ground&water

GROUND INVESTIGATION REPORT

for the site at

8A BELMONT STREET, CHALK FARM, LONDON NW1 8HH

on behalf of

ELI NATHENSON

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<tr><td colspan="2">Report Reference: GWPR1534/GIR/Aug 2016</td><td>Status: FINAL</td></tr>
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1.0 INTRODUCTION

1.1 General

Ground and Water Limited were instructed by Eli Nathenson on the 12th January 2016 to conduct a Ground Investigation at 8A Belmont Street, Chalk Farm, London NW1 8HH. The scope of the investigation was detailed within the Ground and Water Limited fee proposal ref: GWQ2699Rev2 dated 11th January 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 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.

This revision of the report supersedes any previously identified.

The amendments made to the previous report are as follows:

- Undrained shear strength interpretation amended, including reference to Shioi-Fukui removed.
- Bearing capacity and settlement information amended.

2.0 SITE SETTING

2.1 Site Location

The site comprised a 300m^2 rectangular shaped plot of land, orientated in a north-east to south-west direction, located to the south/south-west of Belmont Street, ~70m north-east of Haverstock Hill/Chalk Farm Road. The site was located in the Camden Town/Chalk Farm area of north-west London, within the London Borough of Camden.

The national grid reference for the centre of the site was approximately TQ 28327 84399. A site location plan is given within Figure 1. A plan showing the boundary of the site is provided in Figure 2.

2.2 Site Description

The site was understood to comprise a now closed cafe/restaurant within a single storey elongated rectangular brick building. The site was located adjacent to a high rise residential apartment complex of No. 10a. Double gated access led to a paved off-street parking area. It is understood that the paved landscaping surrounding the property is joint access with the apartment complex.

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

2.3 Proposed Development

At the time of reporting, July 2016, the proposed development is understood to comprise the demolition of the existing properties and construction of a pair of semi-detached two storey residential houses with roof accommodation and basements. The basements are anticipated to be constructed at 3.50m bgl.

It is understood that a contiguous piles wall is being considered in order to aid construction of the basement.

A plan and section view of the proposed development can be seen in Figure 4.

2.4 Geology

The BGS Geological Map (Solid and Drift) for the North London area (Sheet No. 256), and Figure 3 and 4 of the Camden Geological, Hydrogeological and Hydrological Study, revealed that the site was underlain by the London Clay Formation.

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.

A BGS borehole ~60m south of the site revealed 5.30m of Made Ground over a brown/blue mottled fissured clay, becoming a dark brown fissured clay with depth. The soils of the London Clay Formation were proved to 18.20m bgl.

No areas of Made Ground or Worked Ground were noted within a 250m radius of the site.

2.5 Slope Stability and Subterranean Developments

The site was not situated within an area where a natural or man-made slope of greater than 7^o was present (Figure 16 Camden Geological, Hydrogeological and Hydrological Study).

Figure 17 of the Camden Geological, Hydrogeological and Hydrological Study indicated that the site was not situated within an area prone to landslides.

Figure 18 of the Camden Geological, Hydrogeological and Hydrological Study indicated that the Northern Underground Line was located running north-west to south-east ~95m south-west of the site. No other major subterranean infrastructure (including existing and proposed tunnels) were noted within close proximity to the site.

2.6 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, revealed the site to be located on **Unproductive Strata** relating to the bedrock deposits of the London Clay Formation. No designation was given for any superficial deposits due to their likely absence.

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, and Figure 8 of the Camden Geological, Hydrogeological and Hydrological Study, 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.

No surface water features were noted within a 250m radius of the site.

From analysis of hydrogeological and topographical maps groundwater was anticipated to be encountered at depth (>7m below existing ground level (bgl)) and it was considered that the groundwater was flowing in a south-easterly direction in alignment with the local topography.

Examination of the Environment Agency records showed that the site was **not** situated within flood zone or flood warning area.

2.7 Radon

BRE 211 (2015) Map 5 of the London, Sussex and west Kent area revealed the site was located within an area where mandatory protection measures against the ingress of Radon were **unlikely 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

Fieldwork was undertaken on the 19th January and the 2nd February 2016 and comprised the drilling of one Window Sampler Borehole (WS1) to a depth of 4.00m bgl. A Super Heavy Dynamic Probe (SHDP) (DP1) was undertaken adjacent to WS1 to a depth of 10.00m bgl.

A small diameter combined bio-gas and groundwater monitoring well was installed within WS1 to 2.70m bgl. The construction of the well installed can be seen tabulated below.

Combined Bio-gas and Groundwater Monitoring Well Construction				
Trial Hole	**Depth of Installation (m bgl)**	**Depth of slotted piping with gravel filter pack (m)**	**Depth of plain piping with bentonite seal (m bgl)**	**Piping external diameter (mm)**
WS1	2.70	2.70	1.00	19

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

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

3.2 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.

4.0 ENCOUNTERED GROUND CONDITIONS

4.1 Soil Conditions

All exploratory holes were logged by Megan James 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 generally conformed to that anticipated from examination of the geology map. Made Ground was noted to overlie 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 London Clay Formation at particular points, reference must be made to the individual trial hole log within Appendix B.

The trial hole location plan can be viewed in Figure 5.

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

Made Ground
London Clay Formation

Made Ground

Made Ground was encountered from ground level to 2.20m bgl. Concrete was encountered from ground level to 0.15m bgl. From 0.15m to 1.70m bgl the Made Ground was described as a light brown clayey sand and gravel. The sand was fine to coarse grained. The gravel was occasional to abundant, fine to coarse, sub-angular to sub-rounded flint, brick and concrete. From 1.70m to 2.20m bgl the Made Ground comprised a grey/brown sandy gravelly silty clay. The sand was fine to coarse grained. The gravel was occasional, fine to coarse, sub-angular to sub-rounded carbonaceous material (coal/ash), brick and flint. Soft dark blue/grey lenses were also noted.

London Clay Formation

Soils described as representative of the London Clay Formation were encountered underlying the Made Ground within WS1 for the remaining depth of the borehole, a maximum of 4.00m bgl. The London Clay Formation was noted to comprise brown, with occasional orange brown and grey mottling, silty clay.

For details of the composition of the soils encountered at particular points, reference must be made to the individual trial hole log within Appendix B.

