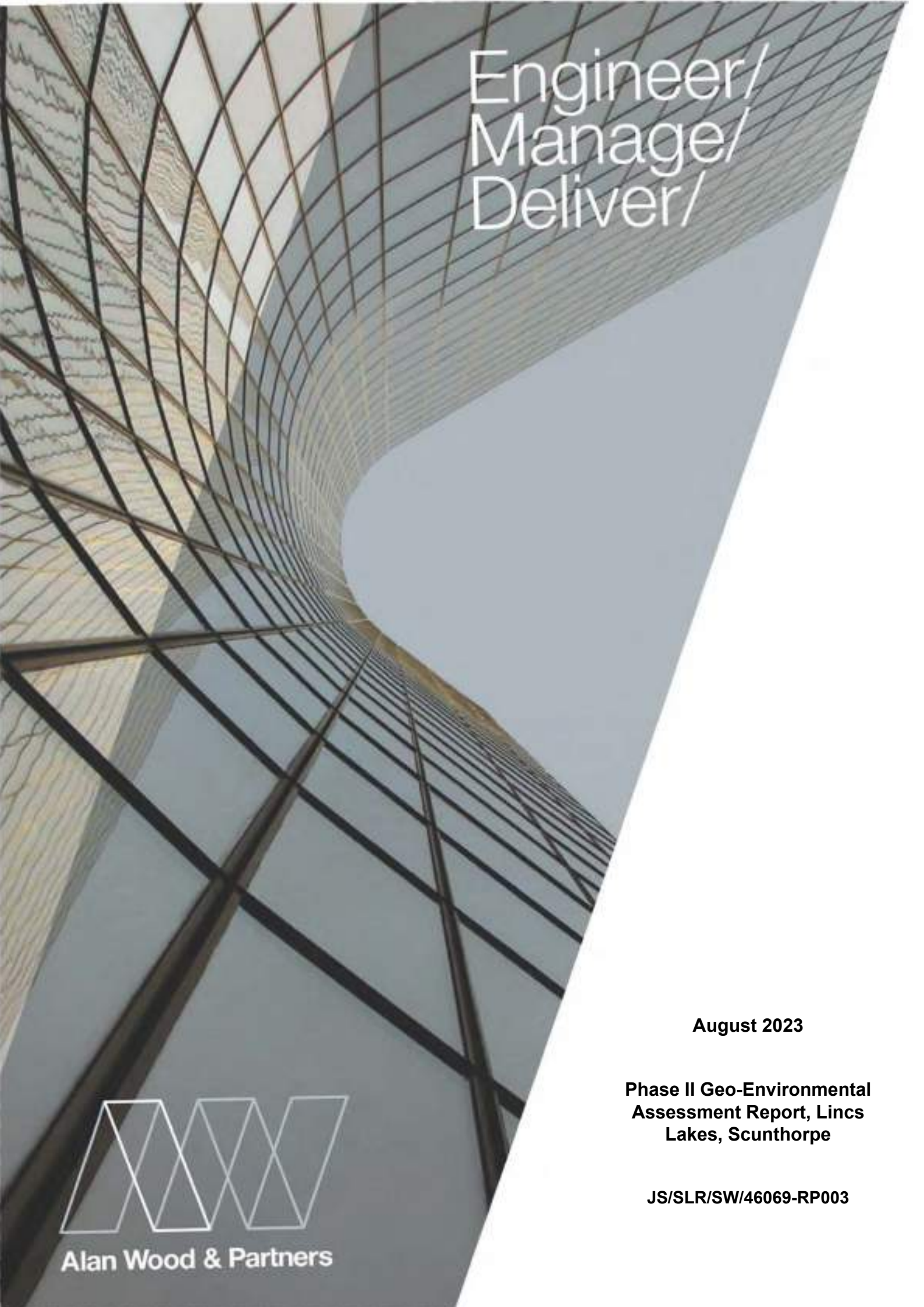




Engineer/
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August 2023

**Phase II Geo-Environmental
Assessment Report, Lincs
Lakes, Scunthorpe**

JS/SLR/SW/46069-RP003



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PHASE II GEO-ENVIRONMENTAL INVESTIGATION REPORT, LINCOLNSHIRE LAKES, SCUNTHORPE

for

Keepmoat Homes Ltd.

Project Reference: JMS/SLR/SW/46069-Rp003

Prepared by: **S. Williams** MGeol, FGS

Signed:



Date: 4th August 2023

Approved by: **S. L. Roberts** BEng (Hons) MSc CEnv MICE



Signed:

Date: 4th August 2023

Issue	Revision	Revised by	Approved by	Revised Date

For the avoidance of doubt, the parties confirm that these conditions of engagement shall not and the parties do not intend that these conditions of engagement shall confer on any party any rights to enforce any term of this Agreement pursuant of the Contracts (Rights of third Parties) Act 1999.

The Appointment of Alan Wood & Partners shall be governed by and construed in all respects in accordance with the laws of England & Wales and each party submits to the exclusive jurisdiction of the Courts of England & Wales

CONTENTS

EXECUTIVE SUMMARY

1	INTRODUCTION.....	7
1.1	Appointment	7
1.2	Development Proposals	7
1.3	Report Status	7
1.4	Objectives of the Investigation.....	8
1.5	Site Works	8
1.6	Limitations of Study	8
2	SITE DETAILS AND DESCRIPTION.....	11
2.1	Introduction.....	11
2.2	Site Location & Description	11
3	PHASE I GEO-ENVIRONMENTAL ASSESSMENT.....	13
3.1	Anticipated Geology, Hydrogeology & Mining	13
3.2	Environmental Records	14
3.3	Historical Land Use	15
3.4	Anticipated Ground Conditions.....	15
3.5	Preliminary Conceptual Site Model	16
4	GROUND INVESTIGATION FIELDWORK.....	24
4.1	Introduction.....	24
4.2	Site Works	24
4.3	Geotechnical Investigation	25
4.4	Environmental Investigation	26
5	RESULTS OF INVESTIGATION.....	28
5.1	Ground Conditions Encountered	28
5.2	Visual & Olfactory Evidence of Contamination	30
5.3	Geotechnical Testing & Material Properties	30
5.4	Contamination and Performance of Building Materials (Cementitious Products).....	33
5.5	Chemical Testing.....	33
6	GEOTECHNICAL ASSESSMENT	35
6.1	Mining Risk.....	35
6.2	Foundations.....	35
6.3	Floor Slabs	35
6.4	Precautions Near Trees.....	35
6.5	Drainage and Soakaways.....	35
6.6	Roads and Car Parks	35
6.7	Ground Stability	36
6.8	Excavations	36
6.9	Sulphate Attack and Aggressive Ground Conditions.....	36
6.10	Earthworks Suitability	37
7	ENVIRONMENTAL ASSESSMENT	38

7.1	Guidance for Analytical Results - Assessment Criteria.....	38
7.2	Human Health Receptors	39
7.3	Controlled Waters Receptors	40
7.4	Ecological Receptors.....	40
7.5	Utilities.....	40
7.6	Potable Water Supplies	40
7.7	Refined Conceptual Site Model	40
7.8	Summary of Identified Contaminant Linkages	43
8	CONCLUSIONS AND RECOMMENDATIONS.....	45
8.1	General.....	45
8.2	Soil Contamination - Risk Evaluation.....	45
8.3	Hazardous Ground Gases.....	45
8.4	Outline Remediation Requirements.....	45
8.5	Disposal of Soils	46
8.6	Further Work	46
9	REGULATORY APPROVAL	47
10	INFORMATION SOURCES	48

TABLES

Table 3-1 - Geological Information	13
Table 3-2 - Environmental Data.....	14
Table 3-3 - Summary of Potential Contaminant Sources.....	18
Table 3-4 - Summary of Potential Receptors.....	18
Table 3-5 - Summary of Plausible Pathways.....	19
Table 3-6 - Risk Categories	21
Table 3-7 - Summary of Phase I Conceptual Site Model & Risk Assessment	22
Table 5-1 - Summary of Ground Conditions (Trial pits)	28
Table 5-2 Summary of Ground Conditions (Windowless Sampler Boreholes)	28
Table 5-3 Summary of Ground Conditions (Cable Percussive Boreholes)	29
Table 5-4 Summary of Shear Box Testing.....	31
Table 5-5 Summary of <i>In-Situ</i> Standard Penetration Test (SPT) Results (Windowless Sampler Boreholes).....	31
Table 5-6 Summary of In-Situ Standard Penetration Test (SPT) Results (Cable Percussive Boreholes).....	32
Table 5-7 Plasticity Index Test Results.....	32
Table 5-8 Summary of Total Soil Concentrations	34
Table 5-9 Summary of Chemical Test Results (PAH).....	34
Table 7-1 - Summary of Revised Conceptual Site Model & Risk Assessment	44

FIGURES

46069 / 001	SITE LOCATION PLAN
	GROUND INVESTIGATION LOCATION PLAN

APPENDICES

APPENDIX A: GROUND INVESTIGATION LOGS

APPENDIX B: LABORATORY TEST RESULTS: GEOTECHNICAL

APPENDIX C: LABORATORY TEST RESULTS: CHEMICAL

APPENDIX D: AWP GENERIC ASSESSMENT CRITERIA

APPENDIX E: LANKELMA: CPT REPORT

EXECUTIVE SUMMARY

Site Location & Description	The site is located to the north of Burringham Road and east of the M181 motorway and is centred at National Grid Reference (NGR) 486176mE, 408593mN.
Historical Land Use	The site is roughly square in shape and covers an area of approximately 30.58ha.
Geology	Superficial soils – Predominantly Warp (clay, silt, sand and gravel), with an area of blown sand present in the south-eastern corner of the site. Solid geology – Mudstone of the Mercia Mudstone Group.
Hydrogeology	Aquifer within Superficial Deposits: Secondary A Aquifer within Bedrock: Secondary B Source Protection Zones: There are no source protection zones within 500m of the site.
Mining Assessment	On the basis of available information risk associated with shallow coal mining subsidence is considered to be negligible.
Geotechnical Assessment	The calculated modified plasticity index (NHBC Chapter 4.2) was found to be 44%, which is equivalent to a high-volume change potential, according to the NHBC guidelines.
Foundations	At this stage, it is anticipated that shallow foundations may be suitable within engineered fill for 2 – 3 storey structures. However, this is to be confirmed once settlement analysis has been completed with subsequent allowable bearable capacities.
Ground Slabs	Suspended floor slabs should be adopted within the development.
Precautions near Trees	There are some trees on the southern boundary of the site, so precautions may be required should structures lie within influencing distance when in clay. In addition, precautions may be required where trees are to be removed or where new planting is proposed. All foundations should be constructed in accordance with current guidelines (e.g. NHBC Standards, Chapter 4.2).
Drainage	Given the shallow groundwater encountered below the site, and the intention to raise levels, soakaways are not considered to be suitable.
Obstruction & Excavations	Obstructions to excavations are not anticipated, as no previous development has taken place on the site.
Sulphate	The results of the assessment indicate that a Design Sulphate classification of DS-1 may be adopted with an ACEC class of AC-1.
Roads	No in situ CBR testing has been carried out to date as the levels on site are to be raised. New roads will be constructed on engineered fill.
Environmental Assessment	A total of six soil samples were analysed for inorganic and organic PAH contaminants. Assessment of the soils data indicates that there are no elevated concentrations of potential contaminants of concern that exceed relevant GAC criteria.
Potable Water Supplies	Risk to potable water supply pipes is considered to be very low. On the basis of available test results, it is unlikely that protective measures will be required.
Gas Protection Measures	As potential sources of ground gases have been identified within influencing distance of the site, six ground gas monitoring visits will be undertaken. This will be reported under separate cover once all the monitoring has been completed.
Further Works	- Assessment of the influence of trees in relation to foundations and floor slabs where clays are present at founding depth. - Completion of ground gas monitoring visits and hazardous ground gas risk assessment (to be reported under a separate cover).

	• Settlement calculations using the parameters derived from the geotechnical results (to be reported under a separate cover). • Foundation design in accordance with NHBC requirements. • Earthworks specification and verification.
NB. The Executive Summary presented above is an overview of the key findings and conclusions of the report. There may be other information contained within the body of the report which puts into context the findings of the Executive Summary. No reliance should therefore be placed on the Executive Summary until the report as a whole has been read in full.	

1 INTRODUCTION

1.1 Appointment

- 1.1.1 Alan Wood & Partners were appointed by Keepmoat Homes Ltd. (the 'Client') to undertake a Phase II Geo-Environmental Assessment.
- 1.1.2 This report provides geotechnical and environmental information in relation to the proposed redevelopment of the site for a residential end use, assuming that ground levels will be raised to facilitate the development. Interpretation and recommendations should not be assumed valid for adjacent areas of land, or for alternative land uses. Should the proposed site usage change, the recommendations and conclusions presented in this report may need to be re-assessed.

1.2 Development Proposals

- 1.2.1 It is understood that the site is to be redeveloped for a residential end-use (with plant uptake). A proposed preliminary development layout was provided to Alan Wood and Partners, which is appended to this report.

1.3 Report Status

- 1.3.1 The geoenvironmental investigation of the site has been carried out in two phases. A Phase I preliminary assessment (desk based study) has previously been completed by Alan Wood & Partners (Ref: JS/SLR/AC/46069-Rp-002, dated 7th February 2023). A subsequent Phase II (intrusive) investigation has been completed on the basis of the findings of the previous report. The results of the recent intrusive investigation are presented in this report.
- 1.3.2 The contents of the Phase I report are not reproduced herein. Salient points have been summarised which form the basis of the Phase II work. For full detail, reference should be made to the Phase I report referenced above.

1.4 Objectives of the Investigation

1.4.1 The scope of works undertaken as part of this appraisal was to:

- Investigate the ground conditions present on-site and identify their geotechnical properties in relation to the site's proposed end use;
- Investigate the hydrogeological regime beneath the site wherever possible;
- Identify the nature and concentration of any contamination within the on-site soils and undertake a tiered risk assessment to establish likely risks to sensitive receptors. Defining a Conceptual Site Model of potential contaminant linkages relevant to the proposed redevelopment of the site;
- Provide preliminary advice in relation to any environmental or geotechnical issues associated with the site including foundation recommendations and other recommendations needed to facilitate the proposed redevelopment, including, where necessary, identifying any additional phases of work or remediation that need to be carried out;
- Assess material suitability for re-use in earthworks.

1.5 Site Works

1.5.1 The findings and recommendations given in this report are based on fieldwork undertaken between the 28th of June and the 10th of July 2023, comprising the completion of seven mechanically excavated trial holes, three windowless boreholes, five cable percussive boreholes and ten cone penetration tests.

1.6 Limitations of Study

1.6.1 This report presents factual and interpretative geotechnical and environmental information, along with provisional construction proposals and recommendations relevant to the objectives of the investigation for the site end-use given above. The report has been prepared for the titled project and Alan Wood and Partners can accept no responsibility or liability for the consequences of the use of this document, wholly or in part, for any other purpose than that for which it was commissioned.

1.6.2 For the purposes of this report and thus defining risk to the proposed development from an environmental point of view, a residential end use has been adopted. Interpretation and recommendations should not be assumed valid for alternate land

uses. Where the proposed site usage changes, the findings of this report should be reassessed to accommodate the change in proposed end-use.

- 1.6.3 The conclusions and recommendations presented in this report are based on site-specific information obtained during the desk study, ground conditions encountered and laboratory analysis and are considered reasonable on the basis of available information at the time the assessment was carried out. They should not necessarily be relied upon to represent site conditions at a substantially later date.
- 1.6.4 The findings and opinions provided in this report are given in good faith and are subject to the limitations and constraints imposed by the methods and information sources described. Factual information has been obtained from a variety of sources. Alan Wood and Partners assumes that third party data is reliable, but has not independently confirmed this. The validity and accuracy of this information is therefore outside the control of Alan Wood and Partners. Professional judgement and experience is however used to ensure that uncertainties are reduced to a level appropriate to the site conditions, the purpose of the investigation and the resources devoted to it by the Client.
- 1.6.5 Whilst every effort has been made to carry out an assessment that enables a realistic characterisation of the geotechnical and environmental parameters at the site, the possibility of significant spatial variation in actual ground, groundwater and environmental (gas and contamination) conditions existing between or beyond exploratory hole locations cannot be discounted. Where information or opinion is given this is for guidance only. Further information, ground investigation, construction activities, change of site use or the passage of time may reveal conditions that were not indicated in the data and therefore could not have been considered in the preparation of this report. Where such information might impact upon stated opinions, Alan Wood and Partners cannot accept responsibility for conditions not encountered and reserves the right to modify or retract the opinions expressed in this report. Where opinions expressed are based on current available guidelines and legislation, no liability can be accepted by AWP for the effects of any future changes to such guidelines and legislation. New information of improved practices and changes in legislation may require reinterpretation of the report as a whole, or in part.

-
- 1.6.6 This report does not constitute an archaeological or ecological assessment, nor does it constitute an asbestos inspection. A suitably qualified consultant should be consulted where these aspects of work are required.
- 1.6.7 A flood risk assessment in accordance with Planning Policy Statement 25, *Development and Flood Risk* (2010) has not been undertaken as part of this commission.
- 1.6.8 All ground investigation works and soil descriptions were undertaken in general accordance with BS EN ISO 14688-1 'Geotechnical Investigation and Testing – Identification and Classification of Soil' (2018), BS10175 (2011), BS 5930 (2015) and/or BS EN 1997-1:2004 (Part 1, General Rules) and BS EN 1997-2:2007 (Part 2, Ground Investigation and Testing).

2 SITE DETAILS AND DESCRIPTION

2.1 Introduction

2.1.1 Published environmental, geological and historical data relating to the site area has been reviewed, in conjunction with a walkover survey undertaken on the 1st of February 2023, the findings of which are presented below. The principal considerations of immediate relevance are presented in the following sections.

2.2 Site Location & Description

2.2.1 The site is located to the north of Burringham Road and east of the M181 motorway and is centred at National Grid Reference (NGR) 486176mE, 408593mN.

2.2.2 The site is square in shape and covers an area of approximately 30.58ha.

2.2.3 The site is generally flat and comprises two agricultural fields with crop, separated by an east-west central drainage ditch and overhead powerlines. The wider site is bound by drainage ditches to the north and west with a 2m high embankment up to the M181 motorway on the western boundary. The east of the site is bounded by a hedgerow separating the site from a north-south road with a care home and residential buildings beyond and to the south by Burringham Road.

2.2.4 Further from the site to the north, west and south, are agricultural fields. A golf course is located to the southeast.

2.2.5 A culvert was located at the western edge of the east-west central drainage ditch, over which farm machinery is able to pass. This drainage ditch connects into to a further ditch on the western boundary. A culvert is also located at the southwest corner of the site running underneath the road bridge to the south.

2.2.6 Powerlines also cross the site from the central drainage ditch northwards to the northern boundary of the site.

2.2.7 Mature trees are located towards the northeast boundary of the site and also the southwest adjacent to the road bridge over the M181.

2.2.8 A mains water stop valve and wash out valve are located within the southeast corner of the site. A drain was located at the southern end of the site, within the verge of Burringham road. The drain appears to run parallel to the road.

2.2.9 Invasive plant species, including Japanese Knotweed and Giant Hogweed were not observed during the site walkover.

2.2.10 No evidence of fly tipping was observed on site.

3 PHASE I GEO-ENVIRONMENTAL ASSESSMENT

3.1 Anticipated Geology, Hydrogeology & Mining

- 3.1.1 Full details of the information reviewed is presented in the Phase I report for the site. Salient points are summarised below in relation to the sites geological and hydrogeological setting.

Table 3-1 - Geological Information

Made Ground and Surface Ground Workings	Information presented in the Groundsure report indicates that there are no areas of artificial/made ground within 500m of the site. There are no recorded entries in the Groundsure report that refer to historical surface ground working features within 250m of the site.
Geology	The site is shown to be underlain by superficial soils of predominantly Warp (clay, silt, sand and gravel), with an area of Blown Sand present in the south-eastern corner of the site. The solid geology underlying the site area is recorded as being mudstone of the Mercia Mudstone Group. There is one available historical BGS borehole on the eastern boundary of the site. The borehole log shows topsoil over made ground to 0.60mbgl. Below this, Blown Sand is recorded to 6.80mbgl, with laminated silty clay present below to 8.00mbgl. Clayey sand is recorded to 13.10m, below which mudstone bedrock is present.
Discontinuities	Information present in the Groundsure report indicates that there are no bedrock faults within 500m of the site. A number of landforms are recorded within the vicinity of the site, described as Dunes, the nearest being located 69m north-east of the site.
Hydrogeology	Aquifer within Superficial Deposits: Secondary A – Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. Aquifer within Bedrock: Secondary B – Predominantly lower permeability layers which may store/yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. Source Protection Zones: There are no source protection zones within 500m of the site. Source Protection Zones within Confined Aquifer: There are no source protection zones within 500m of the site. Vulnerability & Leaching Potential: Superficial soils are recorded as having an intermediate to high leaching potential with high vulnerability. The bedrock geology is recorded as having a low to medium vulnerability.
Hydrology	There are eighteen reported surface water features within 250m of the site. Several of these are located within the site and along the site boundaries thought to comprise drainage ditches.

Mining & Ground Stability	<u>Historic Underground Working Features</u> Information presented in the Groundsure report indicates that there are no historical underground working features within 1km of the site boundary. <u>Coal Mining</u> Information presented on the Cola Authority website (www.coal.decc.gov.uk) indicates that the site does not lie within a Cola Mining Reporting area. There are no known mine entries within or within 20m of, the boundary of the site and there are no reported areas of potential shallow mine workings on the Coal Authority database. On the basis of available information risk associated with shallow coal mining subsidence is considered to be negligible.
Non-coal Mining	Historical information indicates that there are no non-coal mining areas within 1km of the site.
Natural Cavities	The Groundsure data indicates that there are no natural cavities recorded within 1km of the study site.
Radon, Landfill and Mine Gas	The site lies within an area where radon protective measures are not required in construction. Risk associated with mine gas emission requiring action by the Coal Authority within the boundary of the site is not anticipated.

3.2 Environmental Records

3.2.1 A summary of the available environmental information is presented in Table 3.2.

Table 3-2 - Environmental Data

Potentially Harmful Discharges (Red List) to Controlled Waters	There are no records of red list discharge consents reported to be within 500m of the site.
Licensed Discharge Consents	There are no records of licensed discharge consents reported to be within 500m of the site.
EA Recorded Pollution Incidents to Controlled Waters	There are no recorded EA pollution incidents within 500m of the site.
Landfill and Other Waste Sites	There are no active or recent landfill sites within 500m of the site. There is one historical landfill site located 98m to the north-east which received inert industrial waste between 1977 and 1993, when the license is recorded as surrendered.
Flooding	The majority of the site is at a low risk of flooding from rivers and the sea, however, there is a medium risk recorded on the western boundary of the site. There are three recorded historical flood events on the site, all dated 1947, referring to the same flood event where both tidal and fluvial flooding took place. The site does not benefit from flood defences. The majority of the site lies within an Environment Agency Flood Zone 3,

	with the eastern third of the site within an Environment Agency Flood Zone 2.
Abstractions	There is one groundwater abstraction located within 244m to the south-east of the site, while the nearest active surface water abstraction lies 641m west of the site, both being for spray irrigation. There are no potable water abstractions within 2km of the site.
Invasive Plant Species	Japanese Knotweed was not observed during the site walkover. It would be prudent however to undertake an invasive plant species survey to confirm this prior to redevelopment.
Public Register of Contaminated Land: Part 2A (EPA 1990)	There are no sites designated as contaminated land under, Section 78R of the EPA 1990, within 500m of the site.
Dangerous or Hazardous Sites	There are no NIHHS or COMAH sites or high pressure underground pipelines within 500m of the site. There are no current or recent petrol stations within 500m of the site.
Potentially Contaminative Current Land Uses	There are no potentially contaminative industrial sites within 250m of the site.

3.3 Historical Land Use

- 3.3.1 A full record of the historical period reviewed is presented in the desk study report. A summary of significant findings is presented below.
- 3.3.2 From the earliest map examined, the site has never been developed and has remained as open land used for agricultural purposes throughout the historical period reviewed.
- 3.3.3 Some development has taken place more recently to the east of the site, with the construction of a number of buildings during the 1990s. The M181 was also constructed immediately west of the site in the late 1970s.

3.4 Anticipated Ground Conditions

3.4.1 Made Ground

- 3.4.1.1 It is not anticipated that significant made ground will be present on the site. However, localised deposits may be present associated with development to the east and west of the site and infilling of field drains previously present within the site.
- 3.4.1.2 The presence, type and extent of any on-site made ground soils will need to be established through ground investigation.

3.4.2 Natural Strata

3.4.2.1 The site is shown to be underlain by superficial soils of predominantly Warp (clay, silt, sand and gravel), with an area of Blown Sand present in the south-eastern corner of the site. The area of Blown Sand is further present adjacent to the eastern boundary of the site.

3.4.2.2 The solid geology underlying the site area is recorded as being mudstone of the Mercia Mudstone Group.

3.4.3 Groundwater

3.4.3.1 Groundwater has been recorded in previous investigations between 0.70m and 3.40m bgl.

3.5 Preliminary Conceptual Site Model

3.5.1 Introduction

3.5.1.1 The following section summaries the Preliminary Phase I Conceptual Site Model (CSM), which has been produced following the review of available pertinent desk study and third-party information. The CSM summarises the understanding of surface and sub-surface features, the potential sources of contamination, pathways and receptors in order to support the identification and assessment of plausible contaminated linkages.

3.5.2 Initial Conceptual Site Model & Risk Assessment

3.5.2.1 The risk assessment has been carried out to assess the likelihood of risk to human health and the wider environment, on the basis of information reviewed. The risk assessment is a qualitative source-pathway-receptor assessment and its function is to assess the likelihood that each possible linkage exists and to decide whether they pose potentially unacceptable risks to identified receptors (i.e. people, structures, water bodies or ecosystems) that may be harmed.

3.5.2.2 Risk can be defined as the combination of the consequence of a harmful effect and the probability of its occurrence. The existence of a contaminant linkage is dependent on site use, as well as environmental conditions: **if no contaminant linkage(s) can be proven, then the risk(s) may be discounted.**

3.5.3 Site Summary & Environmental Sensitivity

3.5.3.1 A review of available desk study information indicates that the proposed site area has not undergone any previous development. Some development has taken place to the east of the site, with a number of structures having been built more recently, and also adjacent to the western boundary where the construction of the M181 took place. A number of field boundaries, with potential drains have crossed the site, which appear to have been filled in.

3.5.3.2 No considerable amounts of made ground soils are expected on site, although the extent of such material is likely to be localised and would need to be confirmed through ground investigation.

3.5.3.3 The underlying geology is indicated to comprise predominantly Warp (clay, silt, sand and gravel), with an area of Blown Sand present in the south-eastern corner of the site. The area of Blown Sand is further present adjacent to the eastern boundary and north-eastern corner of the site. The solid geology underlying the site area is recorded as being mudstone of the Mercia Mudstone Group.

3.5.3.4 The potential leaching of mobile contaminants of concern to the underlying Secondary A aquifer is considered to be moderate given the reported high leaching potential of soils within the vicinity to the site.

3.5.3.5 In summary, given the site history, the anticipated contaminant load within the on-site soils, its underlying geology, gassing potential and the nature of controlled waters receptors, sensitivity of the site is considered, at this stage, to be **low to moderate**. The nature and concentration of any contamination will need to be confirmed through testing.

3.5.4 Potential Sources

3.5.4.1 A potential source is defined as 'a contaminant which is in, or under the land and has the potential to cause harm to human health or to cause pollution of controlled waters'.

3.5.4.2 The following potential contaminants that may be associated with the site are summarised in Table 3.3.

Table 3-3 - Summary of Potential Contaminant Sources

Potential Sources	Associated Potential Contaminants (<i>not limited to</i>)	
	<i>Metals, inorganics and other contaminants</i>	<i>Organics</i>
Potentially contaminated made ground soils, underlying natural strata / perched groundwater	Heavy metals, metalloids, sulphate, asbestos	PAHs, Pesticides
Ground Gases associated with organic material in superficial deposits	CO ₂ and CH ₄	

* Invasive plant species to be assessed separately if encountered.

3.5.5 Potential Receptors

3.5.5.1 A receptor is the potential target of the source contaminant, to which either significant harm or deterioration in quality may be caused.

3.5.5.2 The potential sensitive receptors with respect to the potential contamination hazards identified above are considered in Table 3.4.

Table 3-4 - Summary of Potential Receptors

Potential Receptor	Comment
Human Health	Site end-users Site operatives (during construction phase only)
Construction	Potable water supply pipes Foundations
Underlying natural strata	Near surface soils and/or any perched groundwater Secondary A Aquifer

3.5.6 Plausible Pathways

3.5.6.1 Migration pathways are routes by which contaminant sources may come into contact with receptors. Potential pathways for different types of contaminants vary depending on the properties of the contaminant, the mechanism of its release and the nature of the receptor. The principal potential pollution pathways by which receptors might become exposed to potential contamination at the site are summarised as follows in Table 3.7.

Table 3-5 - Summary of Plausible Pathways

Potential Source	Pathway
Potentially contaminated made ground soils, underlying natural strata / perched groundwater	Direct ingestion, dermal contact, dust and/or vapour inhalation
	Direct ingestion and/or dermal contact with liquid contaminants
	Inhalation of asbestos fibres
	Leaching and direct contact with foundations and potable water supply pipes. Lateral migration of contaminants through preferential pathways
Ground gases	Migration of gases and/or accumulation in void spaces via transport through service conduit, any permeable made ground and/or underlying permeable natural strata

3.5.7 Risk Assessment

3.5.7.1 The potential contaminant linkages listed above are based on available data and the features noted during the 'walkover'. Therefore, the linkages identified are tentative in nature and are subject to the following uncertainties (to be followed up through ground investigation):

- Nature and extent of the made ground at the site;
- Nature of the underlying natural strata at the site;
- The actual distribution of contaminants within the made ground and underlying natural soils;
- The hydrogeological regime beneath the site.

3.5.7.2 The assessment presented herein assumes that the site end-use is to be residential with gardens. The assessment is not valid for other land uses. Should the proposed end-use of the site change, the assessment contained herein would need to be revised to accommodate this.

3.5.7.3 The identified potential contaminants and receptors have been considered in relation to the pathways that may link them. The risk classification has been estimated in accordance with those methods prescribed in CIRIA publication C552 'Contaminated Land Risk Assessment: A Guide to Good Practice', 2001.

3.5.7.4 Risk is regarded as a combination of the likelihood of an 'event' occurring and its severity: both elements must be taken into account when assessing risk. The method

for risk assessment, or evaluation, is purely qualitative. As defined in CIRIA C552:2001, the magnitude of the potential 'severity' of risk occurring may be assessed against:

- **Severe:** short term risk to human health likely to result in significant harm as defined under EPA 1990, Part 2A. Short term risk of pollution to sensitive water receptor;
- **Medium:** significant harm to human health, pollution of sensitive water resource or significant change to an ecosystem or specific organism;
- **Mild:** pollution of non-sensitive water resource but significant damage to crops, buildings, structures and services or the environment;
- **Minor:** harm, which may result in financial loss, or expenditure to resolve. Non-permanent effects to human health. Easily repairable effects of damage to buildings, structures and services.

3.5.7.5 Similarly, the classification of the magnitude of the 'probability' of the risk occurring may be assessed against:

- **High Likelihood:** a contaminant linkage exists and an event appears very likely in the short term, or almost inevitable in the long term, or pollution is causing harm at the receptor;
- **Likely:** a contaminant linkage exists and it is probable that an event will occur. An event may not occur, but it is possible in the short term and likely over the long term;
- **Low Likelihood:** a contaminant linkage exists and it is possible that an event will occur. It is not certain that an event will occur over time but it is less likely in the short term;
- **Unlikely:** a contaminant linkage exists but it is not possible to say if an event will occur even over a very long time.

3.5.7.6 Following completion of the severity and probability assessment, classifications can be compared to indicate the actual risk each contaminant linkage presents: this can only be undertaken where there is a possibility of there being an active contaminant linkage.

3.5.7.7 The risk categories which can be assigned are presented in Table 3.6 and range between 'very high risk' to 'very low risk'. NB - it is not possible to classify an identified risk as 'no-risk'.

Table 3-6 - Risk Categories

		Consequence			
		Severe	Medium	Mild	Minor
Probability	Highly Likely	Very High	High	Moderate	Moderate / Low
	Likely	High	Moderate	Moderate / Low	Low
	Low Likelihood	Moderate	Moderate / Low	Low	Very Low
	Unlikely	Moderate / Low	Low	Very Low	Very Low

Reproduced from Table 6.5, CIRIA C552/2001.

- **Very High** – severe harm could arise to a designated receptor or that severe harm is occurring. Urgent investigation and remediation is likely to be required;
- **High** – harm could occur to a designated receptor and that urgent investigation and remediation may be needed in the short term, but are likely over the longer term;
- **Moderate** – harm could occur. It is unlikely to be severe, most probably relatively mild. Investigation is normally required to clarify the risk with some remedial works being required in the longer term;
- **Low** – possible that harm could occur, but if it did, at worst it would be mild;
- **Very Low** – low possibility of harm arising, and that if it does it is not likely to be severe.

3.5.7.8 The identified potential contaminants and receptors have been considered in relation to the pathways that may link them. The resulting contaminant linkages are presented in Table 3.7.

Table 3-7 - Summary of Phase I Conceptual Site Model & Risk Assessment

Potential Source	Potential Receptor	Plausible Pathway	Probability	Severity	Initial Risk Rating	Solution
Potentially contaminated made ground, near surface natural strata / perched groundwater	<u>Human Health</u> Site end-users, inc. maintenance and site workers (short term risk during construction)	Direct ingestion or dermal contact with soil, dust and/or vapour inhalation	Low likelihood	Medium	Moderate/Low	Soil capping or removal of contaminated soils where necessary
		Direct ingestion and/or dermal contact with liquid contaminants	Unlikely	Mild	Very Low	
		Inhalation of asbestos fibres	Unlikely	Severe	Moderate/Low	Appropriate removal and disposal, burial at depth or soil capping where necessary
	<u>Construction</u> (Potable Water Supply Pipes)	Direct contact/leaching (tainting)	Low likelihood	Mild	Low	Upgraded water pipes/clean backfill material where necessary
	<u>Construction</u> (Foundations)	Direct contact/leaching	Low likelihood	Mild	Low	Appropriate concrete specification
	Controlled Waters	Surface run-off / lateral migration	Likely	Mild	Moderate/Low	Low to moderate risk anticipated due to intermediate to high soil leaching potential recorded on site. Soakaways not to be adopted for drainage.
Ground Gases associated with organic material in superficial deposits	<u>Human Health</u>	Inhalation (via ingress and accumulation)	Low likelihood	Medium	Moderate/Low	Gas monitoring with necessary precautions appropriate to proposed site end use

3.5.7.9 The preliminary conceptual site model (CSM) presented above has indicated that a small number of contaminant linkages may exist on-site.

3.5.7.10 Fugitive ground gases associated with the potential for organic material within the underlying strata may present a risk to development on the basis of available information. In accordance with BS8485:2007, BS8576:2013, NHBC (2007) and CIRIA C665 (2007), a period of ground gas monitoring appropriate for the proposed end use of the site should be undertaken. It is considered that the likely generation potential for ground gas at the site will be low. The proposed development case indicates that 9 monitoring visits over a period of 6 months should be undertaken to determine the minimum level of protection required. A minimum of 3 boreholes should be installed. It may be prudent, at this stage, to allow for the provision of gas precautions to Characteristic Situation 2 until proven otherwise.

4 GROUND INVESTIGATION FIELDWORK

4.1 Introduction

- 4.1.1 The investigation requirements at the site were twofold: to undertake a geotechnical investigation and an environmental investigation. A ground investigation was carried out to identify geotechnical and environmental liabilities in relation to the proposed development work at the site.
- 4.1.2 The positions of the exploratory locations are limited to areas of the site, within the site boundary, that were accessible during the works.
- 4.1.3 Alan Wood and Partners scoped the intrusive investigation on the basis of information submitted in the desk study report and in general accordance with guidance given in BS5930:2015+A2:2010, BS10175:2011+A1:2013 and BS EN 1997:2004 and 2013.

4.2 Site Works

- 4.2.1 The findings and recommendations given in this report are based on fieldwork undertaken between the 28th June and the 7th July and comprised of five cable percussive boreholes, three windowless sampler boreholes and ten cone penetration tests, and seven machine excavated trial pits.
- 4.2.2 The positions of the exploratory holes are shown on the appended ground investigation plan, Figure 46069/00. They were positioned on the basis of the findings of the site conceptual model and distributed in general accordance with the requirements of BS10175:2011+A1:2013 and the working site conditions at the time each phase of investigation was completed.
- 4.2.3 The areas of investigation were targeted from both a geotechnical or environmental point of view. The windowless sampler boreholes were completed to the west of the site on either side of the current drainage ditch to inform drainage outfall, cable percussive boreholes and CPTs were completed to obtain geotechnical parameters for land raising and settlement. The trial pits were completed to confirm the suitability of material for reuse from both a geotechnical and environmental point of view.

4.2.4 Samples of topsoil and subsoil were collected in sterile containers appropriate to the nature of potential contaminants present for subsequent laboratory chemical and geotechnical testing.

4.2.5 Representative samples of the on-site soils were therefore recovered from the exploratory holes. Sampling was undertaken in accordance with those guidelines prescribed in BS 10175:2011. All environmental samples were collected in 500ml plastic tubs with sealable lids, 250ml glass amber jars or vials (subject to analytical requirements). Care was taken to minimise cross contamination (i.e. wiping of equipment) between sampling. Environmental samples were packed into cool boxes with ice packs and transported by courier to i2, an MCERTS and UKAS accredited laboratory for analysis and subsequent storage.

4.2.6 No groundwater samples were taken from the trial pits excavated.

4.3 Geotechnical Investigation

4.3.1 A geotechnical investigation was carried out to identify constraints in relation to the proposed construction works at the site and aid the design of appropriate foundation solutions. The following objectives of the ground investigation were therefore to:

- Confirm the lateral and vertical extent of any made ground soils, the nature of the underlying natural ground and the depth to bedrock at selected positions across the area under investigation;
- Determine the depth to groundwater and the stability of excavation;
- Recover bulk samples for geotechnical testing where necessary;
- Undertake *in situ* hand shear vane testing (in cohesive soils in trial holes) where encountered and this test could be undertaken (i.e. within soils that were not friable or gravelly).

4.3.2 Standard strata descriptions of the soils encountered are in general compliance with BS EN 1997:2004, BS EN 1997:2007, BS EN ISO 14688:2002, BS EN ISO 14688:2004 and BS EN ISO 14689:2003. The individual strata depths recorded on each hand pit or borehole log are those from existing ground levels.

4.3.3 Geotechnical laboratory testing was undertaken on a selection of soil samples in accordance with those techniques outlined in BS 1377:1990 'Methods of Test for Soils

for Civil Engineering Purposes' at the laboratory of Professional Soils Laboratory in Doncaster. This laboratory is a fully UKAS compliant laboratory.

4.4 Environmental Investigation

4.4.1 The environmental investigation was designed so that site-specific data could be obtained with respect to any potential soil and groundwater contamination associated with the site so that risks could be quantified in relation to the *source-pathway-receptor* scenarios and plausible contaminant linkages postulated in the initial Conceptual Site Model summarised above.

4.4.2 Given the organic material in the superficial deposits, it was considered possible that, when considered within the context of proposed end-use, the on-site soils may present an (albeit low) unacceptable risk to human health and/or the wider environment.

4.4.3 The scope of works undertaken, were therefore to:

- Inspect and identify the general soil conditions that prevail across the site;
- Assess the potential for soil contamination within any made ground, the underlying natural strata or groundwater;
- Recover soil samples to test for heavy metals, metalloids, non-metal inorganics, organics and asbestos fibres.

4.4.4 The analytical strategy adopted for the environmental investigation was designed to provide an overall assessment of potential contaminants thought to likely be present within the on-site soils. Whilst no specific contaminants of concern were anticipated in significant concentrations, the soil testing undertaken was for a suite of contaminants in general accordance with NHBC Standards Chapter 4.1 'Land Quality – Managing Ground Conditions' and CLR 8 'Potential Contaminants for the Assessment of Land' (withdrawn but used for reference purposes where applicable). The testing of the following analytes was scheduled on selected samples:

- Heavy metals suite (including As, Cd, Cr, Cu, Hg, Pb, Ni, Zn);
- Speciated Polycyclic Aromatic Hydrocarbons;
- Cyanide (free and total) and Thiocyanate;
- Phenol (total);
- Sulphates (Total and Water Soluble);

-
- Asbestos fibres;
 - Sulphide; and
 - pH.

5 RESULTS OF INVESTIGATION

5.1 Ground Conditions Encountered

5.1.1 The ground conditions encountered have been divided into the different areas of investigation and are summarised in Table 5.1, 5.2 and 5.3, while discussion about each one is given in the following paragraphs.

5.1.2 A copy of the ground investigation logs are presented in Appendix A.

Table 5-1 - Summary of Ground Conditions (Trial pits)

Lithology	Exploration Location	Approximate proven depth (m) to base from existing ground level	Approximate Thickness (m)
Topsoil	All locations	0.25 - 0.40	
Sand	All locations	0.50 – 1.00	0.20 – 0.70
Organic sand	All locations	0.60 - 1.40	0.20 – 0.60
Grey sand	All locations	2.20 – 2.60 (base not proven)	1.10 – 1.80 (base not proven)
Groundwater	TP102 – 1.70mbgl TP104 – 1.90mbgl TP105 – 2.20mbgl TP107 – 2.00mbgl		

Table 5-2 Summary of Ground Conditions (Windowless Sampler Boreholes)

Lithology	Exploration Location	Approximate proven depth (m) to base from existing ground level	Approximate Thickness (m)
Topsoil	All locations	0.10-0.12	
Silt	All locations	0.60 – 0.80	0.50 – 0.70
Orangish brown clay	WS3	0.95	0.35
Orangish brown sand	All locations	1.15 – 2.65	0.45 – 1.85
Organic sand	All locations	1.42 – 2.85	0.15 – 0.27
Sand	All locations	3 – 4 (Base not proven)	0.15 – 2.58 (Base not proven)

Lithology	Exploration Location	Approximate proven depth (m) to base from existing ground level	Approximate Thickness (m)
Groundwater	WS1 – 2.25m, 3.00m and 3.90mbgl. WS2 – 1.30mbgl. WS3 – 1.95m, 2.10m and 3.40mbgl.		

Table 5-3 Summary of Ground Conditions (Cable Percussive Boreholes)

Lithology	Exploration Location	Approximate proven depth (m) to base from existing ground level	Approximate Thickness (m)
Topsoil	All locations	0.20 – 0.40	
Loose sand	All locations	1.30 – 2.80	0.90 – 2.60
Organic layer	All locations	1.50 - 3.10	0.20 – 1.00
Medium dense sand	All locations	4.90 – 5.80	2.60 – 3.40
Clay	All locations	7.80 – 9.50	2.00 – 3.90
Dense sand	All locations	11.90 – 13.30	3.10 – 5.40
Bedrock	All locations	14.00 – 15.00 (base not proven)	1.70 – 2.40
Groundwater	CP2 – 1.20mbgl Groundwater was not encountered below 1.20m due to using water to advance the borehole.		

5.1.3 Made Ground: No made ground was encountered across the site.

5.1.4 Natural Strata: Topsoil was encountered at all locations across the site and comprised of brown, slightly clayey, silty sand with frequent roots. The underlying ground conditions comprised of sands, silts and clays (Warp Deposits) which was underlain by weathered Mercia Mudstone Group. Further details can be found on the logs (Appendix A)

5.1.5 All windowless sampler boreholes refused on dense sand between 3.00m and 4.00mbgl and one cable percussive borehole (CP1) refused on bedrock at 14.00mbgl.

5.1.6 **Groundwater:** Groundwater was encountered between 1.20m and 3.90mbgl with no groundwater strikes recorded below 1.20mbgl in the cable percussive boreholes due to using water to assist in advancing the boreholes.

5.1.7 Allowable bearing capacities will be given once the settlement calculations have been completed and produced under a separate cover.

5.2 Visual & Olfactory Evidence of Contamination

5.2.1 No visual or olfactory evidence of gross contamination, such as hydrocarbons, was recorded during the ground investigation.

5.3 Geotechnical Testing & Material Properties

Particle Size Distribution Testing

5.3.1 Particle size distribution tests have been completed on eight samples from the near surface. The samples were taken between 0.40m and 2.40mbgl. A copy of the test results is appended to this report.

5.3.2 Using Series 600, Specification for Highways Works, samples from between 1.10m and were typically classed as a 1A, with two of the shallower samples (from TP102 at 0.50m and TP104 at 0.40m) classed as a 2A/2B.

Compaction Testing

5.3.3 Compaction testing has been completed on nine samples from the near surface. The samples were taken between 0.40m and 2.40mbgl. A copy of the test results is appended to this report.

5.3.4 Material was typically found to be wet of optimum and in some cases, where samples had been taken from below the water table, initial moisture content was at least double the optimum. Wetter material was also recorded to the northern end of the site in comparison to that to the south of the central drainage ditch.

Shearbox Testing

5.3.5 Shearbox testing has been completed on three soil samples. The samples were taken between 0.40m and 5.00mbgl. A copy of the test results is appended to this report.

5.3.6 A summary of the results obtained are presented in Table 5.4.

Table 5-4 Summary of Shear Box Testing

Exploration Location	Depth (m)	Moisture Content (%)	Bulk Density (Mg/m ³)	Angle of Shearing Resistance (°)	Effective Cohesion (kPa)
CP1	4.00 – 5.00	20	1.98	33	5
CP3	3.00 – 4.00	20	2.08	32	4
CP5	0.40 – 1.20	19	2.01	31	9

Standard Penetration Testing

5.3.7 *In situ* standard penetration testing was undertaken in all windowless sampler boreholes and cable percussive boreholes so that an assessment on material strength could be ascertained.

5.3.8 The field test is useful for comparing variability of backfill materials as well as undisturbed natural soils to check for possible differential settlement problems. SPT tests were carried out at 1.0m centres through the vertical profile of each borehole.

5.3.9 A summary of the test results is given in table 5.5 and 5.6.

Table 5-5 Summary of *In-Situ* Standard Penetration Test (SPT) Results (Windowless Sampler Boreholes)

Depth in mbgl	Borehole 'N' value			
	WS1	WS2	WS3	Average N ₆₀ Value
1.00	10	18	15	14
2.00	9	18	12	13
3.00	24	50	34	36
4.00	50	-	50	50
	N ₆₀ = (Er / 60) x N Value Energy Ratio (68%)			

Table 5-6 Summary of In-Situ Standard Penetration Test (SPT) Results (Cable Percussive Boreholes)

Depth in mbgl	Borehole 'N' value					
	CP1	CP2	CP3	CP4	CP5	Average N ₆₀ Value
1.20	0	1	16	10	11	8
2.00	18	17	20	8	14	15
3.00	28	13	16	32	8	19
4.00	16	20	10	30	10	17
5.00	16	16	18	23	13	17
6.50	16	6	14	25	4	13
8.00	13	14	14	43	16	20
9.50	2	-	50	50	16	30
11.00	48	47	-	50	29	44
12.50	50	23	14	13	-	25
14.00	50	-	-	-	-	50
15.00	-	38	50	50	50	47
	N ₆₀ = (Er / 60) x N Value Energy Ratio (72%)					

Atterbergs, Moisture Content & Volume Change Potential

5.3.10 The geotechnical laboratory testing was carried out on two samples of cohesive soil by Professional Soils LTD. A copy of the test results are presented in Appendix B but are summarised in Table 5.7.

Table 5-7 Plasticity Index Test Results

Borehole Number	Depth (m)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Passing 0.425mm (%)	Volume Change Potential*
WS3	0.80	75	31	44	100	44

* VCP: 10-19% = Low, 20-39% = Medium, 40% and greater = High (after NHBC:2023).

5.3.11 The Plasticity Index (Ip) of a soil is a measure of its Volume Change Potential (VCP) and is determined by Atterberg Limits tests, the results of which are given in the above table. All tests to determine the liquid limit (w_L) and plastic limit (w_p) were also performed by PSL LTD. A Modified Plasticity Index (I_p) has been calculated for the samples tested, which is defined as the Plasticity Index multiplied by the percentage of

particles less than 425µm. The conversion factor applied is presented in NHBC Standards (2023), Chapter 4.2.

5.3.12 The calculated modified plasticity index (NHBC Chapter 4.2) was found to be 44%, which is equivalent to a **high** volume change potential, according to the NHBC guidelines.

5.4 Contamination and Performance of Building Materials (Cementitious Products)

5.4.1 Six soil samples were analysed for a suite of contaminants consistent with BRE Special Digest 1 'Concrete in Aggressive Ground' (2005). A copy of the individual test results is given in the appended laboratory certificates in Appendix C.

5.4.2 The pH values recorded for the soil samples ranged between 7.9 and 8.4 (pH units) with an average of 8.1, indicating alkaline conditions prevail within the on-site soils.

5.4.3 Water soluble sulphate analysis of the soils yielded concentrations between 0.01g/l (10mg/l) and 0.063g/l (63mg/l) in the samples (0.032g/l on average).

5.5 Chemical Testing

5.5.1 Six representative samples of soil from the trial pits within the near surface and at depth were analysed for the suite of contaminants outlined in Section 4.4.4. This was in order to assess the general degree and nature of contamination within the on-site soils in relation to the site's proposed redevelopment.

5.5.2 A summary of the test results is given in the following tables, whilst a copy of the individual test results is presented in full in Appendix C.

Table 5-8 Summary of Total Soil Concentrations

Contaminant of Concern	GAC* (mg/kg)	Contaminant Concentrations (mg/kg)		No. of Samples Tested	No. of Samples >GAC	Pass/Fail Tier 1 GAC Screen
		Min	Max			
Metals						
Arsenic (inorganic)	37*	2.3	16	6	0	Pass
Cadmium	22*	<0.2	0.6	6	0	Pass
Chromium	910**	5.7	26	6	0	Pass
Copper	2400**	11	27	6	0	Pass
Mercury (inorganic)	40**	<0.3		6	0	Pass
Nickel	130**	6.7	26	6	0	Pass
Lead	200*	15	89	6	0	Pass
Selenium	250**	<1.0		6	0	Pass
Zinc	3700**	23	110	6	0	Pass

* DEFRA (2014). Development of Category 4 Screening Levels (SP1010)

** LQM/CIEH (2015). S4UL for Human Health Risk Assessment.

Table 5-9 Summary of Chemical Test Results (PAH)

Contaminant of Concern	GAC* (mg/kg)	Contaminant Concentrations (mg/kg)		No. of Samples Tested	No. of Samples >GAC	Pass/Fail Tier 1 GAC Screen
		Min	Max			
Phenanthrene	95	<0.05	0.18	6	0	Pass
Pyrene	620	<0.05	0.09	6	0	Pass

* [CLEA/LQM/CIEH, 2015] Calculated for residential end-use scenario, with plant uptake in CLEA v1.071. GAC range for 1.0% SOM used unless stated otherwise. Values will be more conservative for cohesive soils.

5.5.3 No PAH's except the two identified above were detected in any of the samples.

6 GEOTECHNICAL ASSESSMENT

6.1 Mining Risk

- 6.1.1 On the basis of available information, the potential for there to be shallow mine workings beneath the site is considered to be negligible.

6.2 Foundations

- 6.2.1 At this stage, it is anticipated that shallow foundations may be suitable within engineered fill for 2 – 3 storey structures. However, this is to be confirmed once settlement analysis has been completed with subsequent allowable bearing capacities.

6.3 Floor Slabs

- 6.3.1 Suspended floor slabs will be suitable for use at the site given that the site level is to be raised.

6.4 Precautions Near Trees

- 6.4.1 There are some trees on the southern boundary of the site, so precautions may be required should structures lie within influencing distance when in clay; this will be subject to a tree survey and plot specific foundation schedule.
- 6.4.2 In addition, precautions would be required where trees are to be removed or where new planting is proposed. All foundations should be constructed in accordance with NHBC Standards (i.e. Chapter 4.2).

6.5 Drainage and Soakaways

- 6.5.1 Soakaway drainage is not considered to be suitable for the proposed development due to the shallow groundwater encountered across the site between 1.20m and 3.90mbgl.

6.6 Roads and Car Parks

- 6.6.1 No *in situ* CBR testing has been carried out to date as the final development levels at the site are unknown and roads are likely to be constructed within the engineered fill following land raising.
- 6.6.2 Highways Agency document CD225 (2020) states that where a subgrade has a CBR lower than 2.5%, it is considered unsuitable support for a pavement foundation since it

would tend to deform under construction traffic and must be improved. All road design should be discussed with the local authority if highways are to be subject to a Section 38 agreement.

6.7 Ground Stability

6.7.1 Excavations are unstable below groundwater level where granular deposits are encountered. Instability should be anticipated where weak strata is encountered and where excavations are left open over prolonged periods of time and where excavations are left open during prolonged periods of wet weather (e.g. in service trenches). Allowance for instability of the near surface granular deposits should be made where necessary.

6.7.2 An adequate drainage system for surface water may need to be installed by a competent contractor in order to prevent surface water ponding or collection, both during and post construction, as this may lead to deterioration and weakening of the founding stratum.

6.7.3 Where excavations are proposed close to site boundaries and there is the possibility of weak/unstable ground passing across that boundary and beneath adjacent structures, a risk assessment of the integrity/stability should be undertaken prior to such works being carried out. Designed and engineered temporary/permanent measures should be adopted to ensure their continued stability where necessary.

6.8 Excavations

6.8.1 Localised obstructions to excavations or shallow hard rock are not anticipated given the geology and lack of previous development.

6.8.2 No man entry into unsupported excavations should be allowed without an appropriate risk assessment. Reference to CIRIA report 97 (1983) should be made to establish suitable means of support, or battering of excavation sides.

6.9 Sulphate Attack and Aggressive Ground Conditions

6.9.1 An assessment of the data was carried out in accordance with Section C4 'Site Investigation for Aggressive Ground Conditions' and the procedure prescribed in Section C5 'Classification of Site Locations for Chemicals Aggressive to Concrete' of

BRE SD1 (2005) to assess whether ground conditions at the site are potentially aggressive to buried concrete products.

6.9.2 The results of the assessment indicate that a Design Sulphate classification of DS-1 may be adopted along with an ACEC class of AC-1. However, it is recommended that if made ground is encountered DS2 sulphate precautions should be adopted in foundation construction.

6.9.3 Mobile groundwater conditions have been assumed in this assessment.

6.10 Earthworks Suitability

6.10.1 Trial holes were undertaken within the area of the proposed lake to determine if excavated materials were suitable for use in the land raising to take place on the site.

6.10.2 Organic soils, recorded between 0.60 and 1.40m bgl are not suitable for use within the land raising.

6.10.3 Based on the samples taken, the shallow soils are typically a 2A/2B material, with deeper soils, below the organic layer, classed as a 1A.

6.10.4 The excavated material was found to be wet of optimum below the groundwater table. Where used within the earthworks, this material would need to be dried to optimum moisture content prior to placement.

7 ENVIRONMENTAL ASSESSMENT

7.1 Guidance for Analytical Results - Assessment Criteria

Soil

- 7.1.1 With reference to the proposed end use of the site, the results of the chemical testing were assessed as part of an environmental risk assessment against a number of potential receptors, considering risks to human health, environmental quality and the built environment. Such risk assessment comprises the initial comparison of the measured soil concentrations with Generic Assessment Criteria (GAC), which in this instance are considered protective of a residential end use, with plant uptake.
- 7.1.2 In line with current best practice in the UK, initial screening of contaminant concentrations is carried out against appropriate published generic assessment criteria. Currently the authoritative generic assessment criteria are considered to be DEFRA's SGVs, DEFRA's Category 4 Screening Levels (2014) and the LQM/CIEH Suitable 4 Use Levels (2015). The assessment criteria have been derived on the basis of currently widely accepted assumptions relating to the modelling of human exposure to soil contaminants for the standard land uses: residential (with and without home-grown produce), allotments, commercial and public open spaces (close to residential properties and parks).
- 7.1.3 The general consensus between contaminated land practitioners is that the C4SL values, which are based on the low level of toxicological concern (LLTC), are less cautious than the GAC values published by LQM/CIEH and may not, therefore, be wholly applicable for use outside the context of Part 2A Statutory Guidance. Although both publications in no way undermine the validity of existing Environment Agency guidance presented in, for example, SR2, SR3 and the existing CLEA software, we are of the mind that the LQM/CIEH S4UL values, which are based on Health Criteria that represents minimal or tolerable levels of risks to health (as described in the Environment Agency's SR2 guidance) but incorporates the current exposure assumptions presented in DEFRA's C4SL guidance, provide a better starting point from which to generate determine assessment criteria that can be applied to brownfield development sites and are 'suitable for use' under the planning system.
- 7.1.4 It should be noted that all approaches are based on sandy loam soil with 6% soil organic matter (SOM). Whilst this does not affect metal contaminants, as they are not

dependent on soil type or SOM, the algorithms used to model plant uptake and volatilisation for organic contaminants do take account of SOM content in the soil. The GAC values for metals in the standard land uses may therefore be directly applied, whether these are SGVs, C4SL or S4UL derived, whilst independent GAC values for organics (e.g. PAH, TPH) have been generated using CLEA Version 1.071 and the toxicological updates presented in the aforementioned documents. These have also been adjusted for soil type and are calculated for SOM contents at 1%, 2.5% and 6% for a sandy soil.

7.1.5 A summary of the generic assessment criteria values is presented in Appendix D.

7.2 Human Health Receptors

7.2.1 In order to assess the significance of the recorded concentrations of potential contaminants of concern in relation to human health laboratory analysis was compared with the adopted generic assessment criteria.

Metals, Metalloids and Other Inorganic Analytes

7.2.2 A total of six soil samples were analysed. Assessment of the soils data indicates that there are no elevated concentrations of potential contaminants of concern that exceed relevant GAC criteria.

7.2.3 There is considered to be no significant risk to human health in a residential site end use scenario with plant uptake, with respect to metals, metalloids and non-metal inorganics.

Organics (PAH)

7.2.4 A total of six soil samples were analysed for PAH contaminants.

7.2.5 None of the samples analysed for PAH returned concentrations above relevant GAC's.

7.2.6 There is considered to be no significant risk to human health in a residential site end use scenario with plant uptake, with respect to organic contaminants.

Asbestos

7.2.7 A total of six soil samples were analysed. No asbestos fibres were detected in the samples tested.

7.2.8 There is considered to be no significant risk associated with asbestos containing materials within soils at the site.

Topsoil

7.2.9 Environmental analysis has been completed on two samples of topsoil. Concentrations of all potential contaminants of concern were below the adopted GAC value for a residential site end-use, with plant uptake. The existing topsoil deposit is considered likely to be suitable for continued use at the site. However, additional testing should be undertaken in accordance with the requirements of YALPAG guidance to confirm suitability for re-use.

7.3 Controlled Waters Receptors

7.3.1 No sources of potentially significant contamination have been identified which could present a risk to controlled water receptors.

7.4 Ecological Receptors

7.4.1 There are no known ecological receptors at the site.

7.5 Utilities

7.5.1 It is recommended that the results of the chemical testing and details of the proposed redevelopment of the site are provided to the appropriate utility companies to determine the necessity for service protection.

7.6 Potable Water Supplies

7.6.1 Risk to potable water supply pipes is considered to be very low. On the basis of available test results it is unlikely that protective measures will be required. Consultation should however be undertaken with the local water authority with respect to any precautions they may require, prior to construction.

7.7 Refined Conceptual Site Model

7.7.1 Introduction

7.7.1.1 The preliminary CSM given above presented our initial understanding of the site, being based on available geological information, site location, likely contamination status and

the overall risk it presented to the identified receptors through various pollution pathways.

7.7.1.2 This section revises the initial CSM in light of the ground investigation findings and chemical analysis results presented above.

7.7.1.3 The revised conceptual site model has been developed for the proposed future residential site end-use, with plant uptake. This summarises our understanding of surface and sub-surface features, the potential contaminant sources, transport pathways and receptors assuming that no remediation has been undertaken at the site.

7.7.2 Ground Conditions - Summary

7.7.2.1 Made Ground: No made ground was encountered across the site.

7.7.2.2 Natural Strata: Topsoil was encountered at all locations across the site and comprised of brown, slightly clayey, silty sand with frequent roots. The underlying ground conditions comprised of sands, silts and clays (Warp Deposits) which was underlain by weathered Mercia Mudstone Group. Further details can be found on the logs (Appendix A)

7.7.2.3 Groundwater: Groundwater was encountered between 1.20m and 3.90mbgl with no groundwater strikes recorded below 1.20mbgl in the cable percussive boreholes due to using water to assist in advancing the boreholes.

7.7.2.4 All windowless sampler boreholes refused on dense sand between 3.00m and 4.00mbgl and one cable percussive borehole (CP1) refused on bedrock at 14.00mbgl.

7.7.2.5 A total of six soil samples were analysed for inorganic and organic contaminants. Assessment of the soils data indicates that there are no elevated concentrations of potential contaminants of concern that exceed relevant GAC criteria.

7.7.3 Qualitative Contaminated Land Risk Assessment

7.7.3.1 Current UK legislation on contaminated land is principally contained in Sections 78(A) to (YC) in Part 2A of the Environmental Protection Act 1990, which was retrospectively inserted by Section 57 of the Environment Act 1995. The Contaminated Land Regulations 2000 were amended in 2005. The Environmental Protection Act 1990:

Part 2A Contaminated Land, Statutory Guidance, Edition 2, 2006, promulgates the revised statutory guidance with respect to the operation of the Contaminated Land Regime following the implementation of the Contaminated Land Regulations, 2005.

7.7.3.2 The definition of contaminated land is central to the operation of Part 2A. Legislation adopts the principle of a 'suitable for use' approach for the assessment of contaminated land, the rationale reflected in the site-specific risk assessment and determination of remedial strategy. Action is only required if unacceptable risks are posed to human health or to the environment, taking into account the current land use and geo-environmental setting.

7.7.3.3 The legislation places a responsibility on the Local Authority to determine whether the land under its jurisdiction is contaminated by consideration of whether:

- Significant harm is being caused;
- There is a significant possibility of significant harm being caused;
- Significant pollution of controlled waters is being caused or is likely to be caused.

7.7.4 Assessment Framework

7.7.4.1 The statutory guidance describes a risk assessment methodology in terms of 'significant contaminants' and 'contaminant linkages', using 'source-pathway-receptor' scenarios for the site. Contaminant linkages are formed when there is a linkage between a contaminant source and a receptor by means of a pathway. Each element has to be present, or no linkage can be formed.

7.7.4.2 Risk assessment and the procedure of identifying sources, pathways and receptors is recognised as an approach to determine the extent and significance of contamination either within the context of Part 2A (when assessing current site status or when considering the acquisition of an existing development) or the planning process (for the redevelopment of an existing site, or when considering the acquisition of a site for redevelopment purposes). Either way, the 'suitable for use' approach is adopted when assessing risk and the source-pathway-receptor assessment defines the conceptual model for the site.

7.7.4.3 Within the context of this report therefore, the revised risk assessment has been undertaken on the basis that the 'suitable for use' approach remains aligned with the site being redeveloped for the end use given above.

7.8 Summary of Identified Contaminant Linkages

7.8.1.1 On the basis of the ground investigation and laboratory test results, on-site soils have been found to not contain elevated concentrations of inorganic and/or organic contaminants in excess of the adopted GACs.

7.8.1.2 There is considered to be no significant risk to human health, the development or the wider environment, with respect to the identified levels of contaminants within the on-site soils.

7.8.1.3 A summary of the revised risk assessment is given in Table 7.1.

Table 7-1 - Summary of Revised Conceptual Site Model & Risk Assessment

Potential Source	Potential Receptor	Plausible Pathway	Initial Risk Rating	Probability	Severity	Revised Risk Rating	Solution
Localised potentially contaminated made ground, near surface natural strata / perched groundwater	<u>Human Health</u> Site end-users, inc. maintenance and site workers (short term risk during construction)	Direct ingestion or dermal contact with soil, dust and/or vapour inhalation	Moderate/Low	Unlikely	Mild	Very Low	No risk anticipated
		Direct ingestion and/or dermal contact with liquid contaminants	Very Low	Unlikely	Mild	Very Low	
		Inhalation of Asbestos fibres	Moderate	Unlikely	Severe	Moderate / Low	Risk rating cannot be downgraded due to severity. No risk anticipated
	<u>Construction</u> (Potable Water Supply Pipes)	Direct contact/leaching (tainting)	Low	Unlikely	Mild	Very Low	No risk anticipated
	<u>Construction</u> (Foundations)	Direct contact/leaching	Low	Unlikely	Mild	Very Low	No risk anticipated. Appropriate concrete specification
	Controlled Waters	Surface run-off / lateral migration	Moderate/Low	Unlikely	Mild	Very Low	No risk anticipated
Ground Gases associated with organic material in superficial deposits	<u>Human Health</u>	Inhalation (via ingress and accumulation)	Moderate/Low	Low likelihood	Medium	Moderate/Low	Gas monitoring with necessary precautions appropriate to proposed site end use

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 General

8.1.1 This geo-environmental appraisal has been carried out in relation to the redevelopment of land north of Burringham Road, Scunthorpe.

8.1.2 It has been assumed in the production of this report that the site is to be redeveloped for a residential site end use, with plant uptake.

8.2 Soil Contamination - Risk Evaluation

8.2.1 The revised Conceptual Site Model confirms that no significant potential contaminant linkages exist at the site in relation to existing on-site soils.

8.2.2 There is considered to be no significant potential risk to sensitive receptors from soil contamination at the site.

8.2.3 Potential risk to construction worker is considered to be very low.

8.2.4 Contaminant levels are not considered unlikely to be potentially mobile and no significant sources of liquid contaminants have been identified. Controlled water receptors are not considered to be at risk from soil contamination at the site.

8.3 Hazardous Ground Gases

8.3.1 As organic material has been identified beneath the site, ground gas monitoring equipment has been installed in all five of the cable percussive boreholes to a depth of 5mbgl. Six ground gas monitoring visits will be made, and this will be reported under separate cover once the required monitoring has been completed.

8.3.2 No radon protection measures will be required.

8.4 Outline Remediation Requirements

8.4.1 On the basis of available information, it is considered that no particular remediation is required at the site.

8.4.2 Confirmation of the chemical condition of any materials brought to site should be confirmed prior to importation.

8.5 Disposal of Soils

- 8.5.1 Should brightly coloured or odorous soil be encountered during the proposed construction works, Alan Wood and Partners should be notified immediately. An experienced geo-environmental engineer will visit site for further sampling, analysis and risk assessment, where required.
- 8.5.2 Any materials removed from site should be undertaken in accordance with the Duty of Care Regulations 1991 and the Hazardous Waste Regulations 2005. There will also be a requirement to classify the waste in accordance with the European Waste Catalogue. The waste should also be subject to Waste Acceptance Criteria (WAC) testing.

8.6 Further Work

- 8.6.1 Assessment of the influence of trees in relation to foundations and floor slabs where clays are present at founding depth.
- 8.6.2 Completion of ground gas monitoring visits and hazardous ground gas risk assessment (to be reported under separate cover).
- 8.6.3 Settlement calculations using the parameters derived from the geotechnical results (to be reported under a separate cover).
- 8.6.4 Foundation design in accordance with NHBC requirements.
- 8.6.5 Earthworks specification and verification.

9 REGULATORY APPROVAL

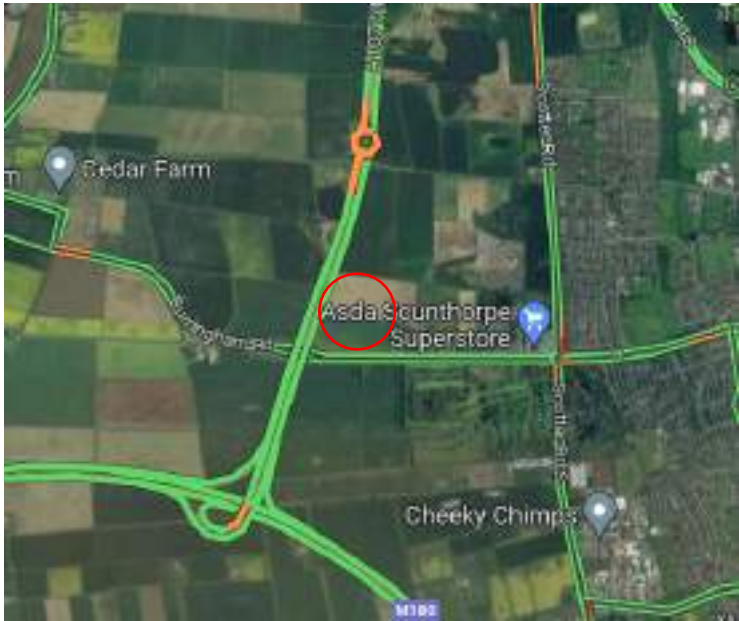
- 9.1.1 The conclusions and recommendations presented in this report are considered reasonable on the basis of available information and the assessment of the site as carried out by Alan Wood and Partners.
- 9.1.2 It should be noted however that the works undertaken cannot be guaranteed to gain approval by the Regulatory Authorities and your Warranty Provider, so copies of this report should be made available to the relevant organisations (as appropriate) for their comment and approval, prior to undertaking any irrecoverable works associated with the site.

10 INFORMATION SOURCES

In addition to the specific references cited in the text, the following references have been referred to in the production of this report, where relevant to the defined project objectives.

- 1 BRE BR211 (2015) *Radon: guidance on protective measures for new dwellings*;
- 2 BRE GBG 75 (2015), '*Radon Protection For New Large Buildings*';
- 3 BS5930 (2015), *Code of practice for site investigations*;
- 4 BS:8576 (2013), *Guidance on Investigations for Ground Gas - Permanent Gases and Volatile Organic Compounds (VOCs)*;
- 5 BSEN 1997-1 (2004), *Geotechnical Design Part 1 – General Rules*;
- 6 BSEN 1997-2 (2007), *Geotechnical Design Part 2 – Ground investigation and testing*;
- 7 Chartered Institute of Environmental Health (CIEH): *Professional Practice Note: Reviewing human health risk assessment reports invoking contaminant oral bioavailability measurements or estimates* (2009);
- 8 CIRIA C552 (2001), *Contaminated Land Risk Assessment, A Guide to Good Practice*;
- 9 CIRIA C665 (2007), *Assessing risks posed by hazardous ground gases to buildings*;
- 10 CL:AIRE / EIC / AGS: *Soil Generic Assessment Criteria for Human Health Risk Assessment* (updated January 2010 version);
- 11 Coal Authority, www.coal.decc.gov.uk;
- 12 DEFRA SP1010: *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination - Policy Companion Document*, December 2014;
- 13 DETR Circular 02/2000 (2000). *Environmental Protection Act 1990 Part 2A. Contaminated Land*. Department of the Environment, Transport and the Regions, Circular 02/2000, Dated 20th March 2000;
- 14 Environment Agency (EA) & DEFRA: *Model Procedures for the Management of Land Contamination – Contaminated Land Report 11 (CLR11)* (2004);
- 15 NHBC Chapter 4.2 (2023), *Building near trees*, NHBC Publication.
- 16 Environment Agency, www.environment-agency.org.uk;
- 17 Environment Agency (2009). *Human Health Toxicological Assessment of Contaminants in Soil*, Science Report SC050021/SR2;
- 18 Environment Agency (2009). *Updated Technical Background to the CLEA Model*, Science Report SC050021/SR3;
- 19 Land Quality Management / CIEH: *The LQM/CIEH S4UL's for Human Health Risk Assessment*, Land Quality Press, Nottingham, 2015. Publication Number S4UL3286;

FIGURES



DO NOT SCALE



Approximate Site Location



Approximate Red Line Site Boundary



Client. Keepmoat Homes Limited		
Project. Lincs lakes, Scunthorpe		
Drawing. Site Location Plan		
Date. 04.08.23	Scale. NTS	
Drawn by. AC	Check by. SLR	Approved by. SLR
Status: FOR INFORMATION		
Job no. 46069	Fig. no. 001	Rev.

APPENDIX A

ALAN WOOD AND PARTNERS: GROUND INVESTIGATION LOGS



Borehole Log

Borehole No.

CP1

Sheet 1 of 2

Project Name: Lincs Lakes

Project No.
46069

Co-ords: 486125.36 - 408845.04

Hole Type
CPLocation: Land to the north-west of Junction 3 (M180), Scunthorpe,
Lincolnshire

Level: 1.95

Scale
1:50

Client: Keepmoat Homes Limited

Dates: 28/06/2023 - 29/06/2023

Logged By
SW

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
					0.40	1.55		TOPSOIL: Brown slightly clayey, silty SAND. Frequent roots.	
		1.20		N=0 (0,0/0,0,0,0)	1.30	0.65		Very loose brown mottled orange slightly clayey, silty SAND. [WARP DEPOSITS]	1
					1.50	0.45		Orangish brown slightly clayey SILT.	
								Very soft grey silty CLAY. Frequent blocks of peat. [WARP DEPOSITS]	
		2.00		N=15 (2,2/3,3,4,5)				Medium dense brown silty SAND. Occasional gravel of fine, subrounded mudstone. [WARP DEPOSITS]	2
								Black silty, organic SAND.	
		3.00		N=23 (2,2/5,6,6,6)					3
		4.00		N=13 (1,2/2,3,4,4)					4
		4.00 - 5.00	B						
		5.00		N=13 (1,2/3,3,3,4)	4.90	-2.95		Stiff brown silty CLAY. [WARP DEPOSITS]	5
		6.50		N=13 (2,2/3,3,3,4)					6
		8.00		N=11 (2,2/2,2,3,4)					7
					8.80	-6.85		Very loose becoming dense dark brown SAND. Occasional gravel of fine, subrounded mudstone, siltstone and quartzite. [WARP DEPOSITS]	8
		9.50		N=2 (1,1/1,1,0,0)					9
									10

Continued on next sheet

Remarks

1. Cable percussive borehole location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater not encountered due to using water to advance the borehole. 3. Borehole refused at 14.00m bgl.





Borehole Log

Borehole No.

CP1

Sheet 2 of 2

Project Name: Lincs Lakes

Project No.
46069

Co-ords: 486125.36 - 408845.04

Hole Type
CPLocation: Land to the north-west of Junction 3 (M180), Scunthorpe,
Lincolnshire

Level: 1.95

Scale
1:50

Client: Keepmoat Homes Limited

Dates: 28/06/2023 - 29/06/2023

Logged By
SW

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		11.00		N=40 (4,3/3,6,13,18)					11
					11.90	-9.95			12
		12.50		N=50 (9,9/50 for 255mm)				Hard brown and blue silty CLAY. [WEATHERED MERCIA MUDSTONE GROUP]	13
									14
		14.00		50 (16,9/50 for 200mm)	14.00	-12.05		End of borehole at 14.00 m	15
									16
									17
									18
									19
									20

Remarks

1. Cable percussive borehole location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater not encountered due to using water to advance the borehole. 3. Borehole refused at 14.00m bgl.





Borehole Log

Borehole No.

CP2

Sheet 1 of 2

Project Name: Lincs Lakes

Project No.
46069

Co-ords: 486480.38 - 408790.61

Hole Type
CPLocation: Land to the north-west of Junction 3 (M180), Scunthorpe,
Lincolnshire

Level: 2.40

Scale
1:50

Client: Keepmoat Homes Limited

Dates: 30/06/2023 - 03/07/2023

Logged By
SW

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
					0.30	2.10		TOPSOIL: Brown silty SAND. Frequent roots.	
					0.90	1.50		Very loose orangish brown silty SAND. [WARP DEPOSITS]	
		1.20		N=1 (0,0/0,0,0,1)				Loose becoming medium dense brown SAND. Occasional gravel of fine, subrounded mudstone. [WARP DEPOSITS]	1
		2.00		N=14 (1,2/1,3,5,5)					2
		3.00		N=11 (1,1/2,2,3,4)	2.80	-0.40		Medium dense black silty organic SAND. [WARP DEPOSITS]	3
					3.10	-0.70		Medium dense dark brown silty SAND. Occasional gravel of fine, subrounded mudstone. [WARP DEPOSITS]	
		4.00		N=17 (2,2/4,3,5,5)					4
		5.00		N=13 (2,2/3,3,3,4)					5
					5.80	-3.40		Firm becoming stiff brown silty CLAY. [WARP DEPOSITS] <i>Becomes sandy.</i>	6
		6.50		N=5 (0,1/1,1,1,2)					7
		8.00		N=12 (2,2/3,3,3,3)				Laminated clay	8
					9.50	-7.10		Medium dense becoming dense dark brown silty SAND. Occasional gravel of fine, subrounded mudstone. [WARP DEPOSITS]	9
									10

Continued on next sheet

Remarks

1. Cable percussive borehole location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater encountered at 1.20mbgl, no further groundwater strikes encountered due to using water to advance the borehole. 3. Borehole terminated at target depth of 15.00mbgl.





Borehole Log

Borehole No.

CP2

Sheet 2 of 2

Project Name: Lincs Lakes

Project No.
46069

Co-ords: 486480.38 - 408790.61

Hole Type
CPLocation: Land to the north-west of Junction 3 (M180), Scunthorpe,
Lincolnshire

Level: 2.40

Scale
1:50

Client: Keepmoat Homes Limited

Dates: 30/06/2023 - 03/07/2023

Logged By
SW

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		11.00		N=39 (5,4/6,9,12,12)					11
		12.50		N=19 (2,3/4,5,5,5)	12.60	-10.20		Becomes more gravelly. Gravel of fine and medium, subrounded siltstone, mudstone and quartzite.	12
		15.00		N=32 (5,5/7,8,8,9)	15.00	-12.60		Hard blue silty CLAY. [WEATHERED MERCIA MUDSTONE GROUP]	13
									14
									15
								End of borehole at 15.00 m	16
									17
									18
									19
									20

Remarks

1. Cable percussive borehole location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater encountered at 1.20mbgl, no further groundwater strikes encountered due to using water to advance the borehole. 3. Borehole terminated at target depth of 15.00mbgl.





Borehole Log

Borehole No.

CP3

Sheet 1 of 2

Project Name: Lincs Lakes

Project No.
46069

Co-ords: 486238.34 - 408596.90

Hole Type
CPLocation: Land to the north-west of Junction 3 (M180), Scunthorpe,
Lincolnshire

Level: 2.17

Scale
1:50

Client: Keepmoat Homes Limited

Dates: 03/07/2023 - 04/07/2023

Logged By
SW

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
					0.20	1.97		TOPSOIL: Brown slightly clayey, silty SAND. Frequent roots	
		1.20		N=13 (2,2/2,3,4,4)				Medium dense orangish brown silty, slightly gravelly SAND. Gravel of fine, subrounded mudstone. [WARP DEPOSITS]	1
					1.65	0.52		Medium dense brown SAND. [WARP DEPOSITS]	
		2.00		N=17 (2,0/4,3,5,5)	2.00	0.17		Medium dense black clayey, silty SAND. Rare wood fragments and frequent blocks of peat. [WARP DEPOSITS]	2
		3.00 3.00 - 4.00		N=13 (0,0/1,3,4,5)	3.00	-0.83		Medium dense greyish brown slightly gravelly SAND. Gravel of fine, subrounded mudstone. [WARP DEPOSITS]	3
		4.00		N=8 (2,1/1,3,2,2)	3.80	-1.63		Medium dense brown SAND. Occasional gravel of fine, subrounded mudstone. [WARP DEPOSITS]	4
		5.00		N=15 (2,3/2,4,4,5)					5
					5.80	-3.63		Stiff brown silty CLAY. [WARP DEPOSITS]	6
		6.50		N=12 (2,2/3,3,3,3)					7
		8.00		N=12 (2,3/2,3,3,4)					8
					9.30	-7.13		Brown slightly gravelly SAND. Gravel of fine, subrounded mudstone, quartzite and siltstone. Rare gravel of fine, subangular flint. [WARP DEPOSITS]	9
		9.50		N=46 (25 for 125mm/22,9,8,7)					10

Continued on next sheet

Remarks

1. Cable percussive borehole location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater not encountered due to using water to advance the borehole. 3. Borehole terminated at target depth of 15.00mbgl.





Alan Wood & Partners

Borehole Log

Borehole No.

CP3

Sheet 2 of 2

Project Name: Lincs Lakes

Project No.
46069

Co-ords: 486238.34 - 408596.90

Hole Type
CP

Location: Land to the north-west of Junction 3 (M180), Scunthorpe,
Lincolnshire

Level: 2.17

Scale
1:50

Client: Keepmoat Homes Limited

Dates: 03/07/2023 - 04/07/2023

Logged By
SW

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		12.50		N=12 (1,1/2,2,3,5)	13.30	-11.13			11
		15.00		50 (25 for 145mm/50 for 285mm)	15.00	-12.83		Very stiff becoming hard brown and blue silty CLAY. [WEATHERED MERCIA MUDSTONE GROUP]	12
								End of borehole at 15.00 m	13
									14
									15
									16
									17
									18
									19
									20

Remarks

1. Cable percussive borehole location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater not encountered due to using water to advance the borehole. 3. Borehole terminated at target depth of 15.00mbgl.





Borehole Log

Borehole No.

CP4

Sheet 1 of 2

Project Name: Lincs Lakes

Project No.
46069

Co-ords: 486185.34 - 408466.00

Hole Type
CPLocation: Land to the north-west of Junction 3 (M180), Scunthorpe,
Lincolnshire

Level: 2.26

Scale
1:50

Client: Keepmoat Homes Limited

Dates: 05/07/2023 - 06/07/2023

Logged By
SW

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
					0.30	1.96		TOPSOIL: Brown slightly clayey, silty SAND. Frequent roots.	
		1.20		N=8 (1,1/2,2,2,2)				Loose brown SAND. Occasional fine, subrounded mudstone. [WARP DEPOSITS]	1
								Light orangish brown SAND.	
		2.00		N=7 (3,2/2,1,1,3)	2.00	0.26		Loose becoming medium dense black organic silty SAND. [WARP DEPOSITS]	2
		3.00		N=27 (4,4/4,5,7,11)	3.00	-0.74		Medium dense brown SAND. Occasional fine, subrounded mudstone. [WARP DEPOSITS]	3
		4.00		N=25 (4,4/4,5,8,8)					4
		5.00		N=19 (1,3/3,5,5,6)					5
					5.80	-3.54		Medium dense brown silty CLAY. [WARP DEPOSITS]	6
		6.50		N=21 (0,2/5,4,6,6)				Brown SAND.	7
		8.00		N=36 (3,3/6,10,10,10)	7.80	-5.54		Dense becoming very dense brown SAND. Occasional fine, subrounded mudstone. [WARP DEPOSITS]	8
		9.50		N=50 (7,8/50 for 230mm)					9
									10

Continued on next sheet

Remarks

1. Cable percussive borehole location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater not encountered due to using water to advance the borehole. 3. Borehole terminated at target depth of 15.00mbgl.





