Phase III Investigation Report

at Sumners Pond, Barns Green, Horsham, RH13 0PR

for Sigma Homes Ltd

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EXECUTIVE SUMMARY

LEAP was commissioned to undertake a Phase III site investigation of a site referred to as Sumners Pond, Barns Green, Horsham, RH13 0PR. The aim of the investigation was to assess the potential desiccation of the underlying clay soils in the north of the site. An assessment of contamination under a former bunded silage stockpile, now accessible, was also undertaken. The site is approximately 1.8 Ha and is part of an active campsite and fishery, although the site itself is used for a combination of vehicle storage, agricultural purposes and car parking. It is proposed to redevelop the site with 7 No. 1 to 1.5 commercial units and 32 No. 1.5 to 2 storey residential dwellings with associated gardens, car parking spaces and access roads.

LEAPs Phase 1 Desk Study highlighted that the site is mapped as being underlain by the Weald Clay Formation. Historically the northern half of the site has remained as agricultural land since 1876 until present day and the southern half of the site remained as agricultural land until the 1960s when it underwent development until present day. The LEAP Phase II Investigation comprised 4 No. windowless with 2 No. installed for gas and groundwater monitoring, 5 No. machine excavated trial pits, 4 No. hand dug and 2 No. BRE DG365 soakage tests. The geotechnical laboratory results indicated that the clay soils may be desiccated down to 2.0mbgl. Further investigation was recommended. Chemical testing identified 2 No. exceedances within the southern half of the site in PAHs, with no exceedances noted within the northern half. Further investigation following demolition and removal of hardstanding to assess the contamination in the southern half of the site was recommended.

The Phase III investigation comprised of 1 No. 20m rotary borehole, 4 No. windowless and 3 No. hand pits. The ground condition encountered across the 2 phases comprised topsoil over made ground over Weald Clay over Mudstone. Groundwater seepages were encountered in 3 No. location ranging from 1.85m to 3.5m with a seepage at 0.3m noted in HA3.

The results of the soil desiccation assessment undertaken through a combination of soil moisture content, plasticity and hand penetrometer testing indicate the soils in the north of the site are potentially desiccated to ~2.0m bgl. As such it is recommended that any shallow foundations are extended below the depth of these desiccated soils to at least 2.0m bgl

An allowable bearing capacity of 120kPa is recommended for 600mm wide conventional foundations on the Weald Clay below about 2.0m. Piled foundations may be the preferred option due to the desiccated soils and the need to deepen foundations. Preliminary pile designs indicate that a 10m long 350mm diameter cfa pile would have a design compressive strength of about 375kN. Suspended floor slabs are recommended.

A preliminary assessment of the foundation type using our carbon calculator indicates that assuming the foundations summarised above are utilised on site then piled would be the less carbon intensive option.

3 No. geo-environmental samples were collected under the former silage stockpile. Contamination testing of the soils identified no exceedances within the soil. One fragment of chrysotile asbestos was identified at surface.

Recommendations are given for additional work required for the detailed design stage. Allowance should be made for investigation in the southern half of the site once the buildings and hardstanding have been demolished. At this stage. allowance for provision of 600mm of clean cover in residential garden areas where made ground is present is advised.

As with any redevelopment site, there is always the risk of hitherto undetected contamination, and further investigations should be carried out prior to redevelopment.

Signed:	 Imogen Adshead Msci FGS
Countersigned:	 Adam Carr BSc MSc FGS
Approved By:	 Richard Brinkworth BEng CEng MICE Registered Ground Engineering Professional
Date:	29 September 2023
Revision:	Issue 1

A INTRODUCTION

1 Authority

RSK Environment Ltd trading as Leap Environmental (hereafter referred to as LEAP) has been appointed by Sigma Homes Ltd to undertake a Phase III intrusive Site Investigation of a site referred to as Sumners Pond, Barns Green, West Sussex, RH13 0PR (Figure 1, Appendix B). The instruction was given in an email dated 26th July 2023 and signed by Adam Light of Sigma Homes.

2 Objective

LEAP understands that it is proposed to redevelop the site with 7 No. up to 2 storey commercial units and 32 No. up to 2 storey residential dwellings with associated gardens, car parking spaces and access roads as per the attached layout in 'Proposed Site Plan Residential and Commercial Scheme 001', Appendix B. The commercial buildings are located in the southernmost part of the site, with residential dwellings located across the rest.

The proposed development has been assessed in accordance with BS EN 1997[1], as being a Geotechnical Category 1 structure.

The objectives of this report are to:

- Assess whether the shallow soils in the north of the site are desiccated and if so, the extent of desiccation;
- Carry out a deep borehole to compile a preliminary pile design parameters;
- Assess the potential for soil heave following the removal of the earth embankment in the south of the site: and
- Provide supplementary information environmental quality of the ground beneath the former silage heap;

3 Previous Studies

The site has been the subject of previous investigations by LEAP. The following site investigation reports should be read in conjunction with this report.

[1] BS EN 1997-1(2004)+A1:2013 Eurocode 7:Geotechnical Design: General Rules

- Phase I Desk Study, Site Reconnaissance & Phase II Site Investigation Report produced for Sigma Homes Ltd by LEAP. Ref LP3019. Issued 13th September 2022.
- Groundwater Monitoring Results Sumners Pond, Horsham produced for Sigma Homes Ltd by LEAP. Ref EL/23/LP3019/GW. Issued 8th June 2023.

4 Scope of Works

This report describes a two stage process whereby the site is investigated and risks are assessed. The terms geotechnical and geoenvironmental are referred to throughout the report.

Geoenvironmental refers principally to the chemical nature of the ground and the degree of soil, water and/or land gas contamination and the impact that contamination may have on current or future development and also on the wider environment.

Geotechnical refers to all other aspects of the ground conditions and the impact they may have on the physical construction of existing or future development, principally foundations, slope stability, drainage, pavement and road design and groundwater control.

4.1 Intrusive Investigation Scope

The Phase III work comprises intrusive investigation and laboratory analysis. The results of this and previous investigation reports are used to validate and update the initial Conceptual Site Model (CSM). This phase of site investigation comprised the following tasks:

- 1 No. 20m deep Rotary borehole drilled with a tracked rig;
- 4 No. 4.0m deep windowless boreholes drilled with a tracked rig;
- 3 No. 0.4m to 0.5m deep hand dug pits;
- In-situ geotechnical testing including Standard Penetrometer Tests in the boreholes;
- Geotechnical Laboratory Testing including Atterberg Limit Tests, Moisture Content and UCS (Uniaxial Compressive Strength), Oedometer Swelling Testing; and
- Chemical Laboratory tests including 3 No. LEAP standard soil suite tests.

The intrusive works were completed by contractors who have been scrutinised and are on LEAP's approved contractor list. The windowless sampling was carried out by Oaklands Site Investigation Ltd, the rotary borehole was carried out by Marshall Drilling Ltd and supervised by LEAP. Each trial hole location was scanned and cleared using ground penetrating radar (GPR) and positioned using GPS prior to breaking ground.

Selected samples of soil were scheduled for laboratory testing for a wide range of potential contaminants including metals, non-metals, polyaromatic and petroleum hydrocarbons and volatile organic compounds. The laboratory testing has been carried out by Envirolab.

Selected soil and rock samples have been classified by laboratory analysis for geotechnical design purposes. The laboratory testing has been carried out by Geolabs Ltd at its laboratories in Watford.

The final stage in the geoenvironmental assessment comprises a quantitative risk assessment and revision of the preliminary Conceptual Site Model. Preliminary recommendations for remediation have been provided, based on various development assumptions which are detailed in the following section and in the text of this report. The risk assessment has been carried out in accordance with UK industry standards and in particular in accordance with LCRM[2] and BS10175:2011+A2:2017.

The final stage of the geotechnical assessment is the provision of preliminary soil parameters for use in geotechnical design, and broad recommendations for appropriate foundation options. It is intended that the Geotechnical Information section of this report will fulfil the general requirements of the Ground Investigation Report as set out in Section 6 of BS EN 1997-2:2007[3].

5 Sustainability Considerations

5.1 Carbon Reduction

There is an urgent need to optimise redevelopment to significantly reduce the carbon footprint of the process without compromising the requirement for delivering a safe and suitable use of the site. With that in mind, Leap has worked in partnership with the University of Surrey to develop a series of carbon reduction design tools (CReDiT). These provide information on the embodied carbon cost of its report recommendations and encourage the conversation about carbon at an early stage in the design process.

Consideration has been taken throughout the report to align the recommendations with climate protection, circular economy and sustainable materials.

Leap recognises the unique position that it occupies at the very beginning of development projects and the value of informing clients on the carbon cost of design recommendations. As

[2] Environment Agency. Land Contamination Risk Management (LCRM),. https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm

[3] BS EN 1997 Eurocode 7- Geotechnical Design- Part 2: Ground Investigation and Testing (2007)

such, headline information from the CReDiT tools will be provided in site investigation reports without additional cost to the client. This is being done in order to engage furthermore detailed consultation where the full range of Leap's sustainability capabilities can be deployed.

5.2 Potential for Ground Source Heating and Cooling

Most locations in the UK are suitable for the installation of ground source heating or cooling (GSHC) systems. The most appropriate type of installation is determined by the available space, heating and cooling demands of the proposed development and a number of geological and hydrogeological factors, and drilling risks (amongst other factors). LEAP can appraise these site-specific conditions through a desk-based feasibility study to assist in determining the viability of this sustainable source of heating/cooling energy at the site, should this be of interest to you. We also have in-house capability to undertake field assessments including soil thermal conductivity surveys and soil thermal response test (TRT), as well as the design and installation of GSHC systems.

6 Limitations

This report has been prepared by Leap Environmental on the basis of information received from a variety of sources which Leap Environmental believes to be accurate. Nevertheless, Leap Environmental cannot and does not guarantee the authenticity or reliability of the information it has obtained from others.

Leap Environmental has used all reasonable skill, care and diligence in the design and execution of this report, taking into account the manpower and resources devoted to it in agreement with the Client. Although every reasonable effort has been made to obtain all relevant information, all potential contamination, environmental constraints or liabilities associated with the site may not necessarily have been revealed.

The conclusions reached in this report are necessarily restricted to those which can be determined from the information consulted and may be subject to amendment in the light of additional information becoming available. These conclusions may not be appropriate for alternative schemes.

This report is confidential to the Client and Leap Environmental accepts no responsibility whatsoever to third parties to whom this report, or any part thereof, is made known, unless formally agreed by Leap Environmental beforehand. Any such party relies upon the report at their own risk.

Full details of the limitations are provided in Appendix A.

B ENVIRONMENTAL SETTING

*The following section summarises the finding of the previous Phase I Desk Study, Site Reconnaissance and Phase II Site Investigation Report (**Ref LP3019**) completed in September 2022.*

7 Site Location and Description

The site is located at Sumners Pond, Barns Green, Horsham, RH13 0PR as shown in Figure 1, Appendix B. The approximate National Grid Reference of the site TQ 12488 26842. The site lies at an estimated elevation of 36m Above Ordnance Datum (m AOD).

The site is approximately 1.8 ha and is part of an active campsite and fishery, although the site itself is used for a combination of vehicle storage, agricultural purposes and car parking.

The site itself can broadly be divided in two due to the difference in land use. The southern half of the site comprises several buildings: one is large (~800m^2) and irregular in shape which is used to house cattle and store hay; one is large (~825m^2) and rectangular in shape which is used to store caravans and vehicles; the others are smaller and rectangularly shaped which are used for repair and sales of second-hand vehicles and garden machinery. Between these structures the ground cover comprises blacktop and concrete in various states of disrepair. In the far southern section of the site is a grass topped mound/ embankment.

The northern half of the site comprises a grassed field which has agricultural equipment and machinery stored in the eastern section of the field along with a former bunded silage area with bunds on the east, north and west. A track runs along the western boundary of the field orientated roughly north south which is used as access to the fishing lakes. Separating the northern and southern halves of the site is an access road to the campsite, which is located to the west of the site, and a car parking area. The field is also used as an overflow car park for the campsite. The field is bounded by a mature hedgerow (including blackthorn) and mature deciduous trees (including oak and beech trees).

The site is relatively level: the elevation in the northern half of the site is 34m AOD at its lowest at the northern boundary, which has a gentle slope of <1° upwards to the south of the site which has an elevation of approximately 35m AOD. A grassed mound/ embankment, known as the "amphitheatre", is located in the southernmost section of the site, which reaches 39.5m AOD and has a gradient of ~23°. The southern slope is benched.

The site is bounded by the campsite to the west, with a pond and fields beyond; fields and woods are located beyond the site to the north; to the east is Chapel Road, with the residential village of Barns Green beyond; and to the south is Sumners Lake and Farm Pond (part of the fishery), with fields and woods beyond.

7.1 Geology

The geology of the site has been ascertained by reference to the 1:50,000 British Geological Survey sheet 302 '*Horsham*', solid and drift edition, the BGS website (www.bgs.ac.uk) and the Groundsure report. The site is mapped as being underlain by the Weald Clay Formation – Mudstone.

The online BGS Geoindex (http://www.bgs.ac.uk/geoindex/) has been reviewed for detailed local geological and hydrogeological information. No boreholes have been identified within 250m of the site.

7.1.1 Weald Clay Formation

The Weald Clay Formation are Lower Cretaceous deposits. They comprise mostly shales and mudstones known as the Weald Clay with subordinate beds of siltstones, sandstones, shelly limestones and clay ironstones. When fresh the beds are normally dark grey but weather to yellow and brown. Conspicuous bands of red clay also occur usually in close association with sandstone beds.

7.2 Hydrogeology and Hydrology

The Weald Clay Formation which is mapped beneath the site is classified as Unproductive Strata. The site is not situated within a Groundwater Source Protection Zone (SPZ).

Five Fishing lakes associated with the campsite are located within 500m of the site to the south west and northwest. It is noted that a ditch is located running along the western boundary of the grassed area in the northern half of the site adjacent to the track.

7.3 Flooding

According to the Environment Agency, the site is not located within a flood zone. However, the Groundsure report indicates the highest risk of surface water flooding on site to be a 1 in 30 year return period with depths between 0.3m – 1.0m in a small section in the north of the site, which is associated with the inland river.

7.4 Unexploded Ordnance (UXO)

The risks from unexploded ordnance have been assessed in accordance with CIRIA guidance[4]. A non-UXO specialist preliminary screening assessment has been carried out. The risks have been assessed by considering firstly the likelihood of military activities on, or in the vicinity of the site as determined from the desk study and historical review. Secondly the risk of UXO

[4] CIRIA C681 2009. Unexploded ordnance (UXO) - A guide for the construction industry

has been assessed by reference to the unexploded WWII aerial delivered bomb (UXB) regional risk maps produced by Zetica.

The Zetica risk maps indicate a low risk. Hence the overall risk of UXO is rated as low.

8 Previous Investigations

The site has been the subject of 2 No. reports undertaken by LEAP, the findings of which are summarised below. Only information considered pertinent to the objectives of this investigation are summarised below.

8.1.1 LEAP Phase I Desk Study, Site Reconnaissance & Phase II Site Investigation Report Ref LP3019

The report outlines the finding of the Phase I desk study and Phase II Investigation undertaken in August 2022. It notes that historically the northern half of the site has remained as agricultural land since 1876 until present day and the southern half of the site remained as agricultural land until the 1960s when it underwent development until present day.

The desk study identified possible sources of contamination in the southern half of the site including polycyclic aromatic hydrocarbons (PAH), metals, petroleum hydrocarbons (PHC), polychlorinated biphenyls (PCB), mineral oils and asbestos, which are associated with made ground, and the vehicle and lawn mower repair services on site. In the northern half of the site possible contamination includes pesticides, herbicides and heavy metals associated with the site's former and current use as agricultural land.

Geotechnical risks identified on site included the presence of made ground, potential swelling and shrinking within clay soils, potential frost susceptible soils and potential sulphate risk to concrete.

The report goes on to outline the findings of the Phase II investigation, comprising of 4 No. windowless boreholes, 2 No. of which were installed for gas and groundwater monitoring, 5 No. machine excavated trial pits (TP1-TP4, TP8), 4 No. hand dug pits (TP5-TP7, TP9) and 2 No. BRE DG365 soakage tests.

Ground conditions in the northern half of the site generally comprise topsoil to 0.18m / 0.40m over reworked clay / silt to 0.5m / 1.6m over clay to 1.1m / 3.0m over mudstone to the full depth of investigation to 5.0m. Groundwater was encountered in WS1 and WS5 ranging from 2.0m to 2.3m. In TP2 and TP8 arisings were noted to be damp to the touch at 2.2m and 2.7m respectively. The natural clays appeared desiccated to depths of between 0.80m and 1.0m bgl within TP1, TP2, TP4 and TP8. Within all trial holes the clay became friable, closely fissured and thinly to thickly laminated below depths of between 1.10m and 2.0m with the exception of TP3.

The results of Atterberg limit testing indicated that the underlying clays exhibit HIGH Volume Change Potential (VCP). Furthermore, geotechnical laboratory results indicated that the clay soils were potentially desiccated to a depth of 2.0m bgl and recommended desiccation analysis be undertaken. Due to the high VCP and desiccated nature of the soils it was outlined that foundations would require deepening and piled foundations may be a more suitable option for some, or all of the site. Deep boreholes were also recommended to confirm the pile design parameters. It should be noted that the site investigation was carried out during a period of hotter than average weather.

Chemical testing identified 2 PAH exceedances within the southern half of the site, no exceedances were noted within the northern half. The report recommends further investigations are conducted once the structures in the southern half are demolished and hard standing removed, to delineate the hotspot(s).

8.1.2 LEAP Groundwater Monitoring Results Sumners Pond, Horsham Ref EL/23/LP3019

This report details the results of six fourtnightly monitoring visits carried out between 6/12/22 to 13/03/23 measuring the groundwater in the 2 installed wells WS2 and WS5. WS2 is located in the north of the site and WS5 in the south.

The groundwater was measured between 1.66m bgl to1.90m bgl in WS2 and 0.45m bgl to 0.60m bgl. It should be noted that in only 3 of the 6 visits WS5 was able to be monitored due to a vehicle being parked over the well.

C REVISED CONCEPTUAL SITE MODEL

9 Geotechnical Risk Assessment

9.1 Revised Ground Model

Based on the findings of the desk study and the Phase II investigation, the ground model for the site is summarised in Table 1 below.

Table 1: Ground Model

Ground Model	Characteristics	Notes
Ground Conditions	Bedrock: Weald Clay Formation.	The Phase II investigation classified the Weald Clay on site as a high plasticity clay over extremely weak to weak mudstone at depth. Selenite crystals were encountered within the clay between depths of 1.45m to 3.0m and chemical testing classified the site as sulphate design class DS-3 and AC-2s. Visual evidence of desiccation was noted within the clay soils as friable, closely fissured and thinly to thickly laminated below 1.1m to 2.0m. Laboratory testing indicated potential desiccation up to 2.0m.
	Made ground (in the southern half of the site)	Made Ground was present predominantly in the south of the site. In the north of the site reworked topsoil or clay were logged in TP3, TP4 and WS2.
Groundwater	The Weald Clay Formation is mapped as Unproductive Strata.	Perched groundwater was encountered within the Weald Clay at the clay/mudstone interface. Arisings were noted as damp to the touch in TP2 and TP8 in the northern half of the site during the Phase II investigation. The six groundwater monitoring visits recorded 0.50m to 1.9m.
Surface Water features	Inland river along the northern site boundary, and several lakes/ ponds >10m to the south, west and northwest.	Catchment of inland river is the Adur West.
Topography	Generally flat, the southern half of the site slopes very gently down to the northern	The mound may have been raised. The source of this material is unknown.

	boundary with a gradient of <1°. A mound is present in the southernmost part of the site with a gradient of ~23°.	

9.2 Revised Geotechnical Risk Register

The following geotechnical hazards have been identified as significant to substantial risks:-

Table 2: Geotechnical Risk Register Summary

Geotechnical Hazard	Overall Risk	Comments
Made ground	Significant	Made ground encountered to a depth of 0.70m to 1.6m in the northern end of the site. In the southern end of the site made ground is logged to a depth of 0.3m to 0.9m. Unknown source, and age across the site. Foundations may require deepening and excavations within the made ground will be unstable.
Shrinkable soils	Substantial	The geotechnical testing in the Weald Clay classified it as a HIGH volume change potential with mature trees and hedgerows present on the perimeter in the northern half of the site, where foundations may require deepening. Based on the Phase II geotechnical laboratory results indicated desiccated clay soils down to 2.0mbgl.
Frost susceptible soils	Significant	Silty pockets are occasionally encountered within the Weald Clay. As such frost susceptible soils may be present on site.
Aggressive ground conditions for concrete	Significant	Naturally occurring selenite crystals within the Weald Clay can produce ground that is aggressive to concrete. Sulphate testing in the Phase II investigation classified the site as DS-3 and AC-2s.

On the basis of the initial review and preliminary risk assessment, the site is given a Geotechnical Classification of **Geotechnical Category 1** in accordance with EN1997-1 §2.1(14)-(21).

10 Sustainability Considerations

The geological, geotechnical and hydrological conditions of the site along with the potential for contamination can significantly influence the suitability of sustainable options on site.

The ground conditions indicate high plasticity clay can be anticipated. A piled foundation be the less carbon intensive option.

D PHASE III - INTRUSIVE INVESTIGATION

11 Investigation Rationale

A further rotary borehole to 20.0m, 4 No. windowless up to 5.0m and 3 No. hand pits up to 0.5m were excavated across the northern half of the site as part of the Phase III investigations. The main purpose of the site investigation was to collect geotechnical information to support the desiccation assessment of the clay soils, to inform a preliminary pile design and collect geo-environmental information where the bunded silage stockpile was located.

The investigation rationale for the investigation locations is summarised below:

Table 3: Rationale and Scope for Investigation Locations

Trial Hole/Test Location	Rationale	Proposed Depth (m bgl)	Achieved Depth (m bgl)	Additional Comments
BH01	Located in the grassed area within the northern half of the site. Provide information on ground conditions and geotechnical parameters for pile design.	20.0	20.0	
WS101-WS104	Provide information on ground conditions and geotechnical parameters for desiccation assessment.	5.0	3.0 – 4.8	Boreholes terminated due to refusals on extremely weak mudstone.
HP1-HP3	Provide information on geo-environmental contamination in the former bunded silage stockpile.	0.5	0.4 – 0.5	

12 Site Work

12.1 Date and Weather Conditions

The intrusive investigations were undertaken between 07/08/23 and 08/08/23. At the time of the investigations, the weather was sunny.

The previous rainfall in May 2023 was 55% UK average, in June 68% and in July 170% making it provisional the July wettest since 2009.

12.2 Site Work Methods

12.2.1 Borehole Drilling

Boreholes were drilled using a Rotary rig. The boreholes were excavated at 90mm diameter. A water flush was added as the boreholes progressed. Borehole diameters and volumes of flush used are recorded on the borehole logs in Appendix D.

12.2.2 Windowless Sampler

The Windowless sampling rig consists of a tracked barrow with a sampling unit mounted on the top. When in the required position, the mast was raised to a height allowing a mechanised drop weight to fall repeatedly onto an anvil, and drive attached sample tubes or probe rods into the ground to produce reasonably intact continuous samples which were then extracted using the integrated hydraulic ram.

To reduce any tendency of the tubes to stick in the ground, a succession of smaller diameters may be used to obtain full depth. Excavated soils were placed aside for inspection and sampling.

On completion the borehole was backfilled with excavated material, placed in reverse order, and the surface reinstated unless otherwise specified.

12.2.3 Hand Pitting

Hand pits were excavated using hand tools at 0.30m diameter. Spoil was placed on plastic sheeting to prevent cross contamination and was reinstated in reverse order.

12.2.4 Soil Logging and Sampling

Soil samples were recovered from the boreholes and trial pits for field screening, logging and sampling.

Boreholes were logged in general accordance with the requirements of BS 5930:[5] and BS EN ISO 14688[6]. Borehole logs are presented in Appendix D.

Visual and olfactory evidence of contamination was noted if encountered. These observations were used to aid scheduling of samples for chemical laboratory analyses, and are included on the borehole logs in Appendix D and summarised in Section 13.1.2.

[5] BS5930:2015+A1:2020 Code of Practice for Ground Investigation

[6] BS EN ISO 14688 Parts 1-2 (2018) Geotechnical Investigation and Testing. Identification and classification of soil

Samples were collected with a clean sampling trowel or by hand (using dedicated nitrile gloves for each sampling location). Samples were placed into laboratory supplied sampling containers, specific to the type of analyses required.

All sample containers were sealed and labelled with a unique location identity, depth and date of sampling.

12.2.5 Monitoring Well Installation

No monitoring wells were installed as part of the Phase III investigation. 2 No. monitoring wells were installed during the Phase II investigation within the windowless boreholes as summarised in the following table. The findings are presented within the Phase II report (Ref LP3019).

Table 4:Borehole installation details

Borehole	Targeted Medium	Installed Depth (m bgl)	Response Zone (m bgl)	Bentonite Seal (m bgl)	Targeted Stratum
WS2	Groundwater	2.4	1.0 – 2.4	GL – 1.0	Weald Clay
WS5	Groundwater	5.0	1.0 – 5.0	GL – 1.0	Weald Clay

12.3 Sampling and Field Tests

12.3.1 Soil Sampling

Geoenvironmental soil samples were selected to ensure that near-surface exposure of human health via direct contact was targeted, as well as to spatially and vertically delineate possible sources of contamination in the area of the former bunded silage stockpile.

Geotechnical soil samples were targeted to characterise the geological sequence, and to obtain characteristic soils properties and specific geotechnical design parameters as per the proposed development. Samples were targeted at every 0.5m to enable the profile of moisture content and liquid limit with depth to assess desiccation.

12.3.2 Standard Penetration Tests

Standard penetration tests were undertaken in the boreholes at 1.0m centres in cohesive soils in the windowless boreholes. In the rotary borehole standard penetration tests were carried out at 1.5m until rockhead was encountered, in accordance with BS EN ISO 22476-3;2005. Uncorrected blow counts, 'N values', are recorded on the borehole logs in Appendix D.

12.4 Laboratory Analysis

12.4.1 Geotechnical Laboratory Testing

Selected samples of the soils have been classified by laboratory analysis for geotechnical design purposes. The laboratory testing has been carried out by Geolabs Ltd at its laboratories in

Watford, in accordance with BS1377[7] and BS EN ISO17892[8]. The sampling technique, type, storage and transport and the number of laboratory tests have been undertaken where possible in accordance with BS EN 1997-2:2007 and BS EN ISO 22475[9].

The following laboratory tests have been undertaken:-

Table 5: Geotechnical Laboratory Testing

Test	Number of tests
Moisture Content	29 (9)
Atterberg Limit Test	16 (9)
Uniaxial Compressive Strength (UCS)	5
Point Load (10 Point)	2
Oedometer Test	2
Sulphate Determination	(5)
Californian Bearing Ratio	(4)

*The geotechnical testing carried in the Phase II Investigation is in brackets.

The geotechnical laboratory test results are provided in Appendix F.

12.4.2 Chemical Soil Analysis

Selected samples of soil were subjected to laboratory testing.

The suite of soil contaminant analysis took into account the contamination identified previously and the potential contaminants of concern identified in the CSM (heavy metals, PAHs, asbestos, petroleum hydrocarbons). Soil samples were also analysed for pH and total organic carbon (TOC) to support the selection of assessment criteria in the subsequent quantitative risk assessment (QRA) for human health.

Sampling techniques and storage have been undertaken as per BS 10175:2011+A1:2013 Code of Practice for Investigation of Potentially Contaminated Sites. The laboratory testing was carried out by Envirolab. Where available, the tests for soils procedures were UKAS and MCERTS accredited.

The following analyses were completed on selected soil samples based on field observations and for general vertical and lateral coverage:

- 3 No. metals (As, Cd, Cr, CrVI, Cu, Pb, Hg, Ni, Se, Zn)
- 3 No. USEPA 16 PAHs

[7] BS1377 Parts 1-9:1990 Methods of test for Soils for Civil Engineering Purposes

[8] BS EN ISO 17892 Parts 1-12 Geotechnical Investigation and Testing. Laboratory testing of soil

[9] BS EN ISO 22475 Parts1-3 Geotechnical Investigation and Testing. Sampling methods and groundwater measurements

- 4 No. x Asbestos identification
- 3 No. x pH
  3 No. x TOC

The laboratory test results are summarised in Section G.

13 Ground Conditions

The ground conditions are described in detail in the logs attached in Appendix D. In summary the soil conditions were as follows:

Table 6: Summary of soils encountered

Depth From (m)	Depth To (m)	Soil Type	Description
GL	0.15 / 0.4	**REWORKED TOPSOIL**	Brown slightly clayey slightly sandy gravelly silt with gravels of flint. Recovered as desiccated with common rootlets.
0.15 / 0.90	0.5 / 1.6	**MADE GROUND**	MADE GROUND composed of light brown slightly clayey sandy gravelly silt with gravels of flint, brick, blacktop and concrete. *Only logged in WS102-104, WS2 and TP3
0.3 / 1.6	1.1* / 4.5*	**CLAY**	Stiff becoming very stiff with depth grey with orangish brown mottled CLAY with occasional black staining and rootlets. (Weald Clay Formation)
2.3 / 3.7	2.4* / 20.0*	**MUDSTONE**	Extremely weak becoming weak with depth dark grey silty locally laminated MUDSTONE (Weald Clay Formation) *Only noted in WS101, WS104, BH01, TP1, TP2 and TP8

*Full depth of investigation.

Ground conditions comprised reworked topsoil over made ground over stiff becoming very stiff clay over extremely weak becoming weak mudstone. The Phase III investigation confirmed the ground conditions encountered in the northern end of the site in the Phase II.

Made ground was encountered predominantly in the southern half of the grassed area, with the greatest depth to 1.6m encountered in TP3 with all other made ground encountered to 1.0m or less. TP3 was located to the south of the carpark and the deeper made ground is likely associated with this. In the Phase II reworked clay was logged in TP3 between 0.9m to 1.6m comprising dark green-grey with black staining and occasional brick fragments. This was not encountered in WS104 within Phase III, where made ground was logged to 1.0m with clay below.

It should be noted that archaeological excavations had been carried out in the area of WS102 between the Phases of LEAP's investigations. In WS102 made ground was logged to 0.7m.

In the Phase II investigation, the clays appeared desiccated between the depths of 0.8m and 1.1m within TP1, TP2, TP4 and TP8. The clay was noted as friable, closely fissured and thinly to thickly laminated below the depths of 1.0m to 2.0m within all Phase II locations except TP3. The Phase III windowless did not note the shallow clays as friable.

Selenite crystals were logged in both Phases between depths of 1.45m and 4.8m.

Mudstone was encountered in WS101, WS104 and BH01, as well as within the Phase II investigation in TP1, TP2 and TP8 from 2.3m / 3.7m to the full depth of investigation. BH01 logged extremely weak mudstone from 3.7m, very weak mudstone 5.7m and weak mudstone from 9.0m. WS101 and WS104 and TP2 all note interbedded extremely weak mudstone and very stiff clay.

