Phase II Ground Investigation Report

at
Newhouse School, Hanworth Road, Hampton, London, TW12 3LT

for
London Borough of Richmond Upon Thames

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This is not a valid document for use in the design of the project unless it is titled Final in the document status box.

Current regulations and good practice were used in the preparation of this report. The recommendations given in this report must be reviewed by an appropriately qualified person 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.

Commission

Soils Limited was commissioned by London Borough of Richmond Upon Thames to undertake a Phase II Ground Investigation on land at Newhouse School, Hanworth Road, Hampton, London, TW12 3LT. The scope of the investigation was outlined in the Soils Limited quotation reference Q18162, dated 10th November 2016.

This document comprises the Phase II Ground Investigation Report and incorporates the results, discussion and conclusions to this intrusive works.

A Phase I Desk Study was not commissioned by the client and nor was a complete Phase I desk study provided to soils limited, therefore it was not possible to create, revise or test a conceptual site model.

Standards

The site works, soil descriptions and geotechnical testing was undertaken in accordance with the following standards:

- BS 5930:2015 and BS EN ISO 22476-2 2005+A1:2011 for WS/DP
- BS EN 1997-1:2004+A1:2013 Eurocode 7. Geotechnical design
- BS EN ISO 14688-1:2002+A1:2013 - Geotechnical investigation and testing - Identification and description
- BS EN ISO 14688-2:2004+A1:2013 - Geotechnical investigation and testing - Principles for a classification

The geotechnical laboratory testing was performed by GEO Site & Testing Services Ltd (GSTL) in accordance with the methods given in BS 1377:1990 Parts 1 to 8 and their UKAS accredited test methods.

For the preparation of this report, the relevant BS code of practice was adopted for the geotechnical laboratory testing technical specifications, in the absence of the relevant Eurocode specifications (ref: ISO TS 17892).

The chemical analyses were undertaken by QTS Environmental Limited in accordance with their UKAS and MCERTS accredited test methods or their documented in-house testing procedures. This investigation did not comprise an environmental audit of the site or its environs.

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

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Section 1 Introduction

1.1 Objective of Investigation

Soils Limited was commissioned by London Borough of Richmond Upon Thames to undertake a Phase II Ground Investigation to supply the client and their designers with information regarding ground conditions, to assist in preparing a foundation scheme for development that was appropriate to the settings present on the site.

The investigation was to be undertaken to provide comment on appropriate foundation options for the proposed school development. The investigation was to be made by means of in-situ testing and geotechnical laboratory testing undertaken on soil samples taken from the trial holes.

Soil samples were taken for chemical laboratory testing to enable recommendations for the safe redevelopment of the site and the protection of site workers, end-users and the public from a wide range of common contaminants. A Phase I Desk Study was not commissioned, nor was a complete Phase I Desk Study provided, therefore it was not possible to target test locations and depths based on a conceptual site model.

1.2 Location

The site was located at Newhouse School, Hanworth Road, Hampton, London, TW12 3LT and had an approximate O.S Land Ranger Grid Reference of TQ 12903 71124.

The site location plan is given in Figure 1.

1.3 Site Description

At the time of reporting the site comprised several single and double storey school buildings, tarmacked play areas and soft landscaped areas.

An aerial photograph has been included in Figure 2.

1.4 Proposed Development

The proposed development comprised extensions to the existing assembly hall, reception classroom, KS2 classroom and toilets.

In compiling this report reliance was placed on drawing number 2010 Stage F, Rev 1, Dated 17.05.2016 and was prepared by DHP Architects. Any change or deviation from the scheme outlined in the drawing could invalidate the foundation design and remediation recommendations presented within this report. Soils Limited must be notified about any such changes.

Development plans provided by the client are presented in Appendix D.

1.5 Anticipated Geology

The 1:50,000 BGS map showed the site to be located on bedrock of the London Clay Formation with overlying superficial deposits of Taplow Gravel Formation.

1.5.1 Taplow Gravel Formation

The rivers of the south-east of England, including the River Thames and its tributaries, have been subject to at least three changes of level since Pleistocene times. One result has been the formation of a complex series of River Terrace Gravels. These terraces represent ancient floodplain deposits that became isolated as the river cut downwards to lower levels. The Taplow Gravel is found at an elevation that approximates to the present floodplain gravel

The composition of the River Terrace Gravel varies greatly, depending on the source material available in the river's catchment. Deposits generally consist of sands and gravels of roughly bedded flint or chert gravels commonly in a matrix of silts and clays.

1.5.2 London Clay Formation

London Clay comprises a 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, and precautions against sulphate attack to concrete are sometimes required.

The lowest part of the formation is a sandy beds with black rounded gravel and occasional layers of sandstone and is known as the Basement Beds.

1.6 Limitations and Disclaimers

This Phase II Ground Investigation Report relates to the site located at Newhouse School, Hanworth Road, Hampton, London, TW12 3LT and was prepared for the sole benefit of London Borough of Richmond Upon Thames (The "Client"). The report was prepared solely for the brief described in Section 1.1 of this report.

Soils Limited disclaims any responsibility to the Client and others in respect of any matters outside the scope of the above.

This report has been prepared by Soils Limited, with all reasonable skill, care and diligence within the terms of the Contract with the Client, incorporation of our General Conditions of Contract of Business and taking into account the resources devoted to us by agreement with the Client.

The report is personal and confidential to the Client and Soils Limited accept no responsibility of whatever nature to third parties to whom this report, or any part thereof, is made known. Any such party relies on the report wholly at its own risk.

The Client may not assign the benefit of the report or any part to any third party without the written consent of Soils Limited.

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 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.

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.

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. Supplied site surveys may not include substantial shrubs or bushes and is also unlikely to have data or any trees, bushes or shrubs removed prior to or following the site survey.

Where trees are mentioned in the text this means existing trees, substantial bushes or shrubs, recently removed trees (approximately 20 years to full recovery on cohesive soils) and those planned as part of the site landscaping).