Borehole Log

Borehole No.

CP4

Sheet 2 of 2

Project Name: Lincs Lakes

Project No.
46069

Co-ords: 486185.34 - 408466.00

Hole Type
CPLocation: Land to the north-west of Junction 3 (M180), Scunthorpe,
Lincolnshire

Level: 2.26

Scale
1:50

Client: Keepmoat Homes Limited

Dates: 05/07/2023 - 06/07/2023

Logged By
SW

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		11.00		N=50 (2,5/50 for 265mm)					11
		12.50		N=11 (3,2/2,1,3,5)	13.20	-10.94		Becomes medium dense	12
		15.00		N=50 (7,8/50 for 245mm)	15.00	-12.74		Hard brown and blue silty CLAY. [WEATHERED MERCIA MUDSTONE GROUP]	13
								End of borehole at 15.00 m	14
									15
									16
									17
									18
									19
									20

Remarks

1. Cable percussive borehole location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater not encountered due to using water to advance the borehole. 3. Borehole terminated at target depth of 15.00mbgl.





Borehole Log

Borehole No.

CP5

Sheet 1 of 2

Project Name: Lincs Lakes

Project No.
46069

Co-ords: 486457.65 - 408442.16

Hole Type
CPLocation: Land to the north-west of Junction 3 (M180), Scunthorpe,
Lincolnshire

Level: 2.51

Scale
1:50

Client: Keepmoat Homes Limited

Dates: 06/07/2023 - 07/07/2023

Logged By
SW

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.40 - 1.20	B		0.40	2.11		TOPSOIL: Brown slightly clayey, silty SAND. Frequent roots.	
		1.20		N=9 (1,1/2,2,3,2)				Loose brown SAND. Occasional gravel of fine, subrounded mudstone. [WARP DEPOSITS]	1
		2.00		N=12 (1,1/2,2,3,5)	2.00	0.51		Orange and light orangish brown SAND.	
		3.00		N=7 (0,0/1,1,2,3)	3.00	-0.49		Medium dense black organic silty SAND. [WARP DEPOSITS]	2
		4.00		N=8 (1,1/2,1,3,2)				Loose becoming medium dense brown SAND. Occasional gravel of fine, subrounded mudstone. [WARP DEPOSITS]	3
		5.00		N=11 (1,2/2,3,3,3)					4
		5.60			5.60	-3.09		Soft becoming stiff brown silty CLAY. [WARP DEPOSITS]	5
		6.50		N=3 (0,0/0,2,1,0)				Becomes soft. Becomes sandy with rare gravel of fine, subrounded mudstone.	6
		8.00		N=13 (3,2/3,3,3,4)					7
		9.20			9.20	-6.69		Medium dense brown gravelly SAND. Gravel of fine and medium, subrounded mudstone, quartz, siltstone and sandstone. [WARP DEPOSITS]	8
		9.50		N=13 (3,2/3,3,3,4)					9
								Continued on next sheet	10

Remarks

1. Cable percussive borehole location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater not encountered due to using water to advance the borehole. 3. Borehole terminated at target depth of 15.00mbgl.





Alan Wood & Partners

Borehole Log

Borehole No.

CP5

Sheet 2 of 2

Project Name: Lincs Lakes

Project No.
46069

Co-ords: 486457.65 - 408442.16

Hole Type
CPLocation: Land to the north-west of Junction 3 (M180), Scunthorpe,
Lincolnshire

Level: 2.51

Scale
1:50

Client: Keepmoat Homes Limited

Dates: 06/07/2023 - 07/07/2023

Logged By
SW

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		11.00		N=24 (2,3/4,5,7,8)					11
					12.90	-10.39			12
									13
								Hard brown and blue silty, gravelly CLAY. Gravel of fine and medium, subrounded mudstone and siltstone. [WEATHERED MERCIA MUDSTONE GROUP]	14
		15.00		N=50 (7,11/50 for 245mm)	15.00	-12.49			15
								End of borehole at 15.00 m	16
									17
									18
									19
									20

Remarks

1. Cable percussive borehole location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater not encountered due to using water to advance the borehole. 3. Borehole terminated at target depth of 15.00mbgl.





Borehole Log

Borehole No.

WS1

Sheet 1 of 1

Project Name: Lincs Lakes

Project No.
46069

Co-ords: 485904.71 - 408626.73

Hole Type
WLSLocation: Land to the north-west of Junction 3 (M180), Scunthorpe,
Lincolnshire

Level: 2.07

Scale
1:50

Client: Keepmoat Homes Limited

Dates: 28/06/2023 - 28/06/2023

Logged By
SW

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
					0.12	1.95		TOPSOIL: Dark brown silty SAND. Frequent roots.	
								Loose orangish brown slightly sandy SILT. [WARP DEPOSITS]	
		1.00		N=9 (0,2/2,3,2,2)	0.70	1.37		Loose brown mottled orange slightly clayey, silty SAND. [WARP DEPOSITS]	1
					1.15	0.92		Loose black clayey, silty SAND with a slight organic odour. [WARP DEPOSITS]	
					1.42	0.65		Damp loose brown SAND. [WARP DEPOSITS]	
		2.00		N=8 (2,0/0,1,3,4)					2
	▼				2.30	-0.23		Medium dense black SAND. [WARP DEPOSITS]	
					2.50	-0.43		Medium dense dark brown SAND. [WARP DEPOSITS]	
	▼	3.00		N=21 (2,2/3,4,6,8)	2.85	-0.78		Damp medium dense dark brown clayey, silty SAND. [WARP DEPOSITS]	3
					3.80	-1.73		Wet dense brown silty SAND. [WARP DEPOSITS]	
	▼	4.00		N=50 (6,8/50 for 265mm)	4.00	-1.93		Wet dense brown silty SAND. [WARP DEPOSITS]	4
								End of borehole at 4.00 m	
									5
									6
									7
									8
									9
									10

Remarks

1. Windowless borehole location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater encountered at 2.25m, 3.00m and 3.90m bgl. 3. Borehole refused at 4.00m bgl.





Borehole Log

Borehole No.

WS2

Sheet 1 of 1

Project Name: Lincs Lakes

Project No.
46069

Co-ords: 485972.27 - 408627.81

Hole Type
WLSLocation: Land to the north-west of Junction 3 (M180), Scunthorpe,
Lincolnshire

Level: 1.79

Scale
1:50

Client: Keepmoat Homes Limited

Dates: 28/06/2023 - 28/06/2023

Logged By
SW

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
					0.10	1.69		TOPSOIL: Brown silty SAND. Frequent roots. Medium dense orangish brown slightly sandy SILT. [WARP DEPOSITS]	
		1.00		N=16 (2,2/3,4,4,5)	0.80 0.90	0.99 0.89		Medium dense black silty SAND. [WARP DEPOSITS]	1
					1.20	0.59		Medium dense light orangish brown SAND. [WARP DEPOSITS]	
					1.40	0.39		Damp medium dense brown mottled orange SAND. [WARP DEPOSITS]	
		2.00		N=16 (1,4/5,5,4,2)				Damp medium dense greyish brown SAND. [WARP DEPOSITS]	2
					2.65	-0.86		Stiff black clayey organic SAND. [WARP DEPOSITS]	
		3.00		N=50 (3,4/7,12,16,15)	2.85 3.00	-1.06 -1.21		Dense dark grey SAND. [WARP DEPOSITS]	3
								End of borehole at 3.00 m	
									4
									5
									6
									7
									8
									9
									10

Remarks

1. Windowless borehole location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater encountered at 1.30m bgl. 3. Borehole refused at 3.00m bgl.





Borehole Log

Borehole No.

WS3

Sheet 1 of 1

Project Name: Lincs Lakes

Project No.
46069

Co-ords: 486023.58 - 408612.51

Hole Type
WLSLocation: Land to the north-west of Junction 3 (M180), Scunthorpe,
Lincolnshire

Level: 2.22

Scale
1:50

Client: Keepmoat Homes Limited

Dates: 28/06/2023 - 28/06/2023

Logged By
SW

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
					0.10	2.12		TOPSOIL: Brown silty SAND. Frequent roots	
								Medium dense orangish brown slightly sandy SILT. [WARP DEPOSITS]	
		0.80	D		0.60	1.62		Firm brown mottled orange silty CLAY. [WARP DEPOSITS]	
		1.00		N=13 (2,2/3,3,3,4)	0.95	1.27		Loose black SAND. [WARP DEPOSITS]	1
					1.00	1.22		Damp medium dense dark brown SAND. [WARP DEPOSITS]	
					1.30	0.92		Damp medium dense orangish brown SAND. [WARP DEPOSITS]	
					1.45	0.77		Damp medium dense light brown SAND. [WARP DEPOSITS]	
					1.65	0.57		Damp medium dense grey SAND. [WARP DEPOSITS]	2
		2.00		N=11 (3,3/3,2,3,3)	2.00	0.22		Wet medium dense brown SAND. [WARP DEPOSITS]	
					2.30	-0.08		Damp loose grey SAND. [WARP DEPOSITS]	
					2.45	-0.23		Medium dense black silty, organic SAND. [WARP DEPOSITS]	3
					2.60	-0.38		Damp medium dense grey SAND. [WARP DEPOSITS]	
								Damp medium dense brown SAND. [WARP DEPOSITS]	
		3.00		N=30 (5,5/5,8,8,9)	3.20	-0.98		Dense orangish brown SAND. [WARP DEPOSITS]	4
					3.90	-1.68			
		4.00		50 (10,11/50 for 200mm)	4.00	-1.78			
								End of borehole at 4.00 m	

Remarks

1. Windowless borehole location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater encountered at 1.95m, 2.10m and 3.40m bgl. 3. Borehole refused at 4.00m bgl.





Trial Pit Log

Trialpit No

TP101

Sheet 1 of 1

Project Name: Lincs Lakes

Project No.
46069Co-ords: 486003.93 - 408857.59
Level: 1.85Date
30/06/2023Location: Land to the north-west of Junction 3 (M180), Scunthorpe,
LincolnshireDimensions
(m):Depth
2.60Scale
1:25Logged
SW

Client: Keepmoat Homes Limited

Water Strike	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
	Depth	Type	Results					
				0.30	1.55		TOPSOIL: Brown slightly clayey, silty SAND. Frequent roots.	
	0.40 0.40	B D					Medium dense brown mottled orange silty SAND. [WARP DEPOSITS]	
				1.00	0.85		Loose black clayey, organic SAND. [WARP DEPOSITS]	1
				1.20	0.65		Loose grey SAND with rare wood fragments. [WARP DEPOSITS] <i>Pockets of orange sand.</i>	
	1.60	D						
	2.00	B					<i>Blocks of orangish brown clay.</i>	2
	2.40	B						
				2.60	-0.75		End of pit at 2.60 m	3
								4
								5

Remarks: 1. Trial pit location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater not encountered.

Stability: Unstable





Trial Pit Log

Trialpit No

TP102

Sheet 1 of 1

Project Name:	Lincs Lakes	Project No.	46069	Co-ords:	486009.79 - 408788.80	Date	30/06/2023
Location:	Land to the north-west of Junction 3 (M180), Scunthorpe, Lincolnshire	Dimensions (m):	Depth 2.50	Level:	1.52	Scale	1:25
Client:	Keepmoat Homes Limited					Logged	SW

Water Strike	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
	Depth	Type	Results					
	0.10	D					TOPSOIL: Brown slightly clayey, silty SAND. Frequent roots.	
	0.50	B		0.40	1.12		Medium dense orangish brown SAND. [WARP DEPOSITS]	
				0.80	0.72		Black clayey, organic SAND. [WARP DEPOSITS]	1
				1.40	0.12		Damp loose grey slightly clayey, silty SAND with blocks of orange clay. Rare wood fragments. [WARP DEPOSITS]	
	1.80	B						2
	2.10	B						
	2.40	B		2.50	-0.98			
							End of pit at 2.50 m	3
								4
								5

Remarks: 1. Trial pit location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater encountered at 1.70mbgl.

Stability: Unstable





Trial Pit Log

Trialpit No

TP103

Sheet 1 of 1

Project Name: Lincs Lakes

Project No.
46069

Co-ords: 485986.95 - 408718.41

Level: 1.52

Date

30/06/2023

Location: Land to the north-west of Junction 3 (M180), Scunthorpe,
LincolnshireDimensions
(m):Depth
2.20

Scale

1:25

Logged
SW

Client: Keepmoat Homes Limited

Water Strike	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
	Depth	Type	Results					
				0.30	1.22		TOPSOIL: Brown slightly clayey, silty SAND. Frequent roots.	
				0.70	0.82		Loose brown mottled orange silty SAND. [WARP DEPOSITS]	
				1.00	0.52		Loose black clayey, organic SAND. [WARP DEPOSITS]	
				1.15	0.37		Loose light grey mottled orange silty SAND. [WARP DEPOSITS]	1
				1.30	0.22		Loose brown silty SAND. [WARP DEPOSITS]	
				2.20	-0.68		Damp loose grey slightly clayey SAND with blocks of orangish grey clay. [WARP DEPOSITS]	2
							End of pit at 2.20 m	
								3
								4
								5

Remarks: 1. Trial pit location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater not encountered.

Stability: Unstable





Trial Pit Log

Trialpit No

TP104

Sheet 1 of 1

Project Name: Lincs Lakes

Project No.
46069

Co-ords: 485969.99 - 408648.15

Level: 1.72

Date

30/06/2023

Location: Land to the north-west of Junction 3 (M180), Scunthorpe,
LincolnshireDimensions
(m):Depth
2.20

Scale

1:25

Logged
SW

Client: Keepmoat Homes Limited

Water Strike	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
	Depth	Type	Results					
				0.25	1.47		TOPSOIL: Brown slightly clayey, silty SAND. Frequent roots.	
	0.40	B					Loose orangeish brown silty SAND with occasional blocks of grey mottled orange clay. [WARP DEPOSITS]	
	0.50	B						
	0.50	D						
				0.70	1.02		Black clayey, organic SAND. [WARP DEPOSITS]	
				0.90	0.82		Loose light orangeish grey silty SAND. [WARP DEPOSITS]	
				1.00	0.72		Damp loose grey slightly clayey SAND with blocks of peat. [WARP DEPOSITS]	1
	1.70	B						
				2.20	-0.48		End of pit at 2.20 m	2
								3
								4
								5

Remarks: 1. Trial pit location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater encountered at 1.90mbgl.

Stability: Unstable





Trial Pit Log

Trialpit No

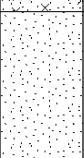
TP106

Sheet 1 of 1

Project Name: Lincs Lakes

Project No.
46069Co-ords: 485961.43 - 408528.27
Level: 1.91Date
30/06/2023Location: Land to the north-west of Junction 3 (M180), Scunthorpe,
LincolnshireDimensions
(m):Depth
2.40Scale
1:25Logged
SW

Client: Keepmoat Homes Limited

Water Strike	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
	Depth	Type	Results					
	0.80	B		0.30 0.50 0.60	1.61 1.41 1.31	   	TOPSOIL: Brown slightly clayey, silty SAND. Medium dense orangish brown silty SAND. [WARP DEPOSITS] Loose black clayey, organic SAND. [WARP DEPOSITS] Medium dense light orange and orange silty SAND. Occasional gravel of fine to coarse, subrounded sandstone. [WARP DEPOSITS]	1
	1.90	B		1.70	0.21		Loose greyish brown SAND. Occasional gravel of fine to coarse, subrounded sandstone. [WARP DEPOSITS]	2
				2.40	-0.49		Gravel of coarse, angular brick. End of pit at 2.40 m	3
								4
								5

Remarks: 1. Trial pit location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater not encountered.

Stability: Unstable





Trial Pit Log

Trialpit No

TP107

Sheet 1 of 1

Project Name: Lincs Lakes

Project No.
46069

Co-ords: 486026.72 - 408592.69

Level: 1.88

Date

30/06/2023

Location: Land to the north-west of Junction 3 (M180), Scunthorpe,
LincolnshireDimensions
(m):Depth
2.40

Scale

1:25

Logged
SW

Client: Keepmoat Homes Limited

Water Strike	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
	Depth	Type	Results					
							TOPSOIL: Brown slightly clayey, silty SAND.	
				0.40	1.48			
				0.60	1.28		Medium dense orangish brown silty SAND. [WARP DEPOSITS]	
	0.70	B		0.70	1.18		Loose black clayey, organic SAND. [WARP DEPOSITS]	
	0.70	D		0.80	1.08		Medium dense light brown mottled orange silty SAND. [WARP DEPOSITS]	
							Damp loose slightly clayey SAND with blocks of peat. [WARP DEPOSITS]	1
								2
	2.40	B		2.40	-0.52		End of pit at 2.40 m	3
								4
								5

Remarks: 1. Trial pit location cleared of below ground utilities using ground penetrating radar and cable avoidance tool with signal generator. 2. Groundwater encountered at 2.00mbgl.

Stability: Unstable



SPT Hammer Energy Test Report

in accordance with BSEN ISO 22476-3:2005

ARCHWAY ENGINEERING (UK) LTD
AINLEYS INDUSTRIAL ESTATE
ELLAND
WEST YORKSHIRE
HX5 9JP

SPT Hammer Ref: RP05
Test Date: 26/05/2022
Report Date: 26/05/2022
File Name: RP05.spt
Test Operator: JL

Instrumented Rod Data

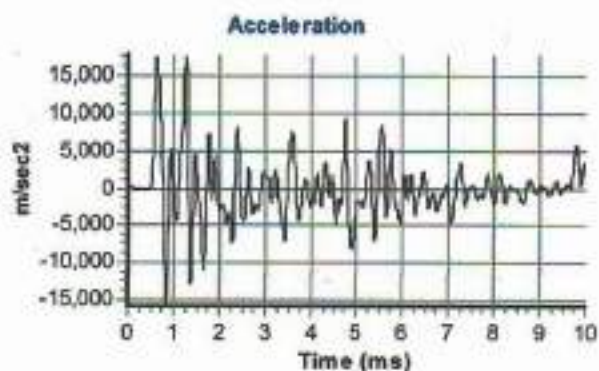
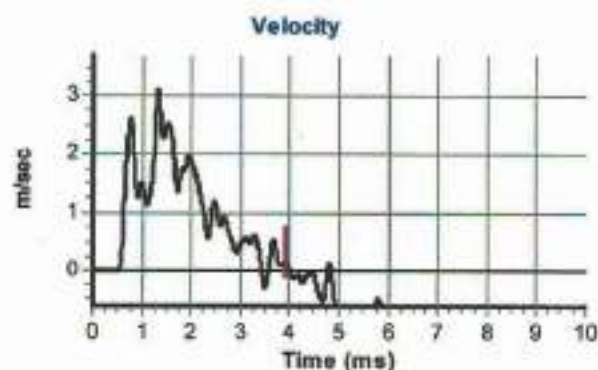
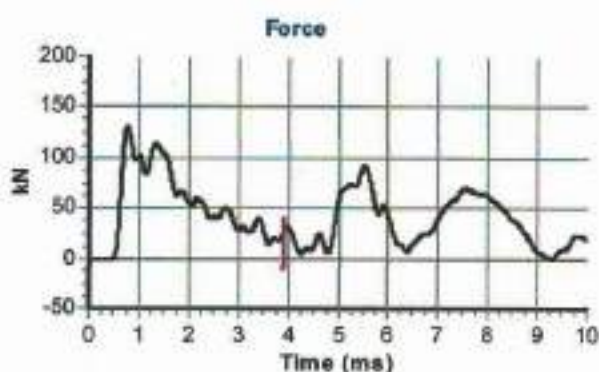
Diameter d_r (mm): 54
Wall Thickness t_r (mm): 6.5
Assumed Modulus E_a (GPa): 208
Accelerometer No.1: 72572
Accelerometer No.2: 72757

SPT Hammer Information

Hammer Mass m (kg): 63.5
Falling Height h (mm): 760
SPT String Length L (m): 10.0

Comments / Location

R P DRILLING - 80485



Calculations

Area of Rod A (mm²): 970
Theoretical Energy E_{theor} (J): 473
Measured Energy E_{meas} (J): 322

Energy Ratio E_r (%): **68**

Signed: J.LOCK

Title: FITTER

The recommended calibration interval is 12 months

SPT Hammer Energy Test Report

in accordance with BSEN ISO 22476-3:2005

ARCHWAY ENGINEERING UK LTD
AINLEYS INDUSTRIAL ESTATE
ELLAND
WEST YORKSHIRE
HX5 9JP

SPT Hammer Ref: CP03
Test Date: 05/09/2022
Report Date: 05/10/2022
File Name: CP03.spt
Test Operator: JL

Instrumented Rod Data

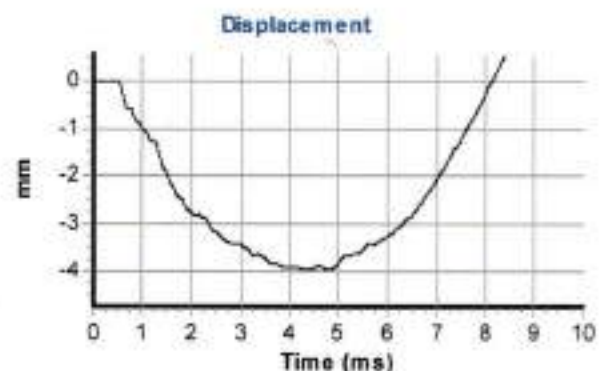
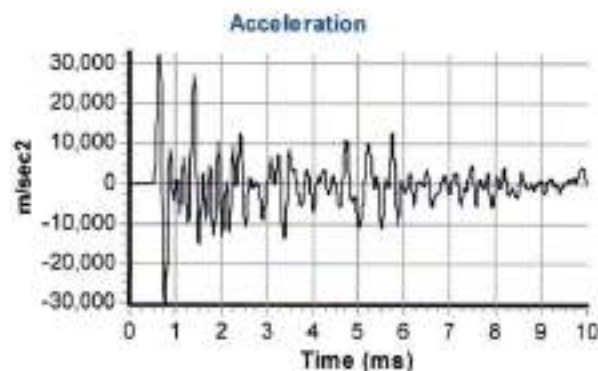
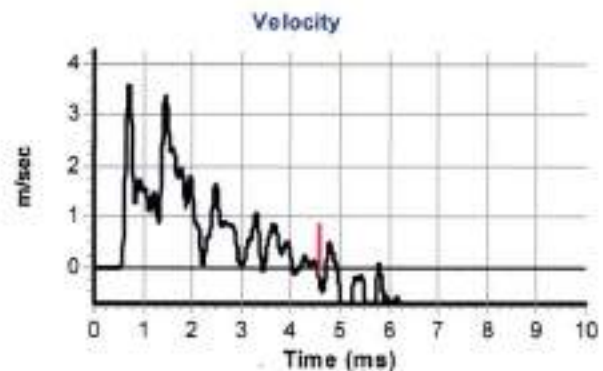
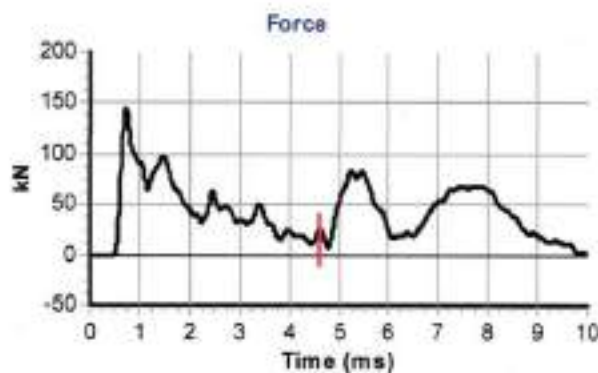
Diameter d_r (mm): 54
Wall Thickness t_r (mm): 6.5
Assumed Modulus E_a (GPa): 208
Accelerometer No.1: 72572
Accelerometer No.2: 72757

SPT Hammer Information

Hammer Mass m (kg): 63.5
Falling Height h (mm): 760
SPT String Length L (m): 10.0

Comments / Location

RP DRILLING - 81765



Calculations

Area of Rod A (mm²): 970
Theoretical Energy E_{theor} (J): 473
Measured Energy E_{meas} (J): 342

Energy Ratio E_r (%): **72**

Signed: J.LOCK
Title: FITTER

APPENDIX B

LABORATORY TESTING: GEOTECHNICAL



LABORATORY REPORT



Contract Number: PSL23/5280

Report Date: 28 July 2023

Client's Reference:

Client Name: Alan Wood & Partners
Hallamshire House
Meadow Court
Hayland Street
Sheffield
S9 1BY

For the attention of: Sophie Williams

Contract Title: Lincs Lakes

Date Received: 4/7/2023

Date Commenced: 4/7/2023

Date Completed: 28/7/2023

Notes: Opinions and Interpretations are outside the UKAS Accreditation

A copy of the Laboratory Schedule of accredited tests as issued by UKAS is attached to this report. This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced other than in full, without the prior written approval of the laboratory.

Checked and Approved Signatories:

A Watkins
(Director)

R Berriman
(Quality Manager)

S Royle
(Laboratory Manager)


L Knight
(Assistant Laboratory Manager)

S Eyre
(Senior Technician)

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Page 1 of

SUMMARY OF LABORATORY SOIL DESCRIPTIONS

Hole Number	Sample Number	Sample Type	Top Depth m	Base Depth m	Description of Sample
TP101	1	B	0.40		Brown slightly clayey very silty SAND.
TP101	2	B	2.00		Brown silty SAND.
TP101	3	B	2.40		Brown silty SAND.
TP102	1	B	1.80		Brown silty SAND.
TP102	2	B	2.10		Brown silty SAND.
TP102	3	B	2.40		Brown silty SAND.
TP102	4	B	0.50		Brown slightly sandy CLAY.
TP104	1	B	0.50		Brown sandy very silty CLAY.
TP104	2	B	0.40		Brown sandy very silty CLAY.
TP104	3	B	1.70		Brown silty SAND.
TP105	1	B	0.60		Brown silty SAND.
TP105	2	B	1.00		Brown silty SAND.
TP105	3	B	1.10		Brown silty SAND.
TP106	1	B	0.80		Brown silty SAND.
TP106	2	B	1.90		Brown silty SAND.
TP107	1	B	0.70		Brown very silty SAND.
TP107	2	B	2.40		Brown slightly gravelly silty SAND.
CP1	1	B	4.00	5.00	Brown silty SAND.
CP3	1	B	3.00	4.00	Brown silty SAND.



Lincs Lakes

Contract No:

PSL23/5280

Client Ref:

S5497/46069

SUMMARY OF LABORATORY SOIL DESCRIPTIONS

[illegible]

Lincs Lakes

Contract No:**PSL23/5280****Client Ref:**

S5497/46069

SUMMARY OF SOIL CLASSIFICATION TESTS

(BS1377 : PART 2 : 1990

[illegible]

SYMBOLS : NP : Non Plastic

*** : Liquid Limit and Plastic Limit Wet Sieved.**



Lincs Lakes

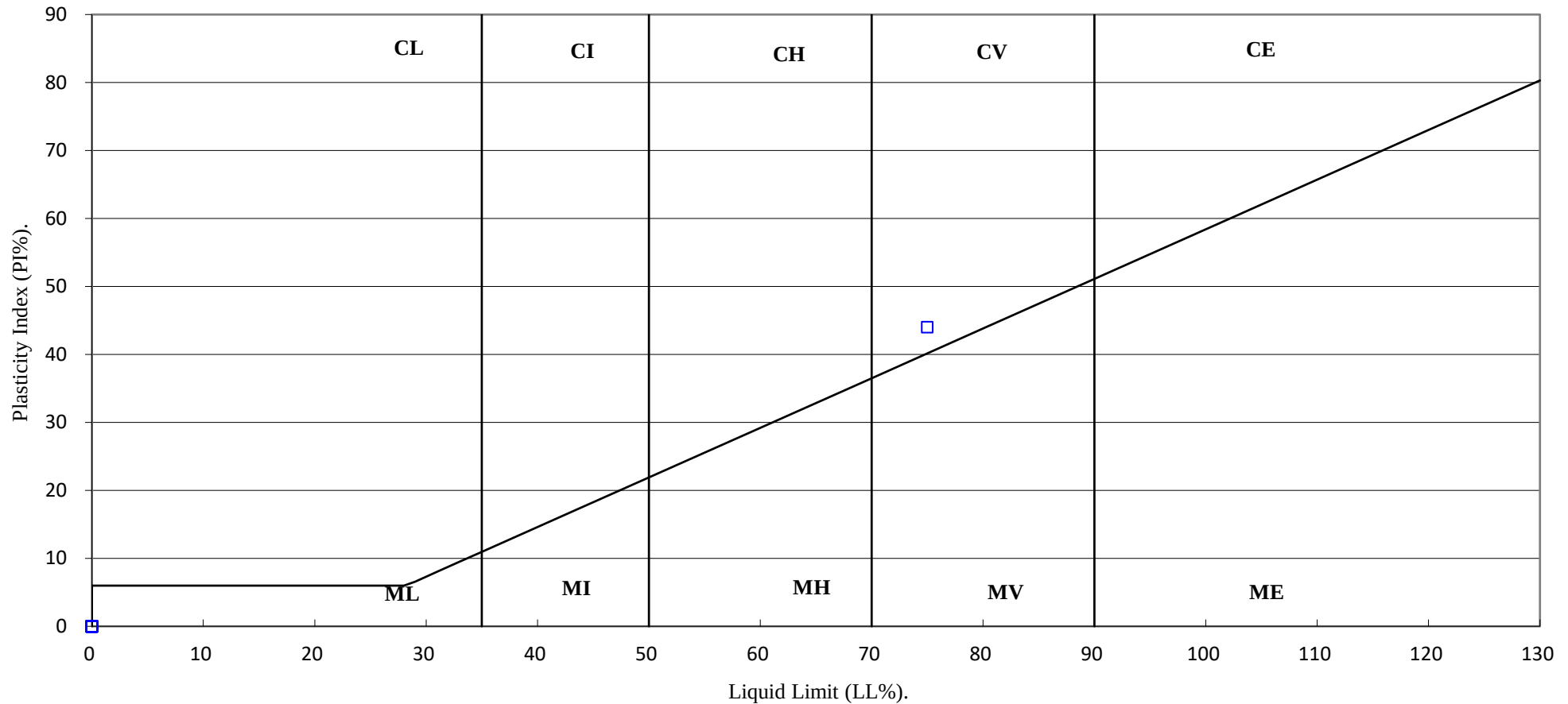
Contract No:

PSL23/5280

Client Ref:

S5497/46069

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION.



Lincs Lakes

Contract No:

PSL23/5280

Client Ref:

S5497/46069

PARTICLE SIZE DISTRIBUTION TEST

BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

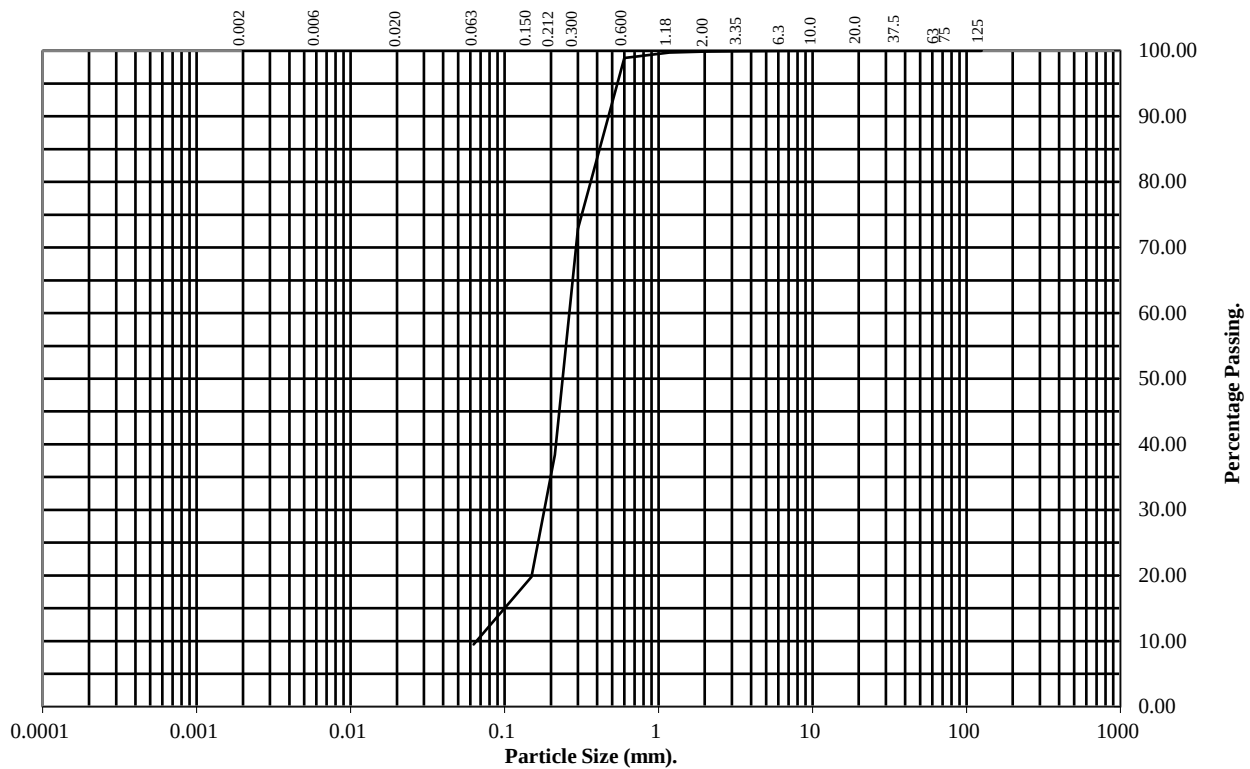
Hole Number: TP101

Top Depth (m): 2.00

Sample Number: 2

Base Depth(m):

Sample Type: B



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	100
6.3	100
3.35	100
2	100
1.18	100
0.6	99
0.3	73
0.212	38
0.15	20
0.063	9

Soil Fraction	Total Percentage
Cobbles	0
Gravel	0
Sand	91
Silt/Clay	9

Remarks:

See Summary of Soil Descriptions



Lincs Lakes

Contract No:
PSL23/5280
Client Ref:
S5497/46069

PARTICLE SIZE DISTRIBUTION TEST

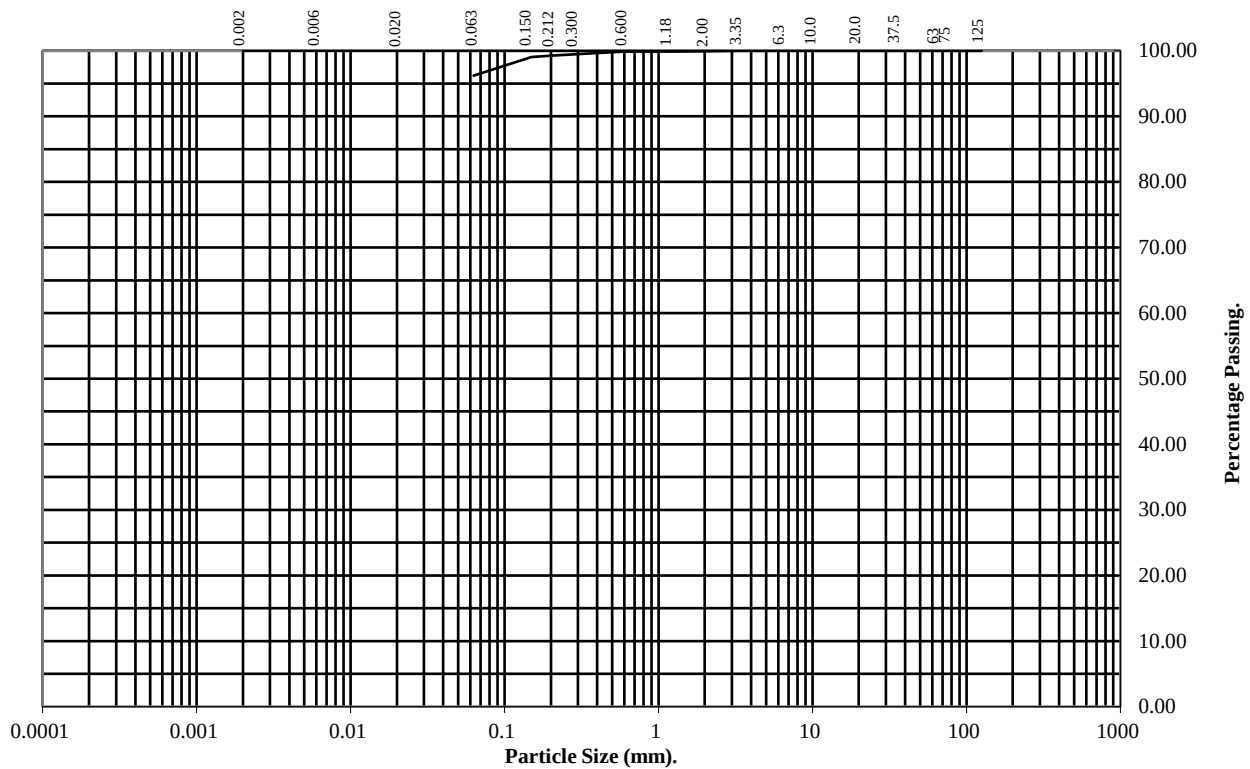
BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

Hole Number: TP102 Top Depth (m): 0.50

Sample Number: 4 Base Depth(m):

Sample Type: B



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	100
6.3	100
3.35	100
2	100
1.18	100
0.6	100
0.3	99
0.212	99
0.15	99
0.063	96

Soil Fraction	Total Percentage
Cobbles	0
Gravel	0
Sand	4
Silt/Clay	96

Remarks:

See Summary of Soil Descriptions



Lincs Lakes

Contract No:
PSL23/5280
Client Ref:
S5497/46069

PARTICLE SIZE DISTRIBUTION TEST

BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

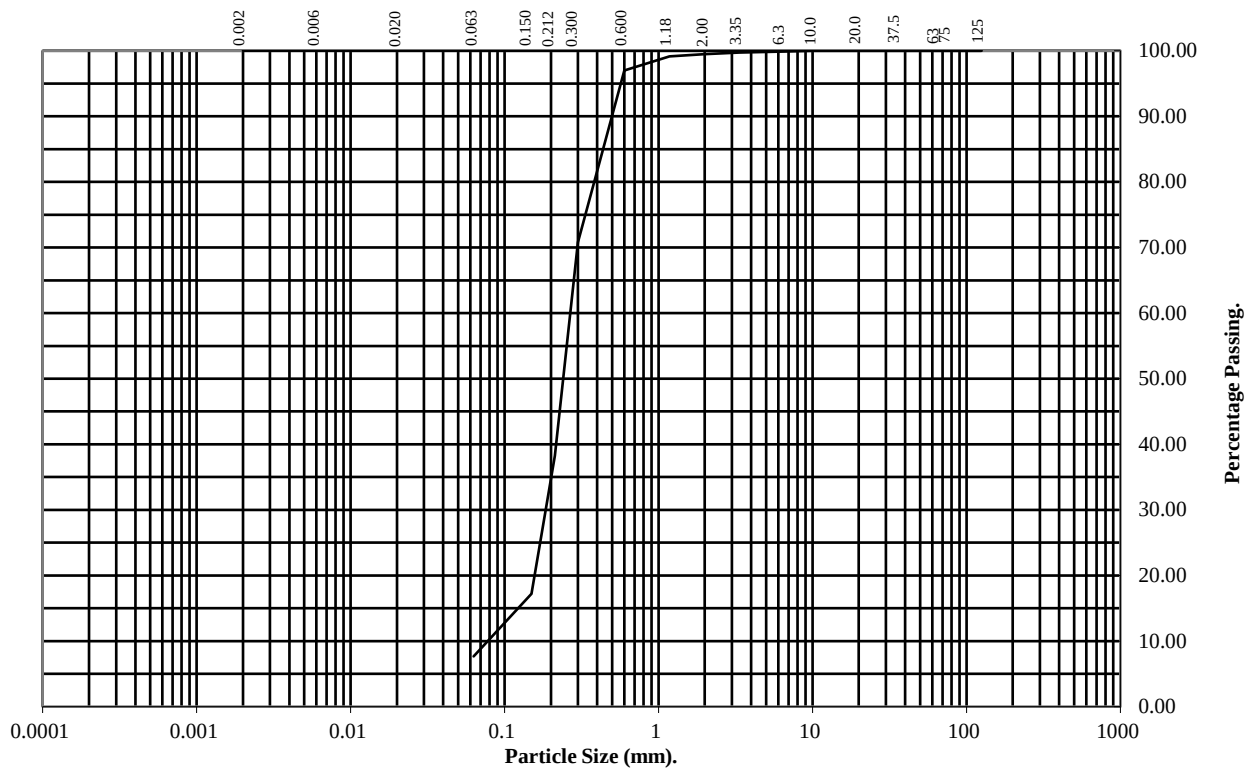
Hole Number: TP102

Top Depth (m): 1.80

Sample Number: 1

Base Depth(m):

Sample Type: B



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	100
6.3	100
3.35	100
2	100
1.18	99
0.6	97
0.3	71
0.212	38
0.15	17
0.063	8

Soil Fraction	Total Percentage
Cobbles	0
Gravel	0
Sand	92
Silt/Clay	8

Remarks:

See Summary of Soil Descriptions



Lincs Lakes

Contract No:
PSL23/5280
Client Ref:
S5497/46069

PARTICLE SIZE DISTRIBUTION TEST

BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

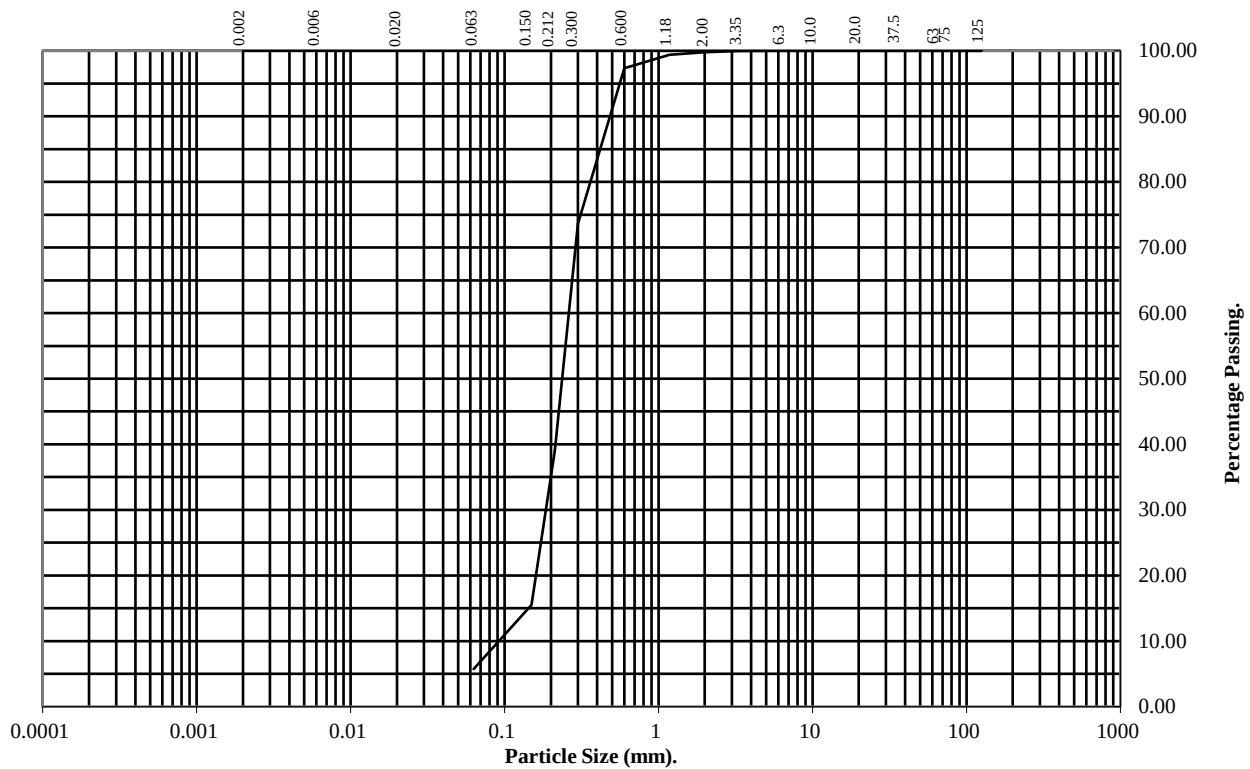
Hole Number: TP102

Top Depth (m): 2.40

Sample Number: 3

Base Depth(m):

Sample Type: B



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	100
6.3	100
3.35	100
2	100
1.18	99
0.6	97
0.3	74
0.212	39
0.15	15
0.063	6

Soil Fraction	Total Percentage
Cobbles	0
Gravel	0
Sand	94
Silt/Clay	6

Remarks:

See Summary of Soil Descriptions



Lincs Lakes

Contract No:
PSL23/5280
Client Ref:
S5497/46069

PARTICLE SIZE DISTRIBUTION TEST

BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

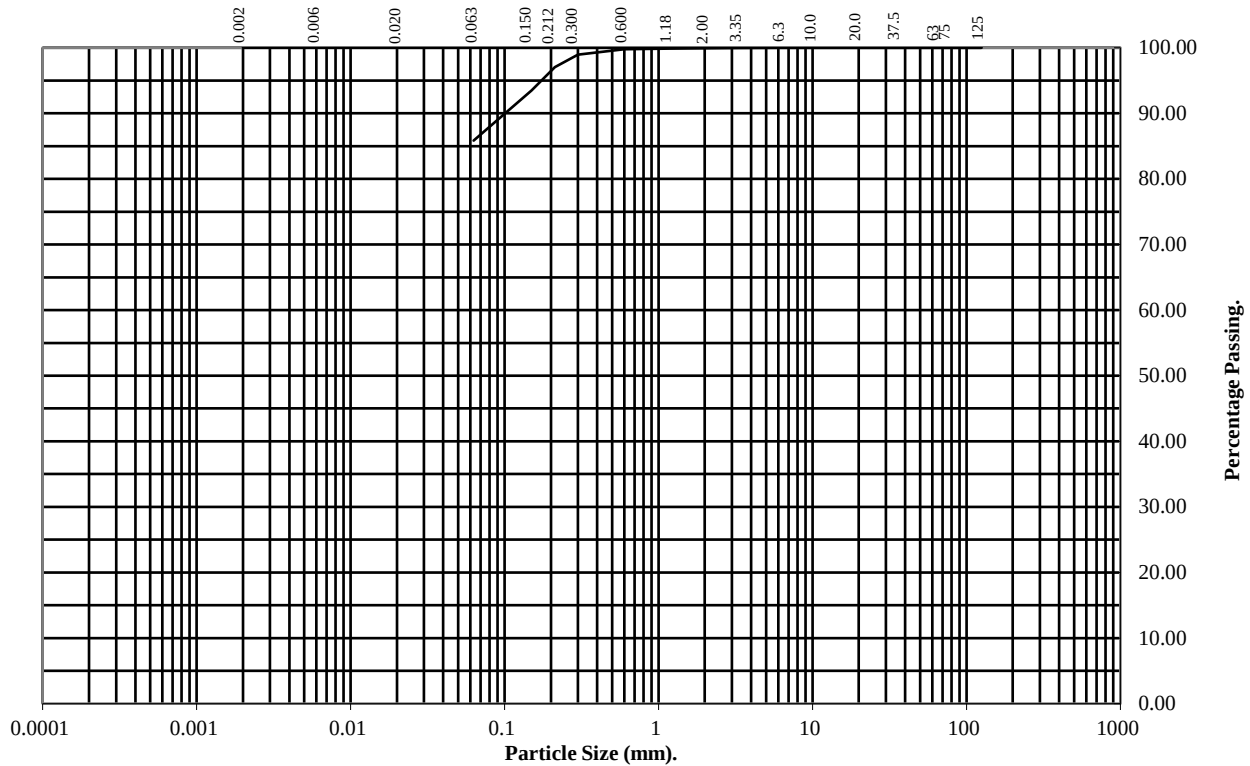
Hole Number: TP104

Top Depth (m): 0.40

Sample Number: 2

Base Depth(m):

Sample Type: B



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	100
6.3	100
3.35	100
2	100
1.18	100
0.6	100
0.3	99
0.212	97
0.15	93
0.063	86

Soil Fraction	Total Percentage
Cobbles	0
Gravel	0
Sand	14
Silt/Clay	86

Remarks:

See Summary of Soil Descriptions



Lincs Lakes

Contract No:
PSL23/5280
Client Ref:
S5497/46069

PARTICLE SIZE DISTRIBUTION TEST

BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

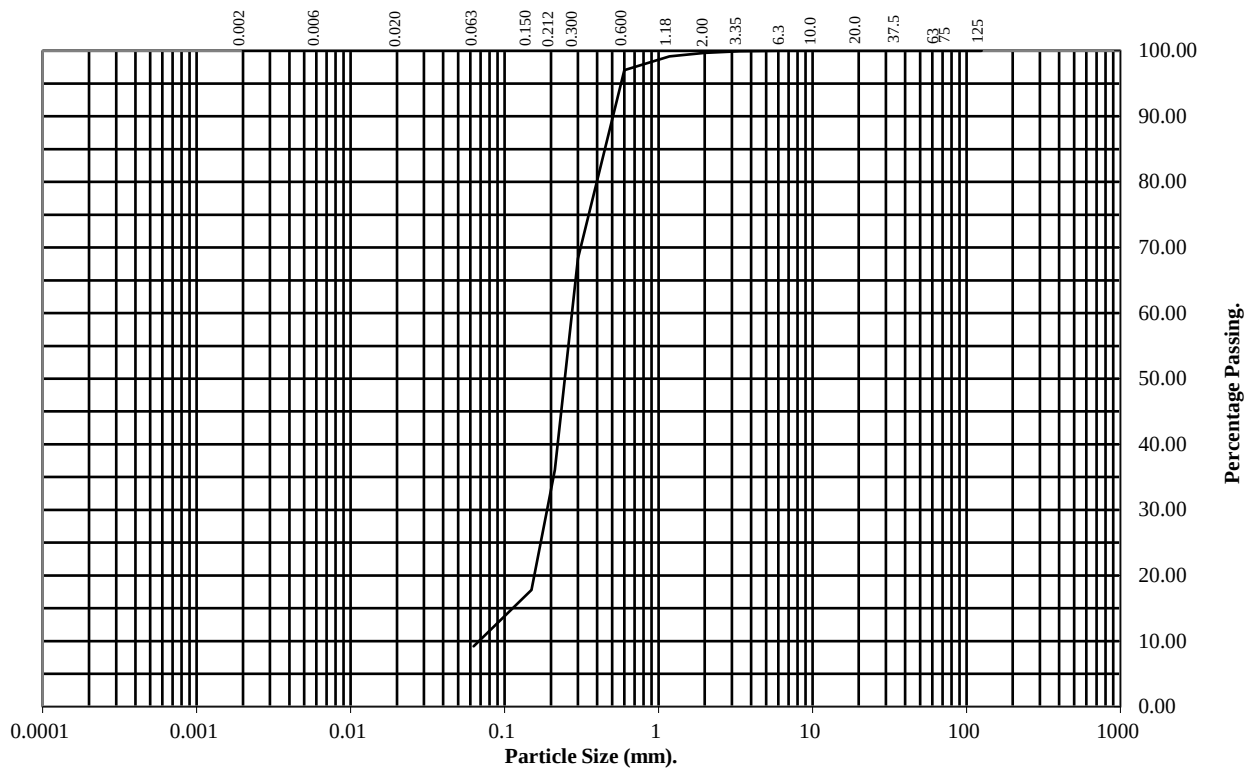
Hole Number: TP105

Top Depth (m): 1.10

Sample Number: 3

Base Depth(m):

Sample Type: B



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	100
6.3	100
3.35	100
2	100
1.18	99
0.6	97
0.3	68
0.212	36
0.15	18
0.063	9

Soil Fraction	Total Percentage
Cobbles	0
Gravel	0
Sand	91
Silt/Clay	9

Remarks:

See Summary of Soil Descriptions



Lincs Lakes

Contract No:
PSL23/5280
Client Ref:
S5497/46069

PARTICLE SIZE DISTRIBUTION TEST

BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

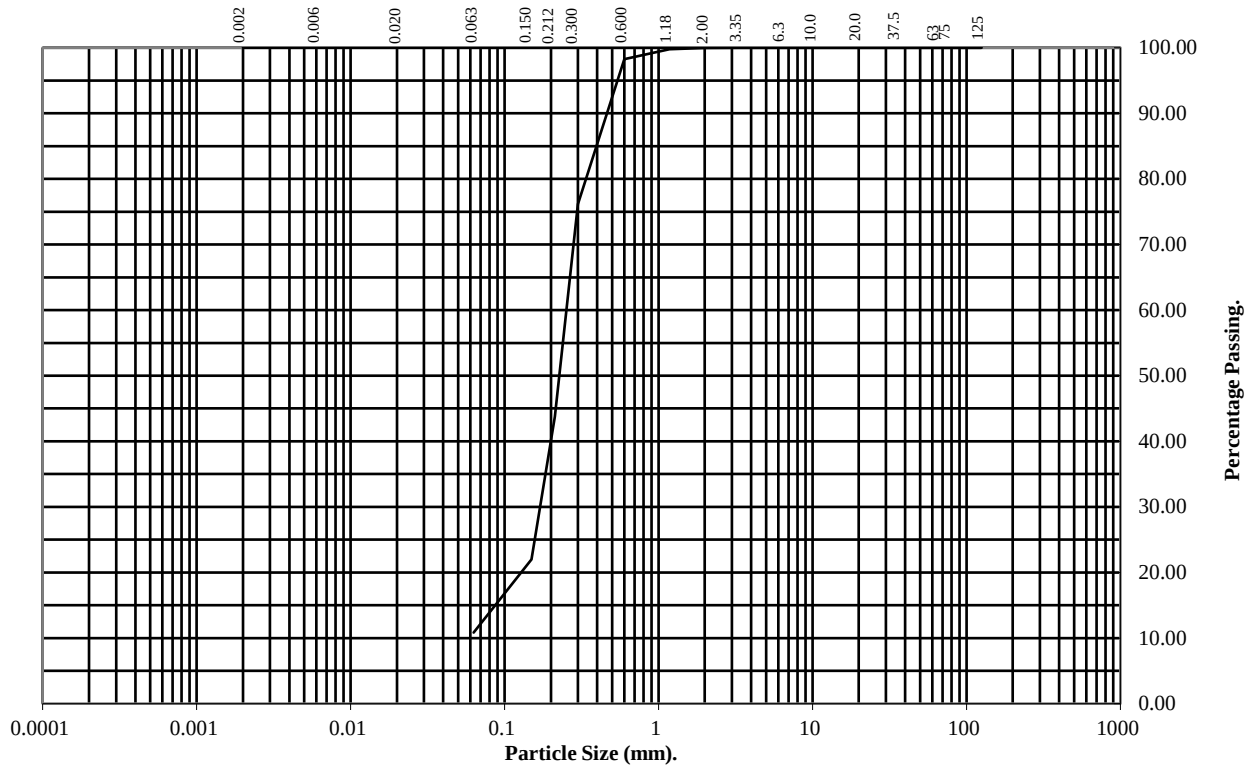
Hole Number: TP106

Top Depth (m): 1.90

Sample Number: 2

Base Depth(m):

Sample Type: B



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	100
6.3	100
3.35	100
2	100
1.18	100
0.6	98
0.3	76
0.212	44
0.15	22
0.063	11

Soil Fraction	Total Percentage
Cobbles	0
Gravel	0
Sand	89
Silt/Clay	11

Remarks:

See Summary of Soil Descriptions



Lincs Lakes

Contract No:
PSL23/5280
Client Ref:
S5497/46069

PARTICLE SIZE DISTRIBUTION TEST

BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

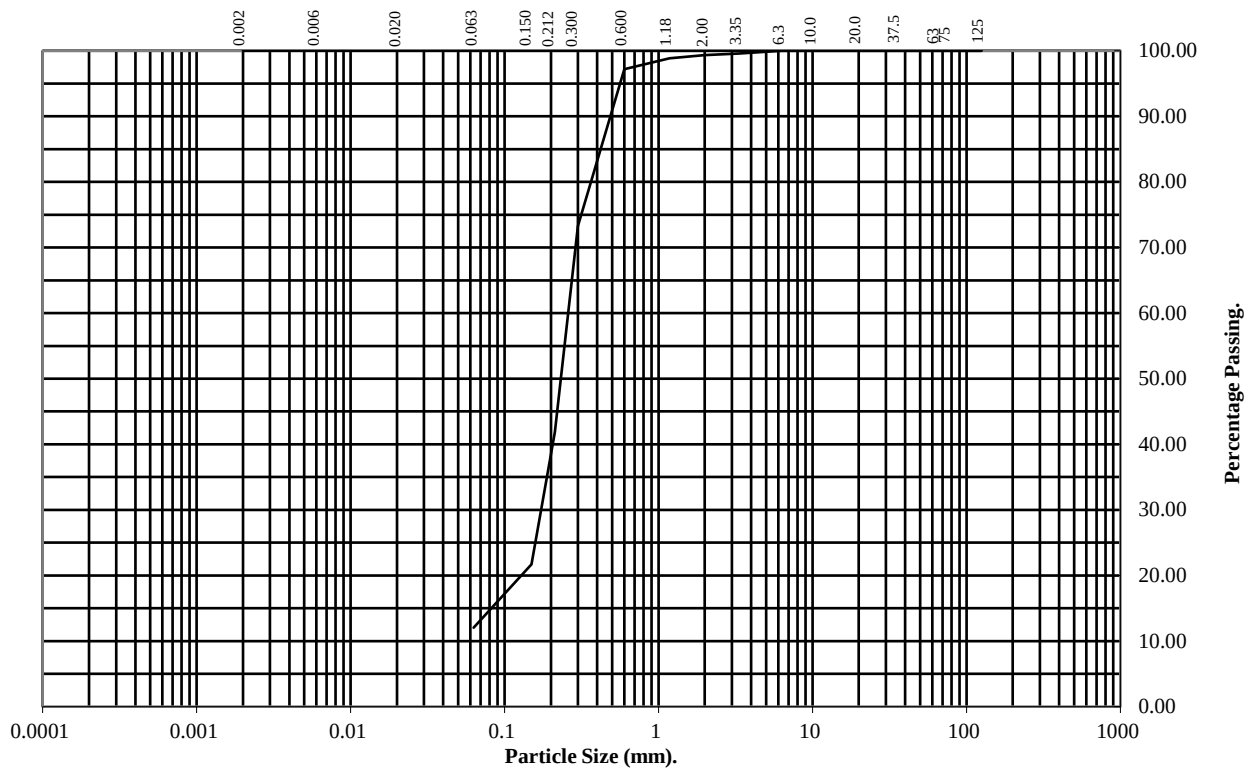
Hole Number: TP107

Top Depth (m): 2.40

Sample Number: 2

Base Depth(m):

Sample Type: B



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	100
6.3	100
3.35	100
2	99
1.18	99
0.6	97
0.3	73
0.212	42
0.15	22
0.063	12

Soil Fraction	Total Percentage
Cobbles	0
Gravel	1
Sand	87
Silt/Clay	12

Remarks:

See Summary of Soil Descriptions



Lincs Lakes

Contract No:
PSL23/5280
Client Ref:
S5497/46069

DRY DENSITY / MOISTURE CONTENT RELATIONSHIP

BS 1377 : Part 4 : Clause 3.5 : 1990

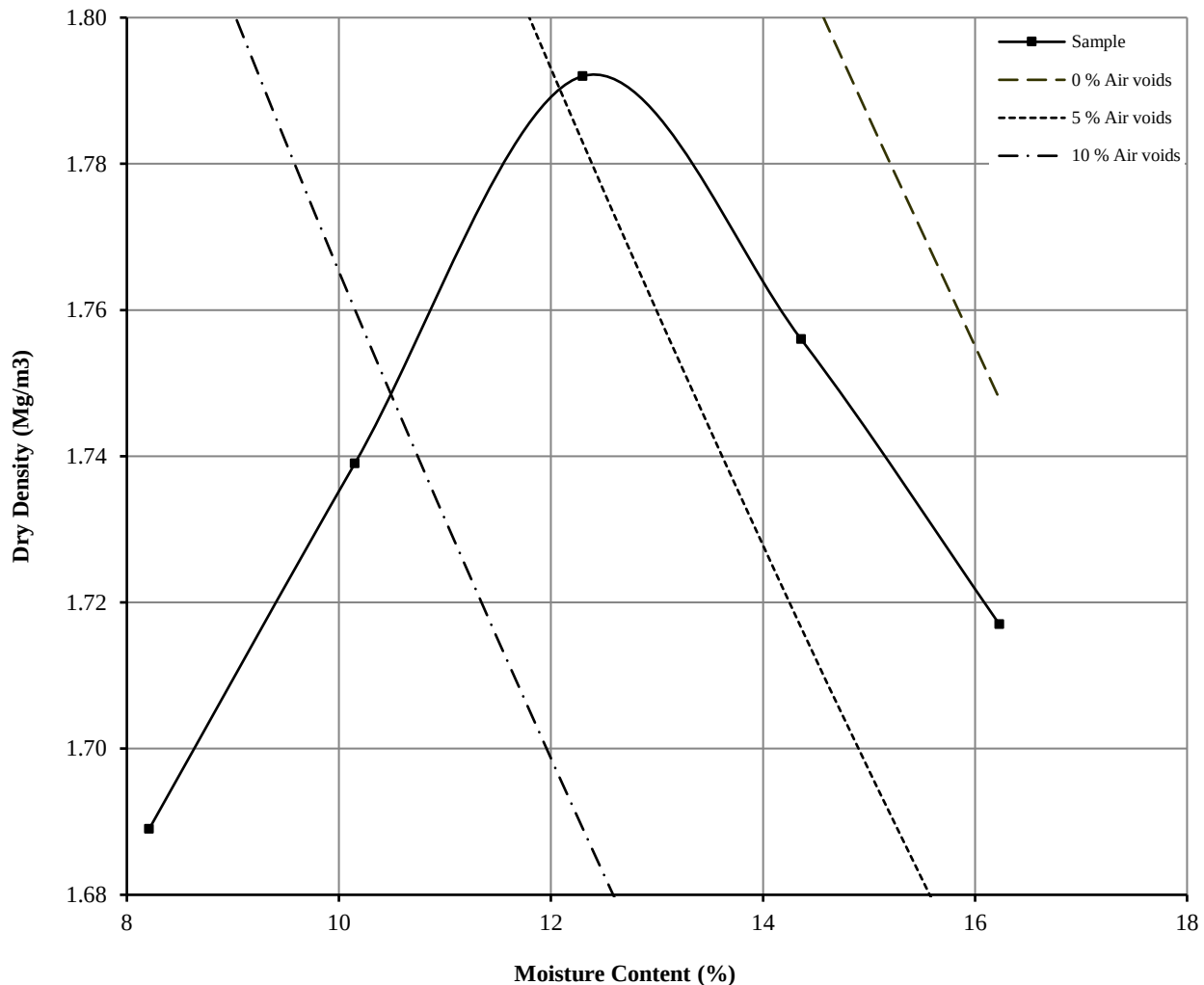
Hole Number: TP101

Top Depth (m) : 0.40

Sample Number: 1

Base Depth (m) :

Sample Type: B



Initial Moisture Content:	24	Method of Compaction:	4.5kg	Separate Samples
Particle Density (Mg/m ³):	2.44	Assumed	Material Retained on 37.5 mm Test Sieve (%):	0
Maximum Dry Density (Mg/m ³):	1.79		Material Retained on 20.0 mm Test Sieve (%):	0
Optimum Moisture Content (%):	12			
Remarks See summary of soil descriptions				



Lincs Lakes

Contract
PSL23/5280
Client Ref
S5497/46069

DRY DENSITY / MOISTURE CONTENT RELATIONSHIP

BS 1377 : Part 4 : Clause 3.5 : 1990

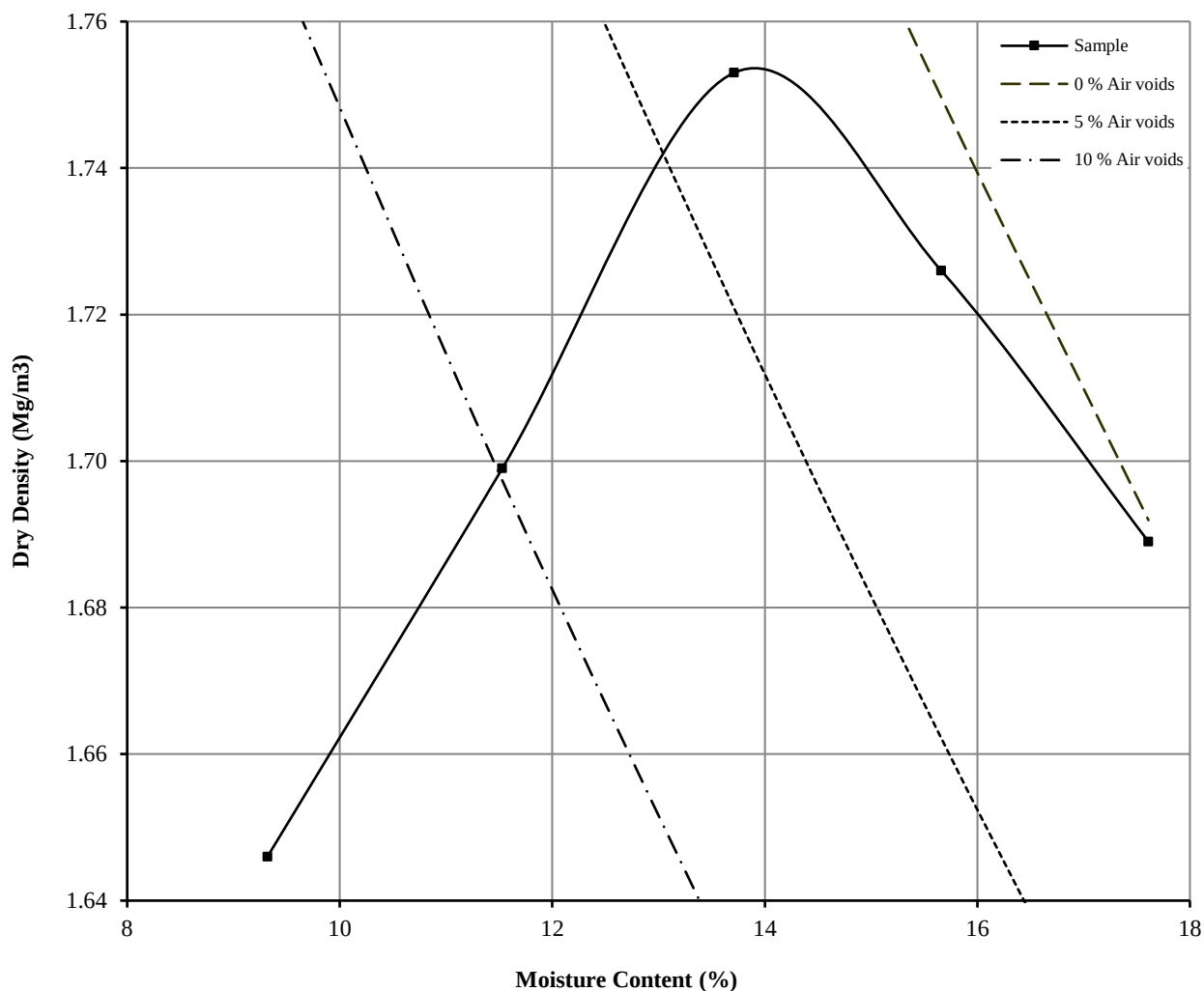
Hole Number: TP101

Top Depth (m) : 2.40

Sample Number: 3

Base Depth (m) :

Sample Type: B



Initial Moisture Content:	22	Method of Compaction:	4.5kg	Separate Samples
Particle Density (Mg/m3):	2.41	Assumed	Material Retained on 37.5 mm Test Sieve (%):	0
Maximum Dry Density (Mg/m3):	1.75		Material Retained on 20.0 mm Test Sieve (%):	0
Optimum Moisture Content (%):	14			
Remarks See summary of soil descriptions				

 	Lincs Lakes		Contract
			PSL23/5280
			Client Ref
			S5497/46069

DRY DENSITY / MOISTURE CONTENT RELATIONSHIP

BS 1377 : Part 4 : Clause 3.5 : 1990

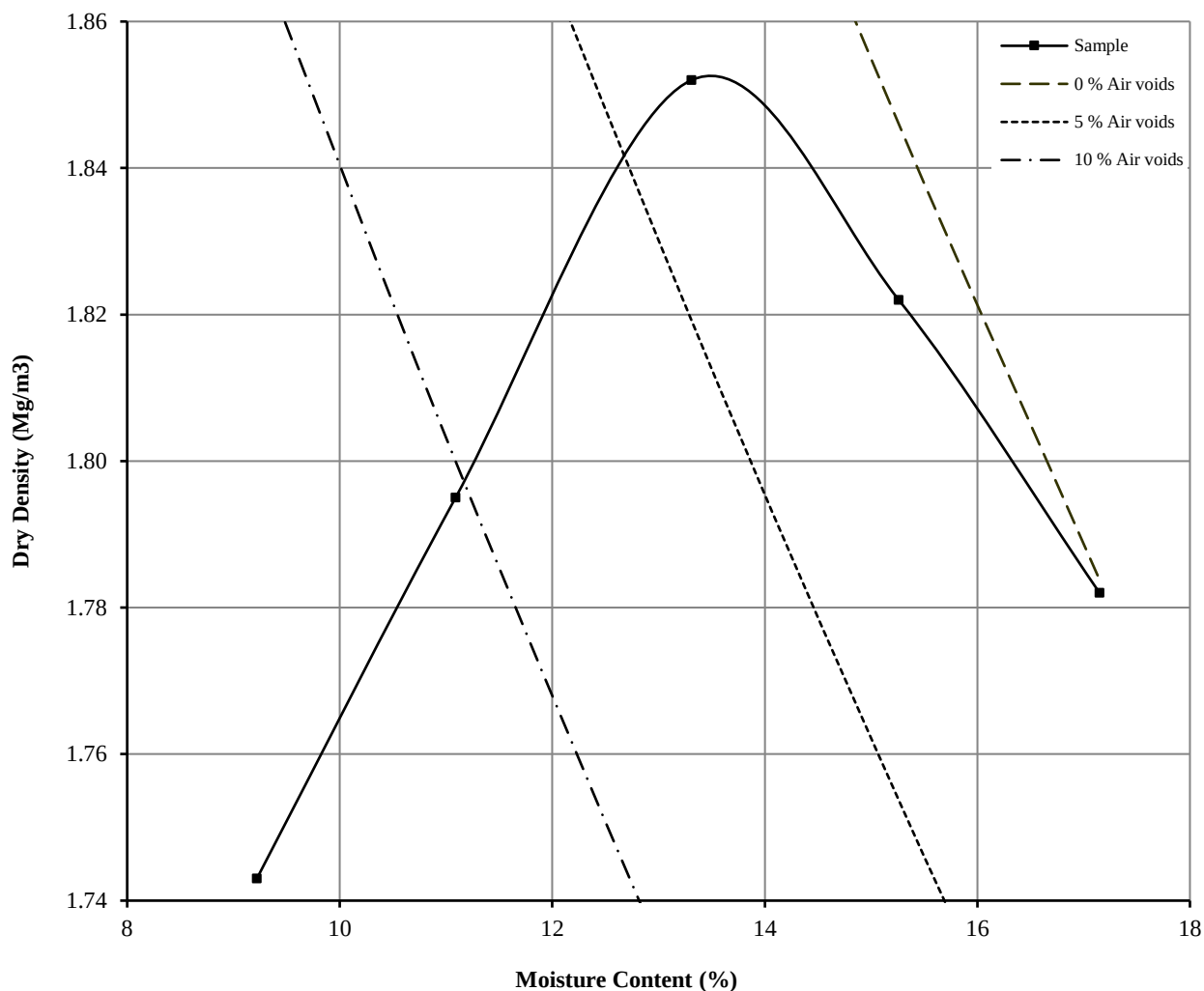
Hole Number: TP102

Top Depth (m) : 2.10

Sample Number: 2

Base Depth (m) :

Sample Type: B



Initial Moisture Content:	27	Method of Compaction:	4.5kg	Separate Samples
Particle Density (Mg/m ³):	2.57	Assumed	Material Retained on 37.5 mm Test Sieve (%):	0
Maximum Dry Density (Mg/m ³):	1.85		Material Retained on 20.0 mm Test Sieve (%):	0
Optimum Moisture Content (%):	13			
Remarks See summary of soil descriptions				

 	Lincs Lakes		Contract
			PSL23/5280
			Client Ref
			S5497/46069

DRY DENSITY / MOISTURE CONTENT RELATIONSHIP

BS 1377 : Part 4 : Clause 3.5 : 1990

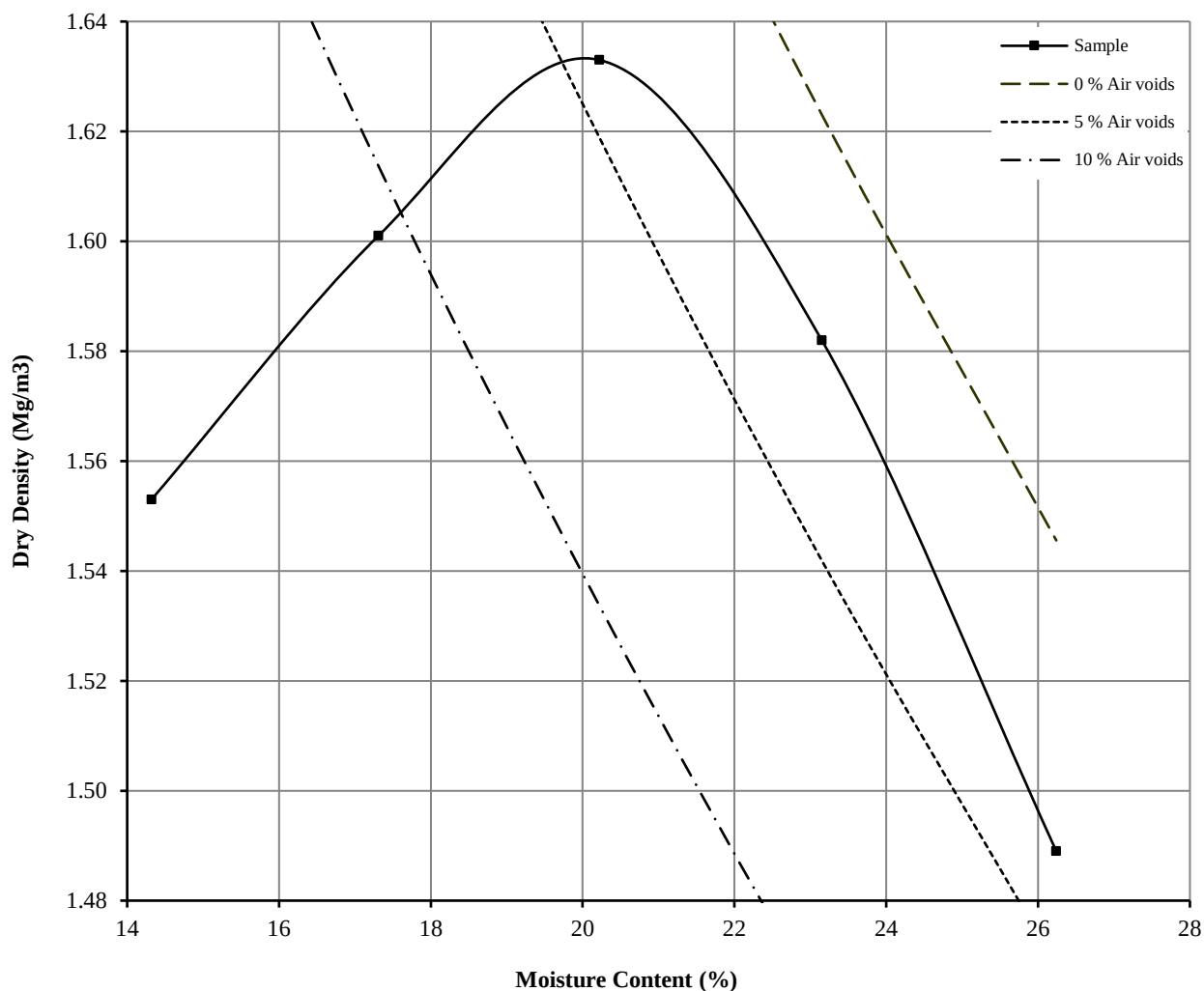
Hole Number: TP104

Top Depth (m) : 0.50

Sample Number: 1

Base Depth (m) :

Sample Type: B



Initial Moisture Content:	20	Method of Compaction:	4.5kg	Separate Samples
Particle Density (Mg/m3):	2.60	Assumed	Material Retained on 37.5 mm Test Sieve (%):	0
Maximum Dry Density (Mg/m3):	1.63		Material Retained on 20.0 mm Test Sieve (%):	0
Optimum Moisture Content (%):	20			
Remarks See summary of soil descriptions				

		Lincs Lakes	Contract
			PSL23/5280
			Client Ref
			S5497/46069

DRY DENSITY / MOISTURE CONTENT RELATIONSHIP

BS 1377 : Part 4 : Clause 3.5 : 1990

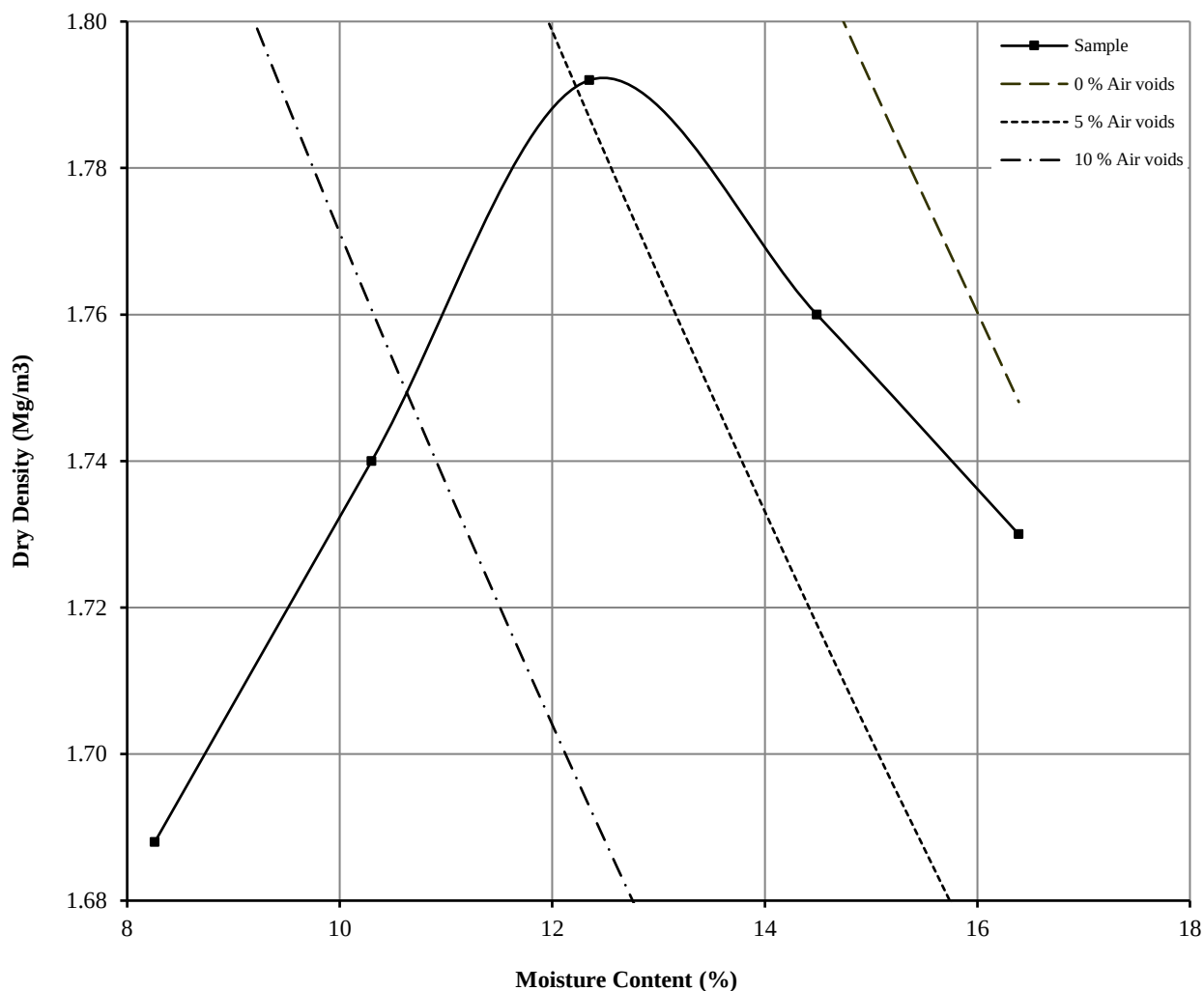
Hole Number: TP104

Top Depth (m) : 1.70

Sample Number: 3

Base Depth (m) :

Sample Type: B



Initial Moisture Content:	24	Method of Compaction:	4.5kg	Separate Samples
Particle Density (Mg/m3):	2.45	Assumed	Material Retained on 37.5 mm Test Sieve (%):	0
Maximum Dry Density (Mg/m3):	1.79		Material Retained on 20.0 mm Test Sieve (%):	0
Optimum Moisture Content (%):	12			
Remarks See summary of soil descriptions				