13.1.1 Groundwater

Groundwater strikes were recorded in the following trial holes:-

Table 7: Groundwater Strikes

Trial Hole	Date of water strike	Depth to Groundwater strike (mbGL)	Comments
WS1*	08/08/2022	2.0	Groundwater seepage between 2.0m and 2.4m bgl
WS5*	08/08/2022	2.3	Groundwater seepage at 2.3m bgl
TP2*	09/08/2022	2.7	Arisings damp to the touch
TP5*	09/08/2022	2.2	Arisings damp to the touch
BH01	07/08/2023	1.85	Groundwater seepage at 1.85m bgl
WS101	08/08/2023	3.5	Groundwater seepage at 3.5m bgl rising to 3.0m on completion.
WS104	08/08/2023	3.5	Groundwater seepage at 3.5m bgl rising to 3.0m on completion.
HP3	08/08/2023	0.3	Groundwater seepage at 0.3m bgl

*Phase II Investigation (Ref LP3019)

Groundwater monitoring results are summarised as follows:-

Table 8: Groundwater Monitoring Results

Monitoring well	Depth to groundwater (mbgl)					
	6/12/22	22/12/22	03/01/23	19/01/23	14/02/23	13/03/23
WS2	1.9	1.9	1.85	1.74	1.84	1.66

WS5	-	0.50	0.60	0.45	-	-

The full monitoring results are provided in the Phase II report. On multiple occasions WS5 was unable to be monitored due to cars parked over the monitoring well. It should be noted that groundwater monitoring was undertaken during a period of prolonged dry weather in August 2022.

13.1.2 Visual and Olfactory Evidence of Contamination

Discounting the presence of Made Ground with anthropogenic items including brick, concrete, blacktop and a chrysotile cement fragment in HP1 evidence of contamination was encountered within the other exploratory locations.

E GEOTECHNICAL INFORMATION

14 Strata Encountered

14.1 Made Ground

The site is underlain by made ground in the south of the site with depths up to 0.9m. In the northern half of the site reworked topsoil and/or clay was encountered in TP3, TP4 and WS2 at depth of 1.6m, 0.5m and 0.4m respectively.

The made ground was generally comprised dark brown sandy gravelly silt with gravels of brick, concrete, blacktop and a fragment of chrysotile cement in HP1.

Made ground or fill is by nature highly variable in both composition and bearing capacity, and can be subject to large differential settlements when loaded. It is therefore generally unsuitable for use as a bearing stratum. In addition, made ground may contain contaminated and/or putrescible material. It can therefore be potential source of contamination and landfill gas.

14.2 Weald Clay Formation

14.2.1 Clay

The made ground / reworked topsoil and/or clays were underlain by stiff to very stiff plastic clays to 1.1m / 4.5m or the full depth of excavation. The results of the geotechnical laboratory testing are summarised in the table below.

Table 9: Summary of Geotechnical Test Results for Clay

Test	Range
SPT 'N value'	7 – 38 (5 – 50)
Corrected SPT 'N' Values	7 – 37 (5 – 50)
Moisture Content (%)	11.9 – 34.1 (17.3 – 30.9)
Coefficient of volume compressibility m_v (m^2/MN)	0.020 – 0.050
Liquid Limit (%)	41 – 75 (51 – 71)
Plastic Limit (%)	20 – 28 (23 – 29)
Plasticity Index (%)	20 – 51 (27 – 44)
Undrained shear strength (kN/m^2)*	(106 – 260)
Sulphate Content (g/l)	(0.031 – 1.1)
pH	(6.9 – 7.6)
California Bearing Ratio (%)	(1.1 – 7.3)

*Measured using a hand shear vane apparatus.

Standard Penetrometer Test (SPT) tests were undertaken at 1.0m centres in the windowless sampler boreholes and 1.5m centres in the rotary borehole. The SPT testing within the clays of the Weald Clay Formation returned N values ranging from N=7 to N=38 and showed a general increase with depth. Stroud (1974) found that a good correlation exists between the undrained shear strength of over-consolidated clays and their corresponding SPT blow count N value, where:

$$Cu = fl \times N$$

fl = factor between 4-6 relating to plasticity of the clay

Corrected SPT blow counts of N= 7 – 37 were recorded within the Clay. Using Stroud's factor fl=4.5 for the soils encountered, the corresponding undrained shear strengths vary from 32 kPa to 171 kPa, indicative of soft clays to stiff. The undrained shear strength results and the SPT correlation are shown in a plot vs depth in Appendix E.

WS101 to WS104 were all terminated due to SPT refusal on the mudstone between 3.0m to 4.8m. WS2 within the Phase II investigation recorded an SPT value of N=48 at 2.0m. Interbedded mudstone was logged in WS101 and WS104 from between 2.5m to 3.5m. The SPT vs depth graph (Figure 5, Appendix E) shows SPT values increasing with depth.

In the previous investigation (ref LP3019) the shallow clay soils visually appeared desiccated which was confirmed by the results of moisture content and plasticity testing. These results and the results of additional assessment as part of this investigation are summarised in Section F below.

Oedometer testing returned coefficients of volume of compressibility in the range of 0.020 – 0.050 m^2/MN, indicative of heavily over consolidated clays.

14.2.2 Mudstone

The clays were underlain by interbedded mudstones and stiff to very stiff clays to the full depth of the windowless boreholes. Mudstone was logged from 3.70m within BH01 to the full depth of 20.0m.

Table 10: Summary of Geotechnical Test Results for Mudstone

Test	Range
SPT 'N value'	50 - 72
Corrected SPT 'N' Values	50 – 71
Uniaxial Compressive Strength (Mpa) Mudstone	0.45 – 2.34
Point Load Index $I_{s(50)}$ (MPa) Mudstone *	0.05 – 0.07
Point Load Index $I_{s(50)}$ (MPa) Mudstone **	0.04 – 0.06
Point Load Index $I_{s(50)}$ (MPa) Mudstone ***	0.02 – 0.03

*Perpendicular to plane of weakness

**Parallel to planes of weakness

***Unknown Orientation of planes of weakness

All Standard Penetrometer Testing undertaken at the rock/soil interface were refusals (N=>50).

Based on field tests the mudstone was classified as extremely weak becoming weak with depth. The results of the uniaxial compressive strength (UCS) testing of the rock ranged from 0.45Mpa to 2.34Mpa at depths of between 7.7 - 8.0m and 11.4 - 11.7m. The lowest result of 0.45MPa was recorded at a depth of 9.35 - 9.65m. The results of UCS testing indicate the mudstone between 7 and 12m bgl ranges from extremely weak to very weak,

Point Load testing undertaken on the rock returned $I_{s(50)}$ values of between 0.02 MPa and 0.07 MPa between the depths 6.0m to 7.10m. Testing was competed on parallel, perpendicular and undefined to bedding. Perpendicular testing values ranged from 0.05MPa to 0.07Mpa, parallel ranged from 0.04MPa to 0.06MPa and unknown orientation ranged from 0.02MPa and 0.03MPa. For design purposes using a conservative conversion factor of C=10 then the approximate uniaxial compressive strength (UCS) can be estimated using the following conversion.

$$UCS = I_{s(50)} \times C$$

Using the above conversion the $I_{s(50)}$ results to an approximate UCS range of 0.2MPa to 0.7MPa. The approximate compressive strength estimated from point load testing is lower than the results of the UCS testing indicating extremely weak rock. A plot showing UCS and $I_{s(50)}$ estimated UCS is in Figure 11, Appendix E.

The plot of UCS and correlated UCS vs depth shows a general increase in UCS with depth. It should be noted that an anomaly is at 11.55m with a UCS value of 0.45Mpa, which could relate to a fractured zone within the mudstone.

F GEOTECHNICAL APPRAISAL

The following geotechnical appraisal focuses solely on the objectives of this investigation as outlined in Section A. For broader Geotechnical information pertaining to the site including soakage potential, settlement, CBR values etc the reader is referred to the Phase II Investigation Report Ref. LP3019.

15 Geotechnical Design

The foregoing geotechnical appraisal does not constitute a Geotechnical Design Report in accordance with BSEN1997. The following recommendations are for preliminary design purposes only.

For the detailed design, the short-term and long-term design situations must be considered. Where relevant, the following limit states should be considered:-

- Loss of equilibrium of the structure or the ground, considered as a rigid body, in which the strengths of structural material and the ground are significant in providing resistance (EQU)
- Internal failure or excessive deformation of the structure or structural elements in which the strength of structural materials is significant in providing resistance (STR)
- Failure or excessive deformation of the ground, in which the strength of soil or rock is significant in providing resistance (GEO)
- Loss of equilibrium of the structure or the ground due to uplift by water pressure or other vertical actions (UPL)
- Hydraulic heave, internal erosion and piping in the ground caused by hydraulic gradients (HYD)

The following factors should also be considered.

- Overall stability and ground movements
- Nature and size of the proposed construction including the design life
- Conditions with regards to the surroundings (e.g. neighbouring structures, traffic, utilities, vegetation, contamination etc.)
- Ground and groundwater conditions
- Influence of the environment.

16 Geotechnical Appraisal

16.1 Soil Desiccation Assessment

Desiccated clay soils typically show a reduction in strength from with depth from ground level, while non desiccated clay would be anticipated to increase in strength linearly with depth. The Phase II (ref LP3019) noted a reduction in strength based on hand penetrometer results in TP1, TP3 and WS2 from ground level to 1.75m bgl below which strengths increased. It should be noted that the investigation undertaken following a period of prolonged hot dry weather in July and August 2022. The current investigation did not show the same reduction in strength with the exception of WS103. However, it should be noted that the investigation was undertaken following an unusually wet July with 170% average rainfall recorded and as such desiccation is likely to be less wide spread during the recent investigation works. Furthermore, roots were noted to depth of ~2.0m in all intrusive locations. The plots of hand penetrometer vs depth is in Figures 7 and 8, Appendices E.

During the 2022 investigation visual evidence of desiccation was noted to depths of between 0.8m and 1.0m within TP1, TP2, TP4 and TP8 as the clay becoming friable and closely fissured.

Samples were taken at 0.5m intervals at the locations in the current investigation and plotted for depth vs moisture content (MC), liquid limit (LL) and plasticity limit. WS104 records a consistent moisture content between 26% to 30%. Based on its location, away from trees and hedgerows, WS104 can be taken as a control, demonstrating non desiccated soils. WS101, WS102 and WS103 all show lower moisture content values in the upper 2m typically ranging from 14.6% to around 20% in the same 2m depth range. The moisture content values then return to assumed equilibrium values of between 26% to 32% by 2.5m depth. In WS103 the profile is slightly less definitive than in WS101 and WS102, with a decrease of moisture content with depth below 2.5m. This is likely associated with bands of mudstone within the Weald Clay rather than desiccation of these deeper soils. During the 2022 investigation less extensive laboratory testing was undertaken in TP1, TP2, TP3, TP4, TP8 and WS2. The results were available with a moisture content of below 20% only noted in TP1 at 1.2m. The plots of MC and LL vs depth for this investigation are presented in Appendix E.

Driscoll[10] and Pugh[11] et al outline that for plastic clays, soils may be considered significantly desiccated where MC is less than 0.4 times the LL. Discounting laboratory results below groundwater seepages as well as test undertaken on the mudstone, six of the 18 No. results exhibited MC values of less than 0.4 times the liquid limit. Of these, four are associated with

[10] Driscoll (1983) The influence of vegetation on the swelling and shrinkage of clay soils in Britain, Geotechnique.

[11] Pugh, Parnell & Parkes (1995) A rapid and reliable on-site method of assessing desiccation in clay soils.

the current site investigation and the remainder from the Phase II when a period of prolonged dry weather was experienced. The MC and LL correlation indicate potential desiccation to a depth of ~2.0m bgl. It should be noted that the Driscoll method is applicable for plastic clays, predominantly the London Clay. It can by applied to Weald Clay, though it should be noted that Weald Clay generally transitions into extremely weak rock at a shallower depth and where mudstone gravels are presence this can erroneously indicate desiccation.

Based on the lines of evidence presented above it is considered that the soils in the northern 2/3 of the site, as represented by WS101, 102 and 103 and TP1 are potentially desiccated to between 1.75m and 2.0m bgl. It is likely that in the Phase II (LP3019) the presence of desiccation may have been more prominent due to the weather conditions. Groundwater monitoring recorded water levels at 1.66m to 1.90m during December 2022 to March 2023. During the summer months this is likely to be lower and therefore there is potential for desiccation at 1.75m within the clay soil.

16.2 Swelling and Shrinkage

Based on the laboratory test results in Section E, an overall classification of NHBC **HIGH** Volume Change Potential (VCP) is recommended for the clay soils. It is noted that several of the test results fell within the range for medium VCP. Foundations should be designed to NHBC High VCP requirements although deepening may be terminated where the mudstone is encountered at depth. If this classification is overly restrictive to the design plot by plot sampling and analysis may enable a reduction in VCP classification on a plot-by-plot basis if required.

Foundations will therefore require deepening in accordance with NHBC Chapter 4.2 where clay soils are encountered near trees. Foundation depths should be calculated based on the mature height of the tree, however, the existing height is relevant for trees which are to be removed.

The BGS GeoClimate study (UKCP18)[12] indicates the potential change in subsidence due to changes in climate. The results project a 6.5% of properties will be affected by swelling and shrinkage by 2030, rising to 11% by 2070 (compared to 3% in 2020).

16.3 Sulphates

Sulphates were beyond the scope of the Phase III investigation, though significant amounts of selenite was encountered in the windowless sampler boreholes. A Design Sulphate class DS-4 and assuming static groundwater, the ACEC class of AC-3s is considered appropriate.

[12] https://www.bgs.ac.uk/news/maps-show-the-real-threat-of-climate-related-subsidence-to-british-homes-and-properties/

However, we would note that the total potential sulphate within the soils falls with design class DS-5 and therefore for highly disturbed soils e.g if pile arising are to be re-used on site, then concrete in contact with this disturbed material should be design to DS-5 specifications.

16.4 Groundwater

Groundwater monitoring was undertaken as part of the Phase II Investigation (ref LP3019) and was beyond the scope in the Phase III.

Six groundwater monitoring visits of the two wells were carried out between the 06/12/22 to the 13/03/23 recording groundwater levels of between 1.66m to 1.90m bgl in the north of the site and 0.45m to 0.60m in the south of the site.

WS2 is located in the in the north of the site and WS5 in the south of the site. WS5 showed only recorded data in 3 of the 6 visits during December and January. It should be noted that December 2022 and February 2023 were drier than average, January 2023 was average and March 2023 was 155% of the average.

Seepages were recorded in the north of the site in TP2 at 2.7m, TP8 at 2.2m, 3.5m in WS101 and 3.5m in WS104.

16.5 Foundations

16.5.1 Shallow Foundations

Allowable Bearing Capacity or Pressure is a conservative estimate of the ultimate bearing resistance of the ground, selected on the basis of the soil/rock description, and taking a presumed degree of settlement into account. It has traditionally been used to check simple foundation designs. The use of this method is acceptable under BS EN 1997-1[13] as a "prescriptive method", with the allowable bearing pressures now termed "presumed bearing resistance".

The presumed bearing resistance is highly dependent on proposed depth of foundation, width of foundation and the structure's tolerance for settlement. The following section provides a preliminary presumed bearing resistance assuming a stated depth and width of foundation and assumes that settlements of up to 25mm can be tolerated by the structure. Should alternative foundation depths and dimensions be required, or the proposed structure have different long term movement requirements then the following assessment should be re-evaluated.

All loads should be transferred beneath any topsoil, made ground, loose, soft, low strength, desiccated or disturbed soils and transferred onto the stiff to very stiff clays. Based on the findings of this additional investigation it is considered the shallow soils in the north section of

[13] BS EN 1997-1(2004)+A1:2013 Eurocode 7:Geotechnical Design: General Rules

the site are potentially desiccated to between 1.75m and ~2.0m bgl. On the basis of the findings of the intrusive investigation, a preliminary presumed bearing resistance of 120kPa may be assumed for a 600mm wide foundation on the stiff to very stiff clays below about 2.0m in the northern half of the site.

However, foundations will require deepening in the clay soils near trees to NHBC HIGH VCP precautions.

Further information may be required for the detailed design stage, including the foundation design details and further investigation to meet the requirements of BS EN 1997 and BS 8004[14].

Where foundations are stepped or span different soil types, allowance should be made for nominal reinforcement.

16.5.2 Piling

Given the VCP of the shallow soils, the presence of large trees and hedge rows on the site boundaries and the potential for desiccation, piled foundations may be a preferred option for some or all of the site.

For the ground conditions encountered on site, driven, bored or continuous flight augered (cfa) piles may be considered.

If trees are to be removed, consideration of the effects of swelling of the clay soils and the potential for uplift should be considered. Allowance should be made for reinforcement of the upper half of the piles if uplift forces are anticipated.

Hard mudstone should be anticipated at depth and allowance should be made for drilling through layers of rock.

Discussions should be held with the specialist piling contractors to assess the technical and financial merits of their various systems for the ground conditions encountered, and the depth and size of pile required, with an adequate safety margin.

The final pile design will be determined by the selected piling contractor as the method of pile formation will affect the bearing capacity. For the purpose of preliminary design, the following soil model may be adopted:

[14] BS 8004:2015+A1:2020 Code of Practice for foundations

Table 11: Soil model for preliminary pile design

Depth to base (m)	Soil Type	Characteristic Shear Strength (kPa) (Shaft Resistance)	Characteristic Shear Strength (kPa) (Base Resistance)
0 – 3.0m	CLAY	ASSUMED TO PROVIDE NO STRENGTH	
3.0m – 4.0m	CLAY	175	70
4.0m – 5.0m	CLAY	225	80
5.0m – 7.5m	CLAY	225	220
7.5m – 20.0m	CLAY	225	225

The characteristic shaft resistance has been calculated from the average undrained shear strength as shown on the plot of undrained shear strength versus depth in Appendix E. The characteristic base resistance has been calculated from the lower bound undrained shear strength relative to the pile length. All SPTs refused at the base of the windowless sampler boreholes and as such for conservatism the base and shaft resistance below this depth have been calculated based on an N value of 50 using Stroud's Correlation. Adopting the model summarised above, example calculations have been undertaken and the results are presented in Table 12 below.

Table 12: Preliminary pile resistance.

Pile type	Pile Length (m)	Pile Diameter (mm)	Preliminary Compressive Resistance (kN)
CFA	7.5m	350	265
		400	315
	10.0m	350	375
		400	440

Example calculations indicate that assuming the above model a 10m long, 350mm diameter cfa pile would provide a design compressive resistance of approximately 375kN. Driven piles would likely provide a significantly greater compressive resistance assuming that the piles extend to rock head.

The final design must be carried out by the specialist contractor in accordance with their preferred method of formation.

16.5.3 Sustainability Considerations for Foundations

LEAP's foundation carbon calculator has been used to assess the relative embodied carbon output of the recommended foundation options. The tool considers the intrinsic carbon

dioxide generated from the materials which make up the foundation as well as emissions associated with onsite plant, earthworks and the disposal of trench/pile arisings.

Based on the limited information available to date on the proposed construction, the carbon calculator indicates that assuming the foundations summarised above are utilised on site then piled foundations would be the less carbon intensive option.

The model also indicates that where traditional foundations are to be extended below 1.2bgl then piled foundations are the less carbon intensive foundation option.

Further more detailed calculations and wider sustainability assessments can be provided and you can register your interest in such an assessment via the sustainability section of our website here.

16.6 Heave and Uplift

In accordance with NHBC Standards Chapter 4.2, precautions against heave should be used where foundations are within the influence of trees and the resulting foundation depth is greater than 1.5m. Compressible material must be provided against the inside faces of all external wall foundations greater than 1.5m in depth. For pier and beam foundations, additional voids are required below ring beams.

Heave may also occur where shrinkable soils are unloaded, in say, basement excavations. To avoid uplift pressures, voids or buffer zones should be left beneath floor slabs. As a preliminary guide, allowance should be made for a 300mm void for highly shrinkable clays, reducing for lower plasticity soils. This should be confirmed at the detailed design stage.

For piled foundations, the effect of uplift induced by heave must be included in the pile design. Piles should be reinforced for the length of pile governed by the heave design, and allowance should be made for the inclusion of void former or similar on the underside of ground beams.

17 Geotechnical Recommendations

Further assessment including a geotechnical design report will be required once the details of the proposed construction are known. It should be noted that the intrusive investigation was only carried out in the north of the site. Further investigation is recommended in the south once the hardstanding and buildings are removed.

As outlined in section 19.5 above a preliminary carbon calculation indicates that where traditional foundations are to be extended below 1.2m bgl then piled foundations are the less carbon intensive foundation option.

Further calculations and wider sustainability assessments can be provided if required.

G GEO-ENVIRONMENTAL ASSESSMENT

18 Geo-environmental Testing

18.1 Introduction

Geo-environmental testing was undertaken in HP1-HP3 under the former bunded silage storage area to the immediate northeast of the parking area. The conceptual site model identified a number of plausible contaminant linkages.

To fully assess the risk to human health further testing will be required in the south of the site once demolition of the buildings and removal of the hardstanding has been completed.

19 Human Health Risk Assessment

19.1 Rationale and Approach

The generic quantitative risk assessment (GQRA) for human health was conducted in line with the CLEA methodology by comparing the soil analytical results from the ground investigation with Generic Assessment Criteria (GAC). The GACs were selected using the rationale and assumptions provided in Appendix I.

Sets of soil GACs are available for SOMs of 1%, 2.5% and 6%. In this case, TOC in the Made Ground samples that were analysed ranged from 0.66% to 2.69%. Using the conversion of SOM = TOC x 1.72, this equates to a SOM range of 1.14% to 4.63%. 1% SOM was considered to be appropriate to maintain conservatism.

For some contaminants of concern, direct contact will be the dominant pathway for exposure. In order to support with development options, human exposure to all unsaturated soils, irrespective of depth, has been considered for the purpose of this assessment. This will maximise the information available to the design team on the suitability of all unsaturated material and can support with their materials management options.

The risk assessment did not include statistical analysis. CL:AIRE 2020[15] provides guidance on the appropriate sample sizes for particular statistical distributions of data and non-targeted soil sampling approaches. The number of soil samples collected in the site investigation indicates that statistics are not appropriate to use in this case.

[15] CL;AIRE, 2020 'Professional Guidance: Comparing Soil Contamination Data with a Critical Concentration.' CL:AIRE, Buckinghamshire. ISBN 978-1-905046-35-5.

19.2 Evaluation of Potential Risks to Future Residents

The soils that were analysed comprised of 3 made ground samples. The laboratory analytical results were assessed to determine the potential risks to future site users under a generic residential land use scenario assuming that homegrown produce are consumed (resi HGP). The laboratory certificates are provided in Appendix H. A summary table is provided in Table 13: below.

Table 13:Summary of Soil Contamination Test Results

Determinand	Number of samples	Number >LOD	Maximum Conc. (mg/kg unless otherwise stated)	Generic Assessment Criteria (mg/kg)	Number of Exceedances
METALS					
Arsenic	3	3	14	37	0
Cadmium	3	1	0.7	22	0
Chromium	3	3	26	910	0
Hexavalent Chromium	3	0	<1	21	0
Copper	3	3	20	2,400	0
Lead	3	3	39	200	0
Mercury[1]	3	2	1.55	40	0
Nickel	3	3	18	130	0
Selenium	3	1	1	250	0
Zinc	3	3	53	3,700	0
ASBESTOS					
Asbestos	4	1	Detected	Presence	1 (Chrysotile cement fragment in HP1)
HYDROCARBONS					
Benzo(a)pyrene[2]	3	3	4.87	5.0	0
Naphthalene	3	0	<0.03	2.3	0
Total PAHs	3	3	41.7	n.v.	-

Notes to table

1. *Assessment criterion based on inorganic mercury*
2. *As a surrogate marker for genotoxic PAH*
3. *As a marker compound for threshold PAH*

n.v. – no appropriate value

The made ground comprised of dark blackish brown sandy slightly clayey gravelly silt with gravels of brick, concrete and flint. A fragment of chrysotile cement was identified within the gravels of HP1. No other asbestos was detected.

Slightly elevated concentrations of PAH compounds benzo(b)fluoranthene and dibenzo(ah)anthracene were noted in HP3. Phase II laboratory testing identified localised elevated concentrations of benzo(a)pyrene within the made ground of TP5 and TP6, both located within the southern half of the site.

19.3 Evaluation of Potential Risks to Groundworkers

There is a legal duty for employers to ensure that suitable health and safety controls should be in place to protect groundworkers and they should evaluate the potential for exposure including using data provided in this report which should be included in any future Health and Safety file for the site under The Construction (Design and Management) Regulations 2015.

In this case, employers should consider, amongst others: exposure to loose asbestos fibres, and exposure to PAHs. Further investigation into the south of the site is recommended to fully characterise any geo-environmental contamination present.

20 Geo-Environmental Conclusions

Based on the investigation undertaken and the samples that were analysed in the made ground beneath the former silage storage area are impacted with the PAH compounds benzo(b)fluoranthene and dibenzo(ah)anthracene. A chrysotile cement fragment was identified in HP1 within the made ground.

The PAH contamination identified poses a risk to human health, where present in critical areas such as gardens or areas of soft landscaping. Contamination may impact human health through the direct ingestion, inhalation, skin contact and/or plant uptake pathways that would be present in a residential setting. The contaminated ground is considered to pose an unacceptable risk if it is to be retained in the near surface of garden/outdoor soft covered areas where direct human contact is feasible.

21 Geoenvironmental Recommendations

Access into the southern half of the site was restricted due to buildings, roads and services. It is recommended that once the structures have been demolished and hard standing removed, formation inspections and further intrusive investigations undertaken.

Following the additional investigation, a remediation strategy to mitigate risks to the proposed development from identified contamination should be prepared. The scope for any additional

investigation and remediation strategy should be approved through the planning process prior to their investigation.

At this stage, an allowance for provision of 600mm of clean cover in proposed residential garden areas where made ground is present is advised.

APPENDIX A – Limitations

Limitations

LIMITATIONS

This report is confidential to the Client and RSK Environment Ltd trading as Leap Environmental and Leap Environmental accepts no responsibility whatsoever to third parties to whom this report, or any part thereof, is made known, unless formally agreed by Leap Environmental beforehand. Any such party relies upon the report at their own risk. Unless explicitly agreed otherwise in writing, this report has been prepared under LEAP's standard terms and conditions, as included in the quotation for this works.

This report has been prepared by Leap Environmental on the basis of information received from a variety of sources which Leap Environmental believes to be accurate. Nevertheless, Leap Environmental cannot and does not guarantee the authenticity or reliability of the information it has obtained from others.

Leap Environmental has used all reasonable skill, care and diligence in the design and execution of this report, taking into account the manpower and resources devoted to it in agreement with the Client. Although every reasonable effort has been made to obtain all relevant information, all potential contamination, environmental constraints or liabilities associated with the site may not necessarily have been revealed. LEAP cannot be held responsible for any disclosures or changes in regulation that are provided post production of this report, and will not automatically update the report.

The conclusions reached in this report are necessarily restricted to those which can be determined from the information consulted, and may be subject to amendment in the light of additional information becoming available. These conclusions may not be appropriate for alternative schemes.

The extent of the exploratory holes, laboratory testing and monitoring undertaken may have been restricted due to a number of factors including accessibility, the presence of buried or overhead services, current development and site usage, timescales or client's specification. The exploratory holes only assess a small proportion of the site area with respect to the site as a whole, and as such may only provide an overall assessment of ground conditions on site. The presence of hotspots of undisclosed contamination or exceptional and unforeseen ground conditions cannot be discounted.

Eurocode 7 gives guidance on the type of sampling, sample quality, number and spacing of intrusive investigations, and number of laboratory tests required. It is intended that the Geotechnical Information section of this report will fulfil the general requirements of the Ground Investigation Report as set out in section 6 of Eurocode7[16], although this is subject to the restrictions imposed on the investigation as listed above. For geotechnical design,

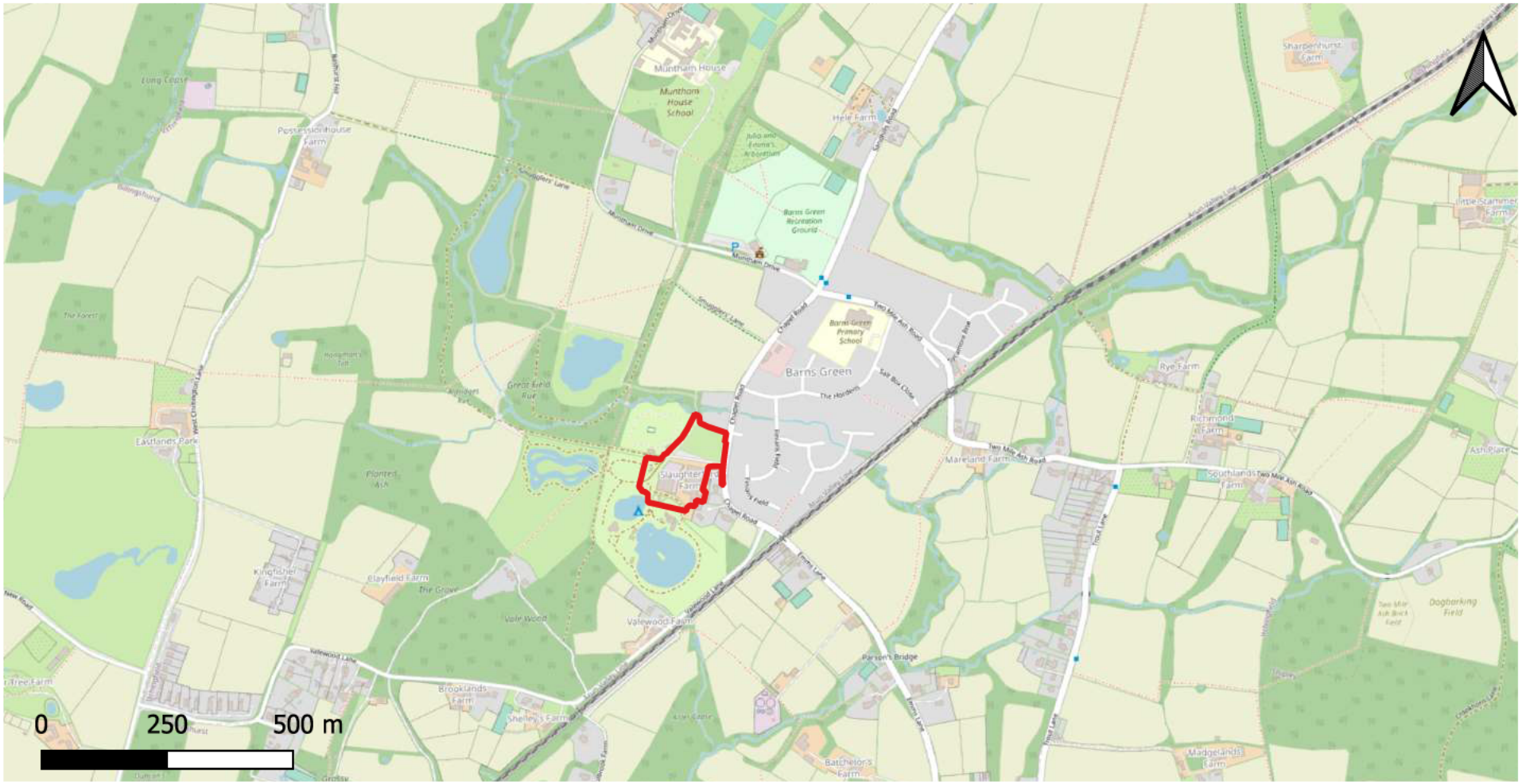
[16] BS EN 1997 Eurocode 7- Geotechnical Design - Part 1: General Rules (2004) and Part 2: Ground Investigation and Testing (2007)

Eurocode 7 requires the Geotechnical Design Report to address both the geotechnical and structural aspects of the geotechnical design for both the limit and serviceability states. The Geotechnical Appraisal section of this report will not meet the requirements of a Geotechnical Design Report (GDR) and should therefore be used for preliminary guidance only.