Ownership of land brings with it onerous legal liabilities in respect of harm to the environment. “Contaminated Land” is defined in Section 57 of the Environment Act 1995 as:

“Land which is in such a condition by reason of substances in, on or under the land that significant harm is being caused or that there is a significant possibility of such harm being caused or that pollution of controlled waters is being, or is likely to be caused”.

The investigation, analysis or recommendations in respect of contamination are made solely in respect of the prevention of harm to vulnerable receptors, using where possible best practice at the date of preparation of the report. The investigation and report do not address, define or make recommendations in respect of environmental liabilities. A separate environmental audit and liaison with statutory authorities is required to address these issues.

Ownership of copyright of all printed material including reports, laboratory test results, trial pit and borehole log sheets, including drillers log sheets remains with Soils Limited.

License is for the sole use of the client and may not be assigned, transferred or given to a third party

Section 2 Site Works

2.1 Proposed Project Works

The proposed intrusive investigation was designed to provide information on the ground conditions and to aid the design of foundations for the proposed development. The intended investigation, as outlined within the Soils Limited quotation (Q18162, dated 10th November 2016), was therefore to comprise the following items:

- 1Day. Windowless Sampling and Dynamic Probing;
- 3No. Hand Excavated Foundation Exposures;
- Geotechnical laboratory testing;
- Contamination laboratory testing.

2.1.1 Actual Project Works

The actual project works were undertaken on 5th December 2016 and comprised:

- 3No. Windowless Sampler and Dynamic Probe Boreholes;
- 3No. Hand Excavated Foundation Exposures;
- Geotechnical laboratory testing
- Chemical laboratory testing.

Three windowless sampler boreholes (WS1, WS2 and WS3) were backfilled with gravel upon completion. All trial hole locations have been presented in Figure 3.

Following completion of site works, soil cores were logged and sub sampled so that samples could be sent to the laboratory for both contamination and geotechnical testing.

2.2 Ground Conditions

On 5th December 2016 three windowless sampler boreholes (WS1 – WS3) were drilled, using a Premier tracked windowless sampler and dynamic probing drilling rig, to depths ranging between 1.10 and 1.60m below ground level (bgl) at locations selected by Soils Limited using a development plan provided by the client.

Three super heavy dynamic probes, (DP2a, DP2b and DP3) were driven prior and adjacent to their corresponding windowless sampler borehole to depths ranging between 1.20 and 1.80m bgl.

Three hand dug foundation exposures were excavated at locations selected by soils limited based on the provided proposed development plan. The maximum depths of trial holes have been included in Table 2.1.

All trial holes were scanned with a Cable Avoidance Tool (C.A.T.) and GENNY prior to excavation to ensure the health and safety of the operatives.

Table 2.1 Final Depth of Trial Holes

Trial Hole	Depth (m bgl)	Trial Hole	Depth (m bgl)
WS1	1.10	FE3	1.10
WS2	1.60	DP2a	1.80
WS3	1.10	DP2b	1.50
FE1	1.10	DP3	1.20
FE2	0.60		

Note:

The approximate trial hole locations are shown on Figure 3.

The soil conditions encountered were recorded and soil sampling commensurate with the purposes of the investigation was carried out. The depths given on the trial hole logs and quoted in this report were measured from ground level.

The soils encountered from immediately below ground surface have been described in the following manner. Where the soil incorporated an organic content such as either decomposing leaf litter or roots, or has been identified as part of the in-situ weathering profile, it has been described as Topsoil both on the logs and within this report. Where man has clearly either placed the soil, or the composition altered, with say greater than an estimated 5% of a non-natural constituent, it has been referred to as Made Ground both on the log and within this report.

For more complete information about the soils encountered within the general area of the site reference should be made to the detailed records given within Appendix A, but for the purposes of discussion, the succession of conditions encountered in the trial holes in descending order can be summarised:

Made Ground/Topsoil (MG/TS)
Taplow Gravel Formation (TGF)

The ground conditions encountered in the trial holes are summarised in

Table 2.2.

Table 2.2 Ground Conditions

Strata	Epoch	Depth Encountered (m bgl)		Typical Thickness (m)	Typical Description
		Top	Bottom		
MG	Holocene	0.00	0.50 – 0.75	0.70	Soft dark brown slightly sandy slightly gravelly clayey SILT with roots.
TGF	Pleistocene	0.50 – 0.75	>1.80[2]	Not proven	Orangish grey slightly clayey very sandy fine to coarse rounded to sub-rounded flint GRAVEL.

Note: [1] Final depth of trial hole. [2] Base of strata not encountered

2.3 Ground Conditions Encountered in Trial Holes

The ground conditions encountered in trial holes have been described below in descending order. The engineering logs are presented in Appendix A.1.

2.3.1 Made Ground

Soils described as Made Ground were encountered in each of the nine trial holes from surface to depths of between 0.45 and 1.00m bgl.

The Made Ground typically comprised soft dark brown slightly sandy slightly gravelly clayey SILT with roots. Sand is fine to medium. Gravel is fine to medium, sub-angular flint with brick and concrete fragments.

The depths of Made Ground have been included in Table 2.3

Table 2.3 Final Depth of Made Ground

Trial Hole	Strata	Depth (m bgl)
WS1	MG	0.45
WS2	MG	0.70
WS3	MG	0.70
FE1	MG	0.75
FE2	MG	0.60*
FE3	MG	0.50
DP2a	MG	1.00
DP2b	MG	0.90
DP3	MG	0.60

Notes: *=unit present to base of trial hole.

2.3.2 Taplow Gravel Formation

Soils described as the Taplow Gravel Formation were encountered in eight out of the nine trial holes immediately underlying the Made Ground and was present to the base of the investigation, 1.80m bgl.

The Taplow Gravel Formation typically comprised orangish grey slightly clayey very sandy fine to coarse rounded to sub-rounded flint GRAVEL.

The depth of Taplow Gravel Formation has been included in Table 2.4.

Table 2.4 Final Depth of Taplow Gravel Formation

Trial Hole	Depth (m bgl)
WS1	1.10*
WS2	1.60*
WS3	1.10*
FE1	1.20*
FE2	Not Encountered
FE3	1.30*
DP2a	1.80*
DP2b	1.60*
DP3	1.20*

Notes: *=unit present to base of trial hole.