		Lincs Lakes	Contract
			PSL23/5280
			Client Ref
			S5497/46069

DRY DENSITY / MOISTURE CONTENT RELATIONSHIP

BS 1377 : Part 4 : Clause 3.5 : 1990

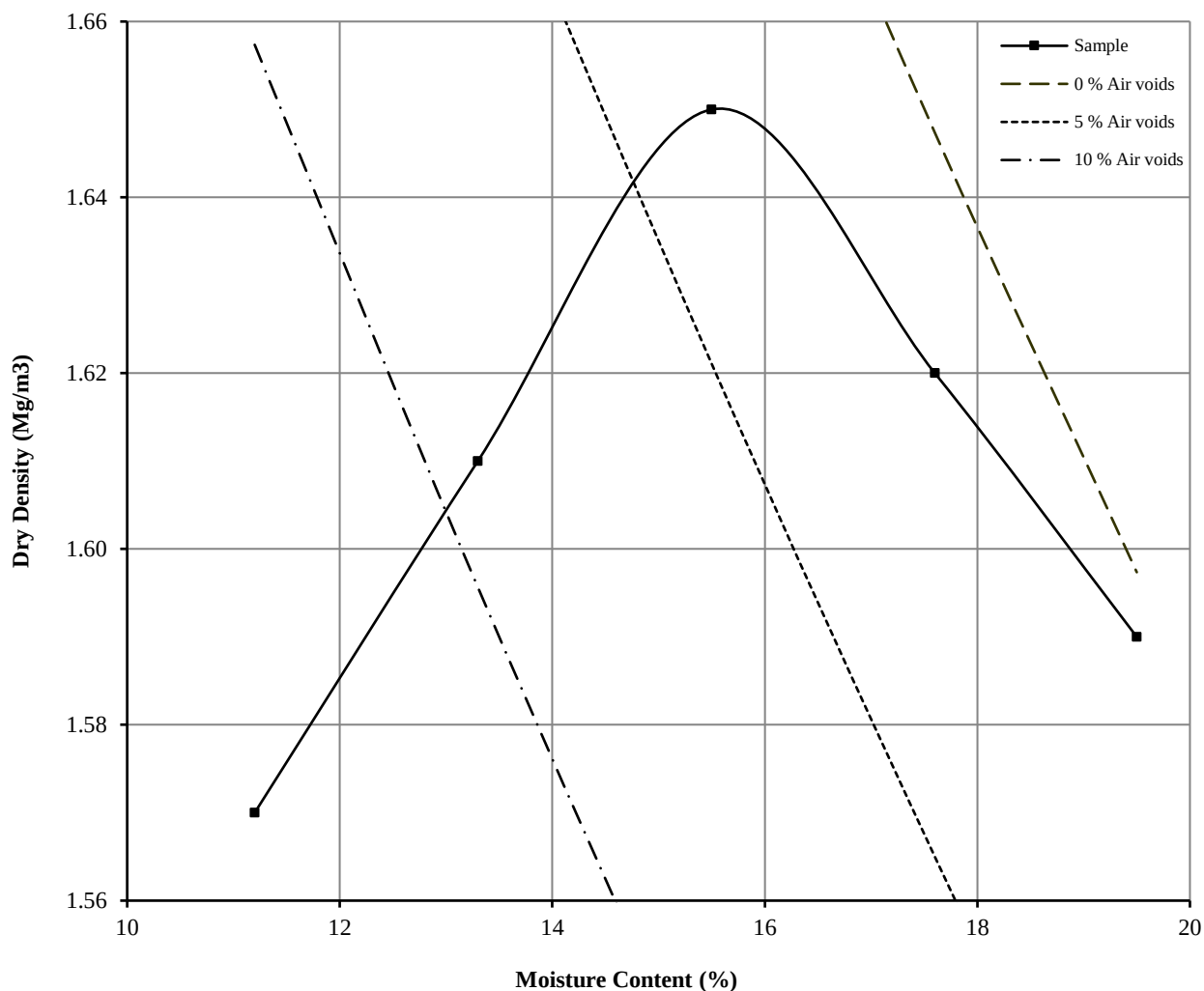
Hole Number: TP105

Top Depth (m) : 0.60

Sample Number: 1

Base Depth (m) :

Sample Type: B



Initial Moisture Content:	16	Method of Compaction:	4.5kg	Separate Samples
Particle Density (Mg/m3):	2.32	Assumed	Material Retained on 37.5 mm Test Sieve (%):	0
Maximum Dry Density (Mg/m3):	1.65		Material Retained on 20.0 mm Test Sieve (%):	0
Optimum Moisture Content (%):	16			
Remarks See summary of soil descriptions				

		Lincs Lakes	Contract
			PSL23/5280
			Client Ref
			S5497/46069

DRY DENSITY / MOISTURE CONTENT RELATIONSHIP

BS 1377 : Part 4 : Clause 3.5 : 1990

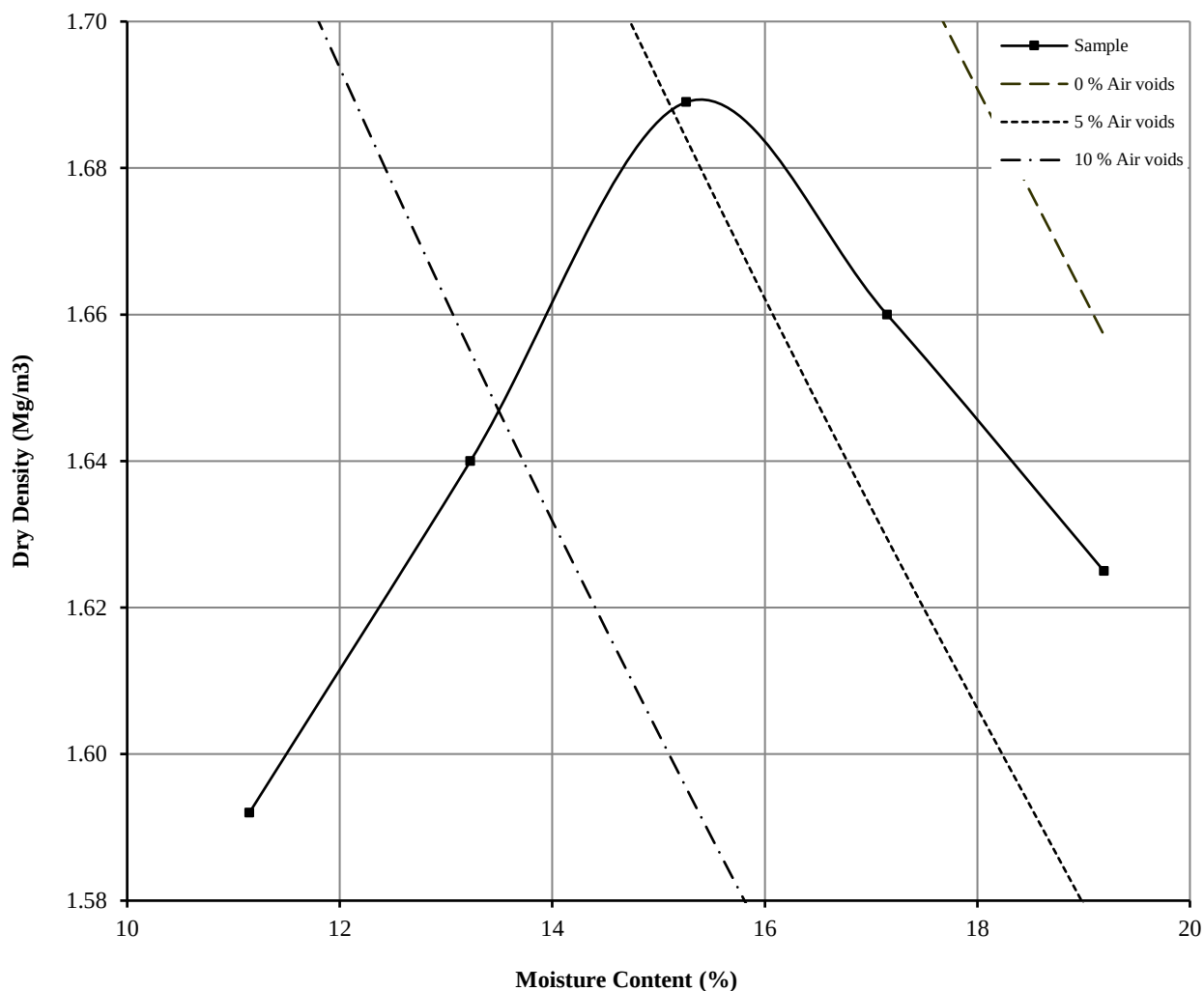
Hole Number: TP105

Top Depth (m) : 1.00

Sample Number: 2

Base Depth (m) :

Sample Type: B



Initial Moisture Content:	13	Method of Compaction:	4.5kg	Separate Samples
Particle Density (Mg/m3):	2.43	Assumed	Material Retained on 37.5 mm Test Sieve (%):	0
Maximum Dry Density (Mg/m3):	1.69		Material Retained on 20.0 mm Test Sieve (%):	0
Optimum Moisture Content (%):	15			
Remarks See summary of soil descriptions				

		Lincs Lakes	Contract
			PSL23/5280
			Client Ref
			S5497/46069

DRY DENSITY / MOISTURE CONTENT RELATIONSHIP

BS 1377 : Part 4 : Clause 3.5 : 1990

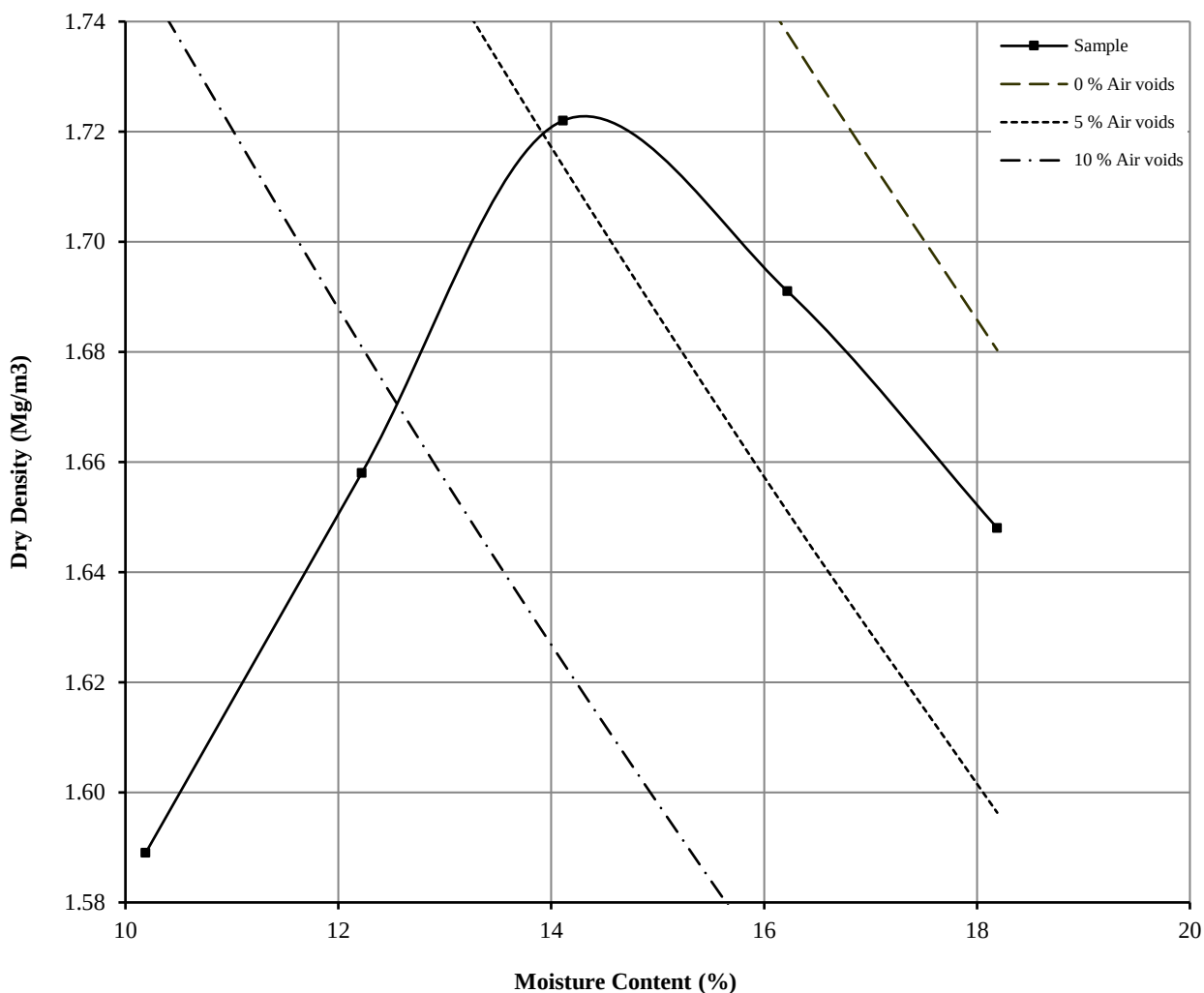
Hole Number: TP106

Top Depth (m) : 0.80

Sample Number: 1

Base Depth (m) :

Sample Type: B



Initial Moisture Content:	10	Method of Compaction:	4.5kg	Separate Samples
Particle Density (Mg/m3):	2.42	Assumed	Material Retained on 37.5 mm Test Sieve (%):	0
Maximum Dry Density (Mg/m3):	1.72		Material Retained on 20.0 mm Test Sieve (%):	0
Optimum Moisture Content (%):	14			
Remarks See summary of soil descriptions				

		Lincs Lakes	Contract
			PSL23/5280
			Client Ref
			S5497/46069

DRY DENSITY / MOISTURE CONTENT RELATIONSHIP

BS 1377 : Part 4 : Clause 3.5 : 1990

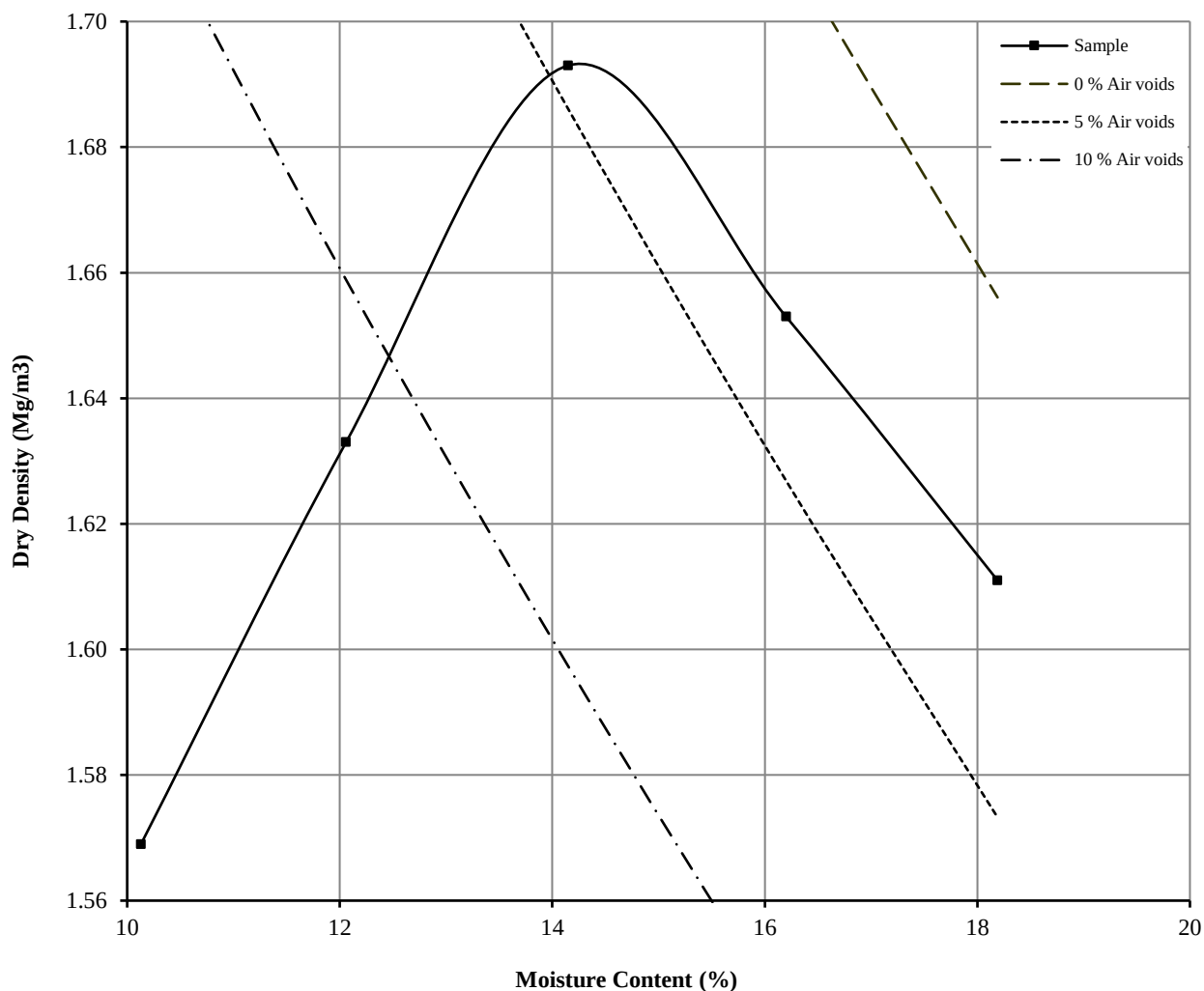
Hole Number: TP107

Top Depth (m) : 0.70

Sample Number: 1

Base Depth (m) :

Sample Type: B



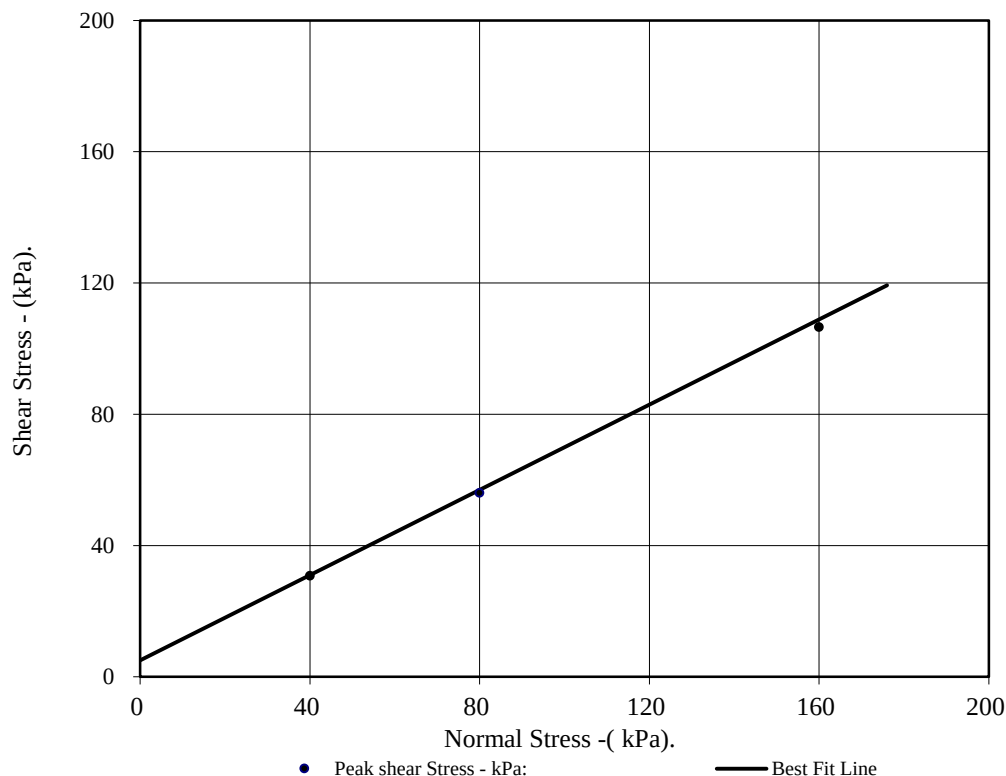
Initial Moisture Content:	14	Method of Compaction:	4.5kg	Separate Samples
Particle Density (Mg/m ³):	2.37	Assumed	Material Retained on 37.5 mm Test Sieve (%):	0
Maximum Dry Density (Mg/m ³):	1.69		Material Retained on 20.0 mm Test Sieve (%):	0
Optimum Moisture Content (%):	14			
Remarks See summary of soil descriptions				

		Lincs Lakes	Contract
			PSL23/5280
			Client Ref
			S5497/46069

CONSOLIDATED DRAINED SHEARBOX TEST

BS1377:Part 7:1990 Clause 4

Hole Number:	CP1		Top Depth:	4.00	
Sample Number:	1		Base Depth:	5.00	
Sample Conditions:	Dry		Sample Type	B	
Particle Density - Mg/m3:	2.53	Assumed	Remarks:		
Sample Preparation:	Material tested passing 2mm sieve Remoulded using hand tamped effort.				
Sample Description:	See summary of soil descriptions.				
STAGE			1	2	3
Initial Conditions					
Height - mm:			19.99	19.99	19.99
Length - mm:			60.05	60.05	60.05
Moisture Content - %:			20	20	20
Bulk Density - Mg/m3:			1.98	1.98	1.98
Dry Density - Mg/m3:			1.65	1.65	1.65
Voids Ratio:			0.530	0.530	0.530
Normal Pressure- kPa			40	80	160
Consolidation Stage					
Consolidated Height - mm:			19.71	19.56	19.36
Shearing Stage					
Rate of Strain - mm/min			0.60	0.60	0.60
Displacement at peak shear stress - mm			9.00	2.40	2.70
Peak shear Stress - kPa:			31	56	107
Final Consolidated Conditions					
Moisture Content - %:			19	19	18
Bulk Density - Mg/m3:			2.01	2.03	2.05
Dry Density - Mg/m3:			1.69	1.71	1.73
Peak					
Angle of Shearing Resistance:(θ)			33		
Effective Cohesion - kPa:			5		



Lincs Lakes

Contract No:

PSL23/5280

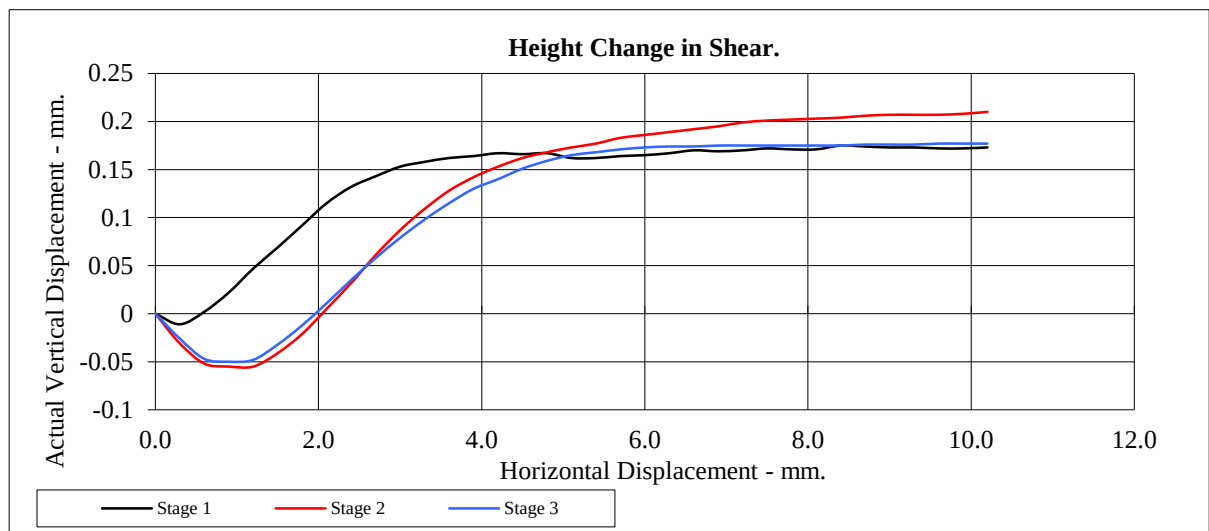
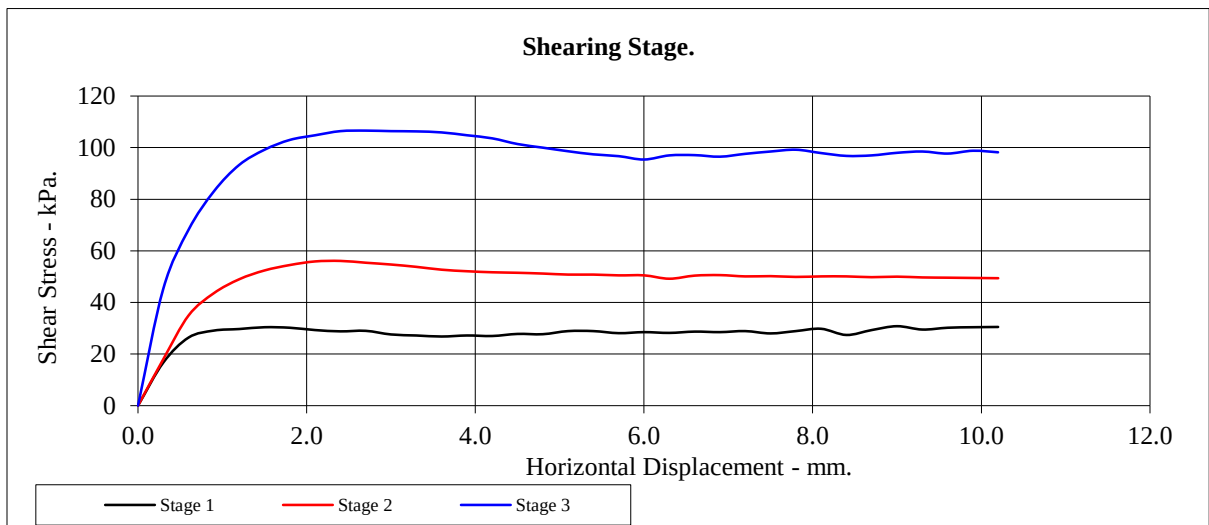
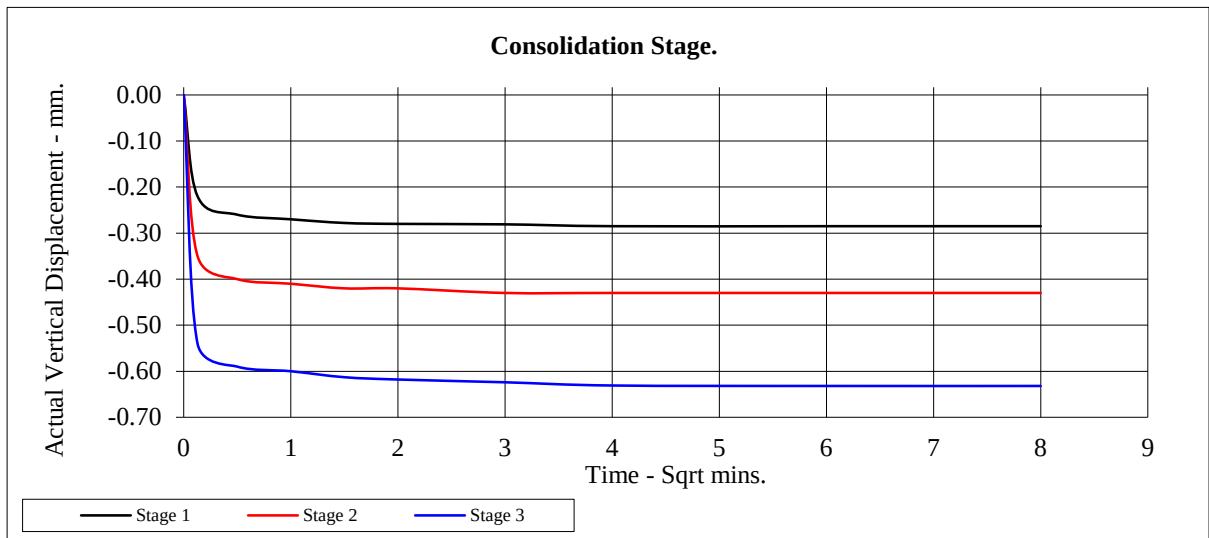
Client Ref:

S5497/46069

CONSOLIDATED DRAINED SHEARBOX TEST

BS1377:Part 7:1990 Clause 4

Hole Number:	CP1	Top Depth:	4.00
Sample Number:	1	Base Depth:	5.00



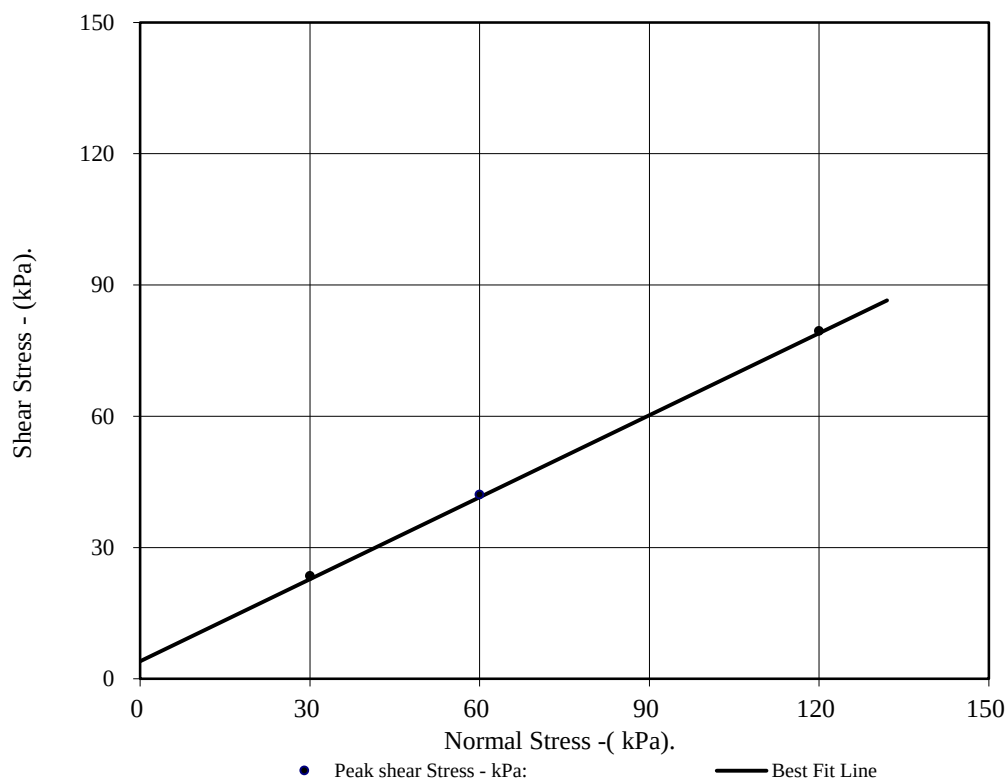
Lincs Lakes

Contract No:
PSL23/5280
Client Ref:
S5497/46069

CONSOLIDATED DRAINED SHEARBOX TEST

BS1377:Part 7:1990 Clause 4

Hole Number:	CP3		Top Depth:	3.00	
Sample Number:	1		Base Depth:	4.00	
Sample Conditions:	Dry		Sample Type	B	
Particle Density - Mg/m3:	2.51	Assumed	Remarks:		
Sample Preparation:	Material tested passing 2mm sieve Remoulded using hand tamped effort.				
Sample Description:	See summary of soil descriptions.				
STAGE			1	2	3
Initial Conditions					
Height - mm:			19.99	19.99	19.99
Length - mm:			60.05	60.05	60.05
Moisture Content - %:			20	20	20
Bulk Density - Mg/m3:			2.08	2.08	2.08
Dry Density - Mg/m3:			1.74	1.74	1.74
Voids Ratio:			0.443	0.443	0.443
Normal Pressure- kPa			30	60	120
Consolidation Stage					
Consolidated Height - mm:			19.70	19.61	19.46
Shearing Stage					
Rate of Strain - mm/min			0.60	0.60	0.60
Displacement at peak shear stress - mm			1.80	2.10	3.00
Peak shear Stress - kPa:			24	42	80
Final Consolidated Conditions					
Moisture Content - %:			19	18	17
Bulk Density - Mg/m3:			2.11	2.12	2.14
Dry Density - Mg/m3:			1.78	1.80	1.82
Peak					
Angle of Shearing Resistance:(θ)			32		
Effective Cohesion - kPa:			4		



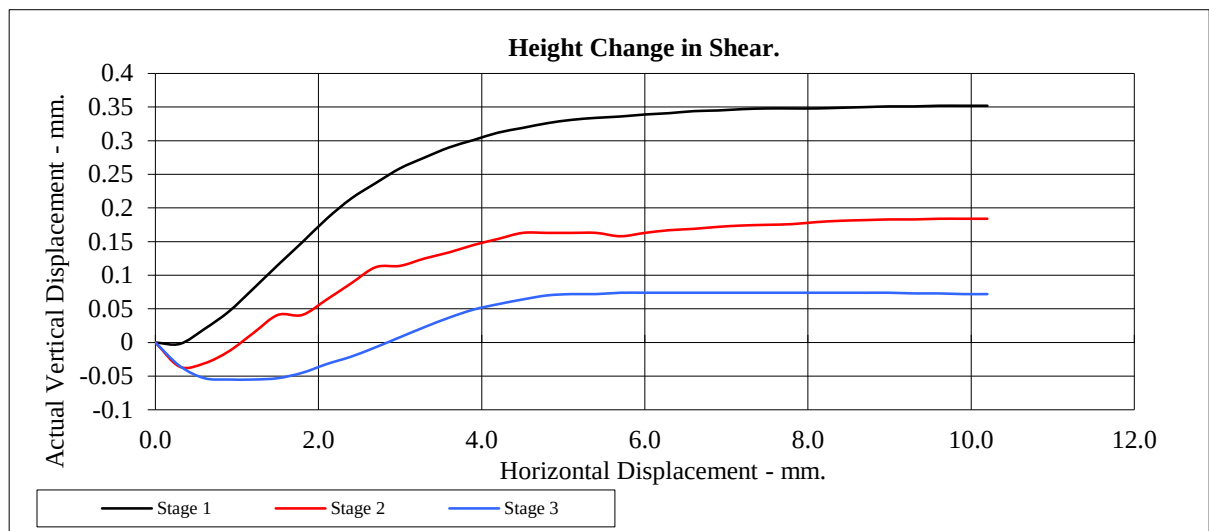
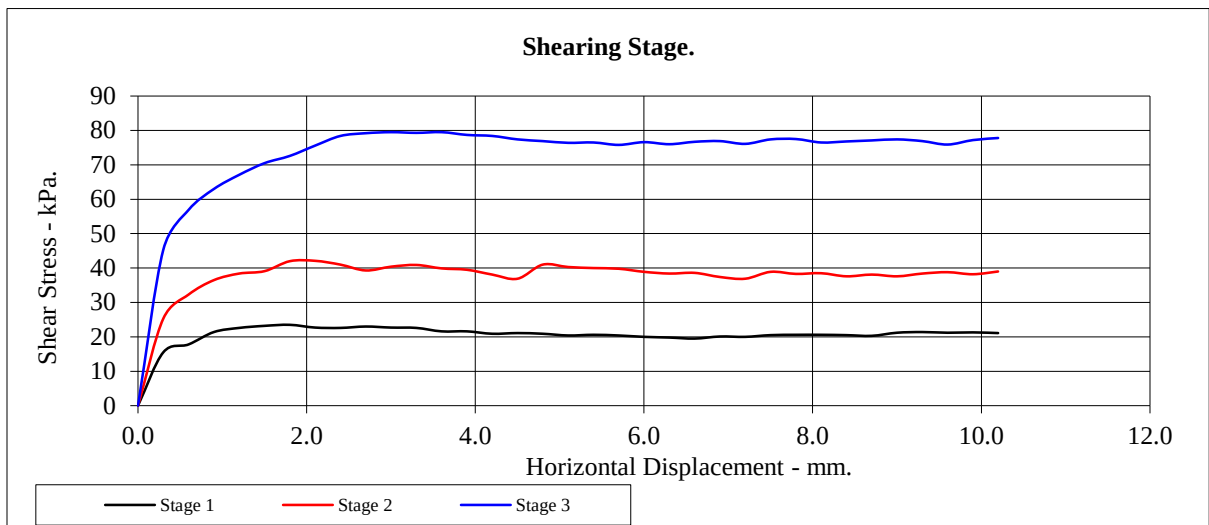
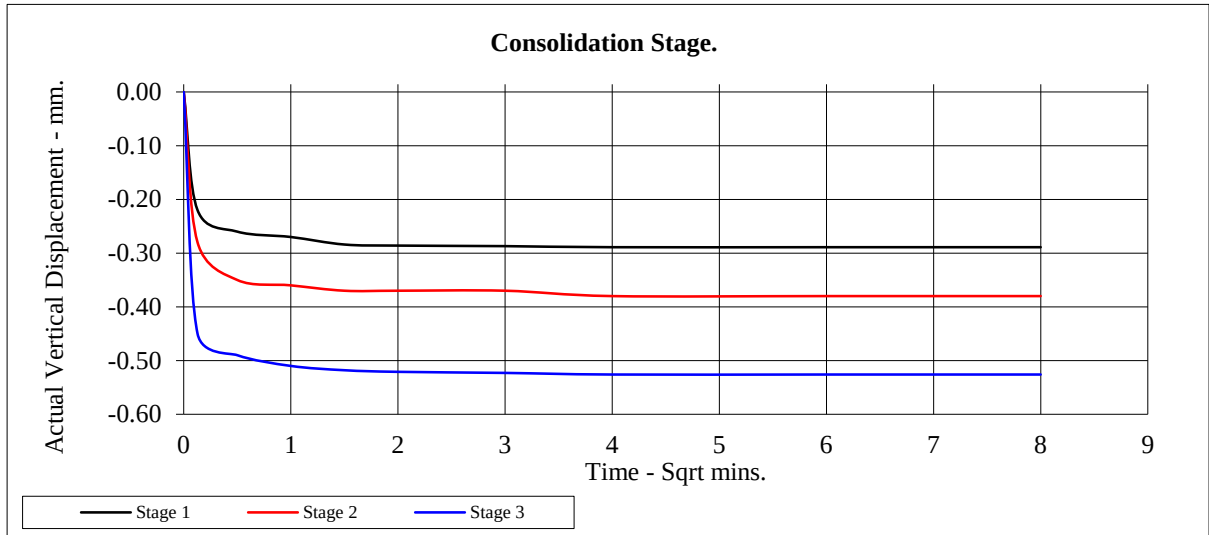
Lincs Lakes

Contract No:
PSL23/5280
Client Ref:
S5497/46069

CONSOLIDATED DRAINED SHEARBOX TEST

BS1377:Part 7:1990 Clause 4

Hole Number:	CP3	Top Depth:	3.00
Sample Number:	1	Base Depth:	4.00



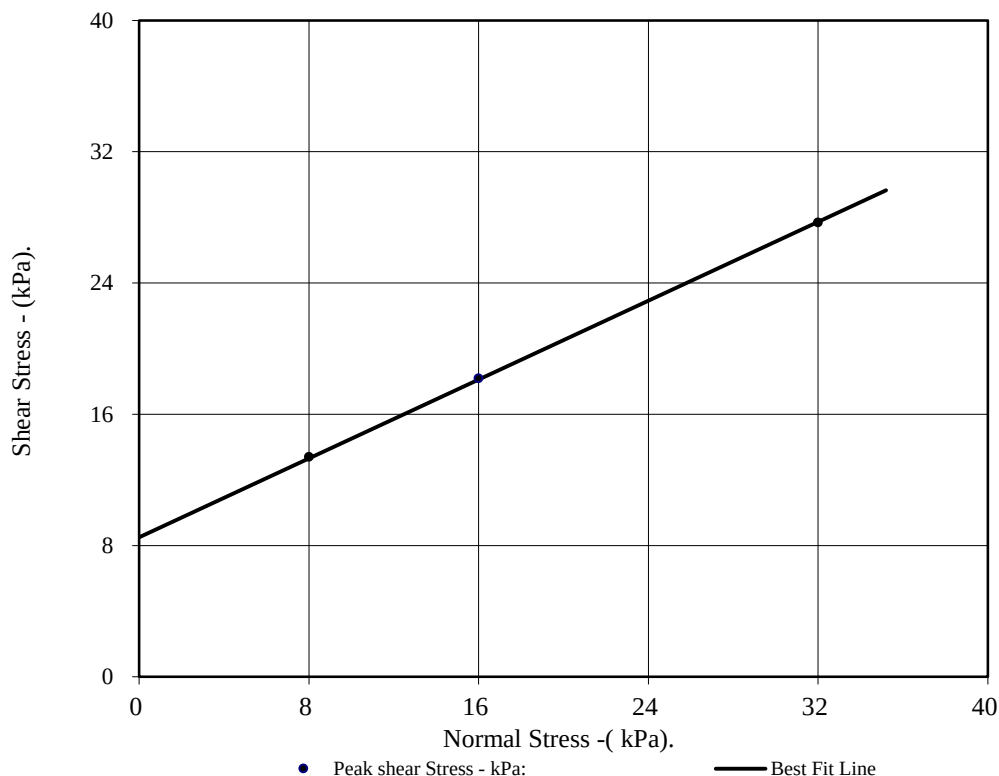
Lincs Lakes

Contract No:
PSL23/5280
Client Ref:
S5497/46069

CONSOLIDATED DRAINED SHEARBOX TEST

BS1377:Part 7:1990 Clause 4

Hole Number:	CP05		Top Depth:	0.40	
Sample Number:	1		Base Depth:	1.20	
Sample Conditions:	Dry		Sample Type	B	
Particle Density - Mg/m3:	2.54	Assumed	Remarks:		
Sample Preparation:	Material tested passing 2mm sieve Remoulded using hand tamped effort.				
Sample Description:	See summary of soil descriptions.				
STAGE			1	2	3
Initial Conditions					
Height - mm:			19.99	19.99	19.99
Length - mm:			60.05	60.05	60.05
Moisture Content - %:			19	19	19
Bulk Density - Mg/m3:			2.01	2.01	2.01
Dry Density - Mg/m3:			1.68	1.68	1.68
Voids Ratio:			0.507	0.507	0.507
Normal Pressure- kPa			8	16	32
Consolidation Stage					
Consolidated Height - mm:			19.97	19.96	19.93
Shearing Stage					
Rate of Strain - mm/min			0.60	0.60	0.60
Displacement at peak shear stress - mm			1.50	2.10	2.10
Peak shear Stress - kPa:			13	18	28
Final Consolidated Conditions					
Moisture Content - %:			18	18	17
Bulk Density - Mg/m3:			2.02	2.02	2.02
Dry Density - Mg/m3:			1.71	1.72	1.72
Peak					
Angle of Shearing Resistance:(θ)			31		
Effective Cohesion - kPa:			9		



Lincs Lakes

Contract No:

PSL23/5280

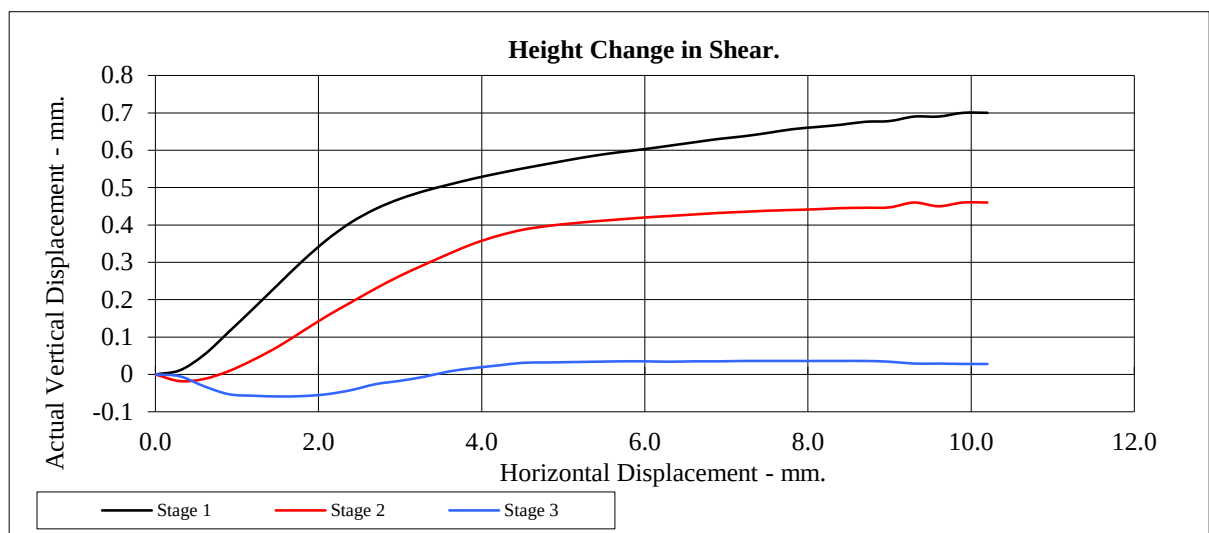
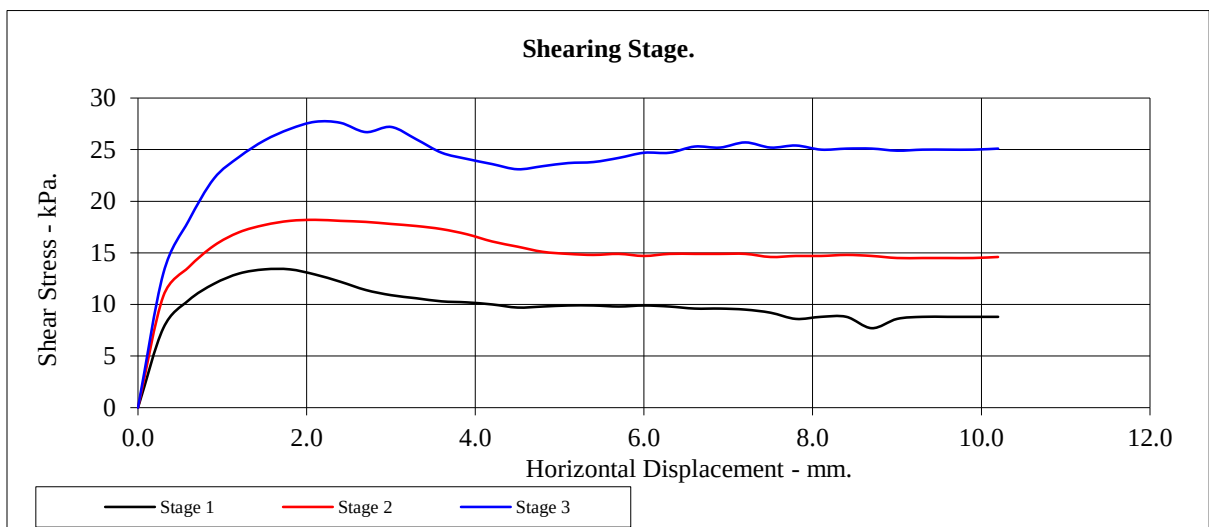
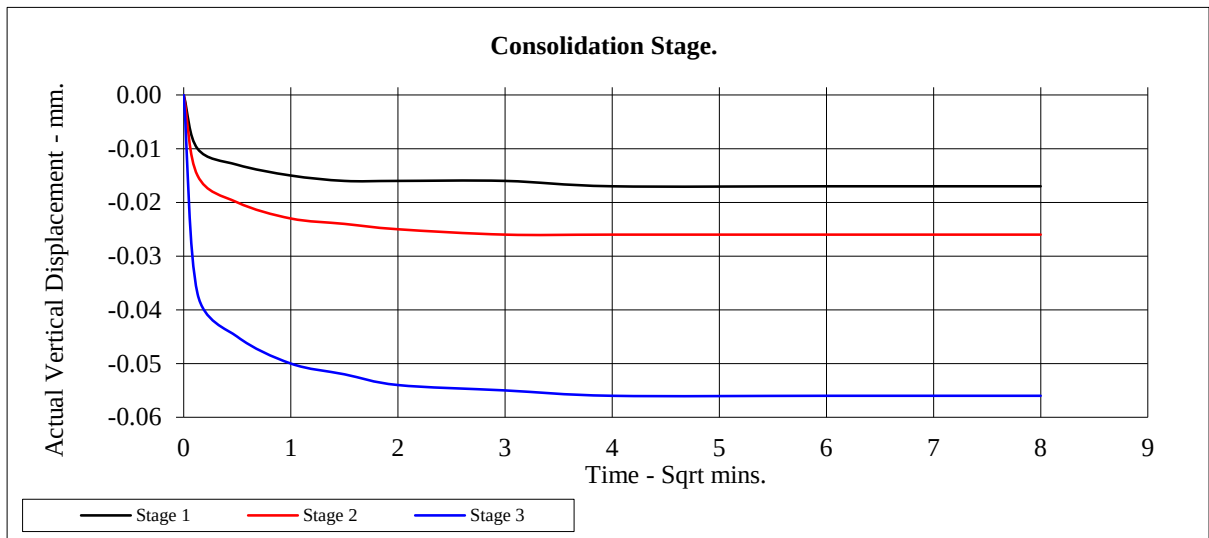
Client Ref:

S5497/46069

CONSOLIDATED DRAINED SHEARBOX TEST

BS1377:Part 7:1990 Clause 4

Hole Number:	CP05	Top Depth:	0.40
Sample Number:	1	Base Depth:	1.20



Lincs Lakes

Contract No:
PSL23/5280
Client Ref:
S5497/46069

APPENDIX C

LABORATORY TESTING: CHEMICAL



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Analytical Report Number : 23-42767

Project / Site name:	Lincs Lakes	Samples received on:	03/07/2023
Your job number:	46069	Samples instructed on/ Analysis started on:	03/07/2023
Your order number:		Analysis completed by:	10/07/2023
Report Issue Number:	1	Report issued on:	10/07/2023
Samples Analysed:	6 soil samples		

Signed:

Elżbieta Suchy
Junior Reporting Specialist
For & on behalf of i2 Analytical Ltd.

Standard Geotechnical, Asbestos and Chemical Testing Laboratory located at: ul. Pionierów 39, 41-711 Ruda Śląska, Poland.

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils	- 4 weeks from reporting
leachates	- 2 weeks from reporting
waters	- 2 weeks from reporting
asbestos	- 6 months from reporting

Excel copies of reports are only valid when accompanied by this PDF certificate.

Any assessments of compliance with specifications are based on actual analytical results with no contribution from uncertainty of measurement.
Application of uncertainty of measurement would provide a range within which the true result lies.
An estimate of measurement uncertainty can be provided on request.

Analytical Report Number: 23-42767
Project / Site name: Lincs Lakes

Lab Sample Number				2734682	2734683	2734684	2734685	2734686
Sample Reference				TP101 D1	TP101 D2	TP102 D1	TP104 D1	TP105 D1
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				0.40	1.60	0.10	0.50	0.20
Date Sampled				Deviating	Deviating	Deviating	Deviating	Deviating
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	Units	Limit of detection	Accreditation Status					
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Moisture Content	%	0.01	NONE	14	17	9	9.6	7.6
Total mass of sample received	kg	0.001	NONE	0.9	0.9	0.9	0.9	0.9

Asbestos in Soil	Type	N/A	ISO 17025	Not-detected	Not-detected	Not-detected	Not-detected	Not-detected
Asbestos Analyst ID	N/A	N/A	N/A	KSZ	KSZ	KSZ	KSZ	KSZ

General Inorganics

pH - Automated	pH Units	N/A	MCERTS	8.4	8.4	8.1	8.1	8.1
Total Cyanide	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Free Cyanide	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Thiocyanate as SCN	mg/kg	5	NONE	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Total Sulphate as SO ₄	%	0.005	MCERTS	0.023	0.016	0.034	0.048	0.049
Water Soluble Sulphate as SO ₄ 16hr extraction (2:1)	mg/kg	2.5	MCERTS	37	63	21	20	10
Water Soluble SO ₄ 16hr extraction (2:1 Leachate Equivalent)	g/l	0.00125	MCERTS	0.019	0.032	0.011	0.01	0.005
Water Soluble SO ₄ 16hr extraction (2:1 Leachate Equivalent)	mg/l	1.25	MCERTS	18.7	31.5	10.5	10.2	5
Sulphide	mg/kg	1	MCERTS	< 1.0	1.1	< 1.0	< 1.0	< 1.0
Organic Matter (automated)	%	0.1	MCERTS	1.2	0.6	3.1	2.8	3.5

Total Phenols

Total Phenols (monohydric)	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
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Speciated PAHs

Naphthalene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Acenaphthylene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Acenaphthene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Fluorene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Phenanthrene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	0.11	0.11
Anthracene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Fluoranthene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Pyrene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	0.05
Benzo(a)anthracene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Chrysene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Benzo(b)fluoranthene	mg/kg	0.05	ISO 17025	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Benzo(k)fluoranthene	mg/kg	0.05	ISO 17025	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Benzo(a)pyrene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Indeno(1,2,3-cd)pyrene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Dibenz(a,h)anthracene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

Total PAH

Speciated Total EPA-16 PAHs	mg/kg	0.8	ISO 17025	< 0.80	< 0.80	< 0.80	< 0.80	< 0.80
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Analytical Report Number: 23-42767
Project / Site name: Lincs Lakes

Lab Sample Number				2734682	2734683	2734684	2734685	2734686
Sample Reference				TP101 D1	TP101 D2	TP102 D1	TP104 D1	TP105 D1
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				0.40	1.60	0.10	0.50	0.20
Date Sampled				Deviating	Deviating	Deviating	Deviating	Deviating
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)				Units	Limit of detection	Accreditation Status		
Heavy Metals / Metalloids								
Arsenic (aqua regia extractable)	mg/kg	1	MCERTS	6.5	2.3	15	14	16
Boron (water soluble)	mg/kg	0.2	MCERTS	0.3	0.2	0.3	0.4	0.5
Cadmium (aqua regia extractable)	mg/kg	0.2	MCERTS	0.3	< 0.2	0.6	< 0.2	0.6
Chromium (hexavalent)	mg/kg	1.8	MCERTS	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8
Chromium (aqua regia extractable)	mg/kg	1	MCERTS	11	5.7	26	24	21
Copper (aqua regia extractable)	mg/kg	1	MCERTS	13	11	21	27	18
Lead (aqua regia extractable)	mg/kg	1	MCERTS	39	15	89	82	77
Mercury (aqua regia extractable)	mg/kg	0.3	MCERTS	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Nickel (aqua regia extractable)	mg/kg	1	MCERTS	12	6.7	26	24	22
Selenium (aqua regia extractable)	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (aqua regia extractable)	mg/kg	1	MCERTS	46	23	110	97	92

U/S = Unsuitable Sample I/S = Insufficient Sample ND = Not detected

Analytical Report Number: 23-42767
Project / Site name: Lincs Lakes

Lab Sample Number				2734687
Sample Reference				TP107 D1
Sample Number				None Supplied
Depth (m)				0.70
Date Sampled				Deviating
Time Taken				None Supplied
Analytical Parameter (Soil Analysis)	Units	Limit of detection	Accreditation Status	
Stone Content	%	0.1	NONE	< 0.1
Moisture Content	%	0.01	NONE	7.5
Total mass of sample received	kg	0.001	NONE	0.9

Asbestos in Soil	Type	N/A	ISO 17025	Not-detected
Asbestos Analyst ID	N/A	N/A	N/A	KSZ

General Inorganics

pH - Automated	pH Units	N/A	MCERTS	7.9
Total Cyanide	mg/kg	1	MCERTS	< 1.0
Free Cyanide	mg/kg	1	MCERTS	< 1.0
Thiocyanate as SCN	mg/kg	5	NONE	< 5.0
Total Sulphate as SO ₄	%	0.005	MCERTS	0.039
Water Soluble Sulphate as SO ₄ 16hr extraction (2:1)	mg/kg	2.5	MCERTS	42
Water Soluble SO ₄ 16hr extraction (2:1 Leachate Equivalent)	g/l	0.00125	MCERTS	0.021
Water Soluble SO ₄ 16hr extraction (2:1 Leachate Equivalent)	mg/l	1.25	MCERTS	21.2
Sulphide	mg/kg	1	MCERTS	< 1.0
Organic Matter (automated)	%	0.1	MCERTS	2.8

Total Phenols

Total Phenols (monohydric)	mg/kg	1	MCERTS	< 1.0
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Speciated PAHs

Naphthalene	mg/kg	0.05	MCERTS	< 0.05
Acenaphthylene	mg/kg	0.05	MCERTS	< 0.05
Acenaphthene	mg/kg	0.05	MCERTS	< 0.05
Fluorene	mg/kg	0.05	MCERTS	< 0.05
Phenanthrene	mg/kg	0.05	MCERTS	0.18
Anthracene	mg/kg	0.05	MCERTS	< 0.05
Fluoranthene	mg/kg	0.05	MCERTS	0.09
Pyrene	mg/kg	0.05	MCERTS	0.09
Benzo(a)anthracene	mg/kg	0.05	MCERTS	< 0.05
Chrysene	mg/kg	0.05	MCERTS	< 0.05
Benzo(b)fluoranthene	mg/kg	0.05	ISO 17025	< 0.05
Benzo(k)fluoranthene	mg/kg	0.05	ISO 17025	< 0.05
Benzo(a)pyrene	mg/kg	0.05	MCERTS	< 0.05
Indeno(1,2,3-cd)pyrene	mg/kg	0.05	MCERTS	< 0.05
Dibenz(a,h)anthracene	mg/kg	0.05	MCERTS	< 0.05
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	< 0.05

Total PAH

Speciated Total EPA-16 PAHs	mg/kg	0.8	ISO 17025	< 0.80
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Analytical Report Number: 23-42767
Project / Site name: Lincs Lakes

Lab Sample Number				2734687
Sample Reference				TP107 D1
Sample Number				None Supplied
Depth (m)				0.70
Date Sampled				Deviating
Time Taken				None Supplied
Analytical Parameter (Soil Analysis)	Units	Limit of detection	Accreditation Status	
Heavy Metals / Metalloids				
Arsenic (aqua regia extractable)	mg/kg	1	MCERTS	16
Boron (water soluble)	mg/kg	0.2	MCERTS	0.8
Cadmium (aqua regia extractable)	mg/kg	0.2	MCERTS	< 0.2
Chromium (hexavalent)	mg/kg	1.8	MCERTS	< 1.8
Chromium (aqua regia extractable)	mg/kg	1	MCERTS	20
Copper (aqua regia extractable)	mg/kg	1	MCERTS	22
Lead (aqua regia extractable)	mg/kg	1	MCERTS	79
Mercury (aqua regia extractable)	mg/kg	0.3	MCERTS	< 0.3
Nickel (aqua regia extractable)	mg/kg	1	MCERTS	22
Selenium (aqua regia extractable)	mg/kg	1	MCERTS	< 1.0
Zinc (aqua regia extractable)	mg/kg	1	MCERTS	84

U/S = Unsuitable Sample I/S = Insufficient Sample ND = Not detected

Analytical Report Number : 23-42767

Project / Site name: Lincs Lakes

* These descriptions are only intended to act as a cross check if sample identities are questioned. The major constituent of the sample is intended to act with respect to MCERTS validation. The laboratory is accredited for sand, clay and loam (MCERTS) soil types. Data for unaccredited types of solid should be interpreted with care.

Stone content of a sample is calculated as the % weight of the stones not passing a 10 mm sieve. Results are not corrected for stone content.

Lab Sample Number	Sample Reference	Sample Number	Depth (m)	Sample Description *
2734682	TP101 D1	None Supplied	0.4	Brown sand with gravel.
2734683	TP101 D2	None Supplied	1.6	Brown clay and sand with gravel.
2734684	TP102 D1	None Supplied	0.1	Brown loam and sand with gravel and vegetation.
2734685	TP104 D1	None Supplied	0.5	Brown loam and sand with gravel and vegetation.
2734686	TP105 D1	None Supplied	0.2	Brown loam and sand with gravel and vegetation.
2734687	TP107 D1	None Supplied	0.7	Brown loam and sand with gravel and vegetation.

Analytical Report Number : 23-42767

Project / Site name: Lincs Lakes

Water matrix abbreviations:

Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Waters (PrW) Final Sewage Effluent (FSE) Landfill Leachate (LL)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Sulphate, water soluble, in soil (16hr extraction)	Determination of water soluble sulphate by ICP-OES. Results reported directly (leachate equivalent) and corrected for extraction ratio (soil equivalent).	In house method.	L038-PL	D	MCERTS
Metals in soil by ICP-OES	Determination of metals in soil by aqua-regia digestion followed by ICP-OES.	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L038-PL	D	MCERTS
Asbestos identification in soil	Asbestos Identification with the use of polarised light microscopy in conjunction with dispersion staining techniques.	In house method based on HSG 248	A001-PL	D	ISO 17025
Boron, water soluble, in soil	Determination of water soluble boron in soil by hot water extract followed by ICP-OES.	In-house method based on Second Site Properties version 3	L038-PL	D	MCERTS
Free cyanide in soil	Determination of free cyanide by distillation followed by colorimetry.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton (Skalar)	L080-PL	W	MCERTS
Moisture Content	Moisture content, determined gravimetrically. (30 oC)	In house method.	L019-UK/PL	W	NONE
Monohydric phenols in soil	Determination of phenols in soil by extraction with sodium hydroxide followed by distillation followed by colorimetry.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton (skalar)	L080-PL	W	MCERTS
Speciated EPA-16 PAHs in soil	Determination of PAH compounds in soil by extraction in dichloromethane and hexane followed by GC-MS with the use of surrogate and internal standards.	In-house method based on USEPA 8270	L064-PL	D	MCERTS
pH in soil (automated)	Determination of pH in soil by addition of water followed by automated electrometric measurement.	In house method.	L099-PL	D	MCERTS
Sulphide in soil	Determination of sulphide in soil by acidification and heating to liberate hydrogen sulphide, trapped in an alkaline solution then assayed by ion selective electrode.	In-house method	L010-PL	D	MCERTS
Thiocyanate in soil	Determination of thiocyanate in soil by extraction in water followed by acidification followed by addition of ferric nitrate followed by discrete analyser (spectrophotometer).	In-house method	L082-PL	D	NONE
Stones content of soil	Standard preparation for all samples unless otherwise detailed. Gravimetric determination of stone > 10 mm as % dry weight.	In-house method based on British Standard Methods and MCERTS requirements.	L019-UK/PL	D	NONE
Total cyanide in soil	Determination of total cyanide by distillation followed by colorimetry.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton (Skalar)	L080-PL	W	MCERTS
Organic matter (Automated) in soil	Determination of organic matter in soil by oxidising with potassium dichromate followed by titration with iron (II) sulphate.	In house method.	L009-PL	D	MCERTS
Hexavalent chromium in soil	Determination of hexavalent chromium in soil by extraction in NaOH and addition of 1,5 diphenylcarbazide followed by colorimetry.	In-house method	L080-PL	W	MCERTS
Total Sulphate in soil as %	Determination of total sulphate in soil by extraction with 10% HCl followed by ICP-OES.	In house method.	L038-PL	D	MCERTS
Sulphate, water soluble, in soil	Determination of water soluble sulphate by ICP-OES. Results reported directly (leachate equivalent) and corrected for extraction ratio (soil equivalent).	In house method.	L038-PL	D	MCERTS



Analytical Report Number : 23-42767

Project / Site name: Lincs Lakes

Water matrix abbreviations:

Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Waters (PrW) Final Sewage Effluent (FSE) Landfill Leachate (LL)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
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For method numbers ending in 'UK or A' analysis have been carried out in our laboratory in the United Kingdom (WATFORD).

For method numbers ending in 'F' analysis have been carried out in our laboratory in the United Kingdom (East Kilbride).

For method numbers ending in 'PL or B' analysis have been carried out in our laboratory in Poland.

Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30°C. Unless otherwise indicated, site information, order number, project number, sampling date, time, sample reference and depth are provided by the client. The instructed on date indicates the date on which this information was provided to the laboratory.

Sample Deviation Report



Analytical Report Number : 23-42767

Project / Site name: Lincs Lakes

This deviation report indicates the sample and test deviations that apply to the samples submitted for analysis. Please note that the associated result(s) may be unreliable and should be interpreted with care.

Key: a - No sampling date b - Incorrect container c - Holding time d - Headspace e - Temperature

Sample ID	Other ID	Sample Type	Lab Sample Number	Sample Deviation	Test Name	Test Ref	Test Deviation
TP101 D1	None Supplied	S	2734682	a	None Supplied	None Supplied	None Supplied
TP101 D2	None Supplied	S	2734683	a	None Supplied	None Supplied	None Supplied
TP102 D1	None Supplied	S	2734684	a	None Supplied	None Supplied	None Supplied
TP104 D1	None Supplied	S	2734685	a	None Supplied	None Supplied	None Supplied
TP105 D1	None Supplied	S	2734686	a	None Supplied	None Supplied	None Supplied
TP107 D1	None Supplied	S	2734687	a	None Supplied	None Supplied	None Supplied

APPENDIX D

AWP GENERIC ASSESSMENT CRITERIA

Alan Wood & Partners
Generic Assessment Criteria for Soils



Revision Version: V.8 - September 2018

Parameter	Residential						Commercial			Allotment			Public Open Space near Residential land (POS _{res})			Public Park Land (POS _{park})			Source
	With Plant Uptake			Without Plant Uptake															
	1-6% SOM			1-6% SOM			1-6% SOM			1-6% SOM			1-6% SOM						
Metals/Metalloids ^(a)																			
Arsenic (inorganic)	37			40			640			49			79			170			DEFRA C4SL ^(b)
Beryllium	1.7			1.7			12			35			22			63			LQM/CIEH ^(c)
Boron	290			11,000			240,000			45			21,000			46,000			LQM/CIEH ^(c)
Cadmium ^(d)	22			150			410			3.9			220			880			DEFRA C4SL ^(b)
Chromium (III)	910			910			8,600			18,000			1,500			33,000			LQM/CIEH ^(c)
Chromium (VI) ^(e)	21			21			49			170			21			250			DEFRA C4SL ^(b)
Copper	2,400			7,100			68,000			520			12,000			44,000			LQM/CIEH ^(c)
Lead ^(f)	200			310			2,300			80			630			1,300			DEFRA C4SL ^(b)
Mercury (inorganic)	40			56			1,100			19			120			240			LQM/CIEH ^(c)
Nickel	130			180			980			53			230			800			LQM/CIEH ^(c)
Selenium	250			430			12,000			88			1,100			1,800			LQM/CIEH ^(c)
Vanadium	410			1,200			9,000			91			2,000			5,000			LQM/CIEH ^(c)
Zinc	3,700			40,000			730,000			620			81,000			170,000			LQM/CIEH ^(c)
Other Inorganics																			
pH	<5			<5			<5			<5			<5			<5			-
Total Sulphate	2400			2400			2400			2400			2400			2400			BRE (2005) ^(g)
Water-Soluble Sulphate	0.5g/l			0.5g/l			0.5g/l			0.5g/l			0.5g/l			0.5g/l			BRE (2005)
Parameter	Residential						Commercial ^(h)			Allotment			Public Open Space near Residential land (POS _{res})			Public Park Land (POS _{park})			
	With Plant Uptake			Without Plant Uptake															
	1% SOM	2.5% SOM	6% SOM	1% SOM	2.5% SOM	6% SOM	1% SOM	2.5% SOM	6% SOM	1% SOM	2.5% SOM	6% SOM	1% SOM	2.5% SOM	6% SOM	1% SOM	2.5% SOM	6% SOM	
Organics ^(h)																			
Acenaphthene	200	490	1,080	2,000	3,600	5,200	75,000	92,000	100,000	34	85	202	15,000	15,000	15,000	29,000	30,000	30,000	CLEA/LQM/CIEH
Acenaphthylene	170	400	900	2,000	3,600	5,200	76,000	92,000	100,000	28	68	163	15,000	15,000	15,000	29,000	30,000	30,000	CLEA/LQM/CIEH
Anthracene	2,300	5,400	10,700	30,000	34,000	36,000	520,000	530,000	540,000	380	947	2,230	74,000	74,000	74,000	150,000	150,000	150,000	CLEA/LQM/CIEH
Benzo(a)anthracene	7.5	11	13	12	14	15	170	170	180	2.9	6.5	13	29	29	29	49	56	62	CLEA/LQM/CIEH
Benzo(a)pyrene	2.2	2.7	3	3.2	3.2	3.2	35	35	36	3.6	3.7	3.7	5.7	5.7	5.7	11	12	13	CLEA/LQM/CIEH
Benzo(b)fluoranthene	2.6	3.3	3.7	3.9	4	4	44	45	45	1	2.2	3.9	7.1	7.2	7.2	13	15	16	CLEA/LQM/CIEH
Benzo(g,h,i)perylene	315	340	350	360	360	360	3,900	4,000	4,000	290	480	646	640	640	640	1,400	1,500	1,600	CLEA/LQM/CIEH
Benzo(k)fluoranthene	77	93	100	110	110	110	1,200	1,200	1,200	37	76	129	190	190	190	370	410	440	CLEA/LQM/CIEH
Chrysene	15	22	27	30	31	32	350	350	350	4.1	9.5	19	57	57	57	93	110	120	CLEA/LQM/CIEH
Dibenz(a,h)anthracene	0.24	0.28	0.30	0.31	0.32	0.32	3.5	3.6	3.6	0.14	0.27	0.44	0.57	0.57	0.58	1.1	1.3	1.4	CLEA/LQM/CIEH
Fluoranthene	280	560	890	1,500	1,600	1,600	23,000	23,000	23,000	52	127	288	3,100	3,100	3,100	6,300	6,300	6,400	CLEA/LQM/CIEH
Fluorene	165	390	850	2,200	3,400	4,200	60,000	67,000	70,000	27	67	158	9,900	9,900	9,900	20,000	20,000	20,000	CLEA/LQM/CIEH
Indeno(1,2,3-cd)pyrene	27	36	41	45	46	46	500	510	510	9.5	21	40	82	82	82	150	170	180	CLEA/LQM/CIEH
Naphthalene	1	2.3	5.5	1	2.4	6	100	260	600	4	9.8	23	4900	4900	4900	1200	1900	3000	CLEA/LQM/CIEH
Phenanthrene	95.0	220	440	1,300	1,400	1,500	22,000	22,000	23,000	15	38	90	3,100	3,100	3,100	6,200	6,200	6,300	CLEA/LQM/CIEH
Pyrene	620	1,200	2,000	3,700	3,800	3,800	54,000	54,000	55,000	111	271	620	7,400	7,400	7,400	15,000	15,000	15,000	CLEA/LQM/CIEH
Aliphatic EC 5-6 (benzene)	24	40	80	24	40	80	2,400	4,000	8,000	752	1,730	3,900	570,000	590,000	600,000	95,000	130,000	180,000	CLEA/LQM/CIEH
Aliphatic EC >6-8 (toluene)	52	110	250	52	110	250	5,200	11,000	25,000	2,304	5,580	13,000	600,000	610,000	620,000	150,000	220,000	320,000	CLEA/LQM/CIEH
Aliphatic EC >8-10	13	30	70	13	30	70	1,300	3,000	7,000	321	770	1,700	13,000	13,000	13,000	14,000	18,000	21,000	CLEA/LQM/CIEH
Aliphatic EC >10-12	60	150	360	60	150	360	6,000	15,000	32,000	2,153	4,300	7,150	13,000	13,000	13,000	21,000	23,000	24,000	CLEA/LQM/CIEH
Aliphatic EC >12-16	500	1,200	2,600	500	1,200	2,600	42,000	72,000	90,000	10,800	12,400	13,200	13,000	13,000	13,000	25,000	25,000	26,000	CLEA/LQM/CIEH
Aliphatic EC >16-35	41,000	69,000	94,000	41,000	69,000	94,000	140,000	160,000	180,000	240,000	260,000	260,000	250,000	250,000	250,000	450,000	480,000	490,000	CLEA/LQM/CIEH
Aliphatic EC >35-44	41,000	69,000	94,000	41,000	69,000	94,000	140,000	160,000	180,000	240,000	260,000	260,000	250,000	250,000	250,000	450,000	480,000	490,000	CLEA/LQM/CIEH

Alan Wood & Partners
Generic Assessment Criteria for Soils



Revision Version: V.8 - Septmeber 2018

Parameter	Residential						Commercial ⁽ⁱ⁾			Allotment			Public Open Space near Residential land (POS _{resi})			Public Park Land (POS _{park})			
	With Plant Uptake			Without Plant Uptake															
	1% SOM	2.5% SOM	6% SOM	1% SOM	2.5% SOM	6% SOM	1% SOM	2.5% SOM	6% SOM	1% SOM	2.5% SOM	6% SOM	1% SOM	2.5% SOM	6% SOM	1% SOM	2.5% SOM	6% SOM	
Organics contd./ ^(h)																			
Aromatic EC >5-7	50	110	240	155	300	630	15,000	28,000	55,000	12	25	57	56,000	56,000	56,000	76,000	84,000	92,000	CLEA/LQM/CIEH
Aromatic EC >7-8	100	240	550	370	800	1,800	33,000	68,000	130,000	21	50	117	56,000	56,000	56,000	87,000	95,000	100,000	CLEA/LQM/CIEH
Aromatic EC >8-10	20	50	110	20	53	125	2,000	5,000	120,000	8.6	21	50	5,000.0	5,000	5,000	7,200.0	8,500	9,300	CLEA/LQM/CIEH
Aromatic EC >10-12	63	150	340	120	280	650	11,000	22,000	31,000	12.5	31	74	5,000.0	5,000	5,000	9,200.0	9,700	10,000	CLEA/LQM/CIEH
Aromatic EC >12-16	140	320	660	1,100	1,900	2,300	35,000	37,000	38,000	23	57	134	5,100	5,100	5,000	10,000	10,000	10,000	CLEA/LQM/CIEH
Aromatic EC >16-21	260	540	930	1,800	1,900	1,900	28,000	28,000	28,000	47	112	260	3,800	3,800	3,800	7,600	7,700	7,800	CLEA/LQM/CIEH
Aromatic EC >21-35	1,100	1,400	1,700	1,900	1,900	1,900	28,000	28,000	28,000	370	820	1,500	3,800	3,800	3,800	7,800	7,800	7,900	CLEA/LQM/CIEH
Aromatic EC >35-44	1,100	1,400	1,700	1,900	1,900	1,900	28,000	28,000	28,000	370	820	1,500	3,800	3,800	3,800	7,800	7,800	7,900	CLEA/LQM/CIEH
Benzene	0.06	0.13	0.30	0.16	0.30	0.64	15	28	57	0.016	0.033	0.073	72	72	73	90	100	110	CLEA/LQM/CIEH
Toluene	104	240	550	370	830	1800	33,000	68,000	130,000	22	50	117	56,000	56,000	56,000	87,000	95,000	100,000	CLEA/LQM/CIEH
Ethylbenzene	30	62	150	34	81	190	3,200	7,000	16,000	16	38	91	24,000	24,000	25,000	1,700	22,000	27,000	CLEA/LQM/CIEH
o-xylene	30	70	170	40	90	200	3,700	8,000	19,000	28	67	160	41,000	42,000	43,000	17,000	24,000	33,000	CLEA/LQM/CIEH
m-xylene	30	70	160	34	80	190	3,400	8,000	18,000	30	74	170	41,000	42,000	43,000	17,000	24,000	32,000	CLEA/LQM/CIEH
p-xylene	30	70	160	33	80	180	3,200	8,000	17,000	28	69	160	41,000	42,000	43,000	17,000	23,000	31,000	CLEA/LQM/CIEH

NOTES

- All values are rounded to 1 or 2 significant figures. All values mg/kg unless otherwise stated.

(a) Generic Assessment Criteria presented by DEFRA (2014) and LQM/CIEH (2015) for metals are not sensitive to Soil Organic Matter content and may be applied directly across the SOM range 1-6% for the land uses given.

(b) Final Category 4 Screening Levels given in DEFRA SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination - Policy Companion Document, December 2014. Calculated for sandy loam soils with 6% SOM.

(c) Nathaniel, C.P., McCaffrey, C., Gillett, A.C., Ogden, R.C. And Nathaniel, J.F. (2015). The LQM/CIEH S4ULs for Human Health Risk Assessment. Land Quality Press, Nottingham. Publication Number **S4UL3286**.

(d) GAC for cadmium are calculated for soils with pH values between 6 and 8. Care should be applied when using the GAC values outside this range and particularly below 5.

(e) Additional site specific risk assessment may be required where elevated concentrations of Chromium (VI) are measured on site.

(f) DEFRA (2014) indicate that the BGS have derived 'normal' background lead concentrations for England & Wales. In England normal background concentrations are 180mg/kg for the principal domain, 2400mg/kg for the mineralisation domain and 820mg/kg for the urban domain (DEFRA, 2012). Calculated C4SL values to be adopted for residential, allotment and POS_{resi} are lower therefore than the 'normal' background concentration of lead in urban areas.

(g) BRE (2005) Special Digest 1, 3rd Edition 'Concrete in Aggressive Ground'. GAC is the upper limit for DS-1 sulphate class concrete.

(h) Organic contaminant GAC values calculated using CLEA v1.06 for sandy soil with SOM of 1%, 2.5% and 6%. Sandy soil type is considered to be conservative for the majority of soils, including brownfield soils on (potentially contaminated) sites. Changes made to default CLEA exposure parameters as per updated information given in DEFRA (2014) (C4SL Tables 3.2 and 3.5) and LQM/CIEH (2015).

(i) GAC derived for pre-1970 office buildings using default commercial CLEA model with adjustment to CLEA exposure parameters as per DEFRA (2014) (C4SL Tables 3.2 and 3.5).

APPENDIX E

LANKELMA: CPT REPORT

BURRINGHAM ROAD, SCUNTHORPE

SOIL INVESTIGATION

CPT REPORT

**Cone penetration testing
Parameter interpretation**

Project Reference.: P-108354-1

Report Issue No.: 01 P-108354_01

PROJECT:	Burringham Road, Scunthorpe
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CLIENT:	Alan Wood & Partners
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FIELDWORK

CPT rig	18.0-tonne track-truck mounted CPT unit (UK22)
Date fieldwork started	3 rd July 2023
Date fieldwork completed	4 th July 2023
Lankelma's representative	Paul Dimelow
Client's representative	Toni Clark

DOCUMENT CHECKING

Action	Date	Name
Completed	10/07/2023	Nick Mason
Checked	10/07/2023	Christopher Player
Approved	10/07/2023	Joseph Hobbs

Issue	Date	Status
01_01	10/07/2023	Final

CONTENTS

1	INTRODUCTION	1
2	DISCLAIMER	1
3	COMPLETED WORKS	1
4	FIELDWORK GENERAL	1
5	CONE PENETRATION TESTS	2
5.1	<i>Glossary of CPT Terms and Symbols</i>	2
5.2	<i>CPT Data Reduction and Presentation</i>	4
5.3	<i>In-situ Stress Conditions</i>	6
5.4	<i>Soil Unit Weight</i>	7
5.5	<i>Soil Behaviour Type</i>	7
5.6	<i>Soil Behaviour Type Index – I_c</i>	11
5.7	<i>Relative Density</i>	12
5.8	<i>Undrained Shear Strength</i>	12
5.9	<i>Overconsolidation Ratio</i>	13
5.10	<i>SPT N60 Values</i>	14
5.11	<i>Friction Angle</i>	15
5.12	<i>Coefficient of Volume Change</i>	16
5.13	<i>Young's Modulus</i>	17
6	CPT INTERPRETATION NOTES	17
7	REFERENCES	20
Appendix A	SUMMARY TABLES	
Appendix B	GENERAL INFORMATION	
Appendix C	CONE PENETRATION TEST RESULTS	
Appendix D	SOIL BEHAVIOUR TYPE RESULTS	
Appendix E	PARAMETER RESULTS 1 – s_u, m_v, OCR, SBT, I_c	
Appendix F	PARAMETER RESULTS 2 – SPT N60, Φ, D_r, E, I_c	
Appendix G	PENETROMETER TEMPERATURE RESULTS	

1 INTRODUCTION

At the request of Alan Wood & Partners, a soils investigation was carried out on project *Burringham Road Scunthorpe*.

Site location:

(In the general region of)

Burringham Road
Scunthorpe
DN17 2AA

2 DISCLAIMER

The investigation information, raw data and interpretations provided in this report are for the sole benefit of the Client identified at the front of the report.

Lankelma has exercised reasonable skill and care in the fieldwork and preparation of this report. This report has been completed based on information available to Lankelma at the time of preparation. The measurement and interpreted data in this report do not constitute recommendations for design purposes. An appropriately qualified person must review and interpret the data given in this report, together with any assumptions we have made that affect the data, before using the data for design or recommendation. Lankelma accepts no responsibility for the accuracy or suitability of any assumptions, derived soil parameters, soil classification descriptions or soil layer boundaries contained in this report.

3 COMPLETED WORKS

- 5 nr. cone penetration tests without pore pressure measurement (CPT)
- 5 nr. cone penetration tests with pore pressure measurement (CPTu)
- Factual report including point data interpretation of selected parameters

Appendix A contains tabulated details of the works completed together with analysis results where applicable.

4 FIELDWORK GENERAL

Fieldwork was performed with an 18.0-tonne track-truck mounted CPT unit (UK22) equipped with a 17.5-tonne capacity hydraulic ram set.

The Client was responsible for the positioning and re-survey of all investigative locations.

The target depth for the investigation was 15 m below ground level. Table 3 details the final test depths and reasons for test termination (*refusal factor*). Where required, each penetration refusal decision was verbally confirmed with the Client's on-site representative.

5 CONE PENETRATION TESTS

Cone penetration testing was carried out in general accordance with BS ISO 22476-1:2012.

Penetrometer measurements included cone tip resistance, friction sleeve resistance and dynamic pore water pressure (selected tests only) sampled at a 10 mm resolution.

Penetrometers were calibrated in accordance with ISO 376:2011. The management of calibration records is in accordance with ISO 10012. Copies of all calibration certificates for the cones used are provided in Appendix B.