The presence of asbestos may be noted during the site walkover survey, intrusive investigations and/or from the results of contamination testing. However, this report does not constitute an asbestos survey. On this basis, the presence of asbestos on site cannot be discounted and a full asbestos survey should be undertaken.

APPENDIX B – Figures and Drawings

Figures and Drawings



Basemap: © OpenStreetMapcontributors

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Client:	Sigma Homes	Title:	Site Location	Project ID:	LP3019
Project:	Sumners Pond	Date:	13/09/2022	Figure No.	1



Basemap: © OpenStreetMapcontributors

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Client:	Sigma Homes Ltd	Title:	Intrusive Location Plan	Project ID:	LP3444
Project:	Sumners Pond, Barns Green, Horsham, RH13 0PR	Date:	16/08/2023	Figure No.	2



Basemap: © ECE Architecture

Client:	Sigma Homes Ltd	Title:	Proposed Site Plan overlayed with Intrusive Locations	Project ID:	LP3444
Project:	Sumners Pond, Barns Green, Horsham, RH13 0PR	Date:	16/08/2023	Figure No.	3


N
Little Slaughterford
New fence south of concrete bridge
Red-line taken to post and wire fence
1.1m high post & rail fence to rear garden with increased buffer tree & hedgerow planting
Bird nesting boxes to be installed on the retained mature trees within the site
1.1m high post & rail fence to rear gardens to protect & position the existing hedgerow outside of private domain
Existing hedgerow to be retained and protected
Northern boundary shown on approx. hedge root line
Existing small tree removed
Existing drainage ditch to be retained and protected
Gas Utility to be diverted
Red-line taken to approx. centre line of hedge
Existing access to caravan pitches retained
Overhead cables to be retained with minimum 5m easement
Public Right of Way to be routed along 2.2m wide footpath
Central Green
Pond
Swale
Farm Cl
Existing hedgerow to be retained and protected
Part of existing hedge to be trimmed back for the proposed site access
Chapel Road
The Old Farm House
Tree to be removed
11 Car Parking Spaces
7 Car Parking Spaces
2 Car Parking Spaces
Reception
6 Car Parking Spaces
3 Car Parking Spaces
Turning Area
Existing wooden bridge
3 minimum good quality bat boxes to be secured to the retained mature trees within and adjacent to the site.
Farm Pond
Existing access to holiday villas retained
4 Car Parking Spaces
8 Car Parking Spaces
24 Car Parking Spaces
Large Vehicle Turning Head
3m wide pedestrian and cycle path
Proposed curtilage alterations to the existing cottage to introduce additional parking spaces & soft landscaping
CONVERTED COTTAGE
Oak tree retained
Existing access to holiday villas retained
Sumners Cottage
Slaughterford Bungalow
Existing hedgerow to be retained and protected
Existing hedgerow to be retained and protected
Existing hedgerow to be retained and protected

APPENDIX C – Photographic Record

Photographic Record



Plate 1 –
A view looking north along the track running along the western boundary.



Plate 2 –
A view looking south from the north west corner with the metal fencing marking a previously installed borehole for monitoring.



Plate 3 –
A view looking west from the north east corner with the rotary rig set up on BH01.



Plate 4 –
BH01 hand pit excavated to 1.2m.



Plate 5 –
Grey with orangish brown mottled CLAY logged from 0.40m within the hand pit.



Plate 6 –
Rotary core from 2.7m to 4.2m.



Plate 7 –
Rotary core from 4.2m to 5.7m.



Plate 8 –
Rotary core from 5.7m to 7.2m.



Plate 9 –
Rotary core from 7.2m to 8.7m.



Plate 10 –
Rotary core from 8.7m to 10.2m.



Plate 11 –
Rotary core from 0.2m to 11.7m.



Plate 10 –
Rotary core from 11.7m to 13.2m.



Plate 11 –
Rotary core from 13.2m to 14.7m.



Plate 12 –
Rotary core from 14.7m to 16.2m.



Plate 13 –
Rotary core from 16.2m to 17.7m.



Plate 14 –
Rotary core from 17.7m to 19.2m.



Plate 15 –
Rotary core from 19.2m to 20.0m.



Plate 16 –
Grass over TOPSOIl recovered from WS104.



Plate 17 –
MADE GROUND with gravels of brick, blacktop, concrete and flint recovered from WS103.



Plate 18 –
Grey with orangish brown mottled CLAY with fine white crystals (selenite) recovered from WS102.



Plate 19 –
A band of MUDSTONE recovered as gravels in WS102.



Plate 20 –
Dark grey MUDSTONE recovered from WS103.



Plate 21 –
Full arisings from WS103 showing TOPSOIL over MADE GROUND over CLAY.



Plate 22 –
The large silage stockpile at the time of the Phase 2 investigation in September 2022 which was clear at the time of the current investigation for HP1-HP3 to be excavated.



Plate 23 –
MADE GROUND excavated from HP1 with gravels of brick concrete and flint with a confirmed cemented asbestos fragment.



Plate 24-
Grey with orangish brown mottled CLAY recovered from HP1 from 0.20m.



Plate 25 –
HP1 excavated to a full depth of 0.40m.



Plate 26 –
MADE GROUND recovered from HP2 with gravels of brick, concrete, flint and occasional whole and half brick.



Plate 27 –
MADE GROUND excavated from HP3 with gravels of brick, concrete, flint and blacktop. The full depth of excavation of 0.40m with water ingress.

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Rotary Core Log

Borehole No. **BH01**

Sheet 1 of 5

Project Name: Sumners Pond	Project No. LP3444	Co-ords: 512484 - 126858	Hole Type RO
Location: Sumners Pond, Barns Green, Horsham, RH13 0PR		Level: 33.90	Scale 1:22
Client: Sigma Homes Ltd		Dates: 07/08/2023 - 08/08/2023	Logged By IA

Well	Water Strikes	Depth (m)	Type / FI	Coring TCR	Coring SCR	Coring RQD	Depth (m)	Level (m)	Legend	Stratum Description
							0.40	33.50		TOPSOIL: Brown slightly clayey slightly sandy gravelly silt. Sand is fine to medium. Gravel is angular to subangular fine to course of flint with common rootlets to 0.10m.
										Stiff grey with orangish brown mottled CLAY with occasional black staining.
	▼									*N=12 (1,1/1,2,3,6)*
							2.70	31.20		Very Stiff grey with organish brown mottled CLAY with common mudstone gravels.
										N=50 (7,8/15,15,15,5)
										with no recovery between 2.7m to 2.9m
		2.70 - 4.20		83	80	76				
							3.70	30.20		Extremely weak dark grey silty MUDSTONE locally laminated.
										with orangish brown linear laminations at 3.7m
										with an orangish brown fracture surface at 3.9m
										50 (8,9/50 for 225mm)
										Continued on next sheet

1 2 3 4

Remarks

Borehole cased to 2.5m and cored at 90mm diameter. Groundwater seepage at 1.85m. Backfilled with bentonite. SPT hammer energy ratio 59%.

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Rotary Core Log

Borehole No. **BH01**

Project Name: Sumners Pond	Project No. LP3444	Co-ords: 512484 - 126858	Hole Type RO
Location: Sumners Pond, Barns Green, Horsham, RH13 0PR		Level: 33.90	Scale 1:22
Client: Sigma Homes Ltd		Dates: 07/08/2023 - 08/08/2023	Logged By IA

Well	Water Strikes	Depth (m)	Type / FI	Coring TCR	Coring SCR	Coring RQD	Depth (m)	Level (m)	Legend	Stratum Description
		4.20 - 5.70		100	100	100	5.70	28.20		*with a band of dark grey silt with laminated mudstone gravels between 4.9m to 5.7m*
		5.70 - 7.20		83	83	83				Very weak dark grey silty MUDSTONE locally laminated. *50 (10,13/50 for 150mm)* *with a band of dark grey silt with laminated mudstone gravels between 6.42m to 6.90m*
		7.20 - 8.70		92	92	92				*with a dark grey fracture surface at 7.5m* *with a dark grey fracture surface at 7.65m* *with a dark grey fracture surface at 8.01m* *with a dark grey fracture surface at 8.04m* *with a dark grey fracture surface at 8.3m* *with a dark grey fracture surface at 8.5m*

Continued on next sheet

5 6 7 8

Remarks

Borehole cased to 2.5m and cored at 90mm diameter. Groundwater seepage at 1.85m. Backfilled with bentonite. SPT hammer energy ratio 59%.

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Rotary Core Log

Borehole No. **BH01**

Sheet 3 of 5

Project Name: Sumners Pond	Project No. LP3444	Co-ords: 512484 - 126858	Hole Type RO
Location: Sumners Pond, Barns Green, Horsham, RH13 0PR		Level: 33.90	Scale 1:22
Client: Sigma Homes Ltd		Dates: 07/08/2023 - 08/08/2023	Logged By IA

Well	Water Strikes	Depth (m)	Type / FI	Coring TCR	Coring SCR	Coring RQD	Depth (m)	Level (m)	Legend	Stratum Description
		8.70 - 10.20		100	100	100	9.00	24.90		Weak dark grey silty MUDSTONE locally laminated.
		10.20 - 11.70		100	100	100				*with a dark grey fracture surface at 10.1m*
		11.70 - 13.20		100	100	100				*with a dark grey fracture surface at 12.4m*
										with a dark grey fracture surface at 13.1m
										Continued on next sheet

9 10 11 12 13

Remarks

Borehole cased to 2.5m and cored at 90mm diameter. Groundwater seepage at 1.85m. Backfilled with bentonite. SPT hammer energy ratio 59%.

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Rotary Core Log

Borehole No. **BH01**

Project Name: Sumners Pond	Project No. LP3444	Co-ords: 512484 - 126858	Hole Type RO
Location: Sumners Pond, Barns Green, Horsham, RH13 0PR		Level: 33.90	Scale 1:22
Client: Sigma Homes Ltd		Dates: 07/08/2023 - 08/08/2023	Logged By IA

Well	Water Strikes	Depth (m)	Type / FI	Coring TCR	Coring SCR	Coring RQD	Depth (m)	Level (m)	Legend	Stratum Description
		13.20 - 14.70		77	63	57				*with no recovery between 13.20m to 13.45m* *with no recovery between 13.52m and 13.58m* *with visible laminations at 13.7m*
		14.70 - 16.20		99	99	87				*with a dark grey fracture surface at 14.9m* *with a dark grey fracture surface at 14.92m* *with a dark grey fracture surface at 14.94m* *with fracture between 15.08m and 15.14m with visible laminations. Recovered as gravels of mudstone*
		16.20 - 17.70		95	95	87				*with a dark grey fracture surface at 16.1m* *with a dark grey fracture surface at 16.35m* *with fracture at 16.55m. Recovered as gravels of mudstone* *with visible laminations between 16.72m and 16.76m* *with visible laminations between 17.0m and 17.3m* *with a dark grey fracture surface at 17.15m*

14 15 16 17

Continued on next sheet

Remarks

Borehole cased to 2.5m and cored at 90mm diameter. Groundwater seepage at 1.85m. Backfilled with bentonite. SPT hammer energy ratio 59%.

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Rotary Core Log

Borehole No. **BH01**

Sheet 5 of 5

Project Name:	Sumners Pond	Project No. LP3444	Co-ords:	512484 - 126858	Hole Type RO
Location:	Sumners Pond, Barns Green, Horsham, RH13 0PR		Level:	33.90	Scale 1:22
Client:	Sigma Homes Ltd		Dates:	07/08/2023 - 08/08/2023	Logged By IA

Well	Water Strikes	Depth (m)	Type / FI	Coring TCR	Coring SCR	Coring RQD	Depth (m)	Level (m)	Legend	Stratum Description
		17.70 - 19.20		99	95	93				*with a dark grey fracture surface at 17.88m* *with a dark grey fracture surface at 17.92m* *with fracture between 18.35m and 18.58m. Recovered as gravels of mudstone*
		19.20 - 20.00		97	97	92				*with a dark grey fracture surface at 19.3m* *with gravels of mudstone between 19.4m and 19.8m* *with a dark grey fracture surface at 19.63m* *with visible laminations between 19.75m and 19.80m* *with a dark grey fracture surface at 19.8m* *with a dark grey fracture surface at 19.86m* *with a dark grey fracture surface at 19.92m*
							20.00	13.90		End of borehole at 20.00 m

18 19 20 21 22

Remarks

Borehole cased to 2.5m and cored at 90mm diameter. Groundwater seepage at 1.85m. Backfilled with bentonite. SPT hammer energy ratio 59%.

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Borehole Log

Borehole No.
HP1
Sheet 1 of 1

Project Name: Sumners Pond	Project No. LP3444	Co-ords: -	Hole Type HA
Location: Sumners Pond, Barns Green, Horsham, RH13 0PR		Level:	Scale 1:10
Client: Sigma Homes Ltd		Dates: 09/08/2023 - 09/08/2023	Logged By IA

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
								MADE GROUND: Dark blackish brown sandy slightly clayey gravelly silt. Sand is fine to medium. Gravel is fine to coarse angular to subrounded of brick, concrete and flint with a rare fibrous fragment (possible ACM).
					0.20			Grey slightly sandy with orangish brown mottled CLAY. Sand is fine to medium.
		0.40	ES		0.40			End of borehole at 0.40 m

Remarks
Hand pit remained dry.

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Borehole Log

Borehole No.
HP2
Sheet 1 of 1

Project Name: Sumners Pond	Project No. LP3444	Co-ords: -	Hole Type HA
Location: Sumners Pond, Barns Green, Horsham, RH13 0PR		Level:	Scale 1:10
Client: Sigma Homes Ltd		Dates: 09/08/2023 - 09/08/2023	Logged By IA

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
		0.30	ES					MADE GROUND: Dark blackish brown sandy slightly clayey gravelly silt. Sand is fine to medium. Gravel is fine to coarse angular to subangular of brick, concrete and flint with occasional half and whole bricks.
					0.40			Grey slightly sandy with orangish brown mottled CLAY. Sand is fine to medium.
					0.50			End of borehole at 0.50 m

Remarks
Hand pit remained dry.

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Borehole Log

Borehole No.
HP3
Sheet 1 of 1

Project Name: Sumners Pond	Project No. LP3444	Co-ords: -	Hole Type HA
Location: Sumners Pond, Barns Green, Horsham, RH13 0PR		Level:	Scale 1:10
Client: Sigma Homes Ltd		Dates: 09/08/2023 - 09/08/2023	Logged By IA

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
	▼	0.15	ES					MADE GROUND: Dark blackish brown sandy slightly clayey gravelly silt. Sand is fine to medium. Gravel is fine to coarse angular to subangular of brick, concrete, flint and blacktop.
					0.40			End of borehole at 0.40 m

1
2

Remarks
Hand pit remained dry. No further progress below 0.40m due to a water seepage at 0.30m.

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Borehole Log

Borehole No. **WS101**
Sheet 1 of 1

Project Name:	Sumners Pond	Project No. LP3444	Co-ords:	512486 - 126837	Hole Type WS
Location:	Sumners Pond, Barns Green, Horsham, RH13 0PR		Level:	34.08	Scale 1:21
Client:	Sigma Homes Ltd		Dates:	08/08/2023 - 08/08/2023	Logged By IA

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.30	33.78		REWORKED TOPSOIL: Dark brown sandy gravelly slightly clayey silt. Sand is fine to medium. Gravel is fine to coarse subangular to subrounded of flint with common rootlets to 0.10m.
								Stiff becoming very stiff grey with orangish brown mottled CLAY with occasional black staining.
								with a band of mudstone from 0.90m to 1.05m
		1.00	D					*with an orangish brown domination of mottling from 1.0m with fine to course angular gravels of mudstone between 1.0m to 1.15m*
		1.20		N=9 (1,1/1,2,3,3)				*Hand Penetrometer at 1.25m = 240kPa*
		1.50	D					*Hand Penetrometer at 1.75m = 450kPa*
		2.00	D					
		2.00		N=15 (2,2/3,4,4,4)				*Hand Penetrometer at 2.25m = 330kPa*
		2.50	D		2.50	31.58		Interbedded extremely weak dark grey MUDSTONE with very stiff grey with orangish brown mottled CLAY.
								with a band of mudstone from 2.50m to 2.65m
								with a band of mudstone from 2.70m to 2.95m
								Hand Penetrometer at 2.75m = 480kPa
		3.00	D					*recovery too friable for hand penetrometers between 3.0m and 4.0m*
		3.00		N=36 (2,8/10,10,8,8)				
	▼	3.50	D					*with a water seepage at 3.5m*
		4.00	D		4.00	30.08		End of borehole at 4.00 m
		4.00		N=59 (3,3/12,12,15,20)				

Remarks

Borehole remained stable. Groundwater seepage at 3.5m rising to 3.0m on completion. No further progress below 4.0m due to refusal on extremely weak mudstone. Borehole located in position of previously excavated archeological trench to c.0.3m. SPT hammer energy ratio 72%.

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Borehole Log

Borehole No. **WS102**
Sheet 1 of 1

Project Name:	Sumners Pond	Project No. LP3444	Co-ords:	512453 - 126853	Hole Type WS
Location:	Sumners Pond, Barns Green, Horsham, RH13 0PR		Level:	34.09	Scale 1:21
Client:	Sigma Homes Ltd		Dates:	08/08/2023 - 08/08/2023	Logged By IA / AL

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.15	33.94		Grass over TOPSOIL: Dark brown slightly clayey slightly sandy slightly gravelly silt with common rootlets to 0.15m and desiccated recovery. Gravel is fine and angular of flint.
								MADE GROUND: Light brown slightly clayey slightly sandy gravelly silt. Sand is fine to medium. Gravel is angular to rounded fine to course of flint, brick and concrete with occasional cobbles of brick.
					0.70	33.39		Stiff becoming very stiff grey with orangish brown mottled CLAY with occasional rootlets. Sand is fine.
		1.00	D					*with a band of mudstone from 1.0m to 1.15m*
		1.20		N=7 (1,1/2,1,2,2)				*Hand Penetrometer at 1.25m = 180kPa*
		1.50	D					*with fine white crystals (selenite) between 1.55m and 1.60m*
								with a band of mudstone from 1.7m to 1.8m
								Hand Penetrometer at 1.75m = 270kPa
		2.00	D					*with fine white crystals (selenite) between 2.0m and 2.1m*
		2.00		N=12 (1,1/2,3,3,4)				*with abundant fine white crystals (selenite) at 2.1m*
								Hand Penetrometer at 2.25m = 320kPa
		2.50	D					*becoming dark grey from 2.6m*
								Hand Penetrometer at 2.75m = 280kPa
		3.00	D		3.00	31.09		End of borehole at 3.00 m
		3.00		N=63 (3,4/10,15,18,20)				

Remarks
Borehole remained dry and stable. No further progress below 3.0m due to refusal on extremely weak mudstone. SPT hammer energy ratio 72%.

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Borehole Log

Borehole No. **WS103**
Sheet 1 of 2

Project Name: Sumners Pond	Project No. LP3444	Co-ords: 512434 - 126832	Hole Type WS
Location: Sumners Pond, Barns Green, Horsham, RH13 0PR		Level: 34.61	Scale 1:21
Client: Sigma Homes Ltd		Dates: 08/08/2023 - 08/08/2023	Logged By IA / AL

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
					0.15	34.46		Grass over TOPSOIL: Dark brown slightly clayey slightly sandy slightly gravelly silt with common rootlets to 0.1m and desiccated recovery. Gravel is fine and angular of flint.	
								MADE GROUND: Light brown slightly clayey slightly sandy gravelly silt. Sand is fine to medium. Gravel is angular to subangular fine to course of brick, concrete, blacktop and flint with occasional cobbles of brick.	
		1.00 1.00	D	N=7 (1,2/1,2,2,2)	1.00	33.61		Stiff becoming very stiff grey with orangish brown mottled CLAY with occasional rootlets. Sand is fine.	1
								Hand Penetrometer at 1.25m = 390kPa	
		1.50	D					*Hand Penetrometer at 1.75m = 190kPa*	
								with a band of mudstone from 1.9m to 2.0m	
		2.00 2.00	D	N=12 (1,2/3,2,3,4)				*with fine white crystals (selenite) between 2.10m and 2.15m*	2
								Hand Penetrometer at 2.25m = 190kPa	
		2.50	D					*Hand Penetrometer at 2.75m = 190kPa*	
		3.00 3.00	D	N=14 (2,3/3,3,4,4)				*Hand Penetrometer at 3.25m = 220kPa*	3
		3.50	D					*Hand Penetrometer at 3.75m = 290kPa*	
		4.00 4.00	D	N=38 (2,4/4,9,12,13)				*Hand Penetrometer at 4.0m = 600kPa+*	4
								Continued on next sheet	

Remarks
Borehole remained dry and stable. No further progress below 4.5m due to refusal on extremely weak mudstone. SPT hammer energy ratio 72%.

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Borehole Log

Borehole No.
WS103
Sheet 2 of 2

Project Name:	Sumners Pond	Project No. LP3444	Co-ords:	512434 - 126832	Hole Type WS
Location:	Sumners Pond, Barns Green, Horsham, RH13 0PR		Level:	34.61	Scale 1:21
Client:	Sigma Homes Ltd		Dates:	08/08/2023 - 08/08/2023	Logged By IA / AL

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
		4.50 4.50	D	50 (24,42/0 for 0mm)	4.50	30.11		End of borehole at 4.50 m

Remarks
Borehole remained dry and stable. No further progress below 4.5m due to refusal on extremely weak mudstone. SPT hammer energy ratio 72%.

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Borehole Log

Borehole No. **WS104**
Sheet 1 of 2

Project Name:	Sumners Pond	Project No. LP3444	Co-ords:	512465 - 126821	Hole Type WS
Location:	Sumners Pond, Barns Green, Horsham, RH13 0PR		Level:	34.78	Scale 1:21
Client:	Sigma Homes Ltd		Dates:	08/08/2023 - 08/08/2023	Logged By IA

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.15	34.63		Grass over TOPSOIL: Dark brown slightly clayey slightly sandy slightly gravelly silt with common rootlets to 0.15m and desiccated recovery. Gravel is fine and angular of flint.
								MADE GROUND: Light brown slightly clayey sandy gravelly silt. Sand is fine to medium. Gravel is angular to subangular fine to course of flint, brick and concrete with rare plastic.
		1.00	D		1.00	33.78		Stiff becoming very stiff grey with orangish brown mottled CLAY with occasional black staining and rootlets.
		1.20		N=7 (1,1/1,2,2,2)				*Hand Penetrometer at 1.25m = 210kPa*
								with a band of orangish brown colouration between 1.35m and 1.45m
		1.50	D					*Hand Penetrometer at 1.75m = 230kPa*
		2.00	D					*with abundant fine white crystals (selenite) at between 2.0m and 2.5m*
		2.00		N=11 (1,2/2,2,3,4)				*Hand Penetrometer at 2.25m = 200kPa*
		2.50	D					*with a bands of mudstone with common black staining between 2.6m and 3.0m*
								Hand Penetrometer at 2.75m = 270kPa
		3.00	D					
		3.00		N=29 (1,2/3,6,8,12)				*Hand Penetrometer at 3.25m = 390kPa*
	▼	3.50	D		3.50	31.28		Interbedded extremely weak dark grey MUDSTONE with very stiff grey with orangish brown mottled CLAY.
								with a water seepage at 3.5m
								recovery too friable for hand penetrometers between 3.5m and 4.0m
		4.00	D					*becoming dark grey from 4.0m*
		4.00		N=17 (1,3/2,3,5,7)				

Continued on next sheet

Remarks
Borehole remained stable. Groundwater seepage at 3.5m rising to 3.0m on completion. No further progress below 4.8m due to refusal on extremely weak mudstone. SPT hammer energy ratio 72%.

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Borehole Log

Borehole No.
WS104
Sheet 2 of 2

Project Name:	Sumners Pond	Project No. LP3444	Co-ords:	512465 - 126821	Hole Type WS
Location:	Sumners Pond, Barns Green, Horsham, RH13 0PR		Level:	34.78	Scale 1:21
Client:	Sigma Homes Ltd		Dates:	08/08/2023 - 08/08/2023	Logged By IA

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
		4.50	D					*Hand Penetrometer at 4.25m = 260kPa*
		4.80 4.80	D	N=72 (9,13/13,15,21,23)	4.80	29.98		*Hand Penetrometer at 4.75m = 460kPa* End of borehole at 4.80 m

Remarks
Borehole remained stable. Groundwater seepage at 3.5m rising to 3.0m on completion. No further progress below 4.8m due to refusal on extremely weak mudstone. SPT hammer energy ratio 72%.

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Trial Pit Log

Trialpit No **TP1**
Sheet 1 of 1

Project Name:	Sumners Pond	Project No. LP3019	Co-ords: 512449 - 126849 Level: 34.14
Location:	Sumners Pond, Barns Green, Horsham RH13 0PR	Dimensions (m): Depth 3.00	2.25 × 0.55
Client:	Sigma Homes Ltd		Date 09/08/2022 Scale 1:25 Logged EL

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.10	ES					Grass over TOPSOIL: Brown sandy silty with roots and rootlets.
	0.40	ES		0.35	33.79		Very stiff desiccated brown silty CLAY with rootlets.
	0.60	B					*Hand Pen exceeds 600kPa at 0.9m.*
							Shear van measurement exceeds 260 kPa at 1.0m.
				1.10	33.04		Stiff to very stiff closely fissured friable dark brown silty CLAY.
	1.20	D					*Hand Pen at 1.3m = 300kPa*
			HVP=146				
	1.50	D		1.45	32.69		Stiff mottled blue-grey and orange-brown silty CLAY with occasional roots and rootlets and with medium-grained selenite crystals.
							Hand Pen at 1.6m = 220kPa
	2.00	D					*Becomes friable below 2.2m bgl.*
				2.70	31.44		Extremely weak to very weak thickly laminated blue-grey and orange-brown silty MUDSTONE.
				2.80	31.34		Very stiff blue-grey and orange brown thinly laminated silty CLAY.
				3.00	31.14		*Hand Pen exceeds 600kPa at20.9m.*
							End of pit at 3.00 m

Remarks: Trial pit remained dry and stable and was backfilled with gravel from the base to 1.4m bgl (for soakage test) and arisings from 1.4m bgl to ground level. Installed with a 110mm slotted monitoring pipe from the base up to 0.04m above GL.

Stability: Stable

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Trial Pit Log

Trialpit No **TP2**
Sheet 1 of 1

Project Name:	Sumners Pond	Project No. LP3019	Co-ords: 512487 - 126852 Level: 33.92
Location:	Sumners Pond, Barns Green, Horsham RH13 0PR	Dimensions (m): Depth 2.90	Date 09/08/2022 Scale 1:25
Client:	Sigma Homes Ltd		Logged EL

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.15	ES		0.30	33.62		Grass over TOPSOIL: Brown silt with roots and rootlets.
	0.40	ES					Desiccated pale brown-grey mottled orange-brown with occasional black staining very silty CLAY with rootlets.
	0.60	B					
	0.70	D		0.80	33.12		
			HVP=244				Very stiff friable orange-brown occasionally mottled grey silty CLAY.
							Hand Pen exceeds 600kPa at 0.9m.
	1.10	D					
			HVP=162				*Too friable for hand pen measurement at 1.5m bgl.*
				1.90	32.02		
	2.00	D					Very stiff closely fissured thinly laminated mottled blue-grey and orange-brown silty CLAY.
	2.30	D					*Becomes friable below 2.2m bgl.*
							Hand Pen at 2.3m = 480kPa
				2.70	31.22		Weak thickly laminated (1-2cm) dark brown MUDSTONE interbedded with thinly laminated (0.5cm) friable brown silty CLAY.
				2.90	31.02		*Damp to the touch at 2.7m bgl.*
							Hand Pen at 2.8m = 240kPa
							End of pit at 2.90 m

Remarks: Trial pit remained stable and was backfilled with arisings. Arisings were damp to the touch at 2.7m bgl (at the boundary between the clay and the mudstone).

Stability: Stable

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Trial Pit Log

Trialpit No
TP3
Sheet 1 of 1

Project Name: Sumners Pond	Project No. LP3019	Co-ords: 512469 - 126817 Level: 35.16	Date 09/08/2022
Location: Sumners Pond, Barns Green, Horsham RH13 0PR		Dimensions (m): Depth 3.00 (0.5 × 2.5)	Scale 1:25
Client: Sigma Homes Ltd			Logged EL

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.15	ES		0.30	34.86		Grass over REWORKED TOPSOIL: Brown gravelly sandy silt with rootlets. Gravel is fine to coarse brick fragments, occasional plastic fragments, one piece of rope, fine to coarse subrounded to subangular flint, rare paving slabs, occasional fine to medium chalk, fine clinker, and fine to coarse concrete.
	0.40	ES					Brown gravelly sandy REWORKED SILT with rootlets. Gravel is fine to coarse brick fragments, occasional plastic fragments, one piece of rope, fine to coarse subrounded to subangular flint, rare paving slabs, occasional fine to medium chalk, fine clinker, and fine to coarse concrete.
	1.00	B	HVP=172	0.90	34.26		Dark green-grey with black staining slightly sandy silty REWORKED CLAY with occasional very fine brick. Sand is very fine. *Hand Pen at 1.1m = 320kPa*
	1.70	D	HVP=106	1.60	33.56		Stiff to very stiff mottled blue-grey and orange-brown with occasional red-brown staining gravelly silty CLAY. Gravel is very fine to fine angular dark brown mudstone. *Hand Pen at 1.7m = 210kPa* *Hand Pen at 2m = 330kPa*
	2.40	D					*Shear surface noted at 2.5m bgl.*
	2.70	D					*Selenite crystals noted from 2.6m bgl.*
				3.00	32.16		End of pit at 3.00 m

Remarks: Trial pit remained dry and stable and was backfilled with gravel from the base to 1.5m bgl (for soakage test) and arisings from 1.5m bgl to ground level. Installed with a 110mm slotted monitoring pipe from the base up to 0.05m above GL.

Stability: Stable

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Trial Pit Log

Trialpit No **TP4**
Sheet 1 of 1

Project Name:	Sumners Pond	Project No. LP3019	Co-ords: 512511 - 126835 Level: 33.94	Date 09/08/2022
Location:	Sumners Pond, Barns Green, Horsham RH13 0PR		Dimensions (m): Depth 1.10	Scale 1:25
Client:	Sigma Homes Ltd			Logged EL

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.10	ES					Grass over REWORKED TOPSOIL: Brown occasionally gravelly slightly sandy clayey silt with rootlets. Gravel is fine to coarse chalk and occasional fine clinker.
				0.40	33.54		
	0.50	ES					Very stiff desiccated mottled brown-grey and orange-brown silty CLAY with rootlets.
	1.00	D	HVP=216				*Hand Pen exceeds 600kPa at 1.0m.*
				1.10	32.84		*Blue plastic 30mm water pipe hit at 1.05m bgl.* End of pit at 1.10 m

Remarks: Trial pit remained dry and stable. A blue plastic 30mm diameter water pipe (unmapped and not picked up by GPR survey nor CAT and Genny) was hit at 1.05m bgl. It was repaired by the land owner and on completion the trial pit was backfilled with arisings.

