GROUND INVESTIGATION AND BASEMENT IMPACT ASSESSMENT REPORT

for the site at

20 WELL ROAD, HAMPSTEAD, LONDON NW3 1LH

on behalf of

VINCENT AND RYMILL

Report Reference: GWPR2241/GIR/October 2017 Status: FINAL			
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File Reference: Ground and Water/Project Files/ GWPR2241 20 Well Road, Hampstead			

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1.0 INTRODUCTION

1.1 General

Ground and Water Limited were instructed by Vincent and Rymill, on the 11th August 2017, to undertake a Ground Investigation and Basement Impact Assessment on a site at 20 Well Road, Hampstead, London NW3 1LH. The scope of the investigation was detailed within the Ground and Water Limited fee proposal ref: GWQ3383, dated 10th July 2016.

1.2 Aims of the Investigation

The aim of the investigation was understood to be to supply the client and their designers with information regarding the ground conditions underlying the site to assist them in preparing an appropriate scheme for development.

The investigation was to be undertaken to provide parameters for the design of foundations by means of in-situ and laboratory geotechnical testing undertaken on soil samples recovered from trial holes.

The requirements of the Camden Planning Guidance Basements and Lightwells (CPG4), July 2015, and London Borough of Camden, Camden Geological, Hydrogeological and Hydrological Study, Guidance for Subterranean Development (November 2010) was reviewed with respect to this report.

A Desk Study and full scale contamination assessment were not part of the remit of this report.

The techniques adopted for the investigation were chosen considering the anticipated ground conditions and development proposals on-site, and bearing in mind the nature of the site, limitations to site access and other logistical limitations.

1.3 Conditions and Limitations

This report has been prepared based on the terms, conditions and limitations outlined within Appendix A.

2.0 SITE SETTING/GEOTECHNICAL DESK STUDY

2.1 Site Location

The site comprised a 600m^2 irregular shaped plot of land, orientated in a north-east to north-west direction, located on the north-western side of Well Road. The site was located ~60m south-west of Heath Road which ran parallel along Hampstead Heath. The site was located in central Hampstead, north-west London, within in the London Borough of Camden.

The national grid reference for the centre of the site was approximately TQ 26681 86172. A site location plan is given within Figure 1. A plan showing the site area is given within Figure 2.

2.2 Site Description

A Site Walkover was undertaken in August 2017. The site comprised a three-storey brick built residential dwelling, located as part of the south-west wing of a larger structure. Private gardens were noted to the rear of the dwelling with a ~2-3m high brick wall and overgrown vegetation along each site boundary. The site was accessed through a wooden gate of Well Road. It was understood that No. 1 and 2 Cannon Lane and 19 Well Road have existing basements.

Well Road appeared to lie at 106.7m AOD. However, the garden level is understood to sit ~2.00m above the entrance from Well Road to the south-east, which leads up to the garden via stone steps. The existing property and small patio area is then understood to lie ~1.00m below the garden level.

An aerial view of the site is given within Figure 3.

2.3 Proposed Development

At the time of reporting, October 2017, the proposed development was understood to comprise the construction of a basement below the entire footprint of the ground floor, including construction of lightwells. The floor level of the basement is to be formed at ~3.20m bgl, with the retaining wall foundation formed at 3.60m bgl. A proposed development plan can be seen in Figure 4.

The proposed development fell within Geotechnical Design Category 2 in accordance with Eurocode 7.

It is understood that the south-eastern wall (Wall D and F, with reference to Figure 5) and western wall (Wall J, with reference to Figure 5) of the basement will be constructed utilising 7.00m deep contiguous piling, with an expected load of 40kN/m^2. A proposed development plan of the basement with the areas that include contiguous piling can be seen in Figure 6.

The remainder of the basement will be constructed based on load bearing retaining wall underpins, with thickened edges and a semi-ground bearing slab. It is anticipated that the thickened edges will range between 2.00m – 2.60m, with loads implied by the retaining wall ranging between 76.60 – 92.00kN/m^2.

Based on data supplied by the structural engineer, the existing party wall between 20 and 19 Well Road (Wall G, see Figure 5) is 2.90m bgl in depth and the party wall between 20 and 18 Well Road (Wall H/D, see Figure 5), founding at 1.20m bgl. Both walls were assumed to comprise brick corbel footings, 600mm wide.

It was understood that the existing footings of 20 Well Road (Wall A, see Figure 5) were 0.70m bgl in depth, comprising brick corbel footings that are 600mm wide.

The proposed development was understood not to involve any re-profiling of the site and its immediate environs. It is understood that no trees will be removed to facilitate the construction of the basement.

2.4 Site History

The object of this search was to report on the history of the site and its environs from available County Series, Ordnance Survey and Aerial Photography Maps dating from the mid 19th Century to the present day and downloaded from Groundsure Environmental Insight. In the following sections dealing with individual maps, only features considered to have a potential impact on the site and usually within a notional 250 metre radius of the site boundaries are discussed. Any distances quoted for features remote from the site have been scaled from the maps and are only approximate. The north point and approximate extent of the site are indicated on each figure. The historical maps referred to are given within Appendix B. The implications of the map search are discussed later within this report. The historic map review can be seen tabulated below.

Table 1: Environmental Significance of Data From Historical Maps

Date	Scale	Site	Environs
1870	1:2,500	The site was occupied by undeveloped open space.	The site was located ~50m south of Hampstead Heath. Hampstead Ponds and associated earthworks were noted ~250m north of site. Pumps were noted ~200m east and ~250m south-west. To the south-east to the south-west, the area was scattered with residential developments. A pond was noted ~200m south-east. A Militia Barracks were noted ~250m south of site. Christ Church noted ~250m south-west. Squire's Mount, a residential development was noted ~50m north-west. Cuttings associated with a road or path within Hampstead Heath were located ~230m north-west.
1871	1:1,056	As previous map.	As previous map.
1871	1:1,056	As previous map.	As previous map.
1896	1:2,500	The site was occupied by the south-west portion of a larger building, named The Logs. The majority of the site comprised a greenhouse associated with the larger building. Remainder as previous map.	Pond noted ~200m south-east had been infilled and redeveloped into Gainsborough Gardens. The south-east to south-west of the site was fully developed into residential housing. Remainder as previous map.
1896	1:1,056	As previous map.	As previous map.
1915	1:2.500	As previous map.	As previous map.
1953	1:1,250	The greenhouse located over the site was demolished and the existing building was extended in its place. Remainder as previous map.	A subway was noted ~170m east of site. An electricity sub-substation was noted ~200m south-west. Remainder as previous map.
1953	1:1,250	As previous map.	As previous map.
1952 - 1953	1:2,500	No data.	As previous map.
1953	1:2,500	No data.	As previous map.
1954	1:1,250	As previous map.	As previous map.
1986 - 1991	1:1,250	As previous map	As previous map.
1897 – 1991	1:1,250	As previous map.	Subway ~170m east of site was no longer noted. Remainder as previous map.
1991	1:1,250	As previous map.	As previous map.
1991	1:1,250	As previous map.	As previous map.

2.5 Geology

The geology map of the British Geological Survey of Great Britain of the Hampstead area (Sheet No. 256 North London) revealed the site to be situated on the Claygate Member of the London Clay Formation. The overlying Bagshot Formation was noted ~75 west of site and the underlying London Clay Formation was noted ~385m south-east.

Both Figure 3 of the Camden Geological, Hydrogeological and Hydrological Study (see Figure 7 of this report) and the BGS geology maps indicated that no Made Ground or Worked Ground was noted within a close proximity of the site

Claygate Member of the London Clay Formation
The Claygate Member of the London Clay Formation comprises alternating layers of clayey sand and sandy clays. The sands usually overlie the clays. The clays are typically brown to mauve mottled and are overconsolidated. The bed is transitional and overlays the undivided London Clay Formation. It has been used extensively for brick making.

A BGS borehole ~50m south-east revealed Made Ground to 1.20m bgl, overlying a mottled brown and grey fine sandy clay to 2.70m bgl. A dark grey silty sandy clay was encountered to 3.60m bgl overlying a stiff dark grey silty clay to 10.66m bgl. A medium dense silty sand was then noted to the final depth of the borehole, a depth of 12.20m bgl.

2.6 Slope Stability and Subterranean Developments

The site was situated within an area where a natural or man-made slope of less than 7^o was present (Figure 16 Camden Geological, Hydrogeological and Hydrological Study, Figure 8 of this report).

Figure 17 of the Camden Geological, Hydrogeological and Hydrological Study indicated the site was not situated within an area prone to landslides (see Figure 9 of this report).

Figure 18 of the Camden Geological, Hydrogeological and Hydrological Study indicated that a no mainline railway tunnels were located within close proximity to the site (see Figure 10 of this report).

2.7 Hydrogeology and Hydrology

A study of the aquifer maps on the Environment Agency website, and Figure 8 of the Camden Geological, Hydrogeological and Hydrological Study (see Figure 11 of this report), revealed the site to be located on a **Secondary A Aquifer** relating to the bedrock deposits of the Claygate Member of the London Clay Formation. No designation was given for any superficial deposits due to their likely absence.

Secondary A Aquifers are permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers;

Superficial (Drift) deposits are permeable unconsolidated (loose) deposits, for example, sands and gravels. The bedrock is described as solid permeable formations e.g. sandstone, chalk and limestone.

Examination of the Environment Agency records and Figure 8 of the Camden Geological, Hydrogeological and Hydrological Study (see Figure 11 of this report) showed that the site did not fall within a Groundwater Source Protection Zone as classified in the Policy and Practice for the Protection of Groundwater.

In accordance with Figure 12 of the Camden Geological, Hydrogeological and Hydrological Study (see Figure 12 of this report), the Vale of Heath Pond was noted ~220m north of site.

Figure 14 of the Camden Geological, Hydrogeological and Hydrological Study revealed the site was not located within the catchment of Hampstead Ponds (see Figure 14 of this report).

From analysis of hydrogeological and topographical maps, groundwater was anticipated to be encountered at moderate depth (5 – 8m below existing ground level (bgl)) and it was considered that the groundwater was flowing in a south-easterly direction in accordance with the local topography.

Examination of the Environment Agency records showed that the site was not situated within a floodplain or flood warning area. Figure 15 the Camden Geological, Hydrogeological and Hydrological Study revealed that neither 20 Well Road nor the immediately surrounding roads suffered surface water flooding in either 1975 or 2002 (see Figure 15 of this report).

A plan showing the location of the site with respect to Environment Agency Flood Maps can be seen in Figure 16.

Data from the Environment Agency website indicated Well Road was not at a risk of surface water flooding. A plan showing the location of the site with respect to Environment Agency Surface Water Flooding Maps can be seen in Figure 17.

2.8 Radon

BRE 211 (2015) Map 5 of London, Sussex and West Kent revealed the site **was not** located within an area where mandatory protection measures against the ingress of Radon were required. The site **was not** located within an area where a risk assessment was required.

2.9 Geotechnical Conceptual Site Model

The following geotechnical concerns have been formulated by this desk based review and should be analysed by intrusive investigation:

- Soils with the potential for volume change potential are likely to be encountered under the site. Soils volume change potential to be determined along with depth of root penetration with reference to proximity of nearby trees;
- Potential for Made Ground due to construction activities in site history;
- Basement excavation and land stability given neighbouring properties and roads;
- Potential for shallow groundwater to be encountered perched within shallow Made Ground;
- Presence of a Secondary Aquifer and whether basement will affect saturated Aquifer;
- Temporary works whilst underpinning;
- Surface Water Run-off;
- Heave of soils following overburden pressure release.

3.0 BASEMENT IMPACT ASSESSMENT

This stage should identify any areas of concern and therefore focus efforts on further investigation.

3.1 Stage 1: Screening

3.1.1 Subterranean (Groundwater) Screening Flowchart

Question 1a. Is the site located directly above an aquifer?
Yes. A study of the aquifer maps on the Environment Agency website, and Figure 8 of the Camden Geological, Hydrogeological and Hydrological Study, revealed the site to be located on a Secondary A Aquifer relating to the bedrock of the Claygate Member of the London Clay Formation (see Figure 11 of this report). **Take forward to scoping.**

Question 1b. Will the proposed basement extend beneath the water table surface?
Unlikely. From analysis of hydrogeological and topographical maps, groundwater was anticipated to be encountered at moderate depth (5 – 8m below existing ground level (bgl)). A maximum dig depth of 3.60m bgl is being considered. **However, Ground Investigation could be considered. Take forward to scoping.**

Question 2. Is the site within 100m of a watercourse, well (used/disused) or potential spring line?
No. In accordance with Figure 12 of the Camden Geological, Hydrogeological and Hydrological Study there were no watercourses, wells (used/disused) or potential spring lines within 100m of the site (see Figure 12 of this report). **No further action.**

Question 3. Is the site within the catchment of the pond chains on Hampstead Heath?
No. Figure 14 of the Camden Geological, Hydrogeological and Hydrological Study revealed the site was not located within the catchment of Hampstead Ponds (see Figure 14 of this report). **No further action.**

Question 4. Will the proposed development result in a change in the proportion of hard surface/paved areas?
Marginally. The basement includes the construction of a lightwell, which will only increase the amounts of hard-surfaces and paved areas by 12m^2. **Take forward to scoping.**

Question 5. As part of the drainage, will more surface water (e.g. rainfall and run-off) than at present be discharged to the ground (e.g. via soakaways and/or SUDS)?
Marginally. At the time of reporting, October 2017, no significant change in the amount of surface water discharged into the ground was anticipated. **Take forward to scoping.**

Question 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. As the basement floor is proposed to be founded 3.20 – 3.60m bgl, the lowest point of the proposed excavation will not be in close proximity or lower than the mean water level. **No further action.**

3.1.2 Land Stability Screening Flowchart

Question 1. Does the existing site include slopes, natural or manmade, greater than 7 degrees (approximately 1 in 8)?

No. The property is located at around 106.7m AOD. The site is set into an easterly slope, but does not exceed 7^{o} or is within an area prone to land sliding. The garden level is understood to sit ~2.00m above the entrance from Well Road to the south-east, which leads up to the garden via stone steps. The existing property and small patio area is then understood to lie ~1.00m below the garden level. **No further action.**

Question 2. Will the proposed re-profiling of landscaping at site change slopes at the property boundary to more than 7deg (approximately 1 in 8)?

No. No re-profiling of landscaping is anticipated to occur. **No further action.**

Question 3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7deg (approximately 1 in 8)?

No. There are no railway cuttings in the immediate vicinity. **No further action.**

Question 4. Is the site within a wider hillside setting in which the general slope is greater than 7degrees (approximately 1 in 8)?

No. The site in general is set into an easterly slope, but the slope angles are less than 7 degrees (Figure 16 of the Camden Geological, Hydrogeological and Hydrological Study). There is one area ~250m north which shows angles of >7^{o} (see Figure 8 of the report). **No further action.**

Question 5: Is the London Clay the shallowest strata at the site?

No, the geological map (sheet 256) indicates that the site is underlain the Claygate Member of the London Clay Formation. **No further action.**

Question 6: Will any tree/s be felled as part of the proposed development and/or are any works proposed within any tree protection zones where trees are to be retained? (Note that consent is required from LB Camden to undertake work to any tree/s protected by a Tree Protection Order or to tree/s in a Conservation Area if the tree is over certain dimensions).

No. In accordance with sections 6.2 and 6.2 of the Tree Survey Report undertaken in September 2017, no trees are to be removed in the excavation of the basement. Any remaining trees will be protected during development. The Arboricultural Assessment indicated that trees in a close proximity of the basement will not be affect by the works. The Tree Survey Report can be seen in Appendix C. **No further action.**

Question 7: Is there a history of seasonal shrink-swell subsidence in the local area, and/or evidence of such effects at the site?

None known. However, the Claygate Member of the London Clay Formation is indicated as being present at the property, which has the potential for volume change. **Take forward to scoping.**

Question 8: Is the site within 100m of a watercourse or a potential spring line?

No, Figure 11 of the Camden Geological, Hydrogeological and Hydrological Study indicates no watercourses or potential spring lines are present in the vicinity of the site (see Figure 13 of this report). **No further action.**

Question 9: Is the site within an area of previously worked ground?
None known. There will be some Made Ground associated with past construction activities (see Geotechnical Desk Study). **Take forward to scoping.**

Question 10: Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?
Yes. The Claygate Member of the London Clay Formation is classified by the Environment Agency as a **Secondary A Aquifer** (permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers). **Take forward to scoping.**

Question 11: Is the site within 50m of the Hampstead Heath ponds?
No. The ponds are 550m – 580m north-east. **No further action.**

Question 12: Is the site within 5m of a highway or pedestrian right of way?
No. The nearest highway and pedestrian right of way was noted ~16m south-east. **No further action.**

Question 13: Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties? Possibly. It was understood that No.1 and 2 Cannon Lane and 19 Well Road have existing basements. However, 18 Well Road directly north does not have a basement (see Figure 18). Given the properties to the south-west appear a sufficient distance away from the proposed basement, it is likely Ground Movement Analysis (GMA) will only be required on 18 Well Road.

Based on data supplied by the structural engineer, the existing party wall between 20 and 19 Well Road (Wall G, see Figure 5) is 2.90m bgl in depth and the party wall between 20 and 18 Well Road (Wall H/D, see Figure 5), founding at 1.20m bgl. Both walls were assumed to comprise brick corbel footings, 600mm wide.

It was understood that the existing footings of 20 Well Road (Wall A, see Figure 5) were 0.70m bgl in depth, comprising brick corbel footings that are 600mm wide. **Carry forward to scoping.**

Question 14: Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?
No. The site is approximately 400m of the nearest tunnel and 700m of the nearest railway. **No further action.**

3.1.3 Surface Water and Flooding Screening Flowchart

1. Is the site within the catchment of the pond chains of Hampstead Heath?
No. Figure 14 of the Camden Geological, Hydrogeological and Hydrological Study revealed the site was not located within the catchment of Hampstead Ponds (see Figure 14 of this report).

2. As part of the of the proposed site drainage, will surface water flows be materially changed from the existing route?
No. The existing surface water routes will be not changed by the development. **No further action**.

3. Will the proposed basement development result in a change to the hard surfaces/paved external areas?
Marginally. The basement includes the construction of a lightwell, which will only increase the amounts of hard-surfaces and paved areas by 12m^2. **Take forward to scoping.**

4. Will the proposed basement result in changes to the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses?
No. Surface water that is received by adjacent properties and downstream watercourses is not from the site. This will remain the case with the proposed development.

5. Will the proposed basement result in a change to the surface water being received by adjacent properties or downstream watercourses?
No. Collected surface water will be from building roofs and paving, as before. The quality of the water received downstream will therefore not change.

6. Is the site in an area identified to have surface water flood risk according to either the Local Flood Risk Management Strategy or the Strategic Flood Risk Assessment or is it at risk from flooding, for example, because the basement is below the static water level of a nearby surface water feature?

No.

Please see table overleaf:

Flood Risks Overview		
Potential Source	**Potential Flood Risk at Site?**	**Justification**
Fluvial Flooding	No	EA Flood Mapping shows site was not located within a Flood Zone. No surface water features within a close proximity of the site.
Tidal Flooding	No.	EA Flood Mapping shows site was not located within a Flood Zone.
Flooding from Rising/High Groundwater	No.	From analysis of hydrogeological and topographical maps groundwater was anticipated to be encountered at moderate depth (5 - 8m bgl).
Surface Water (Pluvial) Flooding	No	Figure 12 the Camden Geological, Hydrogeological and Hydrological Study revealed that whilst the site was not subject to surface water flooding (See Figure 12 of this report).
Flooding From Infrastructure Failure	No	Figure 12 the Camden Geological, Hydrogeological and Hydrological Study revealed that whilst the site was not subject to surface water flooding (See Figure 12 of this report).
Flooding from Reservoirs, Canals and other artificial sources	No.	There were no reservoirs, canals or other artificial sources in a close proximity of the site that could give rise to a flood risk.

3.2 Stage 2: Scoping

3.2.1 Conceptual Site Model & Matters of Concern

There are nine areas of concerns that the Screening process have highlighted.

1. **Perched water within the Made Ground or Groundwater within the Claygate Member of the London Clay Formation** – the basement may encounter groundwater, associated with perched groundwater within any Made Ground or groundwater relating to the saturated aquifer of the Claygate Member of the London Clay Formation, during construction. This is to be taken forward for further assessment to confirm depth of the saturated Aquifer;

2. **Soil Moisture** – There is potential for soil moisture content to affect the development. This is to be taken forward for further assessment;

3. **Claygate Member of the London Clay Formation/Shrink and Swell** – The basement is anticipated to be founded in the Claygate Member of the London Clay Formation. The soils

are likely to have medium to high plasticity and volume change potential. The concrete mix design should take appropriate account of sulphate levels (testing to BRE Special Digest). Heave on removal of overburden pressure may be a risk;

4. **Previous area of Worked Ground;** Suspected, to be taken forward for further assessment.