4.2 Roots Encountered

No roots were encountered within WS1.

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.

4.3 Groundwater Conditions

No groundwater was encountered during the drilling of the borehole. A return visit to site on the 8th March 2016 revealed a standing water level of 2.10m bgl within the well installed in WS1.

The standing water level recorded in WS1 during the return visit is likely to represent surface water or perched groundwater migrating through the Made Ground or silt/sand horizons within the London Clay Formation and collecting within the installed standpipe.

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 January and March 2016, when groundwater levels should be near their annual maximum (i.e. highest). 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 the intrusive investigation.

5.0 INSITU AND LABORATORY GEOTECHNICAL TESTING

5.1 In-Situ Geotechnical Testing

A Super Heavy Dynamic Probe (SHDP) (DP1) was undertaken adjacent to WS1 to a depth of 10.00m bgl. The test results are presented within Appendix B.

Window Sampler Boreholes provide samples of the ground for assessment but they do not give any engineering data.

Super Heavy 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 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 Dynamic Probe 'Super Heavy' (SHDP) Tests were conducted in accordance with BS 1377; 1990; Part 9, Clause 3.2).*

The cohesive soils of the Made Ground and London Clay Formation were classified based on the table below.

Undrained Shear Strength from Field Inspection/equivalent 'SPT's derived from SHDP 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	-

The granular soils of the Made Ground were classified based on the table below.

Correlation between Equivalent SPT "N" Blow Counts derived from HDP and granular classification.	
Classification	**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 overleaf.

Interpretation of In-situ Geotechnical Testing Results					
Strata	Equivalent SPT "N" Blow Counts derived from SHDP	Equivalent Undrained Shear Strength (kPa) Cohesive Soils (Based on Stroud 1974)	Soil Type		Trial Hole/s
			Cohesive	Granular	
Made Ground	0 – 4	<10 – 20	Extremely low – very low/low	Very Loose - Loose	*DP1 (GL – 2.60m bgl)
London Clay Formation	8 – 15	40 - 75	Medium	-	*DP1 (2.60 – 3.70m bgl)
London Clay Formation	15 - >30	75 - >150	High		*DP1 (3.70 – 5.10m bgl)
London Clay Formation**	>30	>150	Very High +	-	*DP1 (5.10 – 10.00m bgl)

*Depth inferred from results of Super Heavy Dynamic Probe (SHDP)
**Assumed London Clay Formation, assumed from the results of the dynamic probing

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 within Appendix B.

5.2 Laboratory Geotechnical Testing

A programme of geotechnical laboratory testing scheduled by Ground and Water Limited and carried out by K4 Soils Laboratory Limited was undertaken on samples recovered from the London Clay Formation. 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	3
One Dimensional Swelling Test	BS1377:1990:Part 5:Clause 3 & 4	1
Water Soluble Sulphate & pH	BS1377:1990:Part 3:Clause 5	2

5.2.1 Atterberg Limit Tests

The results of Atterberg Limit Tests undertaken on three samples of the London Clay Formation can be seen tabulated overleaf.

Atterberg Limit Tests Results Summary							
Stratum/Trial Hole/Depth (m bgl)	Moisture Content (%)	Passing 425 µm sieve (%)	Modified PI (%)	Soil Class	Consistency Index (Ic)	Volume Change Potential	
						BRE	NHBC
London Clay Formation WS1/2.50m bgl	31	95	43.70	CV	Stiff	High	High
London Clay Formation WS1/3.00m bgl	32	100	50.00	CV	Stiff	High	High
London Clay Formation WS1/3.50m bgl	31	99	50.49	CV	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 ISO 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 three 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 overpage.

The test results are presented within Appendix C.

Liquidity Index Calculations Summary					
Stratum/Trial Hole/Depth	Moisture Content (%)	Plastic Limit (%)	Modified Plasticity Index (%)	Liquidity Index	Result
London Clay Formation WS1/2.50m bgl (Greyish brown slightly sandy slightly gravelly silty CLAY (gravel is fm and sub-angular))	31	28	43.70	0.07	Heavily Overconsolidated
London Clay Formation WS1/3.00m bgl (Brown silty CLAY with rare pockets of fine sand/silt)	32	27	50.00	0.10	Heavily Overconsolidated
London Clay Formation WS1/3.50m bgl (Brown silty CLAY with rare selenite crystals)	31	28	50.49	0.06	Heavily Overconsolidated

The results in the table above indicated that there were no moisture deficits 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 WS1/2.50m bgl (Greyish brown slightly sandy slightly gravelly silty CLAY (gravel is fm and sub-angular))	31	74	29.6	MC > 0.4 x LL (Not Significantly Desiccated)
London Clay Formation WS1/3.00m bgl (Brown silty CLAY with rare pockets of fine sand/silt)	32	77	30.8	MC > 0.4 x LL (Not Significantly Desiccated)
London Clay Formation WS1/3.50m bgl (Brown silty CLAY with rare selenite crystals)	31	79	31.6	**MC < 0.4 x LL (Potential Significant Moisture Deficit)**

The results in the table above indicated that a potential significant moisture deficit was present within one sample of the London Clay Formation tested (WS1/3.50m). The moisture content value was below 40% of the liquid limit.

The sample was described as a brown silty clay with rare selenite crystals. Roots were note encountered within the borehole. Consequently the apparent moisture deficit was likely to be related to the lithology of the soil (heavily overconsolidated soils) rather than the water demand of roots from nearby trees.

The results in the table above indicate that the remaining samples of the London Clay Formation tested showed no evidence of a significant moisture deficit.

5.2.3 One Dimensional Swelling Test

A one dimensional swelling test was undertaken on a disturbed sample obtained from WS1 at a depth of 4.00m bgl. The results of the test are tabulated below.

One Dimensional Consolidation Test - Swelling									
Stratum/Depth		**Height (mm)**	**Moisture Content (%)**	**Bulk Density (Mg/m^3)**	**Dry Density (Mg/m^3)**	**Void Ratio**	**Degree of Saturation (%)**	**Particle Density (Mg/m^3)**	**Swelling Pressure (kpa)**
London Clay Formation WS1/4.00m bgl (Orangish brown mottled bluish grey CLAY with occasional selenite crystals)	Initial	15.90	30.2	1.83	1.41	0.917	89	2.70	70
	Final	16.63	37.3	1.83	1.33	1.023	98		

It must be noted that the sample was remoulded and this must be taken into account in final design.