Stability: Stable

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Trial Pit Log

Trialpit No **TP8**
Sheet 1 of 1

Project Name: Sumners Pond	Project No. LP3019	Co-ords: 512472 - 126856 Level: 34.00	Date 09/08/2022
Location: Sumners Pond, Barns Green, Horsham RH13 0PR		Dimensions (m): Depth 2.40	Scale 1:25
Client: Sigma Homes Ltd			Logged EL

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.20	ES					Grass over TOPSOIL: Desiccated brown slightly sandy silt with rootlets.
	0.40	ES		0.40	33.60		Very stiff desiccated mottled grey and orange-brown silty CLAY with rootlets.
	0.80	B					*Hand Pen at 0.9m = 500kPa*
			HVP=246				
	1.20	D		1.10	32.90		Stiff to very stiff friable brown occasionally mottled grey silty CLAY.
							Too friable for hand pen measurement at 1.3m bgl.
			HVP=156	1.70	32.30		Very stiff mottled blue-grey and orange-brown silty CLAY.
							Hand Pen at 1.75m = 320kPa
	1.90	D					*Thin layer of dark brown fine mudstone gravel at 1.8m - 1.9m bgl.*
				2.00	32.00		Thickly laminated mottled blue-grey and orange-brown gravelly silty CLAY. Gravel is weak fine to coarse angular mudstone.
							Damp to the touch at 2.2m bgl.
	2.35	B		2.30	31.70		Very weak thickly laminated brown silty MUDSTONE with occasional fine selenite crystals recovered as fine to coarse tabular gravel.
				2.40	31.60		End of pit at 2.40 m

Remarks: Trial pit remained stable and was backfilled with arisings. Arisings were damp to the touch at 2.2m bgl.

Stability: Stable

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Borehole Log

Borehole No. **WS2**
Sheet 1 of 1

Project Name:	Sumners Pond	Project No. LP3019	Co-ords:	512467 - 126877	Hole Type WS
Location:	Sumners Pond, Barns Green, Horsham RH13 0PR		Level:	33.62	Scale 1:20
Client:	Sigma Homes Ltd		Dates:	08/08/2022 - 08/08/2022	Logged By EL

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
		0.15	ES		0.18	33.44		Grass over TOPSOIL: grey brown slightly sandy silt with rootlets.
					0.50	33.12		Brown sandy REWORKED SILT with rare gravel of concrete. Rootlets present.
								Very stiff mottled orange brown and grey silty CLAY with occasional rootlets.
								Hand Pen exceeds 600kPa at 0.8m.
		1.00	D					
		1.00		N=12 (2,3/3,3,3,3)				
								Hand Pen at 1.2m =520kPa
		1.50	D					*Medium-grained selenite crystals noted at 1.5m bgl.*
					1.70	31.92		Stiff friable dark brown silty CLAY with mudstone gravel.
		1.75	D		1.80	31.82		*Hand Pen at 1.75m =220kPa*
								Stiff mottled orange brown and grey friable thinly laminated silty CLAY with fine mudstone gravel.
		2.00	D					*Hand Pen at 1.9m =200kPa*
		2.00		48 (3,6/48 for 225mm)				
								Hand Pen exceeds 600kPa at 2.2m.
					2.40	31.22		End of borehole at 2.40 m

Remarks
Borehole remained dry and stable. Install to 2.4m comprising 1m plain pipe surrounded by bentonite over 1.4m slotted pipe surrounded by gravel with a raised cover.

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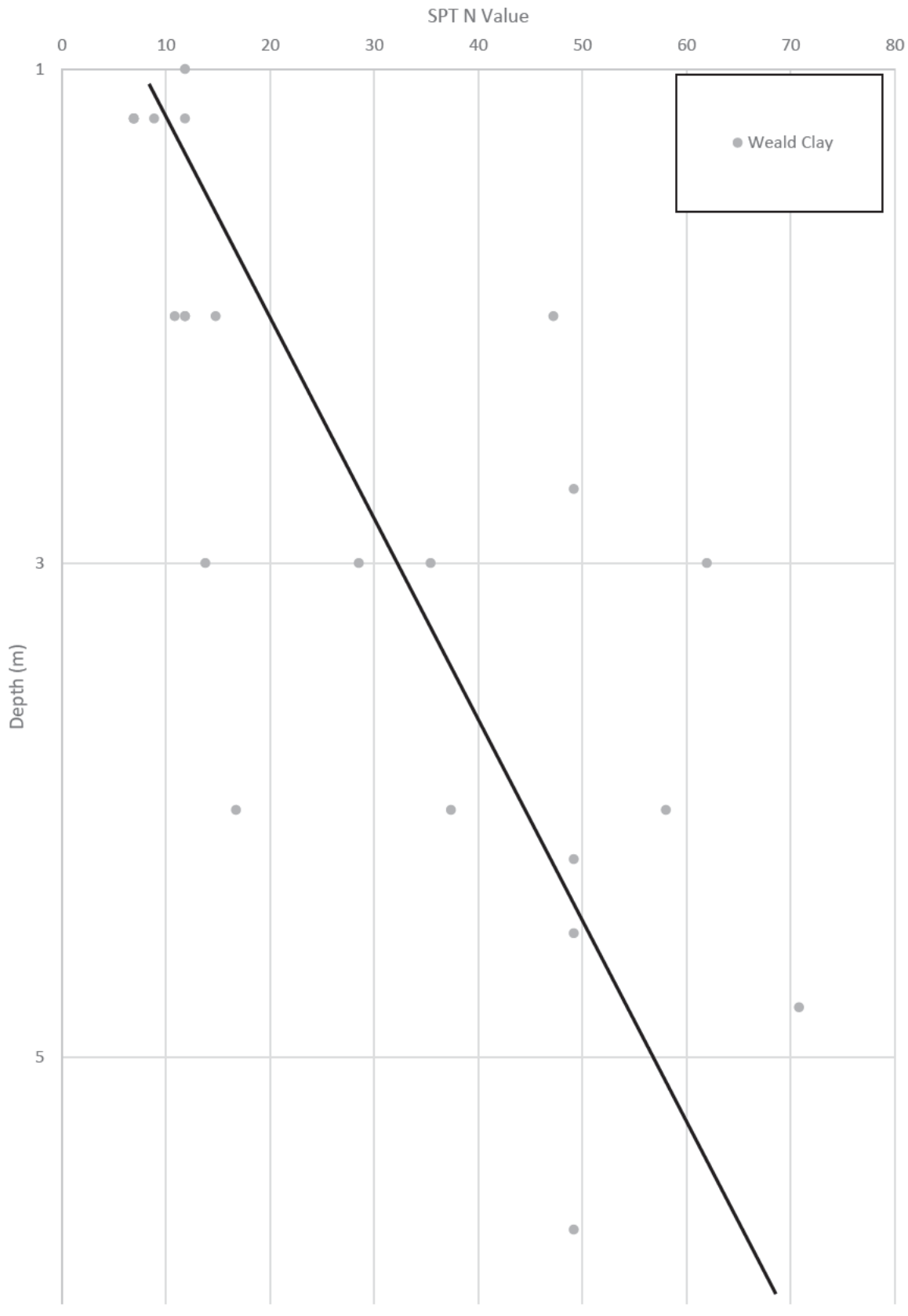
APPENDIX E – Desiccation Assessment Plots and Field Test Results

Desiccation Assessment Plots and Field Test Results

Plot of SPT N Value v. Depth



Project Number:	LP3444
Site:	Sumners Pond
Client:	Sigma Homes
Date:	08/09/2023
Figure:	5

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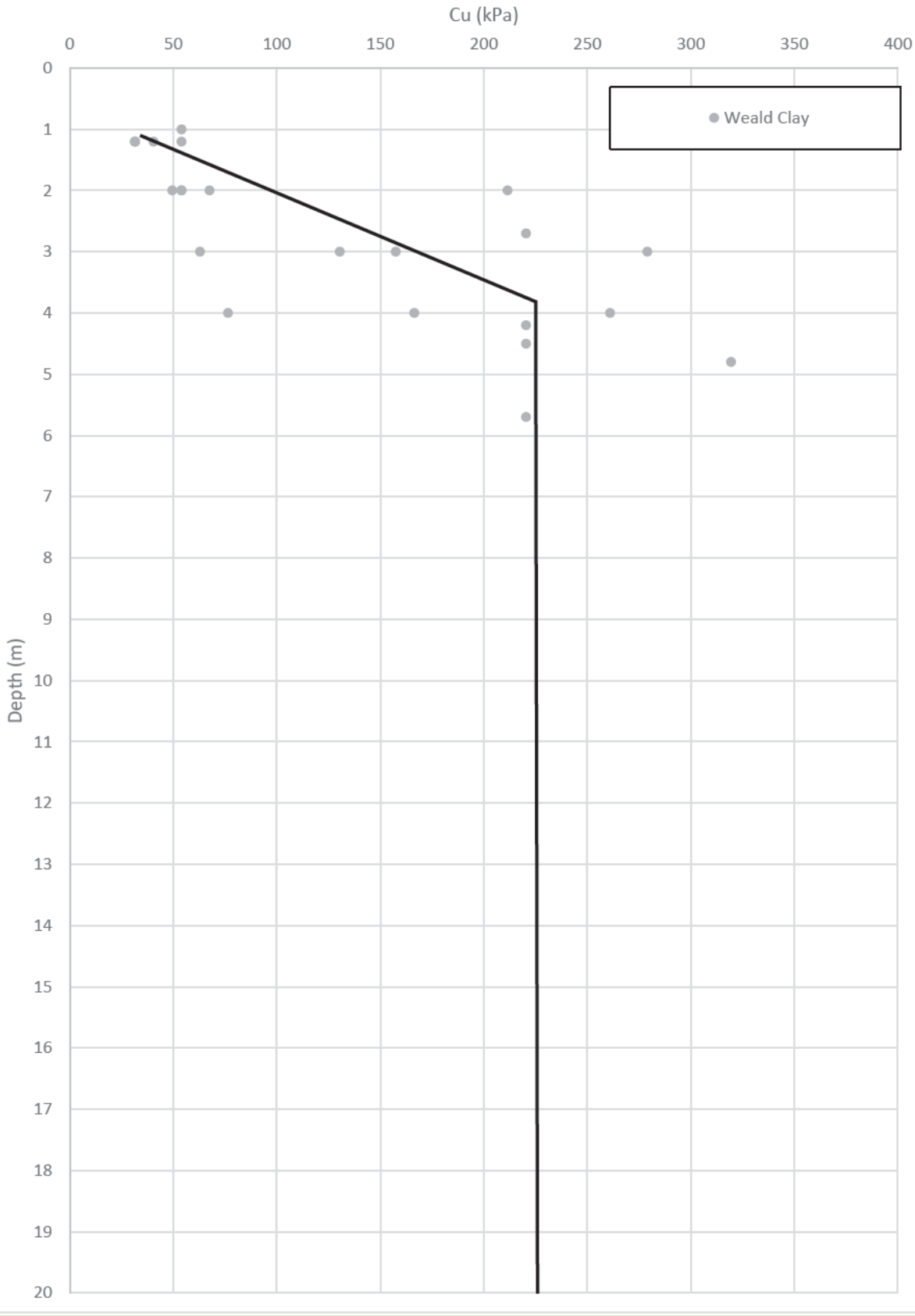
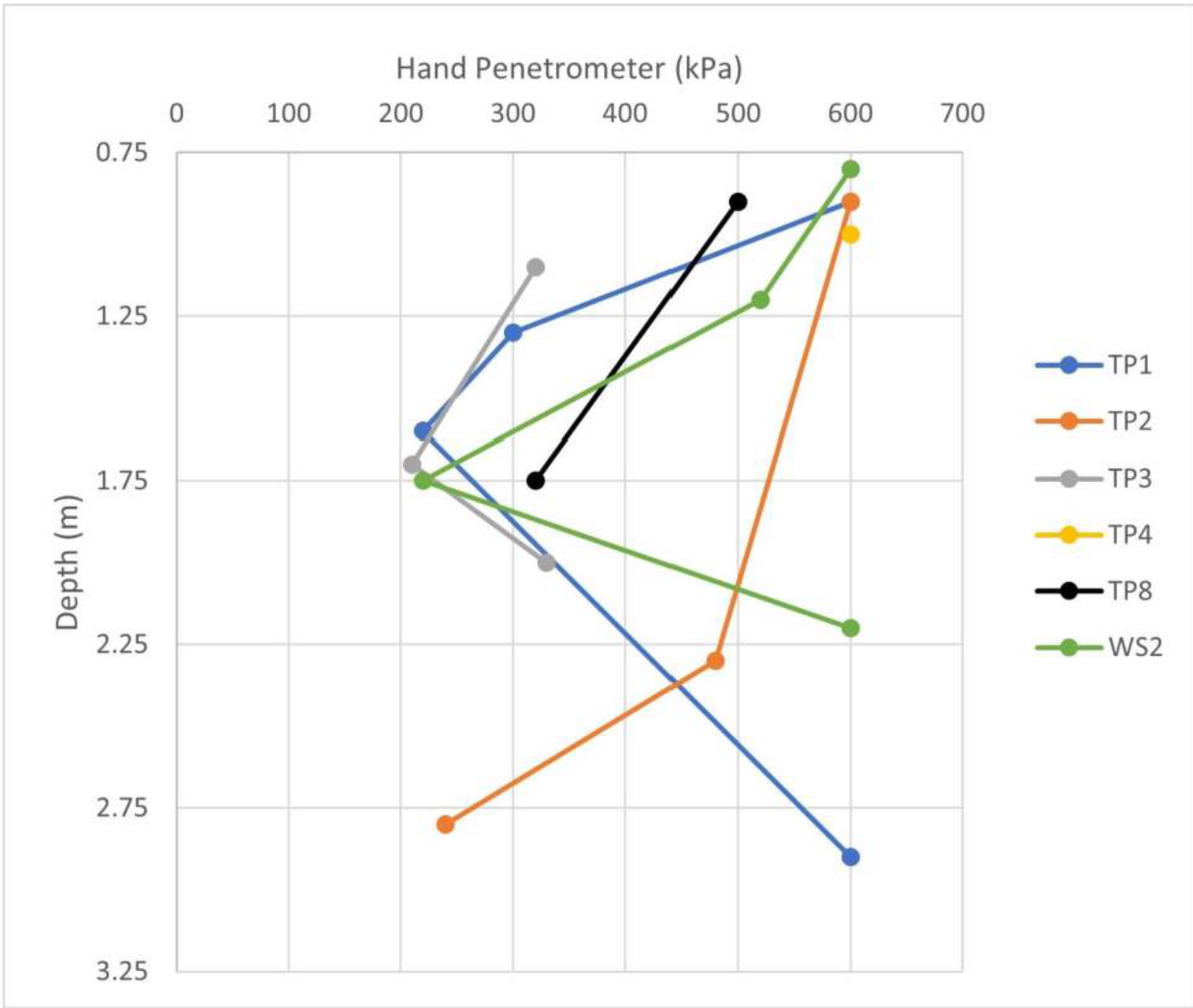
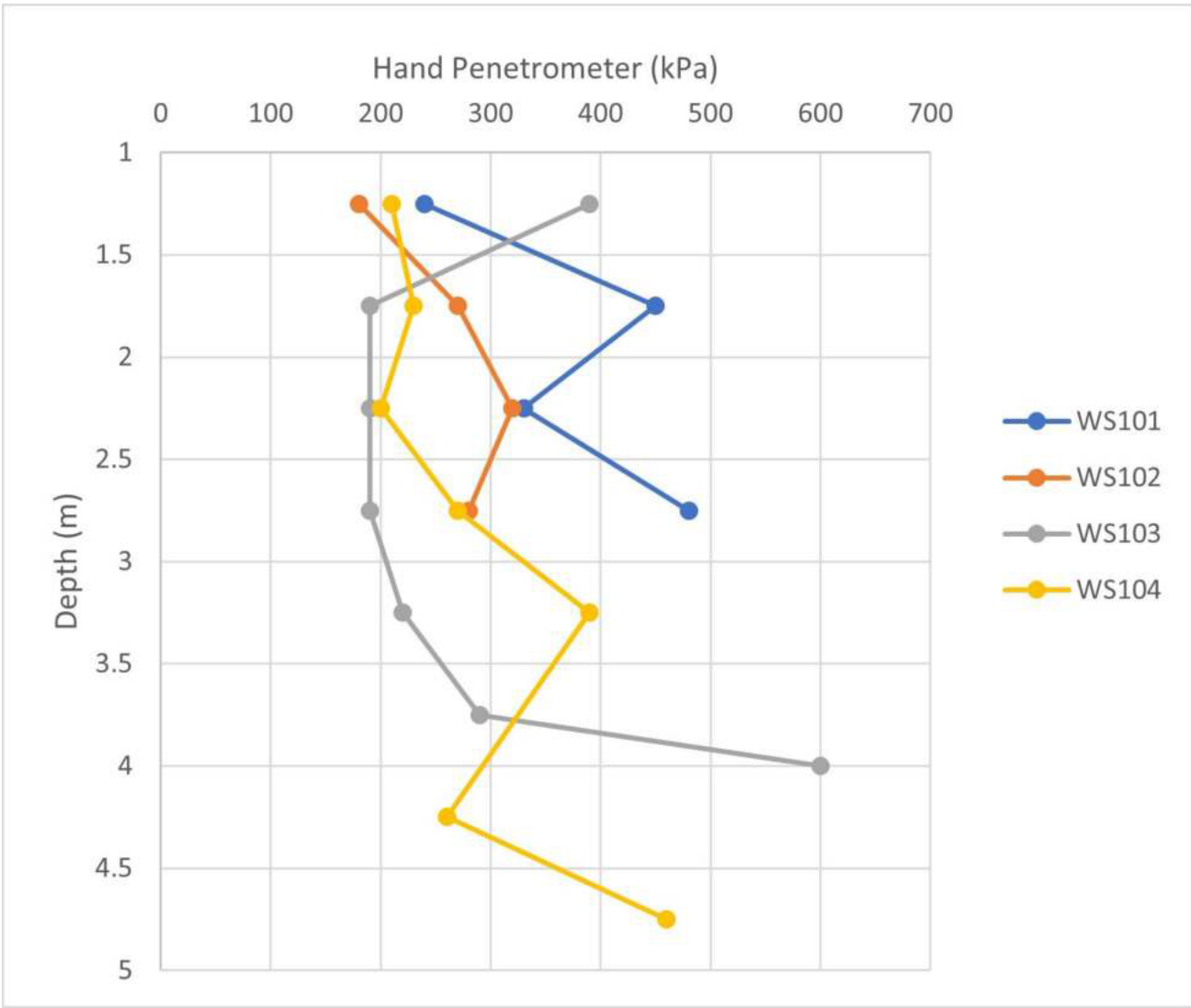
Plot of Cu v. Depth



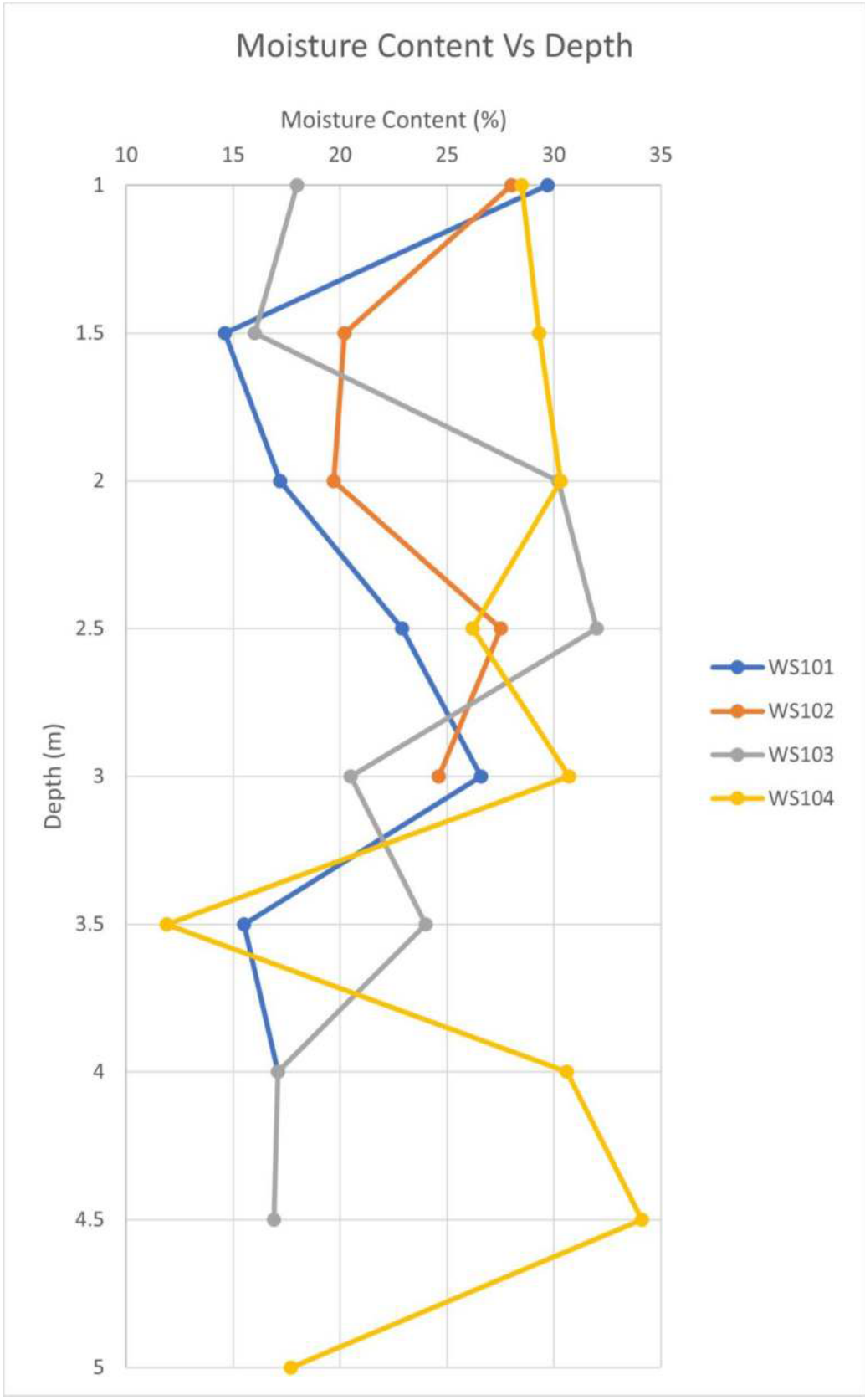
Project Number:	LP3444	leap environmental	
Site:	Sumners Pond		**Fig. No**
Client:	Sigma Pond		6
Date:	07/09/2023		



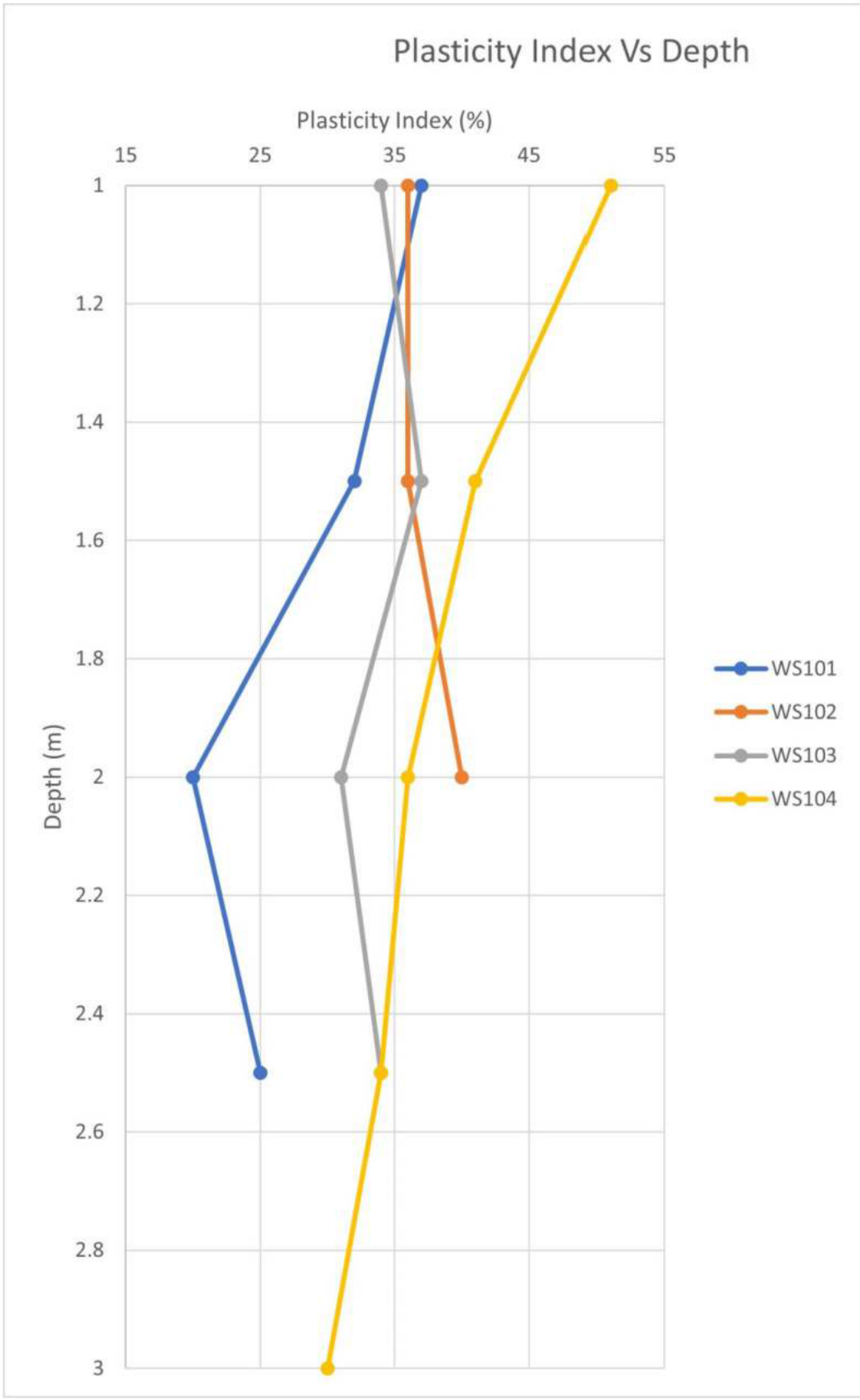
leap environmental	Client:	Sigma Homes	Date:	08/09/23	Project ID:	LP3444
	Project:	Sumners Pond	Title:	Phase II (LP3019) Hand Penetrometer Vs Depth	Fig. No.	7



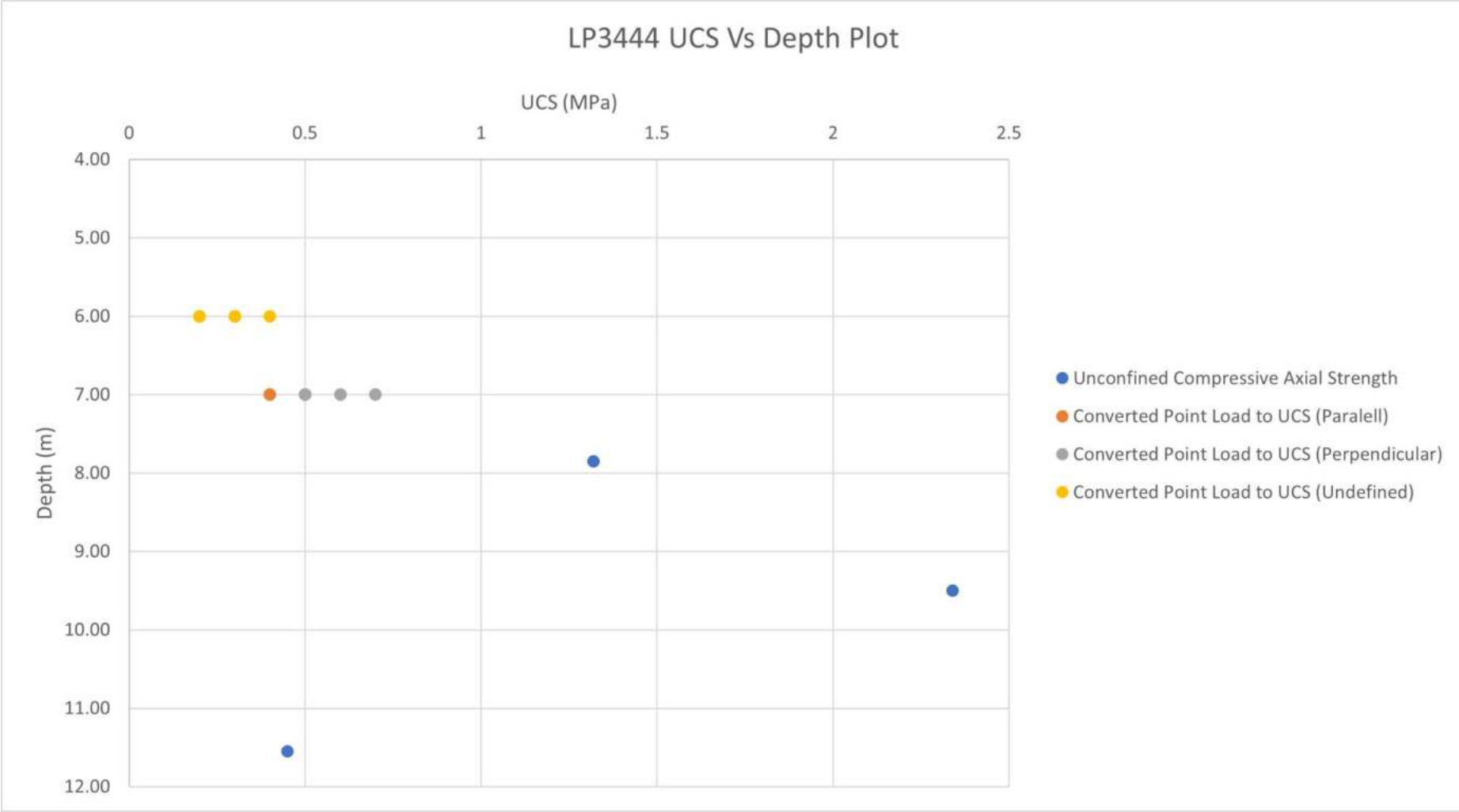
leap environmental	Client:	Sigma Homes	Date:	08/09/23	Project ID:	LP3444
	Project:	Sumners Pond	Title:	Hand Penetrometer Vs Depth	Fig. No.	8



leap environmental	Client:	Sigma Homes	Date:	08/09/23	Project ID:	LP3444
	Project:	Sumners Pond	Title:	Moisture Content Vs Depth	Fig. No.	9

