TECHNICAL NOTE

Job Name:	Land East of Rayleigh Road, Thundersley
Job No:	332210105/350.001_Rev 01
Note No:	TN-GEO-01
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Approved:	**O Belson**
Subject:	**Preliminary Ground Investigation at Hadleigh Site Castle Point**

Introduction

Stantec UK has been commissioned by This Land Development Limited (the client) to undertake a preliminary ground investigation for the site at Land East of Rayleigh Road, Thundersley, Essex, to be referred to hereafter as the 'site'.

The site is centred upon approximate National Grid Reference TQ 802 891. A site location plan is presented as **Figure 1**.

The site comprises an irregular shaped piece of land covering approximately 28 hectares, located due north of Daws Heath Road and due east of Rayleigh Road in Rayleigh, Essex. It currently comprises largely open agricultural fields with some horse grazing paddocks, associated stables and a fishing lake.

At present the site is owned by two separate landowners. The land generally located within the central and eastern areas of the site is known as 'Cook's Land' and the land to the west is currently owned by the Barbers. The current division of land ownership is illustrated on attached **Figure 2**.

The site falls from a high point of approximately 80m AOD in the south, to a low point of approximately 30m AOD in the northeast corner.

Proposed Development

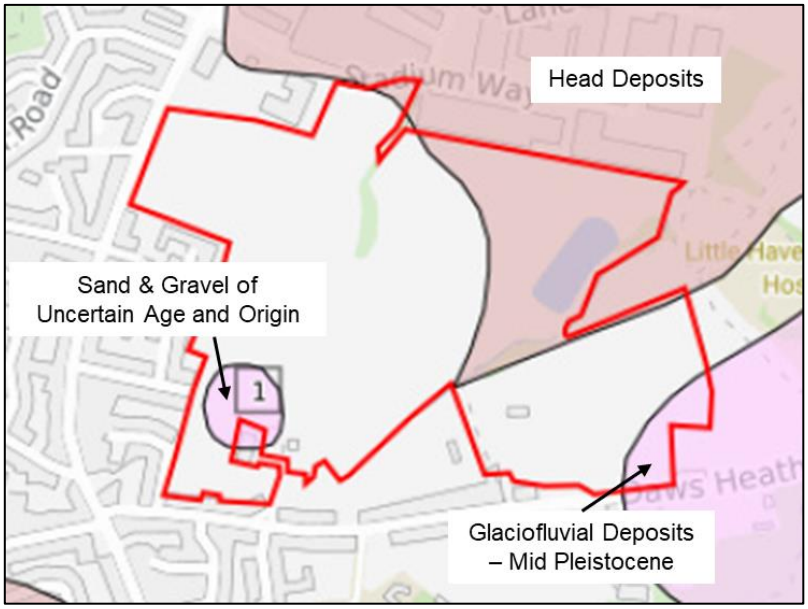
The proposed development comprises outline planning application for the development of up to 455 new homes, a new multi-use community hall, land for the provision of a healthcare facility (1,000sqm), land for a stand-alone early years and childcare nursery (0.13ha), new vehicular/pedestrian access points from Stadium Way in the north and Daws Heath Road in the south, new greenways and green links, multi-functional open space, green infrastructure, surface water attenuation, landscaping and associated infrastructure. All matters reserved except access.

Published Site Geology

The 1:50,000 series Geological Survey of England and Wales Sheet 258/259 (BGS, 1976) and BGS GeoIndex (onshore) (BSG, 2021) indicate the following geological sequence underlying the site.

Superficial Deposits

Mapping of the superficial deposits present at the site is presented below.



