FACTUAL GROUND INVESTIGATION REPORT

for the site at

251 GOLDHURST TERRACE, SOUTH HAMPSTEAD, LONDON NW6 3EP

on behalf of

483 NCR Ltd c/o GML Architects

Report Reference: GWPR1852/GIR/April 2017		Status: FINAL
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File Reference: Ground and Water/Project Files/ GWPR1852 521 Goldhurst Terrace, South Hampstead, London, NW6 3EP		

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1.0 INTRODUCTION

1.1 General

Ground and Water Limited were instructed by 438 NCR Ltd c/o GML Artchitects, on the 4th October 2016, to conduct a Ground Investigation on the site at 251 Goldhurst Terrace, South Hampstead, London, NW6 3EP. The scope of the investigation was detailed within the Ground and Water Limited quotation ref. GWQ3037 dated 13th September 2016.

1.2 Aims of the Investigation

The aim of the investigation was understood to be to supply the client and their designers with factual 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 boreholes.

A Desk Study and full scale contamination and geotechnical 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

2.1 Site Location

The site comprised a 750m^2 rectangular shaped plot of land, orientated in north to south direction, located on the southern side of Goldhurst Terrace. The site was located ~90m south-east of Goldhurst Terrace's junction with Aberdare Gardens. The site was located South Hampstead within the London Borough of Camden.

A site location plan can be seen in Figure 1 with a plan showing the site area presented in Figure 2. The approximate O.S. National Grid Reference for the centre of the site was TQ 25794 84027.

2.2 Site Description

The site comprised a semi-detached two storey property with paved/crazy paved frontage/off-street parking and side access along the eastern side of the property, allowing access to the rear garden.
An aerial view of the site showing the site and an approximate site boundary is given within Figure 3.

2.3 Proposed Development

At the time of reporting, April 2017, it was our understanding that the proposed development will comprise the construction of a basement under the property, to a depth of 3.00 – 3.50 m bgl. A plan and section view of the proposed development is given in Figure 4.

2.4 Geology

The British Geological Survey Geology Map (Solid and Drift) for the North London (Sheet No. 256) area revealed the site to be underlain by the London Clay Formation. No areas of Made Ground, Worked Ground or Infilled Land were noted within 250m of the site.

London Clay Formation
The London Clay Formation comprises stiff grey fissured clay, weathering to brown near surface. Concretions of argillaceous limestone in nodular form (Claystones) occur throughout the formation. Crystals of Gypsum (Selenite) are often found within the weathered part of the London Clay Formation, and precautions against sulphate attack to concrete are sometimes required. The lowest part of the formation is a sandy bed with black rounded gravel and occasional layers of sandstone and is known as the Basement Bed.

2.5 Hydrogeology and Hydrology

An examination of the Environment Agency records revealed that the bedrock deposits of the London Clay Formation, underlying the site, was designated as **Unproductive Strata**. No superficial designation was present due to the absence of such deposits.

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.

Unproductive Strata are rock layers with low permeability that have negligible significance for water supply or river base flow. These were formerly classified as non-aquifers.

Examination of the Environment Agency records showed that the site **was not** located within a Groundwater Source Protection Zone (SPZ) as classified in the Policy and Practice for the Protection of Groundwater.

The nearest surface water feature to the site appears to be Regents Canal, located about 1.7 km

south-east of the site, passing through the northern section of the Regents Park.

From analysis of hydrogeological and topographical maps groundwater was anticipated to be encountered at depth (i.e. below 4.00m bgl) and it was considered that the groundwater was flowing in a general south / south easterly direction in alignment with local topography and towards River Thames, which is located further, towards the south / south east.

Examination of the Environment Agency records showed that the site was situated within a **Flood Zone 1**, i.e. low risk of flooding. The site was also shown **not** to be situated within a flood warning area.

2.6 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 likely to be required. The site **was not** located within an area where a risk assessment was required.

3.0 FIELDWORK

3.1 Scope of Works

Site works were undertaken on the 18th October 2016 and comprised the drilling of one Dart Windowless Sampler Borehole (BH1) to a depth of 10.45m bgl, with Standard Penetration Tests (SPTs) carried out at 1.00m intervals, for the full depth of the borehole. A Hand Held Window Sampler Borehole (BH2) was also drilled to a depth of 5.00m bgl. Two Foundation Exposure Trial Pits (TP1 and TP2) were also excavated to depths of 1.30 and 1.73m bgl.

A groundwater monitoring well was constructed within BH1.

Combined Bio-gas and Groundwater Monitoring Well Construction				
Trial Hole	**Depth of Installation (m bgl)**	**Thickness of slotted piping with gravel filter pack (m)**	**Depth of plain piping with bentonite seal (m bgl)**	**Piping external diameter (mm)**
BH1	5.00	4.00	1.00	63

The locations of each trial holes can be seen in Figure 5.

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.

As a further precautionary measure, the boreholes were hand excavated to 1.20m bgl and scanned with a Cable Avoidance Tool (CAT scanner) to minimise the risk to services.

Upon completion of the site works, the boreholes and trial pits were backfilled and made good/reinstated in relation to the surrounding area.

3.2 Sampling Procedures

Small disturbed samples were recovered from the boreholes 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.

4.0 ENCOUNTERED GROUND CONDITIONS

4.1 Soil Conditions

BH1 and BH2 were logged by Robert Terrell of Ground and Water Limited generally in accordance with BS EN 14688 'Geotechnical Investigation and Testing – Identification and Classification of Soil'.

The natural ground conditions recorded on the site were found to be in a broad accordance with the anticipated geology onsite.

Made ground was recorded in both boreholes to depths of 0.60 and 1.30m bgl, over cohesive soils representative of the Head Deposits, frequently encountered at shallow depths in the area, over soils of the London Clay Formation.

For the purposes of discussion, the succession of conditions encountered in the boreholes (BH1, BH2) in descending order can be broadly summarised as follows:

Made Ground
Head Deposits
London Clay Formation

Made Ground

A 180mm thick concrete slab was recorded in BH1 at surface, over Made Ground, to a depth of 1.30m bgl. The Made ground mainly comprised an orange brown sandy gravelly clay. The sand was fine to coarse grained and gravel was occasional, fine to medium, sub-angular brick, locally clinker, and flint. The Made Ground was more sandy and gravelly between 0.80 and 1.00m bgl.

Made Ground comprising a brown gravelly sand, with clay lenses, was recorded in BH2 to 0.35m bgl. The sand was fine to coarse grained and the gravel was occasional, fine to coarse, sub-angular to sub-rounded flint and brick. A reworked orange brown sandy gravelly clay was then recorded to 0.60m bgl, with the gravel being sub-angular to sub-rounded flint and brick.

In Foundation Exposure TP1, Made Ground was recorded to a depth of 0.70m bgl and generally comprised a dark brown very sandy gravelly clay, with the gravel being occasional, fine to coarse, sub-angular to sub-rounded brick and concrete.

Foundation Exposure TP2 recorded concrete over clinker to 0.40m bgl, above a void proved to at least 1.30m bgl.

Head Deposits

Soils representative of superficial Head Deposits were recorded below the Made Ground in BH1 and BH2 to depths of 1.60m and 1.80m bgl respectively. These broadly comprised orange/brown and brown silty gravelly clays. The gravel was found to be rare to occasional, fine to coarse, sub-angular to sub-rounded flint. The gravel content generally reduced with depth.

London Clay Formation

Soils representative of the London Clay Formation were encountered in BH1 and BH2 at depths of 1.60m and 1.80m bgl respectively. These comprised orange/brown silty clays, with pockets of silt and sand occasionally encountered. Selenite crystals were also recorded in BH2 from 3.70m bgl. The clay was generally becoming more brown and dark grey with depth.