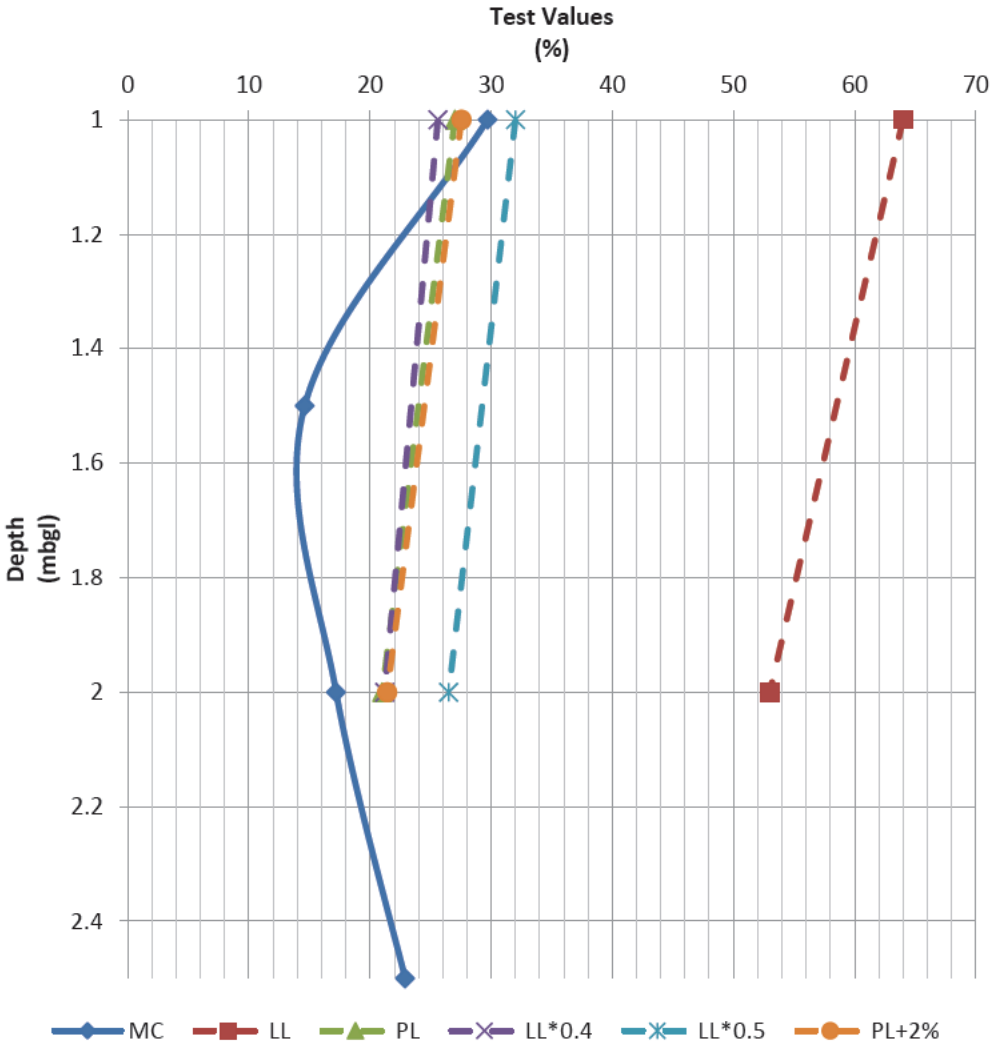


leap environmental	Client:	Sigma Homes	Date:	08/09/23	Project ID:	LP3444
	Project:	Sumners Pond	Title:	Plasticity Index Vs Depth	Fig. No.	10



leap environmental	Client:	Sigma Homes	Date:	08/09/23	Project ID:	LP3444
	Project:	Sumners Pond	Title:	UCS Vs Depth	Fig. No.	11

DESICCATION ASSESSMENT FORM



Project: Sumners Pond

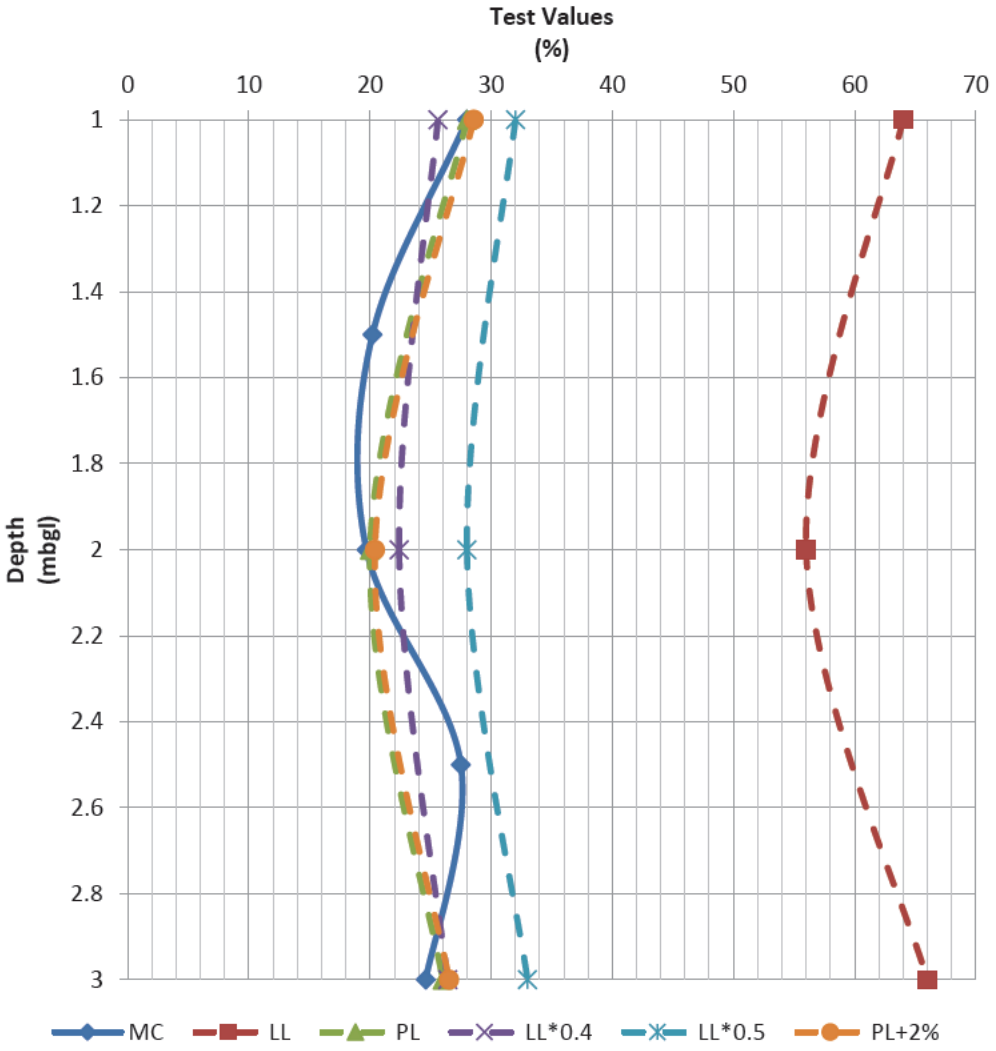
Project ID: LP3444
Client: Sigma Homes Ltd

Date: 21/09/2023
Hole ID: WS101
Chart 12

SUMMARY OF RESULTS FROM MOISTURE CONTENT AND ATTERBERG LIMITS

Depth	MC	LL	PL	PL+2%	LL*0.4	LL*0.5
1	29.7	64	27	27.54	25.6	32
1.5	14.6					
2	17.2	53	21	21.42	21.2	26.5
2.5	22.9					

DESICCATION ASSESSMENT FORM



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Project: Sumners Pond

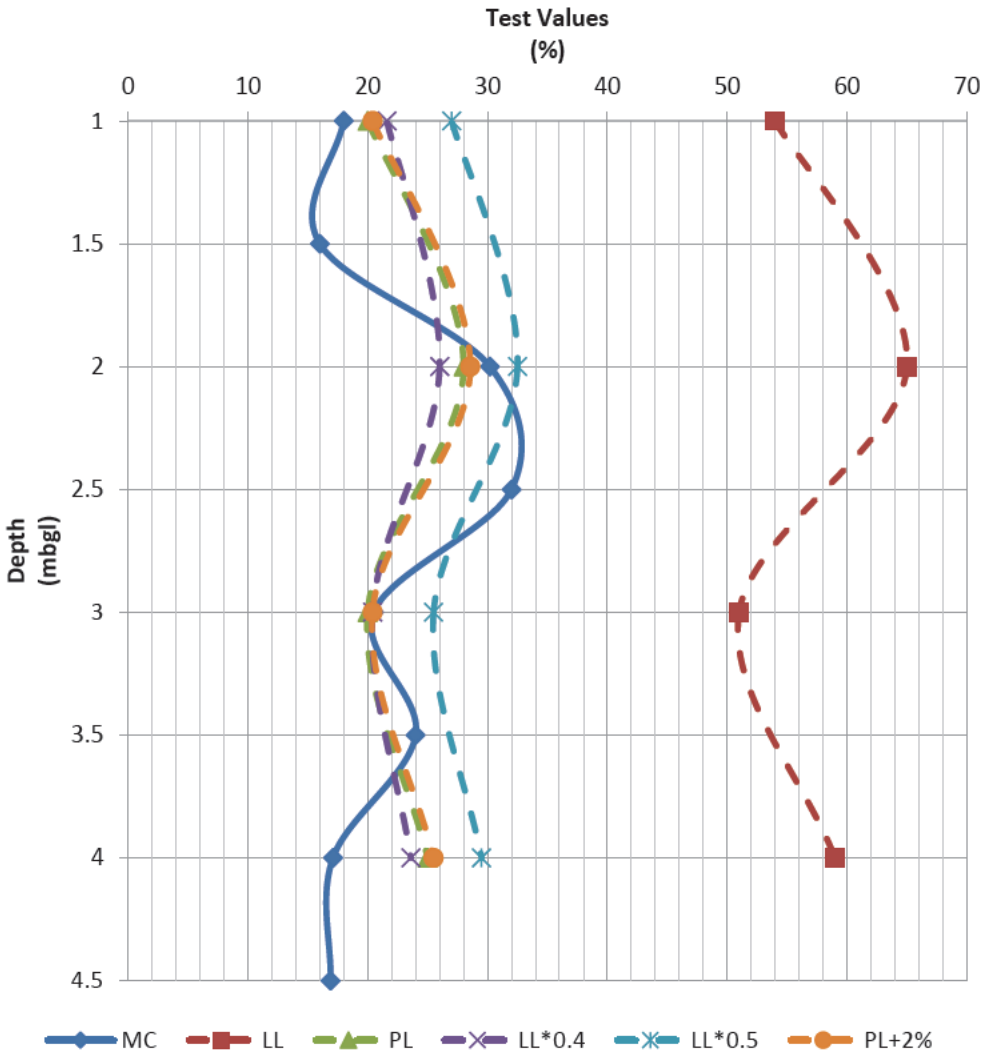
Project ID: LP3444
Client: Sigma Homes Ltd

Date: 21/09/2023
Hole ID: WS102
Chart 12

SUMMARY OF RESULTS FROM MOISTURE CONTENT AND ATTERBERG LIMITS

Depth	MC	LL	PL	PL+2%	LL*0.4	LL*0.5
1	28	64	28	28.56	25.6	32
1.5	20.2					
2	19.7	56	20	20.4	22.4	28
2.5	27.5					
3	24.6	66	26	26.52	26.4	33

DESICCATION ASSESSMENT FORM



Project: Sumners Pond

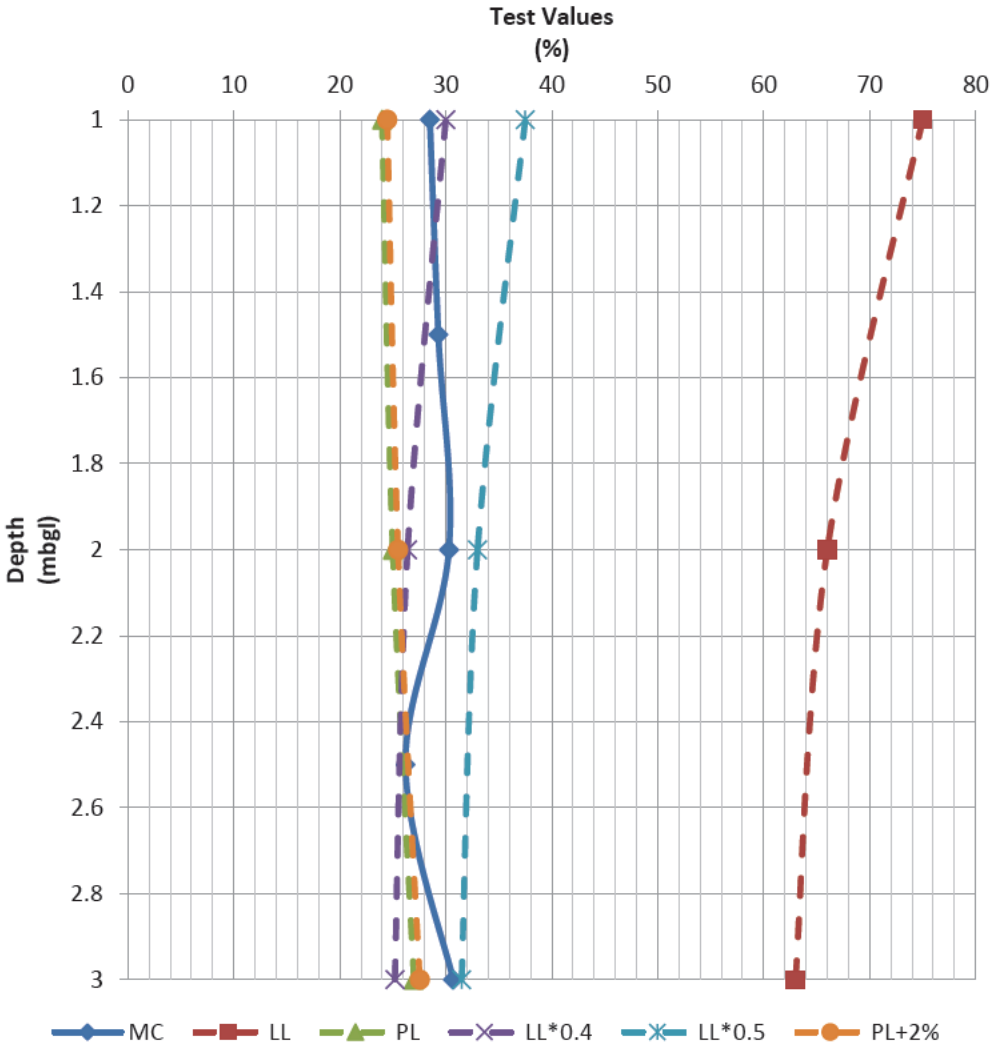
Project ID: LP3444
Client: Sigma Homes Ltd

Date: 21/09/2023
Hole ID: WS103
Chart 12

SUMMARY OF RESULTS FROM MOISTURE CONTENT AND ATTERBERG LIMITS

Depth	MC	LL	PL	PL+2%	LL*0.4	LL*0.5
1	18	54	20	20.4	21.6	27
1.5	16					
2	30.2	65	28	28.56	26	32.5
2.5	32					
3	20.5	51	20	20.4	20.4	25.5
3.5	24					
4	17.1	59	25	25.5	23.6	29.5
4.5	16.9					

DESICCATION ASSESSMENT FORM



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Project: Sumners Pond

Project ID: LP3444
Client: Sigma Homes Ltd

Date: 21/09/2023
Hole ID: WS104
Chart 12

SUMMARY OF RESULTS FROM MOISTURE CONTENT AND ATTERBERG LIMITS

Depth	MC	LL	PL	PL+2%	LL*0.4	LL*0.5
1	28.5	75	24	24.48	30	37.5
1.5	29.3					
2	30.3	66	25	25.5	26.4	33
2.5	26.2					
3	30.7	63	27	27.54	25.2	31.5

APPENDIX F – Geotechnical Laboratory Test Results

Geotechnical Laboratory
Test Results

GEOLABS Limited
Bucknalls Lane
Garston
Watford
Hertfordshire
WD25 9XX
Tel: +44(0) 1923 892 190
Fax: +44(0) 1923 892 191
email: admin@geolabs.co.uk
web: www.geolabs.co.uk

Leap Environmental Limited
Book House
Glebelands Centre
Vincent Lane
Dorking
Surrey
RH4 3HW

For the attention of Ms I Adshead

06 September 2023
Report No : GEO/38654/01

Date samples received 11/08/2023
Date written instructions received 15/08/2023
Our ref **GEO / 38654** Date testing commenced 16/08/2023
Your Ref **LP3444** **Date of sample disposal 04/10/2023**

Project **SUMNERS POND**

Further to your instructions we have pleasure in enclosing the results of the tests you requested in the attached figures.

LABORATORY TEST REPORT

Item No	Test Quantity	Description
1	~	Geotechnical Test Summary
2	~	Liquid & Plastic Limits Summary
	29	Water Content
	16	Liquid & Plastic Limits
3	2	Incremental Loading Oedometer
4	3	Unconfined Compressive Strength
5	2	Point Load Strength Index - set of 10

Any opinions or interpretations expressed herein are outside the scope of UKAS accreditation. All results contained in this report are provisional unless signed by an approved signatory. The results contained in this report relate only to samples received in the laboratory and are tested 'as received' unless otherwise stated. This report should not be reproduced, except in full, without the written approval of the laboratory. The results reported are applicable only to the test items received by the laboratory.

All the necessary data required by the documented test procedures has been recorded and will be stored for a period of not less than 6 years. This data will be issued to yourselves at your request. All samples will be disposed of after the date shown above. Written confirmation will be required to retain the samples beyond this period and a storage charge may be applied.

We trust that the above meets your requirements and should you require any further information or assistance, please do not hesitate to contact us.

Yours faithfully
on behalf of **GEOLABS Limited**

[redacted]

J Sturges
Operations Manager

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Registered Office: Bucknalls Lane Garston Watford Hertfordshire WD25 9XX Registered in England and Wales No: 3177641

SUMMARY OF GEOTECHNICAL TESTING

Sample details					Classification Tests					Density Tests		Undrained Triaxial Compression				Chemical Tests			Other tests and comments
Location	Depth (m)	Sample Ref	Type	Description	WC %	LL %	PL %	PI %	<425 µm %	Bulk Mg/m³	Dry Mg/m³	Condition	Cell Pressure kPa	Deviator Stress kPa	Shear Stress kPa	pH	2:1 W/S SO4 g/L	W/S Mg mg/L	
BH01	1.20-2.70	0	WS	Very stiff yellowish brown mottled light grey slightly sandy silty CLAY. Sand is fine.															One Dimensional Consolidation
BH01	2.70-4.20	1	WS	Stiff fissured greenish grey CLAY.															One Dimensional Consolidation
WS101	1.00	1	D	Brown mottled grey slightly sandy silty CLAY with rare gravel.	29.7	64	27	37	99										
WS101	1.50	2	D	Yellowish brown and grey mottled silty CLAY.	14.6														
WS101	2.00	3	D	Brown and grey mottled silty CLAY.	17.2	53	21	32	100										
WS101	2.50	4	D	Greyish brown mottled grey and dark brown silty CLAY.	22.9														
WS101	3.00	5	D	Greyish brown slightly gravelly slightly sandy CLAY. Gravel is fine to medium gravel.	26.6	41	21	20	62										
WS101	3.50	6	D	Greyish brown sandy silty CLAY with rare fine to medium gravel.	15.5														
WS101	4.00	7	D	Brown grey slightly gravelly silty CLAY. Gravel is fine to medium siltstone.	17.1	51	26	25	71										
WS102	1.00	1	D	Brown and grey mottled silty CLAY.	28.0	64	28	36	100										

Sample type: B (Bulk disturb.) BLK (Block) C (Core) D (Disturbed) LB (Large Bulk dist.) U (Undisturbed)

Checked and Approved by

[redacted]

J Sturges - Operations Manager
06/09/2023

Project Number:

GEO / 38654

Project Name:

SUMNERS POND
LP3444

GEOLABS®

SUMMARY OF GEOTECHNICAL TESTING

Sample details					Classification Tests					Density Tests		Undrained Triaxial Compression				Chemical Tests			Other tests and comments
Location	Depth (m)	Sample Ref	Type	Description	WC %	LL %	PL %	PI %	<425 µm %	Bulk Mg/m³	Dry Mg/m³	Condition	Cell Pressure kPa	Deviator Stress kPa	Shear Stress kPa	pH	2:1 W/S SO4 g/L	W/S Mg mg/L	
WS102	1.50	2	D	Greyish brown and grey mottled silty CLAY with rare gypsum.	20.2														
WS102	2.00	3	D	Brown and grey mottled silty CLAY.	19.7	56	20	36	100										
WS102	2.50	4	D	Brown and grey CLAY with rare fine sand.	27.5														
WS102	3.00	5	D	Brown and grey CLAY with rare fine sand.	24.6	66	26	40	100										
WS103	1.00	1	D	Brown mottled orangish brown and grey silty CLAY with rare fine gravel.	18.0	54	20	34	99										
WS103	1.50	2	D	Yellowish brown mottled red slightly sandy silty CLAY.	16.0														
WS103	2.00	3	D	Multicoloured slightly sandy silty CLAY with rare fine gravel.	30.2	65	28	37	99										
WS103	2.50	4	D	Brown mottled grey slightly sandy silty CLAY.	32.0														
WS103	3.00	5	D	Brown and grey slightly sandy silty CLAY. Sand is fine.	20.5	51	20	31	100										
WS103	3.50	6	D	Greyish brown mottled brown slightly sandy silty CLAY.	24.0														

Sample type: B (Bulk disturb.) BLK (Block) C (Core) D (Disturbed) LB (Large Bulk dist.) U (Undisturbed)

Checked and Approved by

[redacted]

J Sturges - Operations Manager
06/09/2023

Project Number:

GEO / 38654

Project Name:

SUMNERS POND
LP3444

GEOLABS®

SUMMARY OF GEOTECHNICAL TESTING

Sample details					Classification Tests					Density Tests		Undrained Triaxial Compression				Chemical Tests			Other tests and comments
Location	Depth (m)	Sample Ref	Type	Description	WC %	LL %	PL %	PI %	<425 µm %	Bulk Mg/m³	Dry Mg/m³	Condition	Cell Pressure kPa	Deviator Stress kPa	Shear Stress kPa	pH	2:1 W/S SO4 g/L	W/S Mg mg/L	
WS103	4.00	7	D	Brown and grey slightly sandy silty CLAY. Sand is fine.	17.1	59	25	34	100										
WS103	4.50	8	D	Greyish brown mottled brown slightly sandy silty CLAY.	16.9														
WS104	1.00	1	D	Multicoloured silty CLAY with rare fine sand.	28.5	75	24	51	100										
WS104	1.50	2	D	Brown mottled grey slightly gravelly slightly sandy CLAY. Gravel is fine to medium.	29.3														
WS104	2.00	3	D	Brown mottled orangish brown and grey slightly sandy silty CLAY with rare gypsum.	30.3	66	25	41	99										
WS104	2.50	4	D	Brown mottled orangish brown and grey slightly sandy silty CLAY with rare gypsum.	26.2														
WS104	3.00	5	D	Multicoloured slightly sandy silty CLAY with rare fine gravel.	30.7	63	27	36	99										
WS104	3.50	6	D	Greyish brown slightly sandy silty CLAY with occasional mudstone.	11.9														
WS104	4.00	7	D	Greyish brown mottled orangish brown slightly gravelly slightly sandy silty CLAY. Gravel is fine.	30.6	57	23	34	99										
WS104	4.50	8	D	Greyish brown mottled brown slightly sandy silty CLAY.	34.1														

Sample type: B (Bulk disturb.) BLK (Block) C (Core) D (Disturbed) LB (Large Bulk dist.) U (Undisturbed)

Checked and Approved by

[redacted]

J Sturges - Operations Manager
06/09/2023

Project Number:

GEO / 38654

Project Name:

SUMNERS POND
LP3444

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SUMMARY OF GEOTECHNICAL TESTING

Sample details					Classification Tests					Density Tests		Undrained Triaxial Compression				Chemical Tests			Other tests and comments
Location	Depth (m)	Sample Ref	Type	Description	WC %	LL %	PL %	PI %	<425 µm %	Bulk Mg/m³	Dry Mg/m³	Condition	Cell Pressure kPa	Deviator Stress kPa	Shear Stress kPa	pH	2:1 W/S SO4 g/L	W/S Mg mg/L	
WS104	5.00	9	D	Brown and yellowish brown slightly gravelly slightly sandy silty CLAY with rare rootlets. Gravel is fine.	17.7	50	20	30	99										

Sample type: B (Bulk disturb.) BLK (Block) C (Core) D (Disturbed) LB (Large Bulk dist.) U (Undisturbed)

Checked and Approved by

[redacted]

06/09/2023

Project Number:

GEO / 38654

Project Name:

SUMNERS POND
LP3444

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BS EN ISO 17892-12 : 2018+A2:2022

SUMMARY OF LIQUID AND PLASTIC LIMIT TESTS

Location	Depth m	Sample Ref	Sample Type	Description	Water Content BS EN ISO 17892-1 : 2014 +A1:2022 %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Percentage Passing 425µm %	Atterberg Classification	Test Type	Sample Condition
WS101	1.00	1	D	Brown mottled grey slightly sandy silty CLAY with rare gravel.	29.7	64	27	37	99	CH	2	1
WS101	1.50	2	D	Yellowish brown and grey mottled silty CLAY.	14.6	~	~	~	~	~	~	~
WS101	2.00	3	D	Brown and grey mottled silty CLAY.	17.2	53	21	32	100	CH	2	1
WS101	2.50	4	D	Greyish brown mottled grey and dark brown silty CLAY.	22.9	~	~	~	~	~	~	~
WS101	3.00	5	D	Greyish brown slightly gravelly slightly sandy CLAY. Gravel is fine to medium gravel.	26.6	41	21	20	62	CI	2	3
WS101	3.50	6	D	Greyish brown sandy silty CLAY with rare fine to medium gravel.	15.5	~	~	~	~	~	~	~
WS101	4.00	7	D	Brown grey slightly gravelly silty CLAY. Gravel is fine to medium siltstone.	17.1	51	26	25	71	CH	2	3
WS102	1.00	1	D	Brown and grey mottled silty CLAY.	28.0	64	28	36	100	CH	2	1
WS102	1.50	2	D	Greyish brown and grey mottled silty CLAY with rare gypsum.	20.2	~	~	~	~	~	~	~
WS102	2.00	3	D	Brown and grey mottled silty CLAY.	19.7	56	20	36	100	CH	2	1
WS102	2.50	4	D	Brown and grey CLAY with rare fine sand.	27.5	~	~	~	~	~	~	~
WS102	3.00	5	D	Brown and grey CLAY with rare fine sand.	24.6	66	26	40	100	CH	2	1
WS103	1.00	1	D	Brown mottled orangish brown and grey silty CLAY with rare fine gravel.	18.0	54	20	34	99	CH	2	1
WS103	1.50	2	D	Yellowish brown mottled red slightly sandy silty CLAY.	16.0	~	~	~	~	~	~	~
WS103	2.00	3	D	Multicoloured slightly sandy silty CLAY with rare fine gravel.	30.2	65	28	37	99	CH	2	1

Test Type:
1 - 1 point 80g / 30° fall cone method.
2 - 4 point 80g / 30° fall cone method.
3 - Non plastic determination.

Sample condition:
1 - As Received
2 - Air Dried
3 - Washed & Air Dried

Checked and Approved by:
[redacted]
J Sturges - Operations Manager
06/09/2023

Project Number:
GEO / 38654

Project Name:
SUMNERS POND
LP3444

GEOLABS
UKAS TESTING 1982

BS EN ISO 17892-12 : 2018+A2:2022

SUMMARY OF LIQUID AND PLASTIC LIMIT TESTS

Location	Depth m	Sample Ref	Sample Type	Description	Water Content BS EN ISO 17892-1 : 2014 +A1:2022 %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Percentage Passing 425µm %	Atterberg Classification	Test Type	Sample Condition
WS103	2.50	4	D	Brown mottled grey slightly sandy silty CLAY.	32.0	~	~	~	~	~	~	~
WS103	3.00	5	D	Brown and grey slightly sandy silty CLAY. Sand is fine.	20.5	51	20	31	100	CH	2	1
WS103	3.50	6	D	Greyish brown mottled brown slightly sandy silty CLAY.	24.0	~	~	~	~	~	~	~
WS103	4.00	7	D	Brown and grey slightly sandy silty CLAY. Sand is fine.	17.1	59	25	34	100	CH	2	1
WS103	4.50	8	D	Greyish brown mottled brown slightly sandy silty CLAY.	16.9	~	~	~	~	~	~	~
WS104	1.00	1	D	Multicoloured silty CLAY with rare fine sand.	28.5	75	24	51	100	CV	2	1
WS104	1.50	2	D	Brown mottled grey slightly gravelly slightly sandy CLAY. Gravel is fine to medium.	29.3	~	~	~	~	~	~	~
WS104	2.00	3	D	Brown mottled orangish brown and grey slightly sandy silty CLAY with rare gypsum.	30.3	66	25	41	99	CH	2	1
WS104	2.50	4	D	Brown mottled orangish brown and grey slightly sandy silty CLAY with rare gypsum.	26.2	~	~	~	~	~	~	~
WS104	3.00	5	D	Multicoloured slightly sandy silty CLAY with rare fine gravel.	30.7	63	27	36	99	CH	2	1
WS104	3.50	6	D	Greyish brown slightly sandy silty CLAY with occasional mudstone.	11.9	~	~	~	~	~	~	~
WS104	4.00	7	D	Greyish brown mottled orangish brown slightly gravelly slightly sandy silty CLAY. Gravel is fine.	30.6	57	23	34	99	CH	2	1
WS104	4.50	8	D	Greyish brown mottled brown slightly sandy silty CLAY.	34.1	~	~	~	~	~	~	~
WS104	5.00	9	D	Brown and yellowish brown slightly gravelly slightly sandy silty CLAY with rare rootlets. Gravel is fine.	17.7	50	20	30	99	CI	2	1

Test Type:
1 - 1 point 80g / 30° fall cone method.
2 - 4 point 80g / 30° fall cone method.
3 - Non plastic determination.