5. **Differential Foundation Depths** – It is understood that the proposal is to excavate a 3.20m – 3.60m bgl deep basement beneath the entire footprint of the existing building. No.1 and 2 Cannon Lane and 19 Well Road are understood to have existing basements and it is just 18 Well Road, directly north that doesn't have a basement. Given the north-eastern party wall between 20 and 19 Well Road is likely to have been underpinned already, it is likely that only the north-western party wall between 20 and 18 Well Road will mean differential foundation depths. A view of 20 Well Road in relation to the surrounding buildings and basements can be seen in Figure 18. Therefore, further assessment through Ground Movement Analysis (GMA) is required.

   Based on data supplied by the structural engineer, the existing party wall between 20 and 19 Well Road (Wall G, see Figure 5) is 2.90m bgl in depth and the party wall between 20 and 18 Well Road (Wall H/D, see Figure 5), founding at 1.20m bgl. Both walls were assumed to comprise brick corbel footings, 600mm wide.

   It was understood that the existing footings of 20 Well Road (Wall A, see Figure 5) were 0.70m bgl in depth, comprising brick corbel footings that are 600mm wide.

6. **Retaining Walls** should be appropriately designed**;**

7. **Tree and Bushes.** No trees are located in the garden although there are some bushes and small trees in the rear garden. Care should be taken to minimise root damage during construction works. Should bushes be removed there is potential for the soils to swell as a result which may affect this and neighbouring properties and this should be accounted for in design and further assessed;

8. **Surface Water/Drainage.** The basement includes the construction of a lightwell, which will only increase the amounts of hard-surfaces and paved areas by 12m^2. Information from the Architect indicates that rainwater discharges into a combined soil and surface water system within the grounds/garden area, which enters the main public sewer beneath Well Road.

   The foul drainage from the new Lower Ground floor and the surface drainage below the Delta system will be pumped into the existing system. **No further actions considered necessary.**

A site-specific ground investigation should be undertaken to inform design. The scope of the investigation can be seen within Section 4 of this report. The results of the investigation are given within Sections 5 and 6 with the conclusions and recommendations provided within Section 7 of this report.

A ground movement assessment should be undertaken. The results of ground movement assessments undertaken on the neighbouring properties to the site can be seen within Section 7.7 of this report.

4.0 FIELDWORK

4.1 Scope of Works

Site works was undertaken on the 11th August 2017 and comprising the drilling of 2No. Cut-Down/Modular Windowless Sampler Borehole (BH1 & BH2) to 6.45m bgl. Standard Penetration Tests (SPT's) were undertaken at 1.00m intervals in BH1. 1No. Super Heavy Dynamic Probe (DP1) was undertaken from the base of BH1 from 6.00m – 11.80 bgl. A 50mm combined bio-gas and groundwater monitoring well was installed in BH1 to 5.00m bgl. The construction of the well installed can be seen tabulated below.

Combined Ground-gas and Groundwater Monitoring Well Construction				
Trial Hole	**Depth of Installation (mbgl)**	**Thickness of slotted piping with gravel filter pack (m)**	**Depth of plain piping with bentonite seal (m bgl)**	**Piping external diameter (mm)**
BH1	5.00m	4.00m	1.00m	50mm

The approximate locations of the trial holes can be seen within Figure 16.

Prior to commencing the ground investigation, a walkover survey was carried out to identify the presence of underground services and drainage. Where underground services/drainage were suspected and/or positively identified, exploratory positions were relocated away from these areas.

4.2 Sampling Procedures

Small disturbed samples were recovered from the trial holes at the depths shown on the trial hole records. Soil samples were generally retrieved from each change of strata and/or at specific areas of concern. Samples were also taken at approximately 0.5m intervals during broad homogenous soil horizons.

A selection of samples were despatched for geotechnical testing purposes.

5.0 ENCOUNTERED GROUND CONDITIONS

5.1 Soil Conditions

All exploratory holes were logged by James Harvey of Ground and Water Limited, generally in accordance with BS EN 14688 'Geotechnical Investigation and Testing – Identification and Classification of Soil'.

The ground conditions encountered within the trial holes drilled on the site generally conformed to that anticipated from examination of the geology map. A capping of Made Ground was noted to overlie the soils of the Claygate Member of the London Clay Formation.

The ground conditions encountered during the investigation are described in this section. For more complete information about the Made Ground and the Clayglate Member of the London Clay Formation at particular points, reference must be made to the individual trial hole logs within Appendix D.

The trial hole location plan can be viewed in Figure 19.

For the purposes of discussion, the succession of conditions encountered in the trial holes in descending order can be summarised as follows:

Made Ground
Claygate Member of the London Clay Formation

Made Ground
Made Ground was encountered from ground level to a depth of between in 1.80m - 2.60m bgl in BH1 and BH2. The soils comprised a dark to light brown silty gravelly sand. The sand was fine to medium grained. The gravel was occasional to abundant, fine to coarse, sub-rounded to angular flints, brick, tile and coal fragments. A thin clay lens was noted at 1.50m bgl.

Head Deposits
Head Deposits were noted in BH1 and BH2 underlying the Made Ground from 1.80m – 2.60m bgl to depths of between 2.50m – 2.80m bgl. The soils generally comprised a brown gravelly sandy clay to a light brown gravelly silty sand. The sand was fine to medium grained. The gravel was rare to abundant, fine to coarse, sub-angular to sub-rounded flints.

The Claygate Member of the London Clay Formation
Soils of the Claygate Member of the London Clay Formation were encountered underlying the Head Deposits, from 2.50m – 2.80m bgl for the remaining depths of BH1 and BH2, between 6.00m – 6.45m bgl. The soils generally comprised a brown/light brown/grey sandy silty clay. The sand was fine grained. Sand lenses were noted between 2.70m – 2.80m, 2.70m – 2.80m and at 4.80m bgl.

Bands of granular soils of the Claygate Member of the London Clay Formation were noted in BH1 and BH2 between 3.40 – 3.90m, 5.00 – 6.45m and 5.60 – 6.00m bgl. The soils generally comprised a light brown very clayey silty sand. The sand was very fine to medium grained.

5.2 Roots Encountered

Roots were noted to depths of between 0.30m – 1.60m bgl in BH1 and BH2 respectively.

It must be noted that the chance of determining actual depth of root penetration through a narrow diameter borehole is low. Roots may be found to greater depths at other locations on the site, particularly close to trees and/or trees that have been removed both within the site and its close environs.

5.3 Groundwater Conditions

Groundwater observations made during the intrusive and during a subsequent groundwater monitoring visit can be seen tabulated overpage.

Depth of Groundwater Strikes/Standing Groundwater Within Trial Holes			
Trial Hole	**Date**	**Depth of Groundwater (m bgl)**	**Depth to Base of Trial Hole/Standpipe (m bgl)**
BH1	16.08.2017	Dry	5.43m bgl
	23.08.2017		5.30m bgl

Changes in groundwater level occur for a number of reasons including seasonal effects and variations in drainage. Exact groundwater levels may only be determined through long term measurements from monitoring wells installed on-site. The investigation was undertaken in August 2017 when groundwater levels are likely to be close to their annual minimum (lowest elevation).

Isolated pockets of groundwater may be perched within any Made Ground found at other locations around the site.

5.4 Obstructions

No artificial or natural sub-surface obstructions were noted during construction of the trial holes.

6.0 INSITU AND LABORATORY GEOTECHNICAL TESTING

6.1 In-Situ Geotechnical Testing

Standard Penetration Testing (SPT's) was undertaken at 1.00m intervals in BH1. The results of the SPT's have not been amended to take into account hammer efficiency, rod lengths and overburden pressure in accordance with Eurocode 7. The test results are presented on the trial hole logs within Appendix D.

Windowless Sampler Boreholes provide samples of the ground for assessment but they do not give any engineering data. The standard penetration test (SPT) is an in-situ dynamic penetration test designed to provide information on the geotechnical engineering properties of soil. The test uses a thick-walled sample tube, with an outside diameter of 50 mm and an inside diameter of 35 mm, and a length of around 650mm. This is driven into the ground at the bottom of a borehole by blows from a slide hammer with a weight of 63.5 kg falling through a distance of 760 mm. The sample tube is driven 150 mm into the ground and then the number of blows needed for the tube to penetrate each 150 mm up to a depth of 450 mm is recorded. The sum of the number of blows is termed the "standard penetration resistance" or the "N-value".

Dynamic Probing involves the driving of a metal cone into the ground via a series of steel rods. These rods are driven from the surface by a hammer system that lifts and drops a 63.5kg (SHDP) hammer onto the top of the rods through a set height, thus ensuring a consistent energy input. The number of hammer blows that are required to drive the cone down by each 100mm increment are recorded. These blow counts then provide a comparative assessment from which correlations have been published, based on dynamic energy, which permits engineering parameters to be generated. *(The 'Super Heavy' (SHDP) Tests were conducted in accordance with BS 1377; 1990; Part 9, Clause 3.2).*

The cohesive soils of the Claygate Member of the London Clay Formation were classified based on the table below.

Undrained Shear Strength from SPT "N" Blow Counts Cohesive Soils (EN ISO 14688-2:2004 & Stroud (1974))		
Classification	**Undrained Shear Strength (kPa)**	**Field Indications**
Extremely High	>300	-
Very High	150 – 300	Brittle or very tough
High	75 – 150	Cannot be moulded in the fingers
Medium	40 – 75	Can be moulded in the fingers by strong pressure
Low	20 – 40	Easily moulded in the fingers
Very Low	10 – 20	Exudes between fingers when squeezed in the fist
Extremely Low	<10	-

The granular soils of the Claygate Member of the London Clay Formation were classified based on the table overleaf.

Correlation between normalised SPT blow counts $(N_1)_{60}$ or equivalent 'SPT's derived from SHDP results and granular classification.	
Classification	**Equivalent SPT Blow Counts (N1)**
Extremely Dense	>58
Very Dense	42 – 58
Dense	25 – 42
Medium	8 – 25
Loose	3 – 8
Very Loose	0 – 3

An interpretation of the in-situ geotechnical testing results is given in the table below.

In-Situ Geotechnical Testing Results Summary					
Strata	**SPT "N" Blow Counts**	**Undrained Shear Strength kPa (Based on Stroud, 1974)**	**Soil Type**		**Trial Hole**
			Cohesive	**Granular**	
The Claygate Member of the London Clay Formation (cohesive)	14 - 18	70 – 90	Medium to High Undrained Shear Strength	-	BH1 (2.80 – 3.40m, 3.90 – 5.00m bgl)
The Claygate Member of the London Clay Formation (granular)	17 - 20	-	-	Medium Dense	BH1 (2.60 – 2.80m, 3.40m – 3.90m, 5.00 – 6.45m bgl)
ASSUMED Claygate Member of the London Clay Formation (cohesive)	7 - 52	35 - 260	Low to Very High Undrained Shear Strength	-	DP1 (6.20m – 11.90m bgl
ASSUMED Claygate Member of the London Clay Formation (cohesive/granular)	71 – 111	-	-	Extremely Dense	DP1 (10.80 – 11.00m, 11.60m – 11.90m bgl)

It must be noted that field measurements of undrained shear strength are dependent on a number of variables including disturbance of sample, method of investigation and also the size of specimen or test zone etc.

The test results are presented on the trial hole logs within Appendix D.

6.2 Laboratory Geotechnical Testing

A programme of geotechnical laboratory testing, scheduled by Ground and Water Limited and carried out by K4 Soils Laboratory and QTS Environmental Limited, was undertaken on samples recovered from the Claygate Member of the London Clay Formation. The results of the tests are presented in Appendix E.

The test procedures used were generally in accordance with the methods described in BS1377:1990.

Details of the specific tests used in each case are given below:

Standard Methodology for Laboratory Geotechnical Testing		
Test	**Standard**	**Number of Tests**
Atterberg Limit Tests	BS1377:1990:Part 2:Clauses 3.2, 4.3 & 5	4
Moisture Content	BS1377:1990:Part 2:Clause 3.2	4
Water Soluble Sulphate & pH	BS1377:1990:Part 3:Clause 5	2
BRE Special Digest 1 (incl. Ph, Electrical Conductivity, Total Sulphate, W/S Sulphate, Total Chlorine, W/S Chlorine, Total Sulphur, Ammonium as NH4, W/S Nitrate, W/S Magnesium)	BRE Special Digest 1 "Concrete in Aggressive Ground (BRE, 2005).	2

6.2.1 Atterberg Limit Tests

A précis of Atterberg Limit Tests undertaken on two samples of Head Deposits and two samples of the Claygate Member of the London Clay Formation can be seen tabulated below.

Atterberg Limit Tests Results Summary							
Stratum/Depth	**Moisture Content (%)**	**Passing 425 µm sieve (%)**	**Modified PI (%)**	**Soil Class**	**Consistency Index (Ic)**	**Volume Change Potential**	
						NHBC	**BRE**
Head Deposits	19 - 23	92 – 100	13.8 - 21	CH	Stiff 0.81 – 0.94	Low to Medium	Low to Medium
Claygate Member of the London Clay Formation	21 - 26	100	28 – 29	CH	Stiff 0.79 – 0.90	Medium	Medium

NB: NP – Non-plastic
BRE Volume Change Potential refers to BRE Digest 240 (based on Atterberg results)
Soil Classification based on British Soil Classification System.
Consistency Index (Ic) based on BS EN IS0 14688-2:2004.

6.2.2 Comparison of Soil's Moisture Content with Index Properties

6.2.2.1 Liquidity Index Analyses

The results of the Atterberg Limit tests undertaken on two samples of Head Deposits and two samples of the Claygate Member of the London Clay Formation were analysed to determine the Liquidity Index of the samples. This gives an indication as to whether the samples recovered showed a moisture deficit and their degree of consolidation. The results are tabulated overpage.

The test results are presented within Appendix E.

Liquidity Index Calculations Summary					
Stratum/Trial Hole/Depth	**Moisture Content (%)**	**Plastic Limit (%)**	**Modified Plasticity Index (%)**	**Liquidity Index**	**Result**
Claygate Member of the London Clay Formation BH1/3.00m bgl (Orangish brown and greenish grey slightly sandy silty CLAY)	21	18	29.0	0.10	Heavily Overconsolidated.
Claygate Member of the London Clay Formation BH1/4.00m bgl (Brown, grey and orangish brown sandy silty CLAY)	26	20	28.0	0.21	Overconsolidated
Head Deposits BH2/1.80m bgl (Greyish brown and orangish brown slightly gravelly sandy silty CLAY (gravel is fmc and sub-rounded to rounded))	19	17	13.8	0.14	Heavily Overconsolidated.
Head Deposits BH2/2.00m bgl (Orangish brown and greenish grey silty sandy CLAY)	23	19	21.0	0.19	Heavily Overconsolidated.

Liquidity Index testing revealed no evidence for moisture deficit within the overconsolidated to heavily overconsolidated samples of the Head Deposits and Claygate Member of the London Clay Formation tested.

6.2.2.2 Liquid Limit

A comparison of the soil moisture content and the liquid limit can be seen tabulated overleaf.

Moisture Content vs. Liquid Limit				
Strata/Trial Hole/Depth/Soil Description	Moisture Content (MC) (%)	Liquid Limit (LL) (%)	40% Liquid Limit (LL)	Result
Claygate Member of the London Clay Formation BH1/3.00m bgl (Orangish brown and greenish grey slightly sandy silty CLAY)	21	47	18.8	MC > 0.4 x LL (No significant moisture deficit)
Claygate Member of the London Clay Formation BH1/4.00m bgl (Brown, grey and orangish brown sandy silty CLAY)	26	48	19.2	MC > 0.4 x LL (No significant moisture deficit)
Head Deposits BH2/1.80m bgl (Greyish brown and orangish brown slightly gravelly sandy silty CLAY (gravel is fmc and sub-rounded to rounded))	19	32	12.8	MC > 0.4 x LL (No significant moisture deficit)
Head Deposits BH2/2.00m bgl (Orangish brown and greenish grey silty sandy CLAY)	23	40	16.0	MC = 0.4 x LL (No significant moisture deficit)

The results in the table above indicated that the samples of the heavily overconsolidated Head Deposits and Claygate Member of the London Clay Formation tested showed no evidence of a significant moisture deficit.

6.2.4 Moisture Content Profiling

The moisture content versus depth plot for BH2 can be seen within Figures 20.

Figure 20 shows a possible moisture deficit in BH2 at the shallower depth of 1.80m due to the moisture content being relatively high for that sample. Given the depth of Made Ground in BH2 and the granular nature of the soils, it likely to be related to the lithology of the soils (presence of sand and silt).

Figure 17 shows a possible moisture deficit in BH2 at a depth of 3.50m bgl due to the lowering of the moisture content. The strata in the borehole to that depth were generally described as a sandy silty clay. The sand was very fine grained. Roots were noted to 1.60m bgl in BH2. Therefore, the possible moisture content deficit was likely to be related to the lithology of the soils (presence of sand and silt) rather than the water demand of nearby trees.

6.2.5 Sulphate and pH Tests

A sulphate and pH test was undertaken on one sample from the Claygate Member of the London Clay Formation (BH2/2.00m bgl). The sulphate concentration was 220mg/l with a pH of 7.25.

6.2.6 BRE Special Digest 1

In accordance with BRE Special Digest 1 ‘Concrete in Aggressive Ground’ (BRE, 2005) two samples of the Claygate Member of the London Clay Formation (BH1/0.80m and BH2/2.30m bgl) were scheduled for laboratory analysis to determine parameters for concrete specification.

The results are given within Appendix E and a summary is tabulated overleaf.

Summary of Results of BRE Special Digest Testing			
Determinand	**Unit**	**Minimum**	**Maximum**
pH	-	6.9	7.7
Ammonium as NH_4	mg/kg	<0.5	<0.5
Sulphur	mg/kg	<0.02	<0.02
Chloride (water soluble)	mg/kg	10	14
Magnesium (water soluble)	mg/l	0.3	2.5
Nitrate (water soluble)	mg/kg	6	8
Sulphate (water soluble)	g/l	0.01	0.11
Sulphate (total)	%	<0.02	0.02

7.0 ENGINEERING CONSIDERATIONS

7.1 Soil Characteristics and Geotechnical Parameters

Based on the results of the intrusive investigation and geotechnical laboratory testing the following interpretations have been made with respect to engineering considerations.

- Made Ground was encountered from ground level to a depth of between in 1.80m - 2.60m bgl in BH1 and BH2.

  As a result of the inherent variability of Made Ground, it is usually unpredictable in terms of bearing capacity and settlement characteristics. Foundations should, therefore, be taken through any Made Ground and either into, or onto a suitable underlying natural stratum of adequate bearing characteristics.

  Made Ground may be found to deeper depth at other locations on the site, especially close to former structures/foundations and service runs.

- Head Deposits were noted in BH1 and BH2 underlying the Made Ground from 1.80m – 2.60m bgl to depths of between 2.50m – 2.80m bgl. The soils generally comprised a brown gravelly sandy clay to a light brown gravelly silty sand. The sand was fine to medium grained. The gravel was rare to abundant, fine to coarse, sub-angular to sub-rounded flints.

  The cohesive soils of the Head Deposits were shown to have a **low to medium** potential for volume change in accordance both BRE240 and NHBC Standards Chapter 4.2.

  Consistency Index calculations indicated the Head Deposits to be stiff. Geotechnical analysis revealed the soils to be heavily overconsolidated with no potentially significant root exacerbated moisture deficits.

- Soils of the Claygate Member of the London Clay Formation were encountered underlying the Head Deposits, from 2.50m – 2.80m bgl for the remaining depths of BH1 and BH2, between 6.00m – 6.45m bgl. The soils generally comprised a brown/light brown/grey sandy silty clay. The sand was fine grained. Sand lenses were noted between 2.70m – 2.80m, 2.70m – 2.80m and 4.80m bgl.

  Bands of granular soils of the Claygate Member of the London Clay Formation were noted in BH1 and BH2 between 3.40 – 3.90m, 5.00 – 6.45m and 5.60 – 6.00m bgl. The soils generally comprised a light brown very clayey silty sand. The sand was very fine to medium grained.

  The cohesive soils of the Claygate Member of the London Clay Formation were shown to have a **medium** potential for volume change in accordance both BRE240 and NHBC Standards Chapter 4.2.

  The granular soils of the Claygate Member of the London Clay Formation were assumed to have the potential for volume change in accordance both BRE240 and NHBC Standards Chapter 4.2.