For further details of the composition of the made ground and detailed description of the natural soils, reference must be made to the borehole logs within Appendix B.

4.2 Foundation Exposures

A description of the foundation layout and ground conditions encountered within the hand dug trial pit foundation exposures are given within this section of the report.

TP/FE1

Trial pit foundation exposure, TP/FE1, was hand excavated from ground level on the front (northern) wall of the building. The exact location of the trial hole can be seen in Figure 5 and a section drawing of the foundation encountered during TP/FE1 can be seen in Figure 6.

The foundation exposure was measured from ground level. The foundation layout encountered consisted of a rendered brick wall from ground level to a depth of 0.45m bgl over a brick wall to 1.38m bgl. The wall rested upon a brick step that stepped out by 0.05m and was 0.09m in thickness. The brick step rested upon a concrete footing that stepped out by 0.32m and was 0.26m in thickness, resting on natural soils of the London Clay Formation at a depth of 1.73m bgl.

TP/FE2

Trial pit foundation exposure, TP/FE2, was hand excavated from ground level on the eastern wall of the building. The exact location of the trial hole can be seen in Figure 5 and a section drawing of the foundation encountered during TP/FE2 can be seen in Figure 7.

The foundation exposure was measured from ground level. The foundation layout encountered consisted of a brick wall from ground level to a depth of at least 1.30m bgl. The base of the wall / footing could not be determined. A void was present from 0.40 to 1.30m bgl below the paved “suspended” concrete path.

4.3 Roots Encountered

Roots were noted to a depth of 1.00m bgl in BH1 and 0.80m bgl in BH2, by the engineer. Drillers recorded fine roots between 1.60m and 3.10m bgl.

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.

4.4 Groundwater Conditions

No groundwater strikes were noted in either BH1 or BH2 during their construction.

The standing groundwater level noted, in the installed monitoring well, during 2No. return visits to the site can be seen tabulated overleaf.

Groundwater Observations					
Project Ref	**Site Location**	**Borehole Ref.**	**Groundwater reading (m bgl)**	**Depth to base of borehole (m bgl)**	**Date**
GWPR1852	251 Goldhurst Terrace, South Hampstead, London, NW6 3EP	BH1	Dry	5.00	26/10/2016
GWPR1852	251 Goldhurst Terrace, South Hampstead, London, NW6 3EP	BH1	Dry	5.00	11/11/2016

It should be noted that exact groundwater levels may only be determined through long term measurements from monitoring wells installed on-site. It should be noted that changes in groundwater level do occur for a number of reasons including seasonal effects and variations in drainage.

The site investigation was conducted in October and November 2016, when groundwater levels should be relatively close to their annual maximum (highest elevation). The long-term groundwater elevation might increase at some time in the future due to seasonal fluctuation in weather conditions. Isolated pockets of groundwater may be perched within any Made Ground found at other locations around the site.

4.5 Obstructions

No artificial or natural sub-surface obstructions were noted during drilling of the boreholes.

5.0 INSITU AND LABORATORY GEOTECHNICAL TESTING

5.1 In-Situ Geotechnical Testing

Standard Penetration Tests (SPT's) were undertaken within BH1 and BH2 at 1.00m intervals to the base of the boreholes. 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 borehole logs within Appendix B.

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 650 mm. 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 75 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".

The cohesive soils encountered on site were classified based on the table below.

Undrained Shear Strength from Field Inspection/SPT results 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	-

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

Interpretation of In-situ Geotechnical Testing Results				
Strata	**SPT "N" Blow Counts**	**Equivalent Undrained Shear Strength (kPa) Cohesive Soils**	**Soil Type** **Cohesive**	**Trial Hole/s - Depth**
London Clay Formation (cohesive)	8-33	40 - 165	Medium - Very High Undrained Shear Strength	BH1 (1.60-10.45m 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.

5.2 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 natural ground. The results of the tests are presented in Appendix C. 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
Natural Moisture Content (only)	BS1377:1990:Part 2:Clauses 3.2, 4.3 & 5	8 (in total)
Water Soluble Sulphate & pH	BS1377:1990:Part 3:Clause 5	1
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

5.2.1 Atterberg Limit Tests

A précis of the results of Atterberg Limit Tests undertaken on four samples of the London Clay Formation can be seen tabulated overleaf.

The natural moisture content was determined in four additional samples of the London Clay Formation.

Atterberg Limit Tests Results Summary							
Stratum	**Moisture Content (%)**	**Passing 425 µm sieve (%)**	**Modified PI (%)**	**Soil Class Range**	**Consistency Index (Ic)**	**Volume Change Potential Range**	
						NHBC	**BRE**
London Clay Formation BH1 (1.30-10.45m bgl) BH2 (1.80-5.00m bgl)	24 – 33 (from eight samples in total)	100	42.00 - 50.00	CV	0.93 - 1.00 (Stiff)	High	High

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.

5.2.2 Comparison of Soil's Moisture Content with Index Properties

5.2.2.1 Liquidity Index Analyses

The results of the Atterberg Limit tests undertaken on four samples 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 overleaf.

Liquidity Index Calculations Summary					
Strata/Trial Hole/Depth/Soil Description	**Moisture Content (%)**	**Plastic Limit (%)**	**Modified Plasticity Index (%)**	**Liquidity Index**	**Result**
London Clay Formation **BH1 / 2.50m bgl** Orange brown/brown mottled silty CLAY. Pockets of silt and fine roots noted between 1.60-3.10m bgl.	24	23	42.00	0.02	Heavily Overconsolidated
London Clay Formation **BH1 / 3.50m bgl** Orange brown/brown mottled silty CLAY. Pockets of silt and fine roots noted between 1.60 - 3.10m bgl. Pockets of orange silt between 3.10 – 4.30m bgl.	26	26	44.00	0.00	Heavily Overconsolidated
London Clay Formation **BH1 / 8.00m bgl** Dark grey brown silty CLAY.	26	25	50.00	0.02	Heavily Overconsolidated
London Clay Formation **BH2 / 3.00m bgl** Brown/orange, brown/grey mottled silty CLAY. Pockets of fine grained orange sand noted. Selenite crystals noted from 3.70m bgl.	28	25	45.00	0.06	Heavily Overconsolidated

Liquidity Index testing revealed no evidence for moisture deficit within the heavily overconsolidated samples of the London Clay Formation tested.

5.2.2.2 Liquid Limit

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

Moisture Content vs. Liquid Limit				
Strata/Trial Hole/Depth/Soil Description	**Moisture Content (MC) (%)**	**Liquid Limit (LL) (%)**	**40% Liquid Limit (LL)**	**Result**
London Clay Formation **BH1 / 2.50m bgl** Orange brown/brown mottled silty CLAY. Pockets of silt and fine roots noted between 1.60-3.10m bgl.	24	65	26	**MC < 0.4 x LL** **(Potentially significant moisture deficit)**
London Clay Formation **BH1 / 3.50m bgl** Orange brown/brown mottled silty CLAY. Pockets of silt and fine roots noted between 1.60 - 3.10m bgl. Pockets of orange silt between 3.10 – 4.30m bgl.	26	70	28	**MC < 0.4 x LL** **(Potentially significant moisture deficit)**
London Clay Formation **BH1 / 8.00m bgl** Dark grey brown silty CLAY.	26	75	30	**MC < 0.4 x LL** **(Potentially significant moisture deficit)**
London Clay Formation **BH2 / 3.00m bgl** Brown/orange, brown/grey mottled silty CLAY. Pockets of fine grained orange sand noted. Selenite crystals noted from 3.70m bgl.	28	70	28	MC = 0.4 x LL (Sample on the boundary of a significant moisture deficit)

The results in the table above indicated that a potential significant moisture deficit was present within three samples of the London Clay Formation tested

(BH1/2.50m, BH1/3.50 and BH1/8.00m bgl). The moisture content values were below 40% of the liquid limit. One sample (BH2 / 3.00m) was found to be at the boundary.