Sample condition:
1 - As Received
2 - Air Dried
3 - Washed & Air Dried

Checked and Approved by:

[redacted]

J Sturges - Operations Manager
06/09/2023

Project Number:

GEO / 38654

Project Name:

SUMNERS POND
LP3444

GEOLABS

UKAS TESTING 1982

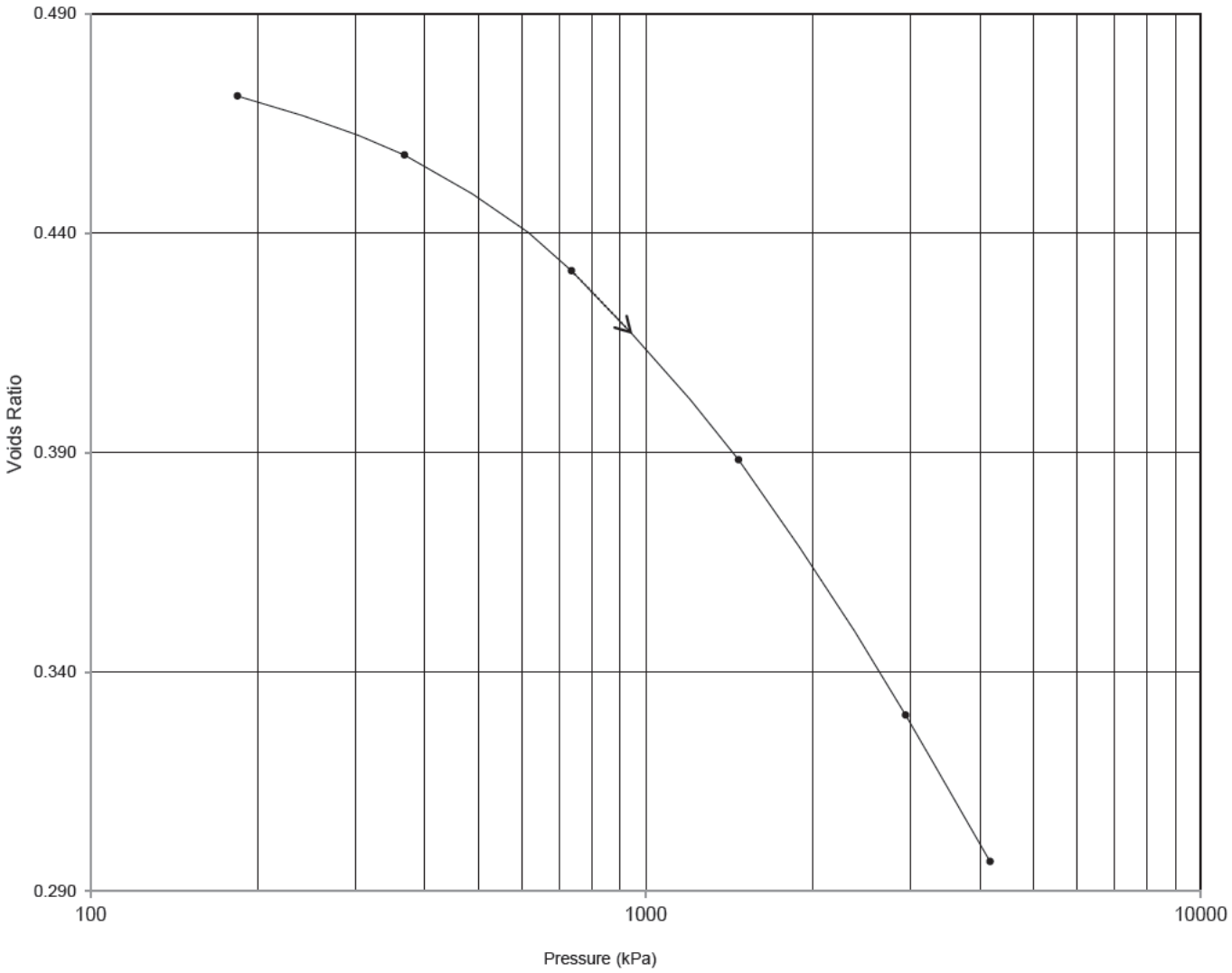
BS EN ISO 17892-5 : 2017

INCREMENTAL LOADING OEDOMETER TEST

Location	BH01
Sample Ref.	0
Depth (m)	1.20-2.70
Sample Type	WS
Depth within original (mm)	300
Orientation within original	Vertical
Specimen preparation	Undisturbed

Description:

Very stiff yellowish brown mottled light grey slightly sandy silty CLAY. Sand is fine.



Initial Conditions:

Height	(mm)	19.03	Water Content	(%)	23.5	(from trimmings)
Diameter	(mm)	63.43	Voids Ratio		0.585	
Area	(mm²)	3160	Bulk Density	(Mg/m³)	2.06	
Volume	(cm³)	60.13	Dry Density	(Mg/m³)	1.67	
Laboratory Temperature	(ºC)	23.4	Particle density	(Mg/m³)	2.65 (Assumed)	
			Degree of Saturation	(%)	100.0	

Results have been corrected for equipment deformation

Checked and Approved by

J Sturges - Operations Manager
06/09/2023

Project Number:

GEO / 38654

Project Name:

SUMNERS POND

LP3444

GEOLABS

UKAS TESTING 1982

BS EN ISO 17892-5 : 2017

INCREMENTAL LOADING OEDOMETER TEST

Location	BH01
Sample Ref.	0
Depth (m)	1.20-2.70
Sample Type	WS
Depth within original (mm)	300
Orientation within original	Vertical
Specimen preparation	Undisturbed

Description:

Very stiff yellowish brown mottled light grey slightly sandy silty CLAY. Sand is fine.

Pressure Range (kPa)	m_v (m^2/MN)	c_v (m^2/year)	Time Fitting		Voids Ratio
			Method	minutes	
0 - 184	-	Swelling Pressure	-	-	0.471
184 - 368	0.050	2.3	t90	15.2	0.458
368 - 736	0.049	2.1	t50	3.80	0.431
736 - 1472	0.041	1.5	t50	5.13	0.388
1472 - 2944	0.028	1.3	t50	5.19	0.330
2944 - 4177	0.020	0.94	t50	6.89	0.297

Checked and Approved by

[redacted]

J Sturges - Operations Manager
06/09/2023

Project Number:

GEO / 38654

Project Name:

SUMNERS POND

LP3444

GEOLABS

UKAS TESTING 1982

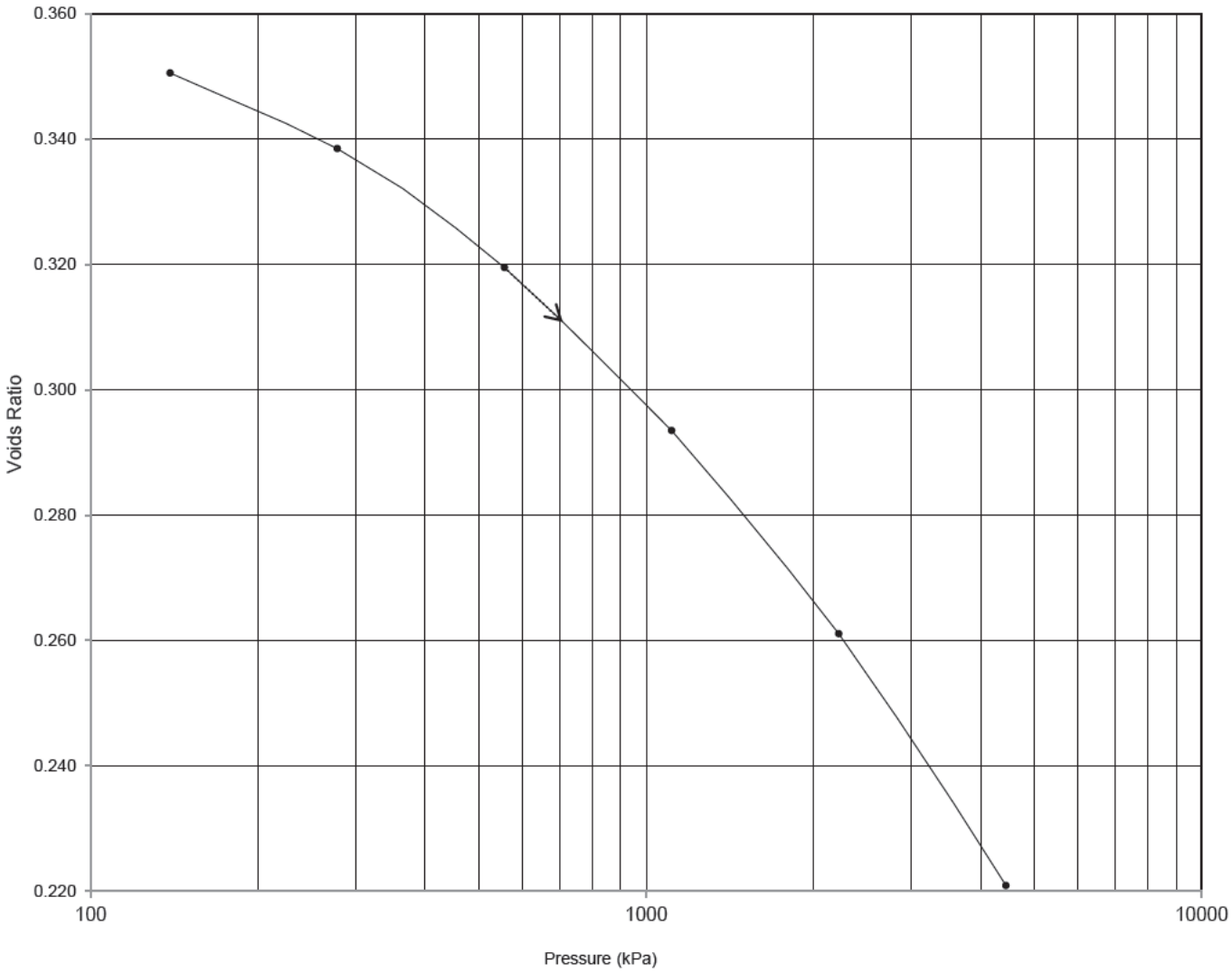
BS EN ISO 17892-5 : 2017

INCREMENTAL LOADING OEDOMETER TEST

Location	BH01
Sample Ref.	1
Depth (m)	2.70-4.20
Sample Type	WS
Depth within original (mm)	1300
Orientation within original	Vertical
Specimen preparation	Undisturbed

Description:

Stiff fissured greenish grey CLAY.



Initial Conditions:

Height	(mm)	18.63	Water Content	(%)	15.5	(from trimmings)
Diameter	(mm)	63.63	Voids Ratio		0.361	
Area	(mm²)	3180	Bulk Density	(Mg/m³)	2.25	
Volume	(cm³)	59.24	Dry Density	(Mg/m³)	1.95	
Laboratory Temperature	(ºC)	23.5	Particle density	(Mg/m³)	2.65 (Assumed)	
			Degree of Saturation	(%)	100.0	

Results have been corrected for equipment deformation

Checked and Approved by

[redacted]

06/09/2023

Project Number:

GEO / 38654

Project Name:

SUMNERS POND

LP3444

GEOLABS

UKAS TESTING 1982

BS EN ISO 17892-5 : 2017

INCREMENTAL LOADING OEDOMETER TEST

Location	BH01
Sample Ref.	1
Depth (m)	2.70-4.20
Sample Type	WS
Depth within original (mm)	1300
Orientation within original	Vertical
Specimen preparation	Undisturbed

Description:

Stiff fissured greenish grey CLAY.

Pressure Range (kPa)	m_v (m²/MN)	c_v (m²/year)	Time Fitting		Voids Ratio
			Method	minutes	
0 - 139	-	Swelling Pressure	-	-	0.351
139 - 278	0.064	4.4	t50	1.99	0.339
278 - 556	0.051	4.9	t50	1.75	0.320
556 - 1112	0.035	4.2	t50	1.96	0.294
1112 - 2224	0.023	4.1	t50	1.94	0.261
2224 - 4448	0.014	3.7	t50	2.01	0.221

Checked and Approved by

[redacted]

J Sturges - Operations Manager
06/09/2023

Project Number:

GEO / 38654

Project Name:

SUMNERS POND
LP3444

GEOLABS®

UKAS TESTING 1982

ISRM Suggested Methods - Rock Characterization Testing and Monitoring 1974 - 2006

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK MATERIALS

Sample details						Density		Uniaxial Compression Test (LF0879C (1000kN) compression frame used)							
								Mean after prep.							
Borehole Ref.	Sample Ref.	Depth (m)	Description	MC (%)	Degree of Saturation (%)	Bulk (Mg/m³)	Dry (Mg/m³)	Diameter (mm)	Height (mm)	H/D Ratio	Load at Failure (kN)	UCS (MPa) 3 sig. fig.	Failure Sketch	D. Tested	Remarks
BH01	4	7.70-8.00	Very weak thinly laminated dark grey SILTSTONE / MUDSTONE. Moderately to highly weathered	11	83.4	2.34	2.12	90.00	232.00	2.6	8.4	1.32		18/08/23	
BH01	5	9.35-9.65	Very weak thinly laminated dark grey SILTSTONE / MUDSTONE. Moderately to highly weathered	7.9	72.3	2.38	2.20	89.80	230.00	2.6	14.8	2.34		18/08/23	
BH01	6	11.40-11.70	Extremely weak dark grey MUDSTONE. Highly to completely weathered	10	86.6	2.37	2.15	89.00	223.00	2.5	2.8	0.45		18/08/23	

Note: The dimensional requirements of flatness (<0.02 mm), perpendicularity (<0.05 / 50 mm) and straightness (0.3 mm deviation) are all met. Specific Gravity used for Degree of Saturation is assumed unless specified by the client.

Checked and Approved by



I Tabios (Head of Department)

Date: 30/08/2023

Project Number:

GEO / 38654

Project Name:

SUMNERS POND
LP3444

GEOLABS

UKAS TESTING 1982

ISRM Suggested Methods - Rock Characterization Testing and Monitoring 1974 - 2006

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK MATERIALS

Borehole Ref.:	BH01
Sample Ref.:	4
Depth (m):	7.70-8.00

Description:
Very weak thinly laminated dark grey SILTSTONE / MUDSTONE. Moderately to highly weathered

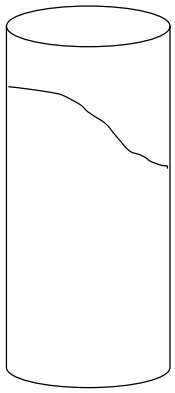
Diameter	90.00 mm
Height	232.00 mm
Bulk Density	2.34 Mg/m³
Dry Density	2.12 Mg/m³
Water Content	11 %

Degree of Saturation: 83.4 % Specific Gravity: 2.9 Mg/m³ (Assumed)

LF0879C (1000kN) compression frame used

Failure Sketch

Mode of failure: Diagonal shearing



Solid lines for material failures.
Dashed lines for apparent weakness failure.

Angle of foliation/Axis of loading: n/a
Angle of shear plane/Axis of loading: n/a

Sample type	**WS**

Date tested: 18/08/2023

Test results

Unconfined Compressive Strength Maximum load (kN): 8.40	1.32 MPa
Young's Modulus (tangential at 50% failure load)	n/a
Poisson's Ratio (tangential at 50% failure load)	n/a
Young's Modulus (secant at 10% failure load)	n/a
Poisson's Ratio (secant at 10% failure load)	n/a

Note: The dimensional requirements of Flatness (<0.02 mm), Perpendicularity (<0.05 / 50 mm) and Straightness (0.3 mm deviation) are all met.

Checked and Approved by

I Tabios (Head of Department)

Date: 30/08/2023

Project Number:

GEO / 38654

Project Name:

SUMNERS POND
LP3444

GEOLABS

UKAS TESTING 1982

ISRM Suggested Methods - Rock Characterization Testing and Monitoring 1974 - 2006

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK MATERIALS

Borehole Ref.:	BH01
Sample Ref.:	5
Depth (m):	9.35-9.65

Description:
Very weak thinly laminated dark grey SILTSTONE / MUDSTONE. Moderately to highly weathered

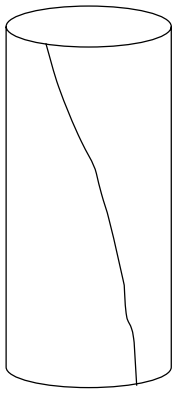
Diameter	89.80 mm
Height	230.00 mm
Bulk Density	2.38 Mg/m³
Dry Density	2.20 Mg/m³
Water Content	7.9 %

Degree of Saturation: 72.3 % Specific Gravity: 2.9 Mg/m³ (Assumed)

LF0879C (1000kN) compression frame used

Failure Sketch

Mode of failure: Diagonal shearing



Solid lines for material failures.
Dashed lines for apparent weakness failure.

Angle of foliation/Axis of loading: n/a
Angle of shear plane/Axis of loading: n/a

Sample type	**WS**

Date tested: 18/08/2023

Test results

Unconfined Compressive Strength Maximum load (kN): 14.80	2.34 MPa
Young's Modulus (tangential at 50% failure load)	n/a
Poisson's Ratio (tangential at 50% failure load)	n/a
Young's Modulus (secant at 10% failure load)	n/a
Poisson's Ratio (secant at 10% failure load)	n/a

Note: The dimensional requirements of Flatness (<0.02 mm), Perpendicularity (<0.05 / 50 mm) and Straightness (0.3 mm deviation) are all met.

Checked and Approved by

I Tabios (Head of Department)

Date: 30/08/2023

Project Number:

GEO / 38654

Project Name:

SUMNERS POND
LP3444

GEOLABS

UKAS TESTING 1982

ISRM Suggested Methods - Rock Characterization Testing and Monitoring 1974 - 2006

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK MATERIALS

Borehole Ref.:	BH01
Sample Ref.:	6
Depth (m):	11.40-11.70

Description:
Extremely weak dark grey MUDSTONE. Highly to completely weathered

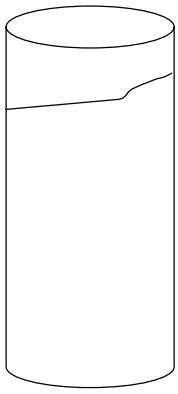
Diameter	89.00 mm
Height	223.00 mm
Bulk Density	2.37 Mg/m³
Dry Density	2.15 Mg/m³
Water Content	10 %

Degree of Saturation: 86.6 % Specific Gravity: 2.9 Mg/m³ (Assumed)

LF0879C (1000kN) compression frame used

Failure Sketch

Mode of failure: Diagonal shearing



Solid lines for material failures.
Dashed lines for apparent weakness failure.

Angle of foliation/Axis of loading: n/a
Angle of shear plane/Axis of loading: n/a

Sample type	**WS**

Date tested: 18/08/2023

Test results

Unconfined Compressive Strength Maximum load (kN): 2.80	0.45 MPa
Young's Modulus (tangential at 50% failure load)	n/a
Poisson's Ratio (tangential at 50% failure load)	n/a
Young's Modulus (secant at 10% failure load)	n/a
Poisson's Ratio (secant at 10% failure load)	n/a

Note: The dimensional requirements of Flatness (<0.02 mm), Perpendicularity (<0.05 / 50 mm) and Straightness (0.3 mm deviation) are all met.

Checked and Approved by

I Tabios (Head of Department)

Date: 30/08/2023

Project Number:

GEO / 38654

Project Name:

SUMNERS POND
LP3444

GEOLABS

UKAS TESTING 1982

ISRM Suggested Methods - Rock Characterization Testing and Monitoring 1974 - 2006 In-house Technical Procedure TP35

DETERMINATION OF POINT LOAD STRENGTH ON ROCK

Sample details				Point Load test											
Borehole Ref.	Sample Ref.	Depth (m)	Description	D. Tested	Test type & Direction		Sample width W (mm)	Platen separation (mm) Start D	Platen separation (mm) End D'	Water Content (%)	Equiv. Diameter D_e (mm)	Failure Load P (kN)	I_s P/De^2 (MPa)	Correction Factor F	Point Load Index $I_{s(50)}$ (MPa)
BH01	3	6.00-6.20	Extremely weak dark grey SILTSTONE / MUDSTONE. Highly to completely weathered	18/08/23	D	U	92.0	91.8	86.1		88.9	0.19	0.02	1.30	0.03
			Determination 2	18/08/23	D	U	91.0	90.7	84.5		87.5	0.17	0.02	1.29	0.03
			Determination 3	18/08/23	D	U	91.3	90.5	84.8		87.6	0.15	0.02	1.29	0.03
			Determination 4	18/08/23	A	U	90.6	48.1	42.6		70.1	0.15	0.03	1.16	0.03
			Determination 5	18/08/23	A	U	91.0	50.6	43.7		71.2	0.16	0.03	1.17	0.04
			Determination 6	18/08/23	A	U	89.9	49.8	43.4		70.5	0.12	0.02	1.17	0.02
			Determination 7	18/08/23	I	U	55.6	46.3	42.1		54.6	0.06	0.02	1.04	0.02
			Determination 8	18/08/23	I	U	50.2	45.1	43.3		52.6	0.08	0.03	1.02	0.03
			Determination 9	18/08/23	I	U	52.6	42.8	38.7		50.9	0.06	0.02	1.01	0.02
			Determination 10	18/08/23	I	U	53.8	48.7	43.5		54.6	0.05	0.02	1.04	0.02

(*) Sample failed on weakness

Test type and direction: **D** - Diametral **A** - Axial **B** - Block **I** - Irregular lump **P** - Perpendicular to planes of weakness **U** - Random or unknown orientation **L** - Parallel to planes of weakness

Checked and Approved by

[redacted]

I Tabios (Head of Department)

Date: 30/08/2023

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UKAS TESTING 1982

ISRM Suggested Methods - Rock Characterization Testing and Monitoring 1974 - 2006 In-house Technical Procedure TP35

DETERMINATION OF POINT LOAD STRENGTH ON ROCK

Sample details				Point Load test											
Borehole Ref.	Sample Ref.	Depth (m)	Description	D. Tested	Test type & Direction		Sample width W (mm)	Platen separation (mm) Start D	Platen separation (mm) End D'	Water Content (%)	Equiv. Diameter D_e (mm)	Failure Load P (kN)	I_s P/De^2 (MPa)	Correction Factor F	Point Load Index $I_{s(50)}$ (MPa)
BH01	3	6.90-7.10	Very weak thinly laminated grey SILTSTONE / MUDSTONE. Highly to completely weathered	21/08/23	D	L	92.0	91.5	83.8		87.6	0.21	0.03	1.29	0.04
			Determination 2	21/08/23	D	L	91.0	90.8	82.7		86.7	0.25	0.03	1.28	0.04
			Determination 3	21/08/23	D	L	90.6	90.5	86.3		88.4	0.34	0.04	1.29	0.05
			Determination 4	21/08/23	A	P	91.0	53.6	48.2		74.7	0.32	0.06	1.20	0.07
			Determination 5	21/08/23	A	P	90.4	51.1	46.5		73.2	0.24	0.05	1.19	0.06
			Determination 6	21/08/23	A	P	90.0	36.3	31.7		60.3	0.18	0.05	1.09	0.05
			Determination 7	21/08/23	A	P	91.0	48.8	42.1		69.8	0.31	0.06	1.16	0.07
			Determination 8	21/08/23	I	L	57.0	46.7	41.3		54.7	0.14	0.05	1.04	0.05
			Determination 9	21/08/23	I	L	55.3	33.4	28.2		44.6	0.13	0.06	0.95	0.06
			Determination 10	21/08/23	I	L	58.6	40.3	33.8		50.2	0.13	0.05	1.00	0.05

(*) Sample failed on weakness

Test type and direction: **D** - Diametral **A** - Axial **B** - Block **I** - Irregular lump **P** - Perpendicular to planes of weakness **U** - Random or unknown orientation **L** - Parallel to planes of weakness

Checked and Approved by

[redacted]

I Tabios (Head of Department)

Date: 30/08/2023

Project Number:

GEO / 38654

Project Name:

SUMNERS POND
LP3444

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UKAS TESTING 1982

SUMMARY OF GEOTECHNICAL TESTING

Sample details					Classification Tests					Density Tests		Undrained Triaxial Compression				Chemical Tests			Other tests and comments
Location	Depth (m)	Sample Ref	Type	Description	WC %	LL %	PL %	PI %	<425 µm %	Bulk Mg/m³	Dry Mg/m³	Condition	Cell Pressure kPa	Deviator Stress kPa	Shear Stress kPa	pH	2:1 W/S SO4 g/L	W/S Mg mg/L	
TP1	0.60		B	Brown, light brown and light grey mottled slightly sandy CLAY.															California Bearing Ratio
TP1	1.20		D	Yellowish brown and grey mottled silty CLAY.	17.3	63	25	38	100										
TP1	1.50		D																Chemical
TP2	0.60		B	Brown mottled grey slightly sandy CLAY.															California Bearing Ratio
TP2	0.70		D	Orangish brown and grey mottled silty CLAY.	25.3	67	29	38	100										
TP3	1.00		B	Brown mottled grey sandy gravelly CLAY with rare brick fragments.															California Bearing Ratio
TP3	1.70		D	Brown, grey and greyish brown mottled CLAY with rare fine to medium gravel.	28.0	59	24	35	98										
TP3	2.70		D																Chemical
TP4	1.00		D	Yellowish brown mottled grey silty CLAY.	20.5	53	24	29	100										
TP8	0.80		D	Light brown, brown and light grey mottled slightly sandy silty CLAY with rare fine to medium gravel.															California Bearing Ratio

Sample type: B (Bulk disturb.) BLK (Block) C (Core) D (Disturbed) LB (Large Bulk dist.) U (Undisturbed)

Checked and Approved by

[redacted]

J Sturges - Operations Manager
31/08/2022

Project Number:

GEO / 36112

Project Name:

SUMNERS POND, HORSHAM
LP3019

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SUMMARY OF GEOTECHNICAL TESTING

Sample details					Classification Tests					Density Tests		Undrained Triaxial Compression				Chemical Tests			Other tests and comments
Location	Depth (m)	Sample Ref	Type	Description	WC %	LL %	PL %	PI %	<425 µm %	Bulk Mg/m³	Dry Mg/m³	Condition	Cell Pressure kPa	Deviator Stress kPa	Shear Stress kPa	pH	2:1 W/S SO4 g/L	W/S Mg mg/L	
TP8	1.20		D	Yellowish brown mottled grey silty CLAY.	21.8	51	24	27	100										
WS1	2.10		D	Greyish brown, grey and brown mottled silty CLAY with rare fine to medium gravel.	30.9	71	27	44	99										
WS1	4.00		D																Chemical
WS2	1.50		D																Chemical
WS2	1.75		D	Dark brown, grey and yellowish brown mottled silty CLAY with rare fine to medium gravel.	26.4	67	25	42	98										
WS4	1.00		D	Yellowish brown and grey mottled silty CLAY with rare fine gravel and rootlets.	20.5	61	23	38	99										
WS5	2.00		D	Yellowish brown mottled grey silty CLAY.	24.6	59	25	34	100										
WS5	5.00		D																Chemical

Sample type: B (Bulk disturb.) BLK (Block) C (Core) D (Disturbed) LB (Large Bulk dist.) U (Undisturbed)

Checked and Approved by

[redacted]

J Sturges - Operations Manager
31/08/2022

Project Number:

GEO / 36112

Project Name:

SUMNERS POND, HORSHAM
LP3019

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BS EN ISO 17892-12 : 2018

SUMMARY OF LIQUID AND PLASTIC LIMIT TESTS

Location	Depth m	Sample Ref	Sample Type	Description	Water Content BS EN ISO 17892-1 : 2014 %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Percentage Passing 425µm %	Atterberg Classification	Test Type	Sample Condition
TP1	1.20		D	Yellowish brown and grey mottled silty CLAY.	17.3	63	25	38	100	CH	2	1
TP2	0.70		D	Orangish brown and grey mottled silty CLAY.	25.3	67	29	38	100	CH	2	1
TP3	1.70		D	Brown, grey and greyish brown mottled CLAY with rare fine to medium gravel.	28.0	59	24	35	98	CH	2	1
TP4	1.00		D	Yellowish brown mottled grey silty CLAY.	20.5	53	24	29	100	CH	2	1
TP8	1.20		D	Yellowish brown mottled grey silty CLAY.	21.8	51	24	27	100	CH	2	1
WS1	2.10		D	Greyish brown, grey and brown mottled silty CLAY with rare fine to medium gravel.	30.9	71	27	44	99	CV	2	1
WS2	1.75		D	Dark brown, grey and yellowish brown mottled silty CLAY with rare fine to medium gravel.	26.4	67	25	42	98	CH	2	1
WS4	1.00		D	Yellowish brown and grey mottled silty CLAY with rare fine gravel and rootlets.	20.5	61	23	38	99	CH	2	1
WS5	2.00		D	Yellowish brown mottled grey silty CLAY.	24.6	59	25	34	100	CH	2	1

Test Type:
1 - 1 point 80g / 30° fall cone method.
2 - 4 point 80g / 30° fall cone method.
3 - Non plastic determination.

Sample condition:
1 - As Received
2 - Air Dried
3 - Washed & Air Dried

Checked and Approved by:
[redacted]
J Sturges - Operations Manager
31/08/2022

Project Number:
GEO / 36112

Project Name:
SUMNERS POND, HORSHAM
LP3019

GEOLABS
UKAS TESTING 1982

BS1377 : Part 4 : Clause 7 : 1990

CALIFORNIA BEARING RATIO

Location:	TP1
Depth (m):	0.60
Sample Type:	B

Description:

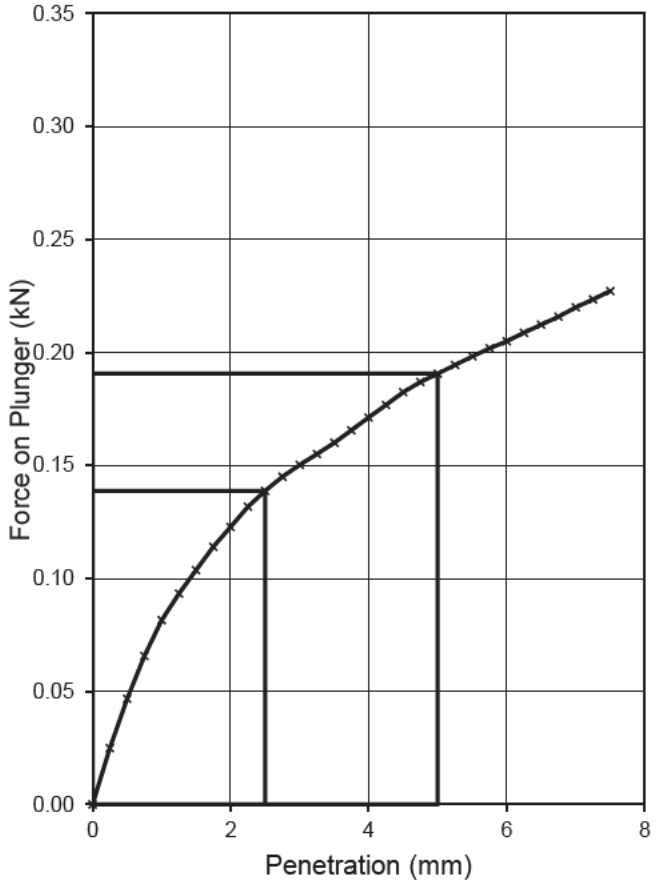
Brown, light brown and light grey mottled slightly sandy CLAY.