The penetrometer used was a digital model (down-hole digitisation) with internal measurement of load cell temperature. The temperature data was used for QA during the test and QC during processing. The test operative aimed to keep the rate of temperature change to less than $0.5^{\circ}/\text{min}$ in low strength soils to maintain acceptable measurement error. The temperature data can be used to assess ground temperature at depths where the cone has paused for more than 10 minutes with an accuracy of $\pm 0.5^{\circ}$.

The piezometer filter element was in the u_2 position and was vacuum saturated in a $> 99.9\%$ vacuum under 1000 cSt silicone oil for > 7 days prior to mobilisation. The pore pressure system was vacuum saturated in the disassembled state under 500 cSt glycerine oil (dipropylene glycol or propylene glycol) and assembled under oil prior to each test.

5.1 GLOSSARY OF CPT TERMS AND SYMBOLS

SYMBOLS & ABBREVIATIONS

B_q	Pore pressure ratio. The net pore pressure normalized with respect to the net cone resistance: $B_q = (u_2 - u_0)/(q_t - \sigma_v)$
F_r	Normalised friction sleeve resistance: $F_r = f_s / (q_c - \sigma_v)$
f_s	Friction sleeve resistance: The total frictional force acting on the friction sleeve, F_s , divided by its surface area A_s : $f_s = F_s/A_s$.
G	Shear modulus
g	Gravitational field strength: $g = 9.81 \text{ m/s}^2$
G_0	Small strain shear modulus
G_s	Specific gravity of solids
HOC	Heavily overconsolidated
I_c	Soil Behaviour Type Index: Continuous numerical representation of Robertson (1990) soil behaviour type classification chart.
LOC	Lightly overconsolidated
NC	Normally consolidated
OC	Overconsolidated
q_c	Cone resistance: The total force acting on the cone Q_c , divided by the projected area of the cone, A_c : $q_c = Q_c/A_c$.
Q_t	Normalised cone resistance (Method 1): $Q_t = (q_c - \sigma_v)/\sigma'_v$

q_t	Corrected tip resistance: The cone tip resistance q_c corrected for pore water pressure effects on the cone shoulder.
q_{t-net}	Net cone resistance: $q_{t-net} = q_t - \sigma_v$. Where q_t is unavailable q_c is applied.
q_{t1}	Normalised cone resistance (Method 2): $q_{t1} = (q_t) / (\sigma'_v)^{0.5}$
R_f	Friction ratio: The ratio, expressed as a percentage, of the sleeve friction, f_s , to the cone resistance, q_c , at a given depth: $R_f = (f_s / q_c) \cdot 100$
SBT or SBTn	Soil behaviour type classification
SPT	Standard Penetration Test
u_0	Equilibrium pore pressure
u_2	Pore pressure: Dynamic pore pressure measured at the shoulder position (u_2) during penetration and during dissipation tests. $u_2 = \Delta u_2 + u_0$
Δu_2	Excess pore pressure: $\Delta u_2 = u_2 - u_0$
V_s, V_p	Shear wave velocity, V_s, and pressure wave velocity, V_p. Measured with use of a seismic receiver.
z	Depth below ground level: Depth as penetration length without correction for inclination, or true depth after correction for inclination.
<u>Greek</u>	
γ	Unit weight of soil
γ_w	Unit weight of water
ρ	Volumetric mass density (or specific mass) of soil: $\rho = \gamma / g$
σ_v	Total overburden stress
σ'_v	Effective overburden stress
σ_{atm} , or, P_a	Reference atmospheric stress: $\sigma_{atm} = 101.3 \text{ kPa}$

TERMS

Cone or 'tip': The conical tip of the cone penetrometer.

Friction sleeve: The section of the cone penetrometer upon which the sleeve friction is measured, located behind the cone tip.

Piezocone: A cone penetrometer with a pore pressure sensor (u_2 or u_1)

Seismic cone: A cone penetrometer with a seismic receiver incorporated inside or behind.

Dynamic pore pressure: The pore pressure measured during penetration (u_2 or u_1) .

Soil behaviour type, or 'SBT': Soil classification scheme or classified soil type according to Robertson (1990, 2016) often abbreviated to SBT or according to normalised cone parameters SBTn.

Rod string: The series of hollow tube push rods that transmit force to the penetrometer.

5.2 CPT DATA REDUCTION AND PRESENTATION

The CPT results are presented in Appendix C. The corrected cone resistance (q_t), local side friction (f_s), dynamic pore water pressure (u_2), friction ratio (R_f) and inclination are all presented against depth and elevation in accordance BS ISO 22476-1:2012. CPT data and the associated derived geotechnical parameters are included in the 4.0 data file provided.

The cone tip and sleeve force measurements were converted to pressure using the nominal dimensions of the penetrometer.

Zero load output values were recorded before and after each test. The set of zero values applied to the measurements (subtracted from the raw output measurement) were those deemed to be obtained at a temperature closest to ground temperature, or the average of the two sets where appropriate.

For tests performed with digital cones, the tip sleeve and pore pressure measurements were corrected for static and transient temperature effects using parameters obtained from the *TEMPERATURE EFFECTS* section of the calibration certificate. For each CPT, the dataset was first grouped into penetration strokes (max 1.2 m) and then locally sub-grouped by tip resistance above and below 2 MPa. For each sub-group of $q_c < 2$ MPa, the slope of the temperature (T) profile with time (t) was determined by regression to obtain the rate of temperature change $\Delta T/\Delta t$. For each recorded value, the static and transient temperature error component (apparent sensor output due to change in temperature) was subtracted from the reading.

For subtraction type cones incorporating traditional temperature compensation wiring in the strain gauge circuit, the residual apparent cone tip resistance ($q_{c:a}$) and sleeve resistance ($f_{s:a}$) due to static and transient temperature effects can be approximated by

$$q_{c:a} = a(\Delta T/\Delta t) + b(\Delta T),$$

$$f_{s:a} = a(\Delta T/\Delta t) + b(\Delta T) - q_{c:a}$$

and

$$u_a = b(\Delta T)$$

Where $q_{c:a}$ is the apparent tip resistance, $f_{s:a}$ is the apparent sleeve resistance, a is the apparent resistance due to unit transient temperature change $\Delta T/\Delta t$, and b is the change in apparent resistance per unit static temperature change relative to the temperature of the penetrometer at the time of zero load output measurement. Note that for the piezometer sensor only the static temperature component is considered and is only applied to piezometer sensors without temperature compensation circuitry.

Parameter a is established by subjecting the cone to a positive and negative nominal temperature change ($\Delta T \sim \pm 9^\circ$) in water and measuring the apparent output corresponding to the maximum rate of temperature change at the load cells. Parameter b is established by measuring the apparent output after the cone has temperature stabilised.

The temperature corrected tip ($q_{c:c}$), sleeve resistance ($f_{s:c}$) and pore pressure (u_c) are then found from

$$q_{c:c} = q_{c:m} - q_{c:a},$$

$$f_{s:c} = f_{s:m} - f_{s:a}$$

$$u_{:c} = u_{:m} - u_{:a}$$

Where subscript ‘:m’, denotes the field measured resistance/pressure as recorded in the raw data files.

Notes:

1. Depending on the temperature performance of the individual cone, temperature correction of the sleeve is often not warranted as it does not substantially improve accuracy. This is because for subtraction type cones the errors in the sleeve force largely cancel with errors in the tip force when they have the same sign.
2. There is currently no recognised nomenclature for CPT parameters with temperature correction applied during post processing. To avoid confusion the nomenclature is kept unchanged in the logs and AGS data (q_c/q_t , f_s , and u_2) and unless stated otherwise, temperature correction has been applied using the parameters reported in the calibration certificate.

For piezocone tests the total cone resistance (or ‘corrected cone resistance’) was calculated according to the formula

$$q_t = q_c + u_2 \times (1 - a)$$

For tests without u_2 pore pressure measurement it is not possible to derive the total cone resistance (or ‘corrected cone resistance’) expressed as

$$q_t = q_c + u_2 \times (1 - a)$$

Where a is the ‘area ratio’ and $(1 - a)$ is the proportion of cross-sectional area between the cone tip and penetrometer body where pore pressures (positive or negative) can act to add or subtract from the total external axial force on the tip. The difference between measured and corrected values is largest in low strength collapsible soils with large excess pore pressures. The percentage adjustment is described by the curves on the chart below for $a = 0.8$:

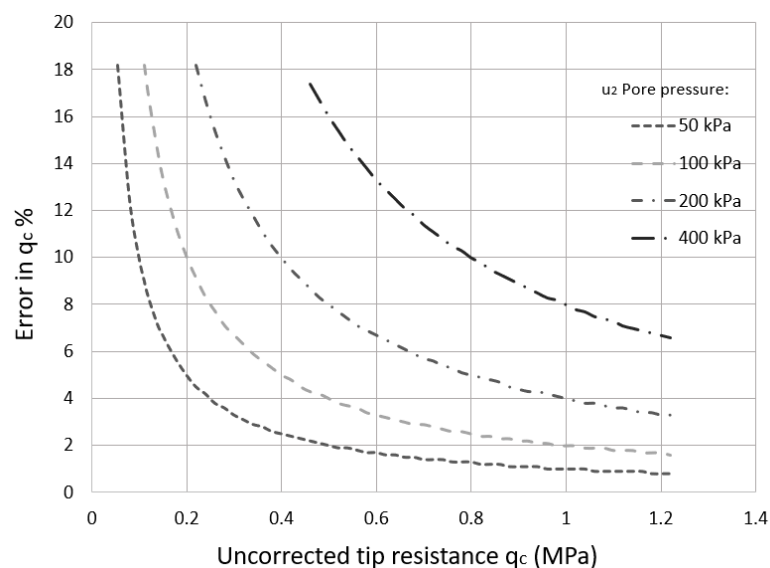


Figure 5-1 Uncorrected tip with measured tip resistance

Penetration length readings were corrected for inclination and sleeve readings were depth corrected for the dimensional offset between cone tip and sleeve during post processing. Rod spikes (artefacts of the pause for push rod addition) were filtered from the cone tip and sleeve data and replaced with an interpolated value. The data was re-sampled from 10 mm resolution to 20 mm to reduce the size of the data set to a more manageable size for end users. A 20 mm resolution is well within the intrinsic influence zone of the cone tip measurement and the loss of meaningful resolution is negligible.

The raw data is presented in Appendix C. For piezocone tests q_t is reported on all logs, and q_c only appears in the digital AGS data.

Geotechnical parameters appropriate for drained and undrained cone penetration conditions were derived for corresponding drained and undrained derived soil behaviour types (SBTs) respectively, however, to account for uncertainty in the SBT correlation with drainage behaviour, all parameters were derived over a range of transitional soils within the range $2.4 < I_c < 2.7$ (see section 6.3).

In general, the engineering parameters derived for fine grain soils (undrained) are suitable for soils of both silicate and carbonate composition, whereas parameters derived for coarse soils are intended for non-cemented silicate composition.

5.3 IN-SITU STRESS CONDITIONS

An estimate of the equilibrium pore pressure and total and effective vertical stress states is required for derivation of most soil parameters obtained from the CPT and dissipation test.

The total vertical stress with depth was calculated as the sum of the derived soil unit weight above a given depth. See section 5.4 for information on the empirical estimate of soil unit weight.

The depth of the phreatic surface applied in the calculation of effective stress was estimated for each location based on interpretation of piezocone measurements in drained soils and/or the final pressure of dissipation tests which proceeded to equilibrium pressure. The project average

piezometric depth (or elevation if available) was applied to locations without direct measurements.

Note: The term phreatic surface is used here, however when it is based on piezometer measurements (piezocone) it is assumed that the piezometric level (under hydrostatic conditions) and phreatic surface coincide. The phreatic or piezometric level reported is intended to provide information about pore pressure distribution assumed for calculation purposes and may not represent the true position of the groundwater table or perched water bodies. Complex groundwater pressure distributions will be applied if they are observed from the measurements and are sufficiently well defined.

5.4 SOIL UNIT WEIGHT

The soil unit weight was estimated using the following method proposed by Robertson (2010b).

$$\frac{\gamma}{\gamma_w} = 0.27 \text{Log}(R_f) + 0.36 (\text{Log}(q_t/R_f)) + 1.236$$

Throughout pre-drilled zones (inspection pits or drill-out) the soil was assigned a nominal unit weight of 17 kN/m³.

For depths where the friction sleeve resistance measurement was less than zero due to measurement limitations, the friction sleeve resistance input parameter was substituted with a nominal 1.0 kPa resistance for the purpose of obtaining an approximate soil unit weight necessary for estimation of total vertical stress over the entire profile.

5.5 SOIL BEHAVIOUR TYPE

The data have been interpreted using 4 soil behaviour type schemes: Robertson (1990, 2010, 2016) and Schneider et al, 2008. The Robertson (1990) scheme is widely used and forms the bases of the layer analysis whereby the profile is split into zones of common classification. The Robertson (2010 & 2016) and Schneider et al methods are less widely used but can provide better or more relevant classification in many instances. Differences in classification between the Robertson 1990, 2016 and Schneider et al schemes can also help to identify significant structure/cementation (Robertson 2016).

A dedicated soil behaviour type comparison log is provided in Appendix D.

Robertson (1990, 2010)

The soil behaviour type (SBT) was interpreted using the Robertson (1990) classification system based on the normalised cone resistance (Q_t) and normalised friction sleeve resistance (F_r) for silicate and organic soils.

While the classification based on normalised parameters is more accurate, particularly for NC soils exceeding 15 m depth, the classification is often significantly in error (artificially granular/drainable) at shallow depth (< 1-3 m). The error at shallow depth is associated with the

potentially large difference between the estimated vertical effective stress (applied in normalisation) and the unknown horizontal stress influencing penetration resistance.

Robertson (2010) proposed a non-normalised version of the 1990 chart which uses dimensionless cone resistance (q_c/P_a) and friction ratio (R_f). The classification according to this chart can be more reliable at shallow depth.

It should be noted that:

- The SBT classification provides a general soil type and tends to show biased towards the soil fraction that dominates the mechanical behaviour.
- If fine cohesive soils are dry and overconsolidated, the classification tends to shift towards a coarser soil type (or lower I_c index)

While the repeatability and behavioural bias of the SBT is usually beneficial, the classification is not always an appropriate substitute for classification based on particle size and plasticity index tests.

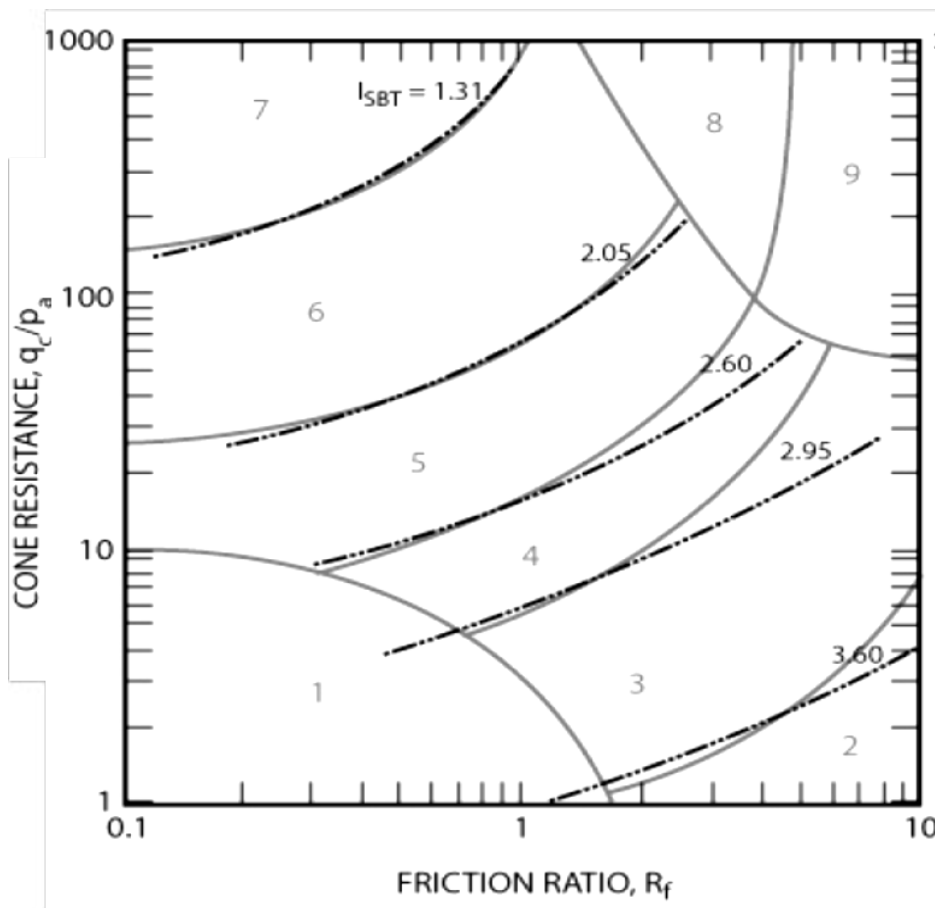


Figure 5-2 Non-normalised SBT chart by Robertson et al. (2010) based on dimensionless cone resistance (q_c/P_a) and friction ratio, R_f , showing contours of SBT index I_{SBT} (denoted I_c on the test plots). The chart is also applicable to normalised tip (Q_t) and sleeve (F_r) values.

Table 1 Robertson (1990, 2010) soil behaviour type zone descriptions

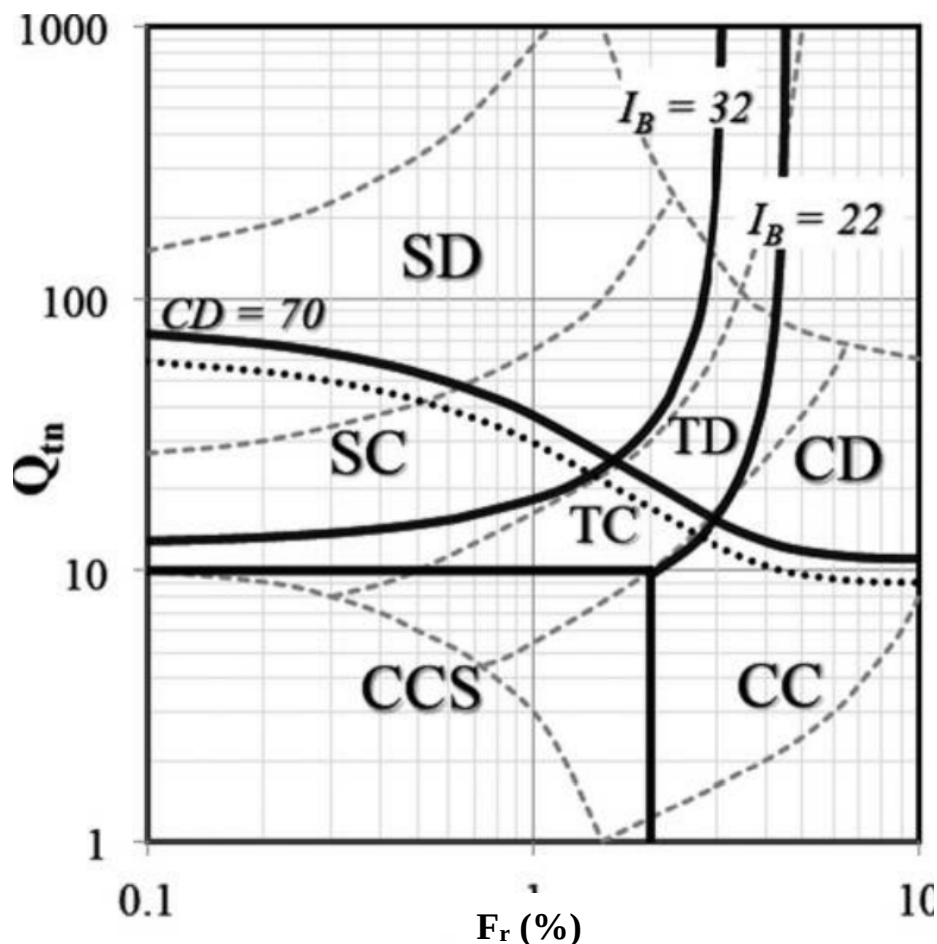
Zone	Soil Behaviour Type (SBT)		
1	Sensitive fine-grained	6	Sands - clean sand to silty sand
2	Organic soils	7	Gravelly sand to sand
3	Clays – clay to silty clay	8*	Very stiff/dense sand to clayey sand ¹
4	Silt mixtures - clayey silt to silty clay	9*	Very stiff fine grained ¹
5	Sand mixtures – silty sand to sandy silt		*Heavily overconsolidated or cemented

¹Note zones 8 and 9 appear as 'Very stiff/dense sand to clayey sand - HOC or cemented' and 'Very stiff fine grained - HOC or cemented' within the soil unit descriptions of plots in Appendix D.

Results are presented in Appendix D.

Robertson 2016

Using the same $Q_t - F_r$ space as above, Robertson (2016) proposed an alternative purely behavioural classification system that places less emphasis on classification according to composition/textural properties and more emphasis on mechanical behaviour - namely the tendency of the soil to dilate or collapse during large strain shear, and sensitivity.



Zone	Soil Behaviour Type (SBT)
CCS	Clay-like – contractive - sensitive
CC	Clay-like – Contractive
CD	Clay-like – Dilative

Zone	Soil Behaviour Type (SBT)
TC	Transitional - Contractive
TD	Transitional - Dilative
SC	Sand-like - Contractive
SD	Sand-like - Dilative

Figure 5-3 Robertson 2016 soil behaviour type classification chart and zone descriptions

Schneider *et al.* (2008)

Schneider *et al.* (2008) proposed a classification system based on the normalised pore pressure B_q and tip resistance Q_t . This system is particularly useful for soils of very low strength or that exhibit drainage behaviour or u_2 response inconsistent with the SBT derived from tip and sleeve measurements. However, when using this method for onshore CPT data, the u_2 piezometer response should be assessed for possible desaturation. Generally, it is safest to only use this method when the piezometer response is 'spikey' and responding dynamically to changes in tip resistance.

A set of logs showing both the Robertson and Schneider *et al.* classification results are provided for comparison in Appendix D.

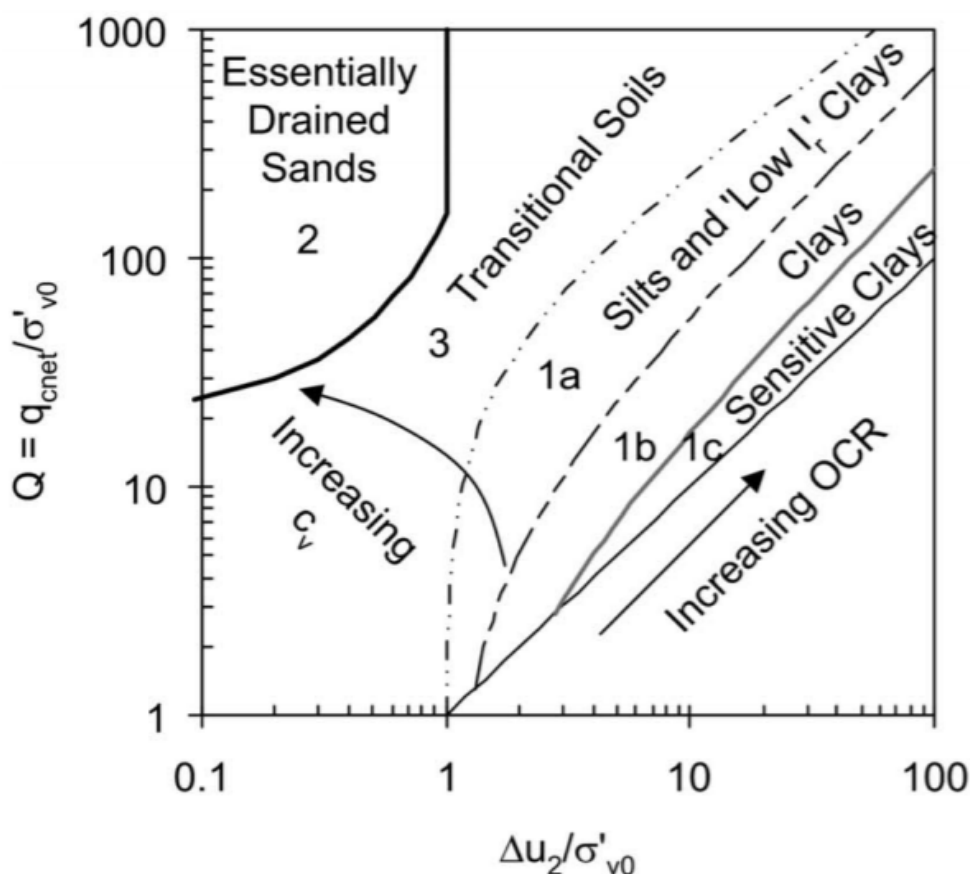


Figure 5-4 Schneider 2008 soil behaviour type classification chart and zone descriptions

Layer Analysis

The layer boundaries are manually interpreted based on broad changes in Robertson 1990 SBT classification or variance with depth. Once layer boundaries are defined, the SBT zones classified within each layer are listed together with the corresponding percentage of data points within the layer (excluding null/filtered data). The modal classification is reported in full, with abbreviated short descriptions for all secondary zones, for example - '*Clays - clay to silty clay [74%]; *Silt mixtures [20%]*', where the asterisk represents an abbreviation of the full description '*Silt mixtures - clayey silt to silty clay*'. It is important to consider that the classification zone boundaries do not exist in nature and small shifts in the cone response can lead to multiple classifications within layers of relatively uniform behaviour; especially were the layer data plot close to a zone junction and/or has spurious spikes or very thin layers. Therefore, some system is required to limit the number of classified zones that appear within each layer description. The following logic has been used to only retain high % constituent classification values:

For $LT \geq 1$, $C = 85$
 For $0.5 \leq LT < 1$, $C = 75$
 For $0 < LT < 0.5$, $C = 65$

Where

C = Minimum % SBT zone classification coverage within the layer description text

LT = Layer thickness (m)

For layers having a thickness of less than 1 m, 10% of data at the top and bottom of the layer are excluded to limit the effect of transition zone data (measured resistance influenced by overlying or underlying strata) being included in the classification.

The continuous SBT index I_c should be used to assess the classification distribution and variation not accounted for by the layer description.

5.6 SOIL BEHAVIOUR TYPE INDEX - I_c

The principal trend in soil behaviour type (SBT) variation can be expressed by a continuous index, I_c , proposed by Robertson and Wride (1998) based on a similar index proposed by Jefferies and Davies (1993). The index provides a continuous profile of SBT variation with depth for end-user analysis of soil units and variation within units. The equivalent non-normalised version proposed by Robertson (2010) is provided for comparison.

The basis of I_c and its approximation of the original chart classification zones may be seen from Figure 5-2. The method does not identify zones 1 (*sensitive fine grained*) or zones 8 & 9 (*heavily overconsolidated or cemented*).

Normalised SBT index I_c (Robertson and Wride, 1998):

$$I_c = [(3.47 - \log Q_t)^2 + (\log F_r + 1.22)^2]^{0.5}$$

Non-normalised SBT index I_c (Robertson, 2010):

$$I_c = \left[\left(3.47 - \log \left(\frac{q_c}{\sigma_{atm}} \right) \right)^2 + (\log R_f + 1.22)^2 \right]^{0.5}$$

The normalised version of I_c is generally more accurate, while the non-normalised version is intended for compatibility with the non-normalised Robertson's (2010) SBT chart and may be more accurate at shallow depths in overconsolidated soils.

The results are presented in Appendix D.

5.7 RELATIVE DENSITY

The relative density of sands was calculated based on an empirical relationship proposed by Jamiolkowski *et al.* (2001) based on a large database of undisturbed frozen samples and calibration chamber tests. The expected accuracy may be evaluated from the figures presented below.

$$D_r = 100 \left[0.268 \cdot \ln \left(\frac{q_t / \sigma_{atm}}{\sqrt{\sigma_{vo}' / \sigma_{atm}}} \right) - k \right]$$

k = Compressibility dependant constant can be taken as -0.675 for medium compressibility (applied value in our interpretation), ≤ 1 for high compressibility and ≥ 2 for compressible sands.

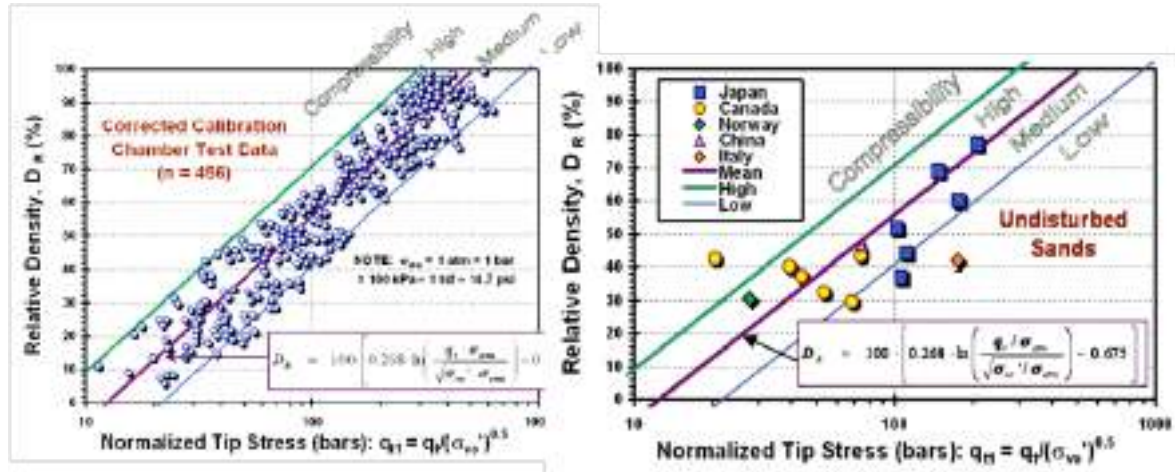


Figure 5-5 Relative density with normalised tip stress and sand compressibility from calibration chamber tests (left) and undisturbed frozen samples (right). Jamiolkowski *et al.* (2001). Reproduced from Mayne (2007).

The results are presented in Appendix F.

5.8 UNDRAINED SHEAR STRENGTH

The undrained shear strength s_u is usually estimated by the bearing capacity method, whereby the net tip resistance is divided by a factor N_k (Lunne *et al.*, 1981):

$$s_u = \frac{q_c - \sigma_{v0}}{N_k}$$

Where N_k is an empirical factor which varies with soil type, stress history, structure/fabric, plasticity, and the mode of shear.

Mayne and Peuchen (2018) performed an evaluation of 407 high-quality undrained anisotropically consolidated triaxial compression tests (CAUC) with net tip resistance data pairs, resulting in N_{kt} factors with regression analysis details for five categories of clays shown in Table 2.

Table 2 Summary of CAUC s_u versus q_{net} for clays. Reproduced from Mayne and Peuchen (2018).

Clay Group	Number of sites	Nr Data	Correlation Coefficient r^2	Factor N_{kt}	Mean Pore Pressure Parameter B_q
Offshore NC-LOC	17	115	0.98	12.32	0.51
Onshore NC-LOC	30	191	0.867	12	0.53
Sensitive NC-LOC	5	43	0.507	10.33	0.84
OC Intact	5	36	0.862	13.57	0.49
OC Fissured	5	22	0.393	22.47	-0.01
All clays	62	407	0.923	13.33	0.55

Alternatively, a variable N_{kt} factor can be estimated for the profile as a function of the pore pressure parameter B_q , applicable for B_q values of > -0.01 . The following equation proposed by Mayne and Peuchen is based on the same database evaluation:

$$N_{kt} = 10.5 - 4.6 \cdot \ln(B_q + 0.1)$$

Where the pore pressure parameter B_q is the ratio of excess pore pressure to net tip resistance:

$$B_q = \frac{u_2 - u_0}{q_t - \sigma_{v0}}$$

The N_{kt} estimate has a standard error of 2.4 N_k and correlation coefficient of 0.645.

The estimate based on B_q is presented as ‘ s_{u5} ’ on the parameter plots and is only suitable for tests that have a high-quality pore pressure data, often indicated by a positive, repeatable, and dynamic response.

Note: N_{kt} (with subscript ‘t’) indicates a N_k factor that has been established using the corrected tip resistance q_t . N_{kt} can be applied to the uncorrected tip resistance q_c (non-piezcone tests) but results in a slightly lower estimate of s_u depending on the correction magnitude ($q_c - q_t$) in lower strength soils.

Undrained shear strengths corresponding to selected values of N_k are presented on the plots of Appendix D. ‘ s_{u3} ’ on the logs ($N_k = 15$) has been included as a reference for comparison to traditionally applied N_k values of 15 and 20.

The results are presented in Appendix E.

5.9 OVERCONSOLIDATION RATIO

The preconsolidation stress σ'_p was calculated based on the method proposed by Mayne et al (2009):

$$\sigma'_p = k \cdot (q_t - \sigma_{v0})^{m'}$$

$$OCR = \sigma'_p / \sigma'_{v0}$$

Mayne *et al* found that the trend with mean grain size followed a power law through the addition of exponent m' and that its value can be estimated by relation to soil behaviour type index I_c :

$$m' = 1 - \frac{0.28}{1 + \frac{I_c}{2.65}}^{25}$$

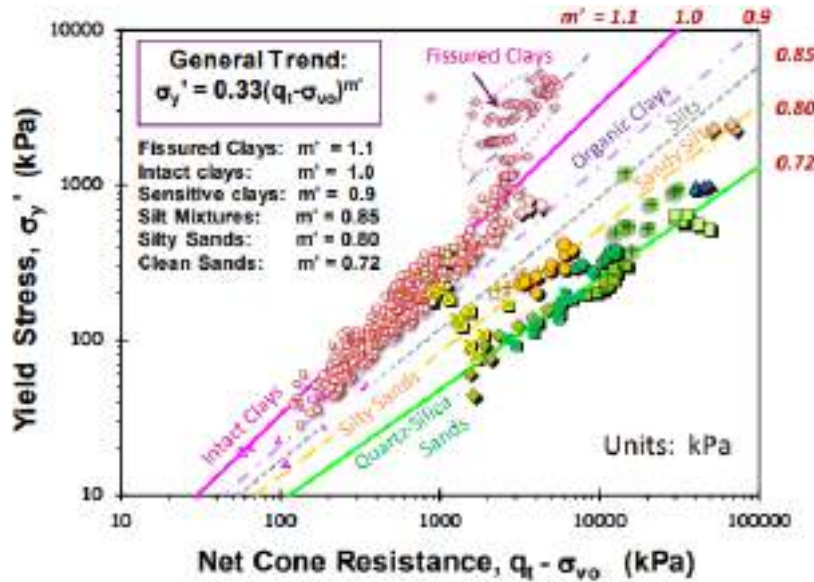


Figure 5-6 Preconsolidation stress with net cone resistance power law, reproduced from Mayne (2014).

An additional set of σ_p' and OCR values were calculated for $m' = 1.1$ to reflect the upper trend for over consolidated fissured clays not captured by the correlation with I_c .

The results are presented in Appendix E.

5.10 SPT N60 VALUES

Equivalent SPT N_{60} values, defined as the non-normalised SPT blow count over a 30 cm interval, with a reference hammer efficiency (energy transfer ratio, 'ETR' or 'ER') of 60%, were derived for two correlations.

Method 1 - Jefferies and Davies (1993) cited in Lunne *et al.* (1997):

$$N_{60} = \frac{q_t}{8.5 \cdot \sigma_{atm} \cdot \left(1 - \frac{I_c}{4.6}\right)}$$

Method 2 - Robertson (2012):

$$\frac{\left(\frac{q_t}{p_a}\right)}{N_{60}} = 10^{(1.268 - 0.2817 I_c)}$$

The correlations are intended for clays, silts and sands and not for carbonates or cemented geo-materials.

Conversion of N_{60} values for comparison to other hammer efficiency values, or vice-versa, uses the relationship:

$$N_{60} \times 60 / \text{ETR} = N$$

The results are presented in Appendix F.

5.11 FRICTION ANGLE

Sands

The peak friction angle of granular materials was calculated using the Kulhawy and Mayne (1990) method. The relationship is based on a calibration chamber database from 24 sands of varying mineralogy and is found from:

$$\phi' = 17.6 + 11.0 \cdot \log(q_{t1})$$

Where:

ϕ' = Peak friction angle (degrees)

q_{t1} = stress normalised cone resistance:

$$q_{t1} = \left(\frac{q_t}{\sigma_{atm}} \right) / \left(\frac{\sigma_{v0'}}{\sigma_{atm}} \right)^{0.5}$$

The presence of compressible minerals tends to reduce tip resistance resulting in lower estimate of friction angle, while very coarse (sand) or larger grain size tends to increase tip resistance resulting in higher estimate. Increased penetration resistance due to high k_0 conditions also results in an overestimate of friction angle.

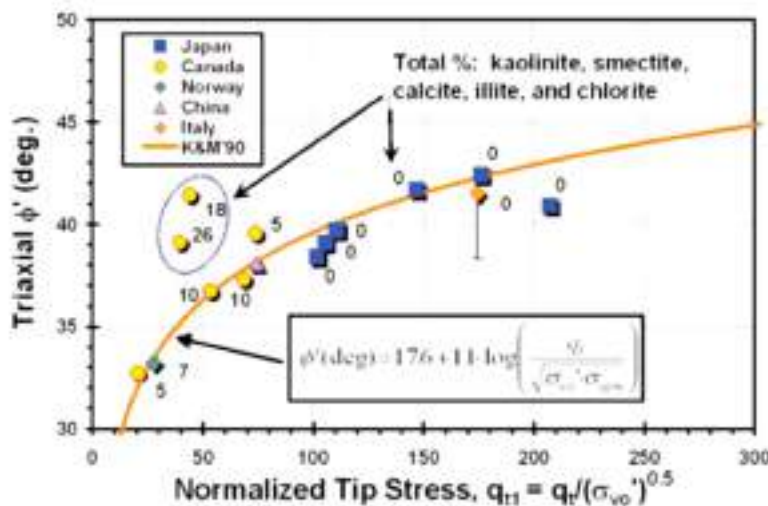


Figure 5-7 Peak triaxial friction angle from undisturbed sands with normalised cone resistance.

Fine grained soils

The effective friction angle for fine grained soils was calculated based on the Senneset *et al.* (1988, 1989) method by applying the approximate closed form solution by Mayne & Campanella (2005) as a direct function of the pore pressure parameter B_q and normalised tip resistance Q . The method is applicable where $0.1 < B_q < 1.0$ and $20^\circ < \phi' < 45^\circ$ and generally appropriate for non-cemented normally consolidated to lightly overconsolidated soils.

$$\phi' = 29.5^\circ B_q^{0.121} [0.256 + 0.336 B_q + \log Q]$$

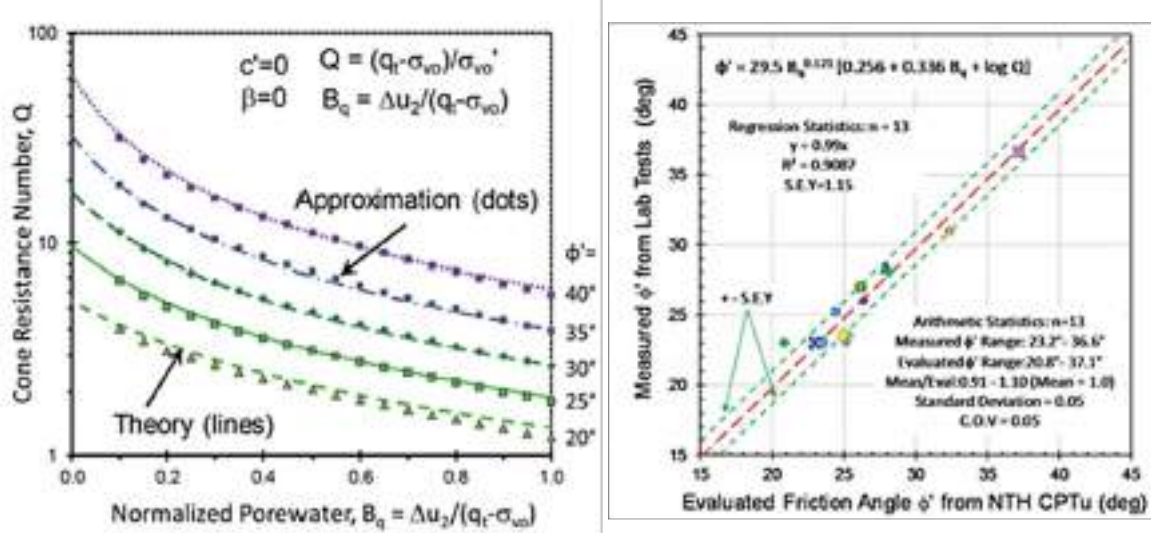


Figure 5-8 [Left] Theoretical curves with function approximation (dots) overlay [Right] calibration data from geotechnical centrifuge tests for a variety of soils. Redrawn from Ouyang & Mayne (2018).

The results are presented in Appendix F.

5.12 COEFFICIENT OF VOLUME CHANGE

Coefficient of volume change m_v defined as the inverse of the constrained modulus M , is evaluated for all soil types using the constrained modulus method proposed by Mayne (2006) cited in Mayne (2007). The value may be used to predict settlement at the end of primary consolidation and is applicable to the present state of vertical effective stress up to the pre-consolidation stress for overconsolidated soils.

$$m_v = \frac{1}{M}$$

Where:

$$M = \alpha \cdot (q_t - \sigma_v)$$

$$\alpha = 5$$

An alpha factor of 8.25 reported by Kulhawy & Mayne (1990) for fine grained soils appears to provide a better fit through the data for intact non-organic clays, reducing to around 1 to 2 for organic plastic clays.

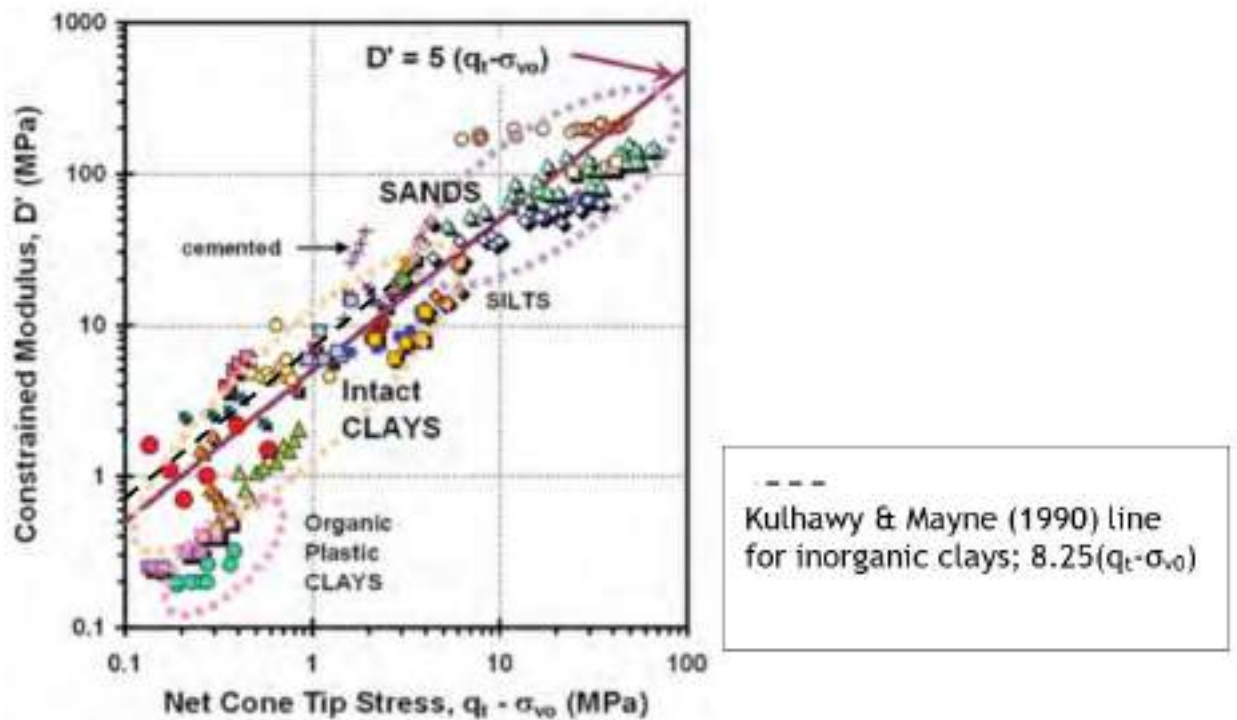


Figure 5-9 Constrained modulus of Mayne (2006). Annotated/redrawn from NCHRP Synthesis 368 (2007).

The results are presented in Appendix E.

5.13 YOUNG'S MODULUS

The secant Young's modulus E' at 25% mobilised shear strength (FOS = 4) was calculated according to the method proposed by Robertson (2009):

$$E' = \alpha(q_t - \sigma_v)$$

Where:

$$\alpha = 0.015(10^{0.55Ic+1.68})$$

The method described by Robertson may be adapted to estimate E' for loading at different percentages of mobilised shear strength.

The results are presented in Appendix F.

6 CPT INTERPRETATION NOTES

Provided below is a non-exhaustive set of notes on interpretation of the acquired CPT data with reference to examples within the dataset where appropriate.

DRAINED AND UNDRAINED SOIL BEHAVIOUR

Geotechnical parameters appropriate for drained and undrained cone penetration conditions are derived for drained and undrained soil behaviour types (SBTs) respectively, however, to help mitigate the uncertainty in the SBT correlation with drainage behaviour, all parameters are derived over the Soil Behaviour Type range $2.4 < I_c < 2.7$. For partially drained conditions, error will be introduced within derived parameters.

Piezocene dynamic pore pressure and dissipation tests may be used to identify drainage conditions. Dissipation t_{50} values exceeding 50 seconds indicate undrained penetration behaviour based on the findings of Kim *et al.* (2008).

In partially drained materials the friction sleeve resistance may rise significantly immediately following a pause in penetration due to consolidation and increased effective stress on the friction sleeve.

DYNAMIC PORE PRESSURE u_2 (CPT u)

While the piezo system is saturated before use, testing through unsaturated soils may result in some degree of desaturation leading to a less accurate and more ‘sluggish’ pore pressure response. Desaturation can also occur during penetration due to suction pressure causing cavitation during dilative shear at the cone shoulder. Dissipation tests that are undertaken following desaturation are likely to have a more pronounced initial rise and the results of analysis may have some degree of error.

If the piezometer system becomes desaturated it may re-saturate at higher excess pressures later in the test as gas dissolves under pressure. The pore pressure response in saturated contractive soils should normally have a dynamic ‘peaky’ appearance.

The tip resistance in lower strength contractive soils without pore pressure measurement in the u_2 position is likely to be significantly lower (up to 20%, typically ~10%) than the equivalent corrected tip resistance depending on the magnitude of excess pore pressure generated during penetration.

CONE TIP AND SLEEVE OFFSET

The accuracy of the SBT over thin layers and at layer boundaries is sensitive to offset error in the friction ratio often resulting in sharp peaks or troughs at boundaries. The friction ratio is often inaccurate in heavily disturbed soils with a ‘blocky’ macro fabric. The last ~8 cm of data is also not included in the SBT material description as no friction sleeve measurements are recorded.

FRICTION SLEEVE DATA

There are three common causes of friction sleeve measurement error; 1) unequal pore pressure acting on the sleeve end areas as the sleeve passes through materials of different permeability and hence excess pore pressure Δu_2 , often resulting in a negative/positive spike, 2) Accuracy limitations and temperature effects in very low strength or sensitive soils, and 3) error associated with bending strain that occurs while the cone inclination deviates rapidly. Temperature effects

are generally mitigated by temperature stabilisation during the test and at the time of zero output measurement.

CONE TYPE

The reference cone type has a 10 cm² projected cone tip area and 150 cm² friction sleeve area, however it is common to use a larger 15 cm² cone with a 225 cm² friction sleeve area for improved sensitivity, temperature stability, damage prevention and penetration depth potential due to the higher bending strength. Use of a 15 cm² cone does however require higher penetration force (reaction force) for a given penetration pressure and produces more pronounced transitions zones and thin layer effects due to the larger influence zone.

TRANSITION ZONES AND THIN LAYER EFFECTS

During penetration at the boundary between soils of contrasting stiffness, a transition zone is often evident prior to mobilisation of the true soil stiffness. These should be cautiously ignored in assessment of soil behaviour type and parameter evaluation. Where the stiff layer is thin (<~1 m) mobilised resistance may be significantly less than that of an equivalent thick layer. The effect for thin low stiffness layers is less significant. Procedures for thin-layer effect correction are provided by Robertson and Wride (1998) and Boulanger & DeJong (2018).

GRAVELS

The presence of gravel or larger clasts in a soil is often characterised by short peaks in the CPT tip and sleeve readings, possibly with associate inclinometer 'shake' and/or short sharp reductions in pore water readings due to dilation effects. Frequent gravels in soft or loose soils may generate localised erroneous friction ratio values.

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APPENDICES

Appendix A	SUMMARY TABLES
Appendix B	GENERAL INFORMATION
Appendix C	CONE PENETRATION TEST RESULTS
Appendix D	SOIL BEHAVIOUR TYPE RESULTS
Appendix E	PARAMETER RESULTS 1 – s_u, m_v, OCR, SBT, I_c
Appendix F	PARAMETER RESULTS 2 – SPT N60, Φ, D_r, E, I_c
Appendix G	PENETROMETER TEMPERATURE RESULTS

APPENDIX A SUMMARY TABLES

Table 3 CPT summary

Location ID	Stroke number	Final depth (m)	Cone ID	Piezococone test	Pre-drilled (m)	Pre-drilling details	Rig	Primary refusal factor	Applied zero values: qc, fs, u2	Tip zero drift (kPa)	Sleeve zero drift (subtraction) (kPa)	Piezo. zero drift (kPa)	Nr dissipation tests	Raw file name	Easting (m)	Northing (m)	Elevation (m)	Date	Remarks
CPT01	1	15.22	S15-CFIPTT.2141	YES			UK22	Target depth	pre, pre, pre	-10.60	0.00	0.20		108354-V1-030723-UK22-LP81.L08				04/07/2023	
CPT02	1	12.86	S15-CFIPTT.2141	NO			UK22	Sleeve load	pre, pre, pre	13.60	0.70	N/A		108354-V1-030723-UK22-LP81.L10				04/07/2023	
CPT03	1	14.84	S15-CFIPTT.2141	YES			UK22	Sleeve load	pre, pre, pre	-24.20	-1.10	6.00		108354-V1-030723-UK22-LP81.L09				04/07/2023	
CPT04	1	15.20	S15-CFIPTT.2141	NO			UK22	Target depth	pre, pre, pre	-8.80	0.00	N/A		108354-V1-030723-UK22-LP81.L07				04/07/2023	
CPT05	1	15.26	S15-CFIPTT.2141	YES			UK22	Target depth	pre, pre, pre	-4.60	-0.10	4.10		108354-V1-030723-UK22-LP81.L06				03/07/2023	
CPT06	1	14.54	S15-CFIPTT.2141	NO			UK22	Sleeve load	pre, pre, pre	0.20	-0.50	N/A		108354-V1-030723-UK22-LP81.L05				03/07/2023	
CPT07	1	12.02	S15-CFIPTT.2141	YES			UK22	Total reaction force	pre, pre, pre	-6.20	-0.30	7.10		108354-V1-030723-UK22-LP81.L04				03/07/2023	
CPT08	1	12.28	S15-CFIPTT.2141	NO			UK22	Total reaction force	pre, pre, pre	-17.60	1.50	N/A		108354-V1-030723-UK22-LP81.L02				03/07/2023	
CPT09	1	11.82	S15-CFIPTT.2141	YES			UK22	Total reaction force	pre, pre, pre	-7.60	-0.10	-6.10		108354-V1-030723-UK22-LP81.L03				03/07/2023	
CPT10	1	14.08	S15-CFIPTT.2213	NO			UK22	Total reaction force	pre, pre, pre	-4.40	-0.50	N/A		108354-V1-030723-UK22-LP81.L01				03/07/2023	

CPT test plots are presented in Appendix C.

APPENDIX B GENERAL INFORMATION

LIST OF FIGURES

Cone calibration certificate: S15-CFIIP.2141

Cone calibration certificate: S15-CFIIP.2213

Data sheet: 18.0-tonne track-truck mounted CPT unit (UK22)

Instrument:	Digital-Geopoint-S15-150kN-5MPa	Location:	Lankelma Calibration Laboratory
Serial number:	S15-CFIPTT.2141	Temperature (°C):	14.8
Manufacturer:	Geopoint	Temperature change (°C):	0.03
Calibration standard:	Conforms to ISO 376:2011 & ISO 22476-1:2012	Calibration engineer:	P Metcalf
ISO 22476-1:2012 application class:	Class 1	Date of calibration:	12/04/2023
		Calibration expiry:	12/10/2023

This calibration certificate is valid for 6 months.

Calibration signed and dated by: 	Calibration checked and dated by: 	Calibration verification signed and dated by:
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REFERENCE INSTRUMENTS	SERIAL NUMBER	UNCERTAINTY OF RECORDED VALUE	CALIBRATION DATE
AM DSCCHA-100kN Load Cell	66914	0.02%	29/04/2021
AM DSCCHA-5kN Load Cell	61065	0.05%	29/04/2021
Omega MMG750V	502273	0.01%	01/09/2022
Keithley 3706A Multimeter	4067652	10ppm	11/08/2022
LD Solar2-45	168558	0.04°	01/08/2022
ETI Ref Thermometer	D20345255	0.01°C	08/09/2022

The calibration tests were made in the Lankelma force standards machine. The applied forces of which are within an uncertainty of:
± 0.050 % of nominal value from 0.5kN up to 10kN, then 0.02% of nominal from 10kN up to 100kN.

MEASUREMENTS

- The forces applied, and the resulting deflections are given in Tables 1. No corrections for temperature have been applied to these results.
 - The cone was loaded to full range 3 times for no less than 1 minute before calibration and after each rotation.
 - The cone was calibrated in low and high range using two reference load cells. The low range calibration consisted of a maximum load of 5kN with 4 sets of increasing forces and 2 sets of decreasing forces. The high range calibration consisted of a maximum load of 100kN with 3 sets of increasing forces and 2 sets of decreasing forces.
 - The difference in deflection for each applied force with rotation is the relative reproducibility error b , shown as a percentage of the recorded value and in units of pressure MPa. The uncertainty relating to the difference in deflection for increasing forces against decreasing forces is the reversibility uncertainty U_{rev} , shown as a percentage of the recorded value and in units of pressure MPa.
 - For each application of force, the coefficients of a linear and third order equation relating the estimate of the mean deflection as a function of the applied calibration force were calculated. Table 2.
 - The combined expanded uncertainty of deflection U for each force is shown as a percentage of the recorded value and in units of pressure MPa.
 - The coefficients of a third order equation relating a given applied force to the estimate of the mean deflection were also calculated. The coefficients are given in Table 3.
 - In use the forces acting on the sleeve load cell element are a combination of tip resistance and sleeve friction, with the tip resistance from the tip load cell element being subtracted to give the sleeve friction value. The resultant error values for differing tip and sleeve values are shown in Table 4.
- * The combined expanded uncertainties shown are to $k=2$ with a 95% coverage factor.

The calibration uncertainty is the uncertainty in the force value calculated from the interpolation equation at any deflection.

 At each calibration point a combined standard uncertainty uc is calculated from the readings obtained during the calibration.

$$uc = \sqrt{\sum_{i=1}^8 u_i^2}$$

and

$$U = k \times uc$$

where

- u_1 is the standard uncertainty associated with the applied calibration force.
 u_2 is the standard uncertainty associated with the reproducibility of the calibration results.
 u_3 is the standard uncertainty associated with the repeatability of the calibration results.
 u_4 is the standard uncertainty associated with the resolution and noise of the system.
 u_5 is the standard uncertainty associated with the creep of the instrument.
 u_6 is the standard uncertainty associated with the drift in zero output.
 u_7 is the standard uncertainty associated with temperature of the instrument.
 u_8 is the standard uncertainty associated with interpolation best fit of the linear or 3rd order polynomial equation.

Symbols and their designations

Symbol	Designation
Ref LC	Reference load cell with calibration force in kN
cts	Counts. Base digital cone units.
0.1N	Interpolated digital cone units from counts
b	Relative reproducibility error
U_{rev}	Reversibility uncertainty
U_c	Combined standard uncertainty
U_{c_sub}	Combined standard uncertainty including sleeve subtraction
U	Combined expanded uncertainty
$k=2$	95% uncertainty coverage factor

Cone temperature effect profile:

This section deals with the apparent pressure readings obtained from sensors due to static and transient temperature change. The parameters for post-processing temperature correction are established and the apparent pressures after correction are presented. Depending on the design or temperature performance, correction of the friction sleeve and/or piezometer readings may not be warranted

CONE END RESISTANCE CALIBRATION

Table 1-a.

Low range calibration									High range calibration								
Ref LC (kN)	Tip change In output (cts)				Reproducibility error <i>b</i>		Reversibility error <i>U_{rev}</i>		Ref LC (kN)	Tip change in output (cts)			Reproducibility error <i>b</i>		Reversibility error <i>U_{rev}</i>		
	1 0°	2 120°	3 240°	4 240°	MPa	%	MPa	%		1 0°	2 120°	3 240°	MPa	%	MPa	%	
0.100	1.128E+05	1.126E+05	1.108E+05	1.108E+05	0.000	0.55			5.000	5.530E+06	5.524E+06	5.525E+06	0.001	0.03			
0.500	5.534E+05	5.510E+05	5.478E+05	5.506E+05	0.001	0.30			10.000	1.105E+07	1.104E+07	1.105E+07	0.001	0.02			
1.000	1.105E+06	1.103E+06	1.097E+06	1.100E+06	0.001	0.22			15.000	1.657E+07	1.656E+07	1.656E+07	0.001	0.01			
1.500	1.658E+06	1.655E+06	1.645E+06	1.647E+06	0.002	0.24			20.000	2.209E+07	2.208E+07	2.208E+07	0.001	0.01			
2.000	2.209E+06	2.205E+06	2.197E+06	2.197E+06	0.002	0.16			30.000	3.311E+07	3.310E+07	3.311E+07	0.002	0.01			
2.500	2.760E+06	2.758E+06	2.748E+06	2.748E+06	0.002	0.14			40.000	4.413E+07	4.412E+07	4.412E+07	0.002	0.01			
3.000	3.314E+06	3.309E+06	3.299E+06	3.298E+06	0.003	0.13			50.000	5.514E+07	5.513E+07	5.513E+07	0.002	0.01			
3.500	3.866E+06	3.861E+06	3.847E+06	3.849E+06	0.003	0.14			60.000	6.613E+07	6.612E+07	6.612E+07	0.002	0.01			
4.000	4.416E+06	4.412E+06	4.399E+06	4.398E+06	0.003	0.11			80.000	8.809E+07	8.808E+07	8.807E+07	0.004	0.01			
5.000	5.520E+06	5.514E+06	5.500E+06	5.499E+06	0.004	0.11			100.000	1.100E+08	1.100E+08	1.100E+08	0.004	0.01			
4.000	4.420E+06	4.421E+06			0.000	0.01	-0.002	-0.08	80.000	8.808E+07	8.807E+07		0.002	0.00	0.004	0.01	
3.500	3.866E+06	3.867E+06			0.000	0.02	-0.001	-0.05	60.000	6.613E+07	6.613E+07		0.001	0.00	-0.001	0.00	
3.000	3.315E+06	3.314E+06			0.000	0.01	-0.001	-0.05	50.000	5.514E+07	5.514E+07		0.001	0.00	-0.001	0.00	
2.500	2.760E+06	2.760E+06			0.000	0.00	0.000	-0.01	40.000	4.413E+07	4.413E+07		0.001	0.00	-0.002	-0.01	
2.000	2.208E+06	2.207E+06			0.000	0.01	0.000	-0.01	30.000	3.312E+07	3.311E+07		0.000	0.00	-0.002	-0.01	
1.500	1.656E+06	1.655E+06			0.000	0.02	0.000	0.04	20.000	2.208E+07	2.208E+07		0.000	0.00	0.001	0.00	
1.000	1.102E+06	1.101E+06			0.000	0.01	0.001	0.14	15.000	1.656E+07	1.656E+07		0.000	0.00	0.001	0.01	
0.500	5.495E+05	5.498E+05			0.000	0.02	0.001	0.27	10.000	1.104E+07	1.104E+07		0.000	0.00	0.002	0.03	
0.100	1.064E+05	1.087E+05			0.001	0.76	0.002	2.63	5.000	5.521E+06	5.523E+06		0.000	0.01	0.002	0.05	

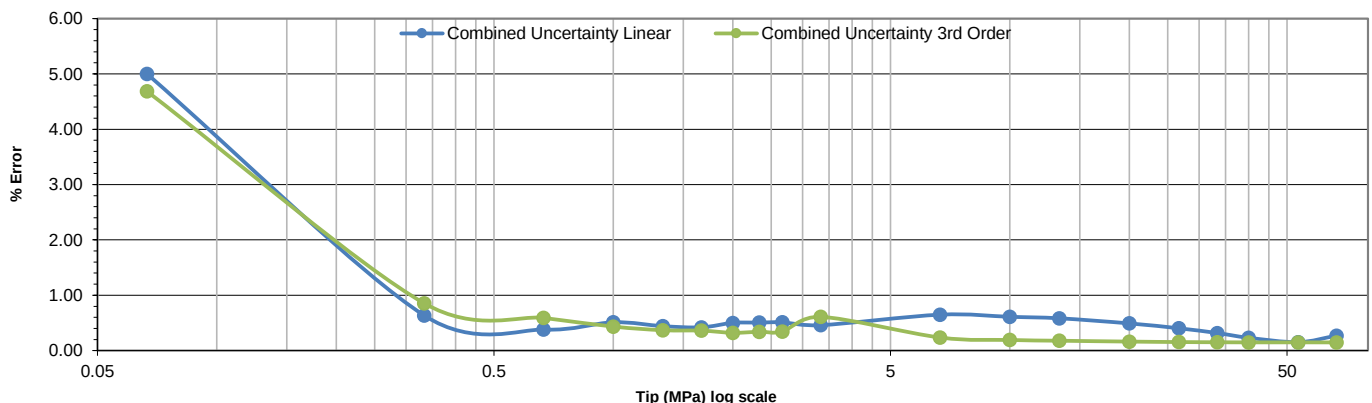
Table 2-a.

Low range calibration									High range calibration								
Reference output		Linear equation			3rd order equation			Ref Load Cell Nom. (MPa)	Ref Load Cell (0.1N)	Linear equation			3rd order equation			Ref Load Cell Nom. (MPa)	Ref Load Cell (0.1N)
Ref Load Cell Nom. (MPa)	Ref Load Cell (0.1N)	Cone output (0.1N)	Expanded uncertainty <i>U</i> *	%	Equation output (0.1N)	Expanded uncertainty <i>U</i> *	%			Cone output (0.1N)	Expanded uncertainty <i>U</i> *	%	Equation output (0.1N)	Expanded uncertainty <i>U</i> *	%		
0.067	1000	1018	0.003	4.16	1020	0.003	4.63	0.067	1000	50184	0.028	0.85	50034	0.014	0.41	0.067	1000
0.333	5000	5001	0.003	0.83	4991	0.003	0.91	0.333	50000	100324	0.046	0.69	100034	0.016	0.24	0.333	50000
0.667	10000	10007	0.004	0.55	9980	0.005	0.68	0.667	100000	150443	0.063	0.63	150032	0.020	0.20	0.667	100000
1.000	15000	15010	0.005	0.52	14967	0.007	0.68	1.000	150000	200554	0.078	0.59	200042	0.024	0.18	1.000	150000
1.333	20000	20015	0.005	0.35	19957	0.007	0.56	1.333	200000	300666	0.095	0.47	300012	0.033	0.16	1.333	200000
1.667	25000	25022	0.005	0.33	24947	0.009	0.53	1.667	250000	400714	0.104	0.39	400006	0.041	0.15	1.667	250000
2.000	30000	30035	0.006	0.32	29945	0.010	0.48	2.000	300000	500672	0.103	0.31	500003	0.050	0.15	2.000	300000
2.333	35000	35036	0.008	0.35	34931	0.012	0.52	2.333	350000	600514	0.091	0.23	599984	0.060	0.15	2.333	350000
2.667	40000	40041	0.008	0.29	39920	0.013	0.49	2.667	400000	799887	0.081	0.15	799962	0.079	0.15	2.667	400000
3.333	50000	50048	0.015	0.46	49897	0.020	0.61	3.333	500000	998875	0.179	0.27	1000033	0.098	0.15	3.333	500000
2.667	40000	40141	0.019	0.73	40020	0.005	0.20	2.667	400000	799819	0.081	0.15	799894	0.079	0.15	2.667	400000
2.333	35000	35113	0.016	0.67	35007	0.004	0.16	2.333	350000	600549	0.094	0.24	600020	0.059	0.15	2.333	350000
2.000	30000	30098	0.014	0.68	30008	0.003	0.16	2.000	300000	500719	0.108	0.32	500050	0.050	0.15	2.000	300000
1.667	25000	25061	0.009	0.51	24986	0.003	0.19	1.667	250000	400770	0.111	0.42	400063	0.041	0.15	1.667	250000
1.333	20000	20050	0.007	0.53	19991	0.002	0.18	1.333	200000	300718	0.101	0.51	300065	0.032	0.16	1.333	200000
1.000	15000	15035	0.005	0.50	14993	0.002	0.19	1.000	150000	200550	0.077	0.58	200038	0.023	0.17	1.000	150000
0.667	10000	10003	0.001	0.20	9977	0.003	0.50	0.667	100000	150418	0.059	0.59	150008	0.019	0.19	0.667	100000
0.333	5000	4991	0.001	0.44	4981	0.003	0.80	0.333	50000	100274	0.040	0.60	99984	0.015	0.23	0.333	50000
0.067	1000	977	0.004	5.84	980	0.003	4.74	0.067	10000	50146	0.024	0.72	49995	0.013	0.38	0.067	10000

Table 3-a. Third order equation

For a given cone indicated output of D (0.1N units), the corrected applied force	a0 = 6.04666	Maximum tip zero drift during the calibration (MPa) =	0.001
F (in 0.1N units) is calculated from :	a1 = 0.99670	Maximum load cell zero drift during the calibration (MPa) =	0.001
F = (a3 x D³) + (a2 x D²) + (a1 x D) + a0	a2 = 3.32582E-09	Factor used to convert from counts to 0.1N units =	0.0090812
	a3 = 1.12918E-15	Maximum tip full scale reading (MPa) =	100.00
		Tip resolution (Pa) =	66.7
		Tip area (cm²) =	15
		Tip area ratio factor =	0.796

COMBINED EXPANDED UNCERTAINTY TIP



SLEEVE FRICTION CALIBRATION

Table1-b.

Low range calibration								High range calibration									
Ref LC (kN)	Sleeve change in output (cts)				Reproducibility error <i>b</i>		Reversibility error <i>U_{rev}</i>		Ref LC (kN)	Sleeve change in output (cts)				Reproducibility error <i>b</i>		Reversibility error <i>U_{rev}</i>	
	1 0°	2 120°	3 240°	4 240°	kPa	%	kPa	%		1 0°	2 120°	3 240°	kPa	%	kPa	%	
0.100	1.147E+05	1.156E+05	1.130E+05	1.130E+05	0.029	0.67			5.000	5.681E+06	5.680E+06	5.681E+06	0.013	0.01			
0.500	5.684E+05	5.695E+05	5.630E+05	5.663E+05	0.078	0.35			10.000	1.136E+07	1.136E+07	1.136E+07	0.020	0.00			
1.000	1.136E+06	1.136E+06	1.131E+06	1.131E+06	0.062	0.14			15.000	1.703E+07	1.703E+07	1.703E+07	0.030	0.00			
1.500	1.703E+06	1.702E+06	1.696E+06	1.700E+06	0.078	0.12			20.000	2.271E+07	2.271E+07	2.271E+07	0.080	0.01			
2.000	2.271E+06	2.269E+06	2.265E+06	2.266E+06	0.061	0.07			30.000	3.406E+07	3.405E+07	3.405E+07	0.117	0.01			
2.500	2.837E+06	2.838E+06	2.831E+06	2.832E+06	0.083	0.08			40.000	4.539E+07	4.539E+07	4.539E+07	0.068	0.00			
3.000	3.404E+06	3.405E+06	3.395E+06	3.398E+06	0.125	0.09			50.000	5.672E+07	5.671E+07	5.671E+07	0.130	0.01			
3.500	3.974E+06	3.971E+06	3.963E+06	3.966E+06	0.121	0.08			60.000	6.805E+07	6.803E+07	6.803E+07	0.201	0.01			
4.000	4.539E+06	4.540E+06	4.531E+06	4.529E+06	0.105	0.06			80.000	9.066E+07	9.064E+07	9.064E+07	0.222	0.01			
5.000	5.675E+06	5.673E+06	5.663E+06	5.665E+06	0.145	0.07			100.000	1.132E+08	1.132E+08	1.132E+08	0.298	0.01			
4.000	4.546E+06	4.549E+06			0.041	0.02	-0.178	-0.10	80.000	9.067E+07	9.065E+07		0.247	0.01	-0.198	-0.01	
3.500	3.979E+06	3.980E+06			0.011	0.01	-0.159	-0.10	60.000	6.806E+07	6.805E+07		0.182	0.01	-0.374	-0.01	
3.000	3.411E+06	3.410E+06			0.007	0.01	-0.137	-0.10	50.000	5.675E+07	5.674E+07		0.152	0.01	-0.502	-0.02	
2.500	2.841E+06	2.842E+06			0.012	0.01	-0.090	-0.08	40.000	4.542E+07	4.541E+07		0.150	0.01	-0.487	-0.03	
2.000	2.272E+06	2.272E+06			0.007	0.01	-0.054	-0.06	30.000	3.408E+07	3.407E+07		0.103	0.01	-0.482	-0.04	
1.500	1.704E+06	1.705E+06			0.018	0.03	-0.053	-0.08	20.000	2.272E+07	2.272E+07		0.059	0.01	-0.200	-0.02	
1.000	1.134E+06	1.136E+06			0.033	0.07	0.018	0.04	15.000	1.705E+07	1.704E+07		0.072	0.01	-0.186	-0.03	
0.500	5.642E+05	5.672E+05			0.041	0.19	0.074	0.33	10.000	1.136E+07	1.136E+07		0.059	0.01	-0.076	-0.02	
0.100	1.128E+05	1.136E+05			0.010	0.23	0.043	0.98	5.000	5.686E+06	5.680E+06		0.079	0.04	-0.064	-0.03	

Table 2-b.

Low range calibration								High range calibration							
Reference output		Linear factor output			3rd order equation			Reference output		Linear factor output			3rd order equation		
Ref Load Cell Nom. (kPa)	Ref Load Cell (0.1N)	Cone output (0.1N)	Expanded uncertainty U^* kPa	%	Equation output (0.1N)	Expanded uncertainty U^* kPa	%	Ref Load Cell Nom. (kPa)	Ref Load Cell (0.1N)	Cone output (0.1N)	Expanded uncertainty U^* kPa	%	Equation output (0.1N)	Expanded uncertainty U^* kPa	%
4	1000	1010	0.109	2.48	1005	0.083	1.87	220	50000	50126	1.385	0.63	50002	0.826	0.38
22	5000	5003	0.212	0.96	4989	0.232	1.05	441	100000	100218	2.158	0.49	99984	1.000	0.11
44	10000	10010	0.168	0.38	9983	0.204	0.46	661	150000	150309	2.988	0.45	149977	1.250	0.09
66	15000	15005	0.241	0.37	14965	0.388	0.59	881	200000	200389	3.754	0.43	199974	1.547	0.09
88	20000	20016	0.234	0.27	19964	0.369	0.42	1322	300000	300475	4.684	0.35	299940	2.169	0.08
110	25000	25020	0.299	0.27	24956	0.460	0.42	1762	400000	400532	5.380	0.31	399944	2.689	0.08
132	30000	30014	0.375	0.28	29938	0.651	0.49	2203	500000	500486	5.371	0.24	499921	3.318	0.08
154	35000	35025	0.420	0.27	34937	0.664	0.43	2643	600000	600371	5.062	0.19	599913	3.941	0.07
176	40000	40032	0.455	0.26	39931	0.705	0.40	3524	800000	799870	5.233	0.15	799909	5.168	0.07
220	50000	50039	0.939	0.43	49915	1.151	0.52	4405	1000000	999045	10.533	0.24	1000011	6.337	0.07
176	40000	40125	1.141	0.65	40025	0.363	0.21	3524	800000	799983	5.036	0.14	800022	5.038	0.07
154	35000	35114	1.032	0.67	35025	0.331	0.21	2643	600000	600547	6.142	0.23	600089	3.886	0.07
132	30000	30097	0.876	0.66	30020	0.274	0.21	2203	500000	500696	6.922	0.31	500131	3.409	0.08
110	25000	25074	0.671	0.61	25009	0.188	0.17	1762	400000	400734	6.973	0.40	400146	2.905	0.08
88	20000	20051	0.465	0.53	19999	0.132	0.15	1322	300000	300674	6.268	0.47	300138	2.354	0.09
66	15000	15043	0.394	0.60	15003	0.111	0.17	881	200000	200481	4.478	0.51	200066	1.565	0.09
44	10000	10017	0.178	0.41	9990	0.129	0.29	661	150000	150389	3.631	0.55	150057	1.305	0.10
22	5000	4992	0.125	0.57	4977	0.224	1.02	441	100000	100252	2.425	0.55	100017	0.994	0.11
4	1000	999	0.039	0.89	995	0.061	1.39	220	50000	50149	1.555	0.71	50025	0.859	0.20

Table 3-b. Third order equation

For a given cone indicated output of D (0.1N units), the corrected applied force F (in 0.1N units) is calculated from : $F = (a_3 \times D^3) + (a_2 \times D^2) + (a_1 \times D) + a_0$	$a_0 =$	-1.76569	Maximum sleeve zero drift during the calibration (kPa) = 0.092 Maximum load cell zero drift during the calibration (kPa) = 0.044 Factor used to convert from counts to 0.1N units = 0.0088242 Physical strength limited maximum sleeve reading (MPa) = 1.333 Sleeve resolution (Pa) = 4.4 Sleeve area (cm²) = 227 Sleeve area ratio factor = -0.001
	$a_1 =$	0.99745	
	$a_2 =$	2.16657E-09	
	$a_3 =$	1.35622E-15	

COMBINED EXPANDED UNCERTAINTY SLEEVE

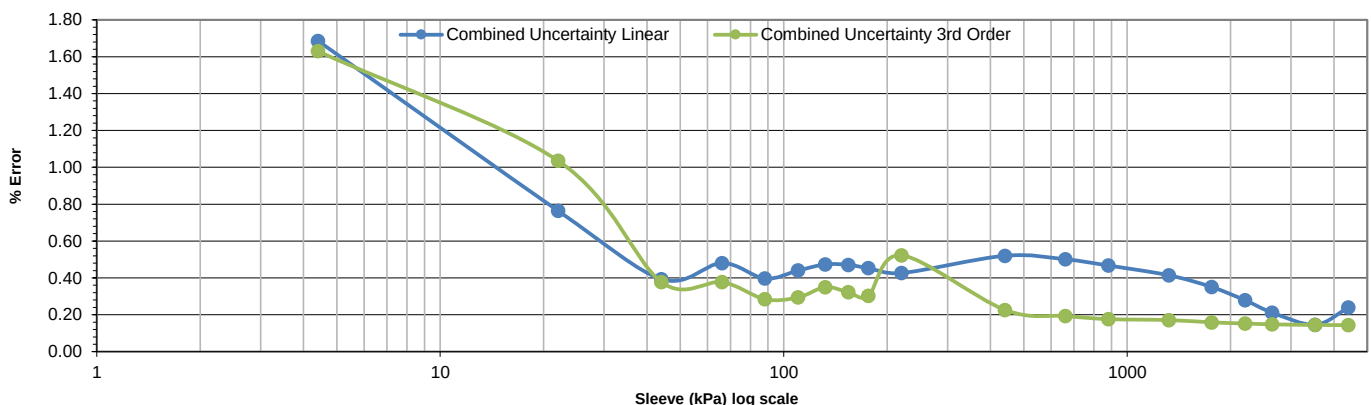


Table 4-b Sleeve friction - tip subtraction combined standard uncertainty U_{c_sub}

Tip MPa ↓		Sleeve linear equation subtraction error (%)							
		Sleeve kPa →							
		4	22	44	66	110	154	220	661
0.07	0.07	4.2	1.1	0.5	0.5	0.4	0.3	0.3	0.3
0.33	0.33	4.3	1.1	0.5	0.5	0.4	0.3	0.3	0.3
0.67	0.67	4.7	1.2	0.6	0.5	0.4	0.3	0.3	0.3
1.00	1.00	8.3	1.9	0.9	0.7	0.5	0.4	0.4	0.3
1.67	1.67	11.6	2.5	1.3	1.0	0.7	0.5	0.4	0.3
2.33	2.33	17.9	3.8	1.9	1.4	0.9	0.7	0.6	0.3
3.33	3.33	23.0	4.8	2.4	1.7	1.1	0.9	0.7	0.3
10.00	10.00	84.1	17.0	8.5	5.8	3.6	2.6	1.9	0.7
13.33	13.33	105.8	21.4	10.7	9.3	4.4	3.2	2.9	0.9

Tip MPa ↓		Sleeve 3rd order equation subtraction error (%)							
		Sleeve kPa →							
		4	22	44	66	110	154	220	661
0.07	0.07	4.0	1.1	0.5	0.4	0.3	0.3	0.3	0.1
0.33	0.33	5.5	1.5	0.7	0.5	0.3	0.3	0.4	0.1
0.67	0.67	5.7	1.5	0.7	0.5	0.3	0.3	0.4	0.1
1.00	1.00	6.9	1.7	0.8	0.6	0.4	0.3	0.4	0.1
1.67	1.67	9.0	2.2	1.0	0.7	0.5	0.4	0.4	0.2
2.33	2.33	12.4	2.8	1.3	1.0	0.6	0.5	0.5	0.2
3.33	3.33	29.1	6.2	3.0	2.1	1.3	1.0	0.8	0.3
10.00	10.00	29.7	6.3	3.1	2.1	1.3	1.0	0.8	0.3
13.33	13.33	36.2	7.6	3.7	3.5	1.6	1.2	1.0	0.3

PORE PRESSURE CALIBRATION

Table 1-c.

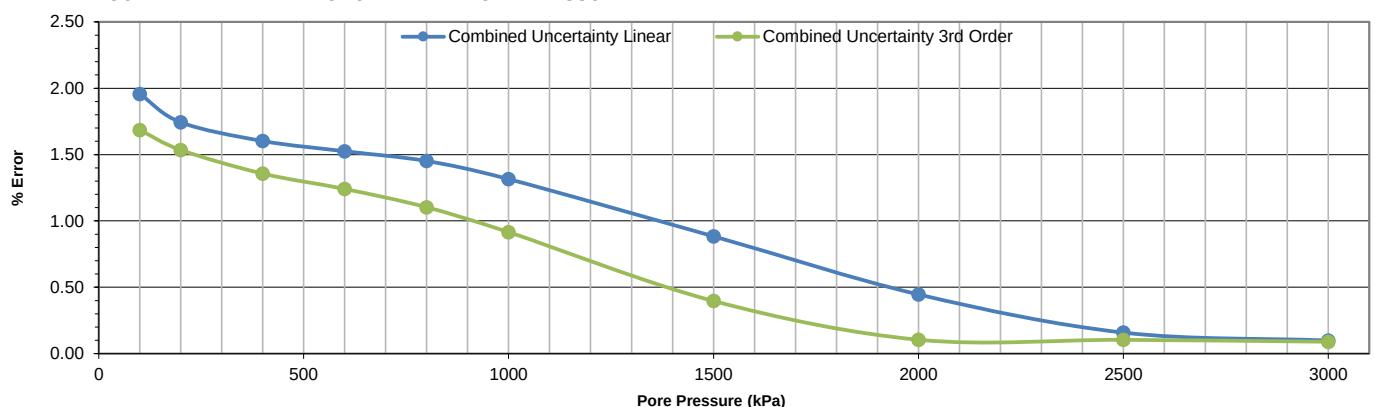
Ref PR (kPa)	PWP change in output (cts)			Reproducibility error b		Reversibility error U_{rev}	
	1	2	3				
	0°	120°	240°	kPa	%	kPa	%
100	2.069E+07	2.066E+07	2.064E+07	0.1	0.07		
200	4.131E+07	4.136E+07	4.134E+07	0.1	0.03		
400	8.262E+07	8.263E+07	8.263E+07	0.0	0.00		
600	1.239E+08	1.239E+08	1.239E+08	0.0	0.00		
800	1.651E+08	1.651E+08	1.651E+08	0.1	0.01		
1000	2.062E+08	2.063E+08	2.063E+08	0.1	0.01		
1500	3.092E+08	3.092E+08	3.093E+08	0.1	0.01		
2000	4.126E+08	4.126E+08	4.126E+08	0.0	0.00		
2500	5.163E+08	5.163E+08	5.163E+08	0.1	0.00		
3000	6.201E+08	6.201E+08	6.202E+08	0.2	0.01		
2500	5.164E+08	5.164E+08		0.1	0.00	-0.2	-0.01
2000	4.124E+08	4.123E+08		0.1	0.01	0.6	0.03
1500	3.082E+08	3.081E+08		0.1	0.01	3.0	0.20
1000	2.045E+08	2.045E+08		0.1	0.01	4.8	0.48
800	1.634E+08	1.634E+08		0.0	0.00	4.7	0.59
600	1.225E+08	1.224E+08		0.0	0.01	4.0	0.66
400	8.161E+07	8.156E+07		0.1	0.02	2.9	0.73
200	4.075E+07	4.075E+07		0.0	0.00	1.6	0.82
100	2.033E+07	2.036E+07		0.1	0.05	0.9	0.93

Table 2-c.