Roots were generally recorded to a depth of 1.00m bgl in BH1 and 0.80m bgl in BH2. Fine roots were also noted in BH1 between 1.60 and 3.10m bgl. However, the soils of the London Clay Formation on site were found to be consistently heavily overconsolidated. It is considered that the apparent moisture deficit could be a result of a combination of the heavily overconsolidated nature of the soils and possibly the water demand from the roots, to a maximum depth of about ~3m However, at deeper depths, it is considered that the apparent moisture deficit could be attributed to the heavily overconsolidated soils, especially since the same result was noted within the sample recovered from 8.00m bgl.

5.2.3 Moisture Content Profiling

The moisture content versus depth plot for BH1 can be seen within Figure 8.

A lowering of the moisture content was noted between 1.50 - 2.50m bgl, 3.00 - 3.50m bgl and 4.00 - 8.00 bgl. The strata were described as orange brown / brown mottled silty clay from 1.60 to 4.30m bgl, with pockets of silt and fine roots between 1.60 and 3.10m bgl. A brown silty clay was generally recorded below to 5.00m bgl, underlain by dark grey brown silty clay to a depth of 10.00m bgl. Geotechnical testing has shown the soils were heavily overconsolidated. It is considered that the apparent moisture deficit could be a result of a combination of the heavily overconsolidated nature of the soils and the water demand from the roots, to depths of about 3.0m. However, at deeper depths, it is considered that the apparent moisture deficit could be attributed to the heavy overconsolidation of the soils and variations in lithology.

5.2.4 Sulphate and pH Tests

Sulphate and pH tests were undertaken on one sample from the London Clay Formation. (BH1/3.50m). The sulphate concentration was found to be 1.45g/l and the pH was recorded as 7.54.

5.2.5 BRE Special Digest 1

In accordance with BRE Special Digest 1 ‘Concrete in Aggressive Ground’ (BRE, 2005) two samples of the London Clay Formation (BH2/2.00m, BH1/4.50m) were scheduled for laboratory analysis to determine parameters for concrete specification.

The results are given within Appendix C and a summary is tabulated overleaf:

Summary of Results of BRE Special Digest Testing			
Determinand	**Unit**	**BH2/2.00m**	**BH1/4.50m**
pH	-	7.6	7.7
Ammonium as NH_4	mg/kg	<0.5	<0.5
Sulphur	%	0.03	0.26
Chloride (water soluble)	mg/kg	61	69
Magnesium (water soluble)	mg/l	24	170
Nitrate (water soluble)	mg/kg	<3	<3
Sulphate (water soluble)	g/l	0.46	2.55
Sulphate (total)	mg/kg	1194	4993

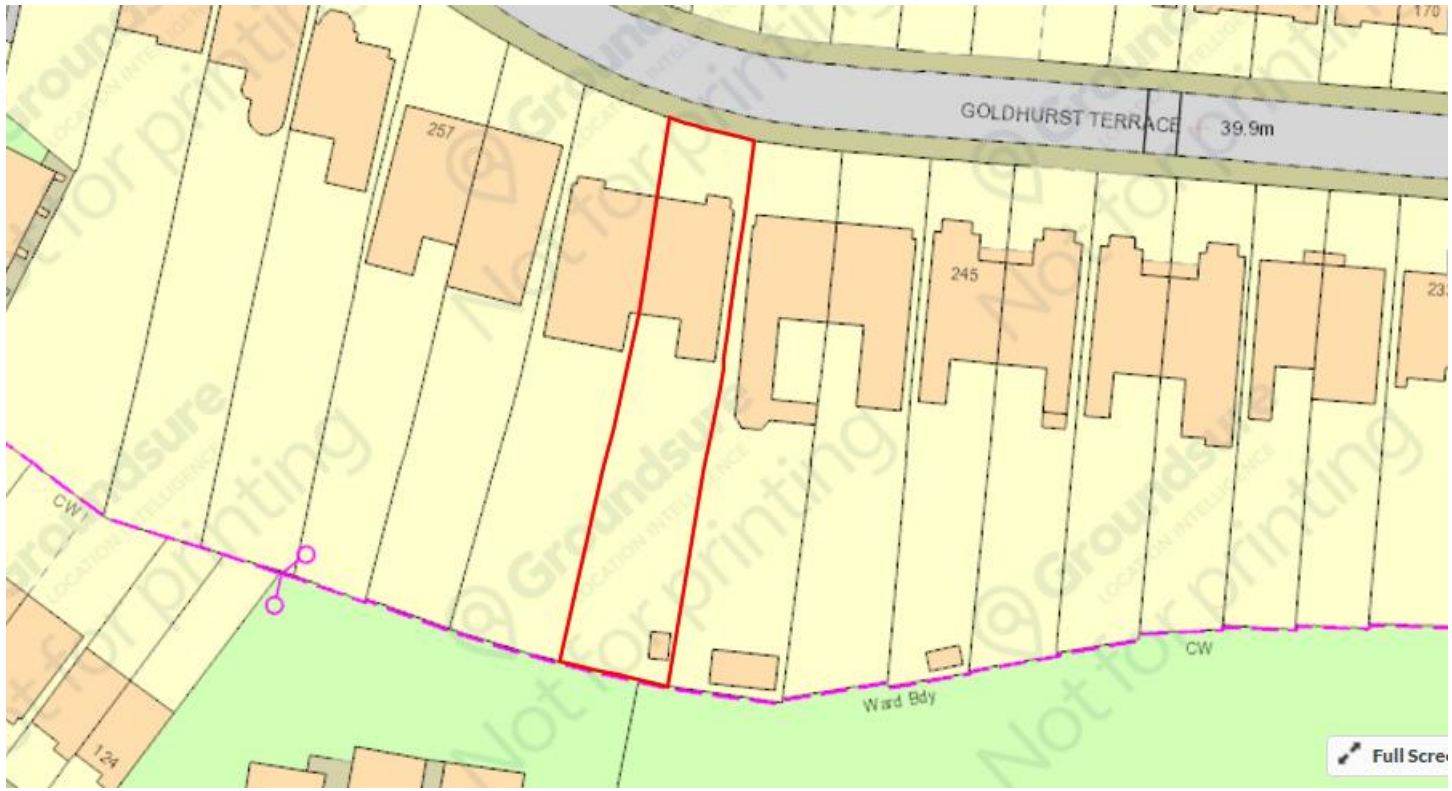
N

APPROXIMATE SITE BOUNDARY

NOT TO SCALE

Project: 251 Goldhurst Terrace, South Hampstead, London, NW6 3EP		Figure 1
Client: 483 NCR Ltd c/o GML Architects	Date: April 2017	ground&water
Site Location Plan	Ref: GWPR1852	

