor rear conservatory extension (used as a kitchen/diner) to the closet wing on the same level as No. 33. The uphill property, No.37, is a substantial five-storey block, set at 0.6m above the floor level to Nos. 35/33. No.37 also has a small cellar alongside the flank wall, with a floor level approximately 1.6m below the ground floor level to No.35. The downhill property, Nos. 29/31, is a flat-roofed three-storey building, with a ground floor set lower than Nos. 33/35, and of lesser total height, with the top storey being set half a storey lower than the third storey of No.33.

2.3 Proposed Development

Ecologia's understanding of the proposed basement development is based on the set of planning drawings provided by the Client, David Mikhail Architects, dated 10th January 2014 (Drawings Nos AL(0) 001, 100, 200, 201, 202 & 203 and AL(1) 100, 200, 203 and 204).

Works at No. 33 South Hill Park will include a new basement of plan area $60m^2$, constructed beneath the footprint of the original main house, its original closet wing and existing single-storey extension to the rear. The basement level will be approximately half a storey below pavement level and to the same depth as the proposed basement at No.35.

No work is to be carried out to change the rear garden of No.33, whilst the front garden will be excavated with new steps and an entrance directly off the street.

Works at the neighbouring property (35 South Hill Park), which it is proposed will be conducted in tandem with the above works, include a new basement of $40m^2$ beneath the footprint of the main house (on the same level as No.33's new basement) and a further basement extension (at higher floor level) to the rear, with similar new access at the front. The ground levels in most of the rear garden to No.35 will also be lowered and terraced, with retaining walls along the boundaries with Nos 33 and 37.

2.4 Ground Conditions

Reference to the British Geological Survey (BGS) Map for the area: Sheet 256, North London, Solid and Drift Edition (1994) indicates that the site is directly underlain by solid geology of the London Clay, described as "*Clay, silty in part*". The London Clay is overlain, 200m to the north-north-east of the property, by the Claygate Member (which forms the natural geological 'cap' that became Parliament Hill). The London Clay beneath the locale, expected to be in excess of 70m thick, is eventually underlain by the Lambeth Group (Woolwich & Reading Beds), over Thanet Sands, and ultimately overlying Chalk strata.

A site investigation was undertaken at Nos. 72 and 74 South Hill Park in 2008. Borehole records from this (on the LBC Planning Portal) state that the London Clay became very stiff between 3.3 and 3.4m below ground level (bgl) in the rear gardens (close to Pond No.1). On the road side of the properties, very stiff clay was not observed until 7.3mbgl (BH3). In the rear garden borehole (BH2) standing water was recorded at 5.9mbgl (date: 4th January 2008) and 2.0mbgl (date: 19th February 2008), indicating some equalisation with time.

Recent investigation work carried out at 85 South Hill Park (Albury SI Ltd, 2011 – Borehole logs in Appx. II) has been able to define the depth to (very stiff) London Clay at the site as being from 3.9 to 4.8mbgl; above the Clay there is a layer of stiff clayey Head material, with a localised deposit of 'downwash' sandy layer in one of the boreholes (in the rear patio area, at 2.9-3.4m bgl.) Albury SI considered this material to be of Claygate Beds origin, i.e. from the hills to the north-east, and this supposition is considered valid given the geological setting.

Albury report that the borehole in No.85's front garden was fitted with a 4m deep standpipe, monitored by them in October 2011, at 11 and 24 days after installation. The recorded depths to groundwater then were 3.39m and 3.44m bgl respectively; after four months, the standpipe was also found to be dry (by Mike Summersgill, in February 2012) to below 3.0m depth.

Closer to this property, boreholes were recently (2012) drilled by Chelmer SI at No.71 South Hill Park, for a basement there (see plan and logs in Appendix II). These both show stiff silty clay at 0.8m depth, becoming very stiff at 2.8-3.3m bgl; the descriptions are typical of weathered London Clay. One borehole had a slight water seepage at 3.3m depth, but no later groundwater level monitoring was reported by Chelmer SI. These records indicate no sandy Head deposits nor any permeable horizons in the London Clay (as was found by Albury at No.85, higher up the street), and should be more representative of No.33 sub-soil.

Three boreholes and five trial pits undertaken in November 2013 at No. 33 SHP (and adjacent) revealed similar conditions to those at No.71, uphill of Nos. 33/35, with London Clay found near-surface and becoming very stiff around 3m depth. Full details are reported later herein (Section 3.3).

2.5 Hydrogeology and Hydrology

The London Clay is classified by the Environment Agency as an 'Unproductive Stratum', meaning a layer with low permeability that has negligible significance for water supply. This does not mean, however, that there is no water in the London Clay. Groundwater will be contained in the microscopic pores of the clayey strata, but permeates so slowly it is commonly regarded as a groundwater barrier. There are localised zones within the London Clay containing a higher proportion of sands or silts, where groundwater flow may occur, but very slowly in most cases.

The nearby Hampstead Heath ponds are the location of the original source of the Fleet River and are fed by springs emerging from the Bagshot Beds and Claygate Beds to the north of South Hill Park. These locations, well to the north of this property, have given rise to the belief that underground streams are prevalent throughout this locale, whereas underground streams within the London Clay (the soil stratum found beneath this property) are very rare.

2.6 Walkover

A visit to both 35 and 33 South Hill Park was made on the 29th January 2013 by Mike Summersgill and Mike Davis of Ecologia Environmental Ltd, and also by Keith Gabriel of Gabriel GeoConsulting Ltd. Selected photographs from the visit are included in Appendix III.

No serious cracking was observed internally in the parts of the properties inspected at ground level(s), but some historical re-pointing and above-window movement could be observed externally. The closet wing at the rear does not seem to abut No.31 directly, but forms its own 'boundary wall' in this location, possibly marginally abutting the rear corner of No. 31 (whose rear wall is set back slightly from the rear of Nos. 33-35).

Due to the slope of the road and the ground upon which the properties were built, the front doors of the two properties are elevated above street level and accessible by steps. There is some old metal strapping and bolting present around both properties, and particularly above the first two floors' bay windows. Some of the strapping has been removed on No.33, although it is not known (by the current Owner) when that was removed, or for what reason – the original strapping remains on No.35's front.

One potential cause for the strapping has been revealed by examination of historical maps of South Hill Park (those dated 1915 and 1952 are included in Appendix I; sourced for No.85 SHP) – there appeared to have been demolition/removal of properties in the 1940s in two parts of SHP, and a search of the planning records for Nos. 29/31 revealed this rebuild was due to 'bomb damage'. As there is an apparent gap in archived 'bomb line' records for Hampstead criss-crossing this location, it is possible that there could have been impact damage caused by an unexploded piece of ordnance, as often was the case in London – the nearby reservoir dams would potentially have been a target for aerial attack.

The ground floor, as accessed via the main front door, leads out to the small lower patio (at the rear), while the upper terrace can be accessed directly from the first floor via the french windows in the rear wall of the study (or via the wide steps from the lower patio). A few further steps lead up from the upper terrace to the rear garden area.

The garden of No.33 is bordered by a brickwork garden wall to the north (separating Nos. 35 and 33); there is a large Ivy plant covering some of the wall and a Laurel bush at the rear. There are no significant trees in the gardens of No.35 and none at all in No.31; however there is a Magnolia in the garden of 37, and an Ash (and other mature trees) in the garden of a property backing onto No.35's garden. The garden of No.33 also contains an immature Sycamore, but nothing of significant current size/age. None of the larger mature trees in adjacent gardens are, however, within 10 metres of this property.

The gardens of the two properties back onto the rear gardens of the properties of Parliament Hill. The gardens of the Parliament Hill properties quickly fall away from the boundary fence, with a steep scarp to the east (of about 2 metres height). There is evidence of subsidence or slope movement at the rear garden boundaries, as the brick garden walls separating Nos. 35, 37 and 39 SHP had severely cracked and the wall between Nos. 37/39 was leaning significantly downslope towards the gardens of the Parliament Hill properties.

Roof waters (and probably patio run-off) drain through downpipes to a combined sewer system, passing from the rear down the side of the property, and thence out to the main combined sewer system (assumed) in South Hill Park highway.

There are several large, pollarded plane trees on the pavement areas of South Hill Park (SHP), albeit none are directly outside Nos. 33 or 35; they are obviously frequently maintained by the Council/Highways Dept. A smaller tree was noted in the front garden of No. 31 SHP, and one of the larger pollarded trees was on the pavement outside No.29 SHP.

3. Basement Impact Assessment

3.1 Stage One – Screening

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 Camden geological, hydrogeological and hydrological study (Arup, 2010), and historic maps.

Subterranean (groundwater) flow screening flowchart:

Question		Response, with justification of 'No' answers	Clauses where considered or further scoping
1a	Is the site located directly above an aquifer?	No – Figure 4 (Arup, 2010) shows site underlain by London Clay, as confirmed by recent ground investigation.	
1b	Will the proposed basement extend beneath the water table surface?	No, not beneath the water table in an aquifer, though it probably will extend below the phreatic surface of groundwater in the London Clay.	2.4; 2.5 3.3.1
2	Is the site within 100m of a watercourse or spring line?	Yes	3.4.1.6
3	Is the site within the catchment of the pond chains on Hampstead Heath?	No – Figure 14 (Arup, 2010) indicates that this property is outside the catchment, despite its close proximity.	2.1
4	Will the proposed basement development result in a change in the proportion of hard surfaced/ paved areas?	Yes, but only a small increase in the front garden (5.6m^2 + 2.7m^2 sedum roof to bike store). The rear patio area, upper terrace and the rear garden will remain as is.	3.4.1.5
5	As part of the site drainage, will more surface water than at present be discharged to the ground (eg: via soakaways and/or SUDS)?	No – hard surfaced area will increase slightly (only at front), so surface water discharging to the ground (infiltrating) will reduce very slightly.	2.6; 3.4.1.5
6	Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to, or lower than, the mean water level in any local pond or spring line?	No – site is circa. 10m above Pond No.1 (Figure 10, Arup, 2010)	2.1 3.3.1

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 – Figure 16 (Arup, 2010). Existing retaining walls in place at rear.	3.4.2
2	Will the proposed re-profiling of landscaping at site change slopes at the property boundary to more than 7°?	No – no external variation to boundary slopes	
3	Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	No – Figure 16 (Arup, 2010)	3.4.2
4	Is the site in a wider hillside setting in which the general slope is greater than 7°?	No, but steeper slopes exist on west side of SHP. Natural cross-slope east-west may have been ca.10°.	3.4.3
5	Is the London Clay the shallowest strata at the site?	Yes – Figure 4 (Arup, 2010) and recent investigations.	3.4.4; 3.3.1
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	2.6
7	Is there a history of seasonal shrink/swell subsidence in the local area, and/or evidence of such effects at site?	Yes – London Clay has a history of seasonal effects.	2.6; 3.4.3
8	Is the site within 100m of a watercourse or potential spring line?	Yes – Figures 11 & 12 (Arup, 2010)	3.4.1.6
9	Is the site within an area of previously worked ground?	No – Figure 16 (Arup, 2010). Historical Maps also confirm; previous BIAs.	
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?	No – Figure 4 (Arup, 2010)	
11	Is the site within 50m of the Hampstead Heath ponds?	Yes, albeit no stability issues are envisaged at all, as site is ca.45m from Pond No.1 and at a higher elevation.	The Panel Engineer for the Reservoir needs notifying at design stage.
12	Is the site within 5m of a highway or a pedestrian right of way?	Yes, fronting South Hill Park road/footway	3.4.3
13	Will the proposed basement substantially increase the differential depth of foundations relative to neighbouring properties?	Yes – if No.35 basement is not proceeded with at the same time. And No. 31 is close to flank of No. 33, and does not have a basement.	3.4.7; 3.4.8.2
14	Is the site over or within the exclusion zone of any tunnels, eg railway lines.	Not for Railways. Unknown in relation to other tunnels (Utilities, GPO, etc)	3.4.8

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 – Figure 14 (Arup, 2010)	2.1
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?	Yes – minor increase of hard surfacing in front lightwell will require installation of a new surface water drain (where surface water previously infiltrated or evaporated, see Q4 below). Flow from that drain can be mitigated by use of SUDS techniques.	3.4.1.5
3	Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?	Yes, but minor in front garden only - see Answers to Subterranean Flow screening, Qns 4 & 5 above	3.4.1.5
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 – Rear garden essentially level; area of hard-standing will not change. Run-off from the paved area of front garden is unlikely to change; this runs onto the highway and then to sewer. Flower bed is fully walled so no surface water runs off (it must either infiltrate or evaporate).	3.4.1.5
5	Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No, for the same reasons as Answer to Qn.4 above	

Non-technical Summary:

This screening exercise, in accordance with CPG4, has identified eleven issues which need to be taken forward to Scoping (Stage 2 – Section 3.2); two are related to Groundwater issues, seven to Ground Stability and two to Surface Flow issues. Some of these are inter-related, with the same 'issue' applying to more than one of the three 'flowcharts'.

3.2 Stage Two – Scoping

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.

Subterranean (groundwater) flow scoping:

Issue (=Screening Question)		Potential Impacts and actions
2	Is the site within 100m of a watercourse or spring line?	**Potential Impact:** Local restriction of groundwater flow through any Made Ground or Head deposits overlying the London Clay, or within permeable horizons in the London Clay. Water ingress into excavations. **Action:** Ground investigation (see Section 3.3); Sump pumping during dig.
4	Will the proposed basement development result in a change in the proportion of hard surfaced/ paved areas?	**Potential Impact:** Possible slight reduction of infiltration. **Action:** Provide appropriate mitigation, using appropriate SUDS techniques, for the small increase in hard-standing at front (5.6m^2 , with 2.7m^2 sedum roof already proposed for the bike store).

Slope/ground stability scoping:

Issue (=Screening Question)		Potential Impacts and actions
5	Is the London Clay the shallowest strata at the site?	**Potential impact:** Heave from removal of bushes and unloading caused by the basement excavations. **Action**: Ground investigation findings to be considered by designer; guidance and preliminary quantification of structural movements given in Section 3.4.6.
7	Is there a history of seasonal shrink/swell subsidence in the local area, and/or evidence of such effects at the site?	**Potential impact:** Heave from removal of bushes and unloading caused by the basement excavations. Differential foundation movement if the proposed basement below No.35 is not built. **Action:** Designer needs to confirm root zone effects of neighbours' trees are outwith footprint. See also Q13 below.
8	Is the site within 100m of a watercourse or potential spring line?	**Potential Impact:** Instability of excavation. **Action:** Suitable temporary support, installed in accordance with best practice.
11	Is the site within 50m of the Hampstead Heath ponds?	**Action:** Designer to notify The Panel Engineer for the Reservoirs, with details of the excavation. Not envisaged to be of concern.
12	Is the site within 5m of a highway or a pedestrian right of way?	**Potential Impact:** Instability of excavation on road side of site. **Action:** Suitable temporary works, installed in accordance with best practice.
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 Nos 35 and 31 if basement excavations are inadequately supported**.** Long term differential movements if No.35's basement is not built. **Action:** Ensure adequate temporary and permanent support by use of best practice underpinning methods and appropriate design

		(ref. Construction Method Statement as compiled by structural engineers BTA). Consider the need for transition underpinning below No.35 if proposed basement beneath No.35 is not constructed at same time as No.33's basement.
14	Is the site over or within the exclusion zone of any tunnels, e.g. railway lines.	**Potential impact:** Stress changes on the tunnel lining**.** **Action**: To be considered by designer; services search or enquiries.

Surface Flow and flooding scoping:

Issue (=Screening Question)		**Potential Impacts 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:** Without mitigation, a slight increase in flow to the mains drainage system. **Action:** Provide appropriate mitigation, using appropriate SUDS techniques.
3	Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?	**Potential Impact:** As Q2 above. **Action:** As Q2 above.

Non-technical Summary:

The scoping exercise has reviewed the potential impacts for each of the items taken forward from Stage 1 screening (Section 3.1), and has identified the following actions to be undertaken:

- A ground investigation is required (which has already been undertaken, see Section 3.3);
- Sump pumping to remove groundwater inflows to excavations;
- Designer and Contractor need to take account of potential weakening of structure caused by past movements (No.35 front bay and front wall is underpinned, No.33 is not – both buildings have 'strapping');
- The Designer needs to check that the root zone effects from highway/neighbours' trees are outside the basement footprint;
- The Designer needs to consider the effects of long-term heave of the structure, on this and adjacent/adjoining properties, caused by the excavation of the basement clay soil (Section 3.4.6 provides further comment on this, with preliminary heave quantification);
- The Designer needs to check that there are no Utilities in tunnel beneath the site;
- The Designer needs to inform the Panel Engineer for the Hampstead Ponds reservoir that these Works are to take place (no stability issues for the reservoir are envisaged);
- The (very minor) change from planting to hard-cover in the front garden should be designed so that the extra run-off from rainfall to sewer is mitigated by sustainable drainage (SUDS);
- Contractor must ensure that adequate temporary and permanent support is provided during construction, by the use of best practice underpinning methods;
- Owing to South Hill Park having been recorded as flooded during 2002, the future flood risk should be assessed (the subsequent Section 3.4.1.8 covers this aspect).

3.3 Stage Three – Site Investigation

As already mentioned, stage 3 is a site investigation, involving the review of existing data and the collection of new, site-specific data. There was a consistency of information from other basement projects upslope on South Hill Park to confirm the expectation of a possible thin surface layer of Head soils overlying weathered/stiff then very stiff London Clay (reached at or around basement floor level), but a site investigation has been undertaken to verify this.

3.3.1 Site Investigation Description & Findings

Chelmer Site Investigations (CSI) were appointed by the client to drill 3 boreholes to depths of 6-10m (one in rear garden of No. 33 and the other two in front & rear gardens of No. 35) and to excavate five trial pits. The latter were located alongside the front wall/ front bays (TPs 1 & 4), alongside No.35's rear wall (TP2), alongside No.33's sidewall (No.5) and in the rear garden alongside the 35/37 boundary wall (No.6). Standpipes were placed in two boreholes and monitored 1, 2 & 8 weeks after installation; the boreholes having been 'dry' when drilled. CSI's factual report on the investigation is presented in Appendix IV.

