APPENDIX 12C: GROUND INVESTIGATION REPORT VOLUME 2: INTERPRETIVE REPORT

SOUTH HUMBER BANK ENERGY CENTRE – SITE INVESTIGATION WORKS

REPORT ON GROUND INVESTIGATION

Report No A9020-19/2

VOLUME 2 : INTERPRETATIVE REPORT

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REPORT STRUCTURE

DATE	TITLE	REPORT No
Dec 2019	VOLUME 1 : FACTUAL REPORT	A9020-19/1
Dec 2019	**VOLUME 2: INTERPRETATIVE REPORT**	**A9020-19/2**

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1 INTRODUCTION

SOCOTEC UK Limited was commissioned in July 2019 by EP UK Investments Ltd (EPUKi) to carry out a ground investigation for South Humber Bank Energy Centre. The investigation was required to obtain information for a proposed new energy from waste centre and associated auxiliary structures.

The scope of the investigation was specified by Fitchner Consulting Engineers (FCE) and comprised boreholes, trial pits, in situ testing, monitoring, laboratory testing and reporting. The investigation was performed in accordance with the contract specification, and the general requirements of BS 5930 (2015), BS EN 1997-2 (2007), BS EN ISO 22475-1 (2006) and other relevant related standards identified below. The fieldwork took place between 12 August and 12 September 2019.

This report is presented in two volumes. Volume 1 presents the factual records of the fieldwork, monitoring and laboratory testing. This volume, Volume 2, presents a geotechnical and geoenvironmental assessment of the investigation findings in relation to the proposed works.

2 SITE SETTING

2.1 Location and Description

South Humber Bank Energy Centre is located approximately 3 km north east of Stallingborough town centre centred at National Grid reference TA 235135, see Site Location Plan in Appendix A. The site address is: South Humber Bank Power Station, South Marsh Road, Stallingborough, DN41 8BZ.

The site is set within the confines of the existing South Humber Bank Power Station, located on grassland to the east of the existing power generation buildings. The site is bounded to the north and west by South Marsh Road and other industrial plant works, to the south by farm land and to the east by the River Humber. The site is generally flat and is split into two areas either side of the main access road from the main generation plant to the pumping station adjacent to the River Humber. The area north of the access road is approximately 240 m by 100 m in area roughly rectangular and grass covered with occasional shrubs. The area to the south is irregular shaped and approximately 480 m by 120 m and grass covered. Both sites were recently used by a local farmer to graze sheep.

2.2 Published Geology

The published geological map for the area, (BGS Sheet 81, 1991), and the BGS GeoIndex Onshore online viewer (2019) show the site located on Tidal Flat Deposits (clay and silt) over Glacial Till (diamicton). This is underlain by bedrock of the Cretaceous Flamborough Chalk Formation. Made Ground is shown directly north of the investigated area.

3 FACTUAL REPORT SUMMARY

3.1 General

The Volume 1 Factual report presents the records from the fieldwork and laboratory testing and should be consulted for full details of the investigation findings. A summary of the exploratory holes and in situ tests undertaken is presented in Section 3.2 below.

3.2 Factual Report Summary

The exploratory holes are listed in the following table.

TABLE 1 : SUMMARY OF EXPLORATORY HOLES

TYPE	QUANTITY	DEPTH RANGE (m)	REMARKS
Cable Percussion Boring	10	25.00 to 35.00	BH4, BH6, BH7, BH8, BH9, BH10, BH11 and BH12
Cable Percussion Boring extended by Rotary Core Drilling	4	35.00 to 46.60	BH1, BH2, BH3 and BH5
Trial Pits (Machine Dug)	12	4.50	TP1 to TP12
Dynamic Sampling	9	5.00	WS1 to WS10 – WS8 not possible due to obstruction.

The field (in situ) testing is summarised in the following table.

TABLE 2 : SUMMARY OF FIELD TESTING

TYPE	QUANTITY	REMARKS
Cone Penetration Testing	11	CPT01 to 04, 04A, 05, 06, 06A, 07, 09 and 10
Falling Head Permeability	9	BS EN ISO 22282-2 (2012)
Apparent Resistivity of Soil	10	BS 1377 : Part 9 (1990) Carried out within TP01 to TP10
Plate Bearing Test	12	IAN 73/06 Rev 1 (2009) Carried out within TP01 to TP12

Records of monitoring carried out by SOCOTEC during and after the fieldwork period are also presented in the factual report. Geotechnical and geoenvironmental laboratory testing results are discussed in Sections 4 and 6.

4 GROUND CONDITIONS AND GROUNDWATER

4.1 Strata Encountered

Descriptions of the strata encountered are given on the exploratory hole records. The downward succession encountered is broadly uniform cross the site, is summarised in Table 3 below and is shown on the cross-sections presented as Section 1 and 2 in Appendix A.

TABLE 3 : SUMMARY OF GROUND CONDITIONS

STRATUM	TOP (m)	THICKNESS RANGE (m)	REMARKS
MADE GROUND / TOPSOIL	Ground Level	0.20 to 3.05	Predominantly related to earth movements and embankments on site
TIDAL FLAT DEPOSITS	Ground Level to 3.05	8.05 to 16.80	Variable top depth depending on thickness of Made Ground/Topsoil Top generally 0 to 2 mOD
GLACIAL TILL	8.15 to 13.60	5.50 to 14.35 Boreholes only	Granular and cohesive layers Top generally -7 to -11 mOD, locally -5 mOD to east (BH11) and -6.6 mOD to south (BH14)
CHALK	20.70 to 22.50	2.30 to 24.80 Boreholes only	Base not proven. Top generally -19 to -20 mOD

4.2 Topsoil / Made Ground

The ground surfacing comprised a cohesive material of either a thin layer of topsoil (BH06, BH11) or a reworked natural deposits with some man made gravel, eg concrete, brick and tile. This layer is not considered to be of engineering significance and no further assessment has been carried out.

4.3 Tidal Flat Deposits

The Tidal Flat Deposits comprise predominantly clay or silt with organic layers (including peat) and occasional very silty fine sand bands. Field consistency of the cohesive material is generally very soft to soft.

The peat was not recorded in all locations, though it does appear locally between 8 to 10 m as generally fibrous, occasionally firm. Pockets of plant remains and/or fibrous peat tends to appear at shallower depths, often above a peat stratum, though it has been encountered in both the 2 to 4 m range and the 7 to 12 m range independent of any peat stratum. Organic matter content tests carried out on four samples between 3.50 and 9.50 m measured 3.9 to 11.3 %, indicating slightly organic to organic. Even small quantities of organic matter content can have an effect on plasticity values and subsequently the engineering properties.

Thirty five Atterberg limit determinations measured liquid limits of between 33 and 99 % and plastic limits of between 16 and 45 %. These tests indicate that the materials comprise predominantly clays (locally silt), generally of medium and high plasticity, with some low and very high results, see Plasticity Chart Figure 1. Two samples, BH03 9.50 m and BH05 8.00 m were recorded as non plastic. Moisture contents typically ranged from 26 to 81 %, with one extreme result of 338 % on a stratum described as a peat. The moisture contents are generally closer to the liquid limit, though above 2 m tend to be closer to the plastic limit indicating a higher strength (possibly a dessicated crust), see Figure 2.

Quick undrained triaxial tests carried out on eleven cohesive samples revealed undrained shear strengths of between 7 and 38.5 kPa to 11 m, indicating a generally very low to low strength, with two higher values of 62.5 (BH11) and 83.5 kPa (BH04) at 2 m, indicating a medium to high strength at these locations which is in agreement with the plasticity results above, see Figure 3. The strength indicators above are in general agreement with the consistency assessed from sample inspection, indicating little variation across the site. Cone Penetration testing carried out within the Tidal Flat Deposits records a similar depth profile with a Su of 50 kPa around 1 to 2 m with a decrease in strength to around 25 kPa below this depth.

Six SPTs carried out within the granular material (BH13 only) recorded 'N' values of between 2 and 12, which indicated a very loose to medium dense relative density, see Figure 4.

Thirty one SPTs carried out within the cohesive material recorded 'N' values of between 1 and 19, with a further twenty seven dropping with the self-weight of the rods and hammer weight for the full penetration depth of the test (450 mm), see Figure 4.

One laboratory California Bearing Ratio (CBR) was carried out on a sample recovered from TP09 (0.45 m) giving results of 4.8 % (sample top) and 7.3 % (sample base).

4.4 Glacial Till

The Glacial Till deposits comprise layers of sandy gravelly clay and silty sand, locally gravelly. Field consistency is generally firm to stiff and very stiff.

Seventeen Atterberg limit determinations measured liquid limits of between 24 and 34 % and plastic limits of between 13 and 19 %. These tests indicate the clay is of low plasticity, see Plasticity Chart Figure 1. Moisture contents typically ranged from 11 to 19 %. The moisture contents generally fall around the plastic limit, and are reasonably consistent with depth, see Figure 2.

Quick undrained triaxial tests carried out on nine cohesive samples revealed undrained shear strengths of between 37.5 and 150 kPa, indicating a low to high strength, see Figure 3.

Thirty seven SPTs carried out within the cohesive material recorded 'N' values of between 2 and 45 (9.30 to 21.80 m depth), see Figure 4. Published correlations between SPT 'N' values and strength suggests undrained shear strength of 10 to 225 kPa (very low to very high strength), with no apparent pattern within the data, see Figure 3.

Seventeen SPTs carried out within the granular material recorded 'N' values of between 4 and 28, indicating a loose to medium dense relative density. One further test recording 50 blows without reaching the full 300 mm penetration, ie refusal, indicating a very dense relative density, see Figure 4.

The strength indicators above are in general agreement with the consistency assessed from sample inspection, indicating little variation across the site. Cone penetration testing indicates a similar profile with results greater than 100 kPa.

4.5 Chalk

The upper part of the chalk was recovered as a sandy gravel with occasional cobbles or gravel in a silt matrix. Coring of the chalk was carried out with variable recovery (average of 50% recovery) and comprised a very weak to weak high density material with closely spaced fractures. It should be noted that, due to potential sample disturbance during the boring process, the in situ materials may be less weathered than indicated by the borehole logs.

SPT carried out within the Chalk recorded SPT N blows of between 18 and 42 blows, and 3 tests recording refusal at 50 blows, in the cohesive materials. In the granular materials recorded SPT N blows of between 5 and 47 blows, with 33 tests recording refusal, see Figure 4.