5.2.4 Sulphate and pH Tests

A sulphate and pH test was undertaken on two samples from the London Clay Formation (WS1/2.50m and WS1/3.50m bgl). The sulphate concentration in the samples ranged from 530 - 1230mg/l with a pH range of 7.74 – 7.78.

6.0 ENGINEERING CONSIDERATIONS

6.1 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 2.20m bgl.

  Super Heavy Dynamic Probing indicated the cohesive Made Ground to be of extremely low – very low/low (<10 – 20kpa – Stroud) undrained shear strength. The granular Made Ground was shown to be very loose to loose.

  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.

- Soils described as representative of the London Clay Formation were encountered underlying the Made Ground within WS1 (2.20m bgl) for the remaining depth of the borehole, a maximum of 4.00m bgl. The Super Heavy Dynamic Probe indicates the London Clay Formation might be noted from ~2.60m bgl.

  The deposits were noted to comprise a brown, with occasional orange brown and grey mottling, silty clay.

  The results of the Super Heavy Dynamic Probing indicated that the London Clay Formation, once encountered, was shown to have a medium undrained shear strength from 2.60 – 3.70m bgl, becoming high from 3.70 – 5.10m bgl. The undrained shear strength was very high from 5.10m bgl to 10.00m bgl.

  Geotechnical testing revealed the soils of the London Clay Formation have a **high volume change potential** in accordance with both BRE240 and NHBC Standards Chapter 4.2. Consistency Index calculations indicated these soils to be stiff. The deposits of the London Clay Formation were shown to be heavily overconsolidated cohesive soils.

  A potential significant moisture deficit was present within one sample of the London Clay Formation tested (WS1/3.50m bgl). The apparent moisture deficit was likely to be related to the lithology of the soil (heavily overconsolidated soils) rather than the water demand of roots from nearby trees.

  The heavily overconsolidated cohesive soils of the London Clay Formation were considered a suitable bearing stratum for moderately loaded footings/foundations. Settlements on loading are likely to be 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 desiccation and the likely serviceability and settlement requirements of the proposed structure. These parameters for design are discussed in the next section of this report.

- No groundwater was encountered during the drilling of the borehole. A return visit to site on the 8th March 2016 revealed a standing water level of 2.10m bgl within the well installed in WS1.

  The standing water level recorded in WS1 during the return visit is likely to represent surface water or perched groundwater migrating through the Made Ground or silt/sand horizons within the London Clay Formation and collecting within the installed standpipe.

- No roots were noted.

6.2 Basement Foundations

At the time of reporting, July 2016, the proposed development is understood to comprise the demolition of the existing properties and construction of a pair of semi-detached two storey residential houses with roof accommodation and basements. The basements are anticipated to be constructed at 3.50m bgl.

A plan showing the proposed development can be seen in Figure 4.

The proposed development is likely to fall within Geotechnical Design Category 2 in accordance with Eurocode 7. The proposed foundation loads were not known to Ground and Water Limited at the time of reporting but are likely to range from 75 – 150kN/m^2.

Foundations constructed within the soils of the London Clay Formation should be designed based on soils of **high 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.

No roots were encountered within the borehole.

Foundations must be taken through any Made Ground and into the underlying London Clay Formation.

The following bearing capacities could be adopted for 5.0m long by 0.75m and 1.0m wide footings, or 1.50m by 1.50m pads at depths of 3.50m bgl. The bearing capacities are tabulated overpage.

Limit State: Bearing Capacities Calculated (Based on DP1)		
Depth (m BGL)	Foundation System	Limit Bearing Capacity (kN/m^2) (EC2)
3.50m	5.00m by 0.75m Strip	175.57
	5.00m by 1.00m Strip	174.06
	1.50m by 1.50m Pad	199.80

Serviceability State: Settlement Parameters Calculated (Based on DP1)			
Depth (m BGL)	Foundation System	Limit Bearing Capacity (kN/m^2)	Settlement (mm)
3.50m	5.00m by 0.75m Strip	125	<10
	5.00m by 1.00m Strip	125	<8
	1.50m by 1.50m Pad	125	<9

It must be noted that a bearing capacity of less than 49kN/m^2 and 57kN/m^2 at 3.00m and 3.50m bgl respectively could result in heave due to a reduction in effective stress at depth. This will need to be taken into account in the final design. A swelling pressure of 70kPa was determined on a disturbed sample recovered from WS1 at 4.00m bgl.

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 level 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.

No groundwater was encountered during the drilling of the borehole. A return visit to site on the 8th March 2016 revealed a standing water level of 2.10m bgl within the well installed in WS1.

The standing water level recorded in WS1 during the return visit is likely to represent surface water or perched groundwater migrating through the Made Ground or silt/sand horizons within the London Clay Formation and collecting within the installed standpipe.

Based on the groundwater data obtained during the investigation it was considered unlikely that construction will take place at or below the groundwater table, but **perched will likely be encountered** migrating through the Made Ground or within silt/sand horizons within the London Clay Formation. The advice of a reputable dewatering contractor, familiar with the type of ground and groundwater conditions encountered on this site, should be sought prior to finalising the design of the excavation for the basement.

If the construction works take place during the winter months, when the groundwater level is expected to be at its higher elevation, additional perched water could accumulate.

General Recommendations for Spread Foundations:

- Foundation excavations must be carefully bottomed out and any loose soil or soft spots removed prior to the foundation concrete or blinding being placed. Failure to ensure that foundation excavations are suitably bottomed out could result in additional settlements.

- Inspection of foundation excavations, prior to concreting, must be made by a competent and suitably qualified person to check for any soft spots and to check for the presence of roots.

- The excavation must be kept dry as accumulation of water could result in increased settlements.

- Foundations must not be cast over foundations of former structures and/or other hard spots.

- Any groundwater or surface water ingress must be prevented from entering foundation trenches.

- Isolated Pad Foundations must be at least 1.5 times the width of the widest pad apart to keep to the anticipated settlements.