The boreholes recorded up to 1.0m of Made Ground (though none in BH3), below which all three boreholes recorded stiff, orange-brown, silty CLAY with grey veining (gleying), partings of silt and fine sand, claystone nodules and crystals (probably selenite, which is a form of sulphate). These clays became very stiff beneath 3.5-3.8m below ground level (bgl) and are typical of the weathered London Clay Formation. No groundwater entries were recorded in any of the boreholes or trial pits, though in low permeability clays this does not mean that groundwater is absent. The groundwater monitoring to date has recorded groundwater levels in the clays of up to 1.67 m bgl in the front garden, which is approximately 2.5m below site datum (bSD) and 4.79m bgl in the rear garden to No.33 which is approximately 1.3m bSD.

The trial pits showed that the house foundations, at the locations investigated, were founded between 0.33m and 1.03m bgl. The low wall on the 33/35 boundary in the front garden was founded at 0.2m bgl. Of particular note is the comparison between TP1 and TP4, both of which were on the front walls to Nos 35 and 33 respectively; these pits showed wide concrete underpinning to the front wall (and bay?) of No.35 but only the original brickwork footing to No.33.

The ground investigation has therefore confirmed the anticipated geology beneath these properties. Of particular note is the absence of any evidence for significant horizons of granular soils containing free groundwater.

3.3.2 Non-technical Summary:

The ground investigation confirmed the presence of weathered London Clay beneath the building at front and rear, with no Made Ground at the rear; the Clay became 'very stiff' at 3.5m depth, approximately the basement formation level. No groundwater entries or significant horizons of granular soils (which may facilitate groundwater flow) were recorded, and groundwater levels were recorded at 1.67m (front) and 4.79m (rear) below ground level, seven weeks after installation of the standpipes (a period which saw well above average rainfall, with southeast England approaching double its normal rainfall in December 2013).

3.4 Stage Four – Impact Assessment

3.4.1 Hydrogeology and Hydrology

This section of the report collates data pertinent to both groundwater and surface water, based on parameters identified in Guidance CGHHS and in CPG4.

The requirement for examination of the subterranean flow aspect is primarily that the property lies "*within 100m of a watercourse, well or potential spring line*", which is relevant for the Hampstead Pond No.1 being some 45-50m distant, and downslope of the site.

3.4.1.1 Existing situation and Hydrogeological Ground Model

A preliminary hydrogeological ground model has been compiled based on the mapped geology, the BGS memoir, and the borehole records as described in Sections 2.4 & 3.3.1:

- Geology: The site is directly upon the London Clay, and is approximately 200m from any boundary with the overlying Claygate Beds, at a higher level and to the north. The site is located at the crest of a 'ridge' trending southwards between South Hill Park and Parliament Hill, suggesting any groundwater flow direction from the site would be to the west towards the Hampstead Ponds. Variable thicknesses of Made Ground will be present overlying the London Clay, especially immediately behind the retaining walls, as backfill to the footing trenches and in the front garden – no Made Ground was found in BH3 in the rear garden here, and there was only a minor depth at the front BH1.

- Hydrogeology:
  The provisional hydrogeological ground model within a curtilage of No.33 comprises:
  - Perched groundwater in the variable layer of Made Ground, at least during the winter and spring seasons. Groundwater levels will fluctuate seasonally. Groundwater flow through this stratum from the rear garden to the front garden (and beyond) is likely to be limited to the backfill in service trenches because the house foundations, which span the full width of the plot, will block more widespread flow.
  - Hydrostatic groundwater pressures (increasing linearly with depth) in the London Clay within the depth of current interest; the groundwater monitoring readings suggested water levels at 4.8m depth in the rear garden and at 1.6m depth in the front garden (which represents a level difference of approximately 1.2m relative to Ordnance Datum). Groundwater flow in the London Clay of relevance to the proposed basement scheme is likely to be limited to seepage through any of the silt/fine sand partings which are sufficiently interconnected, though few were observed in the three boreholes. These clays are generally found to be fissured; in the uppermost 3m to 5m, some of these fissures will have been opened by desiccation (resulting from seasonal climatic changes and tree root activity), which can cause a slight increase in the general hydraulic conductivity of the clay.

  This hydrogeological regime will be affected by long-term climatic variations as well as by 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 and so a conservative approach will be needed. Provisional design groundwater levels of 0.5m below ground level at the front of the house, and at ground level at the rear of the house (and 1.0m bgl alongside the rear wall of the closet wing), are recommended. This means that the basement must be able to resist buoyant uplift pressures (un-factored) of 15-35kN/m^2 and locally up to 50kN/m^2.

3.4.1.2 Aquifer and Catchment Designation

The Environment Agency website indicates that the underlying London Clay geology is defined as unproductive with respect to groundwater status; a non-aquifer. According to ARUP (CGHHS Figure 14), the site is not located within any of the specified relevant drainage catchment areas for the Hampstead Ponds, their boundary being on the highway.

3.4.1.3 Groundwater Presence

The nature of the solid geology, which is characterised by sandier capping soils on Hampstead Heath overlying a substantial thickness of low permeability London Clay, suggests that a continuous groundwater body is unlikely to be present in the immediate location of this site (which is expected to be underlain by stiff Clay), but it is clear that rainwaters that fall on the Heath do emerge downslope of the Heath, and have been captured as springs which are evidential in parkland/woodland to the north (and possibly also at the northern end of South Hill Park Gardens).

As the underlying London Clay was eroded into major and minor valleys in previous geological timescales, so 'slopewash' material will subsequently have been transported into the contoured 'valleys' and this can be found as a near-surface layer which can be more permeable than the very stiff London Clay. It is envisaged that any shallow sub-surface groundwater flows will gravitate, with the topography, into these valley features from the 'capping' soil strata on the Heath, generally following the 'visible' surface watershed/boundaries and slope profiles towards the Hampstead Ponds or southwards beneath the Parliament Hill roadway.

However, the sub-surface groundwater catchment watershed that probably exists beneath the ridge between South Hill Park and Parliament Hill (so possibly beneath the back garden to No.33) may not exactly match the surface water catchment boundary (in the rear gardens to these properties) because it will be modified by the extent and degree of interconnection between any more permeable horizons within the underlying London Clay.

3.4.1.4 Depth and Orientation of Groundwater

The extent of groundwater flow within the more permeable horizons will be controlled in part by the degree of interconnections between the units. Human activities such as the construction of wells, and service trenches, are likely to have created pathways between potential upslope permeable horizons; as a result the groundwater catchment area for No. 33 could possibly extend upslope some distance 'into' adjacent gardens. The lack of significant permeable granular soil horizons in the boreholes means that any such flow will be limited to the thin partings of silt and fine sand so the groundwater catchment area is unlikely to extend more than a few metres or tens of metres upslope. The direction of groundwater flow will be determined by a combination of the hydraulic 'head' (pressure difference) driving the flow, the orientation of the strata, slope profile and the outcrop alignment of the permeable horizons on the slope.

Groundwater levels/pressures will also be affected by seasonal and long-term climatic fluctuations. The monitoring should be continued through the current winter with at least one further set of readings in order to refine the understanding of the likely range of groundwater levels/pressures.

3.4.1.5 Surface Rainfall Catchment and Surface Cover

The site is located at the top of a minor ridge between South Hill Park and Parliament Hill. This ridge runs in a south-southwest direction with the slope falling off rapidly, both to the west and east. Therefore it is possible for rainwater falling on these rear gardens to flow either east to Parliament Hill or west to the Hampstead Ponds.

According to the Arup Report (Figure 14, the yellow shaded area), however, the site is NOT within the catchment zone of the Hampstead Ponds, but evidence from topography during the site walkover suggests that at least a small part of the front garden area, the paved entrance section and steps, may be within that 'zone' as it drains onto the highway.

At this site, the only significant areas of "open" ground are the front garden's small flower-bed and the rear garden (with 3 different ground levels); top level is predominantly a grass lawn with narrow flower beds around the sides while the middle and lower levels are fully paved patio areas with limited areas of raised planters. The rear garden is bounded by fencing which effectively restricts surface run-off into this garden from No. 35.

The proposed development will not change the extent of hard surfaced areas at the rear of the site, whereas the paved area of front garden will increase by only 5.6m^2 plus 2.7m^2 of sedum roof to the bike store. The scheme will therefore result in a very slight decrease in surface water infiltrating the ground.

3.4.1.6 Springs, Wells and Watercourses

The closest surface water features to the site are the Hampstead Ponds. Hampstead No 1 Pond is the closest to the site, being slightly less than 50m to the west (and at a much lower level). The ARUP Guidance indicates that these ponds are part of a former surface water course that originated from high ground (approximately 120-130m AOD) at Hampstead Heath. The watercourse flowed in a south-easterly direction, via the current Hampstead Ponds, eventually forming the River Fleet, with a second arm that originated from the vicinity of Highgate Ponds.

There are no springs or wells apparent in the vicinity, but evidence for these can be noted on Parliament Hill (just north of the end of the housing zone) some 250-300m away.

3.4.1.7 Sewer Drainage

The property is apparently served by a combined sewer system, which discharges foul sewerage and all rainwaters (falling onto the roof/hardcover patio areas) into the public system.

As already noted, the proposed front lightwell will cause a slight increase in the area of hard surfacing (overall) from which surface water is discharged into the property's drainage system, In order to mitigate that increased flow, one or more appropriate Sustainable Urban Drainage System (SUDS) techniques should be implemented, such as the installation of a water butt or other interception storage, i.e. the installation of more green roofs as with the proposed cycle store, or directing some roof water (limited quantity only) to a rain garden.

3.4.1.8 Flood Risk

Figure 15 in the ARUP report states that South Hill Park was a flooded street in 2002, although anecdotally the current occupier of 35 SHP had no recollection of any neighbouring property flooding being reported, nor sustained highway/footway damage at that time. Enquiries of Camden Council have not elicited any further information/records that they might hold regarding any specific properties affected on SHP in 2002, and it is understood (from our work on other BIAs in Camden) that flooding of any section/area of each street was being recorded as applying to the whole street for the purposes of the '*Report of the Floods Scrutiny Panel (June 2003)*'s Figure 1.

This location is not considered, by dint of walkover, as being at risk of surface water flooding from the highway side, especially as the two houses are set well above the pavement level, and the highway slopes down towards the Heath station at around 1 in 20 gradient; it was also noted that some properties to the west, lower down, are set with courtyards/entrances below the highway, and are therefore vulnerable to overland pluvial flooding. This does not exclude the potential for back garden run-off to cause localised flooding at a rear patio/door.

The whole of SHP is noted to fall into the Environment Agency's Flood Zone 1; deemed to be at insignificant risk of flooding from tidal and/or fluvial origin.

3.4.2 Slope Instability and Landslip Potential

South Hill Park is built upon an underlying geology of London Clay. Figure 16 of the ARUP report gives an indication of where slopes in the area are in excess of 7 degrees and 10 degrees, which the Arup report considers to be the critical angles at which slope instability may occur, with the lower angle related to groundwater/spring issues. This property is not in that slope angle zone; however properties on the opposite side of the road that have rear gardens backing on to the Hampstead No. 1 Pond are within zones of either 7°-10° or >10°.

One of the owners/occupiers of No.37 has suggested that there is a 15° slope within No.35's property, from front to rear, and the same assertion might also be applied to No.33. This ignores the presence of the retaining walls so is not relevant in relation to Arup's requirement that slopes over 7° should be identified, because Arup's concerns related only to un-supported slopes.

The site is just within 50m of the Ponds, which fall under the Reservoirs Act, and means the Panel Engineer for these reservoirs needs to be formally notified regarding the proposed development. However, it is not considered that the Works here will have any effect on dam stability or catchment, as they are at a much higher elevation, there are properties in between, and this side of SHP is not defined as being part of the Ponds' catchment area.

Figure 17 of the same Report gives an indication of 'Areas of significant landslide potential', which (as this Figure is of a small scale, based upon the British Geological Survey mapping) shows a 'red zone' of concern. The red zone is indicative of recognition of the Claygate Beds/London Clay horizon being a potential unstable zone, where springs may emerge. This property is not on the part (the northern end) of South Park Hill that is in the 'red zone'.

Whilst there are significant slopes on the west side of South Hill Park in this locale, related to the valley within which Hampstead Ponds are contained, they do not extend to/beneath the adopted highway in any apparent manner. The natural slopes have been modified by construction in the past (in the 19th Century, see Plan in Appendix II), including forming a cross-level platform for the road itself, and there were no manifestations of continued movement evident in the highway. Some minor tilting/cracking of brick boundary walls was noted in adjacent properties, downslope of this site (on the NW side of SHP).

In the rear garden to No.35 the rear part of the 35/37 boundary wall was seen to have cracked and rotated downslope, away from the SHP properties and towards the Parliament Hill properties; this is irrelevant to the proposed basement. Other cracking in the boundary walls appeared to be associated with normal seasonal shrinkage/swelling of the clays beneath the foundations to these walls.

3.4.3 Shrink/Swell Clays

According to the BGS Shrink/Swell potential map, the area is at Moderate risk, due to its London Clay geology. The site walkover revealed no mature trees in the front or rear gardens of Nos. 31-35. On the east side of the site, next door to No. 33's rear garden, are some mature trees, but their trunks (and therefore their root systems) appear to enter the ground at a lower level than the rear garden of No. 33, as do some mature trees in other adjacent gardens of Parliament Hill properties to the east. On the frontage, there are pollarded trees in front of No. 29, and downslope on the main pavement (and also on the pavement opposite), but none of these are to be found directly outside Nos. 31-37.

3.4.4 Compressible/Collapsible Ground

According to the BGS collapsible/compressible potential map, this site has a low to nil compressibility potential and does not have a significant collapsible potential.

3.4.5 Mining, Quarrying and Landfilling

There is no evidence (from historical maps, walkover observations and the Environment Agency website) that suggests the presence of mines, quarries or landfills in the vicinity of 33 South Hill Park.

3.4.6 Structural Stability of Adjacent Properties

This Report assumes concurrent construction of a basement of similar size and depth at No. 35, so there would be no concern over stability of the attached property, assuming they have 'balanced' loading/wall details. The previous ground floor extension at rear of No.33 (some 15 years ago) would not seem to have changed the structural 'continuity' with No.35, but plans of the foundation details should be sought to aid/inform the structural designer. Should the basement at No.35 not be progressed, then construction of the proposed single storey basement under this property will need to take account of the foundations of No.35 (revealed by the joint site investigation in November 2013). Provision of transition underpins, stepping up in accordance with Building Regulations requirements should be considered by the Designer, in order to minimise the risk of structural damage from future differential foundation movements.

Downhill from the property (No. 31 SHP) does not have a basement/cellar. Although there is a space between Nos. 31 & 33 along much of the common side (less at the rear corner), the proposed basement does not extend beneath the flat roofed section of the rear closet wing so there will be an approximately constant 'gap' (just over a metre wide at ground level) between Nos 31 & 33 where the combined sewer passes, draining rear to front.

The existing foundation type/depth at No. 31 will require careful consideration (trial pit 5 on the flank wall revealed that the property foundation there of No.33 is not on natural ground), to ensure that the excavations along the flank wall of No. 33 are carried out safely and securely, albeit the foundations of No. 31 may be founded at a similar level to the proposed basement of No. 33, as that building is of more recent origin (with potentially deeper foundation standards, post-war) and is located at a lower topographical level.

Some, usually minimal, ground movement is inevitable when basements are constructed; however, heave from the unloading typically acts to offset any settlement caused by the excavations, resulting (subject to best working practices being followed) in minimal or no net vertical ground movements. For basements constructed using underpinning methods, the resultant ground movements depend primarily on the geology and the adequacy of the temporary support to both the underpinning excavations and to the partially complete underpins prior to installation of full permanent support. A high quality of workmanship and use of best practice methods of temporary support are therefore crucial to the satisfactory control of ground movements alongside basement excavations (see 3.4.8 Constructional Aspects below).

<u>Damage Category Assessment:</u>

Potential damage to neighbouring buildings can be assessed using a methodology described by Burland (2001). Provided that the temporary support follows best practice as outlined above and in Section 3.4.8 then extensive past experience has shown that the bulk ground movements caused by underpinning to this depth in London Clay should not exceed ground movements caused by underpinning to this depth in London Clay should not exceed 5mm in either horizontal or vertical directions. This vertical settlement is likely to be partially offset by the anticipated heave caused by excavation of the basement (see section below).

Ground movements associated with the construction of retaining walls have been shown to extend a distance up to 4 times the depth of the excavation, which, for this 2.3-3.3m deep excavation, would be 9m to 13m. Movements associated with the construction of No.33's basement might therefore extend northwards to the 37/39 party wall and southwards to the south flank wall of No.29.

The width of Nos 29/31 (L) is approximately 12.6m and their height is approximately 8.2m (from 1960/61 drawing for No.29), so L/H = 1.54. Thus the maximum horizontal strain beneath these properties would be $\varepsilon h = 3.97 \times 10^{-4}$ (0.040%) and the maximum angular distortion allowing for 1mm to 5mm of heave would range from $\Delta/L = 3.2 \times 10^{-4}$ (0.032%) to zero. For L/H = 1.5 these represent damage categories of 'very slight' (Burland Category 1, εlim =0.05-0.075%) to 'negligible' (Burland Category 0, εlim <0.05%) as given in CPG4.

To the north of No.33 the heights of the buildings are not constant, with the critical element probably being the front wall of the two-storey closet wings to the rear of Nos 35 & 37. This wall has a height H = 7.15m at its highest above No.35's ground floor (ref. David Mikhail Architects' Drg No. AL(1) 200), and extends up to 7.5m from the centreline of the 33/35 party wall, and so L/H = 1.0. For this scenario, the maximum damage category would be 'very slight' (Burland Category 1, εlim =0.05-0.075%) provided that the combination of heave and settlement does not exceed a net settlement of 2mm.

<u>Preliminary heave assessment:</u>

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 rate of plastic swelling will be determined largely by the availability of water and as a result, given the low permeability of the London Clay, can take many years to reach full equilibrium. The basement slab will need to be sufficiently stiff to enable it to accommodate the swelling pressures developed underneath it.

Excavation of 2.3m to 3.3m of ground from beneath No.33 will cause a gross reduction in vertical total stress in the order of 44-65 kPa. The strata beneath the proposed basement floor slab will not have been stressed significantly by the previous foundations. As a result, the estimated loads from the superstructure and basement structure may be deducted from the gross unloading to obtain net unloading loads and stresses.