2.3.3 London Clay Formation

The London Clay Formation was not encountered during this investigation due to the dense nature of the overlying Taplow Gravel Formation. Based on a review of BGS borehole data from locations within a 500m radius of the site the London Clay Formation is consistently present from approximately 5.50m bgl.

2.4 Roots

Roots were encountered in four out of the six trial holes at depths ranging between 0.50 and 1.10m bgl. The depths of root penetration have been included in Table 2.5.

Table 2.5 Depth of Root Penetration

Trial Hole	Depth (m bgl)
WS1	None observed
WS2	1.00
WS3	1.10
FE1	None observed
FE2	0.50
FE3	0.50

Note:

Roots may be found to greater depth 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.

It must be emphasised that the probability of determining the maximum depth of roots from a narrow diameter borehole is low. A direct observation such as from within a trial pit is necessary to gain a better indication of the maximum root depth.

2.5 Groundwater

Groundwater was not encountered within any of the six trial holes to the maximum depth of the investigation, 1.60m bgl within WS1. Changes in groundwater level occur for a number of reasons including seasonal effects and variations in drainage. The investigation was conducted in December (2016), when groundwater levels should be rising from their annual minimum (lowest) elevation, which typically occurs around September.

Groundwater equilibrium conditions may only be conclusively established, if a series of observations are made via groundwater monitoring wells.

2.6 Foundation Exposures

Foundations exposures were carried out in FE1, FE2, FE3 at locations selected by the Soils Limited based on the provided proposed development plan.

A concrete foundation was encountered at FE1 and FE3 extending to a depth greater than the base of the hand dug pits (1.20 and 1.10m bgl). The foundation extended out from the brickworks by 0.15m to 0.20m.

A concrete foundation was also encountered within FE2 extending to a depth of 0.55m bgl. The foundation extended out from the brickwork by 0.25m.

The full foundation sketches for FE1, FE2 and FE3 are presented in Appendix A.1.

Section 3 Discussion of Geotechnical In-Situ and Laboratory Testing

3.1 Dynamic Probe Tests

Dynamic probing (DPSH) was undertaken at three locations (DP2a, DP2b and DP3) adjacent and prior to the drilling of WS2 and WS3 to depths ranging between 1.20 and 1.80m bgl. The results were converted to equivalent SPT “N” values based on dynamic energy using commercial computer software (Geostru). The results were then interpreted based on the classifications outlined in Appendix B.1, Table B.1.1 to Table B.1.3.

The Taplow Gravel Formation recorded equivalent SPT “N60” values between 4 and >50. Classifying the granular soils as loose to very dense, typically dense to very dense below 1.00m bgl.

It should be noted that SPT ‘N60’ values quoted within Table B.2.1, presented in Appendix B.2 and referred to within this report, are presented as corrected values in accordance with BS EN 22476 Part 3, to account for the rig efficiency, borehole depth, overburden factors etc. Further correction of the ‘N’ values is therefore not necessary. Raw field data is archived within the Soils Limited project file and can be provided on request.

A full interpretation of the DPSH tests are outlined in Appendix B.2, Table B.2.1.

3.2 Atterberg Limit Tests

Atterberg Limit tests were performed on two samples obtained from the Taplow Gravel Formation. The results were classified in accordance with BRE Digest 240 and NHBC Standards Chapter 4.2.

The cohesive beds of the Taplow Gravel Formation was classified as low volume change potential in accordance with both BRE Digest 240 and NHBC Standards Chapter 4.2.

A full interpretation of the Atterberg Limit tests are outlined in Table B.2.2 Appendix B.2 and the laboratory report in Appendix B.3.

3.3 Particle Size Distribution Tests

Particle Size Distribution (PSD) tests were performed on four samples from the Taplow Gravel Formation.

PSD results classified the granular beds of the Taplow Gravel Formation as having no volume change potential in accordance with BRE Digest 240 or NHBC Standards Chapter 4.2. Note that a cohesive soil is only classified as having a volume change potential if it is also plastic and an Atterberg Limit test can be conducted on the strata.

A full interpretation of the PSD tests are outlined in Table B.2.3, Appendix B.2 and the laboratory report in Appendix B.3.

3.4 Sulphate and pH Tests

One sample was taken from the Made Ground and One sample was taken from the Taplow Gravel Formation for water soluble sulphate (2:1) and pH testing in accordance with Building Research Establishment Special Digest 1, 2005, ‘Concrete in Aggressive Ground’.

The tests recorded water soluble sulphate between <10mg/l and 22mg/l with pH values of 6.9 to 7.0.

The significance of the sulphate and pH Test results are discussed in Section 4.4 and the laboratory report in Appendix B.3.

Section 4 Foundation Design

4.1 General

An engineering appraisal of the soil types encountered during the site investigation and likely to be encountered during the redevelopment of this site is presented. Soil descriptions are based on analysis of disturbed samples taken from the trial holes.

4.1.1 Made Ground and Topsoil

The terms *Fill* and *Made Ground* are used to describe material, which has been placed by man either for a particular purpose e.g. to form an embankment, or to dispose of unwanted material. For the former use, the Fill and/or Made Ground may well have been selected for the purpose and placed and compacted in a controlled manner. With the latter, great variations in material type, thickness and degree of compaction invariably occur and there can be deleterious or harmful matter, as well as potentially methanogenic organic material.

The BSI Code of Practice for Foundations, BS 8004:1986, Clause 2.2.2.3.5 Made Ground and Fill, includes the caveat that *'all Topsoil should be treated as suspect, because of the likelihood of extreme variability'*.

Soils described as Made Ground were encountered in each of the nine trial holes from surface to depths of between 0.45 and 1.00m bgl. The Made Ground typically comprised soft dark brown slightly sandy slightly gravelly clayey SILT with roots. Sand is fine to medium. Gravel is fine to medium, sub-angular flint with brick and concrete fragments.