- Special foundation precautions will be required to prevent possible future shrinkage/swelling within clay strata affecting the integrity of the ground beams. A void, void former or compressible layer must be provided to accommodate potential movement below all ground beams. Compressible material or a void former should also be provided against the inside faces of ground beams.

- Final designs for the foundations should be carried out by a suitably qualified Engineer based on the findings of this investigation and with reference to the anticipated loadings, serviceability requirements for the structure and the developments proximity to former, present and proposed trees.

6.3 Piled Foundations

Based on the results of the investigation it was considered unlikely that a piled foundations scheme would be required at this site.

6.4 Basement Excavations and Stability

Shallow excavations in the Made Ground and London Clay Formation are likely to be marginally stable at best. Long, deep excavations, through 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 the following parameters could be used in the design of retaining walls. These have been designed based the results of geotechnical classification tests and reference to literature.

Retaining Wall/Basement Design Parameters					
Strata	**Unit Volume Weight (kN/m^3)**	**Cohesion Intercept (c') (kPa)**	**Angle of Shearing Resistance (Ø)**	**Ka**	**Kp**
Made Ground	~15	0	12	0.66	1.52
London Clay Formation	~20	0	20	0.49	2.04

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.

6.5 Hydrogeological Effects

A study of the aquifer maps on the Environment Agency website revealed the site to be located on **Unproductive Strata** relating to the bedrock deposits of the London Clay Formation. No designation was given for any superficial deposits due to their likely absence.

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

Based on a visual appraisal of the soils encountered, the permeability of the cohesive London Clay Formation was considered to be very low to negligible.

No groundwater was encountered during the drilling of the borehole. A return visit to site on the 8th March 2016 revealed a standing water level of 2.10m bgl within the well installed in WS1.

The standing water level recorded in WS1 during the return visit is likely to represent surface water or perched groundwater migrating through the Made Ground or silt/sand horizons within the London Clay Formation and collecting within the installed standpipe.

Based on the groundwater data obtained during the investigation it was considered unlikely that construction will take place at or below the groundwater table, but **perched will likely be encountered** migrating through the Made Ground or within silt/sand horizons within the London Clay Formation. The advice of a reputable dewatering contractor, familiar with the type of ground and groundwater conditions encountered on this site, should be sought prior to finalising the design of the excavation for the basement.

If the construction works take place during the winter months, when the groundwater level is expected to be at its higher elevation, additional perched water could accumulate.

It is recommended that the well installed is dipped prior to the commencement of construction.

Once constructed, the Made Ground and the London Clay Formation are unlikely to act as a porous medium for water to migrate through; therefore, additional drainage around the basement should be considered.

6.6 Sub-Surface Concrete

Sulphate concentrations were measured in 2:1 water/soil extracts taken from the London Clay Formation fell into class DS-2 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-2. For the classification given, the "mobile" and "natural" case was adopted given the presence of perched water and the residential use of the site. The sulphate concentration in the samples ranged from 530 - 1230mg/l with a pH range of 7.74 – 7.78.

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.

It is prudent to note that pyrite nodules may be present within the London Clay Formation. Pyrite can oxidise to gypsum and this normally only occurs in the upper weathered layer, but excavation allows faster oxidation and water soluble sulphate values can rapidly increase during construction. Therefore rising sulphate values should be taken into account should ferruginous staining/pyrite nodules be encountered within the London Clay Formation.

6.7 Surface Water Disposal

Infiltration tests were beyond the scope of the investigation.

Soakaways constructed within the cohesive soils of the London Clay Formation are unlikely to prove satisfactory due to very low to negligible 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 principles of sustainable urban drainage system (SUDS) should be applied to reduce the risk of flooding from surface water ponding and collection associated with the construction of the basement.

6.8 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.

6.9 Waste Disposal

Foundation excavations on-site are 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 classified 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).

6.10 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.