The reduction in vertical stress will extend to a depth equal to approximately twice the width of the unloaded area (below which the stress reduction is generally considered to be insignificant). The maximum width of the proposed basement will be approximately 5.9m, or 11.8m with No.35's basement. The unloading is therefore anticipated to reduce progressively with depth between the underside of the basement slab and approximately 12m/24m below that level.

Elastic heave will occur immediately, as the excavations progress. Underpinning schemes typically involve construction of the perimeter basement walls before the main central mass of soil is excavated. Most/all of the elastic heave beneath each underpinning base will be reversed as soon as the dry-pack is installed and load from the superstructure is transferred onto the new foundation. Elastic heave from excavation of the central mass of soil will extend beyond the footprint of the basement but will be complete before the new basement slab is cast.

A preliminary assessment of potential heave magnitudes has been undertaken and is presented in Appendix V. This analysis was performed using one–dimensional consolidation theory and estimated values of the Modulus of Volume Change for swelling (M_{vs}) for the appropriate stress range. Values of M_{vs} for London Clay have been measured recently on other projects and found to fall broadly within the same range as M_v values for consolidation.

Loads from the superstructure have been estimated, so are very approximate, in order to identify the net unloading at basement formation level and from that the predicted net reduction in vertical stress. Potential heave was then calculated separately for the basement beneath No.33 only and for the combined basements beneath Nos 33 & 35. The proposed excavations in the rear garden of No.35 have not been modelled (though will be when No.35's basement is considered alone).

These heave analyses gave potential swelling-induced heave values of 5mm beneath No.33 if No.35's basement is not constructed, and 24mm beneath the combined basements to Nos 33 & 35. These values apply only to the centre of the basement slab; the heave experienced would be expected to reduce substantially close to the perimeter and, based on more rigorous analyses for other projects with similar geology, heave values of less than 5mm would be expected outside of the combined basements to Nos 33 & 35. Depending on the type and width of the underpinning it is also likely that the more heavily loaded sections will undergo settlement rather than heave.

Further reasons why these heave values are very conservative include:

1. They make no allowance for the beneficial restraining effects of the stiffness of the basement slab or the surrounding ground.
2. The assumptions about the stress distributions are grossly simplified.
3. The M_{vs} values typically over-estimate the actual heave experienced or calculated by other methods.

These values of heave are provided only to assist in scheme development. They do not comprise detailed design. Further, more rigorous analysis of potential heave in response to construction of the proposed basement(s) could be undertaken during the detailed design phase.

3.4.7 Tunnels

There are no railway or underground tunnels in the immediate vicinity of 33 South Hill Park. The closest rail tunnel is that leading west from Hampstead Heath station, some 200m to the south-west of here. It is assumed, but should be confirmed by the designer at the full design stage, that there are no Utility tunnels beneath South Hill Park.

3.4.8 Constructional Aspects

3.4.8.1 Impact of the Proposed Permanent Works (Hydrogeology)

Owing to the raised position of No.33 relative to the South Hill Park roadway, the proposed basement will only introduce a barrier to any groundwater flow down to a level approximately 1.5m below the adjacent roadway, provided that the basement is constructed using underpinning techniques (as opposed to bored pile walls). The predominant (expected) flow direction of any perched groundwater within the Made Ground would be from rear to front of the properties, given the local topography and the high point/ridge in the rear gardens, however the existing foundations and the clayey nature of the Made Ground means that such flow, if any, is likely to be very limited and/or confined to the backfilled service trenches. Similarly only minimal or no flow is anticipated in the partings of silt and fine sand in the London Clay, where undisturbed. As a result, if the proposed (joint) basement structure at Nos. 33/35 does intersect any of those thin silt/sand partings then at worst a small rise in groundwater pressures would be expected on the upslope side of the basement.

3.4.8.2 Impact of the Proposed Works (Structural Stability)

The excavation for No.33's new basement will go lower than the expected foundation level of the flank wall of No.31, and there is only a small lateral gap between the properties. There is a possible potential to affect the flank wall foundations of No.31 by this basement excavation at No. 33, and mitigation/support works would generally be designed as part of any Party Wall Agreement for basement construction (the current foundations to No.31 may need to be exposed, levelled and logged, as part of a future ground investigation, if details unavailable).

Under UK standard practice the contractor is responsible for designing and implementing the temporary works, so it is considered essential that the contractor employed for these works should have completed similar schemes successfully. For this reason careful pre-selection of the contractors who will be invited to tender for these works is recommended. Full details of the temporary works should be provided in the contractor's method statements.

In intact stiff clay, such excavations will remain stable in the short term (for long enough to construct the underpin) with no additional support and minimal, purely elastic deformations. The presence of fissures in these clays means that intermittent support may be required, especially in excavations for corner pins where there are two rear faces. In the Made Ground full face temporary support may be required, installed as the excavation progresses. Temporary support must be installed to support the new underpins until the full permanent support has been completed, including allowing time for the concrete to gain adequate strength. All temporary support should use high stiffness systems installed in accordance with best practice in order to minimise the ground movements.

In accordance with normal health and safety good practice the requirements for temporary support of any excavation must be assessed by a competent person at the start of every shift and at each significant change in the geometry of the excavations as the work progresses. London Clay is usually fissured; such fissures can cause seemingly strong, stable excavations to collapse with little or no warning. Thus, in addition to normal monitoring of the stability of the excavations, a suitably competent person should check whether such fissuring is present and, if encountered, should assess what support is appropriate.

3.4.8.3 Temporary Works (Groundwater)

Any groundwater entries from the Made Ground and the silt/sand partings/laminations within the London Clay should be amenable to control by simple sump pumping; no evidence of significant Made Ground thickness nor of potentially water-bearing horizons was encountered in the 3 boreholes drilled on this and the adjacent site recently. An appropriate discharge location will need to be identified for pump discharge before the works commence.

If the excavations intersect any laterally extensive service drains then a more substantial groundwater entry might be encountered from the bedding or trench backfill. The layout of the drainage system to the rear of the property should therefore be checked before the works commence, to confirm that it solely serves this property, and appropriate provision made if any laterally extensive 'collector' drains are found to be present.

3.4.8.4 Waterproofing

The proposed basement will need to be fully waterproofed in order to provide adequate long-term control of moisture ingress from the ground. 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.

4. Conclusions / Non-technical Summary for Stage 4

These conclusions, which also provide the non-technical summary to Stage 4, indicate the primary findings of this assessment; the whole report should be read to obtain a full understanding of matters concerned.

Surface Flow and flooding:

No change is proposed to No.33's rear garden, including the lower patio, steps and upper terrace, so it is not envisaged there is to be any significant change to on-site, or off-site, flows in that area; the rear garden catchments are individually 'controlled' by boundary walls and sloping topography. The proposed front lightwell will result in a small increase in hard surfacing and a resultant minor increase in surface water being discharged to the drainage system; this should be mitigated by use of one or more appropriate SUDS system(s).

Whilst reference is made in CGHHS to flooding on South Hill Park in 2002, the location of No. 33 is on a relatively significantly sloping highway and there is no apparent reason why rain-induced flooding would have occurred at this location, nor does No.35's Owner (resident at that time) recall any such problem at these properties. The ground floor to the property is 1.9-2.3m above the pavement (with steps up to the front door), so is at no risk of flooding from the road/footway, while the front lightwell will be protected by a boundary wall and an upstand below the front gate as shown on the proposed front elevation drawing.

Subterranean (Groundwater) Flow:

The proposed basement is considered acceptable in relation to subterranean (groundwater) flow and the only mitigation measures expected would be sump pumping for any temporary groundwater ingress. This evaluation is based upon information from boreholes for basements elsewhere on SHP, and confirmed by investigations on this property (and No.35) which found London Clay at shallow depth with no observed granular layers, only thin partings, and no water ingress.

Groundwater levels during the monitoring period were up to 1.6m below ground level in the front garden and 4.8m bgl in the rear garden. This monitoring should be continued through the current winter in order to assess further the current groundwater levels/pressures.

The basement needs to be fully waterproofed. Provisional design groundwater levels at ground level at the rear of the basement (and 1.0m below ground level alongside the rear wall of the closet wing), and at 0.5m below ground level to the front boundary are proposed, which means that the basement must be able to resist buoyant uplift pressures (un-factored) of 15-35kN/m^2 generally and locally up to 50kN/m^2.

Slope/Ground Stability:

In slope/ground stability terms, as there is to be a concurrent/new basement beneath (conjoined) No.35 at the same depth to that proposed here, then the construction of the floor/walls will tend to be contiguous with the adjacent property, and therefore ground stability should be generally maintained by that activity. Care will be needed for the south-western basement wall, to ensure the adjacent 3-storey flank wall to No.31 is not undermined by lateral movements of ground into the excavated void (or by heave due to ground relaxation).

In order to adequately control ground movements alongside the basement dig (south-west side wall), a construction sequence (and method) must be set out to protect the foundations of No.31; the sequence and support arrangements for the basement dig should utilise best practice underpinning and temporary support methods, to minimise any horizontal & vertical ground movements.

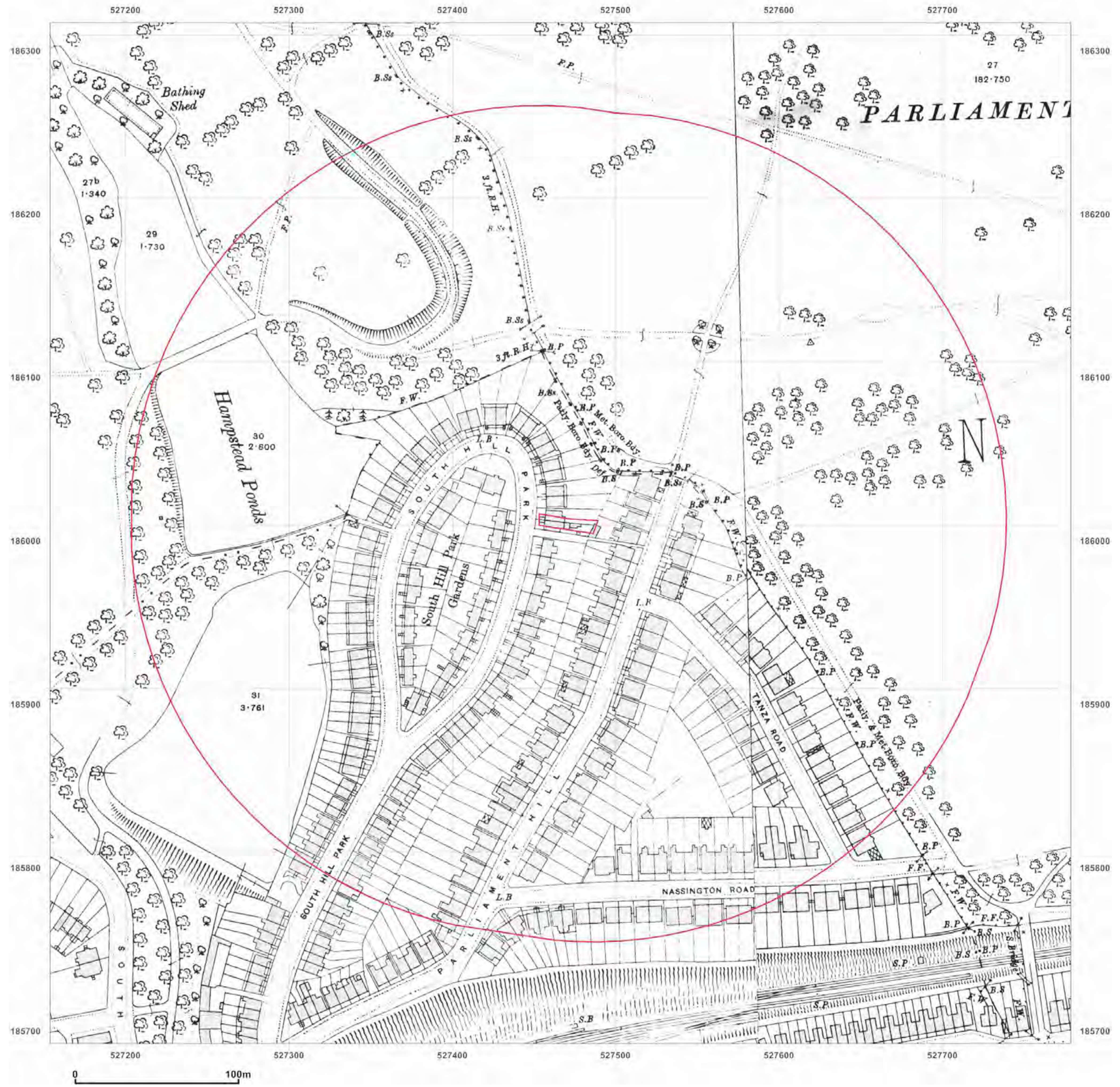
Should the basement at No.35 not be progressed, then construction of a singular basement under this property will need to take account of the foundations of No.35 (revealed by the joint site investigation in November 2013) and provide similar design and constructional provisions and detail, in order to minimise any structural damage. A Construction Method Statement, including construction sequences covering the construction of basements to Nos. 33 & 35 both concurrently and independently, is included as separate documentation with the planning application.

Damage category assessments for the properties to both the north (Nos 35/37) and south (Nos 29/31) indicated that the potential damage is likely to fall within Burland Category 1 ('very slight') to Burland Category 0 ('negligible') provided that best working practices are followed throughout the underpinning works, and in particular for the temporary support of the excavations and the completed underpins.

Preliminary, very simplified, heave analyses indicated potential heave values of 5mm beneath the centre of No.33's basement, if No.35's basement is not constructed, or 24mm beneath the centre of the combined basements to Nos 33 & 35. These values are likely to be over-estimates and the heave experienced would also be expected to reduce substantially close to (and beyond) the perimeter walls of the basement. The more heavily loaded parts of the basement may undergo settlement rather than heave.

APPENDIX I
FIGURES AND MAPS

35 & 33 South Hil Park NW3 2ST



GroundSure ENVIRONMENTAL INSIGHT

Site Details:

85, SOUTH HILL PARK,
LONDON, NW3 2SP

Client Ref: 11/9418/NVM
Report Ref: HMD-170224
Grid Ref: 527466, 186005

Map Name: County Series

Map date: **1915**

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Printed at: 1:2,500

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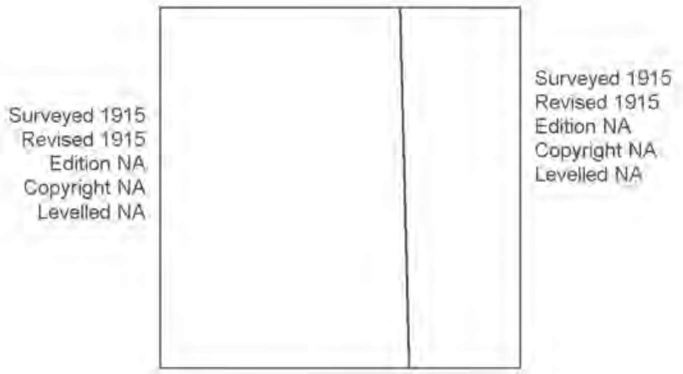

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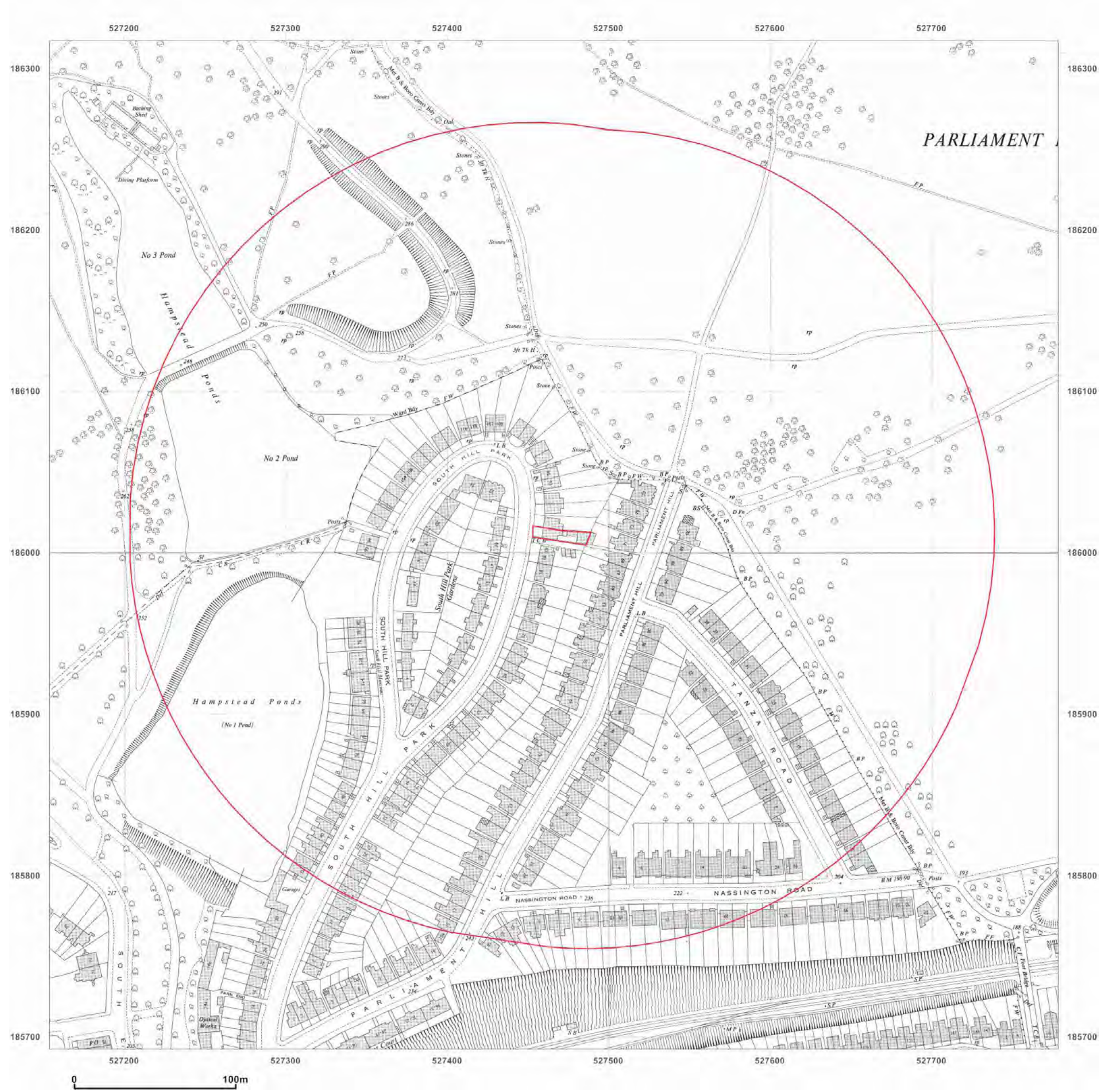
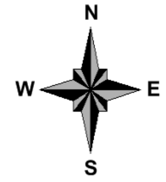
Production date: 06 October 2011