Reference output		Linear factor output			3rd order equation		
Ref Pressure (kPa)	Ref Pressure (0.1Pa)	Cone output (0.1Pa)	Expanded uncertainty U^* kPa	%	Equation output (0.1N)	Expanded uncertainty U^* kPa	%
100	1000000	999821	0.643	0.64	1007794	1.686	1.69
200	2000000	2000057	1.112	0.56	2015108	3.220	1.61
400	4000000	3997857	2.015	0.50	4025214	5.413	1.35
600	6000000	5994238	2.941	0.49	6031501	6.856	1.14
800	8000000	7987964	4.028	0.50	8032794	7.308	0.91
1000	10000000	9980867	5.100	0.51	10030998	7.045	0.70
1500	15000000	14962337	7.952	0.53	15016207	4.041	0.27
2000	20000000	19962040	7.844	0.39	20006744	2.228	0.11
2500	25000000	24981568	4.297	0.17	25004989	2.386	0.10
3000	30000000	30006645	2.965	0.10	29997578	2.689	0.09
2500	25000000	24985555	3.631	0.15	25008954	2.813	0.11
2000	20000000	19951194	10.002	0.50	19995932	1.961	0.10
1500	15000000	14908698	18.569	1.24	14962598	7.859	0.52
1000	10000000	9896248	21.205	2.12	9946200	11.267	1.13
800	8000000	7906300	19.194	2.40	7950865	10.341	1.29
600	6000000	5925206	15.360	2.56	5962166	8.036	1.34
400	4000000	3947588	10.802	2.70	3974665	5.438	1.36
200	2000000	1971633	5.860	2.93	1986492	2.919	1.46
100	1000000	984347	3.271	3.27	992206	1.684	1.68

Table 3-c. Third order equation

For a given cone indicated output of D (0.1N units), the corrected applied force	$a_0 = 275.53023$	Maximum PWP zero drift during the calibration (kPa) =	0.20
F (in 0.1N units) is calculated from :	$a_1 = 1.00801$	Maximum reference zero drift during the calibration (kPa) =	0.098
$F = (a_3 \times D^3) + (a_2 \times D^2) + (a_1 \times D) + a_0$	$a_2 = -3.14697E-10$	Factor used to convert from counts to 0.1Pa units =	0.0483852
	$a_3 = 1.24330E-18$	Maximum PWP full scale reading (kPa) =	5000
		PWP resolution (Pa) =	0.1

COMBINED EXPANDED UNCERTAINTY PORE PRESSURE


INCLINATION CALIBRATION

Ref Inclination (°C)	Cone inclination output	
	X Inc (cts)	Y Inc (cts)
-25	-26337	-24359
0	-584	1681
25	25206	27962

Ref Inclination (°)	Cone inclination output	
	X Inc (°)	Y Inc (°)
-25	-25.0	-24.9
0	0.0	0.0
25	25.0	25.1

	X inc	Y inc
Factor used to convert from counts to 0.1m° units =	9.70063664	9.55632469
Inclination error (°) =	0.0	0.1

TEMPERATURE CALIBRATION

Recorded temp (°C)	Cone output 1 FS (cts)	Cone output 2 QC (cts)
6.95	3051544	3046064
9.88	3101729	3096031
14.83	3187683	3181614
19.95	3277424	3270984
24.76	3362808	3356016

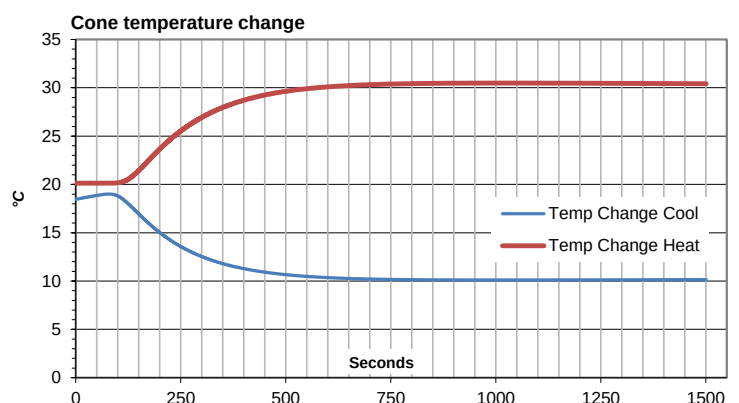
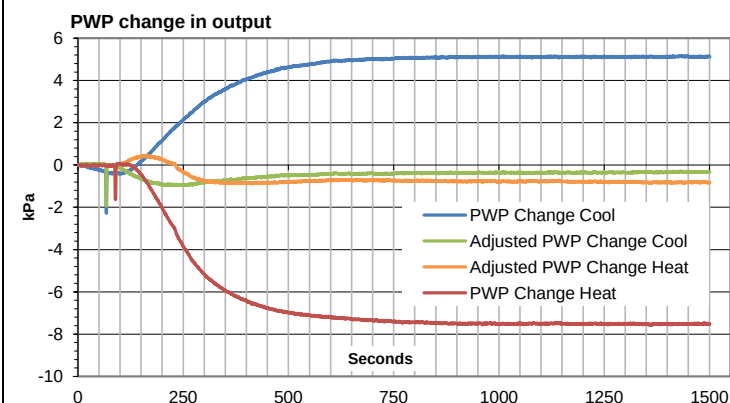
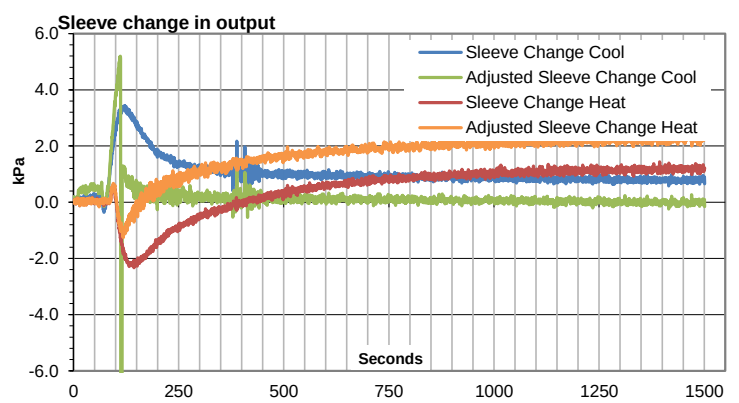
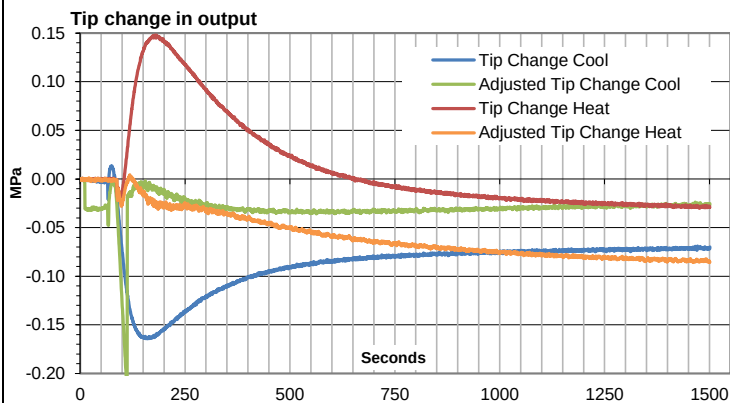
Recorded temp (°C)	Cone output 1 FS (°C)	Cone output 2 QC (°C)
6.95	7.00	7.00
9.88	9.87	9.87
14.83	14.79	14.79
19.95	19.92	19.92
24.76	24.80	24.80

Factor used to convert from counts to 0.00001°C units =	0.572003226	0.574423736
Temperature error (°C) =	0.05	0.05

CONE TEMPERATURE RESPONSE AND CORRECTION

	Cooling	Heating
Start temperature =	19.00	20.13
End temperature =	10.11	30.49
Temperature change =	-8.90	10.37

	Cooling	Heating
Tip maximum rate of change (MPa/(°C/min)) =	0.063	0.053
Tip end change (MPa/°C) =	-0.008	-0.003
Adjusted tip end change (MPa/°C) =	0.003	0.008
Sleeve maximum rate of change (kPa/(°C/min)) =	3.48	2.91
Sleeve end change (kPa/°C) =	0.07	0.12
Adjusted sleeve end change (kPa/°C) =	-0.02	0.23
PWP end change (kPa/°C) =	0.58	-0.72
Adjusted PWP end change (kPa/°C) =	0.04	-0.08



Instrument:	Digital-Geopoint-S15-150kN-5MPa	Location:	Lankelma Calibration Laboratory
Serial number:	S15-CFIPTT.2213	Temperature (°C):	17.3
Manufacturer:	Geopoint	Temperature change (°C):	0.08
Calibration standard:	Conforms to ISO 376:2011 & ISO 22476-1:2012	Calibration engineer:	P Metcalf
ISO 22476-1:2012 application class:	Class 1	Date of calibration:	17/05/2023
		Calibration expiry:	17/11/2023

This calibration certificate is valid for 6 months.

Calibration signed and dated by:



Calibration checked and dated by:



REFERENCE INSTRUMENTS	SERIAL NUMBER	UNCERTAINTY OF RECORDED VALUE	CALIBRATION DATE
AM DSCCHA-100kN Load Cell	66914	0.02%	29/04/2021
AM DSCCHA-5kN Load Cell	61065	0.05%	29/04/2021
Omega MMG750V	502273	0.01%	01/09/2022
Keithley 3706A Multimeter	4067652	10ppm	11/08/2022
LD Solar2-45	168558	0.04°	01/08/2022
ETI Ref Thermometer	D20345255	0.01°C	08/09/2022

The calibration tests were made in the Lankelma force standards machine. The applied forces of which are within an uncertainty of:
± 0.050 % of nominal value from 0.5kN up to 10kN, then 0.02% of nominal from 10kN up to 100kN.

MEASUREMENTS

- The forces applied, and the resulting deflections are given in Tables 1. No corrections for temperature have been applied to these results.
 - The cone was loaded to full range 3 times for no less than 1 minute before calibration and after each rotation.
 - The cone was calibrated in low and high range using two reference load cells. The low range calibration consisted of a maximum load of 5kN with 4 sets of increasing forces and 2 sets of decreasing forces. The high range calibration consisted of a maximum load of 100kN with 3 sets of increasing forces and 2 sets of decreasing forces.
 - The difference in deflection for each applied force with rotation is the relative reproducibility error b , shown as a percentage of the recorded value and in units of pressure MPa. The uncertainty relating to the difference in deflection for increasing forces against decreasing forces is the reversibility uncertainty U_{rev} , shown as a percentage of the recorded value and in units of pressure MPa.
 - For each application of force, the coefficients of a linear and third order equation relating the estimate of the mean deflection as a function of the applied calibration force were calculated. Table 2.
 - The combined expanded uncertainty of deflection U for each force is shown as a percentage of the recorded value and in units of pressure MPa.
 - The coefficients of a third order equation relating a given applied force to the estimate of the mean deflection were also calculated. The coefficients are given in Table 3.
 - In use the forces acting on the sleeve load cell element are a combination of tip resistance and sleeve friction, with the tip resistance from the tip load cell element being subtracted to give the sleeve friction value. The resultant error values for differing tip and sleeve values are shown in Table 4.
- * The combined expanded uncertainties shown are to $k=2$ with a 95% coverage factor.

The calibration uncertainty is the uncertainty in the force value calculated from the interpolation equation at any deflection.

At each calibration point a combined standard uncertainty uc is calculated from the readings obtained during the calibration.

$$uc = \sqrt{\sum_{i=1}^8 u_i^2}$$

and

$$U = k \times uc$$

where

- u_1 is the standard uncertainty associated with the applied calibration force.
 u_2 is the standard uncertainty associated with the reproducibility of the calibration results.
 u_3 is the standard uncertainty associated with the repeatability of the calibration results.
 u_4 is the standard uncertainty associated with the resolution and noise of the system.
 u_5 is the standard uncertainty associated with the creep of the instrument.
 u_6 is the standard uncertainty associated with the drift in zero output.
 u_7 is the standard uncertainty associated with temperature of the instrument.
 u_8 is the standard uncertainty associated with interpolation best fit of the linear or 3rd order polynomial equation.

Symbols and their designations

Symbol	Designation
Ref LC	Reference load cell with calibration force in kN
cts	Counts. Base digital cone units.
0.1N	Interpolated digital cone units from counts
b	Relative reproducibility error
U_{rev}	Reversibility uncertainty
U_c	Combined standard uncertainty
U_{c_sub}	Combined standard uncertainty including sleeve subtraction
U	Combined expanded uncertainty
$k=2$	95% uncertainty coverage factor

Cone temperature effect profile:

This section deals with the apparent pressure readings obtained from sensors due to static and transient temperature change. The parameters for post-processing temperature correction are established and the apparent pressures after correction are presented. Depending on the design or temperature performance, correction of the friction sleeve and/or piezometer readings may not be warranted

CONE END RESISTANCE CALIBRATION

Table 1-a.

Low range calibration								High range calibration								
Ref LC (kN)	Tip change In output (cts)				Reproducibility error <i>b</i>		Reversibility error <i>U_{rev}</i>		Ref LC (kN)	Tip change in output (cts)			Reproducibility error <i>b</i>		Reversibility error <i>U_{rev}</i>	
	1 0°	2 120°	3 240°	4 240°	MPa	%	MPa	%		1 0°	2 120°	3 240°	MPa	%	MPa	%
0.100	1.121E+05	1.091E+05	1.065E+05	1.065E+05	0.001	1.47			5.000	5.533E+06	5.534E+06	5.518E+06	0.003	0.09		
0.500	5.553E+05	5.573E+05	5.509E+05	5.516E+05	0.001	0.34			10.000	1.106E+07	1.106E+07	1.104E+07	0.004	0.07		
1.000	1.095E+06	1.103E+06	1.084E+06	1.099E+06	0.003	0.51			15.000	1.659E+07	1.659E+07	1.656E+07	0.007	0.07		
1.500	1.653E+06	1.659E+06	1.658E+06	1.658E+06	0.001	0.11			20.000	2.212E+07	2.212E+07	2.208E+07	0.009	0.07		
2.000	2.205E+06	2.217E+06	2.210E+06	2.210E+06	0.002	0.15			30.000	3.316E+07	3.317E+07	3.311E+07	0.011	0.06		
2.500	2.762E+06	2.768E+06	2.770E+06	2.765E+06	0.001	0.09			40.000	4.420E+07	4.421E+07	4.414E+07	0.015	0.06		
3.000	3.312E+06	3.328E+06	3.312E+06	3.305E+06	0.003	0.16			50.000	5.523E+07	5.524E+07	5.515E+07	0.018	0.05		
3.500	3.855E+06	3.886E+06	3.859E+06	3.862E+06	0.006	0.25			60.000	6.625E+07	6.626E+07	6.615E+07	0.021	0.05		
4.000	4.419E+06	4.421E+06	4.419E+06	4.412E+06	0.000	0.02			80.000	8.826E+07	8.825E+07	8.813E+07	0.024	0.05		
5.000	5.527E+06	5.524E+06	5.520E+06	5.522E+06	0.001	0.03			100.000	1.102E+08	1.102E+08	1.101E+08	0.029	0.04		
4.000	4.418E+06	4.445E+06			0.006	0.21	-0.004	-0.15	80.000	8.828E+07	8.827E+07		0.001	0.00	-0.008	-0.01
3.500	3.876E+06	3.896E+06			0.004	0.18	-0.005	-0.22	60.000	6.628E+07	6.628E+07		0.000	0.00	-0.010	-0.03
3.000	3.306E+06	3.323E+06			0.004	0.19	0.002	0.09	50.000	5.527E+07	5.527E+07		0.001	0.00	-0.012	-0.04
2.500	2.742E+06	2.769E+06			0.006	0.35	0.003	0.19	40.000	4.424E+07	4.425E+07		0.001	0.01	-0.014	-0.05
2.000	2.190E+06	2.204E+06			0.003	0.23	0.005	0.36	30.000	3.320E+07	3.321E+07		0.003	0.01	-0.014	-0.07
1.500	1.655E+06	1.671E+06			0.003	0.33	-0.002	-0.24	20.000	2.215E+07	2.216E+07		0.003	0.02	-0.011	-0.08
1.000	1.117E+06	1.085E+06			0.007	1.05	-0.001	-0.11	15.000	1.662E+07	1.662E+07		0.001	0.01	-0.010	-0.10
0.500	5.622E+05	5.609E+05			0.000	0.08	-0.002	-0.54	10.000	1.108E+07	1.109E+07		0.001	0.01	-0.007	-0.11
0.100	1.082E+05	1.160E+05			0.002	2.45	-0.001	-0.82	5.000	5.545E+06	5.544E+06		0.000	0.01	-0.004	-0.11

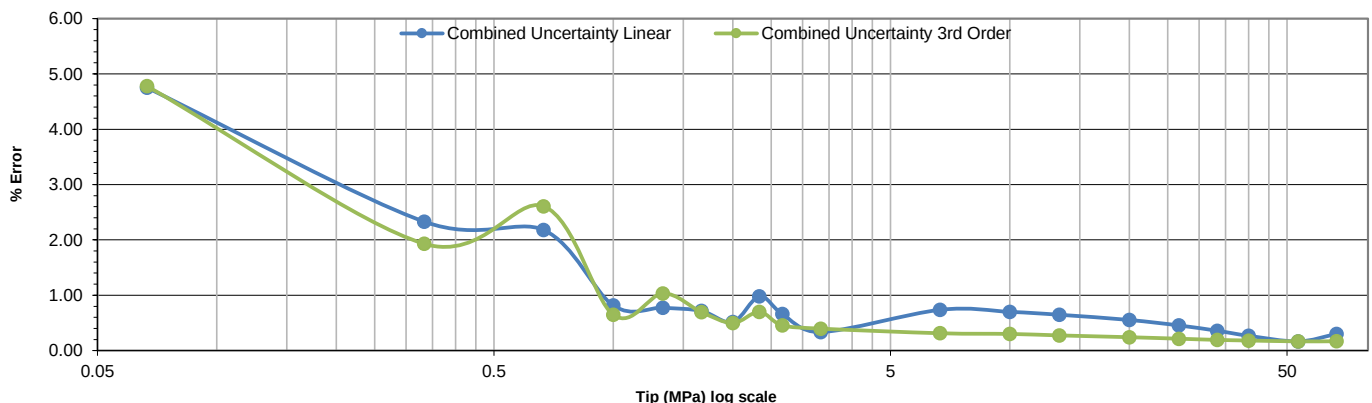
Table 2-a.

Low range calibration								High range calibration							
Reference output		Linear equation			3rd order equation			Reference output		Linear equation			3rd order equation		
Ref Load Cell Nom. (MPa)	Ref Load Cell (0.1N)	Cone output (0.1N)	Expanded uncertainty <i>U</i> *	%	Equation output (0.1N)	Expanded uncertainty <i>U</i> *	%	Ref Load Cell Nom. (MPa)	Ref Load Cell (0.1N)	Cone output (0.1N)	Expanded uncertainty <i>U</i> *	%	Equation output (0.1N)	Expanded uncertainty <i>U</i> *	%
0.067	1000	990	0.002	3.60	987	0.003	3.98	3.333	50000	50118	0.018	0.54	49954	0.010	0.31
0.333	5000	5027	0.004	1.12	5010	0.003	0.90	6.667	100000	100221	0.033	0.49	99911	0.018	0.26
0.667	10000	9918	0.015	2.23	9885	0.019	2.88	10.000	150000	150318	0.047	0.47	149879	0.025	0.25
1.000	15000	15019	0.004	0.41	14968	0.005	0.52	13.333	200000	200405	0.060	0.45	199857	0.032	0.24
1.333	20000	20040	0.008	0.57	19973	0.007	0.49	20.000	300000	300518	0.078	0.39	299815	0.044	0.22
1.667	25000	25081	0.012	0.70	24997	0.005	0.31	26.667	400000	400551	0.088	0.33	399783	0.055	0.21
2.000	30000	30072	0.010	0.51	29972	0.009	0.46	33.333	500000	500499	0.089	0.27	499766	0.066	0.20
2.333	35000	35054	0.014	0.60	34937	0.015	0.65	40.000	600000	600323	0.082	0.20	599732	0.078	0.20
2.667	40000	40066	0.009	0.33	39934	0.011	0.40	53.333	800000	799706	0.098	0.18	799754	0.095	0.18
3.333	50000	50075	0.011	0.33	49911	0.013	0.40	66.667	1000000	998766	0.200	0.30	999984	0.112	0.17
2.667	40000	40175	0.026	0.99	40042	0.013	0.50	53.333	800000	800271	0.079	0.15	800322	0.082	0.15
2.333	35000	35225	0.032	1.36	35108	0.017	0.74	40.000	600000	600903	0.132	0.33	600313	0.067	0.17
2.000	30000	30048	0.010	0.51	29948	0.011	0.53	33.333	500000	501070	0.150	0.45	500337	0.063	0.19
1.667	25000	24983	0.012	0.74	24899	0.018	1.08	26.667	400000	401124	0.155	0.58	400356	0.059	0.22
1.333	20000	19919	0.013	0.97	19852	0.021	1.57	20.000	300000	301044	0.143	0.71	300340	0.053	0.26
1.000	15000	15076	0.012	1.22	15025	0.008	0.77	13.333	200000	200822	0.112	0.84	200273	0.041	0.31
0.667	10000	9983	0.014	2.13	9949	0.016	2.33	10.000	150000	150681	0.093	0.93	150241	0.035	0.35
0.333	5000	5091	0.012	3.54	5073	0.010	2.96	6.667	100000	100478	0.066	0.98	100167	0.024	0.36
0.067	1000	1016	0.004	5.91	1013	0.004	5.58	3.333	50000	50261	0.037	1.10	50097	0.014	0.42

Table 3-a. Third order equation

For a given cone indicated output of D (0.1N units), the corrected applied force	a0 = 0.23998	Maximum tip zero drift during the calibration (MPa) =	0.001
F (in 0.1N units) is calculated from :	a1 = 0.99656	Maximum load cell zero drift during the calibration (MPa) =	0.000
F = (a3 x D³) + (a2 x D²) + (a1 x D) + a0	a2 = 3.21770E-09	Factor used to convert from counts to 0.1N units =	0.0090655
	a3 = 1.44703E-15	Maximum tip full scale reading (MPa) =	100.00
		Tip resolution (Pa) =	66.7
		Tip area (cm²) =	15
		Tip area ratio factor =	0.796

COMBINED EXPANDED UNCERTAINTY TIP



SLEEVE FRICTION CALIBRATION

Table1-b.

Low range calibration								High range calibration									
Ref LC (kN)	Sleeve change in output (cts)				Reproducibility error <i>b</i>		Reversibility error <i>U_{rev}</i>		Ref LC (kN)	Sleeve change in output (cts)				Reproducibility error <i>b</i>		Reversibility error <i>U_{rev}</i>	
	1 0°	2 120°	3 240°	4 240°	kPa	%	kPa	%		1 0°	2 120°	3 240°	kPa	%	kPa	%	
0.100	1.172E+05	1.162E+05	1.108E+05	1.108E+05	0.076	1.73			5.000	5.708E+06	5.714E+06	5.703E+06	0.123	0.06			
0.500	5.772E+05	5.770E+05	5.707E+05	5.708E+05	0.082	0.37			10.000	1.141E+07	1.142E+07	1.141E+07	0.186	0.04			
1.000	1.135E+06	1.141E+06	1.121E+06	1.137E+06	0.229	0.52			15.000	1.712E+07	1.713E+07	1.711E+07	0.266	0.04			
1.500	1.713E+06	1.715E+06	1.712E+06	1.711E+06	0.030	0.05			20.000	2.282E+07	2.283E+07	2.280E+07	0.338	0.04			
2.000	2.284E+06	2.293E+06	2.281E+06	2.282E+06	0.144	0.16			30.000	3.421E+07	3.424E+07	3.420E+07	0.472	0.04			
2.500	2.857E+06	2.862E+06	2.860E+06	2.857E+06	0.053	0.05			40.000	4.561E+07	4.563E+07	4.558E+07	0.595	0.03			
3.000	3.427E+06	3.437E+06	3.419E+06	3.416E+06	0.207	0.16			50.000	5.698E+07	5.702E+07	5.695E+07	0.715	0.03			
3.500	3.984E+06	4.016E+06	3.982E+06	3.990E+06	0.421	0.27			60.000	6.836E+07	6.839E+07	6.831E+07	0.842	0.03			
4.000	4.571E+06	4.567E+06	4.561E+06	4.555E+06	0.110	0.06			80.000	9.107E+07	9.109E+07	9.101E+07	0.968	0.03			
5.000	5.714E+06	5.704E+06	5.698E+06	5.702E+06	0.178	0.08			100.000	1.137E+08	1.138E+08	1.137E+08	1.082	0.02			
4.000	4.569E+06	4.588E+06			0.260	0.15	-0.207	-0.12	80.000	9.109E+07	9.111E+07		0.315	0.01	-0.396	-0.01	
3.500	4.007E+06	4.021E+06			0.187	0.12	-0.321	-0.21	60.000	6.839E+07	6.841E+07		0.324	0.01	-0.534	-0.02	
3.000	3.418E+06	3.431E+06			0.170	0.13	0.165	0.12	50.000	5.702E+07	5.704E+07		0.357	0.02	-0.694	-0.03	
2.500	2.840E+06	2.860E+06			0.280	0.25	0.214	0.19	40.000	4.564E+07	4.567E+07		0.334	0.02	-0.788	-0.04	
2.000	2.266E+06	2.275E+06			0.130	0.15	0.404	0.46	30.000	3.425E+07	3.427E+07		0.327	0.02	-0.819	-0.06	
1.500	1.717E+06	1.725E+06			0.114	0.17	-0.153	-0.23	20.000	2.284E+07	2.286E+07		0.254	0.03	-0.602	-0.07	
1.000	1.159E+06	1.121E+06			0.518	1.18	-0.051	-0.12	15.000	1.714E+07	1.715E+07		0.195	0.03	-0.488	-0.07	
0.500	5.870E+05	5.775E+05			0.126	0.57	-0.113	-0.51	10.000	1.143E+07	1.144E+07		0.106	0.02	-0.363	-0.08	
0.100	1.147E+05	1.176E+05			0.039	0.87	0.011	0.26	5.000	5.719E+06	5.721E+06		0.035	0.02	-0.196	-0.09	

Table 2-b.

Low range calibration								High range calibration							
Reference output		Linear factor output			3rd order equation			Reference output		Linear factor output			3rd order equation		
Ref Load Cell Nom. (kPa)	Ref Load Cell (0.1N)	Cone output (0.1N)	Expanded uncertainty U^* kPa	%	Equation output (0.1N)	Expanded uncertainty U^* kPa	%	Ref Load Cell Nom. (kPa)	Ref Load Cell (0.1N)	Cone output (0.1N)	Expanded uncertainty U^* kPa	%	Equation output (0.1N)	Expanded uncertainty U^* kPa	%
4	1000	1008	0.168	3.80	994	0.163	3.69	220	50000	50142	1.328	0.60	49964	0.546	0.25
22	5000	5050	0.481	2.18	5022	0.269	1.22	441	100000	100258	2.392	0.54	99933	0.942	0.11
44	10000	9947	0.898	2.04	9902	1.157	2.63	661	150000	150356	3.315	0.50	149903	1.378	0.10
66	15000	15049	0.461	0.70	14986	0.195	0.30	881	200000	200434	4.080	0.46	199875	1.809	0.10
88	20000	20079	0.815	0.93	20000	0.417	0.47	1322	300000	300538	5.173	0.39	299833	2.545	0.10
110	25000	25118	1.071	0.97	25021	0.313	0.28	1762	400000	400584	5.795	0.33	399824	3.085	0.09
132	30000	30106	1.053	0.80	29993	0.483	0.37	2203	500000	500523	5.661	0.26	499803	3.716	0.08
154	35000	35081	1.183	0.77	34951	1.040	0.67	2643	600000	600392	5.228	0.20	599812	4.261	0.08
176	40000	40109	1.055	0.60	39963	0.542	0.31	3524	800000	799824	5.343	0.15	799841	5.302	0.08
220	50000	50113	1.130	0.51	49935	0.781	0.35	4405	1000000	998900	11.544	0.26	999963	6.281	0.07
176	40000	40213	1.965	1.12	40066	0.829	0.47	3524	800000	800192	4.988	0.14	800211	5.046	0.07
154	35000	35261	2.347	1.52	35130	1.244	0.81	2643	600000	600784	7.764	0.29	600205	3.981	0.08
132	30000	30080	0.812	0.61	29967	0.494	0.37	2203	500000	500935	8.765	0.40	500215	3.553	0.08
110	25000	25034	0.666	0.61	24937	0.813	0.74	1762	400000	401010	9.222	0.52	400250	3.274	0.09
88	20000	19942	0.644	0.73	19863	1.273	1.44	1322	300000	300945	8.530	0.65	300239	2.819	0.11
66	15000	15115	1.048	1.59	15052	0.529	0.80	881	200000	200734	6.594	0.75	200175	2.003	0.11
44	10000	10016	1.049	2.38	9970	1.072	2.43	661	150000	150596	5.336	0.81	150142	1.585	0.12
22	5000	5114	1.041	4.72	5086	0.801	3.64	441	100000	100434	3.874	0.88	100107	1.143	0.13
4	1000	1020	0.195	4.44	1006	0.096	2.19	220	50000	50242	2.159	0.98	50063	0.659	0.15

Table 3-b. Third order equation

For a given cone indicated output of D (0.1N units), the corrected applied force F (in 0.1N units) is calculated from : $F = (a_3 \times D^3) + (a_2 \times D^2) + (a_1 \times D) + a_0$	$a_0 =$	-10.42682	Maximum sleeve zero drift during the calibration (kPa) =	0.082
	$a_1 =$	0.99646	Maximum load cell zero drift during the calibration (kPa) =	0.016
	$a_2 =$	3.86715E-09	Factor used to convert from counts to 0.1N units =	0.0087836
	$a_3 =$	7.54220E-16	Physical strength limited maximum sleeve reading (MPa) =	1.333
			Sleeve resolution (Pa) =	4.4
			Sleeve area (cm²) =	227
			Sleeve area ratio factor =	-0.001

COMBINED EXPANDED UNCERTAINTY SLEEVE

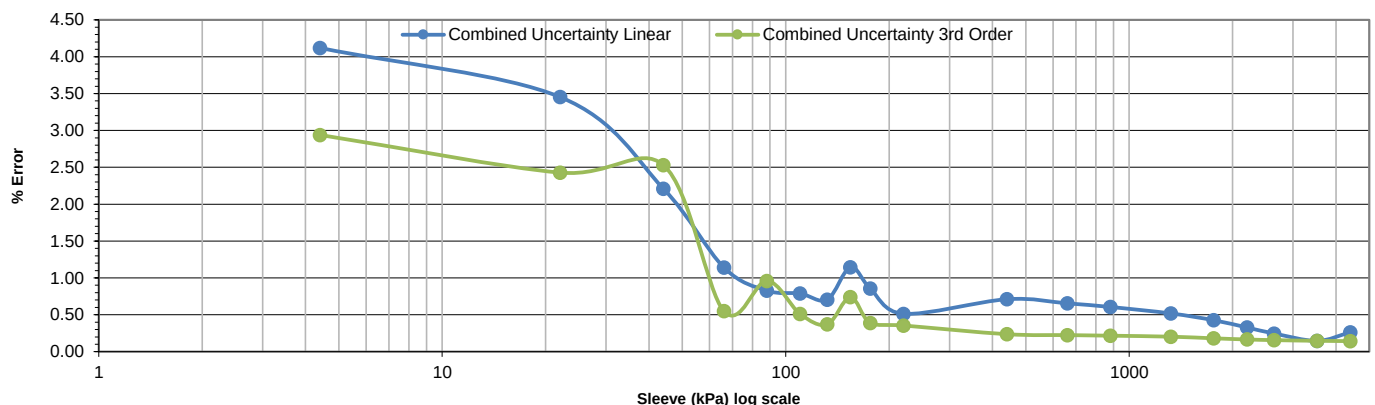


Table 4-b Sleeve friction - tip subtraction combined standard uncertainty U_{c_sub} , where friction ratio is between 0.25% and 10%.

		Sleeve linear equation subtraction error (%)										Sleeve 3rd order equation subtraction error (%)							
		Sleeve kPa →										Sleeve kPa →							
		4	22	44	66	110	154	220	661			4	22	44	66	110	154	220	661
Tip MPa ↓	0.07	2.9	-	-	-	-	-	-	-	Tip MPa ↓	0.07	1.5	-	-	-	-	-	-	-
	0.33	8.9	3.1	-	-	-	-	-	-		0.33	7.1	2.3	-	-	-	-	-	-
	0.67	5.8	2.5	1.5	0.8	-	-	-	-		0.67	6.8	2.3	1.8	0.6	-	-	-	-
	1.00	7.0	2.7	1.6	0.9	-	-	-	-		1.00	4.5	1.8	1.6	0.5	-	-	-	-
	1.67	5.0	2.3	1.4	0.8	0.5	0.7	-	-		1.67	1.8	1.3	1.3	0.3	0.3	0.4	-	-
	2.33	-	4.0	2.2	1.3	0.8	0.9	0.5	-		2.33	-	2.8	2.1	0.8	0.6	0.6	0.3	-
	3.33	-	2.0	1.2	0.7	0.5	0.6	0.3	-		3.33	-	2.2	1.8	0.6	0.5	0.5	0.3	-
	10.00	-	-	1.7	1.0	0.6	0.8	0.4	0.3		10.00	-	-	1.4	0.4	0.3	0.4	0.2	0.1
	13.33	-	-	1.9	1.1	0.7	0.8	0.4	0.3		13.33	-	-	1.3	0.4	0.3	0.4	0.2	0.1

PORE PRESSURE CALIBRATION

Table 1-c.

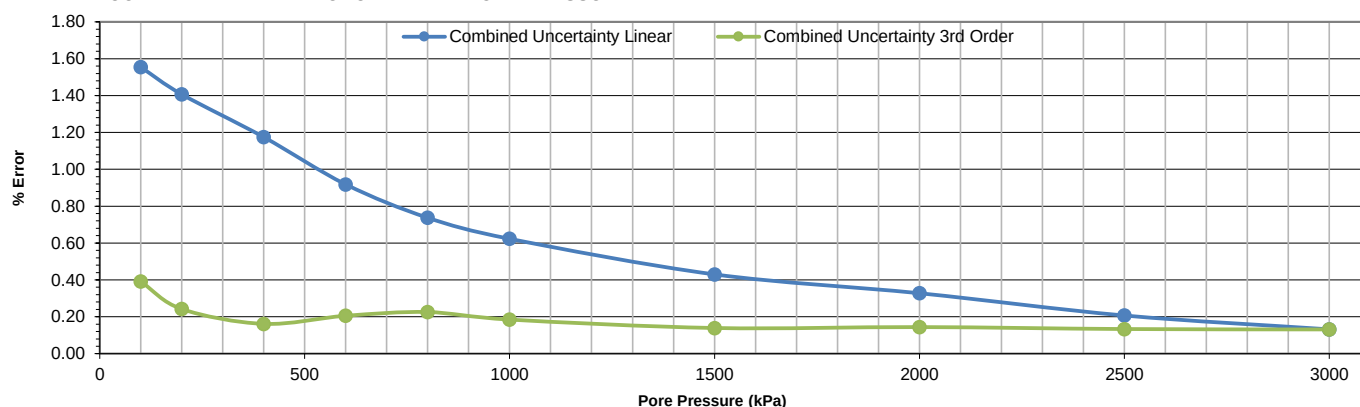
Ref PR (kPa)	PWP change in output (cts)			Reproducibility error b		Reversibility error U_{rev}	
	1	2	3				
	0°	120°	240°	kPa	%	kPa	%
100	2.131E+07	2.134E+07	2.134E+07	0.1	0.05		
200	4.265E+07	4.266E+07	4.268E+07	0.0	0.02		
400	8.533E+07	8.529E+07	8.535E+07	0.1	0.02		
600	1.279E+08	1.279E+08	1.279E+08	0.1	0.01		
800	1.704E+08	1.704E+08	1.704E+08	0.1	0.01		
1000	2.128E+08	2.128E+08	2.128E+08	0.1	0.01		
1500	3.187E+08	3.188E+08	3.187E+08	0.1	0.01		
2000	4.245E+08	4.246E+08	4.246E+08	0.1	0.00		
2500	5.303E+08	5.304E+08	5.305E+08	0.1	0.01		
3000	6.361E+08	6.362E+08	6.363E+08	0.2	0.01		
2500	5.306E+08	5.307E+08		0.0	0.00	-0.7	-0.03
2000	4.249E+08	4.249E+08		0.0	0.00	-0.8	-0.04
1500	3.187E+08	3.187E+08		0.0	0.00	0.1	0.01
1000	2.126E+08	2.125E+08		0.1	0.01	0.6	0.06
800	1.701E+08	1.701E+08		0.0	0.00	0.8	0.10
600	1.277E+08	1.277E+08		0.1	0.01	0.5	0.08
400	8.531E+07	8.526E+07		0.1	0.02	0.1	0.02
200	4.274E+07	4.273E+07		0.0	0.00	-0.2	-0.11
100	2.140E+07	2.139E+07		0.0	0.01	-0.2	-0.20

Table 2-c.

Reference output		Linear factor output			3rd order equation		
Ref Pressure (kPa)	Ref Pressure (0.1Pa)	Cone output (0.1Pa)	Expanded uncertainty U^* kPa	%	Equation output (0.1N)	Expanded uncertainty U^* kPa	%
100	1000000	1005866	1.236	1.24	998411	0.397	0.40
200	2000000	2012116	2.463	1.23	1999354	0.349	0.17
400	4000000	4024092	4.878	1.22	4002532	0.739	0.18
600	6000000	6031557	6.399	1.07	6003457	1.075	0.18
800	8000000	8035261	7.184	0.90	8002651	1.244	0.16
1000	10000000	10035225	7.210	0.72	9999920	1.293	0.13
1500	15000000	15031454	6.595	0.44	14995944	2.017	0.13
2000	20000000	20022917	5.256	0.26	19993948	2.790	0.14
2500	25000000	25014417	4.270	0.17	24995527	3.254	0.13
3000	30000000	30004370	3.951	0.13	29995889	3.938	0.13
2500	25000000	25025893	6.075	0.24	25007027	3.418	0.14
2000	20000000	20036886	7.853	0.39	20007942	2.972	0.15
1500	15000000	15029884	6.302	0.42	14994373	2.157	0.14
1000	10000000	10025198	5.251	0.53	9989902	2.401	0.24
800	8000000	8022157	4.611	0.58	7989570	2.367	0.30
600	6000000	6022508	4.620	0.77	5994433	1.390	0.23
400	4000000	4022141	4.522	1.13	4000589	0.553	0.14
200	2000000	2015453	3.164	1.58	2002674	0.619	0.31
100	1000000	1009062	1.873	1.87	1001589	0.385	0.39

Table 3-c. Third order equation

For a given cone indicated output of D (0.1N units), the corrected applied force	$a_0 = -1510.99867$	Maximum PWP zero drift during the calibration (kPa) =	0.26
F (in 0.1N units) is calculated from :	$a_1 = 0.99376$	Maximum reference zero drift during the calibration (kPa) =	0.028
$F = (a_3 \times D^3) + (a_2 \times D^2) + (a_1 \times D) + a_0$	$a_2 = 3.28961E-10$	Factor used to convert from counts to 0.1Pa units =	0.0471613
	$a_3 = -4.29461E-18$	Maximum PWP full scale reading (kPa) =	5000
		PWP resolution (Pa) =	0.1

COMBINED EXPANDED UNCERTAINTY PORE PRESSURE


INCLINATION CALIBRATION

Ref Inclination (°C)	Cone inclination output	
	X Inc (cts)	Y Inc (cts)
-25	-27874	-26592
0	-2180	-690
25	23657	24704

Ref Inclination (°)	Cone inclination output	
	X Inc (°)	Y Inc (°)
-25	-24.9	-25.2
0	0.0	0.0
25	25.1	24.8

	X inc	Y inc
Factor used to convert from counts to 0.1m° units =	9.70287238	9.74703007
Inclination error (°) =	0.1	0.2

TEMPERATURE CALIBRATION

Recorded temp (°C)	Cone output 1 FS (cts)	Cone output 2 QC (cts)
6.69	3066397	3061952
10.42	3125992	3123729
15.38	3212462	3210229
20.03	3294811	3292487
25.11	3385416	3383180

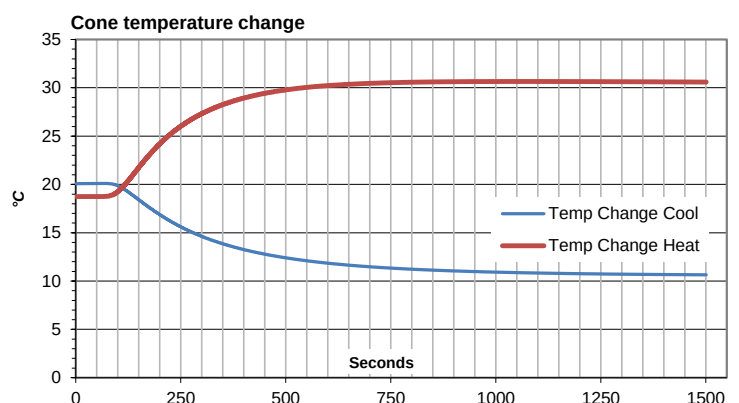
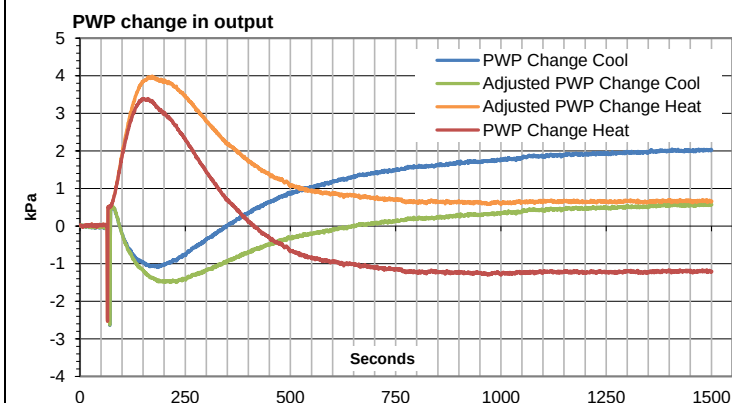
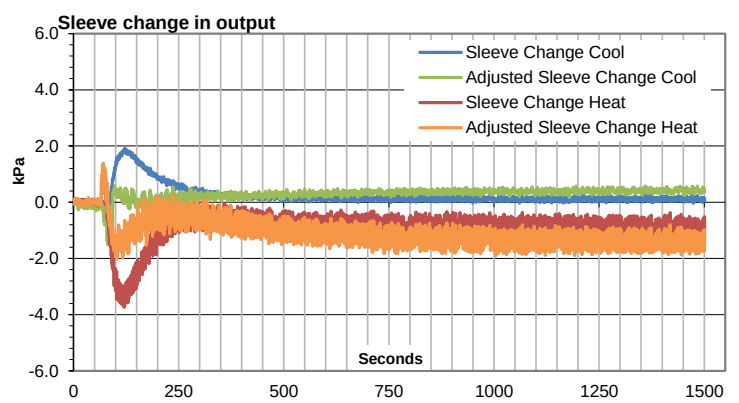
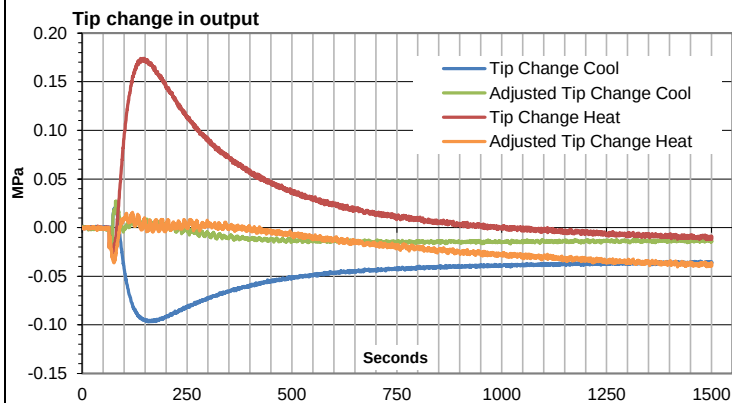
Recorded temp (°C)	Cone output 1 FS (°C)	Cone output 2 QC (°C)
6.69	6.86	6.80
10.42	10.29	10.34
15.38	15.26	15.29
20.03	20.00	20.00
25.11	25.21	25.19

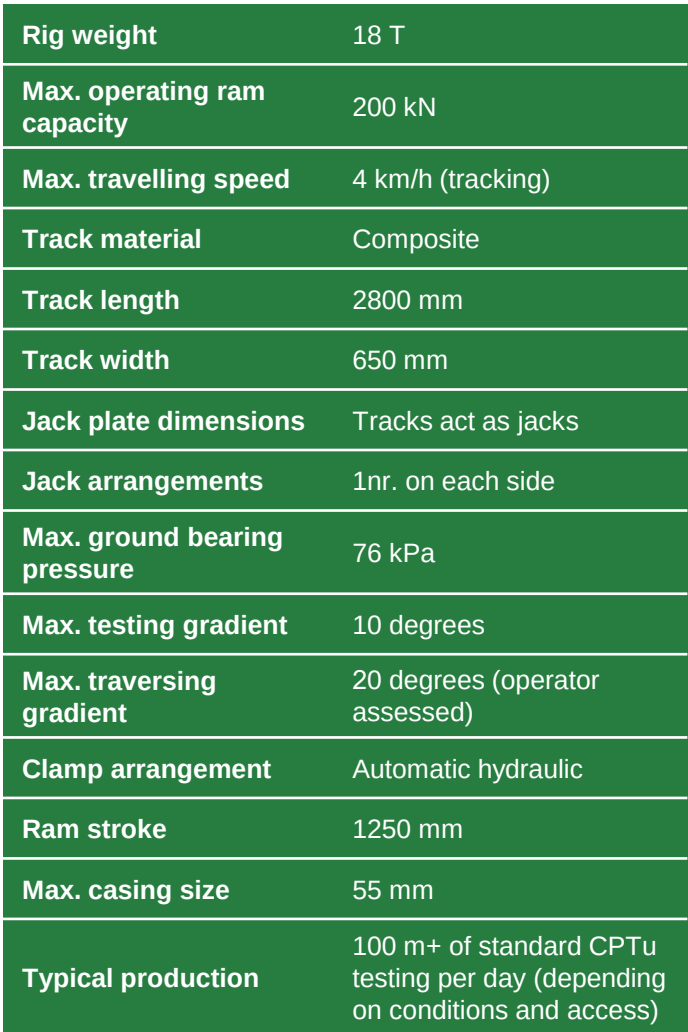
Factor used to convert from counts to 0.00001°C units =	0.575310967	0.572379883
Temperature error (°C) =	0.17	0.12

CONE TEMPERATURE RESPONSE AND CORRECTION

	Cooling	Heating
Start temperature =	20.10	18.74
End temperature =	10.65	30.66
Temperature change =	-9.46	11.91

	Cooling	Heating
Tip maximum rate of change (MPa/(°C/min)) =	0.048	0.051
Tip end change (MPa/°C) =	-0.004	-0.001
Adjusted tip end change (MPa/°C) =	0.002	0.003
Sleeve maximum rate of change (kPa/(°C/min)) =	2.78	2.78
Sleeve end change (kPa/°C) =	0.01	-0.08
Adjusted sleeve end change (kPa/°C) =	0.04	-0.12
PWP end change (kPa/°C) =	0.21	-0.10
Adjusted PWP end change (kPa/°C) =	-0.06	0.06

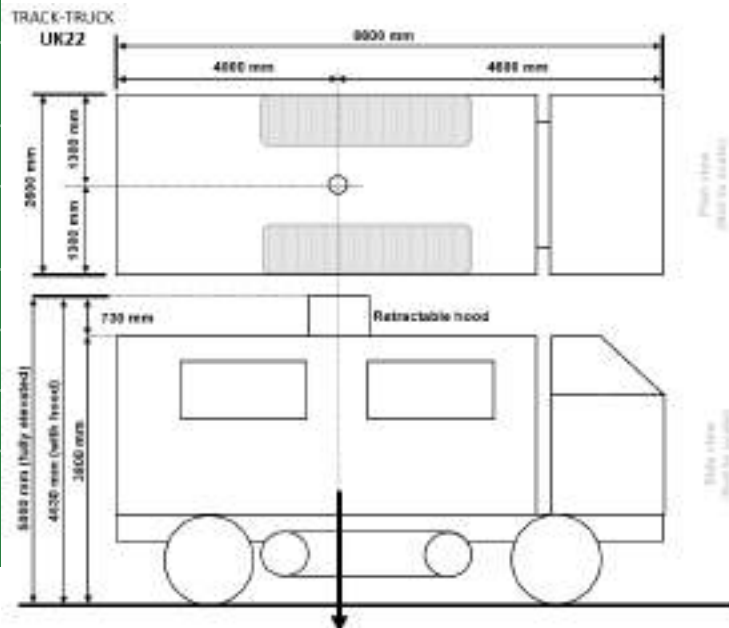




The versatile track-truck is suitable for most geotechnical sites. The rig is driven to site as a self-contained HGV with composite tracks that can be deployed to cope with soft or uneven terrain.

Remote-controlled tracking to assist with manoeuvring onto location.

Complies with Euro 6 emission standards for use in London's low emissions zones (LEZ).



APPENDIX C CONE PENETRATION TEST RESULTS

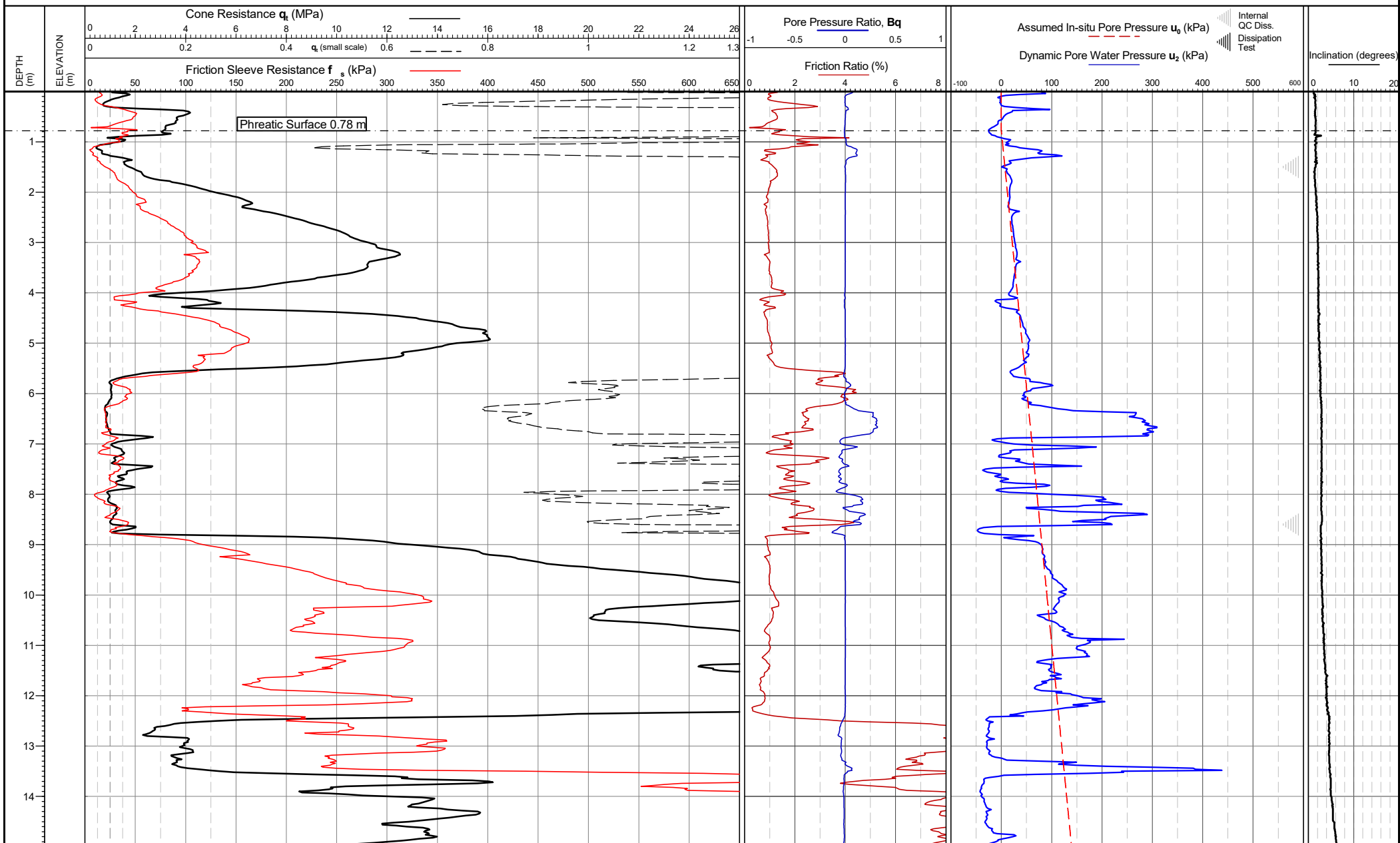
Measured CPT parameters

intermediate parameters R_f and B_q & state parameter u_0



Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
Cone ID: S15-CFIPTT.2141
Operator: Rob Bennett
Rig Used: UK22
Date of test: 04/07/2023 08:52:59

Zero drift (Pre/post test)
 q_c (kPa): -10.6
 f_s (kPa): 0.0 ($f_{s, drift} - q_{c, drift}$)
 u_2 (kPa): 0.3

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks:
*Phreatic surface origin: Average measured piezometric depth at this location, approx. ± 0.5 mgl
Termination Remark: Target depth

Date of plot:
05-07-23
Checked by:
Chris Player

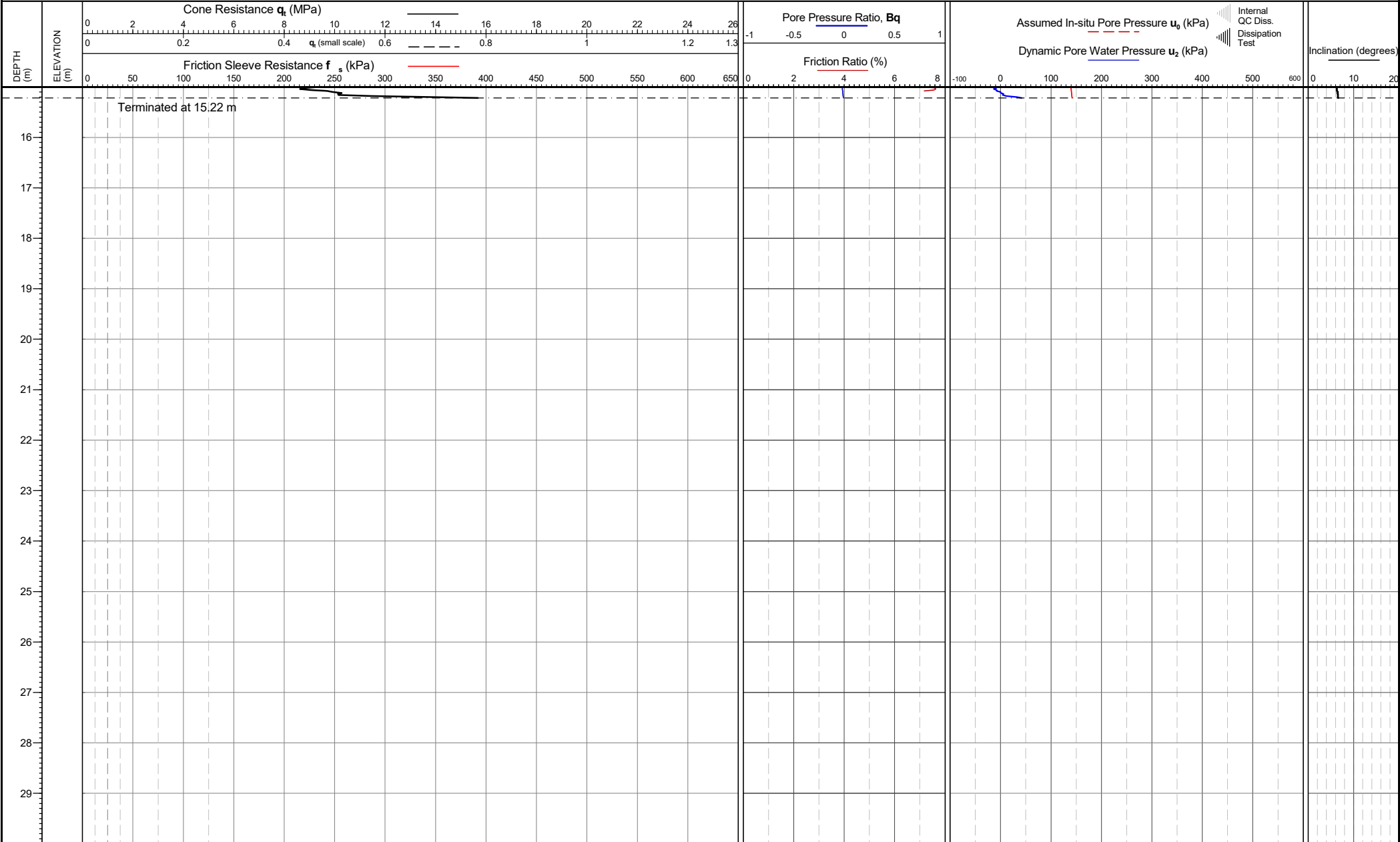
Lankelma Project Ref:
P-108354-1

TEST ID: CPT01

Page 1 of 2



Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS

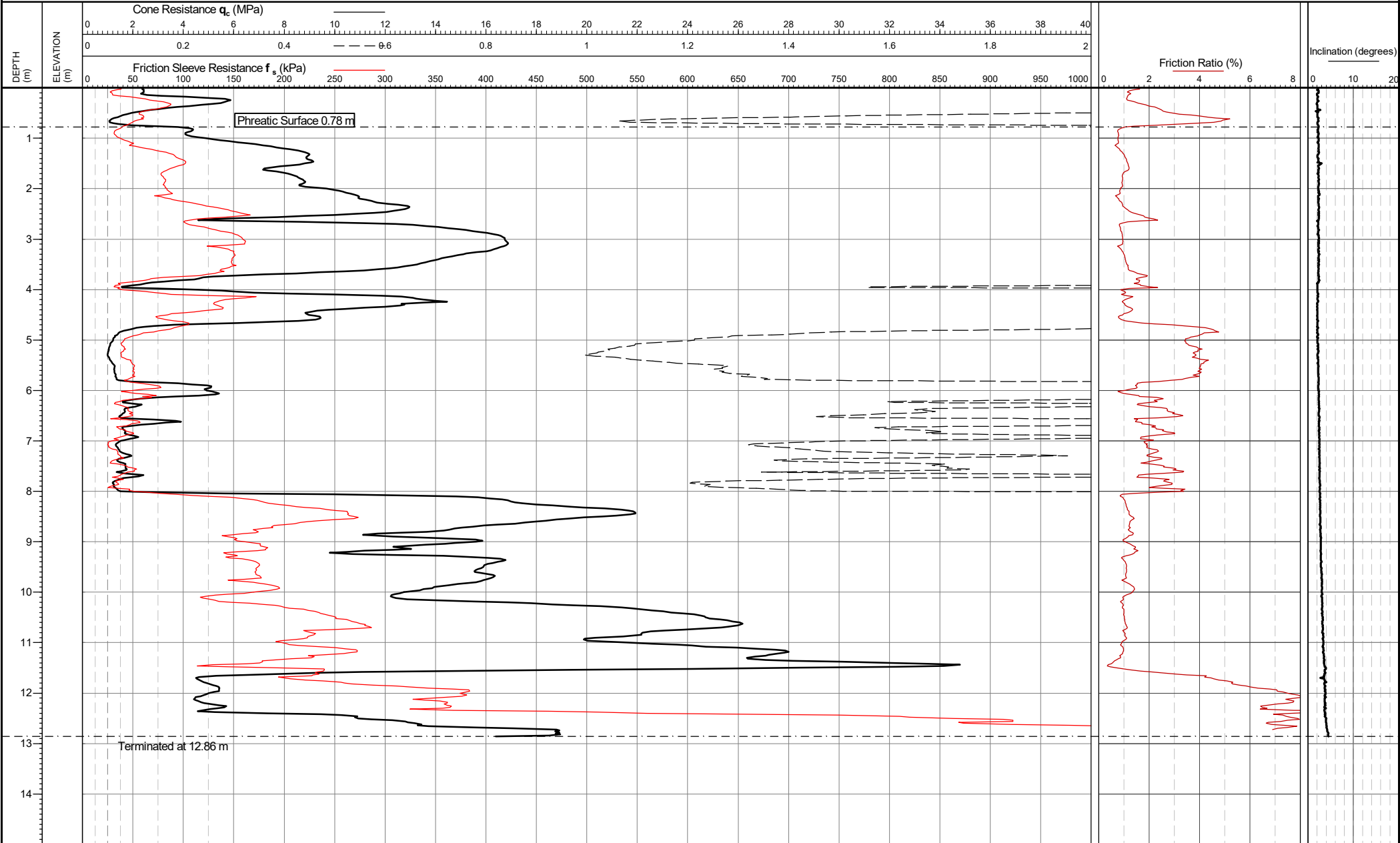


Cone area (mm ²): Cone ID: S15-CFIPTT.2141 Operator: Rob Bennett Rig Used: UK22 Date of test: 04/07/2023 08:52:59	Zero drift (Pre/post test) q_c (kPa): -10.6 f_s (kPa): 0.0 ($f_{s, drift} - q_{c, drift}$) u_2 (kPa): 0.3	Location: North Yorkshire, UK Coordinates: , Elevation: Coordinate system:	Remarks: *Phreatic surface origin: Average measured piezometric depth at this location, approx. +/- 0.5 mbgl Termination Remark: Target depth	Date of plot: 05-07-23 Checked by: Chris Player	Lankelma Project Ref: P-108354-1	TEST ID: CPT01 Page 2 of 2
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Project: BURREINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS

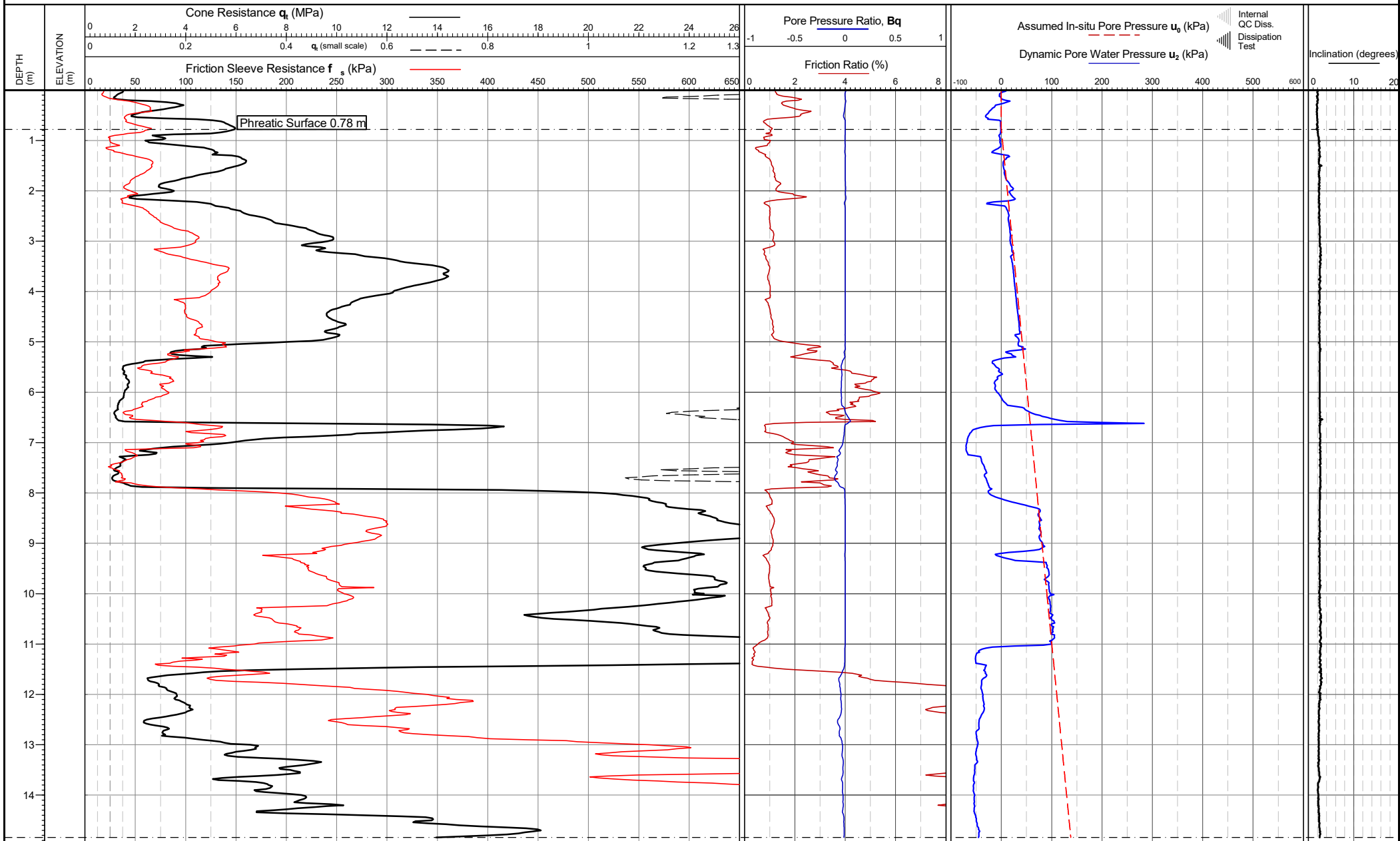


Cone area (mm ²): Cone ID: S15-CFIPTT.2141 Operator: Rob Bennett Rig Used: UK22 Date of test: 04/07/2023 10:50:50	Zero drift (Pre/post test) q_c (kPa): 13.6 f_s (kPa): 0.7 ($f_{s\ drift} - q_{c\ drift}$)	Location: North Yorkshire, UK Coordinates: , Elevation: Coordinate system:	Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s) Refusal criteria: Sleeve load	Date of plot: 05-07-23 Checked by: Chris Player	Lankelma Project Ref: P-108354-1	TEST ID: CPT02 Page 1 of 1
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Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
Cone ID: S15-CFIPTT.2141
Operator: Rob Bennett
Rig Used: UK22
Date of test: 04/07/2023 09:58:58

Zero drift (Pre/post test)
 q_{0c} (kPa): -24.2
 f_{0s} (kPa): -1.1 ($f_{0s\ drift} - q_{0c\ drift}$)
 u_2 (kPa): 6.0

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks:
*Phreatic surface origin: Average measured piezometric depth from other location(s)
Termination Remark: Sleeve load

Date of plot:
05-07-23
Checked by:
Chris Player

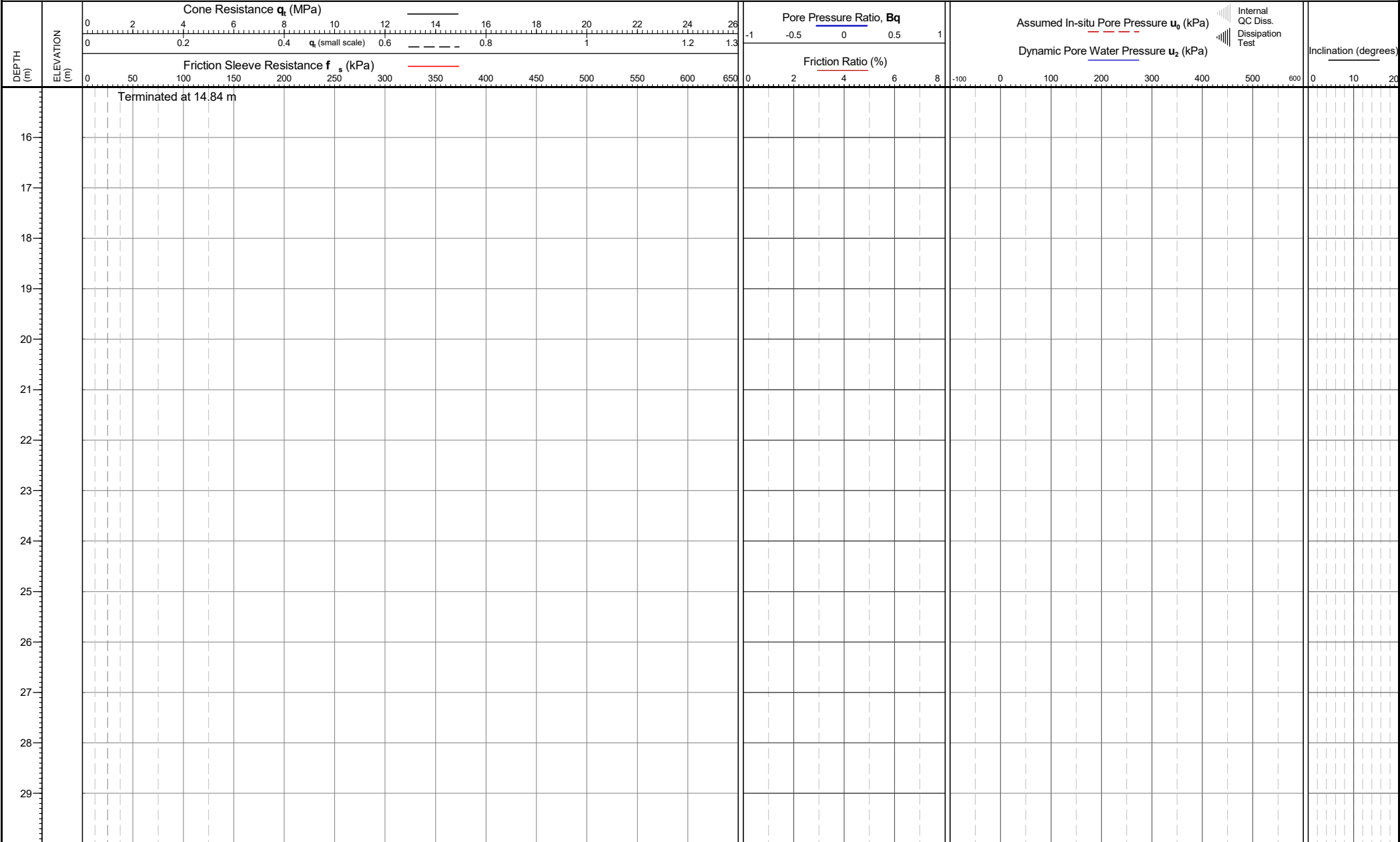
Lankelma Project Ref:
P-108354-1

TEST ID: CPT03

Page 1 of 2



Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS

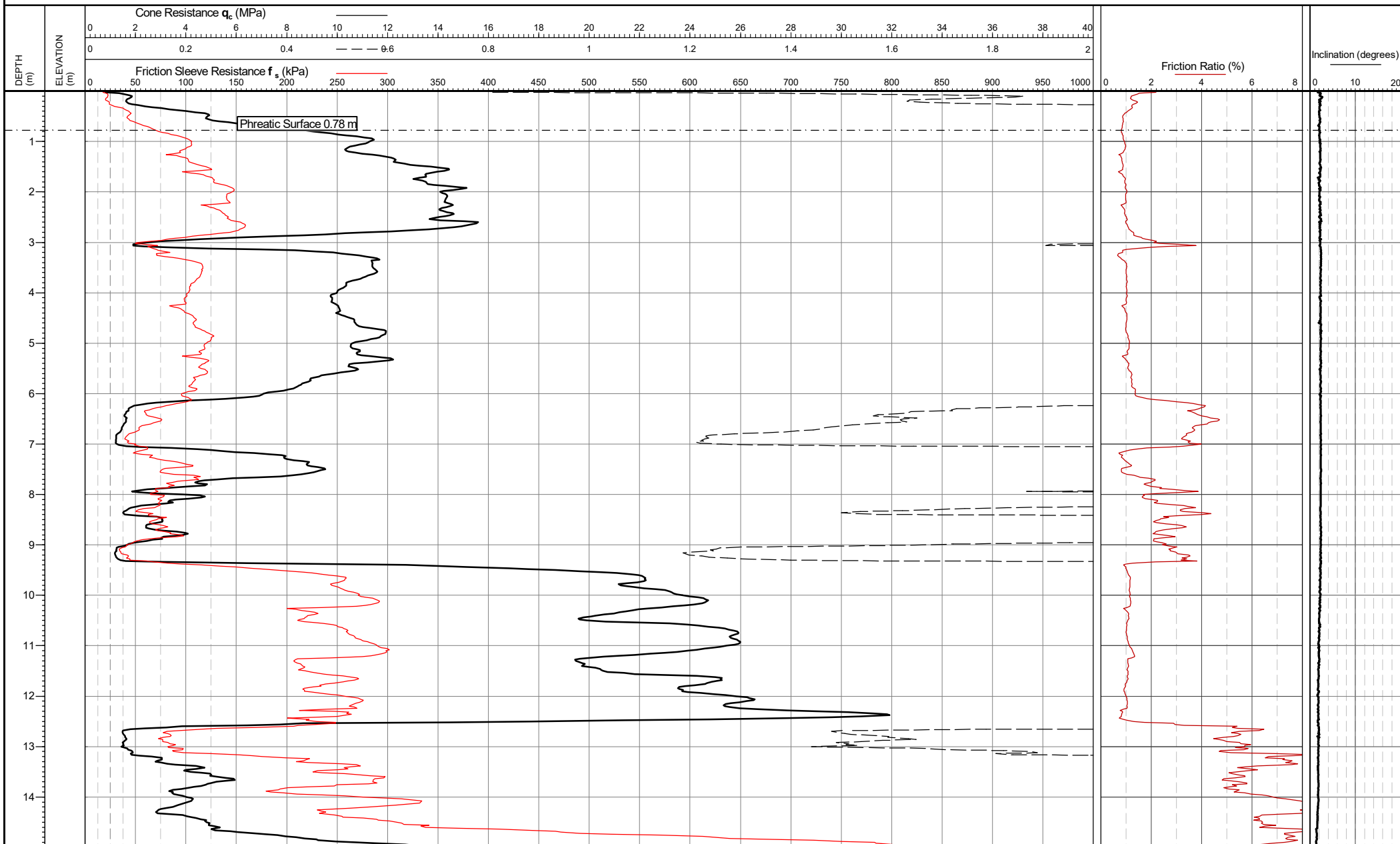


Cone area (mm2): Cone ID: S15-CFIPTT.2141 Operator: Rob Bennett Rig Used: UK22 Date of test: 04/07/2023 09:58:58	Zero drift (Pre/post test) q_c (kPa): -24.2 f_s (kPa): -1.1 ($f_{s\ drift} - q_{c\ drift}$) u_2 (kPa): 6.0	Location: North Yorkshire, UK Coordinates: , Elevation: Coordinate system:	Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s) Termination Remark: Sleeve load	Date of plot: 05-07-23 Checked by: Chris Player	Lankelma Project Ref: P-108354-1	TEST ID: CPT03 Page 2 of 2
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Project: BURRENHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
Cone ID: S15-CFIPTT.2141
Operator: Rob Bennett
Rig Used: UK22
Date of test: 04/07/2023 08:16:22

Zero drift (Pre/post test)
 q_c (kPa): -8.8
 f_s (kPa): 0.0 ($f_{s, drift} - q_{c, drift}$)

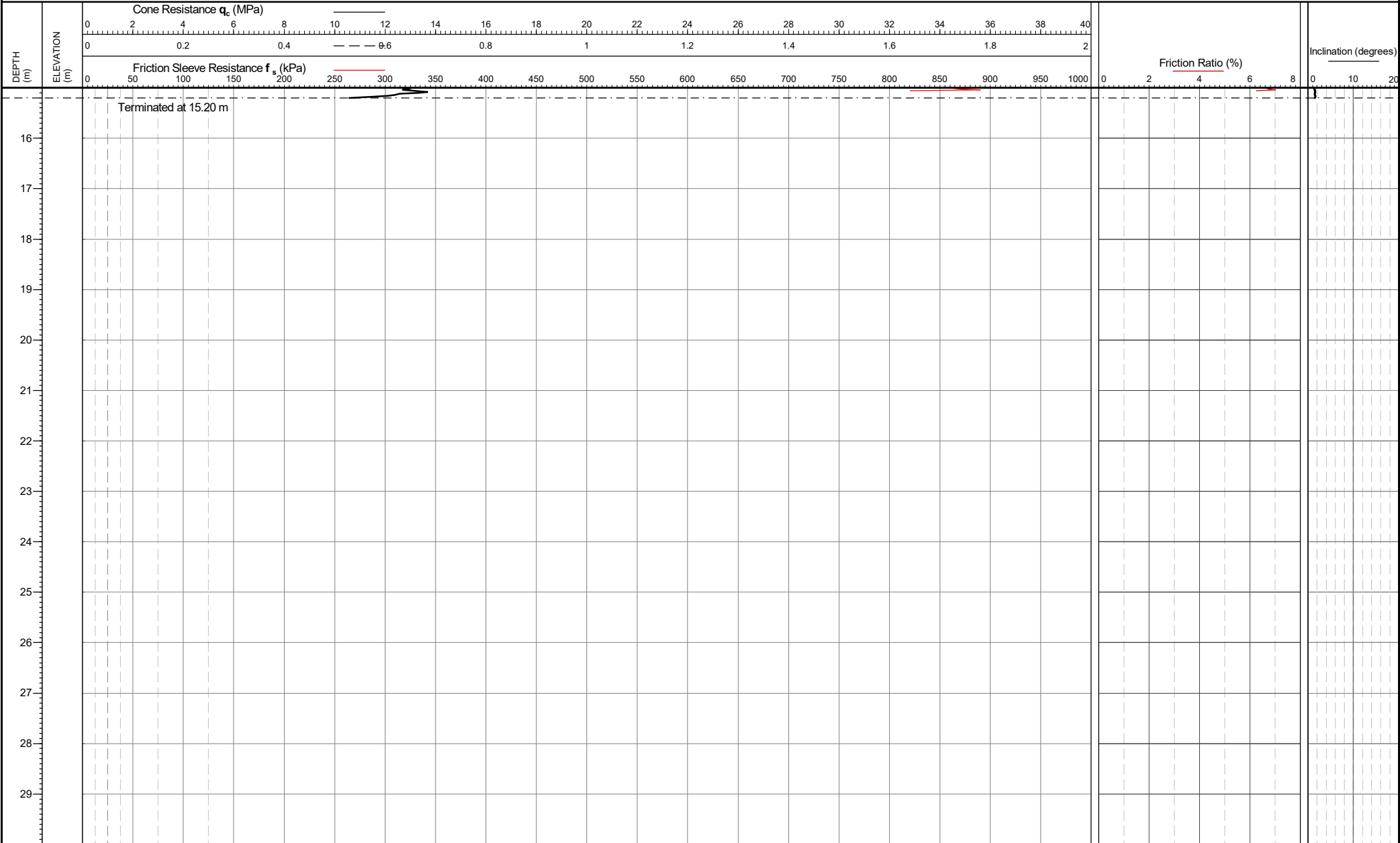
Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks:
*Phreatic surface origin: Average measured piezometric depth from other location(s)
Refusal criteria: Target depth

Date of plot: 05-07-23
Lankelma Project Ref: P-108354-1
Checked by: Chris Player

TEST ID: CPT04

Page 1 of 2

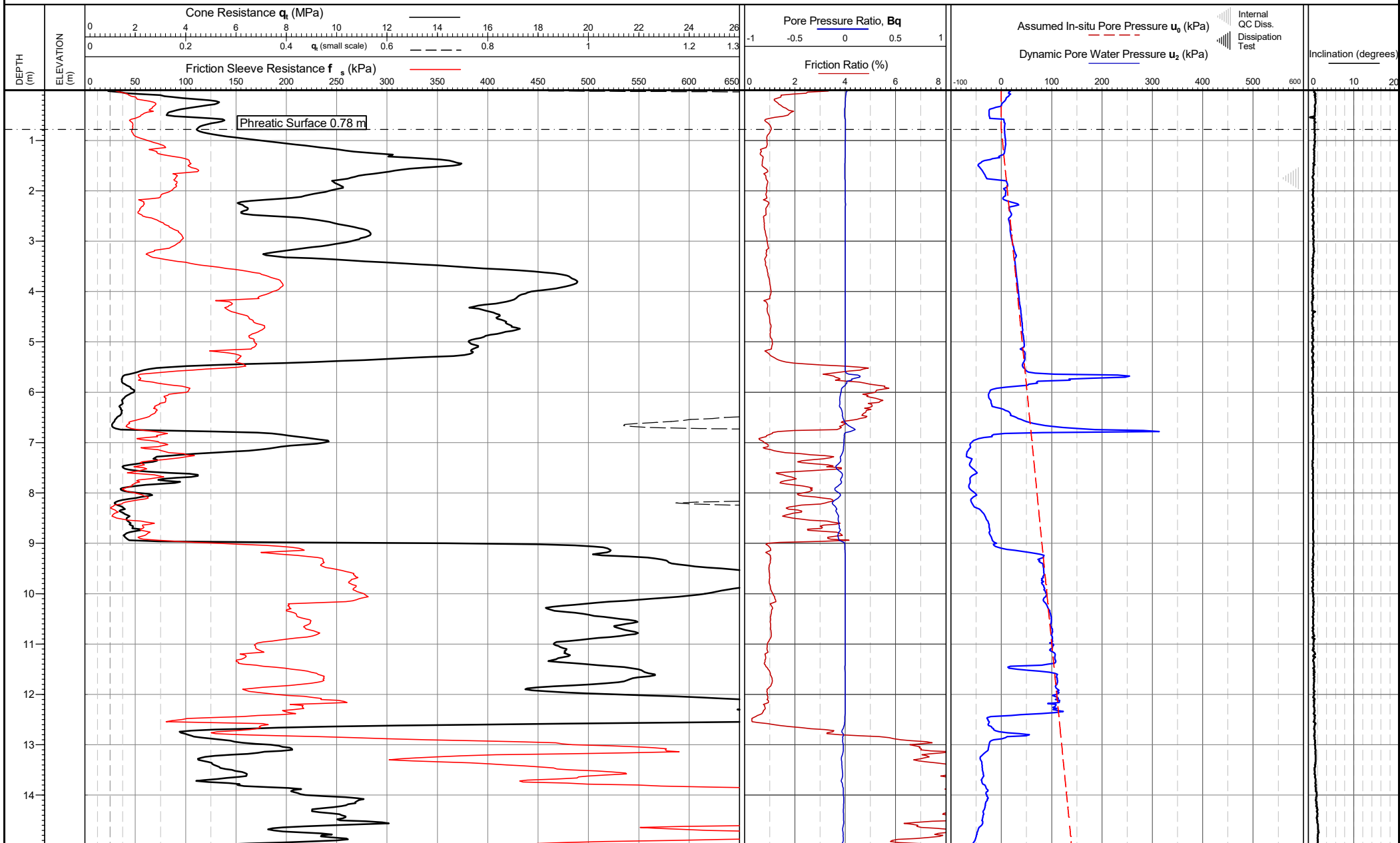


Cone area (mm2): Cone ID: S15-CFIPTT.2141 Operator: Rob Bennett Rig Used: UK22 Date of test: 04/07/2023 08:16:22	Zero drift (Pre/post test) q_c (kPa): -8.8 f_s (kPa): 0.0 ($f_{s\ drift} - q_{c\ drift}$)	Location: North Yorkshire, UK Coordinates: , Elevation: Coordinate system:	Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s) Refusal criteria: Target depth	Date of plot: 05-07-23 Checked by: Chris Player	Lankelma Project Ref: P-108354-1	TEST ID: CPT04 Page 2 of 2
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Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
Cone ID: S15-CFIPTT.2141
Operator: Rob Bennett
Rig Used: UK22
Date of test: 03/07/2023 12:39:33