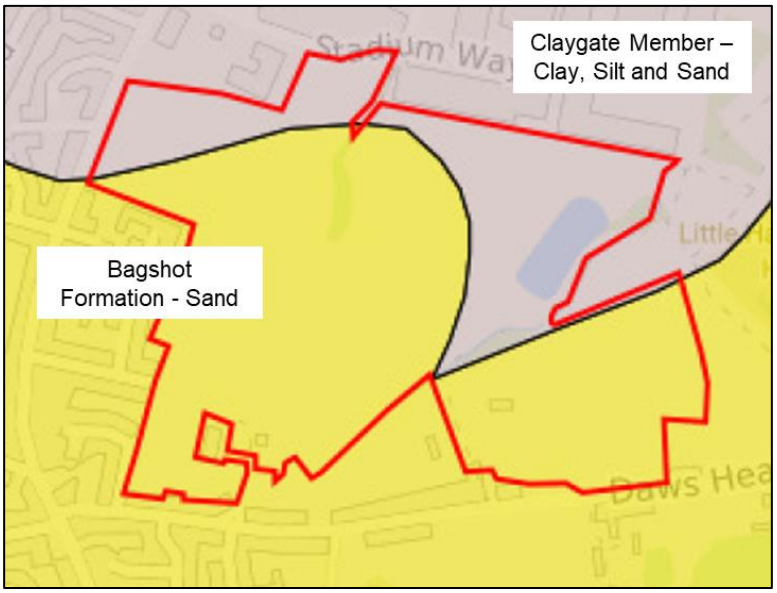
The northeast and centre of the site is underlain by Head, described by the BGS as 'poorly sorted and poorly stratified, angular rock debris and or clayey hillwash and soil creep, mantling a hillslope and deposited by solifluction and gelifluction processes. Polymict deposit comprises gravel, sand and clay depending on upslope source and distance from source. Locally with lenses of silt, clay or peat and organic material'.

Glaciofluvial Deposits, Mid Pleistocene – Sand and Gravel underlie the southeastern site boundary. These are materials deposited by waters issuing from ice sheets and glaciers, including mostly coarse-grained sediments with some finer-grained layers.

A small area of Sand and Gravel of Uncertain Age and Origin is recorded in the southwest of the Site adjacent to Asquith Avenue. This is likely to be sand and gravel with rare lenses of clay, dating from the Quaternary period.

Bedrock

Mapping of the bedrock deposits present at the site is presented below:



The Claygate Member – Clay, Silt and Sand is located across the north and northeast of the site and is described as 'dark grey clays with sand laminae, passing up into thin alternations of clays, silts and fine-grained sand, with beds of bioturbated silt. Ferruginous concretions and septarian nodules occur in places.'

The Bagshot Formation – Sand which underlies most of the site is described as 'pale yellow-brown to pale grey or white, locally orange or crimson, fine- to coarse-grained sand that is frequently micaceous and locally clayey, with sparse glauconite and sparse seams of gravel. The sands are commonly cross-bedded but some are laminated. Thin beds and lenses of laminated pale grey to white sandy or silty clay or clay ('pipe-clay') occur sporadically, becoming thicker towards the top of the formation. A thick clay bed, the Swinley Clay Member, is included at the top. In places, there is a basal bed of gravelly coarse-grained sand'.

Ground Investigation

Ground investigation works comprising of the excavation of trial pits and sinking of window sampler boreholes were carried out between the 13th and 14th May 2021. The ground investigation was proposed to identify ground conditions and to assess infiltration drainage potential to help aid in a site wide Drainage Management Strategy.

The investigation comprised a total of twelve trial pits (TP101 to TP112) and six window sampler boreholes (WS101 to WS106) with standpipe installations to facilitate post site work monitoring of groundwater levels. Locations of completed investigation locations are presented on **Figure 3.**

Soakaway trial pits TP101 to TP112 were excavated to a depth of 2m bgl by a JCB back-hoe loader in general accordance with BRE 365:2015. All trial pits were logged in accordance with BS5930:2015 (BS EN ISO 14688-1:2002+A1:2013). Upon completion, the pits were backfilled with their arisings and compacted, leaving the soils slightly mounded to accommodate future settlement within the backfill.