Rock strengths have been obtained from laboratory testing by one uniaxial compressive strength test (UCS) and twenty six point load tests (PLT) of variable orientation. For indirect estimation of rock strength, UCS values have been taken as 20 times Point Load Index (I_{s50}). It should be noted, however, that a wide range of UCS/PLT factors can occur and therefore these values should be regarded as tentative. Based on the lab results the estimated UCS values for the chalk are between 0.40 and 10.40 MPa, indicating an extremely weak to weak rock strength. Figure 5 shows no apparent correlation between strength and depth.

Fifteen saturated moisture content and intact dry density tests were carried out on samples of the Chalk. These gave results of between 18 and 20 % saturated moisture content and 1.75 to 1.84 Mg/m^3 intact dry density. In accordance with CIRIA 574 (2002) this correlates with a high density material.

The lab test indicators above are in general agreement with the field logging from sample inspection, indicating little variation across the site.

4.6 Groundwater

Twenty water strikes were recorded during fieldwork, and these are summarised in Table 4. These observations do not necessarily indicate equilibrium conditions.

TABLE 4 : SUMMARY OF WATERSTRIKES

DEPTH (m)	DEPTH (mOD)	RISE AFTER 20 MINUTES (m)	STRATA	REMARKS
10.50	-8.26	1.31	Tidal Flat Deposits	Silt
11.70	-9.62	8.70	Tidal Flat Deposits	Thinly laminated clay
10.30	-8.20	5.20	Tidal Flat Deposits	Granular material
4.00	-1.45	2.63	Tidal Flat Deposits	Granular material
9.00	-7.59	4.26	Glacial Till	Driller notes sand lenses
10.00	-7.75	6.48	Glacial Till	Sand pockets within clay
11.20	-8.40	No rise. Seepage	Glacial Till	Clay
12.30	-8.95	7.80	Glacial Till	Clay with sand bands
13.00	-10.45	8.56	Glacial Till	Granular material
15.10	-12.02	4.57	Glacial Till	Thinly to thickly laminated clay
16.50	-12.94	9.09	Glacial Till	granular from 16.80m
15.80	-13.00	6.90	Glacial Till	Granular material
16.00	-13.75	5.72	Glacial Till	Granular material
16.10	-13.94	8.90	Glacial Till	Granular material
17.10	-14.24	10.40	Glacial Till	Granular material
16.40	-14.99	9.68	Glacial Till	Granular material
18.70	-16.15	8.18	Glacial Till	Granular material
20.70	-19.29	5.78	Glacial Till / Chalk	Strata boundary: clay over Chalk recovered as gravelly silt
22.20	-19.95	4.87	Chalk	Granular material
30.60	-28.41	Artesian	Chalk	Non intact

The monitoring carried out within the installations between August and November 2019 is summarised in Table 5. This shows a generally shallow groundwater between 0.24 and 3.62 m, with artesian groundwater within the two installations in the Chalk. This indicates the Glacial Till and the Chalk are not in hydraulic continuity.

The groundwater monitoring results in general show a decrease in depth to water level over time, with the artesian installations reducing towards ground level. See Figure 6. It will be appreciated that seasonal fluctuations in groundwater level occur. Other effects such as investigation and constructional excavation may also change groundwater levels.

TABLE 5 : SUMMARY OF INSTALLATIONS AND MONITORING

HOLE ID	RESPONSE ZONE (m)	GROUNDWATER LEVEL (m)	STRATA	REMARKS
BH01 (S)	7.00 to 11.00	0.24 to 0.57	Tidal Flat Deposits	
BH01 (D)	34.00 to 36.50	-0.18 to -0.32 agl	Chalk	Artesian
BH02 (S)	2.50 to 8.00	1.05 to 1.41	Tidal Flat Deposits	
BH02 (D)	30.60 to 33.00	0.00 to -0.17 agl	Chalk	Artesian
BH04 (S)	3.40 to 3.90	2.22 to 3.19	Tidal Flat Deposits	
BH04 (D)	16.80 to 17.70	1.63 to 2.16	Glacial Till	
BH11 (S)	6.90 to 8.00	0.52 to 1.69	Tidal Flat Deposits	
BH11 (D)	10.00 to 15.00	1.25 to 1.53	Glacial Till	
BH12 (S)	3.20 to 9.70	1.22 to 1.56	Tidal Flat Deposits	
BH12 (D)	18.20 to 21.30	1.17 to 1.50	Glacial Till	
BH13 (1)	4.00 to 7.00	1.53 to 1.79	Tidal Flat Deposits	
WS01 (1)	2.00 to 5.00	1.15 to 1.40	Tidal Flat Deposits	
WS02 (1)	2.60 to 5.00	1.38 to 2.00	Tidal Flat Deposits	
WS03 (1)	2.00 to 5.00	1.25 to 1.53	Tidal Flat Deposits	
WS04 (1)	3.00 to 5.00	1.10 to 1.52	Tidal Flat Deposits	
WS05 (1)	3.00 to 5.00	1.62 to 2.63	Tidal Flat Deposits	
WS06 (1)	3.00 to 5.00	1.49 to 1.75	Tidal Flat Deposits	
WS07 (1)	2.50 to 5.00	1.18 to 2.69	Tidal Flat Deposits	
WS09 (1)	1.00 to 2.00	1.82 to 1.90 and Dry	Made Ground	
WS10 (1)	3.00 to 5.00	1.60 to 3.62	Tidal Flat Deposits	

5 PROPOSED WORKS

The proposed works comprised a new energy from waste centre and associated auxiliary structures. The borehole and trial pit location plan provided by EP UK, 2522-012 R2 presented in Appendix A, shows the below proposed structures:

- RDF reception hall and bunker
- Boiler hall
- Flue gas treatment area
- Chimney stack
- Turbine Hall
- Air cooled condenser
- Substation
- Administration, welfare and stores building
- Storm water attenuation pond, 45000 m^3
- Roads, car parking, drainage and underground services

6 GEOTECHNICAL ENGINEERING ASSESSMENT

6.1 Introduction

The findings of the investigation indicate the following profile of strata beneath the site;

- Made Ground / Topsoil
- Tidal Flat Deposits – generally very low strength material
- Glacial Till – generally low to high strength material
- Chalk – generally very weak to weak high density bedrock

For the purposes of this report it has been assessed that a mix of foundation solutions are likely, with lightly loaded structures utilising pad or strip foundations, subject to appropriate ground conditions, whereas the more heavily loaded structures requiring a piled solution. Details of loadings for individual structures have not been provided. This report should therefore be considered as an overview of the site, addressing the general requirements of the proposed scheme only. It is essential that additional detailed assessments be undertaken for individual structures once further construction proposals are available.

6.2 Shallow Foundations

The Made Ground is not considered suitable for founding purposes.

The Tidal Flat Deposits comprise primarily cohesive materials, consisting of clay or silt with organic (peat) layers. As indicated in Section 5 the reported consistency of the material ranges from very soft to soft. Furthermore, based on the results of the SPT and triaxial lab tests the undrained shear strength of the material is expected to be very low to low strength. The thickness range of the Tidal Flat Deposits is variable, with the depth to the underlying Glacial Till being encountered at depths of between 8.15 and 16.86 m.

Due to the variable nature of the Tidal Flat Deposits, their low strength and high compressibility characteristics, it may be concluded that the ground conditions are unlikely to be suitable for shallow foundations.

6.3 Piled Foundations

For the majority of the proposed structures a piled solution could be considered, with piles extending either to within the Glacial Till or possibly to the underlying Chalk, depending on the structural loads.

The carrying capacity of a pile is dependant not only on the ground conditions but also on the type of pile and its method of installation. It is therefore considered essential that the advice of specialist piling contractors is sought regarding the suitability of their various proprietary systems giving due consideration to the ground conditions present on the site. The piling contractor will be able to provide a pile design and confirm the pile lengths and diameters required to maintain settlements within the specified tolerances under the applied loads for their piling systems.

When evaluating the type of pile to be used on this site the following issues should be considered:

- Any access constraints for piling plant and equipment gaining access onto the site and manoeuvring around the site.
- The effects of noise, vibrations and ground disturbance on any nearby infrastructure including structures, roads and buried services.
- Groundwater was encountered in the exploratory holes during the investigation. Therefore water within the more permeable materials may enter pile holes e.g. perched water from within the Made Ground or water ingress from sand lenses or layers in the Tidal Flat Deposits or Glacial Till.

6.4 Excavations

Should shallow excavation of the materials be required this should generally be within the scope for conventional backhoe excavators. The materials in excavations should be exposed for as little time as is practical in order to minimise the risk of softening of any cohesive materials in the excavation.

Available groundwater information indicates that shallow excavations open for a short period of time are likely to be subject to groundwater ingress, though this should be manageable with pumping.

It should be noted that side stability of excavations may be relatively poor due to low strength materials, requiring suitable support (or being cut to an appropriate batter). Similarly, should man entry be required in any excavations they should be made safe by appropriately supporting the excavations walls, or cutting them to a suitable batter. An appropriate risk assessment should be undertaken for all excavations that may require man entry.

6.5 Roads and Pavements

Pavement design is based on the recommendations given in the Highways Agency Interim Advice Note 73/06 (2009) which requires an assessment of the subgrade stiffness based on California Bearing Ratio (CBR) values. The design CBR is based on a consideration of the soil description and the long-term and short term CBR. Table 5.1 of Advice Note 73/06 provides estimated values for long-term CBR depending on soil type, particularly for clay subgrades, where moisture and plasticity are significant issues. Assessment is provided of pavements at grade.

The near surface material comprises cohesive Made Ground/Topsoil over Tidal Flat Deposits or Tidal Flat Deposits at surface. The consistency of the cohesive material is generally described as very soft and soft. Based on the results of plasticity testing, the soils expected to be at subgrade should be regarded as moisture sensitive (IAN 73/06).

Due to the variability within the near surface material a long-term equilibrium CBR of < 2% as indicated in Table 5.1 (IAN 73/06) for a thin pavement would be appropriate. This is in line with a laboratory CBR result of 4.8 % (TP09, 0.45m) and takes into account the low strength materials across the site. These CBR values should be taken as a preliminary indication only, and once layouts and formation levels have been finalised it is essential that the subgrade be checked on site, with further CBR testing, before construction starts. It is also important that the formation is proof rolled and any softer spots excavated and replaced with suitable compacted granular fill. Subsurface drainage will be required to control free water from pavements.

6.6 Chemical Considerations for Buried Concrete

A total of twenty three samples, recovered from depths of between 0.20 and 33.00 m, were tested for pH, total sulphur, water soluble and acid soluble sulphate, in accordance with BRE Special Digest 1 (2005).

The site has been classified as natural ground with pyrite and a mobile groundwater situation has been assumed. The test results, summarised in Table 6, are separated by strata. The recommendations in the BRE digest should be followed for the design of subsurface concrete.

