Wessex Archaeology

Round 3 Hornsea Offshore Windfarm Subzone 1 and Export Cable Route

Stage 1 and 2 Geoarchaeological Assessment

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ROUND 3 HORNSEA OFFSHORE WINDFARM SUBZONE 1 AND EXPORT CABLE ROUTE

Stage 1 and 2
Geoarchaeological Assessment

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HORNSEA ROUND 3 ZONE SUBZONE 1 AND EXPORT CABLE ROUTE

Stage 1 and 2 Geoarchaeological Assessment

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ROUND 3 HORNSEA OFFSHORE WINDFARM SUBZONE 1 AND EXPORT CABLE ROUTE

Stage 1 and 2 Geoarchaeological Assessment

Summary

Geoarchaeological assessment has been undertaken of sediments retrieved during geotechnical investigations on the site of the Round 3 Hornsea Offshore Windfarm and Export Cable Route. This has comprised the offshore monitoring recording of sediments at 12 borehole locations and the assessment of vibrocore logs and onshore recording of 27 vibrocore samples from the Export Cable Route.

The following geological formations were interpreted within the boreholes and vibrocores.

- Upper Cretaceous Chalk Bedrock
- Yarmouth Roads
- Swarte Bank
- Egmond Ground
- Bolders Bank and Lower Botney Cut
- Upper Botney Cut and Holocene Alluvium
- Seabed Sediment

Pleistocene sediments including the Yarmouth Roads, Swarte Bank and Egmond Ground contain glaciolacustrine, glacimarine, fluvial, estuarine and nearshore shallow marine deposits which are thought to have been deposited during the Lower and Middle Palaeolithic archaeological periods. The Bolders Bank and Lower Botney Cut formations comprise predominantly Glacial Till formed during the last Devensian glaciation a period of extreme cold and interpreted as a period of non occupation of this part of NW Europe. The Upper Botney Cut and Holocene alluvial sediments recorded are thought to relate to relate to glacial, lacustrine fluvial and estuarine environments spanning the Late Upper Palaeolithic and Mesolithic archaeological periods.

With regard to Stage 2/3 analysis of the samples from Subzone 1 and the cable route, further work would be of value in elucidating their palaeoenvironmental/geoarchaeological significance and precise dating. The extent of such analysis can be best assessed once a final design has been agreed and the extent of disturbance of the sediments sampled established.

ROUND 3 HORNSEA OFFSHORE WINDFARM SUBZONE 1 AND EXPORT CABLE ROUTE

Stage 1/2
Geoarchaeological Assessment

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Jack Russell and Patrick Dresch carried out the onboard geoarchaeological monitoring of boreholes. Jack Russell undertook the Stage 2 vibrocore recording. The geoarchaeological assessment and compilation of this report was undertaken by Jack Russell. The illustrations were prepared by Kitty Brandon, Karen Nichols and Michael Grant. Paul Baggaley managed the project for Wessex Archaeology.

ROUND 3 HORNSEA OFFSHORE WINDFARM SUBZONE 1 AND EXPORT CABLE ROUTE

Stage 1 and 2 Geoarchaeological Assessment

1 INTRODUCTION

1.1 Background

1.1.1 Wessex Archaeology (WA) was commissioned by RPS Energy (RPS) on behalf of SMart Wind Limited (SW) to undertake geoarchaeological assessment of borehole and vibrocore samples undertaken as part of the Hornsea Offshore Windfarm Subzone 1 (SZ1) and Export Cable Route (ECR) geotechnical investigations. The collection of core samples from 12 borehole locations was archaeologically monitored offshore during October and November 2012. The preliminary vibrocores logs from 129 locations were assessed (Stage 1) and 27 vibrocores chosen for Stage 2 recording which was undertaken onshore during December 2012. The locations of the boreholes and vibrocores in relation to the proposed development can be seen on **Figure 1**. This report comprises a geoarchaeological assessment and summary of the results of the offshore monitoring and recording of borehole and vibrocore samples.

1.1.2 Previous archaeological work for the Hornsea Project has included a technical archaeological report (RPS 2013) and palaeoenvironmental assessment of core samples (Krawiec *et al*. 2011). The locations of the boreholes and vibrocores subject to earlier palaeoenvironmental assessment are shown on **Figures 1** and **2**.

1.2 Aims and objectives

1.2.1 The specific aims and objectives of this investigation as set out in the Method Statement (RPS and WA 2012) are as follows:

- *To inform the Environmental Impact Assessment;*
- *To inform a better and more detailed understanding of the geomorphology and geoarchaeology of the development zone;*
- *If possible, to inform an archaeological deposit model for the Hornsea Zone;*
- *To log the deposition sequence of the sediments, and determine the environment in which this took place;*
- *To evaluate the potential for past human use;*
- *To determine the archaeological importance of the identified deposits;*
- *To generate geoarchaeological data for archaeological assessment;*
- *To identify sub-samples of sequences of archaeological interest that can be considered in decisions about palaeoenvironmental assessment, analysis and scientific dating.*

2 METHODOLOGY

2.1.1 The specific method for onboard geoarchaeological monitoring of geotechnical boreholes is set out in the Method Statement (RPS and WA 2012). A flow chart (provided by Dong Energy) to demonstrate how the archaeological recording and sampling was undertaken within the geotechnical investigation is given in **Appendix 1**. As only one archaeologist was on board the vessel and operations were conducted 24 hours a day, the geotechnical engineers were informed of sediments of geoarchaeological interest and the need to keep these sediments for further archaeological work rather than destructively test them where practicable so that the staged approach to the use of geotechnical data set out in the Method Statement (RPS and WA 2012) and **Appendix 2** could be achieved.. The offshore work enabled the offshore recording of sediments (Stages 1/2) (**Appendix 3**), selection of samples for onshore recording (Stages 1/2) (**Appendix 4**) and potential palaeoenvironmental assessment (Stage 3) and analyses (Stage 4).

2.1.2 The method for the geoarchaeological assessment of the vibrocores also followed the five Stages set out in **Appendix 2**. As the final vibrocore logs were not available, the preliminary onboard vibrocore logs (Fugro Alluvial Offshore Ltd., 2012) were assessed in relation to the known palaeogeograpic features of interest identified by the British Geological Survey (Cook 1991, Brown 1986), the North Sea Palaeolandscapes Project (NSPP) (Gaffney *et al*. 2007, 2009) and the Humber Regional Environmental Characterisation (REC) (Tappin *et al*. 2011). 27 vibrocores (**VC05**, **VC06**, **VC06C**, **VC08**, **VC31**, **VC32A**, **VC34**, **VC72**, **VC77**, **VC78**, **VC79**, **VC80**, **VC81**, **VC82**, **VC83**, **VC84A**, **VC85A**, **VC86**, **VC87A**, **VC88**, **VC90**, **VC91**, **VC92**, **VC93**, **VC96**, **VC104A** and **VC116A**) were chosen for Stage 2 recording and it was agreed by a teleconference call during November 2012 (with SMW, Dong, RPS and Fugro) that these vibrocores be available for Stage 2 geoarchaeological recording at Fugro Ltd, Great Yarmouth. The Stage 2 geoarchaeological recording was undertaken over two days during December 2012. The results of the Stage 2 recording of vibrocores are given in **Appendix 5**. Samples were taken back to WA for potential Stage 3 dating and palaeoenvironmental assessment (**Appendix 6**). These samples are currently in storage at WA.

2.1.3 This staged approach (**Appendix 2**) to the geoarchaeological assessment of offshore geotechnical data conforms to archaeological standards which are set out in English Heritage guidelines regarding environmental archaeology (English Heritage 2002), geoarchaeology (English Heritage 2007) and management of archaeological projects (English Heritage 2006). More specifically this approach has formed the basis of the COWRIE (Collaborative Offshore Wind Research into the Environment) guidance document on the archaeological use of geotechnical data, (Gribble and Leather for EMU 2011). The stages also conform to the Crown Estate guidelines for Written Schemes of Investigation for offshore renewables projects (Wessex Archaeology 2010a).

3 PROJECT BASELINE

3.1 Development Background

3.1.1 The Hornsea Zone proposed development is located 31 and 190km off the Yorkshire coast within water depths predominantly between 30 and 40m with maximum depths of up to 70m (**Figure 1**).

3.1.2 SZ1 is the first development zone within the Hornsea Round 3 Zone to be assessed in detail and is an irregular area approximately 407km^2 in size located approximately 120km

East of Hornsea in East Yorkshire. The proposed ECR extends approximately 140km from the southern edge of SZ1 to landfall at Horseshoe Point on the North Lincolnshire Coast (**Figure 1**).

3.1.3 A phased development programme including the creation of Subzones is being undertaken in order to deliver the project. The geotechnical survey undertaken as part of this project comprised 11 boreholes within the SZ1 area (**Figure 1**) and also included one borehole at the Reactive Station site (**RS-CS**) which is situated along the route of the ECR. A vibrocores survey of 129 locations along the ECR was also undertaken (**Figure 1**).

3.2 Geoarchaeological Background

3.2.1 The following background summarises the geological formations known to exist at the SZ1 and ECR geotechnical survey areas. The age estimates are given related to the established British and Northwest European stage names. Within the Pleistocene epoch these are also supplemented, where known, with the now more prevalent and comparable Marine Isotope Stages (MIS), where odd numbers indicate an interglacial period and even numbers a glacial period. Ages in years within the Pleistocene epoch are expressed in millions of years ago (MA), thousands of years ago (ka) and within the Holocene epoch as years before present (BP).

3.2.2 The British Geological Survey have mapped and described the geological formations in the area (Cook 1991, Brown 1986) and it is with reference to this framework that the sedimentary sequence is discussed. The bedrock geology beneath the area is predominantly Upper Cretaceous Chalk Bedrock. This is overlain by Pleistocene and Holocene deposits which have been interpreted predominantly from seismic surveys undertaken between 1968 and 1981. The formations have been cored in some areas of the North Sea where microfossil analyses and stratigraphic relationships have been used to determine the ages of the formations (Hopson *et al*. 1991).

3.2.3 Overlying Chalk bedrock are two formations which are shown in profile *c*.15km to the south of the SZ1 area (Cook 1991, Brown 1986). These are the Ijmuiden Ground and the Winterton Shoal formations although are too deep to have been penetrated by this geotechnical survey. The Ijmuiden Ground is thought to be pre-delta deposits of sands silts and clays up to 45m in thickness and though to be of Early Pleistocene age (Late Praetiglian to Tiglian; c. 2MA to 1.5MA). Overlying this, the Winterton Shoal formation comprises delta front and nearshore deposits of sands, silts and clays up to 50m in thickness and is also of Early Pleistocene age (Eburonian to Waalian *c*.1.5 to1.4MA).

3.2.4 Overlying these formations the British Geological Survey have interpreted the Yarmouth Roads formation which reaches a maximum thickness of 120m although notably thins in a westerly direction (along the ECR). The formation contains recognisable infilled channel features and comprises fine and medium grained sands with interbedded silts and clays and intercalated shelly sands and reworked peat. The formation ranges in age from Early to Middle Pleistocene (Baventian to Cromerian *c*. 2.3MA to 480ka). The upper part of the Yarmouth Roads formation is thought comprise deltaic sediments and to be the offshore equivalent of the Cromer Forest-bed formation.

3.2.5 The Swarte Bank formation has also been described by the British Geological survey overlying the Yarmouth Roads formation in the SZ1 area. The Swarte Bank formation comprises the infill of sub glacial valley systems originally cut during the Anglian glaciation and infilled during the early part of the Wolstonian period (MIS 10 to 9; *c*.350 to 280ka).

The valleys are up to 100m deep and 4km in width and form an anastomosing complex delineated predominantly from NNE to SSW. The basal sediments comprise gravels, sands and stiff grey diamictons overlain by glaciolacustrine and glaciomarine sands and muds. (**Figure 2**). Organic sediments, probably from the from the Swarte Bank formation were assessed for their pollen content (Krawiec *et al*. 2012) from previous borehole investigations (Fugro Geoconsulting Ltd. 2012a, 2012b) from borehole locations (**HW25A**, **HW34a**, **HW36a**, **HW61**, **HW73** and **NJ5b**) within the SZ1 area. These predominantly contained pine dominated pollen floras.

3.2.6 To the west of SZ1, along the ECR and at the **RS-CS** location, overlying the Chalk Bedrock, the British Geological Survey have interpreted the Egmond Ground Formation (Cook 1991). This formation is up to 16m in thickness and comprises sands and gravels thought to be marine in origin. The formation is thought to be Wolstonian age (MIS 8; *c*. 280 to 250Ka).

3.2.7 Across most of the SZ1 and ECR areas the Bolders Bank formation has been mapped (Cook 1991, Brown 1986). This blanket of glacial till is extensive, overlying earlier Pleistocene formations and outcropping near the seabed surface. The formation comprises stiff red brown gravelly, sandy clays containing erratics including chalk, red-brown sandstone, grey mudstone and other metamorphic and igneous rocks. The formation is similar to the Hunstanton till of East Anglia and the tills of Holderness north of Spurn point. The formation is thought to be of late Devensian age (MIS 2; *c.* 18ka).

3.2.8 Incised into the Bolders Bank formation are scaphiform glacial valleys which are in places infilled with the Botney Cut formation. These valleys are up to 60m in depth and 4km in width. The basal fill of the Botney Cut formation comprises red brown gravelly, sandy clays which are lithologically indistinct from the Bolders Bank formation (Cameron *et al*. 1992). The upper part of the Botney Cut formation comprises laminated sands and clays thought to have formed in glaciolacustrine and occasionally glaciomarine environments. The formation is thought to be of Devensian to possibly Early Holocene age (*c*. 18 to 12ka).

3.2.9 A radiocarbon date obtained from organic sediment within a vibrocore, from **CR12** (at 3.78m) at the western end of the ECR returned a date of 14700±60BP (16490-15650 cal. BC; 18000 to 17760 cal. BP) (Krawiec *et al*. 2012). Pollen was absent from the sediment and it is somewhat enigmatic as the area is thought to have been ice covered at this time (Clark *et al*. 2012).

3.2.10 The Holocene terrestrial (fluvial, estuarine, lacustrine and coastal) environments and the probability that the areas have been inhabited have been inferred from the relatively shallow bathymetry and the finds made by fishermen of terrestrial sediments such as peat, terrestrial mammal bones and prehistoric archaeological finds across the Southern North Sea (e.g. Reid 1913, Godwin and Godwin 1933 and Coles 1998). Many reconstructions of this former “land bridge” have been made largely focussing on postulated former river courses. With the advent of ^{14}C dating combined with geophysical and geological surveys more accurate wide scale reconstructions of Holocene palaeoenvironments have been made (e.g. Jelgersma 1979). The British Geological Survey (Cook 1991, Brown 1986) have mapped a number of the larger features such as the Silver Pit and Sole Pit thought to have formed major features during the early Holocene. Some of these scaphiform valleys are infilled with the Botney Cut formation. More detailed mapping of these terrestrial features using oil industry geophysical data in the area has been undertaken as part of the (NSPP) (Gaffney *et al*. 2007, 2009).

3.2.11 As part of the Humber (REC) survey two vibrocores (suffixed "**REC_**" to avoid confusion) **REC_VC39** and **REC_VC40**) were recovered from a large channel feature (identified in the NSPP) in the west of SZ1 (**Figures 1** and **2**). OSL dating and microfossil analyses of a 1.48m sequence of grey silt within vibrocore suggest that the sediments were formed in estuarine conditions during the early Holocene (*c*.10,500BP to 8000BP) in the west of SZ1 (Tappin *et al*., 2011). This date is equivalent to the early Mesolithic archaeological period.

3.2.12 Radiocarbon dating and pollen analyses (Krawiec *et al*. 2012) were undertaken on vibrocores **CR1A2** and **CR1A8**, located at the western end of the proposed ECR (**Figure 1**). Within vibrocore **CR1A2** some organic sediment from 5.03m below SB submitted for radiocarbon dating returned a date of 11030±50BP (11,140 to 10,800 cal.BC; 13,090 to 12,750 cal. BP). This date is equivalent to the early Holocene geological epoch, MIS 1 and the late Upper Palaeolithic archaeological period. However, the date from this vibrocore is puzzling as the corresponding pollen analyses identified Elm (*Alnus*) which is noted not generally to appear in the British flora until after *c*.7000BP (Bennett and Birks 1990). Within vibrocore **CR1A8** some (unidentified) wood from 5.20m below SB submitted for radiocarbon dating returned a date of 7360±40BP (6350 to 6100cal.BC; 8300 to 8050 cal. BP). This date is equivalent to the Holocene geological epoch, MIS 1 and the Mesolithic archaeological period and fits well with the corresponding hazel (*Corylus avellana*) dominated pollen flora thought to be prevalent at during this period (Bennett 1983, 1986).

3.2.13 Whilst the exact geomorphology of the areas in the early Holocene, particularly the location and elevation of areas higher ground (which may have been subject to subsequent marine erosion) is unknown, it is possible to guess, based on current bathymetry and with reference to known sea level curves (Shennan *et al*. 2000, 2002; Ward *et al*. 2006) when the area would have become submerged for the last time. It is likely that the SZ1 area would have become submerged for the last time by *c*.9000BP and the ECR with a more varied bathymetry, is likely to have been submerged between *c*.11,000 to 7000 BP.

3.2.14 Recent seabed sediments are known across the SZ1 and ECR areas. These comprise sands and gravels and which are generally less that 2m in thickness where they are associated with the Bolders Bank formation (Cook 1991, Brown 1986).

4 RESULTS

4.1.1 The following results section summarises the sediments noted and recorded within the 12 boreholes which were subject to offshore monitoring and the 27 Stage 2 recorded vibrocores. Depths are given in metres below Lowest Astronomical Tide (m below LAT).

4.1.2 The full results of the onboard geoarchaeological monitoring of boreholes are given in **Appendix 3**. It is noted that the contractor's *Final Laboratory and In-Situ Report* for the SZ1 area has not been supplied neither has the onshore Stage 2 geoarchaeological recording been undertaken at this stage. The preliminary report (Fugro Geoconsulting Ltd 2012c) and preliminary field plots (**Appendix 7**) have however been supplied and integrated with the onboard geoarchaeological monitoring and recording (**Appendix 2**) in order to produce these preliminary results summarised below.

4.1.3 The Stage 2 vibrocore recording of 27 vibrocores (**Appendix 5**) has also been integrated with these results. It is noted that the results of the geotechnical logging and photographing of the vibrocores is ongoing and therefore the *Final Laboratory and In-Situ Report* for the vibrocores from the ECR area is also awaited.

4.1.4 On the basis of the onboard geoarchaeological monitoring and the Stage 2 vibrocore recording the following geological formations were identified:

- Chalk
- Yarmouth Roads
- Swarte Bank
- Egmond Ground
- Bolders Bank and Lower Botney Cut
- Upper Botney Cut and Holocene Alluvium
- Seabed Sediment

4.1.5 A deposit model of SZ1 showing these formations (and the boreholes locations at which they occur) is shown as Rockworks fence diagrams on **Figures 3a** and **3b**. Borehole and vibrocore locations related to Sub-bottom profiler data are shown on **Figures 4** to **13**. Where the Stage 2 recorded vibrocores are clustered (around the Silver Pit), selected vibrocores are shown as Rockworks fence diagrams (**Figures 11a** and **11b**).

4.1.6 It is noted that at a number of the 12 borehole locations several attempts at coring were made. These various attempts have not been referred to individually below as the collated sedimentary sequence at each location is largely the same. The borehole locations (not various attempts) are referred to in the main body of this report. The exact number of attempts and locations of the various attempts at each location are given in **Appendix 7**.

Chalk (29.15 to 105.9m below LAT)

4.1.7 This formation was recorded within vibrocores (**VC79**, **VC80**, **VC81**, **VC82**, **VC83**, **VC84A** and **VC87A**) along the ECR and also at the **RS-CS** borehole location (**Figures 10** and **11**). It was not fully penetrated at any location although a thickness of 63.6m of the formation was drilled at the **RS-CS** location. It comprised white chalk, the upper surface of which appeared to have been burrowed in many cases by bivalve molluscs. It is likely that this is part of the Upper Cretaceous Chalk bedrock formation previously recorded within the area (Cameron *et al.* 1992).

Yarmouth Roads: (62.5 to 114.3m below LAT)

4.1.8 This formation was interpreted within the SZ1 area only at borehole locations **AC1a-CS**, **AC1b-CS**, **AC2-CS**, **DC1-CS** and **NJ105-CS** (**Figures 3**, **4**, **5** and **6**). The formation ranged in thickness from 17.3 (at location **AC1a-CS**) to 44m (at location **DC1-CS**) although was not fully penetrated at any location. The formation comprised grey silty, sands and contained frequent molluscs (especially **AC2-CS**) reworked organic material and wood (**AC1a-CS** and **AC2-CS**; **Plate 1a**). The sediments were which are occasionally laminated and interbedded (**AC1a-CS** and **DC1-CS**; **Plate 1b**). The formation is interpreted as being deposited in comprising, fluvial, estuarine and shallow marine environments.

Swarte Bank (43.3m to 109.5m below LAT)

4.1.9 This formation was interpreted at all of the SZ1 borehole locations (**Figures 3**, **4**, **5**, **6** and **7**). The formation comprised predominantly estuarine and shallow marine green and grey silts and sands. These contained molluscan and organic inclusions including wood (**AC1a-CS**, **AC2-CS**, **NJ101-CS**; **Plate 2a**). Within predominantly finer grained glacial sediments some horizontal and varve like (probably seasonally induced) bedding was also noted within predominantly finer grained sediments (**AC1b-CS**, **AC3-CS** and **DC1-CS**; **Plate 2b**). Some minor slickenside structures were also noted within these finer grained glacial sediments indicative of post depositional dessication. The formation is interpreted as

being deposited in a wide range of environments including glacial (glaciolacustrine and glaciomarine) and nearshore, estuarine and shallow marine environments.

Egmond Ground (36m to 42.3m below LAT)

4.1.10 This formation was recorded at one location only, **RS-CS** (**Figure 10a**). The formation comprised yellowish brown slightly silty fine to coarse grained sand and was 6.3m in thickness Horizontally bedded laminar sediments and organic material including wood were recovered towards the base of the formation (**Appendix 3**).

Bolders Bank and Lower Botney Cut (19.94 to 53.8m below LAT)

4.1.11 This formation was recovered at all of the borehole locations and within 11 of the Export Cable Route vibrocores (**VC05**, **VC06**, **VC06C**, **VC08**, **VC32A**, **VC72**, **VC77**, **VC78**, **VC86**, and **VC92; Figures 3** to **13**). It was fully penetrated within the boreholes only where it ranged in thickness from 11m (**RS-CS** and **AC1a-CS**) to 19.05m (**DC1-CS**) in thickness. The formation comprised predominantly stiff reddish brown sandy, gravelly clay. Frequent poorly sorted inclusions of chalk, flint, red sandstone, shale, coal, mudstone and various metamorphic and igneous rocks were recorded (**Plates 3a**, **3b**). Some laminated bedding and structure was noted at the base of the unit which may be indicative of ice marginal deposition prior to the deposition of the overlying unstratified lodgement till. Other variation within the unit included thick and degraded shale content within vibrocore **VC32A** (**Plate 5b**) and a very high chalk content was noted within the formation within vibrocore **VC78** (**Plate 6a**). The formation is interpreted as glacial sediments, predominantly late Devensian glacial till. The surface of the formation was noted to be disturbed and in many cases burrowed by molluscs (**Plate 4a**, **Appendix 3** and **Appendix 5**).

Upper Botney Cut and Holocene Alluvium (42.97 to 52.31m below LAT)

4.1.12 This formation was recorded within the ECR vibrocores **VC85A**, **VC91**, **VC92**, **VC93** and **VC104A**. It was not recorded within any of the SZ1 boreholes. The deposit was not fully penetrated in any of the vibrocores although a 2.52m thickness of the deposit was recorded within vibrocore **VC85A** (**Figures 10a** and **12**; **Plates 7a** and **7b**).The formation comprised generally grey sandy, silty clays with horizontal interbedding, probably indicative of tidally induced deposition (**VC85A**, and **VC91**). Molluscs, organic inclusions and some mottling indicative of water table fluctuations and sub-aerial exposure were also noted within the sediments. The formation is interpreted as belonging to the Upper Botney Cut (Cameron *et al.* 1992) and Holocene alluvial sediments.

Seabed Sediment (19.9m to 61.25m below LAT)

4.1.13 This formation was recorded overlying the Bolders Bank and Botney Cut Formation within SZ1 and also directly overlying Chalk bedrock and the Upper Botney Cut and Holocene Alluvium formations within the ECR vibrocores (**Figures 3** to **13**). It comprised silty, gravelly sand with frequent marine molluscs and ranged from 0.04m (**VC116A**) to 5.90m (**VC96**) in thickness. Occasional large cobbles were encountered. At location **AC2-CS** a large limestone boulder was cored which had some soft coral (dead man's fingers) adhering to its upper surface (**Plate 4b**). The unit was variable across the SZ1and ECR areas and was recorded at the top of every borehole and vibrocore (**Plates 4** to **5**).

5 DISCUSSION AND ARCHAEOLOGICAL POTENTIAL

5.1.1 Based on the onboard monitoring and recording of sediments summarised above the following comments relating specifically to the archaeological and geoarchaeological potential of the formations can be described as follows:

5.1.2 The Chalk bedrock encountered along the ECR is too old to be of archaeological interest. Its surface however marks the extent of palaeogeographic features such as the Silver and Sole Pits which would have formed significant landscape features during the late Upper Palaeolithic and Mesolithic archaeological periods, prior to their submergence. It is also possible that terrestrial sediments such as soils and/or artefactual evidence relating these periods may be present at its surface. No soil formation or artefacts were however noted on the Chalk surface within the Stage 2 recorded ECR vibrocores or at the **RS-CS** location where in general the surface is noted to have been burrowed by marine molluscs.

5.1.3 The Yarmouth Roads formation encountered within the SZ1 boreholes is known to comprise a complex delta-top sequence forming part of the so-called Ur-Frisia delta plain, consisting of sands with pebbles (including chalk), abundant plant debris and peat clasts (Cameron *et al*. 1992). The Yarmouth Roads formation was deposited between 2.3 MA and 480 ka. Although the earliest deposits are of no archaeological interest, the later deposits equate, in part, to the Cromer Forest-bed formation. Palaeolithic archaeological material has been recovered and identified from the Cromer Forest-bed formation for over 100 years (Reid Moir 1927). This early work was largely dismissed until more recent discoveries within the Cromer Forest-bed formation on the North Sea coast at Happisburgh, Norfolk and Pakefiled, Suffolk coupled with scientific dating techniques have proven this earlier than previously believed hominid occupation in NWEurope (Parfitt *et al.* 2005, 2010).

5.1.4 At Happisburgh, on the north Norfolk coast a series of alluvial sediments and associated with a former course of the river Thames have been investigated along a *c.*1km stretch of coastline. The deposits are thought to be either MIS 25 (*c.* 970 ka) or MIS 21 (*c.* 850 ka). The archaeological excavations there have unearthed flint artefacts within gravel layers belonging to the so called Hill House Formation of the Cromer Forest-bed formation (Parfitt *et al.* 2010). On the Suffolk coast at Pakefield, worked flint has been recovered from within the Cromer Forest-bed formation from the former floodplain of the pre-Anglian Bytham river (Parfitt *et al.* 2005). The age of the site is thought to be MIS 17 (*c.* 680 ka) or MIS 19 (*c.* 740 ka). The SZ1 area, whilst containing sediments of similar type and date to the Cromer Forest-bed formation is located in a much more northerly (*c.*80 to 100km further north) location than these archaeological sites. The archaeological site at Waverley Wood in Warwickshire thought to date to *c.*500ka indicates occupation during the Lower Palaeolithic at similar latitudes to the SZ1 area (Keen *et al*. 2006).

5.1.5 The Swarte Bank formation is extensive across the SZ1 area. This formation has been interpreted from geophysical data as infilling an anastomosing complex of palaeochannels (see **Figure 2b**). The sediments within the Swarte Bank formation are varied and it is noted that it is difficult to distinguish some of the coarser sediments those of the Yarmouth Roads formation. The British Geological Survey indicate that the age of the Swarte Bank sediments (which infill valleys thought to have been cut during the Anglian glaciation, MIS12) date from the early part of the Wolstonian period MIS 10 (*c*. 350ka) including the Purfleet interglacial (MIS 9 *c.* 280ka) (Cameron *et al.* 1992). This period of deposition spans the Lower to Middle Palaeolithic archaeological transition and is also a known period of occupation of the British Isles. The Corbets Tey Gravel at Purfleet, Essex comprises fluviatile, shelly deposits of a former course of the river Thames which are known to contain Levallois type flint artefacts which are possibly demonstrative of the

earliest use of this technique in Britain (Bridgland 1999, Wymer 1999). There are a range of palaeoenvironments represented within the Swarte Bank formation recorded within the SZ1 boreholes from glaciolacustrine to fluvial, estuarine, shallow marine and coastal sediments. These types of environment, the probable date of the deposits and the well preserved organic remains noted within the formation indicate the potential for both palaeoenvironmental and potentially archaeological material to be preserved within the sediments.

5.1.6 The Egmond Ground formation, interpreted at the **RS-CS** location, is thought to have been deposited during the Wolstonian period (MIS 8; *c*. 280 to 250ka). A number of archaeological sites dated to MIS 8 and 7 and containing Early Middle Palaeolithic assemblages are located in Suffolk and along the present-day Thames River (White *et al.* 2006). Although no evidence is preserved for human settlement during the cold extremes of the MIS 8 glacial, sites such as Acton, West London (associated with the top of Lynch Hill/Corbets Tey Gravel) and at Northfleet, Kent and West Thurrock, Essex (associated with the base of the Mucking/Taplow Formations) indicate both early and later MIS 8 occupation (White *et al.* 2006). The sediments recorded at the **RS-CS** location contained well preserved organic material indicating the palaeoenvironmental potential of the sediments.

5.1.7 Around 100km to the south of the **RS-CS** location an aggregate extraction area known as Area 240 has yielded a large number of artefacts including 33 hand axes and 100 fragments of faunal remains including woolly mammoth, woolly rhino, bison, reindeer and horse. The handaxes are datable by typology to the Middle Palaeolithic archaeological period (*c*. 300 to 30ka) thus proving the potential for Middle Palaeolithic archaeological remains to occur within sediments of the Southern North Sea (WA 2010b).

5.1.8 Whilst the SZ1 and ECR area and **RS-CS** locations lie within the limits of the MIS 8 glaciation, Marine Isotope records indicate this was on the whole a relatively mild cold stage with sea levels as low as *c.*100m (Pettit and White 2012).

5.1.9 Whilst no geological formations have been mapped/interpreted in the area spanning the period between the deposition of the Egmond Ground (MIS 8 280 to 250ka and the Bolders Bank MIS2 *c.*18ka formations the possibility that discrete outliers and currently unmapped sediments and associated archaeological remains of this date exist in the SZ1 and ECR area is noted.

5.1.10 The Bolders Bank and Lower Botney Cut have been grouped at this stage as they are sedimentologically indistinct. It is noted that within the SZ1 area there are channels interpreted by EMU in 2011 (RPS 2013) as being related to the Botney Cut formation (**Figure 2a**) although these are not apparent within the borehole data and therefore do not show on the borehole fence diagrams (**Figures 3a** and **3b**). These sediments of the Bolders Bank and Lower Botney Cut predominantly comprise glacial till which has been deposited during the last glacial period, the Devensian (MIS2 *c.*18ka) Archaeological material may be found reworked within these sediments however this is a period of absence from Britain and Northwestern Europe at these latitudes. It is noted that some of the undated palaeolandcape features within SZ1 and the ECR (**Figures 1**, **2a** and **14**) identified in the within the REC project (Tappin *et al.* 2011), the NSPP project (Gaffney *et al*. 2007, 2009) and more recently by EMU (RPS 2013) and in the ECR area by Wessex Archaeology (2013) may be part of the Lower Botney Cut formation as described although not mapped in detail by the BGS (Cook 1991, Brown 1986).

5.1.11 The earliest human reoccupation of Britain is thought to have occurred subsequent to this during lowered sea levels by 14,700BP as exemplified by dated human remains in

Gough's Cave, Cheddar, Somerset (Jacobi and Higham 2009). The late Glacial (radiocarbon dated to 11,740+150BP) harpoon point recovered by fishermen from within a lump of trawled peat from the from the Leman and Owers Bank (Godwin and Godwin 1933) *c*.70km south of the SZ1 area indicates pioneer occupation of the Southern North Sea during this period.

5.1.12 Channel features mapped by the NSPP (Gaffney *et al*. 2007, 2009) and dated as part of the Humber REC (Tappin *et al*., 2011) indicate that sediments relating to terrestrial features from the late Upper Palaeolithic and Mesolithic archaeological periods are extant within the SZ1 and ECR areas (**Figure 1**).

5.1.13 No sediments relating to these Holocene features were recorded within any of the boreholes during this investigation in the SZ1 area although two of the borehole locations (**AC3-CS** and **NJ105**) are close to or within features identified within the NSPP data as Holocene fluvial features. Borehole location **AC3-CS** is located close to an east to west delineated fluvial feature identified within the NSPP data (**Figure 1**) and a similarly delineated Botney Cut channel identified by EMU (**Figure 2a**, **Figure 7a**). Borehole location **NJ103-CS** appears to be within the middle of a north to south delineated fluvial feature identified within the NSPP project (**Figure 1**) although interpretation by EMU places the location adjacent to an east to west delineated Botney Cut channel (**Figure 2a**) which can also be seen on the Sub–bottom profiler data (**Figure 6b**).

5.1.14 Along the ECR, vibrocores containing fluvial and estuarine sediments potentially dating to the Holocene period were Stage 2 recorded (**VC85A**, **VC91**, **VC92**, **VC93** and **VC104A**). Some of these correlated with features recorded in the NSPP data (Gaffney *et al*. 2007, 2009) especially adjacent to and on the edge of the Silver Pit (**Figures 1**, **10b** and **11**). More recent interpretation of Sub-bottom profiler data in the ECR area (Wessex Archaeology 2013) shows the location of palaeolandscape features of archaeological potential identified from geophysical data. These were grouped into Late Devensian to Early Holocene, Early Holocene and Holocene periods (**Figure 14**). An interesting dendritic patten of channels (no.s 75028, 75029, 75027, 75032 and 75033) was interpreted in the northeast of the ECR which notably adjoin the Botney Cut channels interpreted by Emu 2011 (**Figure 2a**) within the SZ1 area (Wessex Archaeology 2013). Unfortunately the majority of these palaeolandscape features of potential interest other than the larger Silver Pit (**Figures 1**, **10**, **11** and **14**) and Sole Pit (**Figures 1**, **9** and **14.**) features were not covered by the vibrocore survey. The exceptions are vibrocores **VC28**, **VC56** and **VC74** where relatively small early Holocene channel features (nos. 75026, 75021 and 75014) were interpreted (**Figure 14**) and vibrocore **VC116** which was interpreted as within a late Devensian (Botney Cut) channel feature (no. 75005; **Figures 13** and **14**). Vibrocores **CR1A2** and **CR1A8** previously obtained from the area of the large feature, possibly part of an offshore extension of the river Humber (no.75005), at the western end of the ECR (**Figure 14**) was radiocarbon dated to the Holocene period (Krawiec *et al*. 2011).

5.1.15 A large amount of literature regarding the possibility of Mesolithic occupation in the North Sea has been produced (e.g. Reid 1913, Coles 1998, Flemming 2004 and Waddington 2007). Whilst no finds of this date have been recovered from within the SZ1 and ECR areas the terrestrial environments and features including those grouped as the Upper Botney Cut and Holocene Alluvium formation identified during this study and within the geophysical data (Wessex Archaeology 2013) could contain Mesolithic archaeological remains. The final submergence of SZ1 at *c*.9000BP and for the shallower areas of the ECR by c.7000BP indicate that no terrestrial archaeological remains would be expected in the areas after the Late Mesolithic Archaeological period.

5.1.16 The seabed sediments interpreted across the SZ1 and ECR areas do not offer any potential for palaeoenvironmental work relating to prehistoric archaeological deposits. It is noted however that the large mammal remains and many of the finds that have been retrieved by fishermen from the North Sea will have derived from similar deposits. Robust archaeological material such as bone, flint and in a submerged context, wood can survive within these types of sediments and whilst may they may not be *in situ*, these types of finds are of interest due to their rarity. Within and on top of these seabed sediments is the likely location of more recent maritime archaeological remains, which are not the subject of this report.

6 POTENTIAL FURTHER WORK

6.1.1 The proposals for further analysis set out below are based on the five-stage assessment process set out in Appendix I. The need for any further work needs to be balanced against the degree to which these sediments will be disturbed by the wind farm proposals. For this reason it may be appropriate to wait until a final design has been decided before agreeing the precise scope of additional analysis.

6.1.2 Glacial, fluvial, estuarine and coastal sediments relating to former potentially inhabited landscapes have been identified. Based on current knowledge, these sediments are thought likely to span the last c. 1 million years encompassing the Lower Palaeolithic to Mesolithic archaeological periods. In order to understand the archaeological significance of these sediments more fully, a more robust chronological and palaeoenvironmental framework will be needed.

6.1.3 This focussed chronological and palaeoenvironmental work should however be integrated with the final results and reports of these geotechnical investigations and any further geotechnical and geophysical investigations in the area.

Boreholes

6.1.4 The onshore Stage 2 recording of the requested core samples (**Appendix 4**) would be required to further understand the sequence of deposits within SZ1 and at the **RS-CS** location. On the basis of the work undertaken so far it is considered that selected samples are suitable proceed to Stage 3 palaeoenvironmental assessment and scientific dating, particularly from the Yarmouth Roads, Swarte Bank and Egmond Ground

6.1.5 The sediments are also considered suitable for Stage 3 archaeological works. Given the potential age of some the sediments (*c*. 250 to 900Kya) and what has been recorded within them so far it is recommended that the Amino Acid Racemisation (AAR) and Optically Stimulated Luminescence (OSL) dating are suitable techniques in order to place the sediments within a more robust chronological framework. The samples listed from locations **AC1b** (**AC1b-CS** and **AC1b-CSa**) and **RS-CS** (**RS-CS** and **RS-CSa**) in **Appendix 4** are considered most important required in order to complete this phase of work

6.1.6 A report should be submitted based on the Stage 2 and 3 results. This will state whether any Stage 4 analysis is warranted.

6.1.7 The borehole samples are currently held at Fugro Wallingford where it is recommended they are stored.

Vibrocores

6.1.8 Stage 3 palaeoenvironmental assessment and scientific dating of the vibrocores samples from the cable route will provide important additional information relating to the Upper Botney Cut and Holocene alluvial sediments.

6.1.9 The Stage 3 assessment should comprise in the first instance scientific, radiocarbon (^{14}C) dating of the sediments to better understand their chronology. Microfossil (pollen, diatoms, foraminfera and ostracods) and macrofossil (plants, molluscs, charcoal and insects) assessments are also recommended to gain a better understanding of the palaeoenvironmental and archaeological potential of the sediments.

6.1.10 A report should be submitted based on the results of the Stage 3 assessment. This report will state whether any further work is warranted.

I

7 REFERENCES

Bennett, K.D. 1983. Postglacial population expansion of forest trees in Norfolk, UK. Nature 303, 164-67.

Bennett, K.D. 1986. The rate of spread and population increase of forest trees during the postglacial. Philosophical Transactions of the Royal Society of London, Series B 314, 523-31.

Bennett, K.D., Birks, H.J,B. 1990. Post-glacial history of alder (Alnus glutinosa) in the british isles. Journal of Quaternary Science, 5, 123-133

Bridgland, D. 1999 "The Pleistocene of north-east England" In: D. Bridgland, B. Horton, and J. Innes (Eds) *The Quaternary of North-East England: a field guide* 1-9. Quaternary Research Association London

Brown, M., 1986. Indefatigable Sheet *53˚N - 02˚E* British Geological Survey, 1:250,000 Series, Quaternary Geology, Offshore Geology

Cameron, T.D.J., Crosby, A., Balson, P.S., Jeffery, D.H., Lott, G.K., Bulat, J. and Harrison, D.J., 1992, *The geology of the Southern North Sea*. British Geological Survey, United Kingdom Offshore Report 7, London: HMSO.

Clark, C.D., Hughes, A.L.C., Greenwood, S.L., Jordan, C. and Serjup, H.P. Pattern and Timing of retreat of the last British-Irish Ice Sheet. *Quaternary Science Reviews*. 44. p.112 -146

Coles, B., 1998, Doggerland: a speculative survey, *Proceedings of the Prehistoric Society* 64: 45-81 Boomer, I., Waddington, C., Stevenson, T., and Hamilton, D. 2007 "Holocene coastal change and geoarchaeology at Howick, Northumberland, UK" *The Holocene* 17, 89-104

Cook, J. 1991, *Spurn Sheet 53˚N - 00˚E*, British Geological Survey, 1:250,000 Series, Quaternary Geology, Offshore Geology

English Heritage, 2002. Environmental Archaeology. A guide to the Theory Practice and Methods, from sampling and recovery to post-excavation.

English Heritage, 2006. Management of Research Projects in the Historic Environment

English Heritage, 2007. Geoarchaeology. Using Earth Sciences to understand the archaeological record.

Flemming, N.C., 2004. Submarine Prehistoric Archaeology of the North Sea: Research Priorities and Collaboration with Industry. CBA Research.

Fugro Geoconsulting Ltd. 2012a Factual Report. Laboratory and *in situ* data. Hornsea and Njord Wind Geotechnical Site Investigation. UK Sector North Sea. Report ref: J11082-3

Fugro Geoconsulting Ltd. 2012b Factual Report. Laboratory and *in situ* data. Heron Wind Geotechnical Site Investigation. UK Sector. North Sea. Report ref: J11082-4

Fugro Geoconsulting Ltd. 2012c. Interim factual report. Hornsea Offshore Windfarm. UK Sector. North Sea. Report ref.: J11155-2

Fugro Alluvial Offshore Ltd. 2012. Hornsea Offshore Windfarm. Field Data. Cable Route Survey. Geotechnical Investigation

Gribble, J. and Leather, S. for EMU Ltd. 2011. Offshore Geotechnical Investigations and Historic Environment Analysis: Guidance for the Renewable Energy Sector. Commissioned by COWRIE (project reference GEOARCH-09)

Gaffney, V., Thomson, K. and Fitch, S. (eds), 2007, *Mapping Doggerland: The Mesolithic Landscapes of the Southern North Sea*, Archaeopress, Oxford

Gaffney, V. Fitch, S. Smith, D, 2009, *Europe's Lost World. The rediscovery of Doggerland*. Research Report No 160. Council for British Archaeology

Godwin, H. and Godwin, M.E., 1933. British Maglemose Harpoon sites. *Antinquity*,7: 36-48

Hopson, P.M., Harrison, D.J., and Zalasiewicz, J.A., 1991. East Anglia. Sheet 52˚*N N-00°. Quaternary Geology. 1:250 000 map series. British Geological Survey/ Rijks Geoogische Dienst*

Jacobi, R.M., and Higham, T.F.G., 2009, 'The early Late glacial re-colonisation of Britain: new radiocarbon evidence from Gough's Cave, southwest England.' *Quaternary Science Reviews*. p1-19

Jelgersma, S., 1979, 'Sea-level changes in the North Sea Basin' In Oele, E., Schüttenhelm, R.T.E. and Wiggers, A.J. (eds.). *The Quaternary History of the North Sea.* Acta Univeritatis Upsaliensis: Symposium Universitatis Upsaliensis Annum Quingentesimum Celebrantis 2

Keen, D.H., Hardaker, T., Lang, A.T.O., 2006. A Lower Palaeolithic industry from the Cromerian (MIS 13) Baginton Formation of Waverley Wood and Wood Farm Pits, Bubbenhall, Warwickshire, UK. *Journal of Quaternary Science* 21, 457-4

Krawiec, K., Hopla, E.and Gearey, B.R., 2011. Palaeoenvironmental Assessment of near shore and offshore cores from the Hornsea Zone. Birmingham ArchaeoEnvironmental

Parfitt, S. a, Ashton, N.M., Lewis, S.G., Abel, R.L., Coope, G.R., Field, M.H., Gale, R., Hoare, P.G., Larkin, N.R., Lewis, M.D., Karloukovski, V., Maher, B. a, Peglar, S.M., Preece, R.C., Whittaker, J.E., and Stringer, C.B., 2010. Early Pleistocene human occupation at the edge of the boreal zone in northwest Europe. *Nature*, 466 (7303), 229–33.