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

4.1.2 Taplow Gravel Formation

Soils described as the Taplow Gravel Formation were encountered in eight out of the nine trial holes immediately underlying the Made Ground and was present to the base of the investigation, 1.80m bgl. The Taplow Gravel Formation typically comprised orangish grey slightly clayey very sandy fine to coarse rounded to sub-rounded flint GRAVEL.

The Taplow Gravel Formation recorded equivalent SPT “N60” values between 4 and >50. Classifying the granular soils as loose to very dense, typically dense to very dense below 1.00m bgl.

The Taplow Gravel Formation was classified as low volume change potential in accordance with both BRE Digest 240 and NHBC Standards Chapter 4.2.

PSD results classified the granular beds of the Taplow Gravel Formation as having no volume change potential in accordance with BRE Digest 240 or NHBC Standards Chapter 4.2. Note that a cohesive soil is only classified as having a volume change potential if it is also plastic and an Atterberg Limit test can be conducted on the strata.

Soils of the Taplow Gravel Formation are normally consolidated granular soils and as such are expected to display moderate bearing capacities with moderate settlement characteristics. The soils of the Taplow Gravel Formation were considered suitable for the proposed development providing that adequate bearing and settlement characteristics can be proven.

4.1.3 London Clay Formation

The London Clay Formation was not encountered during this investigation due to the dense nature of the overlying Taplow Gravel Formation. Based on a review of BGS borehole data the London Clay Formation is expected to be present from approximately 5.50m bgl.

The soils of the London Clay Formation are heavily overconsolidated and are expected to exhibit moderate to high bearing capacities with low to moderate settlement characteristics. The soils of the London Clay Formation are expected to be a suitable bearing stratum if a deep foundation solution is adopted.

4.1.4 Roots

Roots were encountered in four out of the six trial holes at depths ranging between 0.50 and 1.10m bgl. Roots may be found to greater depth 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.

4.1.5 Groundwater

Groundwater was not encountered within any of the six trial holes to the maximum depth of the investigation, 1.60m bgl within WS1. Changes in groundwater level occur for a number of reasons including seasonal effects and variations in drainage. The investigation was conducted in December (2016), when groundwater levels should be rising from their annual minimum (lowest) elevation, which typically occurs around September.

4.2 Foundation Scheme

The proposed development comprised extensions to the existing assembly hall, reception classroom, KS2 classroom and toilets.

In compiling this report reliance was placed on drawing number 2010 Stage F, Rev 1, Dated 17.05.2016 and was prepared by DHP Architects. Any change or deviation from the scheme outlined in the drawing could invalidate the foundation design and remediation recommendations presented within this report. Soils Limited must be notified about any such changes.

Development plans provided by the client are presented in Appendix D.

4.2.1 Guidance on Shrinkable Soils

The Building Research Establishment (BRE) Digests 240, 241 and 242 provide guidance on 'best practice' for the design and construction of foundations on shrinkable soils.

The Taplow Gravel Formation was classified as low volume change potential in accordance with both BRE Digest 240 and NHBC Standards Chapter 4.2. PSD results classified the granular beds of the Taplow Gravel Formation as having no volume change potential in accordance with BRE Digest 240 or NHBC Standards Chapter 4.2.

The cohesive soils of the Taplow Gravel Fromation were encountered in two out of the three trial holes and where present were up to a maximum of 250mm in thickness. Due to the limited thickness of the cohesive soils **no volume change precautions** will be required.

The BRE Digest 241 states: "An increasingly common, potentially damaging situation is where trees or hedges have been cut down prior to building. The subsequent long-term swelling of the zone of clay desiccated by the roots, as moisture slowly returns to the ground, can be substantial. The rate at which the ground recovers is very difficult to predict and if there is any doubt that recovery is complete then bored pile foundations with suspended beams and floors should be used".

The stated intention of the NHBC is to ensure that shrinkage and swelling of plastic soils does not adversely affect the structural integrity of foundations to such a degree that remedial works would be required to restore the serviceability of the building. It must be borne in mind that adherence to the NHBC tables and design recommendations may not, in all cases, totally prevent foundation movement and cracking of brickwork might occur.

The BRE Digest 240 suggests: *"Two courses of action are open:*

Estimate the potential for swelling or shrinkage and try to avoid large changes in the water content, for example by not planting trees near the foundations.

Accept that swelling or shrinkage will occur and take account of it. The foundations can be designed to resist resulting ground movements or the superstructure can be designed to accommodate movement without damage."

The design of foundations suitable to withstand movements is presented in BRE Digest 241 “Low-rise buildings on shrinkable clay soils: Part 2”.

4.3 Foundation Scheme

Foundations **must not** be constructed within any Made Ground due to the likely variability and potential for large load induced settlements both total and differential.

Roots were encountered in four out of the six trial holes at depths ranging between 0.50 and 1.10m bgl. If roots are encountered during the construction phase foundations **must not be placed within any live root penetrated** or desiccated **cohesive soils or those with a volume change potential**. Should the foundation excavations reveal such materials, the excavations **must** be extended to greater depth in order to bypass these unsuitable soils. Excavations must be checked by a suitable person prior to concrete being poured.

Considering the type of development, a shallow foundation solution was considered the most suitable.

4.3.1 Shallow Foundations into the Taplow Gravel Formation

Based on a 5.00 by 0.75m strip foundation, using the method proposed by Burland and Burbidge, an allowable bearing capacity of 150kPa may be used.

The use of reinforced trench fill foundations would simplify construction and reduce the possibility of differential settlement affecting the foundations.

For the allowable bearing value given above, settlements, both total and differential, are not expected to exceed 15mm providing that excavation bases are carefully bottomed out and blinded, or concreted as soon after excavation as possible and kept dry. Foundations must not be constructed over former structures and other hard spots. The foundations design must be suitable for the conditions present at the site.

The anticipated settlement includes both elastic settlement and long-term drained settlement (in the case of cohesive soils).

Anticipated settlements may be taken as proportional to the bearing capacity adopted (for the same configuration of foundation), therefore if the bearing value is halved the anticipated settlement will halve.