TABLE 6 : BRE SD1 CLASSICIFICATION PER STRATA

STRATUM	RANGE OF VALUES				CALCULATIONS			DESIGN SULPHATE CLASS	ACEC CLASS
	Acid Soluble Sulphate (%)	Total Sulphur (%)	pH	Water Soluble Sulphate (g/l)	Total Potential Sulphate (TPS % SO_4)	Oxidisable Sulphides (OS % SO_4)	Pyrite Probably Present		
Made Ground 3 results	0.02 to 0.05	0.04 to 0.06	8.2 to 8.3	17 to 178	0.18 Max value	0.15 Max value	No	DS-1	AC-1
Tidal Flat Deposits 14 results	0.03 to 0.52	0.02 to 3.53	7.4 to 8.5	36 to 2090	5.20 Mean of highest 20%	5.02 Mean of highest 20%	Yes	DS-5*	AC-5
Glacial Till 3 results	0.02 to 0.05	0.15 to 0.24	7.9 to 8.1	63 to 128	0.72 Max value	0.67 Max value	Yes	DS-3	AC-3
Chalk 3 results	0.02 to 0.03	0.01 to 0.04	8.7 to 8.8	14 to 19	0.12 Max value	0.08 Max value	No	DS-2	AC-2

The presence of pyrite may result in an increased risk of sulphate attack of buried concrete where the ground is disturbed during construction. In accordance with recommendations given in BRE Special Digest 1, the assessed Design Sulphate Class for materials in which pyrite is likely to be present, and where ground may be disturbed, should be based on TPS and pH values, as indicated in the table above. Where total potential sulphate is initially found to be DS-5, as seen for the Tidal Flat Deposits (*) in Table 6, a limitation can be applied if the sulphate class for water extracts are sulphate class 3 or below. Assessing the results on this basis would allow the overall reduction of the Tidal Flat Deposits to a DS-4 sulphate class.

However, for concrete that will be placed against material that will not be disturbed during construction (e.g. cast in situ or pre cast piles), then the Design Sulphate Class may be based on water soluble sulphate and pH values. Based on the assumption that a pile would come into contact with all ground conditions then an assessment of the results would indicate for water soluble sulphate a characteristic value of 1005.6 mg/l (mean of highest 20 %) and for pH a characteristic value of 7.6 (mean of lowest 20 %). This would equate to DS-1 and AC-2.

7 GEOENVIRONMENTAL ASSESSMENT

7.1 Assessment Basis

The preparation and development of a conceptual site model (CSM) is key to understanding the risks that may be posed to human health or the environment by contaminated land. To undertake this assessment it is necessary to define a conceptual model for the site which identifies the potential sources of contamination, the receptors and the pathways that can connect them. In order for there to be a risk from contamination, there must first be a source, a receptor and a pathway by which the receptor can be exposed to the contaminant, i.e. a pollutant linkage. This process has been undertaken in accordance with Environment Agency guidance CLR 11, Model Procedures for the Management of Land Contamination (EA, 2004).

7.2 Potential Site Sources of Contamination, Pathways and Receptors

As discussed within Section 5 it is proposed to use the site for a new energy centre. Therefore there is the potential for receptors to be affected by any soil contamination via pathways created during and after the development. Potential receptors relevant for the site are:

- Current and/or future site users
- Site workers during development and subsequent maintenance
- Groundwater underlying the site
- Buildings, structures and services e.g potable water pipes
- Humber Estuary, approximately 160 m east of the site at the closest point

For a commercial development, potential pathways by which the identified human receptors could be exposed to soil contamination include dermal contact, inhalation of dust and vapours and ingestion of soil and dust, plus potentially through leaching and permeation through potable water pipes and ingestion/direct contact of contaminated potable water. For the purposes of the assessment it is assumed that grazing of farm animals would no longer be carried out at the site.

In the case of the groundwater receptor, a potential pathway exists whereby rainfall could leach out soil contaminants into the underlying groundwater. Contaminants could migrate via groundwater flow or man-made pathways (eg services) to the nearby estuary or to offsite groundwater abstraction points (if present).

No desk study information on past uses of the site was available for the purposes of this assessment. The site is currently unutilised land.

The preliminary conceptual model is summarised below:

TABLE 7 : PRELIMINARY CONCEPTUAL SITE MODEL

SOURCE	PATHWAY	RECEPTOR
Potential localised Made Ground.	Soil ingestion Dermal contact Inhalation of soil dust / vapours	Construction site workers Future site users
	Lateral Groundwater Migration	Humber estuary Groundwater underlying the site
	Leaching of contaminants	Humber estuary Groundwater underlying the site Buildings, structures and services

7.3 Technical Approach to Soil Contamination

In accordance with Environment Agency guidance CLR 11, Model Procedures for the Management of Land Contamination, (EA, 2004), human health risk assessment follows a tiered approach, including Generic Quantitative Risk Assessment (GQRA) and Detailed Quantitative Risk Assessment (DQRA), which use data derived from the ground investigation to assess risks to identified receptors. The assessment included in this report comprises a GQRA, which is undertaken by comparing soil contaminant concentrations with conservative Generic Assessment Criteria (GAC).

Generic Assessment Criteria (GAC) for various land use and exposure scenarios have been selected from the following sources:

- CL:AIRE Category 4 Screening Levels (C4SL);
- LQM Suitable for Use Levels (S4UL) ; and
- CL:AIRE/EIC/AGS GAC

The GAC have been derived using the Environment Agency Contaminated Land Exposure Assessment (CLEA) model, for a range of land uses and exposure scenarios, including:

- Residential with the consumption of homegrown produce;
- Residential without the consumption of homegrown produce;
- Commercial;
- Allotments;
- Public Open Space near residential housing (POSresi); and
- Public Open Space public park scenario (POSpark)

It is understood that the site is to be redeveloped for the construction of an unmanned small power generation facility, subsequently the commercial GACs are considered to be the most appropriate selection to use in the comparison of measured contaminant concentrations, whilst being highly conservative.

Provisional C4SL values for a total of six priority substances (arsenic, benzene, benzo(a)pyrene, cadmium, hexavalent chromium and lead) were produced by CL:AIRE, and published in December

2013. A policy companion document was published by DEFRA in March 2014, which confirmed the final C4SL for these determinands. A further tranche of C4SLs are in preparation and expected sometime in 2017. The final C4SL values are considered to represent 'relevant technical tools', as per paragraph 4.21(c) of the Contaminated Land Part IIA Statutory Guidance. Their purpose is to identify land that falls within Category 4 (Human Health) as defined by the Statutory Guidance, i.e. land that is definitely not Contaminated Land as defined by the Part IIA legislation.

It should be noted that the C4SLs have been derived using toxicological criteria that are presented as posing a 'low level of toxicological concern'. This is in comparison with previous Soil Guidelines

Values (SGVs) and LQM GAC, which were derived using toxicological criteria that represent a 'minimal risk' to human health.

The LQM Suitable for Use Levels (S4ULs) have been derived in accordance with the changes in exposure modelling presented within the C4SL framework, whilst still using a set of toxicological criteria that are set within the 'minimal risk' range. The S4ULs were published to offer a set of collated information on the toxicity and transport properties for a number of common contaminants, and should be seen as suitable for use in planning and change of use assessments, as well as in Part IIA assessments.

The CL:AIRE/EIC/AGC Generic Assessment Criteria were published in December 2009. Assessment criteria were produced using the CLEA model for a total of 35 No. less common contaminants, in accordance with the CLEA guidance. The GAC were intended to compliment the SGVs produced by the Environment Agency, and the LQM GAC that were current at the time. These have been used in the assessment for contaminants where S4ULs and C4SLs are not available.

The SOCOTEC approach to human health risk assessment in planning and development risk assessments is to use the various assessment criteria in the following order of preference: S4UL > EIC GAC > C4SLs.

Where contaminants fail the initial screen against S4UL or EIC GAC, a further assessment may be possible by screening against C4SLs. Where this is undertaken it should be clearly understood that the C4SLs represent 'low risk' rather than 'minimal risk' GAC.

7.4 Human Health Risk Assessment Screening

The maximum recorded concentrations of contaminants in the samples are compared with conservative commercial GAC (adjusted for 1 % SOM) in Table 8 below. Six samples were from the Made Ground and four samples from the Tidal Flat Deposits.

TABLE 8 : COMPARISON OF MAXIMUM MEASURED SOIL CONTAMINATION CONCENTRATIONS WITH COMMERCIAL GAC

DETERMINAND	MAXIMUM MEASURED CONCENTRATION (mg/Kg)	GENERIC ASSESSMENT CRITERION (GAC) (mg/Kg)	NO. OF RESULTS EXCEEDING GAC (NO. OF TESTS IN BRACKETS)
Metals & semi- metals			
Arsenic	19.8	640	0 (10)
Beryllium	1.09	12	0 (6)
Cadmium	0.29	190	0 (10)
Chromium III	46.2	8600	0 (10)
Chromium VI	<0.1	33	0 (6)
Copper	28.7	68000	0 (10)
Lead[1]	33.3	2330	0 (10)
Mercury[2]	<0.5	1100	0 (10)
Nickel	49	980	0 (10)
Selenium	0.60	12000	0 (10)
Vanadium	66.2	9000	0 (10)
Zinc	134.2	730000	0 (10)
Polycyclic Aromatic Hydrocarbons			
Acenaphthene	0.14	84000	0 (10)
Acenaphthylene	<0.10	83000	0 (10)
Anthracene	0.52	520000	0 (10)
Benzo(a)anthracene	1.13	170	0 (10)
Benzo(a)pyrene	1	35	0 (10)
Benzo(b)fluoranthene	1.04	44	0 (10)
Benzo(g,h,i)perylene	0.56	3900	0 (10)
Benzo(k)fluoranthene	0.44	1200	0 (10)
Chrysene	1.08	350	0 (10)
Dibenzo(a,h)anthracene	0.18	3.5	0 (10)
Fluoranthene	2.23	23000	0 (10)
Fluorene	0.14	63000	0 (10)

Indeno(1,2,3,c,d)pyrene	0.69	500	0 (10)
Napthalene	<0.10	190	0 (10)
Phenanthrene	1.43	22000	0 (10)
Pyrene	1.89	54000	0 (10)
Total Petroleum Hydrocarbons and BTEX			
TPH by GCFID	464	N/A	N/A
GRO C5-C10[3]	<0.254	7800	0 (10)
TPH Aliphatic >EC08-C10[3]	<4.55	2000	0 (10)
TPH Aliphatic >EC10-C12[3]	<4.55	9700	0 (10)
TPH Aliphatic >EC12-C16[3]	6.82	59000	0 (10)
TPH Aliphatic >EC16-C35[3]	114.1	1600000	0 (10)
TPH Aromatic >EC08-10[3]	<4.55	3500	0 (10)
TPH Aromatic >EC10-12[3]	<4.55	16000	0 (10)
TPH Aromatic >EC12-16[3]	<4.55	36000	0 (10)
TPH Aromatic >EC16-21[3]	4.78	28000	0 (10)
TPH Aromatic >EC21-35[3]	179	28000	0 (10)
Benzene	<0.01	27	0 (10)
Toluene	<0.01	56000	0 (10)
Ethylbenzene	<0.01	5700	0 (10)
m/p-Xylene	<0.02	5900	0 (10)
o-Xylene	<0.01	6600	0 (10)
Other Compounds			
Asbestos	No asbestos detected	0.001%	0 (10)
Phenol (total)	<0.6	760	0 (10)
PCB sum of 12[4]	<0.05	0.24	0 (10)
pH (range of results, pH units)	7.4 to 8.9	N/A	N/A

[1]C4SL
[2]GAC for Inorganic Mercury used
[3]Most conservative aliphatic/aromatic GAC used
[4]GAC for Dioxin, Furans and Dioxin like PCBs (12 Congeners) used

7.5 Risk to Site Users

As highlighted in the above Table 8 none of the chemical contaminants exceeded the GAC for the commercial land use scenario.