Parfitt, S.A, Barendregt, R.W, Breda, M, Candy, I, Collins, M.J, Coope, G.R, Durbidge,P, Field, M.H, Lee, J.R, Lister, A.M, Mutch, R, Penkman, K.E.H, Preece, R.C, Rose, J, Stringer, C.B, Symmons, R, Whittaker, J.E, Wymer J.J. and Stuart, A.J. 2005. The earliest record of human activity in Northern Europe.*Nature*, 438: 1008-1012

Pettitt, P. and White, M.J., 2012. *The British Palaeolithic: Human socieities at the edge of the Pleistocene world*. Abingdon: Routledge

Reid. C., 1913. *Submerged Forests*. Cambridge University Press

Reid Moir, J. 1927. The Antiquity od Man in East Anglia. Cambridge University Press.

RPS and Wessex Archaeology 2012. Hornsea R3 Offshore Windfarm Project 2. Archaeology Method Statement for monitoring offshore Coollection of Geotechnical cores. Prepared by RPS, 21/8/2012

RPS 2013. Hornsea Round 3, Subzone 1: Archaeological Technical Report. Reference Number: 31047

Shennan I., Richard Peltier, W., Drummond, R., and Horton, B. 2002. 'Global to local scale parameters determining relative sea-level changes and the post-glacial isostatic adjustment of Great Britain'. *Quaternary Science Reviews*. 21. 397-408

Shennan, I., Lambeck, K., Flather, R., Horton, B. P., McArthur, J. J., Innes, J. B., Lloyd,J. M., Rutherford, M. M., and Wingfield, R. 2000 "Modelling western North Sea palaeogeographies and tidal changes during the Holocene" In: I. Shennan, and J. Andrews, (Eds) *Holocene land-ocean interaction and environmental change around the North Sea*, 299-319, Geological Society, Special Publications, 166, London

Tappin, D R, Pearce, B, Fitch, S, Dove, D, Geary, B, Hill, J M, Chambers, C, Bates, R, Pinnion, J, Diaz Doce, D, Green, M, Gallyot, J, Georgiou, L, Brutto, D, Marzialetti, S, Hopla, E, Ramsay, E, and Fielding, H., 2011, '*The Humber Regional Environmental Characterisation*'. British Geological Survey Open Report OR/10/54. 357pp

Waddington, Clive (ed.) 2007 Mesolithic Settlement in the North Sea Basin. A case study from Howick, North East England, Oxbow Books

Ward, I., Larcombe, P. and Lillie, M., 2006. The dating of Doggerland – post-glacial geochronology of the southern North Sea. *Environmental Archaeology*, 11, 2, 207-218

Wessex Archaeology, 2010a. Model Clauses for Archaeological Written Schemes of Investigation. Offshore Renewables Projects. Prepared for the Crown Estate. Wessex Archaeology report reference:73340.05

Wessex Archaeology, 2010b. Seabed Prehistory: Site Evaluation Techniques (Area 240): Seabed Sampling. Ref 70752.02

Wessex Archaeology 2013. Hornsea Round 3 Zone. Subzone 1 and Export Cable Route. Archaeological Assessment of Geophysical data. Report ref.: 87152.02

White, M.J., Scott, B., and Ashton, N.M., 2006. The Early Middle Palaeolithic in Britain: archaeology, settlement history and human behaviour. *Journal of Quaternary Science*, 21 (5), 525–541

Wymer, J.J., 1999. *The Lower Palaeolithic Occupation of Britain*. Wessex Archaeology and English Heritage.

8 APPENDIX 1 GEOARCHAEOLOGICAL FRAMEWORK

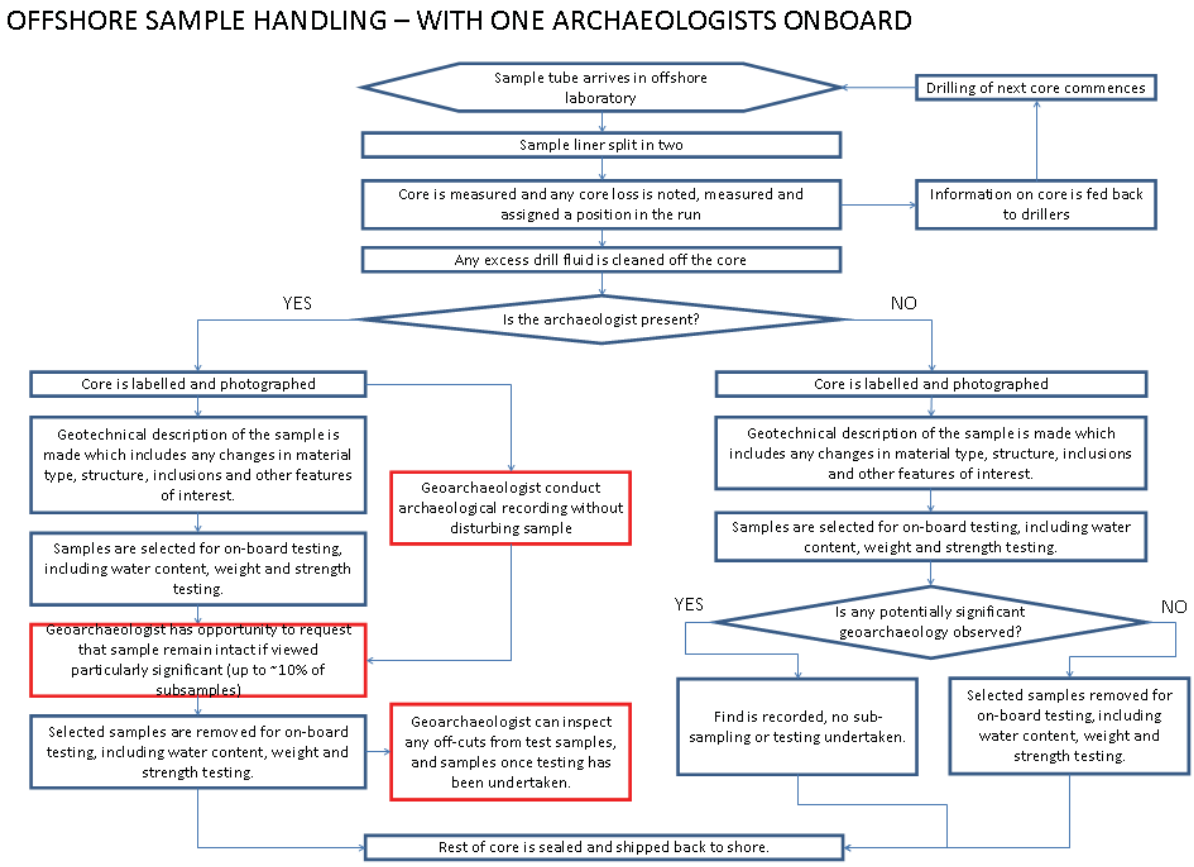
To help frame geoarchaeological investigations of this nature, Wessex Archaeology has developed a five stage approach, encompassing different levels of investigation appropriate to the results obtained, accompanied by formal reporting of the results at the level achieved. The stages are summarised below:

Stage 1: Planning	Archaeological assessment of cores and logs generated by geotechnical contractors. This assessment will establish the presence and location of sediment units with likely archaeological, palaeo-environmental and/or dating potential, as a basis for deciding what Stage 2 archaeological recording is required. The Stage 1 report will state the scale of Stage 2 work proposed. Should no further works be required a brief Stage 1 report outlining the results of the assessment will be prepared.
Stage 2: Core Recording	Each core containing sediment units identified as having archaeological, palaeo-environmental or dating potential in Stage 1 will be split, with half of each core being cleaned and recorded. The stratigraphy of each core will be recorded, a basic sediment description for each of the units will be made and those units of particular archaeological/palaeo-environmental interest will be highlighted. The Stage 2 report will state the nature and scope of any Stage 3 analyses required to characterise and interpret the sediment units in order to build an outline Quaternary deposit model and thus identify areas of potential archaeological significance.
Stage 3: Sub-sampling and Assessment	Sub-sampling and assessment of any units of archaeological and/or palaeo-environmental interest. Sub-samples for the assessment of microfossil environmental indicators (pollen, diatoms, ostracods and/or foraminifera) will be taken from one core-half, with the other core-half retained intact should further sub-sampling be required. Assessment will comprise analysis (identification and quality of preservation) of a series of sub-samples to enable the value of the palaeo-environmental material surviving within the cores to be identified. Sub-samples will also be taken and retained at this stage in case radiocarbon dating is required during Stage 4. Scientific dating may be undertaken at this stage if warranted. The Stage 3 report will set out the results of each laboratory assessment together with an outline of the archaeological implications of the combined results, and will indicate whether and Stage 4 work is warranted.
Stage 4: Analysis and Dating	Full analysis of pollen, diatoms, ostracods and/or foraminifera assessed during Stage 3. Typically, Stage 4 will be supported by scientific dating of suitable sub-samples. Should Stage 3 assessment indicate that there is no further analytical work required on the microfossil assemblages, consideration will still be given for a programme of radiocarbon analyses to provide a chronological framework for the deposits encountered unless no suitable samples could be procured. The Stage 4 report will provide an account of the palaeo-environment(s) at each relevant coring location within a chronological framework (absolute or relative) and an outline of the archaeological implications of the analysis.

Final Reporting	If the archaeological results are sufficiently significant, a final report will be compiled covering all aspects of the palaeo-topography and prehistory of the area affected by the development, incorporating the results of each stage. If the archaeological results are not significant then the relevant Stage Report(s) will constitute the final documents for the investigation. If required, the Final Report will include relevant data generated by the baseline assessment and geophysical (sub-bottom) review, in order to place the results of the core recording and analysis within the context of the broad pattern of deposits within the area. The report will comprise as detailed a Quaternary deposit model for the area as possible, and address the implications of that model in terms of archaeological potential.

8.1.1

9 APPENDIX 2 OFFSHORE ARCHAEOLOGISTS ROLE FLOWCHART



10 APPENDIX 3 OFFSHORE BORHOLE RECORDING

AC1a_CS

Depth mbSB	Core sample	Sediment description	BGS Unit
0 to 15.8		Sediments not geoarchaeologically recorded onboard	
15.8 to 16.1	RC12	Mid brownish grey silty SAND. Possible collapse/downhole disturbance. Occasional shells and small black organic inclusions from 15.8 to 15.9m	SBK
18.3 to 18.8	RC14	Mid greenish grey SAND. Loose, wet. Horizontal laminar bedding of light grey silty sand and dark grey organic layers.	SBK
19.3 to 19.8	RC15	Mid greenish grey slightly silty SAND. Loose. Horizontally bedded layer of high molluscan and organic content at 19.5 to 19.6m below seabed. Frequent molluscs from 19.7 to 19.8m	SBK
23.3 to 23.9	RC19	Mid greenish grey silty SAND. Horizontal interbedded structure of of silty sand, silty clay and darker organic laminae.	SBK
25.2 to 26.3	RC21	Loose mid greenish grey slightly silty SAND. Occasional broken molluscs and darker organic laminae from 25.2 to 25.35m	SBK
28.7 to 29.3	RC24	Wood fragments recovered.	
32.2 to 32.45	RC28	Mid grey silty SAND. Frequent molluscan inclusions and occaional sub angular flint from 20 to 30mm diameter. Fining upwards	SBK
34.7 to 35.2	RC30	Mid greenish grey slightly silty SAND. Includes horizontally bedded layers of molluscan rich sediment and occasional subangular flint. Coarsening upwards.	SBK
36.4 to 37.3	RC32	Mid greenish grey slightly silty SAND. From 36.4 to 36.5, frequent shell inclusions and occasional flint. Coarsening upwards.	SBK
41.4 to 42.05	RC36	Mid greenish grey slightly silt SAND. Wood fragment at 41.6m.	SBK
43.4 to 44.4	RC38	Mid greenish grey slightly silty SAND. Horizontally bedded laminae of grey silty sand and darker organic material	SBK
45.9 to 47.7	RC40	Mid greenish grey slightly clayey silty SAND. Interbedded horizontal laminae of grey silty clay and darker organic matter. Layer of wood, molluscs and organic material from 46.6 to 46.9	SBK
47.4 to 48.65	RC41	Mid greenish grey slightly silty SAND.	SBK

AC1b-CS

Depth mbSB	Core sample	Sediment description	BGS
0 to 0.57	RC01	Dark reddish brown silty SAND. Compact. Frequent pebbles, subrounded to angular of mixed lithologies up to 50mm diameter. Poorly sorted. Abrupt, erosive boundary.	SS
0.57 to 1.5	RC01	Dark reddish brown sandy silty CLAY. Occasional pebbles of mixed litholgy with some horizontal bedding and foliated/platy structure noted.	BB/IBCT
1.5 to 2.35	RC02	Dark reddish brown sandy silty CLAY. Occasional pebbles of mixed lithology with some horizontal bedding and foliated/platy structure noted.	BB/IBCT
2.3 to 3.8	RC03	Dark brownish grey slightly sandy CLAY. Very occasional small pebbles and occasional molluscan fragments. Poorly sorted.	BB/IBCT
3.8 to 5.3	RC04	Dark brownish grey slightly sandy CLAY, as above. Sample disturbed at both ends. Some organic material noted at 4.5 to 4.8m .	BB/IBCT
5.5 to 8.3		Not geoarchaeologically recorded	
8.3 to 9.8	RC08	Dark grey sandy CLAY. Occasional small poorly sorted subangular pebbles comprising predominantly chalk and flint with one belemnite fossil also recorded. Thick laminae of reddish brown clay and sand.	BB/IBCT
		Not geoarchaeologically recorded	
11.3 to 12.65	RC10	Dark grey sandy CLAY. Stiff. Occasional to moderate small (up to 30mm diameter) pebbles comprising predominantly poorly sorted subangular chalk and flint. A band of loose grey silty fine SAND present from 11.85 to 12.3m. Laminae of sand and clay some of which have oxidised at 12.3 to 12.5m.	BB/IBCT
12.65 to 15.8		Not geoarchaeologically recorded	
15.8 to 16.25	RC13	Dark grey silty SAND. Sand is fine grained. Some regularly and tightly spaced *c*. 2mm thick darker and lighter "varve like" bedding especially from 16 to 16.15m.	SBK
16.25 to 81.4		Not geoarchaeologically recorded onboard	

AC2-CS

Depth mbSB	Core sample	Sediment description	BGS Unit
0 to 0.1m	RC01	A 0.1m thick grey limestone boulder was encountered and cored at the seabed surface. Dead mans fingers adhering to it's upper surface. Disturbed sample.	SS
0.1 to 0.15m	RC01	Reddish brown clayey sand adhering to the lower surface of the boulder described above.	BB/IBCT
0.95 to 1.75	RC02	Reddish brown gravelly sandy CLAY. Occasional small pebbles up to 5mm diameter comprising rounded to angular chalk, red sandstone, flint, coal and shale.	BB/IBCT
1.75 to 43.75		Not geoarchaeologically recorded	
43.75 to 45.10	RC31	Grey SAND. Sand is fine to medium grained. Sorted. Fining upwards. Occasional molluscan remains. Disturbed 10mm boundary	SBK
45.1 to 45.15	RC31	Grey CLAY. Bounded by 25mm thick beds of black organic sand.	SBK
45.15 to 45.25	RC31	Grey SAND. Sand is fine grained. Sorted.	SBK
45.25 to 46.75	RC32	Greenish grey SAND. Bands of organic darker material including lignite/wood up to 50mm diameter.	SBK/YM
46.75 to 48.25	RC33	Dark greeish grey SAND. Occasional thin beds of molluscan remains.	YM
48.25 to 49.55	RC34	Dark greenish grey fine SAND. Frequent molluscan remains.	YM
49.75 to 51.25	RC35	Dark greenish grey fine SAND. Frequent molluscan remains including *Cerastoderma edule* and Scrobicularia/Tellina type. Horizontal clayey sand beds from 51m to 51.25 indicative of tidal deposition.	YM
51.25 to 52.75	RC36	Grey SAND. Frequent horizontally interbedded sands/soft grey silty clays and shelly beds including occasional *Mytilus edulis.*	YM
52.75 to 54.25	RC37	Greenish grey SAND. Occasional clay bed fro 52.75 to 53m. Occasional bivalve molluscs and wood (at 54.05m).	YM
54.25 to 55.75	RC38	Greenish grey SAND. Wet. Soft. Occasional hard grey clay horizontally bedded. Occasional broken bivalve molluscs.	YM
55.75 to 57.25	RC39	Greenish grey SAND. Occasional whole bivalve mollusc.	YM
57.25 to 60.25		Not geoarchaeologically recorded	YM
60.25 to 61.65	RC42	Grey SAND. Sorted. From 61.18 to 61.22 horizontally interbedded silty clay. From 61.22 to 61.40 very frequent molluscan remains and moderate wood. From 61.40 to 61.65m very frequent bivalve molluscs.	YM

61.75 to 62.95	RC43	Grey SAND. From 62.05 to 62.25, very frequent (occasionally whole) bivalve molluscs, moderate organic remains and occasional bone (fish vertebra). From 62.45 to 62.85 darker horizontally bedded layers of organic rich sand and clay.	YM
63.25 to 64.75	RC44	Grey sandy CLAY. Sand is fine grained. Horizontally interbedded fine sand layers (possible varves) and pockets of sand up to 5mm diameter. Stiff. From 63.4 to 63.6m some evidence of post depositional frost heave as indicated by a slightly blocky/pellety structure.	YM
64.75 to 80.4m		Not geoarchaeologically recorded.	

AC3-CS

Depth mbSB	Core sample	Sediment description	BGS Unit
0 to 15.8m		Sediments not geoarchaeologically recorded onboard	
15.8 to 16.1	RC12	Mid brownish grey silty SAND. Possible collapse/downhole disturbance. Occasional shells and small black organic inclusions from 15.8 to 15.9m	SBK
18.3 to 18.8	RC14	Mid greenish grey SAND. Loose, wet. Horizontal laminar bedding of light grey silty sand and dark grey organic layers	SBK
19.3 to 19.8	RC15	Mid greenish grey slightly silty SAND. Loose. Horizontally bedded layer of high molluscan and organic content at 19.5 to 19.6m below seabed. Frequent molluscs from 19.7 to 19.8m	SBK
23.3 to 23.9	RC19	Mid greenish grey silty SAND . Horizontal Interbedded structure of silty sand, silty clay and darker organic laminae.	SBK
25.2 to 26.3	RC21	Loose mid greenish grey slightly silty SAND. Occasional broken molluscs and darker organic laminae from 25.2 to 25.35m	SBK
28.7 to 29.3	RC24	Wood fragments recovered.	
32.2 to 32.45	RC28	Mid grey silty SAND. Frequent molluscan inclusions and occasional sub angular flint from 20 to 30mm diameter. Fining upwards	SBK
34.7 to 35.2	RC30	Mid greenish grey slightly silty SAND. Includes horizontally bedded layers of molluscan rich sediment and occasional subangular flint. Coarsening upwards.	SBK
36.4 to 37.3	RC32	Mid greenish grey slightly silty SAND. From 36.4 to 36.5, frequent shell inclusions and occasional flint. Coarsening upwards.	SBK
41.4 to 42.05	RC36	Mid greenish grey slightly silt SAND. Wood fragment at 41.6m.	SBK
43.4 to 44.4	RC38	Mid greenish grey slightly silty SAND. Horizontally bedded laminae of grey silty sand and darker organic material	SBK
45.9 to 47.7	RC40	Mid greenish grey slightly clayey silty SAND. Interbedded horizontal laminae of grey silty clay and darker organic matter. Layer of wood, molluscs and organic material from 46.6 to 46.9	SBK
47.4 to 48.65	RC41	Mid greenish grey slightly silty SAND.	SBK
36.1 to 37.05	RC26	Greyish brown slightly silty sandy CLAY. Horizontal regularly interbedded structure. Rhythmitic possibly tidal deposition.	SBK

37.6 to 39.1	RC27	Grey SAND. Sand is medium grained. Occasional wood up to 40mm diameter. Wet. Frequent broken molluscs up to 3mm diameter, more frequent and larger from 38.6 to 39.1m. Some feintly visible horizontal bedding especially from 37.6 to 37.8m where there are some siltier and darker organic beds/patches. Fining upwards.	SBK
39.1 to 40.25	RC28	Grey SAND. Sand is medium grained. Wet. Frequent broken and whole bivalve molluscs. Some feintly visible horizontal bedding.	SBK
40.60 to 41.5	RC29	Grey SAND. Sand is medium grained. Wet. Very frequent broken and whole bivalve molluscs. Occasional wood/lignite, up to 45mm diameter.	SBK
41.5 to 45.1		Poor sample recovery	SBK
45.1 to 45.85		Grey clayey SAND. Some subvertical bedding with black organic sand, brown clay and grey sand beds. Possible evidence of post depositional slumping convoluted/push morraine complex bedding.	SBK
45.85 to 46.80	RC33	Grey clayey SAND. Mixed horizontal and diagonal bedding as above. Vertically delineated bivalve (*Scrobicularia* type).	SBK
46.8 to 48.3	RC34	Very dark grey CLAY. Occasional pockets of sand.	SBK
48.3 to 49.3	RC35	Grey CLAY. Stiff. Feint horizontal bedding. Occasional fine sand beds up to 5mm in thickness. 50mm diameter brown sandy CLAY at edge of sample. Occasinal very small shell fragments. Some evidence of diagonal bedding at 49m.	SBK
49.8 to 51.3	RC36	Grey sandy CLAY. Stiff. Moderate bivalve molluscs, occasionally whole. Some black possibly organic spots. Becomes slightly browner with more black spots up to 7mm in diameter from 52.5 to 52.8	SBK
51.3 to 52.80	RC37	Grey sandy CLAY. Stiff . Occasional minor slickenside structures from 51.3 to 51.4m. Occasional broken and whole bivalve molluscs.	SBK
52.8 to 54.3	RC38	Grey sandy CLAY. Stiff. Occasinal whole bivalves with both valves still attached and infilled with darker, organic sediment.	SBK
54.3 to 80.4		Not geoarchaeologically monitored	

DC1-CS

Depth mbSB	Core sample	Sediment description	BGS Unit
0.00 to 0.85	RC01	Grey silty clayey SAND. Core loss between 0 and 0.4m Sand is fine, medium, predominantly coarse grained and poorly sorted. Occasional pebbles up to 4mm diameter. 100mm disturbed/burrowed boundary.	SS
0.85 to 1.50	RC01	Reddish brown sandy gravelly CLAY. Stiff. Contains sand pockets which are likelt to be molluscan burrows infilled with the overlying sediment. Gravel is poorly sorted subangular to subrounded chalk, red sandstone and grey sandstone. Feint horizontally bedded structure visible within the sandy clay.	IBCT/BB
1.50 to 3.00	RC02	Reddish brown sandy gravelly CLAY. Stiff. Sand is fine to medium grained within small pockets and bands. One horizontally bedded band of sand at 2.7m. Very sandy from 2.7 to 2.9m. Gravel is subrounded to subangular chalk, sandstone and occasional quartz and shale up to 10mm diameter. From 2.3 to 2.5m a feint laminar/foliated horizontal bedding structure noted - especially towards the core edges.	IBCT/BB
3.00 to 4.50	RC03	Reddish brown sandy gravelly CLAY. Stiff. Sand is fine to medium grained within small pockets and bands. One horizontally bedded band of sand from 3.00 to 3.10m. Gravel is poorly sorted subrounded to subangular chalk, flint, sandstone and occasional quartz and shale up to 24mm diameter. From 3.00 to 3.10m a feint laminar/foliated horizontal bedding structure noted - especially towards the core edges	IBCT/BB
4.50 to 6.00	RC04	Reddish brown sandy gravelly CLAY. Stiff. Sand is fine to medium grained within small pockets and bands. Gravel is poorly sorted subrounded to subangular chalk, flint, sandstone quartz and shale.	IBCT/BB
6.00 to 7.00	RC05	Reddish brown sandy gravelly CLAY. Stiff. Sand is fine to medium grained within small pockets and bands. Gravel is poorly sorted subrounded to subangular chalk, flint, sandstone, quartz and shale	IBCT/BB
7.00 to 8.50	RC06	Reddish brown sandy gravelly CLAY. Stiff. Sand is fine, medium and predominantly coarse grained within small pockets and bands. Gravelly sand bed at 7.50m .Gravel is poorly sorted subrounded to subangular chalk, flint, sandstone, quartz and shale	IBCT/BB
8.50 to 9.40	RC07	Reddish brown sandy gravelly CLAY. Stiff. Sand is fine, medium and coarse grained within small pockets and bands. Gravel is poorly sorted subrounded to subangular chalk with flint, sandstone, quartz and shale also noted.	IBCT/BB

9.40 to 10.9	RC08	Reddish brown sandy gravelly CLAY. Stiff. Sand is fine, medium and coarse grained within small pockets and bands. Gravel is poorly sorted subrounded to subangular chalk with flint, sandstone, quartz and shale also noted. One large quartz veined mudstone cobble.	IBCT/BB
10.90 to 12.40	RC09	Grey silty, gravelly sandy CLAY. Becomes sandier with depth. One 70mm diameter igneous cobble. Some horizontal laminar bedding from 11.55 to 12.4m with sandy layers containg organic remains.	IBCT/BB
12.40 to 13.90	RC10	Reddish brown sandy gravelly CLAY. Stiff. Sand is fine, medium and coarse grained within small pockets and bands of sand.Gravel is poorly sorted subrounded to subangular chalk with flint, sandstone, quartz and shale.	IBCT/BB
13.9 to 15.40	RC11	Not geoarchaeologically recorded onboard	
15.40 to 16.90	RC12	Reddish brown CLAY. Interbedded sand layers. Minor slickenside stuctures and frost shattered sediments at 15.75m. No inclusions.	IBCT/BB
16.9 to 18.4	RC13	Brownish grey sandy CLAY. No inclusions. Horizontally interbedded with sand and minor slickenside structures.	IBCT/BB
18.4 to 19.9	RC14	Brown/grey SAND and CLAY. Horizontally interbedded varve like structures. At 19.55 some small slickenside structures visible.	SWB
19.9 to 21.4	RC15	Brown/grey SAND and CLAY. Horizontally interbedded varve like structure.	SWB
21.4 to 49.00		Not geoarchaeologically recorded onboard	
49.00 to 51.4	RC35	Green SAND. Sand is fine to predominantly medium grained. Very frequent molluscs including Scrobicularia/Tellina type. Hard clay bed at 51m with a valve of *Cerastoderma edule.* Feint laminar silty clay beds. Some darker black organic sand from 51.25 to 51.4m	YM
51.4 to 52.9	RC36	Green SAND. Horizontally bedded organic peaty, molluscs rich sandy layer at 52.8m	YM
52.9 to 54.4	RC37	Green SAND. Occasional organic remains including black wood/twigs up to 50mm in length in beds delineated by a higher organic content at 53.85 and 54.35m. Frequent molluscan remains.	YM
54.4 to 55.9	RC38	Green SAND. Frequent beds of bivalve molluscs and horizontal beds of organic material (2mm thickness). Some rounded peat balls up to 20mm diameter.	YM
55.9 to 57.4	RC39	Greenish grey SAND. Wet. Sand is fine to medium grained. Small horizontal beds, up to 8mm in thickness of organic remains at 56.25 and 57m.	YM
57.4 to 58.9	RC40	Green SAND. Sand is fine to medium grained. Wet. Frequent organic bands from 57.6 to 58.1m.	YM
58.9 to 60.4	RC41	Green SAND. Sand is fine to medium grained. Wet. Frequent organic bands from 57.6 to 58.1m.	YM
60.4 to 61.9	RC42	Green SAND. Sand is fine to medium grained. Wet. Frequent organic bands at 59m.	YM

61.9 to 63.4	RC43	Green SAND. Sand is fine to medium grained. Occasional small grey clay patches and mollusc burrows from 61.9 to 70.2. Organic bands at 63.2m.	YM
63.4 to 64.9	RC44	Green SAND. Sand is fine to medium grained. Frequent molluscs in layers predominantly bivalves (Including Scrobicularia/Tellina type and *Cerastoderma edule*), with occasional gastropods. Organics bands at 64.15 and some cemented sand.	YM
64.9 to 66.4	RC45	Grey SAND with horizontally interbedded sandy clay laminations (possibly tidally induced), thinly spaced. Molluscs frequent from 64.9 to 65.4m .	YM
66.4 to 67.9	RC46	Grey SAND with horizontally interbedded sandy clay laminations (possibly tidally induced), thinly spaced, 2 to 4mm in thickness.	YM
67.9 to 69.4	RC47	Not geoarchaeologically recorded onboard	YM
69.4 to 70.90	RC48	Grey SAND with horizontally interbedded sandy clay laminations (possibly tidally induced), thinly spaced. Occasional bivalve molluscs and beds containing organic remains.	YM
70.9 to 72.4	RC49	Not geoarchaeologically recorded onboard	YM
72.4 to 73.4	RC50	Grey SAND. Sand is fine to medium grained. Occasional bivalve molluscs and grey clay patches up to 10mm diameter.	YM
73.9 to 74.5	RC51	Grey SAND. Well sorted. Intrusive clay smeared on edges of core. Occasional thin 4mm thick horizontally bedded organic layers.	YM
74.5 to 80.1	RC52	Not geoarchaeologically recorded onboard	

NJ101-CS

Depth mbSB	Core sample	Sediment description	BGS Unit
0 to 0.95	RC01	Poor recovery. Some brown silty sand and small to medium sized pebbles including flint, limestone and basalt. One worn *Buccinum undatum* mollusc.	SS
0.95 to 1.50	RC02	No recovery	SS
1.50 to 1.75	RC02	Reddish brown sandy gravelly CLAY. Stiff. No structure. Gravel includes poorly sorted rounded to subangular chalk, red sandstone up to 45mm in diameter.	BB
1.75 to 7.75		Not geoarchaeologically recorded onboard.	
7.75 to 9.25	RC07	Reddish brown sandy gravelly CLAY. Stiff. No structure. Gravel includes poorly sorted rounded to subangular chalk, red sandstone up to 10mm in diameter.	BB
9.25 to 10.75	RC08	Reddish brown sandy gravelly CLAY. Stiff. No structure. Gravel includes poorly sorted subangular chalk and red sandstone up to 5mm in diameter.	BB
10.75 to 15.25		Not geoarchaeologically recorded onboard.	
15.25 to 16.75	RC13	Reddish brown sandy gravelly CLAY. Stiff. No structure. Gravel includes poorly sorted subangular chalk and red sandstone up to 5mm in diameter. At 16.05m some horizontally bedded clay and sand with occasional organics noted.	BB
16.75 to 18.25	RC14	Brown gravelly sandy CLAY. Gravel is chalk and sandstone. At 17.15m a 100mm thick bed of grey silt and feint horizontal laminar bedding. Sandy pocket at 17.75m. Silty fine sand at 18.25m	BB
18.25 to 19.75	RC15	Brown gravelly sandy CLAY. Gravel is chalk, flint and sandstone up to 5mm diameter. The tip of a belemnite was also noted. From 19.05 to 19.75 horizontally interbedded sand and clay layers up to 4mm in thickness. Bedding becomes wavy from 19.5 to 19.75m	BB
19.75 to 21.05	RC16	Beige SAND. Stiff. Interbedded with brown clay layers which are generally horizontal, occasionally diagonal, usually 2 to 10mm in thickness. The bedding is occasionally fractured with occasional small slickensides. From 20.45 to 21.05m brown stiff CLAY with finely bedded horizontal laminations and a slightly blocky structure around 21.00m	SWB
21.25 to 22.75	RC17	Brown stiff slightly sandy CLAY. Occasional small chalk up to 1mm diameter becoming more frequent from 22 to 22.75m	SWB
22.75 to 46.75		Not geoarchaeologically recorded onboard.	

46.75 to 48.25	RC34	Grey SAND with beds of frequent mollusc and gravelly sand at 46.85 to 46.95m and 47.10 to 47.20m. Occasional wood up to 80mm in length and gravel up to 40mm diameter. Some silty clay beds which are noteably wet from 47.5m onwards	SWB
48.25 to 49.75	RC35	Grey SAND with horizontally bedded layers of clay.	SWB
49.75 to 51.25	RC36	Grey SAND with occasional horizontally bedded layers of clay.	SWB

NJ102-CS

Depth mbSB	Core sample	Sediment description	BGS Unit
0 to 0.4m	RC01	Brown silty, gravelly SAND.	SS
0.4 to 1.5	RC01	Mid greyish brown sandy CLAY. Stiff. Gravel is subrounded to subangular chalk, flint and red sandstone. Poorly sorted	BB
1.5 to 15.7		Not geoarchaeologically recorded onboard.	
15.7 to 17.2	RC12	Brown silty SAND. Moderate broken molluscs and small subangular flint pebbles.	SBK
17.2 to 18.7	RC13	Brown silty SAND. Moderate broken molluscs and small subangular flint pebbles. Horizontally bedded grey silty bsand bands.	SBK
18.7 to 20.1	RC14	Mid greenish grey slightly silty CLAY. Feintly visible laminar horizontal bedding delineated by slightly darker possibly organic layers.	SBK
20.2 to 23.2		Not geoarchaeologically recorded onboard.	
23.2 to 24.7	RC17	Mid greenish grey slightly silty SAND. Horizontally bedded organic layers and occasional wood fragments from 23.8 to 24m.	SBK
24.7 to 26.2	RC18	Mid brownish grey very silty SAND. Moderate molluscan inclusions, frequent between 25.8 and 26.2m.	SBK
26.2 to 32.2		Not geoarchaeologically recorded onboard.	
32.2 to 33.55	RC23	Mid greenish grey silty CLAY	SBK
33.55 to 35.2		Not geoarchaeologically recorded onboard.	
35.2 to 36.7	RC25	Mid greenish grey silty CLAY. Some horizontally bedded laminations including beds of organic material at 36.1m	SBK
41.2 to 42.7	RC29	Mid greenish grey silty CLAY. Some horizontally bedded laminations including beds of molluscan and organic material	SBK

NJ103-CS

Depth mbSB	Core sample	Sediment description	BGS Unit
0 to 0.25	RC01	Brown SAND and CLAY. Disturbed	SS
0.25 to 0.9	RC01	Brown sandy gravelly CLAY. Gravel is small up to 5mm subrounded to subangular including chalk and red sandstone	BB
0.9 to 19.3		Not geoarchaeologically recorded onboard	
19.3 to 20.8	RC15	Mid brownish grey slightly silty SAND. Freqquent molluscan remains between 22.8 and 23.3m	SWB
20.8 to 25.3		Not geoarchaeologically recorded onboard	
25.3 to 26.8	RC19	Mid greenish grey slightly silty SAND. Horizontally bedded including darker organic layers at 25.65m	SWB
26.8 to 28.3	RC20	Mid greenish grey slightly silty SAND. Horizontally bedded including darker organic layers at 27.95 to 28.10m	SWB

NJ104-CS

Depth mbSB	Core sample	Sediment description	BGS Unit
0 to 1.5		Sample redrilled and disturbed	
1.5 to 2.1	RC02	Sample disturbed due to redrill with greyish brown gravelly sand overlying. Mid greyish brown gravelly sandy CLAY. Gravel is poorly sorted small subangular including chalk and red sandstone.	SS/BB
2.1 to 5.1		Not geoarchaeologically recorded onboard	
5.1 to 6.6	RC05	Brown silty CLAY. Horizontally bedded laminations of clay and silty sand from 5.75 to 6.2m	BB
6.6 to 9.6		Not geoarchaeologically recorded onboard	
9.6 to 11.1	RC08	Grey/red sandy CLAY. Stiff	BB
11.1 to 12.6	RC09	Sandy CLAY. Includes possible organic laminae at 12.25m	
12.6 to 17.1		Not geoarchaeologically recorded onboard	
17.1 to 18.0	RC13	Greenish grey silty CLAY. Horizontally bedded darker organic and grey silty clay laminae. Occasional molluscan inclusions.	SWB
18.6 to 18.95	RC14	Grey/Brown silty SAND. Horizontally interbedded laminar structure.	SWB
18.95 to 22.1		Not geoarchaeologically recorded onboard	SWB
22.1 to 22.4	RC17	Reddish brown sandy CLAY. Horizontally bedded darker organic laminae from 22.1 to 22.2m	SWB

22.4 to 25.1		Poor sample recovery	SWB
25.1 to 25.45	RC20	Greenish grey silty SAND. Occasional wood fragments from 25.1 to 25.2m	SWB
26.1 to 26.9	RC21	Greenish grey silty SAND. Occasional molluscs. Horizontally bedded laminar structure from 26.45 to 26.55m	SWB
27.1 to 28.1	RC22	Greenish grey silty SAND. Occasional molluscs, more frequent at 27.1m.	SWB
28.1 to 29.1	RC23	Greenish grey silty SAND. Molluscs frequent between 28.25 and 28.35m.	SWB
29.1 to 30.6	RC24	Greenish grey silty SAND. Molluscs frequent between 30.45 and 30.6m.	SWB
		Not geoarchaeologically recorded onboard	
38.1 to 39.6	RC30	Greenish grey silty SAND. Horizontally bedded laminar structure with organic layers at 39.2m	SWB
39.6 to 41.1		Not geoarchaeologically recorded onboard	
41.1 to 42.6	RC32	Greenish grey silty SAND. Horizontally bedded laminar structure with organic layers at 42.45m	SWB

NJ105-CS

Depth mbSB	Core sample	Sediment description	BGS Unit
0 to 0.4	RC01	Brown gravelly SAND. Frequent broken and whole molluscs. Gravel includes small to medium (up to 35mm diameter) subrounded to subangular flint. Occasional black organic patches. Wet. Soft. 100mm burrowed/disturbed boundary.	SS
0.4 to 1.00	RC01	Reddish brown sandy gravelly CLAY. Contains large , 40mm diameter vertical molluscan burrows infilled with overlying sediment and molluscs from 0.4 to 0.6m. From 0.6m onwards some feint horizontal laminar bedding visible. Gravel is small poorly sorted rounded to angular including chalk, sandstone and metamorphic rocks.	IBCT/BB
1.5 to 2.15	RC02	Reddish brown slightly sandy gravelly CLAY. Wet. Stiff. Horizontal closely spaced foliated bedding. Gravel comprises small poorly sorted rounded to angular chalk, flint, metamorphic and igneous rocks. 10mm thick medium to coarse grained sand bed at 2.15m including small medium to coarse grained sand sized particles of chalk.	IBCT/BB
3.00 to 4.00	RC03	Reddish brown slightly sandy gravelly CLAY. Wet. Stiff. Horizontal foliated bedding visible. Gravel comprises small poorly sorted rounded to angular chalk, flint, metamorphic and igneous rocks up to 25mm diameter.	BB
4.5 to 6.00	RC04	Reddish brown slightly sandy gravelly CLAY. Wet. Stiff. Horizontal foliated bedding visible. Gravel comprises small poorly sorted rounded to angular chalk, flint, metamorphic and igneous rocks up to 25mm diameter.	IBCT/BB

6.00 to 7.20	RC05	Reddish brown slightly sandy gravelly CLAY. Wet. Stiff. . Gravel comprises small poorly sorted rounded to angular chalk, flint, metamorphic and igneous rocks up to 25mm diameter.	IBCT/BB
7.5 to 9.00	RC06	Reddish brown slightly sandy gravelly CLAY. Wet. Stiff. . Gravel comprises small poorly sorted rounded to angular chalk, flint, metamorphic and igneous rocks up to 25mm diameter.	IBCT/BB
9.00 to 10.4	RC07	Reddish brown slightly sandy gravelly CLAY. Wet. Stiff. Gravel comprises small poorly sorted rounded to angular chalk, flint, metamorphic and igneous rocks up to 40mm diameter. Occasional 10mm thick beds of silty sand. From 10.2 to 10.4 sand increases with moderate broken molluscan remains. Darker grey/brown silty sand bed from 10.31 to 10.34m Fining upwards.	IBCT/BB

NJ105-CSa

Depth mbSB	Core sample	Sediment description	BGS Unit
14.5 to 15.4	RC01	Dark grey silty SAND. Sand is medium and predominantly fine grained. Sorted. Becomes sandier and contains thin laminae of organic matter from around 15.04 to 15.4m	BB/SWB
15.5 to 16.7	RC02	Dark grey silty SAND. Some yellowish brown patches. Sand is fine, medium and coarse grained. Frequent broken molluscs within an coarser sand bed from 16.3 to 16.7m.	SWB
16.7 to 18.05	RC03	Dark greenish brown silty SAND. Sand medium and predominantly fine grained. Sorted. Horizontally bedded laminae of organic material from 17.94 to 18.06m.Moderate molluscan inclusions	SWB
18.05 to 27.2		Not geoarchaeologically recorded onboard	
27.2 to 28.7	RC10	Dark grey silty SAND. Sand is medium and predominantly fine grained. Sorted. Horizontally bedded laminae of organic material and clay from 27.56 to 27.66	SWB
28.7 to 30.2	RC11	Dark grey silty sandy CLAY. Frequent organic material between 28.7 to 28.8m.	SWB
30.2 to 33.2		Not geoarchaeologically recorded onboard	
33.2 to 34.7	RC14	Grey SAND. Sand is predominantly fine grained. Well sorted. Pockets of organic material between 34.3 to 34.7m.	YM
34.7 to 40.7		Not geoarchaeologically recorded onboard	
40.7 to 42.2	RC19	Dark grey slightly silty SAND. Sand is predominantly fine grained. Well sorted	YM
42.2 to 46.7		Not geoarchaeologically recorded onboard	

46.7 to 48.2	RC23	Grey slightly silty SAND. Sand is predominantly fine grained. Well sorted. Occasional molluscan inclusions at 48.0m	YM
48.2 to 49.6	RC24	Dark grey slightly silty SAND. Sand is predominantly fine grained. Well sorted. Contains horizontally bedded silty laminations throughout	YM
49.7 to 50.2	RC25	Grey silty SAND. Sand is predominantly fine grained. Well sorted. Occasional horizontally bedded laminar structure and molluscan remains especially between 49.7 to 49.9m	YM