N



APPROXIMATE SITE BOUNDARY

NOT TO SCALE

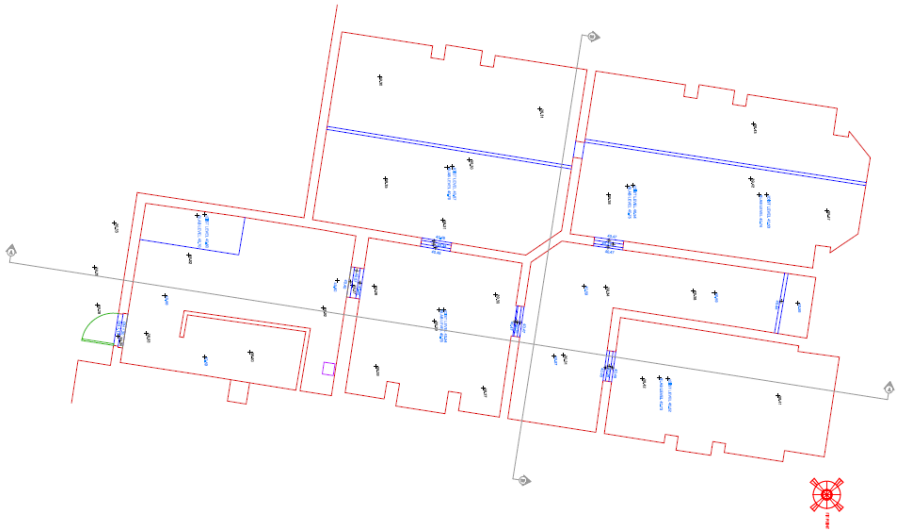
Project: 251 Goldhurst Terrace, South Hampstead, London, NW6 3EP		**Figure 2**
Client: 483 NCR Ltd c/o GML Architects	**Date:** April 2017	ground&water
Site Development Area	**Ref:** GWPR1852	

N

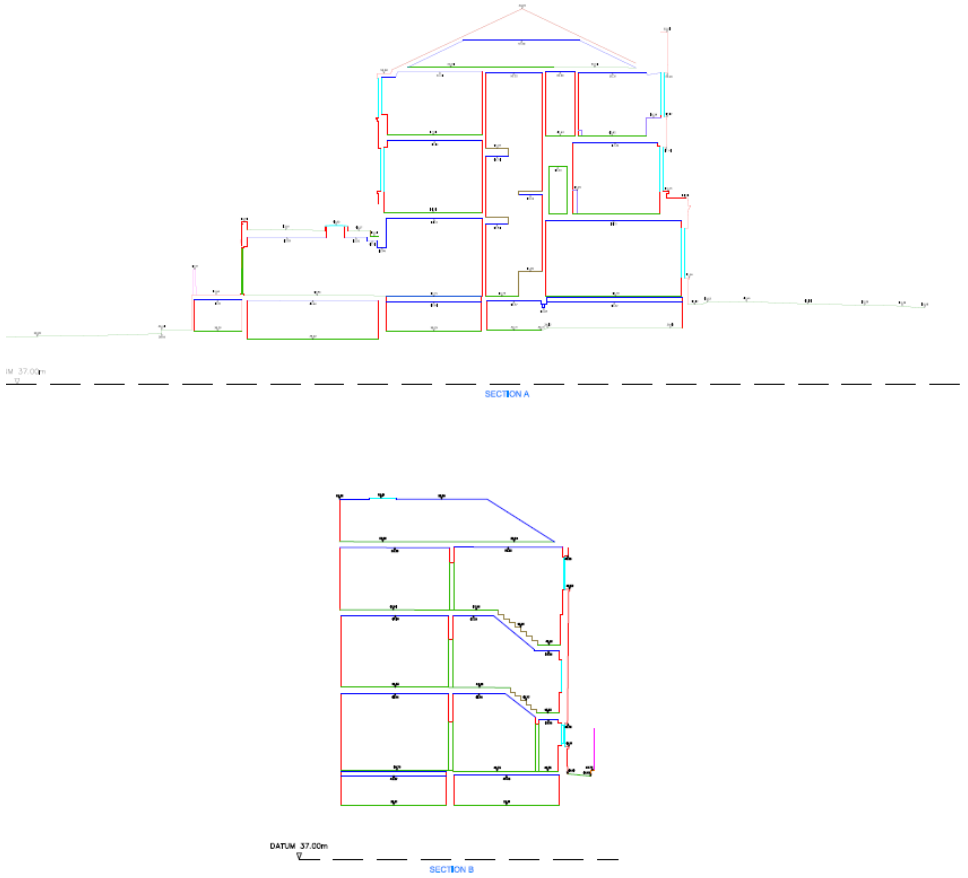
APPROXIMATE SITE BOUNDARY

NOT TO SCALE

Project: 251 Goldhurst Terrace, South Hampstead, London, NW6 3EP		**Figure 3**
Client: 483 NCR Ltd c/o GML Architects	**Date:** April 2017	ground&water
Aerial View of Site	**Ref:** GWPR1852	



Ground Floor and Basement Layout

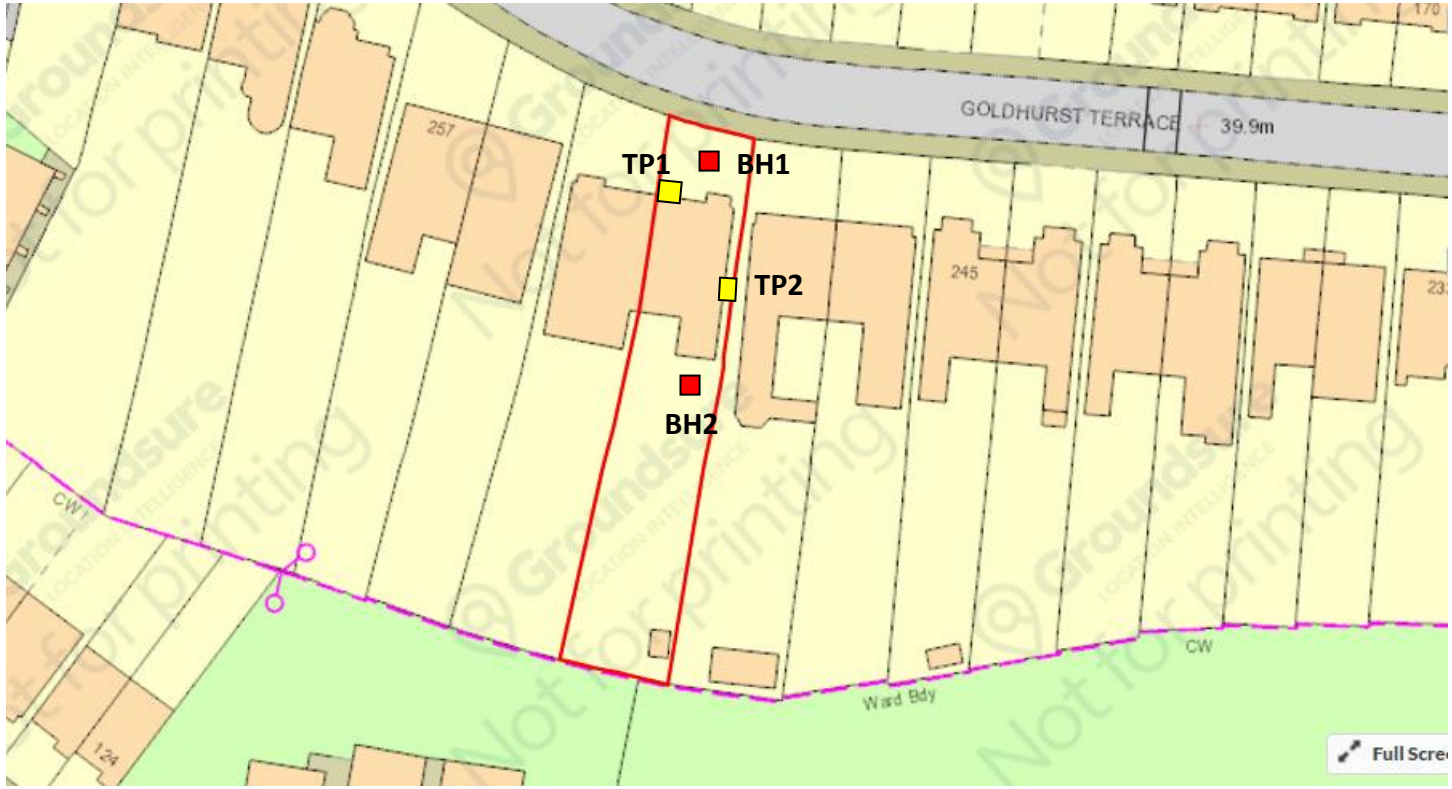


Proposed Sections

NOT TO SCALE

Project: **251 Goldhurst Terrace, South Hampstead, London, NW6 3EP**		**Figure 4**
Client: **483 NCR Ltd c/o GML Architects**	**Date:** **April 2017**	ground&water
Proposed Development – Plan and Section View	**Ref:** **GWPR1852**	