To view map legend click here *Legend*





Site Details:

85, SOUTH HILL PARK,
LONDON, NW3 2SP

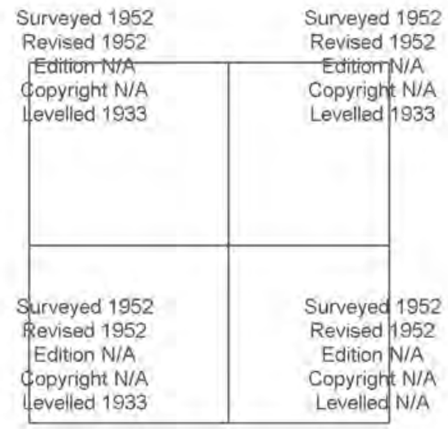
Client Ref: 11/9418/NVM
Report Ref: HMD-170224
Grid Ref: 527466, 186005

Map Name: National Grid

Map date: **1952**

Scale: 1:1,250

Printed at: 1:2,500



Ordnance Survey Licensed Partner

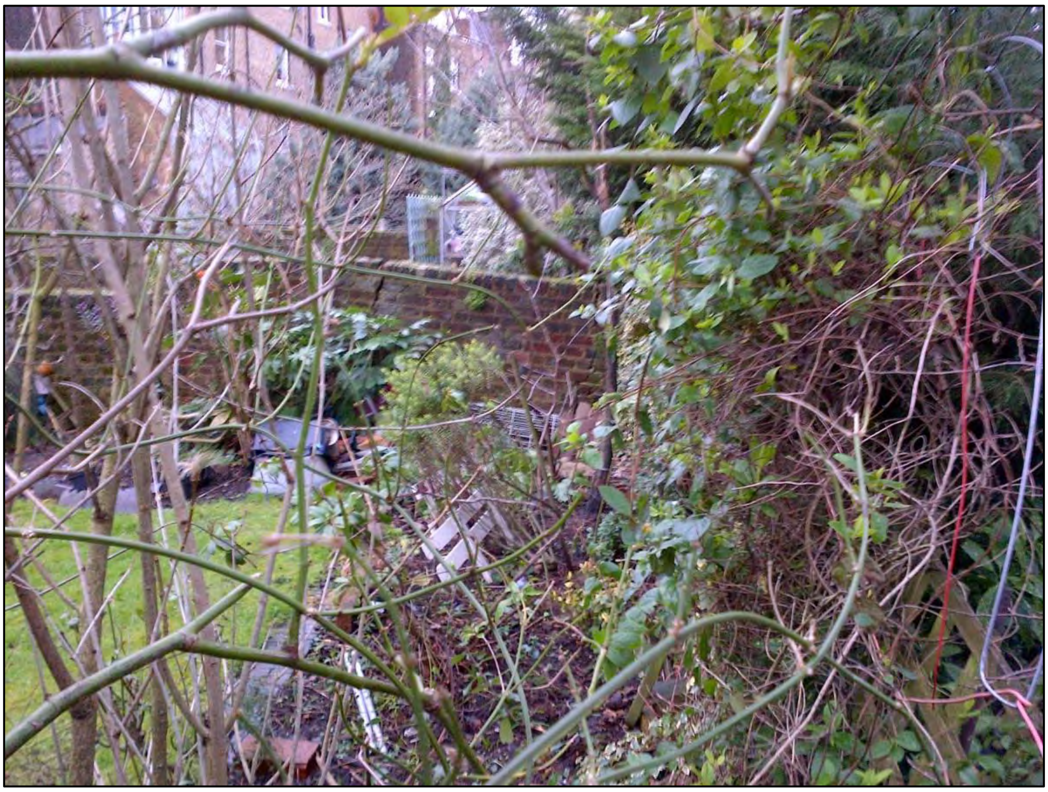
Produced by
GroundSure Environmental Insight
T: 08444 159000
E: info@groundsure.com
W: www.groundsure.com

Production date: 06 October 2011

To view map legend click here *Legend*

APPENDIX II
PHOTOGRAPHIC REPORT

Photograph One: Front view of 35 and 33 South Hill Park. Note the strapping above and below bay windows of No. 35. No. 33 has had them mostly removed, but wall bolts still remain visible.



Photograph Two: Garden wall of number 37 South Hill Park showing large crack and leaning towards Parliament Hill gardens

Photograph Three: Rear garden in No. 33, showing the variable ground levels.

Photograph Four: Rear view of No. 33, showing the large height difference with No. 31 South Hill Park (to left).

Photograph Five: Channel drain in rear garden patio area.

APPENDIX III

SOUTH HILL PARK BOREHOLE RECORDS

A Factual Report on the

Site Investigation undertaken for

Mr & Mrs J Jones

at

71 South Hill Park
Camden
London NW3

CSI Ref: 3012

Dated: 7th February 2012

Chelmer Site Investigation Laboratories Ltd. Unit 15 East Hanningfield Industrial Estate, Old Church Road, East Hanningfield, Essex CM3 8AB
Telephone: 01245 400930 Fax: 01245 400933 Email: info@siteinvestigations.co.uk Website: www.siteinvestigations.co.uk

Chelmer Site Investigations
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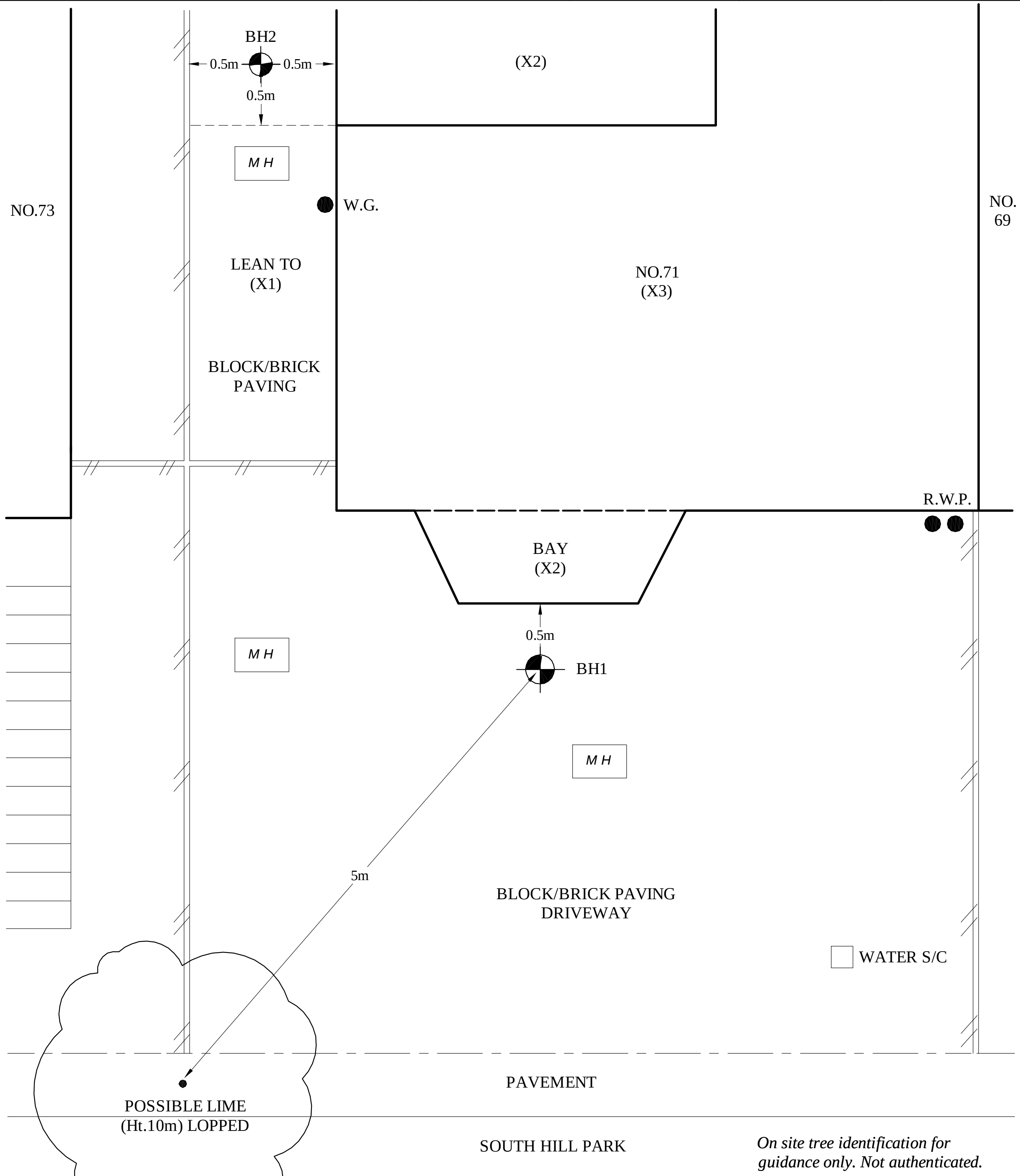
Old Church Road, East Hanningfield, Essex CM3 8AB
Telephone: 01245 400930 Fax: 01245 400933
Email: info@siteinvestigations.co.uk Website: www.siteinvestigations.co.uk

Client: Mr & Mrs J Jones	**Scale:** N.T.S.	**Sheet:** 1 of 1	**Date:** 7.2.12	
Location: 71 South Hill Park Camden, London NW3	**Job No:** 3012	**Weather:** Fine	**Drawn by: DB**	**Checked by: ME**



Notes: Large trees in rear garden Ash tree & Conifer.
Ash = approx (ht.15-20m) Conifer = approx (ht.6-7m)
BH1 relocated to front of bay due to manhole and services in driveway. BH2 relocated outside lean to due to manhole drain runs and WG.

Key:
Tree/Shrub
Borehole
Trial Pit
Gully
Tree Stump
Rain Water/ Soil Pipe
Manhole

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Client: Mr & Mrs J Jones	**Scale:** N.T.S.	**Sheet No:** 1 of 1	**Weather:** Fine	**Date:** 7.2.12
Site: 71 South Hill Park, Camden, London NW3	**Job No:** 3012	**Borehole No:** 1	**Boring method:** Hand auger	

Depth Mtrs.	Description of Strata	Thick-ness	Legend	Sample	Test Type	Test Result	Root Information	Depth to Water	Depth Mtrs
G.L. 0.15	BLOCK PAVING (60mm) over SAND (40mm) over CONCRETE (50mm)	0.15							
0.8	MADE GROUND: soft moist dark brown very silty clay with occasional gravel flint brick and concrete fragments.	0.65		D	M	03 05 04 07	Roots of live and dead appearance to 1mm Ø to 1.4m.		0.5
				D	V	76 82			1.0
				D	V	86 94	Hair and fibrous roots to 2.1m.		1.5
	Stiff mid brown/orange grey veined very silty CLAY with partings of orange and brown silt and fine sand occasional claystone nodules and crystals.	2.0		D	V	102 110	No roots observed below 2.1m.		2.0
2.8				D	V	122 128			2.5
3.4	Very stiff as above.	0.6		D	V	140+ 140+			3.0
				D	V	140+ 140+			3.5
	Very stiff mid brown grey veined silty CLAY with partings of orange and brown silt and fine sand occasional claystone nodules and crystals.	1.6		D	V	140+ 140+			4.0
				D	V	140+ 140+			4.5
5.0				D	V	140+ 140+			5.0
	Borehole ends at 5.0m								

Drawn by: DB **Approved by:** ME

Remarks: Borehole dry and open on completion.

Key: T.D.T.D. Too Dense to Drive
D Small Disturbed Sample J Jar Sample
B Bulk Disturbed Sample V Pilcon Vane (kPa)
U Undisturbed Sample (U100) M Mackintosh Probe
W Water Sample N Standard Penetration Test Blow Count

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Client: Mr & Mrs J Jones	**Scale:** N.T.S.	**Sheet No:** 1 of 1	**Weather:** Fine	**Date:** 7.2.12
Site: 71 South Hill Park, Camden, London NW3	**Job No:** 3012	**Borehole No:** 2	**Boring method:** Hand auger	

Depth Mtrs.	Description of Strata	Thick-ness	Legend	Sample	Test Type	Test Result	Root Information	Depth to Water	Depth Mtrs
G.L. – 0.2	BLOCK PAVING (60mm) over SAND (40mm) over CONCRETE (100mm)	0.2					Roots of live and dead appearance to 1mm Ø to 0.7m.		
0.2 – 0.8	MADE GROUND: soft moist dark brown very silty clay/clayey silt with occasional gravel flint brick and concrete fragments.	0.6		D	M	03 05 06 05	Hair and fibrous roots to 1.1m.		0.5
0.8 – 2.3	Stiff mid brown/orange grey veined very silty CLAY with partings of orange and brown silt and fine sand occasional claystone nodules and crystals.	2.0		D	V	76 82	No roots observed below 1.1m.		1.0
				D	V	88 94			1.5
				D	V	106 112			2.0
2.3 – 3.3	Stiff mid brown grey veined silty CLAY with partings of orange and brown silt and fine sand occasional claystone nodules and crystals.	1.0		D	V	120 126			2.5
				D	V	136 140+			3.0
3.3 – 5.0	Very stiff mid brown grey veined silty CLAY with partings of orange and brown silt and fine sand occasional claystone nodules and crystals.	1.1		D	V	140+ 140+		*3.3*	3.5
				D	V	140+ 140+			4.0
				D	V	140+ 140+			4.5
5.0				D	V	140+ 140+			5.0
	Borehole ends at 5.0m								

Drawn by: DB **Approved by:** ME

Remarks: *Slight water seepage at 3.3m.*
Borehole moist at base and open on completion.

Key: T.D.T.D. Too Dense to Drive
D Small Disturbed Sample J Jar Sample
B Bulk Disturbed Sample V Pilcon Vane (kPa)
U Undisturbed Sample (U100) M Mackintosh Probe
W Water Sample N Standard Penetration Test Blow Count

ALBURY S.I. Ltd Petworth Road, Witley, Surrey GU8 5LH

Borehole No	1		
CONTRACT	South Hill Park, London	Report No	11/9418/KJC
Client	Mr S. Fenton	Ground Level	mOD
Site Address	85, South Hill Park, London, NW3 2SP	Boring Commenced Boring Completed	7/10/11 7/10/11

Type and Diameter of Boring: Tracked Geotool Dynamic Probing/Window Sampling rig

Water Strikes, m	Water Levels Recorded During Siteworks, m	
1 See remarks	Date	7/10
2	Hole Depth	5.00
3	Casing Depth	-
4	Water Level	1.90*

Remarks: Excavation of starter pit to clear services. No groundwater strikes were noted during the construction of the probehole. * water level recorded on completion. Probehole extended by dynamic probing

Samples of Tests Type	Depth, m	Shear Strength kPa	Depth	Legend	Strata Description
D	0.20				Made ground (granite setts over clay and brick fill)
D	0.50		0.40		Stiff orange-brown and grey very silty sandy (fine) clay with inclusions of grey and orange silt/fine sand
D	1.00	130			
D	1.50				
D	2.00	125			
D	2.50				
D	3.00 -3.20		2.90		Brown very silty sand
D	3.50	105	3.40		Stiff orange-brown and grey very silty sandy (fine) clay with inclusions of grey and orange silt/fine sand
D	4.00	120	3.90		Stiff becoming very stiff grey-brown fissured very silty clay with veins of blue-grey clay and selenite crystals
D	4.50				
D	5.00	170	5.00		

Sampling Code: U - Undisturbed B - Large disturbed D - Small disturbed W - Water (U*) Non recovery of U Sample

ALBURY S.I. Ltd Petworth Road, Witley, Surrey GU8 5LH	Borehole No 2
CONTRACT South Hill Park, London	Report No 11/9418/KJC
Client Mr S. Fenton	Ground Level mOD
Site Address 85, South Hill Park, London, NW3 2SP	Boring Commenced 07/10/11 Boring Completed 07/10/11

Type and Diameter of Boring: Tracked Geotool Dynamic Probing/Window Sampling rig

Water Strikes, m	Water Levels Recorded During Siteworks, m							
1 See remarks	Date	7/10	18/10	31/10				
2	Hole Depth	5.00	4.00	4.00				
3	Casing Depth	-	s/p	s/p				
4	Water Level	None	3.39	3.44				

Remarks: Excavation of starter pit to clear services. Probehole extended by dynamic probing. No groundwater strikes were recorded during the construction of the probehole. Standpipe installed to 4.0m

Samples of Tests Type	Depth, m	Shear Strength kPa	Depth	Legend	Strata Description
D	0.10		0.30		Made ground (brown topsoil)
D	0.50				Made ground (brown clay with brick fragments)
D	1.00		1.20		
D	1.50	125			Stiff orange-brown and grey very silty sandy (fine) clay with inclusions of grey and orange silt/fine sand
D	2.00	145			
D	2.50				
D	3.00	125			
D	3.50				
D	4.00	170			
D	4.50		4.80		
D	5.00	175	5.00		Very stiff grey-brown fissured very silty clay with veins of blue-grey clay and selenite crystals

Sampling Code: U - Undisturbed B - Large disturbed D - Small disturbed W - Water (U*) Non recovery of U Sample