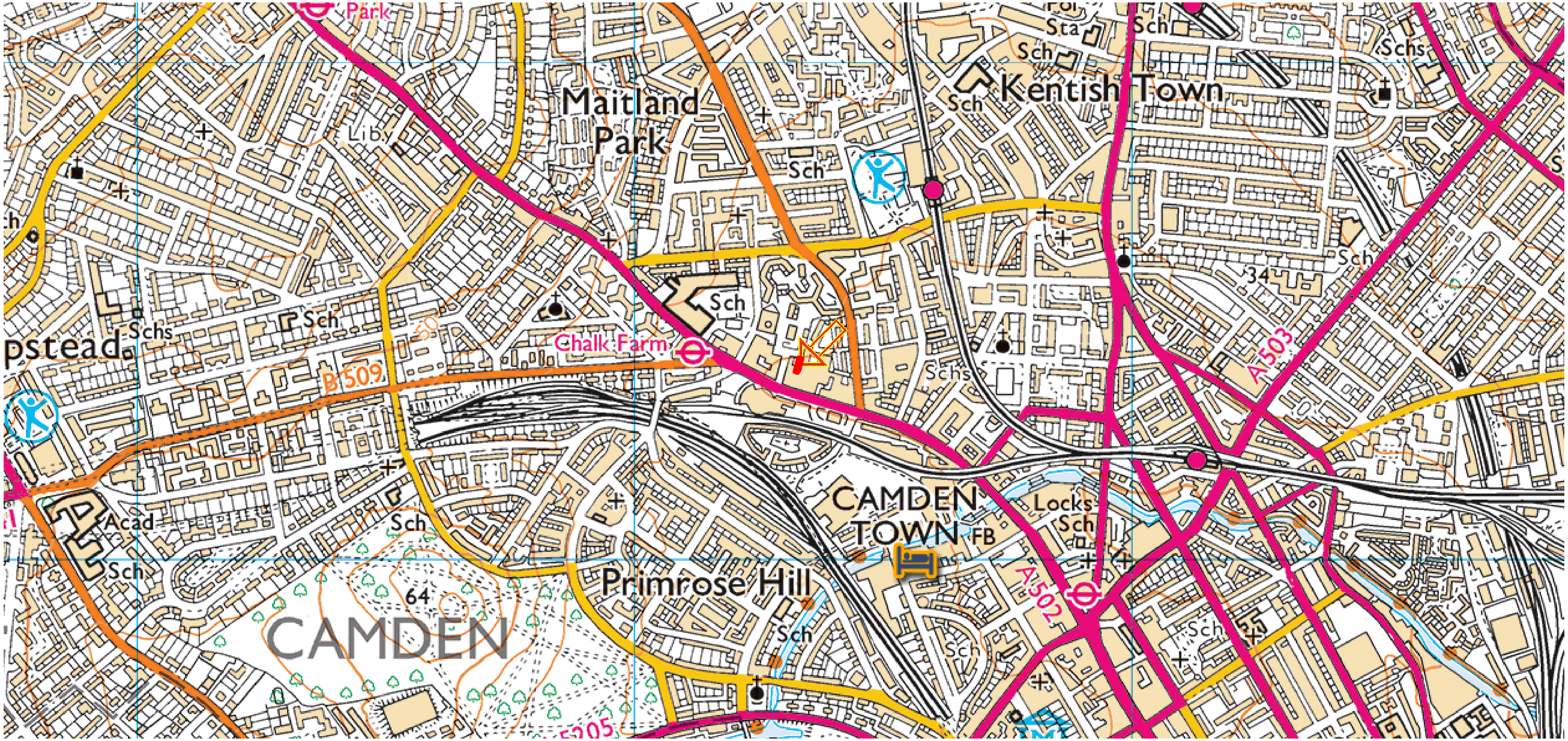
6.11 Duty of Care

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.

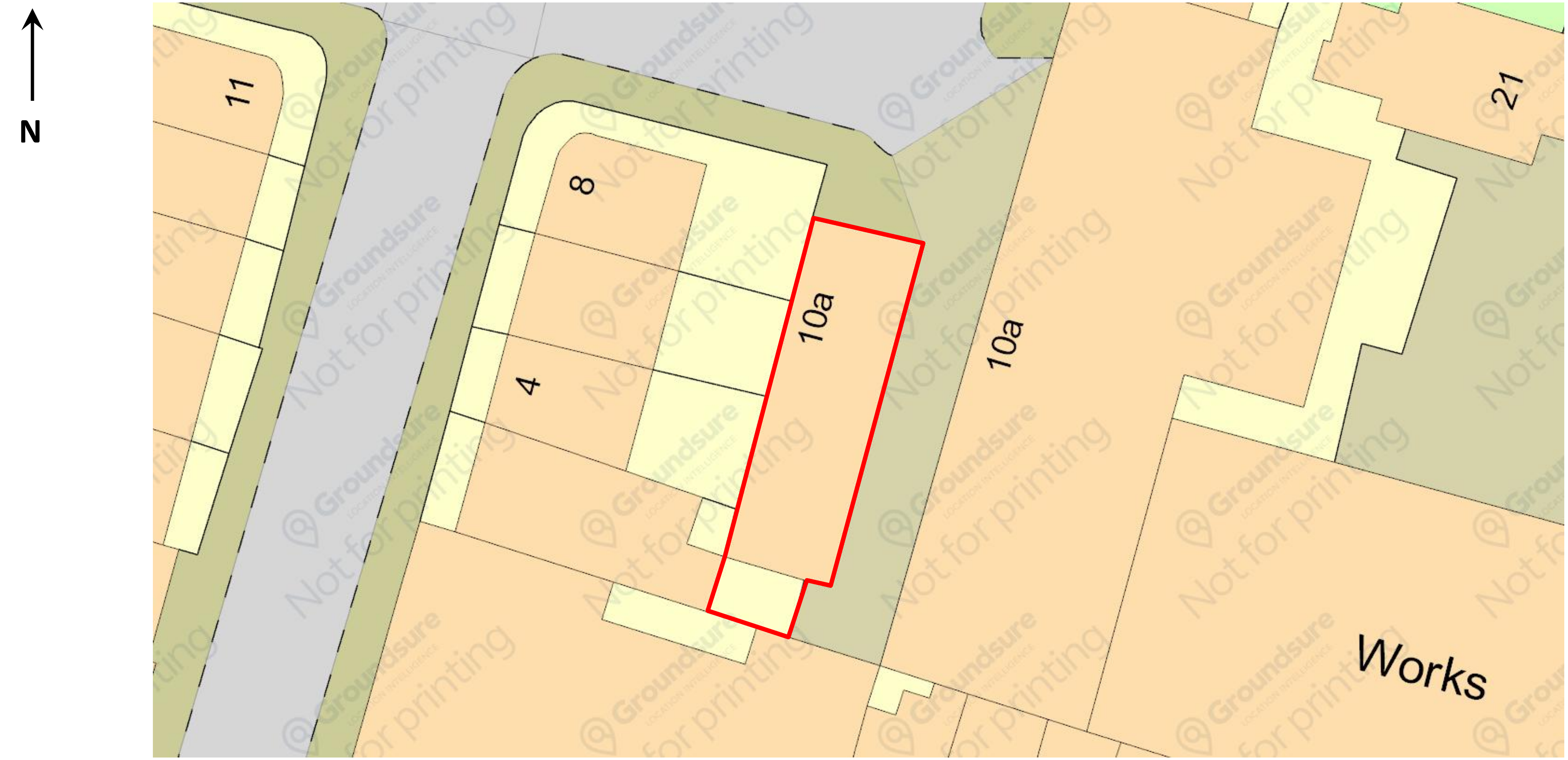
N



APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

Project: 8A Belmont Street, Chalk Farm, London NW1 8HH		**Figure 1**
Client: Eli Nathenson	**Date:** August 2016	ground&water
Site Location Plan	**Ref:** GWPR1534	



APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

Project: 8A Belmont Street, Chalk Farm, London NW1 8HH		Figure 2
Client: Eli Nathenson	Date: August 2016	ground&water
Site Development Area	Ref: GWPR1534	

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APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