4.3.2 Ground Floor Slab

Given the relatively limited thickness of Made Ground (0.50m-1.10m bgl) ground bearing slabs could be adopted for the proposed redevelopment.

4.4 Subsurface Concrete

Sulphate concentration measured in 2:1 water/soil extracts fell into Class **DS-1** of the BRE Special Digest 1 2005, *'Concrete in Aggressive Ground'.* Table C2 of the Digest indicated ACEC (Aggressive Chemical Environment for Concrete) site classifications of **AC-1**. The pH of the soils tested ranged between 6.9 and 7.1. The classification given was determined using the static groundwater case, in the view of groundwater being encountered. The laboratory results are presented in Appendix B.3.

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 any possible exposure of potentially pyrite bearing natural ground and the pH of the soils.

4.5 Excavations

Shallow excavations in the Made Ground and Taplow Gravel Formation are likely to become stable in the short term at best.

Deeper excavations taken into the Taplow Gravel Formation are likely to be rapidly become unstable in the short term. 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 or battered back to a safe angle of repose before excavations are entered by personnel.

Excavations beneath the groundwater table are likely to be unstable and dewatering of foundation trenches may be necessary.

Section 5 Determination of Chemical Analysis

5.1 Site Characterisation and Revised Conceptual Site Model

A Phase I Desk Study was not commissioned as part of the investigation, nor was a completed Phase I Desk Study provided by the client, therefore it was not possible to create, revise or test a conceptual site model.

In the absence of a conceptual site model soil samples were tested for a wide range of common contaminants.

5.2 Soil Sampling

A non-targeted sampling strategy is appropriate when there is:

- No adequate information available regarding the likely locations of contamination;
- No sensitive areas where there is a need for a high degree of confidence.

A targeted sampling strategy is appropriate when there is:

- Adequate information available regarding the likely locations of contamination
- Sensitive areas where there is a need for a high degree of confidence.

The CSM identified potential sources and a non-targeted sampling pattern was adopted as appropriate to these sources. Table 5.1 outlines the sampling undertaken.

Table 5.1 Sampling Strategy

Sample	Strategy	Proposed Use
WS1:0.20	Non-targeted: Made Ground	Beneath new Assembly Hall
WS1:0.80	Non-targeted: Top of natural soils	
WS2:0.80	Non-targeted: Top of natural soils	Beneath new KS2 Classroom
WS3:0.20	Non-targeted: Made Ground	Beneath new Reception classroom

Note:

5.3 Determination of Chemical Analysis

The driver for determination of the analysis suite was the information obtained from the Phase I Desk Study and Phase II intrusive investigation. Table 5.2 outlines the specification for each sample tested.

Table 5.2 Chemical Analysis Specification

Substance	Locations:Depths (m bgl)			
	WS1:0.20^{S}	WS1:0.80^{S}	WS2:0.80^{S}	WS3:0.20^{S}
Asbestos Screen	✓	✓	✓	✓
Total Phenols	✓	✓	✓	✓
Total Cyanide	✓	✓	✓	✓
Organic Matter	✓	✓	✓	✓
pH	✓	✓	✓	✓
Metals	✓	✓	✓	✓
Metalloids	✓	✓	✓	✓
Organics	✓	✓	✓	✓
PAHs	✓	✓	✓	✓

Notes: **Metals**: Cd, Cr, Pb, Hg, Ni, Se, CN, S, Cu, Zn, Bo, V. **metalloids**: As. **organics**: USEPA 16 speciated PAH, TPH-CWG (speciated TPH), BTEX, VOC/SVOC **Asbestos screening** was undertaken in accordance with HSG 248. ^{S} = Soil sample. ^{W} = Water sample. ^{L} = Leachate.

Section 6 Qualitative Risk Assessment

6.1 Assessment Criteria

The assessment criteria used to determine risks to human health are derived and explained within Appendix C.2.

6.2 Representative Contamination Criteria - Soil

The proposed development comprised extensions to the existing assembly hall, reception classroom, KS2 classroom and toilets.

In compiling this report reliance was placed on drawing number 2010 Stage F, Rev 1, Dated 17.05.2016 and was prepared by DHP Architects. Any change or deviation from the scheme outlined in the drawing could invalidate the foundation design and remediation recommendations presented within this report. Soils Limited must be notified about any such changes.

Development plans provided by the client are presented in Appendix D.

The chemical laboratory results were compared against the representative contaminants concentration for human health receptor to Soil Guideline Values (SGV), Category 4 Screening Levels (C4SL's) or Suitable 4 Use Level (S4UL).

Based on the proposed end use the "residential without plant uptake" land use scenario was chosen to offer a conservative approach based on the sensitivity of the critical receptor.

Table 6.1 outlines the samples that have exceeded their relevant assessment criteria. The full laboratory report is presented in Appendix C.1.

Table 6.1 Summary of Chemical Analysis of Soils Sample Exceedance

Substance	Sample locations where SGV, C4SL or S4UL adopted were exceeded for the 'Residential without plant uptake' land-use scenario
Lead	WS3:0.20 (319mg/kg versus a limit of 300mg/kg)

The guideline values are assessed against the "Residential without plant uptake" land-use scenario, which was considered the most appropriate land-use scenario, given the type of the proposed redevelopment.

To assess the potential toxicity to the human health receptor from the concentrations of organic compounds tested for, Soil Organic Matter (SOM) tests were undertaken on the samples submitted for chemical testing, which revealed SOM values of between 0.4% and 2.5%. For each soil sample tested, the Soil Organic Matter recorded was used to derive the appropriate guideline value for organic determinants.

In summary, one of the samples tested showed concentrations in excess of the relevant C4SL for a residential land-use scenario. In WS3 at 0.20m bgl Lead was recorded at a concentration of 319mg/kg against the residential end-use C4SL of 300mg/kg.

None of the other substances tested recorded concentrations above the residential end-use screening values.

6.2.1 Asbestos

Asbestos Containing Material (ACM) was not detected within any of the samples tested. Whilst asbestos containing material was not identified it is possible that asbestos is present in other areas of the site. If encountered, care must be taken to ensure any such material is separated and disposed of in an appropriate manner to a licensed waste facility.