  Consistency Index calculations indicated the Claygate Member of the London Clay Formation to be stiff. Geotechnical analysis revealed the soils to be heavily overconsolidated with no potentially significant root exacerbated moisture deficits.

The soils of the Claygate Member of the London Clay Formation were heavily overconsolidated cohesive soils and are therefore likely to be a suitable stratum for the proposed traditional strip or mat foundations associated with the basement. The settlements induced on loading are likely to be low to moderate.

The final design of foundations will need to take into account the volume change potential of the soil, the depth of root penetration and/or moisture deficit and the likely serviceability and settlement requirements of the proposed structure. These parameters for design are discussed in the next section of this report.

- Groundwater was not encountered during the intrusive investigation and the well installed in BH1 was noted to be dry on both return visits.

- Roots were noted to depths of between 0.30m – 1.60m bgl in BH1 and BH2 respectively.

7.2 Spread and Basement Foundations

At the time of reporting, October 2017, the proposed development was understood to comprise the construction of a basement below the entire footprint of the ground floor, including construction of lightwells. The floor level of the basement is to be formed at ~3.20m bgl, with the retaining wall foundation formed at 3.60m bgl. A proposed development plan can be seen in Figure 4.

The proposed development fell within Geotechnical Design Category 2 in accordance with Eurocode 7.

It is understood that the south-eastern wall (Wall D and F, with reference to Figure 5) and western wall (Wall J, with reference to Figure 5) of the basement will be constructed utilising 7.00m deep contiguous piling, with an expected load of 40kN/m^2. A proposed development plan of the basement with the areas that include contiguous piling can be seen in Figure 6.

The remainder of the basement will be constructed based on load bearing retaining wall underpins, with thickened edges and a semi-ground bearing slab. It is anticipated that the thickened edges will range between 2.00m – 2.60m, with loads implied by the retaining wall ranging between 76.60 – 92.00kN/m^2.

Based on data supplied by the structural engineer, the existing party wall between 20 and 19 Well Road (Wall G, see Figure 5) is 2.90m bgl in depth and the party wall between 20 and 18 Well Road (Wall H/D, see Figure 5), founding at 1.20m bgl. Both walls were assumed to comprise brick corbel footings, 600mm wide.

It was understood that the existing footings of 20 Well Road (Wall A, see Figure 5) were 0.70m bgl in depth, comprising brick corbel footings that are 600mm wide.

Foundations should be designed in accordance with soils of **medium volume change potential** in accordance with BRE Digest 240 and NHBC Chapter 4.2.

Given the cohesive nature of the shallow deposits foundations must therefore **not** be placed within cohesive root penetrated and/or desiccated soils and the influence of the trees surrounding the site must be taken into account (NHBC Standards Chapter 4.2). It is recommended that foundations are taken at least 300mm into non-root penetrated strata or granular soils of no volume change potential.

Where trees are mentioned in the text this means existing trees, recently removed trees (approximately 15 years to full recovery on cohesive soils) and those planned as part of the site landscaping. Should trees be removed from the footprint of the proposed building then an alternative foundation system, such as piles or isolated pads should be considered.

Roots were noted to depths of between 0.30m – 1.60m bgl in BH1 and BH2 respectively. Made Ground was noted to a maximum depth of 1.80m in BH2 and 2.60 bgl in BH1.

Given the above and the depth of roots noted in the boreholes, it was concluded that a minimum founding depth of 1.80m was required for the side extension in the vicinity of BH2 and the proposed foundation depth of 3.60m bgl was considered suitable for the proposed basement.

It should be noted that BH1 and BH2 were excavated in the garden areas, which lies ~1.00m above the current dwelling.

The formation level for the extension must be carefully inspected for the presence of fresh/live roots. Should live roots be noted at formation level then the formation level should be extended at least 300mm into non-root penetrated soils.

The proposed basement will be constructed with load bearing concrete retaining walls with semi-ground bearing concrete floors. The following bearing capacities could be adopted for 11.00 x 2.00, 16.00 x 2.30 and 4.50 x 2.60m wide footings constructed at 3.00m and 3.50m bgl.

Limit State: Bearing Capacities Calculated (Based on BH1)			
Wall	**Depth (m BGL)**	**Foundation System**	**Maximum Bearing Capacity (kN/m²) (EC2)**
Wall G	3.60	11.00 x 2.00	160
Wall H/D	3.60	16.00 x 2.30	141
Wall J	3.60	4.50 x 2.60	136

Limit State: Bearing Capacities Calculated (Based on BH1)				
Wall	**Depth (m BGL)**	**Foundation System**	**Limit Bearing Capacity (kN/m²) (EC2)**	**Settlement (mm)**
Wall G	3.60	11.00 x 2.00	80.30	<7
			56.15	<3
Wall H/D	3.60	16.00 x 2.30	76.60	<6
			52.60	<1
Wall J	3.60	4.50 x 2.60	92.00	<10
			46.00	0*

***No net change in effective stress at depth.**

The structural engineer will be required to account for these movements in the final design.

The basement slab, with a self - weight of ~10kN/m^2, may experience ~3 – 4mm of initial elastic heave at 3.00m and 3.50m bgl. Any basement slab would need to take into account the potential for long term heave to occur in the cohesive soils of the Claygate Member of the London Clay Formation.

It is estimated that 30-50% of the total heave will be immediate, indicating that between 6.00 – 9.00mm of total heave may occur beneath the slab. **The structural engineer will be required to account for this in the final design. Use of clayboard beneath partially suspended slab is likely to be required.**

Excavations must be kept dry and either concreted or blinded as soon after excavation as possible. If water were allowed to accumulate on the formation for even a short time not only would an increase in heave occur resulting from the soil increasing in volume by taking up water, but also the shear strength and hence the bearing capacity would also be reduced.

Groundwater was not encountered during the intrusive investigation and BH1 was noted to be dry on both return visits. Therefore, it is considered unlikely that significant amounts of groundwater would be encountered during foundation excavation.

Perched water maybe encountered within the Made Ground or/and silty pockets of the Claygate Member of the London Clay Formation, especially after period of prolonged rainfall. **This should be taken into account in final design.**

The basement must be suitably tanked to prevent ingress of groundwater and also surface water run-off.

It must be mentioned that it was assumed that excavations will be kept dry and either concreted or blinded as soon after excavation as possible. If water were allowed to accumulate on the formation for even a short time not only would an increase in heave occur resulting from the soil increasing in volume by taking up water, but also the shear strength and hence the bearing capacity would also be reduced.

If the construction works take place during the winter months, when the groundwater level is expected to be at its higher elevation, perched water could accumulate thus dewatering could be required to facilitate the construction and prevent the base of the excavation blowing before the slab was cast.

7.3 Piled Foundations

It is understood that the south-eastern wall (Wall D and F, with reference to Figure 5) and western wall (Wall J, with reference to Figure 5) of the basement will be constructed utilising 7.00m deep contiguous piling, with an expected load of 40kN/m^2. A proposed development plan of the basement with the areas that include contiguous piling can be seen in Figure 6.

It was not part of the remit of this report to include a design for the contiguous piling, this will be undertaken by others.

7.4 Basement Excavations & Stability

Shallow excavations in the Made Ground and the Claygate Member of the London Clay Formation are likely to be marginally stable at best. Long, deep excavations, through both of these strata are likely to become unstable.

The excavation of the basement must not affect the integrity of the adjacent structures beyond the boundaries. The excavation must be supported by suitably designed retaining walls. It is considered unlikely that battering the sides of the excavation, casting the retaining walls and then backfilling to the rear of the walls would be suitable given the close proximity of the party walls.

The retaining walls for the basement will need to be constructed based on cohesive soils with an appropriate angle of shear resistance (*Φ'*) for the ground conditions encountered.

Based on the ground conditions encountered within the boreholes the following parameters could be used in the design of retaining walls. These have been designed based on the SPT profile recorded, results of geotechnical classification tests and reference to literature.

Retaining Wall/Basement Design Parameters					
Strata	**Unit Volume Weight (kN/m³)**	**Cohesion Intercept (c') (kPa)**	**Angle of Shearing Resistance (Ø)**	**Ka**	**Kp**
Made Ground	~13 - 15	0	12	0.66	1.52
Claygate Member of the London Clay Formation	~15 - 20	0	24	0.42	2.37

As geotechnical testing defined the Claygate Member of the London Clay Formation as being heavily overconsolidated, a Ko value was unobtainable due to Overconsolidation Ratio (OCR) being unknown. A Ko range of 1.0 – 2.8 can be used for consolidated Claygate Member of the London Clay Formation.

The value of K adopted in design calculations should allow for the effects of wall installation. In general, it may be appropriate to adopt a K value of 1.0 from simple elastic (i.e. where the pre-failure deformation of the soil is assumed to be linear) soil-structure interaction analysis on overconsolidated fine-grained soils. **The structural engineer will be required to account for this in the final design.**

Unsupported earth faces formed during excavation may be liable to collapse without warning and suitable safety precautions should therefore be taken to ensure that such earth faces are adequately supported before excavations are entered by personnel.

Perched water maybe encountered within the Made Ground or/and silty pockets of the Claygate Member of the London Clay Formation, especially after period of prolonged rainfall. **This should be taken into account in final design.**

Should groundwater be encountered across the site, dewatering from sumps introduced into the floor of the excavation may be required, especially after a period of excessive rainfall. Consideration should be given to creating a coffer dam using contiguous piled or sheet piled walls to aid basement construction below the perched water table. The advice of a reputable dewatering company should be sought.

7.5 Hydrogeological Effects

A study of the aquifer maps on the Environment Agency website, and Figure 8 of the Camden Geological, Hydrogeological and Hydrological Study (see Figure 10 of this report), revealed the site to be located on a **Secondary A Aquifer** relating to the bedrock deposits of the Claygate Member of the London Clay Formation. No designation was given for any superficial deposits due to their likely absence.

The ground conditions encountered generally comprised a capping of Made Ground over cohesive soils with granular bands of the Claygate Member of the London Clay Formation. Based on a visual appraisal of the soils encountered the permeability of the Claygate Member of the London Clay Formation Beds were likely to be very low to low permeability.

Groundwater was not encountered during the intrusive investigation and BH1 was noted to be dry on both return visits.

The Environment Agency records show that the highest recorded tide for the nearest river station on the River Thames at Westminster is 4.70m AOD with high tides generally at ~3.00m AOD. The elevation of the proposed basement slab 103.7m AOD. The basement floor will therefore be constructed above general high tide levels of the River Thames.

Based on the above it is considered unlikely that the basement will be constructed below the groundwater table/or within the saturated aquifer underlying the site.

The basement was therefore considered unlikely to affect the saturated aquifer underlying the site.

No.1 and 2 Cannon Lane, and 18 – 20 Well Road are subdivided sections of a once larger property called "The Logs". The Logs is a detached, isolated, building, with basements under 3/5ths of the property already. Given the properties isolated nature the adding of a 4th basement it not considered likely to have cumulative effects, given groundwater the saturated aquifer won't be affected by the basement and that groundwater percolating through the shallow soils can migrate around the property and basement. **Therefore, the cumulative effects of basements on groundwater are not a significant consideration at this site.**

Perched water maybe encountered within the Made Ground or/and silty pockets of the Claygate Member of the London Clay Formation, especially after period of prolonged rainfall. **This should be taken into account in final design.**

In relation to the basement, once constructed, the Made Ground will act as a slightly porous medium for water to migrate however additional drainage should be considered as the Claygate Member of the London Clay Formation will act as a barrier for groundwater migration.

7.6 Assessment of Ground Movement

At the time of reporting, October 2017, it is proposed to be construct the basement to a level of 3.20m – 3.60m bgl.

It is understood that the basement will be constructed based on load bearing retaining wall underpins, with thickened edges and a semi-ground bearing slab. It is anticipated that the thickened edges will range between 2.00m – 2.60m, with loads implied by the retaining wall ranging between 76.60 – 92.00 kN/m^2.

It is understood that the south-eastern wall and the area of the basement below the extension will comprise 7.00m deep contiguous piling, with an expected load of 40kN/m^2.

No.1 and 2 Cannon Lane and 19 Well Road are understood to have existing basements and it is just 18 Well Road, directly north that doesn't have a basement. Given the north-eastern party wall between 20 and 19 Well Road is likely to have been underpinned already, it is likely that only the north-western party wall between 20 and 18 Well Road will mean differential foundation depths. A view of 20 Well Road in relation to the surrounding buildings and basements can be seen in Figure 18.

Based on data supplied by the structural engineer, the existing party wall between 20 and 19 Well Road (Wall G, see Figure 5) is 2.90m bgl in depth and the party wall between 20 and 18 Well Road (Wall H/D, see Figure 5), founding at 1.20m bgl. Both walls were assumed to comprise brick corbel footings, 600mm wide.

It was understood that the existing footings of 20 Well Road (Wall A, see Figure 5) were 0.70m bgl in depth, comprising brick corbel footings that are 600mm wide.

The basement will consist of reinforced concrete cantilevering retaining walls. These will be designed to resist the lateral loads around the perimeter of the basement. The basement floor structure will comprise a reinforced concrete slab. The slab will be suspended between the bases of perimeter underpins to accommodate heave. The retaining walls will also transfer vertical loads to the ground.

The depth of the basement will be approximately 3.60m bgl, through loose to medium dense sandy Made Ground and founded in interbedded sands and soft to firm clay. The proposed basement will be approximately 16.00m by 11.00m in area.

The proposed development fell within Geotechnical Design Category 2 in accordance with Eurocode 7. The proposed foundation loads were anticipated to be 75 – 150kN/m^2.

According to CIRIA C580 and C760 estimating ground movements in the vicinity of excavations is very complex due to the variety of factors involved. It is also mentioned that ground movements around the excavation can be controlled and minimised by adopting specific measures, which are discussed at the end of this section.

Ground movements can be approximated using available monitoring data presented within CIRIA Report C580 and C760 in conjunction with engineering judgement.

CIRIA C760 states that it is not possible to distinguish between walls embedded in competent (stiff) ground retaining some soft and firm clays from those wholly embedded in soft to firm clays from research to date. However, the totality of the data provides an upper bound to observed experience which the vast majority of ground movements will fall into, including soft clays and alluvium. Therefore, using engineering judgement, we have produced design lines based on a conservative, moderate and actual case in firm clays.

Movement has been assessed for the surrounding properties due to the excavation of the basement below the existing dwellings.

The site was attached to terraced three to four-storey grade two listed building to the north of the site.

Based on the maximum depth of excavation, structures within a 12.00m radius of the proposed basement were considered likely to be influenced by the proposed development. Only 18 Well Road was analysed due to the other properties in a 12.00m radius already have basements.

Parameters of Surrounding Properties			
Property	**Approximate Distance to Closest Wall/Corner (m)**	**Approximate Length (m)**	**Approximate Height (m)**
18 Well Road	0.00	10.00	15.00

- The magnitude of ground movements has been assessed for the excavation of the traditional underpinned retaining wall structures, and also the installation of the Contuous piled wall, where appropriate.
- It is important to note that CIRIA Report C580/760 was written for embedded retaining walls. Therefore, movement calculations for the excavation of soil and installation of the underpinnings does not strictly apply to C580/760.

The following parameters have been used to inform this assessment:

- It is understood that the south-eastern wall (Wall D and F, with reference to Figure 5) and western wall (Wall J, with reference to Figure 5) of the basement will be constructed utilising 7.00m deep contiguous piling, with an expected load of 40kN/m^2;
- The maximum excavation depth is approximately 3.60m below ground level. However, it must be noted that excavations adjacent to No. 19 will be shallower due to the existing basement;
- The method of basement construction will be traditional underpinning;
- A high wall stiffness has been assumed;
- In the permanent case the wall will always be propped at high level;
- The assessed buildings were estimated to be ~15.00m high.
- Soil comprising loose to medium dense sandy Made Ground and founded in interbedded sands and soft to firm, becoming stiff at depth clay;
- Analysis has been undertaken using soft to firm clays and sands.
- Analysis for the installation of the contiguous pile wall has been undertaken for stiff clays for the horizontal movement, as this is the only data available.
- The magnitude of ground movements has been assessed for the excavation in front of the contiguous piled retaining walls

Based on reference to CIRIA Report C760 the following ground movements have been developed based on of the excavation of soils to form the basement.

Given that the contiguous piling will only be used along portions of the basement, analysis has been undertaken for both pile installation and excavation (Wall D, F and J) and excavation only (remainder of basement). The analysis for excavation only can be seen overleaf.

Ground Movement Analysis - Excavation (Soft to Firm Clay)							
Property	**Approx. Horizontal Ground Movement at Closest Wall/Corner (mm)**	**Approx. Horizontal Ground Movement at Furthest Wall/Corner (mm)**	**Horizontal Strain (%)**	**Approx. Vertical Ground Movement at Closest Wall/Corner (mm)**	**Approx. Vertical Ground Movement at Furthest Wall/Corner (mm)**	**Vertical Deflection Ratio (%)**	**Category of Damage**
Highly Conservative Line							
18 Well Road	4.50	0.75	0.03750	7.20	0.03	0.076000	Slight
Moderately Conservative Line							
18 Well Road	4.50	0.75	0.03750	5.40	0.03	0.040000	Very Slight
Conservative Line							
18 Well Road	4.50	0.75	0.03750	3.00	0.03	0.022000	Negligible

Ground Movement Analysis – Excavation (Sand)				
Property	**Approx. Vertical Ground Movement at Closest Wall/Corner (mm)**	**Approx. Vertical Ground Movement at Furthest Wall/Corner (mm)**	**Vertical Deflection Ratio (%)**	**Category of Damage**
18 Well Road	1.08	0.00	0.040000	Negligible

Based on reference to CIRIA Report C760 the following ground movements have been developed based on of the excavation of soils and the construction of contiguous piles to form the basement.

Ground Movement Analysis – Excavation (Soft to Firm Clay) and Contiguous Piling (Stiff Clay)							
Property	**Approx. Horizontal Ground Movement at Closest Wall/Corner (mm)**	**Approx. Horizontal Ground Movement at Furthest Wall/Corner (mm)**	**Horizontal Strain (%)**	**Approx. Vertical Ground Movement at Closest Wall/Corner (mm)**	**Approx. Vertical Ground Movement at Furthest Wall/Corner (mm)**	**Vertical Deflection Ratio (%)**	**Category of Damage**
Highly Conservative Line							
18 Well Road	8.20	0.09	0.08110	10.30	0.80	0.034000	Slight
Moderately Conservative Line							
18 Well Road	8.20	0.09	0.08110	8.20	0.80	0.028000	Slight
Conservative Line							
18 Well Road	8.20	0.09	0.08110	5.80	0.83	0.011000	Slight

Ground Movement Analysis – Excavation (Sand) and Contiguous Piling (Stiff Clay)				
Property	**Approx. Vertical Ground Movement at Closest Wall/Corner (mm)**	**Approx. Vertical Ground Movement at Furthest Wall/Corner (mm)**	**Vertical Deflection Ratio (%)**	**Category of Damage**
18 Well Road	13.60	0.00	0.04400	Negligible

Contour plots showing the horizontal and vertical ground movement due to the construction of the basement can be seen within Figures 21 to 23. The Ground Movement Spreadsheets and Calculations can be seen within Appendix F. Figures of the graphs used for Sand and then Firm to

Soft Clay analyses can be seen in Figures 22 and 23 accordingly.

Contour plots showing the horizontal and vertical ground movement due to the contiguous piling can be seen in Figures 24 to 26.

In terms of building damage assessment and with reference to Table 2.5 of CIRIA Report C580 (after Burland et al, 1977), the 'Description of typical damage' given the calculated movements it is likely that the damage assessment will fall into Category 3, 'Slight', to Category 0, 'Negligible'. Calculations for the potential damage at each property can be seen within Appendix F.

The retaining walls will be constructed in loose to medium dense a dark to light brown silty gravelly sands, therefore the use of the Ground Movement Analysis under a Sand scenario is considered the most appropriate. Therefore, the damage assessment will fall into Category 0, Negligible. Data from the Soft to Firm Clay has been provided for comparison.

Given that the two party walls of 18 Well Road already have basements, it is likely that this will create a level of rigidity, meaning any ground movement caused by the addition of the basement below 20 Well Road will be further reduced.