Dynamic sampling techniques were used to sink boreholes at six locations (WS101 to WS106) to a target depth of 6.0m bgl. Continuous soil cores were recovered from the WS boreholes in PVC liners, which were split to enable logging of the recovered soils by the onsite Engineer in accordance with BS 5930:2015 and BS EN ISO 14688. On completion, all boreholes were installed with nominal 50mm diameter groundwater monitoring pipework. The response zones of each installation were located within both Head Deposits and the Claygate Member. Above each response zone a plain pipe and bentonite seal were installed to prevent downward migration of any surface water. The pipework was encased in a gravel filter pack and the plain section pipework was surrounded with bentonite pellets and a flush cover concreted in place.

The records of the exploratory holes are presented in **Appendix A**.

Upon completion of the excavation and logging of the trial pits, infiltration testing was undertaken. The results of the infiltration have been reported under separate cover in TN002 and provided to the drainage design team.

Ground Conditions

A summary of the stratigraphy encountered is presented in Table 1 below.

Table 1 Summary of Encountered Stratigraphy

Formation	Top Depth Range (bgl)	Base Depth Range (bgl)
Topsoil	Ground Level	0.20 - 0.50m
Made Ground	Ground Level	0.50m
Head Deposits	0.20m – 0.50m	1.50m – 5.60m
Claygate Member	1.10m - 5.60m	2.00m – 6.00m

Topsoil

Topsoil was encountered to a maximum depth of 0.50m bgl in most of the exploratory holes (with the exception of TP103 and TP107) and was typically described as brown friable slightly sandy, slightly gravelly clay with occasional rootlets. The gravel content was recorded as angular to sub-rounded fine to coarse flint.

Made Ground

Made ground was recorded in two locations during the investigation works.

In trial pit TP103, made ground was recorded to 0.50m bgl was described as a 0.10m thickness of topsoil over soft orange brown, very gravelly sandy clay. The sand was recorded as medium to coarse and the gravel content recorded fragments of brick, sandstone, glass and tile.

Trial pit TP107 recorded the presence of made ground from the surface to a depth of 0.30m bgl. The surface was covered by a thin layer of macadam underlain by a soft black to brown very gravelly sandy clay. The gravel contained fragments of clinker, brick, glass and occasional cobbles of angular brick.

Head Deposits

Head Deposits often comprise mixed lithologies depending on the up-slope source from which the deposits were derived. Head Deposits were encountered in each of the exploratory hole locations and were typically described as soft to firm orange-brown sandy clay. Occasionally the clay was described as mottled and in certain locations was recorded as becoming stiffer with depth.

The sand content within the Head Deposits was recorded as fine to medium and was also noted to increase in quantity in localised areas with depth. Increased sand and gravel content was noted in locations TP104, TP105 and TP110. Occasional relic roots were also recorded.

Two samples of Head deposits were submitted for particle size distribution (PSD) tests to clarify the percentages of sand, silt and clay present within the soils. These results are included in **Appendix 5**. The laboratory test results for these samples is summarised in **Table 2** below:

Table 2 Summary of PSD testing – Head Deposits

Location	Depth (m)	Particle Proportions (%)	
		Clay / Silt	Sand
TP104	1.10	26	74
TP108	1.50	18	82

Results of the classification testing undertaken on samples of Head Deposits are presented in **Appendix B**, and are summarised below:

- Liquid Limits – 34% - 97%
- Plastic Limits – 17% - 27%
- Plasticity Indices – 17% to 71%

Given the very high proportion of material retained on the 425µm sieve (99-100%), the modified plasticity indices for the Head Deposits are very similar to the recorded plasticity indices. The recorded liquid limits and plasticity indices are plotted on **Figure 5.**

The results of the classification testing show a wide range, with most of the samples falling into the medium to high volume change potential range based on their plasticity indices (BRE, 1993). On the basis of their liquid limits, the samples vary from intermediate plasticity to extremely high plasticity. The mean liquid limit result of 60% would fall within the high plasticity range.