6.3 Risk to Groundwater

Groundwater sampling was not within the scope of this investigation, nor was groundwater encountered to the maximum depth of the investigation.

6.4 Tier I Quantitative Risk Assessment

The Tier I Quantitative risk assessments have been undertaken for the soil, groundwater and soil gas. As no conceptual site model had been produced the Tier I risk assessment was based purely on the chemical laboratory results. The full laboratory chemical report is presented in Appendix D.2.

6.4.1 Soils

One of the samples tested showed concentrations in excess of the relevant C4SL for a residential without plant uptake land-use scenario. In WS3 at 0.20m bgl lead was recorded at a concentration of 319mg/kg against the residential end-use C4SL of 300mg/kg.

WS3 is located in the area underneath the proposed reception classroom, therefore there is no pathway between the soil and the critical receptor. In addition the exceedance was very close to the limit and was based upon the residential without plant uptake scenario which allows for a significantly longer exposure to the soil than would ever be present at a primary school where the maximum exposure to a child would be limited to one academic year within each classroom. Therefore it is considered that there is no significant risk to the human health receptor.

The Tier 1 Quantitative risk assessment therefore established that there was **no risk to the human health receptors** of construction workers or future end-users.

6.4.2 Groundwater

No groundwater samples were tested as part of this investigation however no groundwater was encountered within the full depth of the investigation, therefore it is considered that **there was no risk** to the groundwater receptor.

6.4.3 Soil Gas

A Phase I Desk Study is required in order to fully assess the soil gas risk. The Phase II Intrusive investigation did not identify any sources of soil gas however in the absence of a CSM it is not possible to dismiss the risk of soil gas being present.

6.5 Remedial Objective

The Tier I Quantitative risk assessment identified no risk for the soil to the end user, therefore there is no requirement for a remedial objective or the development of a soil remediation method statement.

6.6 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 is 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.

6.7 Excavated Material

Excavated material must be classified with the Environment Agency for disposal at an appropriately licensed disposal facility. The requirements of Duty of Care and Health and Safety Guidance must be complied with.

Both Producers and Waste Management companies must ensure compliance with the new Waste Acceptance Criteria (WAC) prior to landfill in hazardous, stable non-reactive cells and inert sites. These regulations govern the operation of landfill in England and Wales. Basic characterisation is the responsibility of the waste producer and compliance checking is generally the responsibility of the landfill operator. Therefore, landfill operators will be unlikely to accept waste that does not meet the Waste Acceptance Criteria for their class of site.

There is an obligation to ‘treat’ all soils destined for landfill, including non-hazardous waste. This treatment must now be documented and presented to the landfill operator or waste may be refused entry. Note that all liquids are banned from landfill.

For the purposes of legal compliance, ‘treatment’ must comprise three things (the ‘threepoint test'):

1. It must be a physical, thermal, chemical or biological process.
2. It must change the characteristics of the waste.
3. It must do so in order to:
    (a) reduce its volume, or
    (b) reduce its hazardous nature, or
    (c) facilitate its handling, or enhance its recovery.

6.8 Re-use of Excavated Material On-site

The re-use of on-site soils may be undertaken either under the Environmental Permitting Regulations 2007 (EPR), in which case soils other than uncontaminated soils are classed as waste, or under the CL:AIRE Voluntary Code of Practice (CoP) which was published in September 2008 and is accepted as an alternative regime to the EPR.

Under the EPR, material that is contaminated but otherwise suitable for re-use is also classified as waste and its re-use should be in accordance with the Environmental Permitting Regulations 2007 (EPR). Environmental Permit Exemptions (EPE) are for the re-use of non-hazardous or inert waste only; hazardous waste cannot be re-used under a permit exemption. EPE apply only to imported inert waste materials; inert material arising on site and recovered on site is not classified as waste and does not require an exemption. It is possible that materials arising on-site will be classified as inert and would not need an exemption.

Environmental Permit Exemptions are only allowed for certain activities, placing controls on the quantities that can be stored and re-used. The re-use of waste shall be within areas and levels defined in planning applications and permissions for the development. An EPE requires a site specific risk assessment for the receptor site to demonstrate that the materials are suitable for use, i.e. that they will not give rise to harm to human health or pollution of the environment.

Under the CL:AIRE voluntary code of practice (CoP) materials excavated on-site are not deemed contaminated if suitable for re-use at specified locations or generally within the site.

Material that may have been classified as hazardous waste under the EPR may be re-used. The CoP regime requires that a 'Qualified Person' as defined under the CoP reviews the development of the Materials Management Plan, including review of Risk Assessments and Remediation Strategy/Design Statement together with documentation relating to Planning and Regulatory issues, and signs a Declaration which is forwarded to the Environment Agency and which confirms compliance with the CoP.

Should it be necessary to import materials from another site where materials are excavated and which is not material from a quarry or produced under a WRAP protocol, then an EPE would be necessary for the imported material whether the work was managed under the CoP or the EPR.

6.9 Imported Material

Any soil, which is to be imported onto the site, must undergo chemical analysis to permit classification prior to its importation and placement in order to ascertain its status with specific regard to contamination, i.e. to prove that it is suitable for the purpose for which it is intended.

6.10 Discovery Strategy

There may be areas of contamination not identified during the course of the investigation. Such occurrences may also be discovered during the demolition and construction phases for the redevelopment of the site.

Care should be taken during excavation works especially to investigate any soils, which appear by eye (e.g. such as fibrous materials, large amounts of ash and unusual discolouration), odour (e.g. fuel, oil and chemical type odours or unusual odours such as sweet odours or fishy odours) or wellbeing (e.g. light headedness and/or nausea, burning of nasal passages and blistering or reddening of skin due to contact with soil) to be contaminated or of unusual and/or different character to standard soils or those analysed.

