Lynn & Inner Dowsing Offshore Wind Farms
Stage 2 Archaeological Recording of Cores

Ref: 59094.01
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LYNN AND INNER DOWSING OFFSHORE WIND FARMS

Stage 2 Archaeological Recording of Cores

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Summary

Wessex Archaeology was commissioned by AMEC Wind Energy, on behalf of Centrica plc., to archaeologically record a series of geotechnical cores extruded from boreholes drilled by Fugro Ltd. as part of the ground investigations for the proposed Lynn and Inner Dowsing Offshore Wind Farms. The geotechnical borehole logs were assessed and a preliminary deposit model was postulated in a previous report (Wessex Archaeology 2005).

The present study comprised the archaeological recording and description of selected core sections in order to determine the archaeological potential of the deposits likely to be impacted by the proposed development and to make recommendations with regard to further analysis of relevant sub-samples.

Sections of two vibrocores and seven borehole cores were identified for archaeological recording. Only three sections of cores with a total length of 2.55m were available, the rest having already been used for geotechnical testing. The cores were transferred to Wessex Archaeology in Salisbury where they were split and archaeologically recorded.

On the basis of the archaeological recording of the core sections and the interpretation of the sedimentary sequence they contain, further sub-sampling and analysis of two of the core sections is recommended. These cores have the potential to contain palaeoenvironmental information and sampling and assessment for pollen, diatoms, foraminifera and ostracods, as well as radiocarbon dating of suitable samples is recommended.

Given that not all requested core sections were available, and that other core sections recorded in the geological log showed considerable potential for the survival of palaeoenvironmental and archaeological evidence, it is also recommended that any future cores from the area undergo an archaeological assessment before further decisions are made as to which are destructively tested.

An archaeological assessment of sub-bottom profiler marine geophysical data would be appropriate in order to determine whether the area to be impacted by the wind farms contains any submerged river valleys and/or pre-transgression deposits. These areas are generally considered to contain the greatest potential for the presence of palaeoenvironmental evidence and their identification would greatly aid this aspect of the archaeological research into the site.

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Dietlind Paddenberg carried out the archaeological recording of the cores and compiled this report. Jack Russell assisted with the geo-archaeological interpretation. John Gribble managed the project for Wessex Archaeology. Quality assurance was carried out by Steve Webster.

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1. INTRODUCTION

1.1. PROJECT BACKGROUND

1.1.1. Wessex Archaeology (WA) was commissioned by AMEC Wind Energy, on behalf of Centrica plc, to undertake the Stage 2 archaeological recording of selected vibrocores and borehole cores collected for the proposed Lynn and Inner Dowsing Offshore Wind Farms.

1.1.2. The core logs generated by geotechnical contractors for these vibrocores and borehole cores were assessed by WA in 2005 during a Stage 1 desk-based assessment. This Stage 1 assessment established the likely presence of horizons of archaeological interest within the cores, broadly characterised them and recommended that Stage 2 archaeological recording was required (WA 2005).

1.1.3. This report relates to the Stage 2 archaeological recording of selected cores. This entailed the splitting of the cores, with half of each core being cleaned and recorded. The Stage 2 report describes the results of the archaeological recording and indicates whether any Stage 3 work is warranted.

1.2. CHARACTERISTICS OF THE AREA

1.2.1. The sedimentary sequence of the area as stated in the previous report (WA 2005) can be summarised as follows:

- **Unit 1**: Recent seabed sediments: brown gravelly sand or sandy gravel, with shell inclusions and flint content.
- **Unit 2**: Glacial till: firm to stiff brown, sometimes speckled white, slightly sandy or gravelly clay; silty lenses.
- **Unit 3**: Glacial till: variation of sometimes clayey, sometimes silty sand and gravel layers.
- **Unit 4**: Bedrock: chalk.