NJ106-CS

Depth mbSB	Core sample	Sediment description	BGS Unit
0.00 to 5.5		Poor sample recovery at these levels/not geoarchaeologically recorded	
5.5 to 7.0	RC05	Reddish brown slightly sandy gravelly CLAY. Gravel is poorly sorted and of mixed lithologies including chalk and flint	BB
7.0 to 19.0		Poor sample recovery/not geoarchaeologically recorded	
19.0 to 20.3	RC14	Yellowish grey SAND. Occasional small gravel including chalk and flint. Moderate molluscan inclusions, more frequent from 19.55 to 19.85m.	SWB
20.3 to 21.8		Not geoarchaeologically recorded	
21.8 to 23.3	RC16	Brownish/greenish grey silty CLAY. Horizontally interbedded with clay and silty clay laminations. Stiff.	SWB
23.3 to 24.8	RC17	Greenish grey CLAY. Horizontally interbedded with laminations of light grey silty CLAY.	SWB
24.8 to 36.7		Not geoarchaeologically recorded	
36.7 to 38.15	RC26	Dark greenish grey silty SAND. Sand is fine to medium and occasionally coarse grained. Sorted. Occasional molluscs and small organics possibly charcoal especially between 37.8 and 38m.	SWB
38.2 to 39.7	RC27	Greenish grey silty SAND. Occasional to moderate small gravel inclusions including broken molluscs. Sand is fine to medium and occasionally coarse grained. Sorted. Some flecks of black possibly organic material.	SWB
39.7 to 41.2	RC28	Dark grey silty SAND. Sand is fine to medium and occasionally coarse grained. Sorted. Occasional to moderate bivalve molluscs.	SWB
412 to 42.7	RC29	Greenish grey silty CLAY. Moderate bivalve molluscs. Horizontal bed of light grey sand 50mm in thickness at 41.3m.	SWB
42.7 to 44.55	RC30	Greenish grey silty SAND. Predominnatly horizontally bedded laminar and lenticular/ slightly wavy bedding including lighter grey sands thickness and from 43.4 to 43.6m and with organic peaty silt beds at 43.85 to 44.05m	SWB
44.2 to 45.7	RC31	Greenish grey silty SAND. Horizontally bedded laminations including organic/peaty layers especially from 45.4 to 45.55m	SWB

RS-CS

Depth mbSB	Core sample	Sediment description	BGS Unit
0.0 to 0.9	RC01	Poor sample recovery	
0.9 to 1.8	RC02	Reddish brown sandy gravelly CLAY. Stiff. Gravel is poorly sorted including subrounded to subangular red sandstone, grey mudstone and coal up to 5mm diameter.	BB
1.8 to 3.3	RC03	Reddish brown sandy gravelly CLAY. Stiff. Gravel is frequent poorly sorted including rounded to subangular chalk, red sandstone, grey mudstone and coal up to 15mm diameter.	BB
3.3 to 4.8	RC04	Reddish brown sandy gravelly CLAY. Stiff. Gravel is frequent poorly sorted including rounded to subangular chalk, red sandstone, grey mudstone, micrite and coal up to 20mm diameter. One subangular 100mm diameter grey conglomerate cobble.	BB
4.8 to 6.3	RC05	Reddish brown slightly silty sandy gravelly CLAY.Stiff. Gravel is frequent poorly sorted including rounded to subangular chalk, red sandstone, grey mudstone and coal up to 15mm diameter.	BB
6.3 to 12.3		Not geoarchaeologically recorded.	
12.3 to 18.45		Recorded predominantly from bagged sediments: Yellowish brown silty SAND with laminar beds of darker organic remains and silt beds (12.3 to 15.3, 18.3 to 18.45m). Wood remains at 17.45m.	EG

RS-CSa

Depth mbSB	Core sample	Sediment description	BGS Unit
0.00 to 0.4	RC01	Beige/brown gravelly SAND. Gravel is poorly sorted broken molluscs *Buccinum* sp., occasionally whole including and subrounded to subangular pebbles up to 60mm diameter. Sand is medium to very coarse grained comprising a high proportion of broken molluscs. Disturbed and burrowed boundary	SS
0.4 to 1.1	RC01	Reddish brown sandy gravelly CLAY. From 0.4 to 0.7m, heavily burrowed. Stiff. Gravel is poorly sorted including subrounded to subangular red sandtone, grey mudstone and coal up to 5mm diameter.	BB

Key to BGS units abbreviations:

Chalk (UCk)
Yarmouth Roads (YR)
Swarte Bank (SWB)
Egmond Ground (EG)

Bolders Bank and Lower Botney Cut (BB/lBCT)
Upper Botney Cut and Holocene Alluvium (uBCT/HA)
Seabed Sediment (SS)

11 APPENDIX 4 BOREHOLE SAMPLES TAKEN FOR STAGE 2 AND 3 WORK

Borehole Number	Sample	Depth from (m)	Sample Type	Sample Length (cm)
AC1a-CS	12BagA	15.80	Bag	10
AC1a-CS	14WaxA	18.30	Wax	5
AC1a-CS	14BagB	18.70	Bag	10
AC1a-CS	15BagB	19.50	Bag	10
AC1a-CS	15BagD	19.70	Bag	10
AC1a-CS	19WaxA	23.30	Wax	15
AC1a-CS	21BagA	25.20	Bag	15
AC1a-CS	24BagA	28.70	Bag	20
AC1a-CS	24WaxA	28.90	Wax	10
AC1a-CS	28BagB	32.30	Bag	5
AC1a-CS	28WaxA	32.35	Wax	10
AC1a-CS	30BagC	35.15	Bag	5
AC1a-CS	32BagA	36.40	Bag	10
AC1a-CS	36WaxA	41.50	Wax	25
AC1a-CS	38BagC	44.10	Bag	10
AC1a-CS	40WaxC	46.50	Wax	10
AC1a-CS	40BagB	46.60	Bag	30
AC1a-CS	41WaxB	48.35	Wax	15
AC1a-CS	45WaxA	53.50	Wax	20
AC1a-CS	63WaxA	76.55	Wax	20
AC1a-CS	65BagB	79.70	Bag	10
AC1b-CS	4WaxA	4.10	Wax	25
AC1b-CS	8WaxB	8.70	Wax	30
AC1b-CS	8BagC	9.40	Bag	20
AC1b-CS	10WaxB	12.30	Wax	20
AC1b-CS	13BagB	16.05	Bag	20
AC1b-CS	14BagC	17.90	Bag	10
AC1b-CS	15WaxA	18.55	Wax	15
AC1b-CS	17WaxA	20.93	Wax	4
AC1b-CSa	6BagC	26.65	Bag	5
AC1b-CSa	17BagC	39.25	Bag	25
AC1b-CSa	21BagA	44.30	Bag	10
AC1b-CSa	21BagC	44.65	Bag	5
AC1b-CSa	22BagD	46.65	Bag	10
AC1b-CSa	22WaxA	46.15	Wax	25
AC1b-CSa	23WaxA	47.45	Wax	20
AC1b-CSa	23BagB	47.65	Bag	30
AC1b-CSa	25WaxA	50.50	Wax	10
AC1b-CSa	25BagB	50.60	Bag	20
AC1b-CSa	34BagC	61.25	Bag	30
AC1b-CSa	35WaxA	62.25	Wax	25
AC1b-CSa	39BagB	66.90	Bag	15
AC1b-CSa	40BagB	67.85	Bag	8
AC1b-CSa	49WaxA	80.10	Wax	20
AC1b-CSa	49BagB	80.30	Bag	20
AC2-CS	17BagC	23.05	Bag	25

AC2-CS	31BagC	45.1	Bag	5
AC2-CS	32BagC	46.6	Bag	15
AC2-CS	36BagB	52.1	Bag	5
AC2-CS	36BagC	52.15	Bag	20
AC2-CS	42BagB	61.15	Bag	5
AC2-CS	42BagC	61.2	Bag	15
AC2-CS	43BagB	62.05	Bag	20
AC2-CS	43BagD	62.45	Bag	5
AC2-CS	43BagF	62.7	Bag	15
AC3-CS	14BagC	19	Bag	5
AC3-CS	15BagC	19.95	Bag	5
AC3-CS	15WaxA	20.1	Wax	30
AC3-CS	16WaxA	21.85	Wax	25
AC3-CS	18WaxA	24.75	Wax	25
AC3-CS	20WaxA	27.1	Wax	30
AC3-CS	20BagA	27.7	Bag	10
AC3-CS	26WaxB	36.45	Wax	20
DC1_CS	9BagB	11.50	Bag	5
DC1_CS	14BagB	19.25	Wax	20
DC1_CS	22BagA	30.40	Bag	25
DC1_CS	28BagC	40.2	Bag	5
DC1_CS	35BagC	51.1	Bag	10
DC1_CS	36BagC	52.7	Bag	10
DC1_CS	37BagC	53.85	Bag	5
DC1_CS	37BagD	54.25	Bag	5
DC1_CS	40BagB	57.6	Bag	30
DC1_CS	44BagC	64.15	Bag	10
NJ101-CS	14BagB	17.15	Bag	5
NJ101-CS	34BagB	46.85	Bag	5
NJ101-CS	34BagC	47.15	Bag	5
NJ102-CS	1BagA	1.10	Bag	5
NJ102-CS	12BagE	17.15	Bag	5
NJ102-CS	13BagA	17.20	Bag	5
NJ102-CS	14WaxD	19.65	Wax	10
NJ102-CS	17BagC	23.80	Bag	20
NJ102-CS	18BagC	25.80	Bag	20
NJ102-CS	23BagC	33.20	Bag	20
NJ102-CS	25BagC	36.10	Bag	15
NJ102-CS	29BagA	41.20	Bag	55
NJ104-CS	2BagC	1.70	Bag	20
NJ104-CS	5BagD	5.75	Bag	25
NJ104-CS	5WaxB	6.00	Wax	20
NJ104-CS	8BagB	9.75	Bag	25
NJ104-CS	9BagD	12.25	Bag	25
NJ104-CS	12BagE	16.95	Bag	5
NJ104-CS	13BagA	17.10	Bag	10
NJ104-CS	14BagB	18.75	Bag	3
NJ104-CS	17BagA	22.10	Bag	30
NJ104-CS	20BagA	25.10	Bag	10
NJ104-CS	21WaxA	26.45	Wax	10
NJ104-CS	22BagA	27.10	Bag	30
NJ104-CS	23BagB	28.35	Bag	10

NJ104-CS	24BagD	30.45	Bag	15
NJ104-CS	30BagC	39.20	Bag	40
NJ104-CS	32WaxE	42.45	Wax	10
NJ106-CS	14BagC	19.55	Bag	15
NJ106-CS	14BagE	19.95	Bag	15
NJ106-CS	16WaxD	22.90	Wax	30
NJ106-CS	23WaxA	32.80	Wax	30
NJ106-CS	25WaxB	35.80	Wax	30
NJ106-CS	26BagC	37.80	Bag	20
NJ106-CS	27WaxA	38.30	Wax	30
NJ106-CS	28BagA	39.70	Bag	10
NJ106-CS	29WaxA	41.20	Wax	20
NJ106-CS	30WaxC	43.40	Wax	20
NJ106-CS	30WaxE	43.85	Wax	20
NJ106-CS	31WaxB	44.60	Wax	25
NJ106-CS	31WaxD	45.40	Wax	15
NJ106-CS	33BagB	47.35	Bag	15
NJ106-CS	33WaxA	47.50	Wax	10
NJ106-CS	33WaxC	48.00	Wax	25
NJ106-CSb	2BagB	1.95	Bag	20
RS-CS	11WaxA	12.40	Wax	20
RS-CS	14WaxA	17.50	Wax	20
RS-CS	15BagA	18.30	Bag	5

12 APPENDIX 5 STAGE 2 ONSHORE VIBROCORE RECORDING

VC05

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.17	10YR 4/3 Brown silty sandy GRAVEL. Poorly sorted. Wet. Frequent broken molluscs including *Pecten* sp. Gravel is predominantly flint up to 50mm diameter, subrounded to subangular. Angled, disturbed by coring boundary.	SS
0.17 to 0.35	7.5YR 4/3 Brown sandy CLAY and 10YR 4/2 Dark greyish brown silty gravelly SAND. Occasional broken molluscs. Wet. Erosive abrupt boundary	SS
0.35 to 1.81	7.5YR 4/3 Brown gravelly sandy CLAY. Stiff. Gravel is chalk, red sandstone and limestone.	lBCT/BB

VC06

Depth mbSB	Sediment description	BGS Unit
0 to 0.10	10YR 4/4 Dark yellowish brown sandy GRAVEL. Sand is fine to coarse (predominantly medium) grained. Gravel is predominantly subrounded to subangular flint up to 80mm diameter. Frequent broken bivalve molluscs. Disturbed boundary	SS
0.10 to 1.53	10YR 3/2 Very dark greyish brown sandy gravelly CLAY. Very stiff. Frequent subrounded to angular chalk up to 15mm diameter, occasional small red sandstone, coal, siltstone and limestone. Molluscan burrow at 0.35m	lBCT/BB

VC06C

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.17	10YR 4/3 Brown sandy GRAVEL. Sand is fine to coarse (predominantly medium) grained. Gravel is predominantly subrounded to subangular flint up to 80mm diameter. Occasional broken bivalve molluscs. Abrupt boundary	SS
0.17 to 0.67	10YR 4/1 Dark grey gravelly sandy CLAY. Frequent subrounded to subangular chalk up to 15mm diameter, occasional small red sandstone, coal and broken molluscs.	lBCT/BB

VC08

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.35	10YR 4/2 Dark greyish brown silty gravelly SAND. Gravel is predominantly subrounded to subangular flint up to 35mm diameter. Moderate broken molluscs and black organic spots up to 20mm diameter. Boundary is clear, 0mm and erosive.	SS
0.35 to 1.85	10YR 3/2 Very dark greyish brown gravelly sandy silty CLAY. Very stiff. Gravel is predominantly poorly sorted subrounded to subangular chalk up to 8mm diameter, occasional flint up to 35mm diameter and occasional red sandstone up to 5mm diameter. From 0.97 to 1.41m a large angled 45degrees band of degraded angular grey siltstone in a silt/clay matrix.	lBCT/BB

VC31

Depth mbSB	Sediment description	BGS Unit
0.00 to 5.15	2.5Y 5/4 Light brown olive SAND. Colour is variable due to core drying out and is a darker grey colour where still wet. Sand is fine to coarse grained. Sorted. Whole bivalves at 0.83 and 3.65m (?horse mussel). Very frequent broken molluscs throughout (*c.*10 to 20% of the sediment).	SS

VC32A

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.58	2.5Y 4/4 Olive brown SAND. Occasional subangular brown sandstone up to 25mm diameter. Frequent broken molluscs up to 4mm diameter. Sand is fine to medium grained. Well sorted. Very diffuse boundary.	SS
0.58 to 1.21	2.5Y 4/3 Olive brown SAND. Drying has caused colour changes and where still wet the colour is darker grey/black. Sand is fine to medium grained. Frequent broken molluscs up to 3mm diameter. Becomes shellier/gravellier at 1.13 to 1.21m including an oxidised/onion weathered 55mm clay pebble. 1mm abrupt boundary	SS
1.21 to 1.49	5Y 4/1 Dark grey gravelly silty clayey SAND. Gravel is angular and bedded grey siltstone/claystone. Sand is fine grained	lBCT/BB

VC34

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.56	2.5Y 6/3 Light yellowish brown SAND. Variable colour due to cores drying out. Where still waterlogged the sediment is a 2.5Y 4/1 grey colour. Sand is fine to medium grained and well sorted. No structure. Frequent sand sized (up to 1mm) broken molluscs, occasionally whole (at 0.20m).	SS

VC72

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.70	2.5Y 7/3 Pale yellow SAND. Frequent broken molluscs up to 5mm diameter (up to 50% of sediment) Sand is medium grained. Clear boundary	SS
0.70 to 1.32	2.5Y 6/3 Light yellowish brown gravelly SAND. Gravel is predominantly subrounded to subangular flint up to 60mm diameter with occasional chalk, quartz, igneous and metamorphic rocks. Frequent broken molluscs including *Gibbula* sp. Boundary 100mm and burrowed	SS
1.32 to 2.82	10YR 3/3 Dark brown gravelly sand CLAY. Very Stiff. Small 8mm diameter molluscan burrow at 1.34m infilled with overlying sediment. At 1.70m 10mm diameter molluscan burrow. From 1.32 to 1.52m very frequent subrounded to subangular grey/black shale up to 8mm diameter. From 1.52m to 2.02m frequent subrounded to subangular shale (up to 10mm diameter), chalk (up to 12mm diameter and red sandstone (up to 6mm diameter)	lBCT/BB

VC77

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.56	2.5Y 5/4 Light olive brown SAND. Frequent broken molluscs up to 3mm diameter. Disturbed/clayey from 0.50 to 0.56m. One large 80mm diameter subrounded ?granite cobble. Fining upwards. Well sorted from 0.00 to 0.48.	SS
0.56 to 1.46	10YR 3/2 Very dark greyish brown gravelly slightly sandy CLAY. Stiff. Gravel is predominantly subrounded to subangular chalk up to 25mm diameter and occasional small pieces of coal and broken molluscs. Molluscan burrows at 0.83m 25mm diameter and infilled with overlying sediment.	lBCT/BB

VC78

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.43	10YR 6/4 Light yellowish brown gravelly SAND. Very frequent broken bivalve molluscs. Gravel is predominantly subrounded to subangular flint with occasional chalk and granite. Occasional echinoid spines. 40mm boundary, disturbed	SS
0.43 to 1.83	5Y 4/1 Dark grey gravelly CLAY. Stiff. Gravel is very frequent subrounded to subangular chalk up to 60mm diameter comprising between 40 and 60% of the sediment. Frequent small subrounded to rounded grey shale and coal up to 4mm diameter.	lBCT/BB

VC79

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.08	10 YR 5/3 Brown gravelly SAND. Very frequent broken molluscs up to 3mm diameter, occasionally whole bivalves. 10mm boundary.	SS
0.08 to 0.24m	White Chalk. 25mm diameter molluscan burrow from 0.08 to 0.24m infilled with the overlying sediment. Edges of the burrow are stained green and orange.	UCk

VC80

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.15	2.5Y 5/4 Light olive brown SAND. Frequent gravel including subrounded to subangular flint and chalk up to 12mm diameter. Very frequent broken molluscs (up to 60% of the sediment). Sand is fine, medium and predominantly coarse grained. 10mm erosive boundary	SS
0.15 to 0.25	White Chalk. Hard. Blocky. Contains small 8mm diameter molluscan burrows infilled with the overlying sediment	UCk

VC81

Depth mbSB	Sediment description	BGS Unit
0.00 to 1.25	10YR 4/2 Dark greyish brown silty sandy GRAVEL. Very frequent whole and broken bivalve molluscs including *Mytilus edulis*, Pecten sp. and occasional serpulid worm tubes. Colour varies due to drying out of core. Frequent subrounded and subangular flint and occasional metamorphic rocks up to 75mm diameter. 3mm boundary, slightly burrowed.	SS
1.25 to 1.60	White Chalk. Soft "Putty Chalk" from 1.25 to 1.28. Wet.	UCk

VC82

Depth mbSB	Sediment description	BGS Unit
0.00 to 1.59	10YR 5/4 Yellowish brown gravelly SAND/ sandy GRAVEL. Gravel is predominantly subrounded to subangular flint up to 15mm diameter and occasional quartz. Very frequent broken and occasionally whole molluscs including *Gibbula* sp. from 0.95 to 1.45m. Bands of gravellier and shellier sediment. Slightly darker and a slightly silty content from 0.00 to 0.33m Sand is fine to very coarse grained. Boundary is disturbed, 100mm	SS
1.59 to 3.19	White Chalk. Slightly wet/soft at its upper surface	UCk

VC83

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.11	10YR 4/3 Brown SAND. Sand is medium to coarse grained. Moderate rounded to subrounded flint up to 10mm diameter. Boundary has been burrowed.	SS
0.11 to 1.88	White Chalk. From 0.11 to 0.16m Soft "Putty Chalk" with a slightly greenish/yellow tinge. Burrow from 0.11 to 0.17m infilled with the overlying sediment.	UCk

VC84A

Depth mbSB	Sediment description	BGS Unit
0 to 0.05	2.5Y 4/4 Olive brown gravelly SAND. Loose. Poorly sorted. Occasional molluscs predominantly broken bivalves up to 10mm diameter. Gravel is rounded to subangular flint up to 55mm diameter. Disturbed 50mm boundary.	SS
0.05 to 2.92	White Chalk. Slightly discoloured yellow from 0.15 to 0.17m. Blocky.	UCk

VC85A

Depth mbSB	Sediment description	BGS Unit
0 to 0.75	Beige SAND. Sand is medium to coarse grained. Very frequent broken molluscs up to 3mm diameter. Well sorted. 5mm boundary	SS
0.75 to 2.50	Beige sandy GRAVEL. Sand is medium to coarse grained. Very frequent broken and occasionally whole (*Mytilus edulis* at 1.61m) molluscs. Sorted. Gravel is predominantly subrounded to angular flint and occasional quartz up to 5mm in diameter. Very diffuse 200mm boundary.	SS
2.50 to 3.02	2.5Y 4/2 Dark greyish brown sandy silty CLAY. Slightly oxidised brown/grey. Burrow at 2.75m 20mm diameter. Very diffuse 300mm boundary.	uBCT/HA
3.02 to 5.93	2.5Y 5/1 Grey sandy silty CLAY. Wet, soft. Horizontally interbedded. Sand is fine grained and occasionally in beds of up to 80mm in thickness. Frequent molluscs especially from 4.67 to 5.02m.	uBCT/HA

VC86

Depth mbSB	Sediment description	BGS Unit
0.00 to 1.56	10YR 4/3 Brown sandy GRAVEL. Sand is fine to coarse grained. Gravel is predominantly subrounded to subangular flint, quartz, sandstone up to 60mm diameter. Poorly sorted. Colour varies dependent on how dried out the core sample is. Very frequent broken and occasionally whole molluscs mostly bivalves including *Pecten sp*.. Boundary clear/erosive and angled.	SS
1.56 to 4.52	7.5YR 3/3 Dark brown gravelly sandy CLAY. Gravel is subrounded to subangular chalk, red sandstone and flint up to 12mm diameter. Stiff. Slightly dark greyish brown 10YR 3/2 from 1.56 to 1.81 probably due to drying out. Molluscan burrows from 1.56 to 1.70 up to 12mm diameter infilled with overlying sediment.	lBCT/BB

VC87A

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.55	10 YR 4/3 Brown sandy GRAVEL. Frequent broken molluscs up to 10mm diameter. Gravel is predominantly subrounded to subangular flint up to 50mm diameter and occasional quartz. Sand is fine to coarse grained. Boundary 4mm but disturbed by coring	SS
0.55 to 2.19	10 YR 3/2 Very dark greyish brown gravelly sandy CLAY. Gravel is predominantly subrounded chalk up to 10mm diameter. Poorly sorted. Occasional to moderate small coal and shale up to 5mm diameter. One diagonal molluscan burrow infilled with the overlying sediment at 0.69m	lBCT/BB

VC88

Depth mbSB	Sediment description	BGS Unit
0 to 1.20	10YR 5/4 Yellowish Brown SAND. Sand is medium to coarse grained. Well sorted. Very frequent broken shell including *Pecten* sp. up to 50mm diameter comprising c.50% of the sediment. Diffuse 150mm boundary.	SS
1.20 to 3.52	10YR 6/3 pale brown sandy GRAVEL. Gravel is predominantly subrounded to subangular flint with quartz up to 35mm diameter. Occasional bryozoans noted on the surface of the flint. Very frequent molluscs including *Gibbula* sp. and Tellina/Scrobicularia type bivalves. Molluscs comprise c. 50% of the sediment.	SS

VC90

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.10	10YR 4/3 Brown clayey gravelly SAND. One large flint with seaweed attached, 100mm diameter, causing disturbance during coring. Sand is fine to coarse grained. Occasional broken molluscs. Disturbed boundary.	SS
0.10 to 1.75	10YR 3/2 Very dark greyish brown gravelly sandy CLAY. Stiff. Gravel is predominantly subrounded to angular chalk (up to 6mm diameter) and siltstone (up to 12mm diameter)	lBCT/BB

VC91

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.10	2.5Y 3/2 Very dark greyish brown silty SAND. Sand is fine to medium grained. Large 100mm diameter subangular grey limestone cobble. Disturbed (by coring/cobble) boundary	SS
0.1 to 0.70	2.5Y 4/1 Dark grey clayey silty SAND. Soft/Wet. Sand is fine grained. Frequent dark/black organic spots/patches.	uBCT/HA
0.70 to 1.42	2.5Y 4/1 Dark grey clayey sandy SILT. Occasional dark/black organic spots/patches. Sand is fine grained. Some feint horizontal bedding of sand visible (0.70 to 0.80m). Gravelly bed from 0.8 to 0.88m including flint up to 10mm diameter and bivalve molluscs. Moderate molluscan content, more frequent from 1.00 to 1.15m. *Cerastoderma edule* at 1.03m. Boundary lost	uBCT/HA
1.42 to 2.57	2.5Y 4/1 Dark grey sandy CLAY. Stiff, drier than above. Occasional small fine horizontally bedded fine to medium grained sand bands from 2.05 to 2.10m, some of which have oxidised to a slightly orange colour, but are mostly light grey and less than 1mm in thickness. Has a slightly blocky structure. 10mm boundary	uBCT/HA
2.57 to 2.81	2.5Y 5/2 Greyish brown silty SAND/sandy SILT. Horizontally bedded with silt/sand beds and occasional organic bands with recognisable plant remains. At 2.81m a 10mm thick bed of predominantly gastropod molluscs. 5mm boundary	uBCT/HA
2.81 to 2.95	2.5Y 3/1 Very dark grey sandy GRAVEL. Sand is fine to very coarse grained. Gravel is subrounded to subangular flint up to 15mm diameter. Occasional bivalve molluscs	uBCT/HA

VC92

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.30	10YR 5/3 Brown SAND. Sand is medium grained. Occasional subrounded to subangular flint up to 35mm diameter. Moderate broken molluscs. 2mm boundary	SS
0.30 to 0.83	2.5Y 5/2 Greyish brown slightly silty clayey SAND. Horizontally bedded with grey and dark grey organic silty CLAY up to 8mm in thickness. Sand is fine to medium grained. Fining upwards. Occasional bivalve including stray valves of *Cerastoderma edule* and Scrobicularia/Tellina type. 5mm boundary	uBCT/HA
0.83 to 0.97	2.5Y 5/4 Light olive brown SAND. Sand is medium grained. Contains occasional broken molluscs. Clear boundary	uBCT/HA
0.97 to 1.83m	10YR 4/1 Dark grey CLAY. Horizontally bedded with fine sand layers up to 1mm in thickness. Occasional organic remains.	uBCT/HA

VC93

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.32	10YR 3/2 Very dark greyish brown gravelly SAND. Sand is fine to coarse grained. Gravel is predominantly subrounded to subangular flint up to 100mm diameter with occasionally bryozoans adhering (at 0.25m). Frequent bivalve molluscs. Burrowed/disturbed boundary.	SS
0.32 to 1.41m	2.5Y 3/1 Very dark grey slightly sandy silty CLAY. Sand is fine grained. Stiff. Plastic. Blue (gleying) streaks. Occasional bivalve molluscs at 1.04m	uBCT/HA

VC96

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.14	Dark grey SAND. Sand is fine to medium grained. Wet. Occasional cobbles of subrounded to subangular flint up to 80mm diameter. Occasional small broken molluscs and dark/black organic spots.	SS
0.14 to 2.10	2.5Y 4/1 Grey SAND. Horizontally interbedded silt/clay and organic beds. Occasional whole bivalve mollusc including Scrobicularia/Tellina type at 2.10m	SS
2.10 to 5.90	2.5Y 6/3 Dark yellowish brown gravelly SAND. Very frequent (c. 40% of total sediment) molluscs mostly broken but occasionally whole (including *Cerastoderma edule*).Very frequent molluscs from 5.63 to 5.78m (c. 80% of the sediment). Occasional greyer patches of sand from 2.10 to 2.97and 5.45 to 5.60m. From 5.60 to 5.63m a bed of 2.5Y 4/1 Dark grey silty organic CLAY.	SS

VC104A

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.20	2.5Y 4/2 Dark greyish brown slightly gravelly silty SAND. Wet. Occasional broken shell. Gravel is subrounded to subangular flint up to 10mm diameter. 20mm boundary.	SS
0.20 to 0.37	10YR 4/1 Dark greyish brown sandy GRAVEL. Gravel is predominantly flint. Sorted. Coarsening upwards.	SS
0.37 to 0.48	10YR 4/3 Brown sandy CLAY. Slightly oxidised. 30mm diameter burrows filled with overlying sediment. Boundary lost (geotechnically sampled)	uBCT/HA
0.48 to 0.57	GAP. Boundary lost (geotechnically sampled)	
0.57 to 3.53	10YR 4/2 Dark greyish brown clayey SAND. Sand is fine, well sorted. Occasional small organic black spot up to 4mm diameter.	uBCT/HA

VC116A

Depth mbSB	Sediment description	BGS Unit
0.00 to 0.04	10YR 4/4 Dark yellowish brown gravelly SAND/ sandy GRAVEL. Gravel is flint subrounded to subangular up to 35mm diameter. Moderate to frequent broken molluscs. Sand is fine to coarse grained. Wet. Clear, erosive and burrowed boundary	SS
0.04 to 1.21	7.5YR 3/2 Dark brown gravelly CLAY. Very stiff. Gravel is poorly sorted rounded to angular flint, chalk and occasional granite up to 5mm diameter. At 0.17m a molluscan burrow, 25mm diameter infilled with the overlying sediment.	lBCT/BB
1.21 to 1.46	GAP (geotechnically sampled)	
1.46 to 2.95	7.5YR 3/2 Dark brown silty CLAY. Stiff. Some feint horizontally bedded structure with a foliated look. Some fine sand and lighter streaks present from 1.45m onwards. Darker ?organic streaks (less than 1mm in thickness).	lBCT/BB

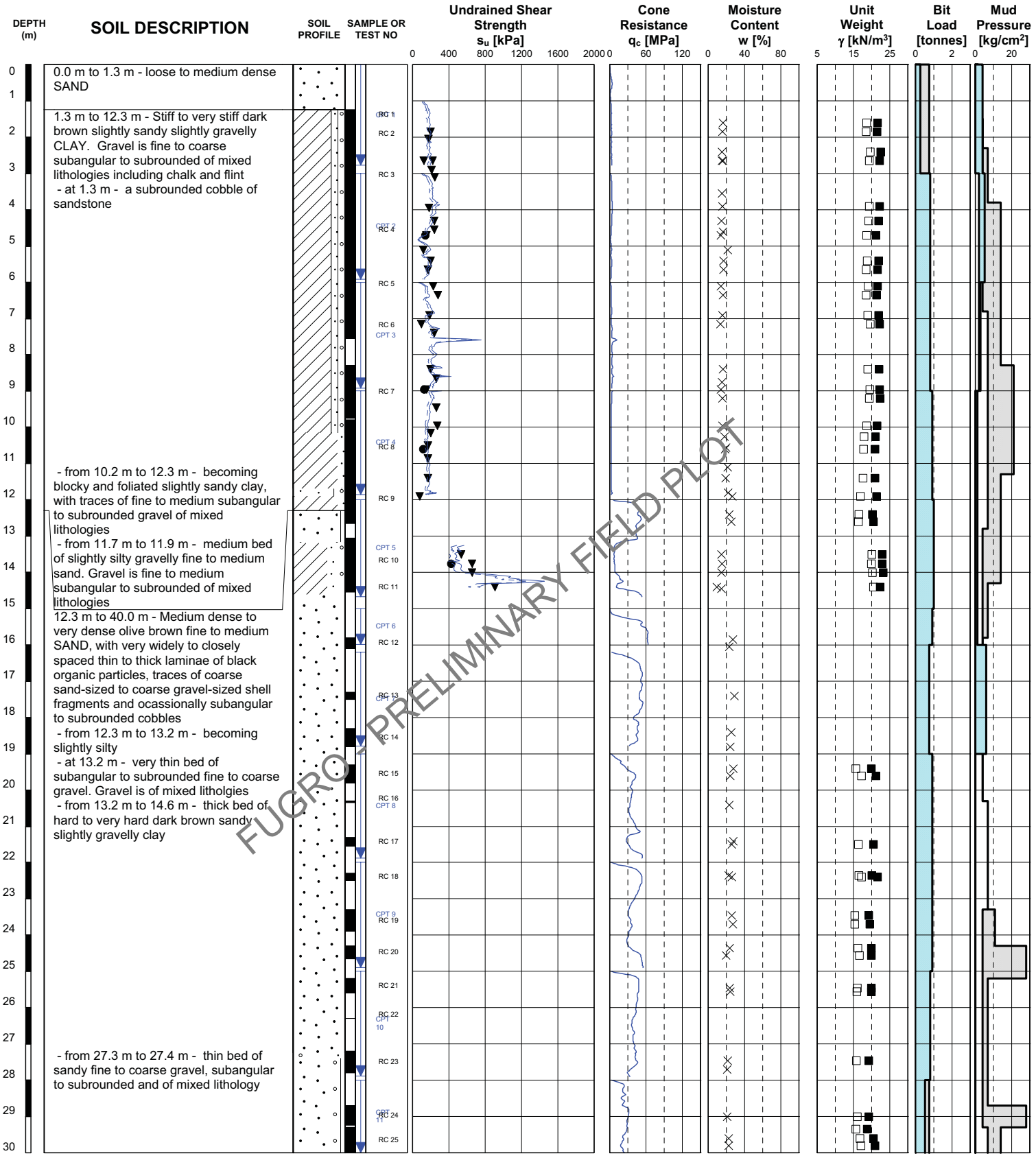
Key to BGS unit abbreviations:

Chalk (UCk)
Yarmouth Roads (YR)
Swarte Bank (SWB)
Egmond Ground (EG)
Bolders Bank and Lower Botney Cut (BB/lBCT)
Upper Botney Cut and Holocene Alluvium (uBCT/HA)
Seabed Sediment (SS)

13 APPENDIX 6 VIBROCORE SAMPLES RETAINED FOR STAGE 3 WORK

Vibrocore	Easting	Northing	Sections retained(mbSB)
VC05	420097	5962220	0.00 to 0.50, 1.51 to 5.93
VC06	419114	5962100	
VC06C	419117	5962101	
VC08	417206	5961545	0.97 to 1.41
VC31	395169	5956105	4.77 to 5.15
VC32A	394575	5955906	0.00 to 1.49
VC34	393749	5955607	
VC72	360723	5943524	
VC77	356885	5942814	
VC78	356479	5942741	
VC79	355820	5942458	
VC80	355919	5942734	
VC81	354998	5942776	
VC82	354980	5942041	
VC83	355392	5942244	
VC84A	355429	5942762	
VC85A	354513	5942798	
VC86	354248	5942805	
VC87A	354277	5941772	
VC88	354532	5941844	
VC90	352948	5941400	
VC91	352662	5941593	0.00 to 2.95
VC92	352049	5941136	0.00 to 1.83
VC93	351578	5940997	0.00 to 1.41
VC96	350544	5940709	0.00 to 2.43, 5.43 to 5.90
VC104A	350145	5942010	0.00 to 1.93
VC116	342253	5933412	2.45 to 2.95

14 APPENDIX 7 PRELIMINARY BOREHOLE LOGS



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) AC1a-CS
(2) AC1a-BH

Soil Profile is represented by location AC1a-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane) ■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer) ● s_u (Undrained Triaxial)
◆ s_u (Fall Cone) ✦ s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane) Estimated from CPT data (N_{kt} = 15 - 20)
Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

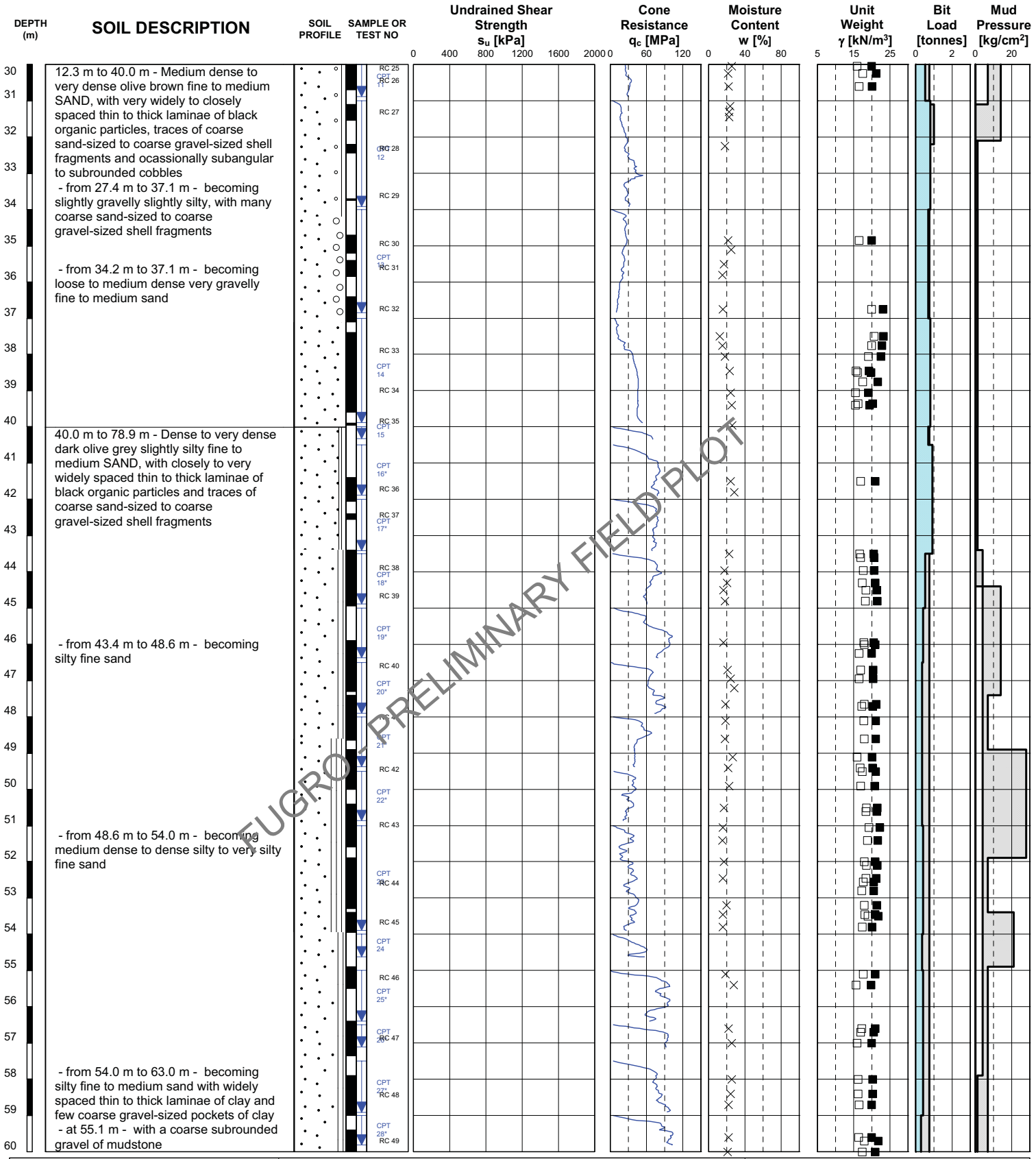
KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

TYPE OF BIT: (1) PCD Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 418021.2 mE 5968359.9 mN (1) WATER DEPTH : 32.9 m LAT (1)
: 418024.7 mE 5968359.4 mN (2) : 33.0 m LAT (2)

DATE : 12/11/2012 - 15/11/2012 (1)
: 25/06/2012 - 27/06/2012 (2)

GeODin-System 7.5//17/11/2012 13:47:54



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) AC1a-CS
(2) AC1a-BH

Soil Profile is represented by location AC1a-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane) ■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer) ● s_u (Undrained Triaxial)
◆ s_u (Fall Cone) ✦ s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane) Estimated from CPT data (N_{kt} = 15 - 20)
Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

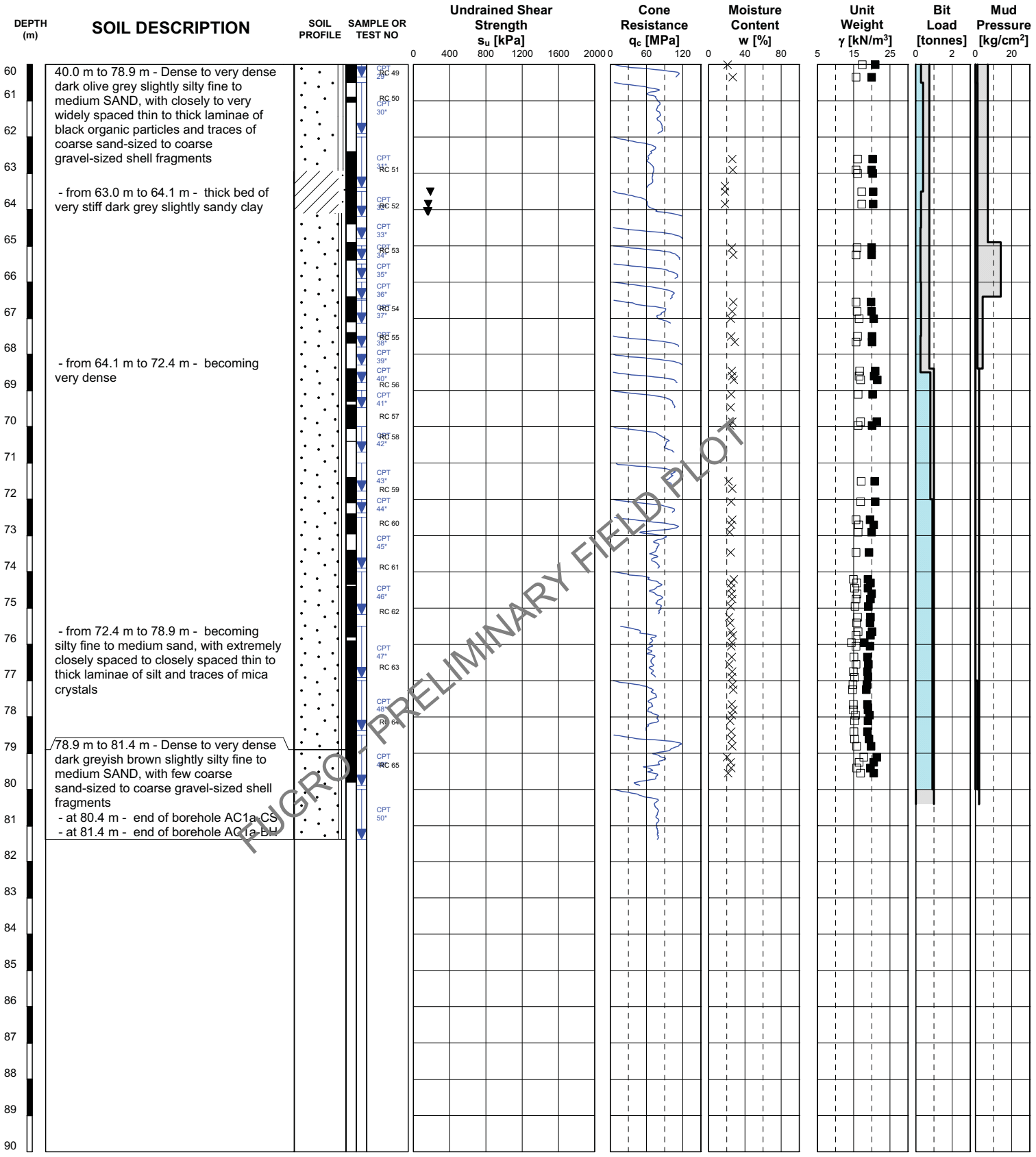
KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

TYPE OF BIT: (1) PCD Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 418021.2 mE 5968359.9 mN (1) WATER DEPTH : 32.9 m LAT (1)
: 418024.7 mE 5968359.4 mN (2) : 33.0 m LAT (2)

DATE : 12/11/2012 - 15/11/2012 (1)
: 25/06/2012 - 27/06/2012 (2)