N



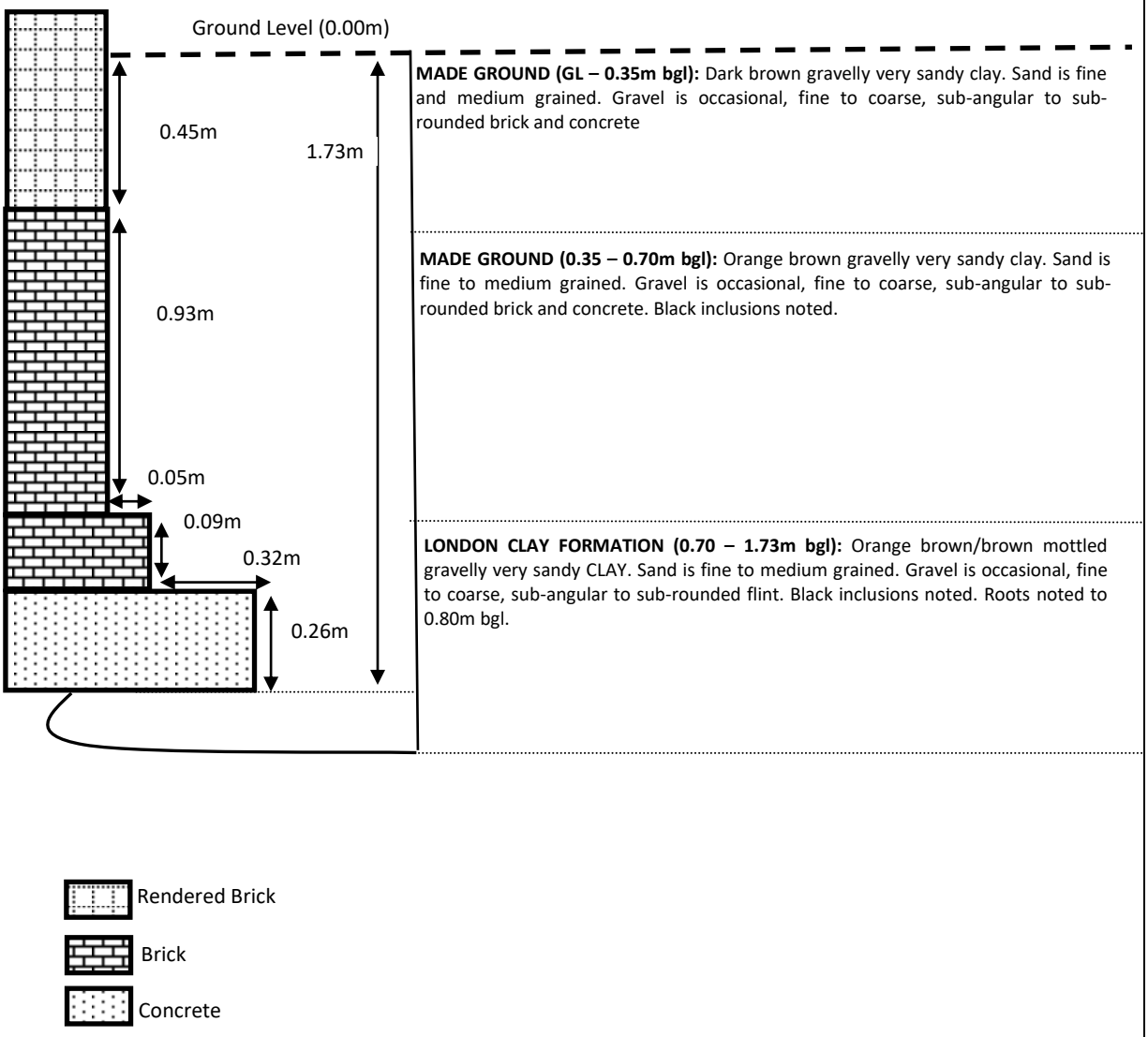
Location of Exposure Trial Pits

Location of Boreholes

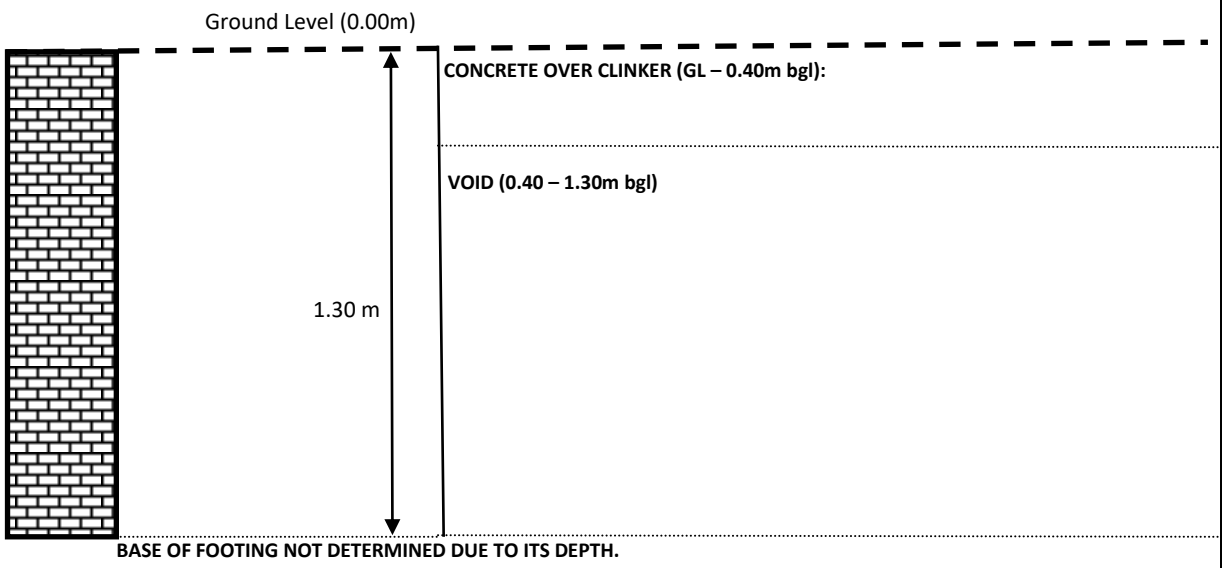
APPROXIMATE SITE BOUNDARY

NOT TO SCALE

Project: 251 Goldhurst Terrace, South Hampstead, London, NW6 3EP		Figure 5
Client: 483 NCR Ltd c/o GML Architects	Date: April 2017	ground&water
Trial Holes Location Plan	Ref: GWPR1852	