Project: 8A Belmont Street, Chalk Farm, London NW1 8HH	Figure 3
Client: Eli Nathenson	Date: August 2016
Aerial View of Site	Ref: GWPR1534

ground&water

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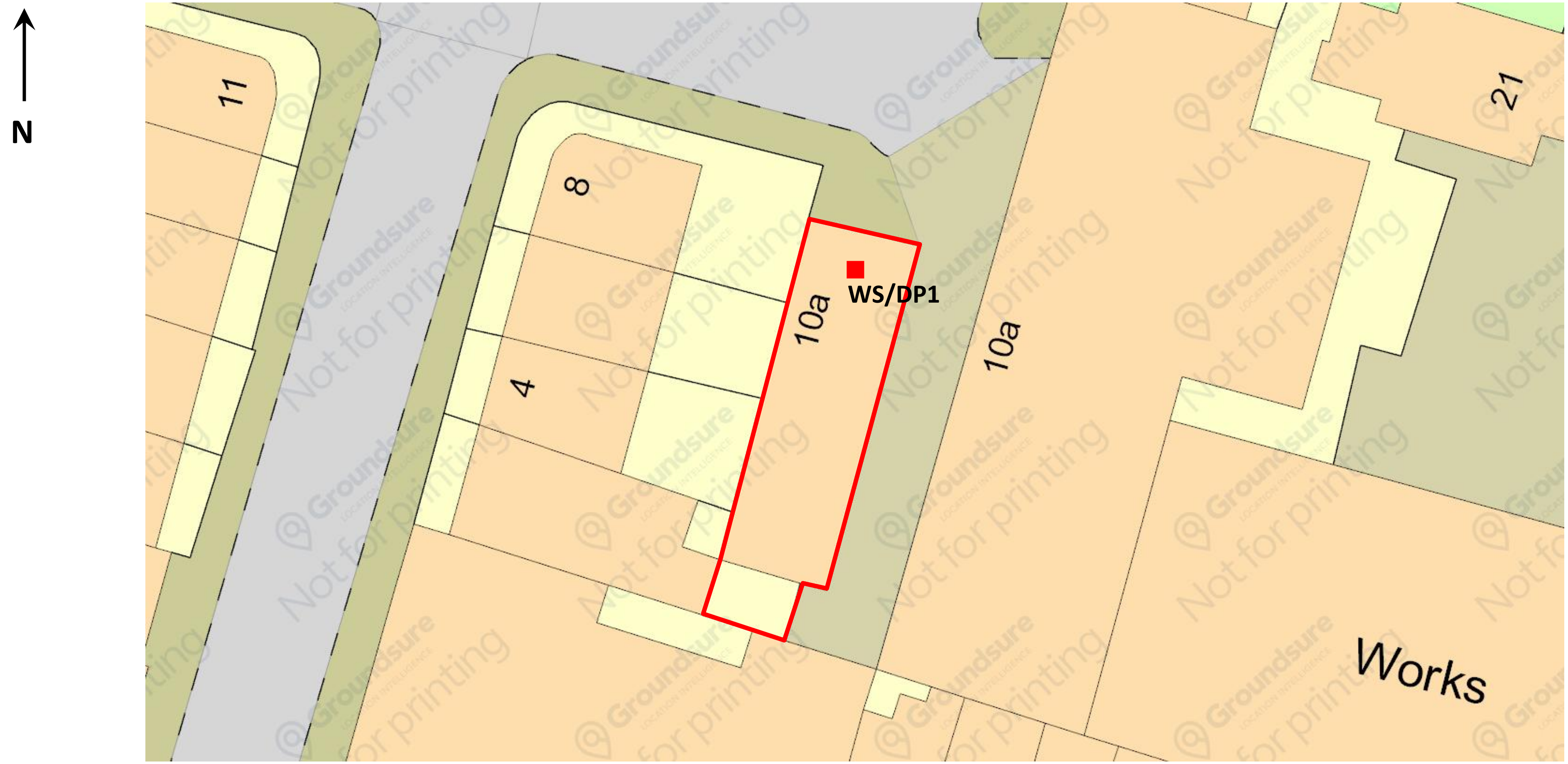
APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

Project: 8A Belmont Street, Chalk Farm, London NW1 8HH		**Figure 4**
Client: Eli Nathenson	**Date:** August 2016	ground&water
Proposed Development Plan	**Ref:** GWPR1534	



APPROXIMATE SITE BOUNDARY

NOTE: NOT TO SCALE

Project: 8A Belmont Street, Chalk Farm, London NW1 8HH		Figure 5
Client: Eli Nathenson	Date: August 2016	ground&water
Trial Hole Location Plan	Ref: GWPR1534	

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 8A Belmont Street, Chalk Farm, London NW1 8HH.

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
WS1
Sheet 1 of 1

Project Name	Project No.	Co-ords: -	Hole Type
8A Belmont Street	GWPR1534		WS
Location: London NW1 8HH		Level: -	Scale 1:50
Client: Eli Nathenson		Dates: 02/02/2016	Logged By MJ

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
					0.15			CONCRETE
		0.50	D					MADE GROUND: Light brown clayey sand and gravel. Sand is fine to coarse grained. Gravel is occasional to abundant, fine to coarse, sub-angular to sub-rounded flint, brick and concrete.
		0.80	D					
		1.00	D					
		1.50	D					
					1.70			
		2.00	D					MADE GROUND: Grey/brown sandy gravelly silty clay. Sand is fine to coarse grained. Gravel is occasional, fine to coarse, sub-angular to sub-rounded carbonaceous material (coal/ash), brick and flint. Soft dark blue/grey lenses noted.
					2.20			
		2.50	D					LONDON CLAY FORMATION: Brown with occasional orange brown and grey mottling silty CLAY.
		3.00	D					
		3.50	D					
		4.00	D		4.00			
								End of Borehole at 4.00 m