Zero drift (Pre/post test)
 q_0 (kPa): -4.6
 f_s (kPa): -0.1 ($f_{s, drift} - q_{0, drift}$)
 u_2 (kPa): 4.1

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks:
*Phreatic surface origin: Average measured piezometric depth from other location(s)
Termination Remark: Target depth

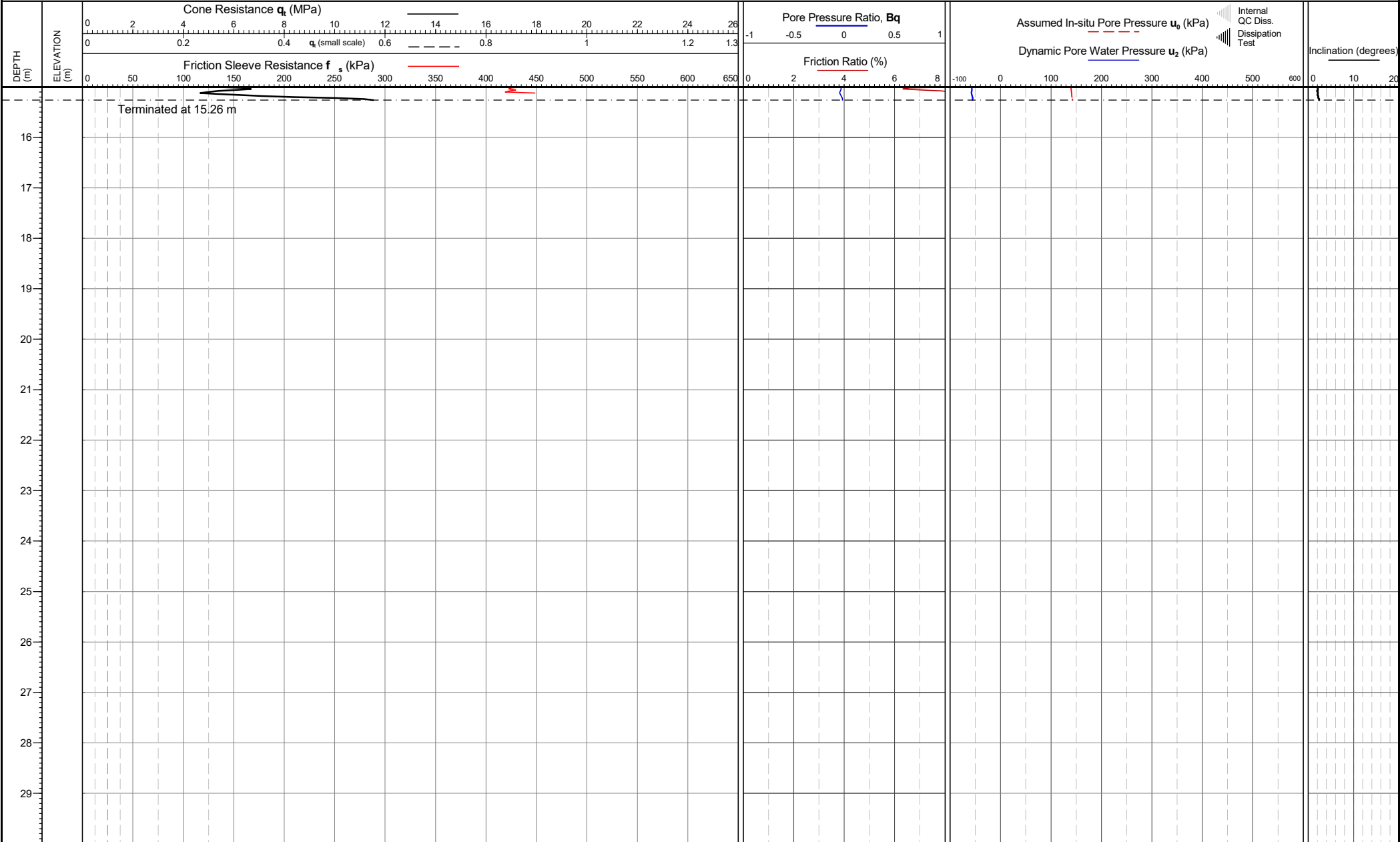
Date of plot: 05-07-23
Lankelma Project Ref: P-108354-1
Checked by: Chris Player

TEST ID: CPT05

Page 1 of 2



Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS

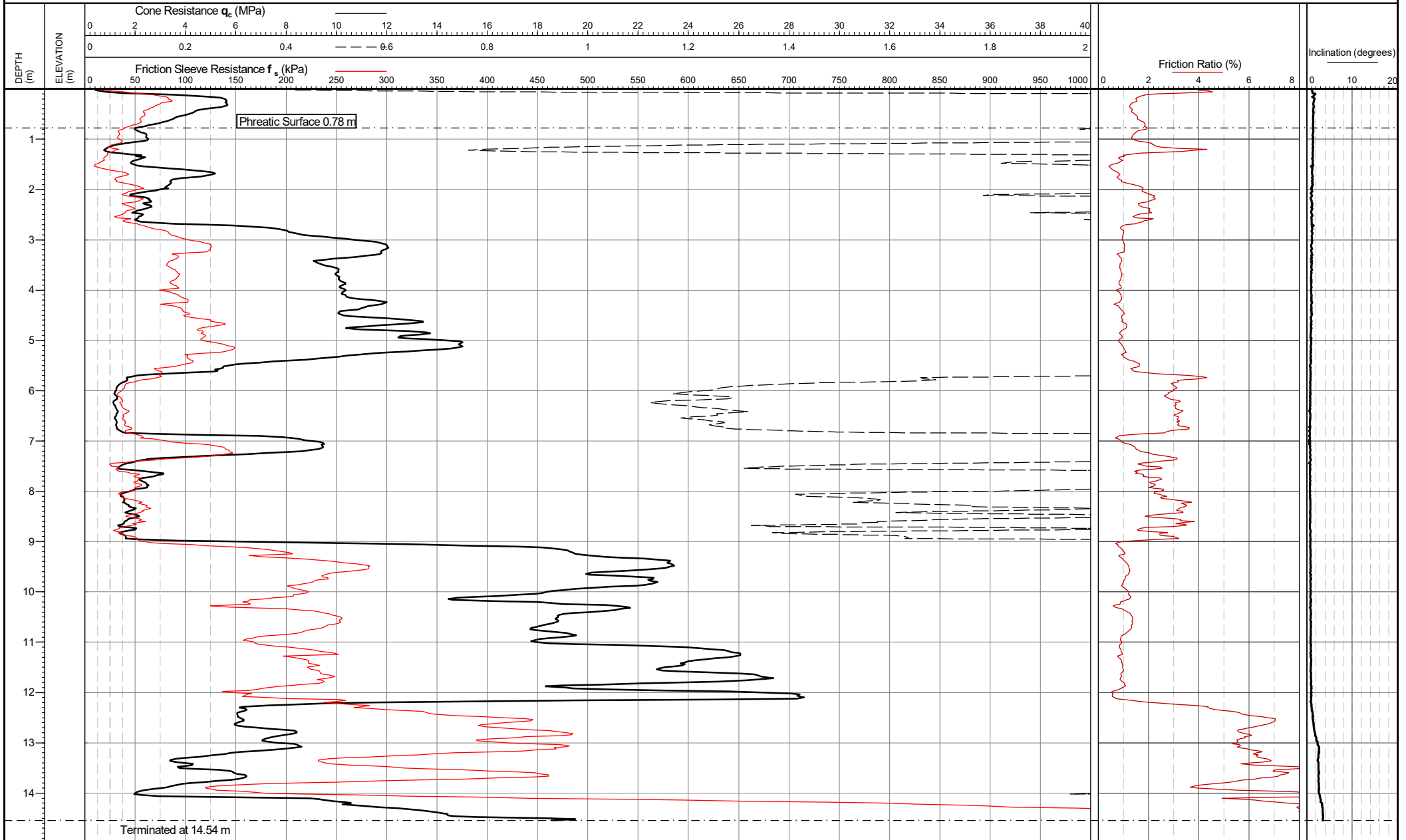


Cone area (mm ²): Cone ID: S15-CFIPTT.2141 Operator: Rob Bennett Rig Used: UK22 Date of test: 03/07/2023 12:39:33	Zero drift (Pre/post test) q_c (kPa): -4.6 f_s (kPa): -0.1 ($f_{s\ drift} - q_{c\ drift}$) u_2 (kPa): 4.1	Location: North Yorkshire, UK Coordinates: , Elevation: Coordinate system:	Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s) Termination Remark: Target depth	Date of plot: 05-07-23 Checked by: Chris Player	Lankelma Project Ref: P-108354-1	TEST ID: CPT05 Page 2 of 2
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Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
Cone ID: S15-CFIPTT.2141
Operator: Rob Bennett
Rig Used: UK22
Date of test: 03/07/2023 11:56:57

Zero drift (Pre/post test)
 q_c (kPa): 0.2
 f_s (kPa): -0.5 ($f_{s \text{ drift}} - q_{c \text{ drift}}$)

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks:
*Phreatic surface origin: Average measured piezometric depth from other location(s)
Refusal criteria: Sleeve load

Date of plot:
05-07-23
Checked by:
Chris Player

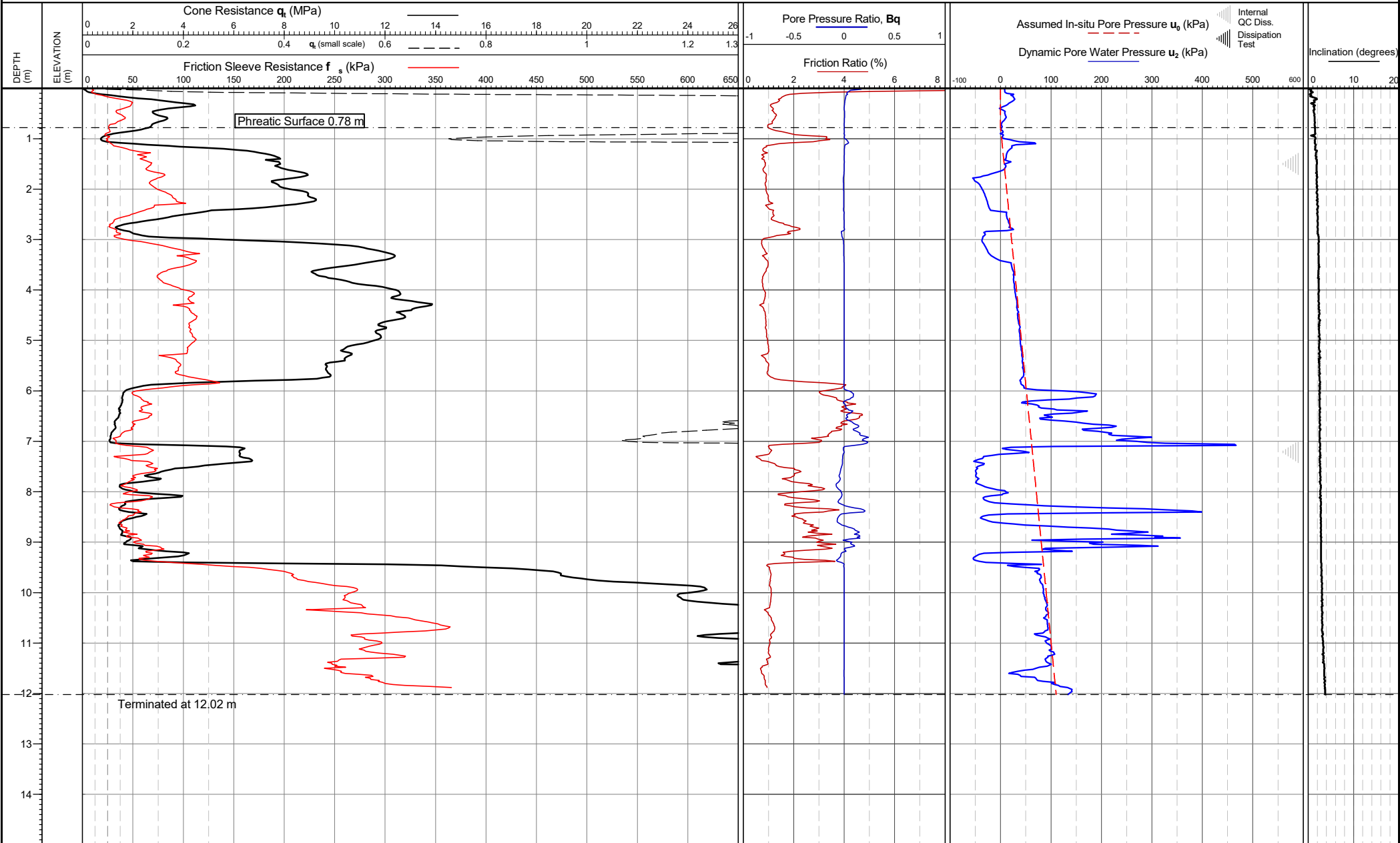
Lankelma Project Ref:
P-108354-1

TEST ID: CPT06

Page 1 of 1



Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS

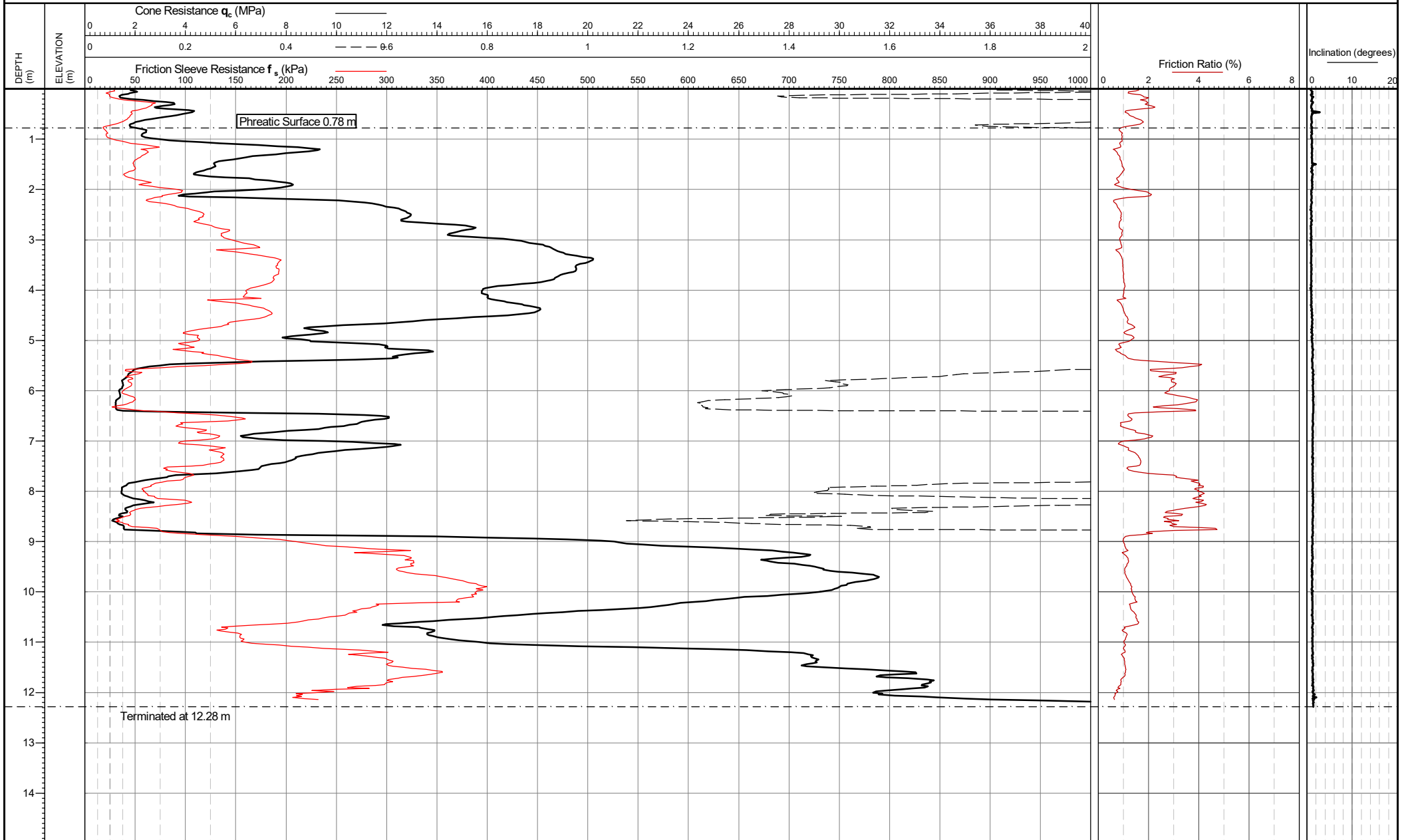


Cone area (mm ²): Cone ID: S15-CFIPTT.2141 Operator: Rob Bennett Rig Used: UK22 Date of test: 03/07/2023 11:11:23	Zero drift (Pre/post test) q_c (kPa): -6.2 f_s (kPa): -0.3 ($f_{s, drift} - q_{c, drift}$) u_2 (kPa): 7.1	Location: North Yorkshire, UK Coordinates: , Elevation: Coordinate system:	Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s) Termination Remark: Total reaction force	Date of plot: 05-07-23 Checked by: Chris Player	Lankelma Project Ref: P-108354-1	TEST ID: CPT07 Page 1 of 1
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Project: BURRENHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
Cone ID: S15-CFIPTT.2141
Operator: Rob Bennett
Rig Used: UK22
Date of test: 03/07/2023 09:41:17

Zero drift (Pre/post test)
 q_c (kPa): -17.6
 f_s (kPa): 1.5 ($f_{s, drift} - q_{c, drift}$)

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks:
*Phreatic surface origin: Average measured piezometric depth from other location(s)
Refusal criteria: Total reaction force

Date of plot:
05-07-23
Checked by:
Chris Player

Lankelma Project Ref:
P-108354-1

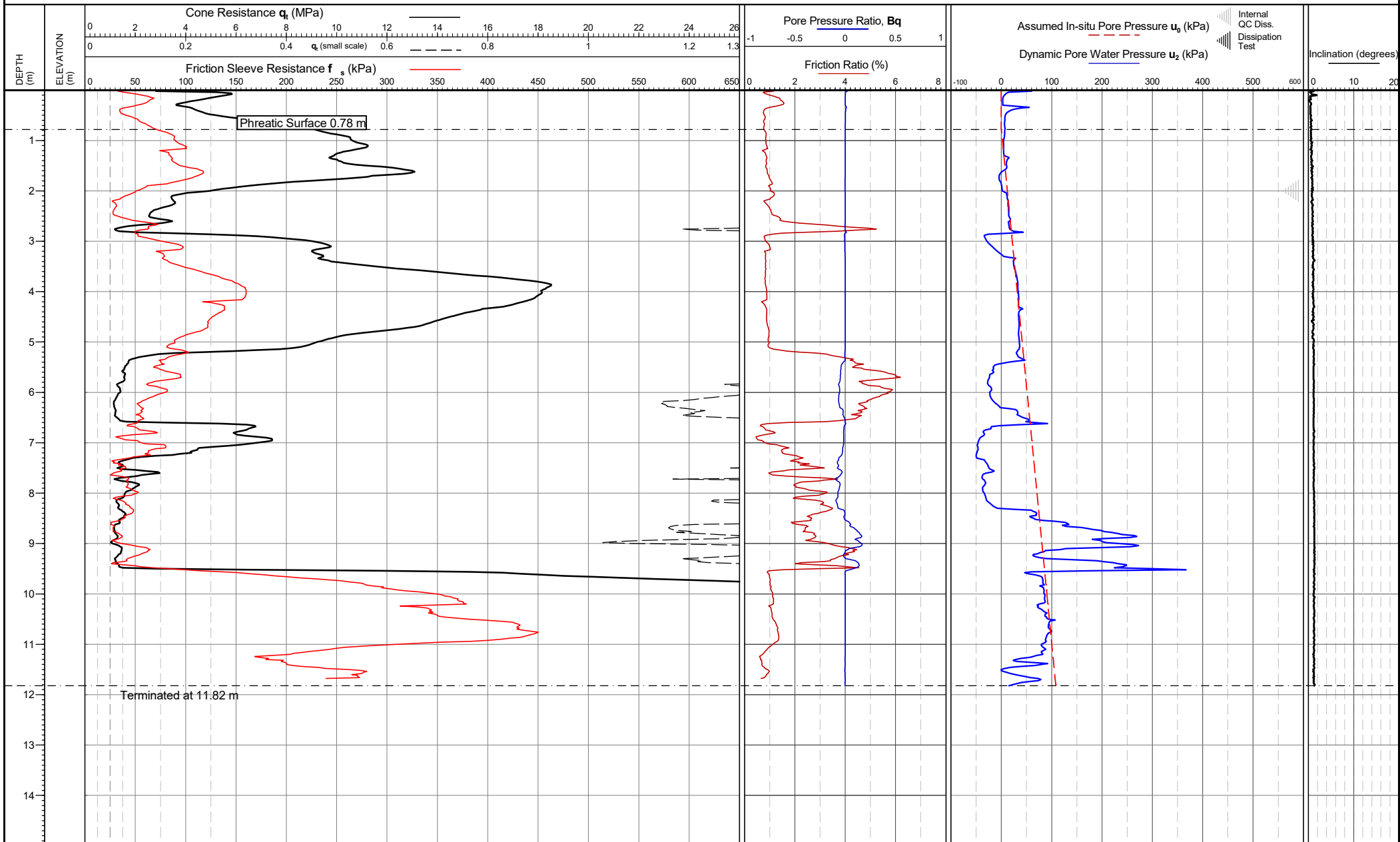
TEST ID: CPT08

Page 1 of 1



Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
Cone ID: S15-CFIPTT.2141
Operator: Rob Bennett
Rig Used: UK22
Date of test: 03/07/2023 10:24:34

Zero drift (Pre/post test)
 q_0 (kPa): -7.6
 f_0 (kPa): -0.1 ($f_{0, drift} - q_{0, drift}$)
 u_2 (kPa): -6.1

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks:
*Phreatic surface origin: Average measured piezometric depth from other location(s)
Termination Remark: Total reaction force

Date of plot:
05-07-23
Checked by:
Chris Player

Lankelma Project Ref:
P-108354-1

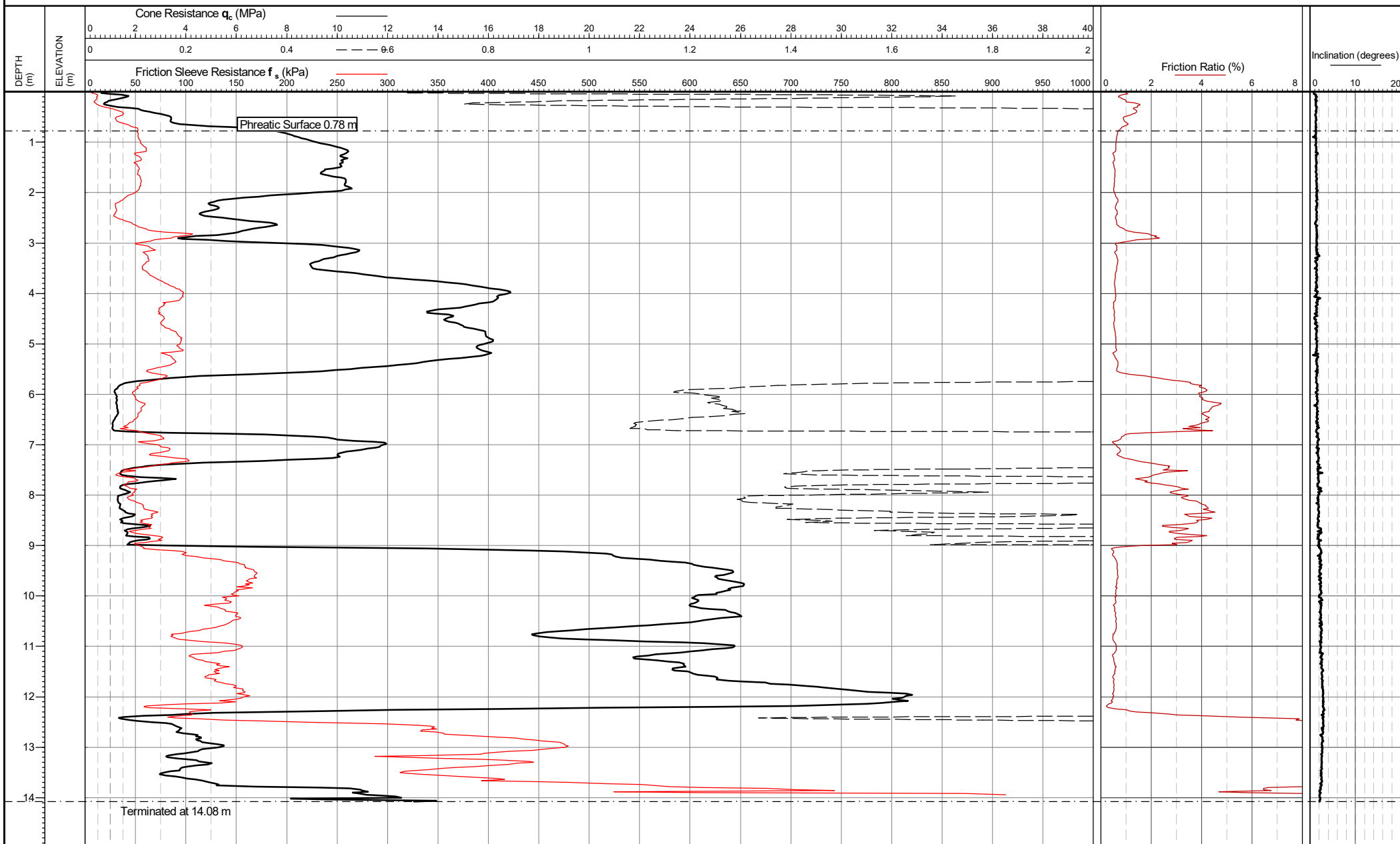
TEST ID: CPT09

Page 1 of 1



Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
Cone ID: S15-CFIPTT.2213
Operator: Rob Bennett
Rig Used: UK22
Date of test: 03/07/2023 08:52:36

Zero drift (Pre/post test)
 q_c (kPa): -4.4
 f_s (kPa): -0.5 ($f_{s, drift} - q_{c, drift}$)

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks:
*Phreatic surface origin: Average measured piezometric depth from other location(s)
Refusal criteria: Total reaction force

Date of plot: 05-07-23
Lankelma Project Ref: P-108354-1
Checked by: Chris Player

TEST ID: CPT10

Page 1 of 1

APPENDIX D SOIL BEHAVIOUR TYPE RESULTS

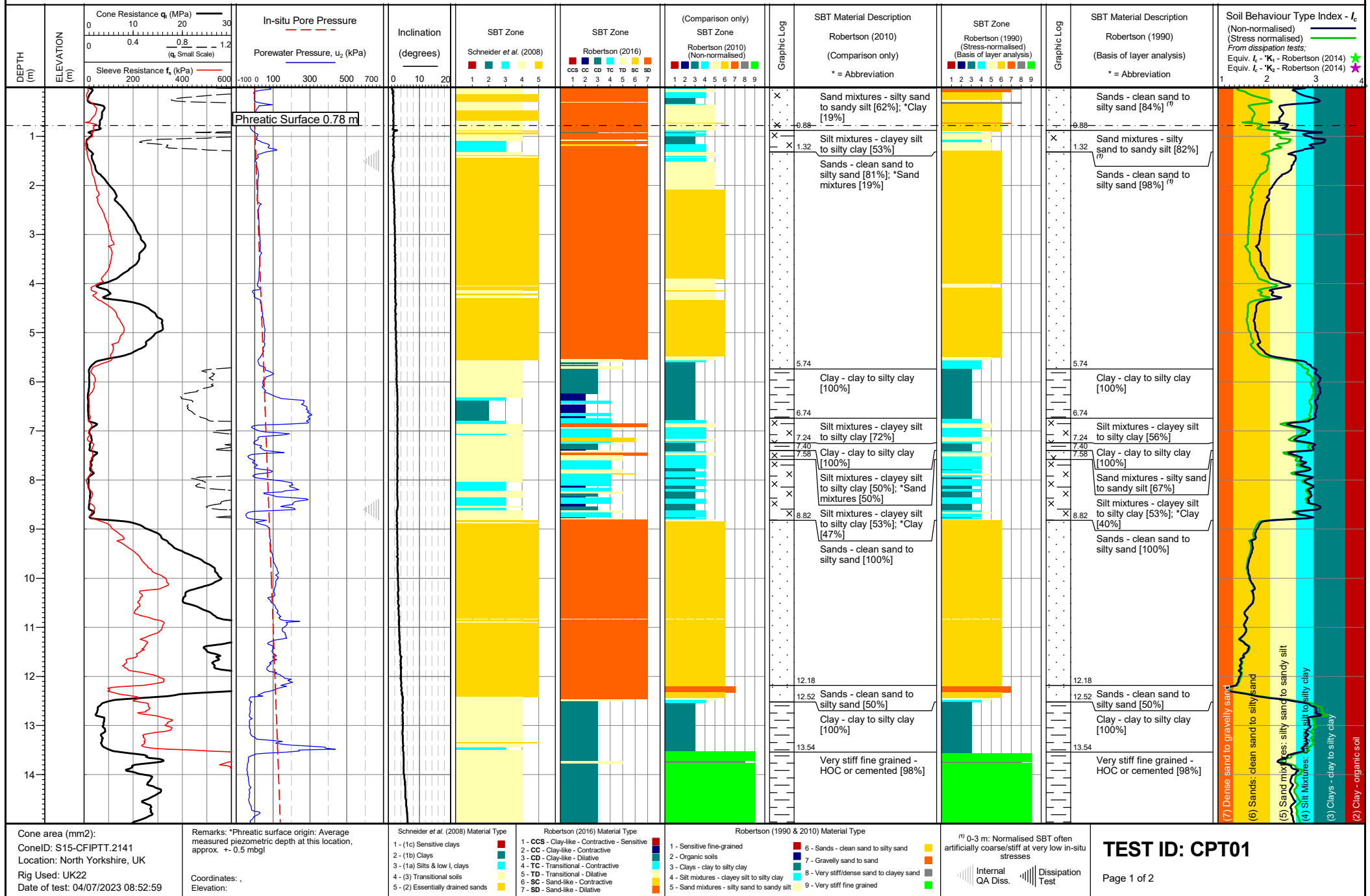
Soil behaviour type (SBT) point data evaluation according to:

Schneider et al (2008)

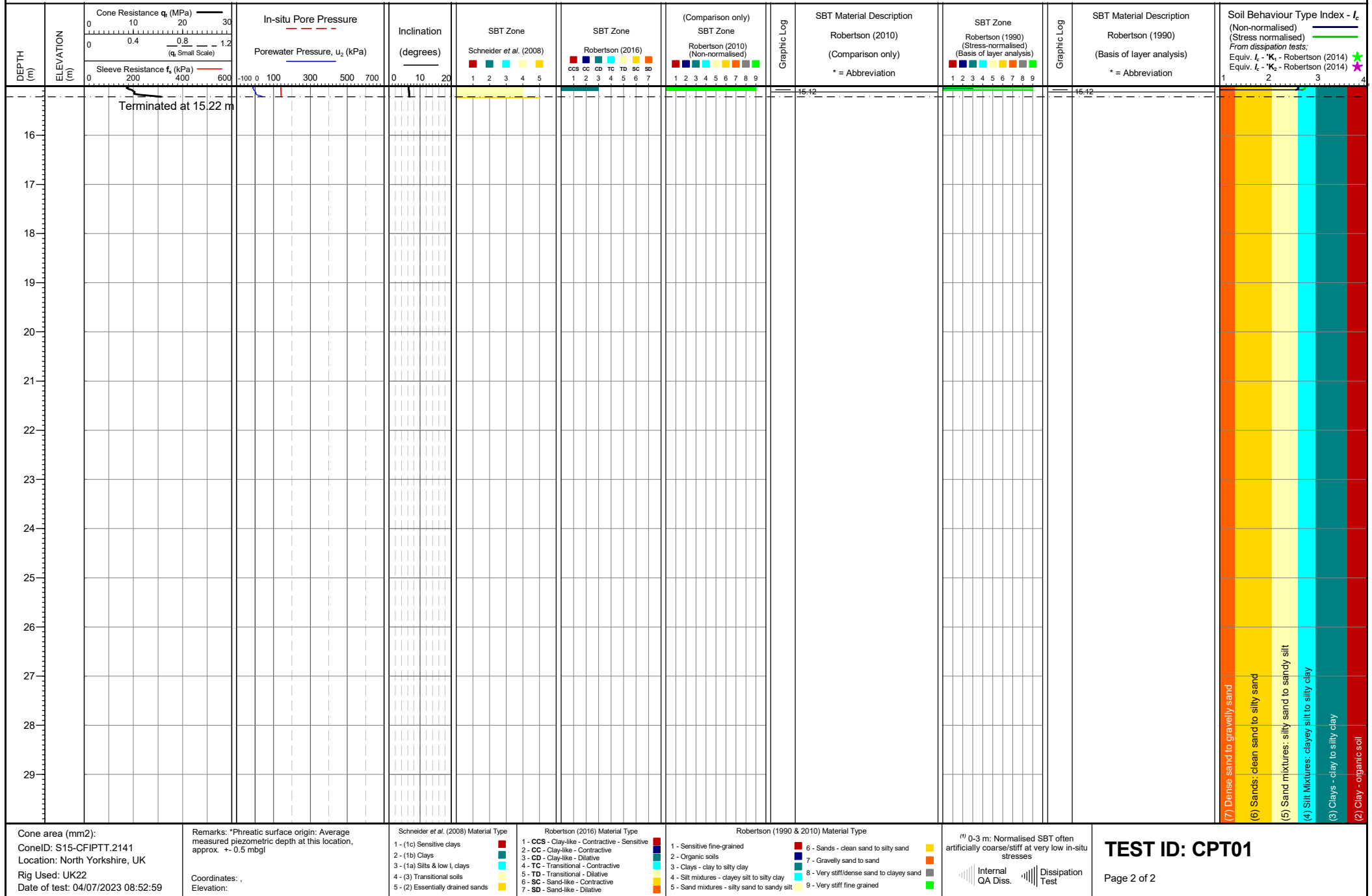
Robertson (2016)

Robertson (2010) with aggregate layer descriptions

Robertson (1990) with aggregate layer descriptions



(7) Dense sand to gravelly sand
(6) Sands: clean sand to silty sand
(5) Sand mixtures: silty sand to sandy silt
(4) Silt Mixtures: silty silt to silty clay
(3) Clays - clay to silty clay
(2) Clay - organic soil



(7) Dense sand to gravelly sand

(6) Sands: clean sand to silty sand

(5) Sand mixtures: silty sand to sandy silt

(4) Silt mixtures: clayey silt to silty clay

(3) Clays - clay to silty clay

(2) Clay - organic soil



Cone area (mm²):
ConeID: S15-CFIPTT.2141
Location: North Yorkshire, UK
Rig Used: UK22
Date of test: 04/07/2023 10:50:50

Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s)
Coordinates: ,
Elevation:

Robertson (2016) Material Type
1 - CCS - Clay-like - Contractive - Sensitive
2 - CC - Clay-like - Contractive
3 - CD - Clay-like - Dilative
4 - TC - Transitional - Contractive
5 - TD - Transitional - Dilative
6 - SC - Sand-like - Contractive
7 - SD - Sand-like - Dilative

Robertson (1990 & 2010) Material Type
1 - Sensitive fine-grained
2 - Organic soils
3 - Clays - clay to silty clay
4 - Silt mixtures - clayey silt to silty clay
5 - Sand mixtures - silty sand to sandy silt
6 - Sands - clean sand to silty sand
7 - Gravelly sand to sand
8 - Very stiff/dense sand to clayey sand
9 - Very stiff fine grained

⁽ⁿ⁾ 0-3 m: Normalised SBT often artificially coarse/stiff at very low in-situ stresses
Internal QA Diss. Dissipation Test

TEST ID: CPT02



Cone area (mm²):
ConeID: S15-CFIPIT.2141
Location: North Yorkshire, UK
Rig Used: UK22
Date of test: 04/07/2023 09:58:58

Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s)

Coordinates: ,
Elevation:

Schneider *et al.* (2008) Material Type

- 1 - (1c) Sensitive clays
- 2 - (1b) Clays
- 3 - (1a) Silts & low I_c clays
- 4 - (3) Transitional soils
- 5 - (2) Essentially drained sands

Robertson (2016) Material Type

- 1 - CCS - Clay-like - Contractive - Sensitive
- 2 - CC - Clay-like - Contractive
- 3 - CD - Clay-like - Dilative
- 4 - TC - Transitional - Contractive
- 5 - TD - Transitional - Dilative
- 6 - SC - Sand-like - Contractive
- 7 - SD - Sand-like - Dilative

Robertson (1990 & 2010) Material Type

- 1 - Sensitive fine-grained
- 2 - Organic soils
- 3 - Clays - clay to silty clay
- 4 - Silt mixtures - clayey silt to silty clay
- 5 - Sand mixtures - silty sand to sandy silt

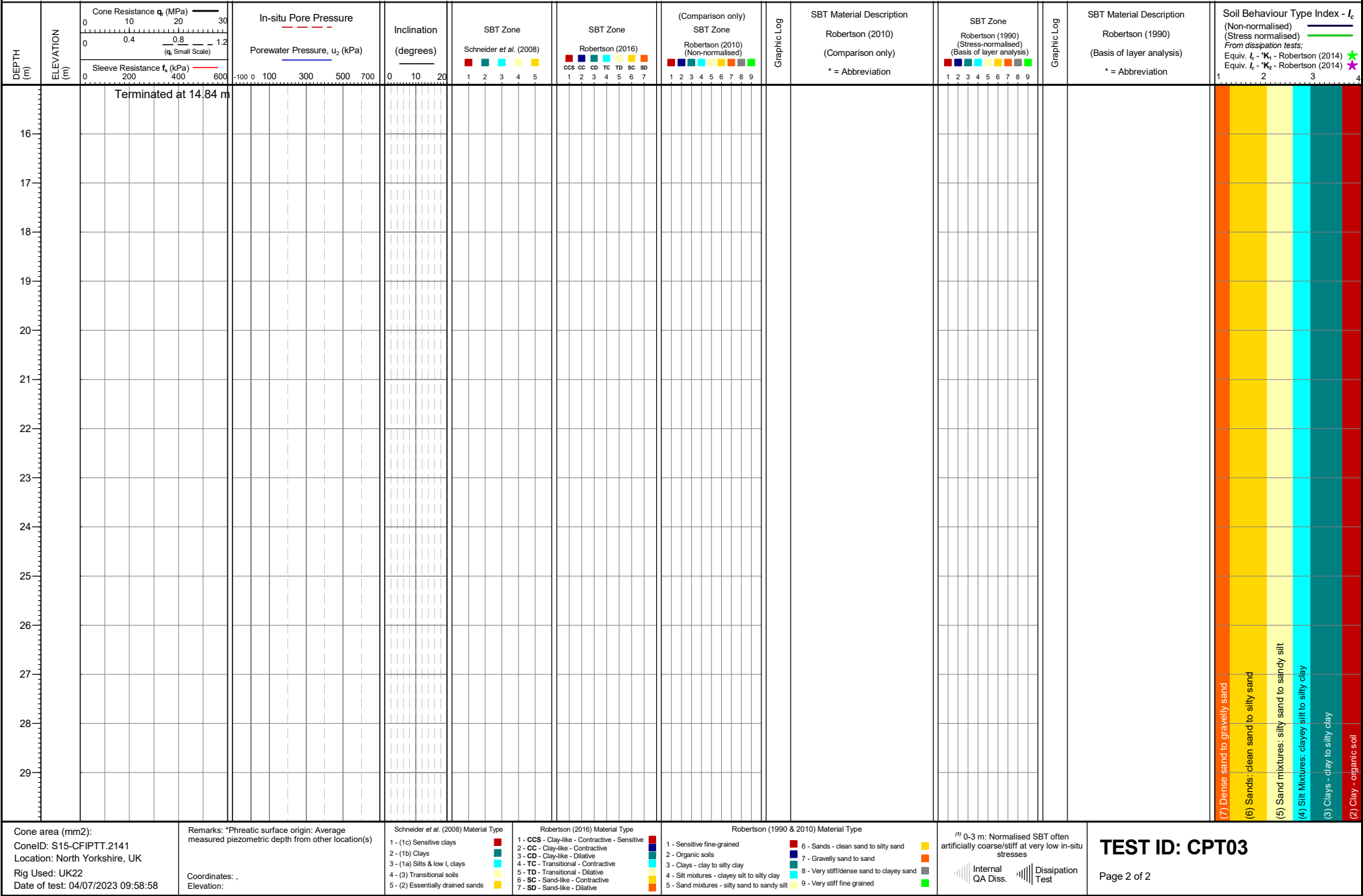
- 6 - Sands - clean sand to silty sand
- 7 - Gravely sand to sand
- 8 - Very stiff/dense sand to clayey sand
- 9 - Very stiff fine grained

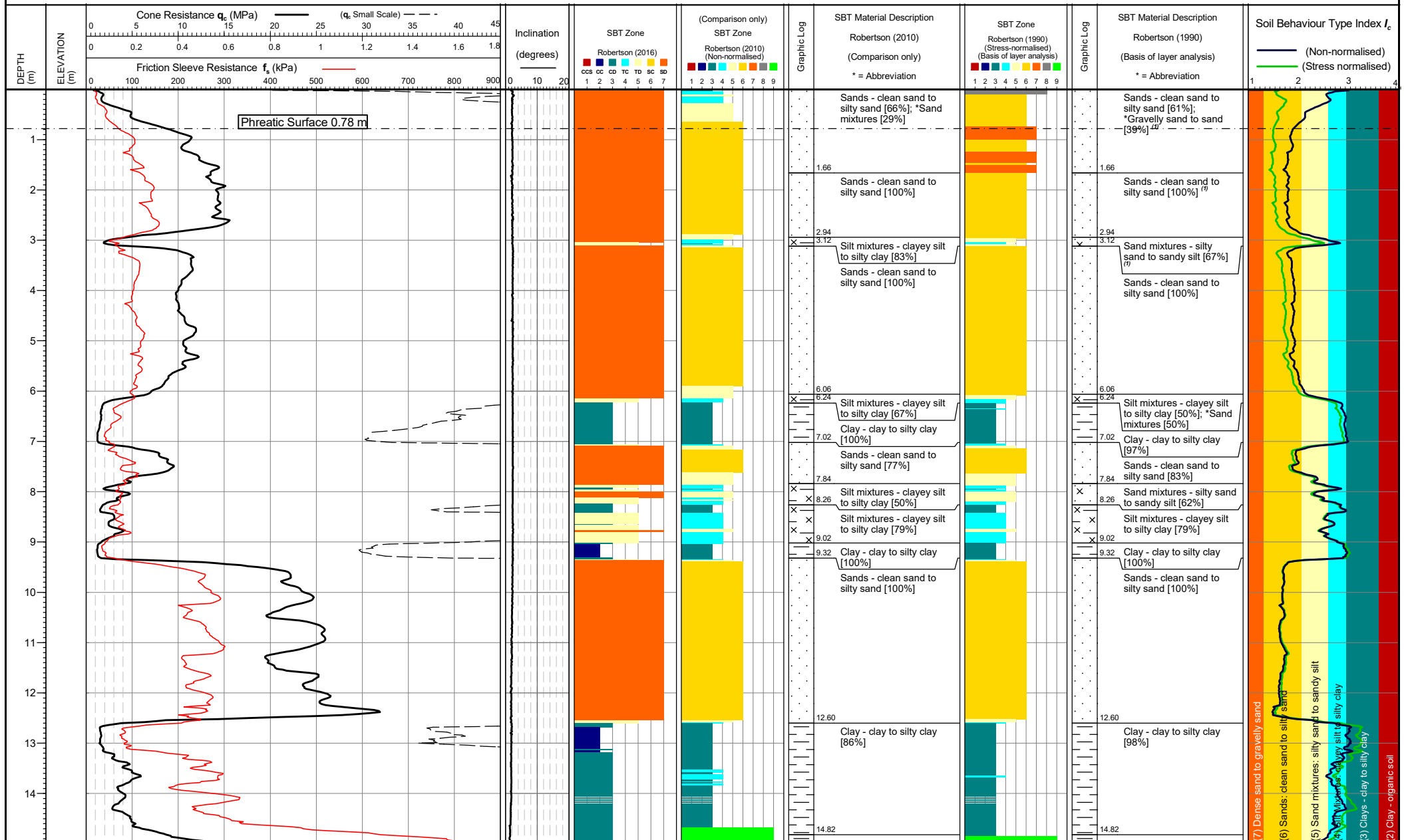
⁽ⁿ⁾ 0-3 m: Normalised SBT often artificially coarse/stiff at very low in-situ stresses

Internal QA Diss. Dissipation Test

TEST ID: CPT03

(7) Dense sand to gravely sand
(6) Sands: clean sand to silty sand
(5) Sand mixtures: silty sand to sandy silt
(4) Silt mixtures: clayey silt to silty clay
(3) Clays - clay to silty clay
(2) Clay - organic soil





Cone area (mm²):
ConeID: S15-CFIPTT.2141
Location: North Yorkshire, UK
Rig Used: UK22
Date of test: 04/07/2023 08:16:22

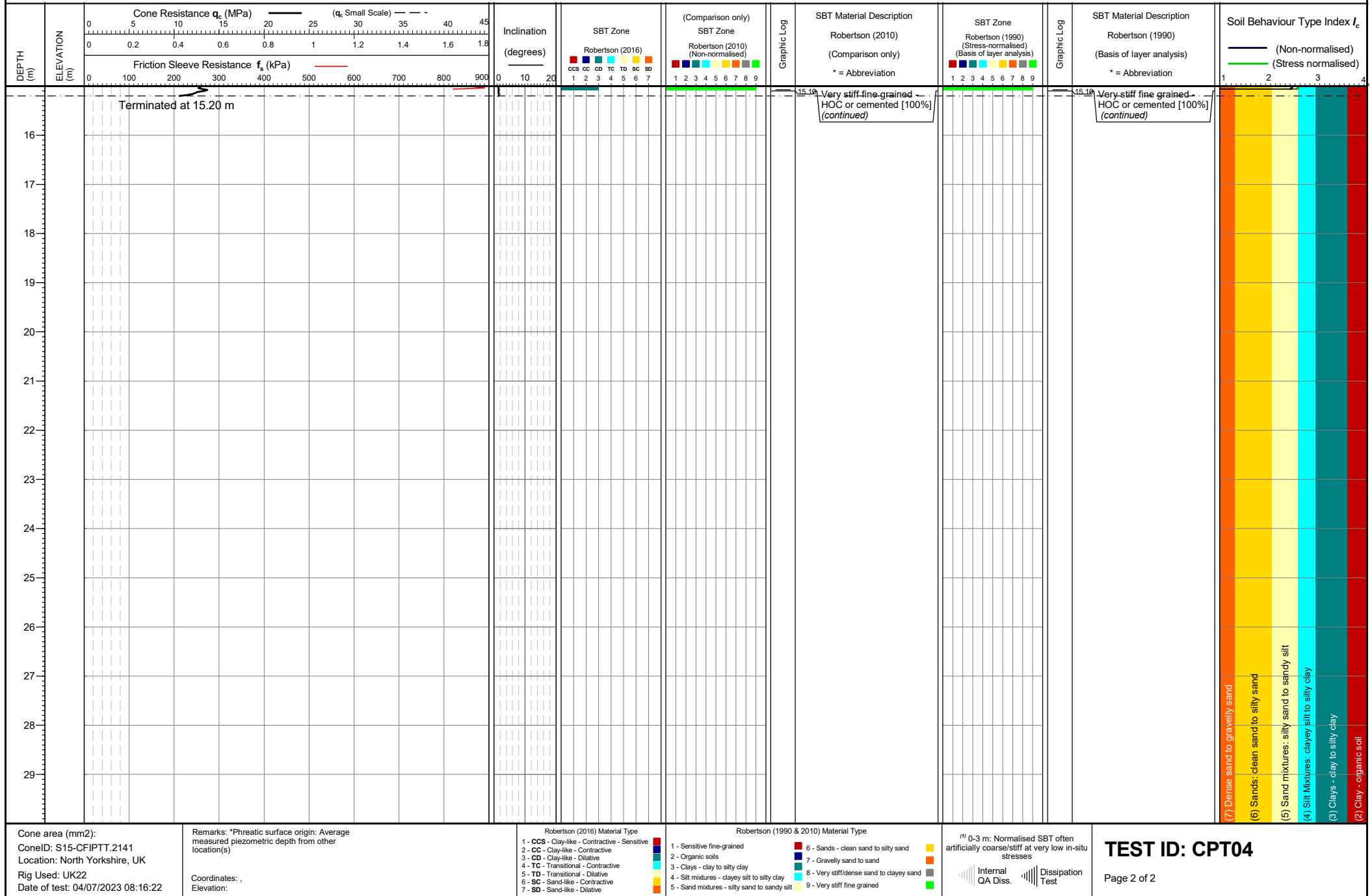
Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s)
Coordinates: ,
Elevation:

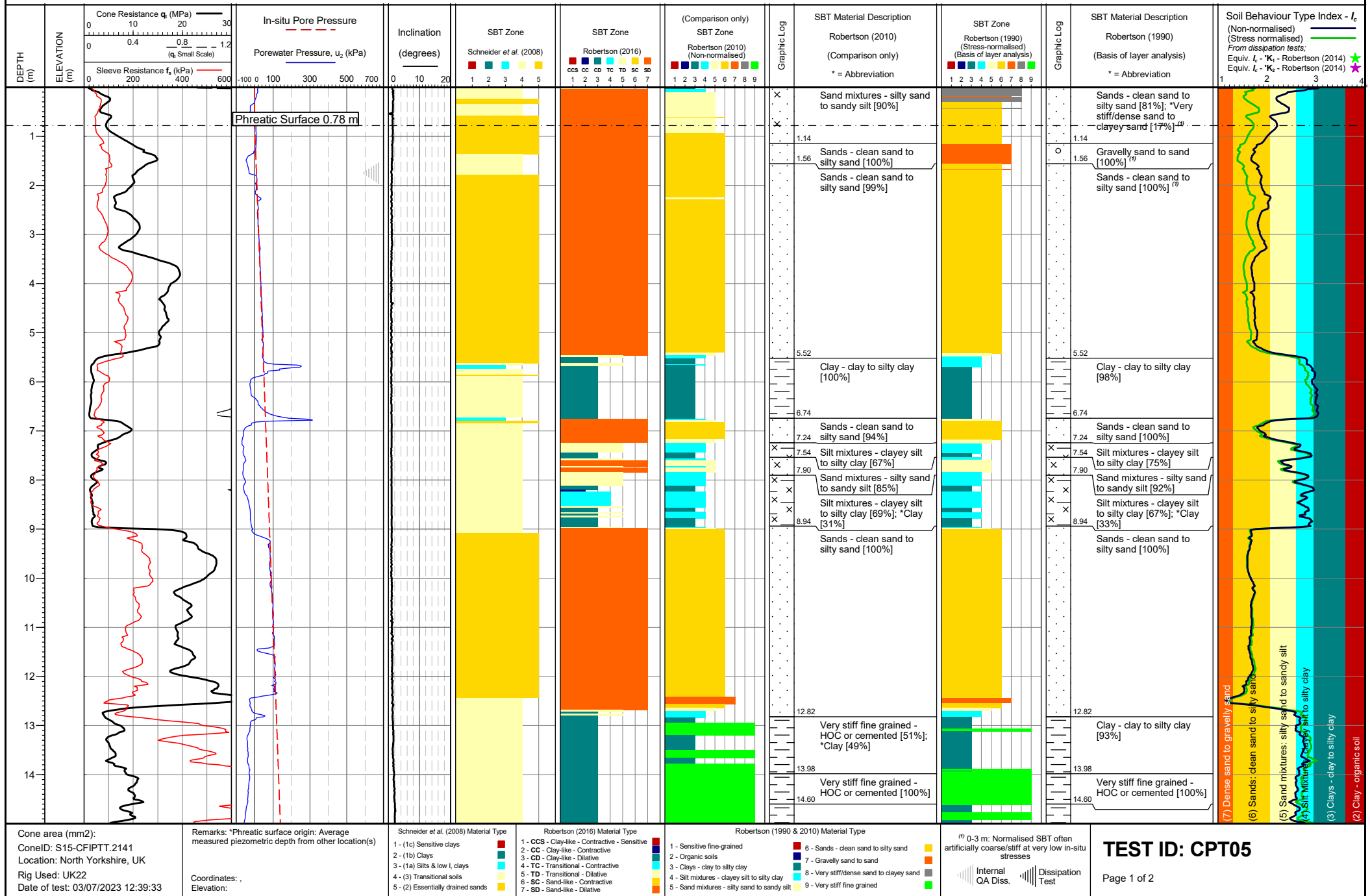
Robertson (2016) Material Type
1 - CCS - Clay-like - Contractive - Sensitive
2 - CC - Clay-like - Contractive
3 - CD - Clay-like - Dilative
4 - TC - Transitional - Contractive
5 - TD - Transitional - Dilative
6 - SC - Sand-like - Contractive
7 - SD - Sand-like - Dilative

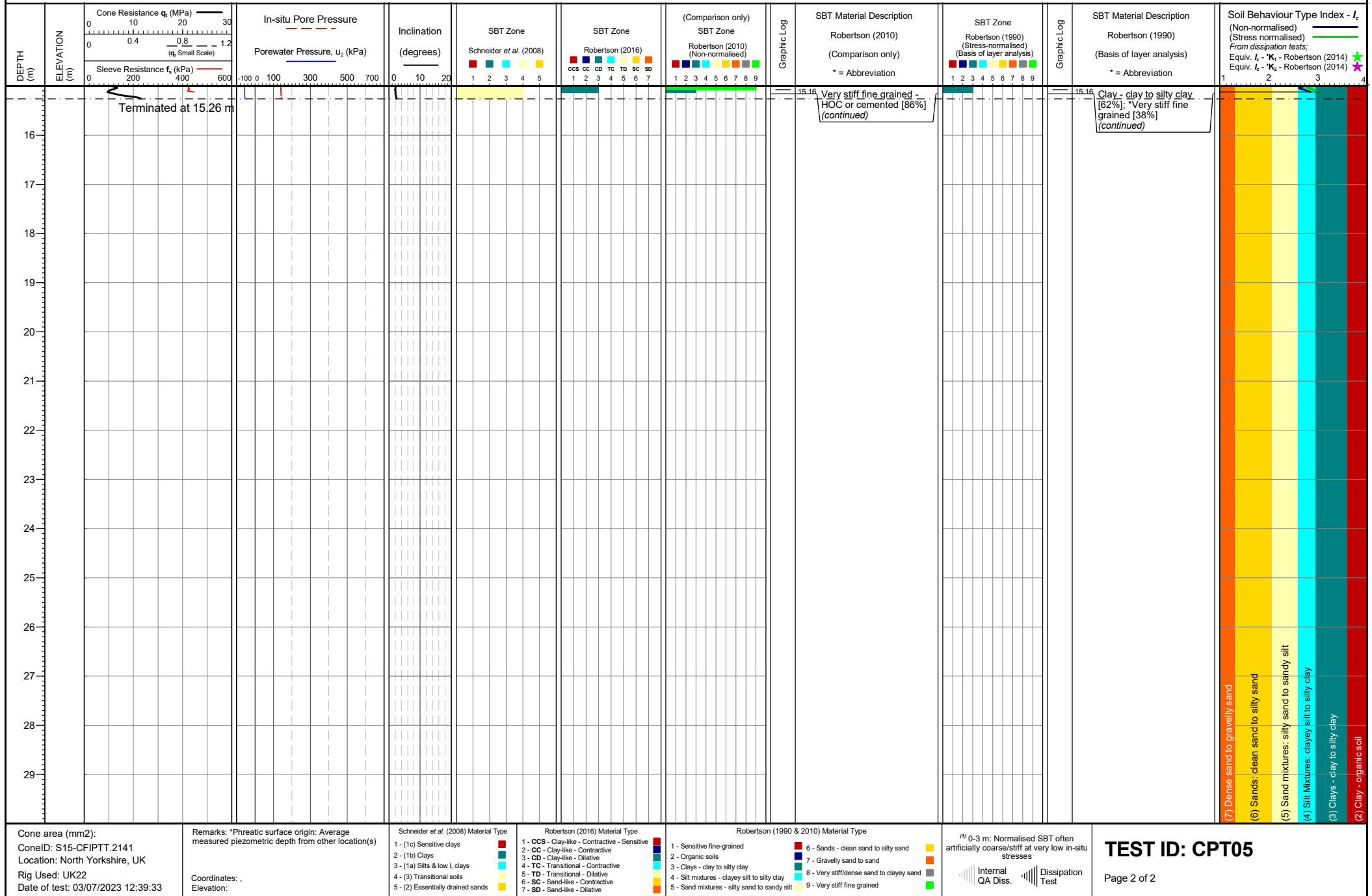
Robertson (1990 & 2010) Material Type
1 - Sensitive fine-grained
2 - Organic soils
3 - Clays - clay to silty clay
4 - Silt mixtures - clayey silt to silty clay
5 - Sand mixtures - silty sand to sandy silt
6 - Sands - clean sand to silty sand
7 - Gravelly sand to sand
8 - Very stiff/dense sand to clayey sand
9 - Very stiff fine grained

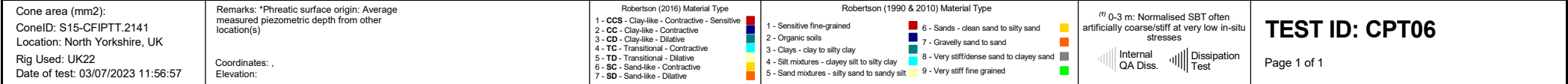
⁽ⁿ⁾ 0-3 m: Normalised SBT often artificially coarse/stiff at very low in-situ stresses
Internal QA Diss. Dissipation Test

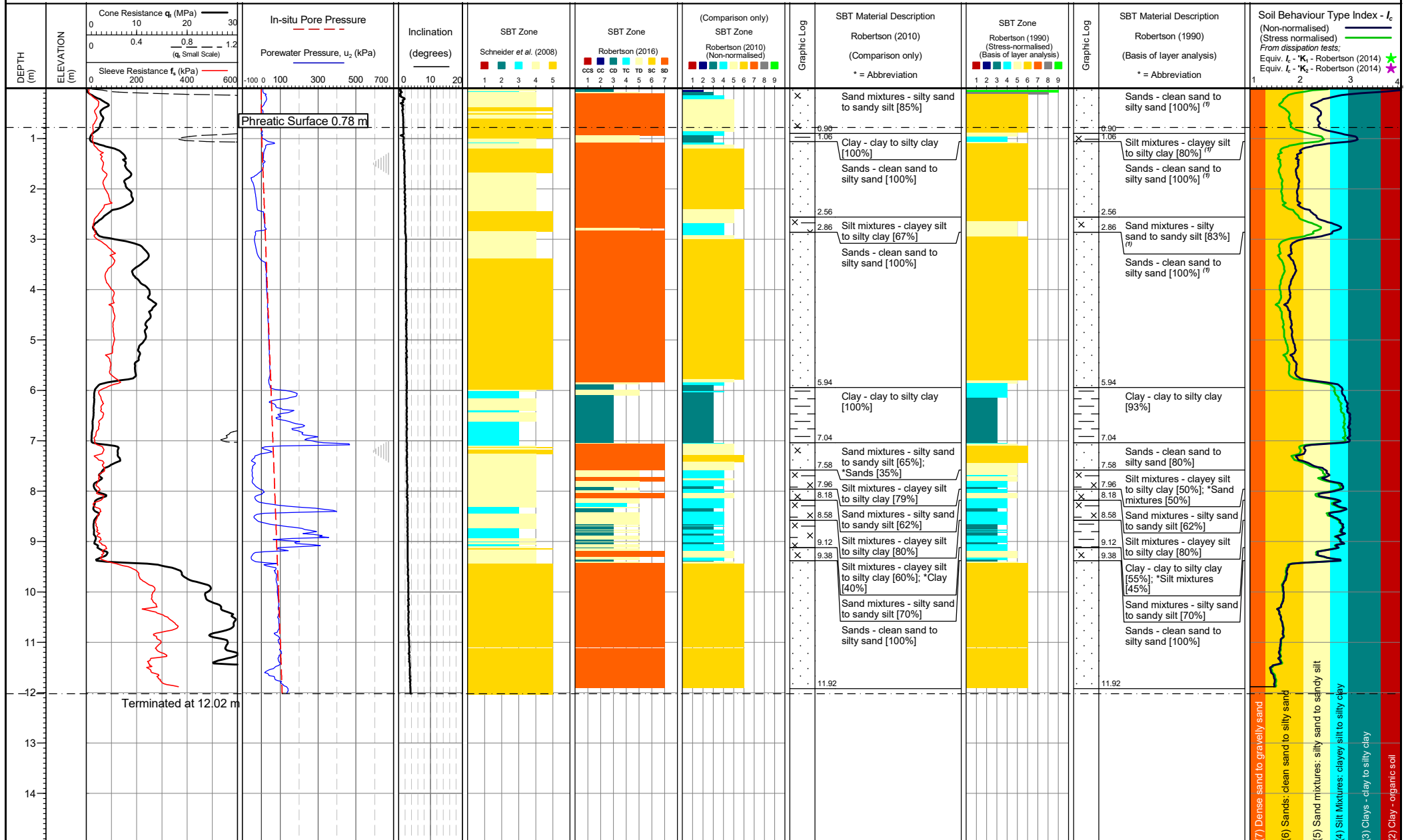
TEST ID: CPT04











Cone area (mm²):
 ConeID: S15-CFIPTT.2141
 Location: North Yorkshire, UK
 Rig Used: UK22
 Date of test: 03/07/2023 11:11:23

Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s)
 Coordinates: ,
 Elevation:

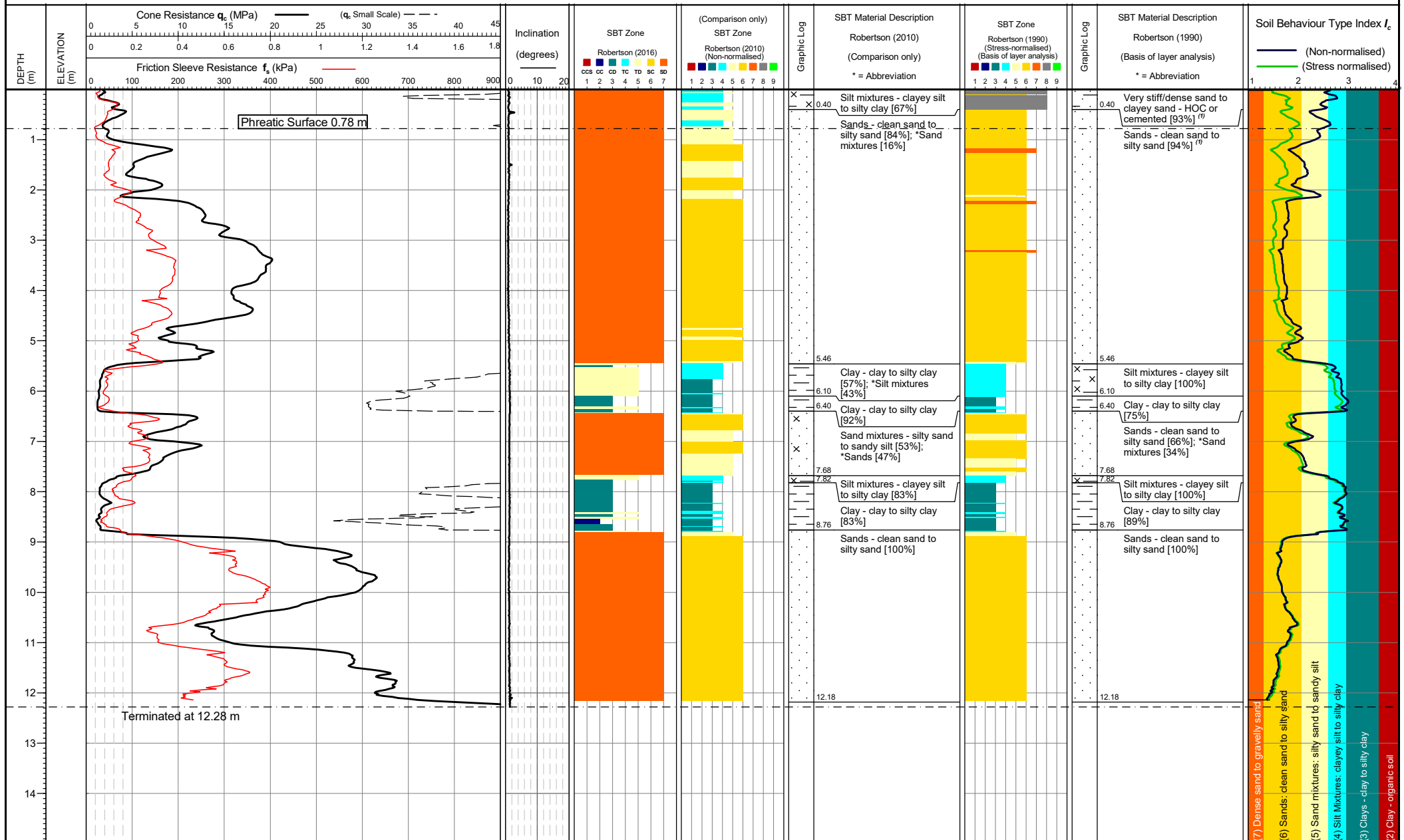
Schneider *et al.* (2008) Material Type
 1 - (1c) Sensitive clays
 2 - (1b) Clays
 3 - (1a) Silts & low l, clays
 4 - (3) Transitional soils
 5 - (2) Essentially drained sands

Robertson (2016) Material Type
 1 - CCS - Clay-like - Contractive - Sensitive
 2 - CC - Clay-like - Contractive
 3 - CD - Clay-like - Dilative
 4 - TC - Transitional - Contractive
 5 - TD - Transitional - Dilative
 6 - SC - Sand-like - Contractive
 7 - SD - Sand-like - Dilative

Robertson (1990 & 2010) Material Type
 1 - Sensitive fine-grained
 2 - Organic soils
 3 - Clays - clay to silty clay
 4 - Silt mixtures - clayey silt to silty clay
 5 - Sand mixtures - silty sand to sandy silt
 6 - Sands - clean sand to silty sand
 7 - Gravelly sand to sand
 8 - Very stiff/dense sand to clayey sand
 9 - Very stiff fine grained

⁽ⁿ⁾ 0-3 m: Normalised SBT often artificially coarse/stiff at very low in-situ stresses
 Internal QA Diss. Dissipation Test

TEST ID: CPT07



Cone area (mm²):
ConeID: S15-CFIPTT.2141
Location: North Yorkshire, UK
Rig Used: UK22
Date of test: 03/07/2023 09:41:17

Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s)
Coordinates: ,
Elevation:

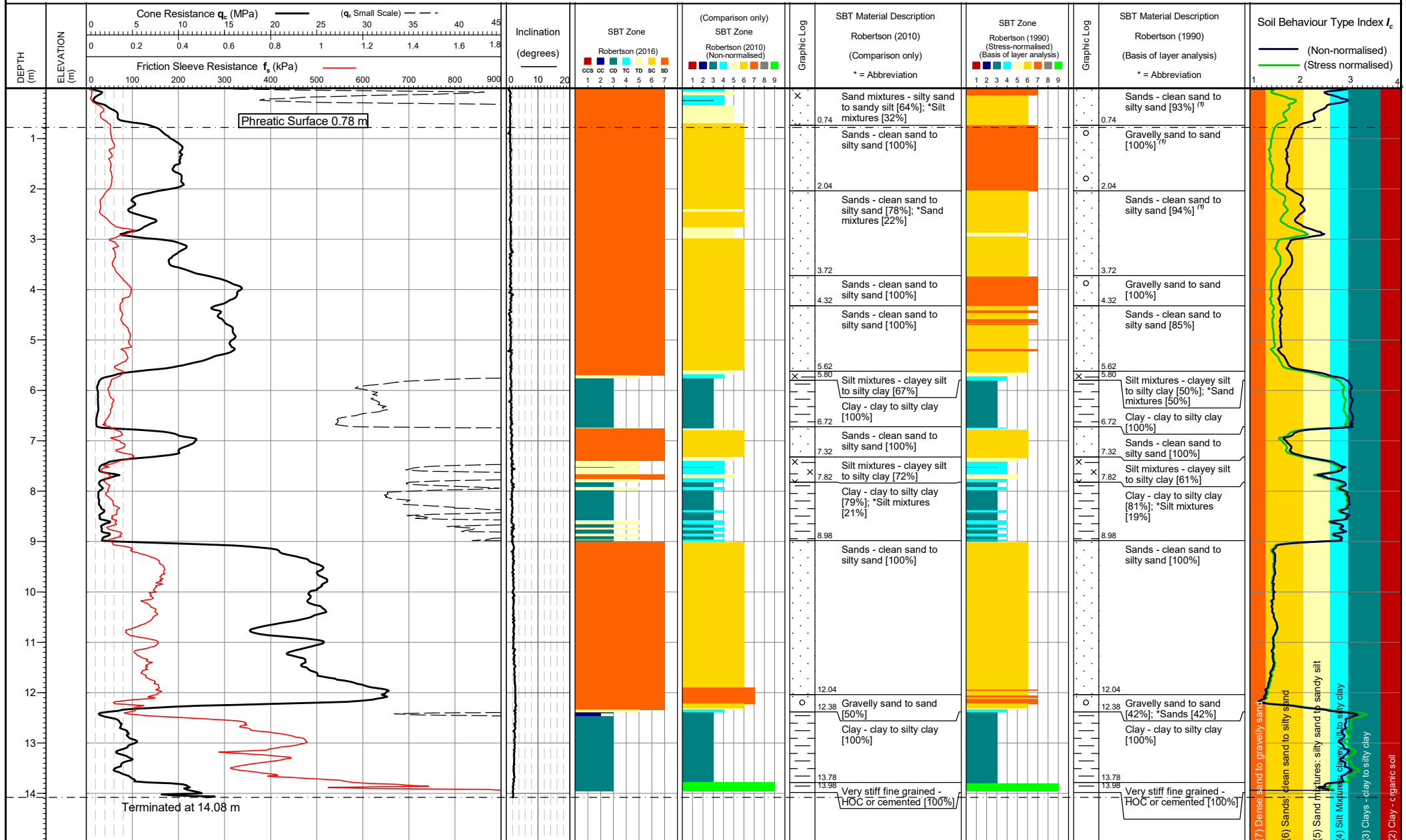
Robertson (2016) Material Type
1 - CCS - Clay-like - Contractive - Sensitive
2 - CC - Clay-like - Contractive
3 - CD - Clay-like - Dilative
4 - TC - Transitional - Contractive
5 - TD - Transitional - Dilative
6 - SC - Sand-like - Contractive
7 - SD - Sand-like - Dilative

Robertson (1990 & 2010) Material Type
1 - Sensitive fine-grained
2 - Organic soils
3 - Clays - clay to silty clay
4 - Silt mixtures - clayey silt to silty clay
5 - Sand mixtures - silty sand to sandy silt
6 - Sands - clean sand to silty sand
7 - Gravelly sand to sand
8 - Very stiff/dense sand to clayey sand
9 - Very stiff fine grained

⁽ⁿ⁾ 0-3 m: Normalised SBT often artificially coarse/stiff at very low in-situ stresses
Internal QA Diss. Dissipation Test

TEST ID: CPT08





Cone area (mm²):
 ConeID: S15-CFIP.TT.2213
 Location: North Yorkshire, UK
 Rig Used: UK22
 Date of test: 03/07/2023 08:52:36

Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s)
 Coordinates: ,
 Elevation:

Robertson (2016) Material Type
 1 - CCS - Clay-like - Contractive - Sensitive
 2 - CC - Clay-like - Contractive
 3 - CD - Clay-like - Dilative
 4 - TC - Transitional - Contractive
 5 - TD - Transitional - Dilative
 6 - SC - Sand-like - Contractive
 7 - SD - Sand-like - Dilative

Robertson (1990 & 2010) Material Type
 1 - Sensitive fine-grained
 2 - Organic soils
 3 - Clays - clay to silty clay
 4 - Silt mixtures - clayey silt to silty clay
 5 - Sand mixtures - silty sand to sandy silt
 6 - Sands - clean sand to silty sand
 7 - Gravelly sand to sand
 8 - Very stiff/dense sand to clayey sand
 9 - Very stiff fine grained

⁽ⁿ⁾ 0-3 m: Normalised SBT often artificially coarse/stiff at very low in-situ stresses
 Internal QA Diss. Dissipation Test

TEST ID: CPT10

APPENDIX E PARAMETER RESULTS 1 - S_u , M_v , OCR, SBT, I_c

Undrained shear strength

Coefficient of volume change

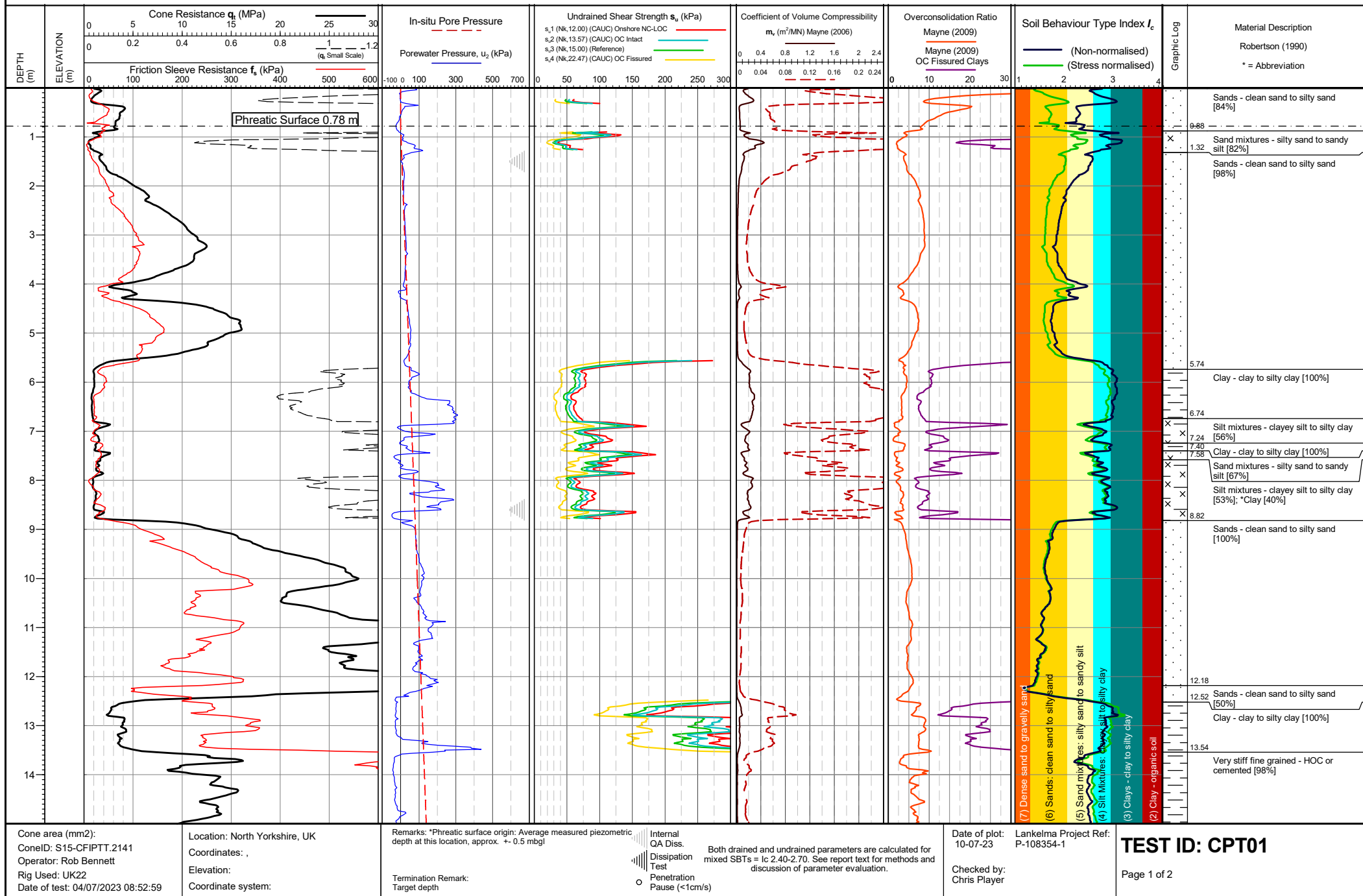
Overconsolidation ratio

Robertson 1990 SBT descriptions & SBT index I_c



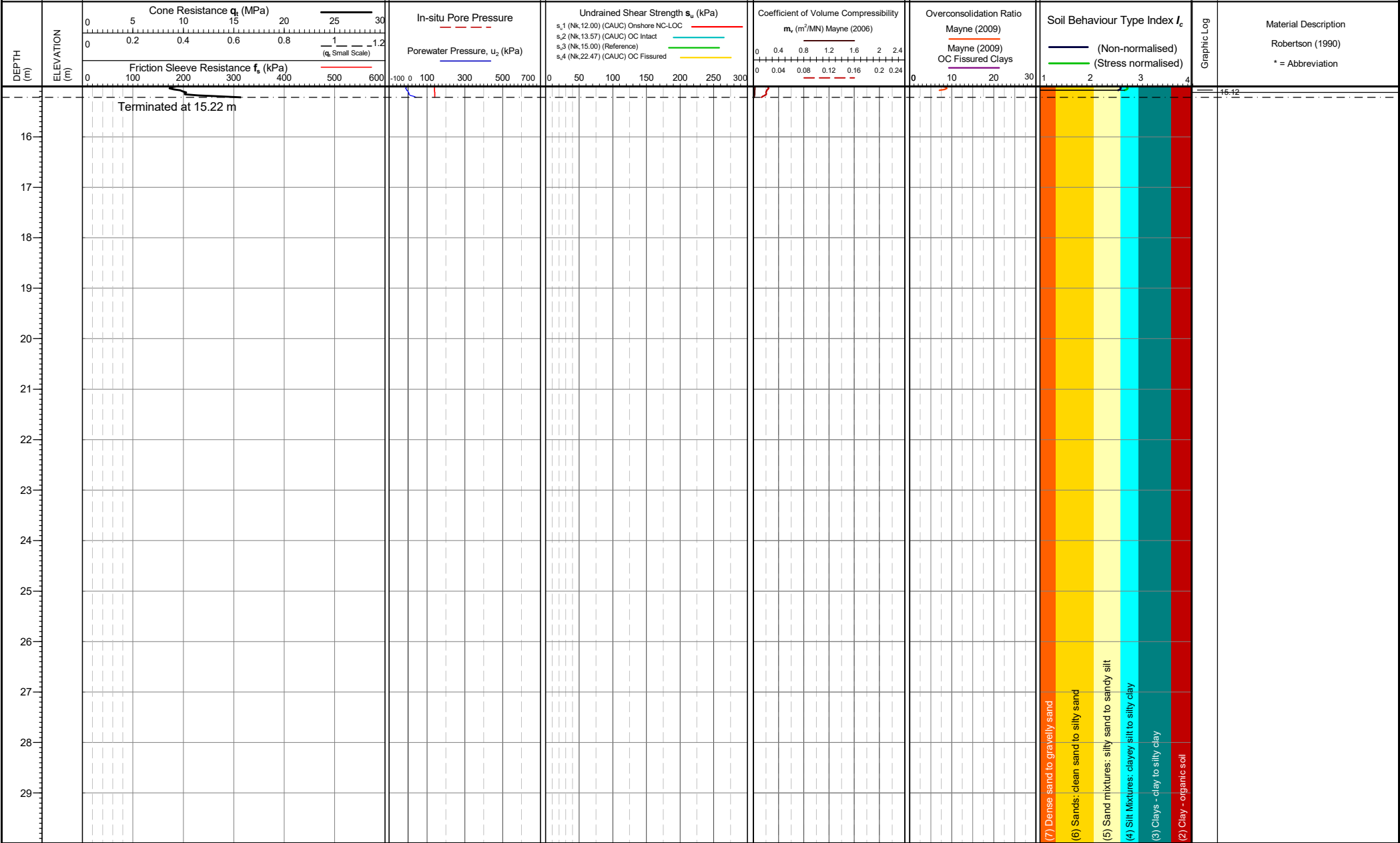
Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS





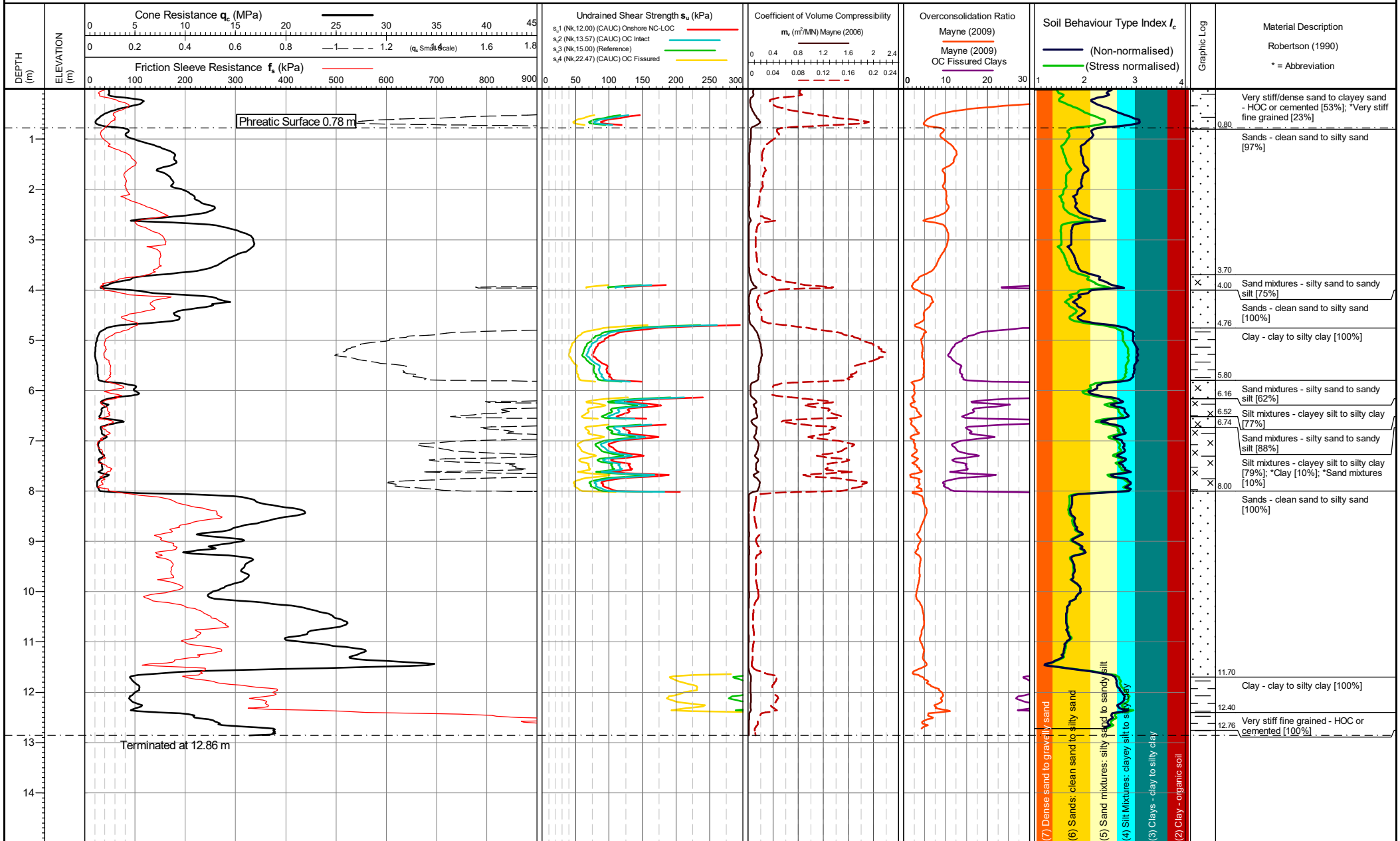
Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS





Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
ConeID: S15-CFIPTT.2141
Operator: Rob Bennett
Rig Used: UK22
Date of test: 04/07/2023 10:50:50

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks: *Phreatic surface origin:
Average measured piezometric depth
from other location(s)
Termination Remark:
Sleeve load

Both drained and undrained parameters are calculated for
mixed SBTs = I_c 2.40-2.70. See report text for methods and
discussion of parameter evaluation.