PREPARATION DETAILS

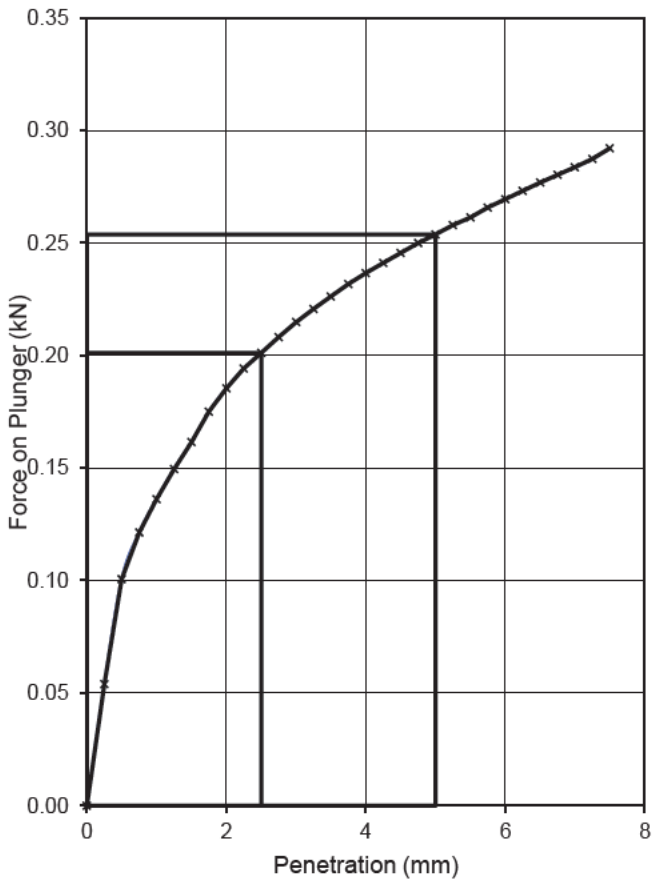
The specimen was soaked for 4 days, after which swelling equilibrium had been reached with 2.5 % vertical swell.
The specimen was prepared at as received moisture content of 19%
The specimen was prepared by dynamic compaction using a 2.5 kg rammer
Soaked specimen bulk density 1.89 Mg/m³ (1.77 Mg/m³ before soaking)
Soaked specimen dry density 1.44 Mg/m³ (1.49 Mg/m³ before soaking)
0.0 % of the sample was retained on a 20mm sieve

Test Details	Top	Base
Surcharge	8.0 kg	8.0 kg
Seating load	10 N	10 N
Water content	31 %	31 %
CBR Value	1.1 %	1.5 %

Top of Specimen



Base of Specimen



Checked and Approved by:

[redacted]

J Sturges - Operations Manager
31/08/2022

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SUMNERS POND, HORSHAM
LP3019

GEOLABS

UKAS TESTING 1982

BS1377 : Part 4 : Clause 7 : 1990

CALIFORNIA BEARING RATIO

Location:	TP2
Depth (m):	0.60
Sample Type:	B

Description:

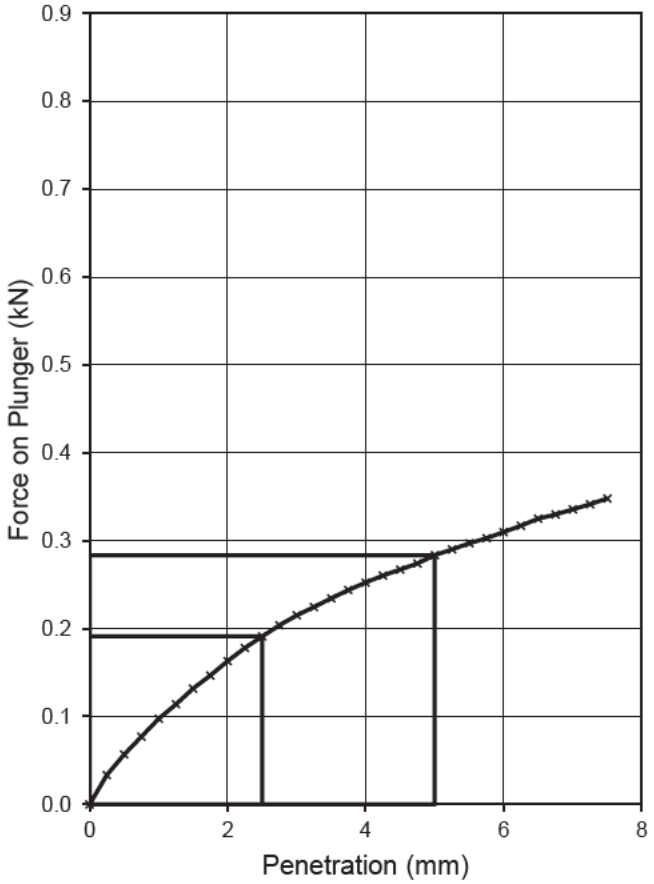
Brown mottled grey slightly sandy CLAY.

PREPARATION DETAILS

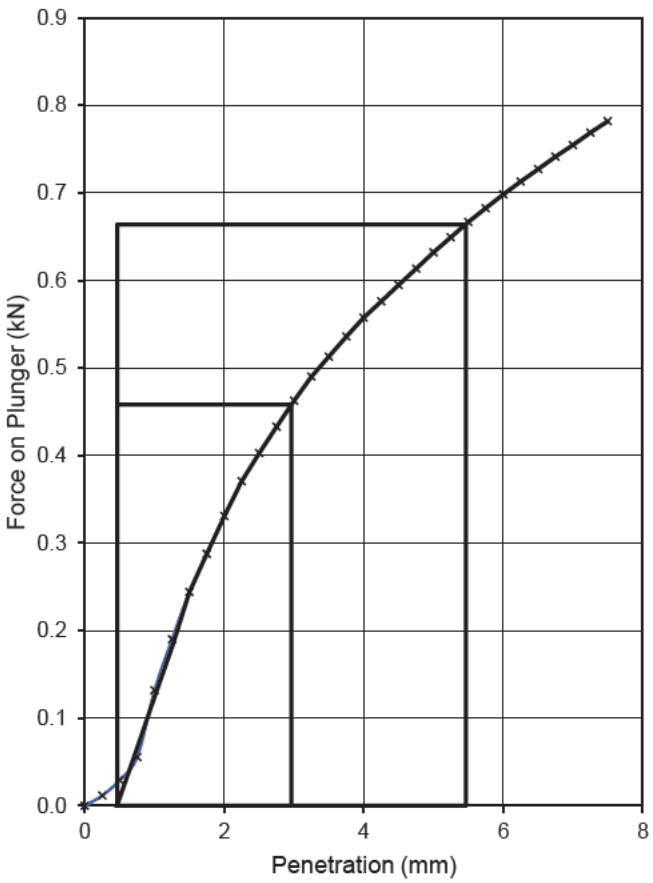
The specimen was soaked for 4 days, after which swelling equilibrium had been reached with 3.2 % vertical swell.
The specimen was prepared at as received moisture content of 21%
The specimen was prepared by dynamic compaction using a 2.5 kg rammer
Soaked specimen bulk density 1.89 Mg/m³ (1.83 Mg/m³ before soaking)
Soaked specimen dry density 1.46 Mg/m³ (1.51 Mg/m³ before soaking)
0.0 % of the sample was retained on a 20mm sieve

Test Details	Top	Base
Surcharge	8.0 kg	8.0 kg
Seating load	10 N	10 N
Water content	31 %	29 %
CBR Value	1.4 %	3.5 %

Top of Specimen



Base of Specimen



Checked and Approved by:

J Sturges - Operations Manager
31/08/2022

Project Number:

GEO / 36112

Project Name:

SUMNERS POND, HORSHAM
LP3019

GEOLABS

UKAS TESTING 1982

BS1377 : Part 4 : Clause 7 : 1990

CALIFORNIA BEARING RATIO

Location:	TP3
Depth (m):	1.00
Sample Type:	B

Description:

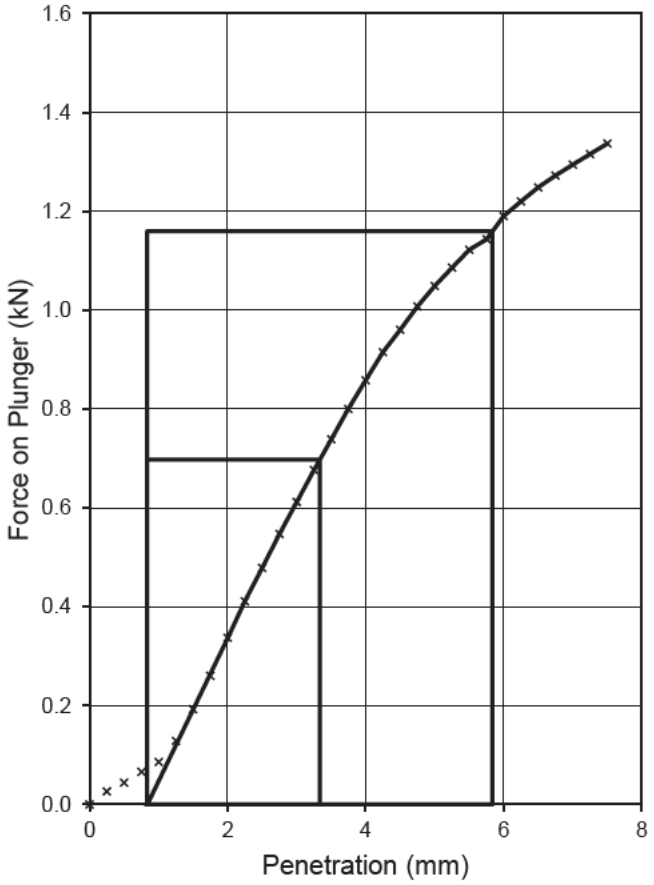
Brown mottled grey sandy gravelly CLAY with rare brick fragments.

PREPARATION DETAILS

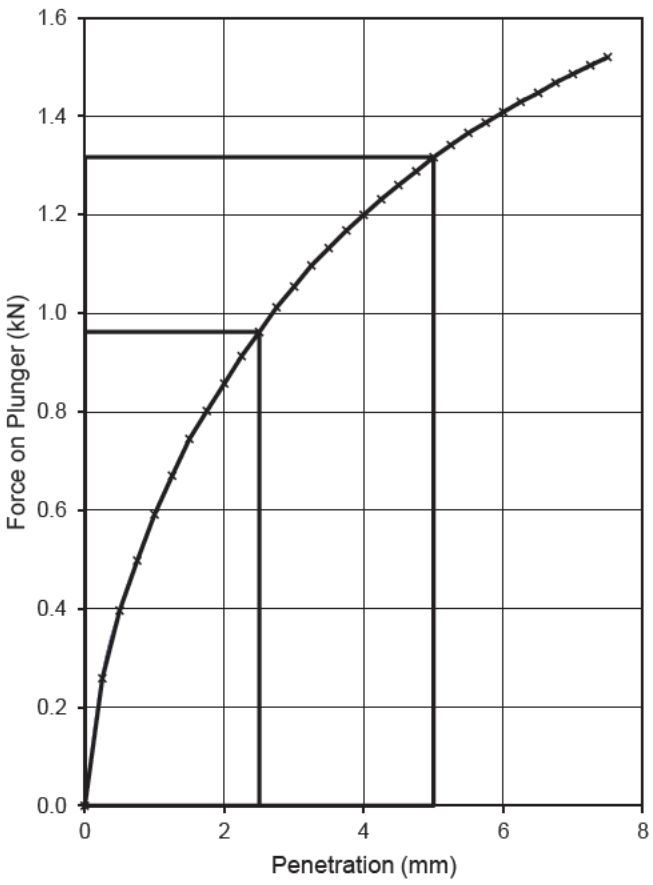
The specimen was soaked for 4 days, after which swelling equilibrium had been reached with 1.0 % vertical swell.
The specimen was prepared at as received moisture content of 26%
The specimen was prepared by dynamic compaction using a 2.5 kg rammer
Soaked specimen bulk density 1.92 Mg/m³ (1.90 Mg/m³ before soaking)
Soaked specimen dry density 1.49 Mg/m³ (1.51 Mg/m³ before soaking)
4.1 % of the sample was retained on a 20mm sieve

Test Details	Top	Base
Surcharge	8.0 kg	8.0 kg
Seating load	50 N	50 N
Water content	29 %	28 %
CBR Value	5.8 %	7.3 %

Top of Specimen



Base of Specimen



Checked and Approved by:

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J Sturges - Operations Manager
31/08/2022

Project Number:

GEO / 36112

Project Name:

SUMNERS POND, HORSHAM
LP3019

GEOLABS

UKAS TESTING 1982

BS1377 : Part 4 : Clause 7 : 1990

CALIFORNIA BEARING RATIO

Location:	TP8
Depth (m):	0.80
Sample Type:	D

Description:

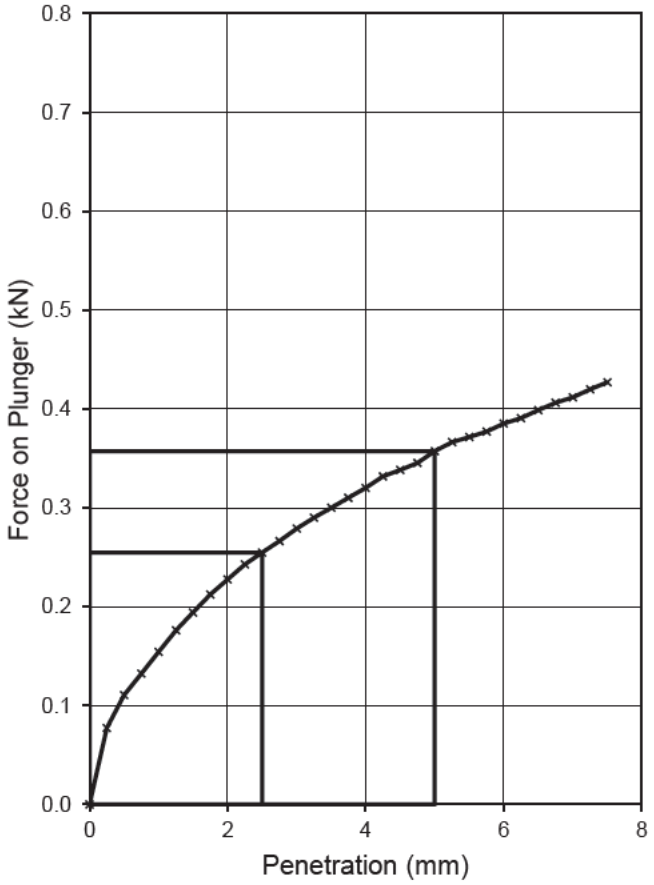
Light brown, brown and light grey mottled slightly sandy silty CLAY with rare fine to medium gravel.

PREPARATION DETAILS

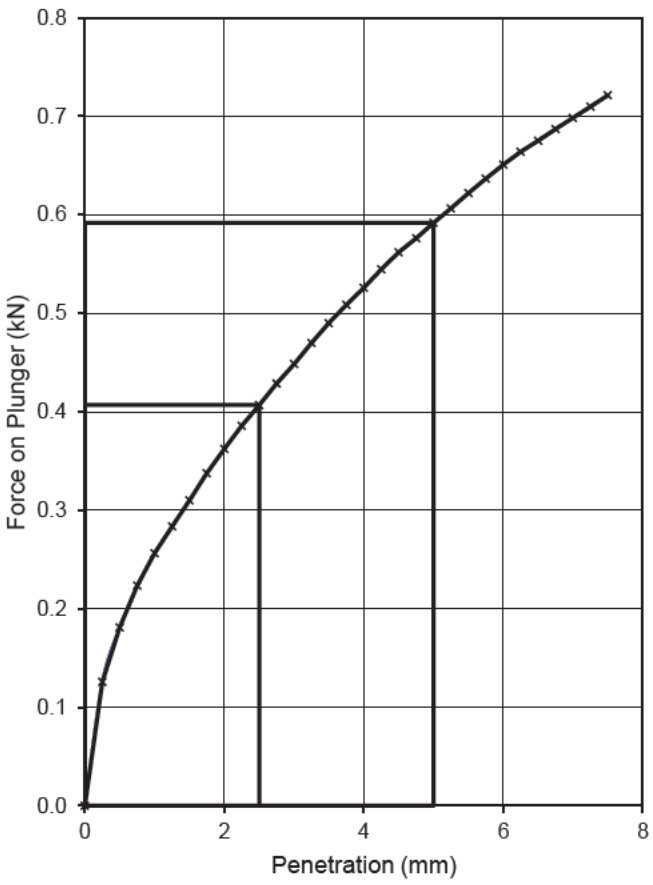
The specimen was soaked for 4 days, after which swelling equilibrium had been reached with 3.2 % vertical swell.
The specimen was prepared at as received moisture content of 22%
The specimen was prepared by dynamic compaction using a 2.5 kg rammer
Soaked specimen bulk density 1.91 Mg/m³ (1.86 Mg/m³ before soaking)
Soaked specimen dry density 1.47 Mg/m³ (1.53 Mg/m³ before soaking)
0.0 % of the sample was retained on a 20mm sieve

Test Details	Top	Base
Surcharge	8.0 kg	8.0 kg
Seating load	10 N	10 N
Water content	30 %	29 %
CBR Value	1.9 %	3.1 %

Top of Specimen



Base of Specimen



Checked and Approved by:

[redacted]

J Sturges - Operations Manager
31/08/2022

Project Number:

GEO / 36112

Project Name:

SUMNERS POND, HORSHAM
LP3019

GEOLABS

UKAS TESTING 1982

1240 - Chemical Test Summary - 36112.XLSM

SUMMARY OF CHEMICAL TESTS ON SOIL

Location	Depth m	Sample Ref	Sample Type	pH Value	Total Acid Soluble Sulphate as SO4 %	Water Soluble Sulphate as SO4 2:1 Water:Soil Extract g/l	Total Sulphur %	Water Soluble Chloride g/l	Water Soluble Nitrate g/l	Magnesium g/l	Organic Content %	Mass Loss on Ignition %	Carbonate Content %
TP1	1.50		D	7.5	1.8	1.1	7.4	-	-	-	-	-	-
TP3	2.70		D	7.5	0.13	0.33	0.064	-	-	-	-	-	-
WS1	4.00		D	7.4	0.012	0.031	0.075	-	-	-	-	-	-
WS2	1.50		D	7.6	0.51	0.36	5.7	-	-	-	-	-	-
WS5	5.00		D	6.9	0.40	0.20	0.27	-	-	-	-	-	-

Tested by Chemtest Ltd : MCERTS / UKAS No 2183

Checked and Approved by:

[redacted]

J Sturges - Operations Manager
31/08/2022

Project Number:

GEO / 36112

Project Name:

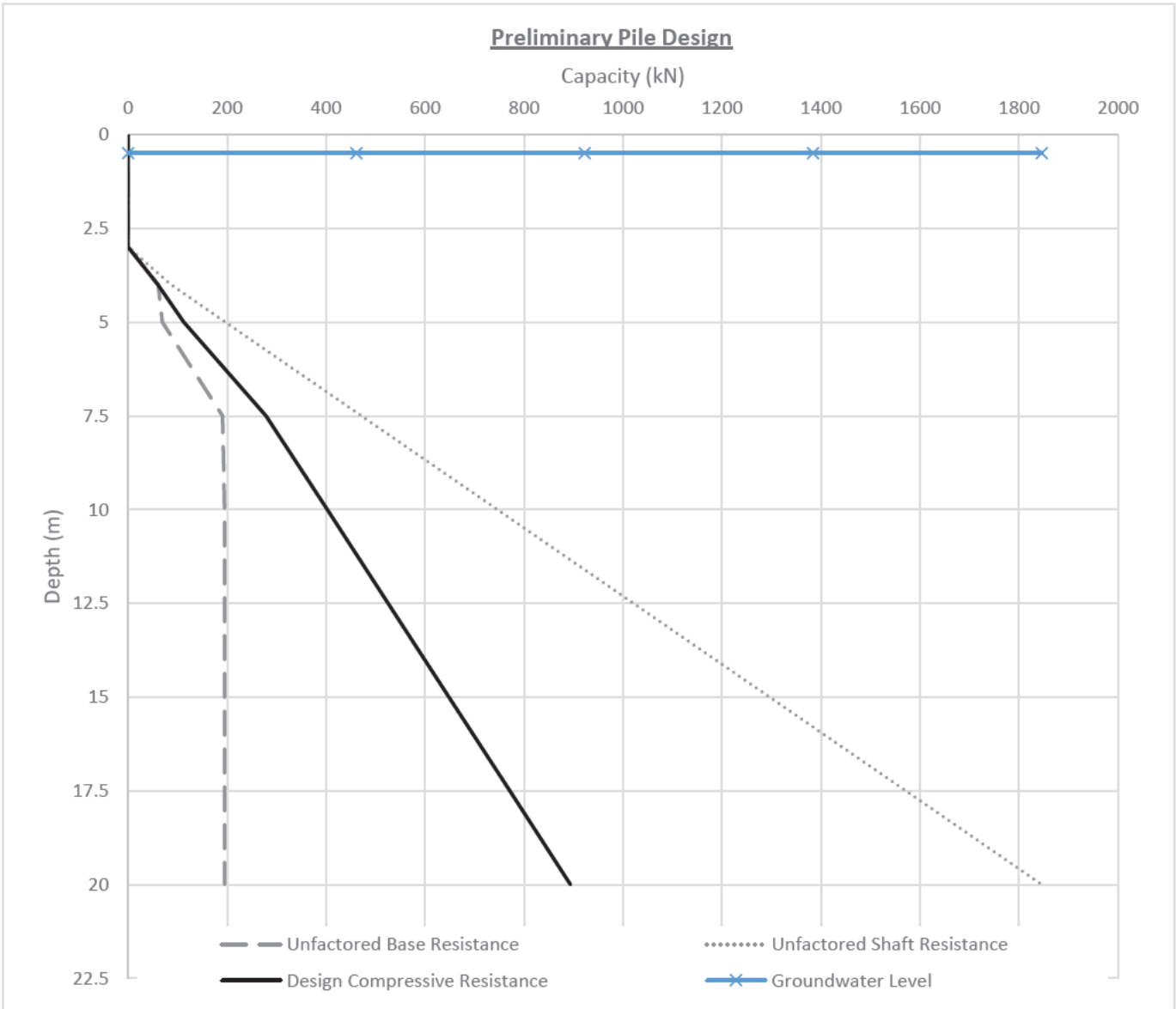
SUMNERS POND, HORSHAM
LP3019

GEOLABS

PILING REPORT SUMMARY TABLE

Soil Type:	CFA Pile		Factors of Safety - EC7; Design Approach 1/Combination 2	
COHESIVE	0.35	diameter (m)	*Shaft FoS - γRd x γs*	2.24
			Base FoS - γRd x γb	2.8
			Lumped FoS	2.5

Pile Length	Unfactored Shaft Resistance, kN	Unfactored Base Resistance, kN	Design Compressive Resistance, kN	Allowable Load using lumped FoS, kN
m	Q_s	Q_b	$R_{sd} + R_{bd}$	$(Q_b+Q_s)/FoS$
5	*197*	*69*	*112*	*106*
7.5	*471*	*190*	*278*	*265*
10	*746*	*195*	*403*	*376*
12.5	*1021*	*195*	*525*	*486*



Project Number:	LP3444
Project Name:	Sumners Pond
Client:	Sigma Homes
Date:	07/09/2023

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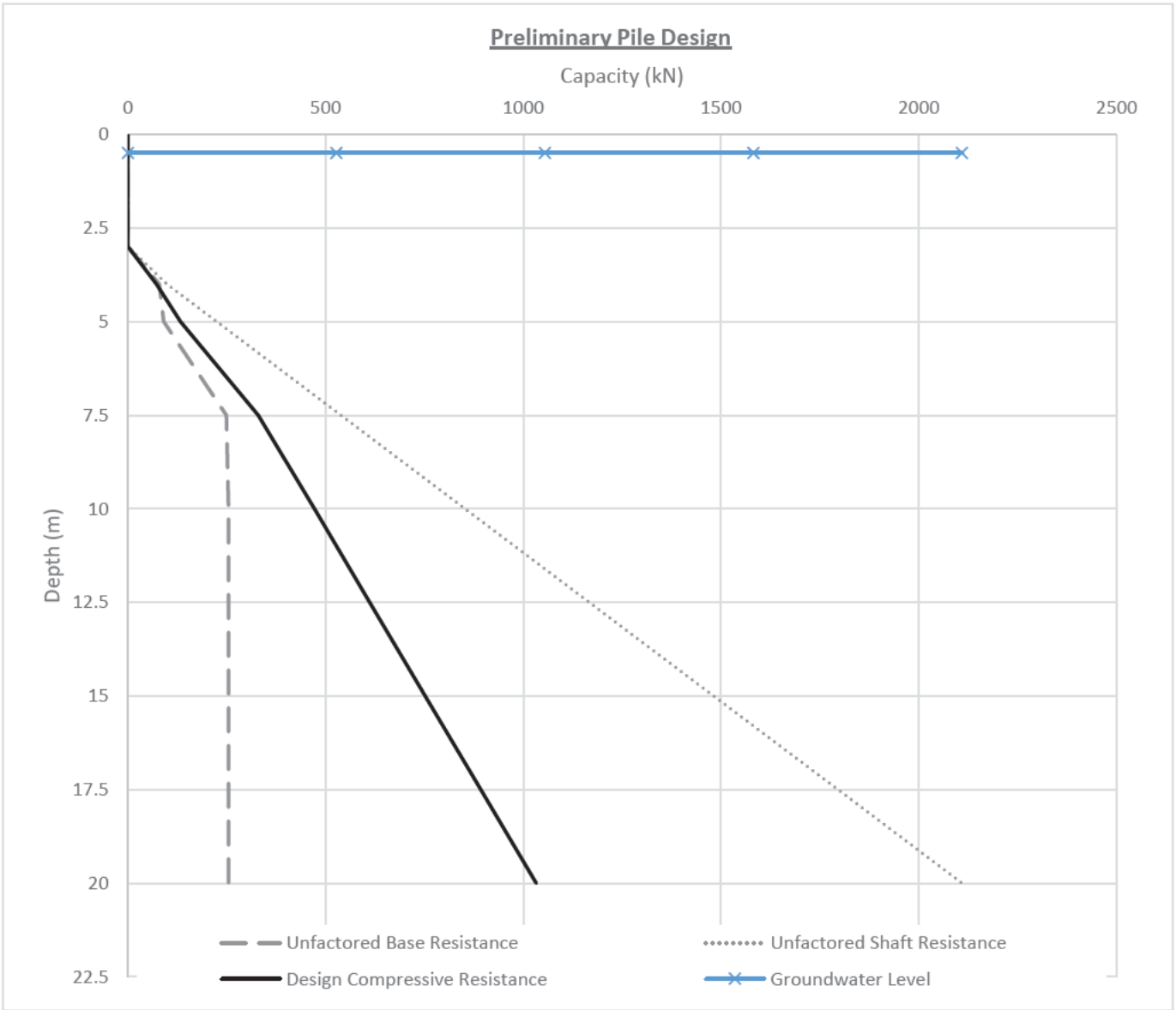
PILING REPORT SUMMARY TABLE

Soil Type:	CFA Pile		Factors of Safety - EC7; Design Approach 1/Combination 2	
COHESIVE	0.40	diameter (m)	*Shaft FoS - γRd x γs*	2.24
			Base FoS - γRd x γb	2.8
			Lumped FoS	2.5

Pile Length	Unfactored Shaft Resistance, kN	Unfactored Base Resistance, kN	Design Compressive Resistance, kN	Allowable Load using lumped FoS, kN
m	Q_s	Q_b	$R_{sd} + R_{bd}$	$(Q_b+Q_s)/FoS$
5	*225*	*90*	*133*	*126*
7.5	*539*	*249*	*329*	*315*
10	*853*	*254*	*472*	*443*
12.5	*1167*	*254*	*612*	*569*



Project Number:	LP3444
Project Name:	Sumners Pond
Client:	Sigma Homes
Date:	07/09/2023

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APPENDIX G – Analytical Summary and Quantitative Risk Assessment Tables

Analytical Summary and Quantitative Risk Assessment Tables

LP3444 Sumners Pond								
Lab Sample ID					23/08013/1	23/08013/2	23/08013/3	23/08013/4
Client Sample No					1	1	1	1
Client Sample ID					HP1	HP2	HP3	HP1 (Pos ASB)
Depth to Top					0.4	0.3	0.15	-
Depth to Bottom								
Date Sampled					08-Aug-23	08-Aug-23	08-Aug-23	08-Aug-23
Sample Type					Soil - ES	Soil - ES	Soil - ES	Solid - Bulk
Sample Matrix Code	**Units**	**Limit of Detection**	**Method**	**GAC - Resi w HGP (1%)**	6A	4AB	5ABE	
% Stones >10mm	% w/w	0.1	A-T-044	-	<0.1	9.8	10.6	
pH	pH	0.01	A-T-031s	-	7.49	8.58	9.63	
Total Organic Carbon	% w/w	0.03	A-T-032s	-	0.66	2.54	2.69	
SOM (TOC*1.72)				-	**1.14**	**4.37**	**4.63**	
Arsenic	mg/kg	1	A-T-024s	37	14	4	5	
Cadmium	mg/kg	0.5	A-T-024s	22	0.7	<0.5	<0.5	
Copper	mg/kg	1	A-T-024s	2400	11	10	20	
Chromium	mg/kg	1	A-T-024s	910	26	19	25	
Chromium (hexavalent)	mg/kg	1	A-T-040s	21	<1	<1	<1	
Lead	mg/kg	1	A-T-024s	200	19	23	39	
Mercury	mg/kg	0.17	A-T-024s	40	<0.17	1.55	0.85	
Nickel	mg/kg	1	A-T-024s	130	13	14	18	
Selenium	mg/kg	1	A-T-024s	250	1	<1	<1	
Zinc	mg/kg	5	A-T-024s	3700	53	32	49	
Asbestos in Soil (inc. matrix) ^								
Asbestos in soil			A-T-045	-	NAD	NAD	NAD	
Asbestos ACM - Suitable for Water Absorption Test?			A-T-045	-	N/A	N/A	N/A	
Bulk Fibre ID (inc. matrix)								
Bulk Fibre Identification			A-T-045	-				**Chrysotile**
Bulk Fibre Identification Matrix (visual)			A-T-045	-				**Cement**
Bulk Fibre Identification - Suitable for Water Absorption Test?			A-T-045	-				**Yes**
PAH-16MS								
Acenaphthene	mg/kg	0.01	A-T-019s	210	<0.01	0.02	0.12	
Acenaphthylene	mg/kg	0.01	A-T-019s	170	<0.01	0.07	0.24	
Anthracene	mg/kg	0.02	A-T-019s	2400	0.03	0.16	0.65	
Benzo(a)anthracene	mg/kg	0.04	A-T-019s	7.2	0.11	0.65	3.84	
Benzo(a)pyrene	**mg/kg**	**0.04**	**A-T-019s**	**5**	**0.09**	**0.85**	**4.87**	
Benzo(b)fluoranthene	mg/kg	0.05	A-T-019s	2.6	0.1	0.87	**5.63**	
Benzo(ghi)perylene	mg/kg	0.05	A-T-019s	320	<0.05	0.56	4	
Benzo(k)fluoranthene	mg/kg	0.07	A-T-019s	77	<0.07	0.34	1.89	
Chrysene	mg/kg	0.06	A-T-019s	15	0.14	0.76	3.74	
Dibenzo(ah)anthracene	mg/kg	0.04	A-T-019s	0.24	<0.04	0.09	**0.57**	
Fluoranthene	mg/kg	0.08	A-T-019s	280	0.26	1.09	5.53	
Fluorene	mg/kg	0.01	A-T-019s	170	0.01	0.02	0.13	
Indeno(123-cd)pyrene	mg/kg	0.03	A-T-019s	27	0.06	0.63	4.23	
Naphthalene	**mg/kg**	**0.03**	**A-T-019s**	**2.3**	**<0.03**	**<0.03**	**<0.03**	
Phenanthrene	mg/kg	0.03	A-T-019s	95	0.16	0.24	1.48	
Pyrene	mg/kg	0.07	A-T-019s	620	0.22	1.04	4.75	
Total PAH-16MS	mg/kg	0.01	A-T-019s	-	1.18	7.39	41.7	