- **The size of the developments used to provide the case histories for C580 are significantly greater than the scale of works proposed. In practice, the range of ground movements (relative to the excavation depth and the building dimensions) is therefore likely to be much smaller for this development.**

- **CIRIA Report C760 strongly advises that ground movements are influenced by the quality of workmanship. The party wall act will apply to this development and will re-inforce good workmanship. The act provides an effective mechanism for ensuring that structural integrity of the neighbouring property is maintained throughout the construction phase. Amongst other procedures, monitoring proposals will ensure that the actual wall movements are controlled and kept within acceptable limits.**

Underpinning proposals are understood to involve a 'hit and miss' approach in stages so each 'panel' is separated by 3-5 others from the next open one. It will be important that the building contractor is closely supervised and is experienced in this type of construction. It will be critical to prevent exposed faces from collapse or significant ground loss into the new excavation and temporary face support should be maintained where practicable. The nature and presence of basements/cellars in the adjoining properties is not known at this stage. Most ground movement should occur during excavation of the basement and construction so the adequacy of temporary support will be critical in limiting ground movements. A number of factors will assist in limiting ground movements:

- Most ground movement will occur during excavation and construction so the adequacy of temporary support will be critical in limiting ground movements;
- The speed of propping and support is key to limiting ground movements;
- Good workmanship will contribute to minimising ground movements;
- The assessment assumes the wall is in competent clay;
- Larger movements will be expected where soft soils are encountered at, above and below formation;
- Ground movement can be minimised by adopting a number of measures, including;
- Ensuring that adequate propping is in place at all times during construction;

- Minimise deterioration of the central soil mass by the use of blinding/covering with a waterproof membrane;
- Installation of the first (stiff) support quickly and early in the construction sequence for each underpin panel;
- Control dewatering to minimise fines removal and drawdown;
- Avoid overbreak;
- Avoidance of ground loss through the gaps between the piles;
- Avoid leaving ground unsupported.

7.8 Sub-Surface Concrete

Sulphate concentrations measured in 2:1 water/soil extracts taken from the Claygate Member of the London Clay Formation, from both the geotechnical and chemical laboratory testing, fell into Class DS-1 of the BRE Special Digest 1, 2005, *'Concrete in Aggressive Ground'.*

Table C1 of the Digest indicated an ACEC (Aggressive Chemical Environment for Concrete) classification of AC-1s for foundations within the Claygate Member of the London Clay Formation. For the classification given, the "static" and "natural" case was adopted given the cohesive soils and the residential use of the site.

The sulphate concentration in the samples ranged from 200 - 220mg/l with a pH range of 6.9 – 7.7. The total sulphate concentration recorded was 0.02%

Concrete to be placed in contact with soil or groundwater must be designed in accordance with the recommendations of Building Research Establishment Special Digest 1, 2005, *'Concrete in Aggressive Ground'* taking into account the pH of the soils.

7.9 Surface Water Disposal

Soakaways constructed within the cohesive soils of the Claygate Formation of the London Clay Formation are unlikely to prove satisfactory due to negligible to low anticipated infiltration rates.

Soakaways constructed within the cohesive soils of the Claygate Formation of the London Clay Formation are unlikely to prove satisfactory due to low anticipated infiltration rates. Therefore, an alternative method of surface water disposal is required.

Consultation with the Environment Agency must be sought regarding any use that may have an impact on groundwater resources.

The submission of a Sustainable Urban Drainage Scheme (SUDS) is unlikely to be required for this site due to the basement not significantly increasing the amounts of hardstanding. The proposed light wells will only create $12m^2$ of additional hardstanding and will be drained via a sump.

7.10 Stage 5 Review

The conceptual site model given within Section 3.2.1 identified five matters of concern for the property. These concerns have been assessed within the report and the conclusions can be seen tabulated overpage.

Stage 5 Review		
Highlighted Area	**Site Specific Concern**	**Assessment**
Perched water within the Made Ground or groundwater within the Claygate Member of the London Clay Formation	The basement may encounter perched water within the Made Ground or silt bands of the Claygate Member London Clay Formation during construction.	Groundwater was not encountered during the intrusive investigation and BH1 was noted to be dry on both return visits. Based on the above it is considered unlikely that the basement will be constructed below the groundwater level. The basement will not affect the saturated aquifer underlying the site. Given the "The Logs" is isolated and the surrounding buildings have basements already, any groundwater will able to flow around the basements. Therefore, the cumulative effects of basements in groundwater is not a consideration at this site.
Soil Moisture/ Trees and Bushes	There is potential for soil moisture content to affect the development.	Geotechnical analysis revealed the soils to be heavily overconsolidated with no potentially root exacerbated moisture deficits. Lithologically controlled moisture deficits noted. Basement will be formed at moisture stable depth.
Claygate Member of the London Clay Formation/ Shrink and Swell	The basement is anticipated to be founded in the Claygate Member of the London Clay Formation. The soils are likely to have medium to high plasticity and volume change potential. The concrete mix design should take appropriate account of sulphate levels (testing to BRE Special Digest). Heave on removal of overburden pressure may be a risk.	Geotechnical testing revealed the Claygate Member of the London Clay Formation to have low to medium volume change potential in accordance with BRE240 and NHBC Standards Chapter 4.2. Sulphate concentrations measured in 2:1 water/soil extracts taken from the Claygate Member of the London Clay Formation from geotechnical analysis fell into Class DS-1 of the BRE Special Digest 1, 2005, 'Concrete in Aggressive Ground'. **Sub-surface concrete specification is discussed further in Section 7.9 of this report.** **Heave on removal of overburden pressure is discussed within Section 6.2 of this report.**
Differential Foundation Depths	It will be important to account for the shallow nature of existing footings at the property and its neighbours. Ground Movement Assessment is required.	Ground movement assessment was carried out on the neighbouring properties within Section 7.7 of this report. In terms of building damage assessment and with reference to Table 2.5 of C580 (after Burland et al, 1977), the 'Description of typical damage' given the calculated movements it is likely to fall within category of damage '0' Negligible. Given that the two party walls of 18 Well Road already have basements, it is likely that this will create a level of rigidity, meaning any ground movement caused by the addition of the basement below 20 Well Road will be further reduced. **Mitigation measures to minimise potential movements are provided in Section 7.7. Structural Design will need to take this into account.**

Cont'd Overleaf

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Stage 5 Review – Cont'd		
Highlighted Area	**Site Specific Concern**	**Assessment**
Retaining Walls	Appropriate Design	Parameters for retaining wall design provided in Section 7.4 of this report. **Structural Design will need to take this into account.**

7.11 Discovery Strategy

There may be areas of contamination that have not been identified during the course of the intrusive investigation. For example, there may have been underground storage tanks (UST's) not identified during the Ground Investigation for which there is no historical or contemporary evidence.

Such occurrences may be discovered during the demolition and construction phases for the redevelopment of the site.

Groundworkers should be instructed to report to the Site Manager any evidence for such contamination; this may comprise visual indicators, such as fibrous materials within the soil, discolouration, or odours and emission. Upon discovery advice must be taken from a suitably qualified person before proceeding, such that appropriate remedial measures and health and safety protection may be applied.

Should a new source of contamination be suspected or identified then the Local Authority will need to be informed.

7.12 Waste Disposal

The excavation of foundations is likely to produce waste which will require classification and then recycling or removal from site.

Under the Landfill (England and Wales) Regulations 2002 (as amended), prior to disposal all waste must be classified as;

- Inert;
- Non-hazardous, or;
- Hazardous.

The Environment Agency's Hazardous Waste Technical Guidance (WM2) document outlines the methodology for classifying wastes.

Once classification was established the waste can be removed to the appropriately licensed facilities, with some waste requiring pre-treatments prior to disposal.

INERT waste classification should be undertaken to determine if the proposed waste confirms to INERT or NON-HAZARDOUS Waste Acceptable Criteria (WAC).

7.13 Imported Material

Any soil which is to be imported onto the site must undergo chemical analysis to prove that it is suitable for the purpose for which it is intended.

The Topsoil must be fit for purpose and must either be supplied with traceable chemical laboratory test certificates or be tested, either prior to placing (ideally) or after placing, to ensure that the human receptor cannot come into contact with compounds that could be detrimental to human health.

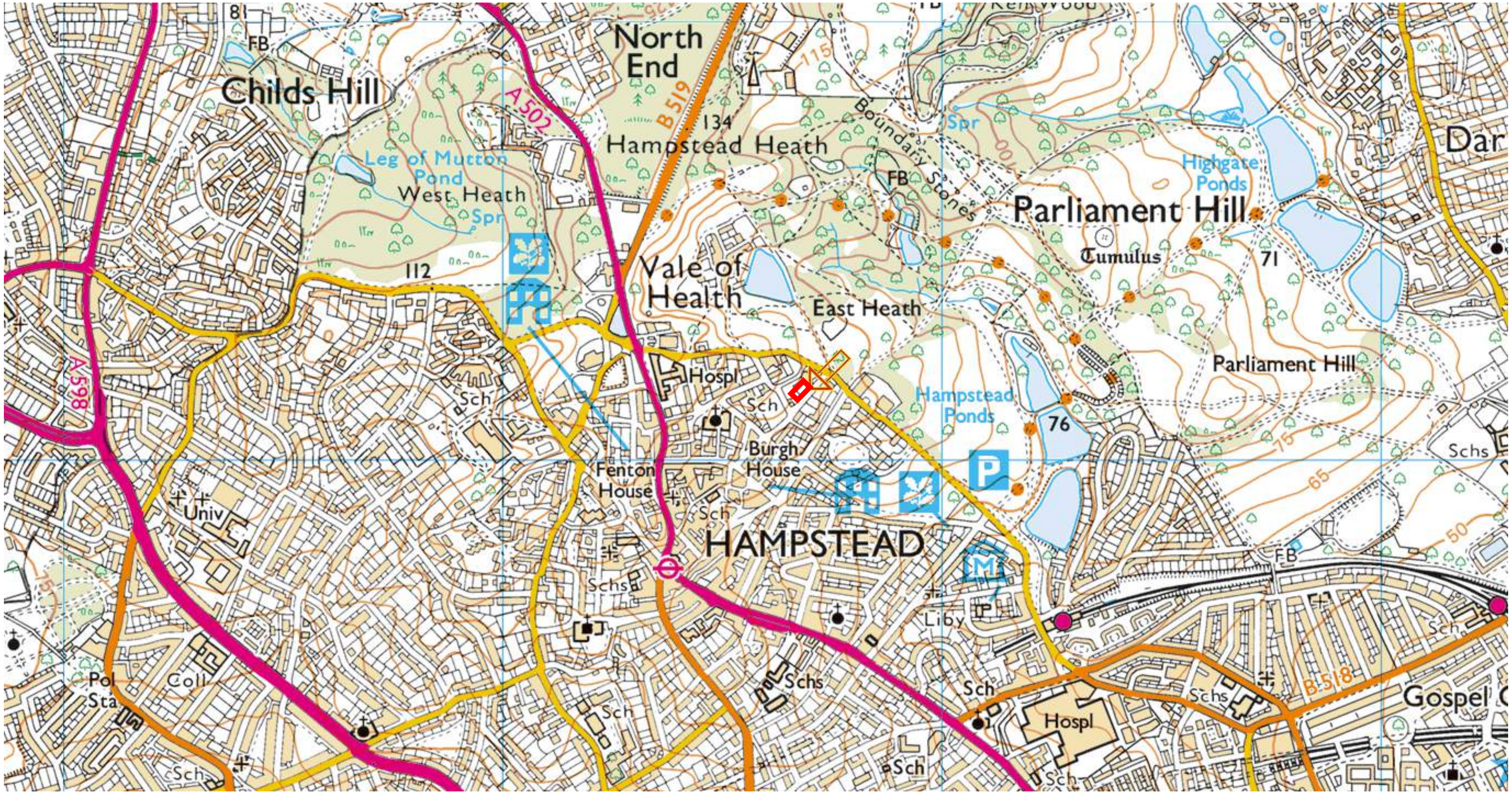
7.14 Duty of Care

Groundworkers must maintain a good standard of personal hygiene including the wearing of overalls, boots, gloves and eye protectors and the use of dust masks during periods of dry weather.

To prevent exposure to airborne dust by both the general public and construction personnel the site should be kept damp during dry weather and at other times when dust were generated as a result of construction activities.

The site should be securely fenced at all times to prevent unauthorised access. Washing facilities should be provided and eating restricted to mess huts.

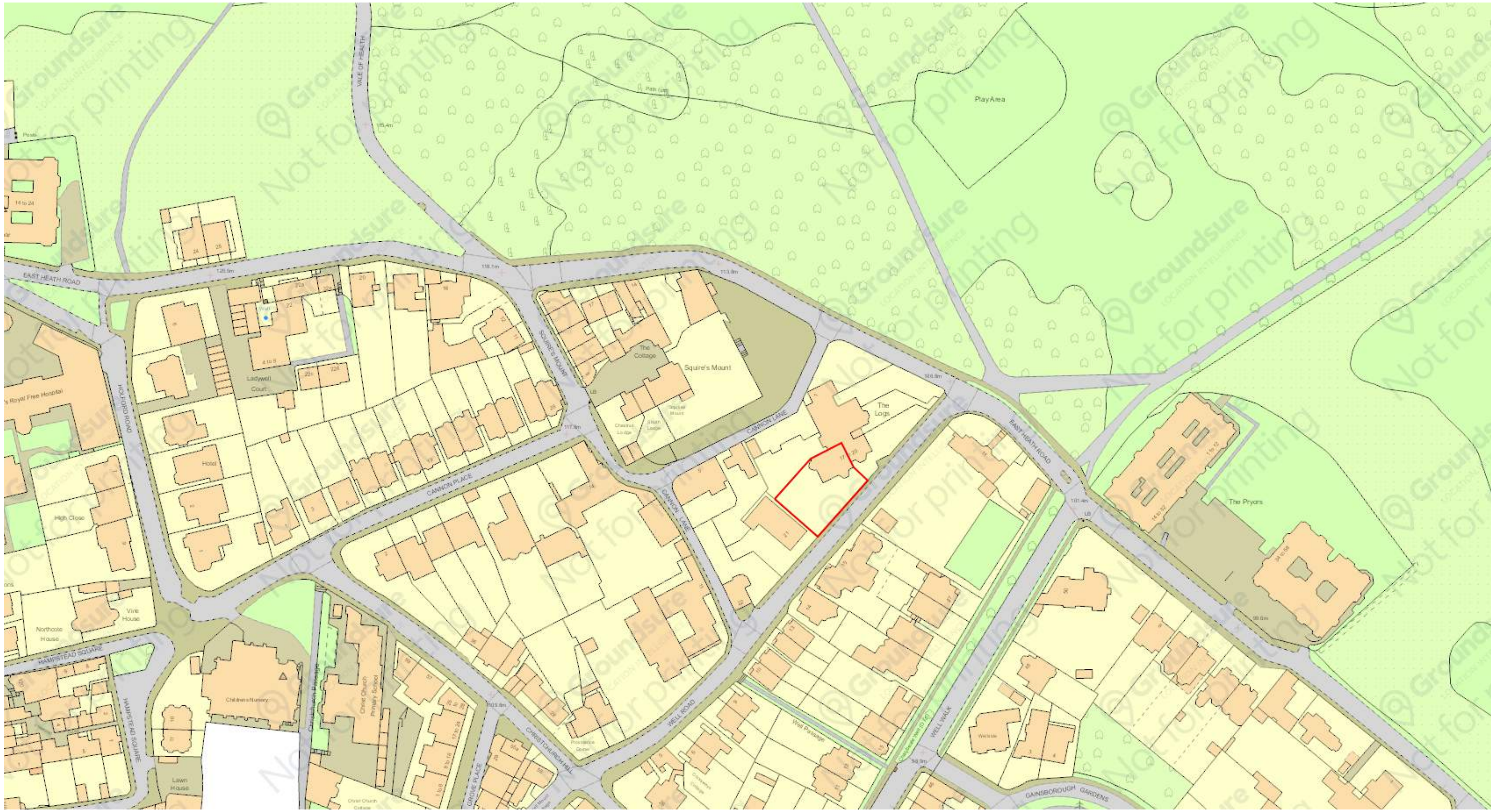
N



APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH		**Figure 1**
Client: Vincent and Rymill	**Date:** October 2017	ground&water
Site Location Plan	**Ref:** GWPR2241	



NOTE: NOT TO SCALE

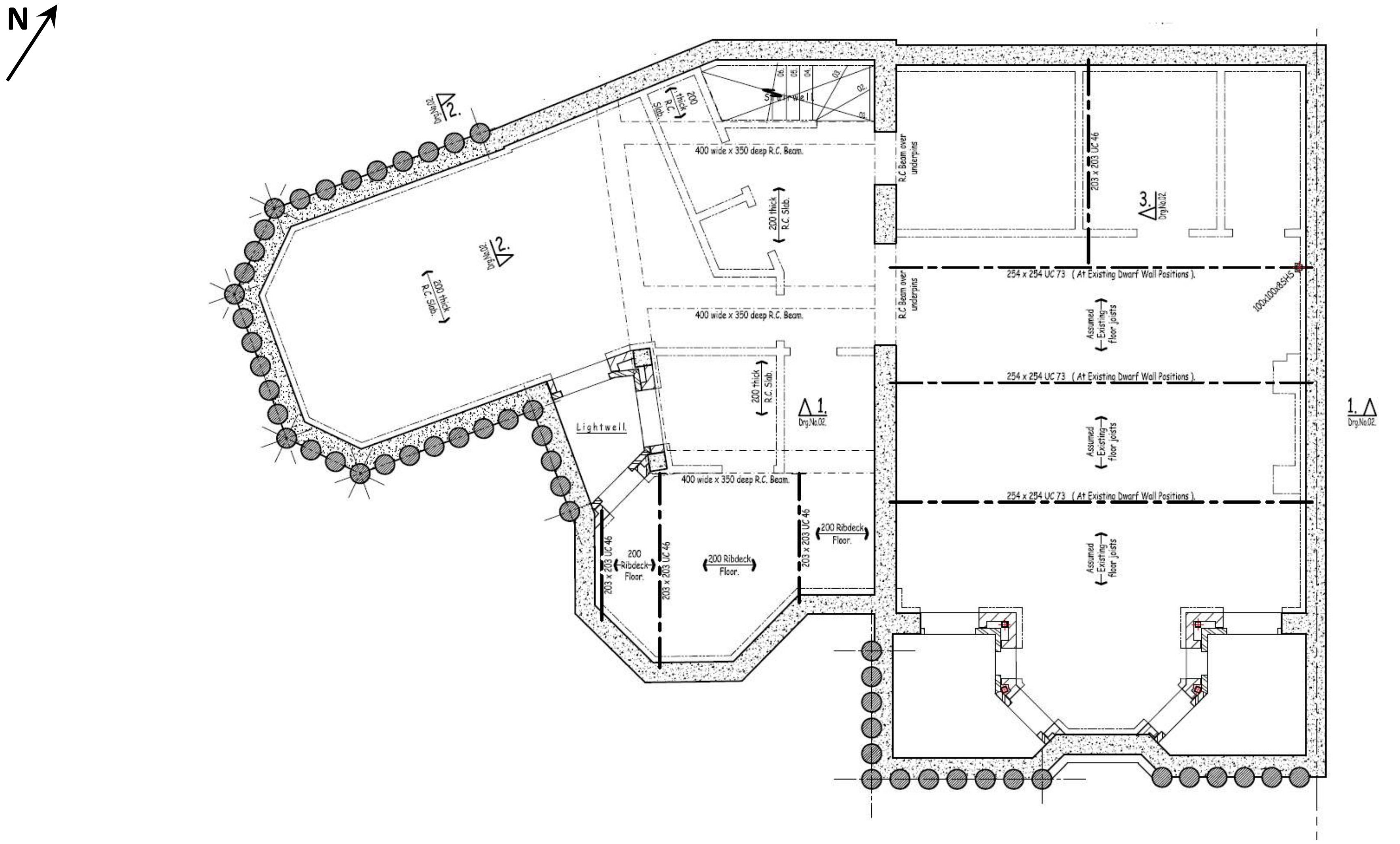
Project: 20 Well Road, Hampstead, London NW3 1LH		**Figure 2**
Client: Vincent and Rymill	**Date:** October 2017	ground&water
Site Development Area	**Ref:** GWPR2241	