Date of plot: 10-07-23
Lankelma Project Ref: P-108354-1

Checked by:
Chris Player

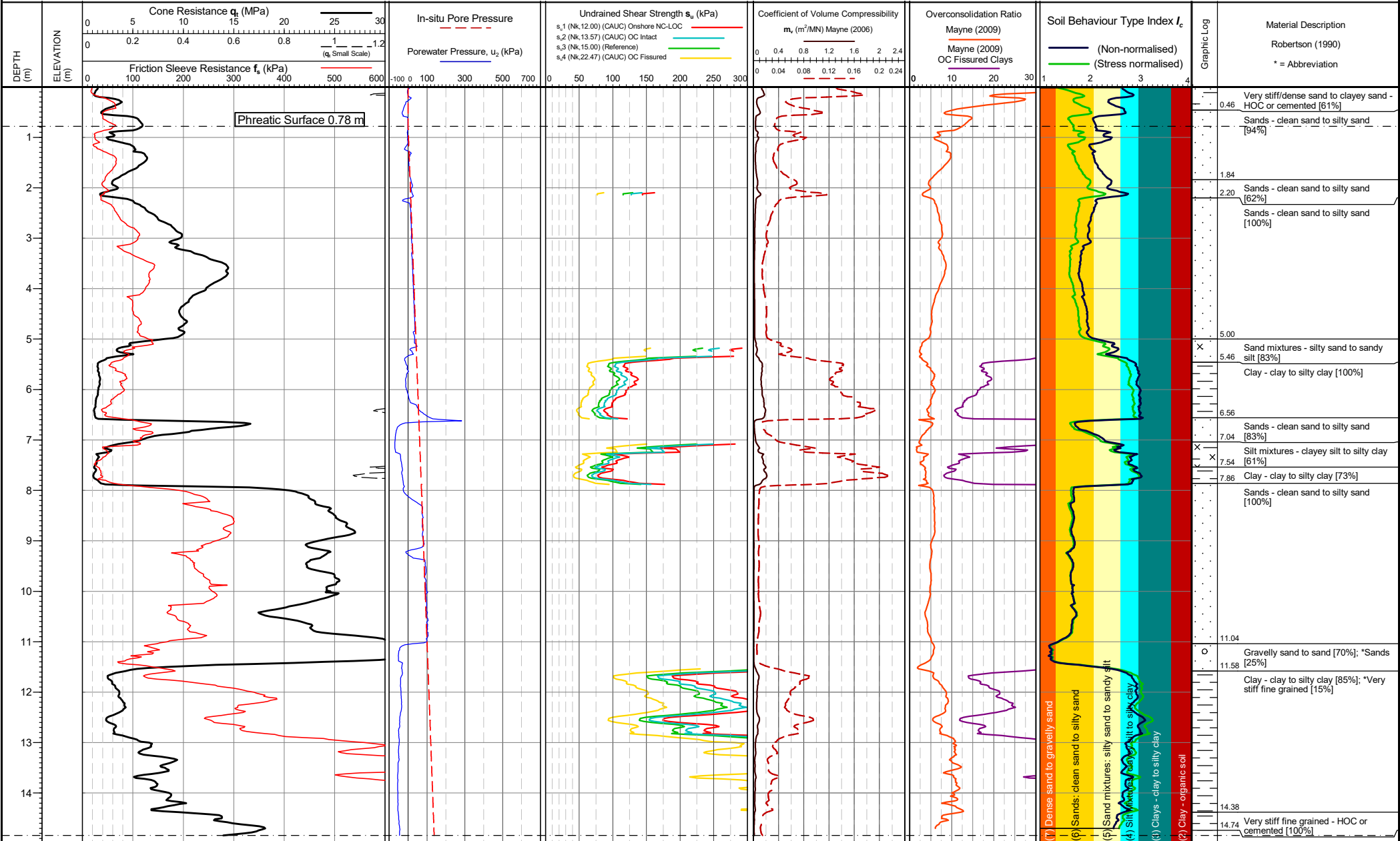
TEST ID: CPT02

Page 1 of 1



Project: BRRINGHAM ROAD, SCUNTHORPE

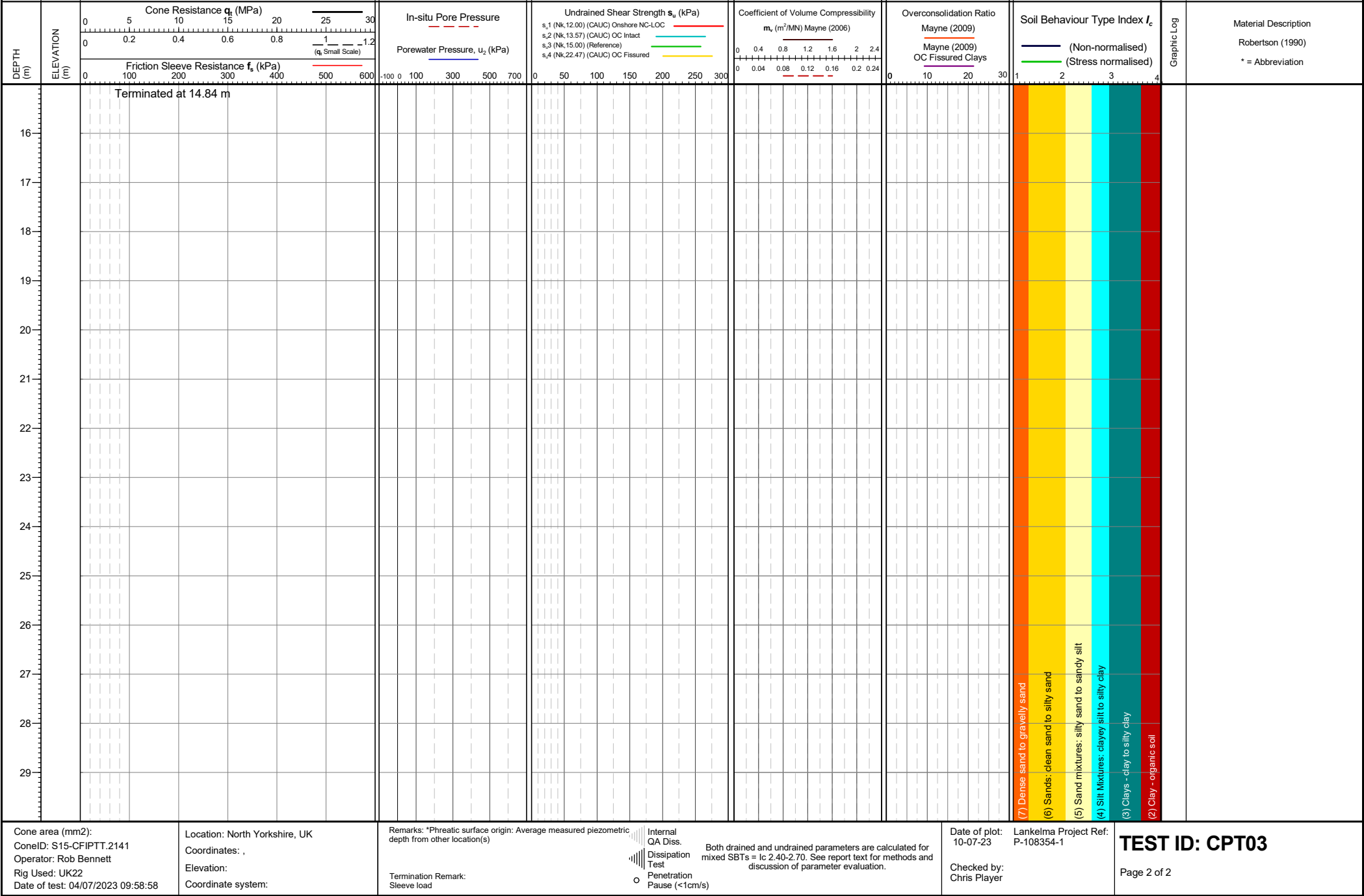
Client: ALAN WOOD & PARTNERS





Project: BRRINGHAM ROAD, SCUNTHORPE

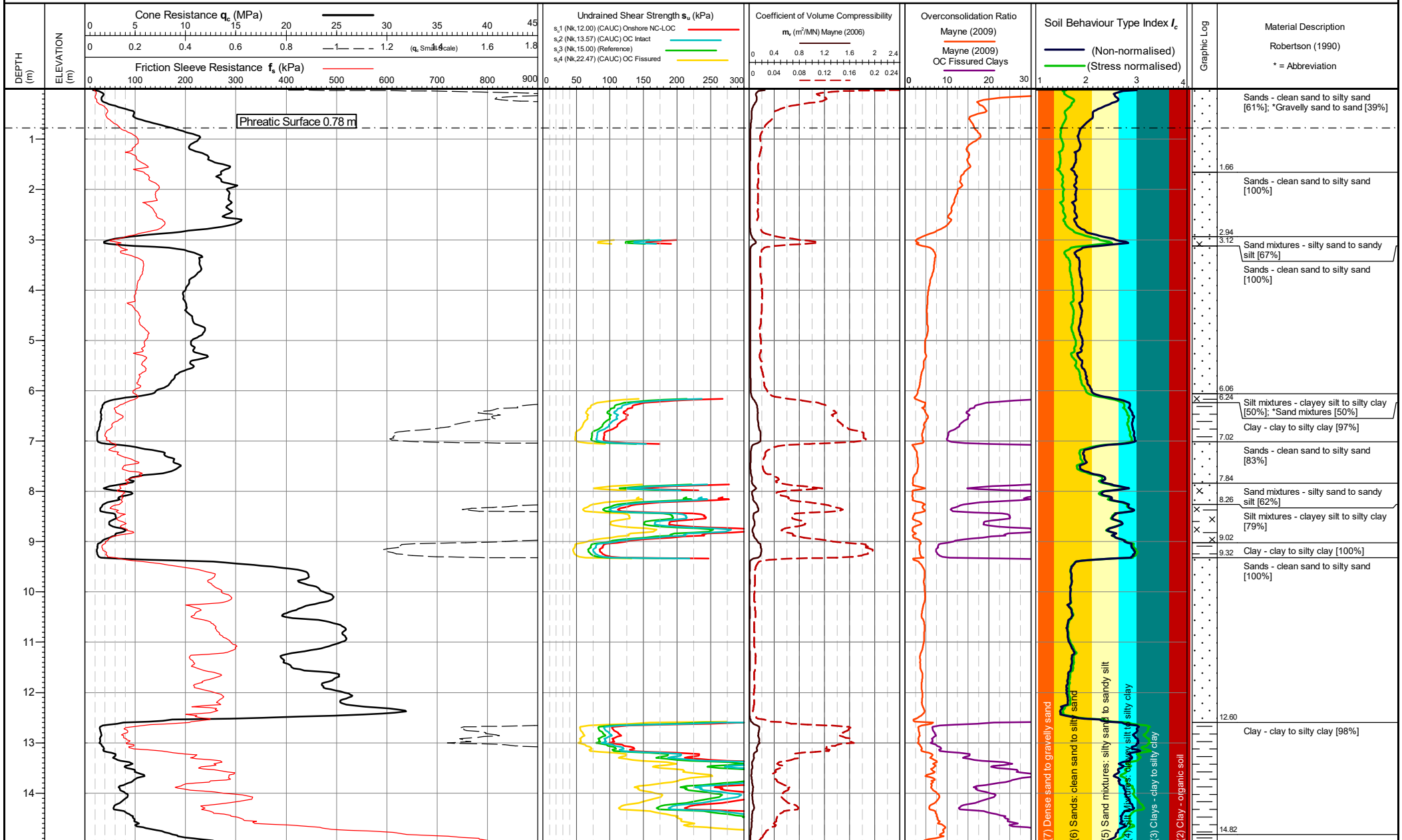
Client: ALAN WOOD & PARTNERS





Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
ConeID: S15-CFIPTT.2141
Operator: Rob Bennett
Rig Used: UK22
Date of test: 04/07/2023 08:16:22

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks: *Phreatic surface origin:
Average measured piezometric depth
from other location(s)

Termination Remark:
Target depth

Both drained and undrained parameters are calculated for
mixed SBTs = I_c 2.40-2.70. See report text for methods and
discussion of parameter evaluation.

Date of plot: 10-07-23
Lankelma Project Ref: P-108354-1

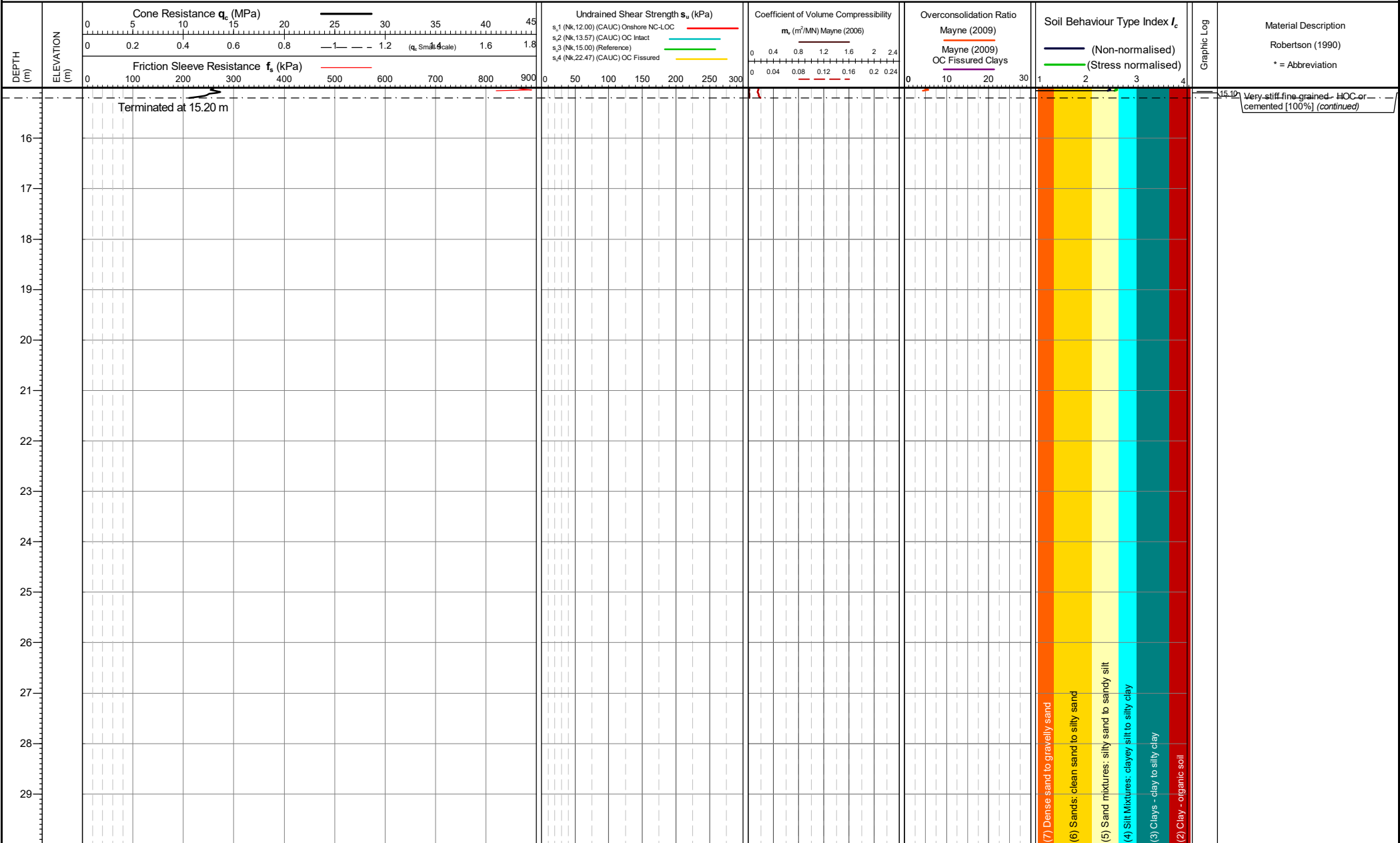
Checked by:
Chris Player

TEST ID: CPT04

Page 1 of 2



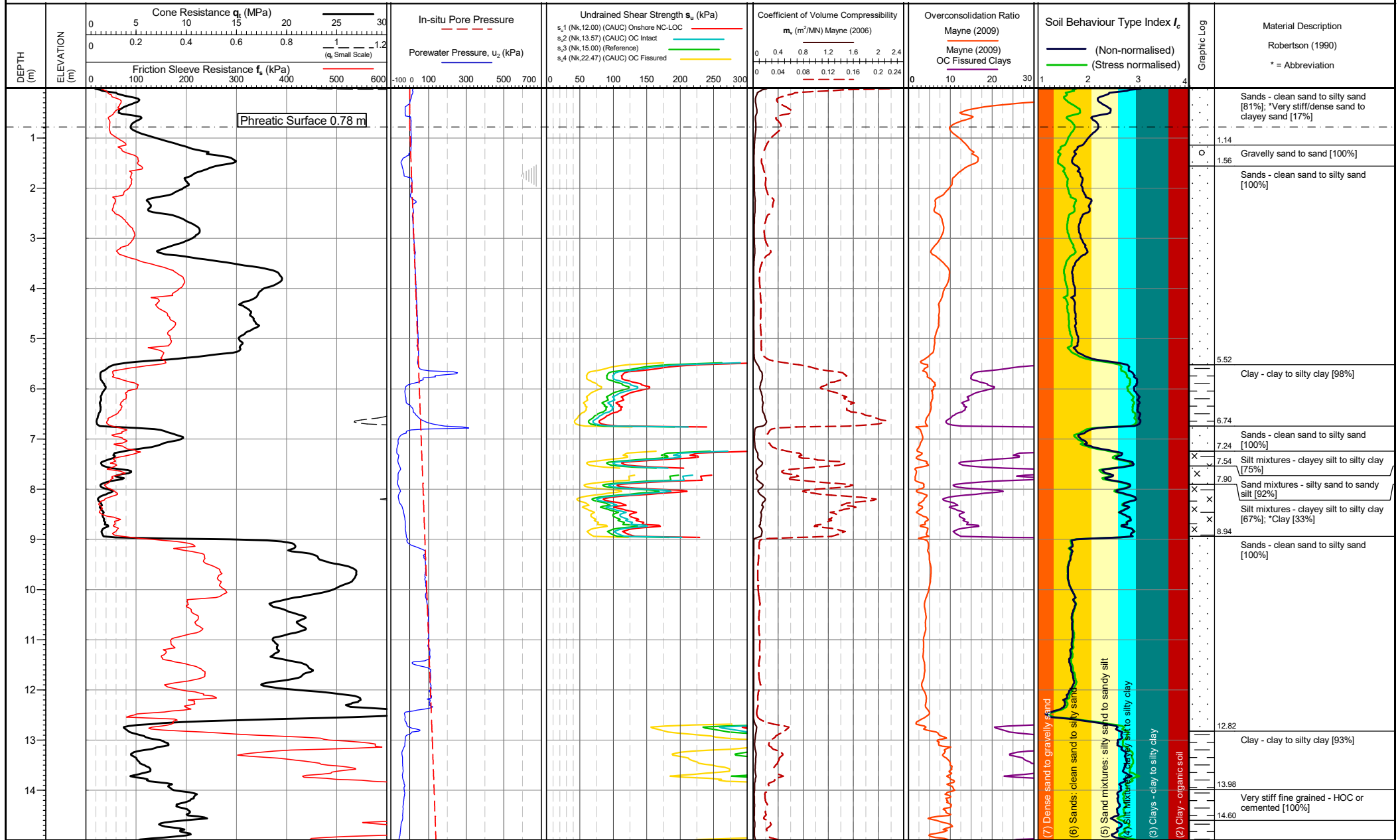
Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS





Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
ConeID: S15-CFIPTT.2141
Operator: Rob Bennett
Rig Used: UK22
Date of test: 03/07/2023 12:39:33

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s)

Termination Remark:
Target depth

Internal
QA Diss.
Dissipation
Test
Penetration
Pause (<1cm/s)

Both drained and undrained parameters are calculated for mixed SBTs = I_c 2.40-2.70. See report text for methods and discussion of parameter evaluation.

Date of plot:
10-07-23

Checked by:
Chris Player

Lankelma Project Ref:
P-108354-1

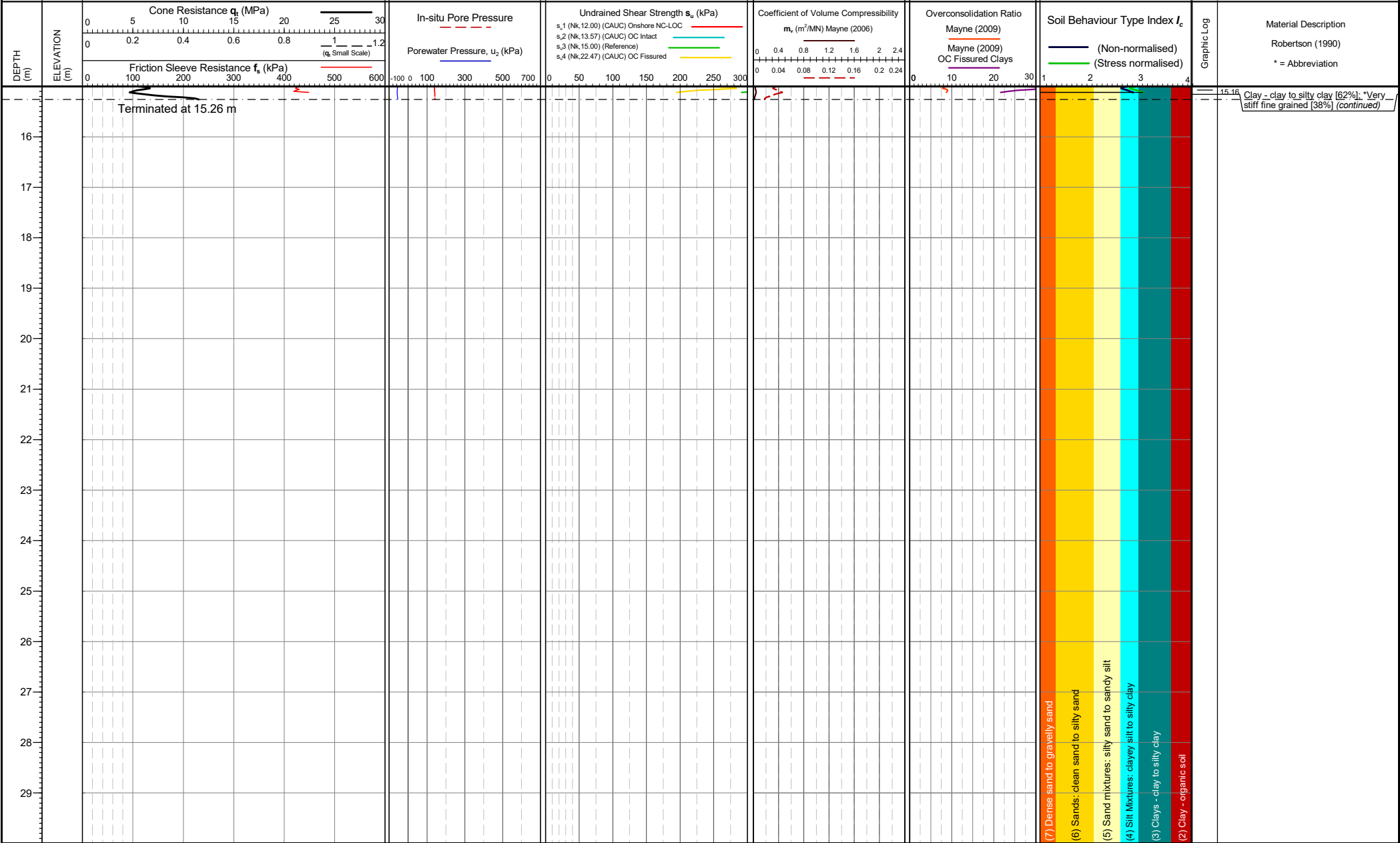
TEST ID: CPT05

Page 1 of 2



Project: BRRINGHAM ROAD, SCUNTHORPE

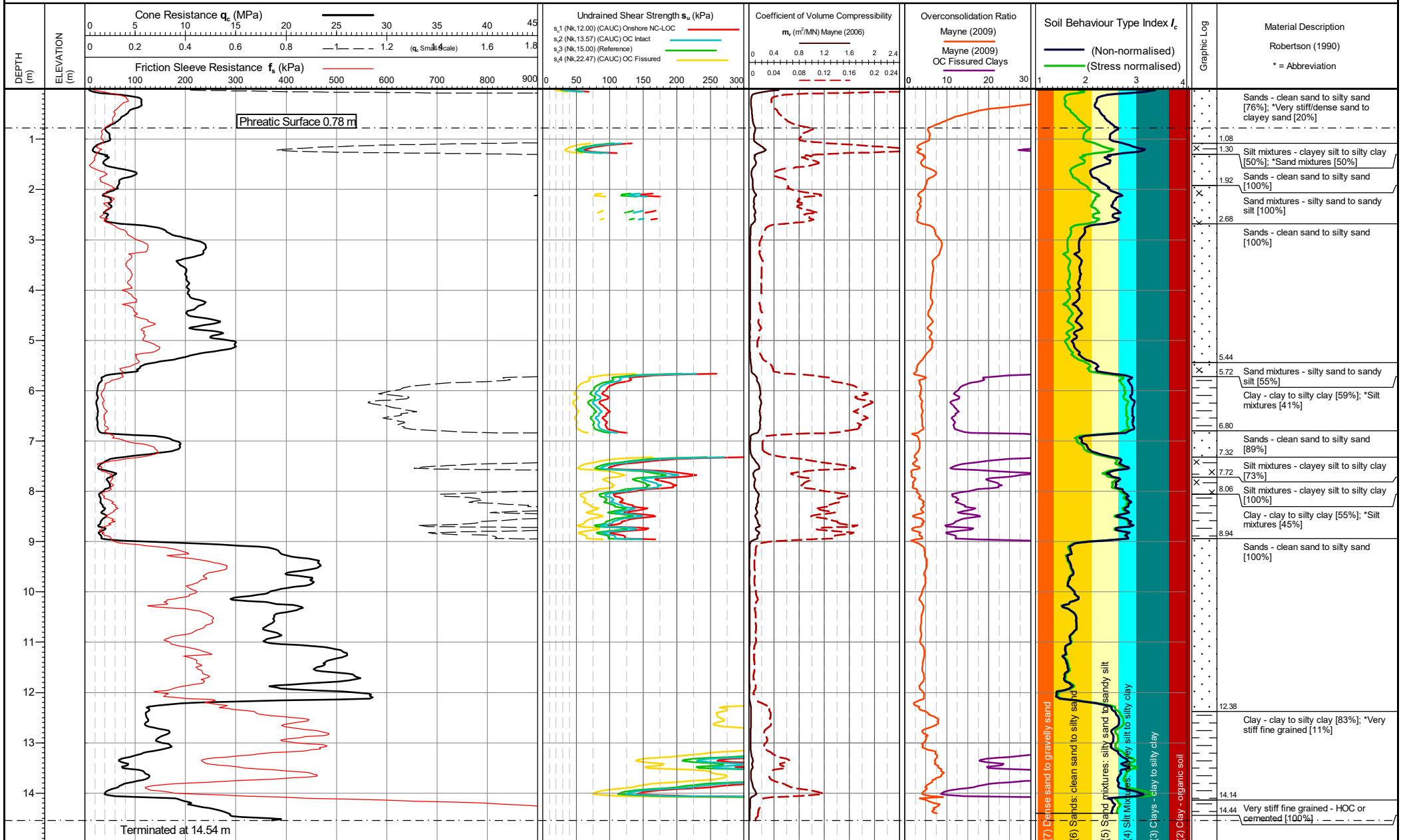
Client: ALAN WOOD & PARTNERS





Project: BURRENTHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
ConeID: S15-CFIPTT.2141
Operator: Rob Bennett
Rig Used: UK22
Date of test: 03/07/2023 11:56:57

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks: *Phreatic surface origin:
Average measured piezometric depth
from other location(s)
Termination Remark:
Sleeve load

Both drained and undrained parameters are calculated for
mixed SBTs = I_c 2.40-2.70. See report text for methods and
discussion of parameter evaluation.

Date of plot: 10-07-23
Lankelma Project Ref: P-108354-1

Checked by:
Chris Player

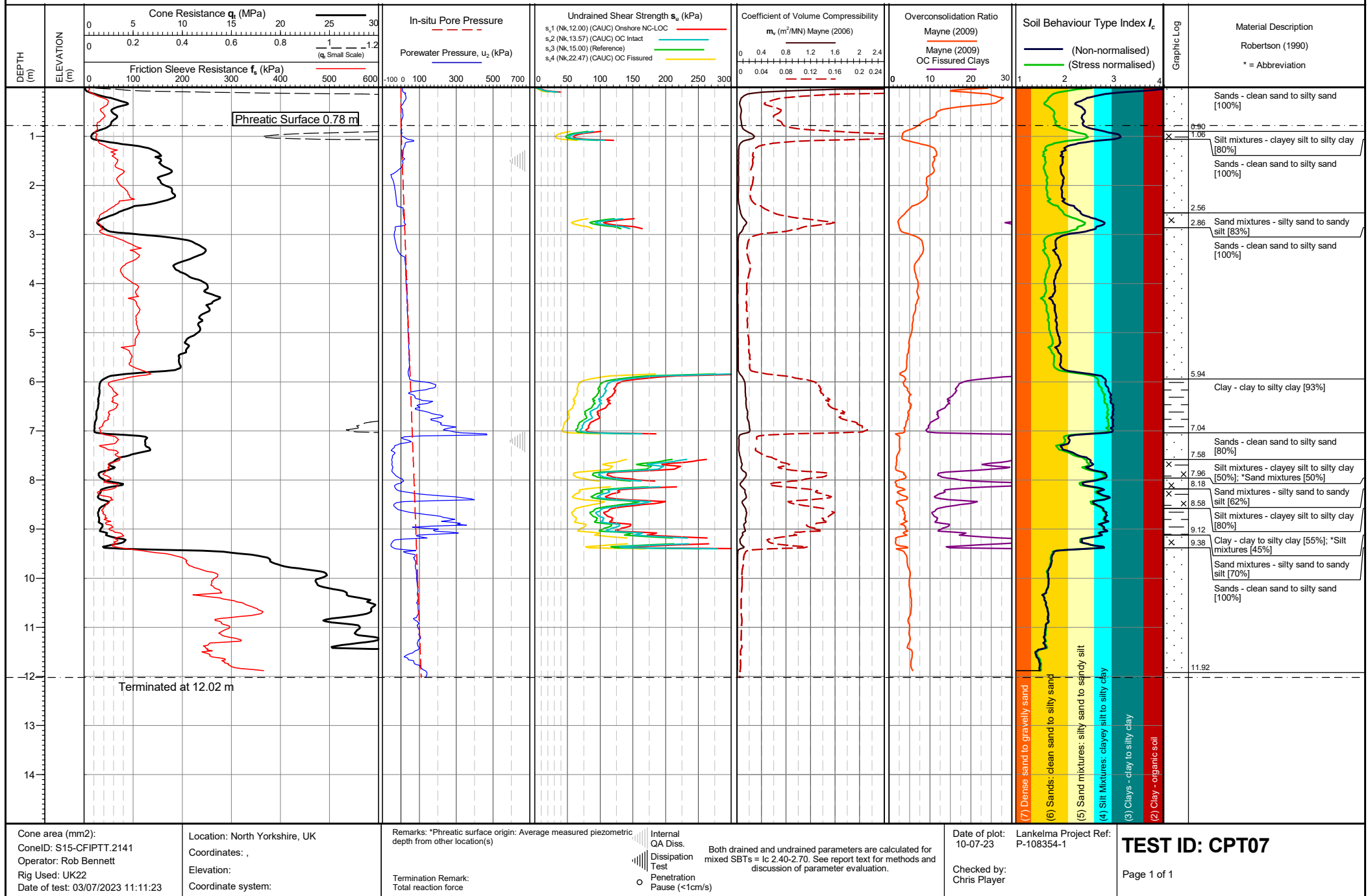
TEST ID: CPT06

Page 1 of 1



Project: BRRINGHAM ROAD, SCUNTHORPE

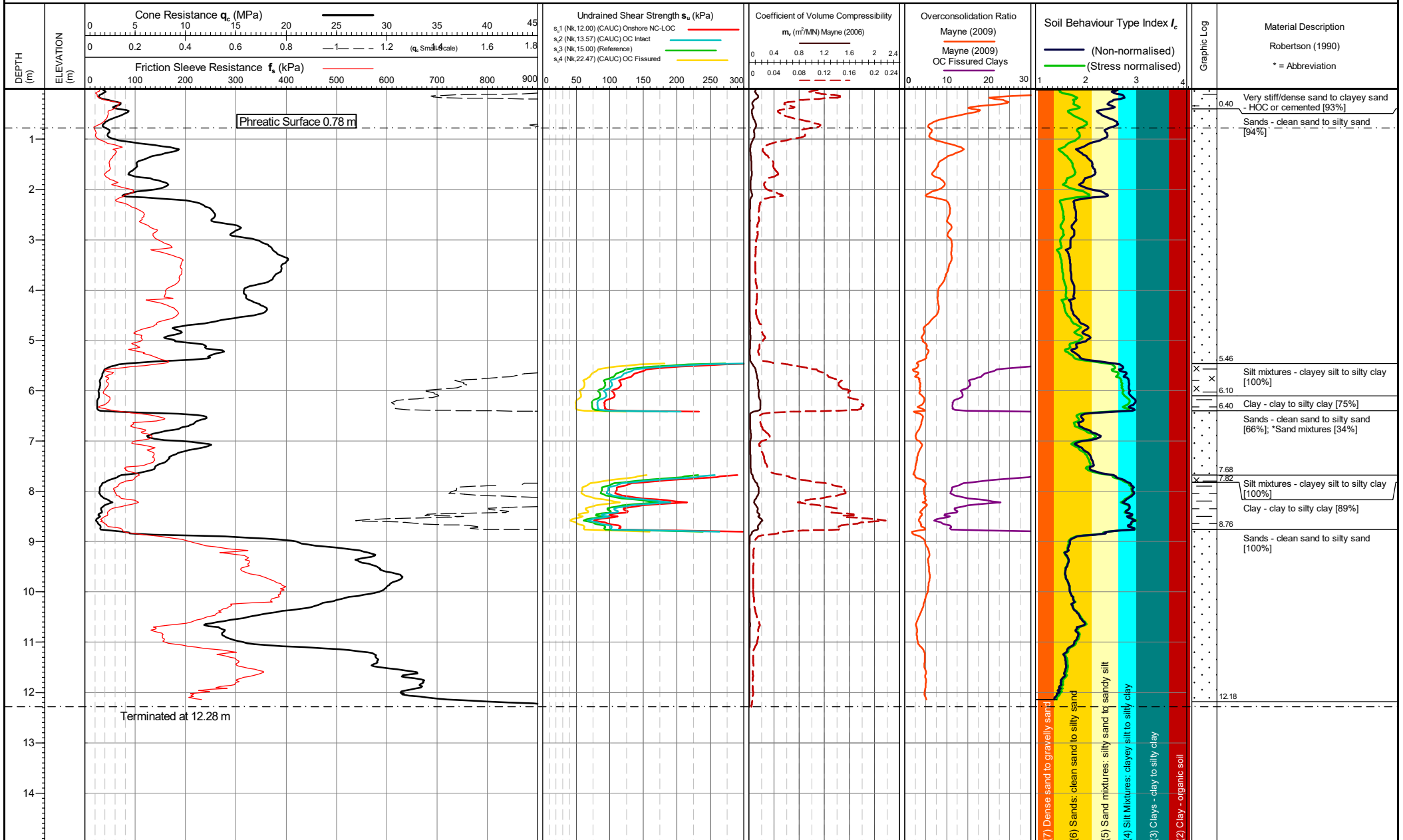
Client: ALAN WOOD & PARTNERS





Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
ConeID: S15-CFIPTT.2141
Operator: Rob Bennett
Rig Used: UK22
Date of test: 03/07/2023 09:41:17

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks: *Phreatic surface origin:
Average measured piezometric depth
from other location(s)
Termination Remark:
Total reaction force

Both drained and undrained parameters are calculated for
mixed SBTs = I_c 2.40-2.70. See report text for methods and
discussion of parameter evaluation.

Date of plot: 10-07-23
Lankelma Project Ref: P-108354-1
Checked by:
Chris Player

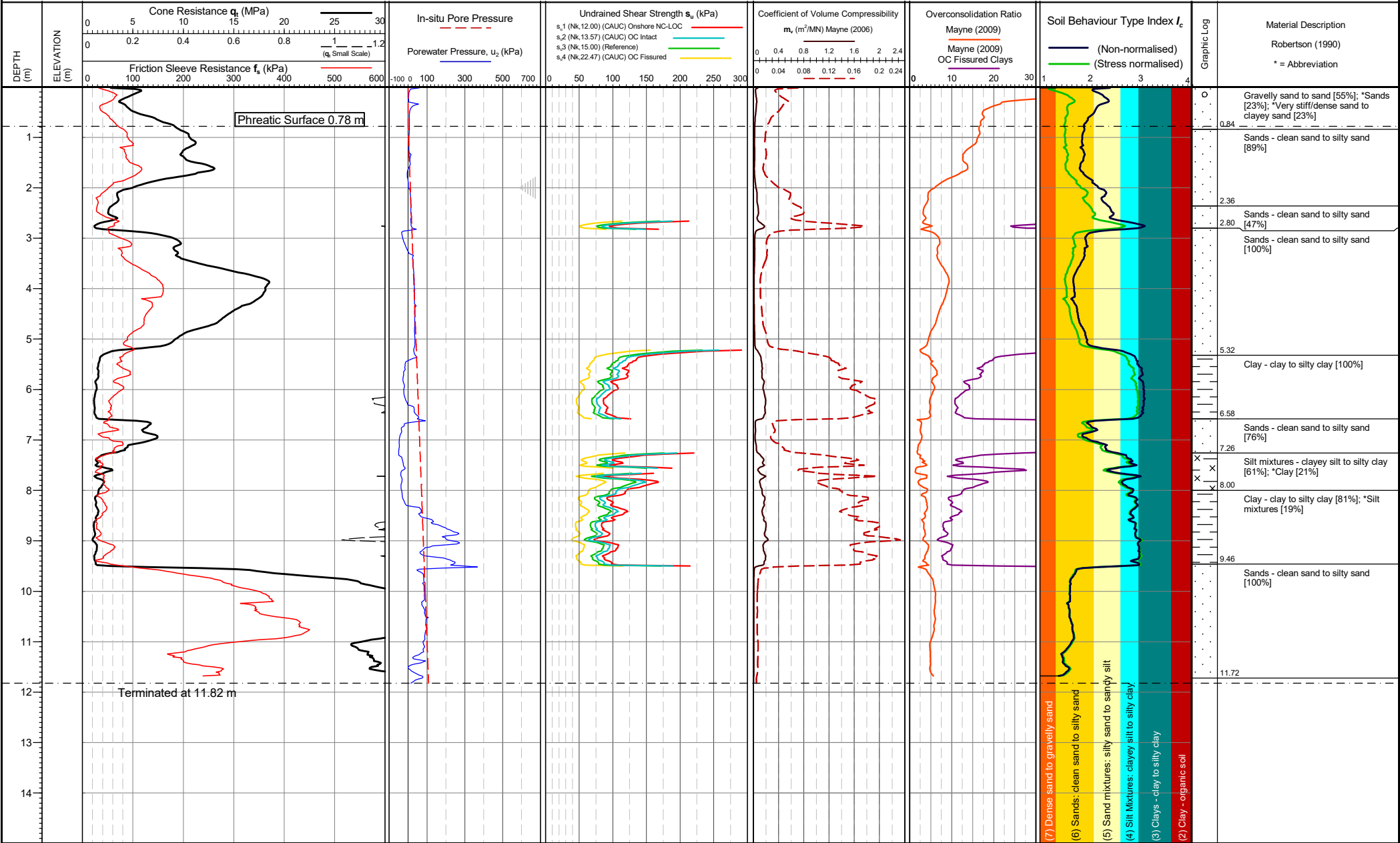
TEST ID: CPT08

Page 1 of 1



Project: BURRENTHAM ROAD, SCUNTHORPE

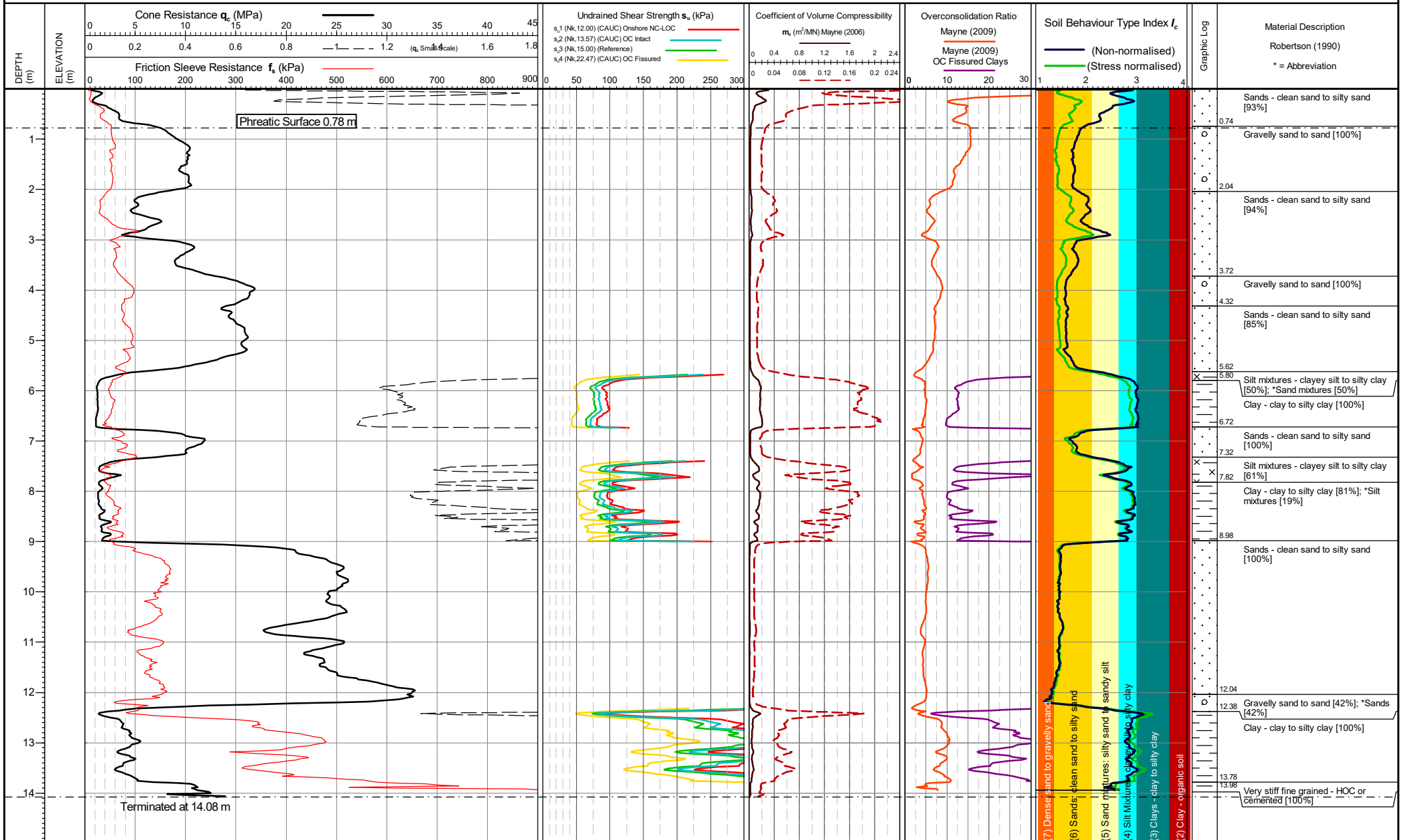
Client: ALAN WOOD & PARTNERS





Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
ConeID: S15-CFIPIT.2213
Operator: Rob Bennett
Rig Used: UK22
Date of test: 03/07/2023 08:52:36

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks: *Phreatic surface origin:
Average measured piezometric depth
from other location(s)

Termination Remark:
Total reaction force

Both drained and undrained parameters are calculated for
mixed SBTs = Ic 2.40-2.70. See report text for methods and
discussion of parameter evaluation.

Date of plot: 10-07-23
Lankelma Project Ref: P-108354-1

Checked by:
Chris Player

TEST ID: CPT10

Page 1 of 1

APPENDIX F PARAMETER RESULTS 2 - SPT N60, ϕ , D_R , E , I_c

Equivalent SPT N60

Peak friction angle

Relative density

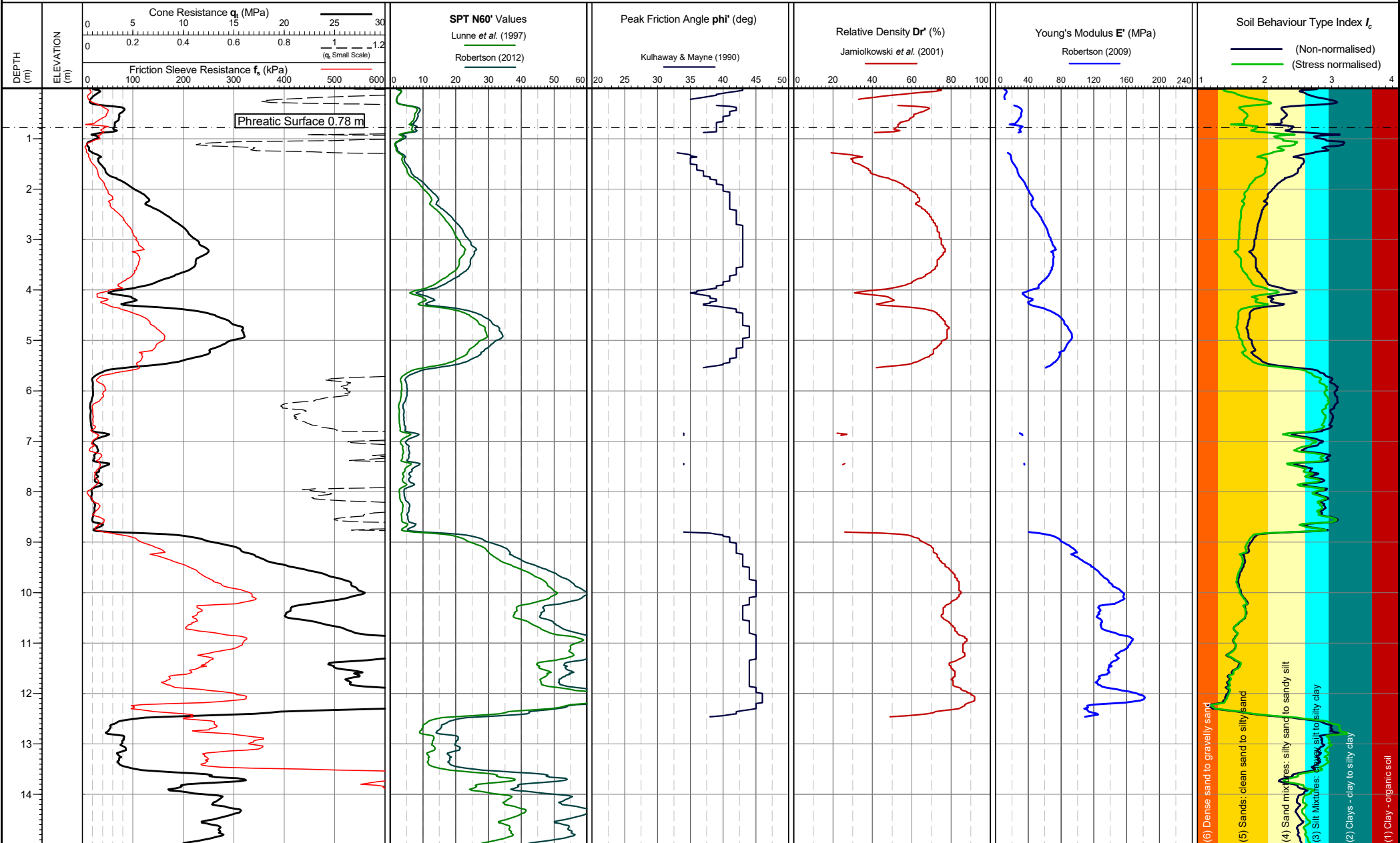
Young's modulus

SBT index I_c



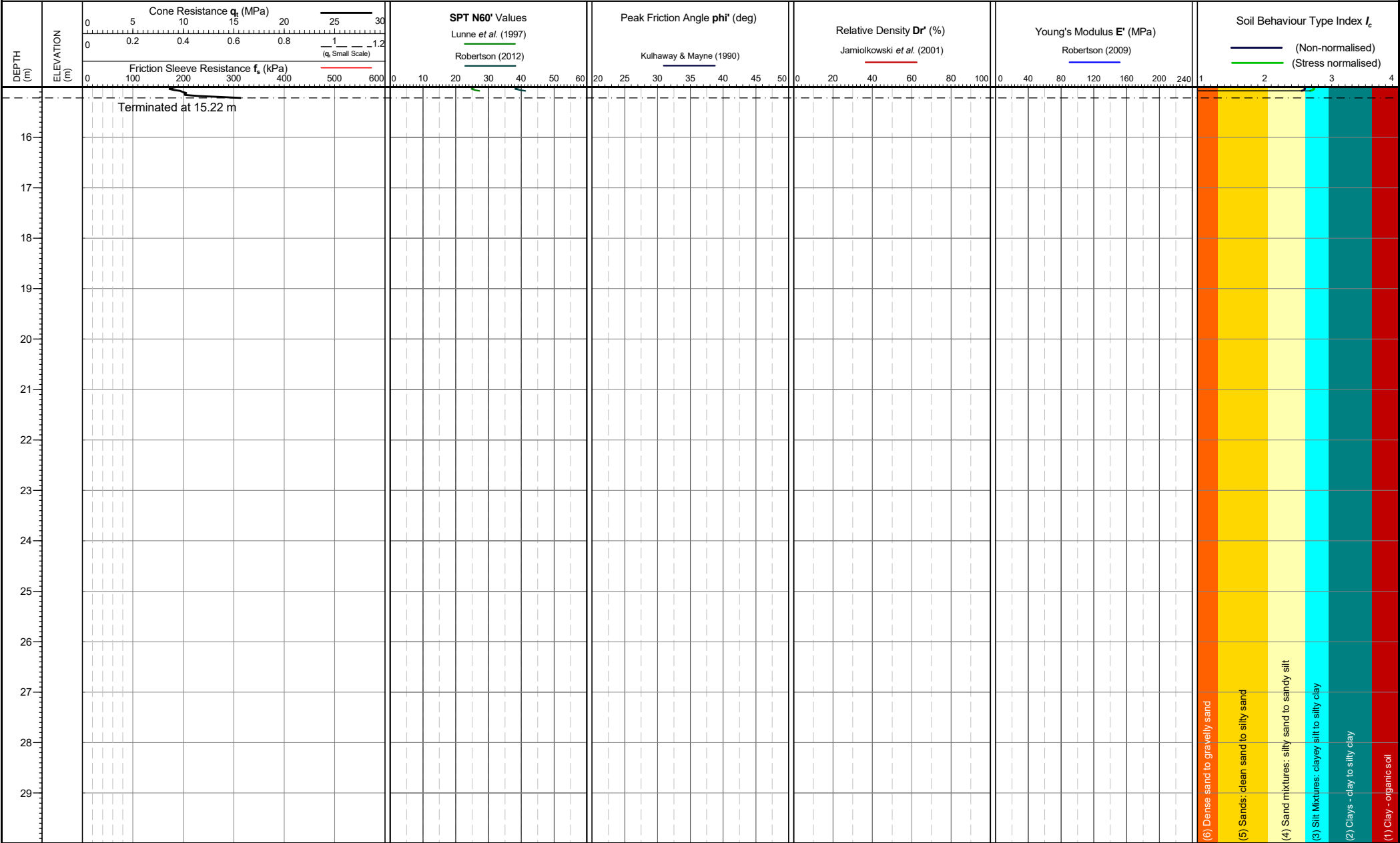
Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



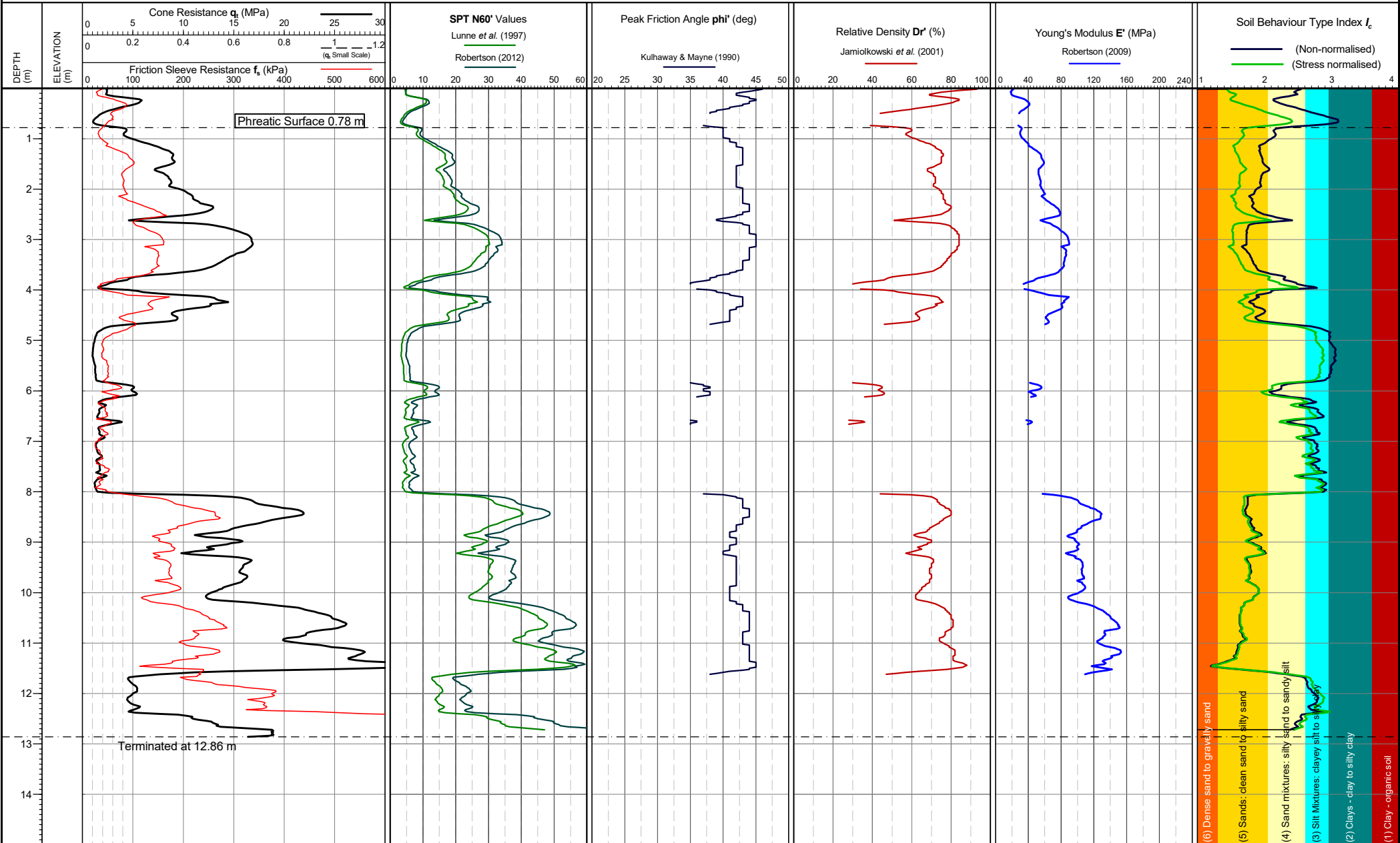


Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS



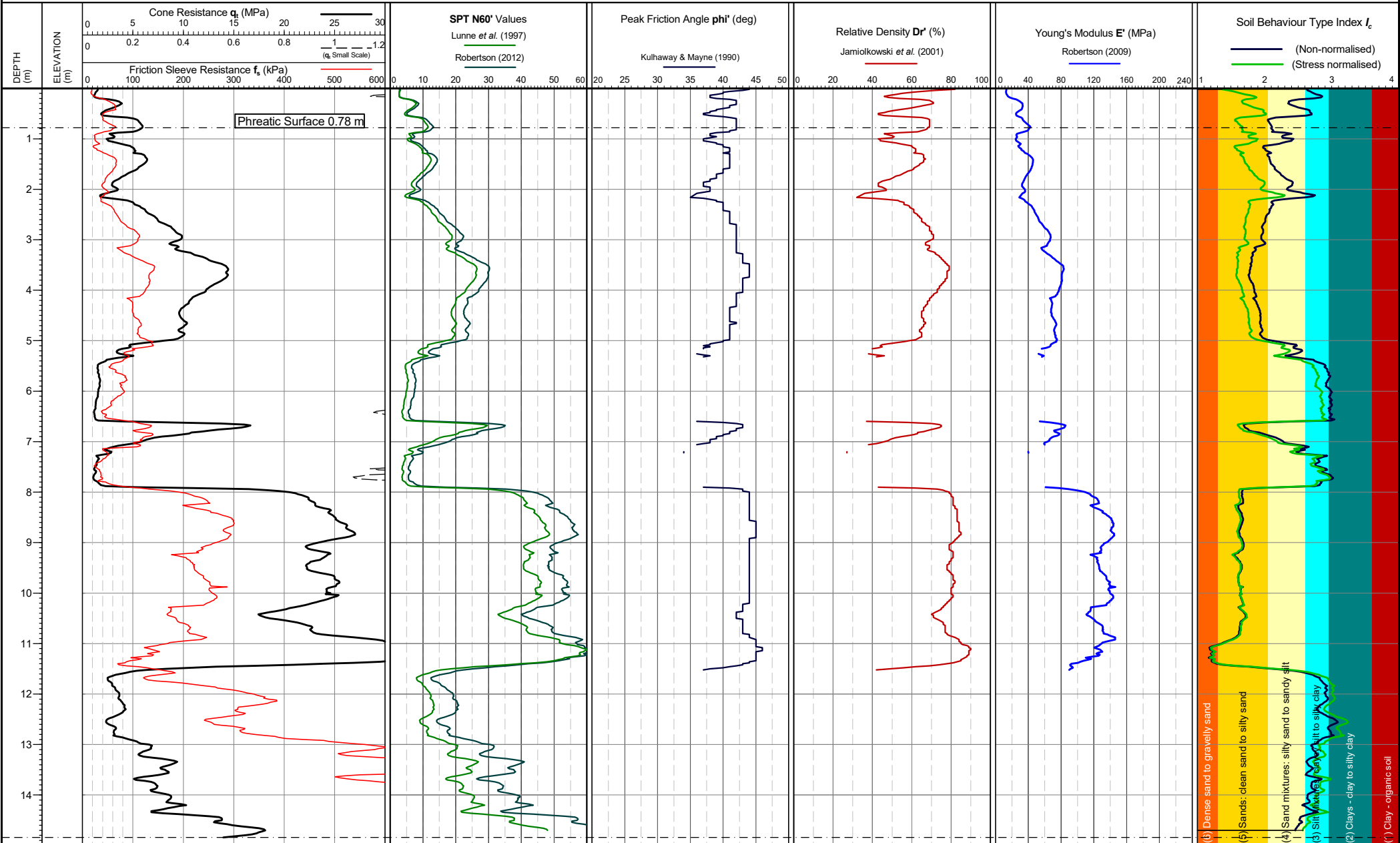


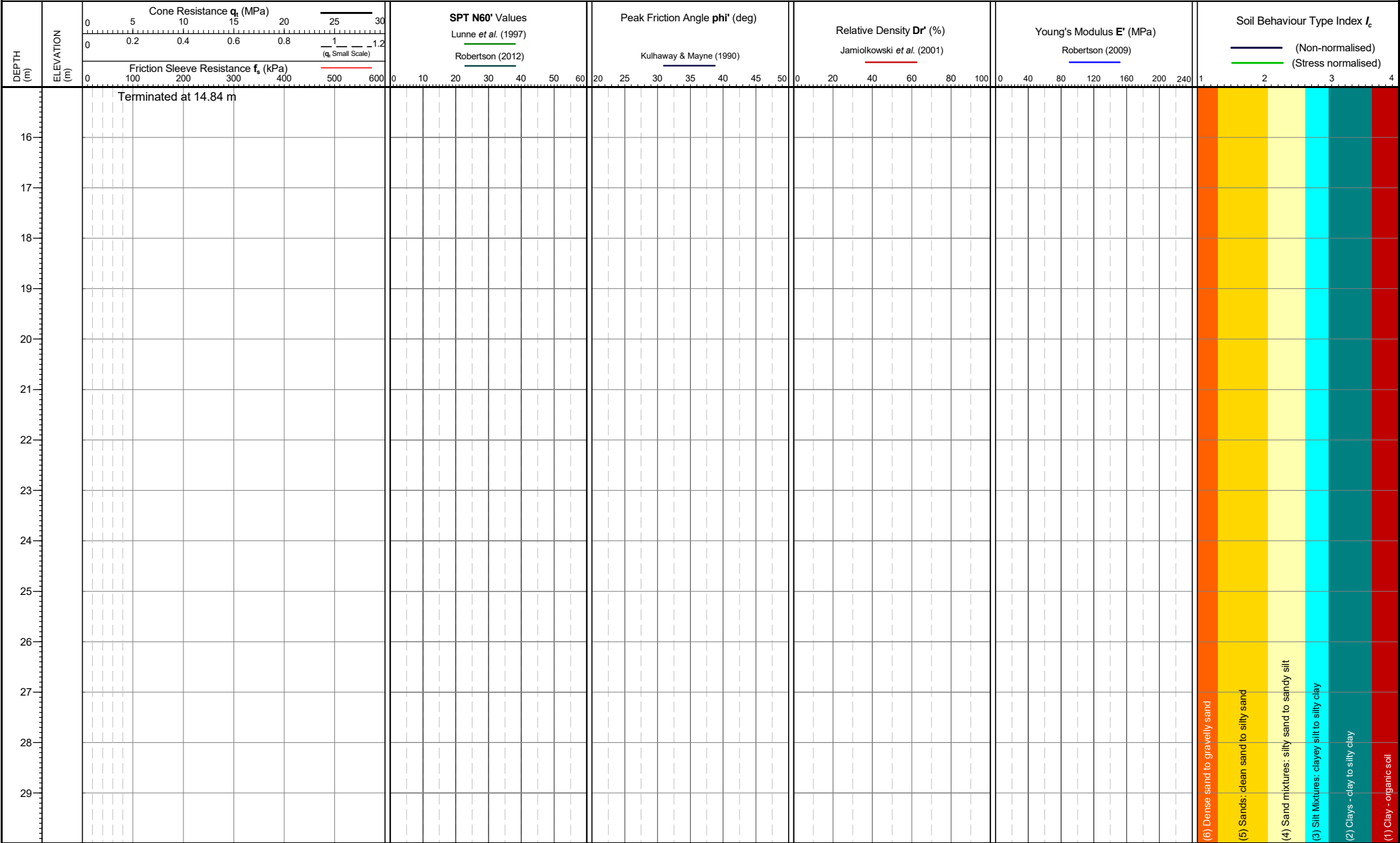
Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS





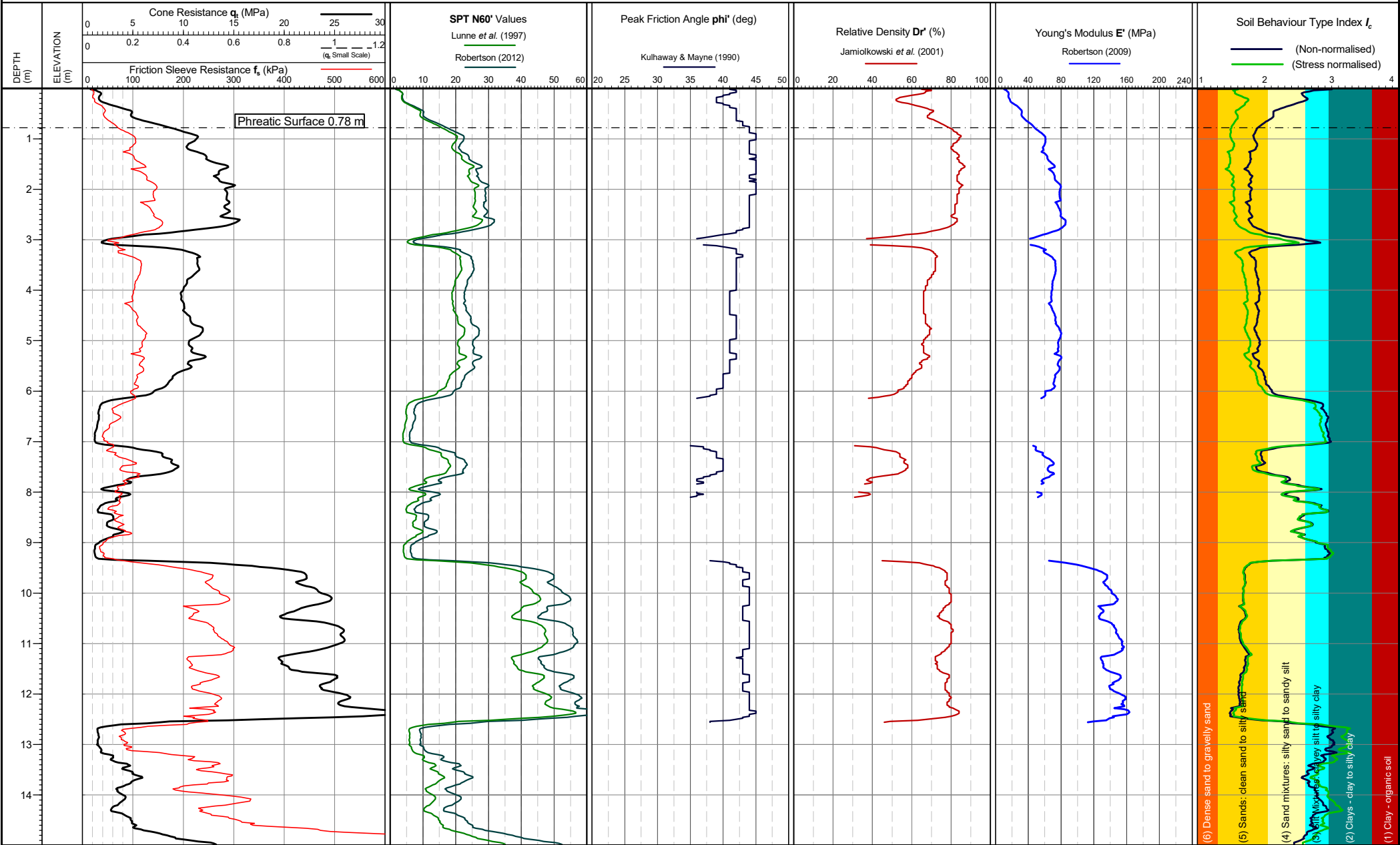
Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS

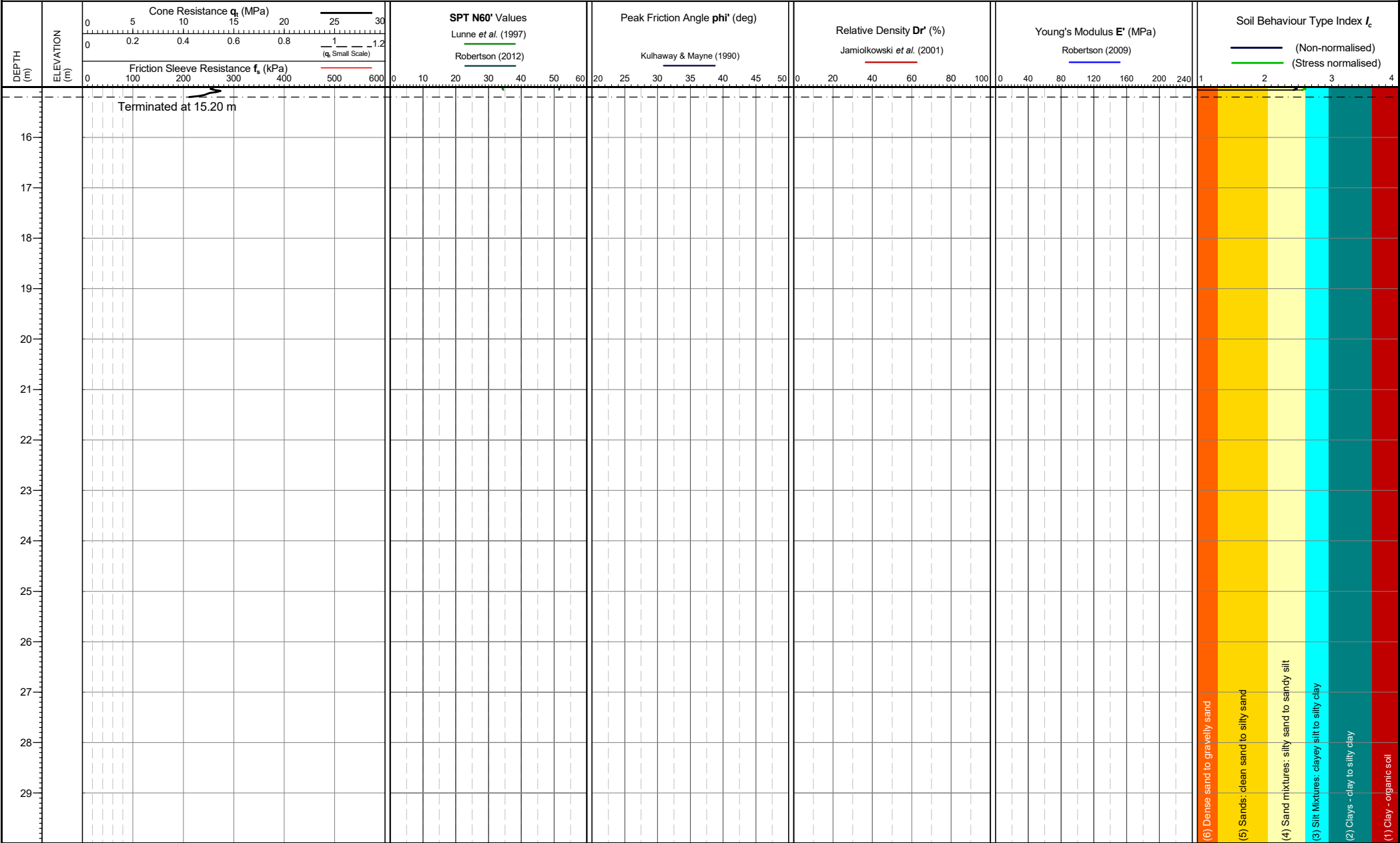






Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS

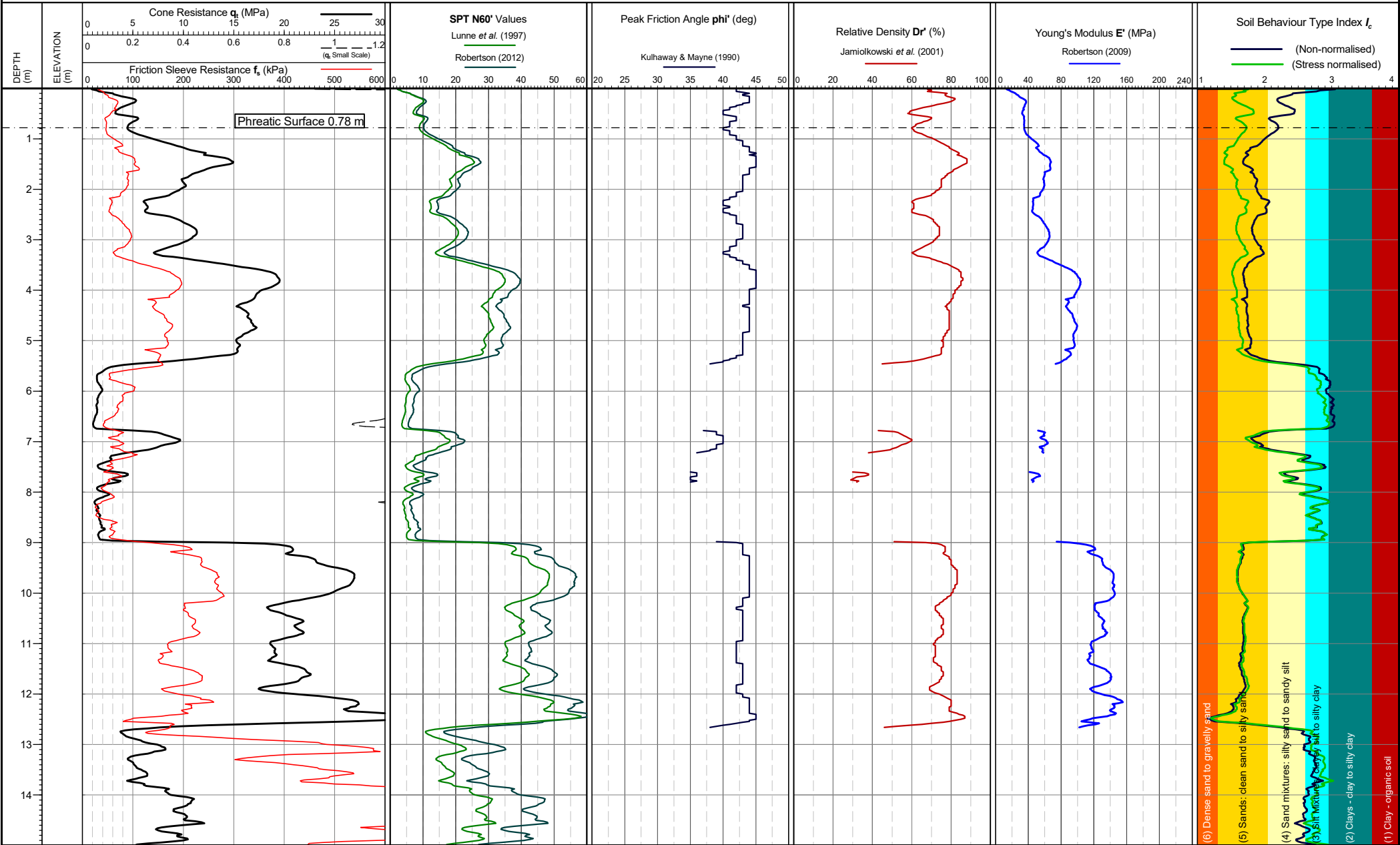




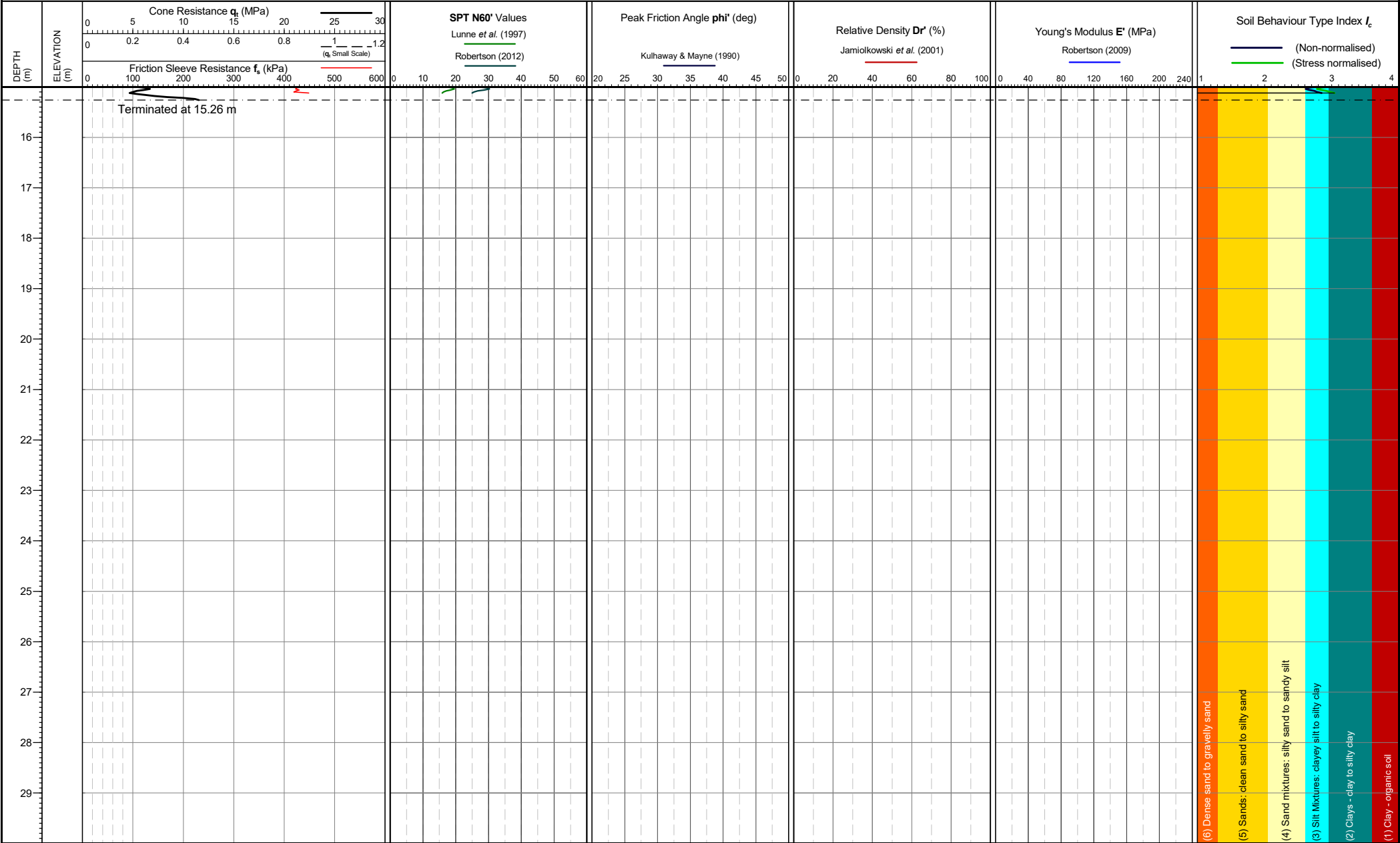


Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



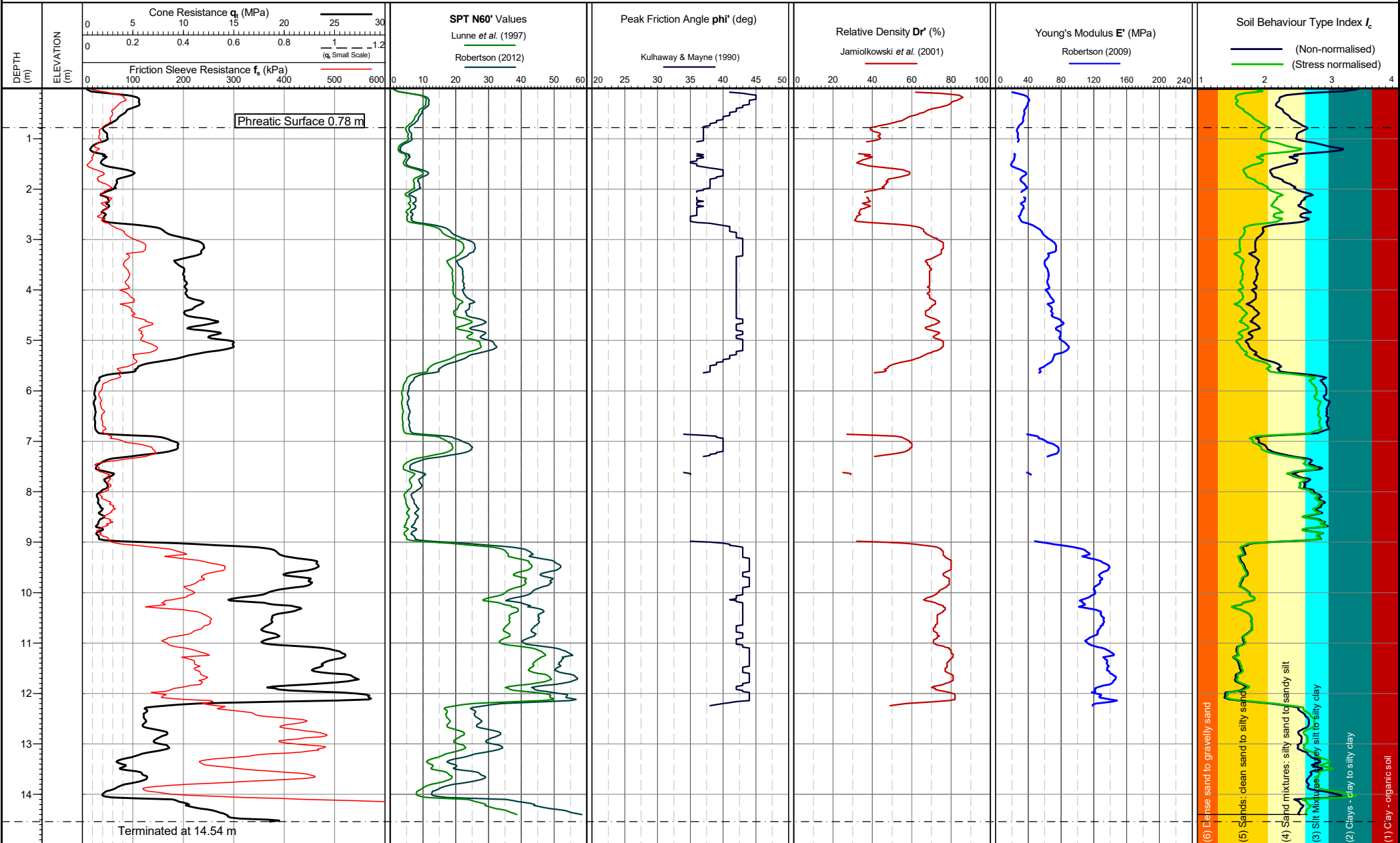
Cone area (mm ²): Cone ID: S15-CFIPTT.2141 Operator: Rob Bennett Date of test: 03/07/2023 12:39:33	Location: North Yorkshire, UK Coordinates: , Elevation: Coordinate system:	Both drained and undrained parameters are calculated for mixed SBTs = I_c 2.40-2.70. See report text for methods and discussion of parameter evaluation.	Date of plot: 10-07-23 Checked by: Chris Player	Lankelma Project Ref: P-108354-1	TEST ID: CPT05 Page 1 of 2
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Project: BRRINGHAM ROAD, SCUNTHORPE