GeODin-System 7.5//17/11/2012 13:47:55



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) AC1a-CS
(2) AC1a-BH

Soil Profile is represented by location AC1a-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane) ■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer) ● s_u (Undrained Triaxial)
◆ s_u (Fall Cone) ✦ s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane) Estimated from CPT data (N_{kt} = 15 - 20)
Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

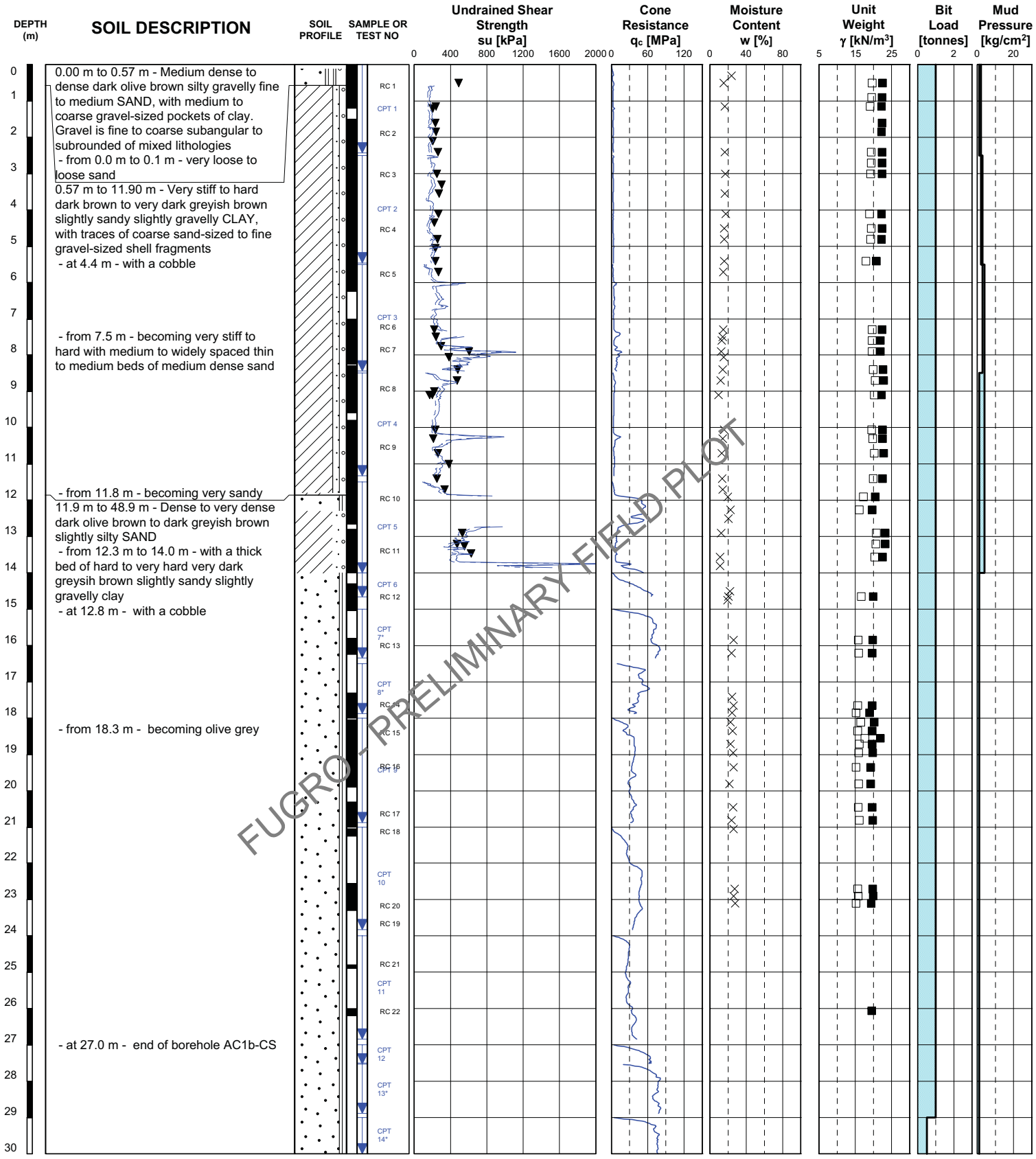
TYPE OF BIT: (1) PCD Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 418021.2 mE 5968359.9 mN (1) WATER DEPTH : 32.9 m LAT (1)
: 418024.7 mE 5968359.4 mN (2) : 33.0 m LAT (2)

DATE : 12/11/2012 - 15/11/2012 (1)
: 25/06/2012 - 27/06/2012 (2)

GeODin-System 7.5//17/11/2012 13:47:55

BOREHOLE AC1a-CS (PRELIMINARY) SHEET 3 OF 3



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) AC1b-CS
(2) AC1b-BH

Soil Profile is represented by location AC1b-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
- ▲ s_u (Torvane)
- ■ s_u (Laboratory Vane)
- ▼ s_u (Pocket Penetrometer)
- ● s_u (Undrained Triaxial)
- ◆ s_u (Fall Cone)
- + s_u (In situ Vane)
- ✳ s_u (Remoulded In situ Vane)
- Estimated from CPT data (N_{kt} = 15 - 20)

Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
- × Moisture Content (w)

KEY FOR UNIT WEIGHT:
- □ Natural Dry Unit Weight (γ_d)
- ■ Natural Wet Unit Weight (γ_w)

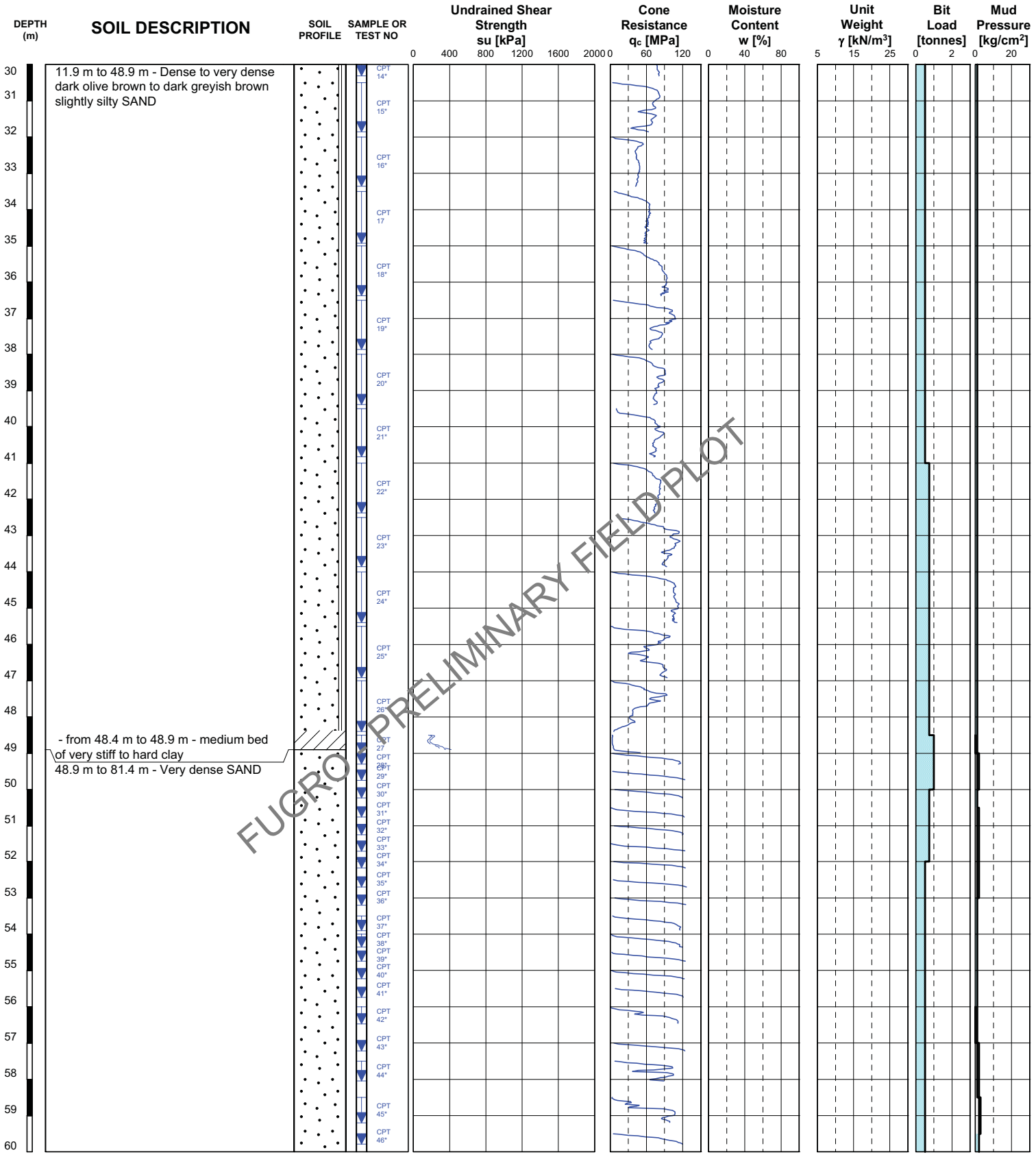
TYPE OF BIT: (1) PCD Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 421993.0 mE 5968116.8 mN (1) WATER DEPTH : 31.5 m LAT (1)
: 421991.6 mE 5968114.3 mN (2) : 31.0 m LAT (2)

DATE : 03/11/2012 - 04/11/2012 (1)
: 03/07/2012 - 04/07/2012 (2)

GeODin-System 7.5//05/11/2012 18:09:52

BOREHOLE AC1b-CS (PRELIMINARY) SHEET 1 OF 3



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) AC1b-CS
(2) AC1b-BH

Soil Profile is represented by location AC1b-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane) ■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer) ● s_u (Undrained Triaxial)
◆ s_u (Fall Cone) ✦ s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane) Estimated from CPT data (N_{kt} = 15 - 20)
Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

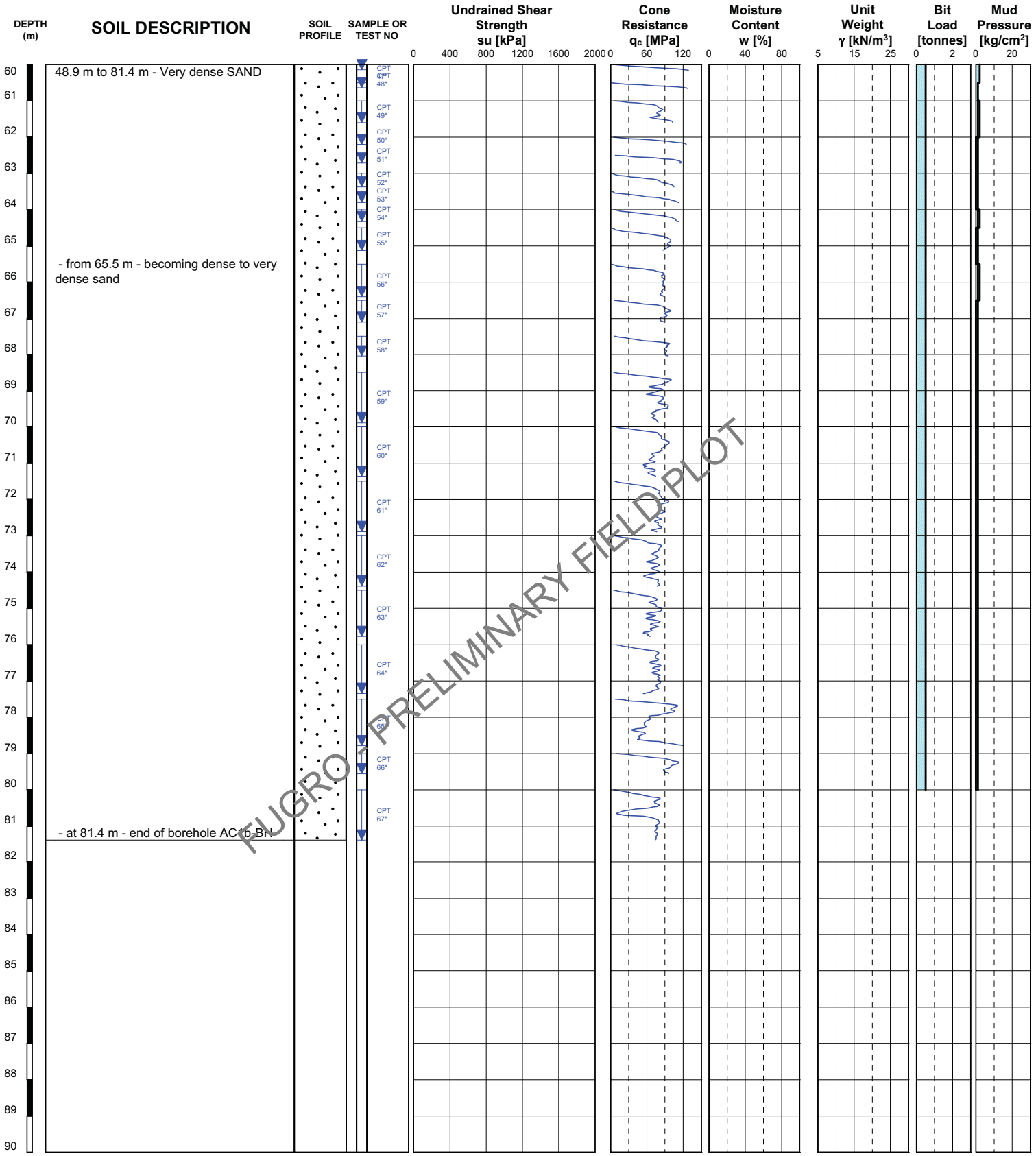
TYPE OF BIT: (1) PCD Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 421993.0 mE 5968116.8 mN (1) WATER DEPTH : 31.5 m LAT (1)
: 421991.6 mE 5968114.3 mN (2) : 31.0 m LAT (2)

DATE : 03/11/2012 - 04/11/2012 (1)
: 03/07/2012 - 04/07/2012 (2)

GeODin-System 7.5//05/11/2012 18:09:53

BOREHOLE AC1b-CS (PRELIMINARY) SHEET 2 OF 3



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) AC1b-CS
(2) AC1b-BH

Soil Profile is represented by location AC1b-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:

▲	s_u (Torvane)	■	s_u (Laboratory Vane)
▼	s_u (Pocket Penetrometer)	●	s_u (Undrained Triaxial)
◆	s_u (Fall Cone)	+	s_u (In situ Vane)
✳	s_u (Remoulded In situ Vane)	⧹/⧸	Estimated from CPT data (N_{kt} = 15 - 20)

Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

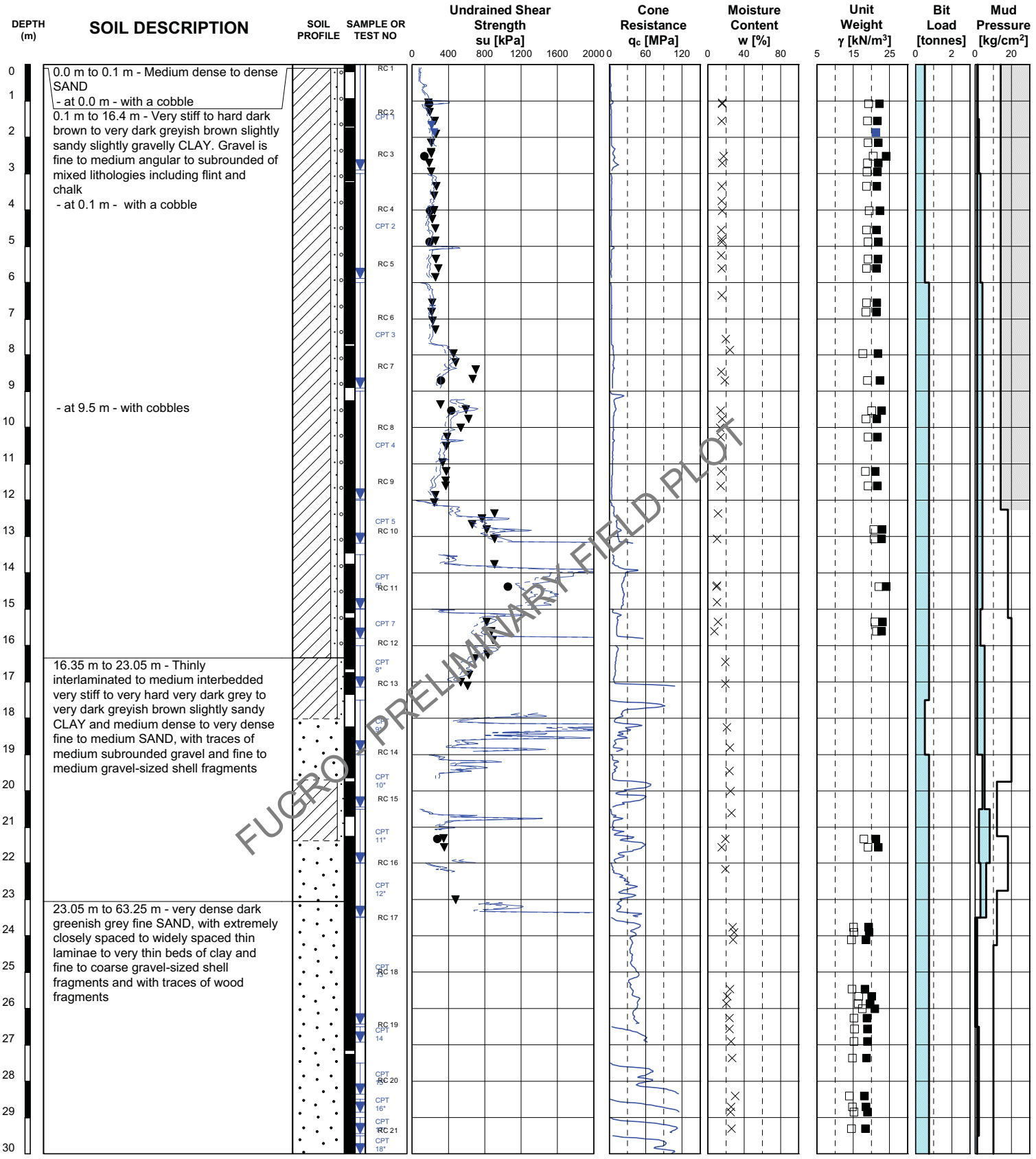
TYPE OF BIT: (1) PCD Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 421993.0 mE 5968116.8 mN (1) WATER DEPTH : 31.5 m LAT (1)
: 421991.6 mE 5968114.3 mN (2) : 31.0 m LAT (2)

DATE : 03/11/2012 - 04/11/2012 (1)
: 03/07/2012 - 04/07/2012 (2)

GeODin-System 7.5//05/11/2012 18:09:53

BOREHOLE AC1b-CS (PRELIMINARY) SHEET 3 OF 3



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) AC2-CS
(2) AC2-BH

Soil Profile is represented by location AC2-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
- ▲ s_u (Torvane)
- ■ s_u (Laboratory Vane)
- ▼ s_u (Pocket Penetrometer)
- ● s_u (Undrained Triaxial)
- ◆ s_u (Fall Cone)
- + s_u (In situ Vane)
- ✳ s_u (Remoulded In situ Vane)
- Estimated from CPT data (N_{kt} = 15 - 20)

Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
- × Moisture Content (w)

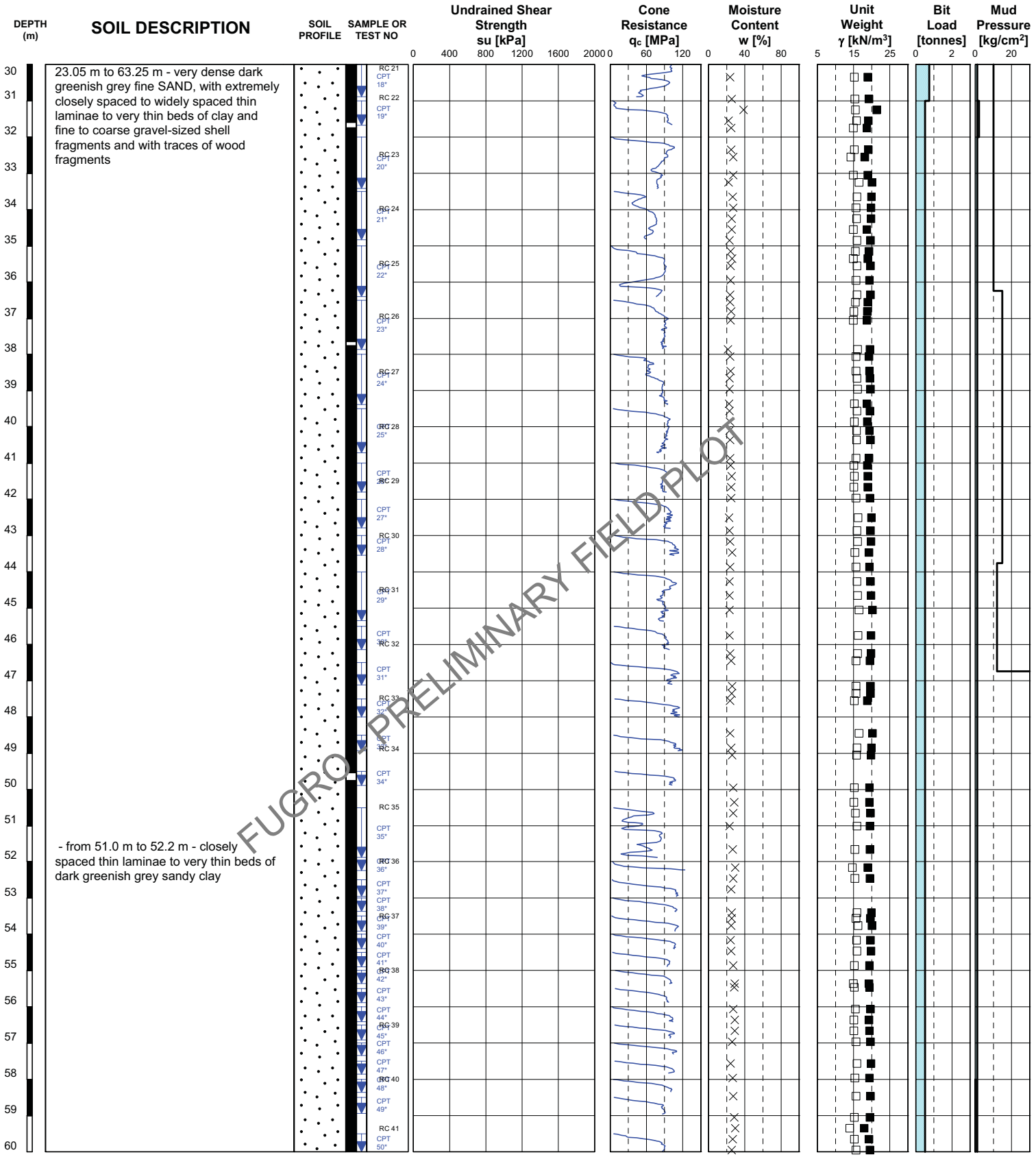
KEY FOR UNIT WEIGHT:
- □ Natural Dry Unit Weight (γ_d)
- ■ Natural Wet Unit Weight (γ_w)

TYPE OF BIT: (1) PCD Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 429924.3 mE 5967620.1 mN (1) WATER DEPTH : 29.2 m LAT (1)
: 429925.1 mE 5967624.5 mN (2) : 29.0 m LAT (2)

DATE : 20/10/2012 - 22/10/2012 (1)
: 05/07/2012 - 07/07/2012 (2)

GeODin-System 7.5//23/10/2012 15:16:20



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) AC2-CS
(2) AC2-BH

Soil Profile is represented by location AC2-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane)
■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer)
● s_u (Undrained Triaxial)
◆ s_u (Fall Cone)
✦ s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane)
Estimated from CPT data (N_{kt} = 15 - 20)
Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

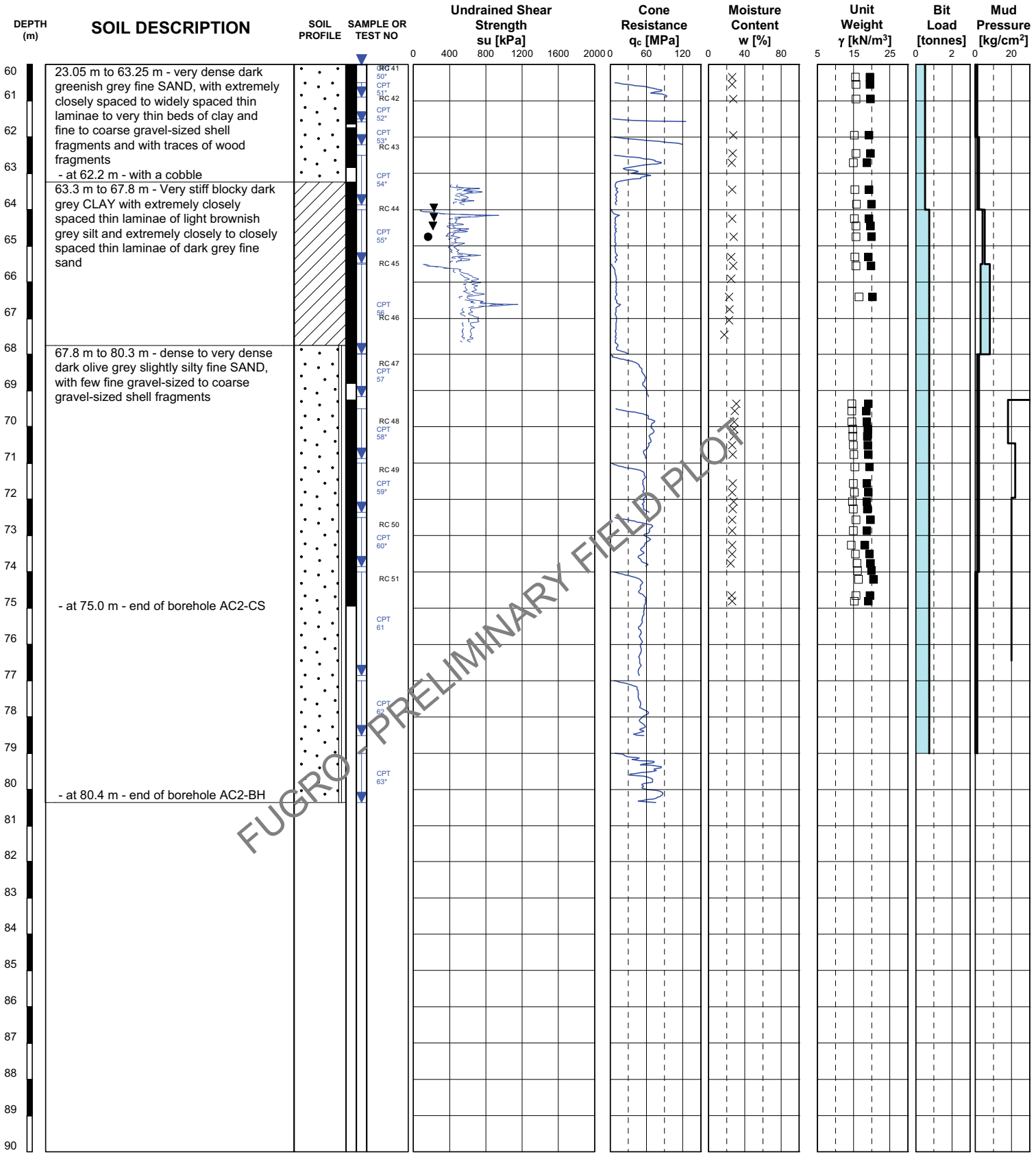
KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

TYPE OF BIT: (1) PCD Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 429924.3 mE 5967620.1 mN (1) WATER DEPTH : 29.2 m LAT (1)
: 429925.1 mE 5967624.5 mN (2) : 29.0 m LAT (2)

DATE : 20/10/2012 - 22/10/2012 (1)
: 05/07/2012 - 07/07/2012 (2)

GeODin-System 7.5//23/10/2012 15:16:20



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) AC2-CS
(2) AC2-BH

Soil Profile is represented by location AC2-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane) ■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer) ● s_u (Undrained Triaxial)
◆ s_u (Fall Cone) ✦ s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane) Estimated from CPT data (N_{kt} = 15 - 20)
Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

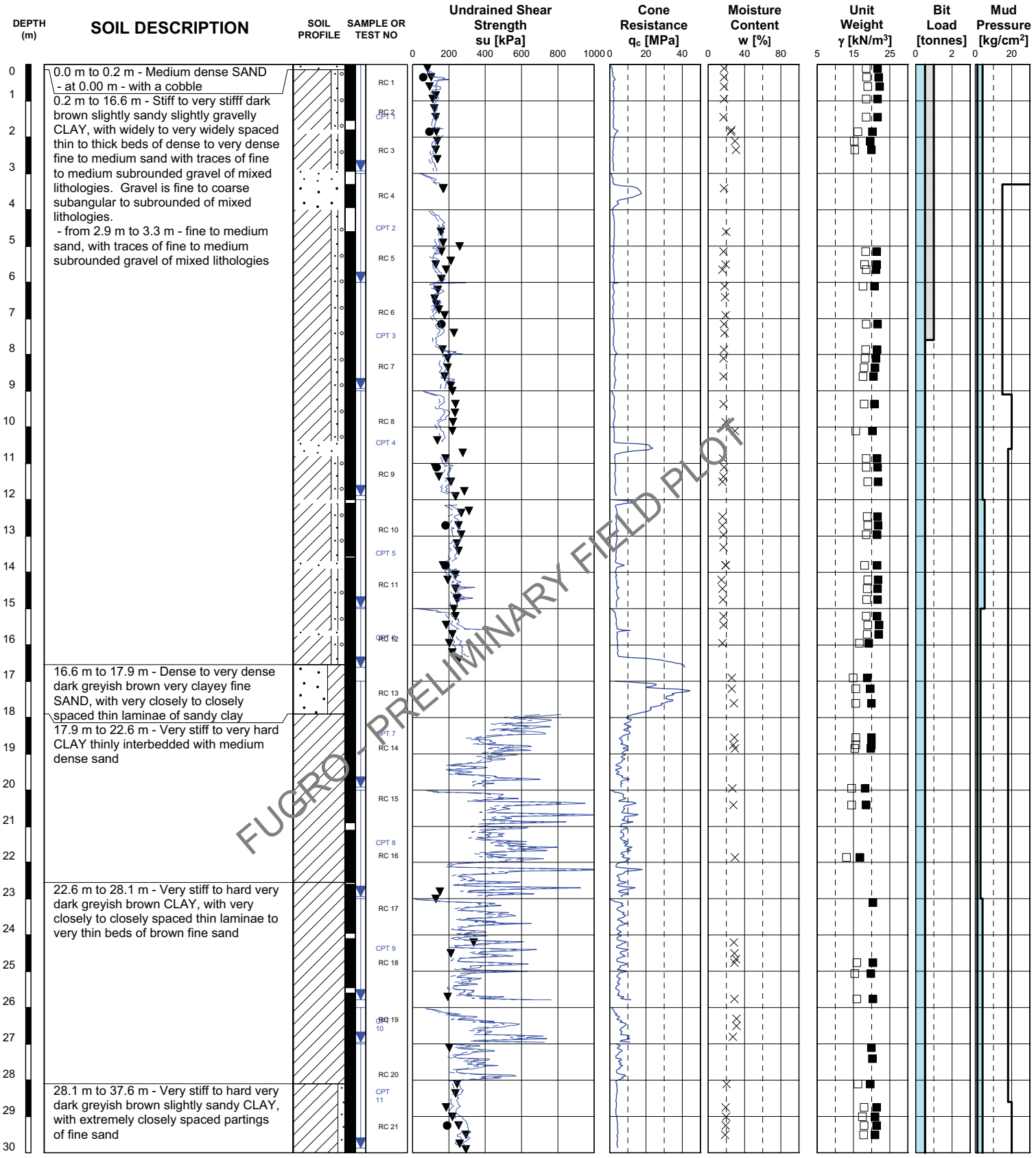
TYPE OF BIT: (1) PCD Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 429924.3 mE 5967620.1 mN (1) WATER DEPTH : 29.2 m LAT (1)
: 429925.1 mE 5967624.5 mN (2) : 29.0 m LAT (2)

DATE : 20/10/2012 - 22/10/2012 (1)
: 05/07/2012 - 07/07/2012 (2)

GeODin-System 7.5//23/10/2012 15:16:21

BOREHOLE AC2-CS (PRELIMINARY) SHEET 3 OF 3



DRILLING REMARKS:
Type of Mud: Guar-Gum
Notes:

Locations: (1) AC3-CS
(2) AC3-BH

Soil Profile is represented by location AC3-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
- ▲ s_u (Torvane)
- ■ s_u (Laboratory Vane)
- ▼ s_u (Pocket Penetrometer)
- ● s_u (Undrained Triaxial)
- ◆ s_u (Fall Cone)
- ✦ s_u (In situ Vane)
- ✳ s_u (Remoulded In situ Vane)
- Estimated from CPT data (N_{kt} = 15 - 20)

Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
- × Moisture Content (w)

KEY FOR UNIT WEIGHT:
- □ Natural Dry Unit Weight (γ_d)
- ■ Natural Wet Unit Weight (γ_w)

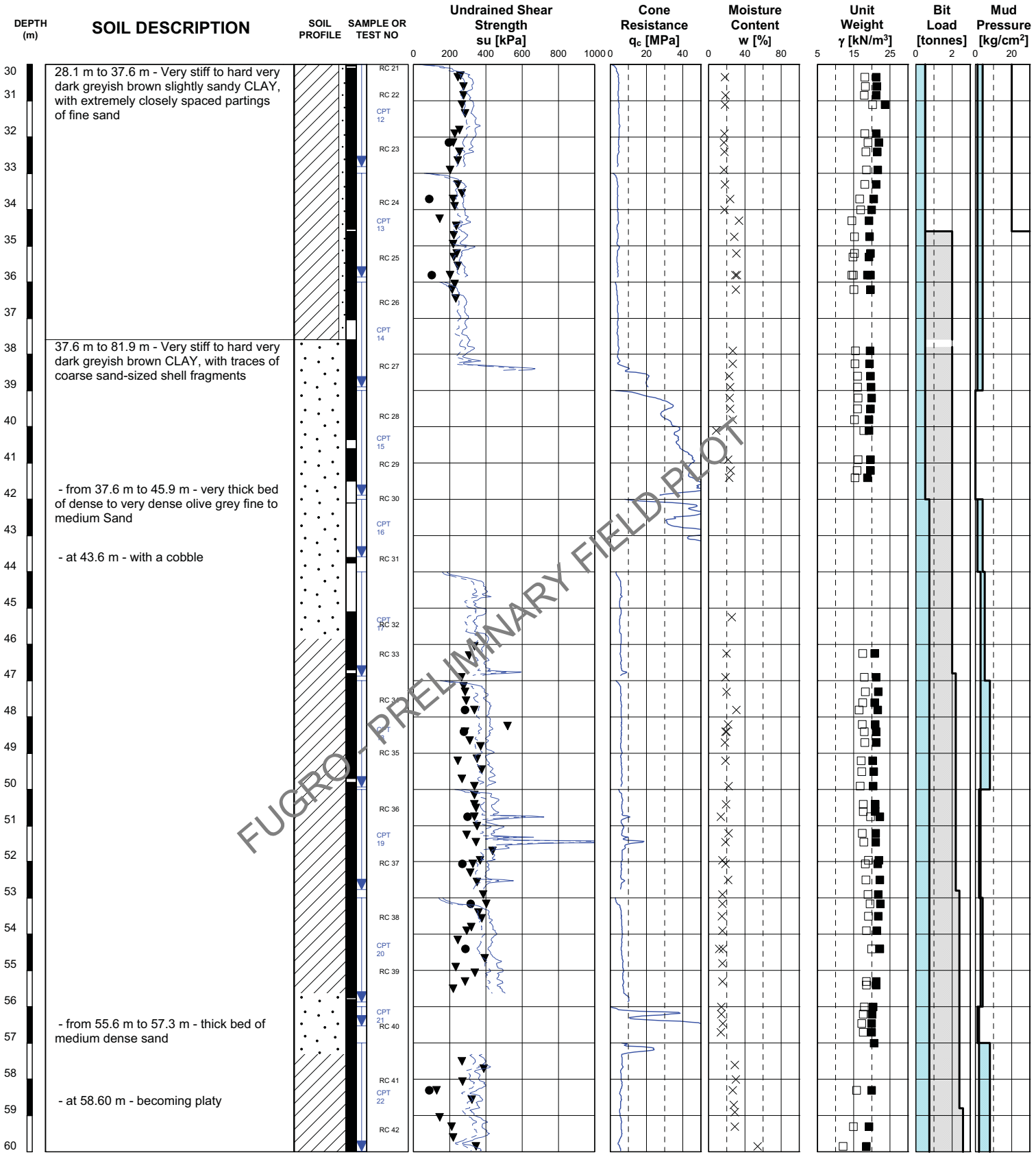
TYPE OF BIT: (1) PCD Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 441215.8 mE 5967863.5 mN (1) WATER DEPTH : 29.1 m LAT (1)
: 441212.7 mE 5967868.0 mN (2) : 30.1 m LAT (2)

DATE : 17/10/2012 - 19/10/2012 (1)
: 07/07/2012 - 08/07/2012 (2)

GeODin-System 7.5//21/10/2012 09:03:59

BOREHOLE AC3-CS (PRELIMINARY) SHEET 1 OF 3



DRILLING REMARKS:
Type of Mud: Guar-Gum
Notes:

Locations: (1) AC3-CS
(2) AC3-BH

Soil Profile is represented by location AC3-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane)
■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer)
● s_u (Undrained Triaxial)
◆ s_u (Fall Cone)
✦ s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane)
Estimated from CPT data (N_{kt} = 15 - 20)
Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

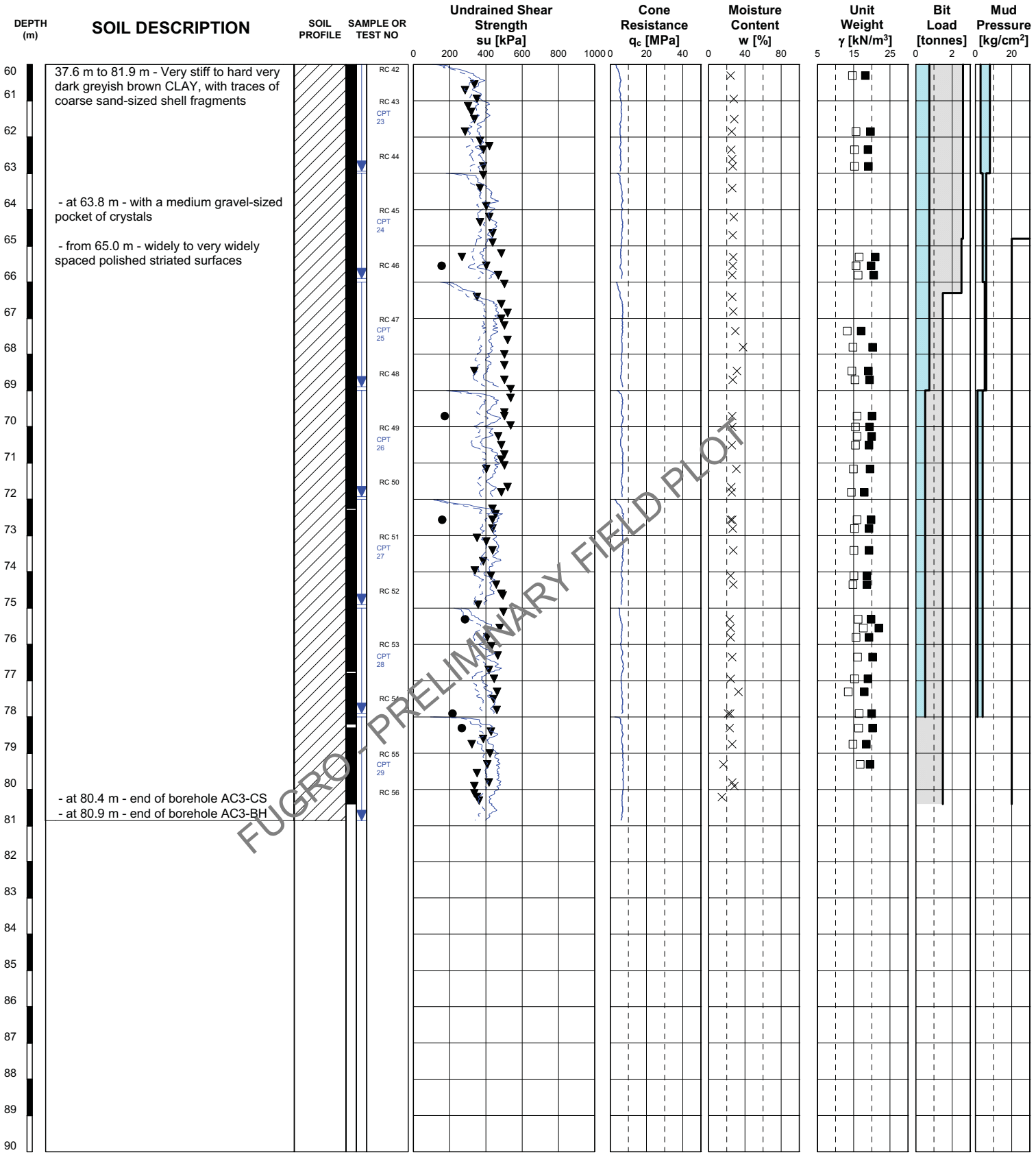
TYPE OF BIT: (1) PCD Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 441215.8 mE 5967863.5 mN (1) WATER DEPTH : 29.1 m LAT (1)
: 441212.7 mE 5967868.0 mN (2) : 30.1 m LAT (2)

DATE : 17/10/2012 - 19/10/2012 (1)
: 07/07/2012 - 08/07/2012 (2)

GeODin-System 7.5/21/10/2012 09:04:00

BOREHOLE AC3-CS (PRELIMINARY) SHEET 2 OF 3



DRILLING REMARKS:
Type of Mud: Guar-Gum
Notes:

Locations: (1) AC3-CS
(2) AC3-BH

Soil Profile is represented by location AC3-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane)
■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer)
● s_u (Undrained Triaxial)
◆ s_u (Fall Cone)
✦ s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane)
Estimated from CPT data (N_{kt} = 15 - 20)
Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