APPENDIX IV

FACTUAL REPORT ON GROUND INVESTIGATION

AT 33 & 35 SOUTH HILL PARK

BY CHELMER SITE INVESTIGATION

Chelmer Site Investigations

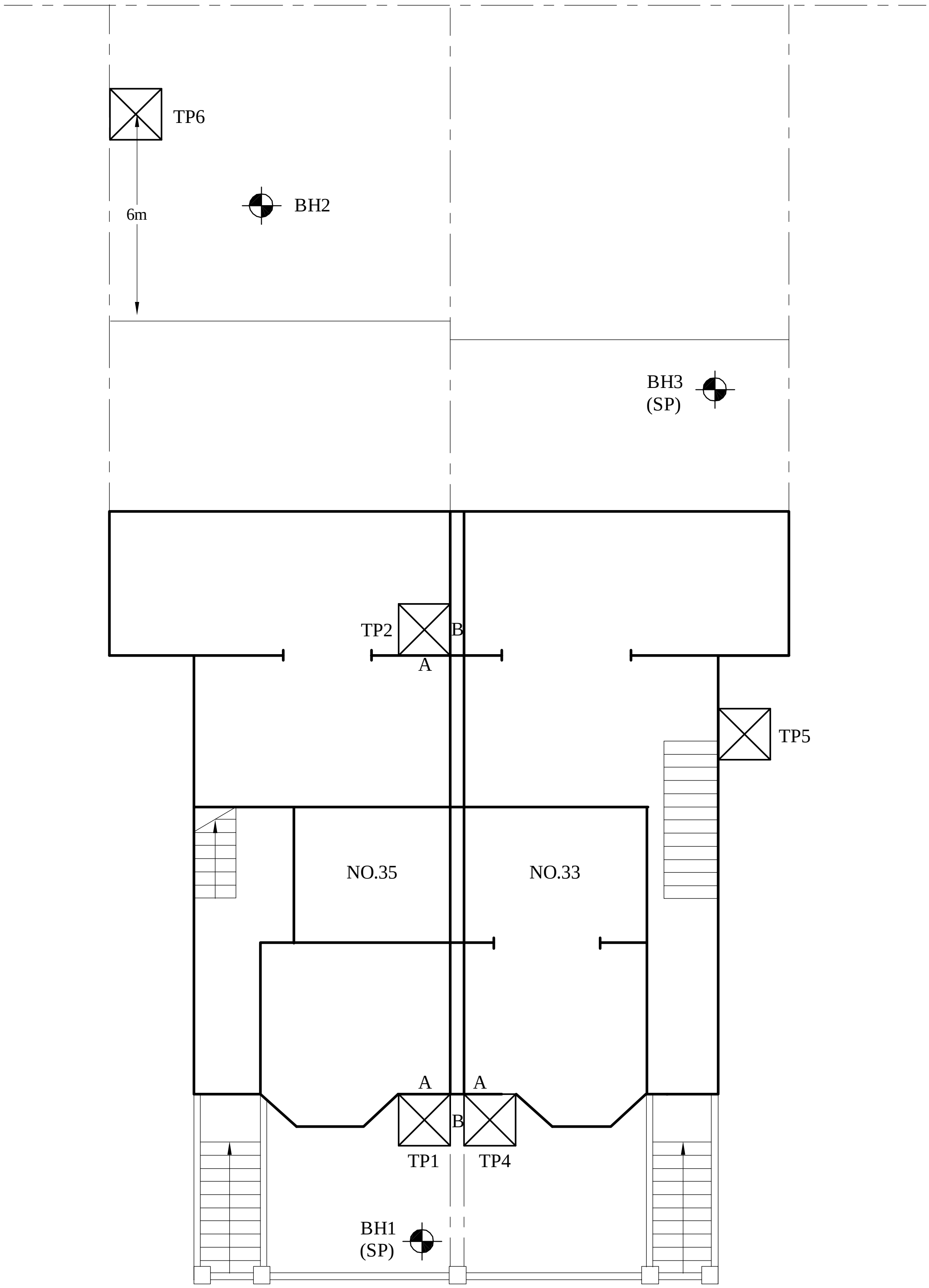
Unit 15, East Hanningfield Industrial Estate
Old Church Road, East Hanningfield, Essex CM3 8AB
Telephone: 01245 400 930 **Fax:** 01245 400 933
Email: info@siteinvestigations.co.uk **Website**: www.siteinvestigations.co.uk

Factual Report

Client:	Carole Markey
Site:	33-35 South Hill Park Hampstead London NW3
CSI Ref:	FACT/4047
Dated:	29th January 2014

Chelmer Site Investigations
Unit 15 East Hanningfield Industrial Estate
Old Church Road, East Hanningfield, Essex CM3 8AB
Telephone: 01245 400930 Fax: 01245 400933
Email: info@siteinvestigations.co.uk Website: www.siteinvestigations.co.uk

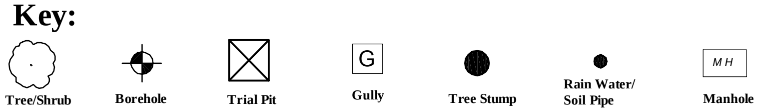
Client: Carole Markey	**Scale:** N.T.S.	**Sheet:** 1 of 1	**Date:** 20.11.13
Location: 33 & 35 South Hill Park Hampstead, London NW3	**Job No:** 4047	**Weather:** Rain	**Drawn by:** ND / **Checked by:** ME



Notes:

On site tree identification for guidance only. Not authenticated.

Key:



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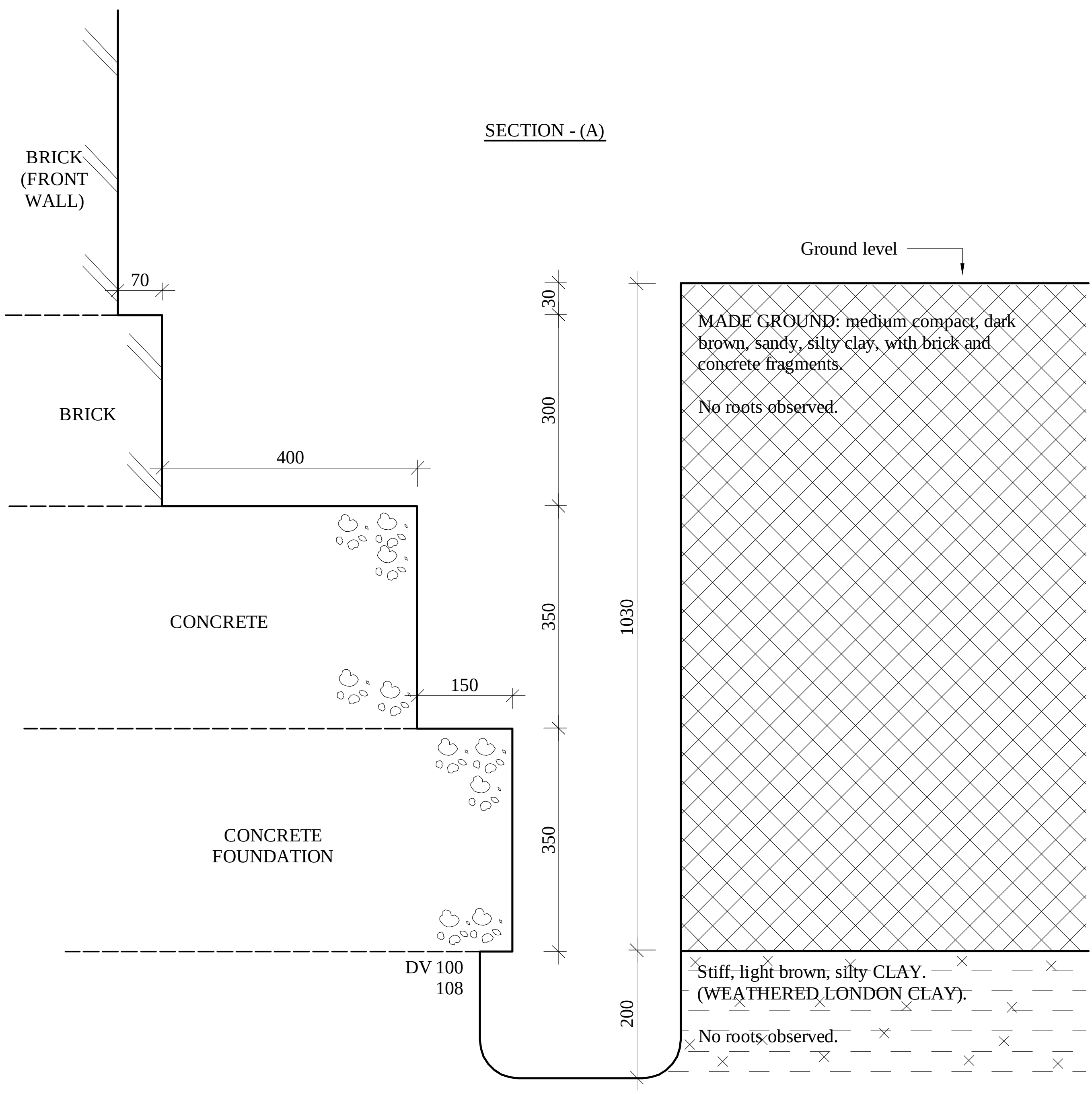
Email: info@siteinvestigations.co.uk Website: www.siteinvestigations.co.uk

Client: Carole Markey	**Scale:** N.T.S.	**Sheet No:** 1 of 2	**Date:** 20.11.13
Location: 22 & 35 South Hill Park Hampstead, London NW3	**Job No:** 4047	**Trial Pit No:** 1	**Weather:** Rain
Excavation Method: Hand tools		**Drawn by:** ND	**Checked by:** ME



TP1 (SECTION A) - ENDS AT 1230mm

Remarks:

Key:
D Small disturbed sample
B Bulk disturbed sample
U Undisturbed sample (U100)
N Standard Penetration Test Blow Count
J Jar sample
V Pilcon Vane (kPa)
M Mackintosh Probe
W Water Sample

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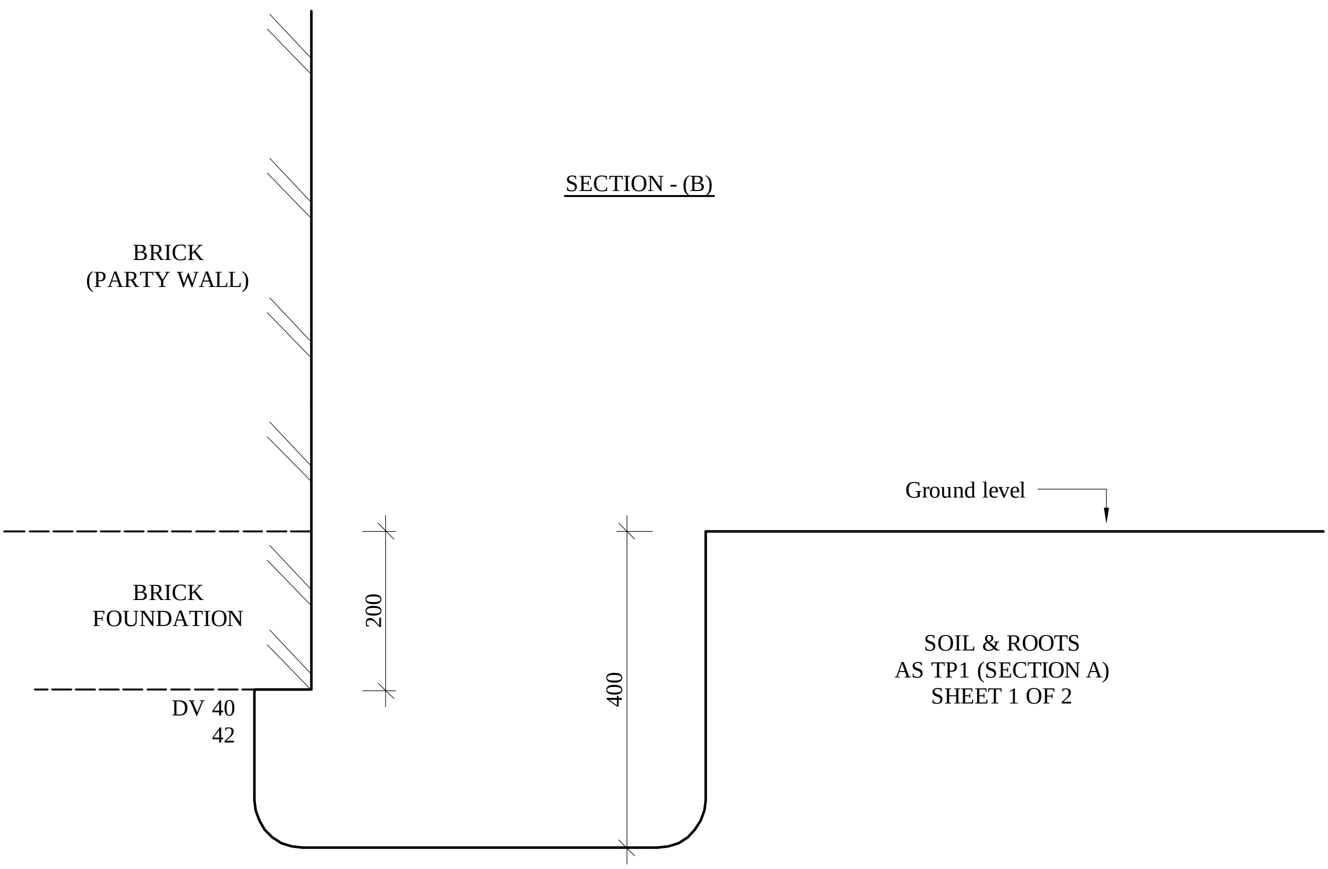
Email: info@siteinvestigations.co.uk Website: www.siteinvestigations.co.uk

Client:	Carole Markey	**Scale:**	N.T.S.	**Sheet No:**	2 of 2	**Date:**	20.11.13
Location:	22 & 35 South Hill Park Hampstead, London NW3	**Job No:**	4047	**Trial Pit No:**	1	**Weather:**	Rain
Excavation Method:	Hand tools			**Drawn by:**	ND	**Checked by:**	ME



TP1 (SECTION B) - ENDS AT 400mm

Remarks:

Key:
D Small disturbed sample
B Bulk disturbed sample
U Undisturbed sample (U100)
N Standard Penetration Test Blow Count
J Jar sample
V Pilcon Vane (kPa)
M Mackintosh Probe
W Water Sample

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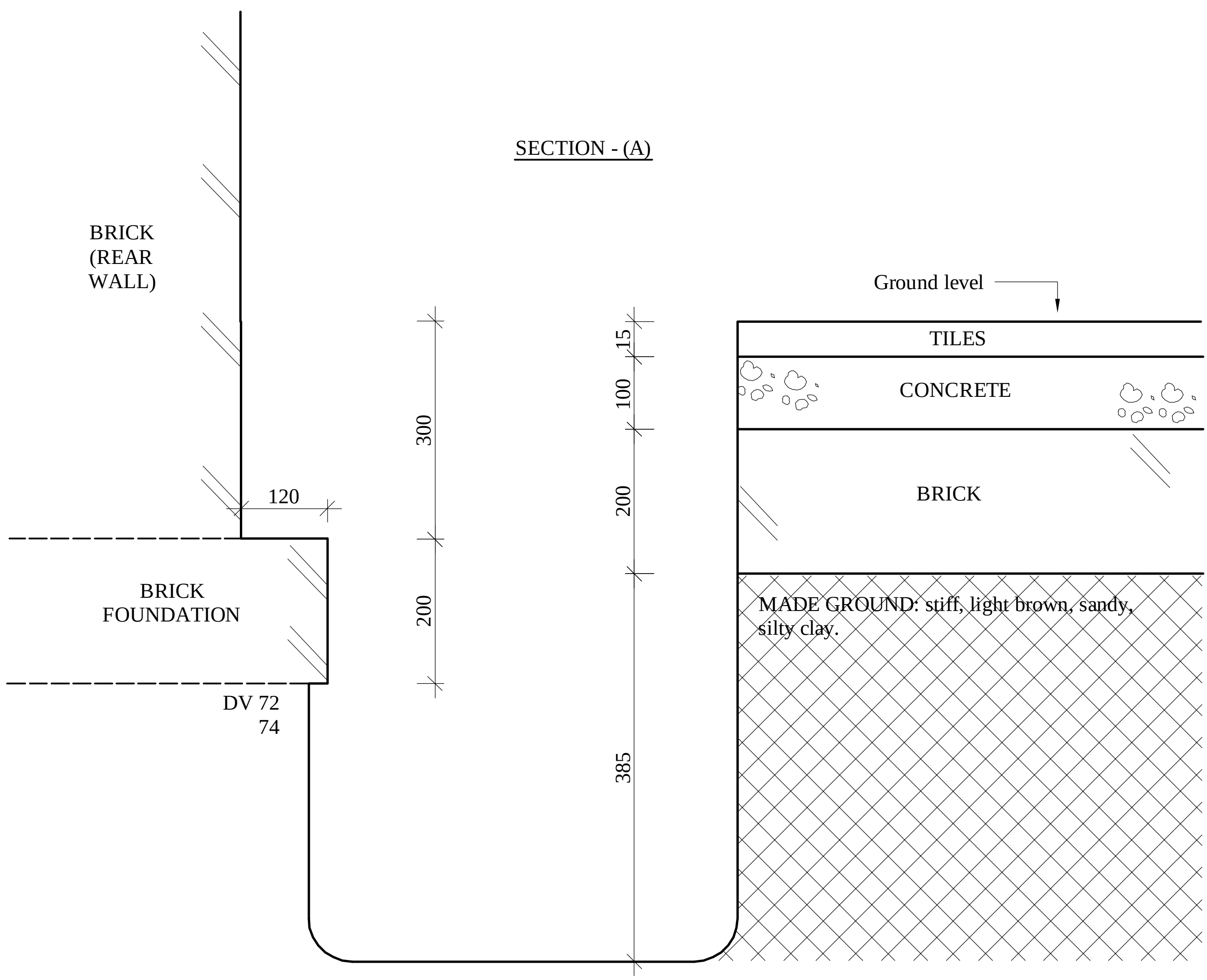
Email: info@siteinvestigations.co.uk Website: www.siteinvestigations.co.uk

Client:	Carole Markey	**Scale:**	N.T.S.	**Sheet No:**	1 of 2	**Date:**	20.11.13
Location:	22 & 35 South Hill Park Hampstead, London NW3	**Job No:**	4047	**Trial Pit No:**	2	**Weather:**	Overcast
Excavation Method:	Hand tools			**Drawn by:**	ND	**Checked by:**	ME



TP2 (SECTION A) - ENDS AT 700mm

Remarks: TP2 Section (B) is the same as TP2 Section (A) - both foundations are similar.	Key: D Small disturbed sample B Bulk disturbed sample U Undisturbed sample (U100) N Standard Penetration Test Blow Count J Jar sample V Pilcon Vane (kPa) M Mackintosh Probe W Water Sample