N

APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

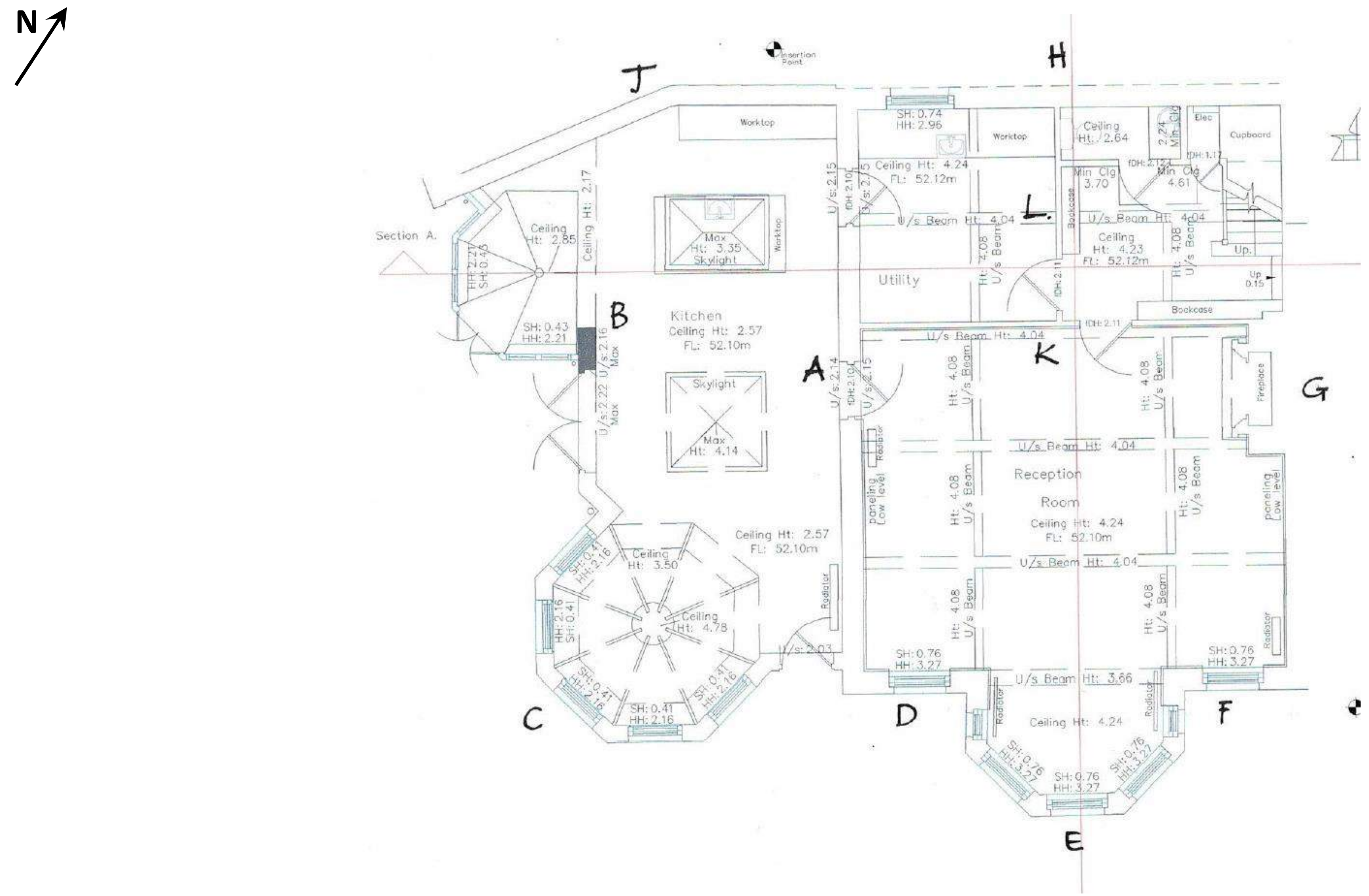
Project: 20 Well Road, Hampstead, London NW3 1LH		Figure 3
Client: Vincent and Rymill	Date: October 2017	ground&water
Aerial View of Site	Ref: GWPR2241	



APPROXIMATE SITE BOUNDARY

NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH		Figure 4
Client: Vincent and Rymill	Date: October 2017	ground&water
Proposed Development Plan	Ref: GWPR2241	

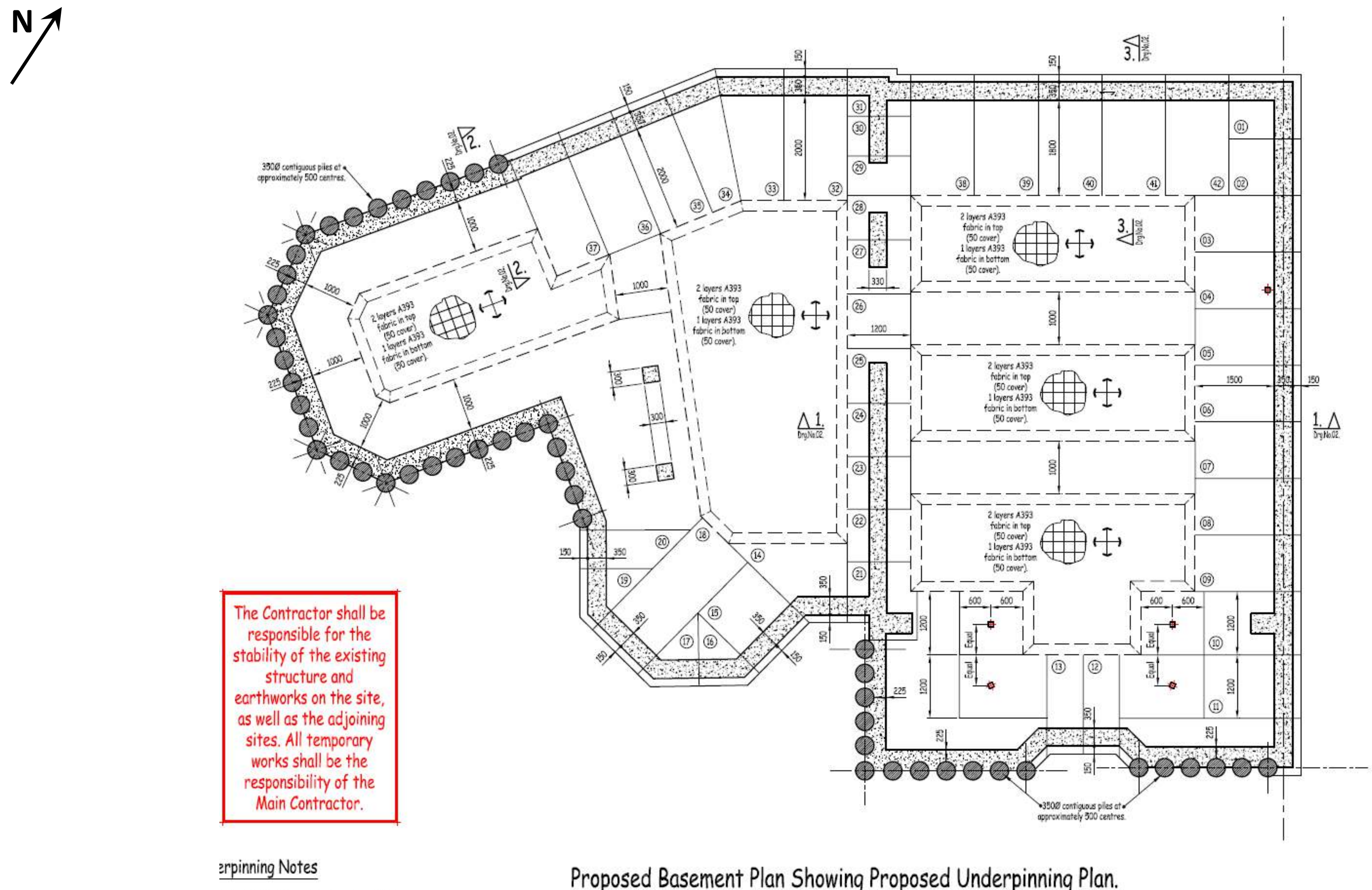


APPROXIMATE SITE BOUNDARY

NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH		**Figure 5**
Client: Vincent and Rymill	**Date:** October 2017	
Existing Ground Floor Plan	**Ref:** GWPR2241	

ground&water



APPROXIMATE SITE BOUNDARY

NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH	**Figure 6**
Client: Vincent and Rymill / **Date:** October 2017	ground&water
Proposed Development Plan – Areas of Contiguous Piling / **Ref:** GWPR2241	

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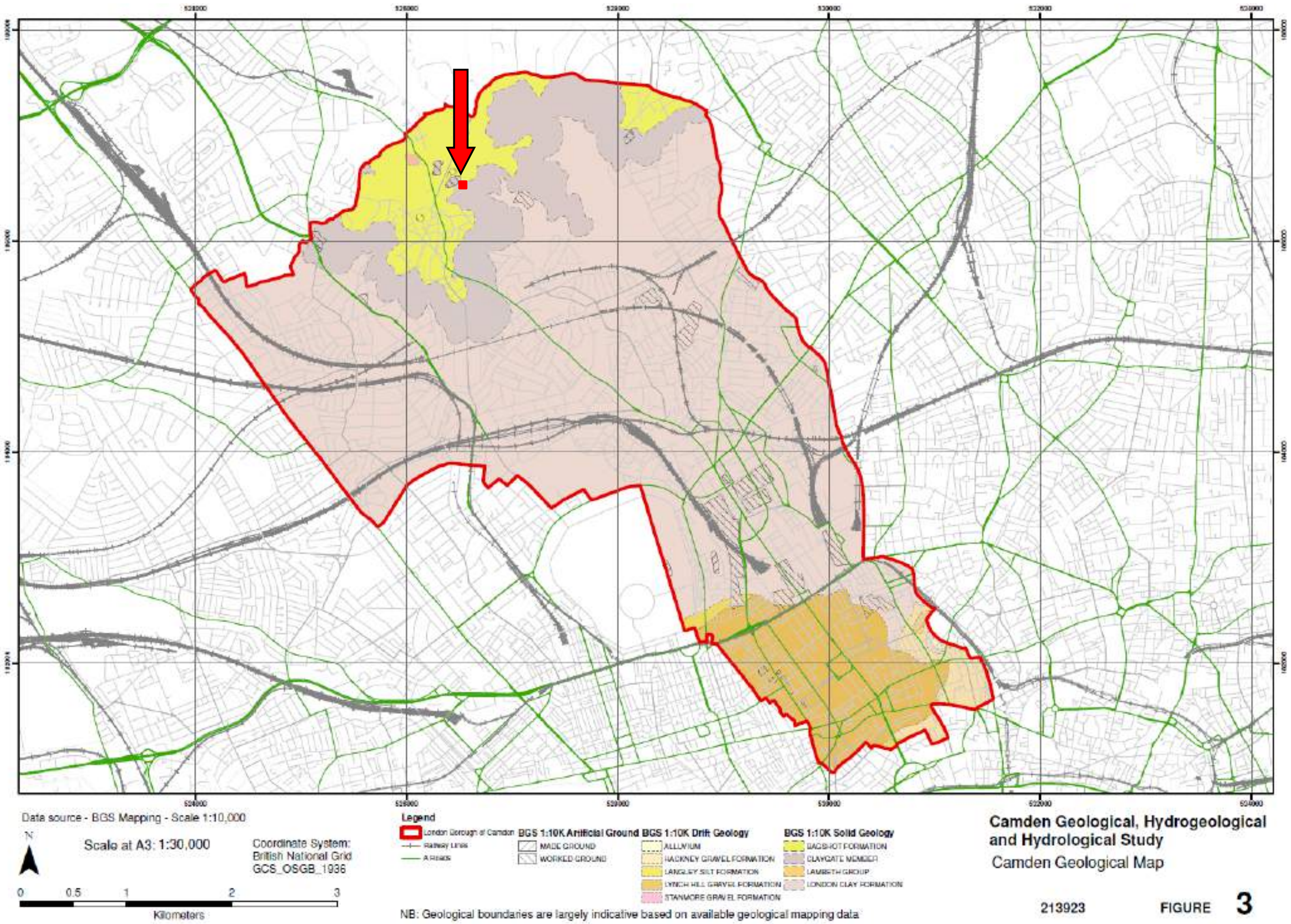

APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH		**Figure 7**
Client: Vincent and Rymill	**Date:** October 2017	ground&water
North Camden Geological, Hydrogeological and Hydrological Study - Figure 3	**Ref:** GWPR2241	

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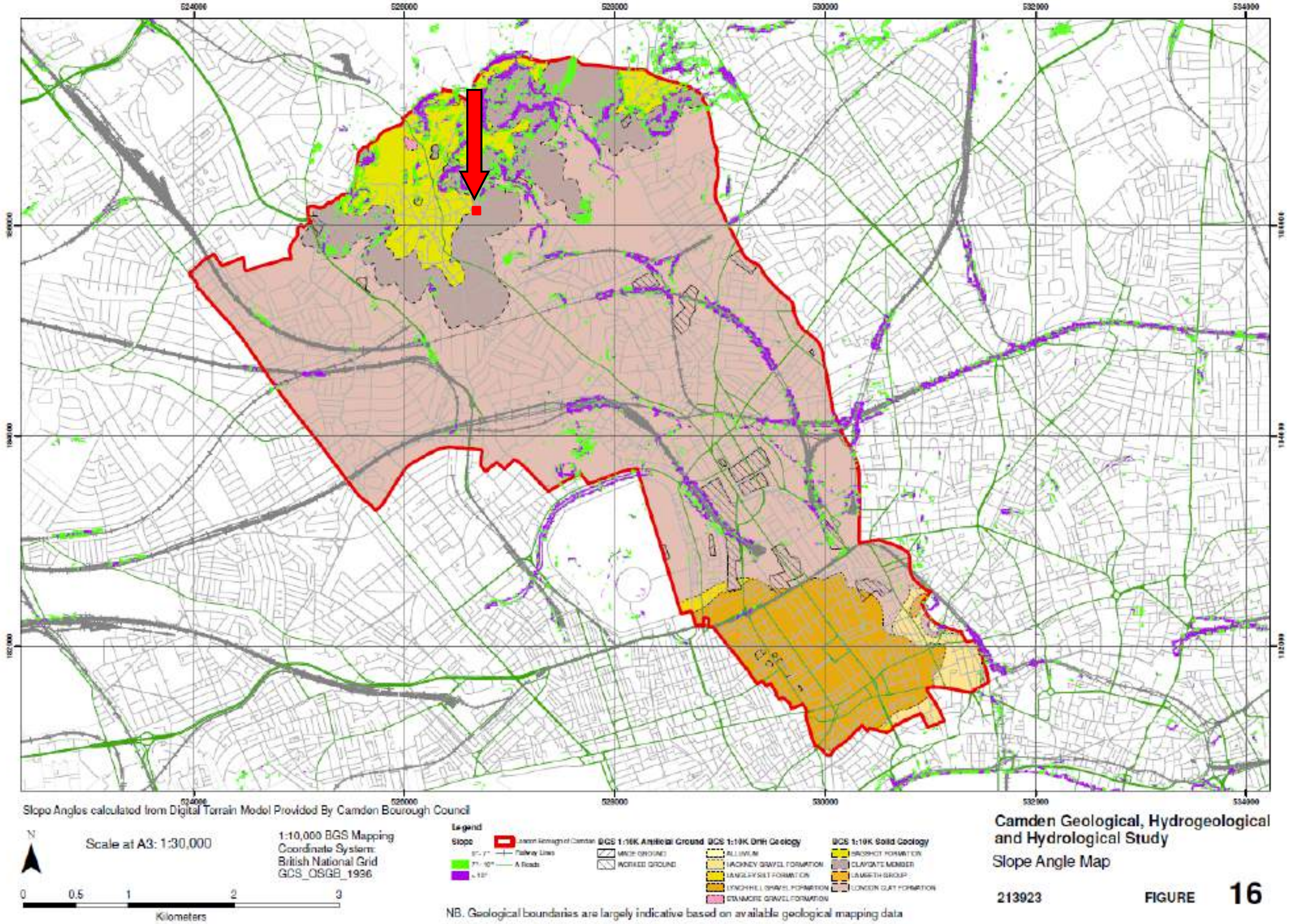
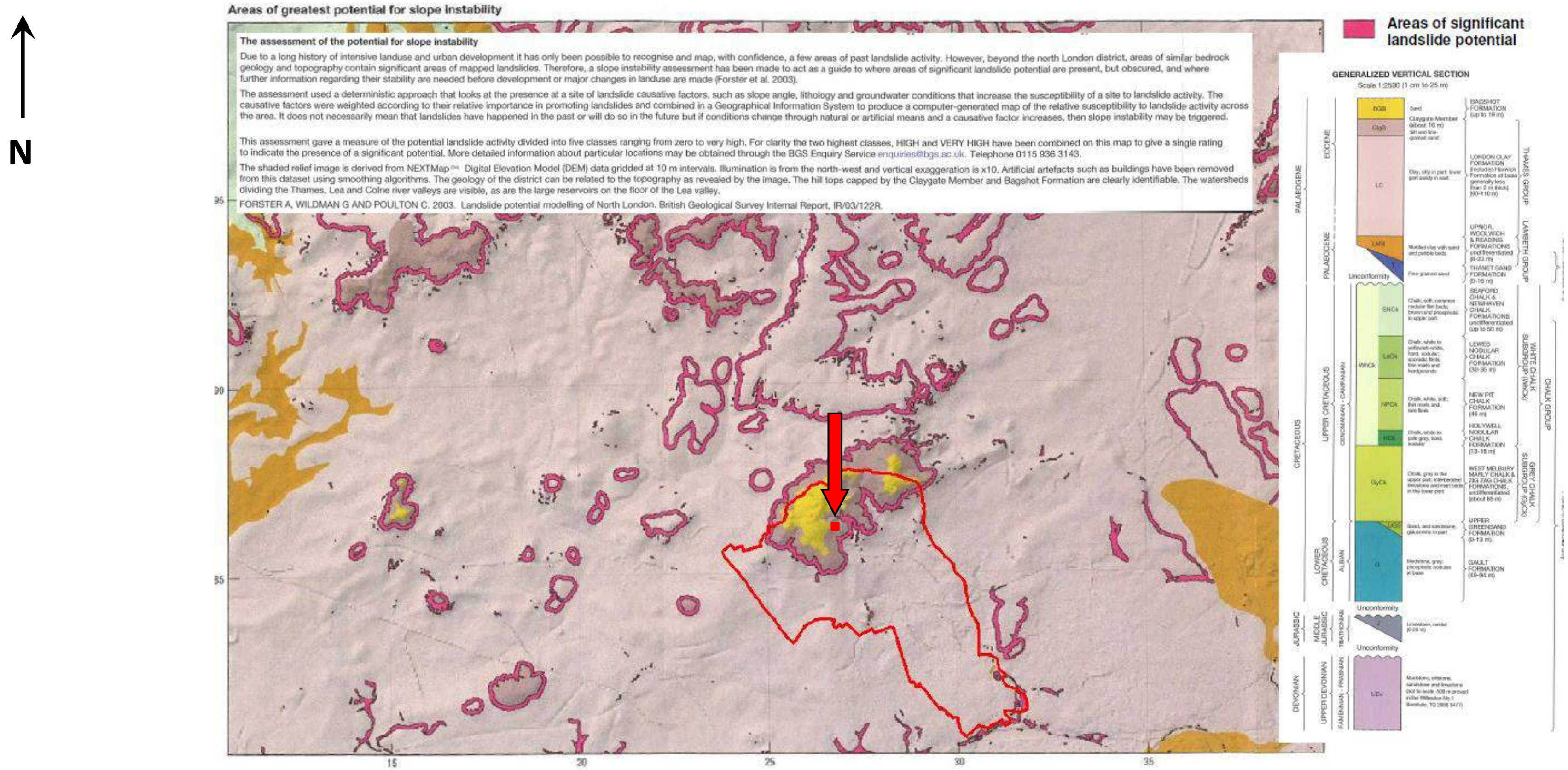


APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH		**Figure 8**
Client: Vincent and Rymill	**Date:** October 2017	ground&water
Camden Geological, Hydrogeological and Hydrological Study - Figure 16	**Ref:** GWPR2241	



Source - British Geological Society, 1:50,000 Series
England and Wales Sheet 256 – North London

Camden Geological, Hydrogeological and Hydrological Study
Areas of landslide potential

213923 FIGURE **17**

APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH		**Figure 9**
Client: Vincent and Rymill	**Date:** October 2017	ground&water
Camden Geological, Hydrogeological and Hydrological Study - Figure 17	**Ref:** GWPR2241	

N

Source - London Borough of Camden, January 2010. *Camden Core Strategy Proposed Submission.*

Camden Geological, Hydrogeological and Hydrological Study
Transport Infrastructure