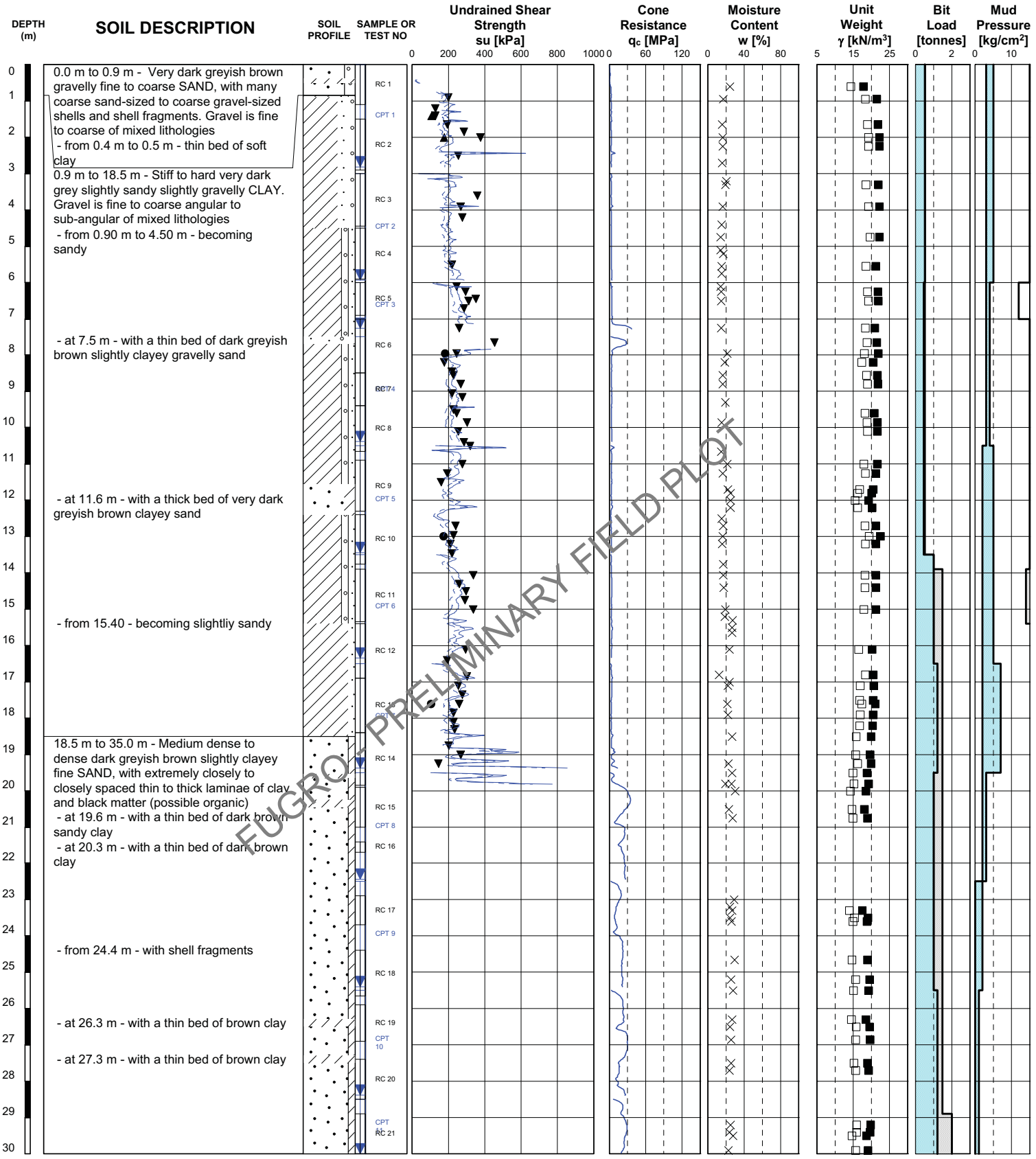
TYPE OF BIT: (1) PCD Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 441215.8 mE 5967863.5 mN (1) WATER DEPTH : 29.1 m LAT (1)
: 441212.7 mE 5967868.0 mN (2) : 30.1 m LAT (2)

DATE : 17/10/2012 - 19/10/2012 (1)
: 07/07/2012 - 08/07/2012 (2)

GeODin-System 7.5/21/10/2012 09:04:01

BOREHOLE AC3-CS (PRELIMINARY) SHEET 3 OF 3



DRILLING REMARKS:
Type of Bit: - CS locations: TC Hexagon Bit
- BH locations: 5 Wing Drag Bit
Type of Mud: Guar Gum water mixture

Notes: (1) DC1-CS
(2) DC1-BH

Soil Profile is represented by location DC1-CS

* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:

- ▲ s_u (Torvane)
- ■ s_u (Laboratory Vane)
- ▼ s_u (Pocket Penetrometer)
- ● s_u (Undrained Triaxial)
- ◆ s_u (Fall Cone)
- + s_u (In situ Vane)
- ✳ s_u (Remoulded In situ Vane)
- Estimated from CPT data (N_{kt} = 15 - 20)

Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:

- × Moisture Content (w)

KEY FOR UNIT WEIGHT:

- □ Natural Dry Unit Weight (γ_d)
- ■ Natural Wet Unit Weight (γ_w)

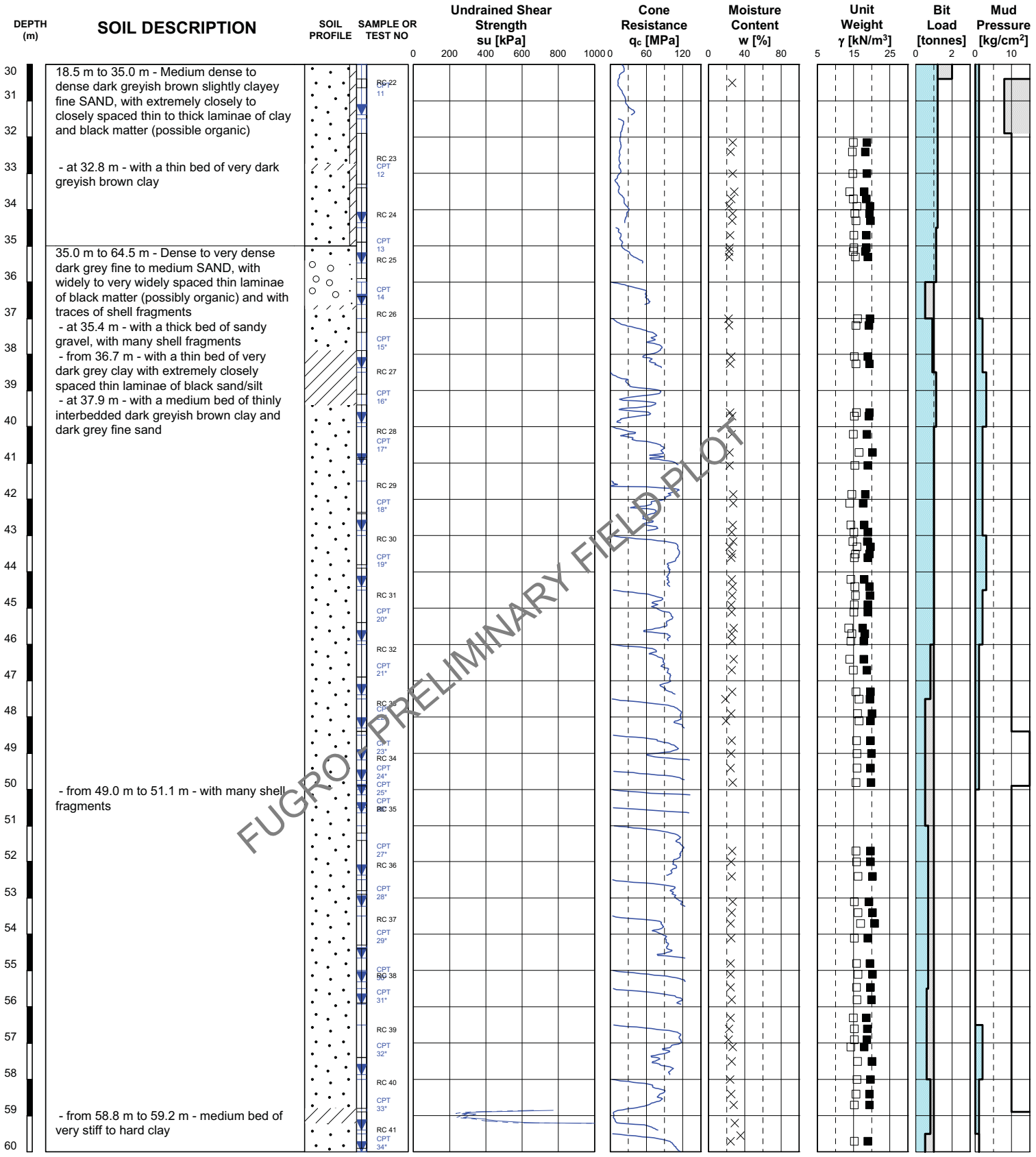
LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 419244.8 mE 5966400.2 mN (1) WATER DEPTH : 33.9 m LAT (1)
: 419249.6 mE 5966400.7 mN (2) : 33.6 m LAT (2)

DATE : 08/10/2012 - 10/10/2012 (1)
: 24/06/2012 - 25/06/2012 (2)

FUGRO

GeODin-System 7.5//12/10/2012 02:59:21

BOREHOLE DC1-CS (PRELIMINARY) SHEET 1 OF 3



DRILLING REMARKS:
Type of Bit: - CS locations: TC Hexagon Bit
- BH locations: 5 Wing Drag Bit
Type of Mud: Guar Gum water mixture

Notes: (1) DC1-CS
(2) DC1-BH

Soil Profile is represented by location DC1-CS

* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:

- ▲ s_u (Torvane)
- ■ s_u (Laboratory Vane)
- ▼ s_u (Pocket Penetrometer)
- ● s_u (Undrained Triaxial)
- ◆ s_u (Fall Cone)
- + s_u (In situ Vane)
- ✳ s_u (Remoulded In situ Vane)
- Estimated from CPT data (N_{kt} = 15 - 20)

Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:

- × Moisture Content (w)

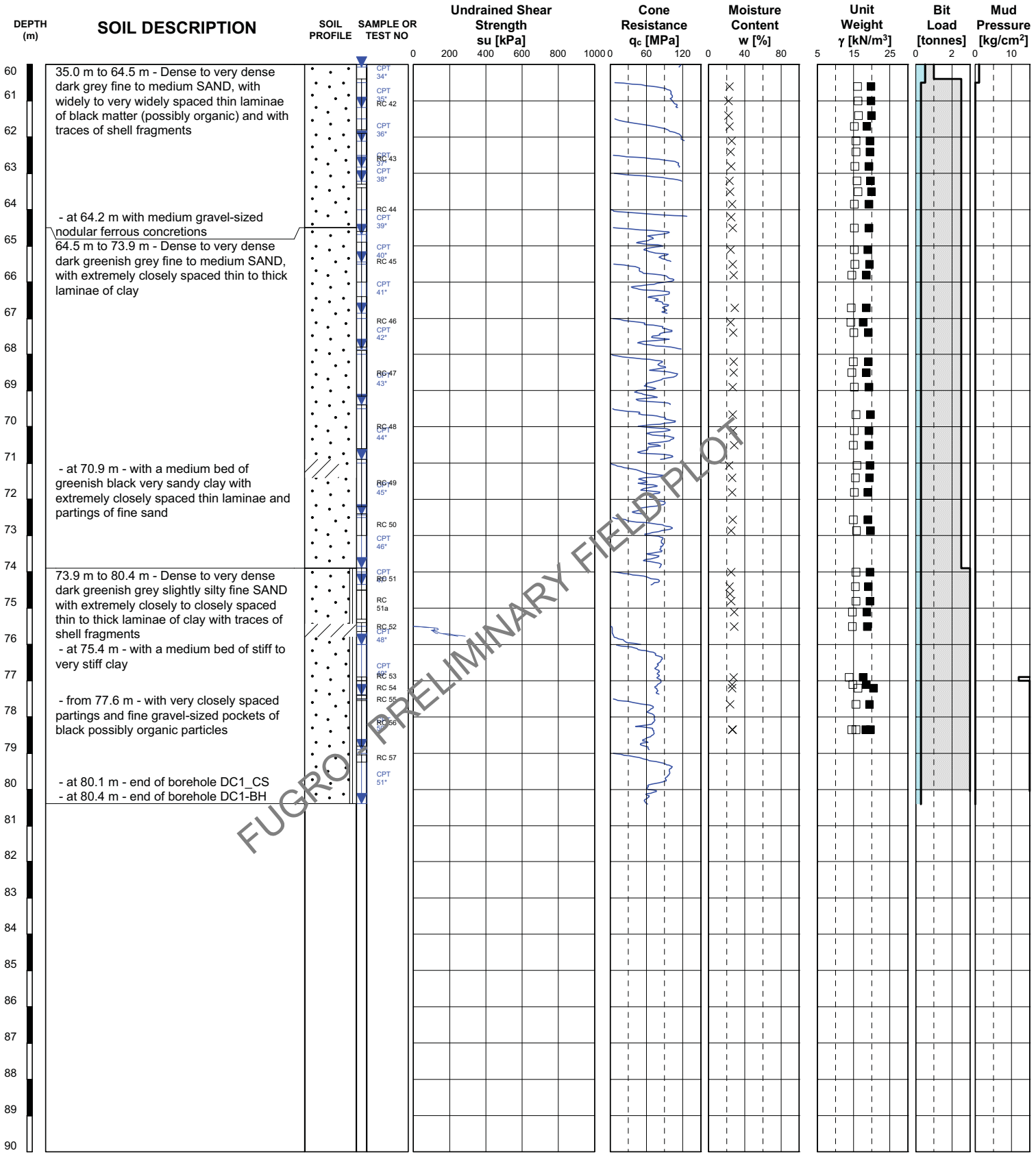
KEY FOR UNIT WEIGHT:

- □ Natural Dry Unit Weight (γ_d)
- ■ Natural Wet Unit Weight (γ_w)

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 419244.8 mE 5966400.2 mN (1) WATER DEPTH : 33.9 m LAT (1)
: 419249.6 mE 5966400.7 mN (2) : 33.6 m LAT (2)

DATE : 08/10/2012 - 10/10/2012 (1)
: 24/06/2012 - 25/06/2012 (2)

GeODin-System 7.5//12/10/2012 02:59:21



DRILLING REMARKS:
Type of Bit: - CS locations: TC Hexagon Bit
- BH locations: 5 Wing Drag Bit
Type of Mud: Guar Gum water mixture

Notes: (1) DC1-CS
(2) DC1-BH

Soil Profile is represented by location DC1-CS

* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:

- ▲ s_u (Torvane)
- ■ s_u (Laboratory Vane)
- ▼ s_u (Pocket Penetrometer)
- ● s_u (Undrained Triaxial)
- ◆ s_u (Fall Cone)
- + s_u (In situ Vane)
- ✳ s_u (Remoulded In situ Vane)
- Estimated from CPT data (N_{kt} = 15 - 20)

Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:

- × Moisture Content (w)

KEY FOR UNIT WEIGHT:

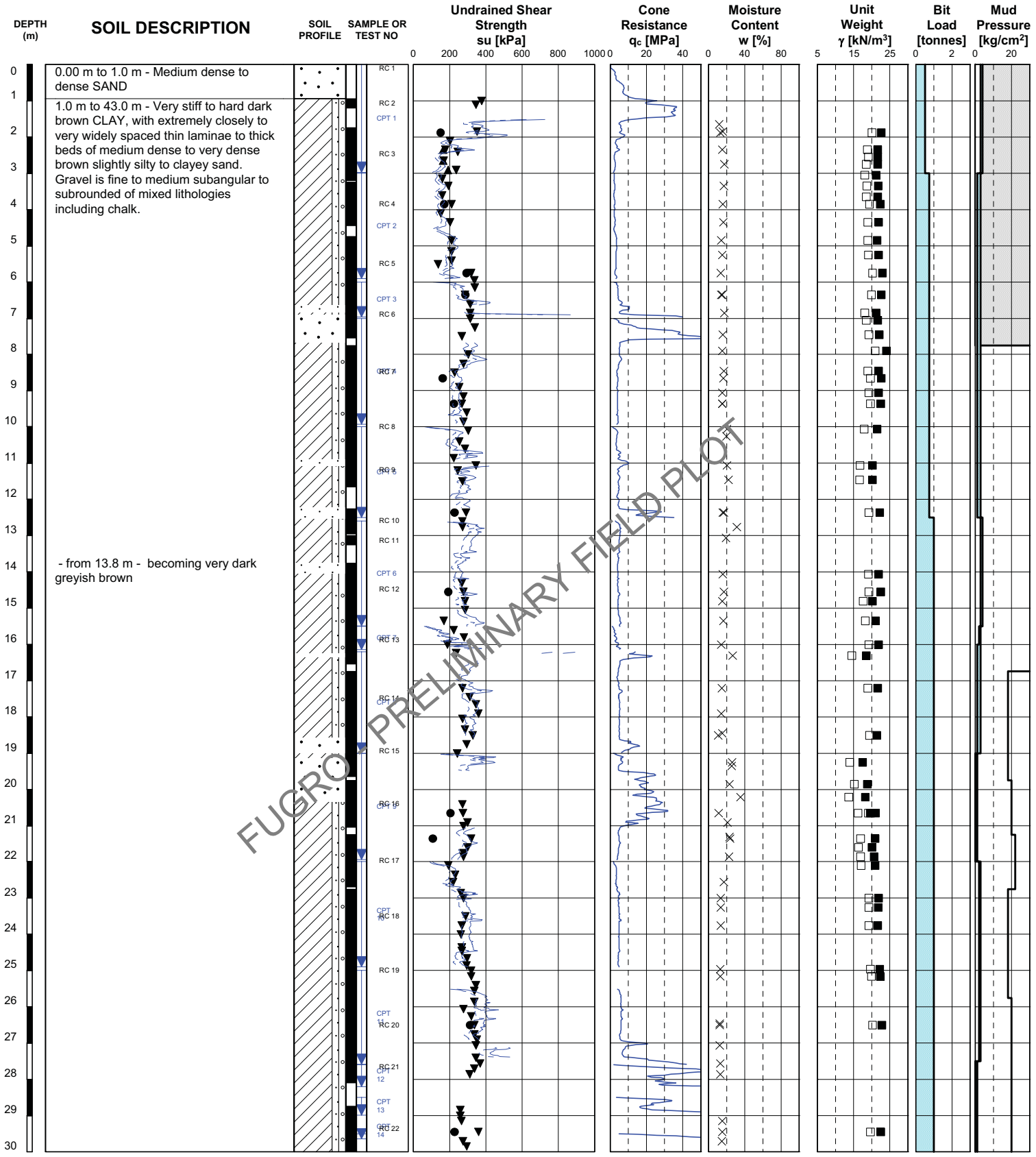
- □ Natural Dry Unit Weight (γ_d)
- ■ Natural Wet Unit Weight (γ_w)

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 419244.8 mE 5966400.2 mN (1) WATER DEPTH : 33.9 m LAT (1)
: 419249.6 mE 5966400.7 mN (2) : 33.6 m LAT (2)

DATE : 08/10/2012 - 10/10/2012 (1)
: 24/06/2012 - 25/06/2012 (2)

GeODin-System 7.5//12/10/2012 02:59:22

BOREHOLE DC1-CS (PRELIMINARY) SHEET 3 OF 3



DRILLING REMARKS:
Type of Mud: Guar-Gum
Notes:

Locations: (1) NJ101-CS
(2) NJ101-BH

Soil Profile is represented by location NJ101-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
- ▲ s_u (Torvane)
- ■ s_u (Laboratory Vane)
- ▼ s_u (Pocket Penetrometer)
- ● s_u (Undrained Triaxial)
- ◆ s_u (Fall Cone)
- + s_u (In situ Vane)
- ✳ s_u (Remoulded In situ Vane)
- Estimated from CPT data (N_{kt} = 15 - 20)

Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
- × Moisture Content (w)

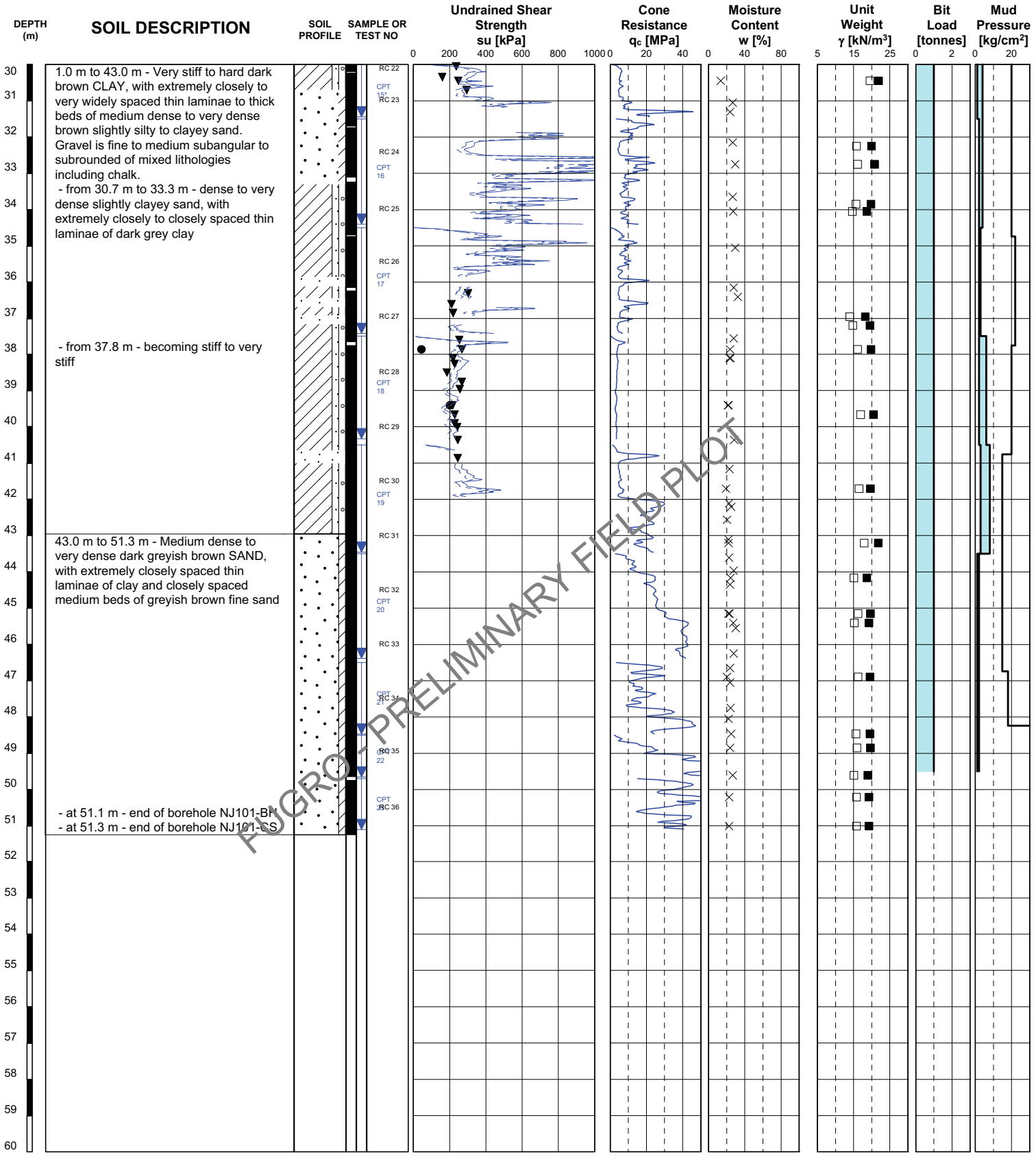
KEY FOR UNIT WEIGHT:
- □ Natural Dry Unit Weight (γ_d)
- ■ Natural Wet Unit Weight (γ_w)

TYPE OF BIT: (1) TC Hexagon Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 432591.3 mE 5970993.2 mN (1) WATER DEPTH : 29.3 m LAT (1)
: 432587.8 mE 5970988.8 mN (2) : 29.1 m LAT (2)

DATE : 19/10/2012 - 20/10/2012 (1)
: 20/07/2012 - 21/07/2012 (2)

GeODin-System 7.5//22/10/2012 04:15:30



DRILLING REMARKS:
Type of Mud: Guar-Gum
Notes:

Locations: (1) NJ101-CS
(2) NJ101-BH

Soil Profile is represented by location NJ101-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
- ▲ s_u (Torvane)
- ■ s_u (Laboratory Vane)
- ▼ s_u (Pocket Penetrometer)
- ● s_u (Undrained Triaxial)
- ◆ s_u (Fall Cone)
- + s_u (In situ Vane)
- ✳ s_u (Remoulded In situ Vane)
- Estimated from CPT data (N_{kt} = 15 - 20)

Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
- × Moisture Content (w)

KEY FOR UNIT WEIGHT:
- □ Natural Dry Unit Weight (γ_d)
- ■ Natural Wet Unit Weight (γ_w)

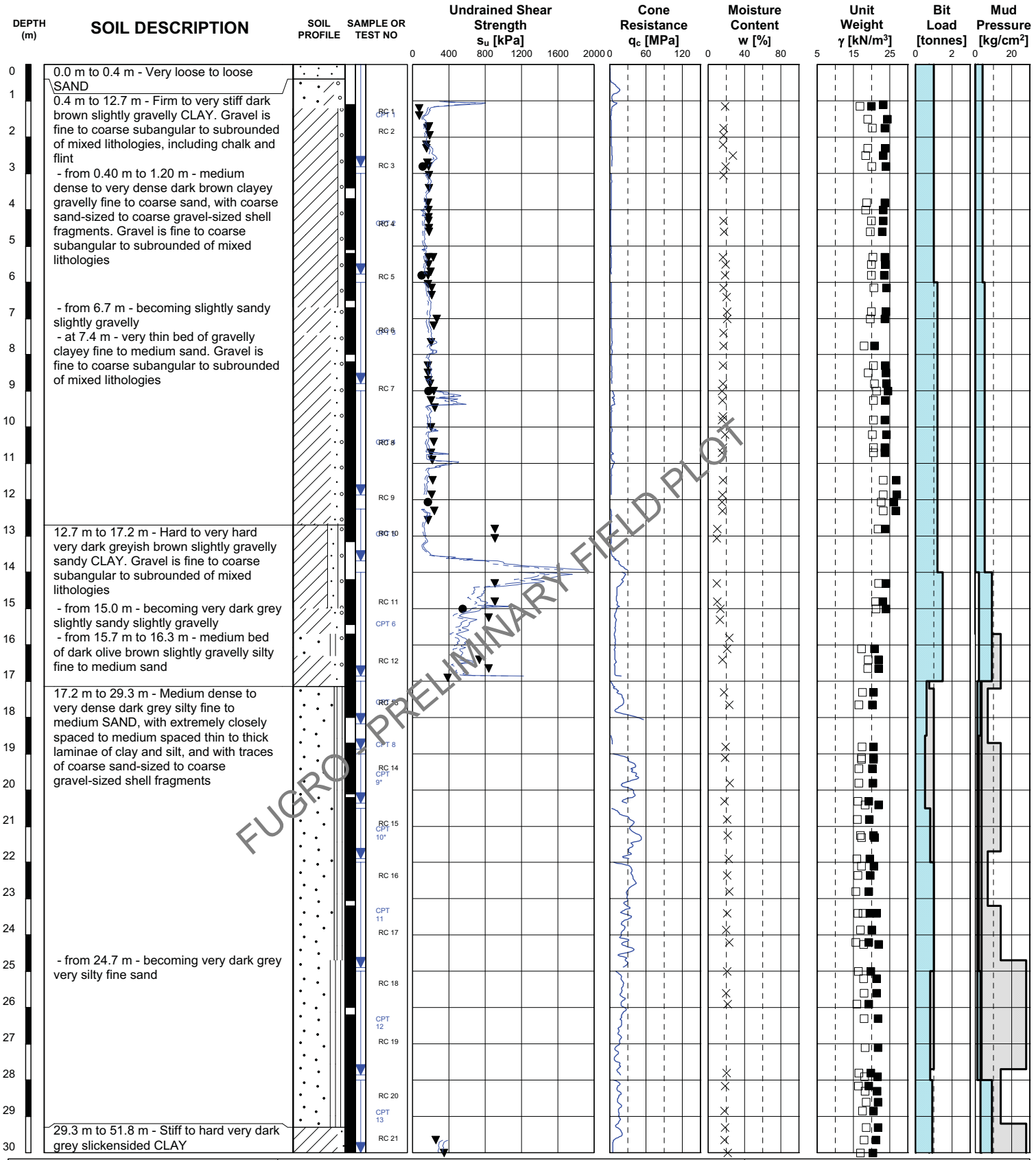
TYPE OF BIT: (1) TC Hexagon Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 432591.3 mE 5970993.2 mN (1) WATER DEPTH : 29.3 m LAT (1)
: 432587.8 mE 5970988.8 mN (2) : 29.1 m LAT (2)

DATE : 19/10/2012 - 20/10/2012 (1)
: 20/07/2012 - 21/07/2012 (2)

GeODin-System 7.5//22/10/2012 04:15:31

BOREHOLE NJ101-CS (PRELIMINARY) SHEET 2 OF 2



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) NJ102-CS
(2) NJ102-BH

Soil Profile is represented by location NJ102-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane) ■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer) ● s_u (Undrained Triaxial)
◆ s_u (Fall Cone) ✦ s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane) Estimated from CPT data (N_{kt} = 15 - 20)
Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

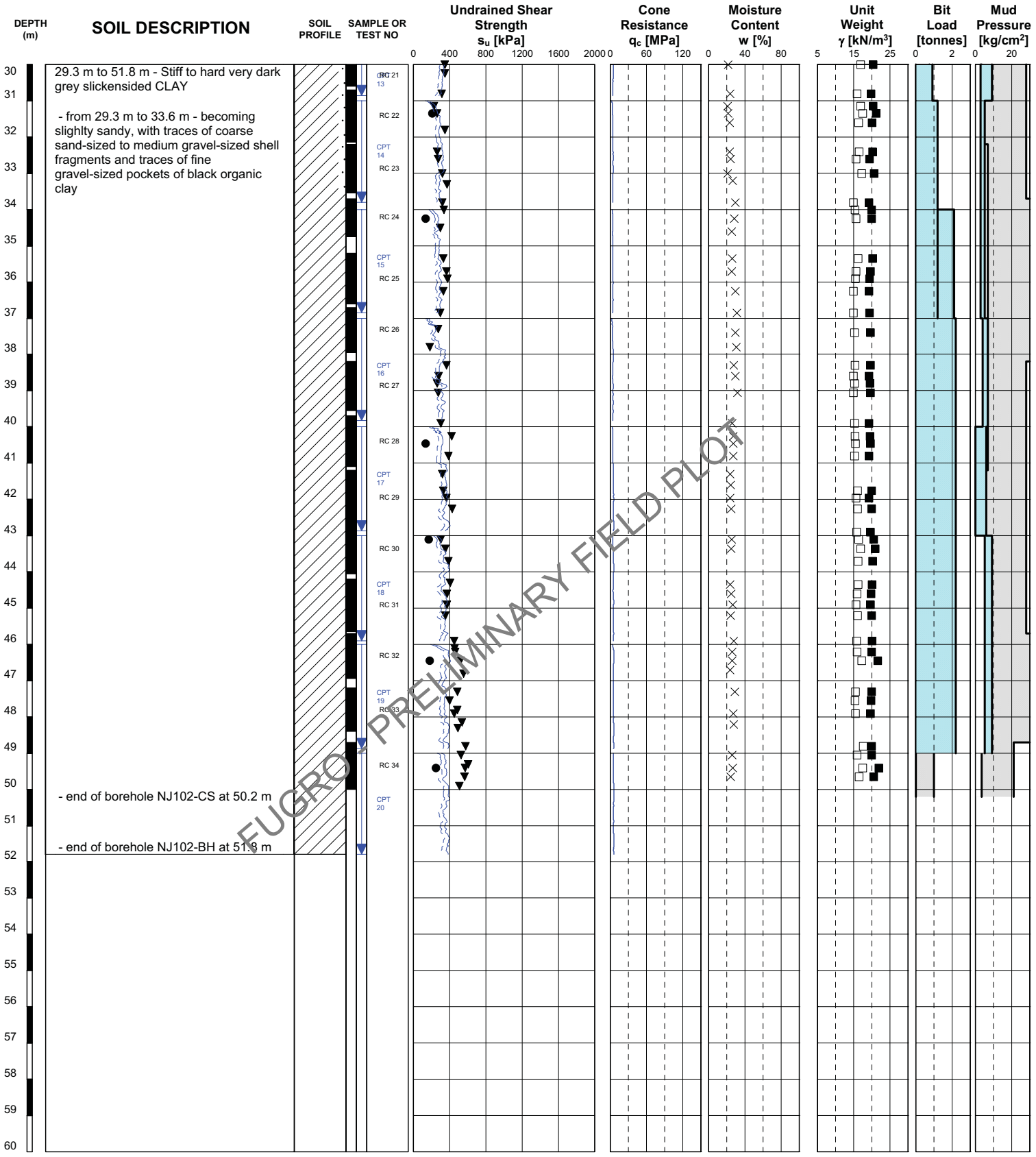
TYPE OF BIT: (1) PCD Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 437322.4 mE 5966456.5 mN (1) WATER DEPTH : 29.5 m LAT (1)
: 437326.6 mE 5966460.4 mN (2) : 29.2 m LAT (2)

DATE : 17/11/2012 - 18/11/2012 (1)
: 31/07/2012 - 01/08/2012 (2)

GeODin-System 7.5//20/11/2012 16:41:26

BOREHOLE NJ102-CS (PRELIMINARY) SHEET 1 OF 2



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) NJ102-CS
(2) NJ102-BH

Soil Profile is represented by location NJ102-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane)
■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer)
● s_u (Undrained Triaxial)
◆ s_u (Fall Cone)
✦ s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane)
Estimated from CPT data (N_{kt} = 15 - 20)
Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

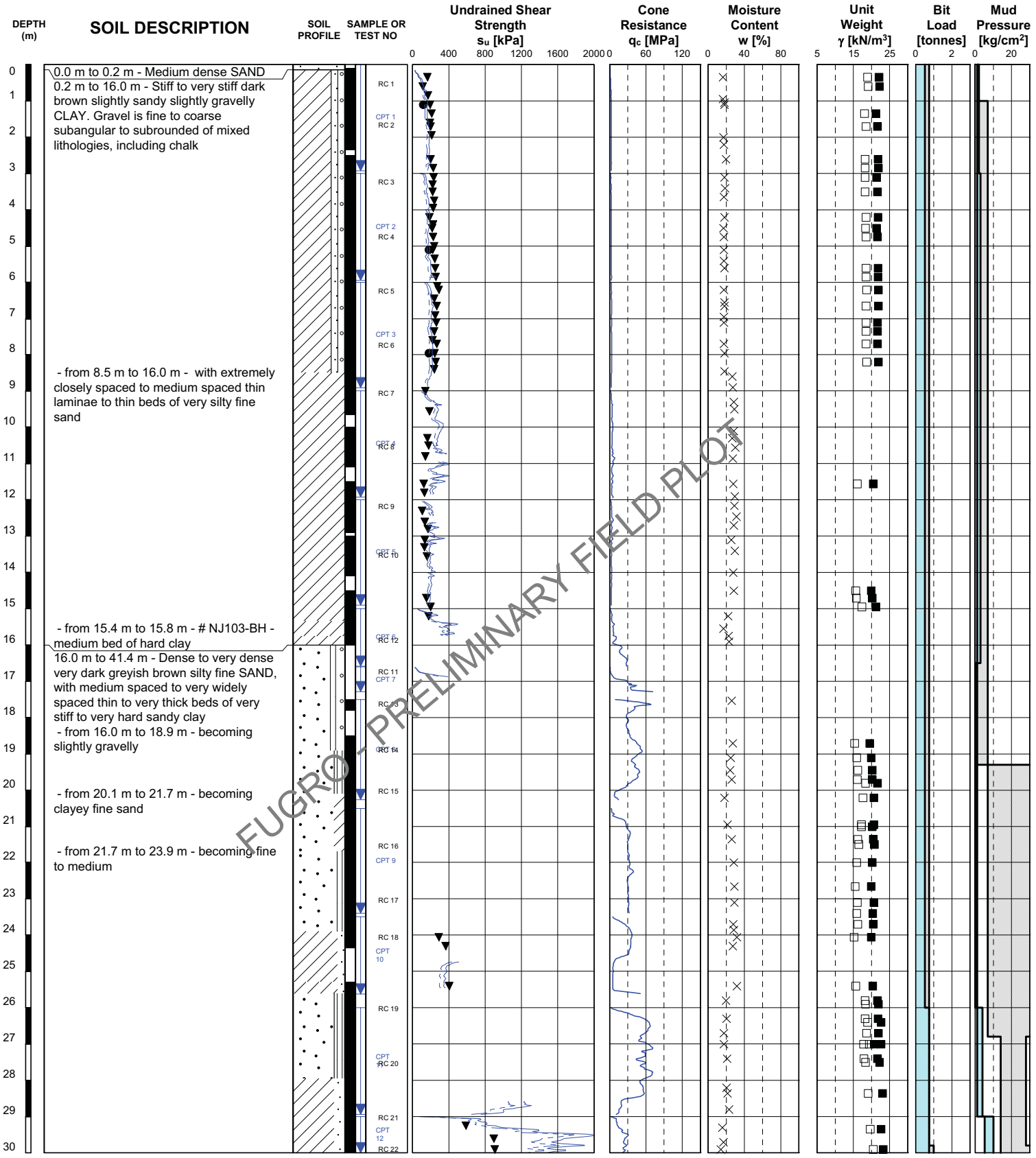
TYPE OF BIT: (1) PCD Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 437322.4 mE 5966456.5 mN (1) WATER DEPTH : 29.5 m LAT (1)
: 437326.6 mE 5966460.4 mN (2) : 29.2 m LAT (2)

DATE : 17/11/2012 - 18/11/2012 (1)
: 31/07/2012 - 01/08/2012 (2)

GeODin-System 7.5//20/11/2012 16:41:26

BOREHOLE NJ102-CS (PRELIMINARY) SHEET 2 OF 2



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) NJ103-CS
(2) NJ103-BH

Soil Profile is represented by location NJ103-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane) ■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer) ● s_u (Undrained Triaxial)
◆ s_u (Fall Cone) ✦ s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane) Estimated from CPT data (N_{kt} = 15 - 20)
Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

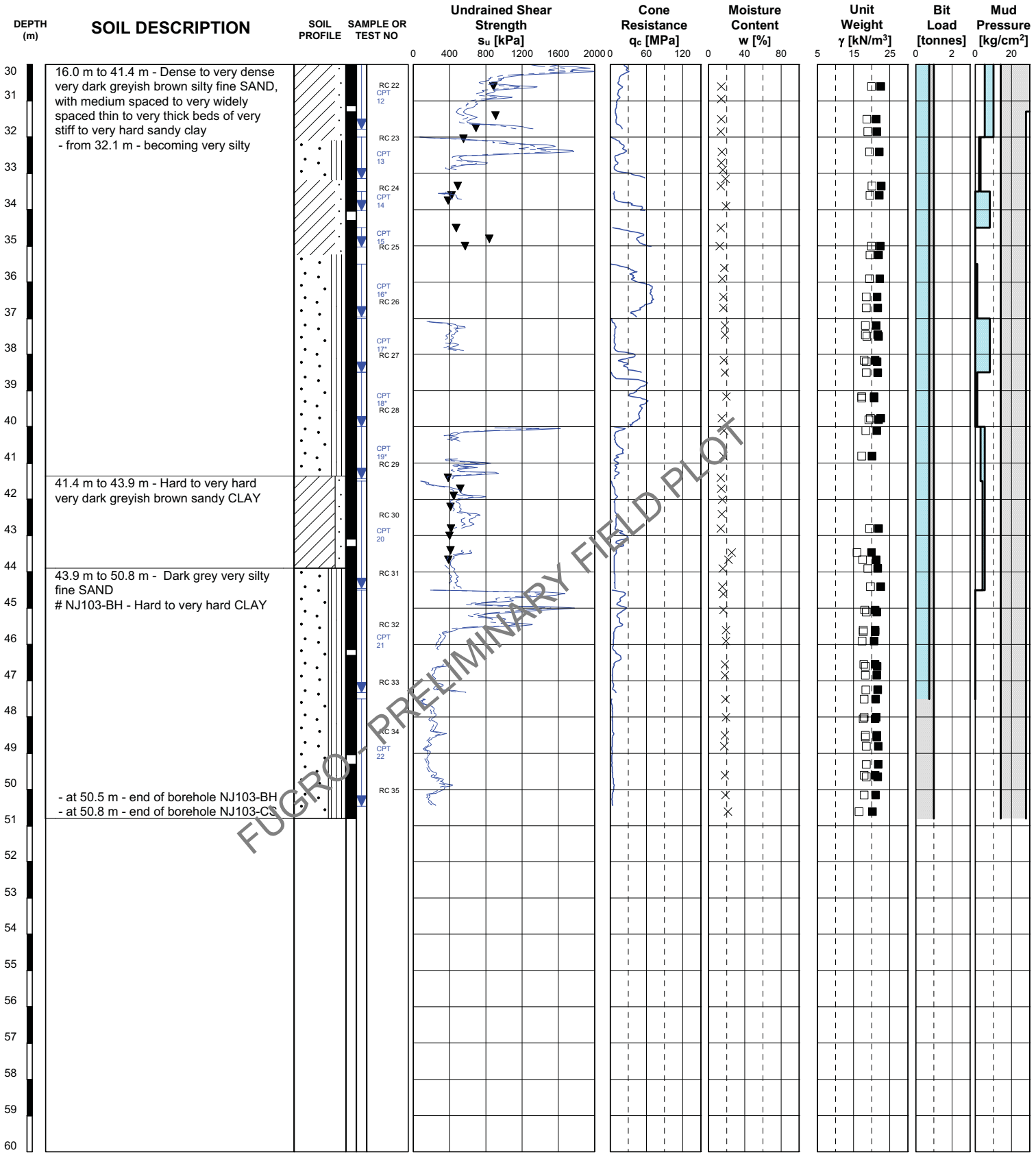
TYPE OF BIT: (1) PCD Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 439292.2 mE 5972458.7 mN (1) WATER DEPTH : 33.8 m LAT (1)
: 439298.1 mE 5972459.0 mN (2) : 34.1 m LAT (2)

DATE : 26/11/2012 - 26/11/2012 (1)
: 24/07/2012 - 25/07/2012 (2)

GeODin-System 7.5//28/11/2012 13:47:25

BOREHOLE NJ103-CS (PRELIMINARY) SHEET 1 OF 2



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) NJ103-CS
(2) NJ103-BH

Soil Profile is represented by location NJ103-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:

- ▲ s_u (Torvane)
- ■ s_u (Laboratory Vane)
- ▼ s_u (Pocket Penetrometer)
- ● s_u (Undrained Triaxial)
- ◆ s_u (Fall Cone)
- + s_u (In situ Vane)
- ✳ s_u (Remoulded In situ Vane)
- Estimated from CPT data (N_{kt} = 15 - 20)

Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:

- × Moisture Content (w)

KEY FOR UNIT WEIGHT:

- □ Natural Dry Unit Weight (γ_d)
- ■ Natural Wet Unit Weight (γ_w)

