

REPORT N^o 70018922-1602

PHASE 2 GROUND CONDITIONS REPORT PLOT 1

LAND AT ROCKINGHAM, BARNSELY

OCTOBER 2016

PHASE 2 GROUND CONDITIONS REPORT PLOT 1

LAND AT ROCKINGHAM, BARNSELEY

Homes & Communities Agency

Type of document (version)
Final Version 1

Project no: 70018992-003

Date: October 2016

WSP | Parsons Brinckerhoff

White Rose Office Park

Millshaw Park Lane

Leeds

LS11 0DL

Tel: 0113 395 6200

www.wsp-pb.com

QUALITY MANAGEMENT

ISSUE/REVISION	FIRST ISSUE	REVISION 1	REVISION 2	REVISION 3
Remarks	Draft V1	Final V1		
Date	August 2016	October 2016		
Prepared by	P. Montes	P. Montes		
Signature				
Checked by	G. Meynell / C. Powell	G. Meynell / C. Powell		
Signature				
Authorised by	A. Moore	A. Moore		
Signature				
Project number	70018992	70018992		
Report number	70018992-003	70018992-003		

PRODUCTION TEAM

CLIENT

Homes & Communities Agency
Leeds City Region and North Yorkshire Team
2nd Floor
Lateral
8 City Walk
LS11 9AT

WSP | PARSONS BRINCKERHOFF

WSP | Parsons Brinckerhoff

Registered Address:
WSP House, 70 Chancery Lane, London, WC2A 1AF

CONTACT

Gareth Meynell
Three White Rose Office Park
Leeds
LS11 0DL

0113 395 6200

TABLE OF CONTENTS

1	EXECUTIVE SUMMARY	1
2	INTRODUCTION.....	3
3	SITE INFORMATION	6
4	PRELIMINARY CONCEPTUAL SITE MODEL.....	8
5	INTRUSIVE GROUND INVESTIGATION	10
6	GROUND CONDITIONS.....	12
7	GENERIC QUANTITATIVE RISK ASSESSMENT	14
8	GROUND GAS ASSESSMENT.....	17
9	REVISED CONCEPTUAL SITE MODEL.....	19
10	PRELIMINARY GEOTECHNICAL ASSESSMENT	20
11	POTENTIAL DEVELOPMENT CONSTRAINTS AND MITIGATION MEASURES.....	24
12	CONCLUSIONS.....	26
	BIBLIOGRAPHY	28

TABLES

TABLE 3-1 SITE DETAILS.....	6
TABLE 4-1: POTENTIAL POLLUTANT LINKAGES.....	9
TABLE 5-1 SUMMARY OF MONITORING WELL INSTALLATIONS.....	10
TABLE 6-1 SUMMARY OF STRATA.....	12
TABLE 6-2 SUMMARY OF GROUNDWATER LEVELS RECORDED POST SITE INVESTIGATION.....	13
TABLE 7-2 SUMMARY OF GROUNDWATER ANALYTICAL RESULTS (µG/L).....	15
TABLE 8-1 SUMMARY OF GROUND GAS MONITORING RESULTS.....	17
TABLE 9-1 CONTAMINANT LINKAGE SUMMARY.....	19
TABLE 11-1 POTENTIAL CONSTRAINTS AND PROPOSED MITIGATION MEASURES	24
TABLE 11-2 UPDATED GROUND ENGINEERING/GEOTECHNICAL CONSTRAINTS.	24

FIGURES

FIGURE 1 SITE LOCATION PLAN
FIGURE 2 EXPLORATORY LOCATION PLAN
FIGURE 3 CROSS SECTION

APPENDICES

A P P E N D I X A	FIGURES
A P P E N D I X B	LIMITATIONS
A P P E N D I X C	EXPLORATORY HOLE RECORDS
	APPENDIX C-1 BOREHOLE LOGS
	APPENDIX C-2 CPT RECORDS
A P P E N D I X D	METHODOLOGY FOR THE DERIVATION OF GENERIC QUANTITATIVE ASSESSMENT CRITERIA TO EVALUATE RISKS TO HUMAN HEALTH FROM SOIL & GROUNDWATER CONTAMINATION
A P P E N D I X E	CHEMICAL ANALYSIS RESULTS
A P P E N D I X F	GEOTECHNICAL ANALYSIS RESULTS
A P P E N D I X G	GROUND GAS AND GROUNDWATER MONITORING RESULTS
A P P E N D I X H	SCREENING TABLES

EXECUTIVE SUMMARY

The Homes & Communities Agency (HCA) commissioned WSP | Parsons Brinckerhoff to undertake a Phase 2 ground investigation at a parcel of land (Plot 1) located at Rockingham, Barnsley

The objectives of this Phase 2 ground investigation were to characterise soil and groundwater conditions on-site, assess potential contaminated land related risks to human health and controlled waters, and provide further information from which to assess potential ground engineering hazards/data gaps that were identified in a Phase 1 Desk Study (WSP | Parsons Brinckerhoff, 2016).

The ground investigation comprised advancement of five boreholes (BH01 to BH05) to depths of between 7.30mbgl (BH01) and 21.0mbgl (BH04) and eleven Cone Penetrometer Tests (CPTs) (CPT01 to CPT11) were carried out to depths of between 2.44mbgl (CPT05) and 6.15mbgl (CPT07). The ground conditions generally comprises topsoil (grass over organic slightly gravelly clay), underlain by Made Ground (clayey gravel or gravelly clay with rare coal fragments indicative of colliery spoil) to depths of between 1.5mbgl and 6.0mbgl, underlain by consolidated mudstone (BH01 to BH04) or sandstone (BH05) of the Pennine Middle Coal Measures Formation. The thickness of Made Ground was noted to increase towards the southern portion of the site.

Groundwater was identified in the northern portion of the site only, at elevations between 134.06mAOD and 134.89mAOD within the fractured mudstone. The groundwater flow direction was estimated to be in a north-easterly direction.

In regards to controlled water receptor sensitivity of the site, the bedrock geology is classified by the Environment Agency as Secondary A Aquifer. The site is not located within a source protection zone and no registered abstraction bores were identified within a 1km from the site. The nearest surface water courses are the Short Wood Dike, located approximately 300m to the northeast, and River Dove, located approximately 600m to the north.

Soil and groundwater characterisation was undertaken for identified potential contaminants of concern, established as part of the Desk Study. A generic quantitative risk assessment (GQRA) was undertaken to assess potential health risks to site users, based on a proposed commercial end use, and risks to controlled waters. The GQRA concluded the following:

- Reported soil concentrations are considered to present a very low risk to future site users.
- Reported groundwater concentrations are not considered likely to present an unacceptable risk to down-gradient surface water bodies.

A ground gas risk assessment was conducted based on four monitoring rounds conducted between June 2016 and September 2016. The ground gas risk assessment concluded that based on the maximum carbon dioxide concentration and flow rate recorded during the ground gas monitoring, the site ground gas protection measure classification corresponds to Characteristic Situation 2 (low risk) with the need for the installation of basic gas protection measures in new buildings.

The additional ground investigation has allowed the geotechnical/ground engineering constraints identified as part of the Desk Study to be further assessed, as follows:

- Settlement of the backfilled opencast materials:

- The depth/variation in Made Ground associated with the backfilled opencast materials has been further assessed, which will allow settlement analysis to be conducted for future proposed development.
- The potential for the collapse of unrecorded shallow mining out with the opencast boundaries to cause ground instability:
- Given that no evidence of shallow mine workings was recorded during the additional ground investigation; and, the extent of opencast workings/deeper Made Ground was greater than previously anticipated, it is considered that if unrecorded shallow working had taken place exist beneath Plot 1 then it is likely that they would have been removed as part of the opencast operations. There is however no evidence/records for this.

An additional geotechnical/ground engineering constraint was identified from the additional ground investigation. This relates to the possibility that obstructions exist within the Made Ground that could be a constraint to the adoption of certain forms of foundation and to excavations within the Made Ground.

1 INTRODUCTION

1.1 AUTHORISATION

The Homes and Communities Agency (HCA) commissioned WSP | Parsons Brinckerhoff to undertake a Phase 2 ground investigation at a parcel of land (Plot 1) located at Rockingham, Barnsley, (henceforth referred to as 'the site'). The site location is presented in Figure 1 within Appendix A.

1.2 BACKGROUND INFORMATION

The HCA are currently in the process of marketing the site for sale, which is to be split into three separate development plots as Barnsley Metropolitan District Council (BMDC) is constructing a new road through the site. The road scheme splits the site into three separate plots as defined below:

- Plot 1: 1.52ha – Commercial proposed end use;
- Plot 2: 4.78ha – Commercial proposed end use; and,
- Plot 3: 1.58ha – Residential or commercial proposed end use.

As part of the road development BMDC requested that a compound to support the works is placed on Plot 1. The HCA therefore commissioned further ground investigation prior to the compound being placed on Plot 1 to obtain pertinent supplementary ground investigation information to support the HCA with divesting the plot.

Historical ground investigation data and backfilling records are available for Plot 1, and have been reviewed as part of recent Desk Study report completed by WSP | Parsons Brinckerhoff⁵. The report identified a number of gaps in the ground related information as outlined below:

Contaminated Land

- Potential contaminants of concern not previously tested (asbestos, benzo(a)pyrene, cyanide);
- No volatile headspace testing undertaken;
- Insufficient data obtained to assess potential ground water flow;
- Limited groundwater chemical data available to characterise potential risks; and,
- Insufficient ground gas monitoring data to characterise potential risks.

Geotechnical

- Uncertainty around depth of fill;
- Missing records to verify that compaction was undertaken in the northeast of Plot 1;
- Insufficient data to assess aggressivity of fill with respect to buried concrete.; and,
- Limited groundwater information.

Further ground investigation was recommended to supplement the existing data to further characterise the potential ground related risks and more accurately understand the potential ground related constraints to assist the HCA in disposing of the land.

PREVIOUS GROUND CONDITION RELATED REPORTS

The following reports / site investigations have been conducted at the wider development site since 2002.

- Symonds, 2002. Preliminary Site Evaluation, prepared on behalf of Yorkshire Forward¹
- Mott MacDonald, 2004. Rockingham Colliery Stage 2 Geotechnical & Geo-Environmental Site Assessment, prepared on behalf of Yorkshire Froward²
- Arup, 2004. Ground Engineering for proposed Masterplan, prepared on behalf of Yorkshire Forward³
- Subsurface North East Ltd, 2014. Ground Investigation at A61 Birdwell Junction Improvement, Tankersley on behalf of Barnsley Metropolitan Borough Council⁴
- WSP | Parsons Brinckerhoff, 2016. Phase 1 Ground Conditions Report, Land at Rockingham, Barnsley⁵

1.3 AIM & OBJECTIVES

The aim of the supplementary ground investigation is to obtain information to further characterise the potential contaminated land and geotechnical issues to allow development constraints to be better understood and associated abnormal costs to be more accurately formulated.

The specific objectives of the investigation are to:

- Further characterise ground conditions to understand the depth, composition and strength of the fill, particularly in north of the plot where compaction validation data is missing/incomplete;
- Investigate for the presence of potential contamination associated with the site, particularly contaminants not previously tested (i.e. asbestos, cyanide, benzo(a)pyrene);
- Assess for the presence of groundwater and whether a shallow groundwater table is present across the plot;
- Assess ground gas concentrations to inform potential ground gas protection measures;
- Provide data suitable to specify below ground concrete requirements;
- Provide information to further characterise ground engineering constraints.

1.4 SCOPE OF WORKS

The investigation has been undertaken with due consideration to the guidance in 'Model Procedures for the Management of Land Contamination', Contaminated Land Report 11 (CLR 11), (Environment Agency, 2004), and in general accordance with the British Standard 'Investigation of potentially contaminated sites - Code of practice' BS EN 10175 2011. In order to meet the project aim and objectives the following scope of works was undertaken:

- Drill five boreholes to depths of between 7.30mbgl and 21.0mbgl; and subsequent installation of groundwater/gas monitoring wells.
- Cone Penetrometer Testing (CPT) to depths of between 2.44mbgl and 6.15mbgl.
- Collection of soil samples during drilling operations.
- Four ground gas monitoring rounds in all five boreholes on-site.
- One groundwater sampling round in boreholes with sufficient volumes of water to sample (three boreholes – BH01, BH02 and BH03) using low flow sampling techniques.
- Laboratory analysis of soil and groundwater samples.

- Geotechnical testing of soil.
- Production of this Ground Conditions report considering the potential land quality and geotechnical issues in the context of redevelopment of the site for commercial end use.

1.5 LIMITATIONS

This report is addressed to and may be relied upon by the following party:

Homes & Communities Agency

This assessment has been prepared for the sole use of the above named party. This report shall not be relied upon or transferred to any other parties without the express written authorisation of WSP | Parsons Brinckerhoff. No responsibility will be accepted where this report is used either in its entirety or in part, by any other party. This Report has been prepared to support the sale of Plot 1 and not for geotechnical design purposes. General limitations are included in Appendix B.

2 SITE INFORMATION

2.1 SITE DETAILS

A summary of the site details is provided in Table 2-1, further details are provided in the Desk Study Report⁵.

Table 2-1 Site details

ASPECT	DESCRIPTION
Site address	Land at Rockingham, Barnsley, South Yorkshire, S70 5TU
National Grid Reference	435073, 400556 (approximate site centre)
Site location	The site is located approximately four miles south of Barnsley and immediately to the east of Junction 36 of the M1 motorway. The site can be accessed via the A16195 Dearne Valley Parkway.
Approximate surface area	Plot 1 has a surface area of 1.52ha
Topography	Plot 1 gently slopes from circa 140m AOD in the southeast to circa 137m AOD in the northwest
Site history	Opencast mine workings are recorded to have taken place between 1989 and late 1993/early 1994. The wider development site appears to have been mined in two phases, firstly in the western half, where Plot 1 is located, followed by the eastern half. Following cessation of opencast mining operations in the west, the area was infilled. By 1991 backfilling of the western half of the site was partially complete, before excavation began in the eastern half.
Current site use	The site is currently vacant land.
Proposed end use	Commercial land use,
Surrounding land uses	<p><u>North:</u> Dearne Valley Parkway and vacant land across Dearne Valley Parkway. Residential land use approximately 150m to the northwest. Plot 2 within the wider site development located to the northeast. Former railway line approximately 300m north.</p> <p><u>East:</u> Plot 3 within the wider site development located to the east across the proposed road. Mixed residential and commercial area approximately 150m to the east. Vehicle service and repair depot approximately 200m to the east. Former Rockingham Colliery and Rockingham Gasworks located to the north and east of the site.</p> <p><u>South:</u> Sheffield Road and vacant land.</p> <p><u>West:</u> Rockingham Industrial Estate (commercial/industrial use) across Dearne Valley Parkway. A historical landfill (1983-1989) was located approximately 100m to the west, associated with a former railway cutting (inert and commercial waste).</p>
Radon	The property is in a lower probability radon area where less than 1% of homes are above the action level. No radon protection measures are necessary.
Coal mining activity	The Coal Authority (CA) and Brine Report indicated the property is in a surface area that could be affected by underground mining in eight seams of coal at 60m to 340m depth, last worked in 1959. The CA interactive mapping service indicates the site is located within a Development High Risk Area.

2.2 SITE DESCRIPTION

A site walkover was conducted on 2 March 2016 by a WSP | Parsons Brinckerhoff representative as part of the Desk Study⁵.

Plot 1 comprises an area of rough grass that gently slopes from the northwest to southeast. The site is bound by a wooden fence to the west, beyond which is located Dearne Valley Parkway. The northwest of the plot is bound by bushes and small trees, beyond which is a stub of a roundabout. Areas of rough grass surround the remainder of the plot.

2.3 SITE SETTING

GEOLOGY

Based on British Geological Survey (BGS) Geology map (1:50,000) sheet 87 and BGS Online Viewer maps, the bedrock underlying the site corresponds to Pennine Middle Coal Measures Formation, described as mudstone, siltstone and sandstone. The Shallow Wood coal seam is shown to out-crop at the surface of the site. It outcropped in a north south direction and dipped beneath the site in a north/north easterly direction.

No superficial deposits are shown across the site. However, deep Made Ground is expected to be present across parts of the site associated with infilling of the former open cast mine.

HYDROGEOLOGY

The bedrock geology (Pennine Coal Measures Formation) is classified by the Environment Agency (EA) as Secondary A Aquifer. These are described as permeable layers capable of supporting water supplies at a local rather than strategic scale.

The site is not located within a source protection zone (SPZ) and no publically registered groundwater abstractions are located within 1km of the site boundary.

HYDROLOGY

The site is located within the EA defined Humber River Basin District and Don and Rother Catchment area. The nearest surface water course is the Short Wood Dike, located approximately 300m to the northeast, and flows north onto the River Dove, located approximately 600m to the north, which is recorded as having Poor ecological potential and Good chemical quality by the EA.

3 PRELIMINARY CONCEPTUAL SITE MODEL & GROUND MODEL

A preliminary conceptual site model (CSM) has been formulated utilising available information to determine the presence of plausible exposure pathways and hence the presence of significant risk to susceptible receptors. For a significant or identifiable risk to exist an exposure pathway must be present which requires each of the following to be identified:

- The presence of substances that may cause harm (source);
- The presence of a receptor which may be harmed at an exposure point (receptor); and
- The existence of means of exposing a receptor to the source (exposure pathway).

Explanatory notes on the CSM developed for the site are provided below.

3.1 POTENTIAL SOURCES OF CONTAMINATION

Based on the site use and the site walkover conducted on 2 March 2016, the potential sources of contamination include the following.

- Colliery spoil, which may have included other waste products associated with coal/coke production (coal tar, PAHs, phenols, cyanides, heavy metals, asbestos, sulphates, sulphides, acidic pH).
- Slurry pond/filter sediments and arisings potentially used in backfilling (heavy metals).
- Burnt colliery spoil materials documented to have been used as backfill.
- Underground coal mining.

Potential off-site sources of contamination include the former railway line, former Rockingham Colliery, former Rockingham Gasworks, vehicle servicing and repair depot and historical landfill (refer to Desk Study for location and distances from site).

The potential contaminants of concern (COC) are considered to include the following.

- Metals, cyanide, polycyclic aromatic hydrocarbons (PAHs) and total petroleum hydrocarbons (TPH).
- Asbestos or asbestos containing materials (ACM) within the Made Ground.
- Hazardous ground gases in filled areas and underground coal mining.

3.2 RECEPTORS

Based on the proposed future use (commercial use) and potential receiving environment, the potential receptors are considered to include the following.

- On-site commercial workers.
- On-site maintenance and construction workers conducting subsurface works.
- Controlled waters: underlying Secondary A aquifer, Short Wood Dike and River Dove.
- Water pipework (drinking water supply).

3.3 EXPOSURE PATHWAYS

The main feasible transport mechanisms and exposure routes include the following:

- Volatilisation of vapours from impacted soil and/or groundwater and subsequent vapour intrusion into buildings leading to vapour inhalation.
- Direct contact with impacted soil (dermal contact and incidental ingestion).
- Dermal contact, incidental ingestion and inhalation of soil particulates (dust).
- Accumulation of gases resulting in potentially explosive / asphyxiating atmosphere.
- Leaching of contamination into groundwater followed by migration of groundwater to the wider groundwater environment and down gradient surface waters.
- Permeation through water pipework leading to contamination of water supply.

3.4 POTENTIAL POLLUTION LINKAGE ASSESSMENT

The identified potential pollutant linkages are presented in Table 3-1 below.

Table 3-1: Potential pollutant linkages

EXPOSURE LINKAGE	ACTIVE	(✓)
	INACTIVE	(*)
HUMAN HEALTH (ON SITE)		
Exposure to contaminated soils via ingestion/dermal contact/inhalation (site users, maintenance and construction workers)		✓
Vapour inhalation (outdoor and indoor)		✓
BUILT ENVIRONMENT		
Migration of ground gas / volatile vapours into buildings		✓
Permeation through water pipework leading to contamination of drinking water supply		✓
CONTROLLED WATERS		
Contamination of groundwater and surface waters		✓
Contamination of abstraction wells		*

The Phase 2 contaminated land investigation strategy was based on the preliminary conceptual site model detailed above.

3.5 PRELIMINARY GROUND MODEL

Reports reviewed as part of the Desk Study⁵ recorded Made Ground (backfill) described as grey gravelly clay with gravel comprising mudstone and occasional sandstone fragments down to between 3.8m and 4.9m bgl. SPT values were recorded in the top 2m and ranged from N12 to N24. The presence of bedrock was not confirmed due to the drilling techniques used and no data was available for the area in the northeast of the plot where no backfill verification records exist. Groundwater was recorded at around 2.5m bgl from a historical borehole.

4 INTRUSIVE GROUND INVESTIGATION

4.1 GROUND INVESTIGATION RATIONALE

The potential sources of contamination identified during desk based assessment included the material used to backfill the open cast mine (Made Ground) and the historical site activities (colliery spoil, which may have included other waste products associated with coal/coke production). This investigation was subsequently undertaken to further assess potential land quality issues and also to gain a preliminary understanding of geotechnical soil properties to identify potential ground engineering constraints.

4.2 EXPLORATORY HOLES AND INSTALLATIONS

The intrusive ground investigation was overseen by WSP | Parsons Brinckerhoff between 24 May and 26 May 2016. Prior to breaking ground a specialist underground utility avoidance engineer was commissioned to assess all proposed exploratory locations.

A total of five boreholes (BH01 to BH05) were advanced to depths of between 7.30mbgl (BH01) and 21.0mbgl (BH04), combining window sampling, rotary coring and rotary open hole drilling techniques. Locations were selected to gain a relatively even spread across the plot. As part of the ground investigation works eleven Cone Penetrometer Tests (CPTs) (CPT01 to CPT11) were also carried out to depths of between 2.44mbgl (CPT05) and 6.15mbgl (CPT07). Following installation, groundwater/ground gas monitoring wells were installed at all five locations.

The exploratory hole location plan is provided in Figure 2 within Appendix A.

Table 4-1 Summary of monitoring well installations

BOREHOLE ID	GROUND ELEVATION (MAOD)	PIEZOMETER DIAMETER (MM)	SCREEN TOP AND BASE DEPTH (MBGL)	SCREEN TOP AND BASE ELEVATION (MAOD)	STRATA TARGETED
BH01	138.150	50	2.0 – 7.0	136.15 – 131.15	Made Ground and Fractured Mudstone
BH02	139.815	50	3.5 – 9.0	136.36 – 130.82	Made Ground and Fractured Mudstone
BH03	138.389	50	1.0 – 5.0	137.38 – 133.39	Made Ground
BH04	141.405	50	10.0 – 15.0	131.46 – 126.46	Mudstone
BH05	140.582	50	1.0 – 5.0	139.58 – 135.58	Made Ground*

* Made Ground was underlain by fractured sandstone.

4.3 IN-SITU AND FIELD TESTING

STANDARD PENETRATION TESTS

Standard Penetration Tests (SPTs) were undertaken within the windowless sample boreholes and the results are presented on the borehole logs (Appendix C).

CONE PENETROMETER TESTS

Cone Penetrometer Tests (CPTs) were undertaken across the site, including a number adjacent to boreholes in order to correlate the ground conditions encountered in the boreholes with the CPT results. The CPT results are presented within Appendix C.

PHOTO-IONISING DETECTOR

A hand held Photo-Ionisation Detector (PID) (fitted with a 10.6eV lamp) was used to provide an indication of the presence of volatile compounds within the soil profile. The PID readings are presented on the borehole logs (Appendix C) and discussed in Section 5.1.

4.4 GROUNDWATER AND GROUND GAS MONITORING

Groundwater monitoring was undertaken on 23 June 2016 using low flow sampling technique. The monitoring wells were firstly purged of three well volumes or until dry to remove stagnant water. Groundwater quality parameters were measured at different intervals to assess water equilibrium.

Ground gas monitoring was undertaken on four occasions (2 June 2016, 23 June 2016, 8 July 2016 and 23 September), which involved the measurement of methane, carbon dioxide, hydrogen sulphide, carbon monoxide and oxygen along with peak and steady gas flows and barometric pressure. A fourth monitoring round is pending, which will be included in the final version of this report.

4.5 LABORATORY ANALYSIS AND TESTING

Selected soil samples were submitted for analysis to Alcontrol Laboratories which uses United Kingdom Accreditation Service (UKAS) and Environment Agency of England & Wales (EA) Monitoring Certification Scheme (MCERTS) accredited methods, where applicable. A total of 12 samples analysed for the identified contaminants of concern, including:

- Asbestos screen
- Metals suite (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc)
- Cyanide total, cyanide free
- Polycyclic aromatic hydrocarbons (PAH)
- Total petroleum hydrocarbons Criteria Working Group (TPH CWG) (in 5 samples only)
- Benzene, toluene, ethylbenzene, xylenes (BTEX) compounds (in 5 samples only)
- Methyl tertiary butyl ether (MTBE) and tert-amyl methyl ether (TAME) (in 5 samples only)

In addition, soil organic matter (SOM), pH and water soluble sulphate was analysed in selected soil samples. Laboratory analytical reports are included in Appendix E.

Groundwater samples were collected from the boreholes with sufficient volumes of water to sample (BH01, BH02 and BH03) and were submitted for analysis to Alcontrol Laboratories which uses UKAS and MCERTS accredited methods, where applicable. Groundwater samples were analysed for metals, PAH, TPH CWG and BTEX compounds. Laboratory analytical reports are included in Appendix F.

Bulk and disturbed samples were sent for geotechnical testing (plasticity Index, moisture content and partial size distribution (PSD)) at Geo Site & Testing Services Ltd (GSTL) laboratory. Results are included within Appendix F.

5 GROUND CONDITIONS

5.1 SUMMARY OF ENCOUNTERED GROUND CONDITIONS

A total of five boreholes were advanced during the site investigation conducted in June 2016 to depths between 7.30mbgl and 21.00mbgl. The ground model sequence generally comprised topsoil (grass over organic slightly gravelly clay), underlain by Made Ground (clayey gravel or gravelly clay with rare coal fragments) to depths of between 3.40mbgl and 6.05mbgl, underlain by mudstone (BH01 to BH04) or sandstone (BH05) of the Pennine Middle Coal Measures Formation.

The thickness of Made Ground was greater in the southern portion of the site (up to 6.05m thick in BH02 and 6.00m thick in BH04). The Made Ground encountered is considered to represent material derived from mudstone dominated strata, as anticipated from the historical records that indicate the backfill was excavated overburden from the opencast and colliery spoil.

A summary table of the strata encountered during this investigation is presented in Table 5-1. Borehole logs are presented within Appendix C.

Table 5-1 Summary of strata

STRATUM NAME	DEPTH TO BASE OF STRATA (MGBL)	ELEVATION OF BASE OF STRATA (MAOD)	THICKNESS (M)
Topsoil	0.10 – 0.18	141.31 – 138.00	0.10 to 0.18
Made Ground	3.40 to 6.05	135.41 to 133.59	3.45 to 5.90
Pennine Middle Coal Measures Formation – Fractured mudstone (BH01 - BH04) / sandstone (BH05)	3.60 to 9.10 (not proven)	134.55 to 130.49 (not proven)	0.20 to 3.10 (not proven)

Boreholes were extended using open hole techniques to 21.00mbgl (120.41mAOD) within the Pennine Middle Coal Measures (no recovery obtained, just descriptions of drilling flush noted).

In general, interpretation of the CPT test results suggests the Made Ground was more granular in nature (sand to clayey sand) than was recorded on the borehole logs. It is considered that this may relate to disturbance of the material recovered (due to window sampling breaking down coarser grained materials) compared to that tested in situ by the CPTs.

5.2 EVIDENCE OF CONTAMINATION

The PID screening of soil samples collected during the advancement of the boreholes reported readings below 1ppm in all soil samples. No visual or olfactory evidence of potential contamination was reported during the advancement of the boreholes.

5.3 GROUNDWATER CONDITIONS

Groundwater strikes were noted during the intrusive investigation in three locations (BH01, BH02 and BH03) at depths between 3.8mbgl (BH03) and 4.6mbgl (BH02), within the Made Ground, and at 4.1mbgl (BH01) within fractured mudstone. Groundwater levels were recorded during the groundwater and ground gas monitoring rounds conducted post site investigation (2 June 2016, 23 June 2016 and 8 July 2016). A summary of the groundwater depths and elevations recorded post site investigation is provided in Table 5-2. Field records are provided in Appendix G.

Table 5-2 Summary of groundwater levels recorded post site investigation

BOREHOLE ID	GROUND ELEVATION (MAOD)	GROUNDWATER DEPTH (MBGL)		GROUNDWATER ELEVATION (MAOD)	
		Min	Max	Min	Max
BH01	138.15	4.08	4.60	133.55	134.07
BH02	139.82	5.78	6.28	133.56	134.03
BH03	138.38	3.44	3.78	134.61	134.94
BH04	141.41	Dry	Dry	Dry	Dry
BH05	140.58	5.21	5.52	135.06	135.37

Groundwater was identified at elevations between 134.06m AOD (BH02) and 134.89m AOD (BH03) within the Made Ground from monitoring in the northern portion of the site. The groundwater flow direction was estimated to be in a north-easterly direction based on triangulation of the groundwater levels and assuming they groundwater is in hydraulic continuity. No groundwater was encountered in BH04 and BH05 during the 2 June 2016 monitoring round, which response zones were within the mudstone and Made Ground respectively.

6 GENERIC QUANTITATIVE RISK ASSESSMENT

6.1 METHODOLOGY

Legislation and guidance on the assessment of contaminated sites acknowledges the need for a tiered risk based approach. This assessment represents a Generic Quantitative Risk Assessment (GQRA), being a comparison of site contaminant levels against generic assessment criteria, including a qualitative assessment of risk using the source-pathway-receptor model.

HUMAN HEALTH

A series of soil Generic Assessment Criteria (GAC) screening values have been calculated by WSP | Parsons Brinckerhoff using the Contaminated Land Exposure Assessment (CLEA) Workbook v1.071 to assess potential health risks associated with contaminants in soil. WSP | Parsons Brinckerhoff has also derived a set of groundwater GACs to evaluate the potential inhalation health risks associated to vapours associated with volatile compounds in groundwater. The WSP | Parsons Brinckerhoff methodology for the derivation of GAC is presented in Appendix D.

CONTROLLED WATERS

Based on the preliminary conceptual site model and the identified receptors, the following water quality standards (WQS) have been adopted.

- The River Basin District Typology, Standards and Groundwater Threshold Values (Water Framework Directive) (England and Wales) Directions 2015.
- Environmental Quality Standards, Directive, 2008/105/EC.

6.2 DATA ASSESSMENT

SOIL ANALYTICAL RESULTS

A total of 12 soil samples collected in Made Ground between 0.05mbgl and 2.6mbgl were analysed for the identified potential contaminants of concern. A summary of the reported soil human health risk assessment is provided below.

6.3 SOIL CHEMICAL ANALYTES

Based on the site intended end use, the soil chemical data have been compared against the GAC derived for commercial use. Site specific soil organic matter (SOM) content was obtained from 7 out of 12 soil samples, with values ranging between 1.76% (BH01 at 1.0-1.0mbgl) and 37.8% (BH05 at 0.05-0.10mbgl). Given the high variability of organic content across the site, GAC for 1% SOM were adopted as a conservative measure. Given no speciation of chromium was undertaken, chromium total was compared against the GAC derived for chromium hexavalent as a conservative measure.

No soil concentrations were reported in exceedance of the adopted GAC for commercial end use. On this basis, the identified concentrations are considered to present a very low health risk to future site users.

The soil screening tables are included in Appendix H.

6.4 ASBESTOS SCREENING

The Control of Asbestos Regulations, 2012 make clear that asbestos management procedures are required on sites where asbestos is present. This includes asbestos in the ground as well as buildings.

No asbestos were identified in any of the 12 samples submitted for screening.

6.5 CONTROLLED WATERS RISK ASSESSMENT

Three groundwater samples were collected from the boreholes with sufficient volumes of water to sample (BH01, BH02 and BH03). A summary of the reported soil analytical results is provided in Appendix E.

Table 6-1 Summary of groundwater analytical results (µg/l)

ANALYTE	CONCENTRATION RANGE	COMMENT
Arsenic	<2 – 2.69	Detected in one groundwater sample (BH02)
Cadmium	<0.5	Not detected
Chromium	6.77 – 13.3	Detected in all three groundwater samples
Copper	<4 – 17.3	Detected in one groundwater sample (BH02)
Lead	<0.5 – 11.1	Detected in one groundwater sample (BH02)
Mercury	<0.02	Not detected
Nickel	20.9 – 58.3	Detected in all three groundwater samples
Selenium	<1 – 1.09	Detected in one groundwater sample (BH02)
Zinc	11.4 – 46.5	Detected in all three groundwater samples
Benzo(a)pyrene	<0.009 – 0.00931	Detected in one groundwater sample (BH02)
Pyrene	<0.015 – 0.0168	Detected in one groundwater sample (BH02)
TPH Aliphatic C21-C35	<10 – 31	Detected in one groundwater sample (BH02)

No cyanide, BTEX compounds, MTBE, TAME, PAHs other than those included above or short chain length TPH fractions were detected above the limit of reporting.

Groundwater analytical results reported concentrations of a number of metals (chromium, copper, lead, nickel and zinc) and benzo(a)pyrene in exceedance of the adopted WQS. It is noted the benzo(a)pyrene was detected at a concentration marginally above the limit of reporting and all analytes were recorded relatively marginally above their respective WQS screening values. No other exceedances were identified. The highest concentrations were detected in BH02, located in the northeast portion of Plot 1.

Given the nearest water bodies are located 300m to the northeast (300m) and 600m to the north (River Dove) and the range of concentrations detected, the reported impact on site is not considered to present unacceptable risks to down gradient surface water bodies hydraulically connected with groundwater beneath the site. The groundwater screening tables are included in Appendix H.

No volatile compounds were identified in groundwater therefore this exposure pathway was not assessed further.

6.6 WATER PIPEWORK

Based on the relatively low concentrations reported in the soil samples submitted as part of this investigation, the leaching of potential contaminants of concern in soil and subsequent permeation through the water pipework is considered to be low. However, further assessment in accordance with the local water supply provided would be required prior to determining the pipe material specification.

7 GROUND GAS ASSESSMENT

7.1 POTENTIAL GROUND GAS SOURCES

The Coal Authority (CA) interactive mapping service indicates the site is located within a Development High Risk Area due to the potential presence of shallow mine workings. There is recorded coal mining at approximately 60m beneath the site therefore former coal mining activities are considered to represent a moderate generation potential of ground gas source at the site.

Additionally, the Made Ground at the site contains relatively high organic matter content at a number of locations and is therefore also considered to represent a moderate level source of ground gas. A historical landfill is located 100m to the west from the site, which is also considered to be a potential source of ground gas, although the generation potential is considered to be low based on the type of waste.

7.2 GROUND GAS MONITORING RESULTS

A total of four ground gas monitoring events were undertaken between 2 June 2016 and 23 September 2016. Regional barometric pressure data measured at Leeds and Bradford weather station indicated the barometric pressure was relatively stable during the first, second and fourth sampling rounds and was falling during the third round. Monitoring results are summarised in Table 7-1 below.

Table 7-1 Summary of ground gas monitoring results

MONITORING POINT	METHANE (% V/V)		CARBON DIOXIDE (% V/V)		OXYGEN (% V/V)		FLOW (l/HR)	
	Min	Max	Min	Max	Min	Max	Min	Max
BH01	<0.01	<0.01	0.1	23.8	<0.1	20.5	-2.1	0.3
BH02	<0.01	<0.01	<0.01	9.2	11.9	20.7	0	0
BH03	<0.01	<0.01	<0.01	13.4	6.3	20.7	-6.1	0.7
BH04	<0.01	<0.01	<0.01	12.0	4.7	20.7	-1.5	2.2
BH05	<0.01	<0.01	<0.01	7.2	9.5	20.7	-5.5	0.7

Methane was not recorded in any of the boreholes during any of the four gas monitoring rounds. A maximum carbon dioxide concentration of 21.8%v/v was recorded in BH01. It is noted flow rates were generally low to negative.

The ground gas data are presented in Appendix G.

7.3 GROUND GAS RISK ASSESSMENT

A hazardous ground gas risk assessment has been carried out as part of this investigation in line with CIRIA Report C665, Assessing risk posed by hazardous ground gases to buildings (CIRIA, 2007). This assessment is based on the ground gas monitoring conducted on-site between June 2016 and July 2016. This risk assessment will be updated with the results from the fourth monitoring round in the final version of the report.

CIRIA publication C665 details the methods for assessing the ground gas regime at a site; it is reliant on the calculation of a Gas Screening Value (GSV) calculated as shown below:

→ $GSV = \text{Maximum steady carbon dioxide or methane concentration (\%)} / 100 \times \text{maximum steady flow rate (l/hr)}$

Based on the maximum carbon dioxide concentration (23.8 %v/v) and flow rate (2.2l/h) recorded, the GSV for the site is 0.524 l/hr. On this basis, the site classification corresponds to Characteristic Situation 2 (low risk), with the need for basic gas protection measures to be incorporated in to new buildings.

8

REVISED CONCEPTUAL SITE MODEL

Based on the preliminary CSM developed for the site and the outcome of the GQRA, the potential contaminant linkages identified are summarised in Table 8-1 below.