APPENDIX H – Geoenvironmental Analytical Laboratory Certificates

Geoenvironmental
Analytical Laboratory
Certificates

Units 7 & 8 Sandpits Business Park
Mottram Road, Hyde, Cheshire, SK14 3AR

FINAL ANALYTICAL TEST REPORT
SUPPLEMENT TO TEST REPORT 23/08013/1

Amendments: Request for Additional Analysis

Envirolab Job Number: 23/08013
Issue Number: 2 **Date:** 21 August, 2023

Client:
RSK Environment Ltd (Leap Dorking)
Book House
Glebelands Centre,
Vincent Lane,
Dorking,
Surrey
RH4 3HW

Project Manager: Imogen Adshead
Project Name: Sumners Pond (LP3444)
Project Ref: 3750304
Order No: PO2139778
Date Samples Received: 10/08/23
Date Instructions Received: 10/08/23
Date Analysis Completed: 19/08/23

Approved by:

[redacted]

Gemma Berrisford
Deputy Client Services Supervisor

mCERTS
THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

Envirolab Job Number: 23/08013

Client Project Name: Sumners Pond (LP3444)

Client Project Ref: 3750304

Lab Sample ID	23/08013/1	23/08013/2	23/08013/3	23/08013/4				Units	Limit of Detection	Method ref
Client Sample No	1	1	1	1						
Client Sample ID	HP1	HP2	HP3	HP1 (Pos ASB)						
Depth to Top	0.4	0.3	0.15							
Depth To Bottom										
Date Sampled	08-Aug-23	08-Aug-23	08-Aug-23	08-Aug-23						
Sample Type	SOIL - ES	SOIL - ES	SOIL - ES	SOLID - BULK						
Sample Matrix Code	6A	4AB	5ABE							
% Stones >10mm$_A$	<0.1	9.8	10.6	-				% w/w	0.1	A-T-044
pH$_D$$^{M\#}$	7.49	8.58	9.63	-				pH	0.01	A-T-031s
Total Organic Carbon$_D$$^{M\#}$	0.66	2.54	2.69	-				% w/w	0.03	A-T-032s
Arsenic$_D$$^{M\#}$	14	4	5	-				mg/kg	1	A-T-024s
Cadmium$_D$$^{M\#}$	0.7	<0.5	<0.5	-				mg/kg	0.5	A-T-024s
Copper$_D$$^{M\#}$	11	10	20	-				mg/kg	1	A-T-024s
Chromium$_D$$^{M\#}$	26	19	25	-				mg/kg	1	A-T-024s
Chromium (hexavalent)$_D$	<1	<1	<1	-				mg/kg	1	A-T-040s
Lead$_D$$^{M\#}$	19	23	39	-				mg/kg	1	A-T-024s
Mercury$_D$	<0.17	1.55	0.85	-				mg/kg	0.17	A-T-024s
Nickel$_D$$^{M\#}$	13	14	18	-				mg/kg	1	A-T-024s
Selenium$_D$$^{M\#}$	1	<1	<1	-				mg/kg	1	A-T-024s
Zinc$_D$$^{M\#}$	53	32	49	-				mg/kg	5	A-T-024s

Envirolab Job Number: 23/08013

Client Project Name: Sumners Pond (LP3444)

Client Project Ref: 3750304

Lab Sample ID	23/08013/1	23/08013/2	23/08013/3	23/08013/4				Units	Limit of Detection	Method ref
Client Sample No	1	1	1	1						
Client Sample ID	HP1	HP2	HP3	HP1 (Pos ASB)						
Depth to Top	0.4	0.3	0.15							
Depth To Bottom										
Date Sampled	08-Aug-23	08-Aug-23	08-Aug-23	08-Aug-23						
Sample Type	SOIL - ES	SOIL - ES	SOIL - ES	SOLID - BULK						
Sample Matrix Code	6A	4AB	5ABE							
Asbestos in Soil (inc. matrix) ^										
Asbestos in soil$_D^{\#}$	NAD	NAD	NAD	-						A-T-045
Asbestos Matrix (visual)$_D$	-	-	-	-						A-T-045
Asbestos Matrix (microscope)$_D$	-	-	-	-						A-T-045
Asbestos ACM - Suitable for Water Absorption Test?$_D$	N/A	N/A	N/A	-						A-T-045
Bulk Fibre ID (inc. matrix)										
Bulk Fibre Identification$_D^{\#}$	-	-	-	Chrysotile						A-T-045
Bulk Fibre Identification Matrix (visual)$_D$	-	-	-	Cement						A-T-045
Bulk Fibre Identification - Suitable for Water Absorption Test?$_D$	-	-	-	Yes						A-T-045

Envirolab Job Number: 23/08013

Client Project Name: Sumners Pond (LP3444)

Client Project Ref: 3750304

Lab Sample ID	23/08013/1	23/08013/2	23/08013/3	23/08013/4				Units	Limit of Detection	Method ref
Client Sample No	1	1	1	1						
Client Sample ID	HP1	HP2	HP3	HP1 (Pos ASB)						
Depth to Top	0.4	0.3	0.15							
Depth To Bottom										
Date Sampled	08-Aug-23	08-Aug-23	08-Aug-23	08-Aug-23						
Sample Type	SOIL - ES	SOIL - ES	SOIL - ES	SOLID - BULK						
Sample Matrix Code	6A	4AB	5ABE							
PAH-16MS										
Acenaphthene$_A^{M\#}$	<0.01	0.02	0.12	-				mg/kg	0.01	A-T-019s
Acenaphthylene$_A^{M\#}$	<0.01	0.07	0.24	-				mg/kg	0.01	A-T-019s
Anthracene$_A^{M\#}$	0.03	0.16	0.65	-				mg/kg	0.02	A-T-019s
Benzo(a)anthracene$_A^{M\#}$	0.11	0.65	3.84	-				mg/kg	0.04	A-T-019s
Benzo(a)pyrene$_A^{M\#}$	0.09	0.85	4.87	-				mg/kg	0.04	A-T-019s
Benzo(b)fluoranthene$_A^{M\#}$	0.10	0.87	5.63	-				mg/kg	0.05	A-T-019s
Benzo(ghi)perylene$_A^{M\#}$	<0.05	0.56	4.00	-				mg/kg	0.05	A-T-019s
Benzo(k)fluoranthene$_A^{M\#}$	<0.07	0.34	1.89	-				mg/kg	0.07	A-T-019s
Chrysene$_A^{M\#}$	0.14	0.76	3.74	-				mg/kg	0.06	A-T-019s
Dibenzo(ah)anthracene$_A$	<0.04	0.09	0.57	-				mg/kg	0.04	A-T-019s
Fluoranthene$_A^{M\#}$	0.26	1.09	5.53	-				mg/kg	0.08	A-T-019s
Fluorene$_A^{M\#}$	0.01	0.02	0.13	-				mg/kg	0.01	A-T-019s
Indeno(123-cd)pyrene$_A^{M\#}$	0.06	0.63	4.23	-				mg/kg	0.03	A-T-019s
Naphthalene $_A^{M\#}$	<0.03	<0.03	<0.03	-				mg/kg	0.03	A-T-019s
Phenanthrene$_A^{M\#}$	0.16	0.24	1.48	-				mg/kg	0.03	A-T-019s
Pyrene$_A^{M\#}$	0.22	1.04	4.75	-				mg/kg	0.07	A-T-019s
Total PAH-16MS$_A$	1.18	7.39	41.7	-				mg/kg	0.01	A-T-019s

Report Notes

General
This report shall not be reproduced, except in full, without written approval from Envirolab.
The results reported herein relate only to the material supplied to the laboratory.
The residue of any samples contained within this report, and any received within the same delivery, will be disposed of **six weeks** after the initial scheduling. For samples tested for Asbestos we will retain a portion of the dried sample for a minimum of **six months** after the initial Asbestos testing is completed.
Analytical results reflect the quality of the sample at the time of analysis only.
Opinions and Interpretations expressed are outside our scope of accreditation.
The client Sample No, Client Sample ID, Depth to top, Depth to Bottom and Date Sampled are all provided by the client.
A deviating sample report is appended and will indicate if samples or tests have been found to be deviating. Any test results affected may not be an accurate record of the concentration at the time of sampling and, as a result, may be invalid.

Key

Superscript "#"	Accredited to ISO 17025
Superscript "M"	Accredited to MCertS
Superscript "U"	Individual result not accredited
None of the above symbols	Analysis unaccredited
Subscript "A"	Analysis performed on as-received Sample
Subscript "D"	Analysis performed on the dried sample, crushed to pass 2mm sieve.
Subscript "^"	Analysis has dependant options against results. Details appear in the comments of your Sample receipt
IS	Insufficient Sample for analysis
US	Unsuitable Sample for analysis
NDP	No Determination Possible
NAD	No Asbestos Detected
N/A	Not applicable

Asbestos
Asbestos in soil analysis is performed on a dried aliquot of the submitted sample and cannot guarantee to identify asbestos if only present in small numbers as discrete fibres/fragments in the original sample.
Stones etc. are not removed from the sample prior to analysis
Quantification of asbestos is a 3 stage process including visual identification, hand picking and weighing, and fibre counting by sedimentation/phase contrast optical microscopy if required. If asbestos is identified as being present but is not in a form that is suitable for analysis by hand picking and weighing (normally if the asbestos is present as free fibres) quantification by sedimentation is performed. Where ACMs are found a percentage asbestos is assigned to each with reference to 'HSG264, Asbestos: The survey guide' and the calculated asbestos content is expressed as a percentage of the dried soil sample aliquot used.

Assigned Matrix Codes

1	SAND	6	CLAY/LOAM	A	Contains Stones
2	LOAM	7	OTHER	B	Contains Construction Rubble
3	CLAY	8	Asbestos Bulk (Only Asbestos ID accredited)	C	Contains visible hydrocarbons
4	LOAM/SAND	9	Incinerator Ash (some Metals accredited)	D	Contains glass / metal
5	SAND/CLAY			E	Contains roots / twigs
Note: 7,8,9 matrices are not covered by our ISO 17025 or MCertS accreditation, unless stated above.					

Soil Chemical Analysis:
All results are reported as dry weight (<40°C).
For samples with Matrix Codes 1 - 6 natural stones, brick and concrete fragments >10mm and any extraneous material (visible glass, metal or twigs) are removed and excluded from the sample prior to analysis and reported results corrected to a whole sample basis. This is reported as '% stones >10mm'.
For samples with Matrix Code 7 the whole sample is dried and crushed prior to analysis and this supersedes any "A" subscripts
All analysis is performed on the sample as received for soil samples which are positive for asbestos or the client has informed asbestos may be present and/or if they are from outside the European Union and this supersedes any "D" subscripts.

TPH by method A-T-007:
For waters, free and visible oils are excluded from the sample used for analysis, so the reported result represents the dissolved phase only.
Results "with Clean up" indicates samples cleaned up with Silica during extraction.

EPH CWG (method A-T-055) from TPH CWG:
EPH CWG results have humics mathematically subtracted through instrument calculation.
Where these humic substances have been identified in any IDs from "TPH CWG with clean up" please note that the concentration is **NOT** included in the quantified results but present in the ID for information.

Electrical Conductivity of water by method A-T-037:
Results greater than 12900µS/cm @ 25ºC / 11550µS/cm @ 20ºC fall outside the accreditation range and as such are unaccredited.

Please contact your client manager if you require any further information.

Envirolab Deviating Samples Report

Units 7&8 Sandpits Business Park, Mottram Road, Hyde, SK14 3AR
Tel. 0161 368 4921 email. ask@envlab.co.uk

Client: RSK Environment Ltd (Leap Dorking) , Book House, Glebelands Centre,, Vincent Lane, Dorking, Surrey , RH4 3HW

Project: Sumners Pond (LP3444)

Clients Project No: 3750304

Project No: 23/08013

Date Received: 10/08/2023 (am)

Cool Box Temperatures (°C): 19.3

NO DEVIATIONS IDENTIFIED with respect to sampling dates or containers received.

Note: If, at any point before reaching the laboratory, the temperature of the samples has breached those set in published standards, e.g. BS-EN 5667-3 (for water samples 5 ± 3°C), ISO 18400-105:2017, then the concentration of any affected analytes may differ from that at the time of sampling.

Envirolab Analysis Dates

Lab Sample ID	23/08013/1	23/08013/2	23/08013/3	23/08013/4
Client Sample No	1	1	1	1
Client Sample ID/Depth	HP1 0.4m	HP2 0.3m	HP3 0.15m	HP1 (Pos ASB)
Date Sampled	08/08/23	08/08/23	08/08/23	08/08/23
A-T-019s	15/08/2023	15/08/2023	17/08/2023	
A-T-024s	14/08/2023	14/08/2023	14/08/2023	
A-T-031s	14/08/2023	14/08/2023	14/08/2023	
A-T-032s	16/08/2023	16/08/2023	16/08/2023	
A-T-040s	15/08/2023	15/08/2023	15/08/2023	
A-T-044	15/08/2023	15/08/2023	15/08/2023	
A-T-045	19/08/2023	19/08/2023	19/08/2023	14/08/2023

The above dates are the analysis completion dates, please note that these are not necessarily the date that the analysis was weighed/extracted.

End of Report

RESULTS

maximum values:

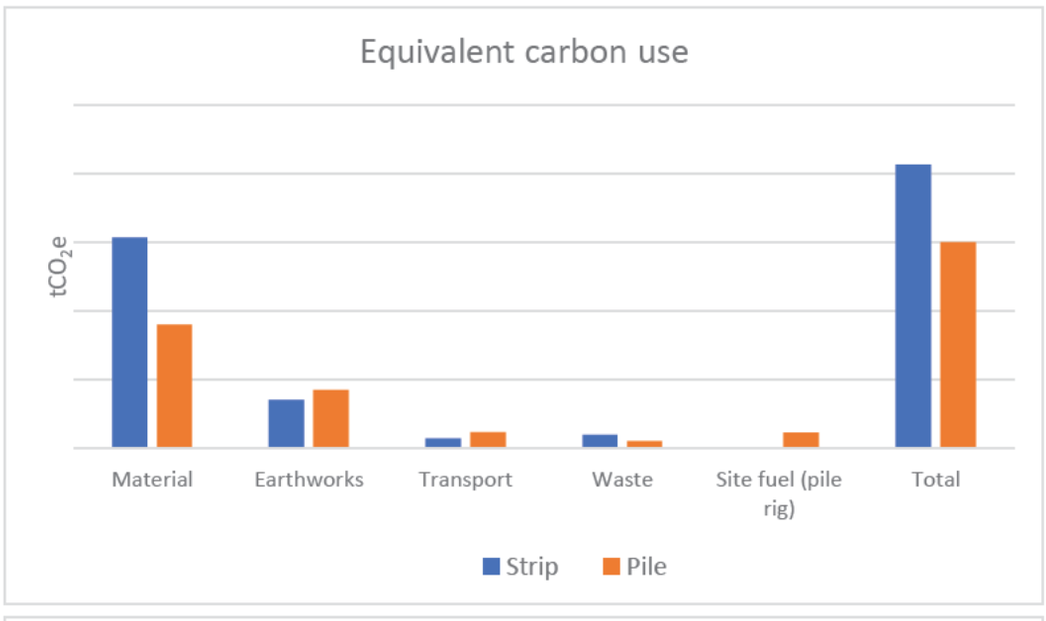
Strip

Width (m)	0.6
Depth (m)	2

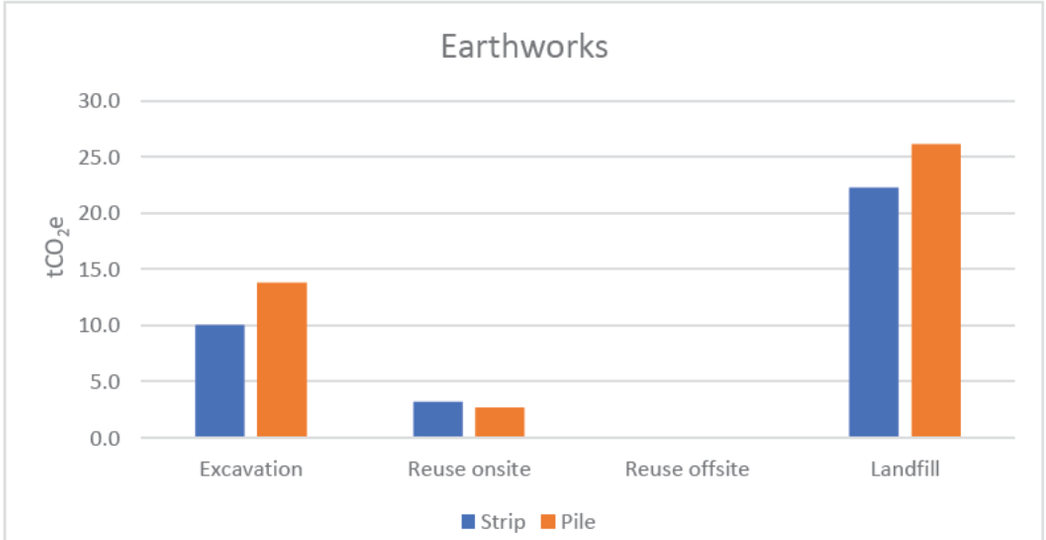
Pile

Diameter (m)	0.35
Length (m)	10

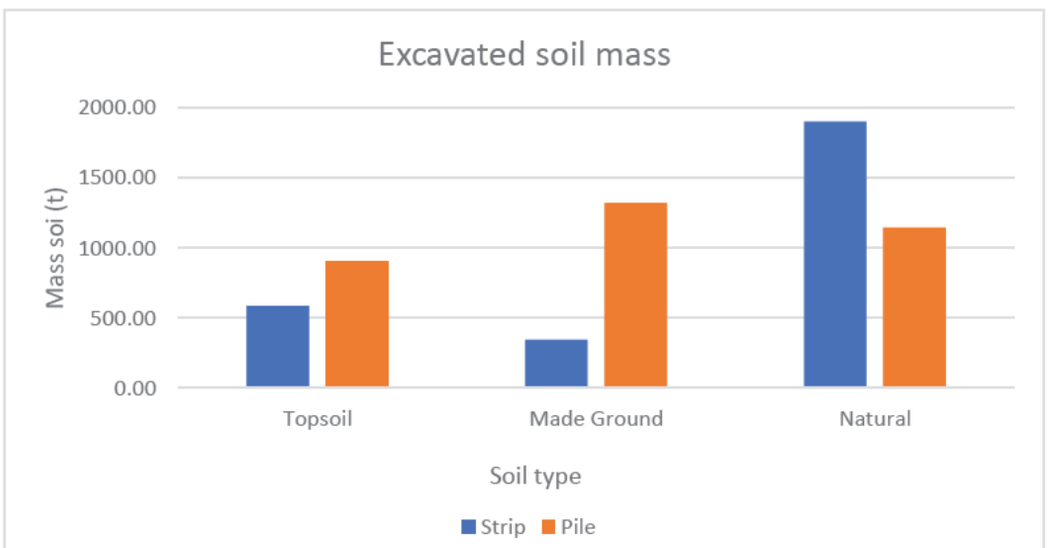
Activity	Strip	Pile
	tCO2e	tCO2e
Material	153.9	90.1
Earthworks	35.5	42.6
Transport	7.5	12.0
Waste	10.0	5.7
Site fuel (pile rig)	0.0	11.6
Total	206.9	150.3



	tCO2e	tCO2e
Excavation	10.0	13.8
Reuse onsite	3.2	2.7
Reuse offsite	0.0	0.0
Landfill	22.2	26.1

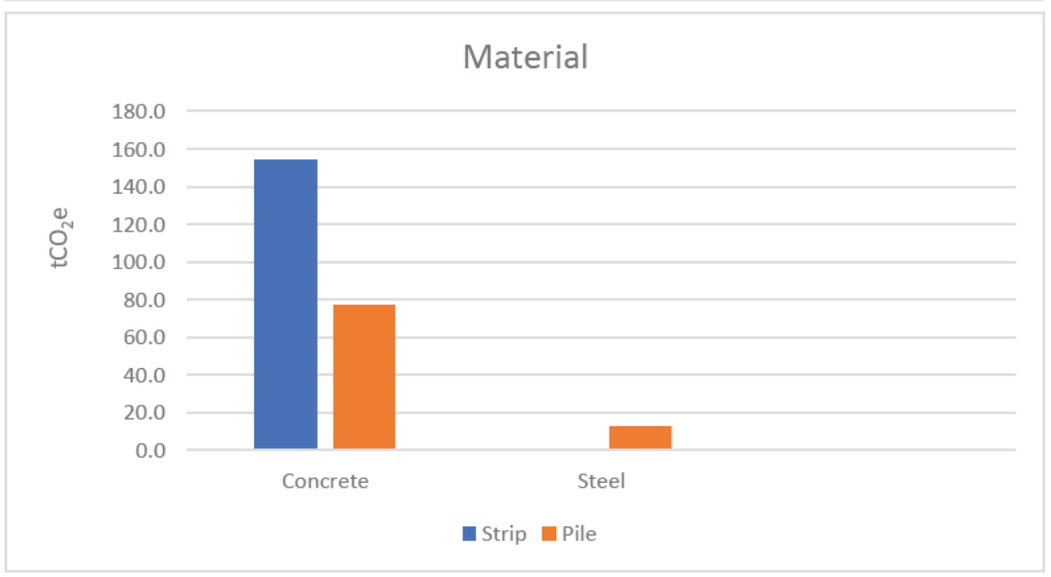


Mass material	Strip t	Pile t
Topsoil	585.30	903.90
Made Ground	342.20	1318.19
Natural	1897.13	1140.00



Volume material	Strip m3	Pile m3
Topsoil	292.65	451.95
Made Ground	171.10	659.09
Natural	903.39	515.71
Total	1367.14	1626.75

Carbon	Strip tCO2e	Pile tCO2e
Concrete	153.9	77.2
Steel	0.0	12.9



APPENDIX I – Approach to the Selection of Generic Assessment Criteria

Approach to the Selection of Generic Assessment Criteria

LEAP APPROACH TO THE SELECTION OF GENERIC ASSESSMENT CRITERIA

Chronic Risks to Human Health

Defra and the EA have published a limited number of Soil Guideline Values (SGVs)[17] that represent minimal chronic risk to human health. CL:AIRE has published a limited number of Category Four Screening Levels (C4SLs)[18] which represent a low but still strongly precautionary level of chronic risk to human health. Both the SGVs and C4SLs have both been derived for a Soil Organic Matter (SOM) content of 6%, which is not always representative of the low SOM that are encountered within Made Ground on brownfield sites.

Land Quality Management Ltd. (LQM) responded to the demand for a more comprehensive set of screening values and for a wider range of SOM by producing Suitable for Use Levels (S4ULs)[19] which are a hybrid of SGVs and C4SLs. The S4ULs have been endorsed by the Chartered Institute of Environmental Health (CIEH).

A smaller set of 35 GACs was published by CL:AIRE in association with AGS and EIC in 2010. These were based on the exposure scenarios that were used to derive the SGVs. These exposure scenarios have since been superseded, in part, by the publication of the C4SLs and the S4ULs. A second phase of C4SLs is currently under development.

LEAP uses C4SLs where they are available as generic assessment criteria to quantitatively assess the potential chronic risks to human health. Where C4SLs are not available, the S4ULs or CL:AIRE GACs are used. It is noted that S4ULs are not equivalent to C4SLs in all their exposure assumptions but are generally more conservative. To ensure the greatest possible consistency in LEAP's human health GQRAs, the physicochemical and toxicological input parameters that were used to derive the CL:AIRE GACs have been re-modelled using the exposure parameters selected by LQM to derive the S4ULs.

For the organic compounds benzene and benzo(a)pyrene) for which C4SLs are available for a SOM of 6% only, LEAP has calculated equivalent C4SLs for 1% and 2.5% SOM. SOM does not affect the inorganic contaminants.

[17] Environment Agency Science Report SC050021 series.

[18] CL:AIRE Final Project Report. 'SP1010 – Development of Category 4 Screening Levels for assessment of land affected by contamination'. CL:AIRE, December 2013

[19] 'The LQM/CIEH S4ULs for Human Health Risk Assessment', Nathaniel P et al, 2015. Copyright Land Quality Management Ltd, reproduced with permission: Publication Number S4UL3509.

In accordance with current Public Health England (PHE) guidance[20], LEAP carries out the assessment of PAHs using a surrogate marker approach, whereby the assessment of risk from benzo(a)pyrene also captures potential risks from other carcinogenic PAHs that may be present. The alternative S4ULs for PAHs using the Toxic Equivalent Factor (TEF) approach are not used because this approach is likely to under predict the true carcinogenicity of PAHs and is not advocated by PHE. The threshold PAHs have been assessed similarly, by using naphthalene as a marker compound due to its high volatility relative to other PAHs.

Total phenols are assessed by LEAP against the S4UL for phenol and total chromium is assessed against the S4UL for trivalent chromium.

LEAP does not consider the theoretical soil saturations in the evaluation of organic compounds and as such, some of the S4ULs for the less sensitive exposure scenarios are lower than their more sensitive equivalents.

Risks to human health from inhalation of vapours derived from groundwater are evaluated by LEAP using the SoBRA groundwater GAC_{gwvap}[21].

Acute Risks to Human Health

Cyanide has not been modelled using CLEA because it has high acute toxicity and CLEA is designed to evaluate chronic risks. Assuming an acute risk and based on a single dose of 3 g of soil, an assessment criterion of 33 $mgkg^{-1}$ free inorganic cyanide and 544 $mgkg^{-1}$ complex cyanide has been calculated by LEAP. At this stage LEAP has chosen to adopt a conservative screening value of 20 $mgkg^{-1}$ for total cyanide (essentially the sum of free and complex cyanides) to highlight any potential risks to human health.

Risks to Controlled Waters

RTM (2006)[22] requires receptor-specific Water Quality Standards (WQS) to be used to determine potentially unacceptable risks to water bodies in England and Wales. It requires appropriate criteria to be taken from a hierarchy of sources, where they are available as follows:

---

[20] HPA 'Contaminated Land Information Sheet. Risk Assessment Approaches for Polycyclic Aromatic Hydrocarbons (PAHs)'. Public Health England, 2017.

[21] Society of Brownfield Risk Assessment (SoBRA) 'Development of Generic Assessment Criteria for Assessing Vapour Risks to Human Health from Volatile Contaminants in Groundwater' Version 1.0. February 2017.

[22] EA 'Remedial Targets Methodology: Hydrogeological Risk Assessment for Land Contamination' 2006.

1. UK published values
2. EU published values
3. WHO published values

Drinking Water Resources

For groundwater and surface waters that are abstracted for potable supply LEAP uses:

- UK Drinking Water Quality Standards (DWS) from *The Water Supply (Water Quality) Regulations* 2016 (England).
- *The Water Supply (Water Quality) Regulations* 2010 (Wales) as amended in 2016.
- World Health Organisation *Guidelines for Drinking Water Quality*, Fourth Edition, Volume 1, (2011).

Where the groundwater is not abstracted for potable supply, this is a precautionary approach which protects the potential future exploitation of the groundwater.

Surface Water (Ecological) Receptors

For surface waters as ecological receptors, LEAP uses the Environmental Quality Standards (EQS) from The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015. There are no appropriate EU or WHO standards available.

Petroleum Hydrocarbons

There are no current UK standards available for petroleum hydrocarbons, either for groundwater or surface water receptors, so an initial assessment criterion of 10µg/l, based on the former target concentration for dissolved or emulsified hydrocarbons, is used to represent a conservative preliminary screening value for total petroleum hydrocarbons.

Where considered appropriate, LEAP then follows the guidance of CL:AIRE 2017[23] for the further assessment of the petroleum hydrocarbon fractions and derivatives. For a drinking water resource, the WHO guidelines are used. For surface waters as ecological receptors, proxy compounds are used to select appropriate EQS based on recommended indicator compounds, as follows:

- Aromatic EC5-EC7 – benzene
- Aromatic >EC7-EC8 – toluene

[23] CL:AIRE, 2017. 'Petroleum Hydrocarbons in Groundwater: Guidance on assessing petroleum hydrocarbons using existing hydrogeological risk assessment methodologies'. CL:AIRE, London. ISBN 978-1-905046-31-7.

- Aromatic >EC8-EC10 – ethylbenzene
- Aromatic >EC10-EC12 – naphthalene
- Aromatic >EC12-EC16 – no proxy
- Aromatic >EC16-EC21 – anthracene
- Aromatic >EC21-EC35 – benzo(a)pyrene

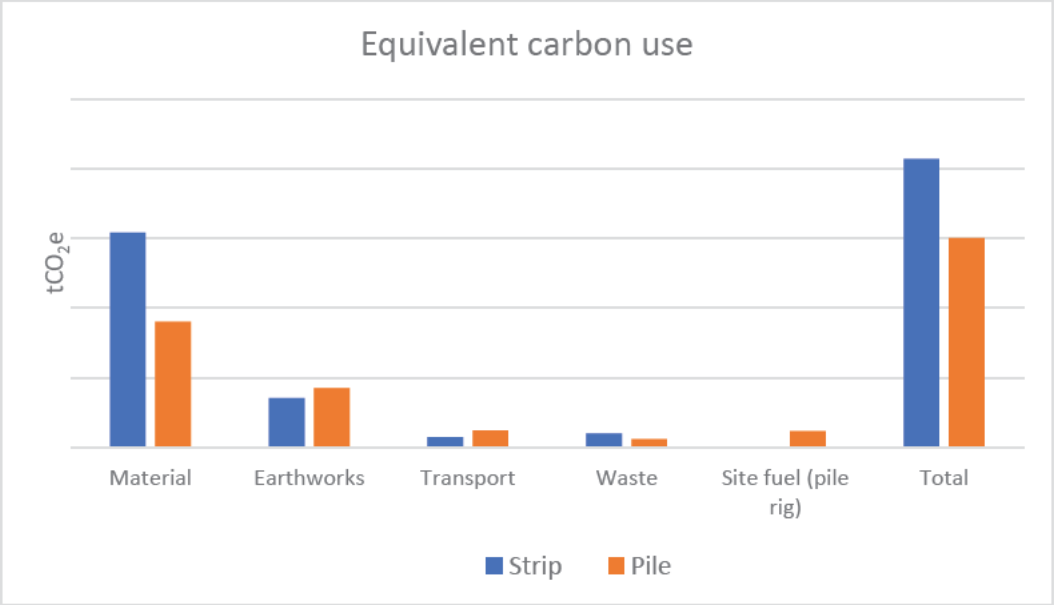
APPENDIX D – Exploratory Logs

Exploratory Logs

CReDiT - Carbon Assessment of Foundations

Site input parameters

Properties included	All properties in northern area
Geology	Topsoil to 0.2m, Made Ground to 0.55m, Natural Soil (clay to 3.3m, mudstone to 20m).
Concrete selected	Unreinforced, C30/37 UK average ready-mixed concrete (35% cement replacement) EPD [1]
Strip Foundation	0.6m wide, 2m deep unreinforced.
Pile Foundation	0.35m diameter, 10m deep. Pile mat depth 0.6m
Soil reuse	100% Topsoil and 70% clay



Depth of strip foundation with equivalent carbon footprint to pile option = **1..2m**

Significant carbon savings can be achieved using alternative concretes, e.g.
Unreinforced, C32/40 UK 50% GGBS cement replacement EPD
Unreinforced, C32/40 UK 75% GGBS cement replacement EPD