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Old Church Road, East Hanningfield, Essex CM3 8AB
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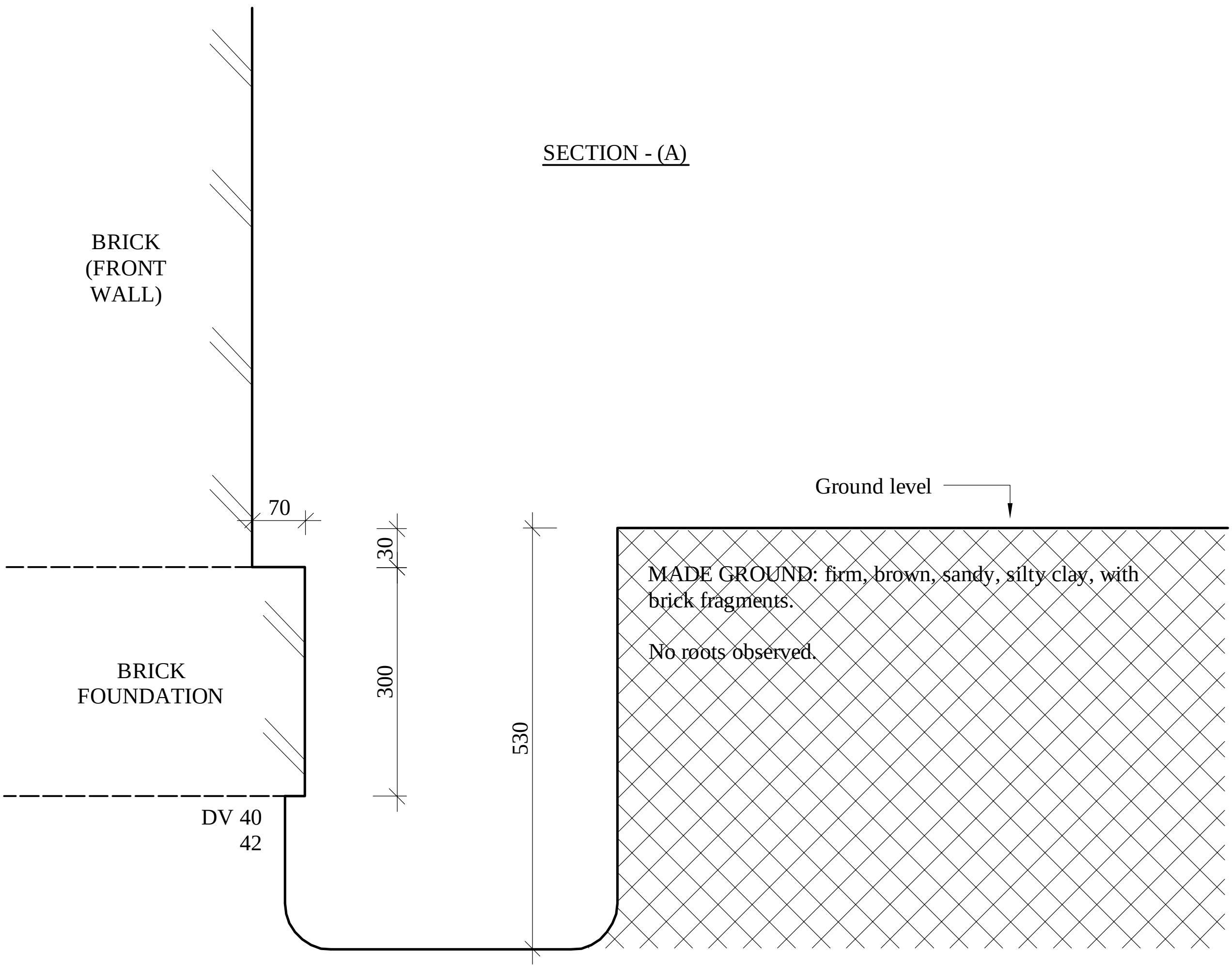
Email: info@siteinvestigations.co.uk Website: www.siteinvestigations.co.uk

Client: Carole Markey	**Scale:** N.T.S.	**Sheet No:** 1 of 2	**Date:** 20.11.13
Location: 22 & 35 South Hill Park Hampstead, London NW3	**Job No:** 4047	**Trial Pit No:** 4	**Weather:** Rain
Excavation Method: Hand tools		**Drawn by:** ND	**Checked by:** ME



TP2 (SECTION A) - ENDS AT 530mm

Remarks:

Key:
D Small disturbed sample
B Bulk disturbed sample
U Undisturbed sample (U100)
N Standard Penetration Test Blow Count
J Jar sample
V Pilcon Vane (kPa)
M Mackintosh Probe
W Water Sample

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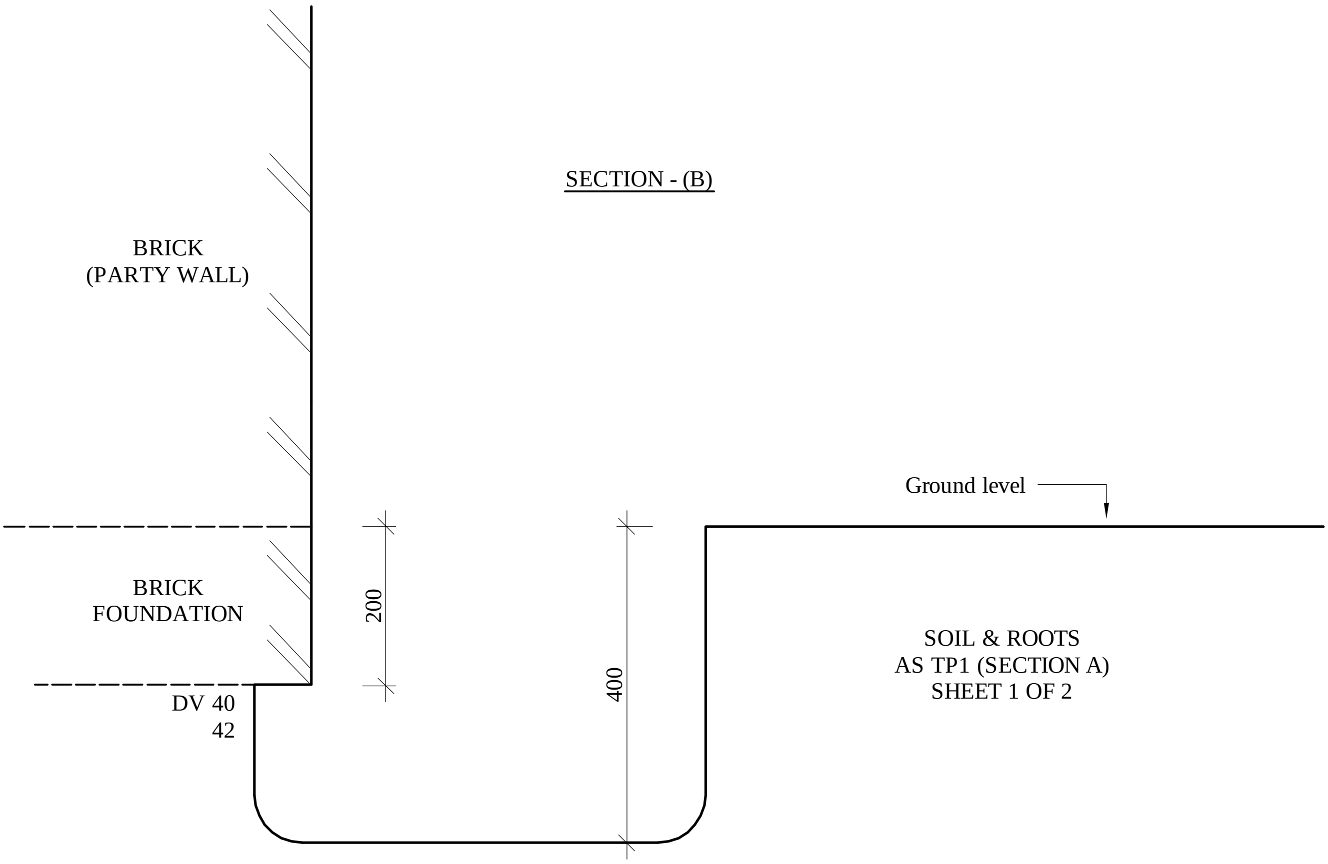
Email: info@siteinvestigations.co.uk Website: www.siteinvestigations.co.uk

Client: Carole Markey	**Scale:** N.T.S.	**Sheet No:** 2 of 2	**Date:** 20.11.13
Location: 22 & 35 South Hill Park, Hampstead, London NW3	**Job No:** 4047	**Trial Pit No:** 4	**Weather:** Rain
Excavation Method: Hand tools		**Drawn by:** ND	**Checked by:** ME

SECTION - (B)



TP4 (SECTION B) - ENDS AT 400mm

Remarks:

Key:

D Small disturbed sample	J Jar sample
B Bulk disturbed sample	V Pilcon Vane (kPa)
U Undisturbed sample (U100)	M Mackintosh Probe
N Standard Penetration Test Blow Count	W Water Sample

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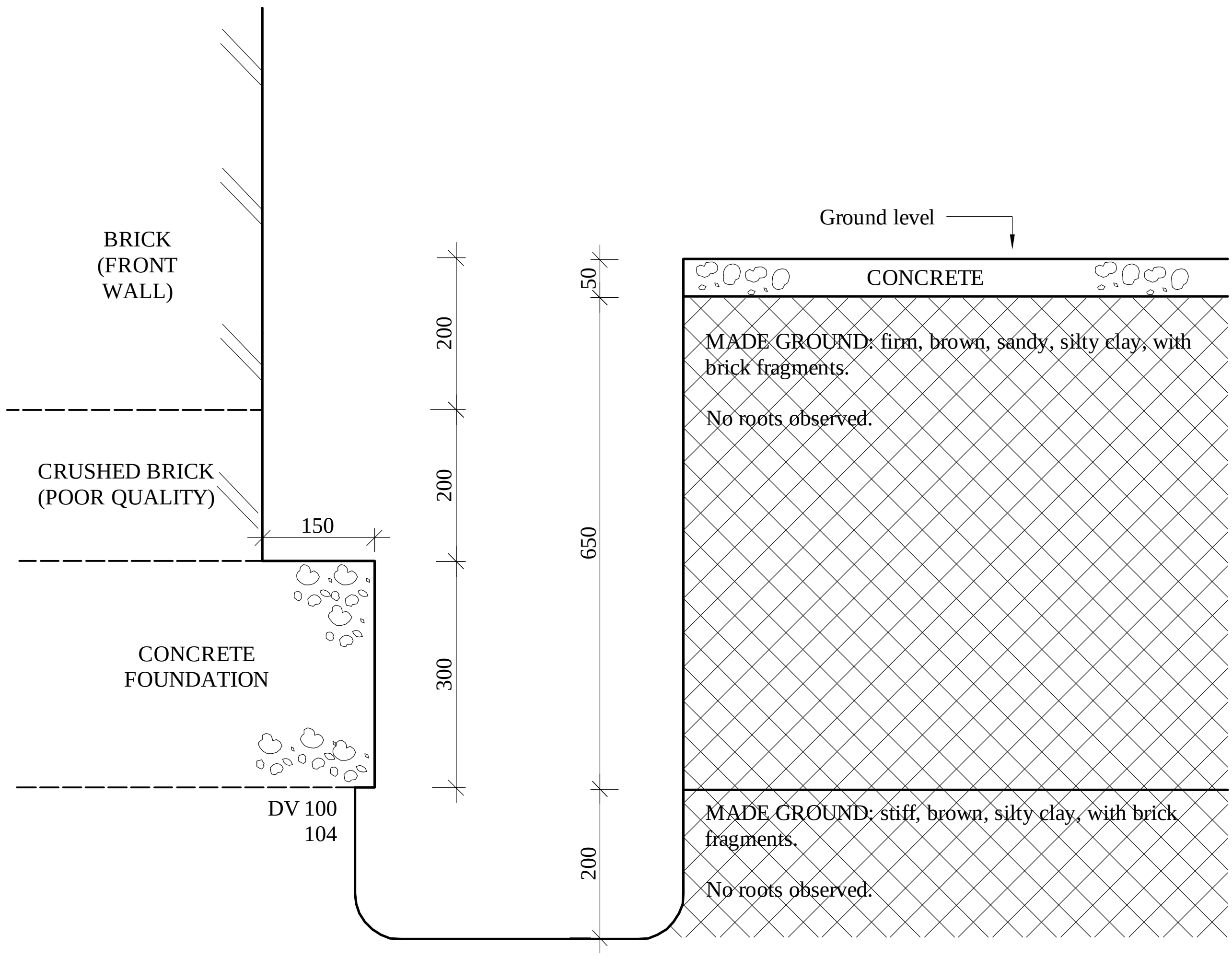
Client: Carole Markey	**Scale:** N.T.S.	**Sheet No:** 1 of 1	**Date:** 20.11.13
Location: 22 & 35 South Hill Park Hampstead, London NW3	**Job No:** 4047	**Trial Pit No:** 5	**Weather:** Rain
Excavation Method: Hand tools		**Drawn by:** ND	**Checked by:** ME



TP5 ENDS AT 900mm

Remarks:

Key:
D Small disturbed sample
B Bulk disturbed sample
U Undisturbed sample (U100)
N Standard Penetration Test Blow Count
J Jar sample
V Pilcon Vane (kPa)
M Mackintosh Probe
W Water Sample

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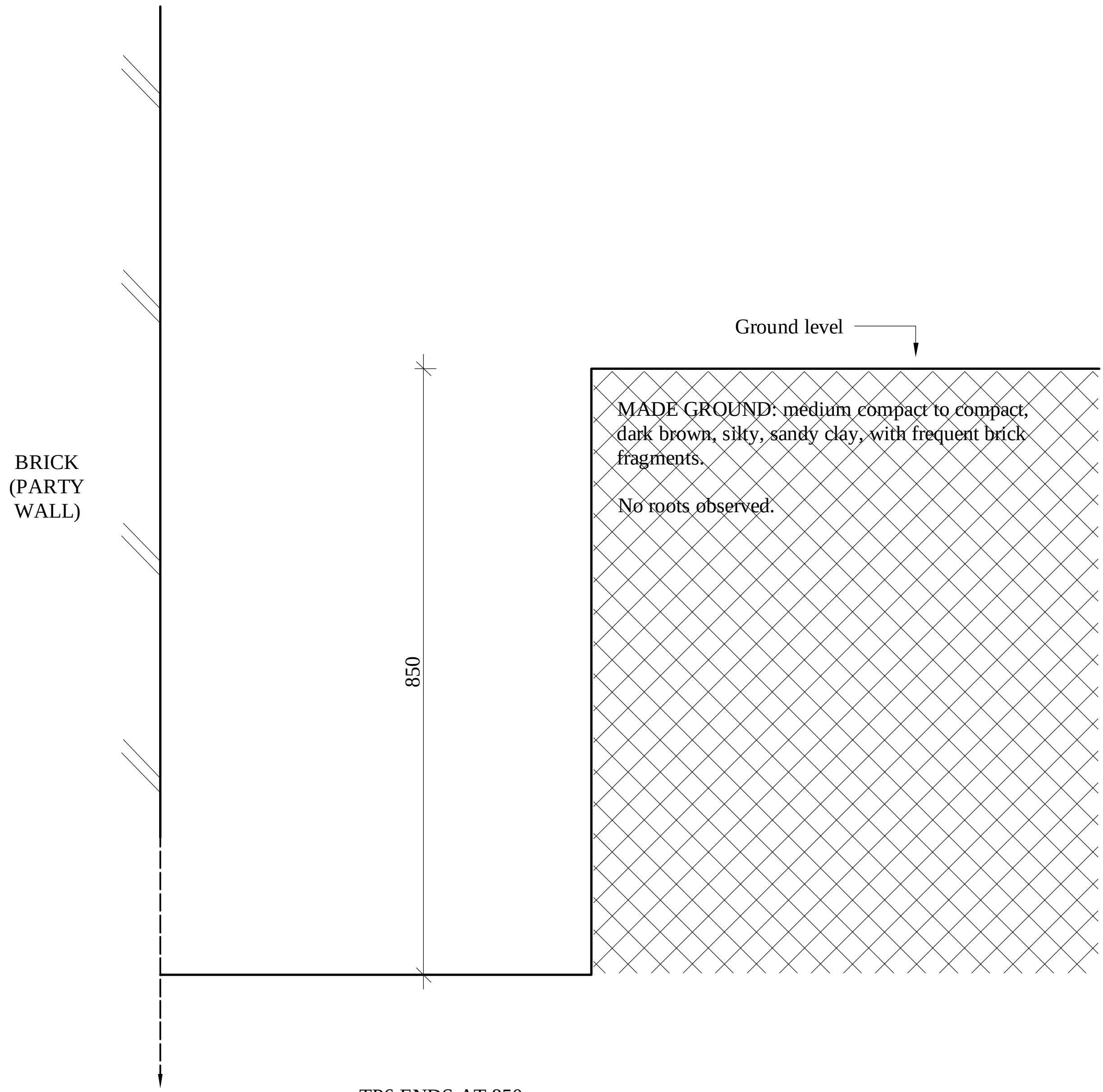
Client: Carole Markey	**Scale:** N.T.S.	**Sheet No:** 1 of 1	**Date:** 20.11.13
Location: 22 & 35 South Hill Park Hampstead, London NW3	**Job No:** 4047	**Trial Pit No:** 6	**Weather:** Rain
Excavation Method: Hand tools		**Drawn by:** ND	**Checked by:** ME



TP6 ENDS AT 850mm

Remarks: TP6 relocated and terminated at 850mm due to party wall restriction - (Engineer aware).