Measured moisture contents ranged from 24.0% to 38.6%. These are indicated on **Figure 6**.

Recorded values of penetration resistance (N60) determined by standard penetration testing (SPT) and corrected for hammer efficiency (in accordance with BS 22475-3: 2005) ranged between 7 and 33 with a strong trend of increasing N value with depth. Full results are provided in the borehole records in **Appendix A** and an SPT plot is presented as **Figure 7**.

Claygate Member

The ground conditions encountered beneath the Head Deposits on site are considered most likely to represent the Claygate Member as these deposits comprised stiff dark grey slightly sandy clays; medium dense brown very clayey silty fine sands and soft orange brown sandy silts.

Recorded values of penetration resistance (N60) determined by standard penetration testing (SPT) and corrected for hammer efficiency (in accordance with BS 22475-3: 2005) ranged between 11 and 24.

Two samples of the Claygate Formation were submitted for particle size distribution (PSD) tests to clarify the percentages of sand, silt and clay present within the soils. Full results of this testing can be found in **Appendix 5**. The laboratory test results for these samples are summarised in **Table 3**.

Table 3 Summary of PSD testing – Claygate Member

Location	Depth (m)	Particle Proportions (%)		
		Clay	Silt	Sand
WS101	3.60	13	19.6	67.4
WS104	2.00	7	11.7	81.3

Groundwater

Groundwater seepages were recorded within some of the exploratory holes during the investigation works. A summary is provided in Table 4 below.

Table 4 Groundwater Strikes in Exploratory Holes

Location	Depth (m)	Detail
TP106	2.0	Minor flow
TP107	1.5	Moderate seepage
TP108	1.5	Minor seepage
TP109	1.3	Slow flow
TP110	2.0	Minor flow
TP112	1.2	Moderate flow
WS102	4.0	Rose to 3.68m in 20m
WS103	2.0	-
WS104	2.0	Rose to 1.38m in 20 mins.
WS105	4.0	-
WS106	2.0	Rose to 1.95m in 15 mins.

Groundwater levels were monitored in the standpipes installed within the window sample hole locations on two occasions (25th May and 9th of June 2021). A summary of the findings is presented in Table 5 below.

Table 5 Summary of Standing Groundwater Levels in Monitoring Wells

Location	Ground Levels (m AOD)	Groundwater Depth			
		25 May 2021		9 June 2021	
		m bgl	m AOD	m bgl	m AOD
WS101	66.0	3.21	62.8	0.91	65.1
WS102	66.2	0.85	65.4	1.23	64.9
WS103	58.1	0.77	57.3	0.91	57.2
WS104	66.8	1.31	65.5	1.34	65.5
WS105	78.0	1.60	76.4	1.71	76.3
WS106	70.1	0.61	69.5	0.75	69.4

Tier 2 Environmental Data Review

In accordance with the Stantec Methodology for the Assessment of Potentially Contaminated Land (**Appendix 2**), the measured concentrations of potential contaminants determined as part of the ground investigation have been compared with published criteria for a defined end-use. If concentrations are below the screening criterion for a specified end-use, the parameter is deemed not to be a potential hazard and is not considered further. A concentration above the screening criterion identifies the parameter is considered as a possible hazard and indicates that either further assessment or risk management is required.

The assessment criteria have been selected based on a Residential End Use with Home Grown Produce as this is considered to represent most closely the proposed development. Guidance on the Stantec rationale for the selection of the generic assessment criteria is presented in **Appendix 3**.

Geoenvironmental Laboratory Analysis

Eurofins Chemtest Laboratories, who hold UKAS accreditation (Laboratory No 2183) and MCERTS accreditation, were commissioned by Stantec to undertake the required geoenvironmental laboratory analysis.

A summary of the scheduled geoenvironmental soil analyses is presented in Table 6 below.