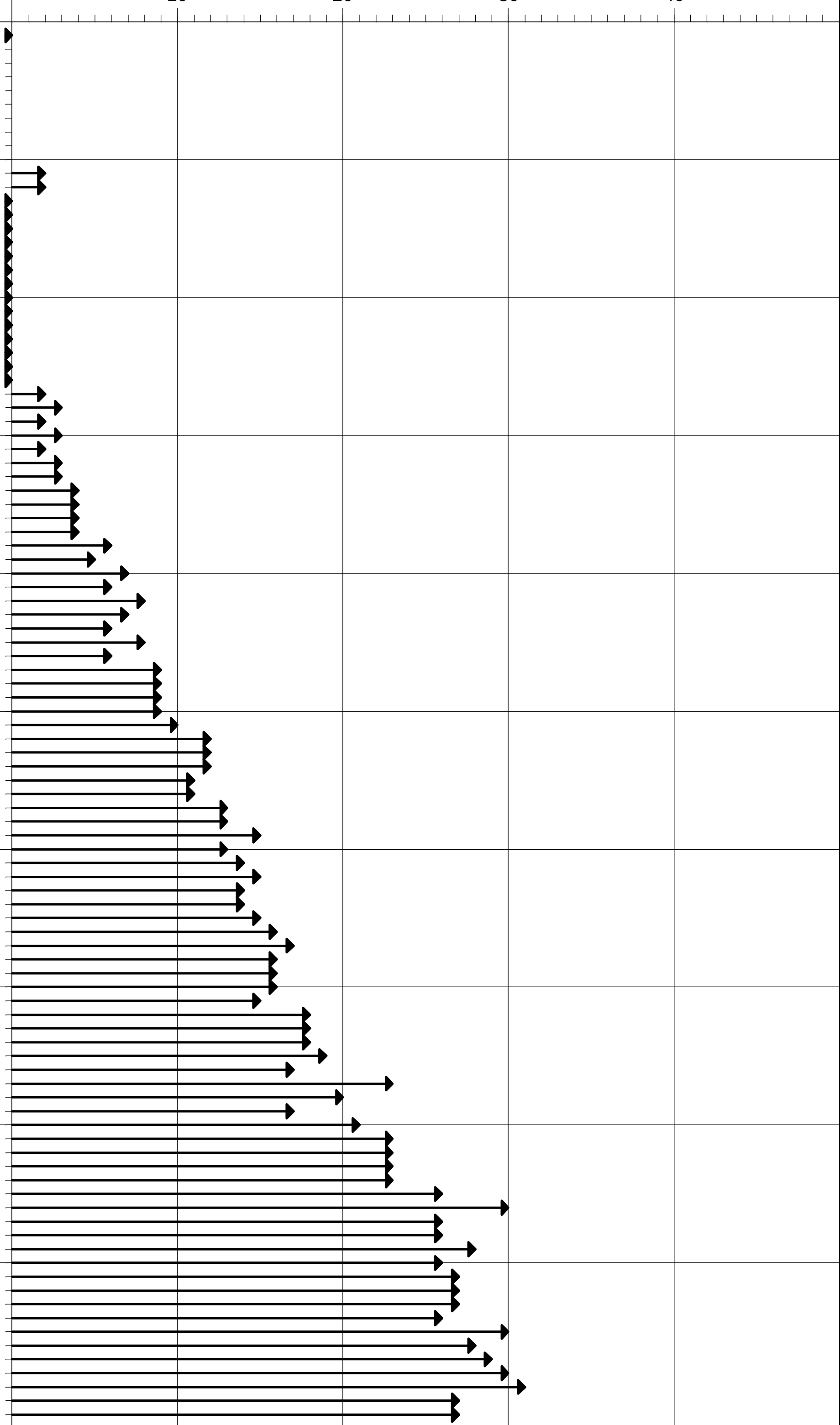
Remarks: No groundwater noted.
No roots noted.
19mm diameter standpipe installed to 2.70m bgl.

DYNAMIC PROBING

Probe No **DP1**			
Client **Eli Nathenson**		Sheet 1 of 1	
Site **8A Belmont Street**		*Project No* **GWPR1534**	
E **-**	*N* **-**	*Level* **-**	*Date* **19/01/2016** *Logged by* **BS Ltd**

Depth (m)	Readings Blows/100mm					Torque (Nm)
0.0	0	-	-	-	-	0
0.5	-	-	-	-	-	
1.0	2	2	0	0	0	
1.5	0	0	0	0	0	
2.0	0	0	0	0	0	
2.5	0	2	3	2	3	
3.0	2	3	3	4	4	
3.5	4	4	6	5	7	
4.0	6	8	7	6	8	
4.5	6	9	9	9	9	
5.0	10	12	12	12	11	
5.5	11	13	13	15	13	
6.0	14	15	14	14	15	
6.5	16	17	16	16	16	
7.0	15	18	18	18	19	
7.5	17	23	20	17	21	
8.0	23	23	23	23	26	
8.5	30	26	26	28	26	
9.0	27	27	27	26	30	
9.5	28	29	30	31	27	
10.0	27					

Diagram (N100 Values)



Ground and Water Ltd

Fall Height	**750**	*Cone Base Diameter*	**50**
Hammer Wt	**63.50**	*Final Depth*	**10.00**
Probe Type	**DPSH**	*Log Scale*	1:50

AGS

APPENDIX C
Geotechnical Laboratory Test Results

Summary of Classification Test Results

Job No.	Project Name	Programme	
20361	8A Belmont Street, London	Samples received	12/02/2016
		Schedule received	12/02/2016
Project No.	Client	Project started	15/02/2016
GWPR1534	Ground and Water Ltd	Testing Started	26/02/2016

Hole No.	Sample				Soil Description	NMC	Passing 425µm	LL	PL	PI	Remarks
	Ref	Top	Base	Type		%	%	%	%	%	
WS1		2.50		D	Greyish brown slightly sandy slightly gravelly silty CLAY (gravel is fm and sub-angular)	31	95	74	28	46	
WS1		3.00		D	Brown silty CLAY with rare pockets of fine sand/silt	32	100	77	27	50	
WS1		3.50		D	Brown silty CLAY with rare selenite crystals	31	99	79	28	51	