Key:
D Small disturbed sample
B Bulk disturbed sample
U Undisturbed sample (U100)
N Standard Penetration Test Blow Count
J Jar sample
V Pilcon Vane (kPa)
M Mackintosh Probe
W Water Sample

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Client: Carole Markey	**Scale:** N.T.S.	**Sheet No:** 1 of 1	**Weather:** Heavy rain	**Date:** 20.11.13
Site: 33 - 35 South Park Hill, London NW3	**Job No:** 4047	**Borehole No:** 1	**Boring method:** Hand auger	

Depth Mtrs.	Description of Strata	Thick-ness	Legend	Sample	Test Type	Test Result	Root Information	Depth to Water	Depth Mtrs
G.L. – 0.3	Turf over TOPSOIL	0.3					No roots observed.		
0.3 – 1.0	MADE GROUND: firm, orange-brown, silty clay, with partings of orange, silt and fine sand.	0.7		D	V	40 42			0.5
1.0 – 6.0	Stiff, orange-brown, grey veined, silty CLAY, with partings of orange and brown, silt and fine sand, claystone nodules and crystals.	5.0		D	V	72 74			1.0
				D	V	80 80			1.5
				D	V	80 82			2.0
				D	V	100 100			2.5
				D	V	100 110			3.0
	.....becoming very stiff from 3.6m.			D	V	120 122			3.5
				D	V	140+ 140+			4.0
				D	V	140+ 140+			4.5
				D	V	140+ 140+			5.0
				D	V	140+ 140+			5.5
6.0				D	V	140+ 140+			6.0
	Borehole ends at 6.0m								

Drawn by: JP **Approved by:** ME

Remarks: Borehole dry and open on completion.
Standpipe installed to 6.0m.

Key: T.D.T.D. Too Dense to Drive
D Small Disturbed Sample J Jar Sample
B Bulk Disturbed Sample V Pilcon Vane (kPa)
U Undisturbed Sample (U100) M Mackintosh Probe
W Water Sample N Standard Penetration Test Blow Count

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Client: Carole Markey	**Scale:** N.T.S.	**Sheet No:** 1 of 1	**Weather:** Heavy rain	**Date:** 20.11.13
Site: 33 - 35 South Park Hill, London NW3	**Job No:** 4047	**Borehole No:** 2	**Boring method:** Hand auger	

Depth Mtrs.	Description of Strata	Thick-ness	Legend	Sample	Test Type	Test Result	Root Information	Depth to Water	Depth Mtrs
G.L. 0.3	TOPSOIL	0.3					No roots observed.		
0.6	MADE GROUND: firm, brown, silty clay, with partings of orange and brown, silt and fine sand.	0.3		D	V	40 42			0.5
	Stiff, orange-brown, grey veined, silty CLAY, with partings of orange and brown, silt and fine sand, claystone nodules and crystals.	5.4		D	V	72 74			1.0
				D	V	80 80			1.5
				D	V	80 82			2.0
				D	V	100 100			2.5
				D	V	100 110			3.0
				D	V	120 122			3.5
	.....becoming very stiff from 3.8m.			D	V	140+ 140+			4.0
				D	V	140+ 140+			4.5
				D	V	140+ 140+			5.0
				D	V	140+ 140+			5.5
6.0				D	V	140+ 140+			6.0
	Borehole ends at 6.0m								

Drawn by: JP **Approved by:** ME

Remarks: Borehole dry and open on completion.

Key: T.D.T.D. Too Dense to Drive
D Small Disturbed Sample J Jar Sample
B Bulk Disturbed Sample V Pilcon Vane (kPa)
U Undisturbed Sample (U100) M Mackintosh Probe
W Water Sample N Standard Penetration Test Blow Count

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Client: Carole Markey	**Scale:** N.T.S.	**Sheet No:** 1 of 1	**Weather:** Heavy rain	**Date:** 20.11.13	
Site: 33 - 35 South Park Hill, London NW3	**Job No:** 4047	**Borehole No:** 3	**Boring method:** Secondman (100mm Ø) C.F.A.		

Depth Mtrs.	Description of Strata	Thick-ness	Legend	Sample	Test Type	Test Result	Root Information	Depth to Water	Depth Mtrs
G.L.									
0.2	Turf over TOPSOIL	0.2					Roots of live appearance to 3mmØ to 1.0m.		
	Stiff, orange-brown, grey veined, silty CLAY, with partings of orange and brown, silt and fine sand, claystone nodules and crystals.	9.7		D					0.5
				D	V	76 76	No roots observed below 1.0m.		1.0
				D					1.5
				D	V	98 98			2.0
				D					2.5
				D	V	110 112			3.0
	.....becoming very stiff from 3.5m.			D					3.5
				D	V	140+ 140+			4.0
				D					4.5
				D	V	140+ 140+			5.0
				D					5.5
				D	V	140+ 140+			6.0
				D	V	140+ 140+			7.0
				D	V	140+ 140+			8.0
				D	V	140+ 140+			9.0
9.9									
10.0	Very stiff, grey, silty CLAY, with partings of grey and brown, silt and fine sand.	0.1		D	V	140+ 140+			10.0
	Borehole ends at 10.0m								

Drawn by: JP **Approved by:** ME

Remarks: Borehole dry and open on completion.
Standpipe installed to 10.0m.

Key: T.D.T.D. Too Dense to Drive
D Small Disturbed Sample — J Jar Sample
B Bulk Disturbed Sample — V Pilcon Vane (kPa)
U Undisturbed Sample (U100) — M Mackintosh Probe
W Water Sample — N Standard Penetration Test Blow Count

Laboratory Testing Results

BS 1377 : 1990

Chelmer Geotechnical Laboratories

Job Number : CGL03715
Client : RHM Architects
Client Reference : CSI4047
Site Name : 33 & 35 South Hill Park London, NW3

Date Received : 27/12/2013
Date Testing Started : 03/12/2013
Date Testing Completed : 04/12/2013
Laboratory Used : Chelmer Geotechnical, CM3 8AB

Sample Ref																	Sulphate Content		
BH/TP/WS	Depth	UID	Sample Type	Moisture Content (%) [1]	Soil Faction > 0.425mm (%) [2]	Liquid Limit (%) [3]	Plastic Limit (%) [4]	Plasticity Index (%) [5]	Liquidity Index (%) [5]	Modified Plasticity Index (%) [6]	Soil Class [7]	Filter Paper Contact Time (h) [8]	Soil Sample Suction (kPa)	Insitu Shear Vane Strength (kPa) [9]	Organic Content (%) [10]	pH Value [11]	SO_3 [12]	SO_4 [13]	Class [14]
BH1	1.0	45946	D	35	<5									73					
BH1	1.5	45947	D	34	<5									80					
BH1	2.0	45948	D	35	<5									81					
BH1	2.5	45949	D	33	<5									100					
BH1	3.0	45950	D	35	<5	80	24	56	0.19	56	CV			105					
BH1	4.0	45952	D	35	<5									>140					
BH1	5.0	45954	D	38	<5									>140					
BH1	6.0	45956	D	32	<5									>140					

Notes :-

[1] BS 1377 : Part 2 : 1990, Test No 3.2
[2] Estimated if <5%, otherwise measured
[3] BS 1377 : Part 2 : 1990, Test No 4.4
[4] BS 1377 : Part 2 : 1990, Test No 5.3
[5] BS 1377 : Part 2 : 1990, Test No 5.4
[6] BRE Digest 240 : 1993
[7] BS 5930 : 1981 : Figure 31 - Plasticity Chart for the classification of fine soils
[8] In-house method S9a adapted from BRE IP 4/93
[9] Values of shear strength were determined in situ by Chelmer Site Investigations using a Pilcon hand vane or Geonor vane (GV).
[10] BS 1377 : Part 3 : 1990, Test No 4
[11] BS 1377 : Part 2 : 1990, Test No 9
[12] BS 1377 : Part 3 : 1990, Test No 5.6
[13] SO_4 = 1.2 x SO_3
[14] BRE Special Digest One (Concrete in Aggressive Ground) 2005

Note that if the SO_4 content falls into the DS-4 or DS-5 class, it would be prudent to consider the sample as falling into the DS-4m or DS-5m class respectively unless water soluble magnesium testing is undertaken to prove otherwise

Key

D	Disturbed sample
B	Bulk sample
U	U100 (undisturbed sample)
W	Water sample
ENP	Essentially Non-Plastic
U/S	Underside Foundation

Comments :-

Produced :- MT
Checked By ;- AK
Date Checked :- 04-Dec-13

Laboratory Testing Results

BS 1377 : 1990

Job Number : CGL03715
Client : RHM Architects
Client Reference : CSI4047
Site Name : 33 & 35 South Hill Park London, NW3

Date Received : 27/12/2013
Date Testing Started : 03/12/2013
Date Testing Completed : 04/12/2013
Laboratory Used : Chelmer Geotechnical, CM3 8AB

Sample Ref																	Sulphate Content		
BH/TP/WS	Depth	UID	Sample Type	Moisture Content (%) [1]	Soil Faction > 0.425mm (%) [2]	Liquid Limit (%) [3]	Plastic Limit (%) [4]	Plasticity Index (%) [5]	Liquidity Index (%) [5]	Modified Plasticity Index (%) [6]	Soil Class [7]	Filter Paper Contact Time (h) [8]	Soil Sample Suction (kPa)	Insitu Shear Vane Strength (kPa) [9]	Organic Content (%) [10]	pH Value [11]	SO_3 [12]	SO_4 [13]	Class [14]
BH2	1.0	45958	D	32	<5									71					
BH2	2.0	45960	D	28	<5									81					
BH2	3.0	45962	D	32	<5									105					
BH2	4.0	45964	D	33	<5									>140					
BH2	6.0	45968	D	30	<5									>140					

Notes :-

[1] BS 1377 : Part 2 : 1990, Test No 3.2
[2] Estimated if <5%, otherwise measured
[3] BS 1377 : Part 2 : 1990, Test No 4.4
[4] BS 1377 : Part 2 : 1990, Test No 5.3
[5] BS 1377 : Part 2 : 1990, Test No 5.4
[6] BRE Digest 240 : 1993
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[11] BS 1377 : Part 2 : 1990, Test No 9
[12] BS 1377 : Part 3 : 1990, Test No 5.6
[13] SO_4 = 1.2 x SO_3
[14] BRE Special Digest One (Concrete in Aggressive Ground) 2005

Note that if the SO_4 content falls into the DS-4 or DS-5 class, it would be prudent to consider the sample as falling into the DS-4m or DS-5m class respectively unless water soluble magnesium testing is undertaken to prove otherwise

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D	Disturbed sample
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ENP	Essentially Non-Plastic
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Comments :-

Produced :- MT
Checked By ;- AK
Date Checked :- 04-Dec-13

Laboratory Testing Results

BS 1377 : 1990

Job Number : CGL03715
Client : RHM Architects
Client Reference : CSI4047
Site Name : 33 & 35 South Hill Park London, NW3

Date Received : 27/12/2013
Date Testing Started : 03/12/2013
Date Testing Completed : 04/12/2013
Laboratory Used : Chelmer Geotechnical, CM3 8AB

Sample Ref																		Sulphate Content		
BH/TP/WS	Depth	UID	Sample Type	Moisture Content (%) [1]	Soil Faction > 0.425mm (%) [2]	Liquid Limit (%) [3]	Plastic Limit (%) [4]	Plasticity Index (%) [5]	Liquidity Index (%) [5]	Modified Plasticity Index (%) [6]	Soil Class [7]	Filter Paper Contact Time (h) [8]	Soil Sample Suction (kPa)	Insitu Shear Vane Strength (kPa) [9]	Organic Content (%) [10]	pH Value [11]	SO_3 [12]	SO_4 [13]	Class [14]
BH3	1.0	45970	D	29	<5	67	18	49	0.23	49	CH			76					
BH3	2.0	45972	D	29	<5									98					
BH3	3.0	45974	D	30	<5	76	22	54	0.16	54	CV			111					
BH3	4.0	45976	D	30	<5									>140					
BH3	5.0	45978	D	32	<5									>140					
BH3	6.0	45980	D	31	<5	78	20	58	0.19	58	CV			>140					
BH3	7.0	45981	D	31	<5									>140					
BH3	8.0	45982	D	31	<5									>140					
BH3	10.0	45984	D	29	<5									>140					

Notes :-

[1] BS 1377 : Part 2 : 1990, Test No 3.2
[2] Estimated if <5%, otherwise measured
[3] BS 1377 : Part 2 : 1990, Test No 4.4
[4] BS 1377 : Part 2 : 1990, Test No 5.3
[5] BS 1377 : Part 2 : 1990, Test No 5.4
[6] BRE Digest 240 : 1993
[7] BS 5930 : 1981 : Figure 31 - Plasticity Chart for the classification of fine soils
[8] In-house method S9a adapted from BRE IP 4/93
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[10] BS 1377 : Part 3 : 1990, Test No 4
[11] BS 1377 : Part 2 : 1990, Test No 9
[12] BS 1377 : Part 3 : 1990, Test No 5.6
[13] SO_4 = 1.2 x SO_3
[14] BRE Special Digest One (Concrete in Aggressive Ground) 2005

Note that if the SO_4 content falls into the DS-4 or DS-5 class, it would be prudent to consider the sample as falling into the DS-4m or DS-5m class respectively unless water soluble magnesium testing is undertaken to prove otherwise

Key

D	Disturbed sample
B	Bulk sample
U	U100 (undisturbed sample)
W	Water sample
ENP	Essentially Non-Plastic
U/S	Underside Foundation

Comments :-

Produced :- MT
Checked By ;- AK
Date Checked :- 04-Dec-13

Laboratory Testing Results

BS 1377 : 1990

Chelmer Geotechnical Laboratories

Job Number : CGL03715
Client : RHM Architects
Client Reference : CSI4047
Site Name : 33 & 35 South Hill Park London, NW3

Date Received : 27/12/2013
Date Testing Started : 03/12/2013
Date Testing Completed : 04/12/2013
Laboratory Used : Chelmer Geotechnical, CM3 8AB

Sample Ref																	Sulphate Content		
BH/TP/WS	Depth	UID	Sample Type	Moisture Content (%) [1]	Soil Faction > 0.425mm (%) [2]	Liquid Limit (%) [3]	Plastic Limit (%) [4]	Plasticity Index (%) [5]	Liquidity Index (%) [5]	Modified Plasticity Index (%) [6]	Soil Class [7]	Filter Paper Contact Time (h) [8]	Soil Sample Suction (kPa)	Insitu Shear Vane Strength (kPa) [9]	Organic Content (%) [10]	pH Value [11]	SO_3 [12]	SO_4 [13]	Class [14]
TP1A	1.0	45985	D	34	<5	80	24	56	0.18	56	CV								

Notes :-

[1] BS 1377 : Part 2 : 1990, Test No 3.2
[2] Estimated if <5%, otherwise measured
[3] BS 1377 : Part 2 : 1990, Test No 4.4
[4] BS 1377 : Part 2 : 1990, Test No 5.3
[5] BS 1377 : Part 2 : 1990, Test No 5.4
[6] BRE Digest 240 : 1993
[7] BS 5930 : 1981 : Figure 31 - Plasticity Chart for the classification of fine soils
[8] In-house method S9a adapted from BRE IP 4/93
[9] Values of shear strength were determined in situ by Chelmer Site Investigations using a Pilcon hand vane or Geonor vane (GV).
[10] BS 1377 : Part 3 : 1990, Test No 4
[11] BS 1377 : Part 2 : 1990, Test No 9
[12] BS 1377 : Part 3 : 1990, Test No 5.6
[13] SO_4 = 1.2 x SO_3
[14] BRE Special Digest One (Concrete in Aggressive Ground) 2005

Note that if the SO_4 content falls into the DS-4 or DS-5 class, it would be prudent to consider the sample as falling into the DS-4m or DS-5m class respectively unless water soluble magnesium testing is undertaken to prove otherwise

Key

D	Disturbed sample
B	Bulk sample
U	U100 (undisturbed sample)
W	Water sample
ENP	Essentially Non-Plastic
U/S	Underside Foundation

Comments :-

Produced :- MT   Checked By ;- AK   Date Checked :- 04-Dec-13

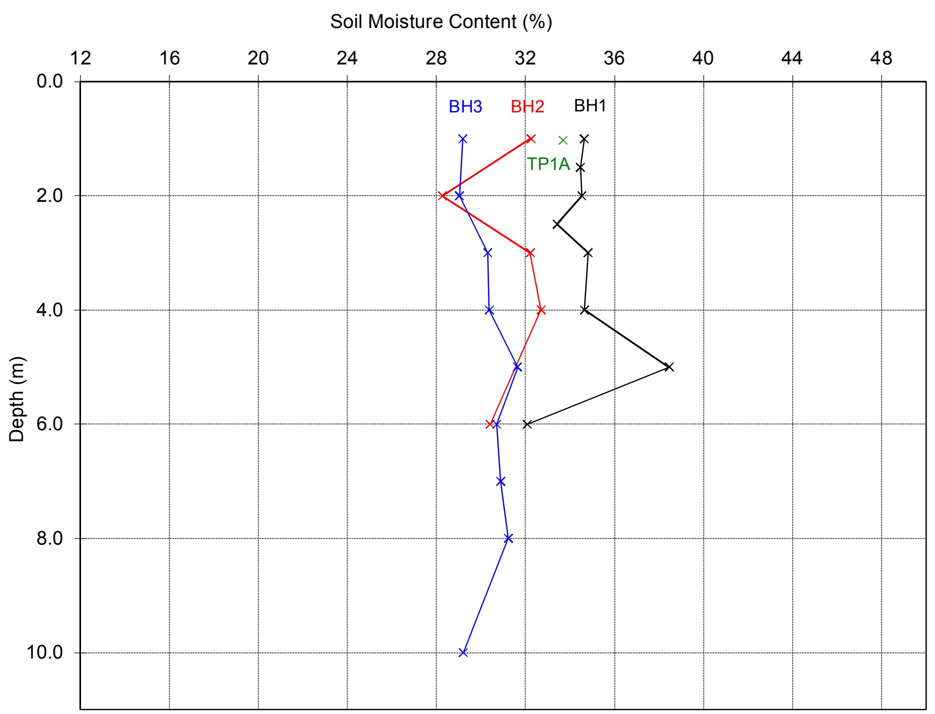
Laboratory Testing Results

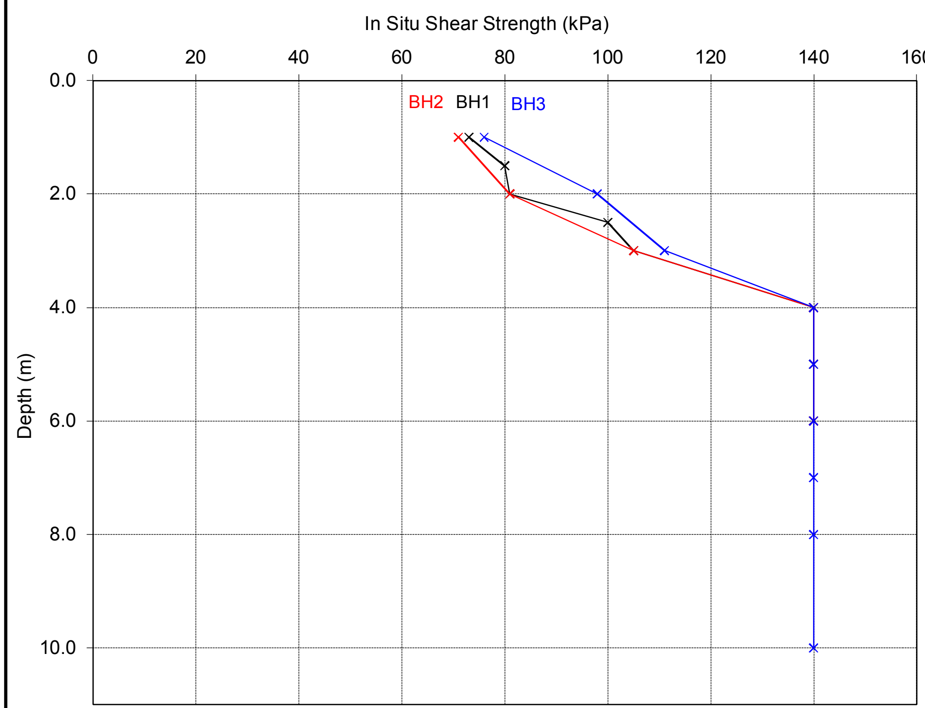
Moisture Content/Shear Strength Profile

Chelmer Geotechnical Laboratories

Job Number : CGL03715
Client : RHM Architects
Client Reference : CSI4047
Site Name : 33 & 35 South Hill Park London, NW3

Date Received : 27/12/2013
Date Testing Started : 03/12/2013
Date Testing Completed : 04/12/2013
Laboratory : Chelmer Geotechnical Laboratories, CM3 8AB





Notes :-

1. If the Soil Fraction > 0.425mm exceeds 5% the Equivalent Moisture Content of the remainder (calculated in accordance with BS 1377: Part 2 : 1990, cl.3.2.4 note 1) is also plotted and the alternative profile additionally shown as an appropriately coloured broken line.
2. If plotted, 0.4 LL and PL+2 (after Driscoll, 1983) should only be applied to London Clay (and similarly over consolidated clays) at shallow depths.