7.6 Risks to Receptors Other than Humans

The CLEA model cannot be used to assess the acute risks to construction and/or maintenance workers from soil contamination. CLEA only deals with chronic long term risks.

In order to assess potential risks to these workers reference has been made to the thresholds for hazardous waste (EA, 2011). Soils with concentrations of hazardous contaminants (e.g. harmful, toxic, carcinogenic) above certain thresholds are classified as hazardous for disposal. These types of contaminated soils would potentially pose a risk to construction and/or maintenance workers.

Based on the chemical analysis results in Section 7.4, the levels of contaminants in the soil at the site are such that they are unlikely to pose a hazard to construction and/or maintenance workers.

Contact with soil should be avoided where possible and standard site hygiene procedures should be implemented, such as wearing gloves and overalls and providing adequate washing facilities. Eating, drinking and smoking should be banned in the working areas to prevent inadvertent ingestion of the soil.

7.7 Risks to Controlled Waters

Currently no groundwater or soil leachate samples have been analysed. Therefore, the potential risk to Controlled Waters cannot be assessed further. However, based on the soil concentrations, which are all very low to low, and ground conditions with no visual or olfactory evidence of contamination at the time of sampling then there is unlikely to be a source of contamination on site. Distance to the nearest receptor is 160 m and the presence of low permeability clay and silt between the Made Ground and the underlying Chalk aquifer (and likely groundwater) would cut this pathway, indicating overall a low risk to controlled waters.

7.8 Site Conceptual Model

In Section 7.2 potential sources of contamination, pathways and receptors were identified for the site based on the available information. These potential pollutant linkages constituted the preliminary conceptual model for the site.

The results of the ground investigation have been used to refine the conceptual model and to define the specific source-pathway-receptor pollutant linkages for the site based on the proposed development.

The chemical analysis results indicate there is currently a very low risk to future site users from soil contamination at the site.

No asbestos was detected in the ten samples analysed.

7.9 Remediation Recommendations

The level of contamination in general is low for the analysed contaminants. In addition the expected hardstanding to be installed at the site would further reduce any risk to likely receptors. Therefore, on the basis of the current investigation and risk assessment, no specific remedial measures are deemed necessary to mitigate potential contamination risk to future site end users.

8 GAS

For the assessment of sites, in terms of the potential for ground gas to present a hazard, the risk based methodology detailed in CIRIA Report C665 (2007) is used. This is primarily based on the method of characterising a site as proposed by Wilson and Card (1999). The method is predominantly centred on a conceptual model which relates possible sources of gas to likely receptors via potential pathways.

Three visits were carried out between 17 September and 12 November 2019 following the investigation to monitor gas and groundwater levels within the installed standpipes. Due to high groundwater levels the majority of the gas monitoring data is discounted as the groundwater level was above the top level of the installation. Shallow groundwater can result in reduced available pore spaced in which soil gas can exist. Some of the gas will dissolve, however, the reduced pores space will result in an increase in gas concentrations and an increase in its potential release of the gas into the atmosphere. Peak readings of some gases were noted and further assessment is recommended as natural alluvial / peat deposits can generate methane and carbon dioxide.

The only installation where the groundwater was below the level of the response zone, allowing gas migration, was WS09, installed within the Made Ground. The results indicate the majority of the readings being either very low or below the detection limits in terms of gas concentrations, see Table 9.

TABLE 9 : SUMMARY OF GAS MONITORING OF WS09 INSTALLATION

DETERMINAND	UNITS	STEADY STATE CONCENTRATIONS		REMARKS
		Min	Max	
Methane, CH_4	% vol	0.0	0.0	
Oxygen, O_2	% vol	16.4	21.1	Low oxygen on single visit – 08/10/19
Carbon Dioxide, CO_2	% vol	0.1	1.4	
Carbon Monoxide, CO	ppm	0.0	0.0	
Flow	l/hr	-0.1	0.0	
Atmospheric Pressure	mbar	1003	1030	
Gas screening value for WS09 <0.07 Characteristic Situation 1, no special precautions				

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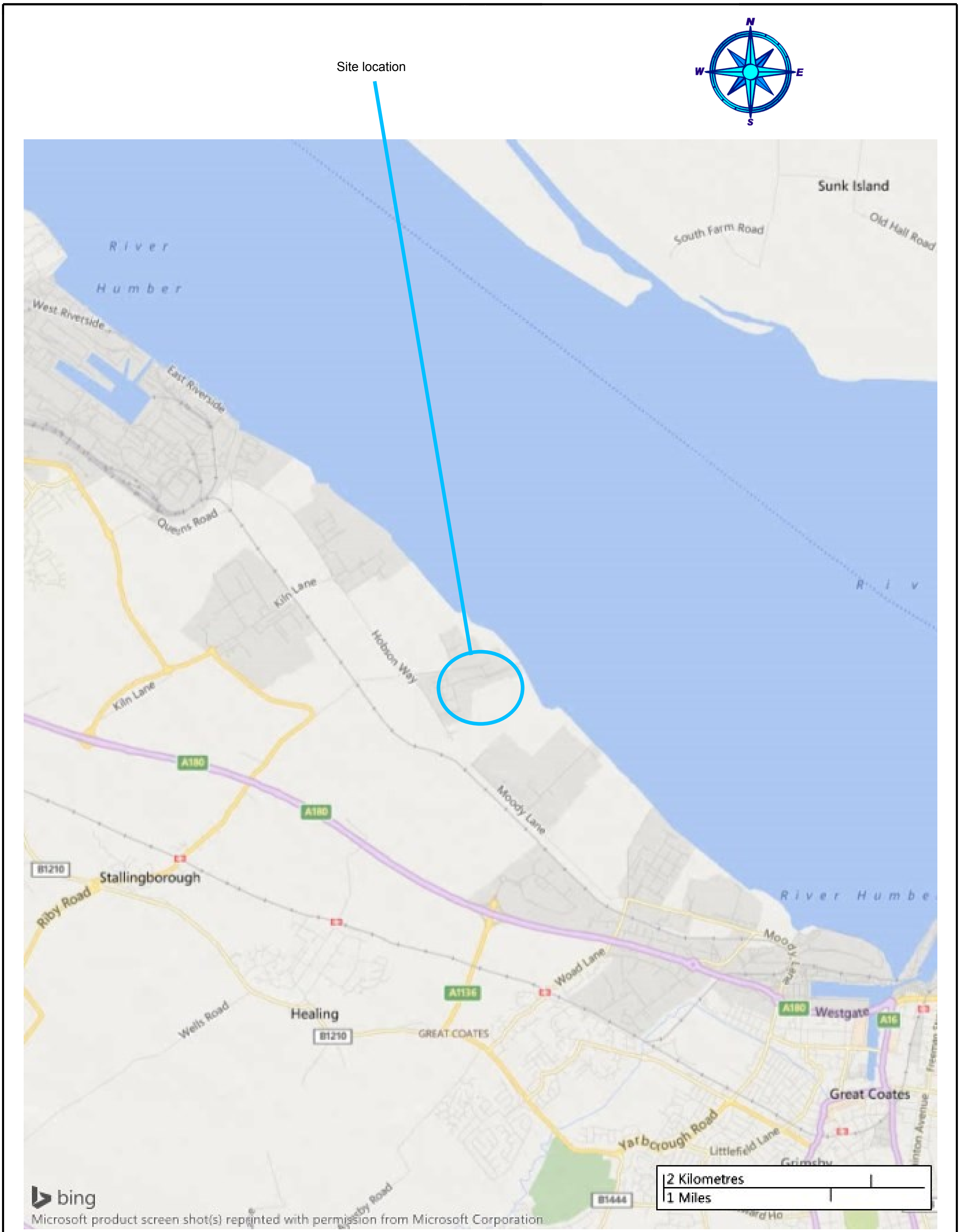
APPENDIX A

DRAWINGS

Site Location Plan	A1
Site Plan	A2
Proposed plan from client	2522-012 R2
Cross Section Plan	A3
Cross Section – north south	Section line 1
Cross Section – east west	Section line 2