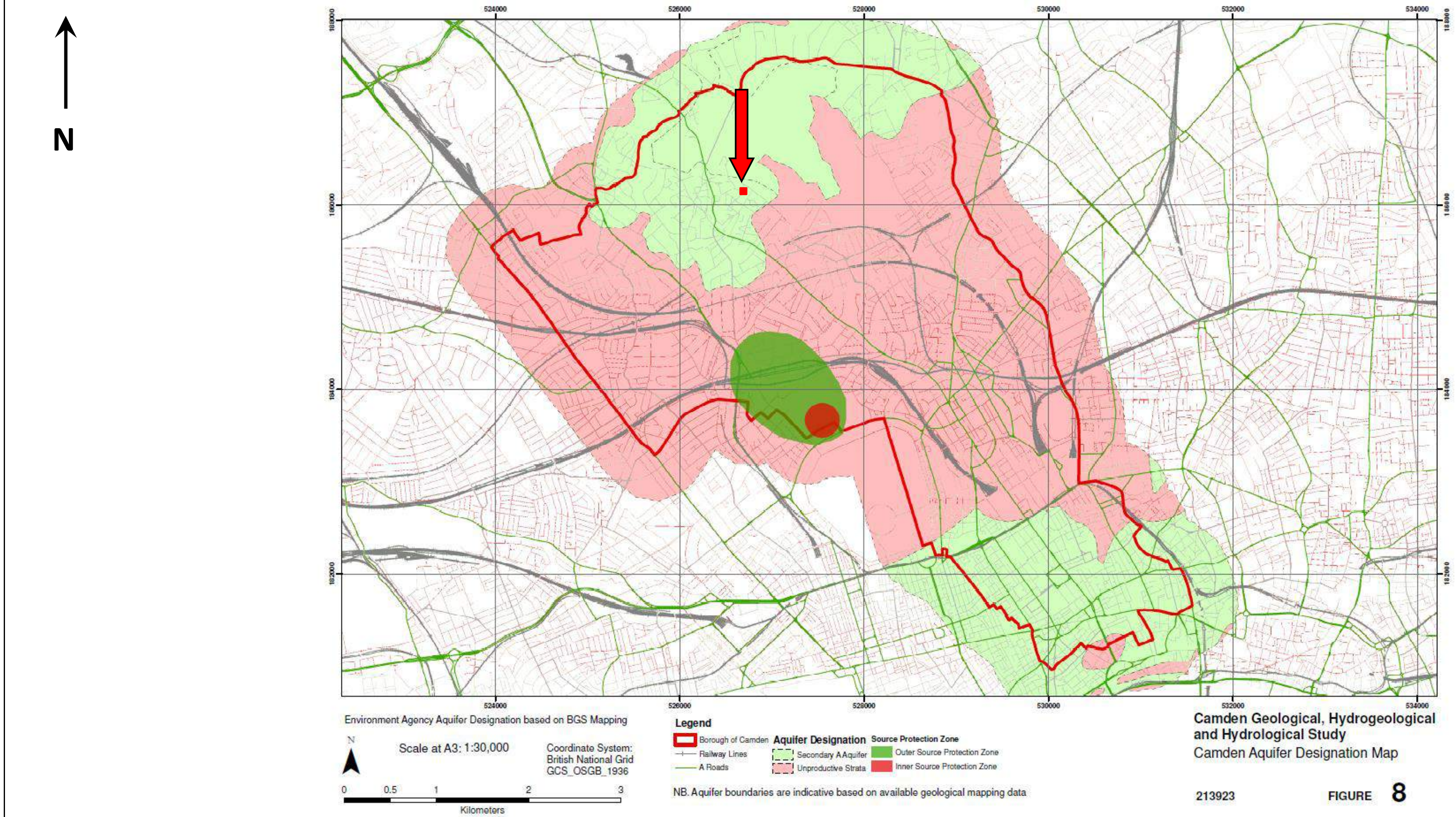
213923 FIGURE **18**

APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH	**Figure 10**
Client: Vincent and Rymill	**Date:** October 2017
Camden Geological, Hydrogeological and Hydrological Study - Figure 18	**Ref:** GWPR2241

ground&water

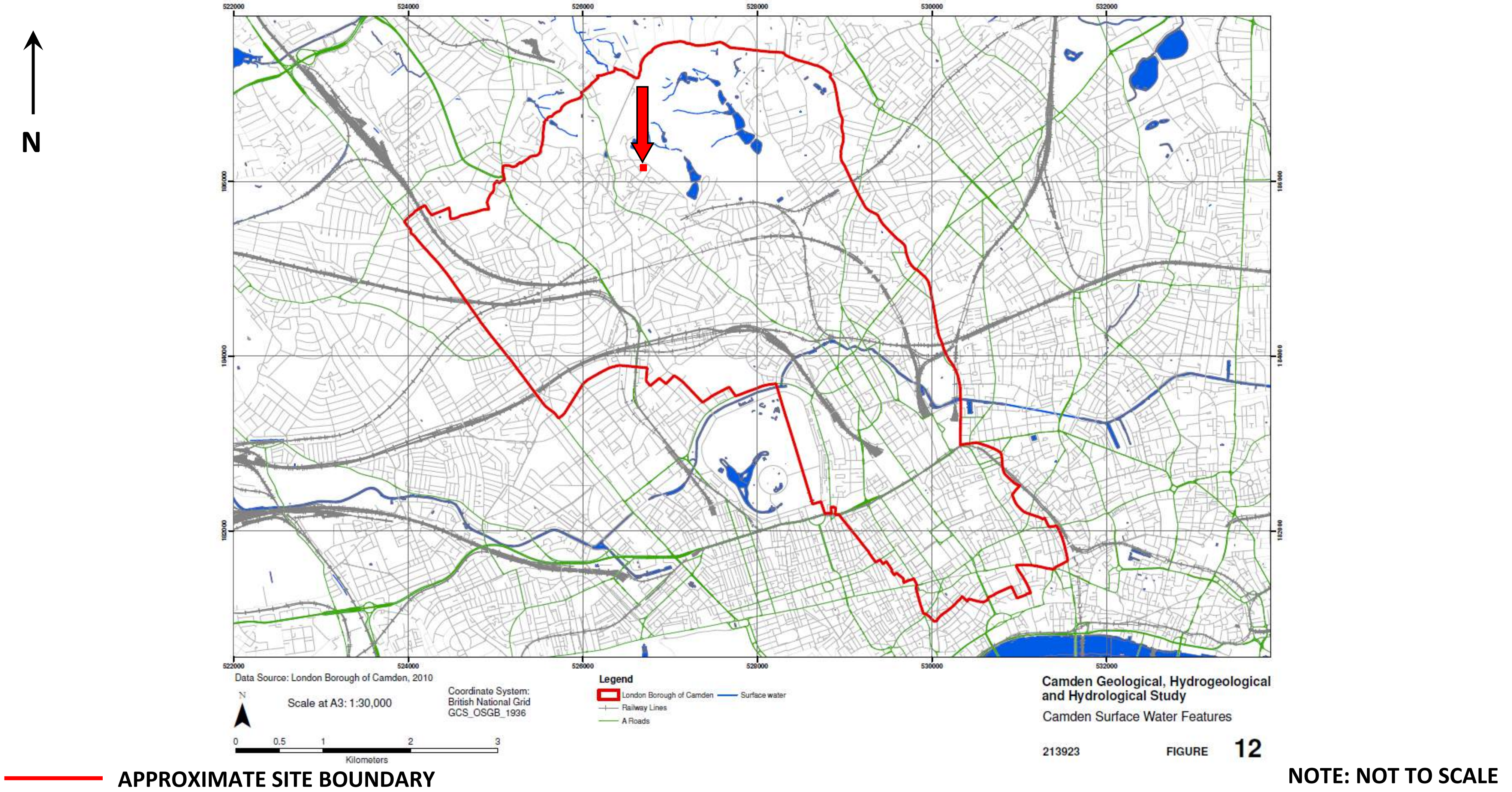


APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH	**Figure 11**
Client: Vincent and Rymill	**Date:** October 2017
Camden Geological, Hydrogeological and Hydrological Study - Figure 8	**Ref:** GWPR2241

ground&water



Project: 20 Well Road, Hampstead, London NW3 1LH	**Figure 12**
Client: Vincent and Rymill	**Date:** October 2017
Camden Geological, Hydrogeological and Hydrological Study - Figure 12	**Ref:** GWPR2241

ground&water

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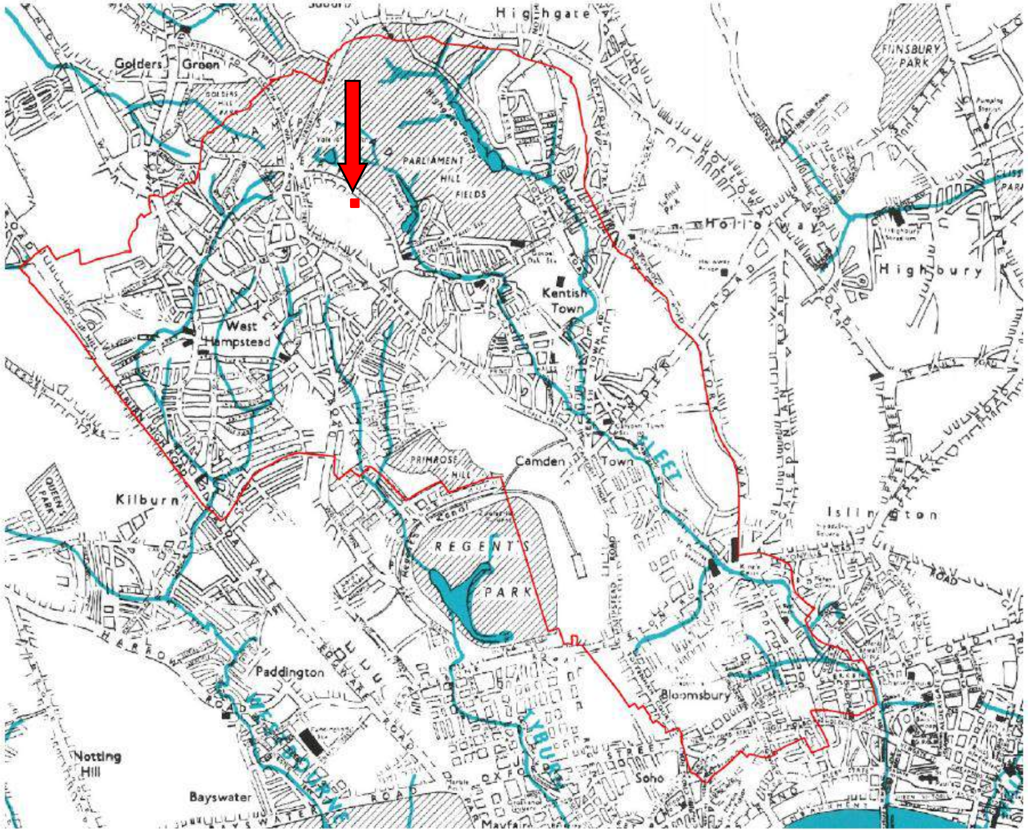

Source – Barton, Lost Rivers of London

Camden Geological, Hydrogeological and Hydrological Study
Watercourses

213923 FIGURE 11

APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

Project:
20 Well Road, Hampstead, London NW3 1LH

Client:
Vincent and Rymill

Date:
October 2017

Camden Geological, Hydrogeological and Hydrological Study - Figure 11

Ref:
GWPR2241

Figure 13

ground&water

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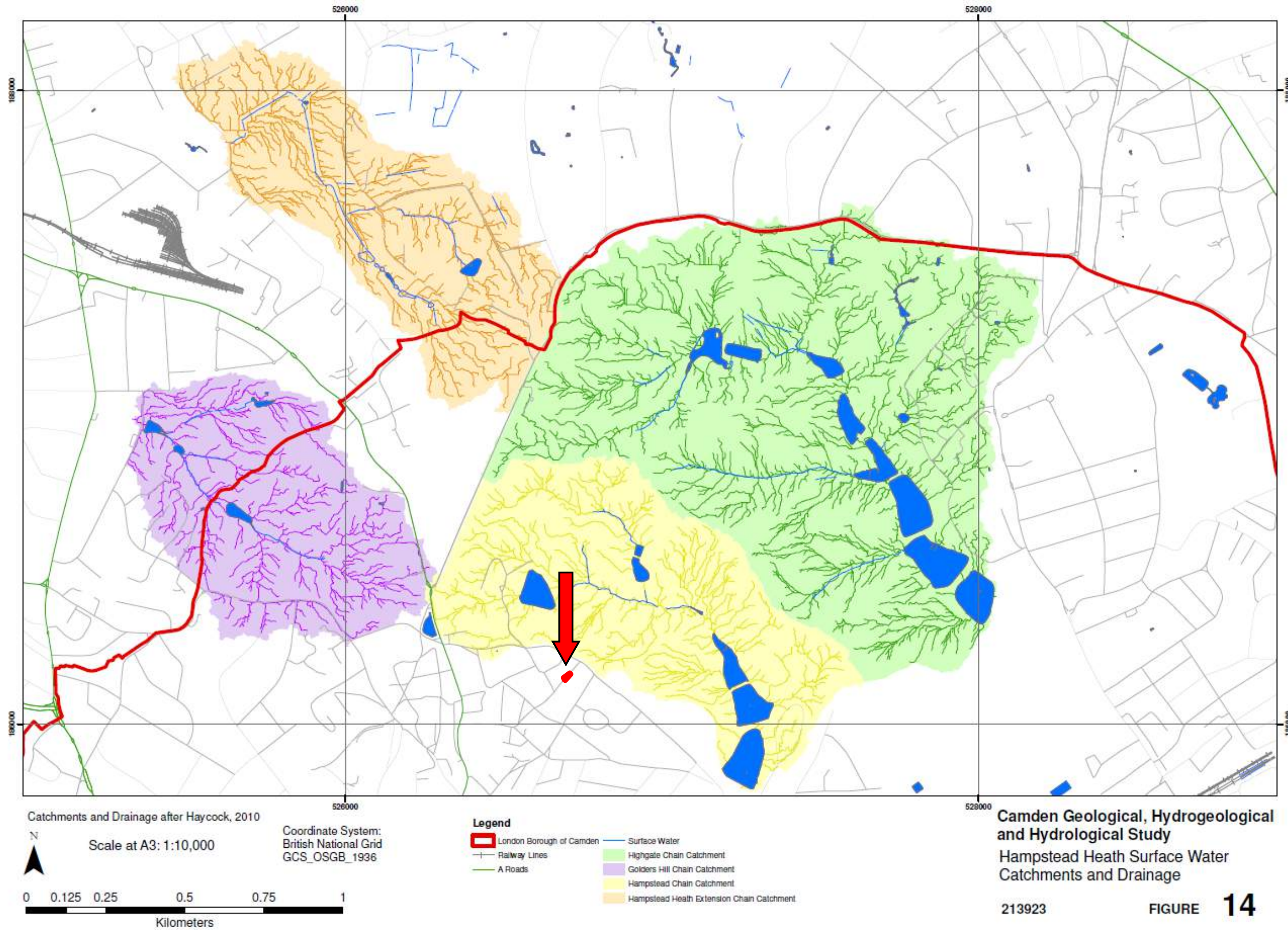

APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH		**Figure 14**
Client: Vincent and Rymill	**Date:** October 2017	
Camden Geological, Hydrogeological and Hydrological Study - Figure 14	**Ref:** GWPR2241	ground&water

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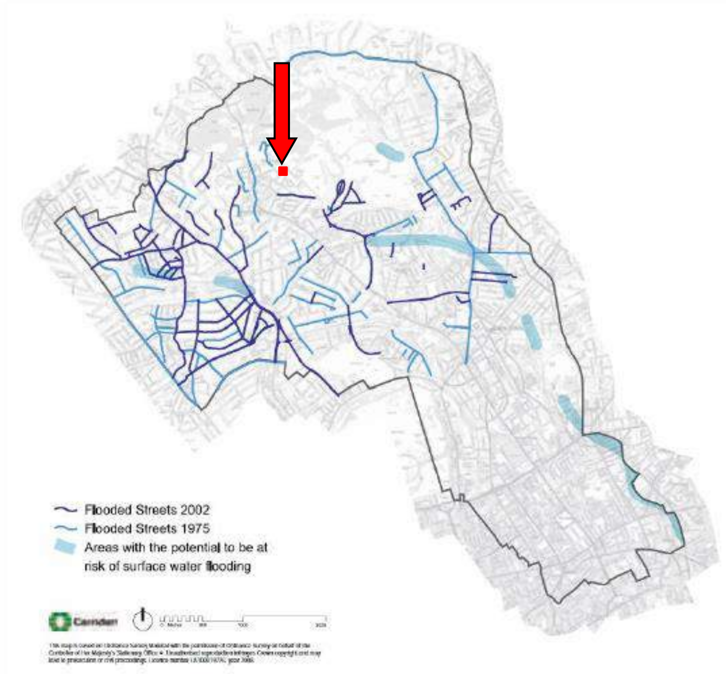


Figure 5 from Core Strategy, London Borough of Camden

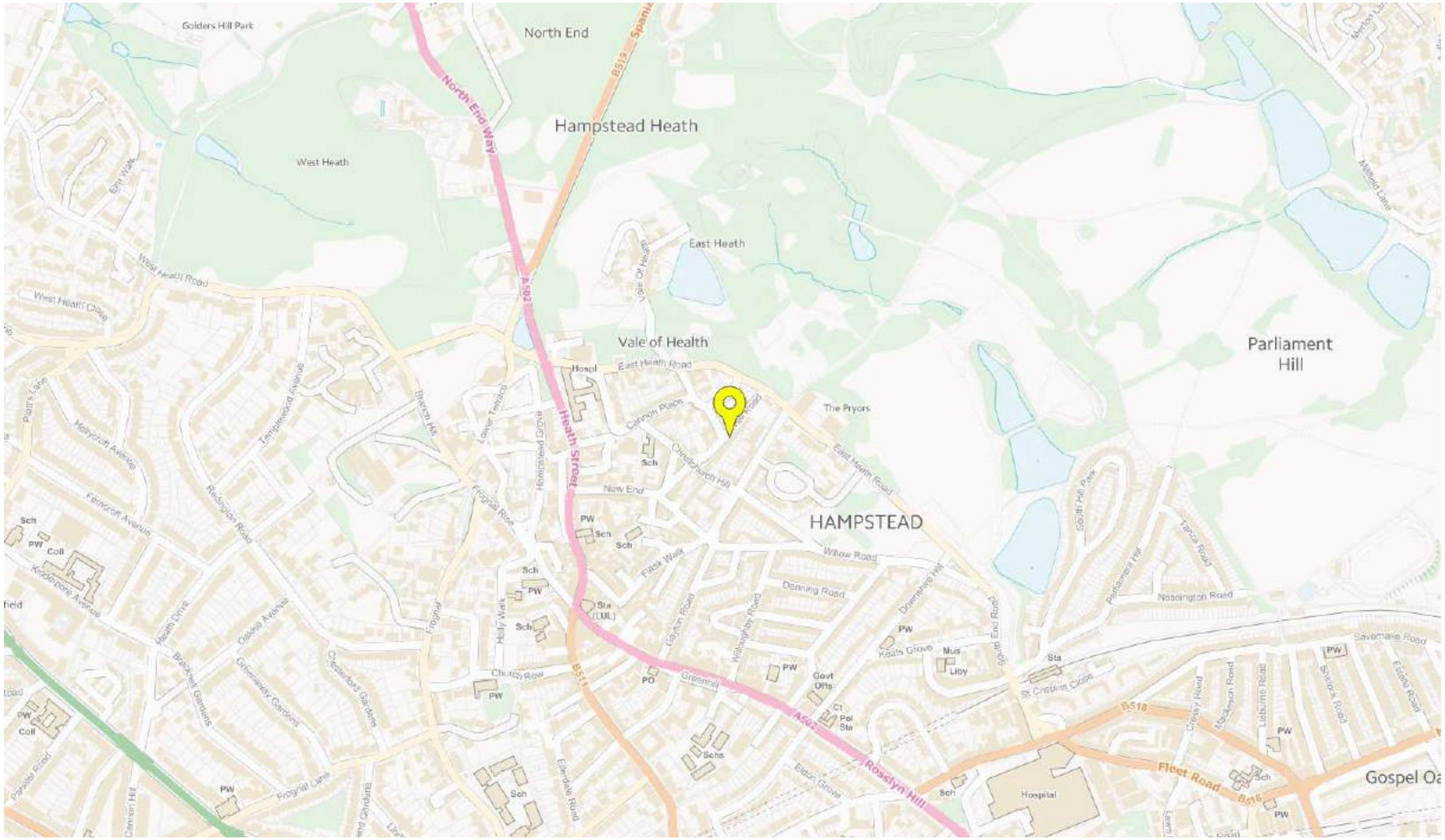
Camden Geological, Hydrogeological and Hydrological Study
Flood Map

213923 FIGURE 15

APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH		**Figure 15**
Client: Vincent and Rymill	**Date:** October 2017	ground&water
Camden Geological, Hydrogeological and Hydrological Study - Figure 15	**Ref:** GWPR2241	



APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH		**Figure 16**
Client: Vincent and Rymill	**Date:** October 2017	ground&water
Flood Map for Planning	**Ref:** GWPR2241	

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APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