Project: **251 Goldhurst Terrace, South Hampstead, London NW6 3EP**		**Figure 6**
Client: **483 NCR c/o GML Architects**	**Date:** **April 2017**	ground&water
Section Drawing: Foundation Exposure TP1	**Ref:** **GWPR1852**	

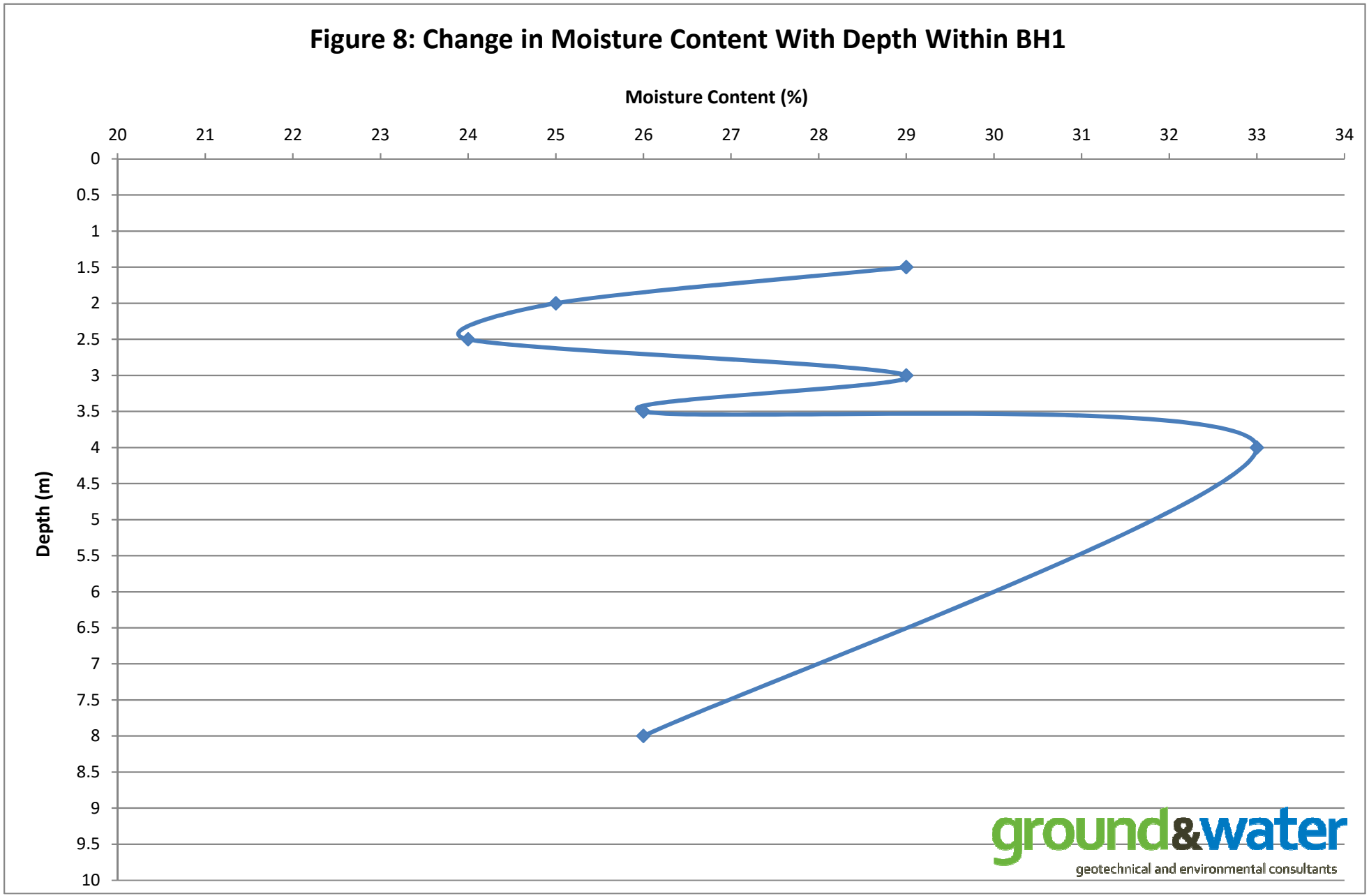


Brick

Concrete

Project: 251 Goldhurst Terrace, South Hampstead, London NW6 3EP		**Figure 7**
Client: 483 NCR Ltd c/o GML Architects	**Date:** April 2017	ground&water
Section Drawing: Foundation Exposure TP2	**Ref:** GWPR1852	

Figure 8: Change in Moisture Content With Depth Within BH1



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 251 Goldhurst Terrace, South Hampstead, London, NW6 3EP.

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
Fieldwork Logs

Ground and Water Ltd

Borehole No **BH1** Sheet 1 of 2

Project Name	Project No.	Co-ords: -	Hole Type
251 Goldhurst Terrace	GWPR1852		WLS
Location: 251 Goldhurst Terrace, South Hampstead, London NW6 3EP		Level: -	Scale 1:50
Client: 483 NCR Ltd c/o GML Architects		Dates: 18/10/2016	Logged By RT

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
					0.18			CONCRETE
		0.30	D					MADE GROUND: Orange brown/brown mottled sandy gravelly clay. Sand is fine to coarse grained. Gravel is occasional, fine to medium, sub-angular brick.
		0.50	D					
		0.80	D		0.80			
		1.00	SPT	N=10	1.00			MADE GROUND: Dark brown sandy gravel. Sand is medium to coarse grained. Gravel is abundant, fine to coarse, sub-angular brick.
		1.00	D	(2,3/ 3,3,2,2)				
					1.30			MADE GROUND: Brown sandy very gravelly clay. Sand is fine to coarse grained. Gravel is occasional, fine to coarse, sub-angular to sub-rounded brick, clinker and flint.
		1.50	D		1.60			
								HEAD DEPOSITS: Orange brown/brown mottled gravelly silty CLAY. Gravel is rare to occasional, medium to coarse, sub-angular to sub-rounded flint. Gravels reduce with depth.
		2.00	SPT	N=8				
		2.00	D	(1,1/ 2,2,2,2)				LONDON CLAY FORMATION: Orange brown/brown mottled silty CLAY. Pockets of silt and fine roots noted between 1.60 - 3.10m bgl. Pockets of orange silt noted between 3.10 - 4.30m bgl.
		2.50	D					
		3.00	SPT	N=9				
		3.00	D	(2,2/ 2,2,2,3)				
		3.50	D					
		4.00	SPT	N=14				
		4.00	D	(2,3/ 3,3,4,4)				
					4.30			LONDON CLAY FORMATION: Brown with grey and orange brown mottling, silty CLAY.
		4.50	D					
		5.00	SPT	N=16	5.00			LONDON CLAY FORMATION: Brown silty CLAY.
		5.00	D	(3,3/ 4,3,4,5)				
		5.50	D					
		6.00	SPT	N=19				
		6.00	D	(4,4/ 4,5,5,5)				
		6.50	D					
		7.00	SPT	N=23				
		7.00	D	(5,5/ 5,6,6,6)				
		7.50	D		7.50			LONDON CLAY FORMATION (BH1): Dark grey brown silty CLAY.
		8.00	SPT	N=31				
		8.00	D	(5,6/ 7,8,8,8)				
		8.50	D					
		9.00	SPT	N=30				
		9.00	D	(7,6/ 7,8,7,8)				
		9.50	D					
			Type	Results				

Continued next sheet

Remarks: No groundwater strikes noted.
Roots noted to 1.00m bgl. by Engineer.
Driller noted fine roots between 1.60 - 3.10m bgl.