Site Location Plan

SOCOTEC



Notes	Project	SOUTH HUMBER BANK ENERGY CENTRE	Figure
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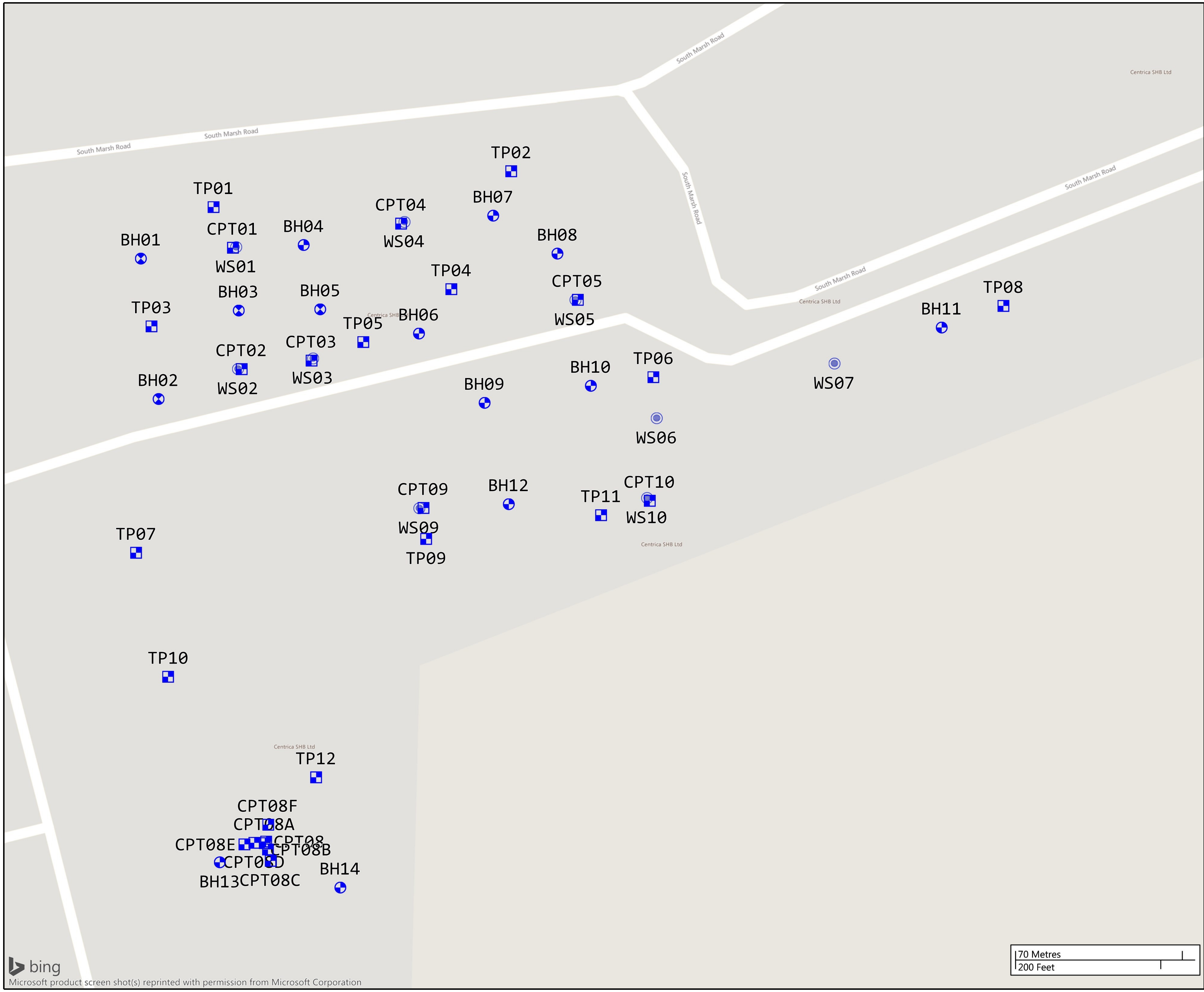
	Carried out for	EP UK Investments Ltd.	



N
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Notes:

Scale:

1:1500

Surveyed By:

SOCOTEC

Surveyed Date:

12/09/2019

Key:

Cable Percussion Borehole

Cable Percussion and Rotary Borehole

Trial Pit

Dynamic Sampling

Site Plan

SOCOTEC

Project ID:

A9020-19

Project Title:

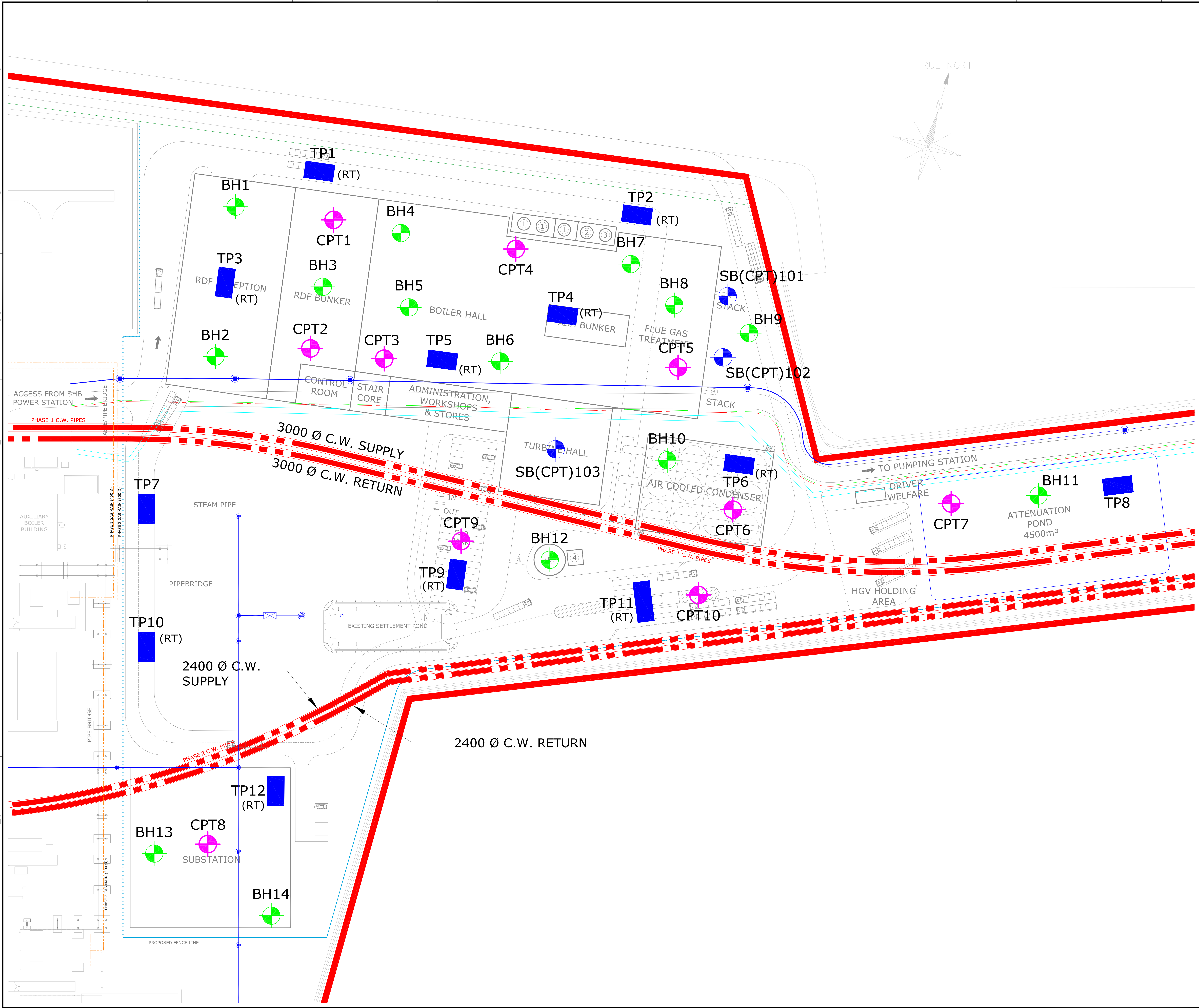
SOUTH HUMBER BANK ENERGY CENTRE

Client:

EP UK Investments Ltd.

Figure:

A2



ALL INFORMATION ON THIS DRAWING IS INDICATIVE ONLY, AND MAY BE SUBJECT TO FURTHER DESIGN DEVELOPMENT.

DO NOT SCALE

LEGEND

- NEW BOREHOLES (14 No. TOTAL) (CABLE PERCUSSION WITH ROTARY CORE FOLLOW ON)
- NEW BOREHOLES (3 No. TOTAL) (SEISMIC DOWN HOLE TESTING TO BE UNDERTAKEN IN CPTu BOREHOLES)
- NEW BOREHOLES (10 No. TOTAL) (CPTu WITH WINDOW SAMPLING ADJACENT)
- SITE BOUNDARY
- TRIAL PIT WITH PLATE AND CBR TESTING (12 No.)
- (RT) ELECTRICAL RESITIVITY TO BE CARRIED OUT AT 10 No. LOCATIONS

EXISTING SERVICES

- SURFACE WATER DRAIN
- FIRE FIGHTING MAIN (WP=10bar)
- POTABLE WATER MAIN (WP=2.5bar)
- ELECTRICAL CABLE TRENCH
- EXISTING ROAD
- EXISTING COOLING WATER PIPES (3000/2400 INT Ø)

REV.	DETAILS OF REVISION	DRAWN	CHKD	DATE
R2	PRELIMINARY	AO	BH	21.05.19
R1	PRELIMINARY	AO	TO	29.04.19

FICHTNER
CONSULTING ENGINEERS LIMITED
Kingsgate, Wellington Road North,
Stockport, Cheshire, SK4 1LW, UK
Tel: 0161 476 0032
Website: www.fichtner.co.uk

CLIENT: EP UK INVESTMENTS LTD

SITE: SOUTH HUMBER BANK

PROJECT: SOUTH HUMBER BANK ENERGY CENTRE

TITLE: FIGURE 2 BOREHOLE AND TRIAL PIT LOCATION PLAN

DRAWING STATUS:	PRELIMINARY		
DRAWN BY:	AO	DATE:	20.06.18
CHECKED BY:	TO	DATE:	20.06.18
FILENAME:	2522-012-R2.DWG		
OFFICE OF ISSUE:	STOCKPORT		
SHEET SIZE:	A2	SCALE:	1:1000
DRAWING No.:	2522-012	REVISION:	R2

Sheet 1 of 1

N
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S

Notes:

Scale:

1:1500

Surveyed By:

SOCOTEC

Surveyed Date:

12/09/2019

Key:

Sections - Section line 1

Sections - Section line 2

Cross Section Plan

SOCOTEC

Project ID:

A9020-19

Project Title:

SOUTH HUMBER BANK ENERGY CENTRE

Client:

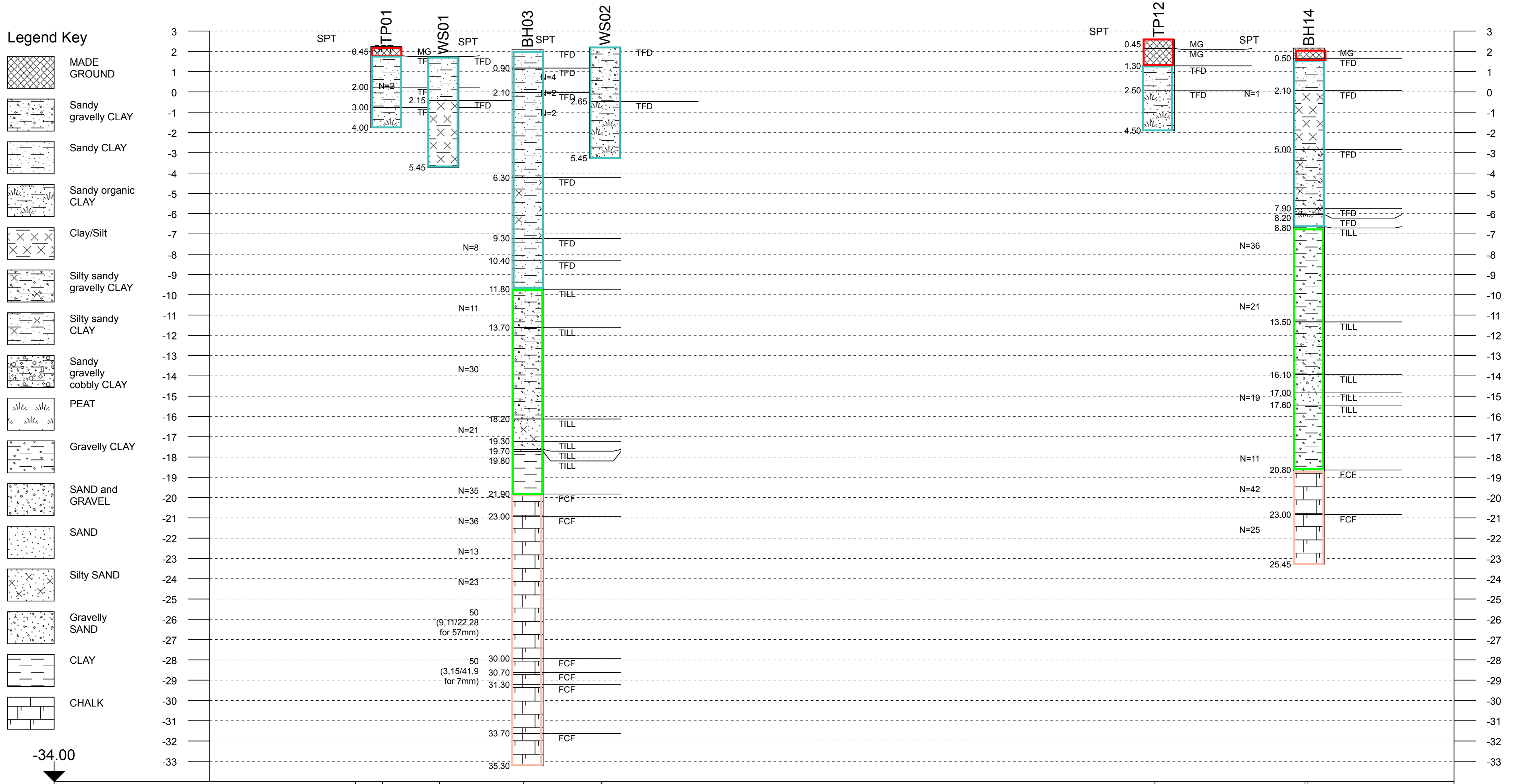
EP UK Investments Ltd.

Figure:

A3

Project No: A9020-19	Title: SOUTH HUMBER BANK ENERGY CENTRE	Scale
Location: Immingham		Vertical: 1:275
Client: EP UK Investments Ltd.	Section Line 1	Horizontal: 1:1763

SOCOTEC



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Elevation (mAOD)		2.23	[illegible]	2.08	[illegible]	2.59	2.16

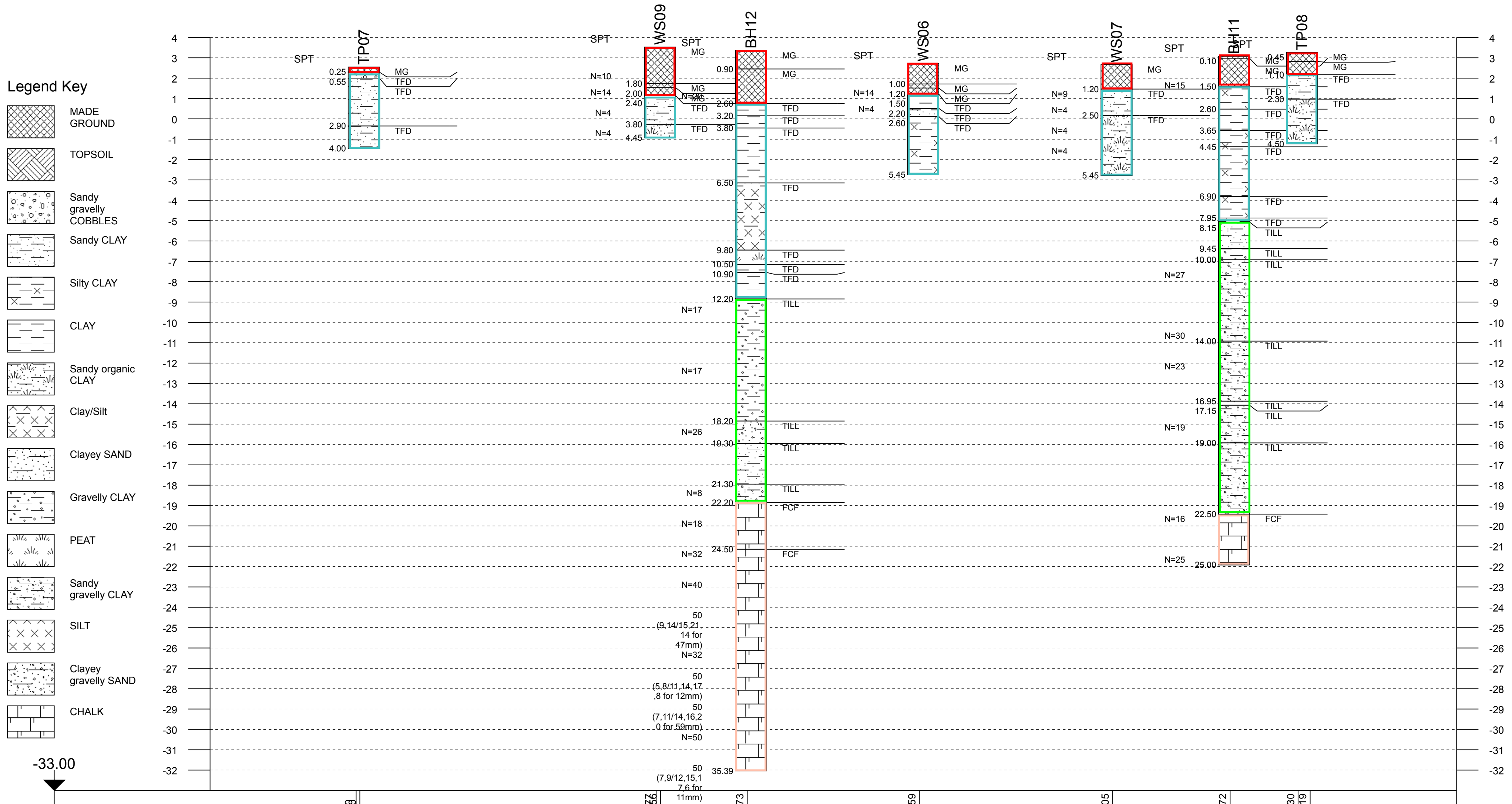
Project No: A9020-19
Location: Immingham
Client: EP UK Investments Ltd.

Title: SOUTH HUMBER BANK ENERGY CENTRE

Section Line 2

Scale
Vertical: 1:275
Horizontal: 1:2271

SOCOTEC

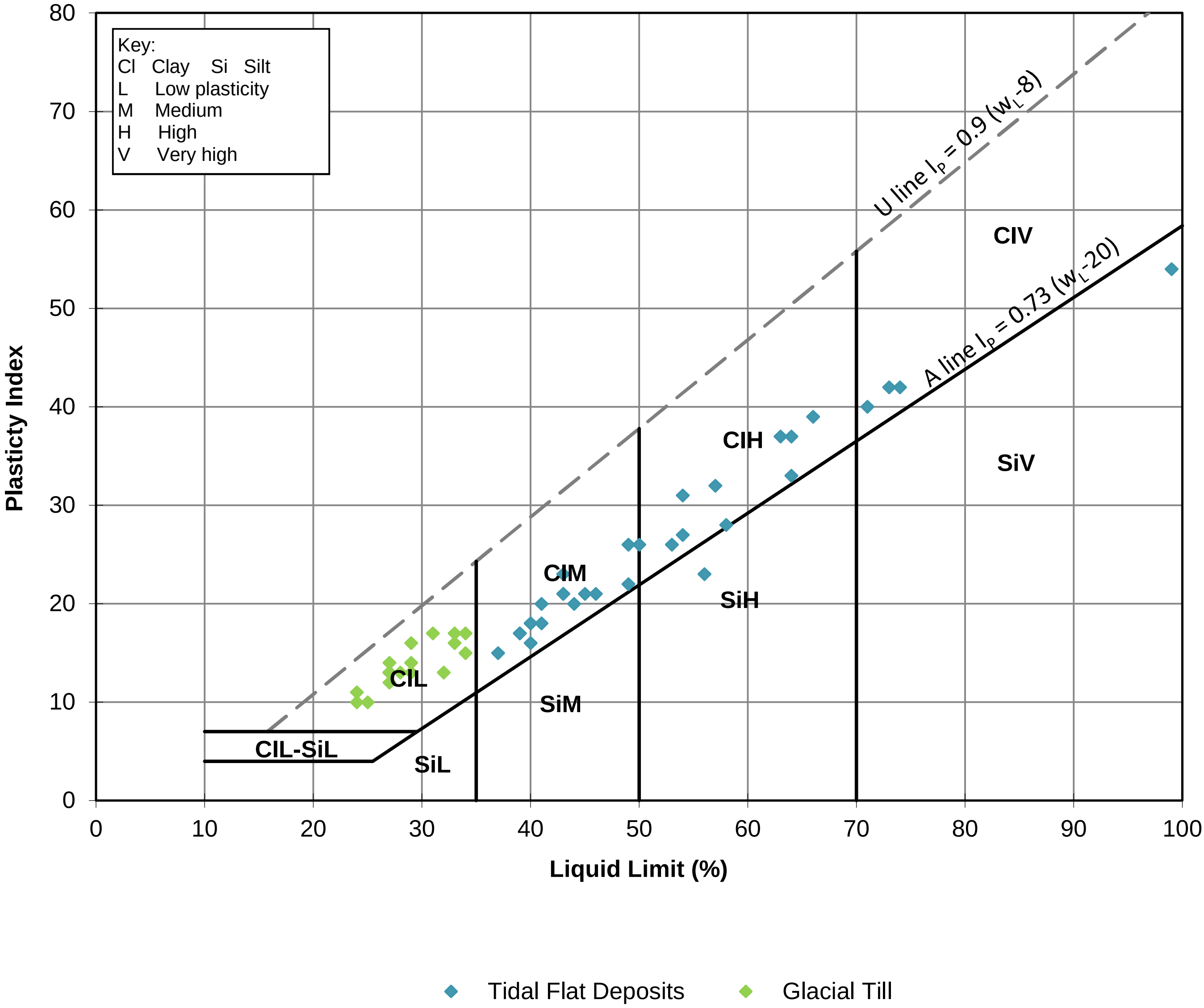


Chainage (m)	0.00	1.50	121.77	123.56	158.73	228.59	307.05	354.72	382.30	387.19
Offset (m)	4.49		8.96	9.29	17.22	1.21	3.65	6.40	8.31	
Elevation (mAOD)	2.55		3.53	3.54	3.35	2.71	2.66	3.08	3.27	