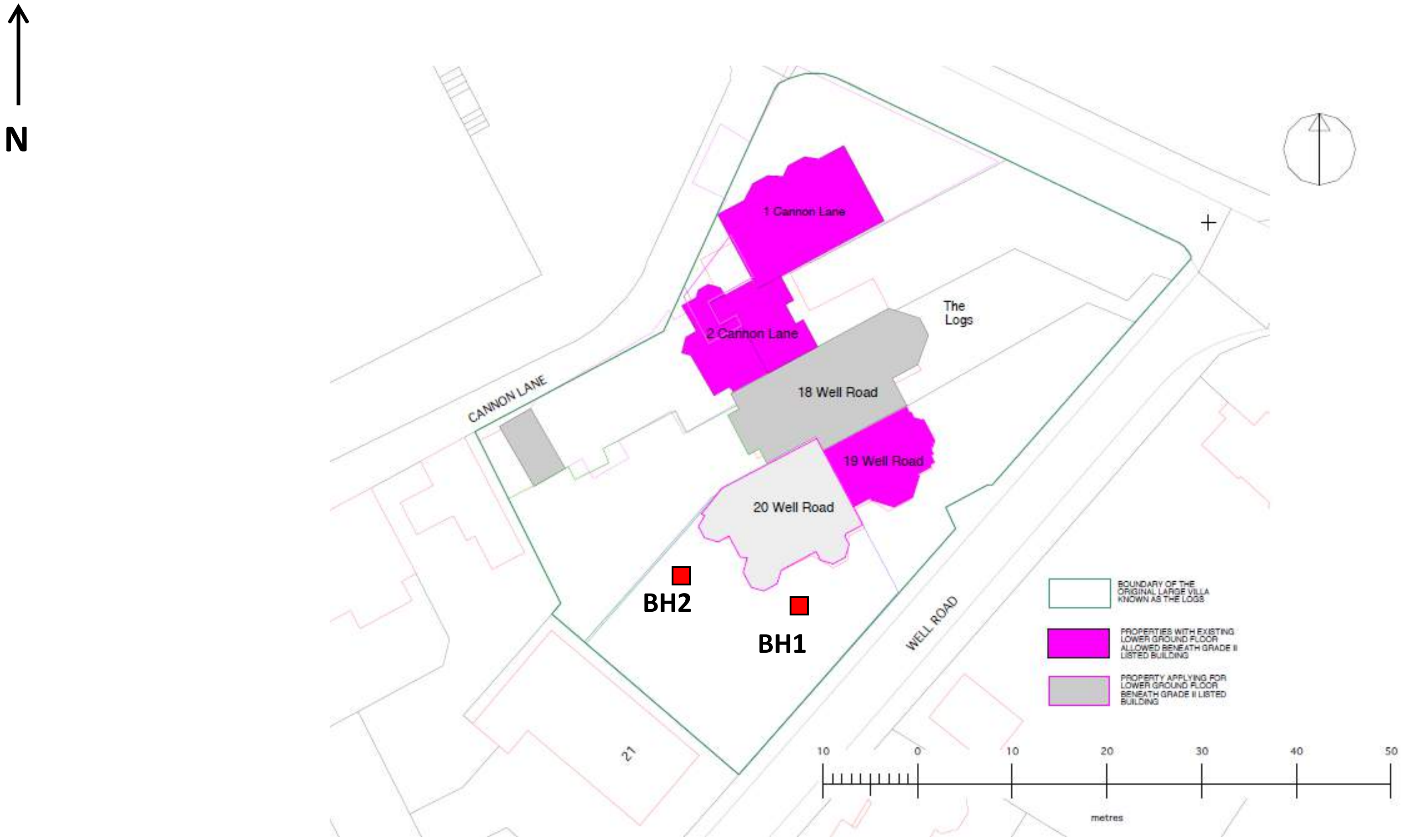
Project: 20 Well Road, Hampstead, London NW3 1LH	**Figure 17**
Client: Vincent and Rymill	**Date:** October 2017
Surface Water Flooding Map	**Ref:** GWPR2241

ground&water

APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH		**Figure 18**
Client: Vincent and Rymill	**Date:** October 2017	ground&water
Neighbouring Property Basement Site Plan	**Ref:** GWPR2241	

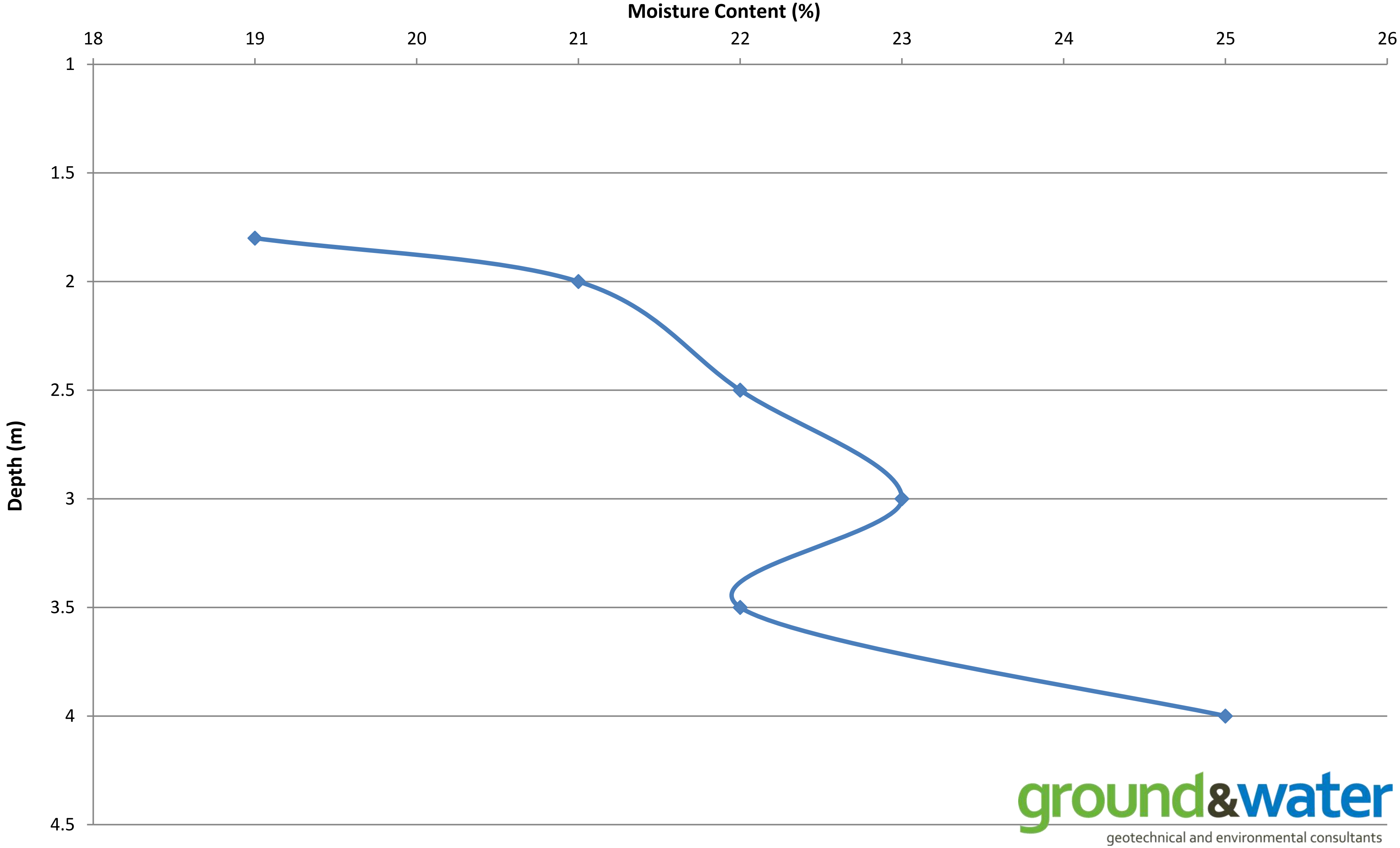


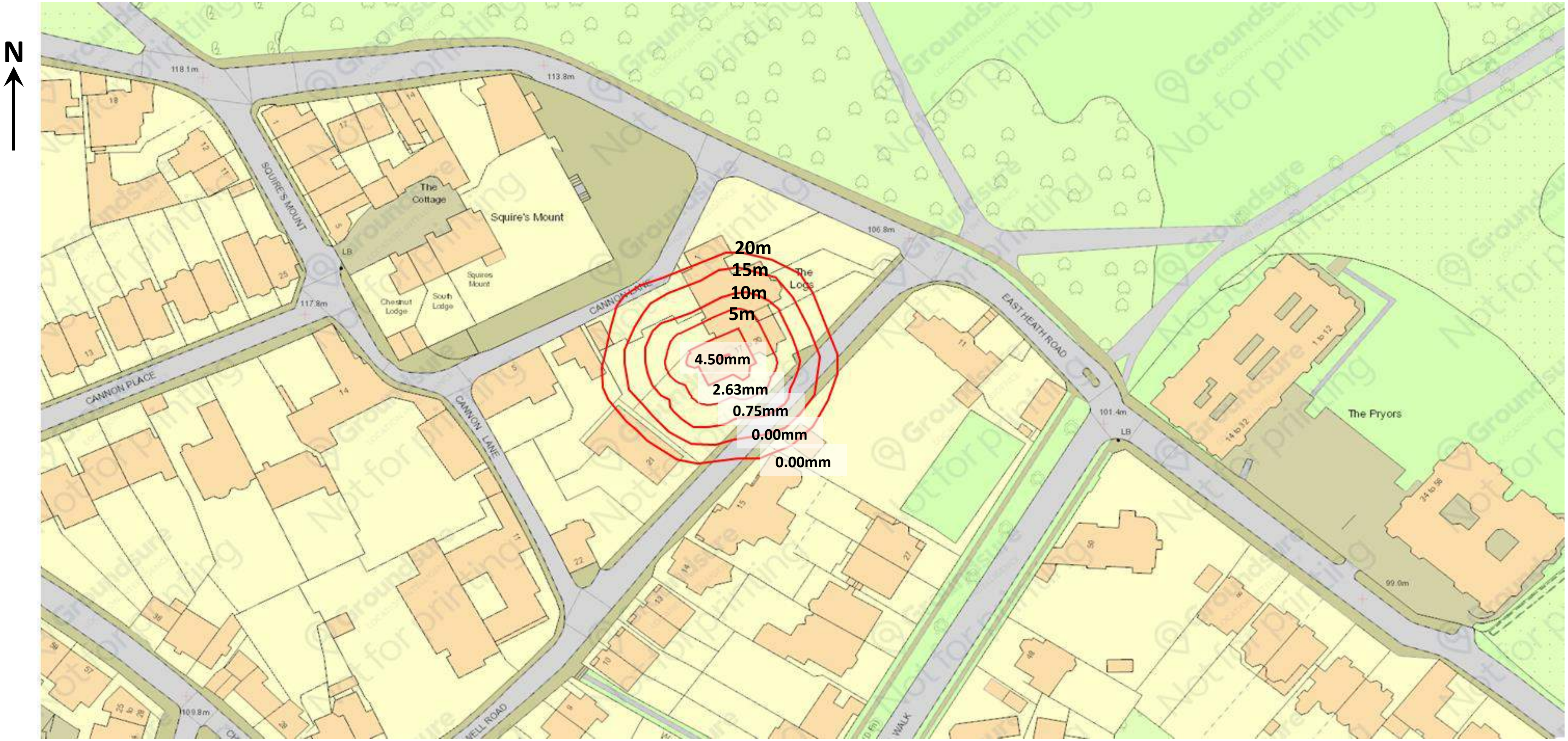
APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH		**Figure 19**
Client: Vincent and Rymill	**Date:** October 2017	ground&water
Trial Hole Location Plan	**Ref:** GWPR2241	

Figure 20: Change in Moisture Content With Depth Within BH2





APPROXIMATE SITE BOUNDARY

NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH		**Figure 21**
Client: Vincent and Rymill	**Date:** October 2017	ground&water
Horizontal Ground Movement – Contour Plot for Stiff Clay	**Ref:** GWPR2241	

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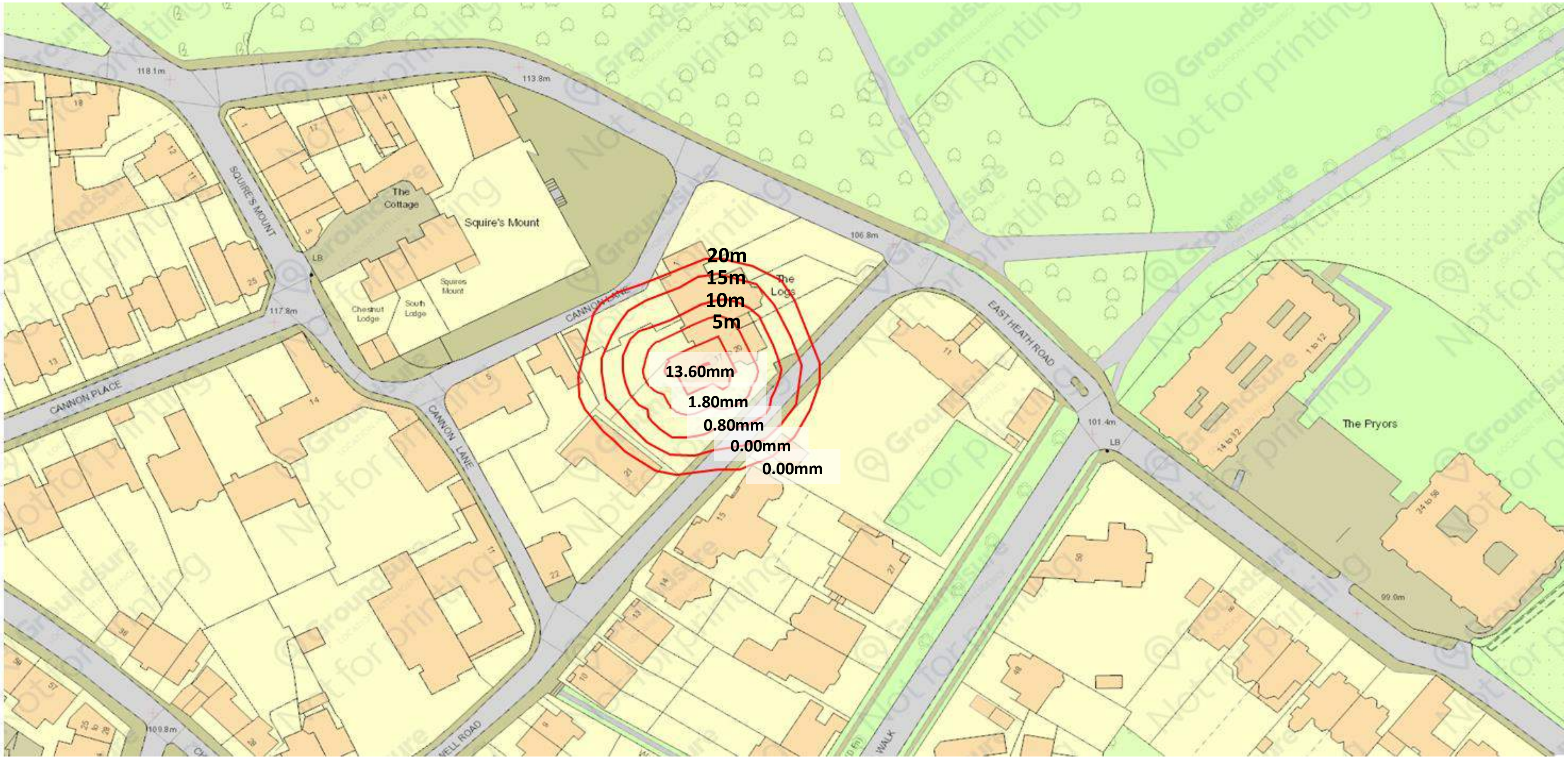
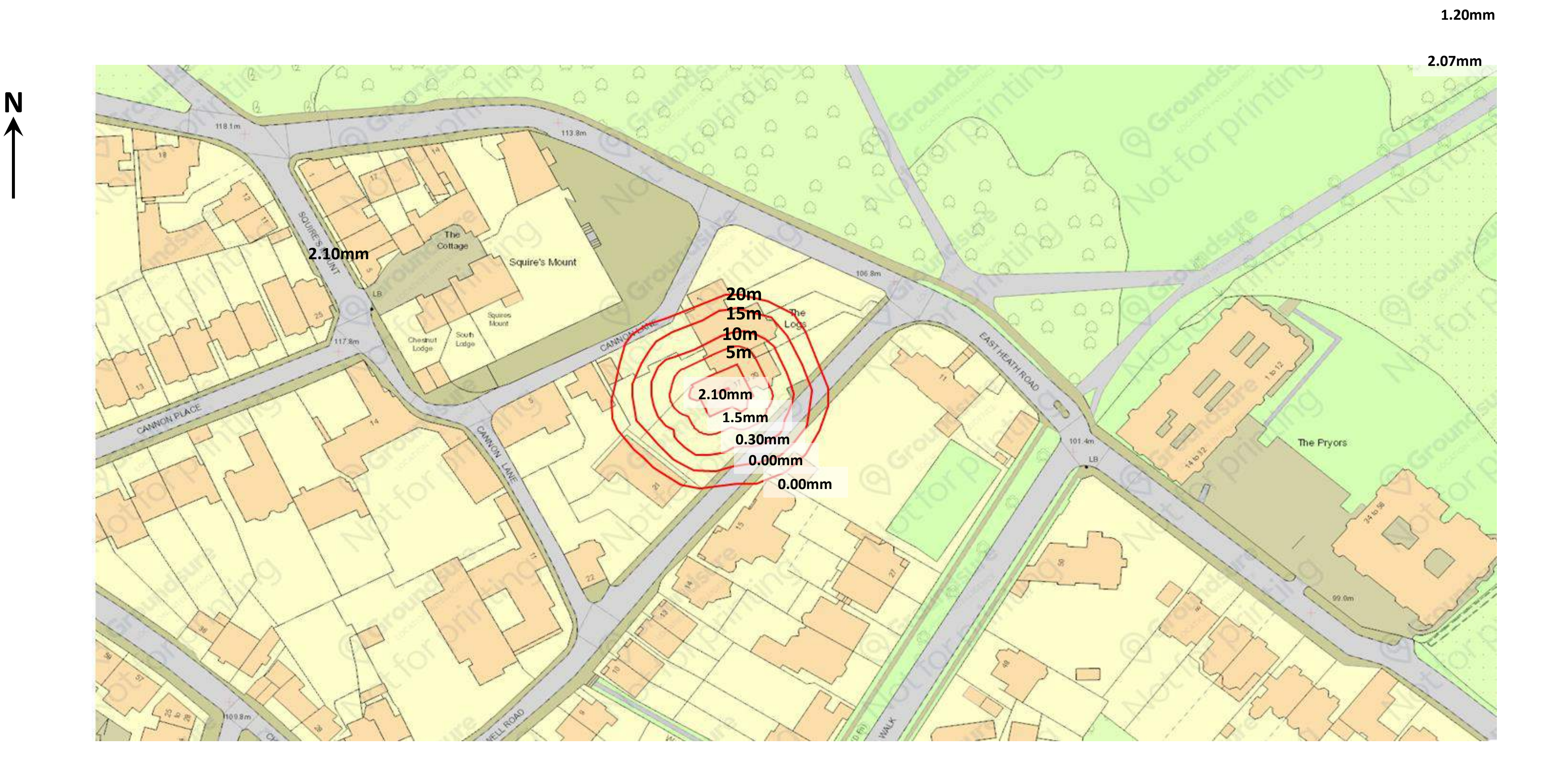


APPROXIMATE SITE BOUNDARY

NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH	Figure 26
Client: Vincent and Rymill — Date: October 2017	ground&water
Vertical Ground Movement – Contour Plot for Sands – Contiguous Piling Movements — Ref: GWPR2241	