Table 6 Summary of Scheduled Geoenvironmental Laboratory Analysis (Soils)

Description	Number of Tests
Metals	2
Banded Total Petroleum Hydrocarbons	2
Speciated Polyaromatic Hydrocarbons (16 PAH)	2
Asbestos	2
Total Cyanide	2
Organic Matter	2

The certificate of laboratory analysis is presented in **Appendix 4**.

Review of Soil Data

The majority of test results identified very limited concentrations of potential contaminants of concern with many below the laboratory method of detection limit. However, one sample, from TP107 recorded a lead concentration at 200mg/kg, which is the GAC for residential end use with home grown produce.

The recorded lead concentration is not considered to present a major risk to future residents but this area of the site will need further assessment as part of future ground investigations.

Preliminary Geotechnical Assessment

This section of the report presents comments on the identified ground conditions and the design and construction of the geotechnical elements of the proposed structures. This geotechnical assessment should be considered as preliminary and all recommendations should be reviewed at the detailed design stage and once the final development layout and ground levels are fixed.

It is understood that the proposed development will comprise predominantly residential development with associated access roads and footpaths, a park and a possible community building. The existing reservoir is to be retained as an amenity feature.

Site Preparation

Stability of Temporary Excavations

The ground investigation has recorded clay soils in the Head and both granular and cohesive soils in the Claygate Member.

The clays are typically firm near surface and should stand unsupported in relatively shallow foundation or infrastructure excavations in the short term and deeper excavations may also remain stable for short periods.

Should any relic shear surfaces be present these will reduce the ability of the soil to stand unsupported in vertically sided excavations. If these occur or where these excavations have to remain open for long periods they will require full side support to remain stable.

Depending on their depth, excavations into the granular soils of the Claygate Member may stand unsupported in shallow trenches in the short term, however, where vertically sided excavations are required to stay open for long periods or where groundwater enters the trench they are unlikely to remain stable if not supported.

Groundwater Control

Low permeability cohesive soils or high fines content within granular soils have reduced the permeability of the site therefore sump pumping should be capable of keeping temporary excavations dry in the event of seepages.

Foundations

Generally, the ground conditions at the site should be suitable for the use of shallow foundations and the predominantly cohesive soils will require a minimum founding depth of 1.0m bgl based on soil shrinkability. However, locally where soft clays are present in the Head Deposits, there is a risk of overstressing the ground, resulting in excessive settlements occurring. If house plots coincide with these locations the soft zones should be bypassed by deepening foundations to bear in firm to stiff clays of the Head or the Claygate Member or granular deposits of the Claygate Member.

It is recommended that the lateral and vertical extents of the soft clays are mapped by additional ground investigation to determine which areas of the site or individual or groups of house plots are affected. If there are areas where soft clays are particularly thick, it may be more economical to use piled foundations.

In accordance with guidance given in the NHBC (2020), the cohesive soils are shrinkable and typically of medium to high volume change potential. Due allowance should be made in the design of foundations for the present hedgerows on site and the trees and hedgerow adjacent to the Site, whether they are to remain or be removed, and any future trees and hedgerows planted as part of the development.

Any shallow foundations to structures within the area of influence of existing or proposed trees and hedgerows should be designed in accordance with guidelines for foundations given in Chapter 4.2 of the NHBC Standards (NHBC, 2020). In accordance with this guidance, the mature height of any trees retained or to be planted should be taken into consideration, whereas the effect of desiccation from trees or hedges that have been removed will be related to their size when felled.

Slope Stability

The site is sloping and is underlain by clay soils and relatively shallow groundwater which put it at an increased risk of potential slope instability. It is understood that cut and fill earthworks will be undertaken to create development platforms and therefore it is recommended that the implications of development in the slope is assessed at the detailed design stage by a qualified geotechnical engineer.

It is understood that an initial appraisal of the existing reservoir has been undertaken by Stantec, as reported in Technical Note 47268/001 dated 24 February 2021. Detailed investigation, soil sampling and testing was recommended to provide information for geotechnical slope stability analysis of the embankment dam.