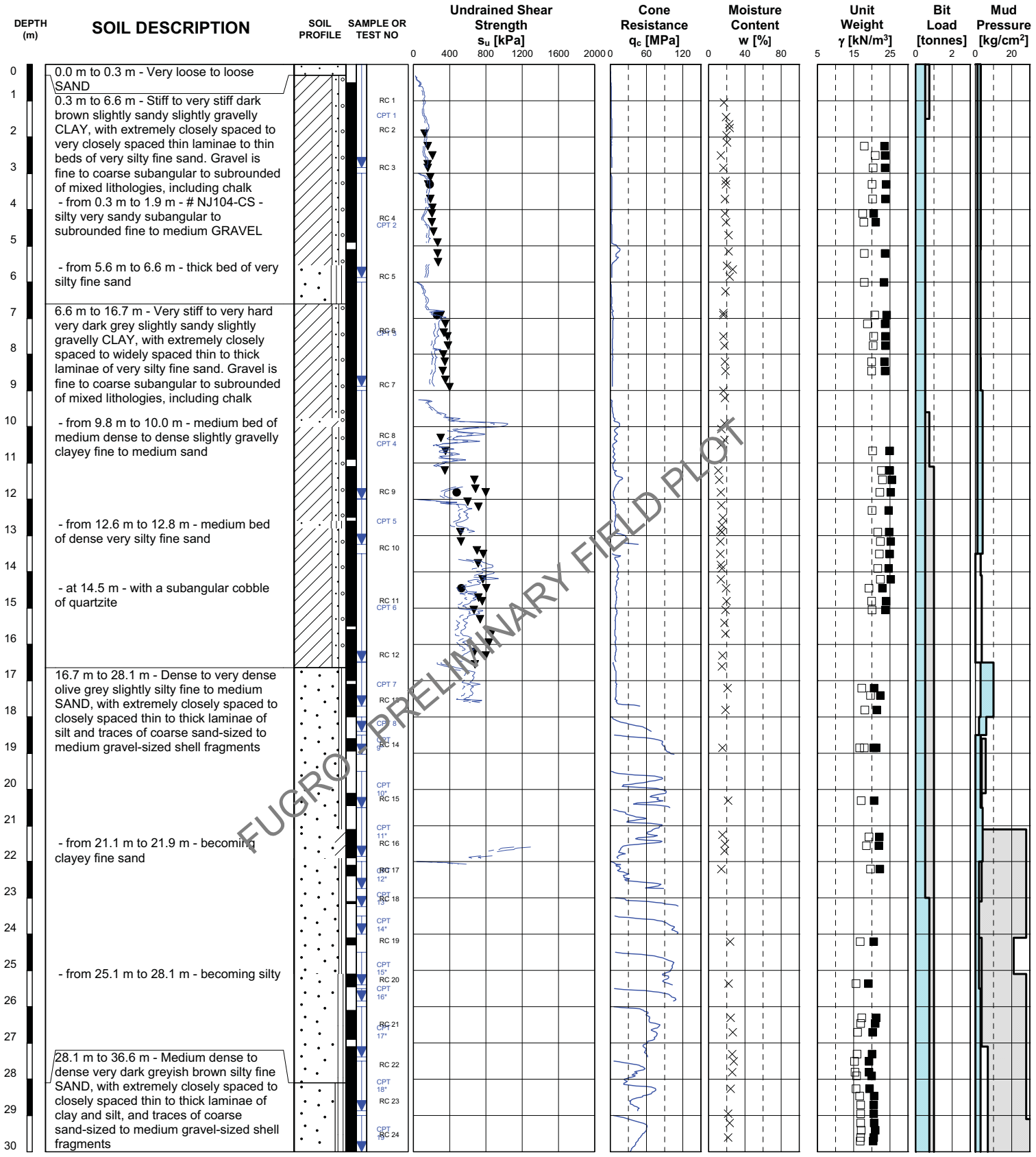
TYPE OF BIT: (1) PCD Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 439292.2 mE 5972458.7 mN (1) WATER DEPTH : 33.8 m LAT (1)
: 439298.1 mE 5972459.0 mN (2) : 34.1 m LAT (2)

DATE : 26/11/2012 - 26/11/2012 (1)
: 24/07/2012 - 25/07/2012 (2)

GeODin-System 7.5//28/11/2012 13:47:26

BOREHOLE NJ103-CS (PRELIMINARY) SHEET 2 OF 2



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) NJ104-CS
(2) NJ104-BH

Soil Profile is represented by location NJ104-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane) ■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer) ● s_u (Undrained Triaxial)
◆ s_u (Fall Cone) ✦ s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane) Estimated from CPT data (N_{kt} = 15 - 20)
Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

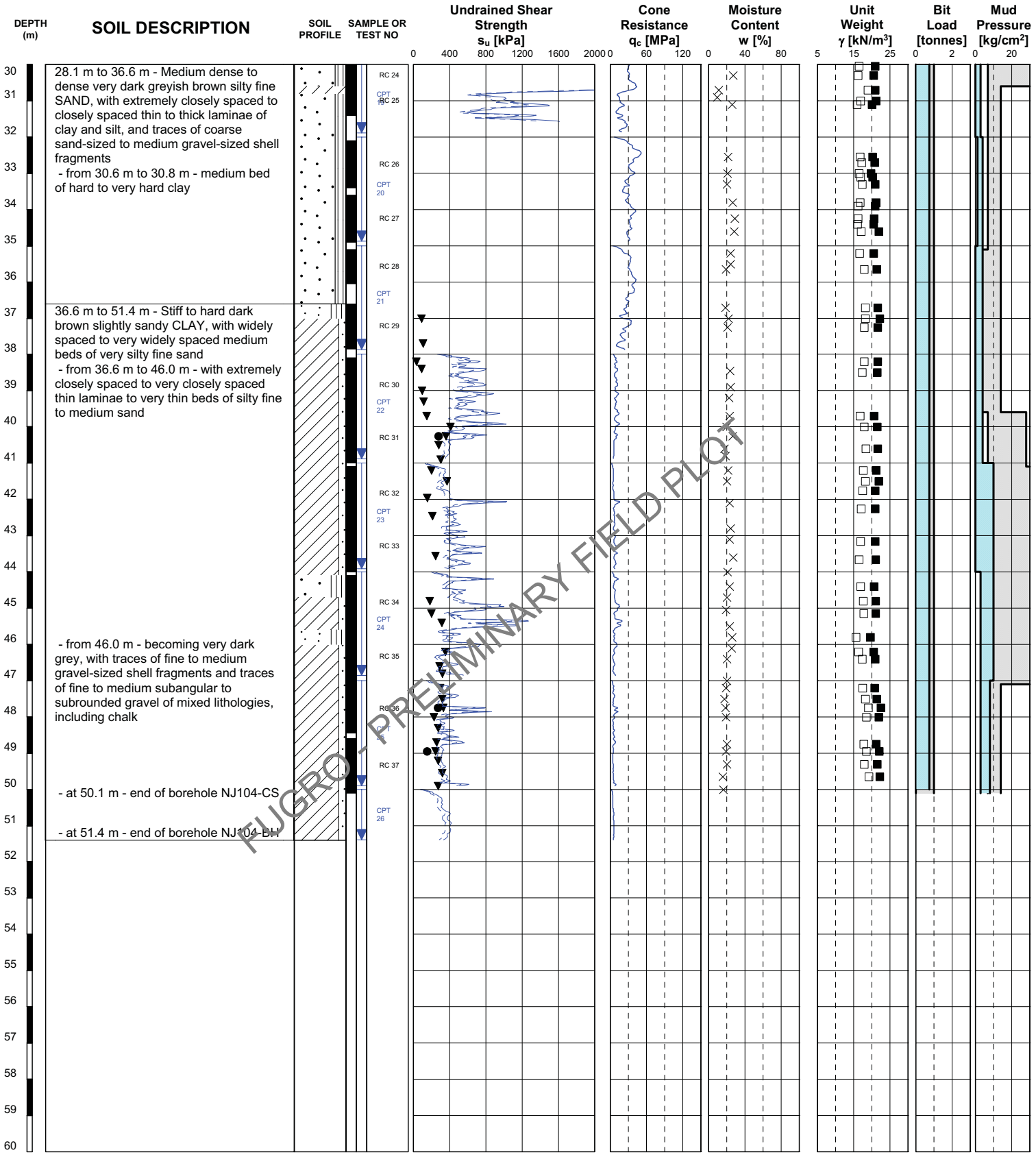
KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

TYPE OF BIT: (1) PCD Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 441901.7 mE 5965239.0 mN (1) WATER DEPTH : 30.3 m LAT (1)
: 441904.0 mE 5965234.5 mN (2) : 30.1 m LAT (2)

DATE : 18/11/2012 - 18/11/2012 (1)
: 09/07/2012 - 10/07/2012 (2)

GeODin-System 7.5//21/11/2012 07:06:30



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) NJ104-CS
(2) NJ104-BH

Soil Profile is represented by location NJ104-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:

▲	s_u (Torvane)	■	s_u (Laboratory Vane)
▼	s_u (Pocket Penetrometer)	●	s_u (Undrained Triaxial)
◆	s_u (Fall Cone)	✦	s_u (In situ Vane)
✳	s_u (Remoulded In situ Vane)	⫧ / ⫧	Estimated from CPT data (N_{kt} = 15 - 20)

Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

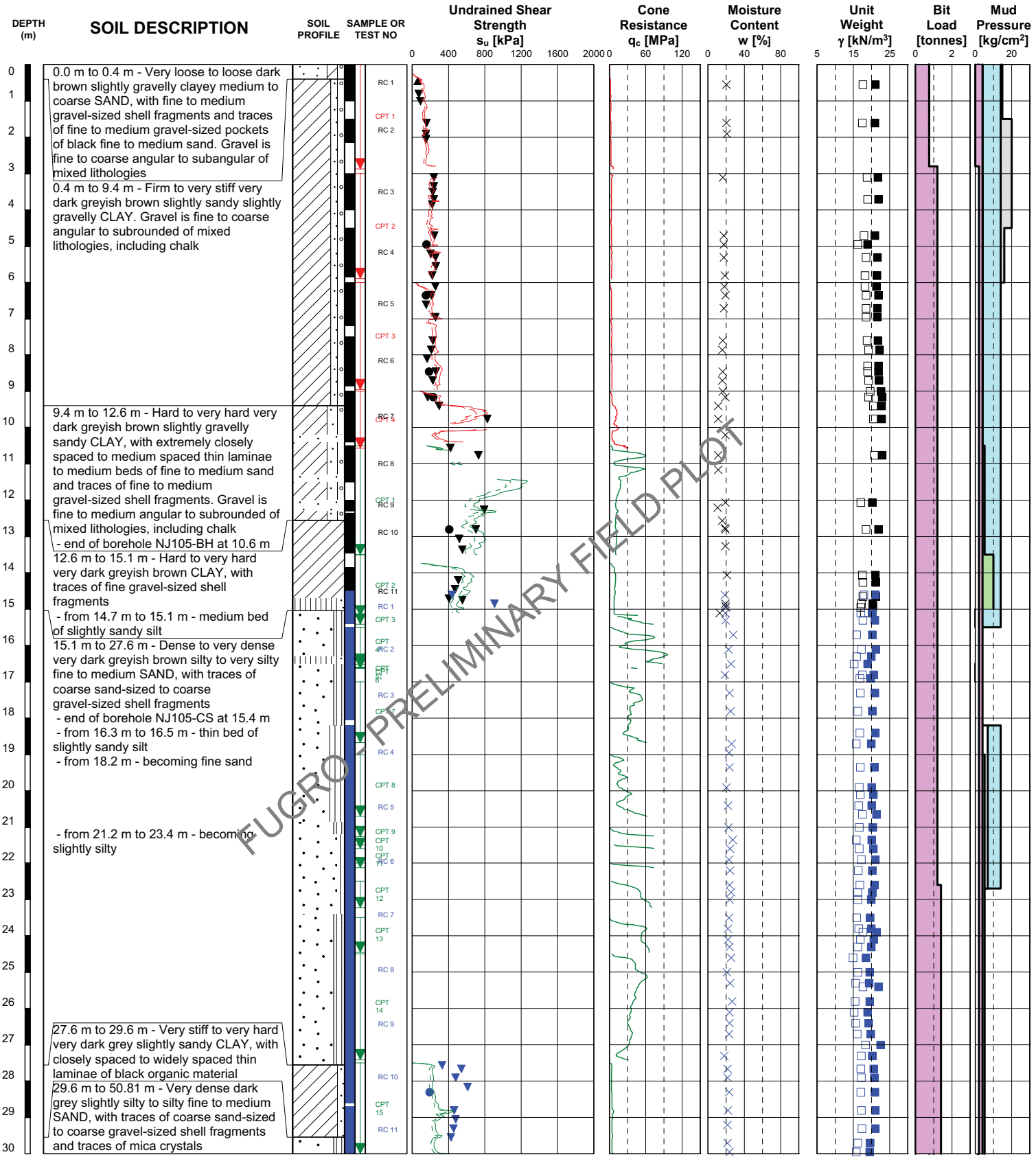
TYPE OF BIT: (1) PCD Bit
(2) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 441901.7 mE 5965239.0 mN (1) WATER DEPTH : 30.3 m LAT (1)
: 441904.0 mE 5965234.5 mN (2) : 30.1 m LAT (2)

DATE : 18/11/2012 - 18/11/2012 (1)
: 09/07/2012 - 10/07/2012 (2)

GeODin-System 7.5//21/11/2012 07:06:31

BOREHOLE NJ104-CS (PRELIMINARY) SHEET 2 OF 2



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) NJ105-CS (2) NJ105-CSa (3) NJ105-BH (4) NJ105a-BH (5) NJ105b-BH
Soil Profile is represented by location NJ105-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane) ■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer) ● s_u (Undrained Triaxial)
◆ s_u (Fall Cone) ✦ s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane) Estimated from CPT data (N_{kt} = 15 - 20)
Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

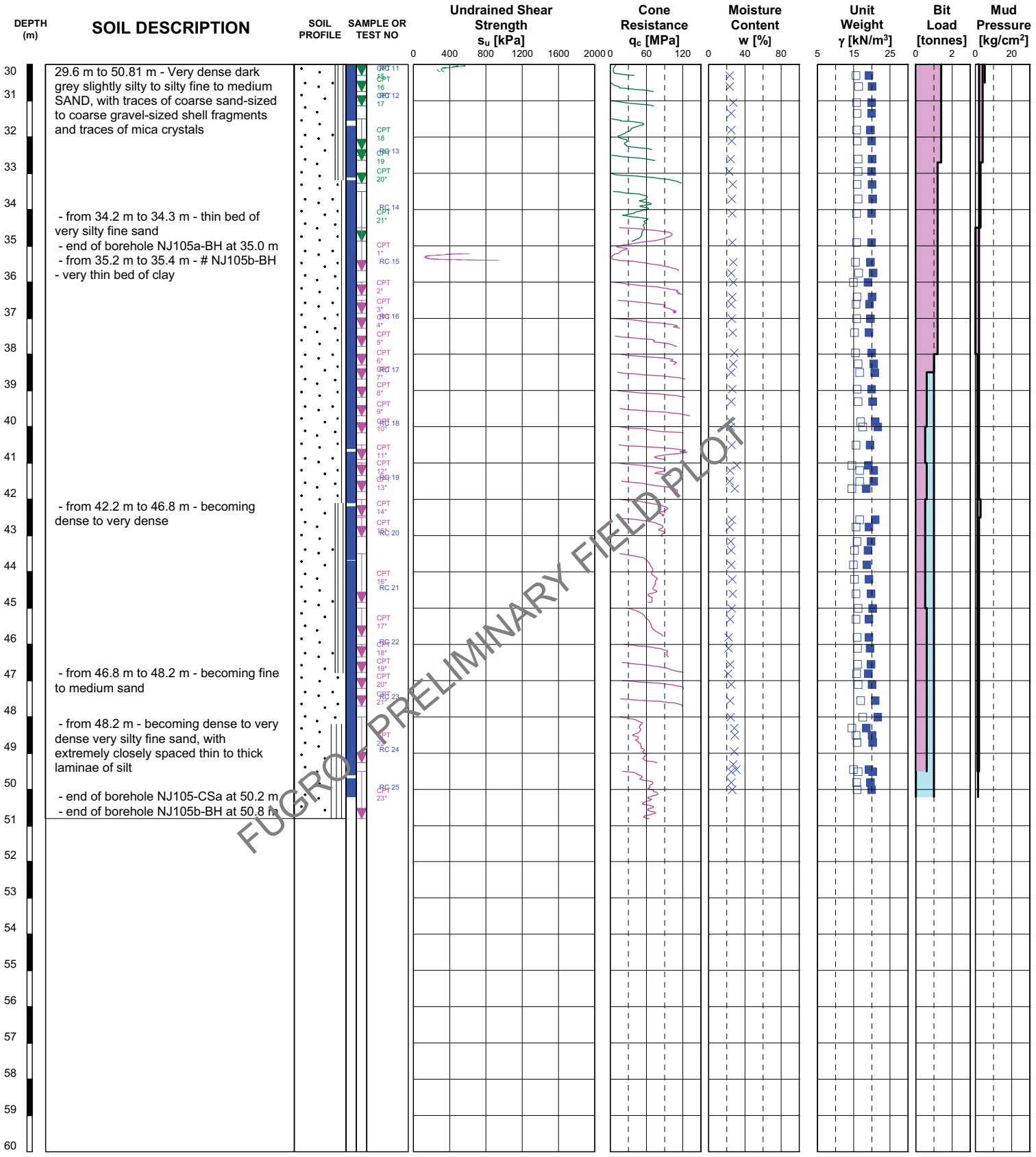
TYPE OF BIT: (1) TC Hexagon Bit (2) PCD Bit (3) 5 Wing Drag Bit (4) 5 Wing Drag Bit (5) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation

COORDINATES		WATER DEPTH	DATE
: 444490.6 mE	5970257.5 mN (1)	: 32.3 m LAT (1)	: 15/12/2012 - 15/10/2012 (1)
: 444488.5 mE	5970251.1 mN (2)	: 32.5 m LAT (2)	: 23/11/2012 - 24/11/2012 (2)
: 444487.9 mE	5970255.2 mN (3)	: 31.6 m LAT (3)	: 22/07/2012 - 22/07/2012 (3)
: 444483.0 mE	5970255.1 mN (4)	: 32.9 m LAT (4)	: 25/07/2012 - 25/07/2012 (4)
: 444493.5 mE	5970255.3 mN (5)	: 32.2 m LAT (5)	: 30/07/2012 - 31/07/2012 (5)

GeODin-System 7.5//26/11/2012 02:59:59

BOREHOLE NJ105-CS (PRELIMINARY) SHEET 1 OF 2



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) NJ105-CS (2) NJ105-CSa (3) NJ105-BH (4) NJ105a-BH (5) NJ105b-BH
Soil Profile is represented by location NJ105-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane) ■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer) ● s_u (Undrained Triaxial)
◆ s_u (Fall Cone) ✦ s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane) Estimated from CPT data (N_{kt} = 15 - 20)
Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

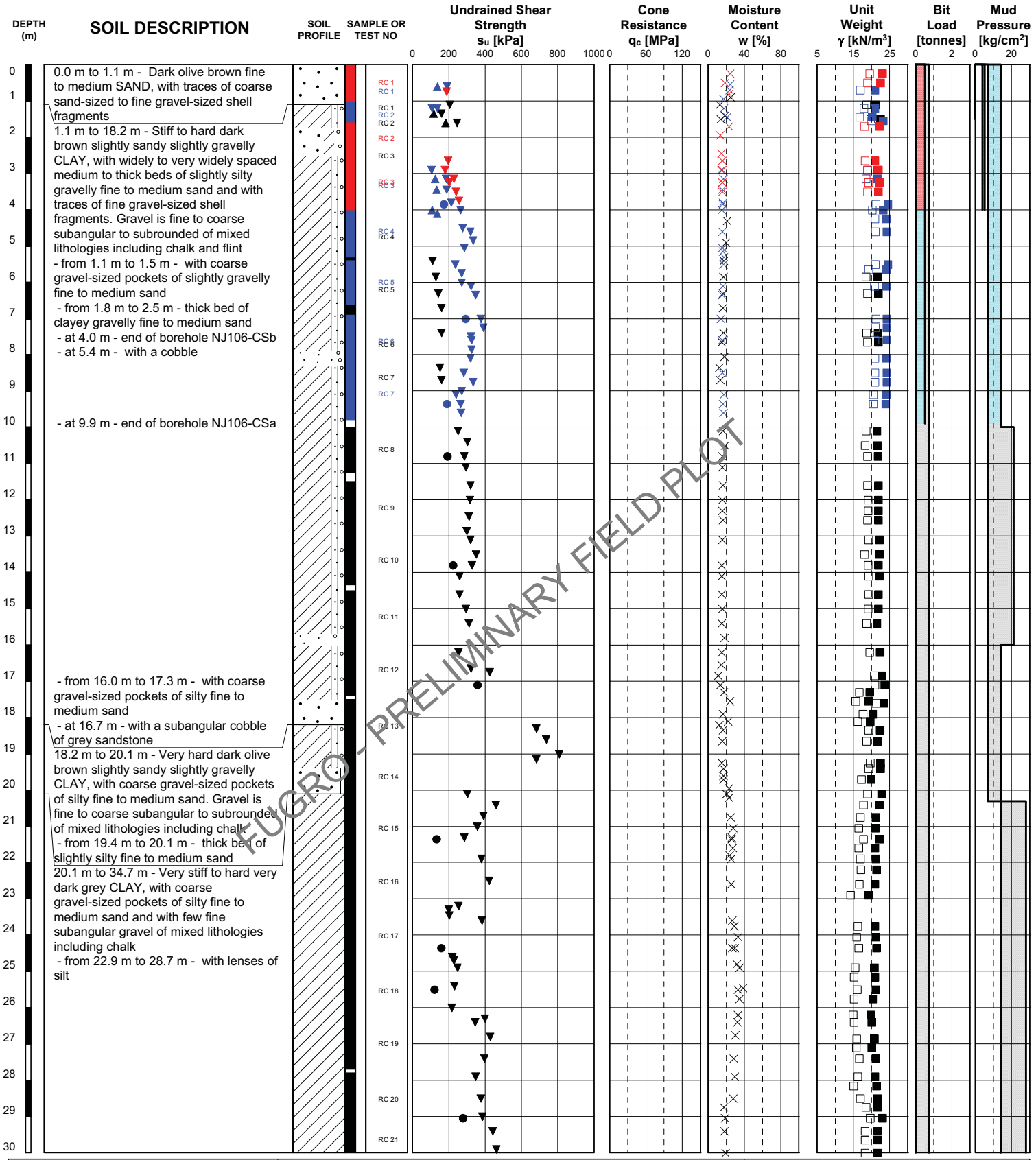
TYPE OF BIT: (1) TC Hexagon Bit (2) PCD Bit (3) 5 Wing Drag Bit (4) 5 Wing Drag Bit (5) 5 Wing Drag Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation

COORDINATES			WATER DEPTH	DATE
: 444490.6 mE	5970257.5 mN (1)		: 32.3 m LAT (1)	: 15/12/2012 - 15/10/2012 (1)
: 444488.5 mE	5970251.1 mN (2)		: 32.5 m LAT (2)	: 23/11/2012 - 24/11/2012 (2)
: 444487.9 mE	5970255.2 mN (3)		: 31.6 m LAT (3)	: 22/07/2012 - 22/07/2012 (3)
: 444483.0 mE	5970255.1 mN (4)		: 32.9 m LAT (4)	: 25/07/2012 - 25/07/2012 (4)
: 444493.5 mE	5970255.3 mN (5)		: 32.2 m LAT (5)	: 30/07/2012 - 31/07/2012 (5)

GeODin-System 7.5//26/11/2012 03:00:00

BOREHOLE NJ105-CS (PRELIMINARY) SHEET 2 OF 2



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) NJ106-CS
(2) NJ106-CSa
(3) NJ106-CSb
Soil Profile is represented by location NJ106-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane) ■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer) ● s_u (Undrained Triaxial)
◆ s_u (Fall Cone) + s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane) Estimated from CPT data (N_{kt} = 15 - 20)
Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

TYPE OF BIT: (1) PCD Bit
(2) PCD Bit
(3) PCD Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 429362.0 mE 5970075.7 mN (1) WATER DEPTH : 28.7 m LAT (1)
: 429363.3 mE 5970080.2 mN (2) : 28.8 m LAT (2)
: 429356.8 mE 5970080.2 mN (3) : 28.8 m LAT (3)

DATE : 10/11/2012 - 11/11/2012 (1)
: 12/11/2012 - 12/11/2012 (2)
: 12/11/2012 - 12/11/2012 (3)

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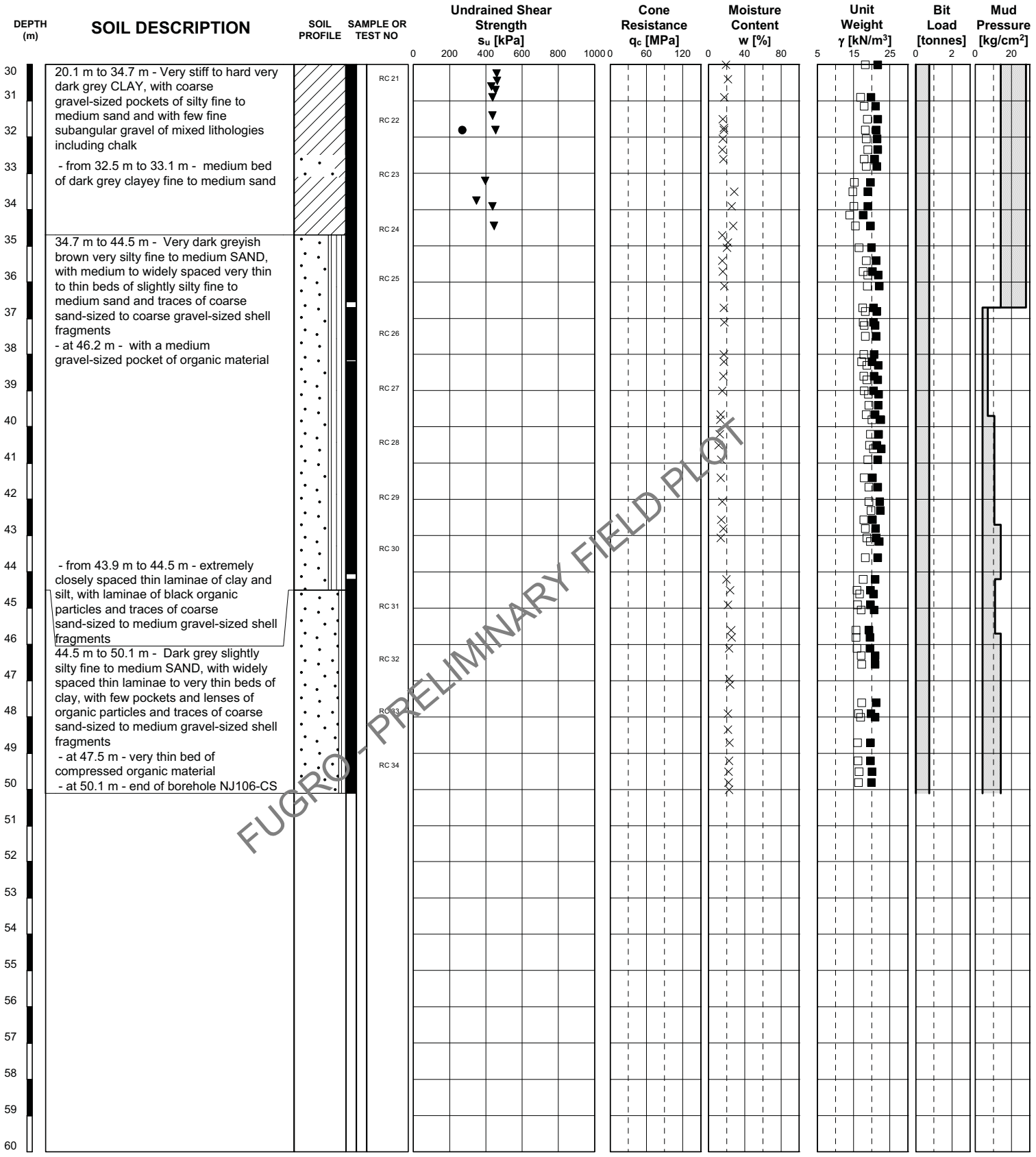
BOREHOLE NJ106-CS (PRELIMINARY) SHEET 1 OF 2



DRILLING REMARKS:
Type of Mud: Guar-Gum/Seawater
Notes:

Locations: (1) NJ106-CS
(2) NJ106-CSa
(3) NJ106-CSb
Soil Profile is represented by location NJ106-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane)
■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer)
● s_u (Undrained Triaxial)
◆ s_u (Fall Cone)
✦ s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane)
Estimated from CPT data (N_{kt} = 15 - 20)
Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

TYPE OF BIT: (1) PCD Bit
(2) PCD Bit
(3) PCD Bit

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 429362.0 mE 5970075.7 mN (1) WATER DEPTH : 28.7 m LAT (1)
: 429363.3 mE 5970080.2 mN (2) : 28.8 m LAT (2)
: 429356.8 mE 5970080.2 mN (3) : 28.8 m LAT (3)

DATE : 10/11/2012 - 11/11/2012 (1)
: 12/11/2012 - 12/11/2012 (2)
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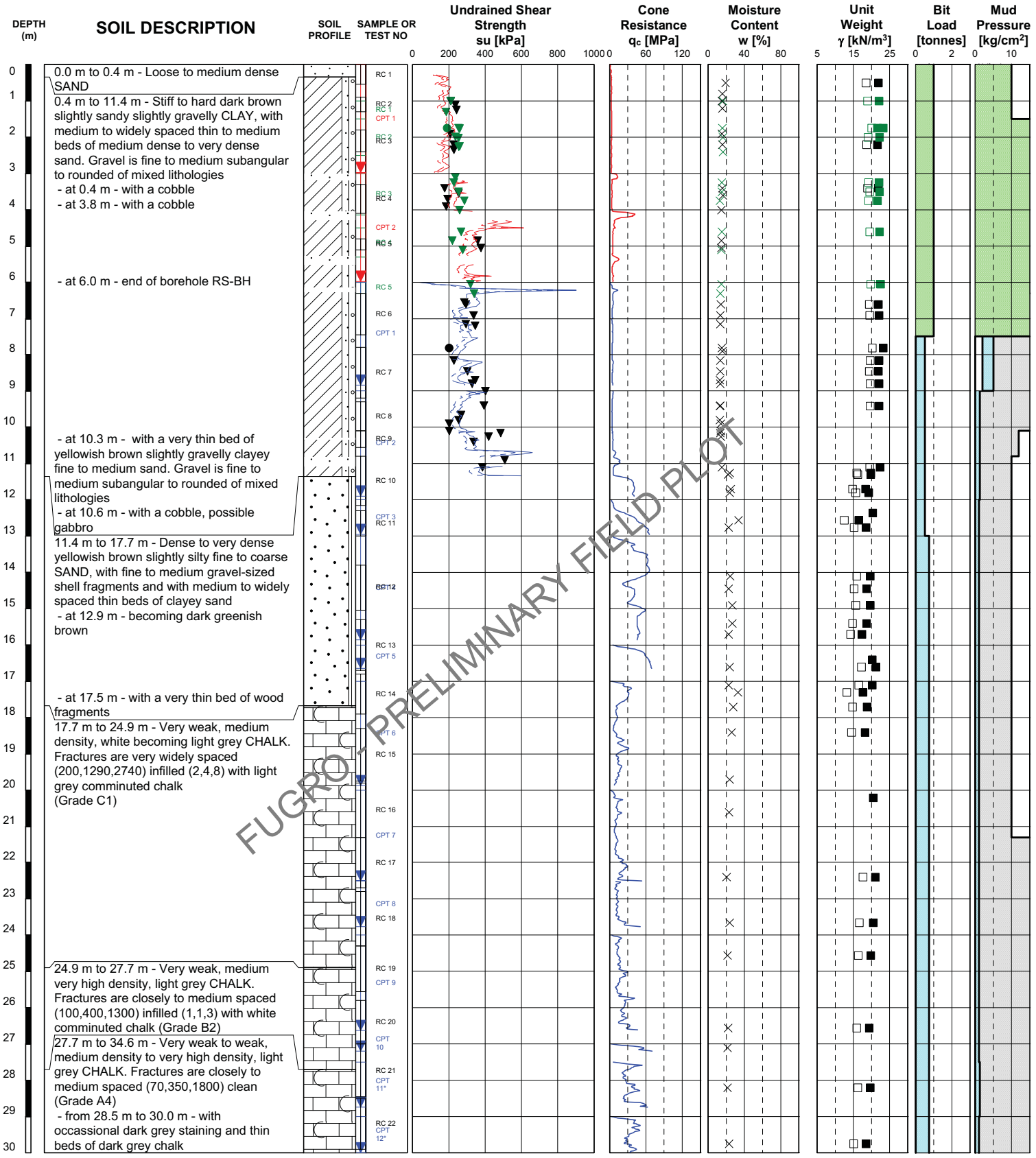
BOREHOLE NJ106-CS (PRELIMINARY) SHEET 2 OF 2



DRILLING REMARKS:
Type of Bit: - CS locations: TC Hexagon Bit
- BH locations: 5 Wing Drag Bit
Type of Mud: Guar Gum water mixture

Notes: (1) RS-CS (2) RSa-BH (3) RS-BH (4) RS-CSa
Soil Profile is represented by location RS-CS
* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane) ■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer) ● s_u (Undrained Triaxial)
◆ s_u (Fall Cone) ✦ s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane) Estimated from CPT data (N_{kt} = 15 - 20)
Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 363516.0 mE 5944069.9 mN (1) WATER DEPTH : 24.6 m LAT (1) DATE : 10/10/2012 - 11/10/2012 (1)
: 363504.9 mE 5944067.7 mN (2) : 24.4 m LAT (2) : 13/07/2012 - 15/07/2012 (2)
: 363513.7 mE 5944066.4 mN (3) : 24.8 m LAT (3) : 02/07/2012 - 02/07/2012 (3)
: 363518.6 mE 5944067.4 mN (4) : 23.9 m LAT (4) : 12/10/2012 - 13/12/2012 (4)

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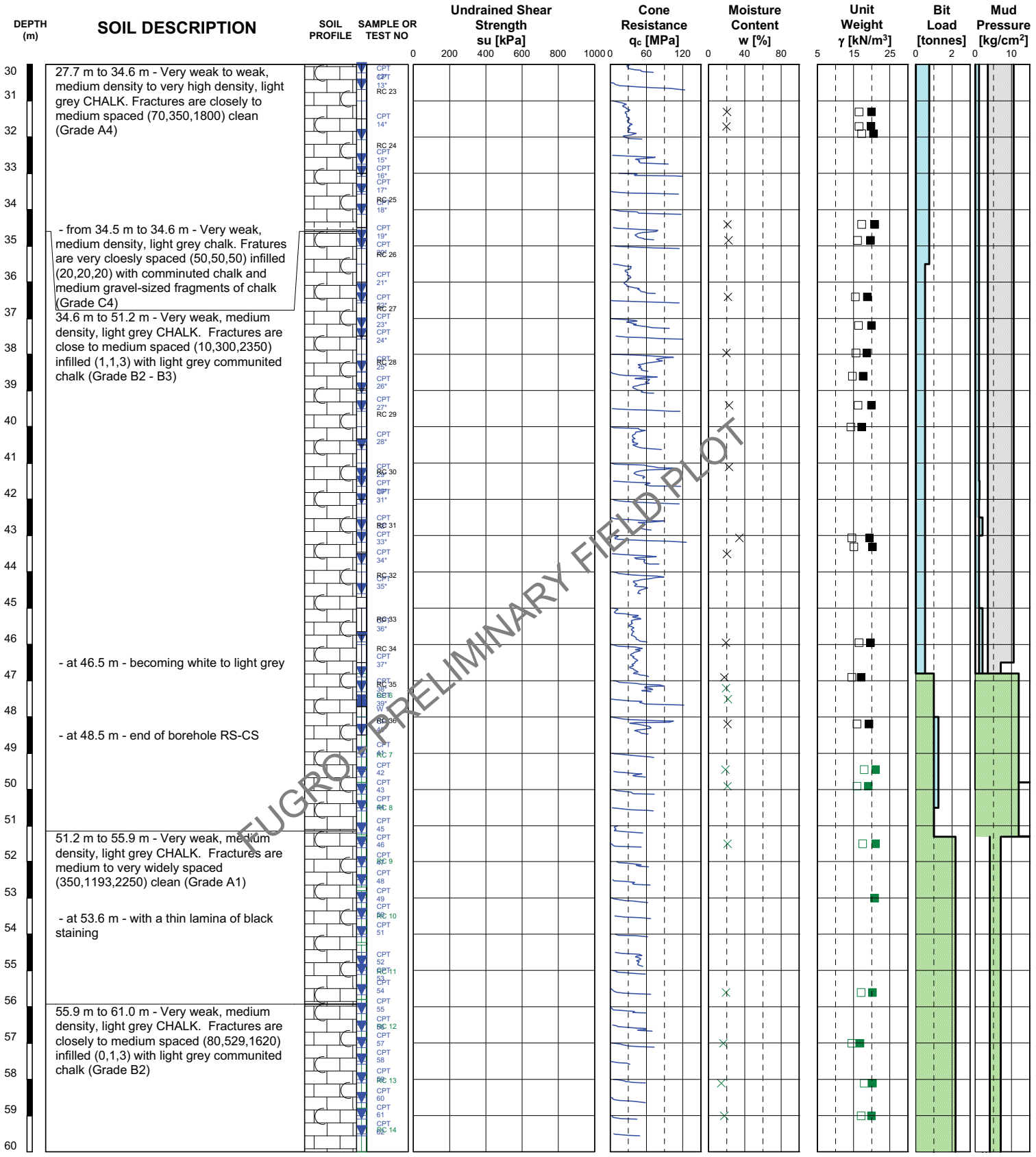
BOREHOLE RS-CS (PRELIMINARY) SHEET 1 OF 3



DRILLING REMARKS:
Type of Bit: - CS locations: TC Hexagon Bit
- BH locations: 5 Wing Drag Bit
Type of Mud: Guar Gum water mixture

Notes: (1) RS-CS (3) RS-BH
(2) RSa-BH (4) RS-CSa

Soil Profile is represented by location RS-CS

* Indicates F8 cone used

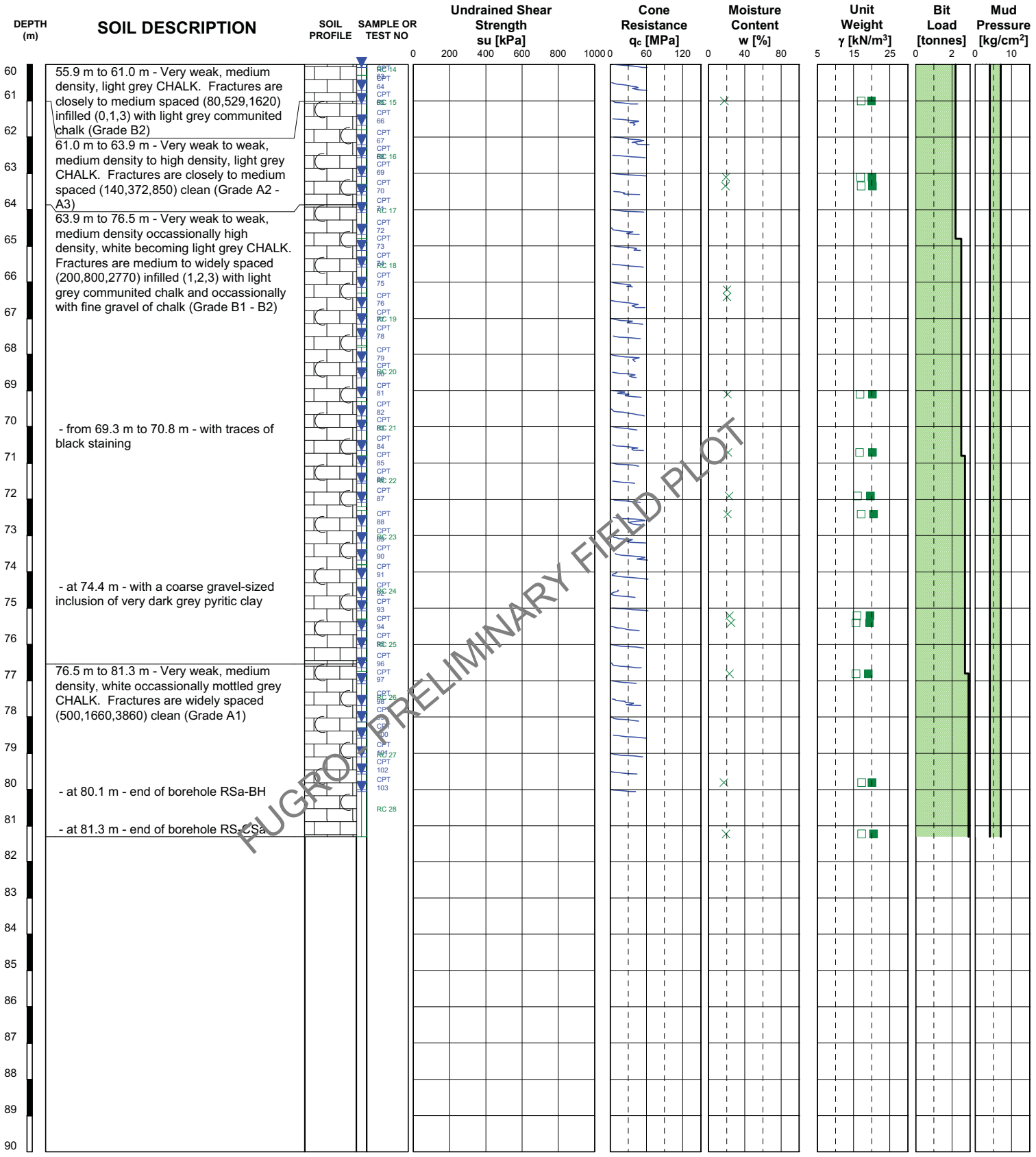
KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane) ■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer) ● s_u (Undrained Triaxial)
◆ s_u (Fall Cone) ✦ s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane) Estimated from CPT data (N_{kt} = 15 - 20)
Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

LOCATION : Hornsea Offshore Wind Farm Site Investigation
COORDINATES : 363516.0 mE 5944069.9 mN (1) WATER DEPTH : 24.6 m LAT (1) DATE : 10/10/2012 - 11/10/2012 (1)
: 363504.9 mE 5944067.7 mN (2) : 24.4 m LAT (2) : 13/07/2012 - 15/07/2012 (2)
: 363513.7 mE 5944066.4 mN (3) : 24.8 m LAT (3) : 02/07/2012 - 02/07/2012 (3)
: 363518.6 mE 5944067.4 mN (4) : 23.9 m LAT (4) : 12/10/2012 - 13/12/2012 (4)

GeODin-System 7.5//15/10/2012 09:41:55



DRILLING REMARKS:
Type of Bit: - CS locations: TC Hexagon Bit
- BH locations: 5 Wing Drag Bit
Type of Mud: Guar Gum water mixture

Notes: (1) RS-CS (3) RS-BH
(2) RSa-BH (4) RS-CSa

Soil Profile is represented by location RS-CS

* Indicates F8 cone used

KEY FOR UNDRAINED SHEAR STRENGTH:
▲ s_u (Torvane) ■ s_u (Laboratory Vane)
▼ s_u (Pocket Penetrometer) ● s_u (Undrained Triaxial)
◆ s_u (Fall Cone) ✦ s_u (In situ Vane)
✳ s_u (Remoulded In situ Vane) Estimated from CPT data (N_{kt} = 15 - 20)

Half full symbols refer to remoulded tests.