Table 8-1 Contaminant linkage summary

SOURCE	PATHWAYS	RECEPTOR	PROBABILITY OF EXPOSURE	POTENTIAL CONSEQUENCE	RISK RATING
Backfill	<ul style="list-style-type: none"> ■ Ingestion of soil; ■ Dermal contact with soil; and, ■ Inhalation of soil-derived dust. 	Construction Workers	Unlikely	Mild	Very Low
	Associated with any proposed landscaped areas where fill is present at the surface	Site workers	Unlikely	Mild	Very Low
	<ul style="list-style-type: none"> ■ Potable water supply pipes 	Pipes/future site users	Low likelihood	Mild	Low
Made Ground / Underlying coal workings – Ground Gas	<ul style="list-style-type: none"> ■ Upward migration and accumulation of ground gases <p>Associated with upward migration of ground gas and accumulation within enclosed spaces</p>	Buildings & Future residents/site workers	Low likelihood	Severe	Moderate

9

GEOTECHNICAL ASSESSMENT

9.1 INTRODUCTION

The Phase 1 report presented a review of the ground conditions encountered/anticipated from previously available information, which identified the following potential ground engineering constraints on Plot 1:

- Uncertainty around depth of fill;
- Missing records to verify that compaction was undertaken in the northeast of the plot;
- Insufficient data to assess aggressivity of fill to buried concrete; and,
- Limited groundwater level information.

The above constraints were generally related to gaps in the information. Following the ground investigation conducted in June 2016, further information has been obtained to allow these geotechnical risks and the ground engineering constraints to be revised and updated, as follows:

9.2 GEOTECHNICAL CONSTRAINTS TO THE DEVELOPMENT

Given the revised ground model, Plot 1 is likely to be subject to the following geotechnical constraints:

FILL WITHIN THE BACKFILLED OPENCAST MINE

The risks associated with developing backfilled opencast sites are well understood, as detailed within the BRE report FB75 '*Building on fill geotechnical aspects*', 3rd edition, 2015. The main risk to development is the total and differential settlement of the backfill due to the following factors:

- Loads imposed by the planned development;
- Self-weight; and/or,
- Inundation by infiltrating sources of water or rebounding groundwater after cessation of de-watering.

The magnitude of the settlement is related to the depth and the composition of the backfill.

A further common risk is the presence of obstructions within the backfill mainly because of un-controlled back filling.

As a result of the additional ground investigation carried out within Plot 1, the likelihood that the above risks will impact any future development has been assessed as follows:

1. **Depth of fill:** The additional ground investigation shows that the depth of fill across Plot 1 varies between 3.40 and 6.05 m bgl. From the cross sections through Plot 1 the depth of fill appears to be deeper in the south western part of the site. The base of the fill was proven using rotary coring, which encountered bedrock of mudstone and sandstone.

The risk that deeper areas of fill exist beneath Plot 1 is considered to be low.

Given the regional dip of strata, and thus the anticipated dip of the former opencast mine, the thickness of fill was anticipated to be less in the south, with the fill deepening towards the north. This does not appear to be in accordance with the records of opencast mining, which suggest that the opencast operations beneath Plot 1 were limited.

2. **Composition and compaction of the fill:** Additional particle size distribution (PSD) testing was carried out on samples taken during the additional Plot 1 ground investigation. Of the samples tested 80% fell within the Class 2C grading band (in accordance with the Highways Agency '*Specification for highways works*'), with the remaining 20% within the Class 2A and 2B grading band.

This is broadly in line with what was reported within the historical reports, which record that the fill materials used were generally classified as a Class 2C material, comprising silty mudstone, sandstone and unburnt colliery spoil. The remainder of material used to backfill the colliery is reported as being a mix of Class 1B, 2B and 6N materials.

The borehole logs and CPT records suggest that the material encountered is principally a granular material, with a percentage of high fine grained components. However, the PSD test results indicate that some of the material tested is a cohesive or fine grain-dominated material. Given the technique used to recover the samples for PSD testing, the material tested may be finer grained than it is in situ, leading to this discrepancy.

From the Mott MacDonald report, the fill is understood to have been generally placed in accordance with an engineering specification (although this specification has not been reviewed by WSP | Parsons Brinckerhoff). Compaction was noted as being conducted to a method specification, with validation compaction testing conducted. However, an area of uncontrolled fill was noted from the historical reports in the northern part of Plot 1, where no earthworks testing results were available. It is considered this related to an area where no testing was conducted, rather than an area that was not placed to the engineering specification.

Additional strength test data was obtained throughout Plot 1 from the ground investigation, including SPTs within the boreholes and static cone penetrometer tests (CPTs). The results from both inside and outside of the area of uncontrolled backfill were compared and this suggests that there is no apparent difference in the cone resistances and hence apparent strength between the two areas of fill at least at the locations where the cone tests were undertaken.

3. **Groundwater regime:** Groundwater monitoring was conducted between August 1993 and September 1996, following backfilling of the opencast mine. However, this monitoring was conducted whilst regional groundwater pumping was ongoing (to depress groundwater levels for the deeper mining). This is understood to have ceased in 2002. None of the piezometers used for the sequence of monitoring between 1993 and 1996 installed were located within Plot 1. The data from this monitoring indicates groundwater levels across the wider site between 90 and 130 m AOD.

Groundwater monitoring within the Made Ground on Plot 1 in 2003 (conducted on three occasions between 20 February 2003 and 28 March 2003) recorded groundwater levels between 2.93 m bgl (139.17 m AOD) and 3.90 m bgl (134.60 m AOD).

Groundwater monitoring as part of the 2016 ground investigation (conducted on three occasions between 6 June 2016 and 8 July 2016) included monitoring of groundwater within both the Made Ground and the coal measures. The monitoring within the coal measures strata (BH04) was recorded as being dry on all three monitoring occasion. The monitoring within the Made Ground recorded groundwater levels between 3.44 m bgl (134.95 m AOD) and 6.28 m bgl (133.54 m AOD).

The results from the recent ground investigation indicate similar (if not slightly deeper) groundwater levels within the Made Ground to those recorded in 2003 (towards the base of the Made Ground). This indicates that groundwater levels do vary and the potential exists for groundwater levels to fluctuate from those monitored recently. There is the potential for groundwater to rise higher than has been monitored, although significant rises are considered unlikely.

4. **Aggressivity of fill materials:** Colliery spoil and fill deriving from coal measures strata has the potential for high sulphate levels, leading to aggressive chemical conditions and attack on buried concrete. The historical testing carried out within Plot 1 has been reviewed and compared to additional sulphate testing carried out as part of the 2016 investigation.

The additional testing from within the back fill material indicates a Design Sulphate Class DS-1 and Aggressive Chemical Environment for Concrete (ACEC) class AC-4z., which is lower than that recommended from historical testing (DS-4 and AC-4 or 5). This variability should be further assessed as part of the design of buried concrete for the site.

5. **Obstructions within the fill materials:** A series of obstructions were encountered within the Made Ground during the 2016 ground investigation, resulting in refusal of the window sampling holes and CPTs before bedrock. Such obstructions could present a risk to below ground excavations and the construction of foundations, particularly piled foundations.

UNDERGROUND COAL MINING

The Phase 1 report (desk study) indicated that the site is underlain by deep coal workings, recorded by the Coal Authority as being between 60m and 340m bgl. Given these depths, deeper coal mining was not assessed by the 2016 ground investigation.

The potential for unrecorded shallow workings to be present towards the south of the site was identified in the Phase 1 report. These workings were interpreted as being up-dip of and pre-dating the opencast operations.

No evidence of shallow unrecorded mine workings was identified during the additional ground investigation carried out across Plot 1. Given the depth and location at which the previous unrecorded mine workings were recorded (between 2.00 and 3.00m bgl to the south of Plot 1), it is considered that if unrecorded shallow mining had occurred beneath Plot 1, these would have been excavated as part of the opencast operations.

However, the potential for unrecorded shallow mining cannot be fully ruled out, particularly out with the opencast boundary.

CALORIFIC VALUE TESTING

Given the site has been backfilled with colliery spoil type material there is potentially a theoretical risk of spontaneous combustion from residual coal present in the spoil, primarily associated with either microbial activity or areas where future underground utilities, which may emit heat, may be buried. The Desk Study⁵ identified that limited calorific value testing had been taken on samples. As part of this investigation three samples were sent for caloric value testing, the results are provided in Table 9-1.

Table 9-1 Calorific testing

SAMPLE	CAL VAL (KJ/KG)
BH01 (0.1-0.15m bgl)	5800
BH02 (0.80 – 0.90 mbgl)	0
BH05 (1.5 – 1.6m bgl)	641

BRE Information Paper entitled 'Fire and Explosion Hazards Associated with Redevelopment of Contaminated Land, states that material with a combustion of more than 10,000 Kj/Kg is likely to be combustible and less than 2,000 Kj/Kg highly unlikely to be so. Limited coal content has been identified within the soil logs and given the levels identified the risk of spontaneous combustion in the spoil is considered to be low.

10 POTENTIAL DEVELOPMENT CONSTRAINTS AND MITIGATION MEASURES

The potential land quality and geotechnical constraints identified for the development of the site for commercial end use are detailed in Table 10-1 and Table 10-2.

Table 10-1 Potential constraints and proposed mitigation measures

CONSTRAINT	COMMENTARY
Land quality	
Movement of soil and waste generation	Should any movement of soil be required as part of the earthworks, a Materials Management Plan shall be prepared in order to set out the steps to be employed when placing and disposing of materials generated during the earthworks activities during the project. In the event material is to be excavated and requires off-site disposal, further analysis may be required to comply with the relevant disposal standards and regulatory requirements
Risk to built environment and human health – Generation of ground gas	Based on the site classification (Characteristic Situation 2), basic ground gas protection measures shall be put in place.

Table 10-2 Updated ground engineering/geotechnical constraints

CONSTRAINT	COMMENTARY
Deep fill	Variation in the depth of the backfill across the site has the potential to cause settlement issues for any proposed development. The additional investigation results indicate that fill material is generally deeper than anticipated beneath Plot 1, particularly towards the south.
Fill material	An area of uncontrolled backfilling was noted on Plot 1, where no compaction test data/records were available. The additional investigation results indicate that fill material within this unrecorded area has similar composition and strength properties to that out with the area of uncontrolled fill. This has been interpreted as indicating that the area of uncontrolled fill was likely to have been placed to the same engineering specification as the rest of the fill, but not tested or the test results have been lost. The potential for spontaneous combustion of unburnt colliery spoil within the backfill was noted as a potential constraint. Additional testing is currently being undertaken with which this risk can be assessed. Obstructions within the fill material were encountered, which may present a risk to excavations and the construction of foundations, particularly piled foundations.
Aggressively of fill material	Additional testing from within the backfill material it indicates a Design Sulphate Class DS-1 and Aggressive Chemical Environment for Concrete (ACEC) class AC-4z. This is generally lower than from previous investigations and should be further assessed during the design of below ground concrete.
Groundwater regime	Uncertainties and variation in the groundwater regime beneath the site were identified. Groundwater monitoring within the backfilled Made Ground recorded groundwater levels between 3.44 m bgl (134.95 m AOD) and 6.28 m bgl (133.54 m AOD), which are slightly lower than those recorded since the regional pumping of groundwater ceased. Monitoring the coal measures strata (BH04) recorded no groundwater during the three monitoring rounds, indicating that the groundwater within the Made Ground is likely to relate to localised perched bodies, rather than the regional groundwater table.

CONSTRAINT	COMMENTARY
Unrecorded shallow mining	<p>The potential risk of unrecorded shallow mining outwith the opencast mine boundaries to affect Plot 1 have been reduced as:</p> <ul style="list-style-type: none">■ There is no evidence of shallow mine workings recorded during the additional ground investigation; and,■ the extent of opencast workings/deeper Made Ground was greater than previously anticipated, indicating that unrecorded shallow workings are likely to have been removed as part of the opencast operations.

11 CONCLUSIONS

11.1 GROUND INVESTIGATION

A total of five boreholes (BH01 to BH05) and eleven CPTs (CPT01 – CPT11) were advanced to depths of between 2.44mbgl (BH01) and 21.00mbgl (BH04). The ground model sequence comprises topsoil, underlain by Made Ground (clayey gravel or gravelly clay with rare coal fragments) to depths of between 3.40mbgl and 6.05mbgl, underlain by mudstone or sandstone of the Pennine Middle Coal Measures Formation, with thickness of Made Ground increasing from the north to the south of the site. Groundwater was identified in the northern portion of the site only at elevations between 134.04mAOD and 134.90mAOD within the Made Ground. The groundwater flow direction was estimated to be in a north-easterly direction.

11.2 LAND QUALITY ASSESSMENT

Soil and groundwater characterisation was undertaken for the identified potential contaminants of concern. A generic quantitative risk assessment (GQRA) was undertaken to assess potential health risks to site users, based on the proposed commercial end use, and risks to controlled waters. The GQRA concluded the following.

- Reported soil concentrations are considered to present an acceptable health risk to future site users in the context of a commercial development.
- Reported groundwater concentrations are not considered likely to present an unacceptable risk to down-gradient surface water bodies hydraulically connected with groundwater beneath the site.

A ground gas risk assessment was conducted based on the three monitoring rounds conducted between June 2016 and July 2016. It is noted a fourth monitoring round is pending, which will be included in the final version of this report. The ground gas risk assessment concluded the following.

- Based on the maximum carbon dioxide concentration and flow rate recorded during the ground gas monitoring, the site classification corresponds to Characteristic Situation 2 (low risk) with the need to incorporate basic gas protection measures within new buildings.

11.3 GEOTECHNICAL ASSESSMENT

The additional investigation was able to further assess the depth of fill across Plot 1 which was shown to vary between 3.40 and 6.05 m bgl. The material forming the backfill is generally a clayey gravel or gravelly clay, which is in line with the historical reports. Comparison of material strength data from inside and outside the area of uncontrolled fill indicates that the materials are broadly similar strengths. From additional testing within the back fill material it indicates that the material requires a Design Sulphate Class DS-1 and Aggressive Chemical Environment for Concrete (ACEC) class AC-4z.

Shallow unrecorded mine workings have been located to the south of Plot 1 during historical ground investigations. From the additional ground investigation carried out at the borehole locations undertaken across Plot 1 no evidence of shallow unrecorded mine working was noted.

The additional ground investigation conducted has allowed the geotechnical/ground engineering constraints identified as part of the Phase 1 (desk study) to be further assessed, as follows:

- Settlement of the backfilled opencast materials:

- The depth/variation in Made Ground associated with the backfilled opencast materials has been further assessed, which will allow settlement analysis to be conducted for future proposed development.
 - Groundwater levels were generally recorded towards the base of the Made Ground. Given that the Made Ground has been placed for approximately 20 years, and groundwater pumping has stopped, it is considered unlikely that groundwater levels will rise significantly in the future, reducing the potential for inundation settlements.
- The potential for spontaneous combustion of unburnt colliery spoil within the backfill:
- Additional testing is currently being undertaken and this risk will be assessed once the results are available.
- The potential for the collapse of unrecorded shallow mining out with the opencast boundaries to cause ground instability within the development plot:
- Given that no evidence of shallow mine workings was recorded during the additional ground investigation; and, the extent of opencast workings/deeper Made Ground was greater than previously anticipated, it is considered that if unrecorded shallow workings did exist beneath Plot 1 they would likely have been removed as part of the opencast operations.

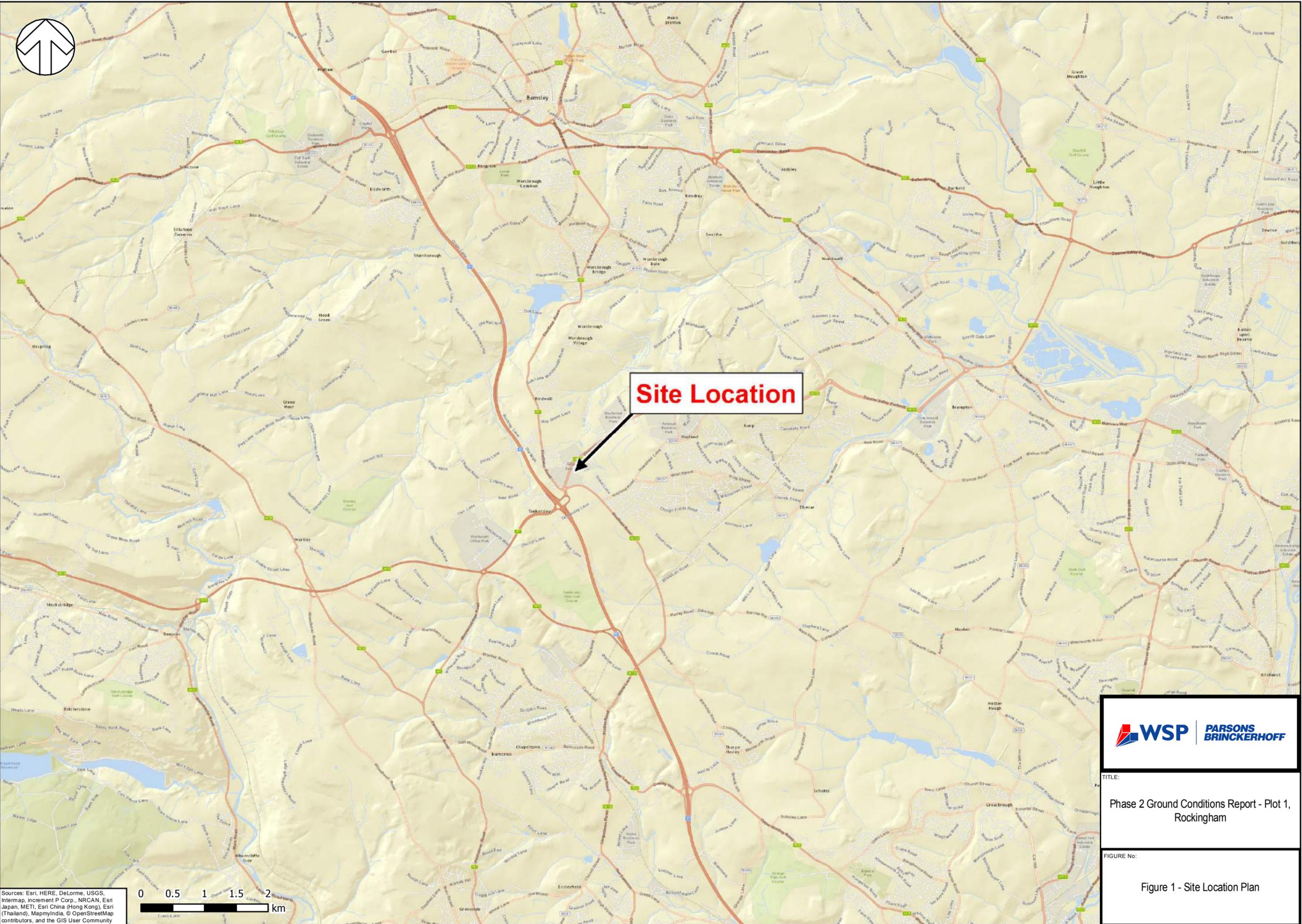
One additional geotechnical/ground engineering constraint was identified from the additional ground investigation, relating to obstructions within the Made Ground and the potential constraint to proposed below ground excavations and foundations.

BIBLIOGRAPHY

- Arup (2004). Ground Engineering for proposed Masterplan.
- BSI (2011) Investigation of potentially contaminated sites - Code of practice', British Standard BS EN 10175 2011, British Standards Institution, 2011.
- CIRIA C665 (2007) Assessing risks posed by hazardous ground gases to buildings, Wilson, S; Olivers S; Mallett, H; Hutchings, Card, G, 2007
- Environment Agency (2004) Model Procedures for the Management of Land Contamination, Environment Agency, 2004.
- Mott MacDonald (2004), Rockingham Colliery Stage 2 Geotechnical & Geo-Environmental Site Assessment.
- Subsurface North East Ltd (2014). Ground Investigation at A61 Birdwell Junction Improvement, Tankersley.
- Symonds (2002), Preliminary Site Evaluation
- WSP | Parsons Brinckerhoff (2016). Phase 1 Ground Conditions Report, Land at Rockingham, Barnsley. Report reference 70018922-001.

Appendix A

FIGURES



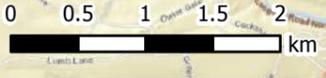
Site Location

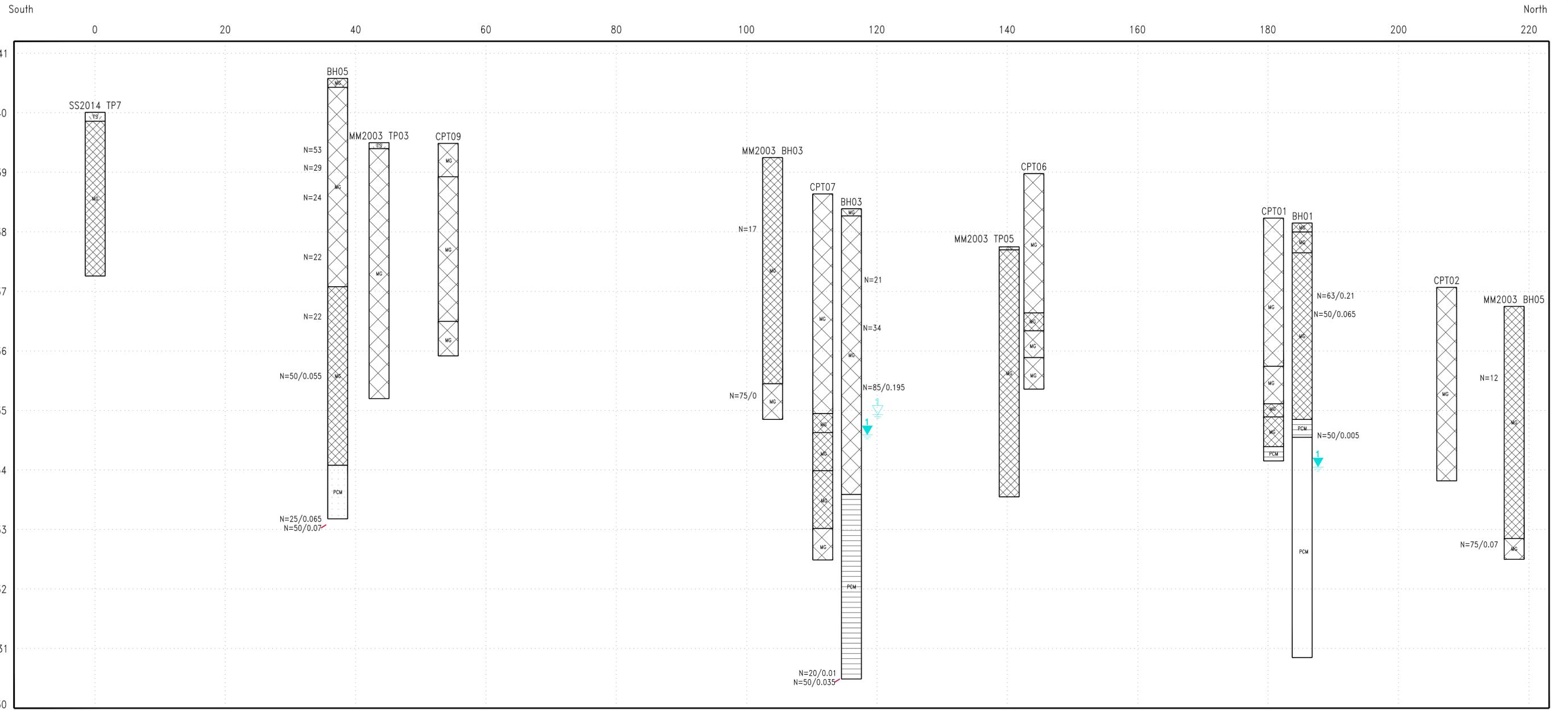


TITLE:
Phase 2 Ground Conditions Report - Plot 1,
Rockingham

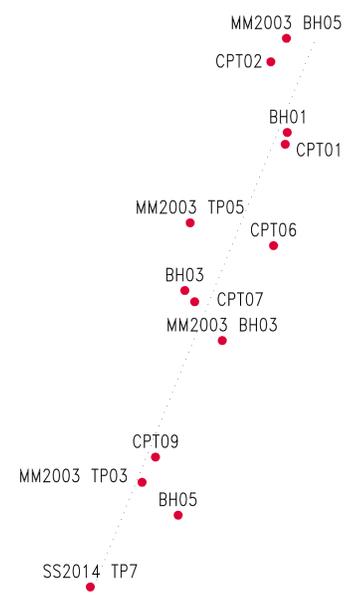
FIGURE No:
Figure 1 - Site Location Plan

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China Hong Kong, Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community





MG = MADE GROUND
 PCM = PENNINE COAL MEASURES GROUP
 TS = TOPSOIL



SUBSURFACE SECTION

Client: Homes and Communities Agency
 Project: Rockingham Development
 Number: 70018922
 Drawing: Figure 3: Geological Cross Section

Appendix B

LIMITATIONS

GENERAL

1. WSP UK Limited has prepared this report solely for the use of the Client and those parties with whom a warranty agreement has been executed, or with whom an assignment has been agreed and outlined in the body of the report.
2. Unless explicitly agreed otherwise, in writing, this report has been prepared under WSP UK Limited standard Terms and Conditions as included within our proposal to the Client.
3. Project specific appointment documents may be agreed at our discretion and a charge may be levied for both the time to review and finalise appointments documents and also for associated changes to the appointment terms. WSP UK Limited reserves the right to amend the fee should any changes to the appointment terms create an increase risk to WSP UK Limited.
4. The report needs to be considered in the light of the WSP UK Limited proposal and associated limitations of scope. The report needs to be read in full and isolated sections cannot be used without full reference to other elements of the report and any previous works referenced within the report.

PHASE 1 GEO ENVIRONMENTAL AND PRELIMINARY RISK ASSESSMENTS

Coverage: *This section covers reports with the following titles or combination of titles: phase 1; desk top study; geo environmental assessment; development appraisal; preliminary environmental risk assessment; constraints report; due diligence report; geotechnical development review; environmental statement; environmental chapter; project scope summary report (PSSR), program environmental impact report (PEIR), geotechnical development risk register; and, baseline environmental assessment.*

5. The works undertaken to prepare this report comprised a study of available and easily documented information from a variety of sources (including the Client), together with (where appropriate) a brief walk over inspection of the Site and correspondence with relevant authorities and other interested parties. Due to the short timescales associated with these projects responses may not have been received from all parties. WSP UK Limited cannot be held responsible for any disclosures that are provided post production of our report and will not automatically update our report.
6. The opinions given in this report have been dictated by the finite data on which they are based and are relevant only for the purpose for which the report was commissioned. The information reviewed should not be considered exhaustive and has been accepted in good faith as providing true and representative data pertaining to site conditions. Should additional information become available which may affect the opinions expressed in this report, WSP UK Limited reserves the right to review such information and, if warranted, to modify the opinions accordingly.
7. It should be noted that any risks identified in this report are perceived risks based on the information reviewed. Actual risks can only be assessed following intrusive investigations of the site.
8. WSP UK Limited does not warrant work / data undertaken / provided by others.

INTRUSIVE INVESTIGATION REPORTS

Coverage: *The following report titles (or combination) may cover this category of work: geo environmental site investigation; geotechnical assessment; GIR (Ground Investigation reports); preliminary environmental and geotechnical risk assessment; and, geotechnical risk register.*

9. The investigation has been undertaken to provide information concerning either:
 - i. The type and degree of contamination present at the site in order to allow a generic quantitative risk assessment to be undertaken; or
 - ii. Information on the soil properties present at the site to allow for geotechnical development constraints to be considered.
10. The scope of the investigation was selected on the basis of the specific development and land use scenario proposed by the Client and may be inappropriate to another form of development or scheme. If the development layout was not known at the time of the investigation the report findings may need revisiting once the development layout is confirmed.
11. For contamination purposes, the objectives of the investigation are limited to establishing the risks associated with potential contamination sources with the potential to cause harm to human health, building materials, the environment (including adjacent land), or controlled waters.
12. For geotechnical investigations the purpose is to broadly consider potential development constraints associated with the physical property of the soils underlying the site within the context of the proposed future or continued use of the site, as stated within the report.
13. The amount of exploratory work, soil property testing and chemical testing undertaken has necessarily been restricted by various factors which may include accessibility, the presence of services; existing buildings; current site usage or short timescales. The exploratory holes completed assess only a small percentage of the area in relation to the overall size of the Site, and as such can only provide a general indication of conditions.
14. The number of sampling points and the methods of sampling and testing do not preclude the possible existence of contamination where concentrations may be significantly higher than those actually encountered or ground conditions that vary from those identified. In addition, there may be exceptional ground conditions elsewhere on the site which have not been disclosed by this investigation and which have therefore not been taken into account in this report.
15. The inspection, testing and monitoring records relate specifically to the investigation points and the timeframe that the works were undertaken. They will also be limited by the techniques employed. As part of this assessment, WSP UK Limited has used reasonable skill and care to extrapolate conditions between these points based upon assumptions to develop our interpretation and conclusions. The assumption made in forming our conclusions is that the ground and groundwater conditions (both chemically and physically) are the same as have been encountered during the works undertaken at the specific points of investigation. Conditions can change between investigation points and these interpretations should be considered indicative.
16. The risk assessment and opinions provided are based on currently available guidance relating to acceptable contamination concentrations; no liability can be accepted for the retrospective effects of any future changes or amendments to these values. Specific assumptions associated with the WSP UK Limited risk assessment process have been outlined within the body or associated appendix of the report.
17. Additional investigations may be required in order to satisfy relevant planning conditions or to resolve any engineering and environmental issues.
18. Where soil contamination concentrations recorded as part of this investigation are used for commentary on potential waste classification of soils for disposal purposes, these should be classed as indicative only. Due consideration should be given to the variability of contaminant

concentrations taken from targeted samples versus bulk excavated soils and the potential variability of contaminant concentrations between sampling locations. Where major waste disposal operations are considered, targeted waste classification investigations should be designed.

19. The results of the asbestos testing are factually reported and interpretation given as to how this relates to the previous use of the site, the types of ground encountered and site conceptualisation. This does not however constitute a formal asbestos assessment. These results should be treated cautiously and should not be relied upon to provide detailed and representative information on the delineation, type and extent of bulk ACMs and / or trace loose asbestos fibres within the soil matrix at the site.
20. If costs have been included in relation to additional site works, and / or site remediation works these must be considered as indicative only and must be confirmed by a qualified quantity surveyor.

EUROCODE 7: GEOTECHNICAL DESIGN

21. On 1st April 2010, BS EN 1997-1:2004 (Eurocode 7: Geotechnical Design – Part 1) became the mandatory baseline standard for geotechnical ground investigations.
22. In terms of geotechnical design for foundations, slopes, retaining walls and earthworks, EC7 sets guidance on design procedures including specific guidance on the numbers and spacings of boreholes for geotechnical design, there are limits to methods of ground investigation and the quality of data obtained and there are also prescriptive methods of assessing soil strengths and methods of design. Unless otherwise explicitly stated, the work has not been undertaken in accordance with EC7. A standard geotechnical interpretative report will not meet the requirements of the Geotechnical Design Report (GDR) under Eurocode 7. The GDR can only be prepared following confirmation of all structural loads and serviceability requirements. The report is likely to represent a Ground Investigation Report (GIR) under the Eurocode 7 guidance.

DETAILED QUANTITATIVE RISK ASSESSMENTS AND REMEDIAL STRATEGY REPORTS

23. These reports build upon previous report versions and associated notes. The scope of the investigation, further testing and monitoring and associated risk assessments were selected on the basis of the specific development and land use scenario proposed by the Client and may not be appropriate to another form of development or scheme layout. The risk assessment and opinions provided are based on currently available approaches in the generation of Site Specific Assessment Criteria relating to contamination concentrations and are not considered to represent a risk in a specific land use scenario to a specific receptor. No liability can be accepted for the retrospective effects of any future changes or amendments to these values, associated models or associated guidance.
24. The outputs of the Detailed Quantitative Risk Assessments are based upon WSP UK Limited manipulation of standard risk assessment models. These are our interpretation of the risk assessment criteria.
25. Prior to adoption on site they will need discussing and agreeing with the Regulatory Authorities prior to adoption on site. The regulatory discussion and engagement process may result in an alternative interpretation being determined and agreed. The process and timescales associated with the Regulatory Authority engagement are not within the control of WSP UK Limited. All costs and programmes presented as a result of this process should be validated by a quantity surveyor and should be presumed to be indicative.

GEOTECHNICAL DESIGN REPORT (GDR)

26. The GDR can only be prepared following confirmation of all structural loads and serviceability requirements. All the relevant information needs to be provided to allow for a GDR to be produced.

MONITORING (INCLUDING REMEDIATION MONITORING REPORTS)

27. These reports are factual in nature and comprise monitoring, normally groundwater and ground gas and data provided by contractors as part of an earthworks or remedial works.

The data is presented and will be compared with assessment criteria

Appendix C

EXPLORATORY HOLE RECORDS

APPENDIX C-1

BOREHOLE LOGS

WSP

Telephone:
Fax:

BOREHOLE LOG

Hole No.

BH01

Project

Phase 2 Ground Conditions Report - Plot 1, Land at Rockingham, Barnsley

Sheet

1 of 1

Job No

70018922

Client

Homes and Communities Agency

Date

24-05-16
26-05-16

Contractor / Driller

Geocore

Method/Plant Used

Commacchio 205

Logged By

AH

Co-Ordinates (NGR)

E 435105.349
N 400629.759

Ground Level (m AOD)

138.150

SAMPLES & TESTS

STRATA

Depth	Type	Test Result	PID (ppmV)	HSV (kN/m ²)	P Pen (kN/m ²)	Water	Elev. (mAOD)	Depth (Thickness)	Description	Legend	Geology	Install / Backfill
0.00-0.15	B		<1				138.00	0.15	MADE GROUND. Grass over soft dark grey slightly gravelly silty clay with frequent rootlets. Gravel is angular fine to coarse of coal and mudstone (TOPSOIL).		MG	
0.00-0.00	EW		<1			137.65	0.50					
0.10-0.15	ES								MADE GROUND. Firm grey friable gravelly CLAY. Gravel is angular fine to coarse mustone.		MG	
0.20-0.60	B											
0.40-0.50	ES								MADE GROUND. Stiff grey gravelly CLAY. Gravel is angular fine to coarse mudstone.		MG	
1.00	SPT	4,17,8 5,50 N=63/ 0.21(S)	<1			136.65	1.50					
1.00-1.10	ES								MADE GROUND. Stiff grey gravelly CLAY. Gravel is angular fine to coarse mudstone.		MG	
1.50	SPT	50 N=50/ 0.065(S)										
3.60	SPT	15,10,50 N=50/ 0.005(S)					134.75	3.40	Light grey MUDSTONE. 3.40 - 3.60 m bgl Fractured		PCM	
							130.85	7.30				

Boring Progress

Water Strikes

Date	Time	Depth	Casing Dpt	Dia. (mm)	Water Dpt	Date	Time	Strike	Minutes	Standing	Casing
								4.10			
Chiselling				Water Added		General Remarks Window sampled from 0 - 1.5m bgl. Hole cleared out from 1.5 - 1.6m bgl using open hole drilling techniques. Hole advanced using rotary coring with air flush from 1.6 - 3.6m bgl. Open holed from 3.6 - 7.3m bgl.					
From	To	Hours	Tool	From	To						

Scale 1:62.5

Notes: All dimensions in metres. Logs should be read in accordance with the provided Key. Descriptions are based on visual and manual identification.

		BOREHOLE LOG			Hole No. BH02
WSP Telephone: Fax:		Project Phase 2 Ground Conditions Report - Plot 1, Land at Rockingham, Barnsley			Sheet 1 of 1
Job No 70018922		Client Homes and Communities Agency			Date 24-05-16 26-05-16
Contractor / Driller Geocore		Method/Plant Used Commacchio 205	Logged By AH	Co-Ordinates (NGR) E 435125.975 N 400583.473	Ground Level (m AOD) 139.815

SAMPLES & TESTS							STRATA					Install / Backfill
Depth	Type	Test Result	PID (ppmV)	HSV (kN/m ²)	P Pen (kN/m ²)	Water	Elev. (mAOD)	Depth (Thickness)	Description	Legend	Geology	Dia. 50 mm
0.00-0.10	EW		<1				139.64	0.18	MADE GROUND. Grass over soft friable dark brown organic slightly gravelly silt with frequent rootlets. Gravel is angular to subangular fine to coarse coal, mudstone and sandstone.		MG	
0.10-0.20	ES						139.12	0.70	MADE GROUND. Grey clayey angular fine to coarse gravel of mudstone with rare coal fragments.		MG	
0.80-0.90	ES		<1						MADE GROUND. Stiff grey very gravelly CLAY with low cobble content. Gravel is angular fine to coarse. Cobbles are angular of mudstone.		MG	
1.20	SPT	7,12,10 16,10,8 N=44(S)										
1.80-1.90	ES		<1					(2.30)			MG	
2.00	SPT	6,8,8 7,7,8 N=30(S)										
3.00	SPT	4,8,6 7,8,9 N=30(S)					136.82	3.00	MADE GROUND. Weak grey fractured sandstone with some coal fragments .		MG	
4.00	SPT	5,12,8 12,12,50 N=82/ 0.295(S)						(3.05)			MG	
6.30	SPT	6,15,30 21 N=51/ 0.085(S)					133.77	6.05				
							133.52	6.30	Grey MUDSTONE.		PCM	
								(2.70)	Grey MUDSTONE.		PCM	
							130.82	9.00				

Boring Progress						Water Strikes					
Date	Time	Depth	Casing Dpt	Dia. (mm)	Water Dpt	Date	Time	Strike	Minutes	Standing	Casing
								4.60			
Chiselling			Water Added			General Remarks Window sampled from 0 - 4m bgl. Hole cleared out from 4 - 4.3m bgl using open hole drilling techniques. Hole advanced using rotary coring with air flush from 4.3 - 6.3m bgl. Open holed from 6.3 - 9m bgl.					
From	To	Hours	Tool	From	To						
Scale 1:62.5		Notes: All dimensions in metres. Logs should be read in accordance with the provided Key. Descriptions are based on visual and manual identification.									