AGS

Ground and Water Ltd

Borehole No
BH1
Sheet 2 of 2

Project Name: 251 Goldhurst Terrace	Project No.: GWPR1852	Co-ords: -	Hole Type: WLS
Location: 251 Goldhurst Terrace, South Hampstead, London NW6 3EP		Level: -	Scale: 1:50
Client: 483 NCR Ltd c/o GML Architects		Dates: 18/10/2016	Logged By: RT

Well	Water Strikes	Samples & In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description
		Depth (m)	Type	Results				
		10.00 10.00	SPT D	N=33 (7,8/ 8,9,8,8)	10.45			LONDON CLAY FORMATION (BH1): Dark grey brown silty CLAY. End of Borehole at 10.45 m

Type	Results

Remarks: No groundwater strikes noted.
Roots noted to 1.00m bgl. by Engineer.
Driller noted fine roots between 1.60 - 3.10m bgl.

AGS

Ground and Water Ltd

Borehole No
BH2
Sheet 1 of 1

Project Name: 251 Goldhurst Terrace	Project No.: GWPR1852	Co-ords: -	Hole Type: WLS
Location: 251 Goldhurst Terrace, South Hampstead, London NW6 3EP		Level: -	Scale: 1:50
Client: 483 NCR Ltd c/o GML Architects		Dates: 18/10/2016	Logged By: RT

Well	Water Strikes	Samples & In Situ Testing: Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.30	D		0.35			MADE GROUND: Brown gravelly sand with clay lenses. Sand is fine to coarse grained. Gravel is rare, fine to medium, sub-angular to sub-rounded brick and flint.
		0.50	D		0.60			MADE GROUND: Orange brown sandy gravelly clay. Sand is fine to coarse grained. Gravel is occasional, fine to coarse, sub-angular to sub-rounded flint and brick.
		0.80	D		0.90			HEAD DEPOSITS: Orange brown/brown mottled silty CLAY.
		1.00	D					HEAD DEPOSITS: Orange brown/brown mottled gravelly silty CLAY. Gravel is rare, fine to coarse, sub-angular flint.
		1.50	D		1.80			LONDON CLAY FORMATION: Brown/orange brown/grey mottled silty CLAY. Pockets of fine grained orange sand noted. Selenite crystals noted from 3.70m bgl.
		2.00	D					
		2.50	D					
		3.00	D					
		3.50	D					
		4.00	D					
		4.50	D					
		5.00	D		5.00			End of Borehole at 5.45 m
			Type	Results				

Remarks: Roots noted to 0.80m bgl.
No groundwater strikes noted.
BH2 approximately 1.5m lower than BH1.

AGS

APPENDIX C
Laboratory Test Results

Summary of Natural Moisture Content, Liquid Limit and Plastic Limit Results

Job No.	Project Name	Programme	
21822	251 Goldhurst Terrace, South Hampstead, London NW6 3EP	Samples received	24/10/2016
		Schedule received	24/10/2016
Project No.	Client	Project started	25/10/2016
GWPR1852	Ground and Water Ltd	Testing Started	03/11/2016

Hole No.	Sample				Soil Description	NMC	Passing 425µm	LL	PL	PI	Remarks
	Ref	Top	Base	Type		%	%	%	%	%	
BH1	-	1.50	-	D	Brown slightly sandy slightly gravelly silty CLAY (gravel is fmc and sub-angular to rounded)	29					
BH1	-	2.00	-	D	Greyish brown silty CLAY with chalk pockets	25					
BH1	-	2.50	-	D	Brown and occasional pale grey silty CLAY	24	100	65	23	42	
BH1	-	3.00	-	D	Greyish brown silty CLAY	29					
BH1	-	3.50	-	D	Brown and occasional bluish grey silty CLAY	26	100	70	26	44	
BH1	-	4.00	-	D	Orangish brown and occasional grey silty CLAY	33					
BH1	-	8.00	-	D	Grey silty CLAY	26	100	75	25	50	
BH2	-	3.00	-	D	Brown and occasional bluish grey silty CLAY with traces of selenite crystals	28	100	70	25	45	

Test Methods: BS1377: Part 2: 1990:
Natural Moisture Content : clause 3.2
Atterberg Limits: clause 4.3 and 5.0

Test Report by K4 SOILS LABORATORY
Unit 8 Olds Close Olds Approach
Watford Herts WD18 9RU

Tel: 01923 711 288
Email: James@k4soils.com

Checked and Approved

Initials **J.P**

Date: 04/11/2016

Sulphate Content (Gravimetric Method) for 2:1 Soil: Water Extract and pH Value - Summary of Results

Tested in accordance with BS1377 : Part 3 : 1990, clause 5.3 and clause 9

Job No.	Project Name	Programme	
21822	251 Goldhurst Terrace, South Hampstead, London NW6 3EP	Samples received	24/10/2016
		Schedule received	24/10/2016
Project No.	Client	Project started	25/10/2016
GWPR1852	Ground and Water Ltd	Testing Started	28/10/2016

Hole No.	Sample				Soil description	Dry Mass passing 2mm	SO3 Content	SO4 Content	pH	Remarks
	Ref	Top	Base	Type		%	g/l	g/l		
BH1	-	3.50	-	D	Brown and occasional bluish grey silty CLAY	100	1.21	1.45	7.54	

Test Report by K4 SOILS LABORATORY
Unit 8 Olds Close Olds Approach
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Tel: 01923 711 288
Email: James@k4soils.com

Checked and Approved

Initials J.P

Date: 04/11/2016

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QTS Environmental Ltd
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Kent
ME17 2JN
t: 01622 850410
russell.jarvis@qtsenvironmental.com

QTS Environmental Report No: 16-50804

Site Reference:	251 Goldhurst Terrace, South Hampstead, London NW6 3EP
Project / Job Ref:	GWPR1852
Order No:	None Supplied
Sample Receipt Date:	24/10/2016
Sample Scheduled Date:	24/10/2016
Report Issue Number:	1
Reporting Date:	31/10/2016

Authorised by:

Russell Jarvis
Associate Director of Client Services

Authorised by:

Ela Mysiara
Inorganics & ICP Section Head

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4480

Soil Analysis Certificate							
QTS Environmental Report No: 16-50804	**Date Sampled**	18/10/16	18/10/16			
Ground & Water Ltd	**Time Sampled**	None Supplied	None Supplied			
Site Reference: 251 Goldhurst Terrace, South Hampstead, London NW6 3EP	**TP / BH No**	BH2	BH1			
Project / Job Ref: GWPR1852	**Additional Refs**	None Supplied	None Supplied			
Order No: None Supplied	**Depth (m)**	2.00	4.50			
Reporting Date: 31/10/2016	**QTSE Sample No**	234776	234777			

Determinand	Unit	RL	Accreditation					
pH	pH Units	N/a	MCERTS	7.7	7.6			
Total Sulphate as SO_4	mg/kg	< 200	NONE	1194	4993			
Total Sulphate as SO_4	%	< 0.02	NONE	0.12	0.50			
W/S Sulphate as SO_4 (2:1)	mg/l	< 10	MCERTS	457	2550			
W/S Sulphate as SO_4 (2:1)	g/l	< 0.01	MCERTS	0.46	2.55			
Total Sulphur	%	< 0.02	NONE	0.03	0.26			
Ammonium as NH_4	mg/kg	< 0.5	NONE	< 0.5	< 0.5			
Ammonium as NH_4	mg/l	< 0.05	NONE	< 0.05	< 0.05			
W/S Chloride (2:1)	mg/kg	< 1	MCERTS	61	69			
W/S Chloride (2:1)	mg/l	< 0.5	MCERTS	30.3	34.4			
Water Soluble Nitrate (2:1) as NO_3	mg/kg	< 3	MCERTS	< 3	< 3			
Water Soluble Nitrate (2:1) as NO_3	mg/l	< 1.5	MCERTS	< 1.5	< 1.5			
W/S Magnesium	mg/l	< 0.1	NONE	24	170			