Earthworks

It is envisaged that cut and fill earthworks will be required at the site to create platforms for construction of the housing plots. The silty nature and high recorded moisture content of the Head may limit its suitability for reuse as fill material. It is recommended that earthworks testing is undertaken on samples of the Head and the Claygate Member to assess their likely fill class and parameters for compaction.

Placement of fill material will result in long term settlement of the clay soils present on site. It is recommended that long term settlements of the ground under loading from fill or other structures such as road embankments, noise bunds or bunds around balancing ponds are assessed at the detailed design stage.

Pavement Design

It is envisaged that road pavements will be founded on in-situ cohesive Head Deposits. CBR testing was outside the scope of this investigation and should be undertaken as part of the next phase of ground investigation to inform pavement design.

As outlined above, the Head Deposits have a moderate susceptibility to volume change potential (BRE, 1993), therefore the subgrade may be susceptible to shrink/swell factors and should be taken into account in future design of the pavement.

Aggressiveness of the Ground

Chemical Attack on Buried Concrete

To date, pH and sulphate testing has only been undertaken on two samples of surface material (made ground/topsoil). These are not considered representative of the ground conditions that concrete foundations will be likely to be in contact with. pH and sulphate testing should be undertaken on samples of the Head deposits and the Claygate Member during further ground investigation works.

The recommendations of BRE (2005) should be followed in the design of mixes for buried concrete for the classifications given.

Design of Water Supply Pipes

The concentrations of potential contaminants measured as part of the limited geoenvironmental analyses undertaken to date indicate no significant potential contaminants in the locations tested. On this basis, it is unlikely that contamination of the water supply will occur via permeation of plastic supply pipes, however further analysis will be required to confirm this conclusion.

Notwithstanding the previous comment, under the Water Supply (Water Fittings) Regulations (DETR, 1999), the Water Supplier has a statutory duty to ensure that the design and material selection for water supply pipes are suitable and their advice and recommendations should be sought with regard to the water supply pipes for the proposed development. It should be noted that the Water Supplier may require additional testing to be carried out.

References

BGS (1976) Geological Map. Solid and Drift. Southend and Foulness Sheet 258/259. Keyworth, Nottingham, British Geological Survey

BGS (2021) British Geological Survey Lexicon of Named Rock Units [online] Accessed May 2021

BRE (1993) Digest 240. Low-rise buildings on shrinkable clay soils: Part 1. Building Research Establishment, Watford.

BRE (2016) Digest 365. Soakaway design. Building Research Establishment, Watford.

BRE Special Digest 1:2005 (Third Edition): Concrete in Aggressive Ground. Building Research Establishment, Watford.

BS EN ISO 14688-1: 2002 Geotechnical Investigation and Testing - Identification and Classification of Soil. Part 1: Identification and description. British Standards Institution, London

BS 10175:2011 (+A2:2017) Investigation of potentially contaminated sites – code of practice. British Standards Institution, London.

BS 22475-3 (2011). Geotechnical investigation and testing. British Standards Institution, London.

BS 5930 (2015+A1:2020) Code of practise for ground investigations. British Standards Institution, London.

BS 8002 (2015). Code of practice for earth retaining structures. British Standards Institution, London.

Look, B (2007) Handbook of Geotechnical Investigation and Design Tables. Taylor & Francis Group, London.

NHBC Technical Standards - 2020 Edition.

Stantec (2021) TN002 - Infiltration Assessment at Land East of Rayleigh Road, Thundersley. Reference 332210105/350.001, Stantec UK Ltd, Cambridge.

Water Supply (Water Fittings) Regulations (DETR, 1999)

FIGURES

APPENDIX 1 – Investigation Logs

APPENDIX 2
Stantec Methodology for Assessment of Contaminated Land

APPENDIX 3
Stantec Rationale for Selection of Generic Assessment Criteria

APPENDIX 4
Geoenvironmental Testing Certificates

APPENDIX 5
Geotechnical Testing Certificates