KEY FOR MOISTURE CONTENT:
× Moisture Content (w)

KEY FOR UNIT WEIGHT:
□ Natural Dry Unit Weight (γ_d)
■ Natural Wet Unit Weight (γ_w)

LOCATION : Hornsea Offshore Wind Farm Site Investigation

COORDINATES			WATER DEPTH	DATE
: 363516.0 mE	5944069.9 mN (1)		: 24.6 m LAT (1)	: 10/10/2012 - 11/10/2012 (1)
: 363504.9 mE	5944067.7 mN (2)		: 24.4 m LAT (2)	: 13/07/2012 - 15/07/2012 (2)
: 363513.7 mE	5944066.4 mN (3)		: 24.8 m LAT (3)	: 02/07/2012 - 02/07/2012 (3)
: 363518.6 mE	5944067.4 mN (4)		: 23.9 m LAT (4)	: 12/10/2012 - 13/12/2012 (4)

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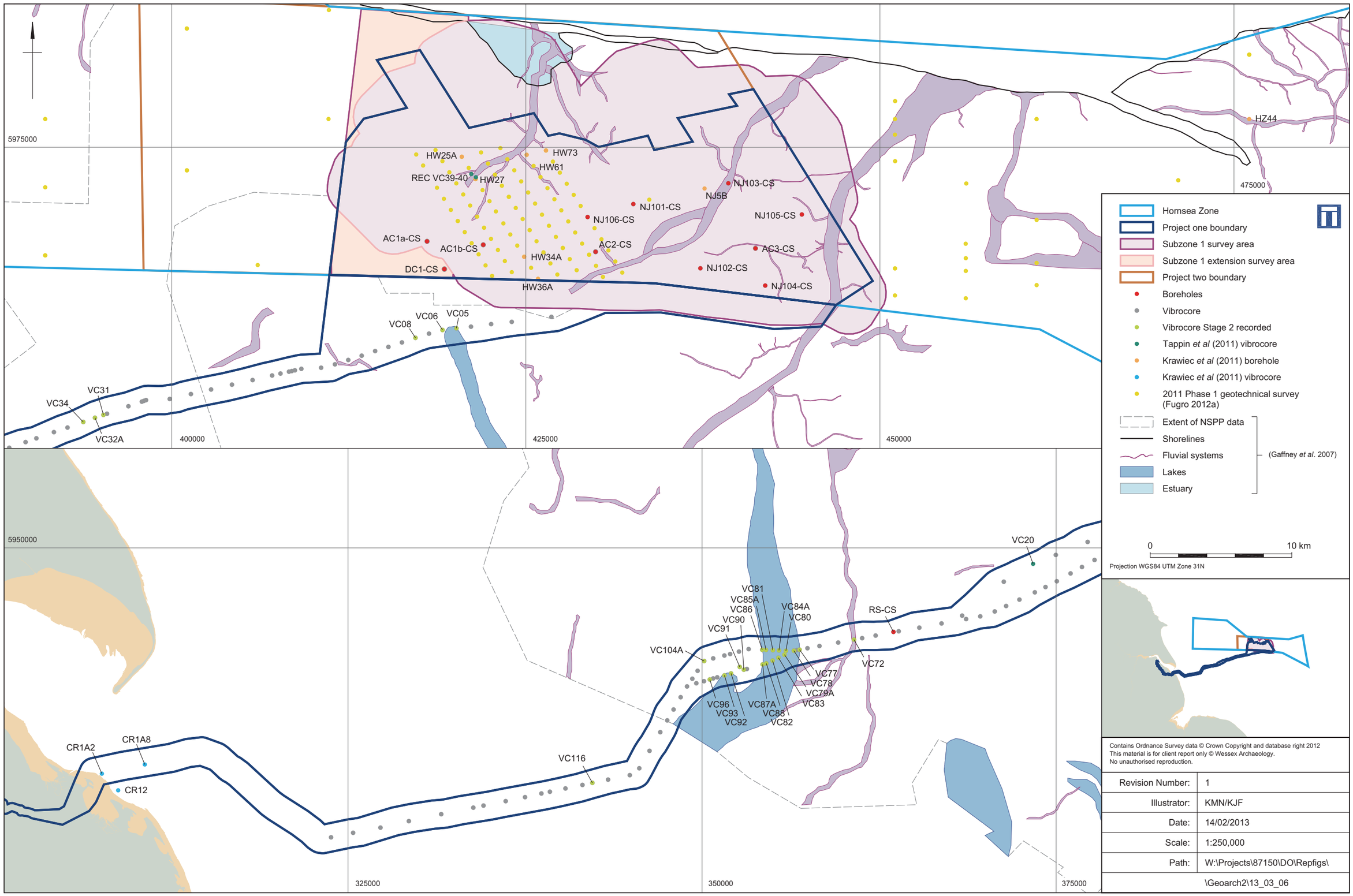
BOREHOLE RS-CS (PRELIMINARY) SHEET 3 OF 3



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Illustrator:	KMN/KJF
Date:	14/02/2013
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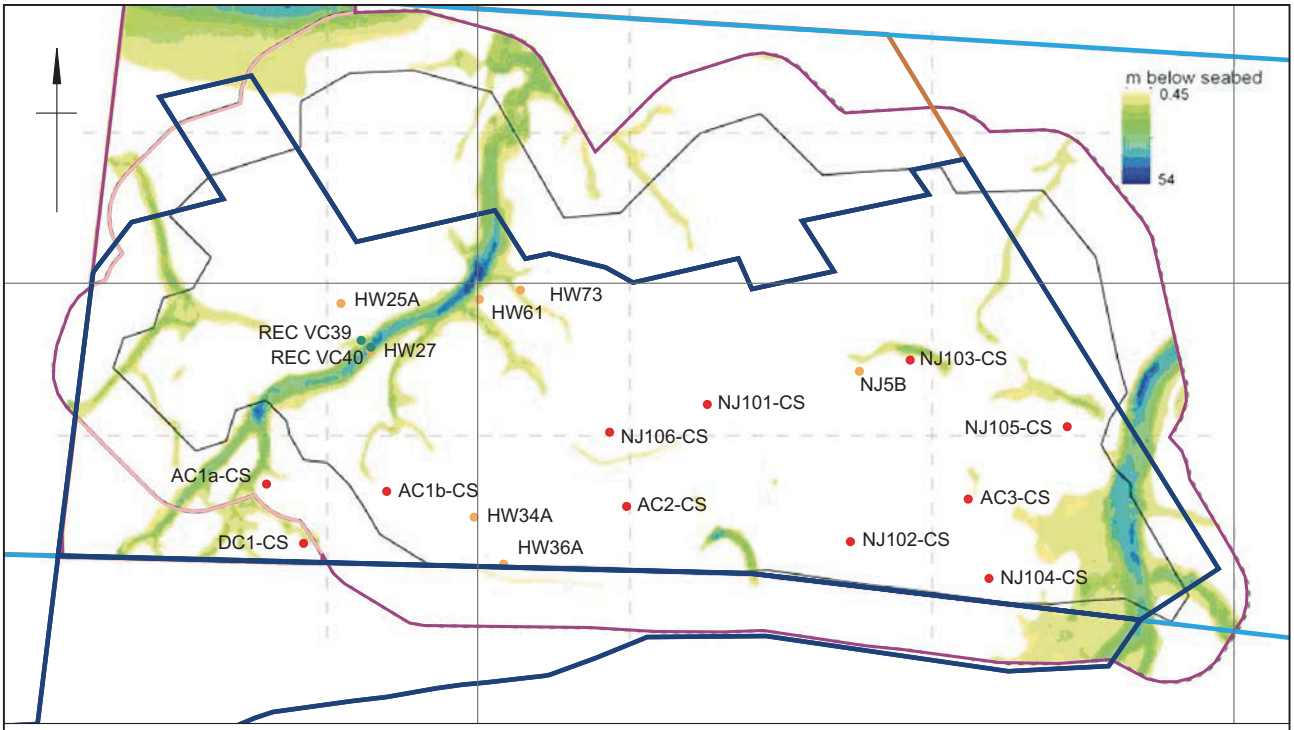
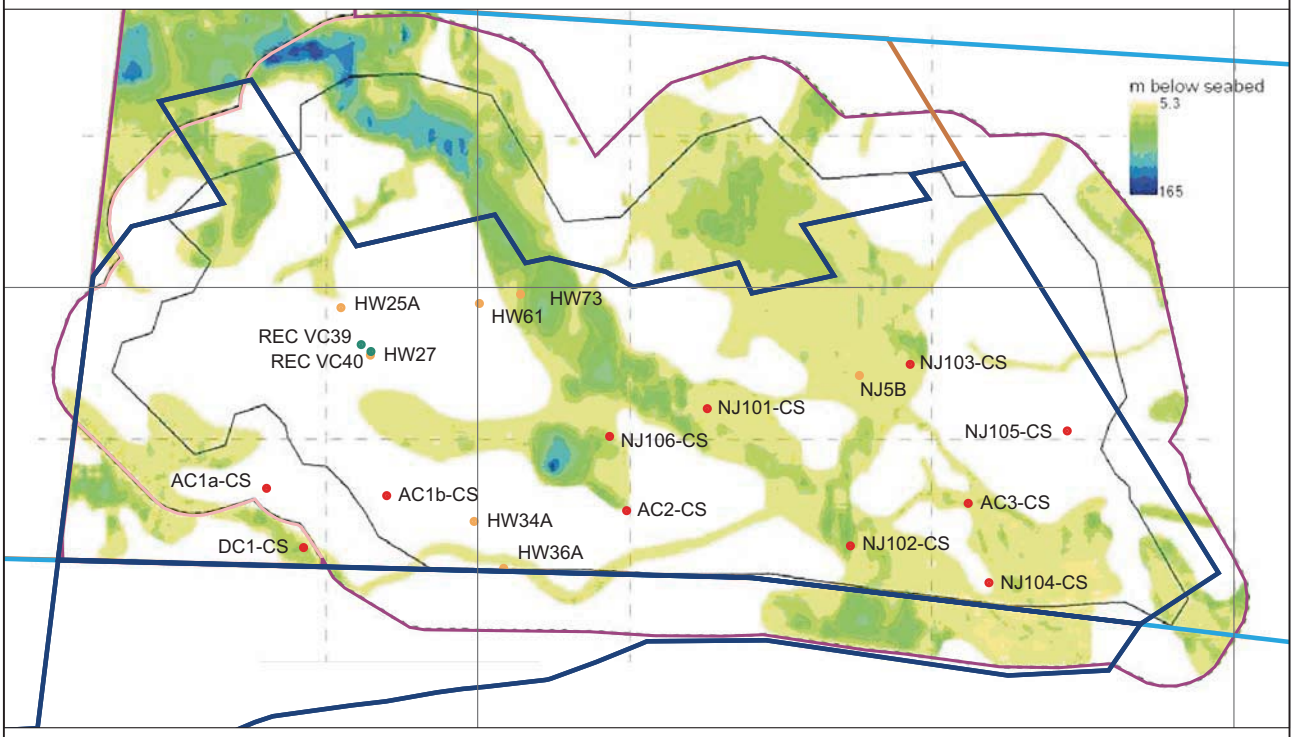
	\Geoarch2\13_03_06

Borehole, vibrocore and site location

Figure 1



A: Subzone 1 boreholes related to Botney Cut formation (using data interpretation from EMU 2011)



B: Subzone 1 boreholes related to Swarte Bank formation (using data interpretation from EMU 2011)

Hornsea Zone
Project one boundary
Subzone 1 survey area
Subzone 1 extension survey area
Project two boundary
Boreholes
Tappin *et al* (2011) vibrocore
Krawiec *et al* (2011) borehole

0 10 km

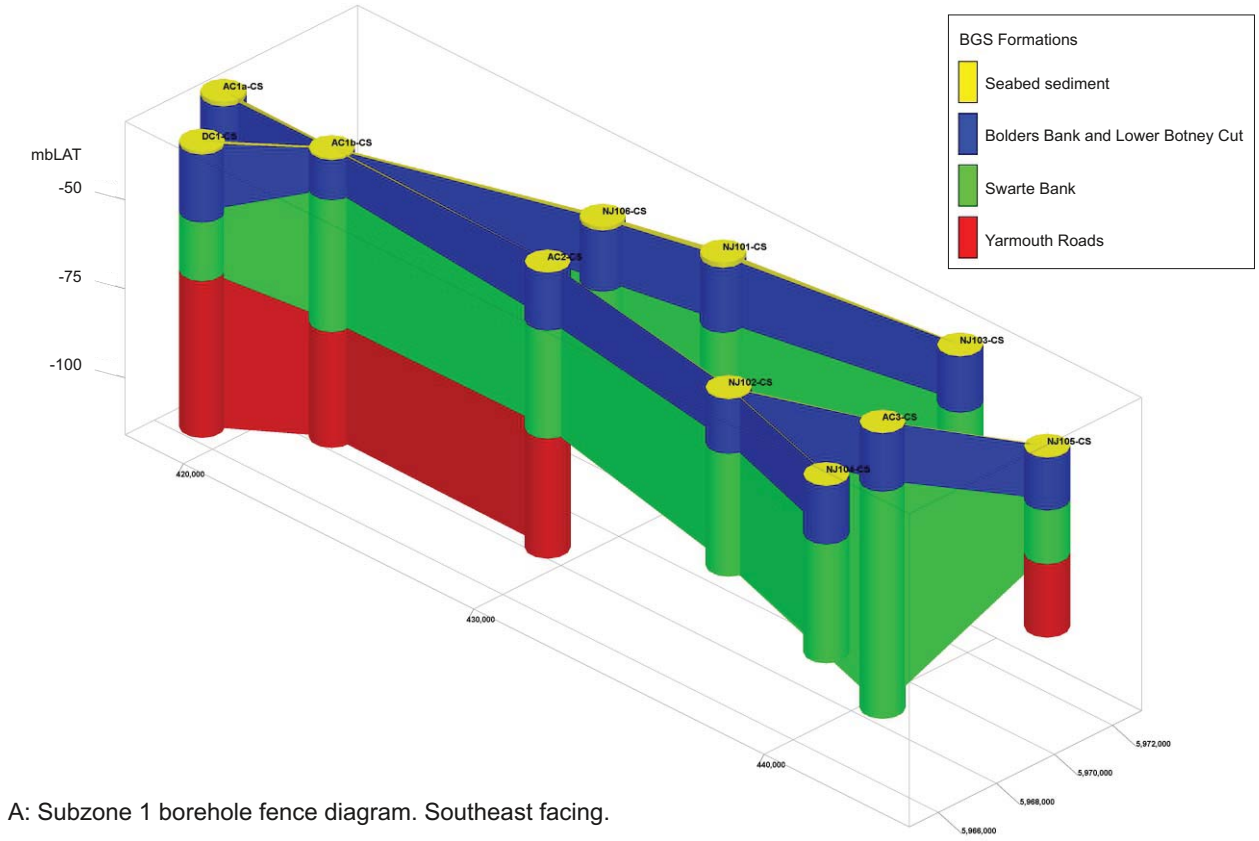
Projection WGS84 UTM Zone 31N

Date:	29/01/2013	Revision Number:	0
Scale:	1:250,000	Illustrator:	KMN
Path:	W:\Projects\87150\Drawing Office\Report figs\Geoarch2\13_01_29		

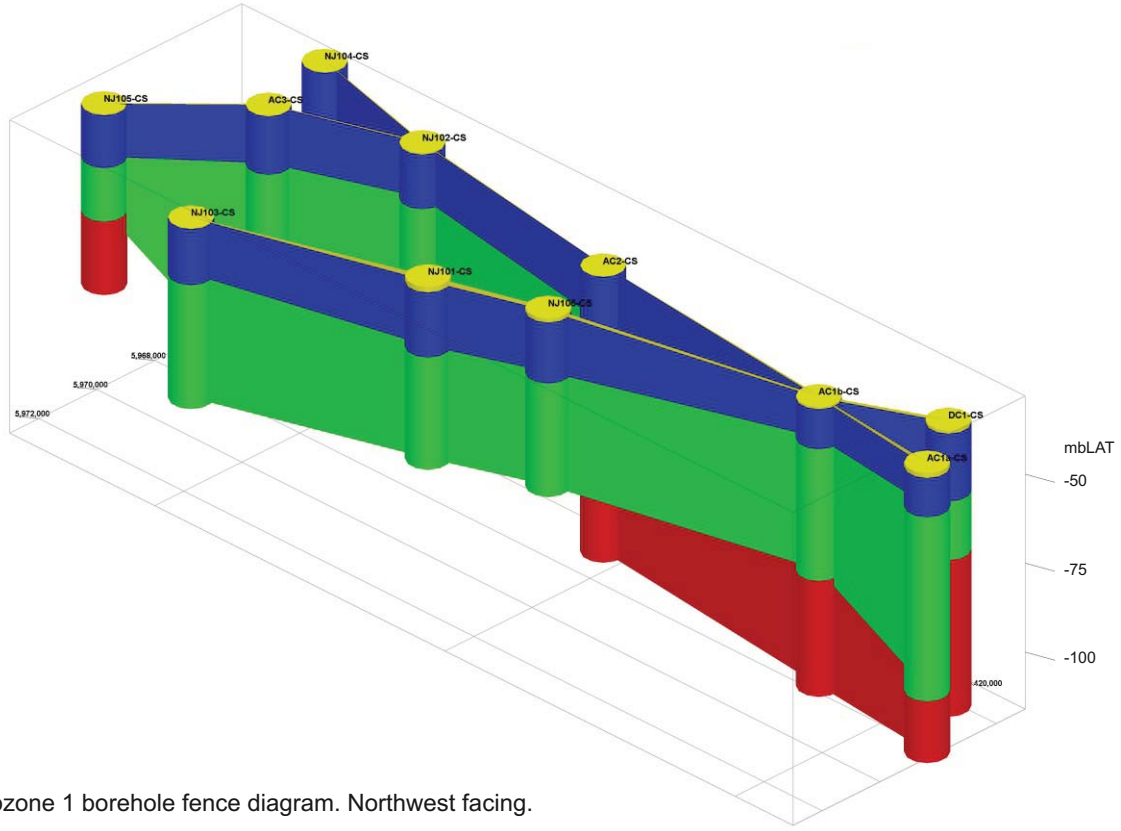
Wessex Archaeology

Subzone 1 boreholes in relation to Botney Cut and Swarte Bank formations

Figure 2



A: Subzone 1 borehole fence diagram. Southeast facing.



B: Subzone 1 borehole fence diagram. Northwest facing.

Date:	29/01/2013	Revision Number:	0
Scale:	N/A	Illustrator:	KMN
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Wessex Archaeology

Borehole fence diagrams

Figure 3

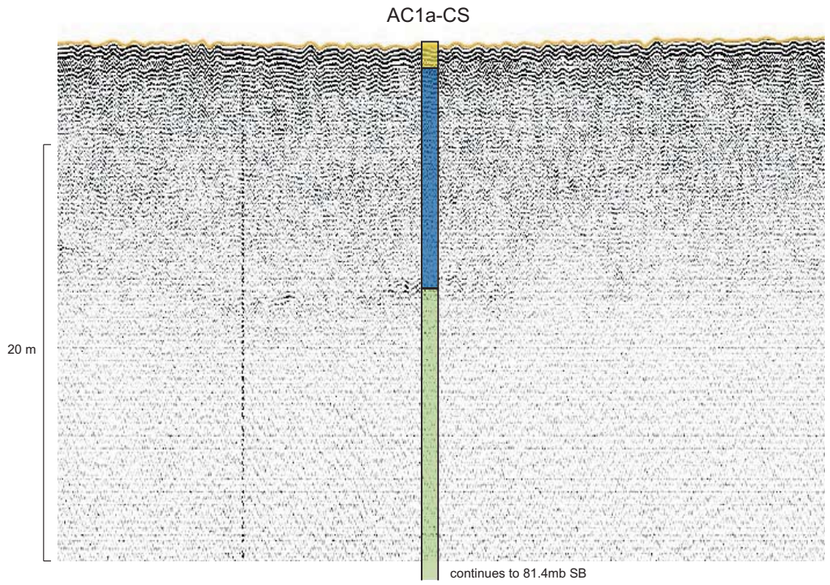


Figure 4a: Borehole AC1a-CS related to Sub-bottom profiler data

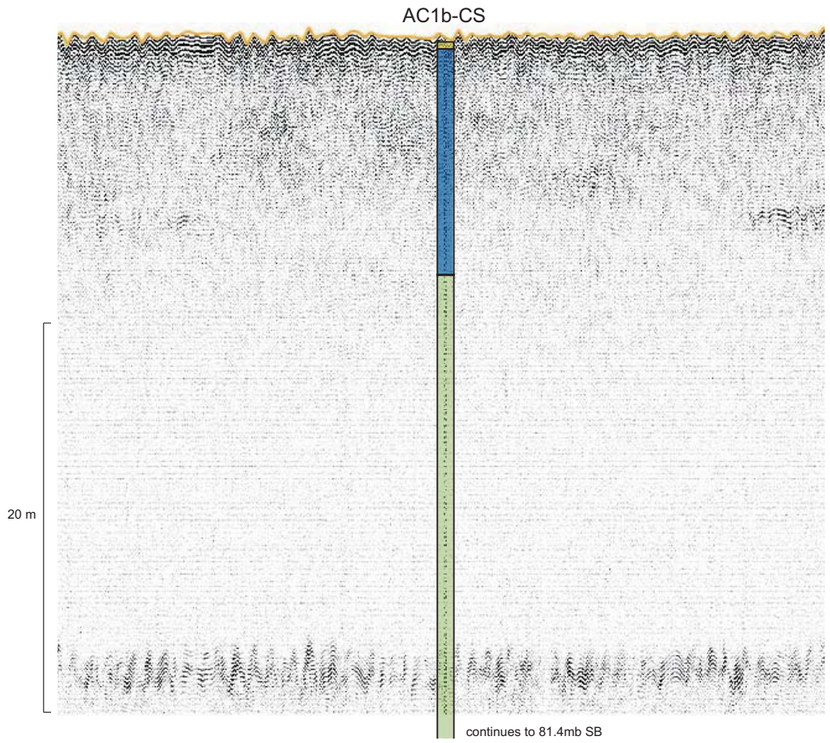
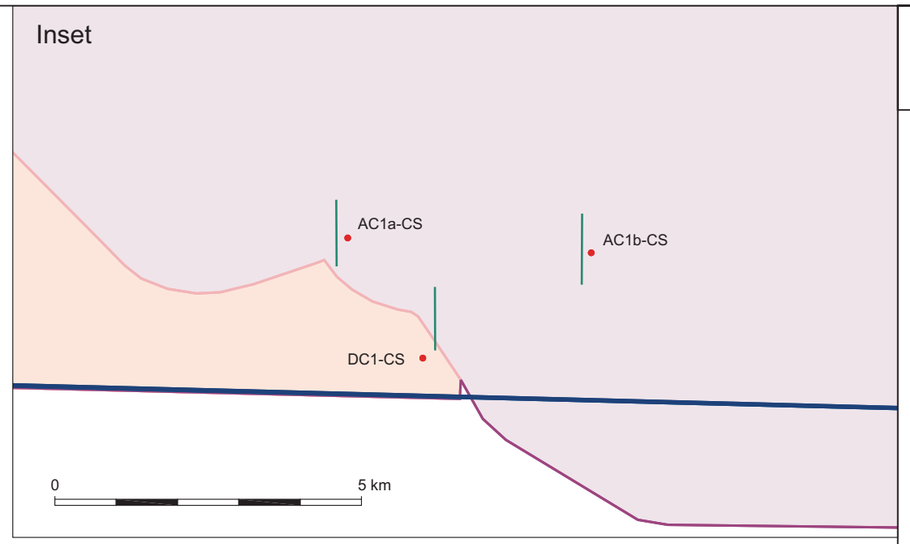


Figure 4b: Borehole AC1b-CS related to Sub-bottom profiler data

Figure 4c: Borehole DC1-CS related to Sub-bottom profiler data

0 100 200 m

Horizontal scale 1:4000



Wessex Archaeology

Project one boundary
Subzone 1 survey area
Subzone 1 extension survey area
Sub-bottom profile location
Boreholes

Seabed Sediment
Bolders Bank and Lower Botney Cut
Swarte Bank
Yarmouth Roads

Revision Number:	0
Illustrator:	KJF
Date:	06/03/2013
Scale:	Inset 1:100,000
Path:	W:\Projects\87150\DO\Repfigs\
	\Geoarch2\13_03_06

Borehole locations AC1a-CS, AC1b-CS and DC1-CS related to Sub-bottom profiler data

Figure 4

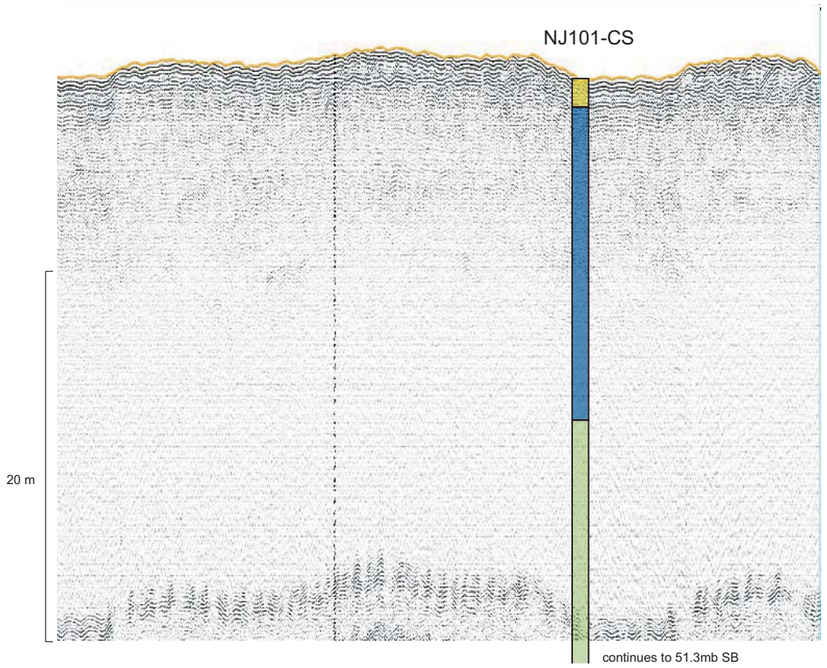


Figure 5a: Borehole NJ101-CS related to Sub-bottom profiler data

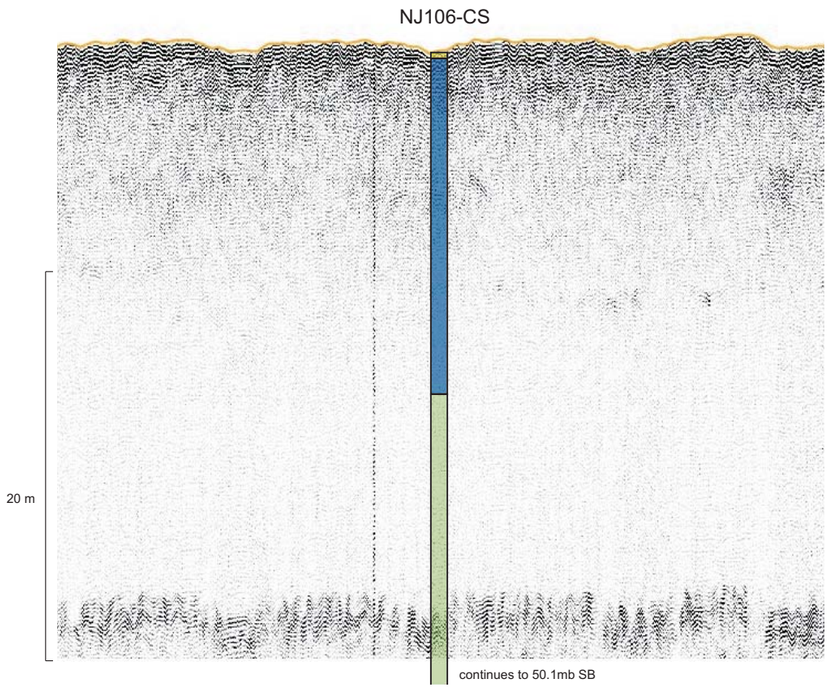
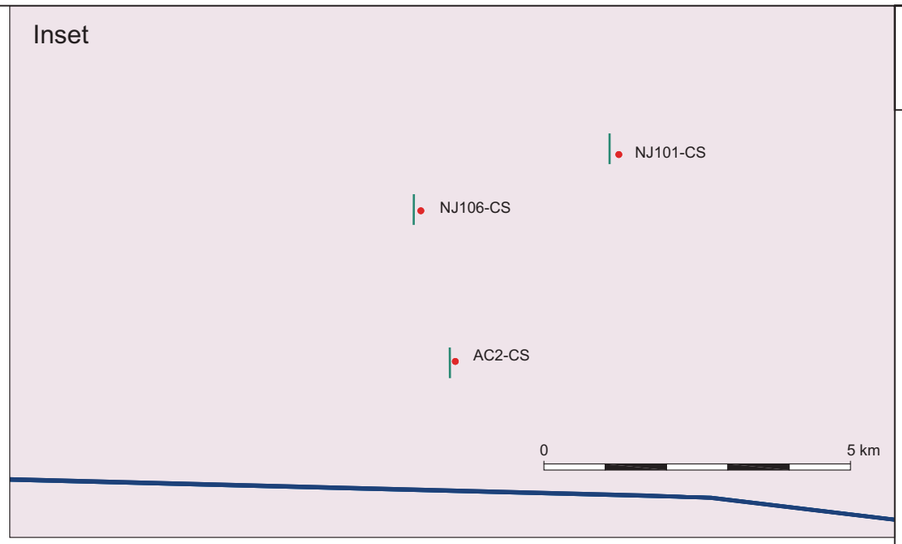


Figure 5b: Borehole NJ106-CS related to Sub-bottom profiler data



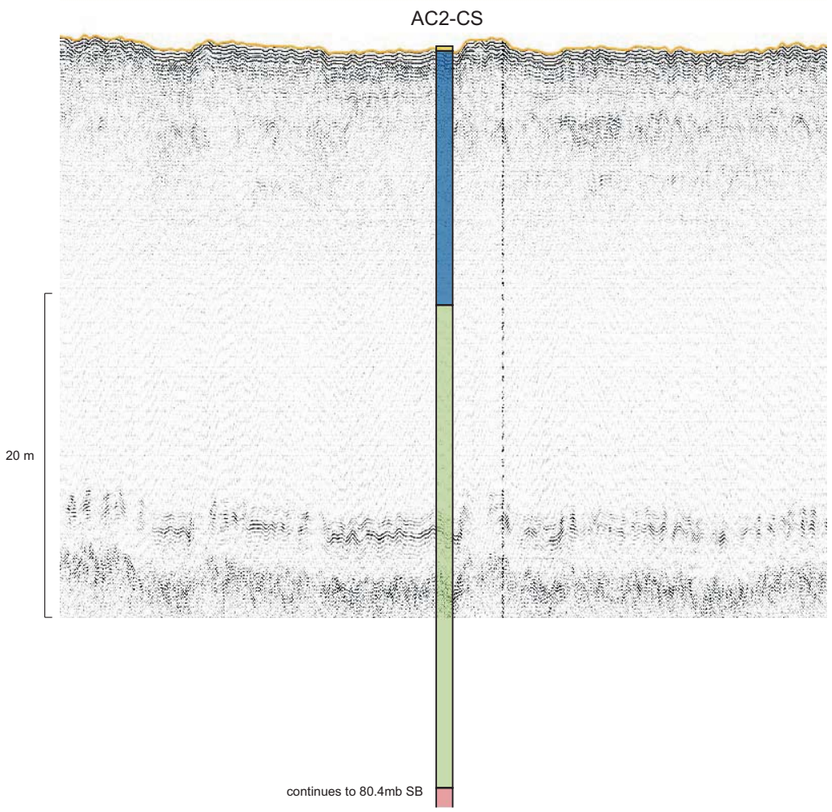


Figure 5c: Borehole AC2-CS related to Sub-bottom profiler data

0 100 200 m

Horizontal scale 1:4000

Wessex Archaeology

Project one boundary
Subzone 1 survey area
Sub-bottom profile location
Boreholes

Seabed Sediment
Bolders Bank and Lower Botney Cut
Swarte Bank
Yarmouth Roads

Revision Number:	0
Illustrator:	KJF
Date:	06/03/2013
Scale:	Inset 1:100,000
Path:	W:\Projects\87150\DO\Repfigs\
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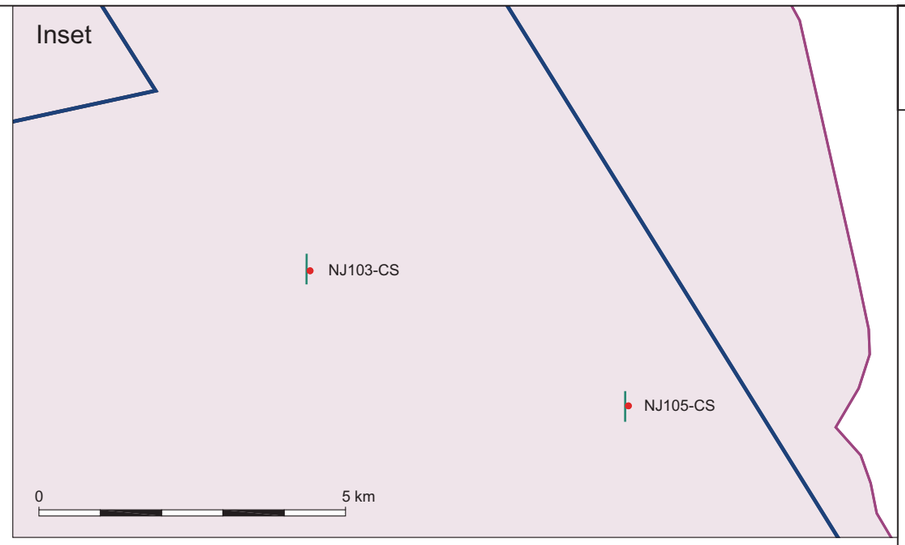
Borehole locations NJ101-CS, NJ106-CS and AC2-CS related to Sub-bottom profiler data

Figure 5



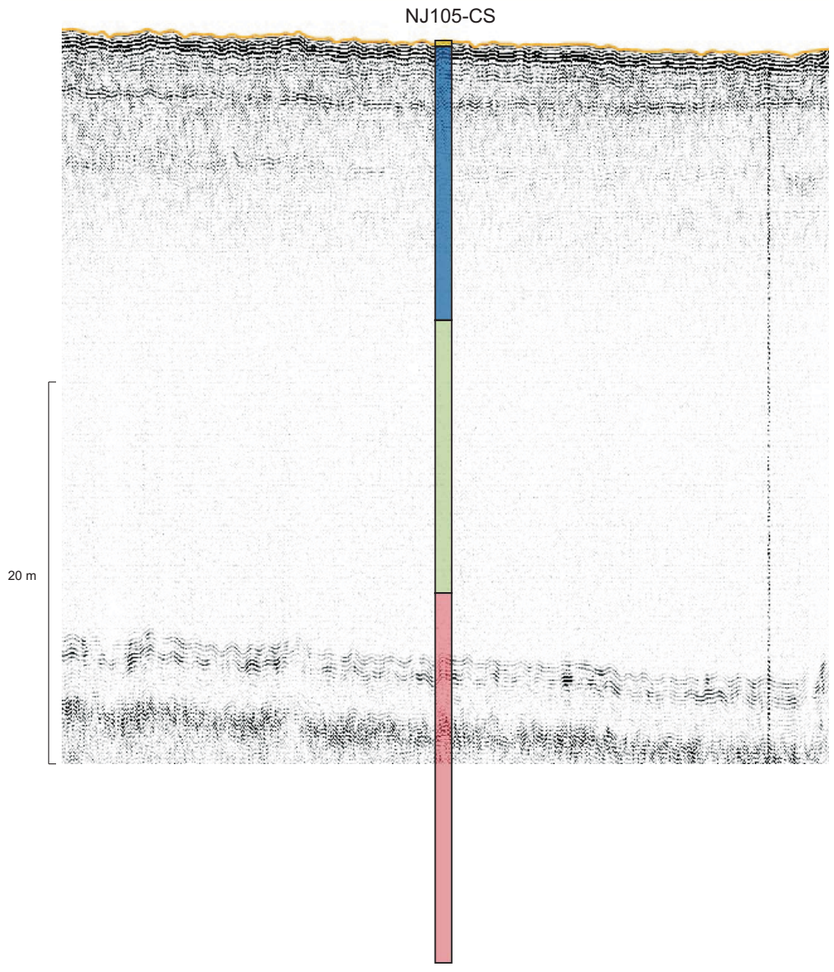


Figure 6a: Borehole NJ105-CS related to Sub-bottom profiler data

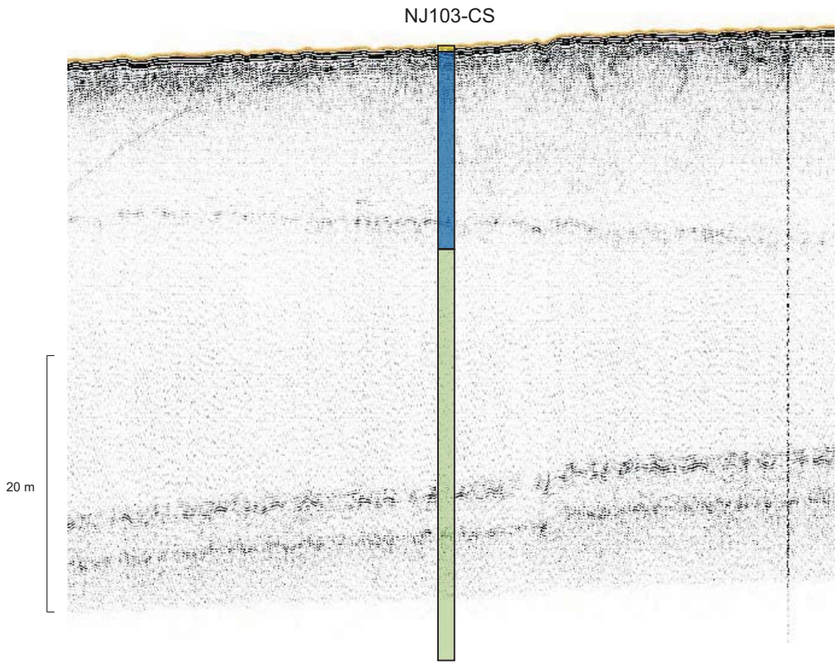


Figure 6b: Borehole NJ103-CS related to Sub-bottom profiler data

0 100 200 m

Horizontal scale 1:4000

Wessex Archaeology

Project one boundary
Subzone 1 survey area
Sub-bottom profile location
Boreholes

Seabed Sediment
Bolders Bank and Lower Botney Cut
Swarte Bank
Yarmouth Roads

Revision Number:	0
Illustrator:	KJF
Date:	06/03/2013
Scale:	Inset 1:100,000
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Borehole locations NJ105-CS and NJ103-CS related to Sub-bottom profiler data

Figure 6

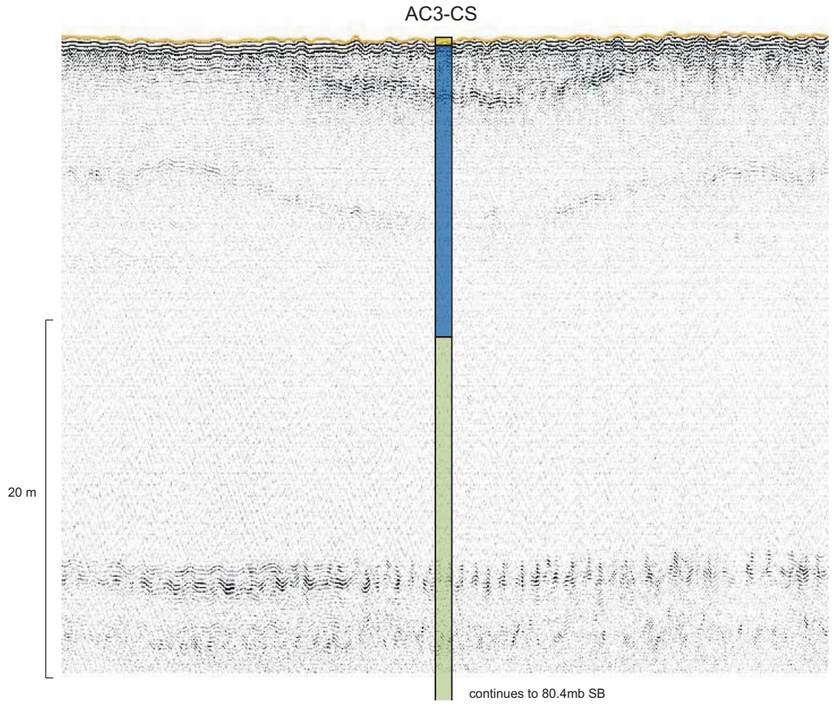


Figure 7a: Borehole AC3-CS related to Sub-bottom profiler data

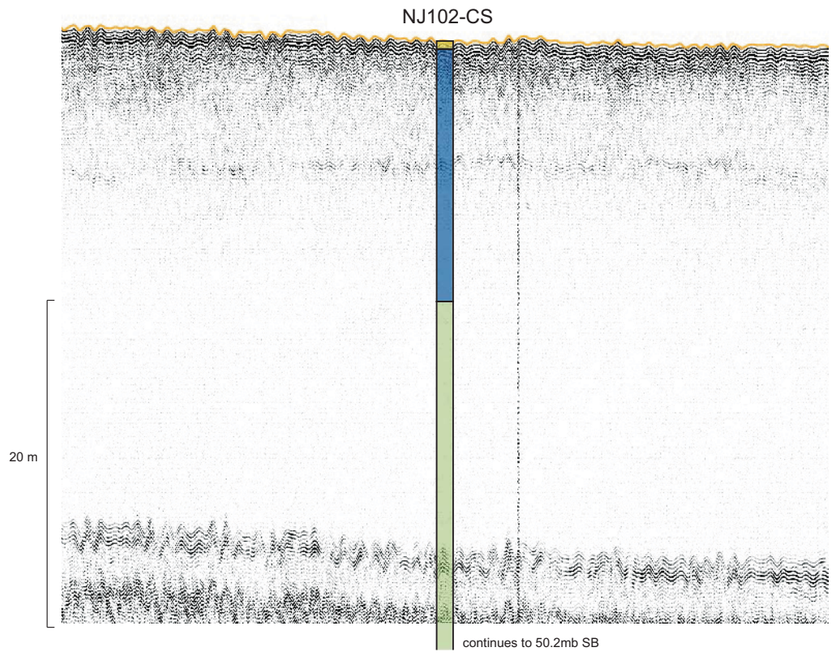
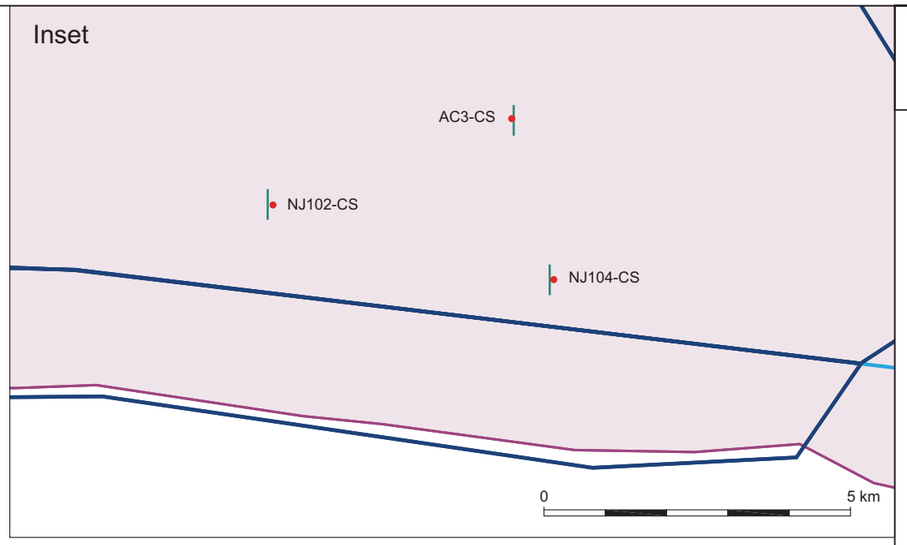