In the event of any discovery of potentially contaminated soils or materials, this discovery should be quarantined and reported to the most senior member of site staff or the designated responsible person at the site for action. The location, type and quantity must be recorded and the Local Authority, and a competent and appropriate third party Engineer/Environmental consultant notified immediately. An approval from the Local authority must be sought prior to implementing any proposed mitigation action.

The discovery strategy must remain on site at all times and must demonstrate a clear allocation of responsibility for reporting and dealing with contamination. A copy of the strategy must be placed on the health and safety notice board and /or displayed in a prominent area where all site staff are able to take note of and consult the document at any time. Any member of the workforce entering the site to undertake any excavation must be made aware of the potential to discover contamination and the discovery strategy

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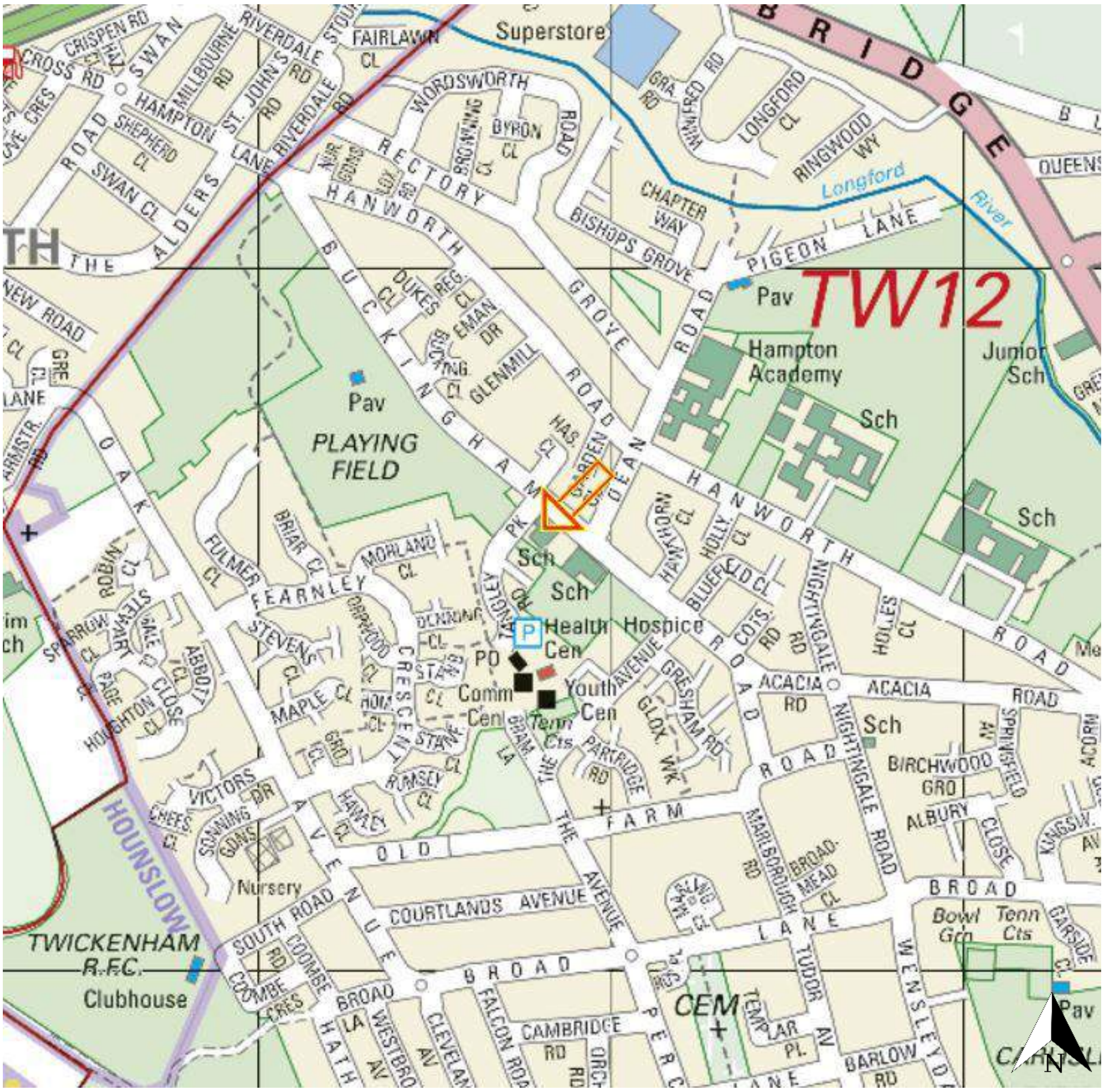

Figure 1 – Site Location Map

Job Number 15937	**Project** Newhouse School, Hanworth Road, Hampton, TW12 3LT
Client London Borough of Richmond Upon Thames	**Date** January 2017

Figure 2 – Aerial Photograph

Project
Newhouse School, Hanworth Road, Hampton, TW12 3LT

Client
London Borough of Richmond Upon Thames

Date
January 2017

Job Number
15937

Figure 3 – Trial Hole Plan

Project
Newhouse School, Hanworth Road, Hampton, TW12 3LT

Client
London Borough of Richmond Upon Thames

Date
January 2017

Job Number
15937

Appendix A Field Work

Appendix A.1 Engineers Logs

Soils Limited
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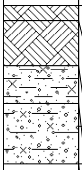
Borehole Log

Borehole No.
WS1
Sheet 1 of 1

Project Name: Newhouse School,	Project No.: 15937	Co-ords:	Hole Type WS
Location: Hanworth Road, Hampton, TW12 3LT		Level:	Scale 1:50
Client: London Borough of Richmond upon Thames		Dates: 05/12/2016	Logged By