Analytical results are expressed on a dry weight basis where samples are assisted-dried at less than 30^{O}C
Analysis carried out on the dried sample is corrected for the stone content
Subcontracted analysis $^{(S)}$

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Soil Analysis Certificate - Sample Descriptions	
QTS Environmental Report No: 16-50804	
Ground & Water Ltd	
Site Reference: 251 Goldhurst Terrace, South Hampstead, London NW6 3EP	
Project / Job Ref: GWPR1852	
Order No: None Supplied	
Reporting Date: 31/10/2016	

QTSE Sample No	TP / BH No	Additional Refs	Depth (m)	Moisture Content (%)	Sample Matrix Description
234776	BH2	None Supplied	2.00	20	Brown clay
234777	BH1	None Supplied	4.50	20.1	Brown clay

Moisture content is part of procedure E003 & is not an accredited test

Insufficient Sample I/S

Unsuitable Sample U/S

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Soil Analysis Certificate - Methodology & Miscellaneous Information
QTS Environmental Report No: 16-50804
Ground & Water Ltd
Site Reference: 251 Goldhurst Terrace, South Hampstead, London NW6 3EP
Project / Job Ref: GWPR1852
Order No: None Supplied
Reporting Date: 31/10/2016

Matrix	Analysed On	Determinand	Brief Method Description	Method No
Soil	D	Boron - Water Soluble	Determination of water soluble boron in soil by 2:1 hot water extract followed by ICP-OES	E012
Soil	AR	BTEX	Determination of BTEX by headspace GC-MS	E001
Soil	D	Cations	Determination of cations in soil by aqua-regia digestion followed by ICP-OES	E002
Soil	D	Chloride - Water Soluble (2:1)	Determination of chloride by extraction with water & analysed by ion chromatography	E009
Soil	AR	Chromium - Hexavalent	Determination of hexavalent chromium in soil by extraction in water then by acidification, addition of 1,5 diphenylcarbazide followed by colorimetry	E016
Soil	AR	Cyanide - Complex	Determination of complex cyanide by distillation followed by colorimetry	E015
Soil	AR	Cyanide - Free	Determination of free cyanide by distillation followed by colorimetry	E015
Soil	AR	Cyanide - Total	Determination of total cyanide by distillation followed by colorimetry	E015
Soil	D	Cyclohexane Extractable Matter (CEM)	Gravimetrically determined through extraction with cyclohexane	E011
Soil	AR	Diesel Range Organics (C10 - C24)	Determination of hexane/acetone extractable hydrocarbons by GC-FID	E004
Soil	AR	Electrical Conductivity	Determination of electrical conductivity by addition of saturated calcium sulphate followed by electrometric measurement	E022
Soil	AR	Electrical Conductivity	Determination of electrical conductivity by addition of water followed by electrometric measurement	E023
Soil	D	Elemental Sulphur	Determination of elemental sulphur by solvent extraction followed by GC-MS	E020
Soil	AR	EPH (C10 – C40)	Determination of acetone/hexane extractable hydrocarbons by GC-FID	E004
Soil	AR	EPH Product ID	Determination of acetone/hexane extractable hydrocarbons by GC-FID	E004
Soil	AR	EPH TEXAS (C6-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C40)	Determination of acetone/hexane extractable hydrocarbons by GC-FID for C8 to C40. C6 to C8 by headspace GC-MS	E004
Soil	D	Fluoride - Water Soluble	Determination of Fluoride by extraction with water & analysed by ion chromatography	E009
Soil	D	FOC (Fraction Organic Carbon)	Determination of fraction of organic carbon by oxidising with potassium dichromate followed by titration with iron (II) sulphate	E010
Soil	D	Loss on Ignition @ 450oC	Determination of loss on ignition in soil by gravimetrically with the sample being ignited in a muffle furnace	E019
Soil	D	Magnesium - Water Soluble	Determination of water soluble magnesium by extraction with water followed by ICP-OES	E025
Soil	D	Metals	Determination of metals by aqua-regia digestion followed by ICP-OES	E002
Soil	AR	Mineral Oil (C10 - C40)	Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE cartridge	E004
Soil	AR	Moisture Content	Moisture content; determined gravimetrically	E003
Soil	D	Nitrate - Water Soluble (2:1)	Determination of nitrate by extraction with water & analysed by ion chromatography	E009
Soil	D	Organic Matter	Determination of organic matter by oxidising with potassium dichromate followed by titration with iron (II) sulphate	E010
Soil	AR	PAH - Speciated (EPA 16)	Determination of PAH compounds by extraction in acetone and hexane followed by GC-MS with the use of surrogate and internal standards	E005
Soil	AR	PCB - 7 Congeners	Determination of PCB by extraction with acetone and hexane followed by GC-MS	E008
Soil	D	Petroleum Ether Extract (PEE)	Gravimetrically determined through extraction with petroleum ether	E011
Soil	AR	pH	Determination of pH by addition of water followed by electrometric measurement	E007
Soil	AR	Phenols - Total (monohydric)	Determination of phenols by distillation followed by colorimetry	E021
Soil	D	Phosphate - Water Soluble (2:1)	Determination of phosphate by extraction with water & analysed by ion chromatography	E009
Soil	D	Sulphate (as SO4) - Total	Determination of total sulphate by extraction with 10% HCl followed by ICP-OES	E013
Soil	D	Sulphate (as SO4) - Water Soluble (2:1)	Determination of sulphate by extraction with water & analysed by ion chromatography	E009
Soil	D	Sulphate (as SO4) - Water Soluble (2:1)	Determination of water soluble sulphate by extraction with water followed by ICP-OES	E014
Soil	AR	Sulphide	Determination of sulphide by distillation followed by colorimetry	E018
Soil	D	Sulphur - Total	Determination of total sulphur by extraction with aqua-regia followed by ICP-OES	E024
Soil	AR	SVOC	Determination of semi-volatile organic compounds by extraction in acetone and hexane followed by GC-MS	E006
Soil	AR	Thiocyanate (as SCN)	Determination of thiocyanate by extraction in caustic soda followed by acidification followed by addition of ferric nitrate followed by colorimetry	E017
Soil	D	Toluene Extractable Matter (TEM)	Gravimetrically determined through extraction with toluene	E011
Soil	D	Total Organic Carbon (TOC)	Determination of organic matter by oxidising with potassium dichromate followed by titration with iron (II) sulphate	E010
Soil	AR	TPH CWG (ali: C5- C6, C6-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C34, aro: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C35)	Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE cartridge for C8 to C35. C5 to C8 by headspace GC-MS	E004
Soil	AR	TPH LQM (ali: C5-C6, C6-C8, C8-C10, C10 C12, C12-C16, C16-C35, C35-C44, aro: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C35, C35-C44)	Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE cartridge for C8 to C44. C5 to C8 by headspace GC-MS	E004
Soil	AR	VOCs	Determination of volatile organic compounds by headspace GC-MS	E001
Soil	AR	VPH (C6-C8 & C8-C10)	Determination of hydrocarbons C6-C8 by headspace GC-MS & C8-C10 by GC-FID	E001

D Dried
AR As Received