08 WSP BH LOG 70018922 - ROCKINGHAM - ROCKINGHAM WITH SAMPLES.GPJ WSPTEMPLATE1.03.GDT 10/10/16

BOREHOLE LOG

Hole No. **BH03**

WSP

Project

Sheet

Telephone:
Fax:

Phase 2 Ground Conditions Report - Plot 1, Land at
Rockingham, Barnsley

1 of 1

Job No
70018922

Client

Homes and Communities Agency

Date
24-05-16
25-05-16

Contractor / Driller
Geocore

Method/Plant Used
Commacchio 205

Logged By
AH

Co-Ordinates (NGR)
E 435067.038
N 400570.651

Ground Level (m AOD)
138.389

SAMPLES & TESTS							STRATA					Install / Backfill
Depth	Type	Test Result	PID (ppmV)	HSV (kN/m ²)	P Pen (kN/m ²)	Water	Elev. (mAOD)	Depth (Thickness)	Description	Legend	Geology	Dia. 50 mm
0.00-0.00	EW						138.27	0.12	MADE GROUND. Soft friable dark brown slightly gravelly CLAY with frequent rootlets. Gravel is subangular to angular fine to coarse mudstone (TOPSOIL).		MG	
0.50-1.00	B							MADE GROUND. Grey very clayey angular fine to coarse mudstone and sandstone GRAVEL. Cobbles are angular of sandstone.				
1.20	SPT	5.44 5.66 N=21(S)										
2.00	SPT	4.67 13.68 N=34(S)						(4.68)			MG	
2.10-2.20	D											
3.00	SPT	7.1,9 22,50 N=81/ 0.195(S)										
							133.59	4.80	Fractured grey and brown MUDSTONE.			
								(3.10)			PCM	
7.80	SPT	20 N=20/ 0.01(S)					130.49	7.90				
7.90	SPT	50 N=50/ 0.035(S)										

08 WSP BH LOG 70018922 - ROCKINGHAM - ROCKINGHAM WITH SAMPLES.GPJ WSPTEMPLATE1.03.GDT 10/10/16

Boring Progress						Water Strikes					
Date	Time	Depth	Casing Dpt	Dia. (mm)	Water Dpt	Date	Time	Strike	Minutes	Standing	Casing
						25-05-16		3.80	20	3.46	1.00
Chiselling			Water Added			General Remarks Window sampled from 0 - 3.3m bgl. Hole advanced from 3.3 - 4.8m bgl using open hole drilling techniques. Hole advanced using rotary coring with air flush from 4.8 - 7.9m bgl.					
From	To	Hours	Tool	From	To						
Scale 1:62.5		Notes: All dimensions in metres. Logs should be read in accordance with the provided Key. Descriptions are based on visual and manual identification.									

BOREHOLE LOG

Hole No. **BH04**

WSP

Telephone:
Fax:

Project

Phase 2 Ground Conditions Report - Plot 1, Land at Rockingham, Barnsley

Sheet

1 of 3

Job No

70018922

Client

Homes and Communities Agency

Date

24-05-16
25-05-16

Contractor / Driller

Geocore

Method/Plant Used

Commacchio 205

Logged By

AH

Co-Ordinates (NGR)

E 435107.447
N 400511.937

Ground Level (m AOD)

141.405

SAMPLES & TESTS

STRATA

Install / Backfill

Dia. 50 mm

Depth	Type	Test Result	PID (ppmV)	HSV (kN/m ²)	P Pen (kN/m ²)	Water	Elev. (mAOD)	Depth (Thickness)	Description	Legend	Geology
0.10-0.20	ES		<1				141.31	0.10	MADE GROUND. Grass over soft friable dark grey slightly gravelly CLAY with frequent rootlets. Gravel is angular to subangular fine and coarse of sandstone coal, clinker and mudstone (TOPSOIL). MADE GROUND. Grey slightly clayey slightly sand fine to coarse mudstone GRAVEL with rare coal fragments.		MG
0.50-1.00	B						(1.70)				
1.00-2.00	B								MADE GROUND. Grey clayey fine to coarse mudstone and sandstone GRAVEL.		MG
1.20	SPT	3.4,8 11.8,14 N=41(S)					139.61	1.80			
2.00	SPT	3.7,9 6.6,6 N=27(S)							MADE GROUND. Grey clayey fine to coarse mudstone and sandstone GRAVEL.		MG
2.50-2.60	ES		<1								
3.00	SPT	4.6,6 7,10,10 N=33(S)							MADE GROUND. Grey clayey fine to coarse mudstone and sandstone GRAVEL.		MG
3.70	SPT	18,8,6 6,4,6 N=22(S)						(4.20)			
4.20-4.30	D								MADE GROUND. Grey clayey fine to coarse mudstone and sandstone GRAVEL.		MG
4.90	SPT	5.8,6 8,8,8 N=30(S)									
5.90	SPT	10,28,35 50 N=85/ 0.125(S)					135.41	6.00	Grey occasionally orange brown fractured MUDSTONE.		PCM
								(3.10)			PCM
9.10	SPT	25 N=25/ 0.035(S)					132.31	9.10	Grey MUDSTONE.		PCM

Boring Progress

Water Strikes

Date	Time	Depth	Casing Dpt	Dia. (mm)	Water Dpt	Date	Time	Strike	Minutes	Standing	Casing
Chiselling				Water Added							
From	To	Hours	Tool	From	To	General Remarks					
						Window sampled from 0 to 6m bgl. Hole cleared out the following day from 0 - 6.1m bgl using open hole drilling techniques. Hole advanced using rotary coring with air flush 6.1 - 9.1m bgl. Open holed from 9.1 - 21m bgl.					

Scale 1:62.5

Notes: All dimensions in metres. Logs should be read in accordance with the provided Key. Descriptions are based on visual and manual identification.



WSP

Telephone:
Fax:

BOREHOLE LOG

Hole No.

BH04

Project

Phase 2 Ground Conditions Report - Plot 1, Land at Rockingham, Barnsley

Sheet

2 of 3

Job No

70018922

Client

Homes and Communities Agency

Date

24-05-16
25-05-16

Contractor / Driller

Geocore

Method/Plant Used

Commacchio 205

Logged By

AH

Co-Ordinates (NGR)

E 435107.447
N 400511.937

Ground Level (m AOD)

141.405

SAMPLES & TESTS

STRATA

Depth	Type	Test Result	PID (ppmV)	HSV (kN/m ²)	P Pen (kN/m ²)	Water	Elev. (mAOD)	Depth (Thickness)	Description	Legend	Geology	Install / Backfill
												Dia. 50 mm
9.35	SPT	50 N=50/ 0.04(S)							Grey MUDSTONE. (continued)			
								(11.90)				PCM

Boring Progress

Water Strikes

Date	Time	Depth	Casing Dpt	Dia. (mm)	Water Dpt	Date	Time	Strike	Minutes	Standing	Casing
Chiselling				Water Added		General Remarks Window sampled from 0 to 6m bgl. Hole cleared out the following day from 0 - 6.1m bgl using open hole drilling techniques. Hole advanced using rotary coring with air flush 6.1 - 9.1m bgl. Open holed from 9.1 - 21m bgl.					
From	To	Hours	Tool	From	To						

Scale 1:62.5

Notes: All dimensions in metres. Logs should be read in accordance with the provided Key. Descriptions are based on visual and manual identification.



WSP

Telephone:
Fax:

BOREHOLE LOG

Hole No.

BH04

Project

Phase 2 Ground Conditions Report - Plot 1, Land at Rockingham, Barnsley

Sheet

3 of 3

Job No

70018922

Client

Homes and Communities Agency

Date

24-05-16
25-05-16

Contractor / Driller

Geocore

Method/Plant Used

Commacchio 205

Logged By

AH

Co-Ordinates (NGR)

E 435107.447
N 400511.937

Ground Level (m AOD)

141.405

SAMPLES & TESTS

STRATA

Install / Backfill

Dia. 50 mm

Depth	Type	Test Result	PID (ppmV)	HSV (kN/m ²)	P Pen (kN/m ²)	Water	Elev. (mAOD)	Depth (Thickness)	Description	Legend	Geology	Install / Backfill
							120.41	21.00	Grey MUDSTONE. (continued)		PCM	

Boring Progress

Water Strikes

Date	Time	Depth	Casing Dpt	Dia. (mm)	Water Dpt	Date	Time	Strike	Minutes	Standing	Casing
Chiselling				Water Added		General Remarks Window sampled from 0 to 6m bgl. Hole cleared out the following day from 0 - 6.1m bgl using open hole drilling techniques. Hole advanced using rotary coring with air flush 6.1 - 9.1m bgl. Open holed from 9.1 - 21m bgl.					
From	To	Hours	Tool	From	To						

Scale 1:62.5

Notes: All dimensions in metres. Logs should be read in accordance with the provided Key. Descriptions are based on visual and manual identification.

WSP

Telephone:
Fax:

BOREHOLE LOG

Hole No.

BH05

Project

Phase 2 Ground Conditions Report - Plot 1, Land at Rockingham, Barnsley

Sheet

1 of 1

Job No

70018922

Client

Homes and Communities Agency

Date

24-05-16
25-05-16

Contractor / Driller

Geocore

Method/Plant Used

Commacchio 205

Logged By

AH

Co-Ordinates (NGR)

E 435064.477
N 400486.729

Ground Level (m AOD)

140.582

SAMPLES & TESTS

STRATA

Depth	Type	Test Result	PID (ppmV)	HSV (kN/m ²)	P Pen (kN/m ²)	Water	Elev. (mAOD)	Depth (Thickness)	Description	Legend	Geology	Install / Backfill
												Dia. 50 mm
0.05-0.10	ES		<1				140.43	0.15	MADE GROUND. Soft dark brown slightly gravelly CLAY with frequent rootlets. Gravel is angular to subangular fine to coarse of sandstone and mudstone.		MG	
0.30-0.35	ES		<1									
0.60-0.70	D								MADE GROUND. Grey slightly clayey sandy angular fine to coarse gravel of mudstone. Cobbles are angular of mudstone.		MG	
1.00	SPT	5,6,6 6,6,35 N=53(S)										
1.00-2.00	B		<1					(3.35)			MG	
1.50	SPT	11,6,5 5,12,7 N=29(S)										
1.50-1.60	ES		<1								MG	
2.00	SPT	4,7,7 5,6,6 N=24(S)										
2.10-2.20	ES										MG	
3.00	SPT	4,6,5 5,6,6 N=22(S)					137.08	3.50				
3.60-3.80	D								MADE GROUND. Stiff dark brown and grey mottled CLAY.		MG	
4.00	SPT	2,3,4 5,6,7 N=22(S)						(1.90)				
5.00	SPT	6,21,50 N=50/ 0.055(S)					135.18	5.40	Fractured yellow SANDSTONE.		PCM	
7.40	SPT	25 N=25/ 0.065(S)						(2.10)				
7.50	SPT	50 N=50/ 0.07(S)					133.08	7.50				

Boring Progress

Water Strikes

Date	Time	Depth	Casing Dpt	Dia. (mm)	Water Dpt	Date	Time	Strike	Minutes	Standing	Casing
Chiselling				Water Added							
From	To	Hours	Tool	From	To	General Remarks					
						Window sampled from 0 to 4m bgl. Hole advanced from 4 - 5.4m bgl using open hole drilling techniques. Hole advanced using rotary coring with air flush from 5.4 - 7.5m bgl.					

Scale 1:62.5

Notes: All dimensions in metres. Logs should be read in accordance with the provided Key. Descriptions are based on visual and manual identification.

APPENDIX C-2

CPT RECORDS

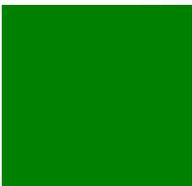
ROCKINGHAM BUSINESS PARK

SOIL INVESTIGATION

CPT REPORT

Cone Penetration Test
Piezocone Test
Standard Data Interpretation

Project Ref.: P-106412-1



PROJECT:	Rockingham Business Park
-----------------	--------------------------

CLIENT:	WSP Group
----------------	-----------

FIELDWORK

CPT Rig	17.9 tonne track-truck mounted CPT unit (UK20)
Date Fieldwork Started	24 th May 2016
Date Fieldwork Completed	24 th May 2016
Lankelma's Representative	Emma Stickland
Client's Representative	Gareth Meynell

REPORT

Status	Revision	Action	Date	Name
Final	00	Completed	13/06/16	Chris Player
		Checked	14/06/16	Emma Stickland
		Approved	14/06/16	Joseph Hobbs

CONTENTS

1	INTRODUCTION	1
1.1	COMPLETED WORKS.....	1
2	FIELDWORK.....	1
2.1	CONE PENETRATION TESTING	1
2.2	FIELD LOGISTICS	1
3	RAW DATA REDUCTION AND PRESENTATION.....	2
4	INTERPRETATIVE DATA.....	2
4.1	IN-SITU STRESS CONDITIONS.....	2
4.2	SOIL BEHAVIOUR TYPE.....	2
4.3	SOIL BEHAVIOUR TYPE – IC INDEX.....	3
4.4	GEOTECHNICAL PARAMETERS.....	3
4.4.1	RELATIVE DENSITY	3
4.4.2	UNDRAINED SHEAR STRENGTH.....	4
4.4.3	OVERCONSOLIDATION RATIO.....	4
4.4.4	SENSITIVITY	5
5	CPT DATA INTERPRETATION NOTES	6
6	REFERENCES	8

SUMMARY TABLES

Table 1 CPT Test Summary	9
--------------------------------	---

APPENDICES

APPENDIX A	General Information
APPENDIX B	Cone Penetration Test Results - Raw Data Plots
APPENDIX C	Standard Interpretation Results

1 INTRODUCTION

At the request of WSP Group, a CPT led soils investigation was carried out on project *Rockingham Business Park*.

Site location:

Rockingham Business Park
Rockingham Row
Birdwell
Barnsley
S70 5TW

1.1 COMPLETED WORKS

- 6 nr. Cone Penetration Tests (CPT);
- 5 nr. Piezocone Tests (CPTu); and
- Factual report plus standard geotechnical data interpretation.

The *Summary Tables* section details the field records.

2 FIELDWORK

2.1 CONE PENETRATION TESTING

Cone Penetration Tests were performed with a 17.9 tonne track-truck mounted CPT unit (UK20) equipped with a 17 tonne capacity hydraulic ram set.

An electric penetrometer of a type conforming to the requirements of BS ISO 22476-1:2012 was used on this project. Cone measurements included cone tip resistance, friction sleeve resistance and dynamic pore water pressure (Piezometer) sampled at a 10mm resolution. Cone maintenance, checks and calibrations were carried out in accordance with recommendations of BS8422:2003, and ASTM E74-13a as referenced by the British Standard. The management of calibration records is in accordance with ISO10012. Copies of all calibration certificates for the cones used are presented in Appendix A. Refer to the cone calibration certificates for the cone type and dimensional data.

The piezometer filter element was located in the u_2 position between the cone and friction sleeve and was replaced after every test. The pore pressure system was saturated with de-aired 1000 cSt silicone fluid.

2.2 FIELD LOGISTICS

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

The target depth for the investigation was 8 m. Table 1 details the final test depths and reasons for test termination (*Refusal Factor*). Termination depths were advised to, and agreed with, the client's on-site representative.

3 RAW DATA REDUCTION AND PRESENTATION

The CPT results are presented in Appendix B. The corrected cone resistance (q_t), local side friction, pore water pressure, friction ratio and inclination are all presented against depth and elevation in accordance with recommendations of the BS ISO 22476-1:2012. CPT data and the associated derived geotechnical parameters are included in the AGS 3.1 and 4.0 data files provided.

Penetration length readings are corrected for inclination and sleeve readings are depth corrected for the dimensional offset between cone tip and sleeve during post processing. An additional shift of -80mm is applied to the sleeve to account for tip failure zone offset (see 'CPT Interpretation Notes'). 'Rod spikes' (artefacts of the 1 m interval pause for rod string addition) are filtered from the cone tip and sleeve data.

4 INTERPRETATIVE DATA

4.1 IN-SITU STRESS CONDITIONS

The in-situ total and effective stress states are calculated based on an assumed total unit weight of soil (17 kN/m^3 above the inferred piezometric surface and 18 kN/m^3 below) and a hydrostatic pore pressure state. The depth of the piezometric surface has been assumed at a generic 1.5 mBGL across the site based on interpretation of piezocone measurements, dissipations or other observations by Lankelma. The data are applied in calculation of stress normalised geotechnical parameters.

In the event that complex groundwater regimes are clearly identified, multiple piezometric surfaces will be applied.

4.2 SOIL BEHAVIOUR TYPE

The Soil Behaviour Type (SBT) has been interpreted using the Robertson 1990 classification system based on the stress normalised cone resistance (Q_t) and Normalised friction sleeve resistance (Fr).

(See glossary of terms and symbols Appendix A)

The results are presented on the plots of Appendix C - *Standard Interpretation Results*.

4.3 SOIL BEHAVIOUR TYPE – I_c INDEX

The Soil Behaviour Type (SBT) is presented as the Soil Behaviour Type Index, I_c , for both stress-normalised and non-normalised evaluations according to the charts of Robertson (1998 & 2010) applicable to predominantly silicate soils.

The I_c provides a continuous profile of SBT variation with depth such that the end user may choose appropriate stratigraphic subdivisions. The basis of I_c and its approximation of the original chart classification zones may be seen from Appendix A figure 'CPT Soil Behaviour Type Chart'. The loss of fidelity is dominantly in zones 1 (*sensitive fine grained*) and zones 8 & 9 (*overconsolidated or cemented*). To account for this approximation a profile of sensitivity and OCR is provided in the Standard Interpretation Results (see section 'Geotechnical Parameters').

Non-stress normalised SBT index I_c :

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

Stress-normalised SBT index I_c :

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

(See glossary of terms and symbols Appendix A)

The results are presented on the plots of Appendix C - *Standard Interpretation Results*.

4.4 GEOTECHNICAL PARAMETERS

4.4.1 RELATIVE DENSITY

The relative density of sands is 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 distribution of calibration data in the figures presented below. The relationship has the following form:

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

(See glossary of terms and symbols Appendix A - *General Information*)

K = Compressibility dependant constant. For medium compressibility = -0.675 (applied generic value), for high compressibility and sands with significant carbonate or calcareous composition ≤ 1 , for low compressibility ≥ -2.0

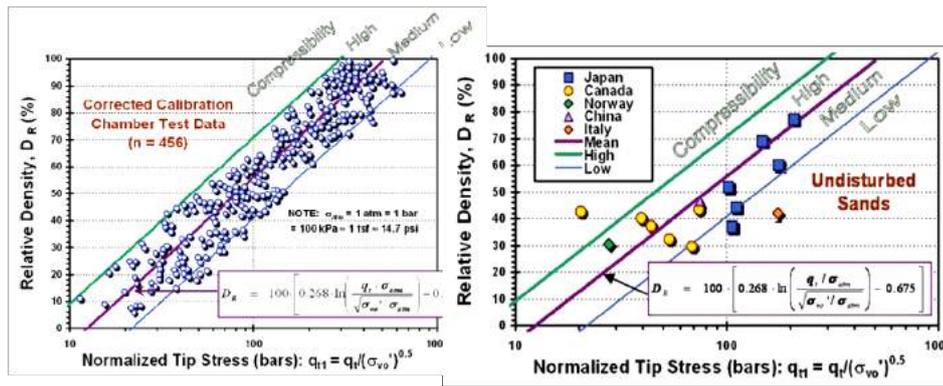


Figure 4-1 Relative density with normalised tip stress and sand compressibility from calibration chamber tests (left) and undisturbed frozen samples (right). Jamiolkowski *et al.* (2001) (Reproduced from NCHRP Synthesis 368 (2007)).

The results are presented on the plots of Appendix C - *Standard Interpretation Results*.

4.4.2 UNDRAINED SHEAR STRENGTH

S_u is estimated from the net cone tip resistance using the following equation:

$$s_u = \frac{(q_c - \sigma_{vo})}{N_k} \quad (\text{Lunne } et al. (1981))$$

where N_k is an empirical cone factor.

Research has shown that the cone factor N_k varies between 11 and 21 for normally to moderately overconsolidated soils with an average value of 15. For moderately to heavily overconsolidated soils the N_k factor may range from 20 to 30+. S_u values are presented for N_k factors of 15 and 20.

The results are presented on the plots of Appendix C - *Standard Interpretation Results*.

4.4.3 OVERCONSOLIDATION RATIO

The preconsolidation stress of clays is calculated based on the method proposed by Mayne (1995) and Demers and Leroueil (2002):

$$\sigma'_p = k \cdot (q_t - \sigma_{vo}) = 0.33(q_t - \sigma_{vo})$$

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

(See glossary of terms and symbols Appendix A)

The factor k may be expected to lie within the range 0.2 to 0.5 with 0.33 representing the average. Higher values of k are recommended for aged heavily overconsolidated clays (Robertson, 2009) and may be calibrated accordingly. The figure below demonstrates the

expected accuracy of the above methods in prediction of preconsolidation stress, of particular note is the under prediction for fissured clays.

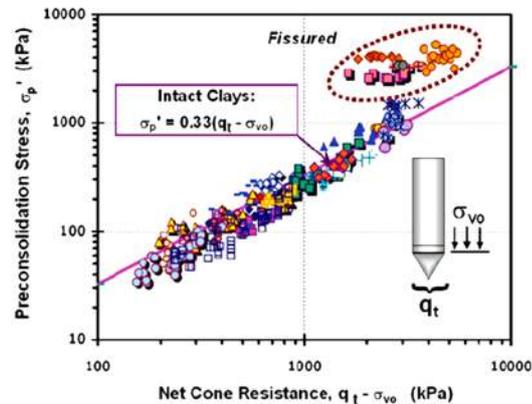


Figure 4-2 Preconsolidation stress from net cone resistance in clays (Reproduced from Mayne (2007)).

4.4.4 SENSITIVITY

The sensitivity of the soil, as defined by the ratio of undrained shear strength to remoulded shear strength, is calculated using the factored normalised cone resistance (S_u) and remoulded shear strength taken as equal to the direct friction sleeve measurement:

$$s_t = 0.073 \cdot \frac{q_t - \sigma_{v0}}{f_s} \quad (\text{Mayne (2007)})$$

(See glossary of terms and symbols Appendix A - *General Information*)

The results are presented on the plots of Appendix C - *Standard Interpretation Results*.

5 CPT DATA INTERPRETATION NOTES

Provided below is an inexhaustive set of cautionary notes on interpretation of the acquired CPT data with reference to examples within the dataset where appropriate.

SOIL BEHAVIOUR TYPE

The soil behaviour type (SBT) as defined by Robertson *et al.* (1986) is not intended to replace soil classification based on particle size fractions. Rather, the SBT will generally show bias in the classification towards the soil fraction that dominates soil behaviour in response to cone penetration (Cone tip: analogous to bearing capacity failure, friction sleeve: analogous to remoulded S_u or simple shear). In general the stress-normalised SBT will be more accurate, but may be less reliable at very shallow depths (1-2 m) due to the particular stress normalisation procedure applied.

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 account for uncertainty in the SBT correlation with drainage behaviour, all parameters are derived over the range of mixed soil types 'Silt Mixtures' and 'Sand Mixtures' or I_c 2.05-2.95 (Robertson, 2010). For partially drained conditions, or for partially saturated low permeability soils, error will be introduced within derived parameters.

Piezocone dynamic pore water pressures behaviour, dissipations or other site specific observations may be used to identify the appropriate limits of application. Dissipations to t_{50} exceeding 30 seconds indicate undrained penetration behaviour (Kim *et al.*, 2010).

DYNAMIC PORE PRESSURE DATA

During penetration, strong dilation in shear at the cone shoulder may result in cavitation and desaturation of the piezo system and may take time to recover (up to 1 m penetration). Penetration through soils of partial saturation will provide unrepresentative readings and may desaturate the piezo system introducing variable error.

CONE TIP AND SLEEVE OFFSET

The accuracy of the SBT is sensitive to offset error in the friction ratio. Penetration through zones of anisotropic soil stiffness may lead to offset of the cone tip and sleeve readings due to variation in the tip failure zone shape/depth. For low to moderate risk projects this is generally insignificant. The friction ratio is often inaccurate in heavily disturbed soils with a 'blocky' macro fabric.

For this investigation a friction sleeve depth offset correction of -80mm was applied together with a 5 data point moving average on the friction ratio to minimise the influence of this effect on derived parameters.

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 the larger 15 cm² cone with 225 cm² friction sleeve area for improved sensitivity and penetration depth potential. Use of the 15 cm² cone will have the following known influences on data with respect to the reference 10 cm²:

- More pronounced transitions zones and thin layer effects (larger zone of influence and failure zone).
- Possible marginal increase in u_2 position dynamic pore pressures during undrained/partially drained penetration.

TRANSITION ZONES AND THIN LAYER EFFECTS

During penetration at the boundary between soils of contrasting stiffness, a transition zone is often evident prior to mobilization 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 (<~0.5m) the true stiffness will not be fully mobilised. The effect for thin low stiffness layers is less significant. Procedures for thin-layer effect correction are provided by Robertson and Wride (1998). In choosing characteristic values of the tip, sleeve and derived parameter results, large scale peak and trough values may be more representative of the local value.

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 sharp reductions in pore water readings due to dilation effects. Frequent gravels in soft or loose soils may generate highly erroneous friction ratio values. Where gravels are matrix supported the tip and sleeve peaks may be ignored or filtered in choosing characteristic values for bulk behaviour.

6 REFERENCES

- Agrawal, G., Pekin, O. & Chandra, D. 2010. Evaluating relative compaction of fills using CPT. 2nd International Symposium on CPT, Huntington Beach, CA, USA. Volume 2&3: Technical Papers, Session 3: Applications, Paper No. 3-46.
- ASTM E74-13a (2013), Standard Practice of Calibration of Force-Measuring Instruments for Verifying the Force Indication of Testing Machines, ASTM International, West Conshohocken, PA.
- Baldi, G., Bellotti, R., Ghionna, V.N., Jamiolkowski, M. and Pusqualini, E. (1986) "Interpretation of CPT's and CPTU's, 2nd Part: Drained Penetration of Sands". Proceedings of the 4th International Geotechnical Seminar, Singapore. pp. 143-156.
- British Standards Institution (2003) BS 8422:2003, Force measurement - Strain gauge load cell systems - Calibration method. London: British Standards Institution.
- Houlsby, G.T. and Teh, C.I. (1988) "Analysis of the Piezocone in Clay". Proceedings of the International Symposium on Penetration Testing (ISOPT-1), Orlando, Vol. 2, pp. 777-783. Balkema Pub., Rotterdam.
- ISO 10012:2003 Measurement management systems - Requirements for measurement processes and measuring equipment. New Delhi: Bureau of Indian Standards (2003).
- ISO 22476-1:2012 Geotechnical investigation and testing - Field testing - Part 1: Electrical cone and piezocone penetration test. New Delhi: Bureau of Indian Standards (2012).
- ISSMGE, 1999. International reference test procedure for the cone penetrometer test CPT and the cone penetration test CPTU, Report of ISSMGE TC16 on Ground Property Characterisation for In situ Testing, In *Proceedings of the 12th European conference on Soil Mechanics and Geotechnical Engineering* 3:2195-222 (1999).
- Jamiolkowski, M., LoPresti, D.C.F., and Manassero, M. (2001) "Evaluation of Relative Density and Shear Strength of Sands from Cone Penetration Test and Flat Dilatometer Test". *Soil Behaviour and Soft Ground Construction (GSP119)*, American Society of Civil Engineers, pp. 201-238. Reston, Va. 2001
- Kim, K., Prezzi, M., Salgado, R., and Lee, W. (2008) "Effect of Penetration Rate on Cone Penetration Resistance in Saturated Clayey Soils", *Journal of Geotech. Geoenviron. Eng.*, Vol. 134(8), pp. 1142-1153.
- Kulhawy, F.H. and Mayne, P.W. (1990) "Manual on Estimating Soil Properties for Foundation Design". Report EPRI EL-6800 Research Project 1493-6, Electric Power Research Institute, Palo Alto, CA, pp. 306.
- Ladd, C.C. and DeGroot, D.J. (2003) "Recommended Practice for Soft Ground Site Characterization: Arthur Casagrande Lecture". *Soil & Rock America 2003 (Proceedings. 12th Pan American Conference on Soil Mechanics and Geotechnical Engineering, Boston, MA)*. Verlag Gluckauf, Essen, Germany. pp. 3-57.
- Lunne, T., Robertson, P.K. and Powell, J.J.M. (1997) "Cone Penetration Testing in Geotechnical Practice" Blackie Academic, New York 1997.
- Lunne, T. and Kleven, A. (1981) "Role of CPT in North Sea Foundation Engineering". Session at the ASCE National Convention: Cone Penetration Testing and Materials. pp. 76-107. American Society of Engineers (ASCE).
- Mayne, P.W. and Campanella, R.G. (2005) "Versatile Site Characterisation by Seismic Piezocone". Proceedings of the 16th International Conference on Soil Mechanics and Geotechnical Engineering, Vol. 2. Millpress, Rotterdam, The Netherlands 2005. pp 721-724.
- Mayne, P.W. (2007) "Cone Penetration Testing - A Synthesis of Highway Practice". NCHRP Synthesis 368, Transportation Research Board, Washington, D.C.
- Robertson, P.K., Campanella, R.G., Gillespie, D. and Greig, J. (1986) "Use of Piezometer Cone Data". Proceedings of the ASCE Specialty Conference, In Situ '86: Use of In-Situ Testing in Geotechnical Engineering. Blacksburg, pp. 1263-1280, American Society of Engineers (ASCE).
- Robertson, P.K., (2010) "Soil Behaviour Type from the CPT: an update". 2nd International Symposium on Cone Penetration Testing. Huntington Beach, CA, USA.
- Robertson, P.K. (2012). Interpretation of in-situ tests - some insights, Proc. 4th Int. Conf. on Geotechnical & Geophysical Site Characterization, ISC'4, Brazil, 1.
- Schmertmann, J., Baker, W., Gupta, R. & Kessler, K. 1986. CPT/DMT OC of Ground Modification at a Power Plant. *Geotechnical Special Publication* 6:985-1001. ASCE.
- Sully, J.P., Robertson, P.K., Campanella, R.G. and Woeller, D.J. (1999) "An approach to evaluation of field CPTU dissipation data in overconsolidated fine-grained soils". *Canadian Geotechnical Journal*. Vol. 36, pp. 369-381.

SUMMARY TABLES

Table 1 CPT Test Summary

TEST ID	FINAL DEPTH (mBGL)	Cone ID {C=Cone tip; F=Friction Sleeve; I=Inclination; P = Piezo; S=Subtraction cone; 15/10 = cone projected area (cm2) }	CPT RIG	PRE DRILLED / INSPECTION PIT (m)	CASING DEPTH (m)	REFUSAL FACTOR	DISSIPATIONS	SEISMIC CONE	SAMPLES	EASTING	NORTHING	ELEVATION (m)	DATE OF TEST	REMARKS
CPT01	4.08	S15-CFIP.915	UK20			Total reaction load				435104.545	400625.373	138.233	24/05/2016	No piezo data available.
CPT02	3.25	S15-CFIP.915	UK20			Total reaction load				435099.159	400656.2	137.069	24/05/2016	
CPT03	5.01	S15-CFIP.915	UK20			Total reaction load				435132.397	400623.985	138.797	24/05/2016	No piezo data available.
CPT04	4.53	S15-CFIP.915	UK20			Total reaction load				435127.497	400608.441	139.071	24/05/2016	
CPT05	2.44	S15-CFIP.915	UK20			Total reaction load				435121.428	400584.177	139.648	24/05/2016	No piezo data available.
CPT06	3.62	S15-CFIP.915	UK20			Total reaction load				435100.167	400587.481	138.98	24/05/2016	
CPT07	6.15	S15-CFIP.915	UK20			Total reaction load				435070.674	400566.489	138.632	24/05/2016	No piezo data available.
CPT08	3.83	S15-CFIP.915	UK20			Total reaction load				435098.121	400516.222	140.779	24/05/2016	No piezo data available.
CPT09	3.57	S15-CFIP.915	UK20			Total reaction load				435056.032	400508.417	139.488	24/05/2016	
CPT10	5.22	S15-CFIP.915	UK20			Total reaction load				435082.268	400489.754	141.107	24/05/2016	
CPT11	3.75	S15-CFIP.915	UK20			Total reaction load							24/05/2016	No piezo data available.

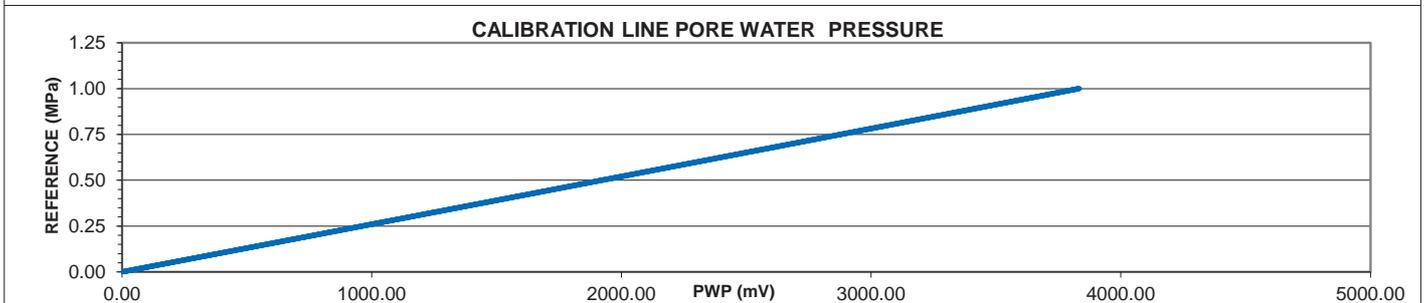
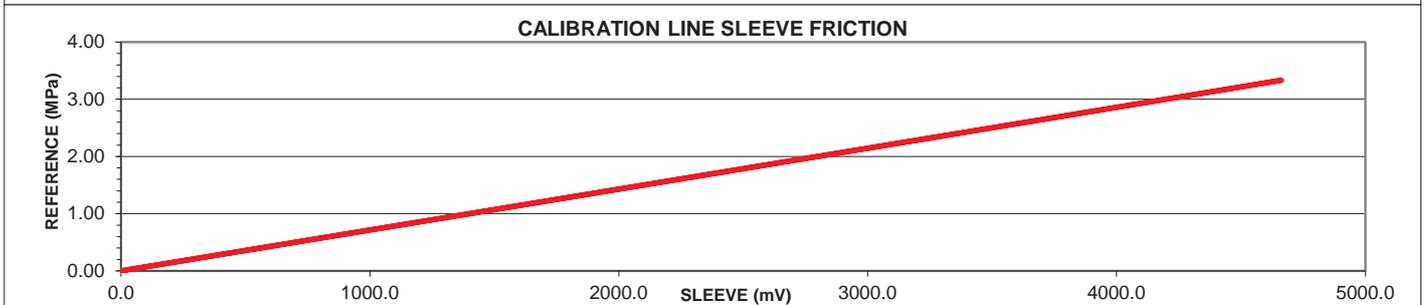
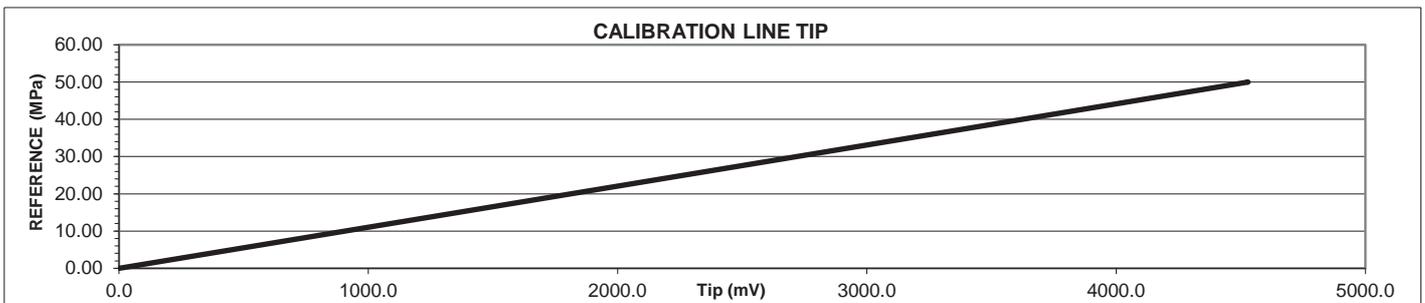
CPT Test Plots are presented in Appendices B & C

APPENDIX A GENERAL INFORMATION

LIST OF FIGURES

Description	Pages Included
Cone Calibration Certificate: S15-CFIP.915	1
Data Sheet: 17.9 Tonne Track-Truck Mounted CPT Unit (UK20)	1
CPT Soil Behaviour Type Chart	1
Glossary of Terms	1

REFERENCE INSTRUMENTS:	CONE END RESISTANCE	SLEEVE FRICTION	PORE WATER PRESSURE
ID	5623	5623	4009509
TYPE	Richmond 300	Richmond 300	Druck DPI 104
UNCERTAINTY (±%)	0.1	0.1	0.05
Nominal pressure (MPa,MPa,MPa)	50.00	3.33	1.00
Maximum pressure (MPa,MPa,MPa)	100.00	6.67	2.00
Area (cm ²)	15	225	N/A
Sensitivity (mV/MPa)	90.58	1398.85	3827.88
Calibration file scaling factor:			
Nominal cal force (kN, kN, BAR)	75	75	10
Calibration number (mV)	4529	4663	3828
Zero point (mV)	369	364	183
Sensitivity (mV/kN, mV/kN, mV/BAR)	60.384	62.171	382.788
Inclination factors (mV)	X -20°= 451, 0°= 2567, 20°= 4536 / Y -20°= 401, 0°= 2226, 20°= 4403		
Measured alpha factor:	0.69		
Uncertainty (%):			
Reproducibility	0.03	0.04	0.04
Linearity	0.06	0.08	0.19
Hysteresis	0.07	0.08	0.13
Combined expanded (k=2)	0.28	0.60	0.48
Application class	1	1	1



Instrument:	S15-150kN	Location:	Lankelma Calibration Laboratory
Serial Number:	S15-CFIIP.915	Temperature(° C)	18.0
Manufacturer:	Geopoint	Calibration Engineer	A Harman
Date of calibration:	30/03/2016	Calibration Expiry	29/06/2016

Calibration signed and dated by:	Calibration checked and dated by:
 Digitally signed by Alastair Harman DN: cn=Alastair Harman, o=Lankelma Ltd, ou=Instrument Engineer, email=Alastairharman@lankelma.com, c=GB Date: 2016.03.30 13:58:19 +01'00'	 Digitally signed by Christopher Player DN: cn=Christopher Player, o=Lankelma, ou=Reporting Engineer, email=christopher.player@lankelma.com, c=GB Date: 2016.03.30 14:35:02 +01'00'

UK20 TRACK-TRUCK RIG



Our track-truck is suitable for most geotechnical sites. This rig is driven as a self-contained HGV to site where it can deploy its tracks to cope with soft or uneven terrain.