APPROXIMATE SITE BOUNDARY

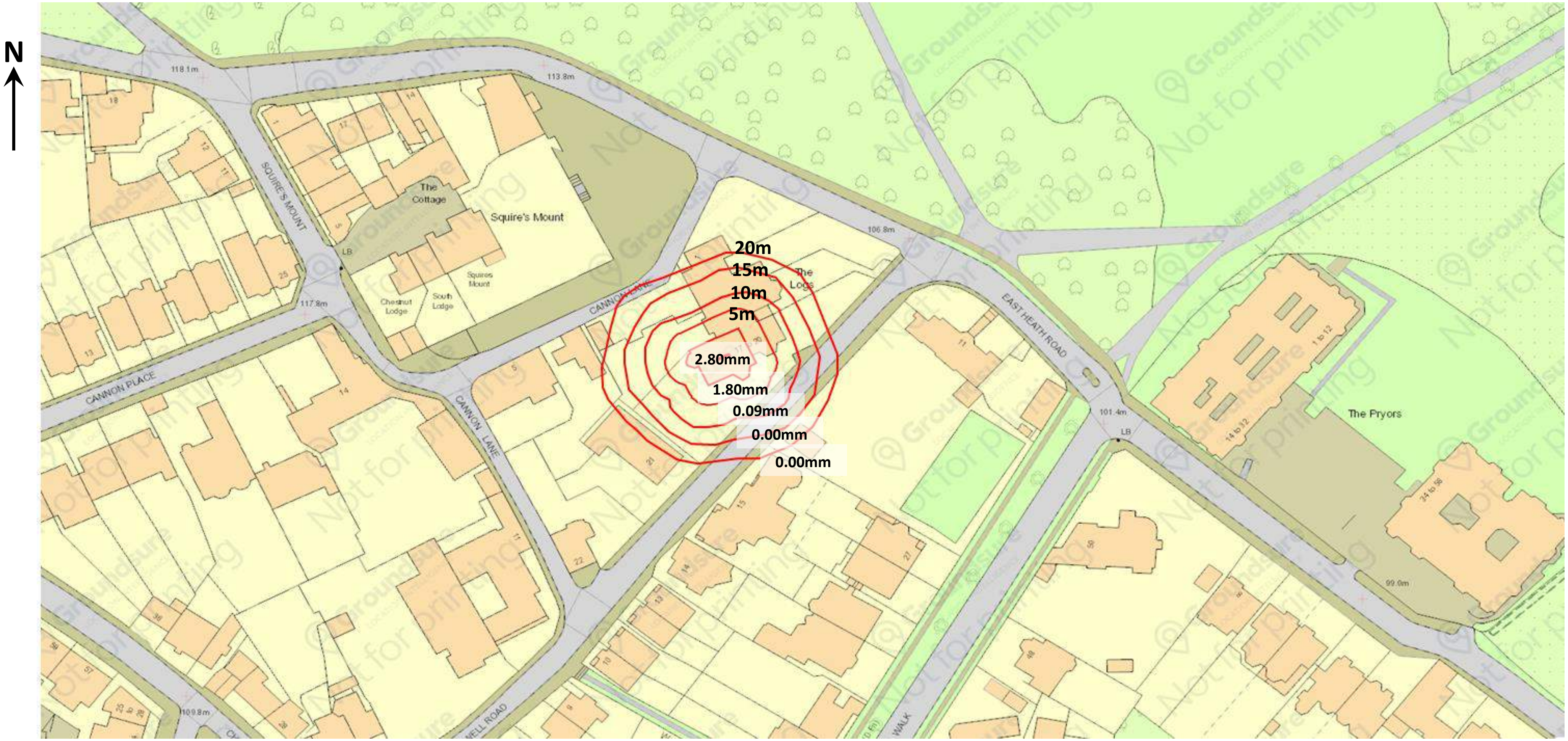
NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH		**Figure 22**
Client: Vincent and Rymill	**Date:** October 2017	
Vertical Ground Movement – Contour Plot for Soft to Firm Clay	**Ref:** GWPR2241	

APPROXIMATE SITE BOUNDARY

NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH		Figure 23
Client: Vincent and Rymill	Date: October 2017	ground&water
Vertical Ground Movement – Contour Plot for Sands	Ref: GWPR2241	



APPROXIMATE SITE BOUNDARY

NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH		Figure 24
Client: Vincent and Rymill	Date: October 2017	ground&water
Horizontal Ground Movement – Contour Plot for Stiff Clay – Contiguous Piling	Ref: GWPR2241	

APPROXIMATE SITE BOUNDARY

NOT TO SCALE

Project:

20 Well Road, Hampstead, London NW3 1LH

Client:

Vincent and Rymill

Date:

October 2017

Vertical Ground Movement – Contour Plot for Soft to Firm Clay – Contiguous Piling

Ref:

GWPR2241

Figure 25

ground&water

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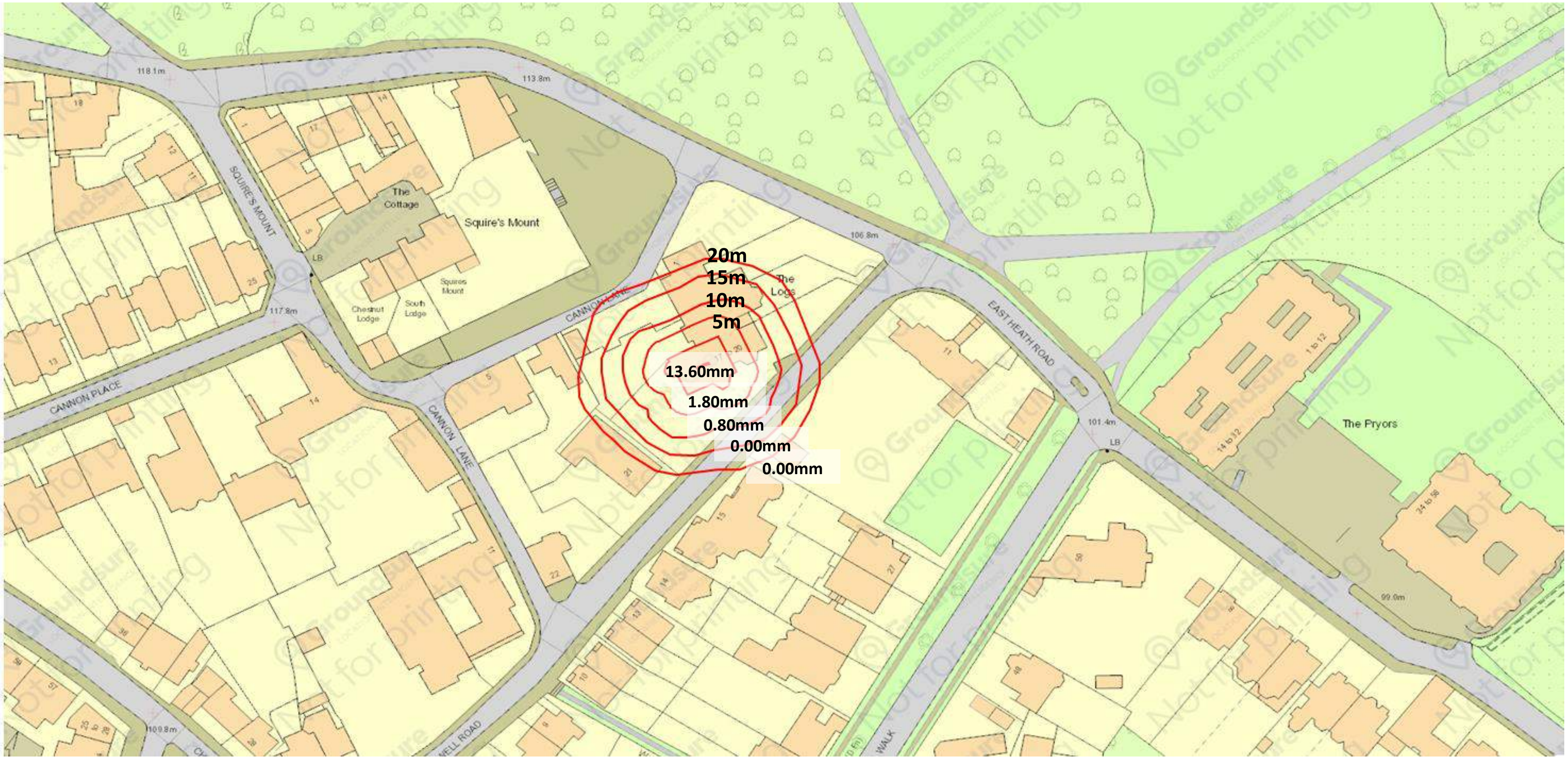


APPROXIMATE SITE BOUNDARY

NOT TO SCALE

Project: 20 Well Road, Hampstead, London NW3 1LH	Figure 26
Client: Vincent and Rymill / Date: October 2017	ground&water
Vertical Ground Movement – Contour Plot for Sands – Contiguous Piling Movements / Ref: GWPR2241	

APPENDIX A
Conditions and Limitations

The ground is a product of continuing natural and artificial processes. As a result, the ground will exhibit a variety of characteristics that vary from place to place across a site, and also with time. Whilst a ground investigation will mitigate to a greater or lesser degree against the resulting risk from variation, the risks cannot be eliminated.

The report has been prepared on the basis of information, data and materials which were available at the time of writing. Accordingly any conclusions, opinions or judgements made in the report should not be regarded as definitive or relied upon to the exclusion of other information, opinions and judgements.

The investigation, interpretations, and recommendations given in this report were prepared for the sole benefit of the client in accordance with their brief; as such these do not necessarily address all aspects of ground behaviour at the site. No liability is accepted for any reliance placed on it by others unless specifically agreed in writing.

Any decisions made by you, or by any organisation, agency or person who has read, received or been provided with information contained in the report ("you" or "the Recipient") are decisions of the Recipient and we will not make, or be deemed to make, any decisions on behalf of any Recipient. We will not be liable for the consequences of any such decisions.

Current regulations and good practice were used in the preparation of this report. An appropriately qualified person must review the recommendations given in this report at the time of preparation of the scheme design to ensure that any recommendations given remain valid in light of changes in regulation and practice, or additional information obtained regarding the site.

Any Recipient must take into account any other factors apart from the Report of which they and their experts and advisers are or should be aware. The information, data, conclusions, opinions and judgements set out in the report may relate to certain contexts and may not be suitable in other contexts. It is your responsibility to ensure that you do not use the information we provide in the wrong context.

This report is based on readily available geological records, the recorded physical investigation, the strata observed in the works, together with the results of completed site and laboratory tests. Whilst skill and care has been taken to interpret these conditions likely between or below investigation points, the possibility of other characteristics not revealed cannot be discounted, for which no liability can be accepted. The impact of our assessment on other aspects of the development required evaluation by other involved parties.

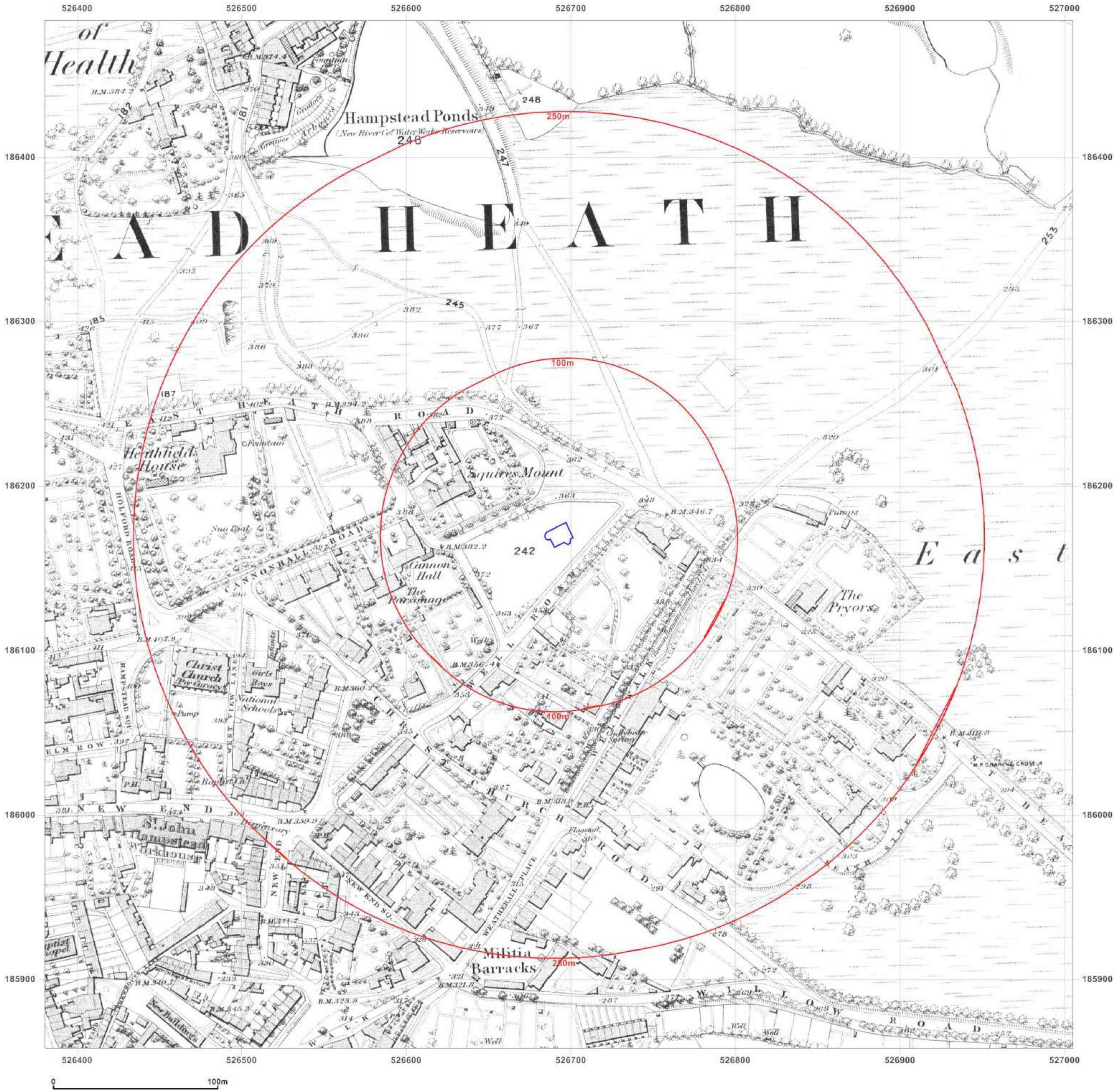
The opinions expressed cannot be absolute due to the limitations of time and resources within the context of the agreed brief and the possibility of unrecorded previous in ground activities. The ground conditions have been sampled or monitored in recorded locations and tests for some of the more common chemicals generally expected. Other concentrations of types of chemicals may exist. It was not part of the scope of this report to comment on environment/contaminated land considerations.

The conclusions and recommendations relate to 20 Well Road, Hampstead, London NW3 1LH.

Trial hole is a generic term used to describe a method of direct investigation. The term trial pit, borehole or window sampler borehole implies the specific technique used to produce a trial hole.

The depth to roots and/or of desiccation may vary from that found during the investigation. The client is responsible for establishing the depth to roots and/or of desiccation on a plot-by-plot basis prior to the construction of foundations. Where trees are mentioned in the text this means existing trees, recently removed trees (approximately 15 years to full recovery on cohesive soils) and those planned as part of the site landscaping.

APPENDIX B
Historical Maps



GROUNDSURE INSIGHTS

Site Details:

20, WELL ROAD, LONDON, NW3 1LH

Client Ref: GWPR2241
Report Ref: HMD-445-4363862
Grid Ref: 526693, 186170

Map Name: County Series

Map date: **1870**

Scale: 1:2,500

Printed at: 1:2,500

N
W E
S

Surveyed 1866
Revised N/A
Edition 1870
Copyright N/A
Levelled N/A

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Production date: 20 October 2017

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Groundsure INSIGHTS

Site Details:

20, WELL ROAD, LONDON, NW3 1LH

Client Ref: GWPR2241
Report Ref: HMD-445-4363862
Grid Ref: 526693, 186170

Map Name: 1056 Scale Town Plan

Map date: **1871**

Scale: 1:1,056

Printed at: 1:1,056

N
W E
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Surveyed N/A
Revised N/A
Edition N/A
Copyright N/A
Levelled N/A

Surveyed N/A
Revised N/A
Edition N/A
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Groundsure INSIGHTS

Site Details:

20, WELL ROAD, LONDON,
NW3 1LH

Client Ref: GWPR2241
Report Ref: HMD-445-4363862
Grid Ref: 526693, 186170

Map Name: 1056 Scale Town Plan

Map date: **1871**

Scale: 1:1,056

Printed at: 1:1,056

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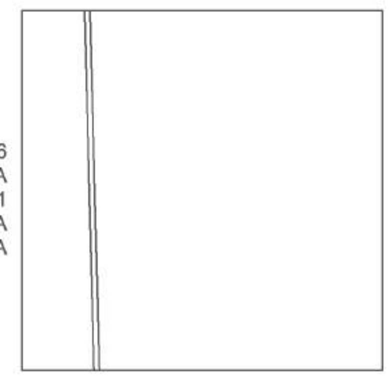

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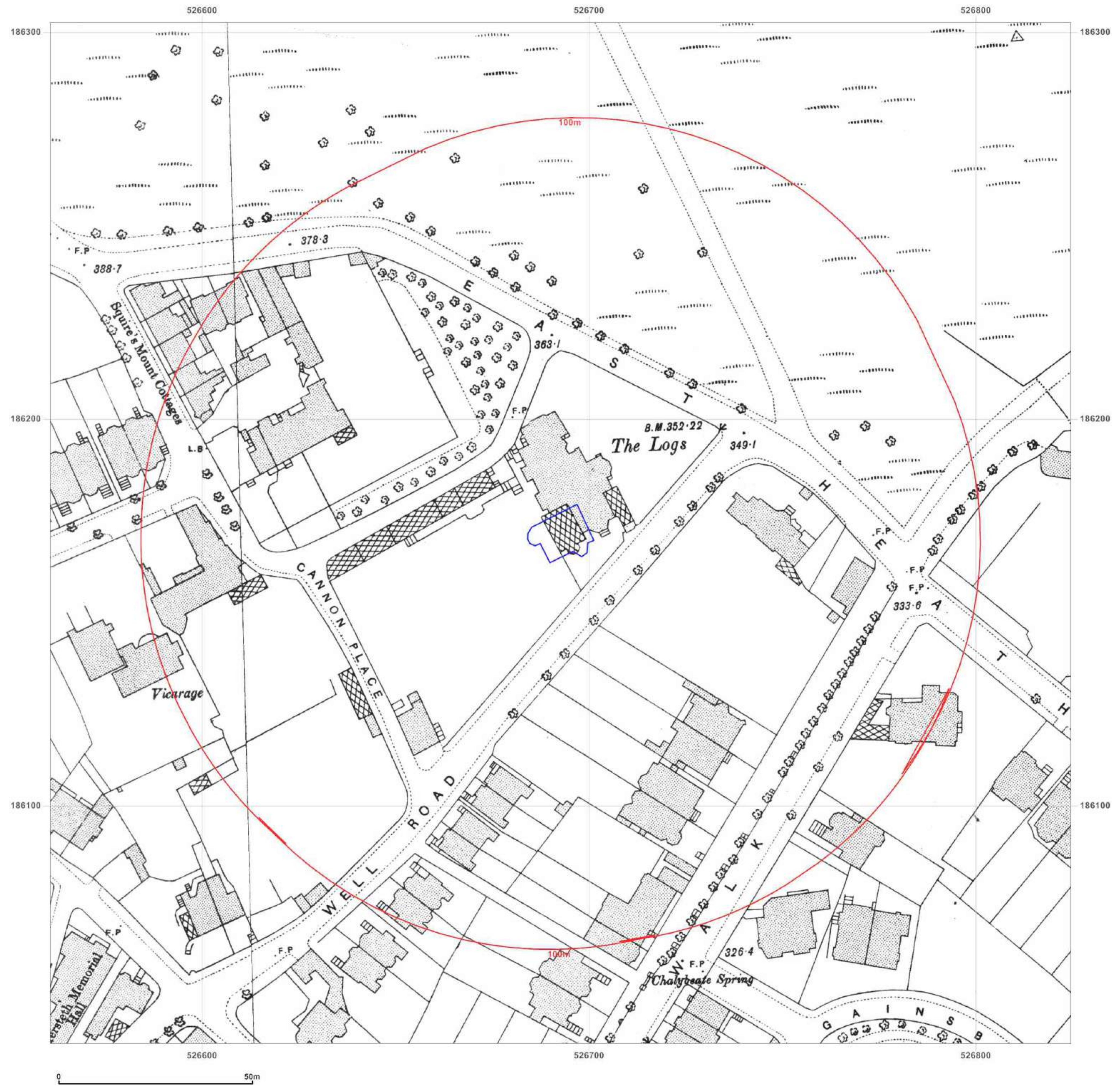

Site Details:

20, WELL ROAD, LONDON,
NW3 1LH

Client Ref: GWPR2241
Report Ref: HMD-445-4363862
Grid Ref: 526693, 186170

Map Name: 1056 Scale Town Plan

Map date: 1896

Scale: 1:1,056

Printed at: 1:1,056

N
W E
S

Surveyed 1893
Revised N/A
Edition 1896
Copyright N/A
Levelled N/A

Surveyed 1893
Revised N/A
Edition 1896
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