Unless otherwise stated, values of Shear Strength were determined in situ by Chelmer Site Investigations using a Pilcon Hand Vane the calibration of which is limited to a maximum reading of 140 kPa.

Comments :-

Checked By :- AK

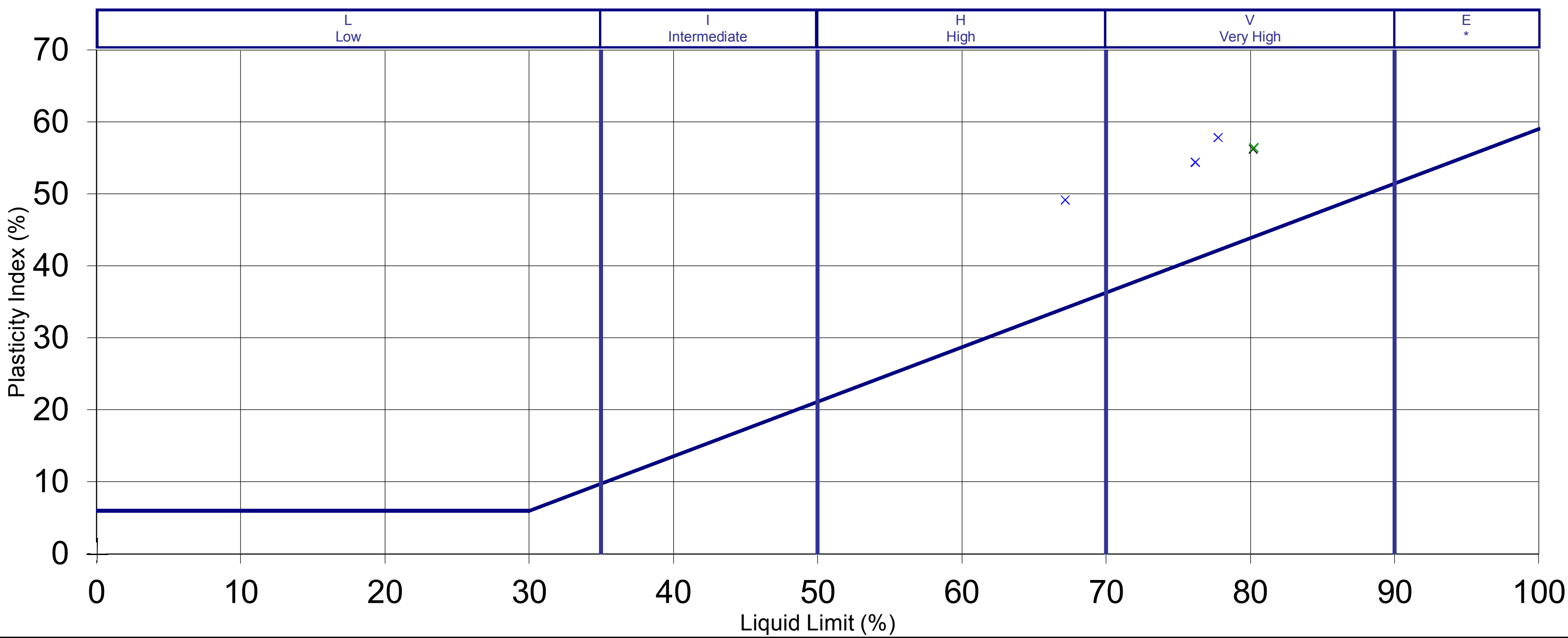
Date Checked :- 04-Dec-13

Laboratory Testing Results

Plasticity Chart for the classification of fine soils and the finer part of coarse soils
In Compliance with BS5930 : 1999

Chelmer Geotechnical Laboratories

Job Number :	CGL03715	Date Received :	27/12/2013
Client :	RHM Architects	Date Testing Started :	03/12/2013
Client Reference :	CSI4047	Date Testing Completed :	04/12/2013
Site Name :	33 & 35 South Hill Park London, NW3	Laboratory :	Chelmer Geotechnical Laboratories, CM3 8AB



Notes :-

SILT (M-SOIL), M, plots below A-Line
CLAY, C, plots above A-Line }M and C may be combined as FINE SOIL, F.

Key :- BH1
BH3
TP1A

Comments :-

Checked By :- AK   Date Checked :- 04-Dec-13

Unit A2
Windmill Road
Ponswood Industrial Estate
St Leonards on Sea
East Sussex
TN38 9BY
Telephone (01424) 718618
Facsimile (01424) 729911

2683

THE ENVIRONMENTAL LABORATORY LTD

F.A.O. Graham Wing
Chelmer Site Investigations Ltd
Unit 15, East Hanningfield Ind Est
Old Church Road
Essex, CM3 8AB

Reporting Date: 18 December 2013

ANALYTICAL REPORT No. 52067

Samples Received By: Laboratory Courier
Sample Receipt Date: 04/12/13
Your Job No: 4047
Your Order No: ---
Site Location: 33 and 35 South Hill Park
ELAB Sales Order:
No Samples Received: 3
Date of Sampling: 20/11/13

This report was written by: N. Williams

Authorised By;

Steve Knight
Reporting Manager

Any comments, opinions or interpretations expressed herein are outside the scope of UKAS accreditation (Accreditation Number 2683)

2683

THE ENVIRONMENTAL LABORATORY LTD

Unit A2, Windmill Road, Ponswood Industrial Estate, St Leonard's on Sea, East Sussex, TN38 9BY
Tel: 01424 718618 Fax: 01424 729911

ANALYTICAL REPORT No. 52067

Location: 33 and 35 South Hill Park

Your Job No: 4047
Your Order No: ---
Reporting Date: 18/12/13

F.A.O. Graham Wing
Chelmer Site Investigations Ltd
Unit 15, East Hanningfield Ind Est
Old Church Road
Essex, CM3 8AB

<u>Soils</u>

	Characteristic	Clay	Silty clay loam	Clay Loam
	Date Sampled	20/11/13	20/11/13	20/11/13
	TP/BH	BH1	BH3	TP5
	Depth (m)	1.50	3.50	0.70
	Our ref	93326	93327	93328
Stone Content	(%)	<1	<1	<1
Water Soluble Sulphate	(mg/l as SO_4)	72	293	222
Water Soluble Sulphate**	(mg/kg SO_4)	145	586	445

All results expressed on dry weight basis
** - MCERTS accredited test
* = UKAS accredited test
N. Williams

Unit A2
Windmill Road
Ponswood Industrial Estate
St Leonards on Sea
East Sussex
TN38 9BY
Telephone (01424) 718618
Facsimile (01424) 729911

THE ENVIRONMENTAL LABORATORY LTD

SAMPLE RECEIPT AND TEST DATES

Our Analytical Report Number	52067
Your Job No:	4047
Sample Receipt Date:	04/12/13
Reporting Date:	18/12/13
Registered:	04/12/13
Prepared:	05/12/13
Analysis complete:	18/12/13

TEST METHOD SUMMARY

PARAMETER	Analysis Undertaken on	Date Tested	Method Number	Technique
Water Soluble Sulphate	Air dried sample	10/12/13	172	BRE SD1

* = UKAS Accredited test
** - MCERTS Accredited test
Determinands not marked with * or ** are not accredited
MCERTS accreditation covers samples which are predominantly sand, clay, loam or combinations of these three soil types
All results have been expressed on a dry weight basis and where appropriate have been corrected for moisture and stone content accordingly

Any comments, opinions, or interpretations expressed herein are outside the scope of UKAS accreditation (Accreditation Number 2683)

Landborne Gas Assessment

Site Ref: **4047**
Site Name: **South Hill Park**

Chelmer Consultancy Services
Unit 15, East Hanningfield Industrial Estate, Old Church Road
East Hanningfield, Essex CM3 8AB
Telephone: 01245 400 930 Fax: 01245 400 933
Email: info@siteinvestigations.co.uk Website: www.siteinvestigations.co.uk

Well	Date	Methane Peak	Methane Steady	Methane GSV	Carbon Dioxide Peak	Carbon Dioxide Steady	Carbon Dioxide GSV	Oxygen	Atmos.	Flow	Response Zone	Depth to Water	CO	H2S
		%v/v	%v/v	l/hr	%v/v	%v/v	l/hr	%v/v	mbar	l/hr	m bgl	m bgl	ppm	ppm
BH1	27.11.13	0.3	0.2	0	0.5	0.2	0	20.1	1025	0.0	1.00 - 6.00	5.00	0	0
	05.12.13	0.3	0.2	0	0.4	0.3	0	20.0	1018	0.0		4.04	0	0
	16.01.14	0.4	0.3	0.0004	0.5	0.4	0.0005	19.8	987	0.1		1.67	0	0
BH3	27.11.13	0.3	0.3	0.0003	3.5	3.5	0.0035	17.2	1025	0.1	1.00 - 10.00	8.18	0	0
	05.12.13	0.3	0.2	0.0003	3.1	3.0	0.0031	18.1	1018	0.1		8.20	0	0
	16.01.14	0.4	0.4	0.0004	3.2	3.1	0.0032	19.3	987	0.1		4.79	0	0

Notes

NR = Not recorded
Values in Bold exceed the CO_2 Building Regulations threshold (>1.5%)
Values in Red exceed the Buildings Regulations Action Level (CO_2 >5.0% and CH_4 >1.5%)

Chelmer Site Investigations
Unit 15, East Hanningfield Industrial Estate, Old Church Road
East Hanningfield, Essex CM3 8AB
Telephone: 01245 400 930 **Fax:** 01245 400 933
Email: info@siteinvestigations.co.uk **Website**: www.siteinvestigations.co.uk

REPORT NOTES

Equipment Used

Hand tools, Mechanical Concrete Breaker and Spade, Hand Augers, 100mm/150mm diameter Mechanical Flight Auger Rig, GEO205 Flight Auger Rig, Window Sampling Rig, and Large or Limited Access Shell & Auger Rig upon request and/or access permitting.

On Site Tests

By Pilcon Shear-Vane Tester (Kn/m^2) in clay soils, and/or Mackintosh Probe in granular soils or made ground and/or upon request Continuous Dynamic Probe Testing and Standard Penetration Testing.

Note:

Details reported in trial-pits and boreholes relate to positions investigated only as instructed by the client or engineer on the date shown.

We are therefore unable to accept any responsibility for changes in soil conditions not investigated i.e. variations due to climate, season, vegetation and varying ground water levels.

Full terms and conditions are available upon request.

APPENDIX V
PRELIMINARY HEAVE ANALYSES

Project:

33 South Hill Park,
London NW3 2ST

13116

EXCAVATION GEOMETRY

Proposed basement as per drawings by David Mikhail Architects dated 10/01/2014:

	No.33 only	Nos 33 & 35
Width, B:	5.9	11.8
Length, L:	Excv'n: 15.4m (House: 8.4m)	Excv'n: 11.8/18.6m (House: 8.4)
Hence: L/B:	2.6	1.3
Excv'n Depth, D:	Front: (3.5-1.16) Rear: 3.30	Fr: (3.5-1.16 / 0.83) Rear: 3.3/2.0/4.3

STRESSES

Assumptions:
1. Loads from external walls = 20/50/75 kN/m run for 1/2/3 storey respectively. Party wall load = 80 kN/m run. Average founding depth = 0.50m below existing ground floor level.
2. Basement slab and underpins = 350mm thick reinforced concrete throughout.
3. Basement slab founded 3.50m below ground floor level.
4. No live loads and all loads distributed uniformly across basement slab.

Hence estimated load from basement (v rough):

No.33 only: = (20.2*75+8.6*80+7.4*50+4*25)+(49.5*2.4*0.35*24)+(75*0.35*24) = 4,342 kN

Nos 33&35: = 1384.4+(0.35*43.24*3.5*24)+((5.5*18.72)+(1.9*1))*0.35*25 = 8,089 kN

Unloading from excavations:

No.33 only: Q = -(15.5*5.9-1.9*1.7)*(((3.5-1.16)+3.3)/2)*19 = -4,727 kN

Nos 33&35: Q = -(127.4+3.1*2+21.8+46.9)*(((3.5-(1.16+0.83)/2)+3.3)/2)*19 = -11,156 kN

Hence:

		No.33 only	Nos 33 & 35
Net unloading, dQ	(kN)	-385.0	-3,067
Net stress reduction, q_b	(kPa)	-4.2	-15.2

Reduction of unloading stress change with depth:

Consider 4 depth zones within the London Clay extending to a depth = 2 * width of excavation.
where $\Delta\sigma_v / q$ values were read or interpolated from chart by Janbu, Bjerrum and Kjaernsli (1956)
for L = approx 2B for No.33 only and L = approx 1.3B for Nos 33&35

	Level of Zone (m below form'n)	Average Depth below form'n, z	z / B	$\Delta\sigma_v / q$	Avr. $\Delta\sigma_v$ (kPa)	Extg σ_v' (kPa)	σ_v' after excv'n (kPa)
No.33 only	0 to -2.0	1.00	0.17	0.99	-4.2	41	37
	-2.0 to -4.0	3.00	0.51	0.8	-3.4	61	58
	-4.0 to -7.0	5.50	0.93	0.51	-2.2	86	84
	-7.0 to -12.0	9.50	1.61	0.28	-1.2	126	125

	Level of Zone (m below form'n)	Average Depth below form'n, z	z / B	$\Delta\sigma_v / q$	Avr. $\Delta\sigma_v$ (kPa)	Extg σ_v' (kPa)	σ_v' after excv'n (kPa)
Nos 33 & 35	0 to -4.0	2.00	0.17	0.98	-14.9	52	37
	-4.0 to -8.0	6.00	0.51	0.74	-11.2	92	81
	-8.0 to -14.0	11.00	0.93	0.40	-6.1	142	136
	-14.0 to -24.0	19.00	1.61	0.20	-3.0	222	219

Notes:

1. These calculations should be read in conjunction with the Basement Impact Assessment report. These are preliminary simplified calculations and do NOT comprise detailed design.
2. These analyses almost always over-estimate the actual heave, so are useful only to identify a worst case scenario from which the need for heave control measures can be assessed.

Title: **Heave Analysis** Sheet: **1 of 2**

Date: January 2014 Checked: Approved: KG Scale: NTS

Project:

33 South Hill Park,
London NW3 2ST

13116

HEAVE CAUSED BY SWELLING

The results from 28 special one-dimensional oedometer swelling tests undertaken recently on samples of London Clay from other sites have been used to determine appropriate Moduli of Swelling Volume Change. One-dimensional consolidation theory and the assessed values of the Modulus of Swelling Volume Change have been used to provide a preliminary assessment of potential swelling-induced heave magnitudes at the **centre** of the proposed basement. These magnitudes will be **over-estimates** because they make no allowance for the beneficial restraining effects of the surrounding ground, or the stiffness of the basement slab, or the connection between the slab and the underpins, or the sensitivity of the Modulus of Volume Change to sample disturbance.

Swelling, δ_s = $\Delta\sigma_v * H * M_{vs}$

No.33 only				
Level of Zone (m below form'n)	Height, H (m)	Avr. $\Delta\sigma_v$ (kPa)	Modulus of Swelling Volume Change, M_{vs} (m^2/MN)	Heave (mm)
0 to -2.0	2.0	-4	0.240	-2
-2.0 to -4.0	2.0	-3	0.180	-1
-4.0 to -7.0	3.0	-2	0.140	-1
-7.0 to -12.0	5.0	-1	0.100	-1
			TOTAL:	-5

Nos 33 & 35				
Level of Zone (m below form'n)	Height, H (m)	Avr. $\Delta\sigma_v$ (kPa)	Modulus of Swelling Volume Change, M_{vs} (m^2/MN)	Heave (mm)
0 to -4.0	4.0	-15	0.220	-13
-4.0 to -8.0	4.0	-11	0.135	-6
-8.0 to -14.0	6.0	-6	0.090	-3
-14.0 to -24.0	10.0	-3	0.060	-2
			TOTAL:	-24

Notes:

See Sheet 1

Title: **Heave Analysis**

Date: January 2014 Checked: Approved: KG. Scale : NTS