The track-truck can be driven from an on-board remote control either from the cabin or externally, and complies with Euro 4 emission standards for use in London's low emissions zones (LEZ).

Performance Rates

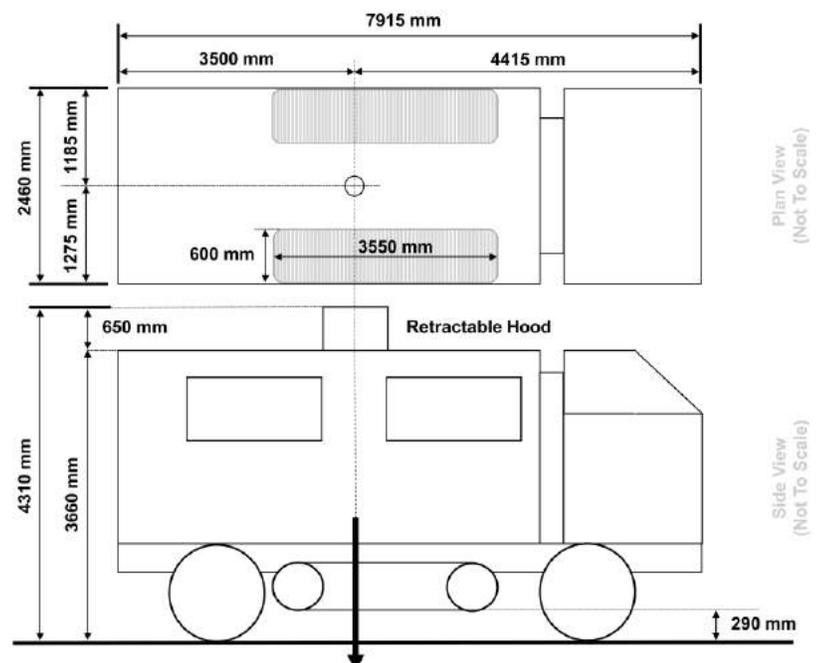
An expected 120 to 150m of standard CPTu testing can be executed in a day (dependent on site conditions and access).

Applications

-  Specialist testing
 - Seismic
 - Pressuremeter
 - Magnetometer
 - Videocone

TECHNICAL DETAILS

RIG WEIGHT	17.9 T
MAX. OPERATING RAM CAPACITY	17.5 T
MAX. TRAVELLING SPEED	86 km/h
TRACK MATERIAL	STEEL
TRACK LENGTH	3.55 m
TRACK WIDTH	0.60 m
JACK PLATE DIMENSIONS	TRACKS ACT AS JACKS
JACK ARRANGEMENTS	1 ON EACH SIDE
MAX. GROUND CLEARANCE ON JACKS	0.29 m
MAX. GROUND BEARING PRESSURE	WHEELS - 300 kPa TRACKS - 48 kPa
MAX. TESTING GRADIENT	10 DEGREES
MAX. TRAVERSING GRADIENT	30 DEGREES (OPERATOR ASSESSED)
NOISE OUTPUT AT 2M	TESTING - 69.5 dBA DRIVING - 78.7 dBA
CLAMP ARRANGEMENT	HYDRAULIC CATCHING - SEMI AUTOMATIC
RAM STROKE	1.2 m
MAX. CASING SIZE	55 mm



www.lankelma.com

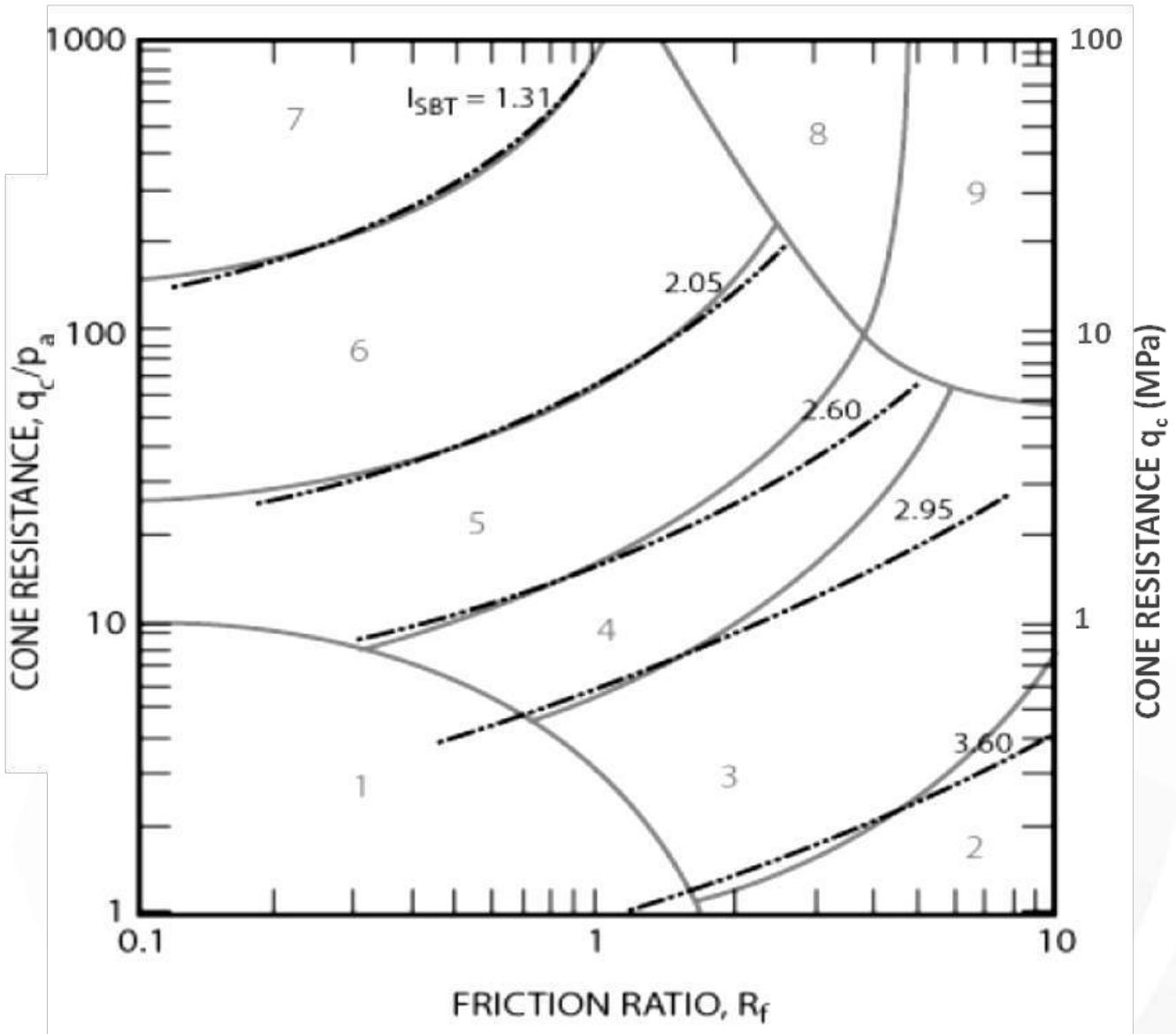
Tel: +44 (0)1797 280050

Fax: +44 (0)1797 280195

Email: info@lankelma.com

Lankelma Limited, Cold Harbour Barn, Cold Harbour Lane, Iden, East Sussex. TN31 7UT

CPT SOIL BEHAVIOUR TYPE CHART



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 I_c index. The chart is also applicable to stress-normalised tip/sleeve values Q_t and F_r .

Zone	Soil Behaviour Type (SBT)		
1	Sensitive fine-grained	6	Sands: clean sand to sandy silt
2	Clay – organic soil	7	Dense sand to gravelly sand
3	Clays: Clay to silty clay	8	Stiff sand to clayey sand*
4	Silt mixtures: clayey silt to silty clay	9	Stiff fine grained*
5	Sand mixtures: Silty sand to sandy silt		*Overconsolidated or cemented

GLOSSARY OF CPT TERMS AND SYMBOLS

SYMBOLS

- q_c** :- **Cone resistance.** The total force acting on the cone Q_c , divided by the projected area of the cone, A_c ; ($q_c=Q_c/A_c$).
- f_s** :- **Friction sleeve resistance.** The total frictional force acting on the friction sleeve, F_s , divided by its surface area, A_s . $f_s= F_s/A_s$.
- q_t** :- **Corrected cone resistance.** The cone resistance q_c corrected for unequal pore water pressure effects on the cone face and shoulder.
- R_f** :- **Friction ratio** The ratio, expressed as a percentage, of the sleeve friction, f_s , to the cone resistance, q_c , both measured at the same depth; [$R_f= (f_s/q_c) \cdot 100$].
- Q_t** :- **Stress normalised cone resistance (Method 1)** = $(q_c - \sigma_v)/\sigma'_v$
- q_{t1}** :- **Stress normalised cone resistance (Method 2)** = $(q_t)/(\sigma'_v)^{0.5}$
- F_r** :- **Normalised friction sleeve resistance** = $f_s / (q_c - \sigma_v)$
- σ_v** :- **Total overburden stress**
- σ'_v** :- **Effective overburden stress**
- σ_{atm} , or, P_a** :- **Reference atmospheric stress = 100kPa**
- I_c** :- **Soil Behaviour Type Index**
- B_q** :- **Pore pressure ratio.** The net pore pressure normalized with respect to the net cone resistance. = $(u_2 - u_0)/(q_t - \sigma_v)$

TERMS

Cone Tip:- The conical tip section 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 measurement system.

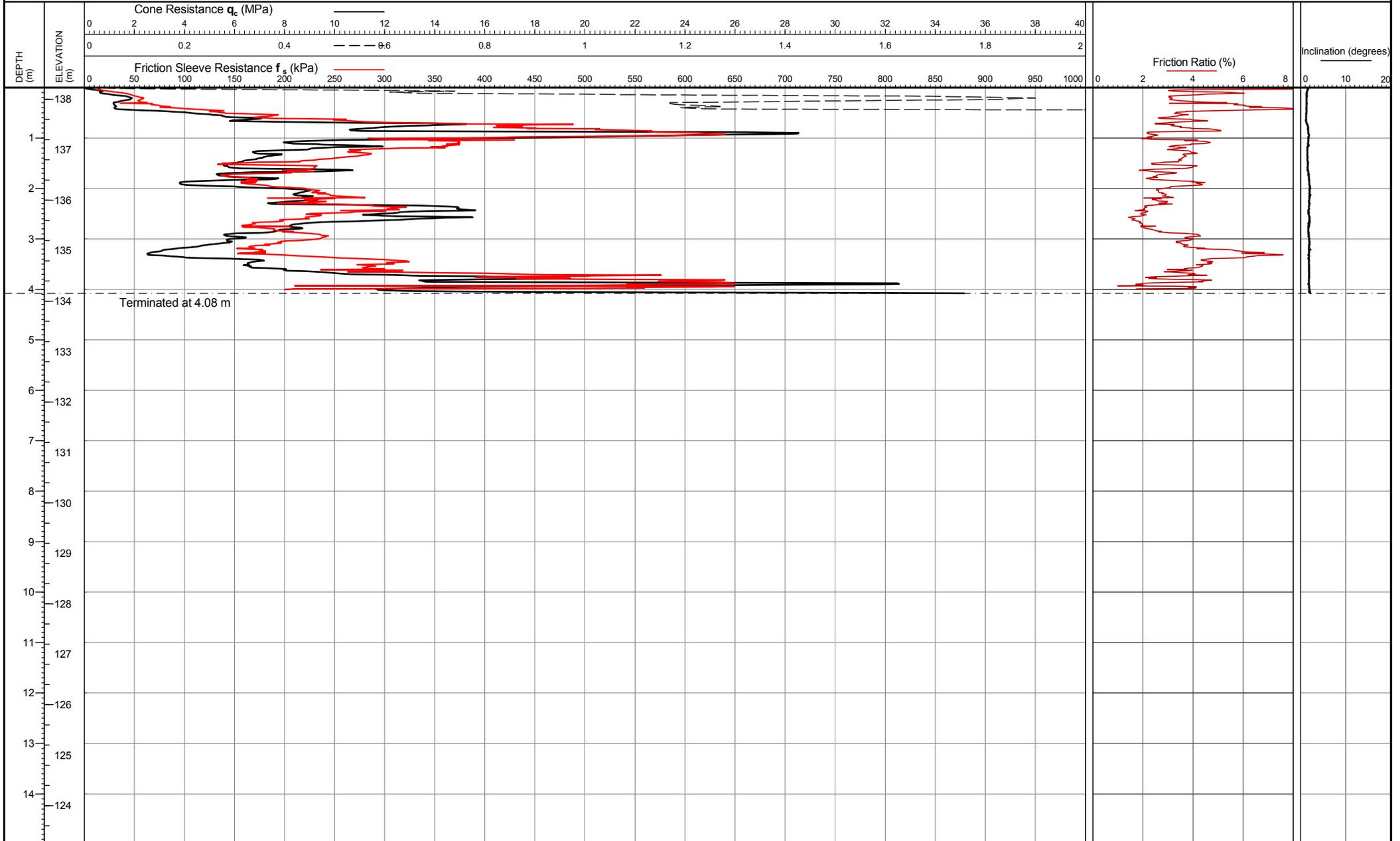
Dynamic pore pressure:- The pore pressure generated during penetration and measured by a pore pressure sensor. u_1 when measured on the conical tip face, u_2 when measured just behind the conical tip.

APPENDIX B CONE PENETRATION TEST RESULTS

RAW DATA PLOTS

LIST OF FIGURES:

Test ID		Pages included
Cone Penetration Test	CPT01	1
Cone Penetration Test	CPT02	1
Cone Penetration Test	CPT03	1
Cone Penetration Test	CPT04	1
Cone Penetration Test	CPT05	1
Cone Penetration Test	CPT06	1
Cone Penetration Test	CPT07	1
Cone Penetration Test	CPT08	1
Cone Penetration Test	CPT09	1
Cone Penetration Test	CPT10	1
Cone Penetration Test	CPT11	1



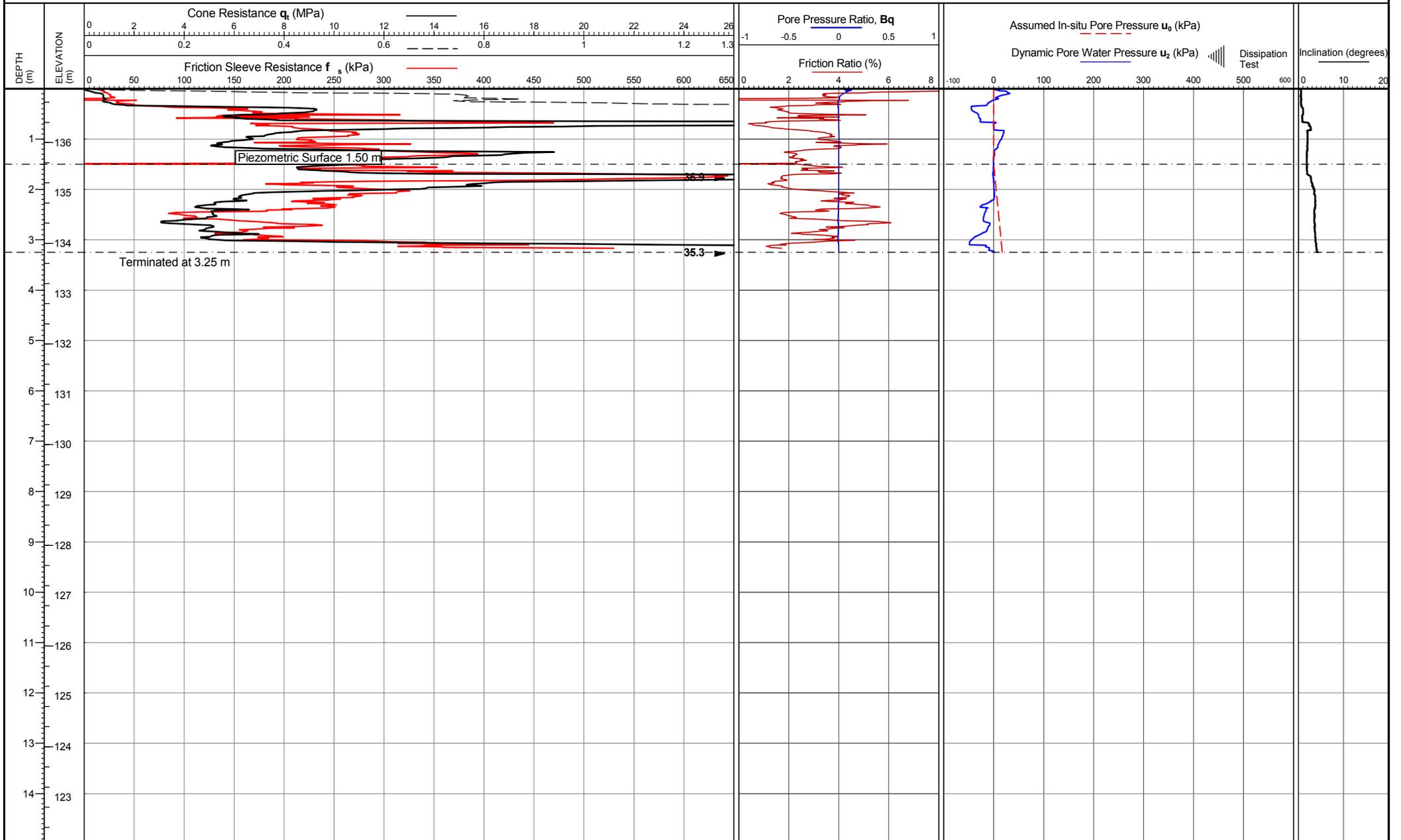
Cone area (mm²):1500
 Cone ID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 11:25:02

Location: Barnsley, UK
 Coordinates: 435104.545, 400625.373
 Elevation: 138.233
 Coordinate system:

Remarks:
 No piezo data available..
 Refusal criteria: Total reaction load

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT01



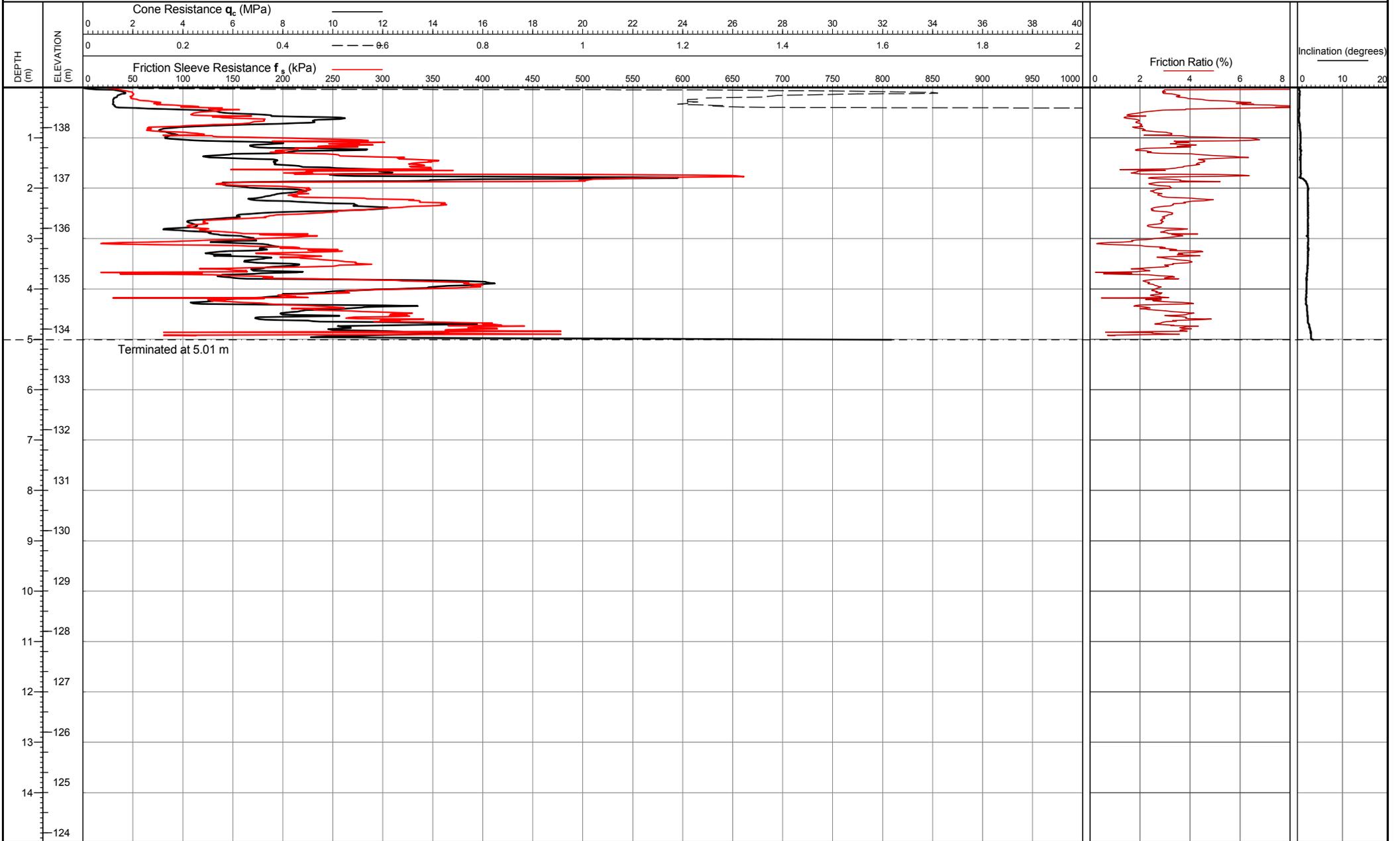
Cone area (mm²):1500
 Cone ID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 10:07:09

Location: Barnsley, UK
 Coordinates: 435099.159, 400656.2
 Elevation: 137.069

Remarks:
 Termination Remark: Total reaction load

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT02



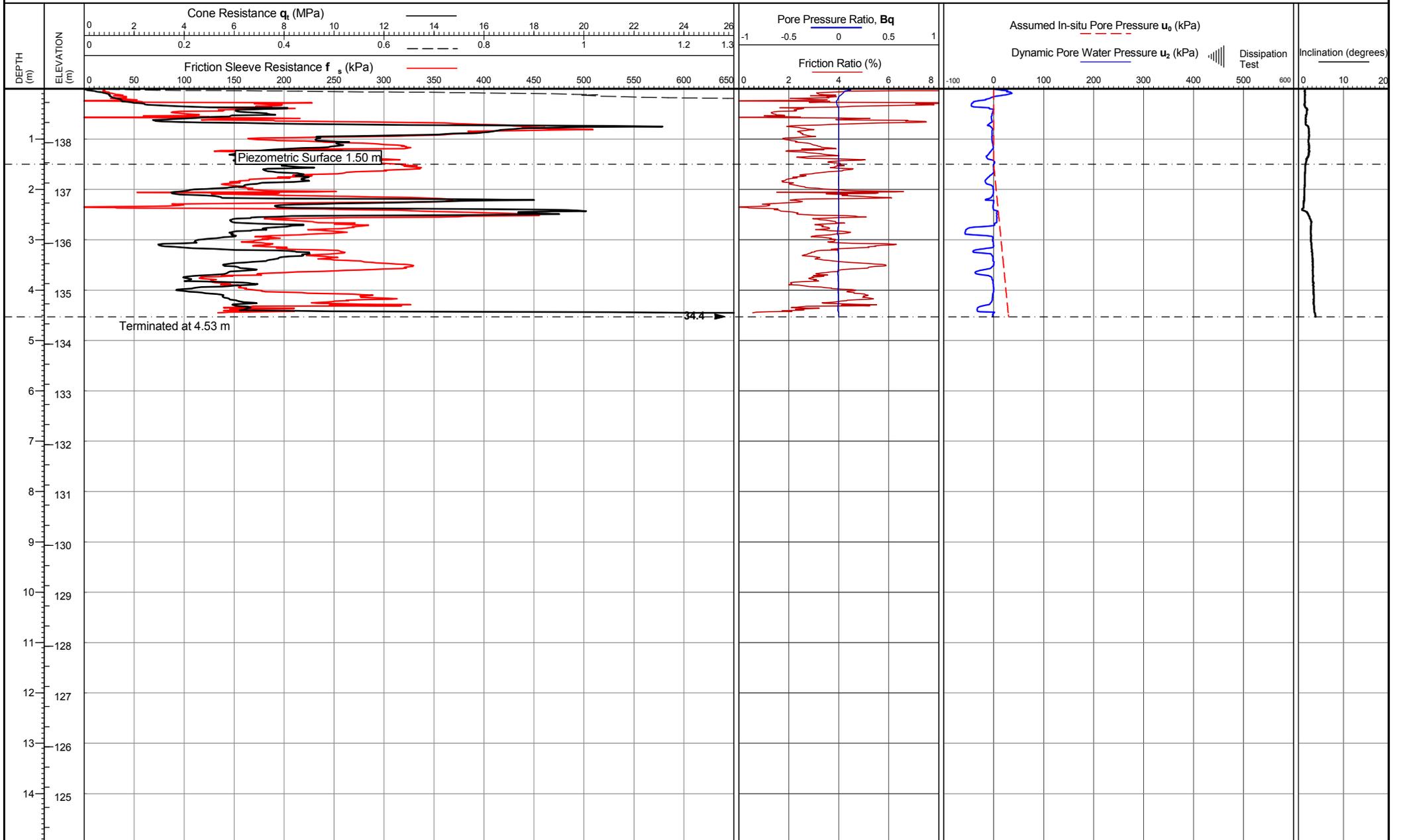
Cone area (mm²):1500
 Cone ID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 10:41:14

Location: Barnsley, UK
 Coordinates: 435132.397, 400623.985
 Elevation: 138.797
 Coordinate system:

Remarks:
 No piezo data available..
 Refusal criteria: Total reaction load

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT03



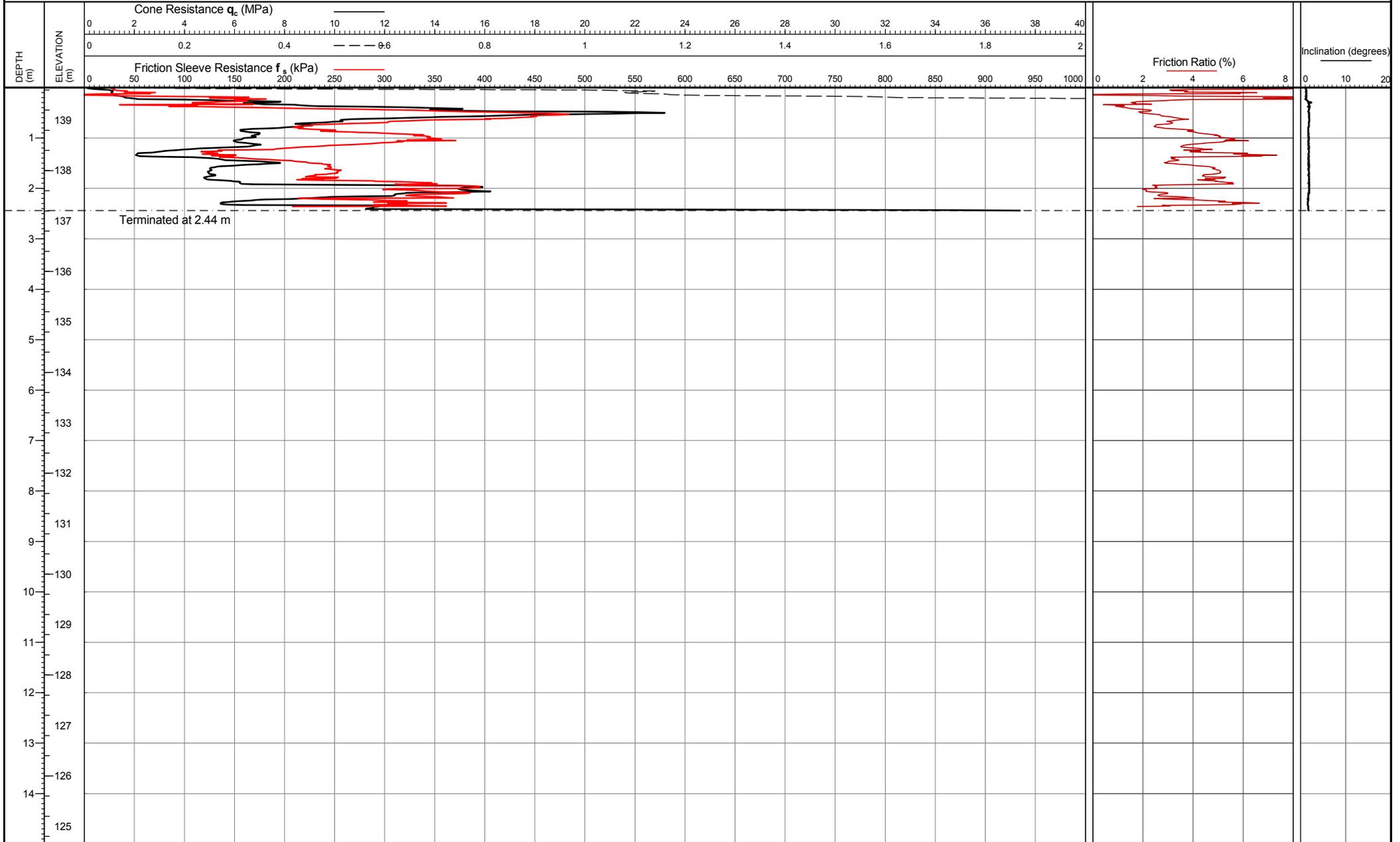
Cone area (mm²):1500
 Cone ID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 11:02:47

Location: Barnsley, UK
 Coordinates: 435127.497, 400608.441
 Elevation: 139.071

Remarks:
 Termination Remark: Total reaction load

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT04



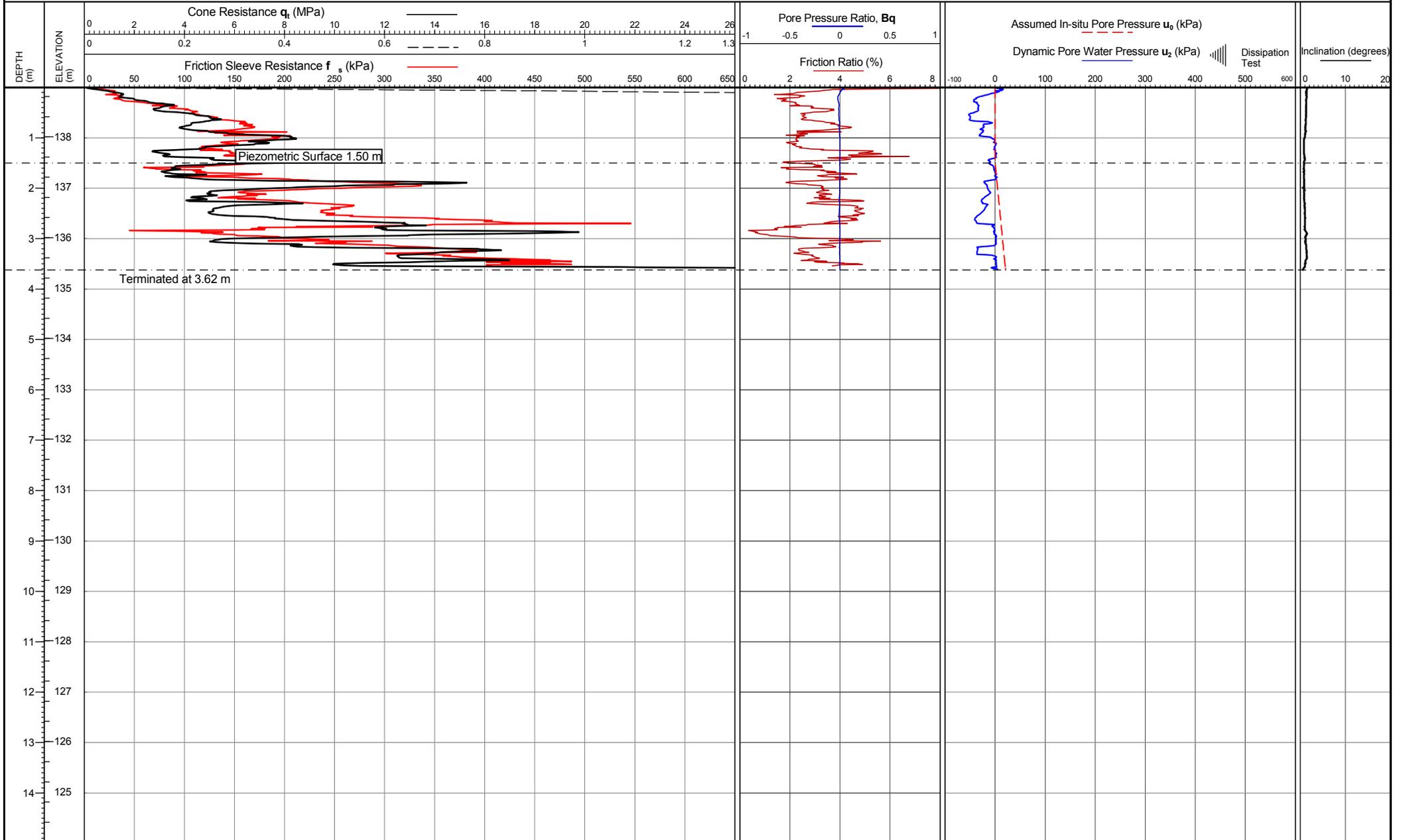
Cone area (mm²):1500
 Cone ID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 14:19:03

Location: Barnsley, UK
 Coordinates: 435121.428, 400584.177
 Elevation: 139.648
 Coordinate system:

Remarks:
 No piezo data available..
 Refusal criteria: Total reaction load

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT05
 Page 1 of 1



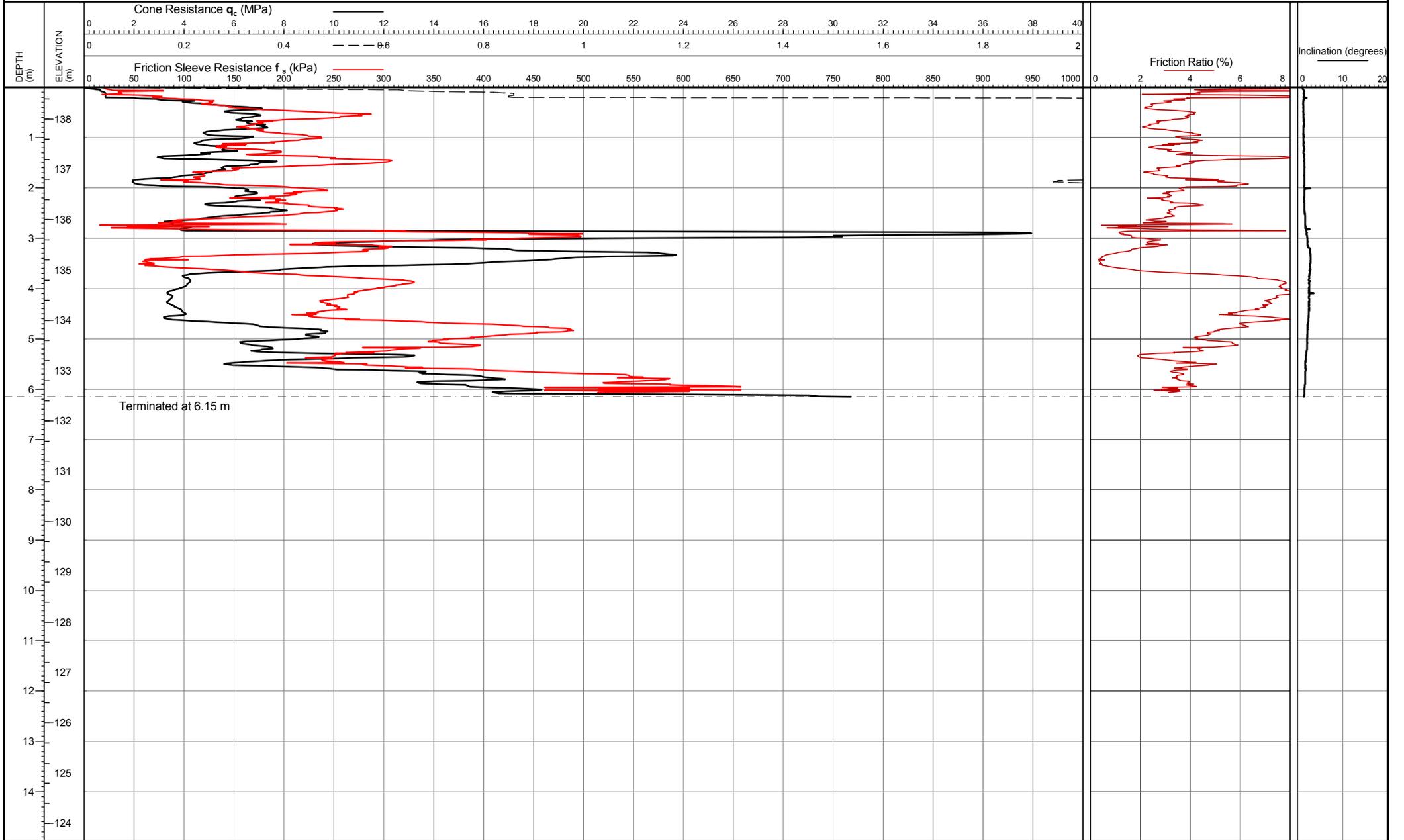
Cone area (mm²):1500
 Cone ID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 11:44:28

Location: Barnsley, UK
 Coordinates: 435100.167, 400587.481
 Elevation: 138.98

Remarks:
 Termination Remark: Total reaction load

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT06



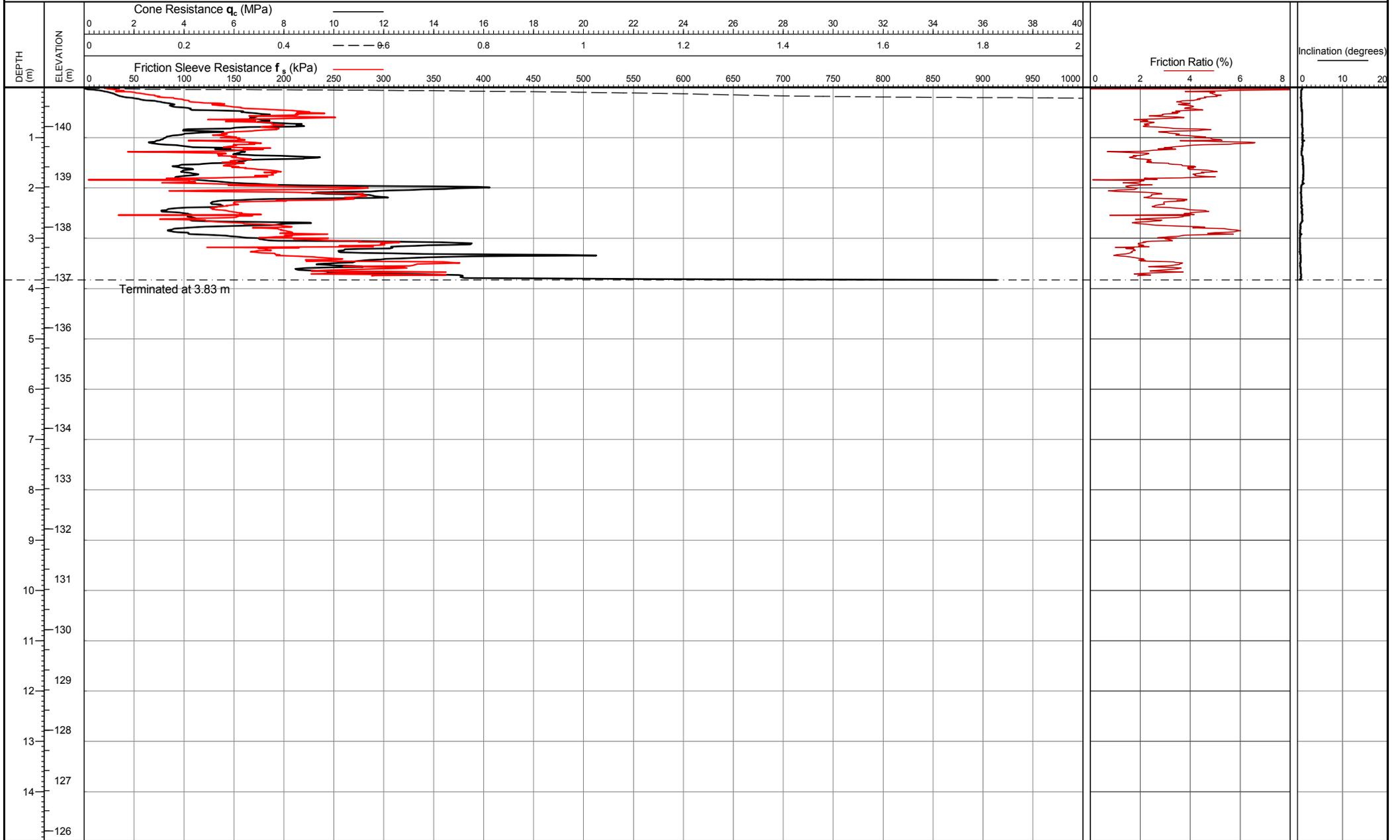
Cone area (mm²):1500
 Cone ID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 12:22:01

Location: Barnsley, UK
 Coordinates: 435070.674, 400566.489
 Elevation: 138.632
 Coordinate system:

Remarks:
 No piezo data available..
 Refusal criteria: Total reaction load

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT07



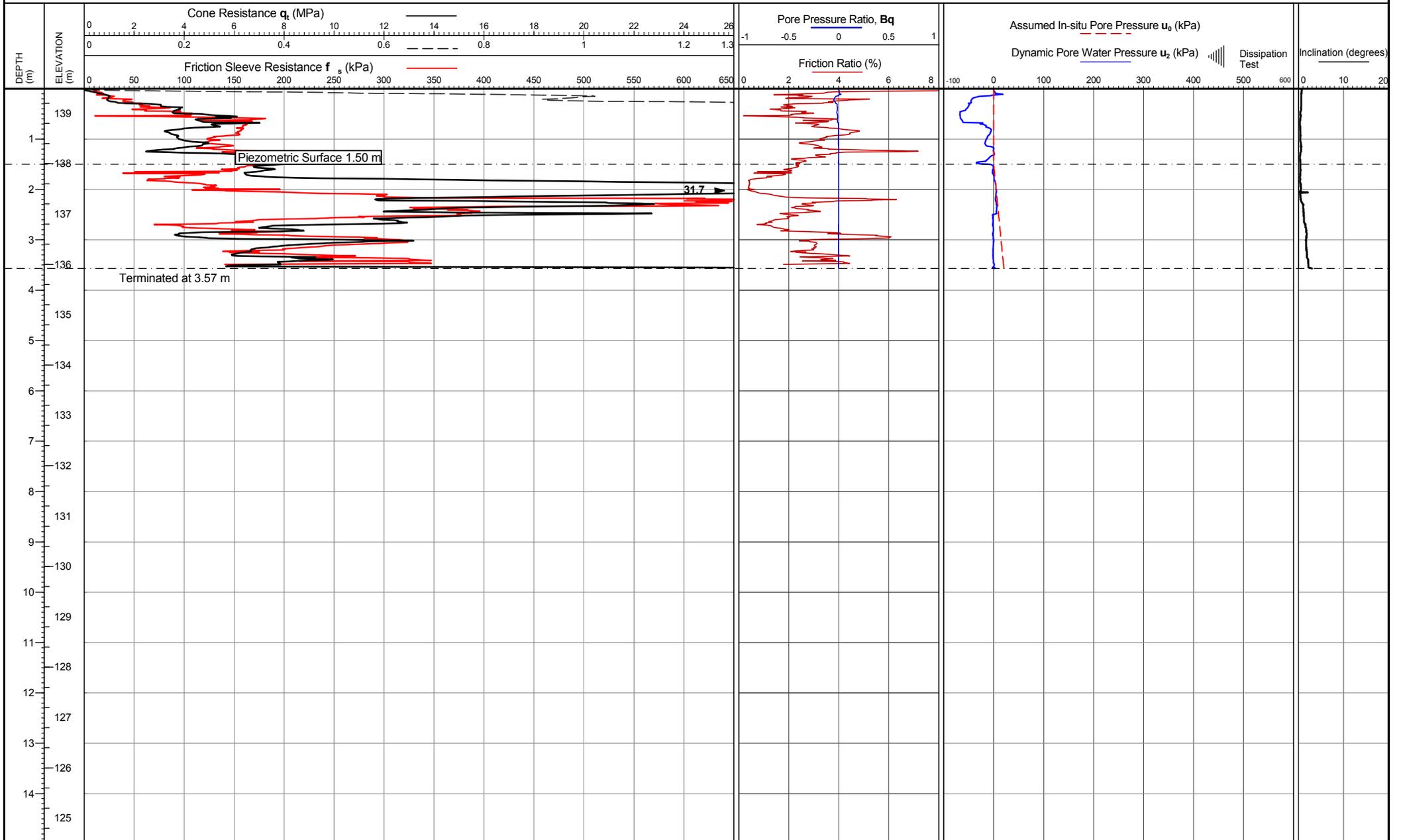
Cone area (mm²):1500
 Cone ID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 13:52:31

Location: Barnsley, UK
 Coordinates: 435098.121, 400516.222
 Elevation: 140.779
 Coordinate system:

Remarks:
 No piezo data available..
 Refusal criteria: Total reaction load

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT08



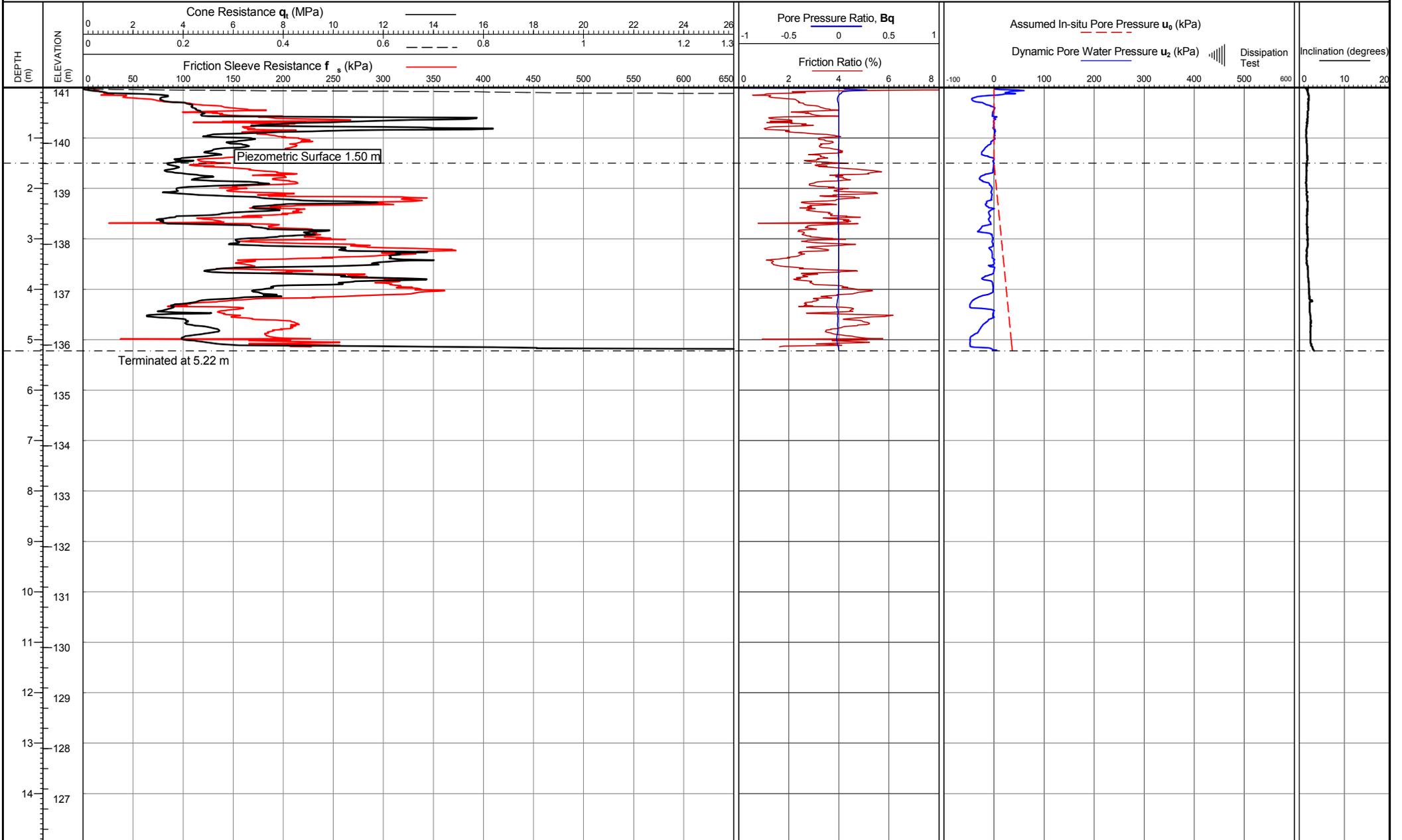
Cone area (mm²):1500
 Cone ID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 12:58:42

Location: Barnsley, UK
 Coordinates: 435056.032, 400508.417
 Elevation: 139.488

Remarks:
 Termination Remark: Total reaction load

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT09



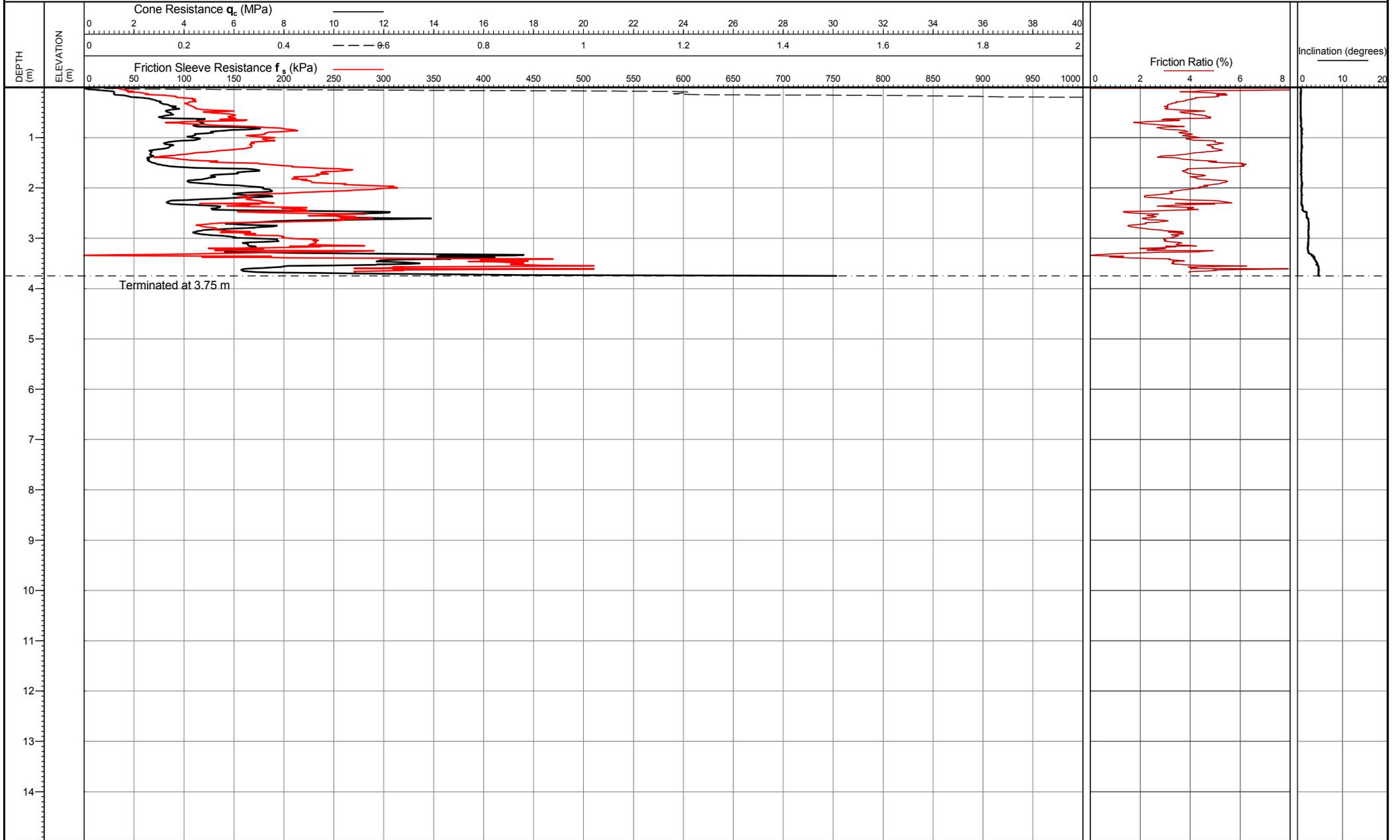
Cone area (mm²):1500
 Cone ID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 13:33:49

Location: Barnsley, UK
 Coordinates: 435082.268, 400489.754
 Elevation: 141.107

Remarks:
 Termination Remark: Total reaction load

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT10



Cone area (mm²):1500
 Cone ID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 14:05:14

Location: Barnsley, UK
 Coordinates: ,
 Elevation:
 Coordinate system:

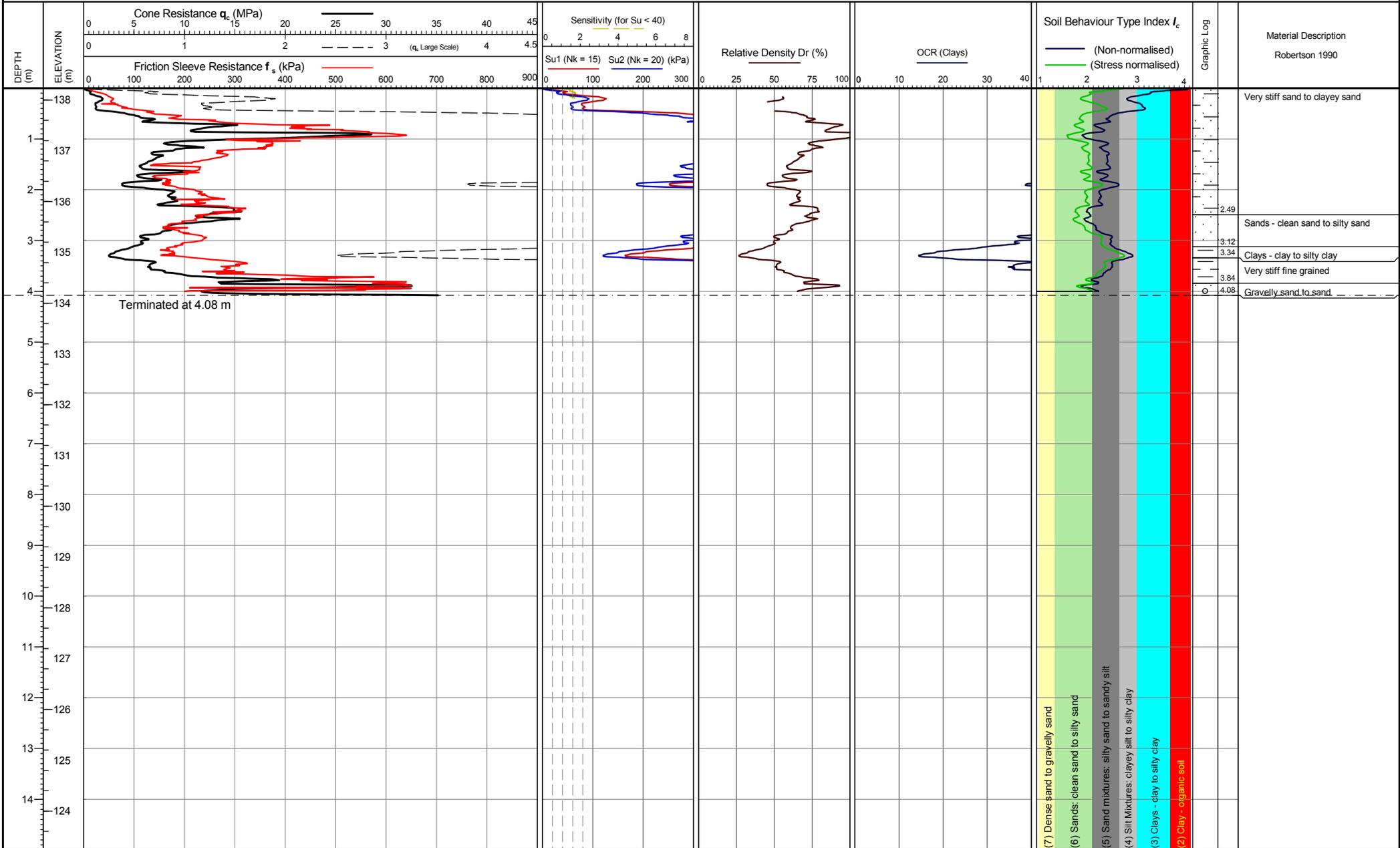
Remarks:
 No piezo data available..
 Refusal criteria: Total reaction load

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT11
 Page 1 of 1

APPENDIX C STANDARD INTERPRETATION RESULTS**LIST OF FIGURES:**

Test ID		Pages included
Cone Penetration Test	CPT01	1
Cone Penetration Test	CPT02	1
Cone Penetration Test	CPT03	1
Cone Penetration Test	CPT04	1
Cone Penetration Test	CPT05	1
Cone Penetration Test	CPT06	1
Cone Penetration Test	CPT07	1
Cone Penetration Test	CPT08	1
Cone Penetration Test	CPT09	1
Cone Penetration Test	CPT10	1
Cone Penetration Test	CPT11	1



Cone area (mm²):1500
 ConeID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 11:25:02

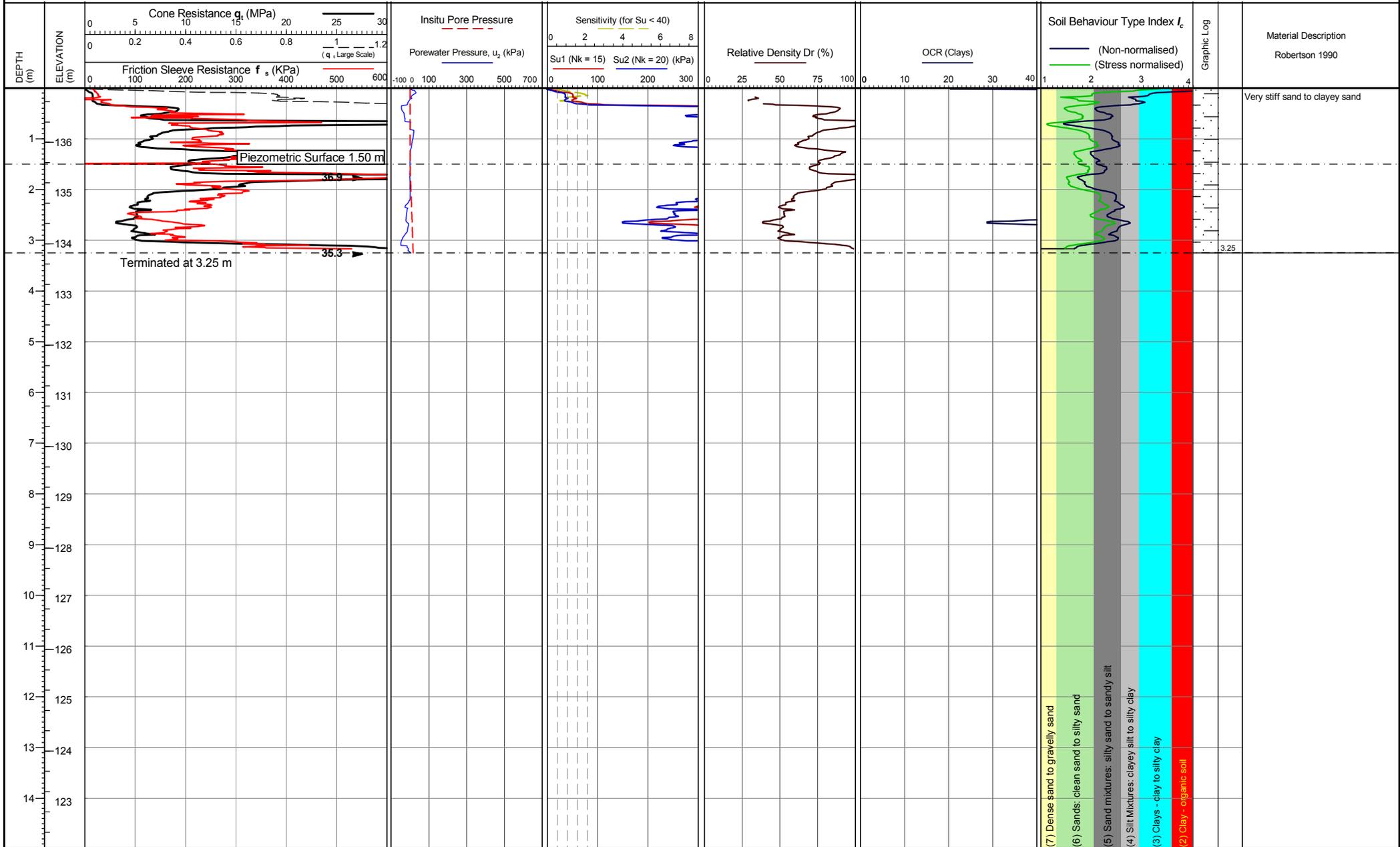
Location: Barnsley, UK
 Coordinates: 435104.545, 400625.373
 Elevation: 138.233
 Coordinate system:

Remarks: No piezo data available..
 Termination Remark: Total reaction load

Both drained and undrained parameters are calculated for mixed SBTs = I_c 2.05-2.95. See report section 'Drained and Undrained Behaviour' for discussion.
 See report section 'Interpretive Data' for methods and discussion of parameter evaluation.

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT01
 Page 1 of 1



Cone area (mm²):1500
 ConeID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 10:07:09

Location: Barnsley, UK
 Coordinates: 435099.159, 400656.2
 Elevation: 137.069
 Coordinate system:

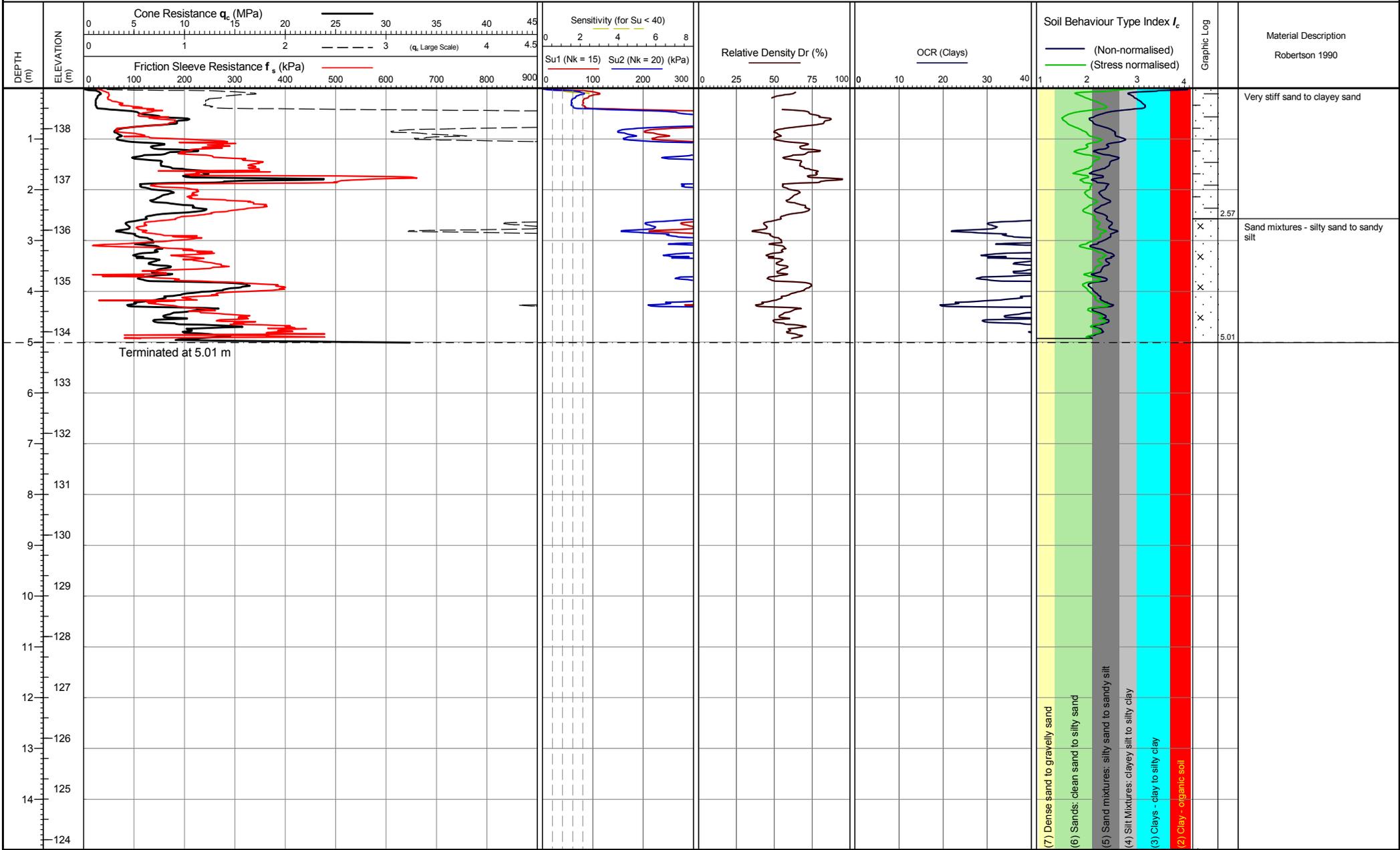
Remarks:
 Termination Remark:
 Total reaction load



Both drained and undrained parameters are calculated for mixed SBTs = Ic 2.05-2.95. See report section 'Drained and Undrained Behaviour' for discussion.
 See report section 'Interpretive Data' for methods and discussion of parameter evaluation.

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT02
 Page 1 of 1



Cone area (mm²):1500
 ConeID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 10:41:14

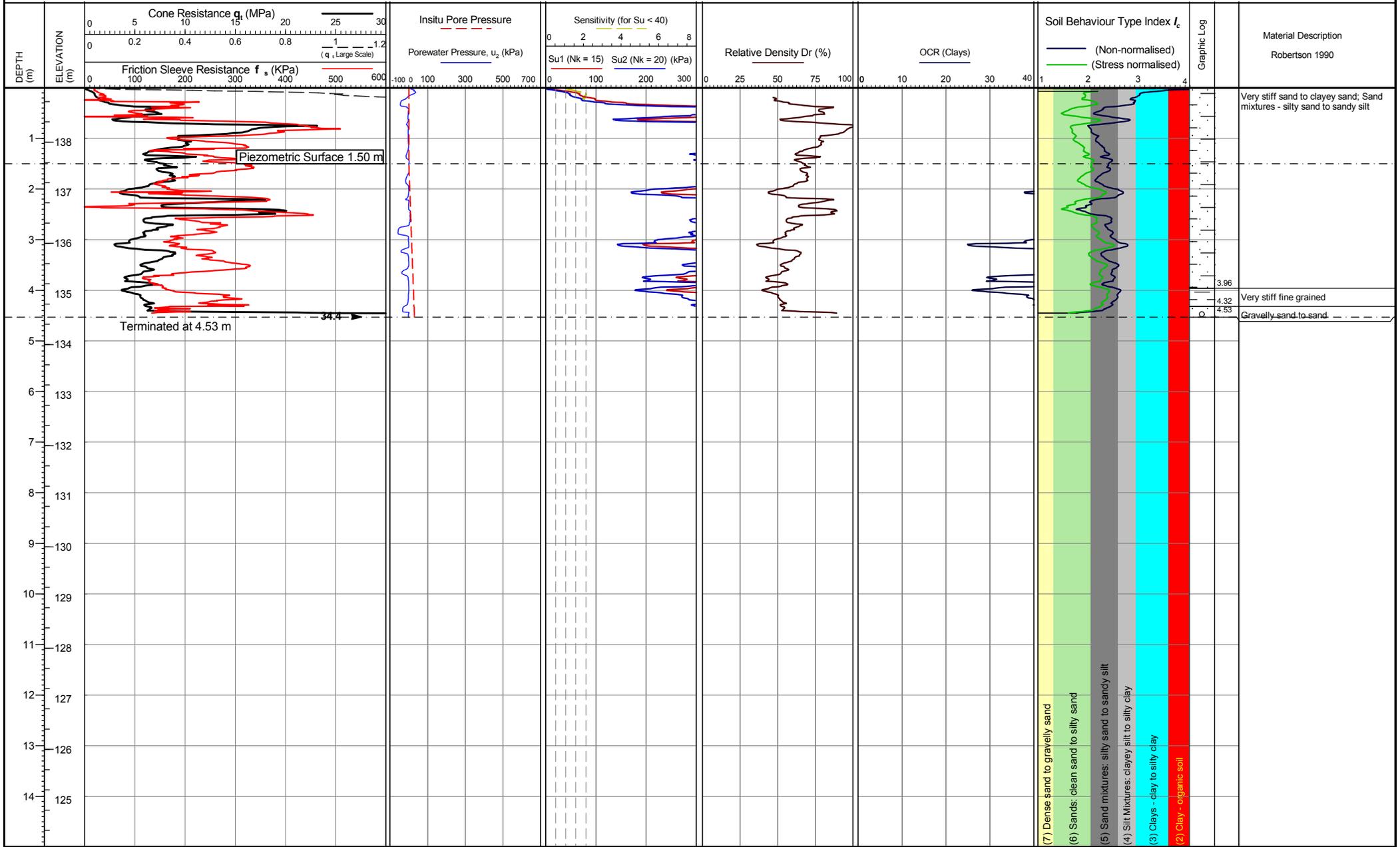
Location: Barnsley, UK
 Coordinates: 435132.397, 400623.985
 Elevation: 138.797
 Coordinate system:

Remarks: No piezo data available..
 Termination Remark: Total reaction load

Both drained and undrained parameters are calculated for mixed SBTs = Ic 2.05-2.95. See report section 'Drained and Undrained Behaviour' for discussion.
 See report section 'Interpretive Data' for methods and discussion of parameter evaluation.