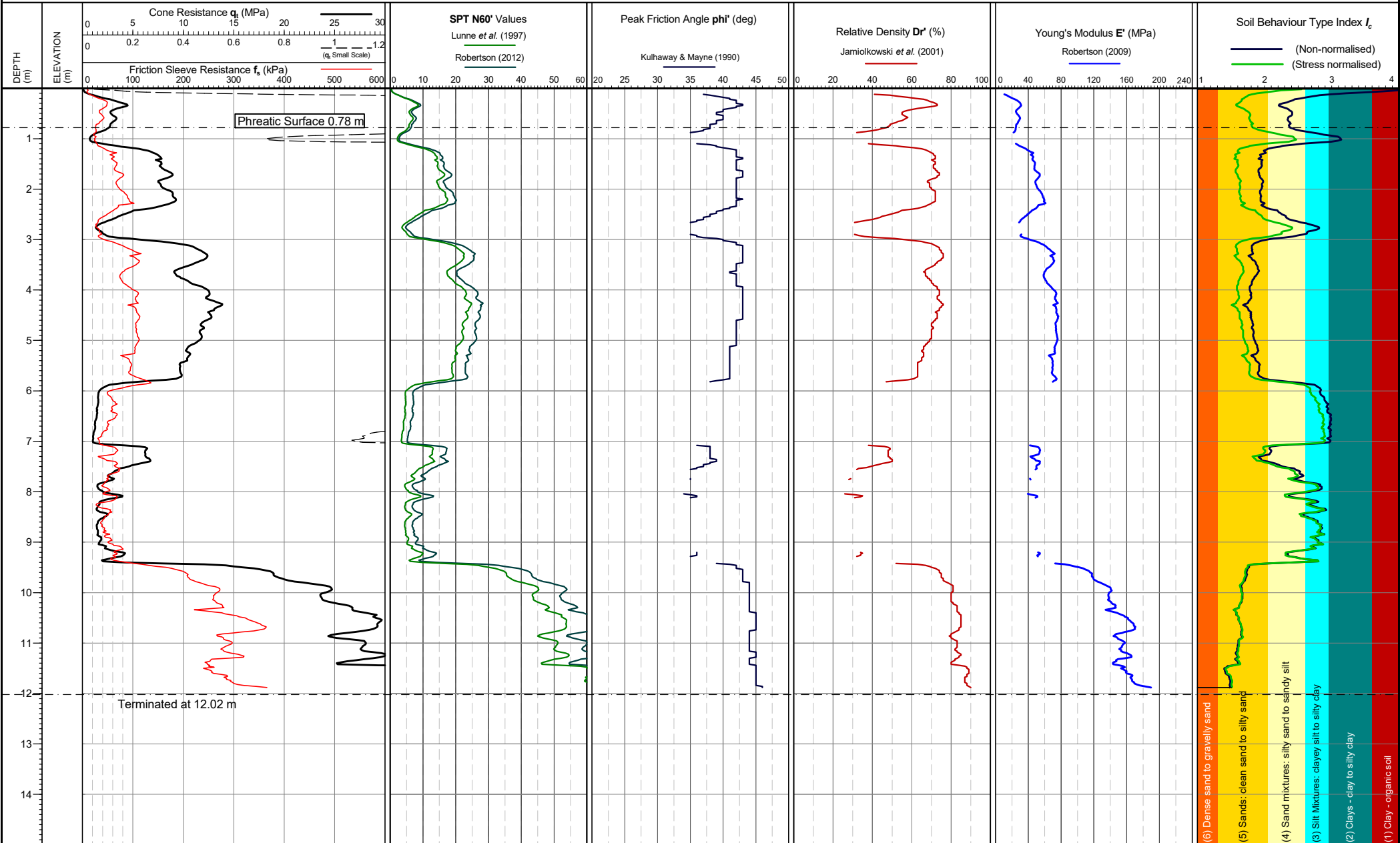
Client: ALAN WOOD & PARTNERS





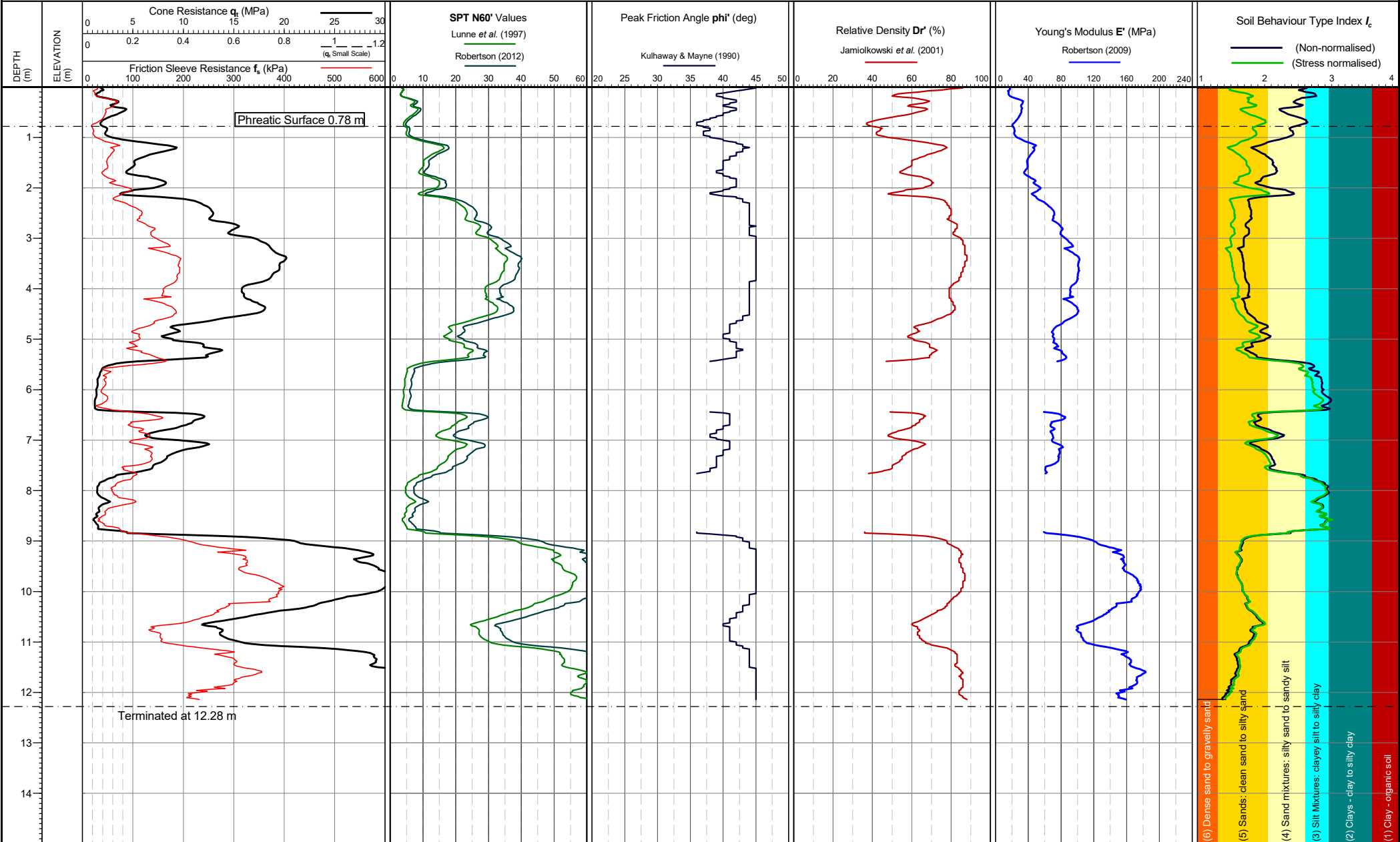
Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS





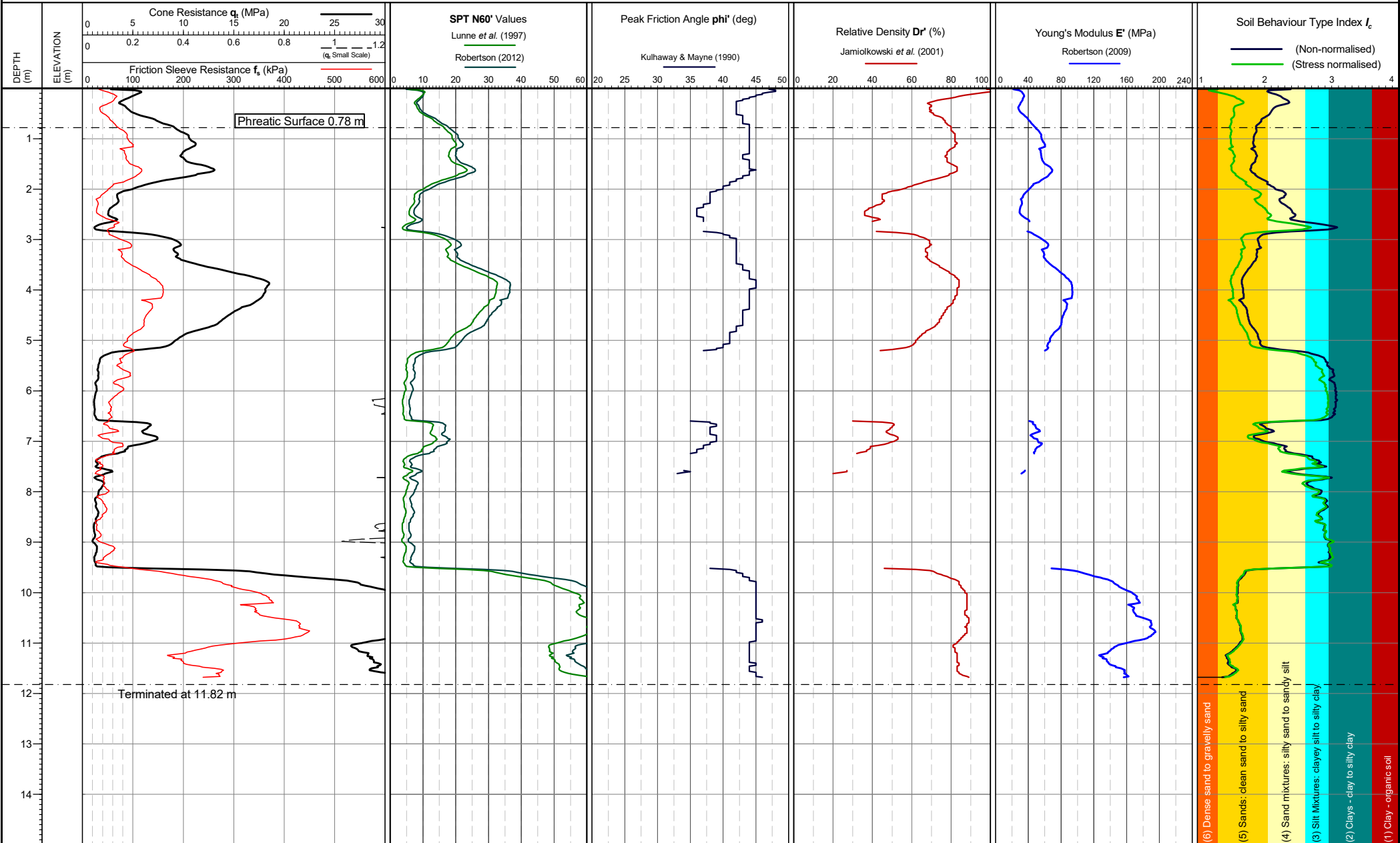
Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS





Project: BRRINGHAM ROAD, SCUNTHORPE

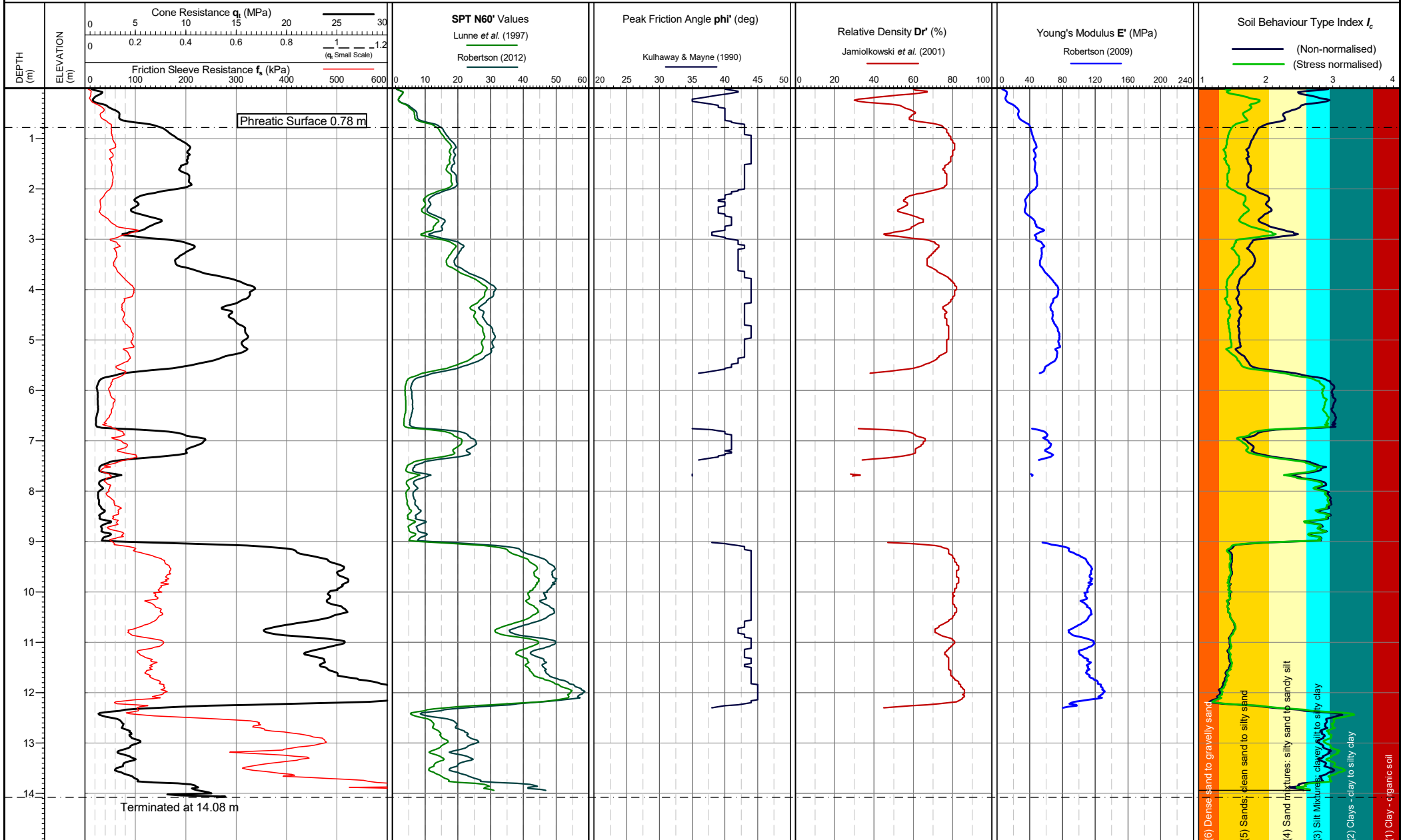
Client: ALAN WOOD & PARTNERS





Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
Cone ID: S15-CFIPTT.2213
Operator: Rob Bennett
Date of test: 03/07/2023 08:52:36

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Both drained and undrained
parameters are calculated for mixed
SBTs = I_c 2.40-2.70. See report text
for methods and discussion of
parameter evaluation.

Date of plot:
10-07-23
Checked by:
Chris Player

Lankelma Project Ref:
P-108354-1

TEST ID: CPT10

Page 1 of 1

APPENDIX G PENETROMETER TEMPERATURE RESULTS

The temperature values in these logs represent the internal load cell temperature of the penetrometer and are used for QC purposes by comparison to the measured temperature response indicated on the calibration certificate. The CPT results have been corrected for transient and static temperature effects during post processing.

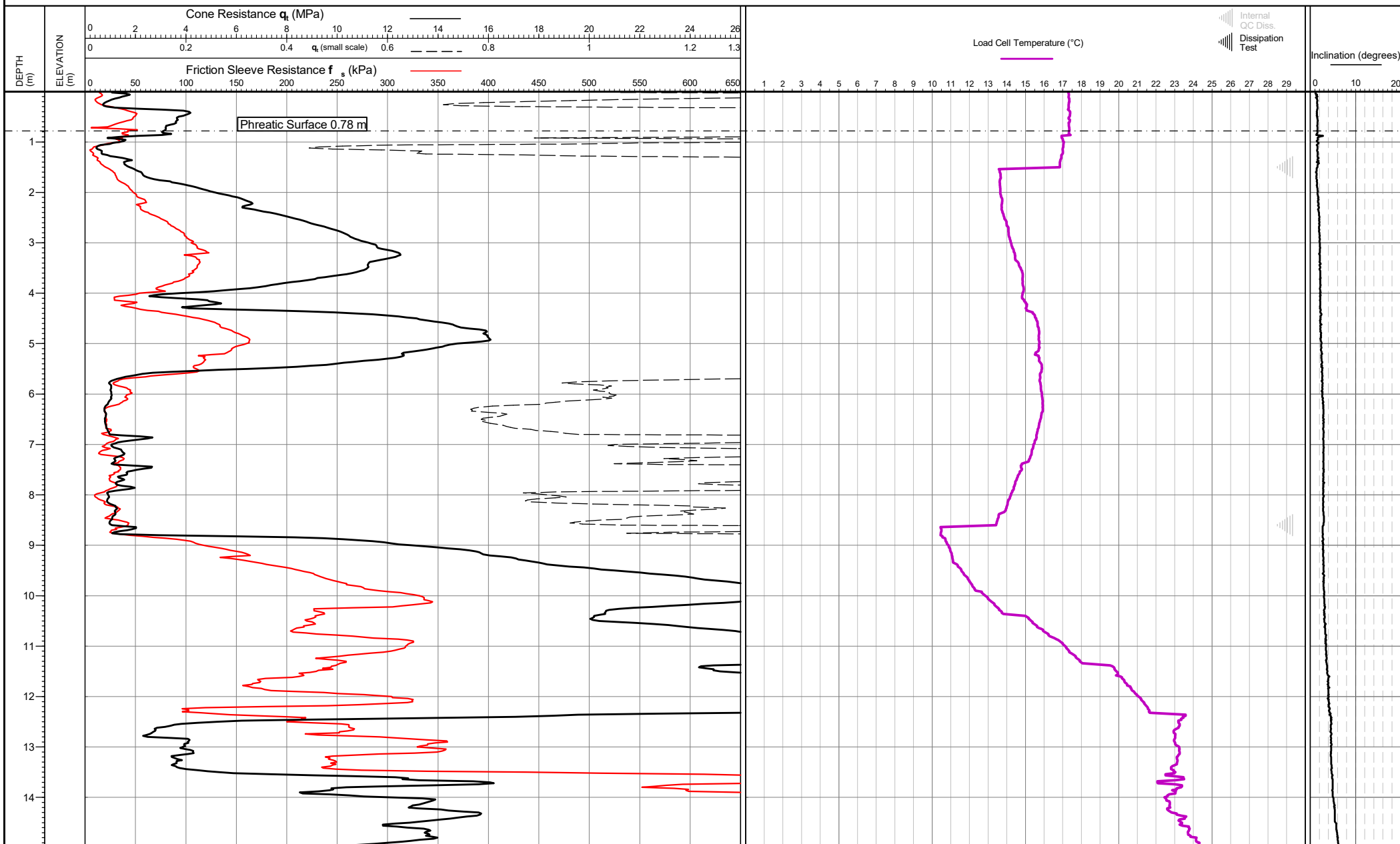
Ground temperature is only represented following a penetration pause of > 11 minutes.

Plots are provided for locations performed with a digital penetrometer measuring internal load cell temperature.



Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
Cone ID: S15-CFIPTT.2141
Operator: Rob Bennett
Rig Used: UK22
Date of test: 04/07/2023 08:52:59

Zero drift (Pre/post test)
 q_c (kPa): -10.6
 f_s (kPa): 0.0 ($f_{s, drift} - q_{c, drift}$)
 u_2 (kPa): 0.3

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks:
*Phreatic surface origin: Average measured piezometric depth at this location, approx. ± 0.5 mbgl
Termination Remark: Target depth

Date of plot: 05-07-23
Checked by: Chris Player

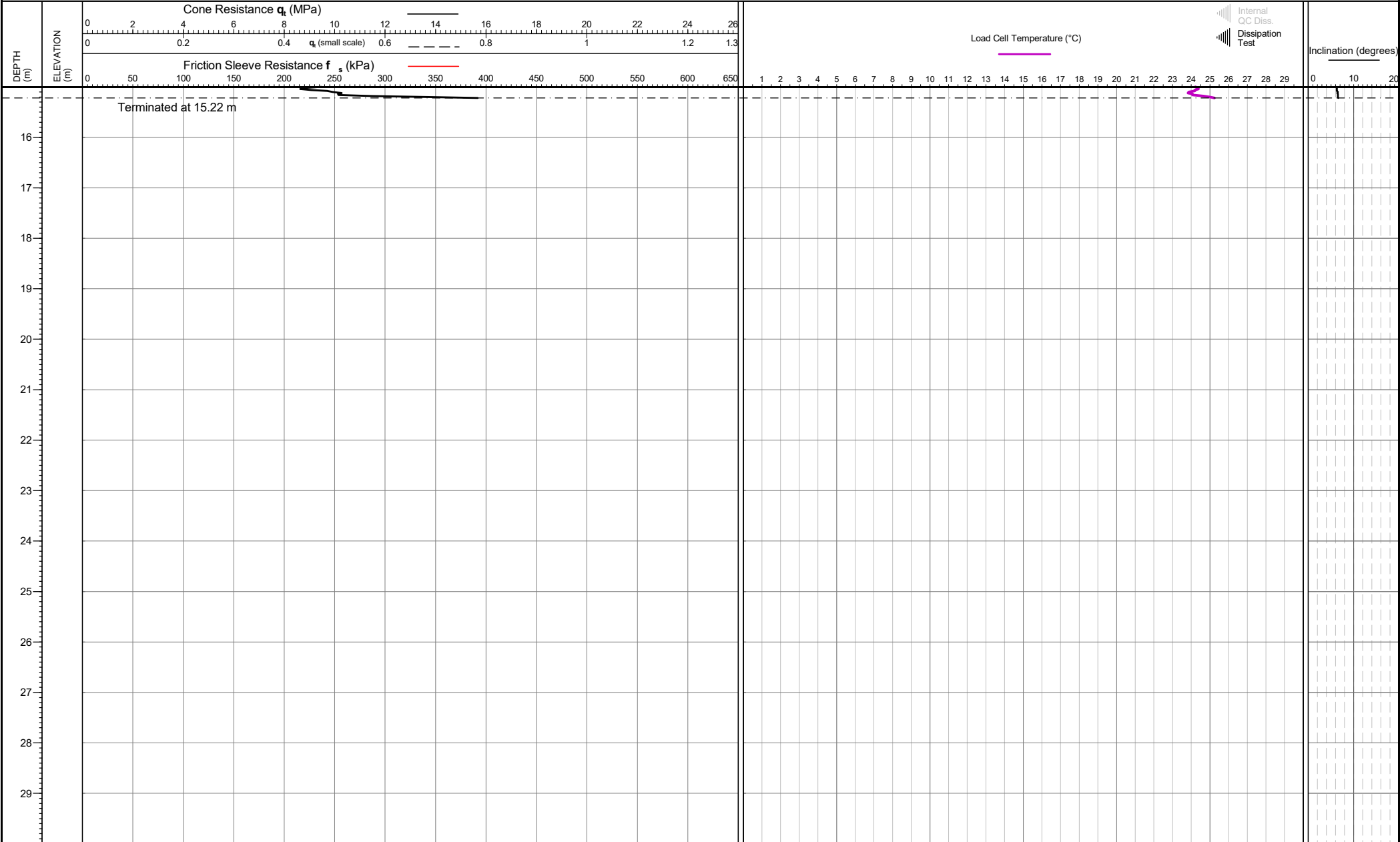
Lankelma Project Ref: P-108354-1

TEST ID: CPT01

Page 1 of 2



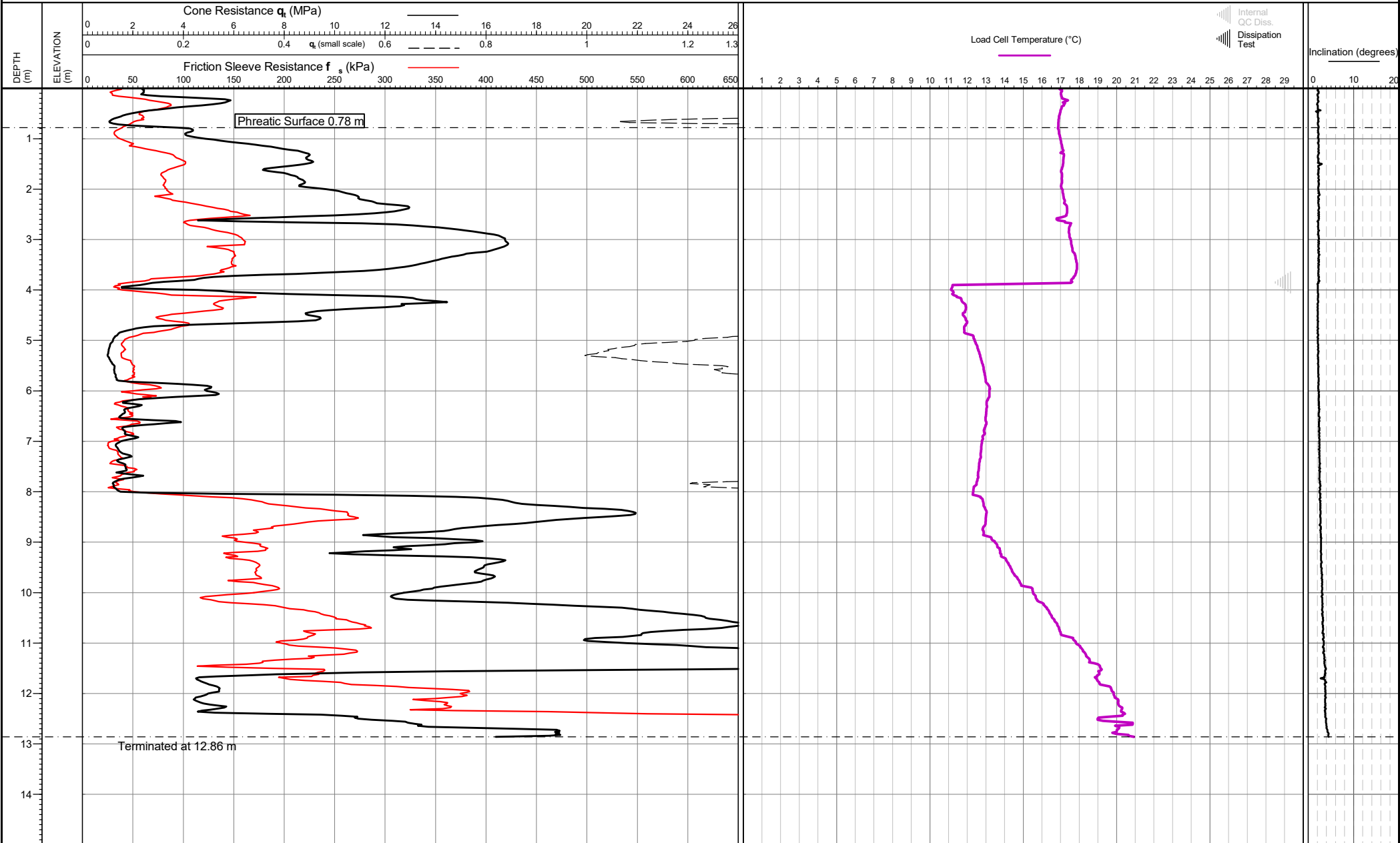
Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS



Cone area (mm ²): Cone ID: S15-CFIPTT.2141 Operator: Rob Bennett Rig Used: UK22 Date of test: 04/07/2023 08:52:59	Zero drift (Pre/post test) q_c (kPa): -10.6 f_s (kPa): 0.0 ($f_{s, drift} - q_{c, drift}$) u_2 (kPa): 0.3	Location: North Yorkshire, UK Coordinates: , Elevation: Coordinate system:	Remarks: *Phreatic surface origin: Average measured piezometric depth at this location, approx. +/- 0.5 mbgl Termination Remark: Target depth	Date of plot: 05-07-23 Lankelma Project Ref: P-108354-1 Checked by: Chris Player	TEST ID: CPT01 Page 2 of 2
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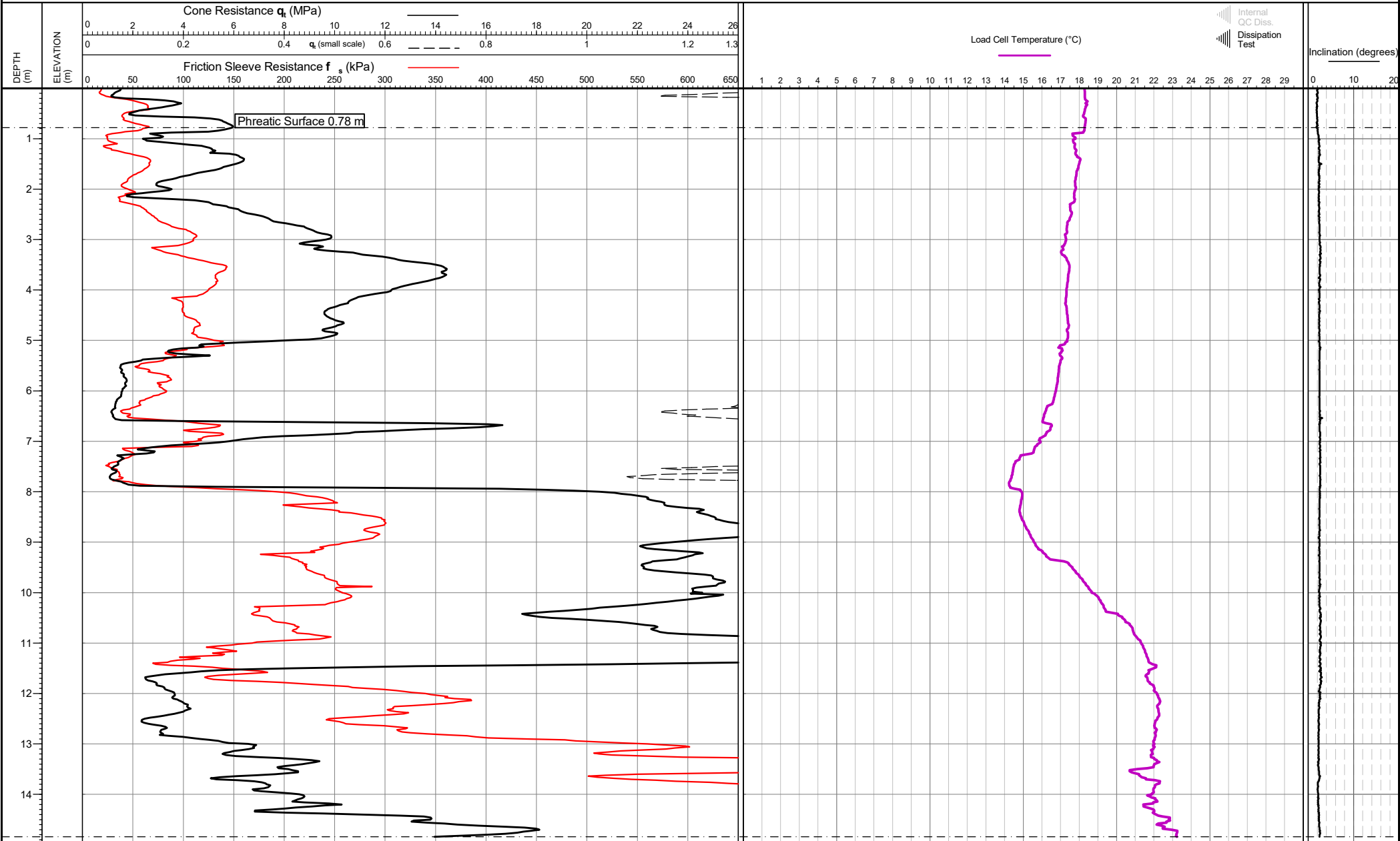
Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS



Cone area (mm ²): Cone ID: S15-CFIPTT.2141 Operator: Rob Bennett Rig Used: UK22 Date of test: 04/07/2023 10:50:50	Zero drift (Pre/post test) q_c (kPa): 13.6 f_s (kPa): 0.7 ($f_{s, drift} - q_{c, drift}$) u_2 (kPa): -5.6	Location: North Yorkshire, UK Coordinates: , Elevation: Coordinate system:	Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s) Termination Remark: Sleeve load	Date of plot: 05-07-23 Lankelma Project Ref: P-108354-1 Checked by: Chris Player	TEST ID: CPT02 Page 1 of 1
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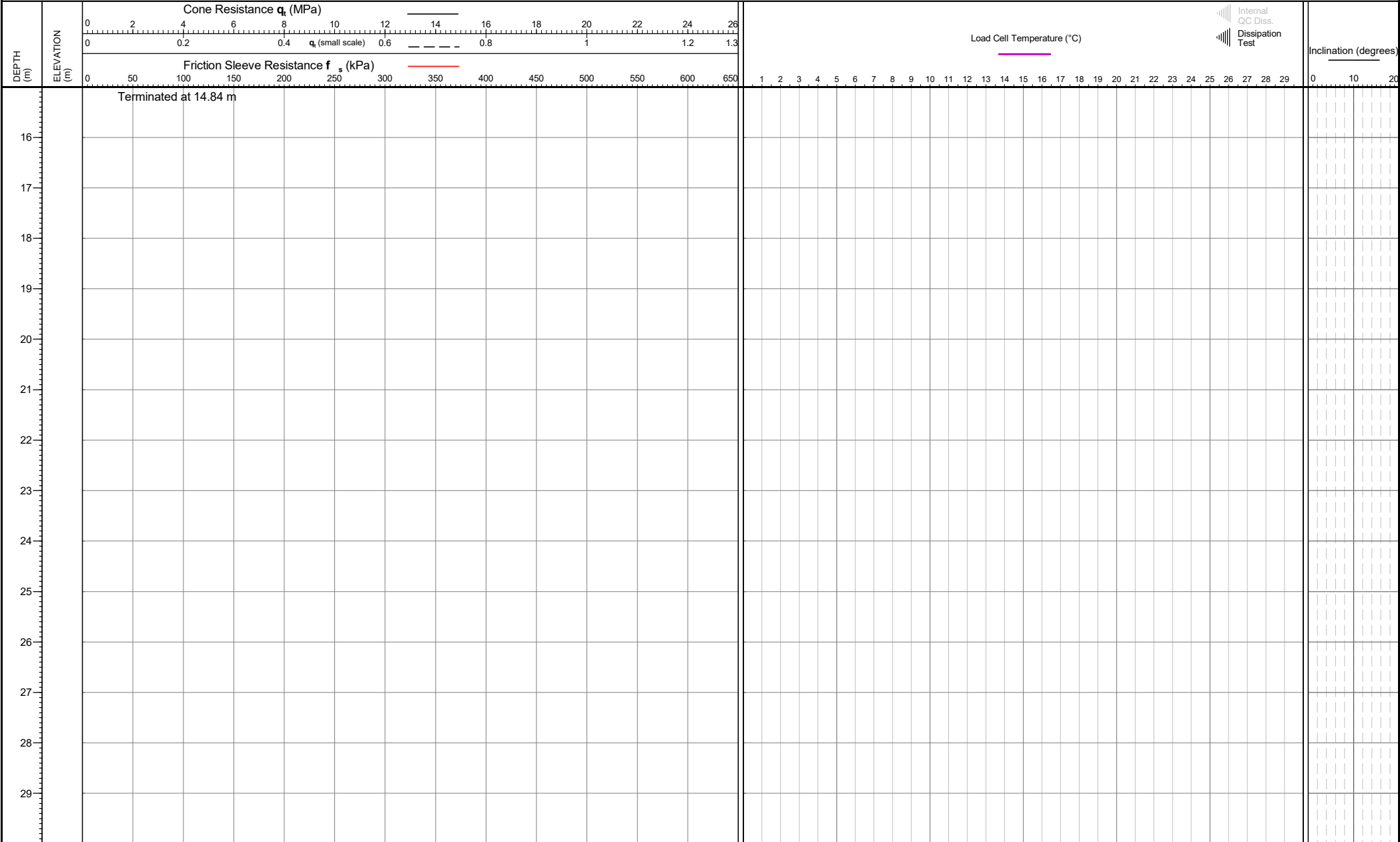
Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS



Cone area (mm ²): Cone ID: S15-CFIPTT.2141 Operator: Rob Bennett Rig Used: UK22 Date of test: 04/07/2023 09:58:58	Zero drift (Pre/post test) q_c (kPa): -24.2 f_s (kPa): -1.1 ($f_{s, drift} - q_{c, drift}$) u_2 (kPa): 6.0	Location: North Yorkshire, UK Coordinates: , Elevation: Coordinate system:	Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s) Termination Remark: Sleeve load	Date of plot: 05-07-23 Checked by: Chris Player	Lankelma Project Ref: P-108354-1	TEST ID: CPT03 Page 1 of 2
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Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS

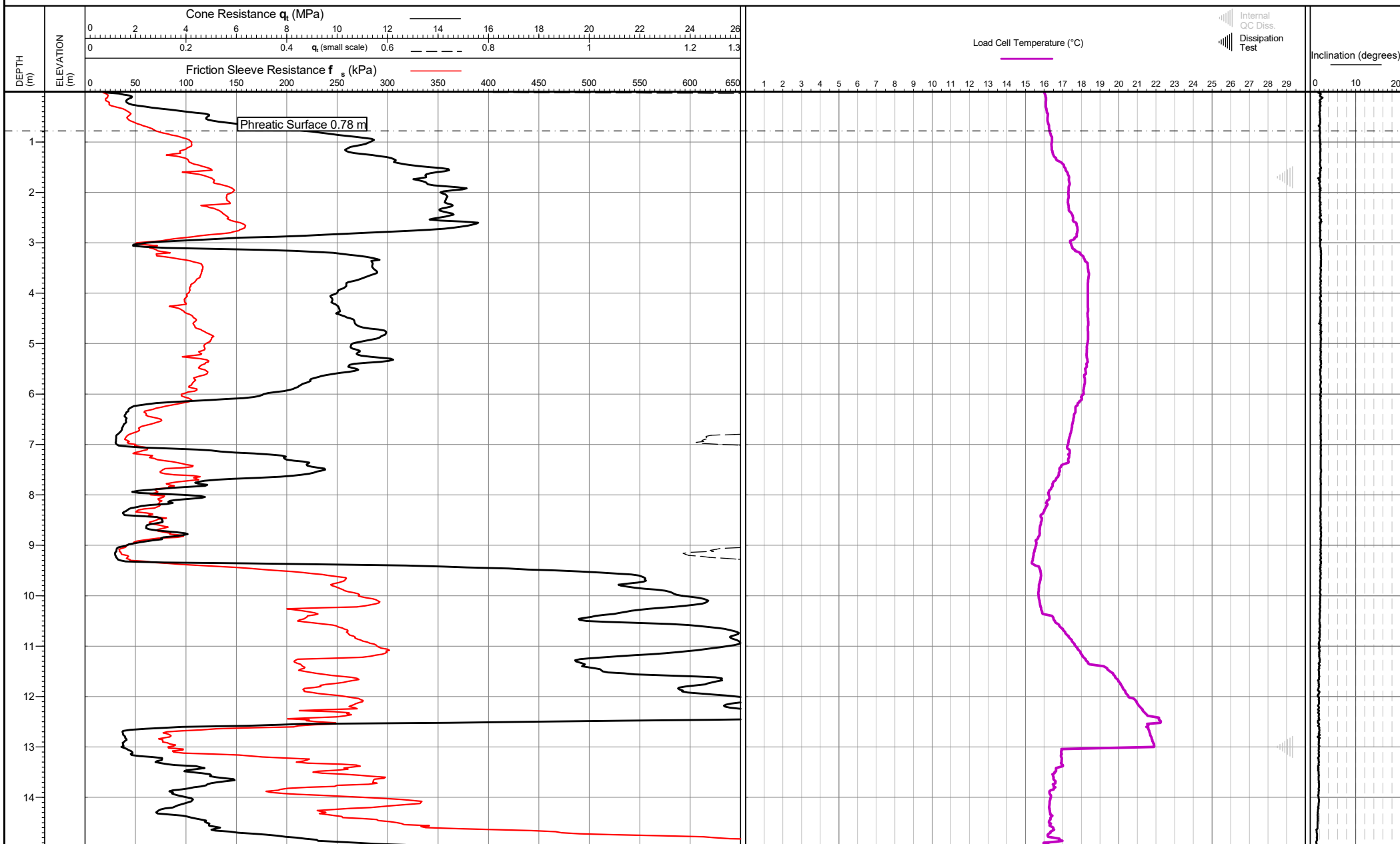


Cone area (mm2): Cone ID: S15-CFIPTT.2141 Operator: Rob Bennett Rig Used: UK22 Date of test: 04/07/2023 09:58:58	Zero drift (Pre/post test) q _e (kPa): -24.2 f _s (kPa): -1.1 (f _{s drift} - q _{e drift}) u ₂ (kPa): 6.0	Location: North Yorkshire, UK Coordinates: , Elevation: Coordinate system:	Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s) Termination Remark: Sleeve load	Date of plot: 05-07-23 Checked by: Chris Player	Lankelma Project Ref: P-108354-1	TEST ID: CPT03 Page 2 of 2
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Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
Cone ID: S15-CFIPTT.2141
Operator: Rob Bennett
Rig Used: UK22
Date of test: 04/07/2023 08:16:22

Zero drift (Pre/post test)
 q_c (kPa): -8.8
 f_s (kPa): 0.0 ($f_{s, drift} - q_{c, drift}$)
 u_2 (kPa): 0.9

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks:
*Phreatic surface origin: Average measured piezometric depth from other location(s)
Termination Remark: Target depth

Date of plot:
05-07-23

Lankelma Project Ref:
P-108354-1

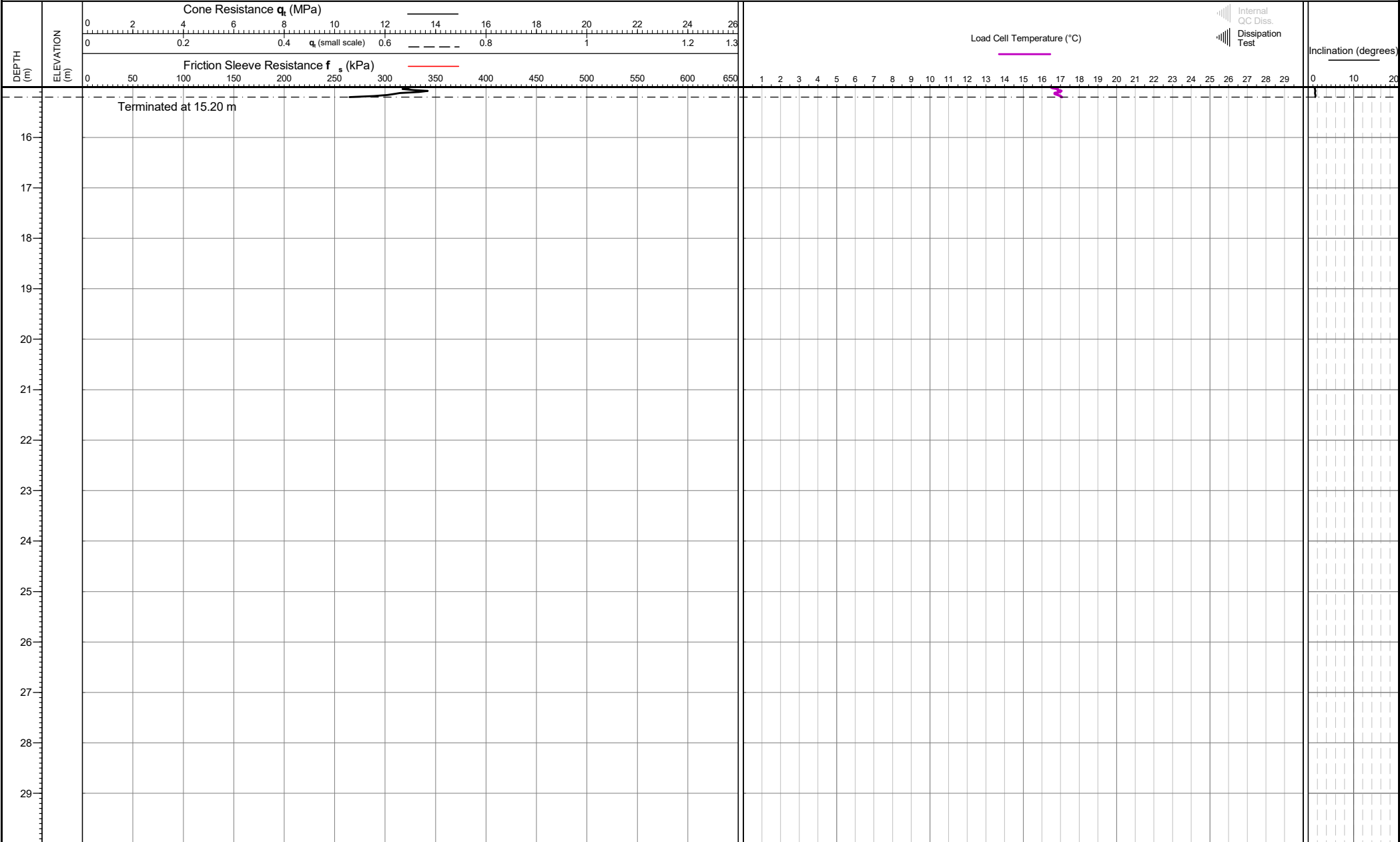
Checked by:
Chris Player

TEST ID: CPT04

Page 1 of 2



Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS

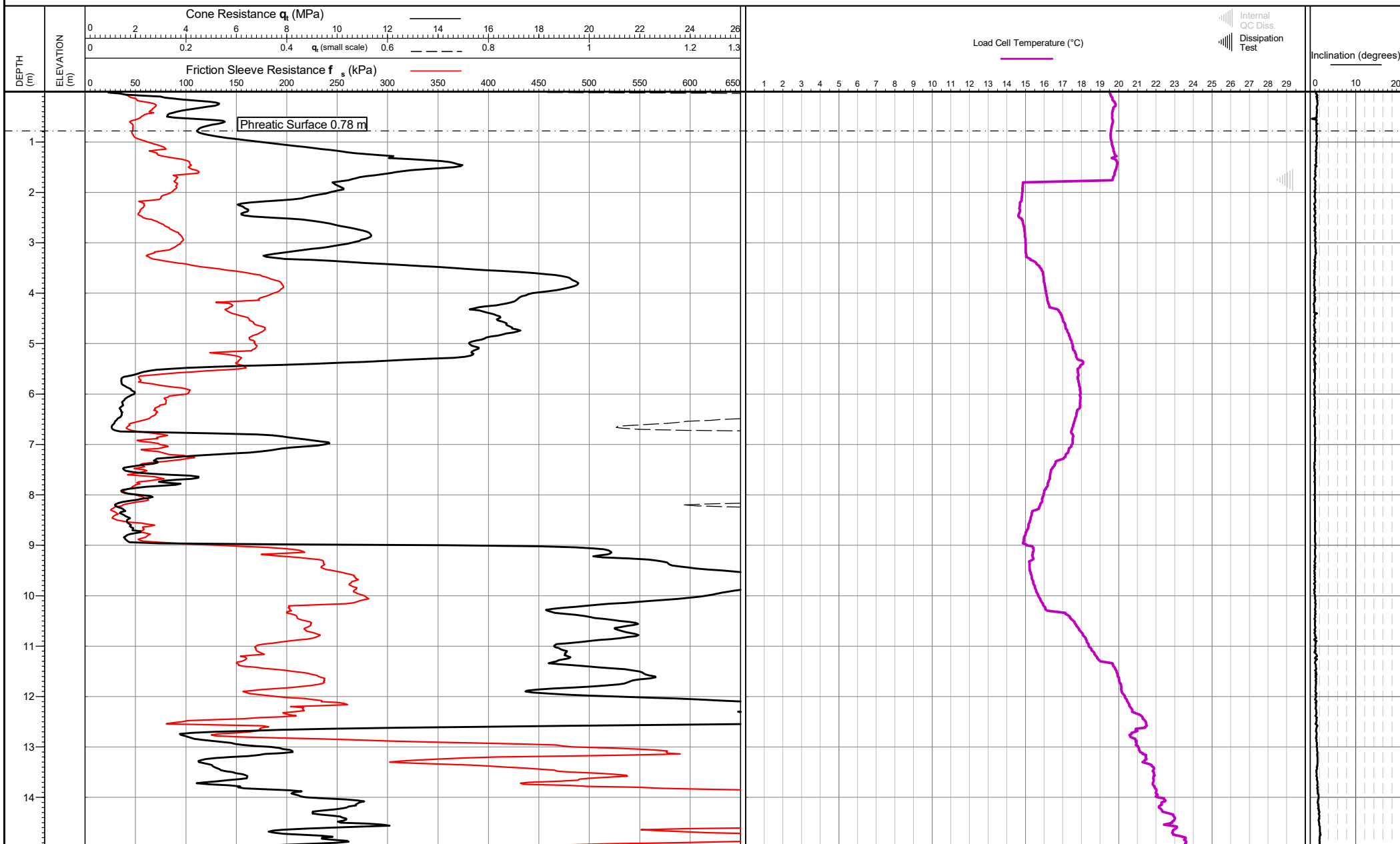


Cone area (mm ²): Cone ID: S15-CFIPTT.2141 Operator: Rob Bennett Rig Used: UK22 Date of test: 04/07/2023 08:16:22	Zero drift (Pre/post test) q_{t0} (kPa): -8.8 f_{s0} (kPa): 0.0 ($f_{s\text{ drift}} - q_{t0\text{ drift}}$) u_2 (kPa): 0.9	Location: North Yorkshire, UK Coordinates: , Elevation: Coordinate system:	Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s) Termination Remark: Target depth	Date of plot: 05-07-23 Checked by: Chris Player	Lankelma Project Ref: P-108354-1	TEST ID: CPT04 Page 2 of 2
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Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
Cone ID: S15-CFIPTT.2141
Operator: Rob Bennett
Rig Used: UK22
Date of test: 03/07/2023 12:39:33

Zero drift (Pre/post test)
 q_{t0} (kPa): -4.6
 f_{s0} (kPa): -0.1 ($f_{s0} = q_{t0} - q_{c0}$)
 u_2 (kPa): 4.1

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks:
*Phreatic surface origin: Average measured piezometric depth from other location(s)
Termination Remark: Target depth

Date of plot:
05-07-23
Checked by:
Chris Player

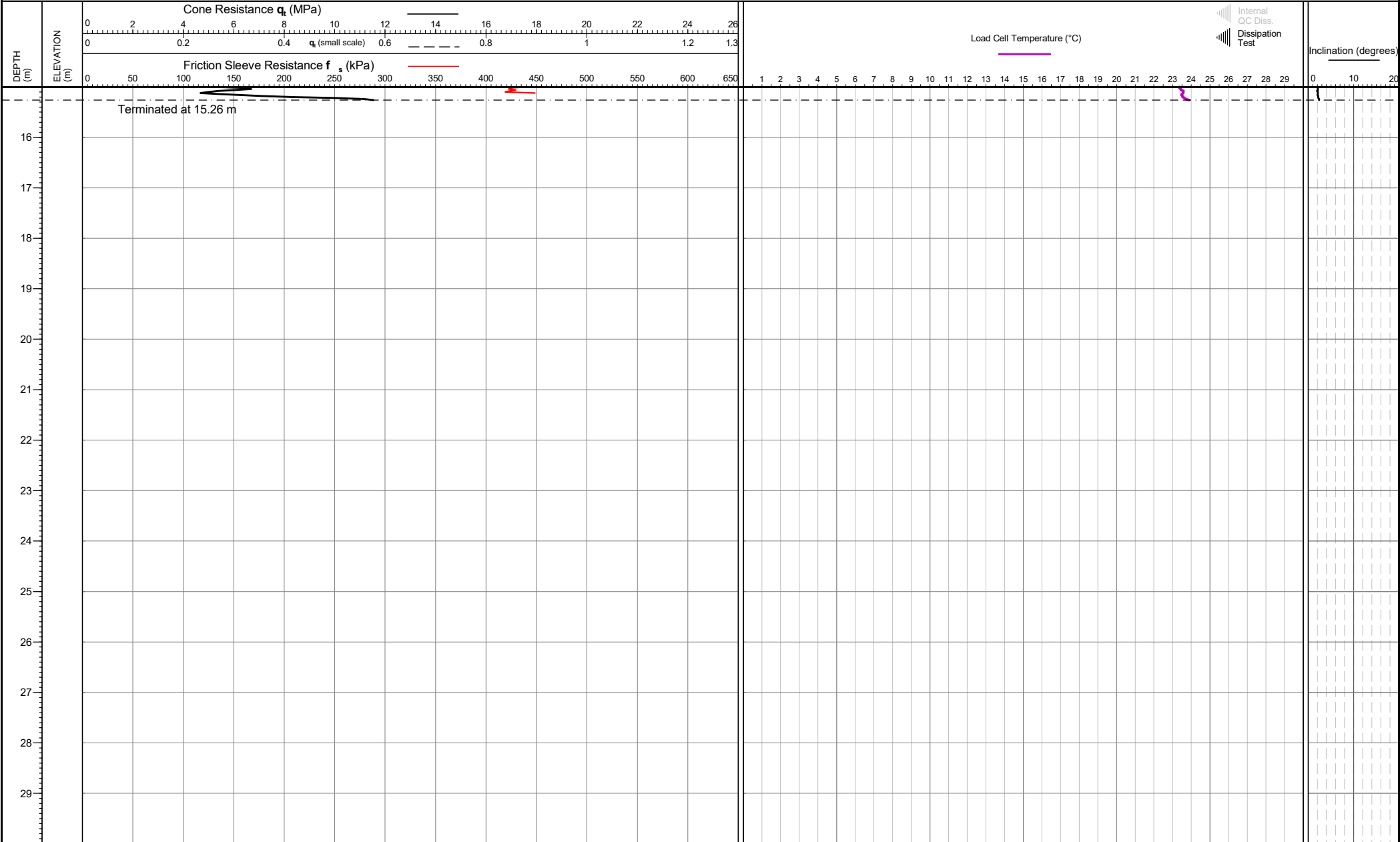
Lankelma Project Ref:
P-108354-1

TEST ID: CPT05

Page 1 of 2



Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS

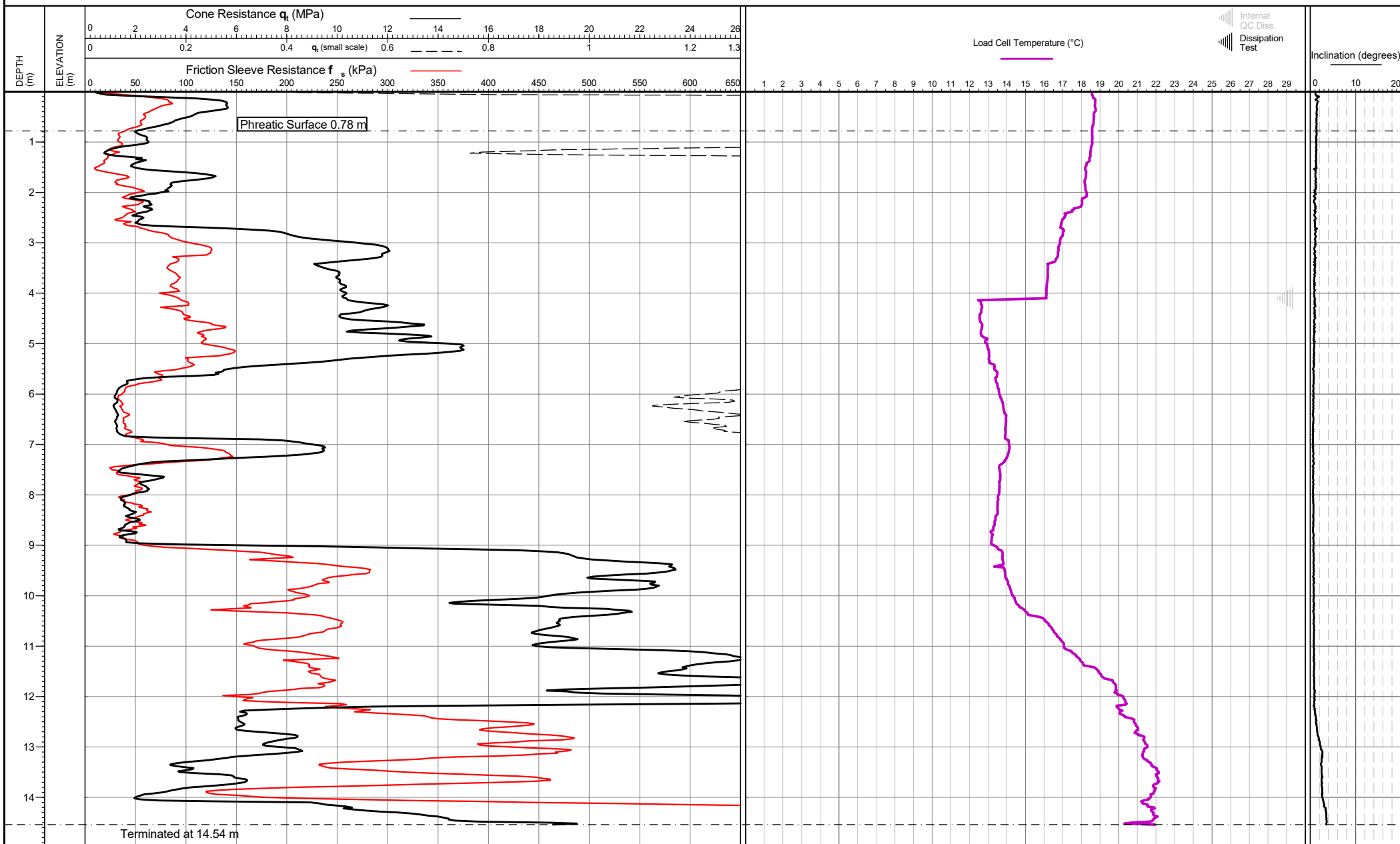


Cone area (mm ²): Cone ID: S15-CFIPTT.2141 Operator: Rob Bennett Rig Used: UK22 Date of test: 03/07/2023 12:39:33	Zero drift (Pre/post test) q _c (kPa): -4.6 f _s (kPa): -0.1 (f _{s drift} - q _{c drift}) u ₂ (kPa): 4.1	Location: North Yorkshire, UK Coordinates: , Elevation: Coordinate system:	Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s) Termination Remark: Target depth	Date of plot: 05-07-23 Checked by: Chris Player	Lankelma Project Ref: P-108354-1	TEST ID: CPT05 Page 2 of 2
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Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
Cone ID: S15-CFIPTT.2141
Operator: Rob Bennett
Rig Used: UK22
Date of test: 03/07/2023 11:56:57

Zero drift (Pre/post test)
 q_c (kPa): 0.2
 f_s (kPa): -0.5 ($f_{s, drift} - q_{c, drift}$)
 u_2 (kPa): -12.0

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks:
*Phreatic surface origin: Average measured piezometric depth from other location(s)
Termination Remark: Sleeve load

Date of plot:
05-07-23
Checked by:
Chris Player

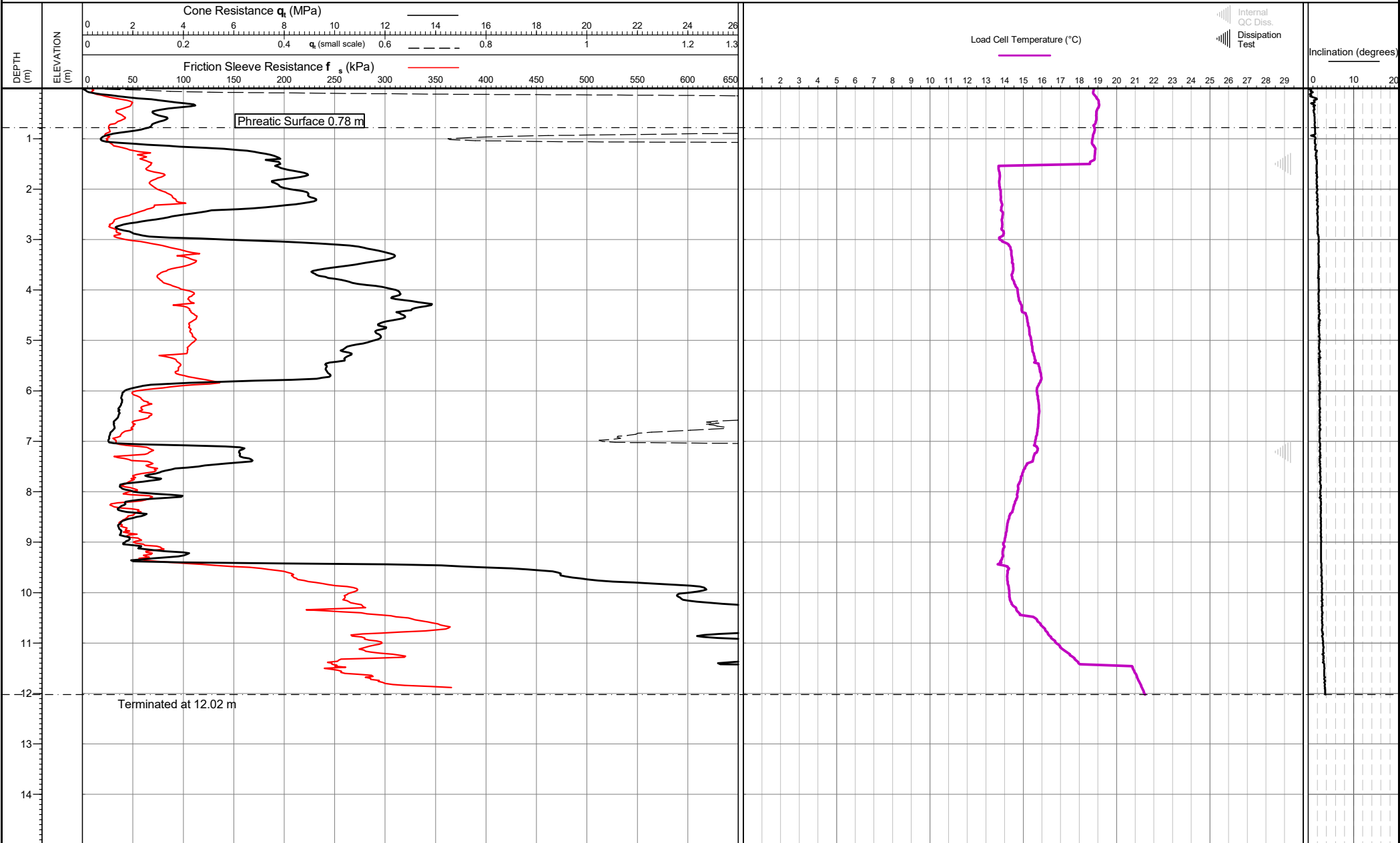
Lankelma Project Ref:
P-108354-1

TEST ID: CPT06

Page 1 of 1



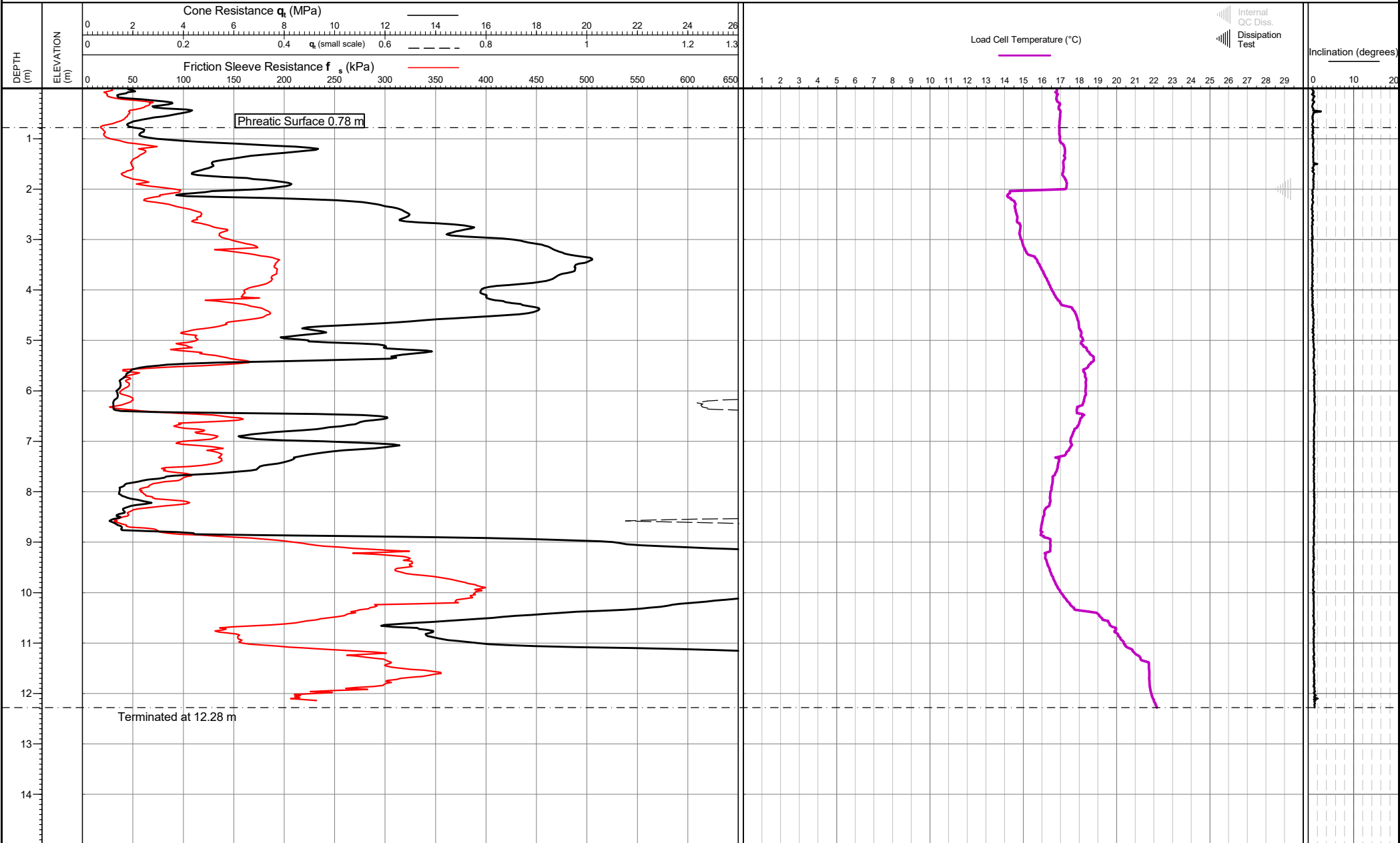
Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS



Cone area (mm ²): Cone ID: S15-CFIPTT.2141 Operator: Rob Bennett Rig Used: UK22 Date of test: 03/07/2023 11:11:23	Zero drift (Pre/post test) q_c (kPa): -6.2 f_s (kPa): -0.3 ($f_{s, drift} - q_{c, drift}$) u_2 (kPa): 7.1	Location: North Yorkshire, UK Coordinates: , Elevation: Coordinate system:	Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s) Termination Remark: Total reaction force	Date of plot: 05-07-23 Checked by: Chris Player	Lankelma Project Ref: P-108354-1	TEST ID: CPT07 Page 1 of 1
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Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS

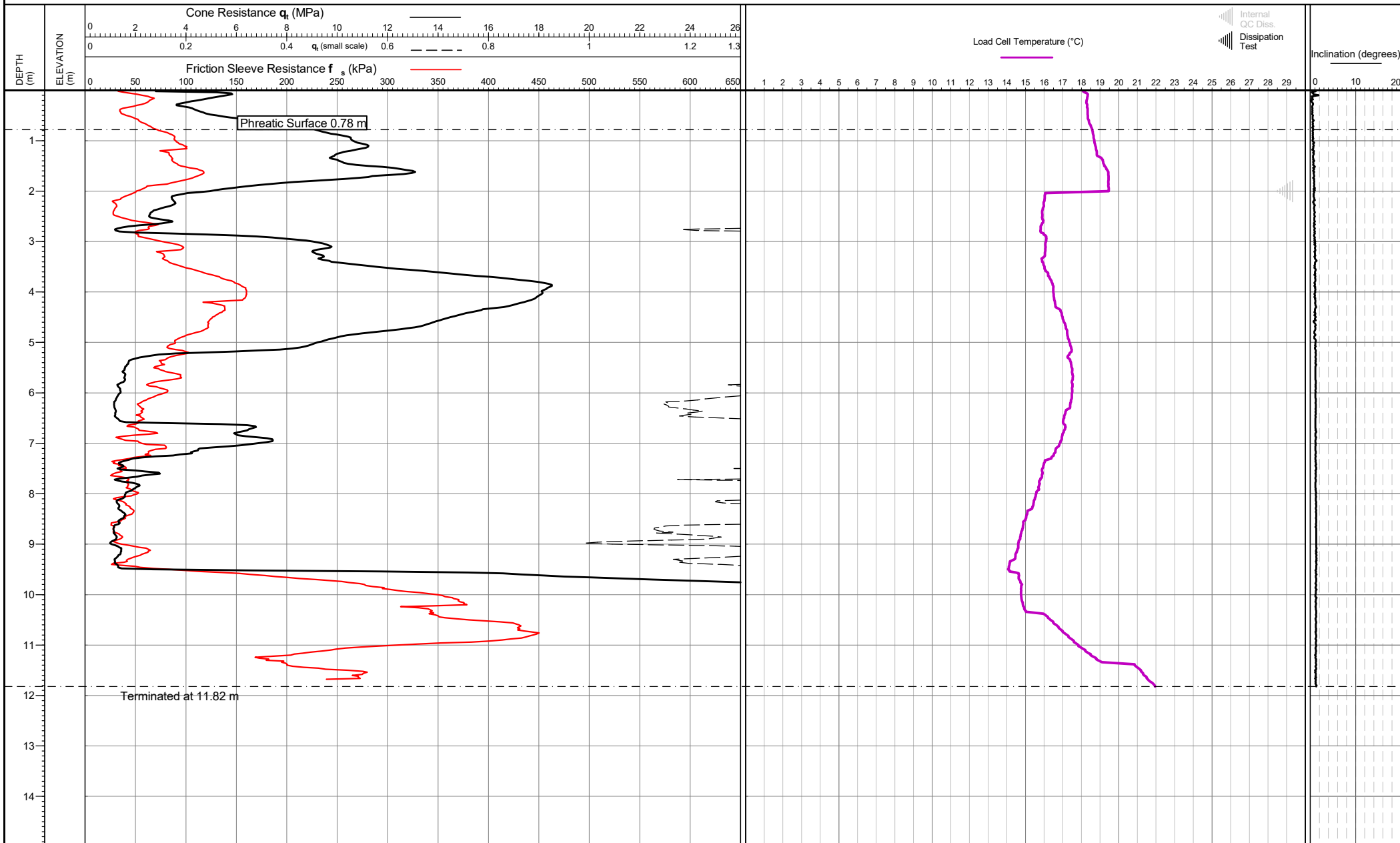


Cone area (mm ²): Cone ID: S15-CFIPTT.2141 Operator: Rob Bennett Rig Used: UK22 Date of test: 03/07/2023 09:41:17	Zero drift (Pre/post test) q _c (kPa): -17.6 f _s (kPa): 1.5 (f _{s,drift} - q _{c,drift}) u ₂ (kPa): -300.9	Location: North Yorkshire, UK Coordinates: , Elevation: Coordinate system:	Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s) Termination Remark: Total reaction force	Date of plot: 05-07-23 Checked by: Chris Player	Lankelma Project Ref: P-108354-1	TEST ID: CPT08 Page 1 of 1
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Project: BRRINGHAM ROAD, SCUNTHORPE

Client: ALAN WOOD & PARTNERS



Cone area (mm²):
Cone ID: S15-CFIPTT.2141
Operator: Rob Bennett
Rig Used: UK22
Date of test: 03/07/2023 10:24:34

Zero drift (Pre/post test)
 q_0 (kPa): -7.6
 f_0 (kPa): -0.1 ($f_{0, \text{drift}} - q_{0, \text{drift}}$)
 u_2 (kPa): -6.1

Location: North Yorkshire, UK
Coordinates: ,
Elevation:
Coordinate system:

Remarks:
*Phreatic surface origin: Average measured piezometric depth from other location(s)
Termination Remark: Total reaction force

Date of plot:
05-07-23
Checked by:
Chris Player

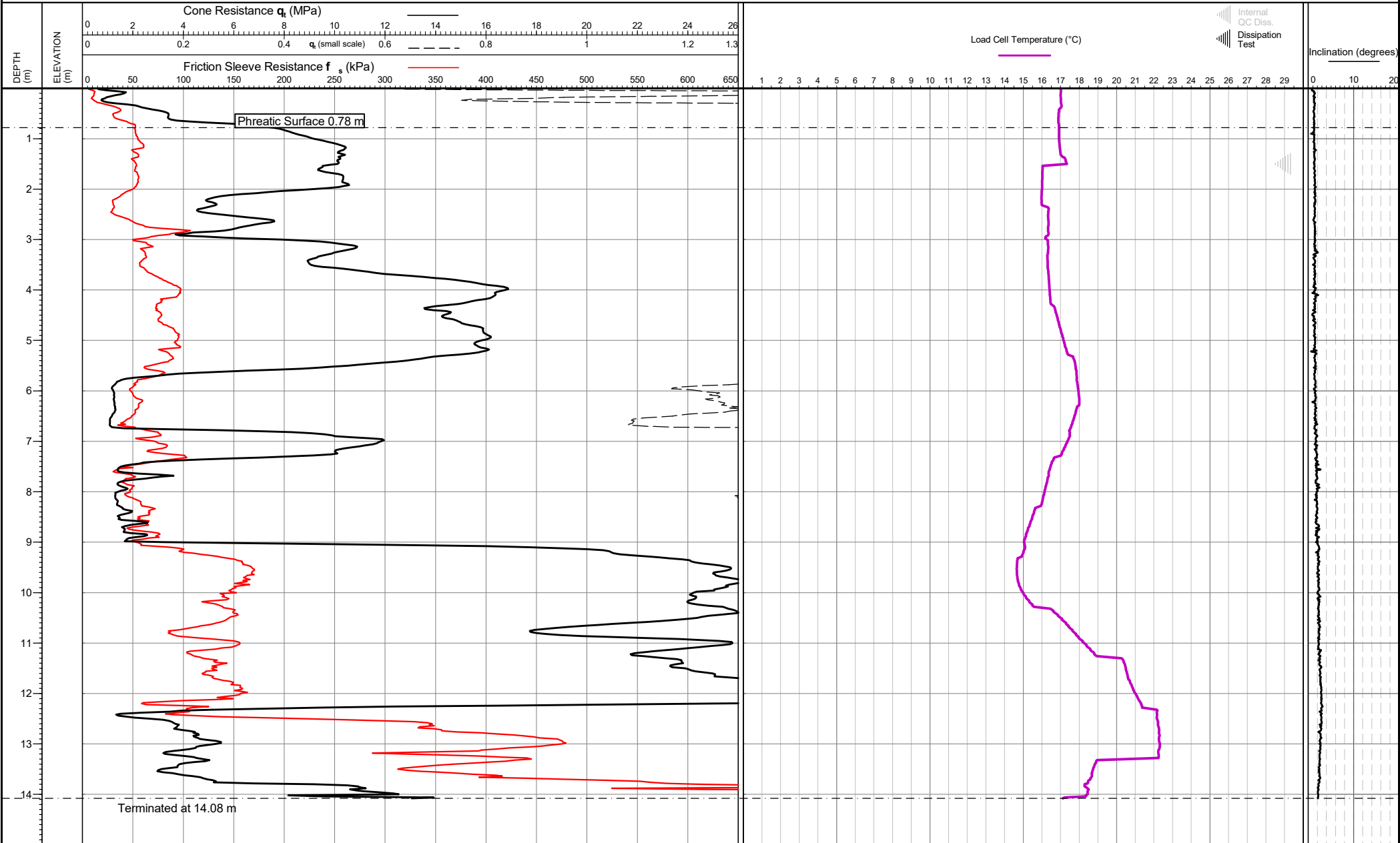
Lankelma Project Ref:
P-108354-1

TEST ID: CPT09

Page 1 of 1



Project: BRRINGHAM ROAD, SCUNTHORPE
Client: ALAN WOOD & PARTNERS



Cone area (mm ²): Cone ID: S15-CFIPTT.2213 Operator: Rob Bennett Rig Used: UK22 Date of test: 03/07/2023 08:52:36	Zero drift (Pre/post test) q_c (kPa): -4.4 f_s (kPa): -0.5 ($f_{s, drift} - q_{c, drift}$) u_z (kPa): -11.5	Location: North Yorkshire, UK Coordinates: , Elevation: Coordinate system:	Remarks: *Phreatic surface origin: Average measured piezometric depth from other location(s) Termination Remark: Total reaction force	Date of plot: 05-07-23 Checked by: Chris Player	Lankelma Project Ref: P-108354-1	TEST ID: CPT10 Page 1 of 1
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Alan Wood & Partners

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Hull	Turnberry Park	Burton Waters
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01723.865484	01142.440077	01904 611594
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Environmental Accreditation

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 Certificate no. GB.09/277b



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