Figure 7b: Borehole NJ102-CS related to Sub-bottom profiler data



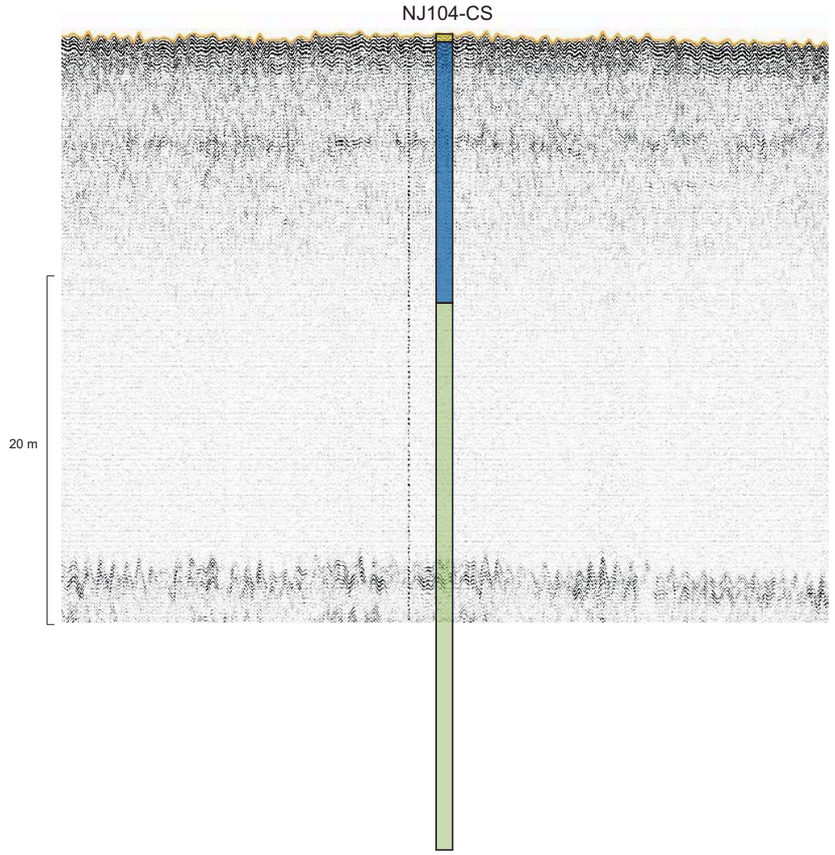


Figure 7c: Borehole NJ104-CS related to Sub-bottom profiler data

0 100 200 m

Horizontal scale 1:4000

Wessex Archaeology

Project one boundary
Subzone 1 survey area
Sub-bottom profile location
Boreholes

Seabed Sediment
Bolders Bank and Lower Botney Cut
Swarte Bank
Yarmouth Roads

Revision Number:	0
Illustrator:	KJF
Date:	06/03/2013
Scale:	Inset 1:100,000
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Borehole locations AC3-CS, NJ102-CS and NJ104-CS related to Sub-bottom profiler data

Figure 7

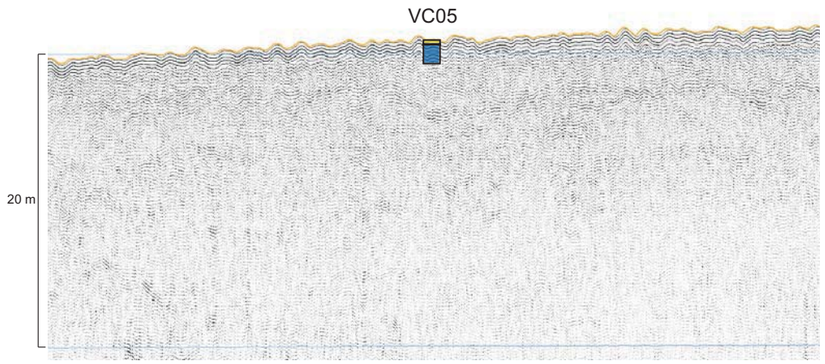
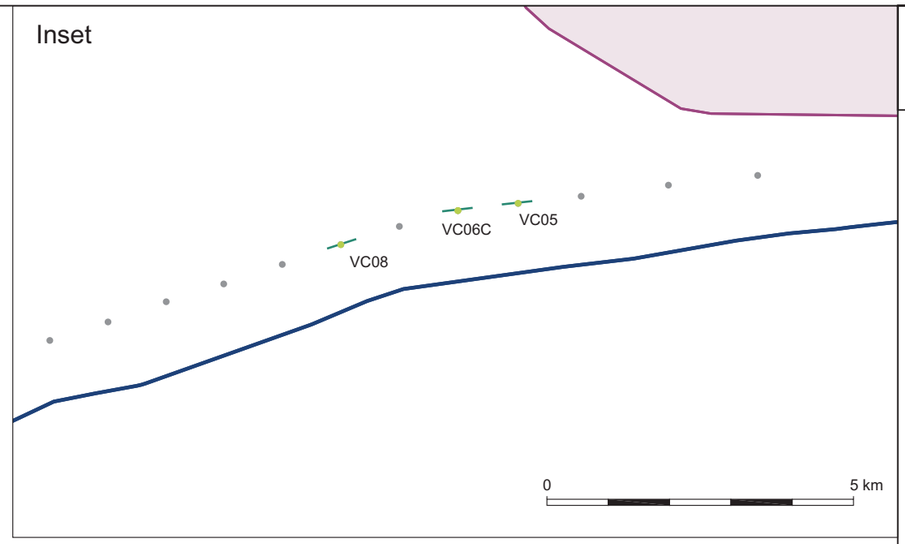


Figure 8a: Vibrocore VC05 related to Sub-bottom profiler data



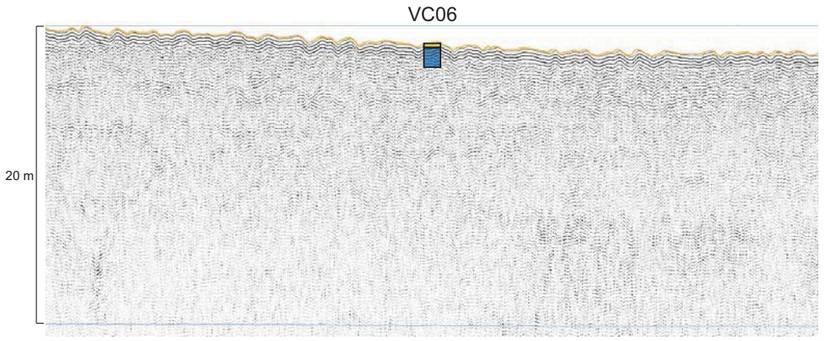


Figure 8b: Vibrocore VC06 related to Sub-bottom profiler data

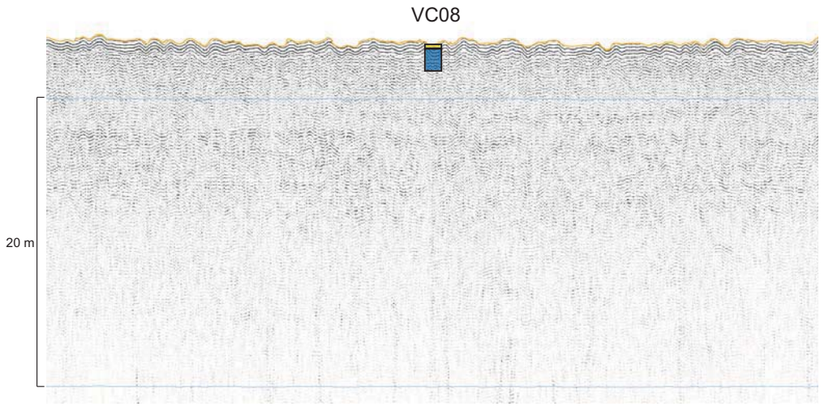


Figure 8c: Vibrocore VC08 related to Sub-bottom profiler data

0 100 200 m

Horizontal scale 1:4000

Wessex Archaeology

Project one boundary

Subzone 1 survey area

Sub-bottom profile location

Vibrocore

Vibrocore Stage 2 recorded

Seabed Sediment

Bolders Bank and Lower Botney Cut

Revision Number:	0
Illustrator:	KJF
Date:	06/03/2013
Scale:	Inset 1:100,000
Path:	W:\Projects\87150\DO\Repfigs\
	\Geoarch2\13_03_06

Vibrocore locations VC05, VC06 and VC08 related to Sub-bottom profiler data

Figure 8

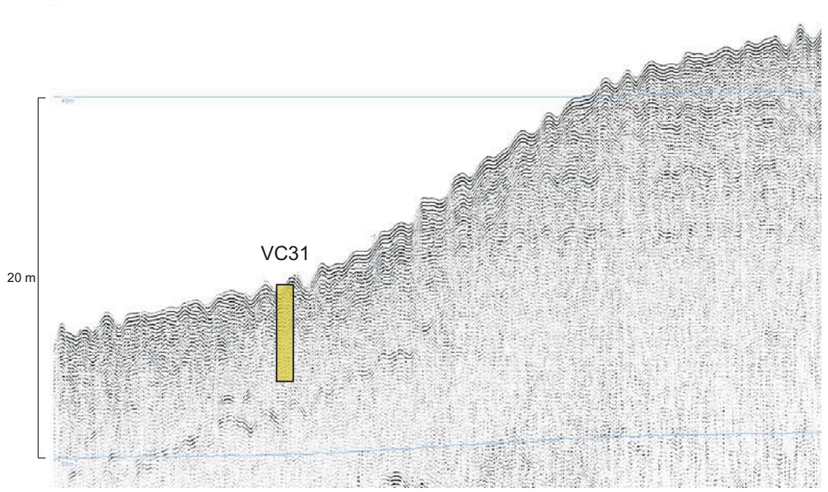
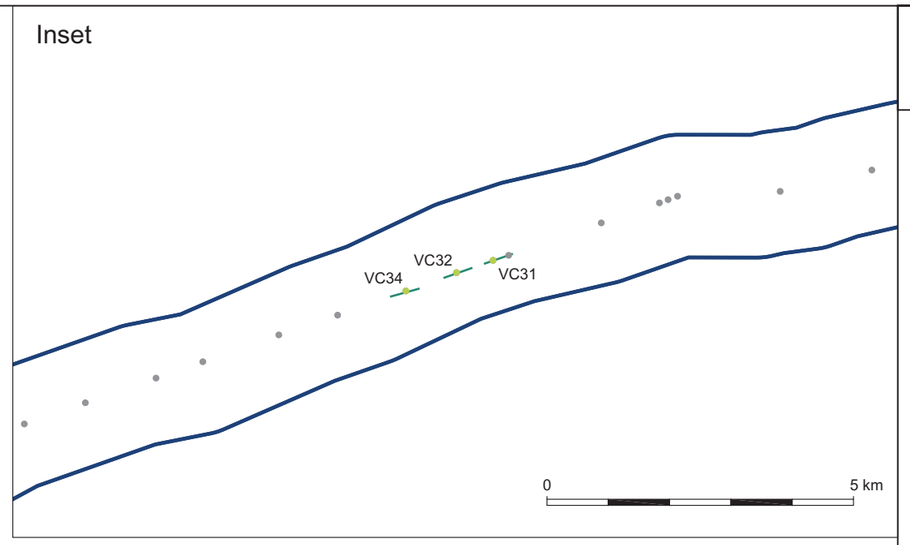


Figure 9a: Vibrocore VC31 related to Sub-bottom profiler data



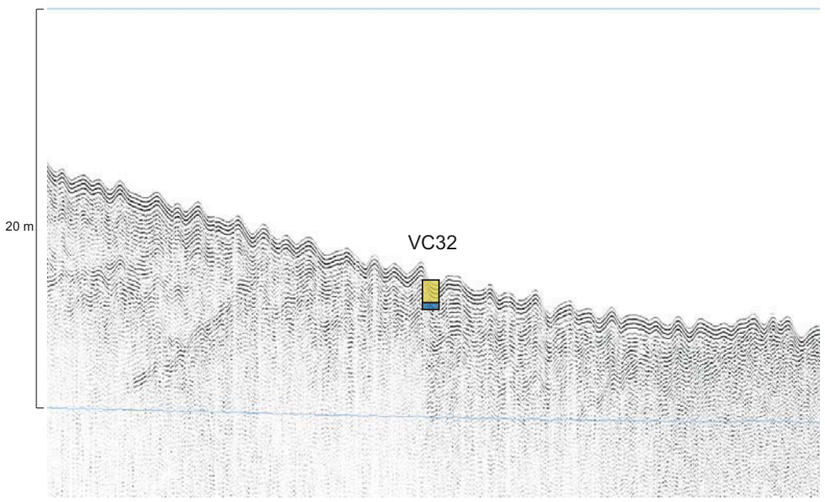


Figure 9b: Vibrocore VC32 related to Sub-bottom profiler data

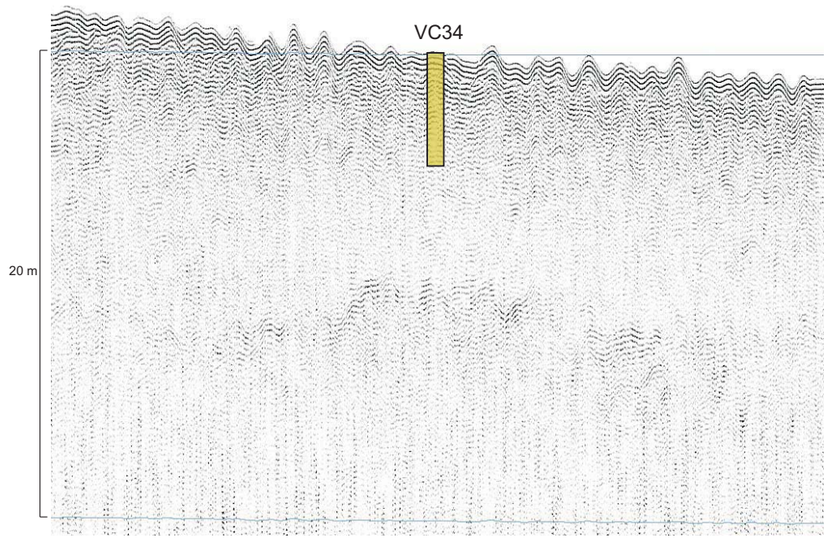


Figure 9c: Vibrocore VC34 related to Sub-bottom profiler data

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Project one boundary
Sub-bottom profile location
Vibrocore
Vibrocore Stage 2 recorded

Seabed Sediment
Bolders Bank and Lower Botney Cut

0 100 200 m
Horizontal scale 1:4000

Revision Number:	0
Illustrator:	KJF
Date:	06/03/2013
Scale:	Inset 1:100,000
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Vibrocore locations VC31, VC32 and VC34 related to Sub-bottom profiler data

Figure 9

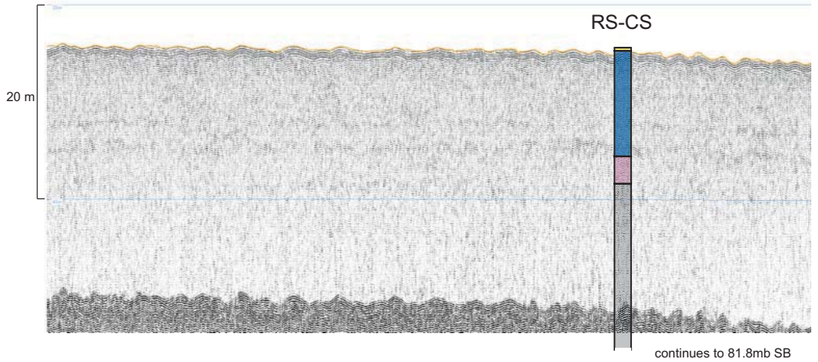
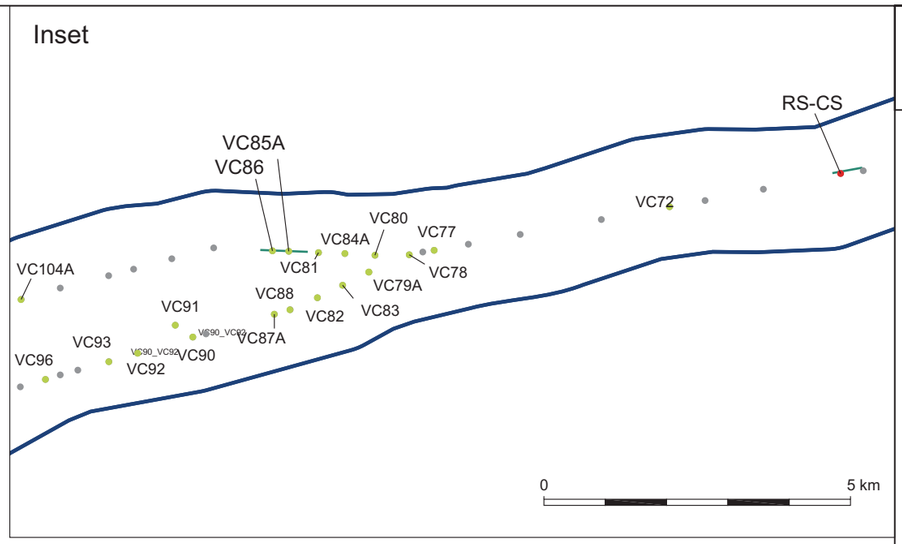


Figure 10a: Borehole location RS-CS related to Sub-bottom profiler data



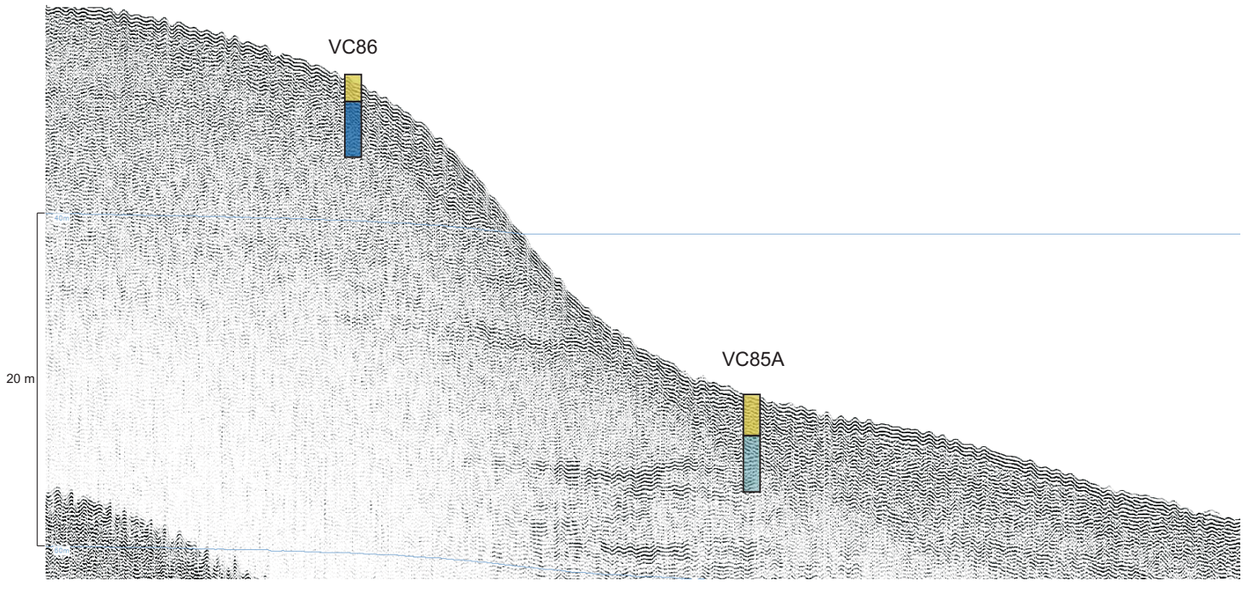


Figure 10b: Vibrocores VC85A and VC86 related to Sub-bottom profiler data

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Project one boundary
Boreholes
Vibrocore Stage 2 recorded

Seabed Sediment
Upper Botney Cut and Holocene Alluvium
Bolders Bank and Lower Botney Cut
Egmond Ground
Chalk

0 100 200 m
Horizontal scale 1:4000

Revision Number:	0
Illustrator:	KMN
Date:	29/01/2013
Scale:	Inset 1:100,000
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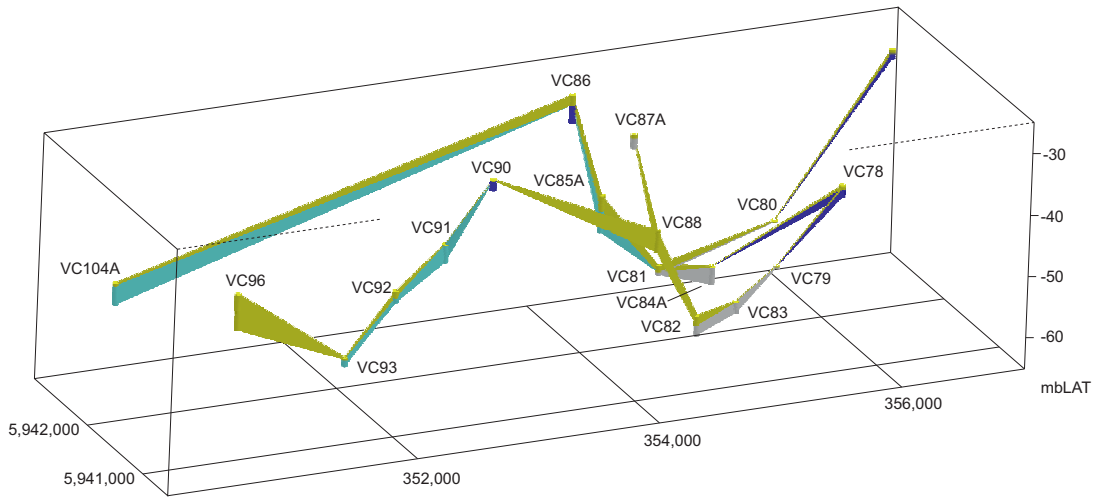
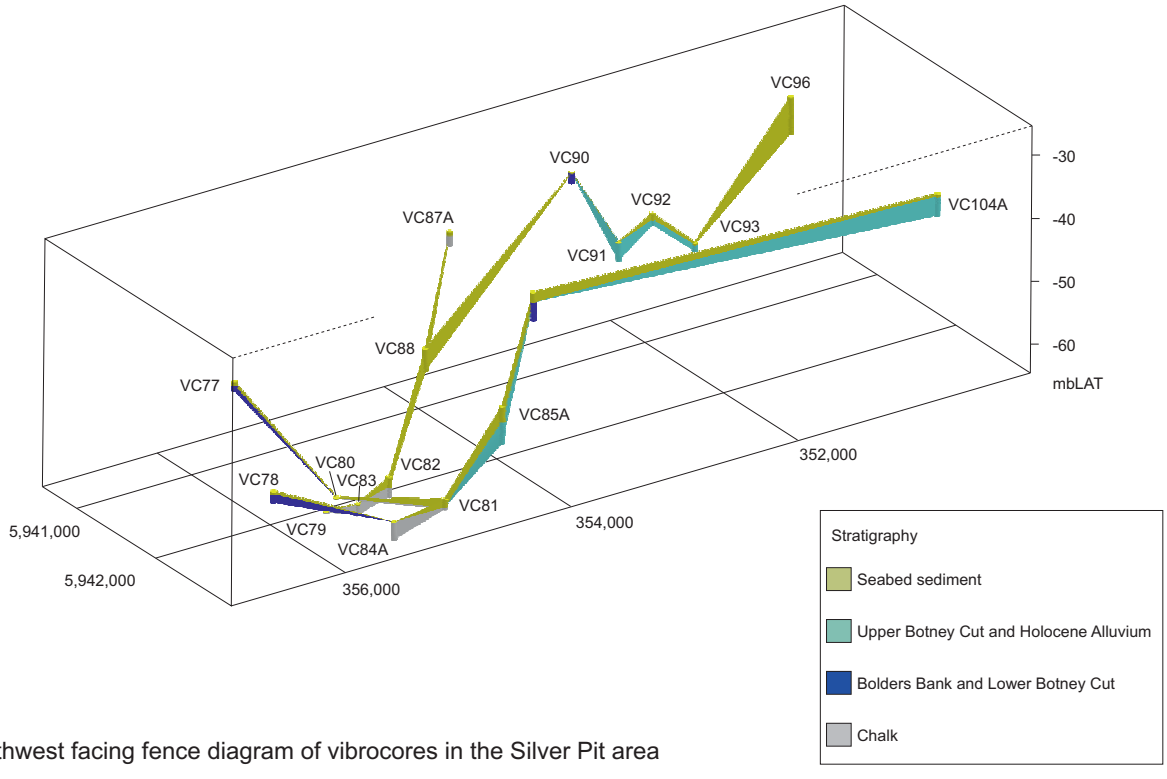
Borehole and vibrocore locations RS-CS, VC85A and VC86 related to Sub-bottom profiler data

Figure 10



A: Northeast facing fence diagram of vibrocores in the Silver Pit area



B: Southwest facing fence diagram of vibrocores in the Silver Pit area

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Scale:	N/A	Illustrator:	KMN
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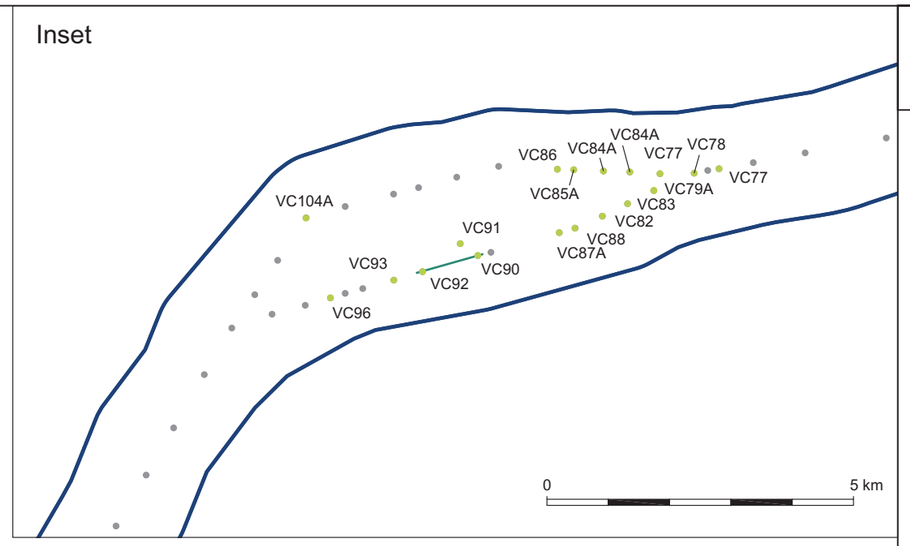
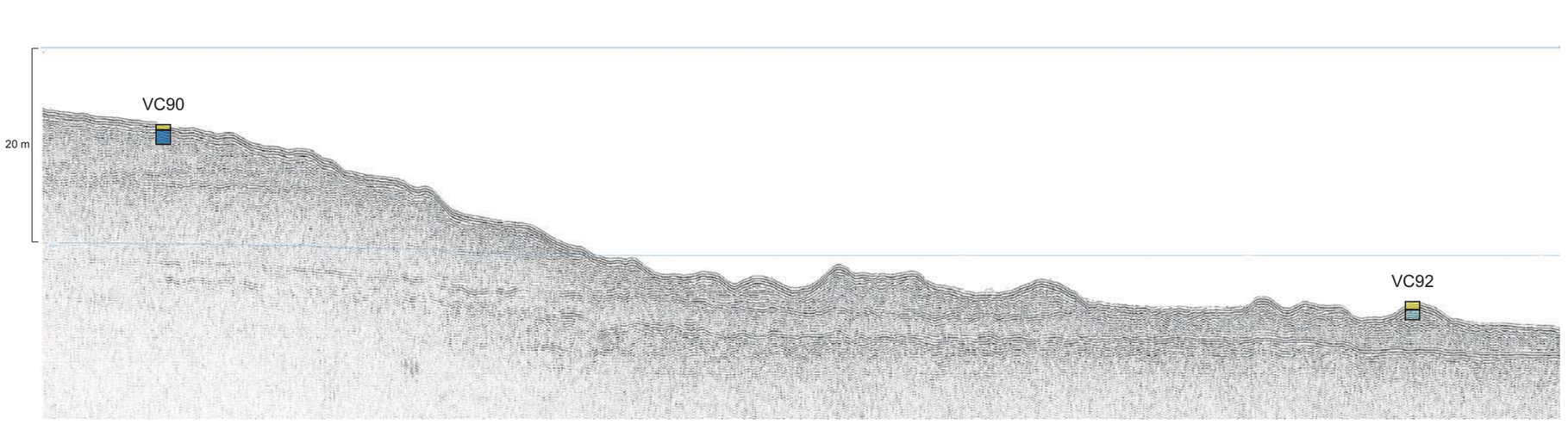
Vibrocore fence diagrams

Figure 11

Inset





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Project one boundary
Sub-bottom profile location
Vibrocore
Vibrocore Stage 2 recorded

Seabed Sediment
Upper Botney Cut and Holocene Alluvium
Bolders Bank and Lower Botney Cut

Revision Number:	0
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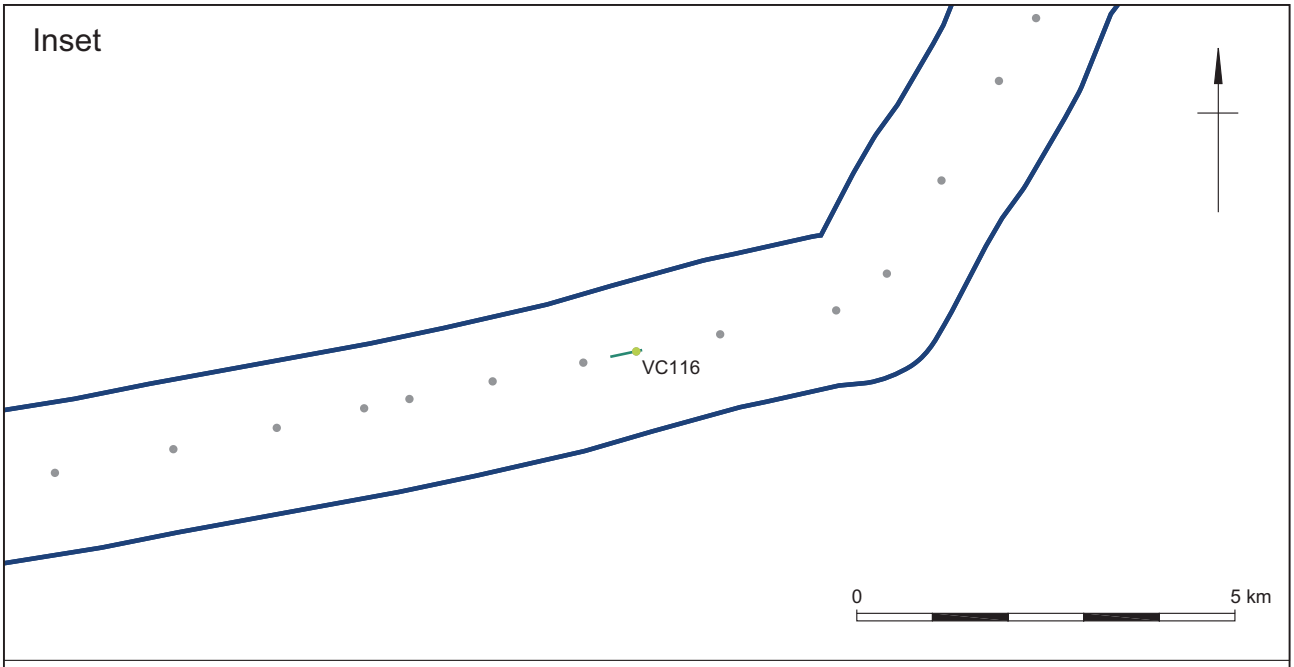
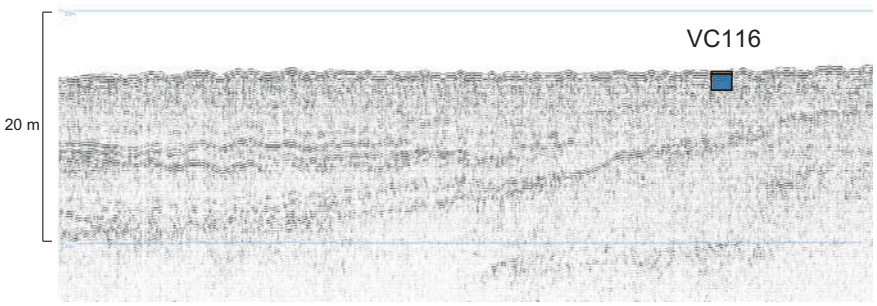
	\Geoarch2\13_03_06

Vibrocore locationsVC90 and VC92 related to Sub-bottom profiler data

Figure 12





Project one boundary
Sub-bottom profile location
Vibrocore
Vibrocore Stage 2 recorded
Seabed Sediment
Bolders Bank and Lower Botney Cut
0 100 200 m
Horizontal scale 1:4000

Date:	06/03/2013	Revision Number:	0
Scale:	Inset 1:100,000	Illustrator:	KJF
Path:	W:\Projects\87150\Drawing Office\Report figs\Geoarch2\13-03-06		

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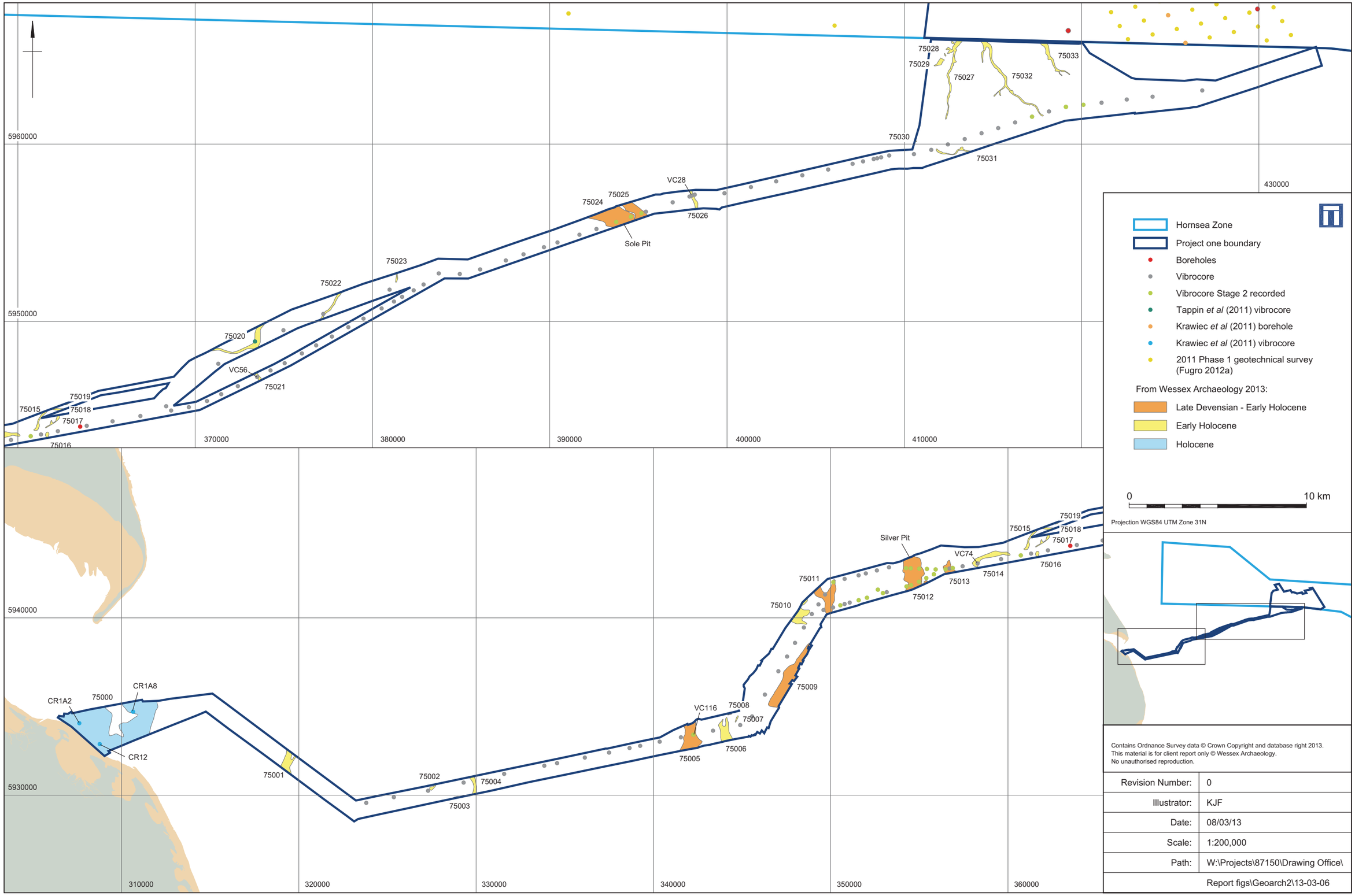
Vibrocore location VC116 related to Sub-bottom profiler data

Figure 13



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Date:	08/03/13
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	Report figs\Geoarch2\13-03-06

Vibrocores related to Palaeolandscape features of Archaeological Potential (Wessex Archaeology 2013)

Figure 14

Plate 1a: AC2-CS at 61.5m below SB

Plate 1b: DC1-CS at 57.4m below SB

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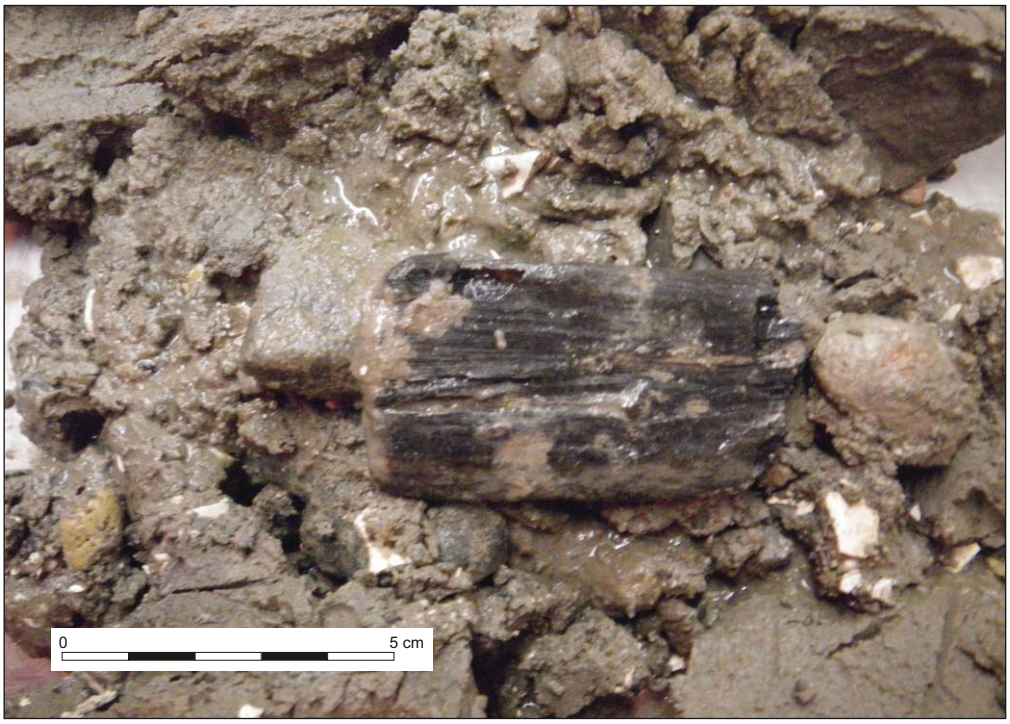

Plate 2a: NJ101-CS at 47.75m below SB

Plate 2b: DC1-CS at 20.10m below SB

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Plate 3a: AC2-CS at 2.50m below SB

Plate 3b: NJ103-CS at 1.95m below SB

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Plate 4a: NJ-103-CS at 0.1m below SB

Plate 4b: AC2-CS at 0 m below SB

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Plate 5a: VC84A 0 to 2.92 m below SB

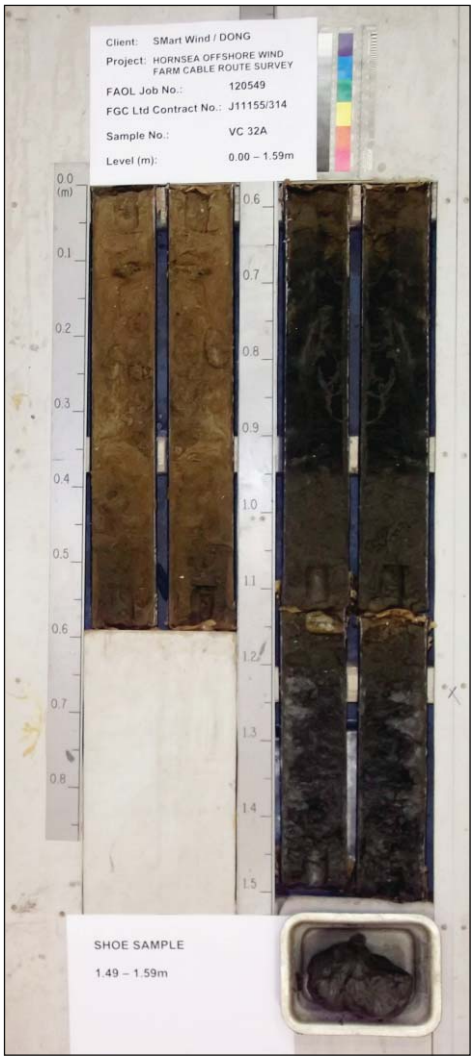

Plate 5b: VC32a 0.00 to 1.49 m below SB

Date:	29/01/2013	Revision Number:	0
Scale:	N/A	Illustrator:	KMN
Path:	W:\Projects\87150\Drawing Office\Report figs\Geoarch2\13_01_29		

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Plate 6a: VC78 0 to 1.92 m below SB

Plate 6b: VC90 0 to 1.75 m below SB

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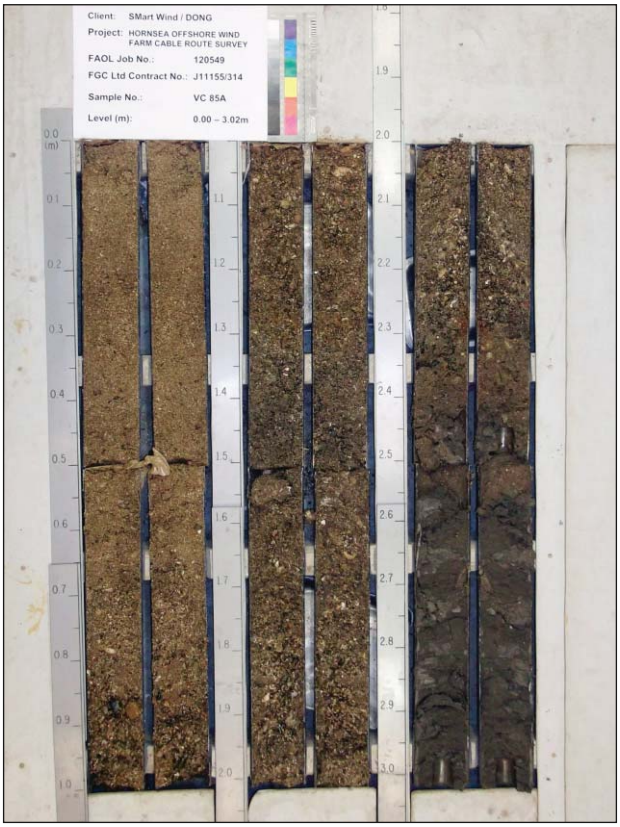

Plate 7a: VC85A 0 to 3.02 m below SB

Plate 7b: VC85A 3.02 to 5.93 m below SB

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Scale:	N/A	Illustrator:	KMN
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Plate 8a: VC92 0 to 1.83 m below SB

Plate 8b: VC88 0 to 3.52 m below SB

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