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT03
 Page 1 of 1



Cone area (mm²):1500
 ConeID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 11:02:47

Location: Barnsley, UK
 Coordinates: 435127.497, 400608.441
 Elevation: 139.071
 Coordinate system:

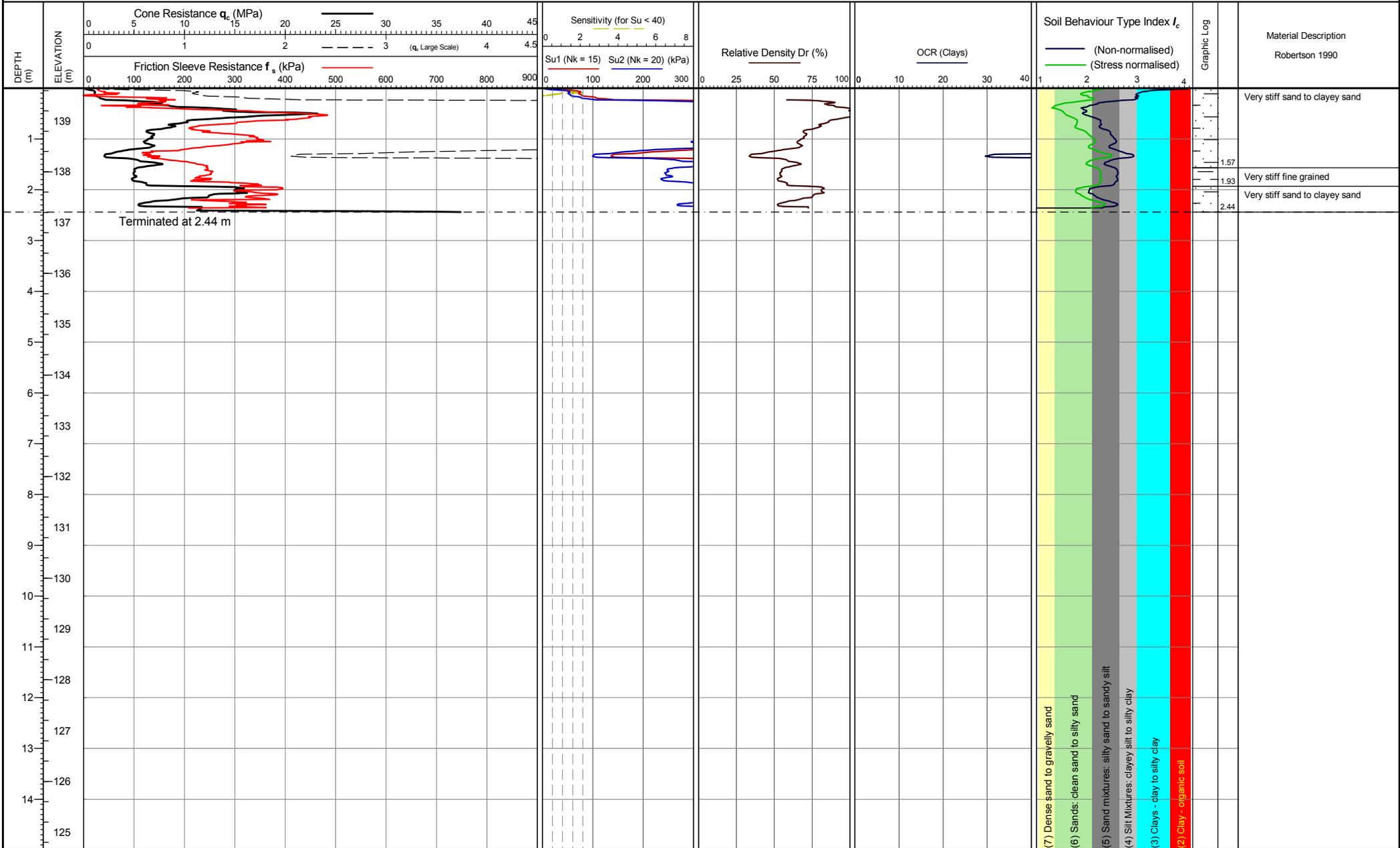
Remarks:
 Termination Remark:
 Total reaction load

Both drained and undrained parameters are calculated for mixed SBTs = I_c 2.05-2.95. See report section 'Drained and Undrained Behaviour' for discussion.
 See report section 'Interpretive Data' for methods and discussion of parameter evaluation.



Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT04
 Page 1 of 1



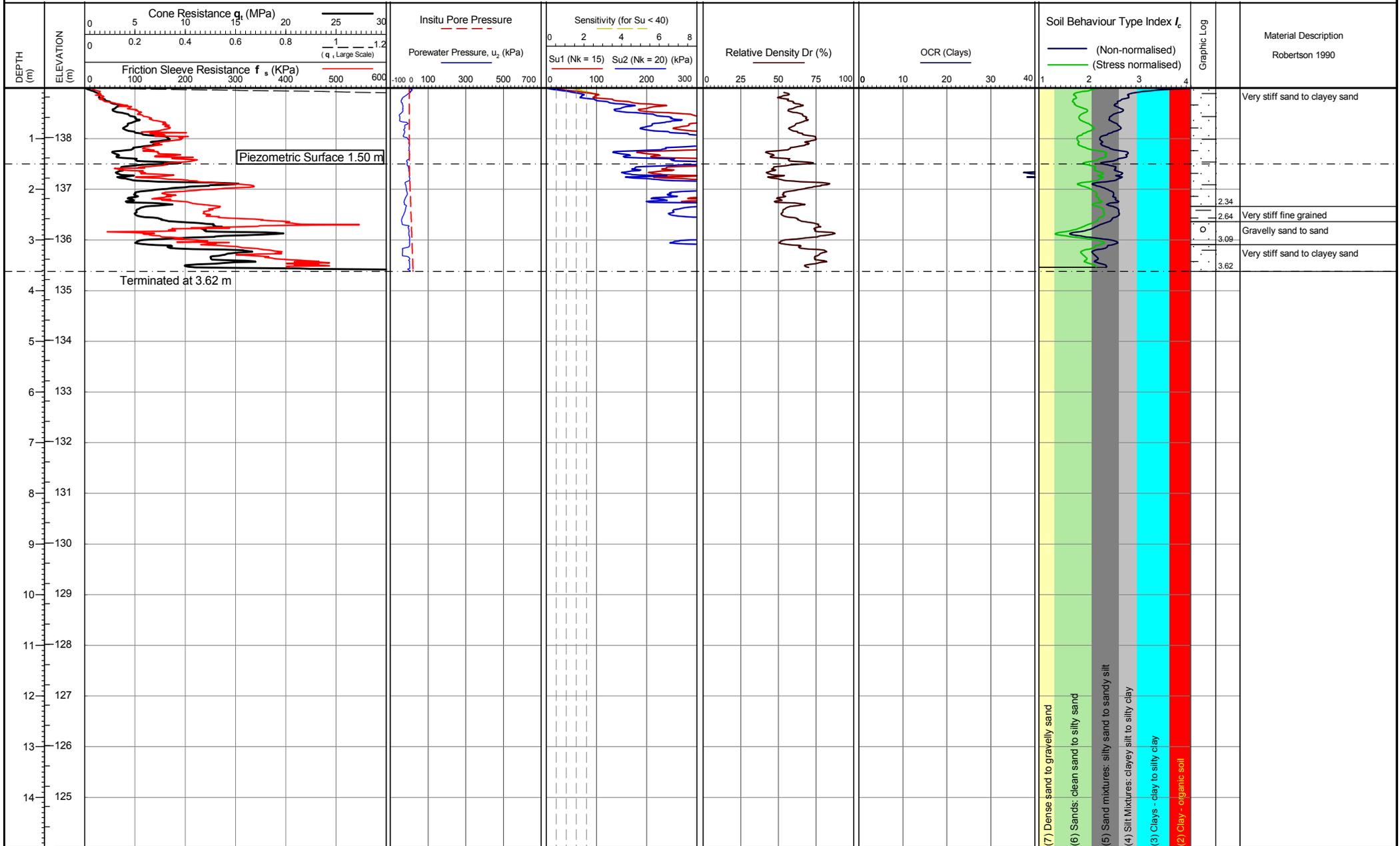
Cone area (mm²):1500
 ConeID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 14:19:03

Location: Barnsley, UK
 Coordinates: 435121.428, 400584.177
 Elevation: 139.648
 Coordinate system:

Remarks: No piezo data available..
 Termination Remark:
 Total reaction load

Both drained and undrained parameters are calculated for mixed SBTs = Ic 2.05-2.95. See report section 'Drained and Undrained Behaviour' for discussion.
 See report section 'Interpretive Data' for methods and discussion of parameter evaluation.

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player



Cone area (mm²):1500
 ConeID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 11:44:28

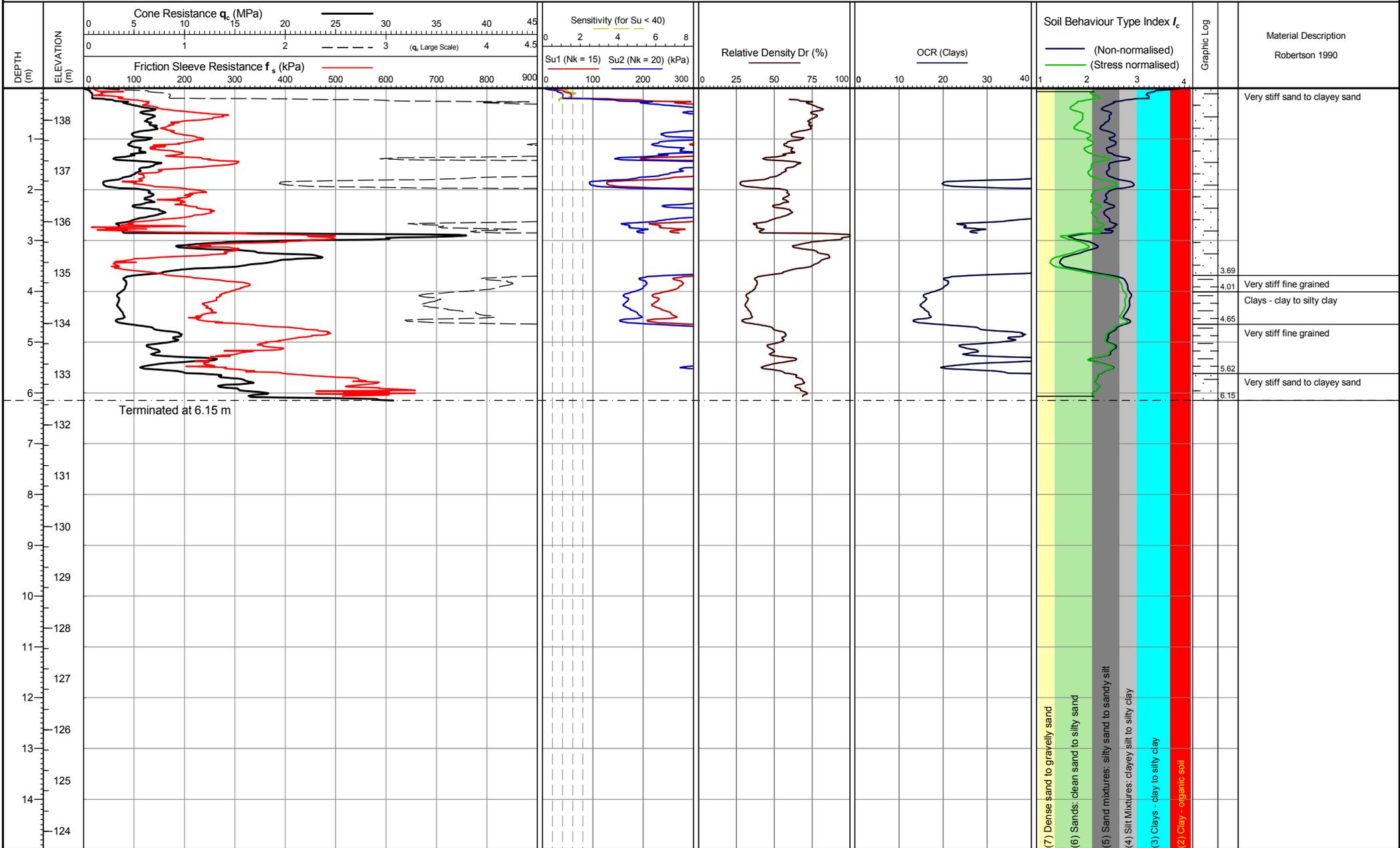
Location: Barnsley, UK
 Coordinates: 435100.167, 400587.481
 Elevation: 138.98
 Coordinate system:

Remarks:
 Termination Remark:
 Total reaction load

Both drained and undrained parameters are calculated for mixed SBTs = Ic 2.05-2.95. See report section 'Drained and Undrained Behaviour' for discussion.
 See report section 'Interpretive Data' for methods and discussion of parameter evaluation.

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT06
 Page 1 of 1



Cone area (mm²):1500
 ConeID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 12:22:01

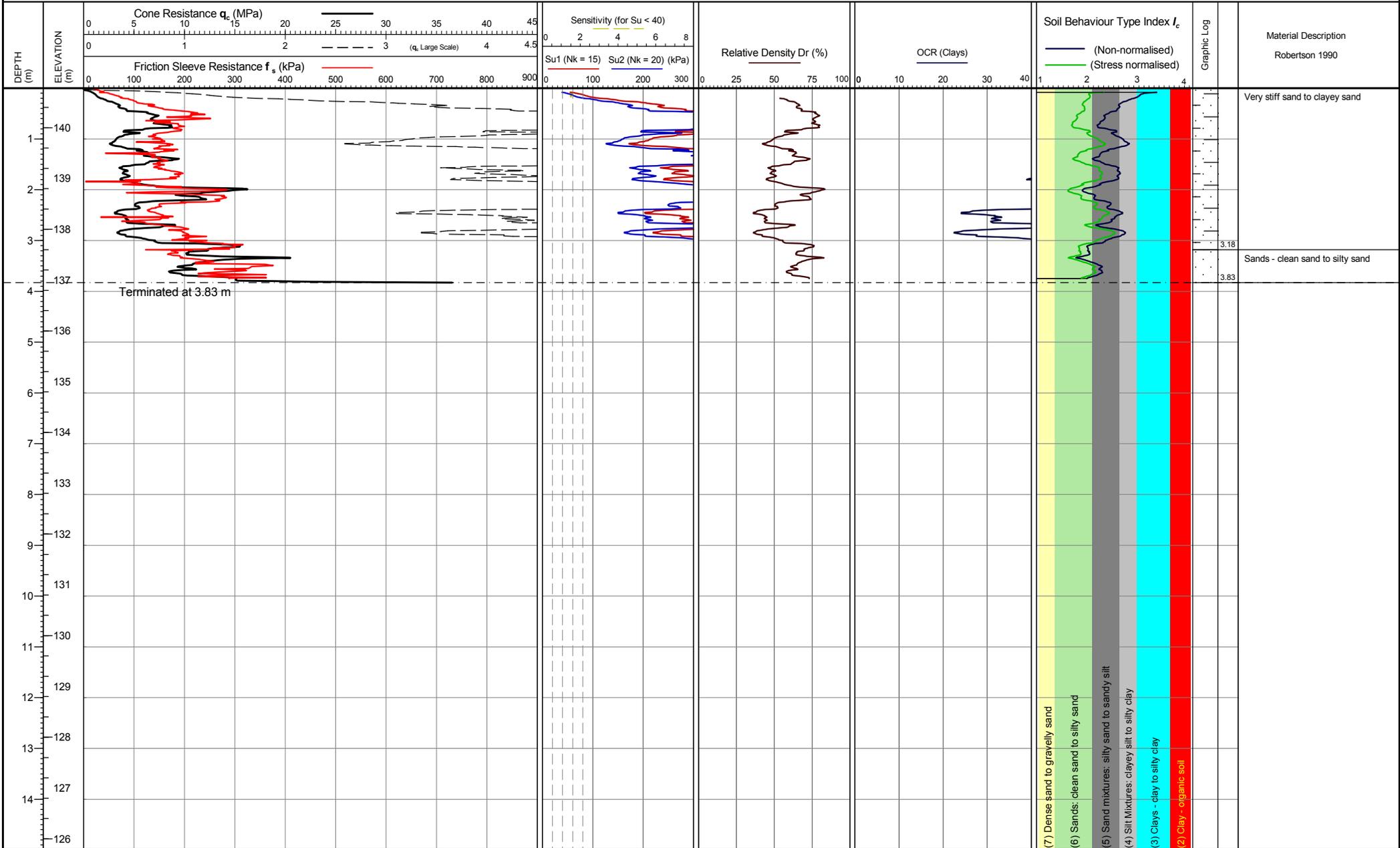
Location: Barnsley, UK
 Coordinates: 435070.674, 400566.489
 Elevation: 138.632
 Coordinate system:

Remarks: No piezo data available..
 Termination Remark: Total reaction load

Both drained and undrained parameters are calculated for mixed SBTs = I_c 2.05-2.95. See report section 'Drained and Undrained Behaviour' for discussion.
 See report section 'Interpretive Data' for methods and discussion of parameter evaluation.

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT07
 Page 1 of 1



Cone area (mm²):1500
 ConeID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 13:52:31

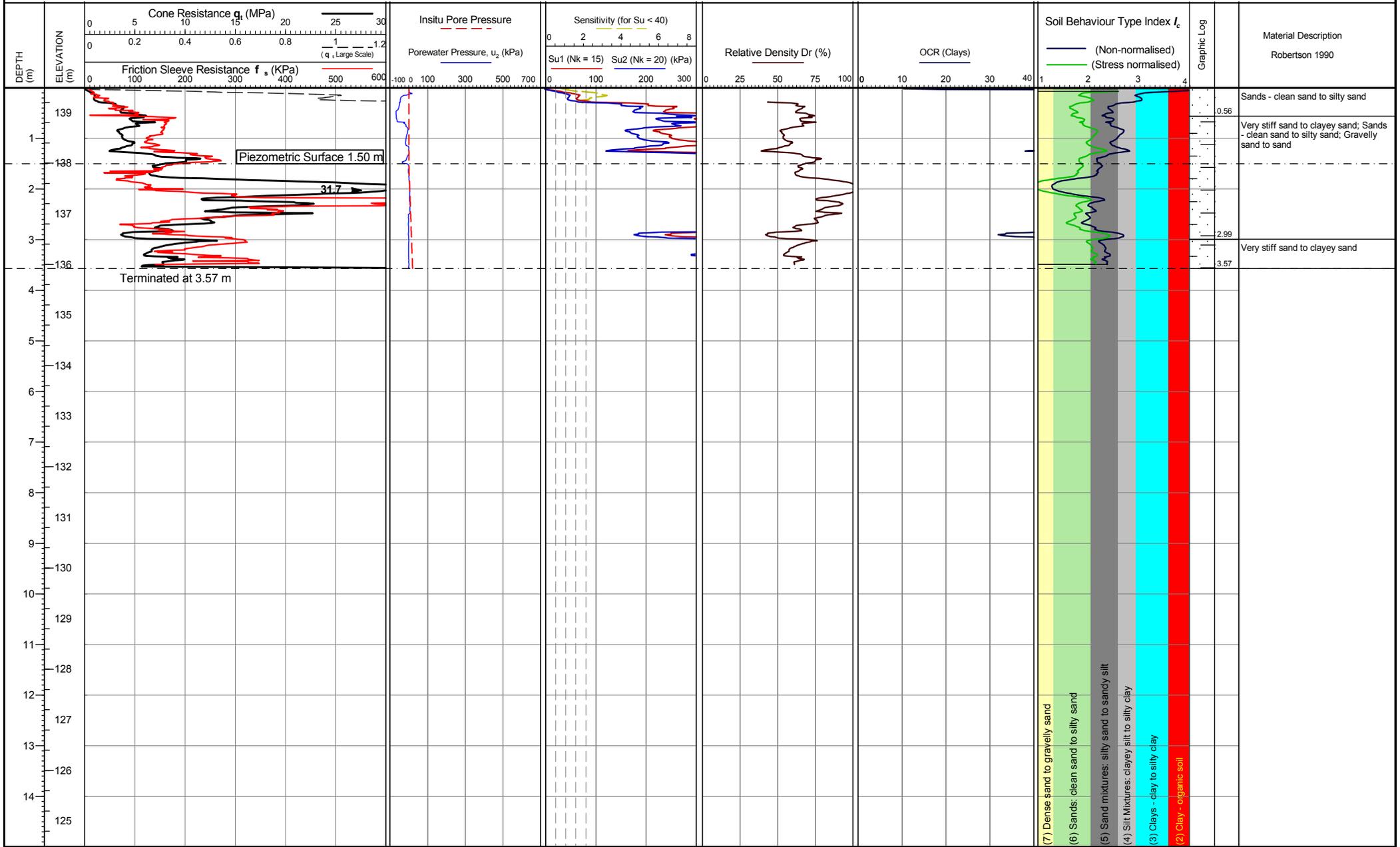
Location: Barnsley, UK
 Coordinates: 435098.121, 400516.222
 Elevation: 140.779
 Coordinate system:

Remarks: No piezo data available..
 Termination Remark: Total reaction load

Both drained and undrained parameters are calculated for mixed SBTs = I_c 2.05-2.95. See report section 'Drained and Undrained Behaviour' for discussion.
 See report section 'Interpretive Data' for methods and discussion of parameter evaluation.

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT08
 Page 1 of 1



Cone area (mm²):1500
 ConeID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 12:58:42

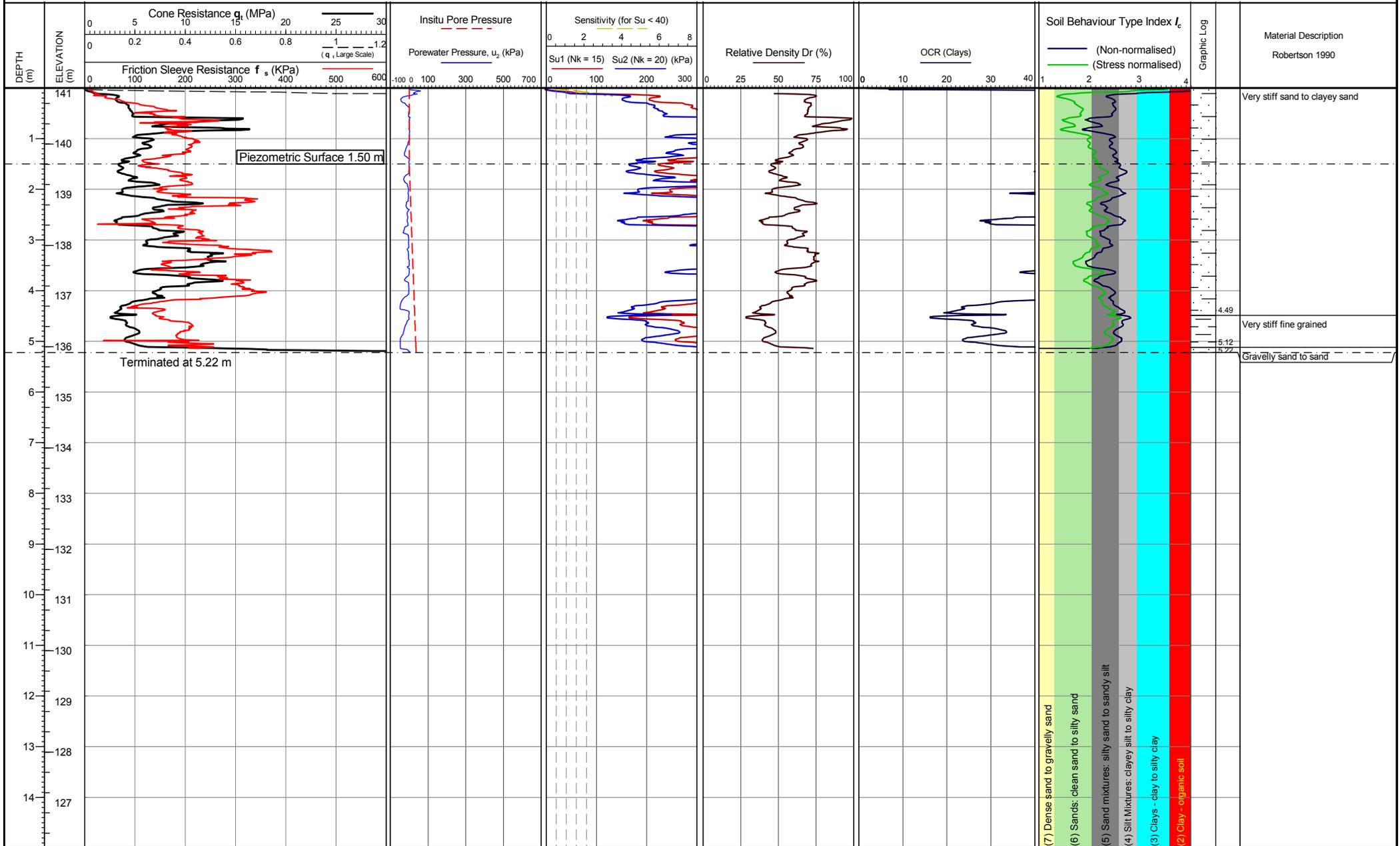
Location: Barnsley, UK
 Coordinates: 435056.032, 400508.417
 Elevation: 139.488
 Coordinate system:

Remarks:
 Termination Remark:
 Total reaction load

Both drained and undrained parameters are calculated for mixed SBTs = Ic 2.05-2.95. See report section 'Drained and Undrained Behaviour' for discussion.
 See report section 'Interpretive Data' for methods and discussion of parameter evaluation.

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

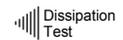
TEST ID: CPT09
 Page 1 of 1



Cone area (mm²):1500
 ConeID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 13:33:49

Location: Barnsley, UK
 Coordinates: 435082.268, 400489.754
 Elevation: 141.107
 Coordinate system:

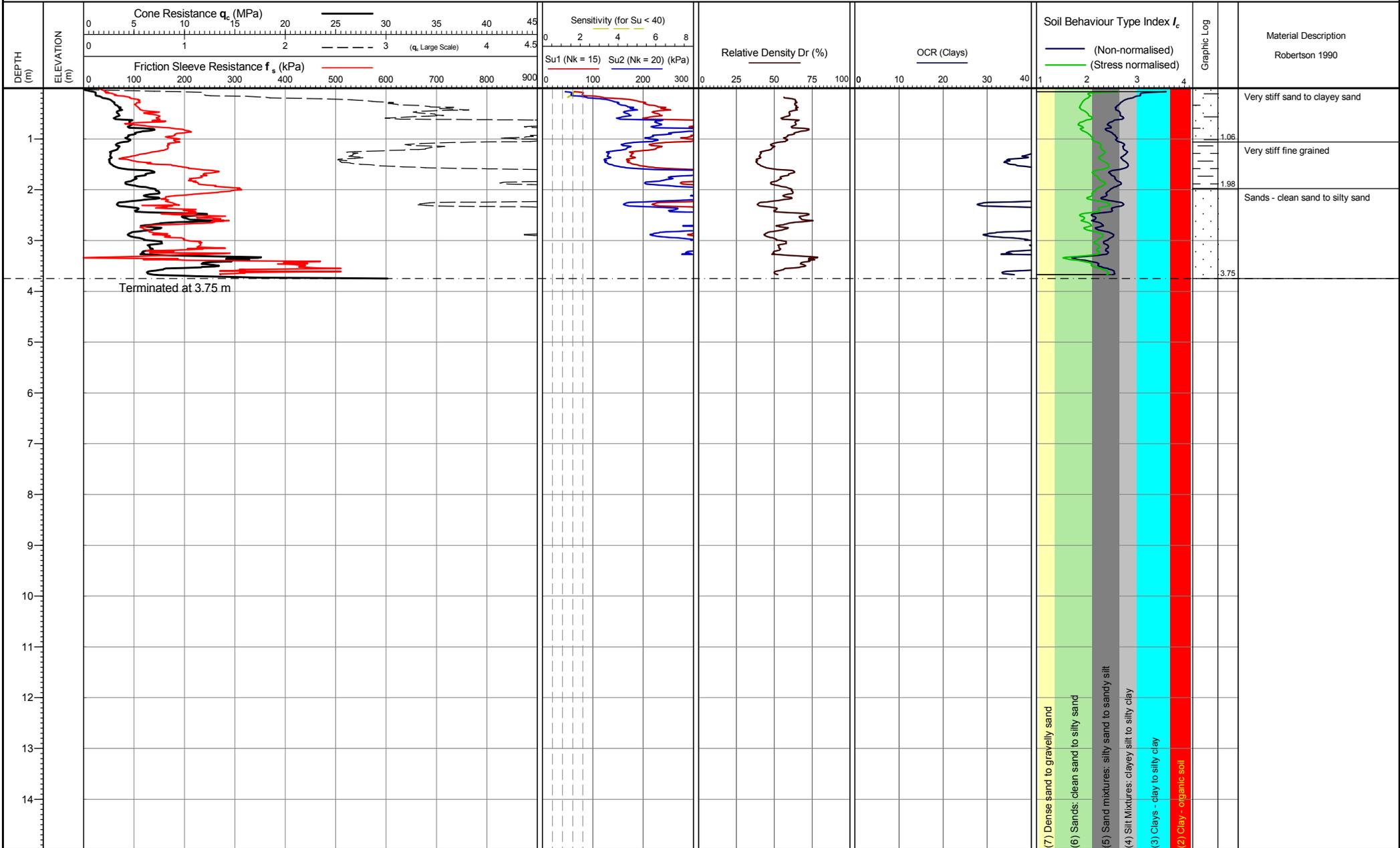
Remarks:
 Termination Remark:
 Total reaction load



Both drained and undrained parameters are calculated for mixed SBTs = Ic 2.05-2.95. See report section 'Drained and Undrained Behaviour' for discussion.
 See report section 'Interpretive Data' for methods and discussion of parameter evaluation.

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT10
 Page 1 of 1



Cone area (mm²):1500
 ConeID: S15-CFIP.915
 Operator: Phillip Case
 Rig Used: UK20
 Date of test: 24/05/2016 14:05:14

Location: Barnsley, UK
 Coordinates: ,
 Elevation:
 Coordinate system:

Remarks: No piezo data available..
 Termination Remark: Total reaction load

Both drained and undrained parameters are calculated for mixed SBTs = I_c 2.05-2.95. See report section 'Drained and Undrained Behaviour' for discussion.
 See report section 'Interpretive Data' for methods and discussion of parameter evaluation.

Date of plot: 13-06-16
 Lankelma Project Ref: P-106412-1
 Checked by: Chris Player

TEST ID: CPT11
 Page 1 of 1

Appendix D

**METHODOLOGY FOR THE DERIVATION OF GENERIC
QUANTITATIVE ASSESSMENT CRITERIA TO EVALUATE RISKS TO
HUMAN HEALTH FROM SOIL & GROUNDWATER CONTAMINATION**

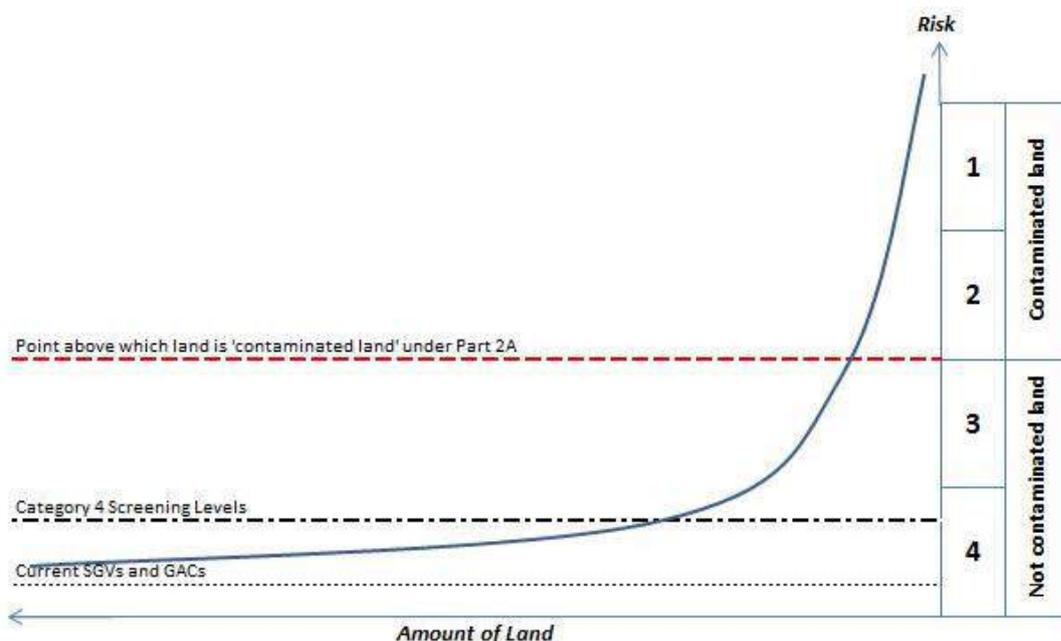
UK APPROACH

In the UK, the potential risks to human health from contamination in the ground are usually evaluated through a generic quantitative risk assessment (GQRA) approach. This allows generic and conservative exposure assumptions to be readily applied to risk assessments and can be a useful tool for rapidly screening data and to identify those contaminants or scenarios that could benefit from further investigation and/or site-specific detailed quantitative risk assessment (DQRA).

Current industry good practice is to use the approach presented in the Environment Agency (EA) publications SR2¹ and SR3². This approach allows the derivation of Generic Assessment Criteria (GACs), primarily for chronic exposure. The Environment Agency's published Soil Guideline Values (SGVs) follow the same approach, but are limited to a small number of substances.

In April 2012, the Department of Environment, Food and Rural Affairs (Defra) published updated statutory guidance³ which introduced a four category approach to determining whether land in England and Wales is contaminated or not on the grounds of significant possibility of significant harm (SPOSH). **Figure 1** presents a graphical representation of the categories.

Figure 1: Four Categories for Determining if Land Represent a SPOSH



Cases classified as Category 1 are considered to be SPOSH based on actual evidence or an unacceptably high probability of harm existing. Category 4 cases are those where there is no risk, or a low risk of SPOSH.

¹ Environment Agency 'Human Health Toxicological Assessment of Contaminants in Soil', Report SC050021/SR2. January 2009.
² Environment Agency 'Updated Technical Background to the CLEA Model,' Report SC050021/SR3. January 2009.
³ Defra 'Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance'. April 2012.

GACs and SGVs represent a minimal risk level, well within Category 4. A 2014 publication by Contaminated Land: Applications in Real Environments (CL:AIRE), SP1010⁴ and endorsed by Defra⁵ provided an approach to determine Category 4 Screening Levels (C4SLs) which are higher than the GACs whilst being “more pragmatic but still strongly precautionary”. It also provided C4SLs for six contaminants of concern.

Although the C4SLs were designed to support Part 2A assessments to determine ‘contaminated land’ they are specifically mentioned, along with reference to the Part 2A statutory guidance, by the Department for Communities and Local Government (DCLG) for use in a planning context⁶.

The SGVs were derived using the Contaminated Land Exposure Assessment (CLEA) Workbook v1.06. An updated version (v1.071) was released by the EA in September 2015 to take into account the publication of SP1010. The updates comprised: additional toxicity data for the six chemicals for which C4SLs were derived; two new public open space land use scenarios; updated exposure parameters; options to run the model using C4SL exposure assumptions; and increased functionality. There were no changes to algorithms, so it is still possible to replicate the SGVs using the input parameters held within v1.071.

It should be noted that the four category approach has not been adopted in Scotland either under Part 2A or the planning regime. The Part 2A statutory guidance applicable in Scotland (Paper SE/2006/44 dated May 2006) does not reflect the changes introduced by Defra in April 2012 which allow for the use of C4SLs within Part 2A risk assessments. Additionally, it is considered that the principal of ‘minimal risk’ should still apply under planning in Scotland, based on current guidance.

WSP | PARSONS BRINCKERHOFF APPROACH

In the absence of a comprehensive set of SGVs it is down to individual practitioners to derive their own GACs. WSP | Parsons Brinckerhoff has used the approach provided within SR2, SR3, SP1010, CLEA Workbook v1.071 and SR4⁷ to produce a set of minimal risk GACs. The chemical-specific data within two key publications were considered during their production: CL:AIRE 2010⁸ and LQM 2015⁹. Both documents provide comprehensive sets of GACs for different contaminants of concern.

The LQM Suitable For Use Levels (S4ULs) have selected exposure parameters somewhere between those of the SR3 land uses and the C4SL exposure scenarios. This approach was rejected by WSP | Parsons Brinckerhoff as not representing minimal risk, however, the LQM S4UL document was critically reviewed and the approach and chemical input parameters were utilised where considered to be appropriate.

⁴ CL:AIRE ‘Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination’ SP1010, Final Project Report (Revision 2). September 2014.

⁵ Defra ‘SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document’. December 2014.

⁶ DCLG Planning Practice Guidance ‘Land Affected by Contamination’, particularly Paragraphs 001 and 007. Ref IDs: 33-001-20140306 & 33-007-20140612.

⁷ Environment Agency ‘CLEA Software (Version 1.05) Handbook (and Software)’, Report SC050021/SR4. September 2009.

⁸ CL:AIRE ‘The EIC/AGS/CL:AIRE Soil Generic Assessment Criteria for Human Health Risk Assessment’. ISBN 978-1-05046-20-1. January 2010.

⁹ Nathanail et al ‘The LQM/CIEH S4ULs for Human Health Risk Assessment’, Land Quality Press, ISBN 978-0-9931084-0-2. 2015.

A C4SL Working Group is planning to derive a larger set of C4SLs during 2016, and it is understood that this will include a critical review of the chemical input data for all selected substances. This may lead to further amendments to the chemical input data used in the WSP | Parsons Brinckerhoff in-house screening values. It is considered likely that the contaminant list will crossover with the current CL:AIRE GACs. As such, this document was not critically reviewed by WSP | Parsons Brinckerhoff.

WSP | Parsons Brinckerhoff's current approach to the assessment of risks to human health is to continue to evaluate minimal risk through the use of SGVs and in-house derived GACs, and to use the published C4SLs as a secondary tier of assessment until such time as additional suitable C4SLs are published and/or in-house values are derived.

EXPOSURE MODELS

LAND USES

WSP | Parsons Brinckerhoff has largely adopted the exposure assumptions of the generic land use scenarios included within SR3 with two additional public open space scenarios included within SP1010:

- Residential with homegrown produce consumption
- Residential without homegrown produce consumption
- Allotments
- Commercial
- Public open space near residential housing (POS_{resi})
- Public park (POS_{park})

Exceptions are described in the following Sections.

SOIL PROPERTIES

SR3 assumes a sandy loam soil with a pH of 7 and Soil Organic Matter (SOM) content of 6% for its generic land uses, based on the geographical spread of topsoils in the UK. WSP | Parsons Brinckerhoff has adopted these default values. In addition, GACs based on SOM of 1% and 2.5% have also been derived based on common experience of the nature of Made Ground and lack of topsoil on many brownfield sites.

RECEPTOR CHARACTERISTICS AND BEHAVIOURS

SP1010 provides some updated exposure parameters for long-term inhalation rates¹⁰ and the consumption rates for homegrown produce¹¹ compared to those provided in SR3. This data was used to derived WSP | Parsons Brinckerhoff's GACs. The changes in inhalation rates do not apply to the allotment generic land use scenario. These are based on the breathing rates for short-term exposure of light to moderate intensity activity which were derived from a study that was not updated in USEPA 2011, so the SR3 rates were retained.