APPENDIX B

FIGURES

Plasticity Chart



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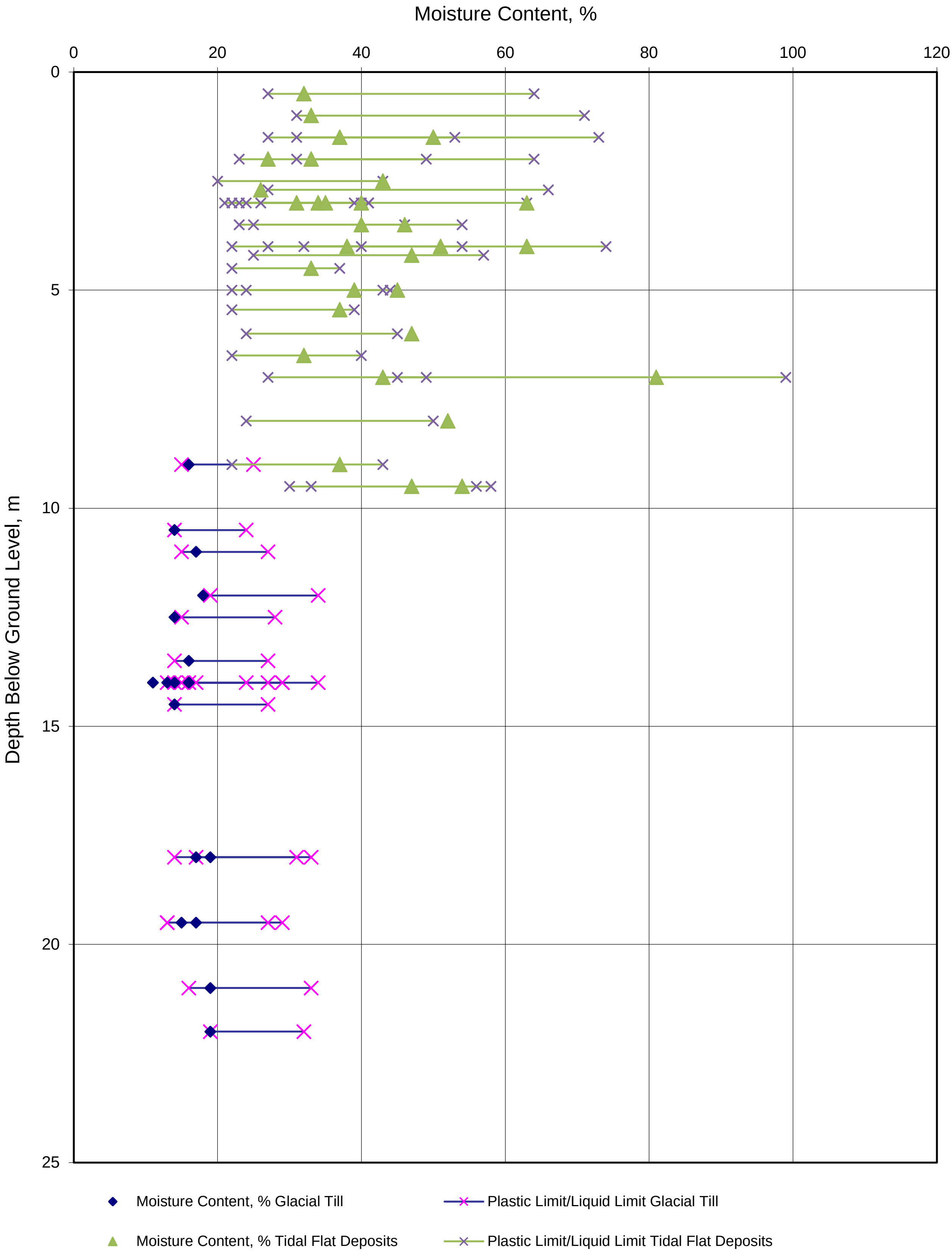
	Carried out for	EP UK Investments Ltd.	

Moisture Content and Atterberg Limits Profile

SOCOTEC



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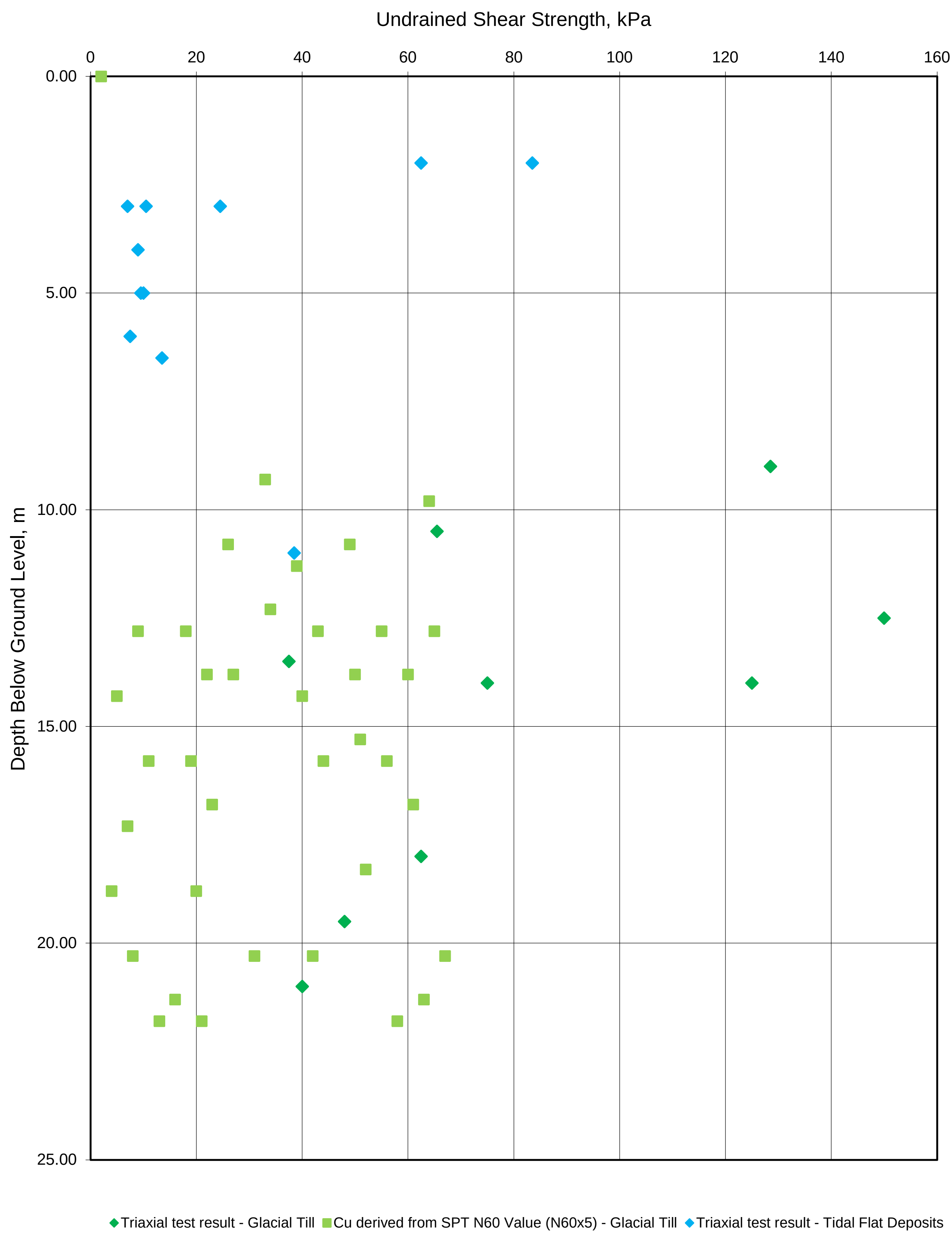
	Project No.	A9020-19	2
	Carried out for	EP UK Investments Ltd.	