1.2.2. A blanket deposit of Devensian till, the Bolders Bank Formation, appears from available data to be the prevailing sediment near the seabed surface within the Lynn and Inner Dowsing Offshore Wind Farm areas. The formation is internally largely structureless on geological seismic profiles and consists of red-brown, calcareous, gravelly, sandy clay with erratics which are predominantly of chalk, red-brown sandstone and grey mudstone. The formation is up to 25m thick (BGS Sheet, Spurn).

1.2.3. Seismic profiles interpretation and micromorphological studies imply that the Bolders Bank Formation is a composite of subglacial and supraglacial deposits. It

appears to be the lateral equivalent of the Hunstanton Till of East Anglia and the tills of Holderness north of Spurn Point, both of which it resembles lithologically (Cameron et al. 1992, 113; BGS Sheet, Spurn).

2. PROJECT AIMS AND OBJECTIVES

2.1. AIM

2.1.1. The aim of the Stage 2 archaeological recording of the cores was to examine in detail their archaeological potential, and to determine whether further archaeological work, in the form of sampling and analysis is warranted.

2.2. OBJECTIVES

2.2.1. The objectives of the study were:

- to describe the sediments contained within the core section in terms of their structure and form and the depth and thickness of the horizons;
- to identify sediments with archaeological potential;
- to comment on the archaeological character and importance of these identified sediments;
- to assess the need for sampling and further analysis.

3. METHODOLOGY

3.1. INTRODUCTION

3.1.1. In advance of this Stage 2 assessment, core logs and photos provided by Fugro Ltd. were assessed by WA, and a shortlist of cores for recording was drawn up. WA identified sections of nine cores, four from the Lynn Offshore Wind Farm, three from the Inner Dowsing Offshore Wind Farm, and two from the cable route, that required recording (WA 2005). These are summarised in the following table:

Area	Core	Requested sections	Particularly interesting	Interest rating	Reason of interest
Inner Dowsing	BHID6	0-7m	6-6.4m	*	Organic silty clay
	BHID13	0-8m	0-8m	*	Seabed deposits (?)
	BHID25	0-8m	6.8-7.7m	**	Organic silts/clays
Lynn	BHL2	0-4.1m	0-4.1m	*	Seabed deposits (?)
	BHL17	0-4.5m	0.9-1.7m	**	Organic (?) silt/clay
	BHL21	0-7m	0-3.1m	*	Significant depth of Holocene sediments
	BHL28	0.5.7m	3.7-4m	**	Silt with organic (?) odour
Cable route	TB10-02	0-5.95m	0-0.7m, 0.94-1.35m, 3.1-3.4m	***	Organic silts/clays, palaeochannels (?)
	TB10-10	0-5.78m	4.4m (peat)	***	Peat/laminated silts/clays

3.1.2. These cores were chosen on the basis of their potential to provide information about the palaeoenvironment of the area and their potential to allow reconstruction of the sedimentary sequence.

3.1.3. The cores that appeared the most promising from the Stage 1 review of the geotechnical logs were two vibrocores from the cable route, TB10-02 and TB10-10. Within their upper six metres they contained organic silts/clays and peat/laminated silts/clays respectively, indicating possible palaeochannels and/or former landsurfaces.

3.1.4. The archaeological potential of the borehole cores was perhaps lower, but the core sections BHID6 (0-7m), BHID25 (0-8m), BHL17 (0-4.5m) and BHL28 (0-5.7m) were identified as having the most potential because of their possibly organic silty layers.

3.1.5. A third option was to investigate the three cores BHID13 (0-8m), BHL2 (0-4.1m) and BHL21 (0-7m) which appeared from the core logs to contain seabed deposits and low energy deposits like clay, possibly indicative of Holocene coastal or estuarine deposits.