¹⁰ USEPA, National Centre for Environmental Assessment 'Exposure Factors Handbook: 2011 Edition' EPA/600/R-09/052F. September 2011.

¹¹ National Diet and Nutrition Survey 2008/2009 to 2010/2011.

CHEMICAL DATA

PHYSICO-CHEMICAL PARAMETERS

Physico-chemical properties for the contaminants for which GACs have been derived have been obtained following critical review of the following hierarchy of data sources:

1. Environment Agency/Defra SGV reports where available.
2. Environment Agency '*Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values*', Report SC050021/SR7, November 2008.
3. Published fate and transport reviews within Nathanail et. al 2015 and CL:AIRE 2010.

Where appropriate, and where sufficient data is available, values were adjusted to reflect a UK soil temperature of 10°C (e.g. K_{aw}).

TOXICOLOGICAL DATA

Toxicological data for the derivation of minimal risk Health Criteria Values (HCV) for each contaminant was selected with due regard to the approach presented in SR2. Where appropriate, the following hierarchy of data sources was used:

1. UK toxicity reviews published by authoritative bodies including:
 - EA
 - Public Health England (PHE)
 - Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT)
 - Committee on Carcinogenicity of Chemicals in Food, Consumer Products and the Environment (COC)
2. Authoritative European sources such as European Food Standards Agency (EFSA)
3. International organisations including:
 - World Health Organisation (WHO)
 - Joint FAO/WHO Expert Committee on Food Additives (JECFA)
4. Authoritative country-specific sources including:
 - United States Environmental Protection Agency (USEPA)
 - US Agency for Toxic Substances and Disease Registry (ATSDR)
 - US Integrated Risk Information System (IRIS)
 - Netherlands National Institute for Public Health and the Environment (RIVM)

Factors such as the applicability of the data to human health (e.g. epidemiological vs. animal studies), the quality of the data, the level of uncertainty in the results and the age of the data were also taken into account in the final selection. Details for specific substances are available on request.

MEAN DAILY INTAKES

Estimations of background exposure for each threshold substance have been updated. In line with the SR2 approach, the exposure from non-threshold substances in the soil does not take into account

exposure from other sources, and as such GACs were derived without consideration of the Mean Daily Intakes (MDI) for those substances.

The data published by the EA in its series of TOX reports between 2002 and 2009 was evaluated to determine whether the values were considered to remain valid today. Values from these current UK published sources were not amended unless they were considered to be significantly different so that the GACs remained as comparable as possible with the still commonly used SGVs.

ORAL MEAN DAILY INTAKES

Oral MDI were generally estimated as the sum of exposure via the ingestion of food and drinking water using the default adult physiological parameters presented in Table 3.3 of SR2.

Data on the exposure of substances from food ingestion was generally obtained from UK Total Diet Studies (TDS) published by the Food Standards Agency (FSA) and its predecessor the Ministry of Agriculture, Fisheries and Food (MAFF) and from studies commissioned by COT. Where no UK-specific data was available, MDI were derived from the European Food Safety Authority (EFSA), Health Canada and US sources. This was a rare occurrence, and in these instances, the data was evaluated to determine its applicability to the UK.

Data on the concentrations of substances in tap water was obtained from a variety of sources. UK data was used where available, with preference given to Drinking Water Inspectorate (DWI) 2014 data from water company tap water testing (LOD, 1st and 99th percentile data is available). Where the substance was not included in tap water testing, other UK sources of information were considered including:

- DWI data from water company tap water testing from previous years;
- COT; and
- FSA.

Where UK data was not available, a number of other data sources were considered, largely WHO International Programme on Chemical Safety (IPCS) Concise International Chemical Assessment Documents (CICADs) and background documents for the development of Guidelines for Drinking Water Quality, using professional judgement on the relevance of the data to the UK. The final decision on the MDI from drinking water was made using professional judgement on the balance of relevance and probability, taking into account the detection limit where not detected, Koc and solubility, reduction in use of the substance, banned substances, tight controls (e.g. on explosives) and with due consideration to the SR2 instruction that “if no data or information in background exposure are available, background exposure should be assumed to be negligible and the MDI set to zero....”.

Data from other countries was generally not used because it was considered that the hydrogeology of these countries along with industrial practices were unlikely to be reflective of the UK.

INHALATION MEAN DAILY INTAKES

Inhalation MDIs were based on estimates of average daily exposure by the inhalation pathway and calculated using the default adult physiological parameters presented in Table 3.3 of SR2.

The inhalation MDIs were generally estimated using background exposure data from the UK, derived from Defra's UK-AIR: Air Information Resource¹², which provides ambient air quality data from a number of sites forming a UK-wide monitoring network. The MDIs for heavy metals were based on rolling annual average metal mass concentration data from Defra's UK Heavy Metals Monitoring Network from the period October 2009 to September 2010¹³.

Information for some substances was obtained from UK sources including Environment Agency TOX reports and data from the UK Expert Panel on Air Quality Standards (EPAQS). Where recent UK data was not available, data was sourced from the International Programme on Chemical Safety (IPCS), the World Health Organisation (WHO), the Agency for Toxic Substances and Diseases Registry (ATSDR), Health Canada, and various other peer-reviewed sources summarised by LQM/CIEH¹⁴.

For other substances, where no data or information on background exposure was available, background exposure was assumed to be negligible and the MDI set at 0.5*TDI in accordance with guidance in SR2.

PLANT UPTAKE

Soil to plant concentration factors are available in CLEA v1.071 for arsenic, cadmium, hexavalent chromium, lead, mercury, nickel and selenium. For all remaining inorganic chemicals, concentration factors were obtained using the PRISM model. Substance-specific correction factors have been selected in accordance with the guidance established within SR3. This is consistent to the approach utilised in the derivation of the LQM S4UL values and the EIC/AGS/CL:AIRE GAC.

Where there is a lack of appropriate data to enable the derivation of specific soil to plant concentrations factors for organic chemicals, plant uptake was modelled within CLEA v1.071 using the generic equations recommended within SR3, as follows:

- Green Vegetables – Ryan et al. (1988);
- Root Vegetables – Trapp (2002);
- Tuber Vegetables – Trapp et al. (2007); and
- Tree Fruit – Trapp et al. (2003).

There are no suitable models available for modelling uptake for herbaceous fruit or shrub fruit. Exposure is considered negligible.

SOIL SATURATION LIMITS

GACs are not limited to their theoretical soil saturation within CLEA, although where either the aqueous or the vapour-based saturation is exceeded, this is highlighted within the Workbook (compared with the lower of the two values). This affects pathways which depend on partitioning calculations so in reality this only affects the vapour pathways and is relevant to organic substances

¹² Crown 2016 copyright Defra via uk-air.defra.gov.uk, licenced under the Open Government Licence (OGL).

¹³ Defra, 20143 Spreadsheet of historic data for multiple years for the Metals network. Available online at: <http://uk-air.defra.gov.uk/data/metals-data>. [Accessed 13/03/2016].

¹⁴ LQM/CIEH, 2015. The LQM/CIEH S4ULs for Human Health Risk Assessment.

and other substances, such as elemental mercury, that have a significant volatile component. However, the Workbook highlights saturation for direct contact pathways to indicate to the user where further qualitative consideration of free phase contamination at surface may be required.

Where the lower of the two saturation limits is exceeded and the vapour pathway is the only exposure route being considered, the chronic risks to human health are likely to be negligible. Further evaluation could be undertaken using an alternative model suitable for evaluating non-aqueous phase liquids (NAPLs), such as the Johnson & Ettinger (J&E) approach described in USEPA 2003. However, WSP | Parsons Brinckerhoff considers that if NAPLs are suspected, given the known limitations and over-simplifications of J&E, soil vapour monitoring is a more accurate way of assessing potential risks.

Where the lower saturation limit is exceeded for the vapour pathway and a number of exposure routes are being considered, then the contribution from the NAPL via vapour inhalation to the overall exposure can be evaluated using the procedure provided in SR4. WSP | Parsons Brinckerhoff would evaluate this as part of a DQRA process or through soil vapour monitoring on-site to determine site-specific soil vapour concentrations.

CHEMICAL SPECIFIC ASSUMPTIONS

CYANIDES

Cyanide has high acute toxicity, and short term exposure is an important consideration when assessing the risks from soils contaminated with cyanide. The primary risk to human receptors from free cyanide in soils is an acute risk.

There is no current UK guidance available for calculating acute risks from free cyanide. Consequently, GAC for acute exposure were derived using the algorithms presented in MADEP 1992¹⁵ and assuming a one-off ingestion of 10g of soil (this conservative value has been taken as an upper bound estimate for pica amongst children). Receptor body weights have been selected according to the critical receptor for each exposure scenario.

The lowest of the chronic and acute GAC for each land use scenario were adopted by WSP | Parsons Brinckerhoff.

LEAD

The SGV for lead was withdrawn by the EA in 2009, and in 2011 the EA withdrew their published TOX report in light of new scientific evidence. The C4SL for lead was derived using the latest scientific evidence from a large human dataset. As such, no chemical-specific margin was applied in the derivation of the C4SL for lead. It may be possible for WSP | Parsons Brinckerhoff to derive a GAC for lead using the same dataset and applying a chemical-specific margin, but the value is likely to be lower than UK natural background concentrations. Therefore, WSP | Parsons Brinckerhoff has adopted the toxicological data used to derive the C4SLs in deriving the GAC for lead until such time as alternative GACs are published by an authoritative body. The relative bioavailability was set at 100% in line with the approach taken for other GACs, whereas the C4SL assumes 60% for soil and 64% for airborne dust. Thus, the WSP | Parsons Brinckerhoff GAC are lower than the C4SLs.

¹⁵ MADEP 'Background Documentation for the Development of an "Available Cyanide" Benchmark Concentration' 1992. http://www.mass.gov/dep/toxics/cn_soil.htm

POLYCYCLIC AROMATIC HYDROCARBONS

WSP | Parsons Brinckerhoff's approach to the assessment of polycyclic aromatic hydrocarbons (PAHs) uses the surrogate marker approach. BaP was used as a surrogate marker for all genotoxic PAHs in line with the Health Protection Agency 2010¹⁶ recommendations and SP1010. This assumes that the PAH profile of the data is similar to that of the coal tars used in the Culp *et al* oral carcinogenicity study from which the toxicity data for BaP was produced. In reality, this profile has been shown by HPA to be applicable on the majority of contaminated sites based on assessment of sites across the country.

The alternative is the Toxic Equivalency Factor (TEF) approach which uses a reference compound and assigns TEFs for other compounds based on estimates of potency. Key uncertainties with this approach include the assumption that all compounds have the same toxic mechanism of action within the body and that no compounds with a greater potency than the reference compound are present. It is considered by the HPA that the TEF approach is likely to under predict the true carcinogenicity of PAHs and therefore favours the surrogate marker approach.

For these reasons, WSP | Parsons Brinckerhoff considers that the adoption of BaP as a surrogate marker for genotoxic PAHs as opposed to the TEF approach is reasonable, even in cases where the PAH profile may differ from that of the Culp *et al* study. In addition, WSP | Parsons Brinckerhoff has derived a GAC for naphthalene, which is commonly a risk driver due to its high volatility, relative to other PAH compounds, as an indicator compound for threshold PAHs.

CHEMICAL GROUPS

For a number of chemical groups, the available toxicity data is for combinations of chemicals. Given that the physico-chemical parameters may differ between the chemicals, the GACs for the chemicals within the groups has been calculated and then the lowest GAC selected to represent the entire group. This was the approach taken by the EA for m-, o- and p-xylenes, and has also been adopted by WSP | Parsons Brinckerhoff for:

- 2-chlorophenol, 2,4-dichlorophenol, 2,4,6-trichlorophenol and 2,3,4,6-tetrachlorophenol;
- 2-, 3- and 4-methylphenol (total cresols);
- aldrin and dieldrin; and
- α - and β -endosulphan.

EXPOSURE TO VAPOURS

INHALATION OF MEASURED VAPOURS

WSP | Parsons Brinckerhoff has derived a set of soil vapour GACs (GAC_{sv}) that allow for the assessment of measured site soil vapour concentrations, using J&E, in order to establish potential risks via indoor inhalation of vapours. This methodology enables a more robust assessment of exposure via the inhalation of soil vapours indoors than using CLEA-derived soil GAC, as it is based upon measured soil vapour concentrations beneath the site. It also allows for the assessment of vapours from all source terms (i.e. groundwater, soil or NAPL). Outdoor inhalation was not included. WSP | Parsons Brinckerhoff considers that the indoor inhalation pathway is the significantly dominant risk-driver.

¹⁶ HPA Contaminated Land Information Sheet 'Risk Assessment Approaches for Polycyclic Aromatic Hydrocarbons (PAHs) 2010

The generic land use scenarios within CLEA (residential and commercial) that were used to derive the soil GAC were used to define the receptor and building characteristics for the soil vapour GAC. Only residential and commercial generic land use scenarios include the indoor inhalation of vapours pathway.

The GAC_{sv} were derived for three different soil types; sand, sandy loam and clay, reflecting the importance of this parameter within the J&E model. A depth to contamination of 0.85m below the base of the building foundation was assumed (i.e. 1m below ground level). This differs from the depth assumed for the soil GAC (0.5m bgl), but was selected by WSP | Parsons Brinckerhoff as a reasonable worst case scenario. It is acknowledged that the J&E commonly over-predicts indoor vapour concentrations. In particular, it will significantly over-predict vapour concentrations for suspended floor slabs, which many new builds are constructed with, it does not take into account lateral migration and assumes an infinite source of contamination at steady state conditions. In addition, it is common for soil gas/vapour wells to be installed with at least 1m of plain riser at the surface and this equates to a total depth of 0.85m below the building foundation plus a 0.15m thick foundation, and so is more representative of the depth that samples will be taken from.

The TDSIs and IDs for each substance were converted from $\mu\text{gkg}^{-1}\text{bday}^{-1}$ to μgm^{-3} using the standard conversions quoted in Table 3.3 of SR2, thereby replacing the need to model C_{air} in the equation:

$$C_{air} = \alpha \cdot C_{vap} \cdot 1,000,000\text{cm}^3\text{m}^{-3}$$

Where:

C_{air} is the concentration of vapours within the building, mg^{-3}

α is the steady state attenuation coefficient between soil and indoor air, dimensionless

C_{vap} is the soil vapour concentration, mgcm^{-3}

The target concentrations within indoor air for each substance (C_{air}) are a function of receptor inhalation rates and occupancy periods, as defined by the site conceptual exposure model (assuming standard CLEA occupancy periods and receptors).

The attenuation factor was calculated using J&E (Equation 10.4 in SR3) and the resulting C_{vap} is equivalent to the GAC_{sv} for the modelled exposure scenario.

Where the calculated GAC_{sv} for a substance exceeds the vapour saturation limit, no GAC_{sv} has been proposed.

INHALATION OF GROUNDWATER-DERIVED VAPOURS

The CLEA model does not have the capacity to derive GACs to assess vapours derived from dissolved phase contamination. WSP | Parsons Brinckerhoff has derived a set of groundwater GACs (GAC_{gw}) to evaluate the potential risks through the indoor inhalation of groundwater-derived vapours by first applying the approach described above for the derivation of the WSP | Parsons Brinckerhoff GAC_{sv} to determine the acceptable concentration in soil vapour directly above the water table.

The depth to groundwater was assumed to be 1m bgl (i.e. 0.85m below the base of the building foundation). This depth was considered to be more representative of commonly encountered groundwater conditions than the 0.5m below the base of the building foundation (i.e. 0.65m bgl) that is used by CLEA for an unsaturated source present in the overlying soil.

The GAC_{gw} was then back-calculated from the GAC_{sv} using the air-water partition coefficient (K_{aw}) for each substance.

Where the calculated GAC_{gw} for a substance exceeds the solubility limit, no GAC_{gw} has been proposed.

Appendix E

CHEMICAL ANALYSIS RESULTS



WSP PB MLN
The Victoria
150-182 The Quays
Salford
Manchester
Lancashire
M50 3SP

Attention: Gareth Maynell

CERTIFICATE OF ANALYSIS

Date: 27 July 2016
Customer: H_WSP_MAN
Sample Delivery Group (SDG): 160602-104
Your Reference: Rockingham
Location: Rockingham, Barnsley
Report No: 370706

This report has been revised and directly supersedes 370548 in its entirety.

We received 12 samples on Thursday June 02, 2016 and 12 of these samples were scheduled for analysis which was completed on Tuesday July 19, 2016. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

All chemical testing (unless subcontracted) is performed at ALcontrol Hawarden Laboratories.

Approved By:

Sonia McWhan
Operations Manager





SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
13531216	BH01	ES	0.10 - 0.15	24/05/2016
13531236	BH01	ES	0.40 - 0.50	24/05/2016
13531241	BH01	ES	1.00 - 1.10	24/05/2016
13531246	BH02	ES	0.10 - 0.20	24/05/2016
13531251	BH02	ES	0.80 - 0.90	24/05/2016
13531256	BH02	ES	1.80 - 1.90	24/05/2016
13531260	BH04	ES	0.10 - 0.20	24/05/2016
13531265	BH04	ES	2.50 - 2.60	24/05/2016
13531226	BH05	ES	0.05 - 0.10	24/05/2016
13531271	BH05	ES	0.30 - 0.35	24/05/2016
13531231	BH05	ES	1.50 - 1.60	24/05/2016
13531221	BH05	ES	2.10 - 2.20	24/05/2016

Only received samples which have had analysis scheduled will be shown on the following pages.



SDG: 160602-104
 Job: H_WSP_MAN-355
 Client Reference: Rockingham

Location: Rockingham, Barnsley
 Customer: WSP PB MLN
 Attention: Gareth Maynell

Order Number: 70018922-S01
 Report Number: 370706
 Superseded Report: 370548

SOLID Results Legend <input checked="" type="checkbox"/> Test <input checked="" type="checkbox"/> No Determination Possible	Lab Sample No(s)		Customer Sample Reference		AGS Reference		Depth (m)		Container	
	13531216		BH01		ES		0.10 - 0.15		250g Amber Jar 1kg TUB	
	13531236		BH01		ES		0.40 - 0.50		60g VOC (ALE215) 250g Amber Jar 1kg TUB	
	13531241		BH01		ES		1.00 - 1.10		60g VOC (ALE215) 250g Amber Jar 1kg TUB	
	13531246		BH02		ES		0.10 - 0.20		250g Amber Jar 1kg TUB	
13531251		BH02		ES		0.80 - 0.90		60g VOC (ALE215) 250g Amber Jar 1kg TUB		
13531256		BH02		ES		1.80 - 1.90		250g Amber Jar 1kg TUB		
13531260		BH04		ES		0.10 - 0.20		250g Amber Jar 1kg TUB		
13531265		BH04		ES		2.50 - 2.60		250g Amber Jar 1kg TUB		
13531226		BH05		ES		0.05 - 0.10		250g Amber Jar 1kg TUB		
13531271		BH05		ES		0.30 - 0.35		60g VOC (ALE215) 250g Amber Jar 1kg TUB		
13531231		BH05		ES		1.50 - 1.60		60g VOC (ALE215) 250g Amber Jar 1kg TUB		
13531221		BH05		ES		2.10 - 2.20		250g Amber Jar 1kg TUB		
Anions by Kone (soil)	All	NDPs: 0 Tests: 6	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>					
Asbestos ID in Solid Samples	All	NDPs: 0 Tests: 12	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>					
Cyanide Comp/Free/Total/Thiocyanate	All	NDPs: 0 Tests: 12	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>					
EPH CWG (Aliphatic) GC (S)	All	NDPs: 0 Tests: 6		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
EPH CWG (Aromatic) GC (S)	All	NDPs: 0 Tests: 6		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GRO by GC-FID (S)	All	NDPs: 0 Tests: 6		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Metals in solid samples by OES	All	NDPs: 0 Tests: 12	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>					
PAH by GCMS	All	NDPs: 0 Tests: 12	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>					
pH	All	NDPs: 0 Tests: 6	<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Sample description	All	NDPs: 0 Tests: 12	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>					
Total Organic Carbon	All	NDPs: 0 Tests: 7	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
TPH CWG GC (S)	All	NDPs: 0 Tests: 6		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
VOC MS (S)	All	NDPs: 0 Tests: 6		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>



SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

Sample Descriptions

Grain Sizes

very fine	<0.063mm	fine	0.063mm - 0.1mm	medium	0.1mm - 2mm	coarse	2mm - 10mm	very coarse	>10mm
-----------	----------	------	-----------------	--------	-------------	--------	------------	-------------	-------

Lab Sample No(s)	Customer Sample Ref.	Depth (m)	Colour	Description	Grain size	Inclusions	Inclusions 2
13531216	BH01	0.10 - 0.15	Dark Brown	Silty Clay	0.002 - 0.063 mm	Coal fragments	Stones
13531236	BH01	0.40 - 0.50	Dark Brown	Silty Clay Loam	0.002 - 0.063 mm	Vegetation	Stones
13531241	BH01	1.00 - 1.10	Dark Brown	Sandy Clay Loam	0.063 - 2.00 mm	Stones	Vegetation
13531246	BH02	0.10 - 0.20	Black	Sandy Clay Loam	0.063 - 2.00 mm	Stones	Vegetation
13531251	BH02	0.80 - 0.90	Grey	Silty Clay	0.002 - 0.063 mm	Stones	Vegetation
13531256	BH02	1.80 - 1.90	Grey	Clay	<0.002 mm	Stones	None
13531260	BH04	0.10 - 0.20	Grey	Silty Clay	0.002 - 0.063 mm	Stones	Vegetation
13531265	BH04	2.50 - 2.60	Grey	Silty Clay Loam	0.002 - 0.063 mm	Stones	Vegetation
13531221	BH05	2.10 - 2.20	Dark Brown	Silty Clay Loam	0.002 - 0.063 mm	Vegetation	Stones
13531226	BH05	0.05 - 0.10	Dark Brown	Loamy Sand	0.063 - 2.00 mm	Vegetation	Stones
13531231	BH05	1.50 - 1.60	Dark Brown	Silty Clay Loam	0.002 - 0.063 mm	Vegetation	Stones
13531271	BH05	0.30 - 0.35	Dark Brown	Silty Clay	0.002 - 0.063 mm	None	None

These descriptions are only intended to act as a cross check if sample identities are questioned, and to provide a log of sample matrices with respect to MCERTS validation. They are not intended as full geological descriptions.

We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally occurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample.

Other coarse granular materials such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

Results Legend		Customer Sample Ref.	BH01	BH01	BH01	BH02	BH02	BH02
#	ISO17025 accredited.	Depth (m) Sample Type Date Sampled Date Received SDG Ref Lab Sample No.(s) AGS Reference	0.10 - 0.15	0.40 - 0.50	1.00 - 1.10	0.10 - 0.20	0.80 - 0.90	1.80 - 1.90
M	mCERTS accredited.		Soil/Solid	Soil/Solid	Soil/Solid	Soil/Solid	Soil/Solid	Soil/Solid
aq	Aqueous / settled sample.		24/05/2016	24/05/2016	24/05/2016	24/05/2016	24/05/2016	24/05/2016
diss.filt	Dissolved / filtered sample.		02/06/2016	02/06/2016	02/06/2016	02/06/2016	02/06/2016	02/06/2016
tot.unfilt	Total / unfiltered sample.		160602-104	160602-104	160602-104	160602-104	160602-104	160602-104
*	Subcontracted test.		13531216	13531236	13531241	13531246	13531251	13531256
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery		ES	ES	ES	ES	ES	ES
(F)	Trigger breach confirmed							
1-5&*\$@	Sample deviation (see appendix)							
Component	LOD/Units		Method					
Moisture Content Ratio (% of as received sample)	%	PM024	13	8.9	16	17	7.2	6
Soil Organic Matter (SOM)	<0.35 %	TM132	22.2	3.33	1.76			2.16
pH	1 pH Units	TM133	3.46				7.81	7.72
Cyanide, Total	<1 mg/kg	TM153	<1	<1	<1	17.6	1.41	<1
Cyanide, Free	<1 mg/kg	TM153	<1					
Arsenic	<0.6 mg/kg	TM181	46	10.8	9.05	47.3	8.79	4.12
Cadmium	<0.02 mg/kg	TM181	0.496	0.693	0.149	0.395	0.186	0.854
Chromium	<0.9 mg/kg	TM181	11.8	16.8	18.3	16.1	20.2	18.3
Copper	<1.4 mg/kg	TM181	44.8	45.1	34.5	60.3	32.7	29.3
Lead	<0.7 mg/kg	TM181	31.5	34.3	15.4	54.5	19.2	17.8
Mercury	<0.14 mg/kg	TM181	<0.14	<0.14	<0.14	0.331	<0.14	<0.14
Nickel	<0.2 mg/kg	TM181	17.6	55.3	42.1	35.6	43.4	35.1
Selenium	<1 mg/kg	TM181	<1	<1	<1	<1	<1	<1
Zinc	<1.9 mg/kg	TM181	48.5	138	89.3	102	108	98.1
Water Soluble Sulphate as SO4 2:1 Extract	<0.004 g/l	TM243	0.127		0.165		0.0702	0.0631



CERTIFICATE OF ANALYSIS

Validated

SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

Results Legend			Customer Sample Ref.		BH04	BH04	BH05	BH05	BH05	BH05
#	ISO17025 accredited.									
M	mCERTS accredited.									
aq	Aqueous / settled sample.									
diss.filt	Dissolved / filtered sample.									
tot.unfilt	Total / unfiltered sample.									
*	Subcontracted test.									
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery									
(F)	Trigger breach confirmed									
1-5&*\$@	Sample deviation (see appendix)									
			Depth (m)	0.10 - 0.20	2.50 - 2.60	0.05 - 0.10	0.30 - 0.35	1.50 - 1.60	2.10 - 2.20	
			Sample Type	Soil/Solid	Soil/Solid	Soil/Solid	Soil/Solid	Soil/Solid	Soil/Solid	
			Date Sampled	24/05/2016	24/05/2016	24/05/2016	24/05/2016	24/05/2016	24/05/2016	
			Sampled Time							
			Date Received	02/06/2016	02/06/2016	02/06/2016	02/06/2016	02/06/2016	02/06/2016	
			SDG Ref	160602-104	160602-104	160602-104	160602-104	160602-104	160602-104	
			Lab Sample No.(s)	13531260	13531265	13531226	13531271	13531231	13531221	
			AGS Reference	ES	ES	ES	ES	ES	ES	
Component	LOD/Units	Method								
Moisture Content Ratio (% of as received sample)	%	PM024	14	8.2	21	9.4	14	6.7		
Soil Organic Matter (SOM)	<0.35 %	TM132		2.07	37.8		4.43			
pH	1 pH Units	TM133		8.04	6.78		8.01			
Cyanide, Total	<1 mg/kg	TM153	8.73	<1	53.4	<1	<1	<1	<1	
Cyanide, Free	<1 mg/kg	TM153	<1		<1					
Arsenic	<0.6 mg/kg	TM181	36	19.1	37.2	12.9	19	7.35		
Cadmium	<0.02 mg/kg	TM181	0.0927	0.736	0.354	0.62	0.739	0.68		
Chromium	<0.9 mg/kg	TM181	14.7	18.2	16.2	20.9	19.8	20		
Copper	<1.4 mg/kg	TM181	52.6	43.3	67	33.8	41.5	31.9		
Lead	<0.7 mg/kg	TM181	37.8	23.6	68	22.6	34.4	17.9		
Mercury	<0.14 mg/kg	TM181	0.233	<0.14	0.44	<0.14	<0.14	<0.14	<0.14	
Nickel	<0.2 mg/kg	TM181	19.7	45.1	39.8	46.1	44.6	42		
Selenium	<1 mg/kg	TM181	<1	<1	1.02	<1	<1	<1	<1	
Zinc	<1.9 mg/kg	TM181	53.4	116	142	114	135	107		
Water Soluble Sulphate as SO4 2:1 Extract	<0.004 g/l	TM243		0.115				0.173		

SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

PAH by GCMS

Results Legend			Customer Sample Ref.	BH01	BH01	BH01	BH02	BH02	BH02
#	ISO17025 accredited.								
M	mCERTS accredited.								
aq	Aqueous / settled sample.								
diss.filt	Dissolved / filtered sample.								
tot.unfilt	Total / unfiltered sample.								
*	Subcontracted test.								
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery								
(F)	Trigger breach confirmed								
1-5&*\$@	Sample deviation (see appendix)								
Component	LOD/Units	Method	Depth (m)	0.10 - 0.15	0.40 - 0.50	1.00 - 1.10	0.10 - 0.20	0.80 - 0.90	1.80 - 1.90
			Sample Type	Soil/Solid	Soil/Solid	Soil/Solid	Soil/Solid	Soil/Solid	Soil/Solid
			Date Sampled	24/05/2016	24/05/2016	24/05/2016	24/05/2016	24/05/2016	24/05/2016
			Sampled Time						
			Date Received	02/06/2016	02/06/2016	02/06/2016	02/06/2016	02/06/2016	02/06/2016
			SDG Ref	160602-104	160602-104	160602-104	160602-104	160602-104	160602-104
			Lab Sample No.(s)	13531216	13531236	13531241	13531246	13531251	13531256
			AGS Reference	ES	ES	ES	ES	ES	ES
Naphthalene-d8 % recovery**	%	TM218		105	99.9	99.7	125	97.3	99.4
Acenaphthene-d10 % recovery**	%	TM218		98.6	99.1	98.9	117	91.8	92.9
Phenanthrene-d10 % recovery**	%	TM218		95.3	94.3	94.7	113	89.4	90
Chrysene-d12 % recovery**	%	TM218		98.5	87	85.1	118	89.8	90.3
Perylene-d12 % recovery**	%	TM218		97	83.5	80.6	121	94.1	94.8
Naphthalene	<0.009 mg/kg	TM218		1.89	0.143	0.176	5.3	0.44	0.138
Acenaphthylene	<0.012 mg/kg	TM218		<0.012	<0.012	<0.012	0.117	0.0137	<0.012
Acenaphthene	<0.008 mg/kg	TM218		0.0497	<0.008	<0.008	0.217	0.0199	<0.008
Fluorene	<0.01 mg/kg	TM218		0.076	0.0321	0.0254	0.267	0.0398	0.0358
Phenanthrene	<0.015 mg/kg	TM218		1.8	0.276	0.138	3.25	0.359	0.148
Anthracene	<0.016 mg/kg	TM218		0.0881	<0.016	<0.016	0.659	0.0687	<0.016
Fluoranthene	<0.017 mg/kg	TM218		0.478	0.0467	0.0306	1.35	0.147	0.0216
Pyrene	<0.015 mg/kg	TM218		0.497	0.0563	0.0343	1.06	0.119	0.028
Benz(a)anthracene	<0.014 mg/kg	TM218		0.352	0.0239	<0.014	1	0.0881	<0.014
Chrysene	<0.01 mg/kg	TM218		0.4	0.0393	0.0171	0.964	0.0785	0.0198
Benzo(b)fluoranthene	<0.015 mg/kg	TM218		0.435	0.0527	0.0198	1.7	0.161	0.0346
Benzo(k)fluoranthene	<0.014 mg/kg	TM218		0.12	<0.014	<0.014	0.608	0.0484	<0.014
Benzo(a)pyrene	<0.015 mg/kg	TM218		0.257	0.0332	<0.015	0.778	0.0872	0.0258
Indeno(1,2,3-cd)pyrene	<0.018 mg/kg	TM218		0.132	<0.018	<0.018	0.655	0.0696	<0.018
Dibenzo(a,h)anthracene	<0.023 mg/kg	TM218		0.0818	<0.023	<0.023	0.271	0.0276	<0.023
Benzo(g,h,i)perylene	<0.024 mg/kg	TM218		0.432	0.077	0.0367	0.799	0.138	0.0535
PAH, Total Detected USEPA 16	<0.118 mg/kg	TM218		7.1	0.78	0.479	19	1.91	0.505

SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

PAH by GCMS

Results Legend			Customer Sample Ref.		BH04	BH04	BH05	BH05	BH05	BH05
#	ISO17025 accredited.									
M	mCERTS accredited.									
aq	Aqueous / settled sample.									
diss.filt	Dissolved / filtered sample.									
tot.unfilt	Total / unfiltered sample.									
*	Subcontracted test.									
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery									
(F)	Trigger breach confirmed									
1-5&*\$@	Sample deviation (see appendix)									
Component	LOD/Units	Method	Depth (m)	Sample Type	Date Sampled	Date Received	SDG Ref	Lab Sample No.(s)	AGS Reference	
Naphthalene-d8 % recovery**	%	TM218	0.10 - 0.20	Soil/Solid	24/05/2016	02/06/2016	160602-104	13531260	ES	110
Acenaphthene-d10 % recovery**	%	TM218	2.50 - 2.60	Soil/Solid	24/05/2016	02/06/2016	160602-104	13531265	ES	93.6
Phenanthrene-d10 % recovery**	%	TM218	0.05 - 0.10	Soil/Solid	24/05/2016	02/06/2016	160602-104	13531226	ES	99.3
Chrysene-d12 % recovery**	%	TM218	0.30 - 0.35	Soil/Solid	24/05/2016	02/06/2016	160602-104	13531271	ES	101
Perylene-d12 % recovery**	%	TM218	1.50 - 1.60	Soil/Solid	24/05/2016	02/06/2016	160602-104	13531231	ES	106
Naphthalene	<0.009 mg/kg	TM218	2.10 - 2.20	Soil/Solid	24/05/2016	02/06/2016	160602-104	13531221	ES	101
Acenaphthylene	<0.012 mg/kg	TM218								4.63
Acenaphthene	<0.008 mg/kg	TM218								0.0969
Fluorene	<0.01 mg/kg	TM218								7.32
Phenanthrene	<0.015 mg/kg	TM218								0.101
Anthracene	<0.016 mg/kg	TM218								5.22
Fluoranthene	<0.017 mg/kg	TM218								0.119
Pyrene	<0.015 mg/kg	TM218								0.119
Benz(a)anthracene	<0.014 mg/kg	TM218								0.119
Chrysene	<0.01 mg/kg	TM218								0.119
Benzo(b)fluoranthene	<0.015 mg/kg	TM218								0.119
Benzo(k)fluoranthene	<0.014 mg/kg	TM218								0.119
Benzo(a)pyrene	<0.015 mg/kg	TM218								0.119
Indeno(1,2,3-cd)pyrene	<0.018 mg/kg	TM218								0.119
Dibenzo(a,h)anthracene	<0.023 mg/kg	TM218								0.119
Benzo(g,h,i)perylene	<0.024 mg/kg	TM218								0.119
PAH, Total Detected USEPA 16	<0.118 mg/kg	TM218								17.6



SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

Asbestos Identification - Soil

		Date of Analysis	Analysed By	Comments	Amosite (Brown) Asbestos	Chrysotile (White) Asbestos	Crocidolite (Blue) Asbestos	Fibrous Actinolite	Fibrous Anthophyllite	Fibrous Tremolite	Non-Asbestos Fibre
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Received SDG Original Sample Method Number	BH01 ES 0.10 - 0.15 SOLID 24/05/2016 00:00:00 02/06/2016 19:36:38 160602-104 13531216 TM048	07/06/2016	Rebecca Rawlings	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Received SDG Original Sample Method Number	BH01 ES 0.40 - 0.50 SOLID 24/05/2016 00:00:00 02/06/2016 18:04:15 160602-104 13531236 TM048	07/06/2016	Rebecca Rawlings	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Detected
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Received SDG Original Sample Method Number	BH01 ES 1.00 - 1.10 SOLID 24/05/2016 00:00:00 02/06/2016 19:28:55 160602-104 13531241 TM048	07/06/2016	Rebecca Rawlings	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Received SDG Original Sample Method Number	BH02 ES 0.10 - 0.20 SOLID 24/05/2016 00:00:00 02/06/2016 18:10:18 160602-104 13531246 TM048	07/06/2016	Rebecca Rawlings	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Received SDG Original Sample Method Number	BH02 ES 0.80 - 0.90 SOLID 24/05/2016 00:00:00 02/06/2016 18:07:23 160602-104 13531251 TM048	07/06/2016	Rebecca Rawlings	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Detected



SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

		Date of Analysis	Analysed By	Comments	Amosite (Brown) Asbestos	Chrysotile (White) Asbestos	Crocidolite (Blue) Asbestos	Fibrous Actinolite	Fibrous Anthophyllite	Fibrous Tremolite	Non-Asbestos Fibre
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Received SDG Original Sample Method Number	BH02 ES 1.80 - 1.90 SOLID 24/05/2016 00:00:00 02/06/2016 19:33:09 160602-104 13531256 TM048	07/06/2016	Rebecca Rawlings	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Received SDG Original Sample Method Number	BH04 ES 0.10 - 0.20 SOLID 24/05/2016 00:00:00 04/06/2016 15:41:56 160602-104 13531260 TM048	07/06/2016	Rebecca Rawlings	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Received SDG Original Sample Method Number	BH04 ES 2.50 - 2.60 SOLID 24/05/2016 00:00:00 04/06/2016 15:45:31 160602-104 13531265 TM048	07/06/2016	Rebecca Rawlings	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Received SDG Original Sample Method Number	BH05 ES 0.05 - 0.10 SOLID 24/05/2016 00:00:00 02/06/2016 19:16:10 160602-104 13531226 TM048	07/06/2016	Rebecca Rawlings	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Received SDG Original Sample Method Number	BH05 ES 0.30 - 0.35 SOLID 24/05/2016 00:00:00 02/06/2016 19:26:13 160602-104 13531271 TM048	07/06/2016	Rebecca Rawlings	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Received SDG Original Sample Method Number	BH05 ES 1.50 - 1.60 SOLID 24/05/2016 00:00:00 02/06/2016 19:23:12 160602-104 13531231 TM048	07/06/2016	Rebecca Rawlings	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected



CERTIFICATE OF ANALYSIS

Validated

SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

		Date of Analysis	Analysed By	Comments	Amosite (Brown) Asbestos	Chrysotile (White) Asbestos	Crocidolite (Blue) Asbestos	Fibrous Actinolite	Fibrous Anthophyllite	Fibrous Tremolite	Non-Asbestos Fibre
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Received SDG Original Sample Method Number	BH05 ES 2.10 - 2.20 SOLID 24/05/2016 00:00:00 02/06/2016 19:20:01 160602-104 13531221 TM048	07/06/2016	Rebecca Rawlings	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected



SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

Table of Results - Appendix

Method No	Reference	Description	Wet/Dry Sample ¹	Surrogate Corrected
PM001		Preparation of Samples for Metals Analysis		
PM024	Modified BS 1377	Soil preparation including homogenisation, moisture screens of soils for Asbestos Containing Material		
TM048	HSG 248, Asbestos: The analysts' guide for sampling, analysis and clearance procedures	Identification of Asbestos in Bulk Material		
TM089	Modified: US EPA Methods 8020 & 602	Determination of Gasoline Range Hydrocarbons (GRO) and BTEX (MTBE) compounds by Headspace GC-FID (C4-C12)		
TM116	Modified: US EPA Method 8260, 8120, 8020, 624, 610 & 602	Determination of Volatile Organic Compounds by Headspace / GC-MS		
TM132	In - house Method	ELTRA CS800 Operators Guide		
TM133	BS 1377: Part 3 1990;BS 6068-2.5	Determination of pH in Soil and Water using the GLpH pH Meter		
TM153	Method 4500A,B,C, I, M AWWA/APHA, 20th Ed., 1999	Determination of Total Cyanide, Free (Easily Liberatable) Cyanide and Thiocyanate using the Skalar SANS+ System Segmented Flow Analyser		
TM173	Analysis of Petroleum Hydrocarbons in Environmental Media – Total Petroleum Hydrocarbon Criteria	Determination of Speciated Extractable Petroleum Hydrocarbons in Soils by GC-FID		
TM181	US EPA Method 6010B	Determination of Routine Metals in Soil by iCap 6500 Duo ICP-OES		
TM218	Microwave extraction – EPA method 3546	Microwave extraction - EPA method 3546		
TM243		Mixed Anions In Soils By Kone		

¹ Applies to Solid samples only. DRY indicates samples have been dried at 35°C. NA = not applicable.



SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

Test Completion Dates

Lab Sample No(s) Customer Sample Ref. AGS Ref. Depth Type	13531216	13531236	13531241	13531246	13531251	13531256	13531260	13531265	13531221	13531226
	BH01	BH01	BH01	BH02	BH02	BH02	BH04	BH04	BH05	BH05
	ES									
Depth	0.10 - 0.15	0.40 - 0.50	1.00 - 1.10	0.10 - 0.20	0.80 - 0.90	1.80 - 1.90	0.10 - 0.20	2.50 - 2.60	2.10 - 2.20	0.05 - 0.10
Type	SOLID									
Anions by Kone (soil)	07-Jun-2016		08-Jun-2016		08-Jun-2016	07-Jun-2016		08-Jun-2016	07-Jun-2016	
Asbestos ID in Solid Samples	07-Jun-2016									
Cyanide Comp/Free/Total/Thiocyanate	19-Jul-2016	08-Jun-2016	08-Jun-2016	08-Jun-2016	08-Jun-2016	08-Jun-2016	08-Jun-2016	19-Jul-2016	08-Jun-2016	19-Jul-2016
EPH CWG (Aliphatic) GC (S)		07-Jun-2016	07-Jun-2016		07-Jun-2016			07-Jun-2016		
EPH CWG (Aromatic) GC (S)		07-Jun-2016	07-Jun-2016		07-Jun-2016			07-Jun-2016		
GRO by GC-FID (S)		06-Jun-2016	07-Jun-2016		07-Jun-2016			07-Jun-2016		
Metals in solid samples by OES	08-Jun-2016									
PAH by GCMS	08-Jun-2016									
pH	03-Jun-2016				06-Jun-2016	06-Jun-2016		06-Jun-2016		06-Jun-2016
Sample description	02-Jun-2016	03-Jun-2016	03-Jun-2016	02-Jun-2016	02-Jun-2016	02-Jun-2016	02-Jun-2016	02-Jun-2016	03-Jun-2016	03-Jun-2016
Total Organic Carbon	07-Jun-2016	07-Jun-2016	07-Jun-2016			07-Jun-2016		08-Jun-2016		07-Jun-2016
TPH CWG GC (S)		07-Jun-2016	07-Jun-2016		07-Jun-2016			07-Jun-2016		
VOC MS (S)		06-Jun-2016	08-Jun-2016		08-Jun-2016			08-Jun-2016		

Lab Sample No(s) Customer Sample Ref. AGS Ref. Depth Type	13531231	13531271
	BH05	BH05
	ES	ES
Depth	1.50 - 1.60	0.30 - 0.35
Type	SOLID	SOLID
Asbestos ID in Solid Samples	07-Jun-2016	07-Jun-2016
Cyanide Comp/Free/Total/Thiocyanate	08-Jun-2016	08-Jun-2016
EPH CWG (Aliphatic) GC (S)	07-Jun-2016	07-Jun-2016
EPH CWG (Aromatic) GC (S)	07-Jun-2016	07-Jun-2016
GRO by GC-FID (S)	06-Jun-2016	06-Jun-2016
Metals in solid samples by OES	08-Jun-2016	08-Jun-2016
PAH by GCMS	08-Jun-2016	08-Jun-2016
pH	03-Jun-2016	
Sample description	03-Jun-2016	03-Jun-2016
Total Organic Carbon	07-Jun-2016	
TPH CWG GC (S)	07-Jun-2016	07-Jun-2016
VOC MS (S)	06-Jun-2016	06-Jun-2016



SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

Chromatogram

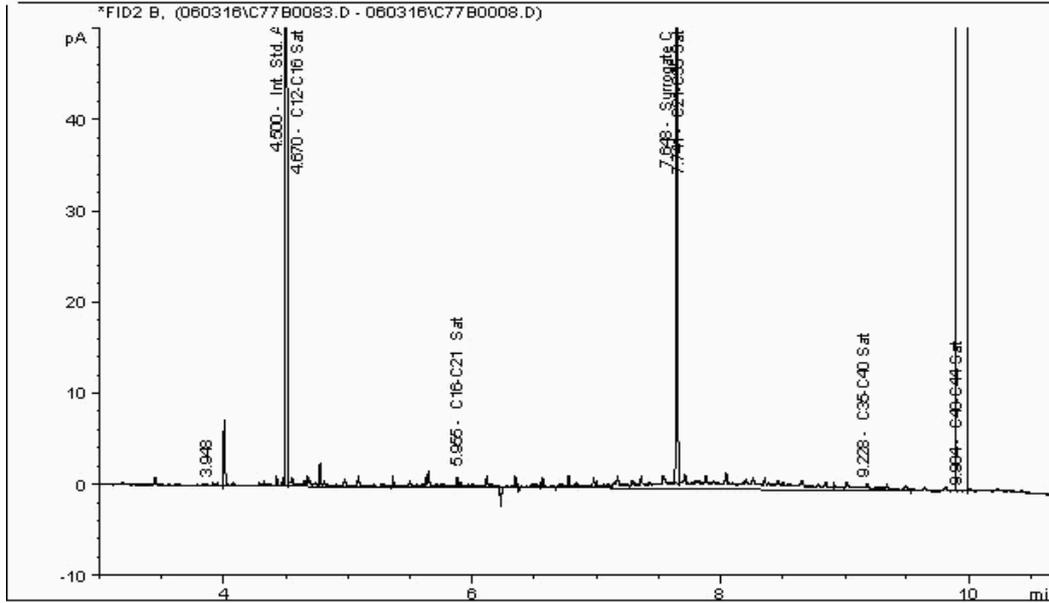
Analysis: EPH CWG (Aliphatic) GC (S)

Sample No : 13531698
Sample ID : BH02

Depth : 0.80 - 0.90

Alcontrol/Geochem Analytical Services
Speciated TPH - SATS (C12 - C40)

Sample Identity: 12727786-
Date Acquired : 04/06/2016 12:15:19 PM
Units : ppb
Dilution:





SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

Chromatogram

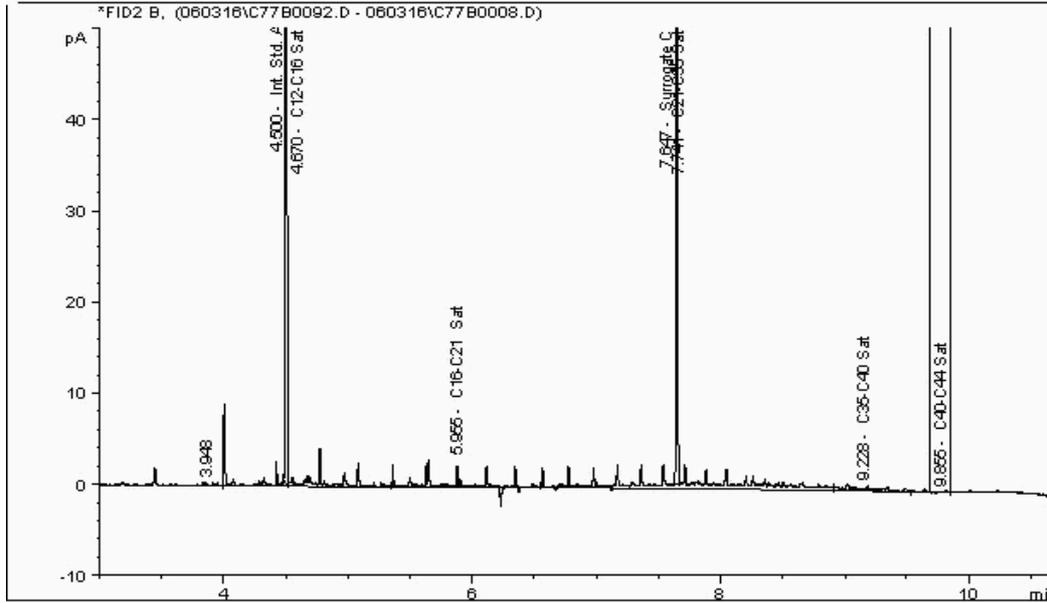
Analysis: EPH CWG (Aliphatic) GC (S)

Sample No : 13531725
Sample ID : BH04

Depth : 2.50 - 2.60

Alcontrol/Geochem Analytical Services
Speciated TPH - SATS (C12 - C40)

Sample Identity: 12727846-
Date Acquired : 04/06/2016 14:45:06 PM
Units : ppb
Dilution:





SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

Chromatogram

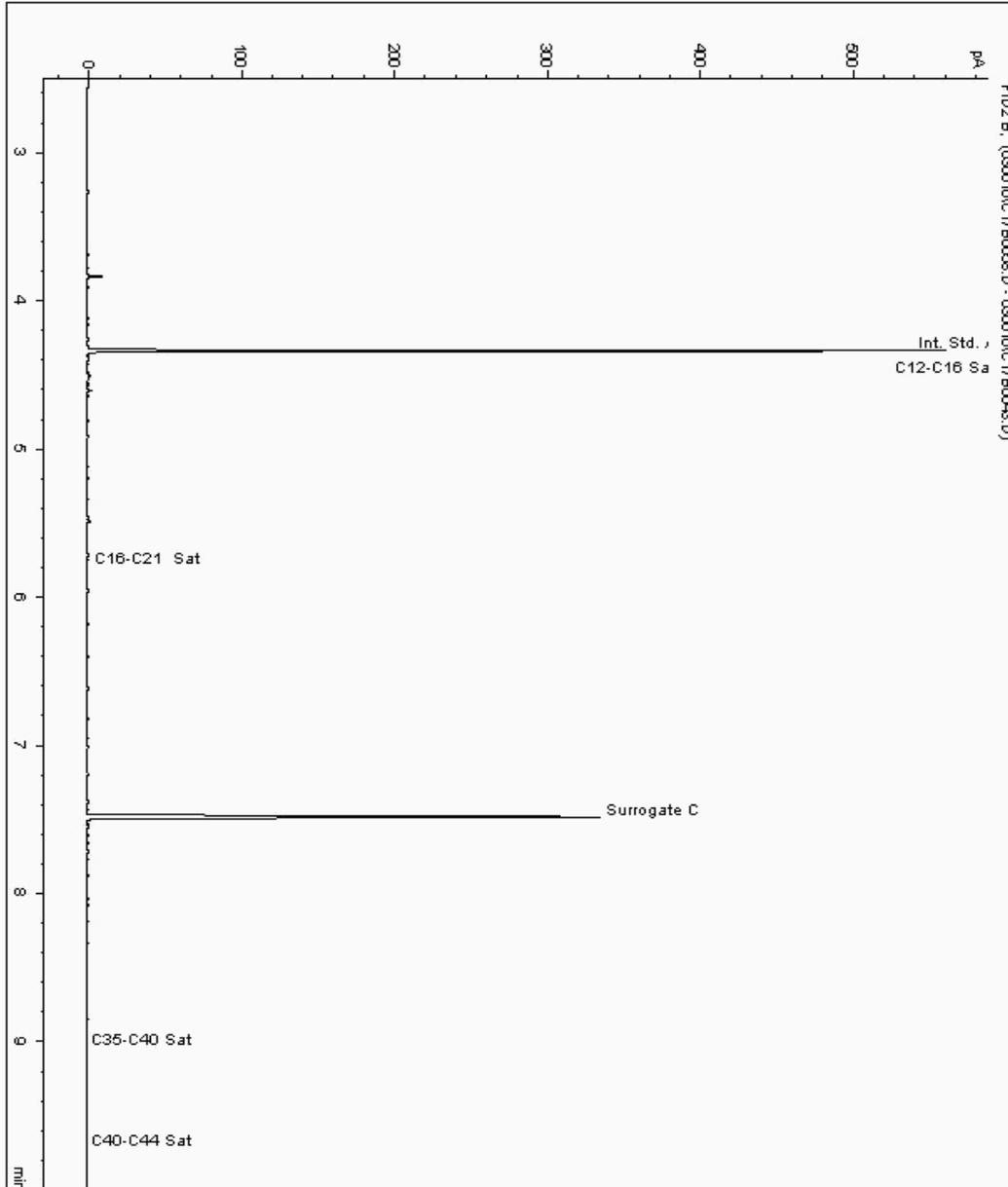
Analysis: EPH CWG (Aliphatic) GC (S)

Sample No : 13532685
Sample ID : BH01

Depth : 1.00 - 1.10

Alcontrol/Geochem Analytical Services
Speciated TPH - SATS (C12 - C40)

Sample Identity: 12727760-
Date Acquired : 06/06/2016 13:43:38 PM
Units : ppb
Dilution :
CF : 1
Multiplier : 1.000





SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

Chromatogram

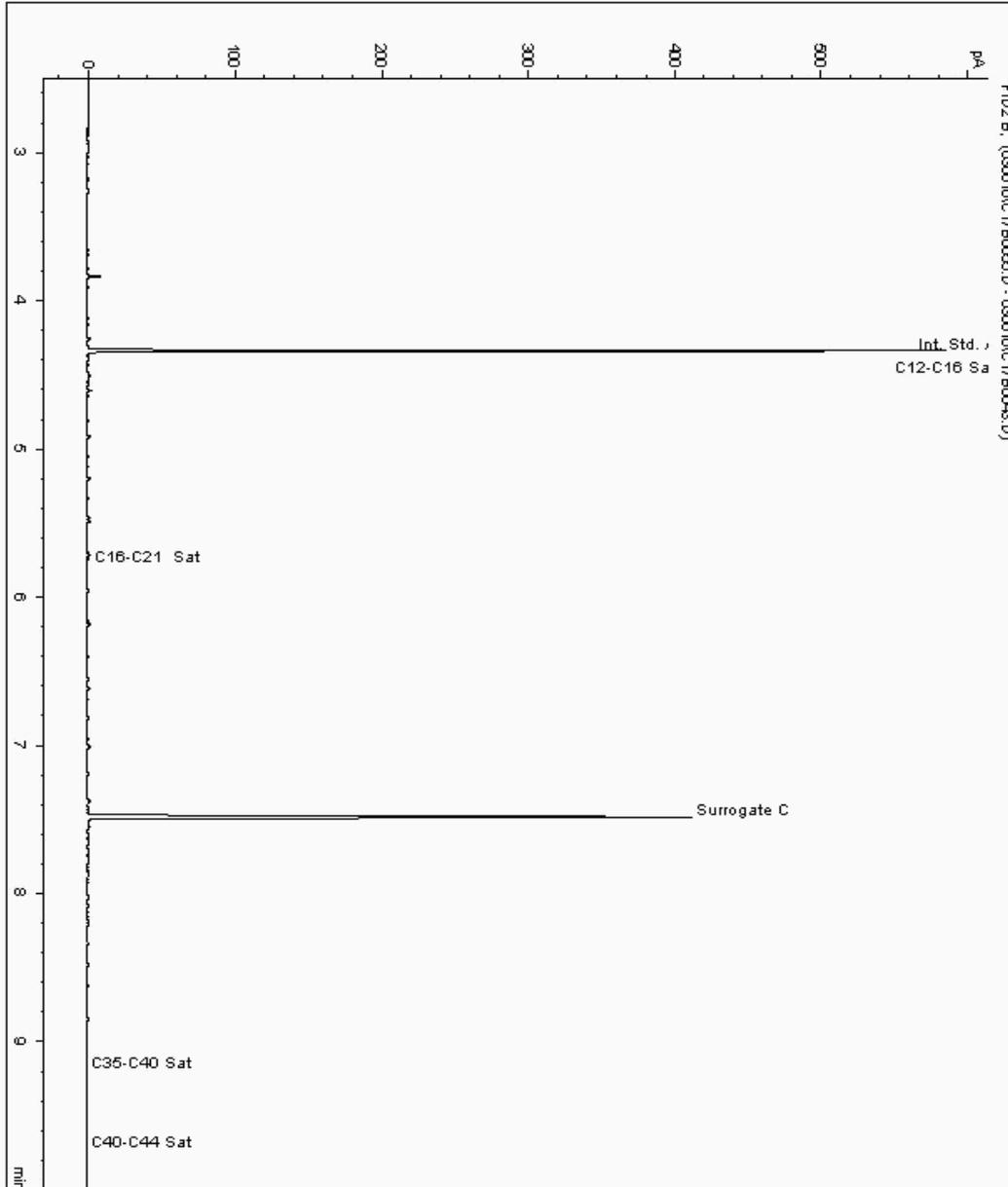
Analysis: EPH CWG (Aliphatic) GC (S)

Sample No : 13532761
Sample ID : BH05

Depth : 0.30 - 0.35

Alcontrol/Geochem Analytical Services
Speciated TPH - SATS (C12 - C40)

Sample Identity: 12727873-
Date Acquired : 06/06/2016 12:42:06 PM
Units : ppb
Dilution :
CF : 1
Multiplier : 1.040





SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

Chromatogram

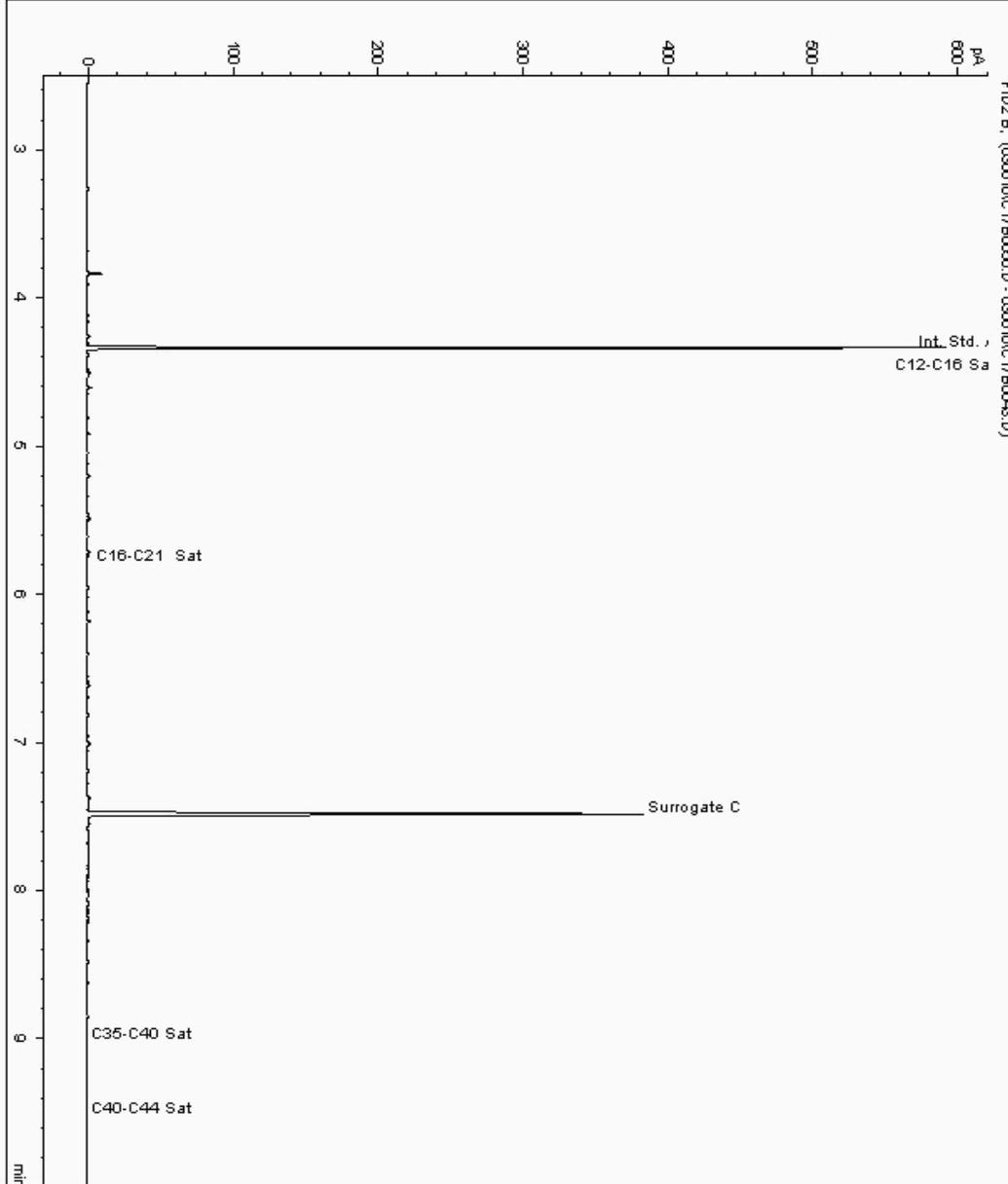
Analysis: EPH CWG (Aliphatic) GC (S)

Sample No : 13532883
Sample ID : BH05

Depth : 1.50 - 1.60

Alcontrol/Geochem Analytical Services
Speciated TPH - SATS (C12 - C40)

Sample Identity: 12727730-
Date Acquired : 06/06/2016 13:02:45 PM
Units : ppb
Dilution :
CF : 1
Multiplier : 1.000





SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

Chromatogram

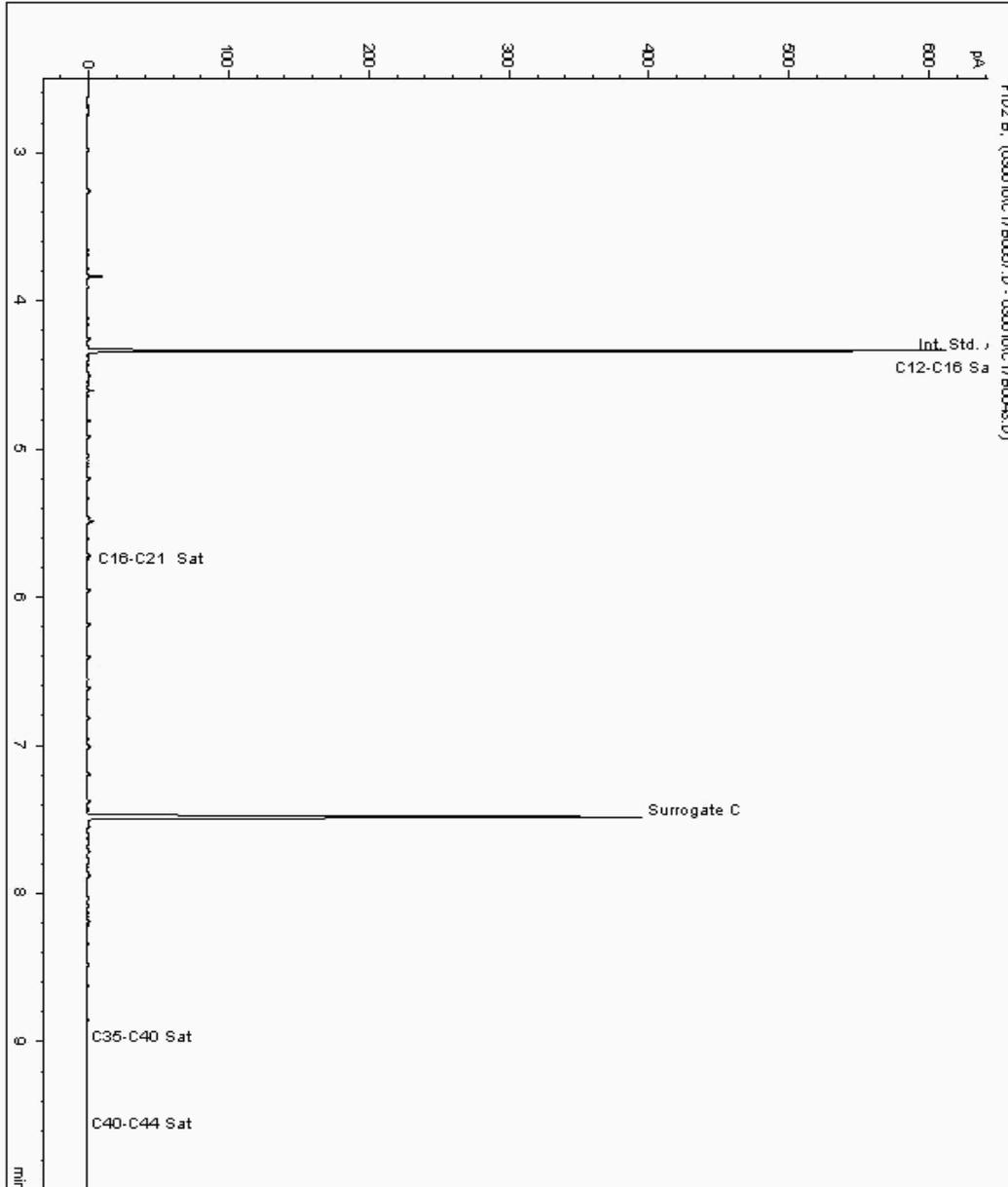
Analysis: EPH CWG (Aliphatic) GC (S)

Sample No : 13532917
Sample ID : BH01

Depth : 0.40 - 0.50

Alcontrol/Geochem Analytical Services
Speciated TPH - SATS (C12 - C40)

Sample Identity: 12727745-
Date Acquired : 06/06/2016 13:23:12 PM
Units : ppb
Dilution :
CF : 1
Multiplier : 0.980





SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

Chromatogram

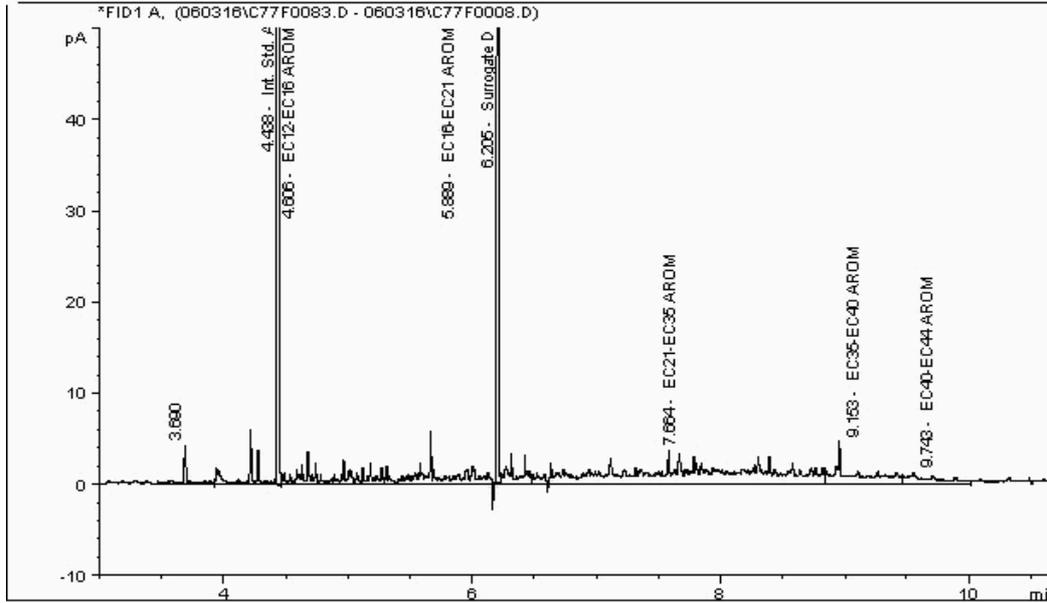
Analysis: EPH CWG (Aromatic) GC (S)

Sample No : 13531698
Sample ID : BH02

Depth : 0.80 - 0.90

Alcontrol/Geochem Analytical Services
Speciated TPH - SATS (C12 - C40)

Sample Identity: 12727787-
Date Acquired : 04/06/2016 12:15:19 PM
Units : ppb
Dilution:





SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

Chromatogram

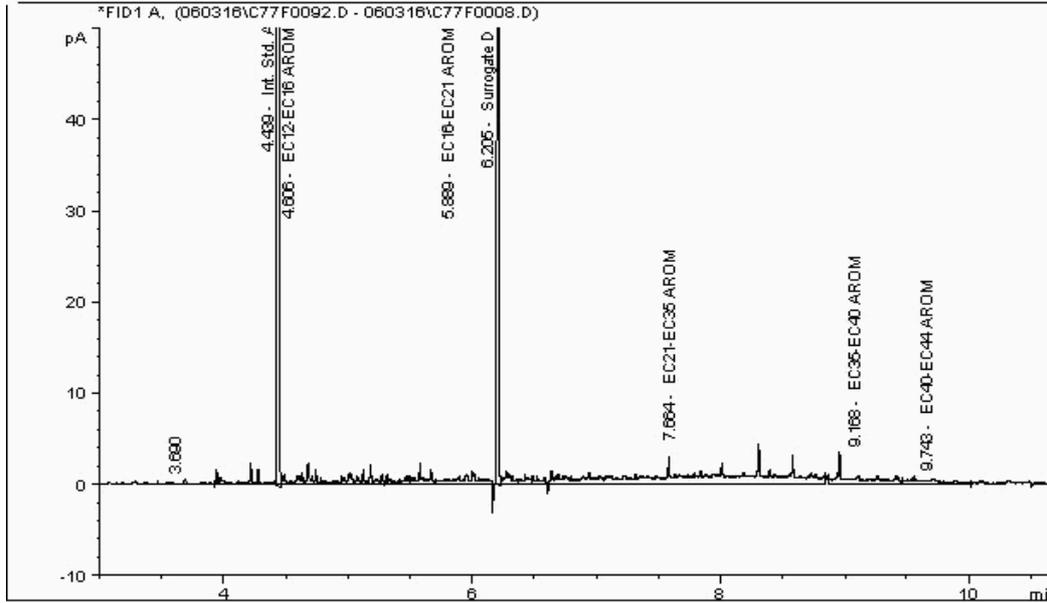
Analysis: EPH CWG (Aromatic) GC (S)

Sample No : 13531725
Sample ID : BH04

Depth : 2.50 - 2.60

Alcontrol/Geochem Analytical Services
Speciated TPH - SATS (C12 - C40)

Sample Identity: 12727847-
Date Acquired : 04/06/2016 14:45:06 PM
Units : ppb
Dilution:





SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

Chromatogram

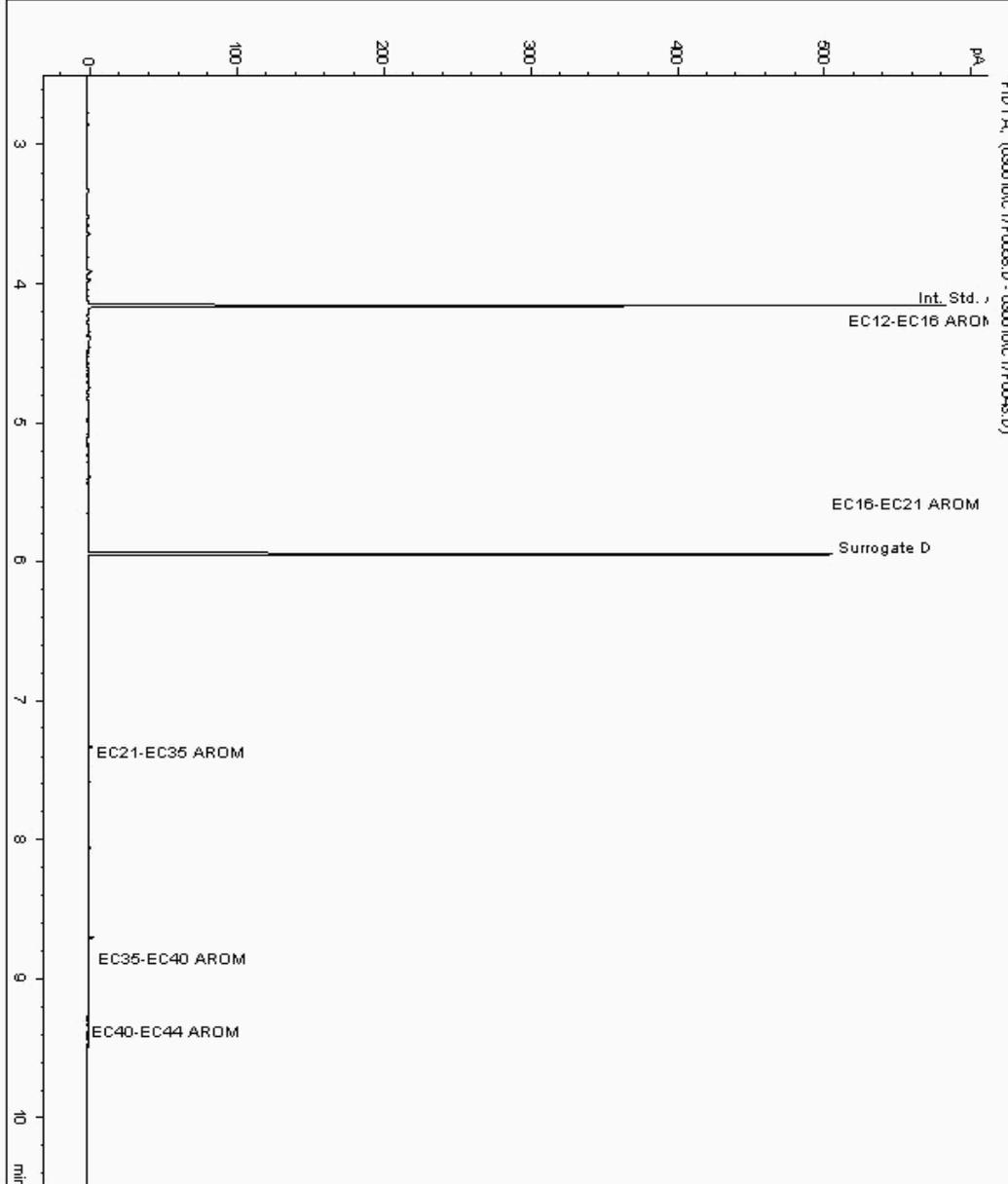
Analysis: EPH CWG (Aromatic) GC (S)

Sample No : 13532685
Sample ID : BH01

Depth : 1.00 - 1.10

Alcontrol/Geochem Analytical Services
Speciated TPH - AROM (C12 - C40)

Sample Identity: 12727761-
Date Acquired : 06/06/2016 13:43:38 PM
Units : ppb
Dilution :
CF : 1
Multiplier : 1.000





SDG: 160602-104
Job: H_WSP_MAN-355
Client Reference: Rockingham

Location: Rockingham, Barnsley
Customer: WSP PB MLN
Attention: Gareth Maynell

Order Number: 70018922-S01
Report Number: 370706
Superseded Report: 370548

Chromatogram

Analysis: EPH CWG (Aromatic) GC (S)

Sample No : 13532761
Sample ID : BH05

Depth : 0.30 - 0.35

Alcontrol/Geochem Analytical Services
Speciated TPH - AROM (C12 - C40)

Sample Identity: 12727874-
Date Acquired : 06/06/2016 12:42:06 PM
Units : ppb
Dilution :
CF : 1
Multiplier : 1.040