Undrained Shear Strength Profile

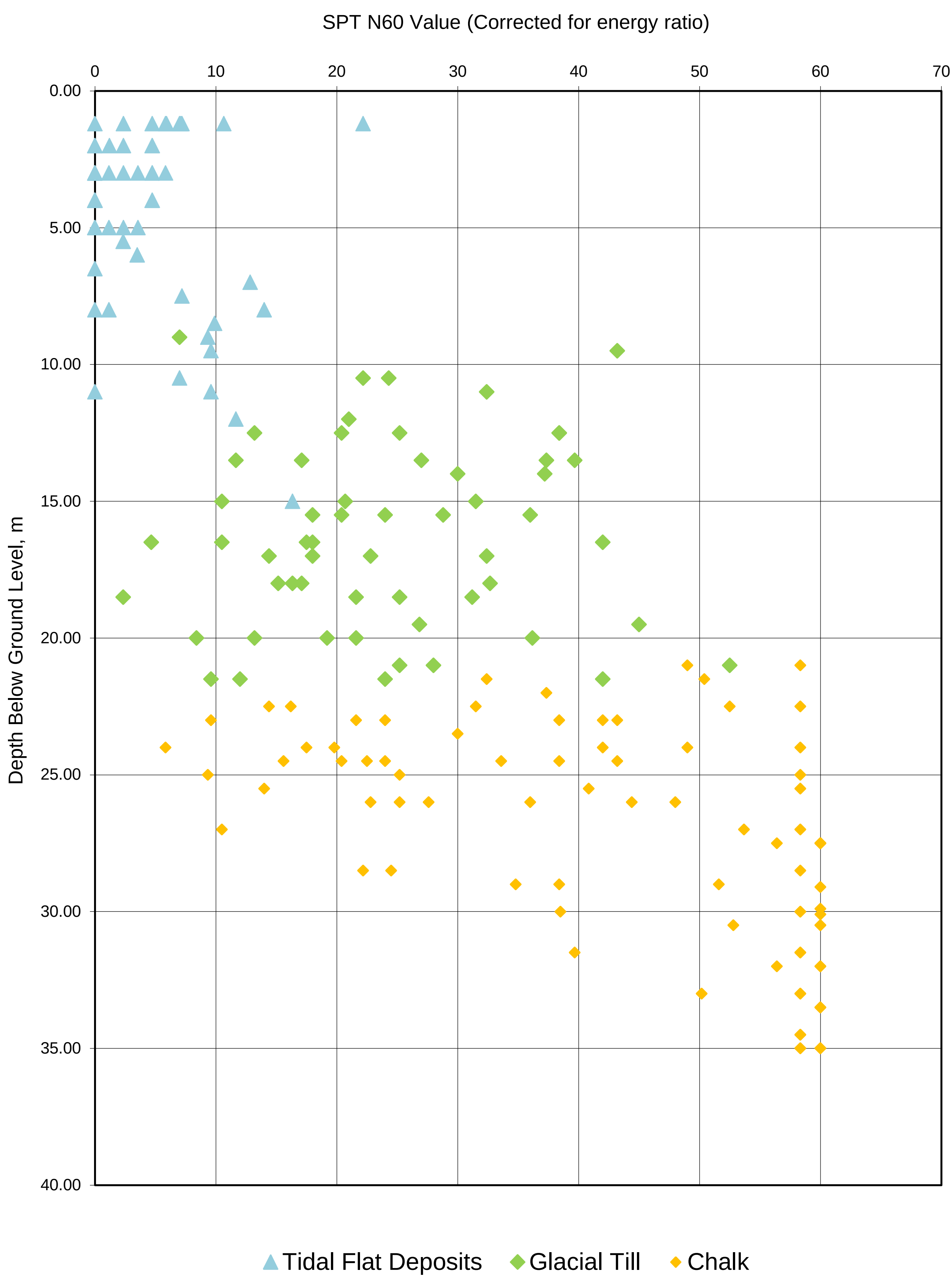
SOCOTEC



Notes:	Project	SOUTH HUMBER BANK ENERGY CENTRE	Sheet
	Project No.	A9020-19	3
	Carried out for	EP UK Investments Ltd.	Sheet 1 of 1

SPT N Depth Profile

SOCOTEC

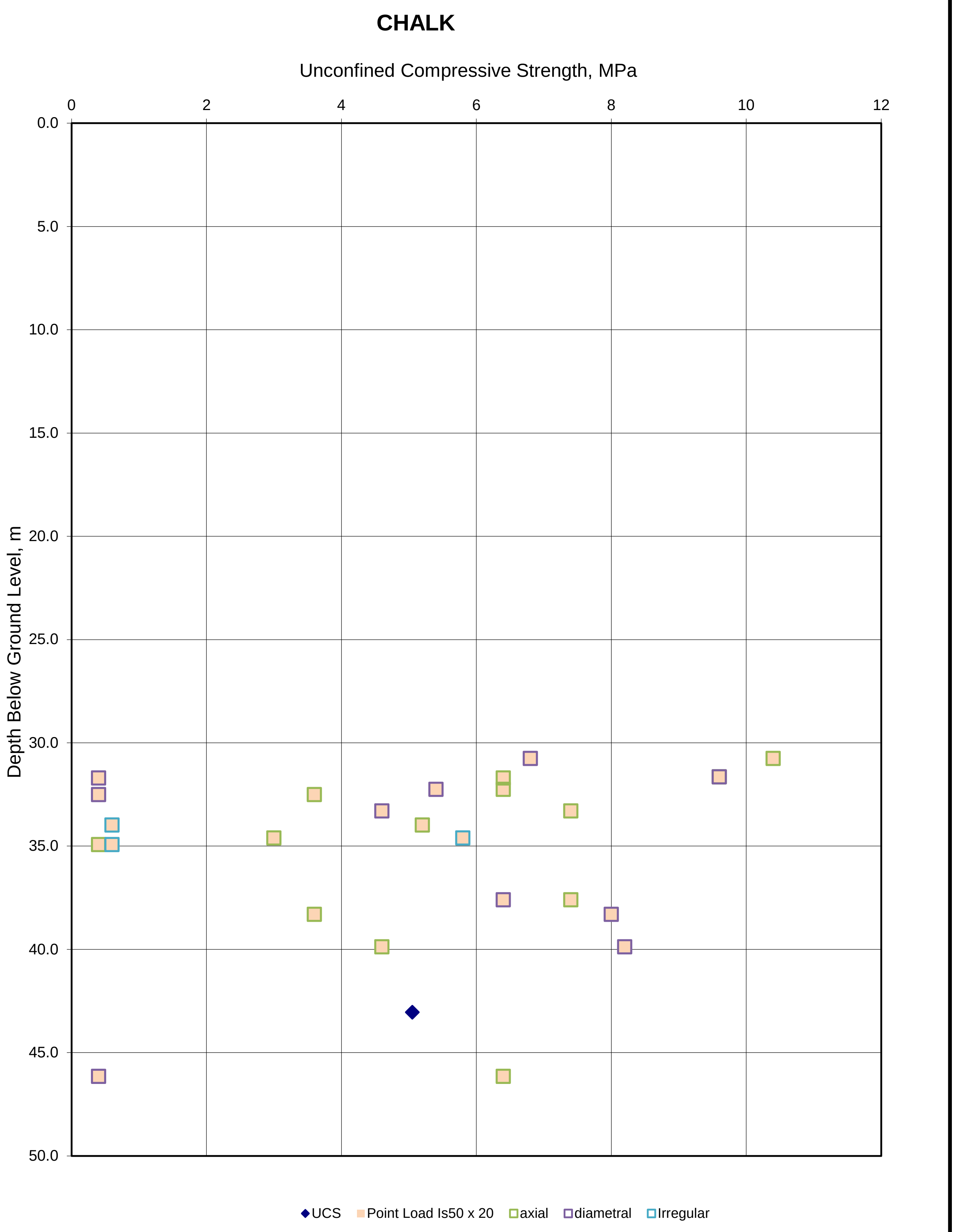


Notes: Values shown as 60 represent tests which were terminated without full penetration (refusal).

Values shown as 0 represent tests which terminated without any blow counts for full penetration (self weight)

Project	**SOUTH HUMBER BANK ENERGY CENTRE**
Project No.	**A9020-19**
Carried out for	**EP UK Investments Ltd.**
Figure	**4**

Unconfined Compressive Strength Depth Profile



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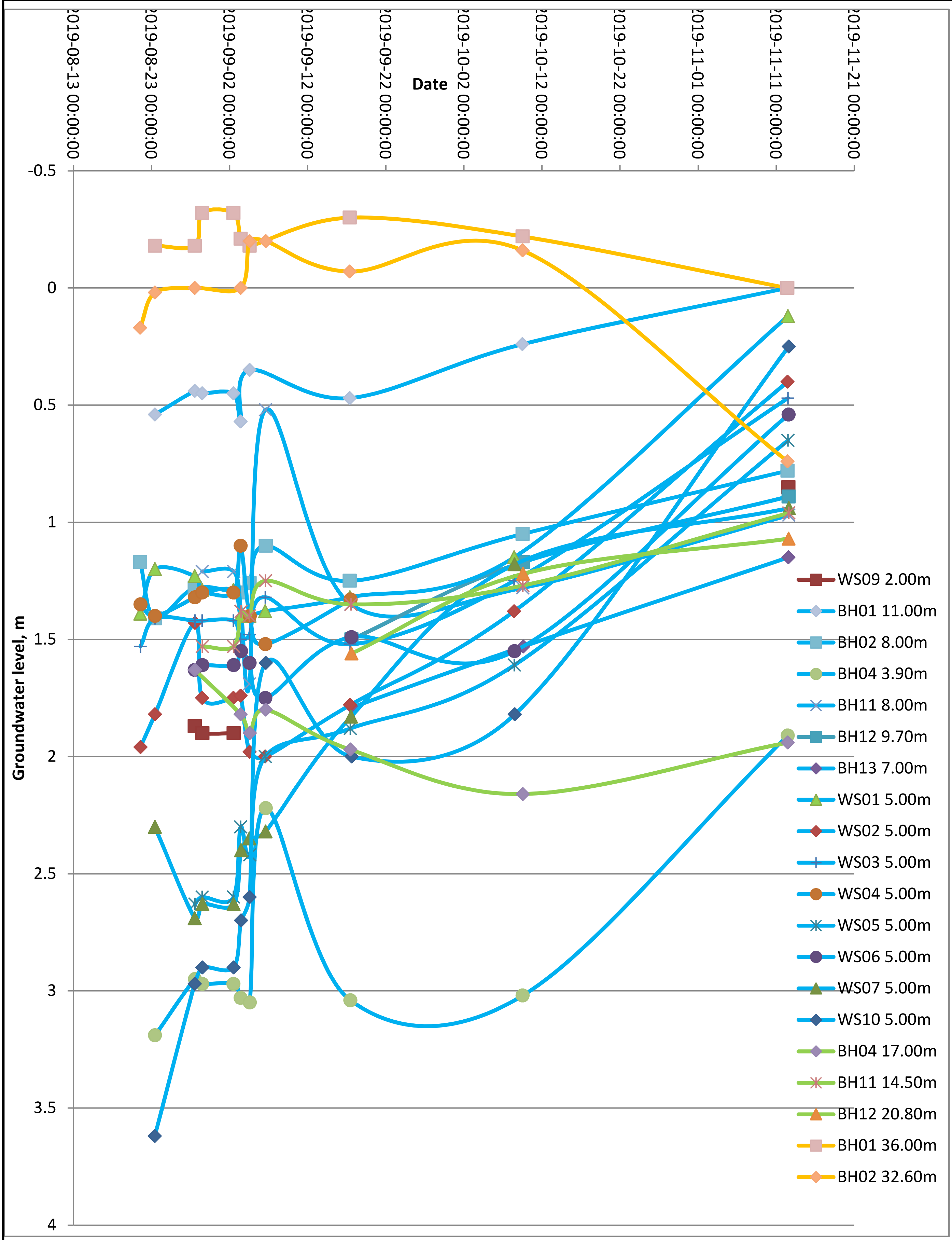
	Project No.	**A9020-19**	**5**
	Carried out for	**EP UK Investments Ltd.**	Sheet 1 of 1

Groundwater Monitoring



Notes: Red line is Made Ground, Blue line is Tidal Flat Deposits, Green line is Glacial Till, Orange line is Chalk	Project	SOUTH HUMBER BANK ENERGY CENTRE	Sheet
	Project No.	A9020-19	6
	Carried out for	EP UK Investments Ltd.	