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description
		Depth (m)	Type	Results				
		0.10	J					
					0.15			Yellowish brown slighlty clayey gravelly fine to coarse SAND. Gravel is fine to coarse, angular to rounded flint and occasional tarmac. Slight hydrocarbon type odour. MADE GROUND
		0.20	J					
		0.40	J					
					0.45			Stiff friable brownish black slighlty sandy slighlty gravelly clayey SILT with roots <1mm to 3mm diameter. Sand is fine to coarse. Gravel is fine to medium, sub-angular flint, brick and ash. Slight hydrocarbon type odour. MADE GROUND
		0.50	D					
					0.70			Soft light greyish yellow mottled orange slightly sandy slighlty gravelly very silty CLAY. Sand is fine. Gravel is fine, sub-angular flint. TAPLOW GRAVEL FORMATION
		0.75	D					
		0.80	J					
		1.00	D					
					1.10			Greyish brown mottled reddish brown sandy very clayey fine to coarse rounded to angular flint GRAVEL. Sand is fine to coarse. Slightly clayey from 0.85m bgl. TAPLOW GRAVEL FORMATION

End of Borehole at 1.10m

General Remarks:

Groundwater Remarks:

Borehole Type
CP: Cable Percussive
WS: Windowless Sampler
RC: Rotary Cored

Sample Types
D: Disturbed
B: Bulk
J: Jar
W: Water
U: Undisturbed

In-Situ Testing
SPT: Split spoon - Standard Penetration Test
CPT: Cone - Standard Penetration Test

soils LIMITED
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Borehole Log

Borehole No.
WS2
Sheet 1 of 1

Project Name: Newhouse School,	Project No.: 15937	Co-ords:	Hole Type WS
Location: Hanworth Road, Hampton, TW12 3LT		Level:	Scale 1:50
Client: London Borough of Richmond upon Thames		Dates: 05/12/2016	Logged By

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description
		Depth (m)	Type	Results				
		0.20 0.50	J J		0.70			Soft dark brown slighlty sandy slighlty gravelly clayey SILT with roots <1mm to 1mm diameter. Sand is fine to medium. Gravel is fine to medium, sub-angular flint and rare brick and ash fragments. MADE GROUND
		0.80	D+J		0.90			Soft light greyish yellow mottled orange slighlty gravelly sandy silty CLAY. Sand is fine to medium. Gravel is fine to medium, sub-angular flint.
		1.10	D		1.20			Greyish brown mottled orange sandy very clayey fine to coarse rounded to angular flint GRAVEL. Sand is fine to coarse. Rare pockets of dark grey brown sandy silty clay to 1.0m bgl. TAPLOW GRAVEL FORMATION
		1.50	D		1.60			Greyish orangish brown slighlty clayey very sandy fine to coarse rounded to angular flint GRAVEL. Sand is fine to coarse. TAPLOW GRAVEL FORMATION

End of Borehole at 1.60m

1
2
3
4
5
6
7
8
9
10

General Remarks:

Roots encountered to 1.0m bgl.

Groundwater Remarks:

Borehole Type
CP: Cable Percussive
WS: Windowless Sampler
RC: Rotary Cored

Sample Types
D: Disturbed
B: Bulk
J: Jar
W: Water
U: Undisturbed

In-Situ Testing
SPT: Split spoon - Standard Penetration Test
CPT: Cone - Standard Penetration Test

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Borehole Log

Borehole No.
WS3
Sheet 1 of 1

Project Name: Newhouse School,
Project No.: 15937
Co-ords:
Hole Type: WS
Location: Hanworth Road, Hampton, TW12 3LT
Level:
Scale: 1:50
Client: London Borough of Richmond upon Thames
Dates: 05/12/2016
Logged By:

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description
		Depth (m)	Type	Results				
		0.20	D+J				▨	Soft dark brown slighlty sandy slighlty gravelly clayey SILT with roots <1mm to 4mm diameter. Sand is fine to medium. Gravel is fine to medium, sub-angular flint and occasinal brick and concrete fragments. MADE GROUND
		0.50	D+J					
					0.70			
		0.80	D+J				⁙	Orangish grey slighlty clayey very sandy fine to coarse rounded to angular flint GRAVEL. Sand is fine to coarse. TAPLOW GRAVEL FORMATION
					1.10			End of Borehole at 1.10m

General Remarks:

Roots encountered to 1.1m bgl.

Groundwater Remarks:

Borehole Type
CP: Cable Percussive
WS: Windowless Sampler
RC: Rotary Cored

Sample Types
D: Disturbed
B: Bulk
J: Jar
W: Water
U: Undisturbed

In-Situ Testing
SPT: Split spoon - Standard Penetration Test
CPT: Cone - Standard Penetration Test

Appendix B Geotechnical In-Situ and Laboratory Testing

Appendix B.1 Classification

Classification based on SPT "N" values:

The inferred undrained strength of the cohesive soils was based on the SPT "N" blow counts, derived from the relationship suggested by Stroud (1974) and classified using Table B.1.1. (Ref: Stroud, M. A. 1974, "The Standard Penetration Test – its application and interpretation", Proc. ICE Conf. on Penetration Testing in the UK, Birmingham. Thomas Telford, London.).

Table B.1.1 SPT "N" Blow Count Cohesive Classification

Classification	Undrained Cohesive Strength C_u (kPa)
Extremely low	<10
Very low	10 – 20
Low	20 – 40
Medium	40 – 75
High	75 – 150
Very high	150 – 300
Extremely high	> 300

Note: (Ref: BS EN ISO 14688-2:2004+A1:2013 Clause 5.3.)

The relative density of granular soils was classified based of the relationship given in Table B.1.2.

The *UK National Annex to Eurocode 7: Geotechnical design – Part 2: Ground investigation and testing, NA 3.7 SPT test, BS EN 1997-2:2007, Annex F* states "Relative density descriptions on borehole records should also be based on uncorrected SPT N values, unless significantly disturbed, using the density classification in BS 5930:2015, Table 7.

Table B.1.2 SPT "N" Blow Count Granular Classification

Classification	SPT "N" blow count (blows/300mm)
Very loose	0 to 4
Loose	4 to 10
Medium dense	10 to 30
Dense	30 to 50
Very dense	Greater than 50

Note: (Ref: The Standard Penetration Test (SPT): Methods and Use, CIRIA Report 143, 1995)

Chalk samples recovered are disturbed by the sampling process. Therefore, it is difficult to assess an accurate chalk grade for in accordance with CIRIA C574 'Engineering in