UKAS TESTING 2519

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

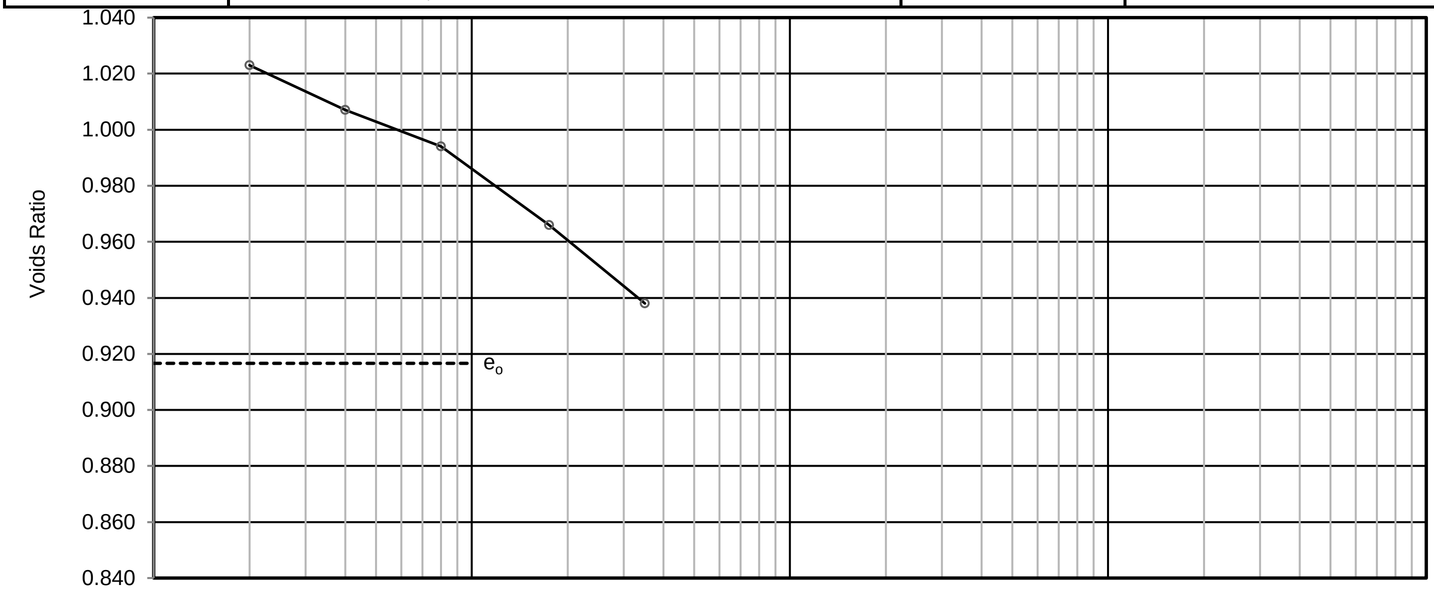
Test Report by K4 SOILS LABORATORY
Unit 8 Olds Close Olds Approach
Watford Herts WD18 9RU

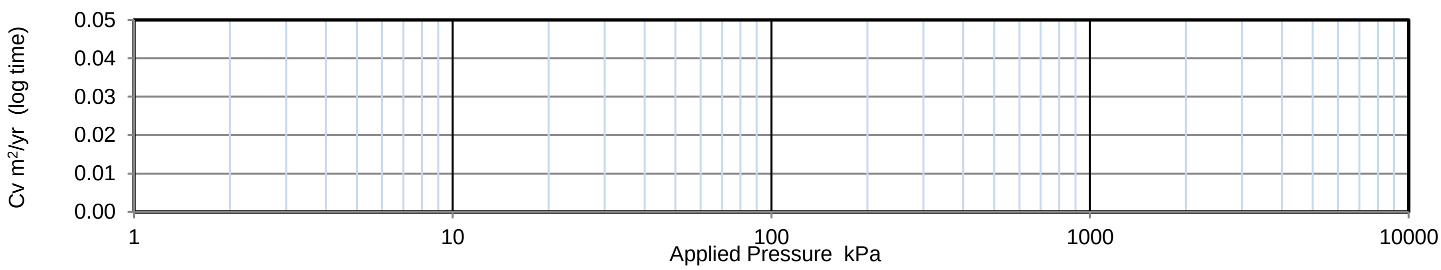
Tel: 01923 711 288
Email: James@k4soils.com

Checked and Approved
Initials **J.P**
Date: 01/03/2016

Approved Signatories: K.Phaure (Tech.Mgr) J.Phaure (Lab.Mgr)

	ONE DIMENSIONAL CONSOLIDATION TEST	Job Ref	20361
		Borehole/Pit No.	WS1
Site Name	8A Belmont Street, London	Sample No.	
Project ID	GWPR1534 · Client · Ground and Water Ltd	Depth	4.00
Soil Description	Orangish brown mottled bluish grey CLAY with occasional selenite crystals	Sample Type	D
		Sample Received	12/02/2016
		Schedule received	12/02/2016
		Project Started	15/02/2016
Test Method	BS1377:Part 5:1990, clause 3	Date Test started	23/02/2016





Applied Pressure kPa	Voids ratio	Mv m2/MN	Cv (t50, log) m2/yr	Cv (t90, root) m2/yr	Csec
70.0	0.917	-	-	-	-
35	0.938	0.32			
18	0.966	0.84			
8	0.994	1.5			
4	1.007	1.5			
2	1.023	4.1			

Preparation

Orientation wthin sample: Vertical

Particle density: assumed 2.70 Mg/m3

Specimen details	Initial	Final	
Diameter	75.05	-	mm
Height	15.96	16.85	mm
Moisture Content	30.2	37.3	%
Bulk density	1.83	1.83	Mg/m3
Dry density	1.41	1.33	Mg/m3
Voids Ratio	0.917	1.023	
Saturation	89	98	%
Average temperature for test	20.0		oC
Swelling Pressure	70		kPa
Settlement on saturation			%

Remarks

Test Report by K4 SOILS LABORATORY
Unit 8 Olds Close Olds Approach
Watford Herts WD18 9RU
Tel: 01923 711 288
Email: James@k4soils.com

UKAS TESTING 2519

Checked and Approved

Initials K.P

Date: 03/03/2016

Approved Signatories: K.Phaure (Tech.Mgr) J.Phaure (Lab.Mgr)

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	
20361	8A Belmont Street, London	Samples received	12/02/2016
		Schedule received	12/02/2016
Project No.	Client	Project started	15/02/2016
GWPR1534	Ground and Water Ltd	Testing Started	22/02/2016

Hole No.	Sample				Soil description	Dry Mass passing 2mm	SO3 Content	SO4 Content	pH	Remarks
	Ref	Top	Base	Type		%	g/l	g/l		
WS1		2.50		D	Greyish brown slightly sandy slightly gravelly silty CLAY (gravel is fm and sub-angular)	95	0.44	0.53	7.74	
WS1		3.50		D	Brown silty CLAY with rare selenite crystals	99	1.03	1.23	7.78	