3.2. RECORDING

3.2.1. Unfortunately, many of the requested core sections were not available as they had been used for geotechnical testing. However, the following samples were delivered to WA either because no testing was done on them or because a portion was returned to stores after testing. They are currently being stored at the environmental laboratory at WA in Salisbury:

Borehole	NGR		Section	Total length of section
	Easting	Northing		
BHL21	564358/	371262	1.60-1.96m	0.36m
BHID25	564455/	369106	0.50-0.75m	0.25m
			1.50-1.93m	0.43m
			2.50-2.89m	0.39m
			6.00-6.23m	0.23m
			7.00-7.35m	0.35m
BHL28	565905/	362905	1.50-1.69m	0.19m
			2.50-2.85m	0.35m
Total length of core sections delivered				**2.55m**

3.2.2. The core sections have been described in this report to an archaeological (c. 1cm resolution) rather than geotechnical (c. 50cm resolution) level and the results compiled in **Appendix I**. The descriptions broadly follow the conventions of Hodgson (1976) and include colour, texture, internal structures and nature of inclusions and boundaries to enable correlation of strata across the site and a detailed interpretation of the sedimentary history.

3.2.3. Particular consideration was given to the existence of any stases in the sequences, notably the presence of soils and stases within terrestrial peat horizons, which would have existed as land surfaces, and therefore offered opportunities for human activity at the site. Such horizons are often not recorded in geotechnical logging due to the coarser recording resolution employed for engineering purposes.

4. RESULTS

4.1.1. A result of the Stage 1 borehole assessment (WA 2005) was the postulation of a preliminary model of the local sedimentary sequence, based on an archaeological

assessment of the descriptions provided in the geological borehole logs and the geotechnical report compiled by Fugro Engineering Services Ltd. (Fugro 2004).

4.1.2. According to the Fugro Report, the strata encountered were Holocene sediments, sediments of the Devensian Bolders Bank Formation and Cretaceous chalk bedrock. The archaeological assessment enabled the identification by WA of four broad sedimentary units (see **1.2.1**) (WA 2005).

4.1.3. The results of the Stage 2 archaeological recording of the available sections of BH21 (**WA1-3**), BH25 (**WA4-8**) and BH28 (**WA9-10**) are set out below, and compared with the results of the Stage 1 assessment. As no Unit 3 and 4 sediments were present in any of the available core sections, only Units 1 and 2 are considered in the results set out below.

4.1 UNIT 1: BROWN GRAVELLY SAND OR SANDY GRAVEL WITH SHELL INCLUSIONS

4.2. STAGE 1 RESULTS

4.2.1. Sediments attributed to Unit 1 were identified as a Holocene stratum in the Fugro report (Fugro 2004), and were present as the uppermost layer in all cores. In most cases only very little of this layer remained (0.2–1.0m). Only core BHL21 contained a significant depth (3.1m) of this sediment. In some cases, the sediment was only observed by the drill operator and did not survive in the core.

4.2.2. This layer was interpreted as the modern (i.e. post transgression) marine seabed sediment, and was largely made up of sand and gravel. If this interpretation was found to be accurate then the palaeoenvironmental potential was likely to be low. However, some potential was identified for the presence of pre-transgression deposits in the lower reaches of this deposit, and if present any such deposits were characterised as having a high potential for palaeoenvironmental deposits likely to be of high regional and possibly national importance.

4.3. STAGE 2 RESULTS

4.3.1. The archaeological recording of BHL21 (**WA1-3**) showed the sand deposit of Unit 1 to be only 0.17m thick, ending at -14.67m OD. This deposit was labelled **WA1**. Furthermore, the loose consistency of this deposit suggested it may be intrusive and possibly contaminated.

4.3.2. A sequence of Unit 2 layers was also recorded (**WA2** and **3**) below **WA1** in BHL21, indicated that Unit 1 sediments did not directly overlay the chalk bedrock (Unit 4), as observed during the geotechnical recording.

4.3.3. Core BHL21 fits within the overall sedimentary sequence of the area which consists of chalk bedrock (Unit 4) overlain by clay sediments (Unit 2) with occasional sand/gravel sediments (Unit 3) between them, and a surface layer of modern marine seabed sediment (Unit 1) recorded in some cores.

4.3.4. Unit 1 of BHL21 (**WA1**) consists of possibly intrusive and contaminated loose sand with no indications of preserved pre-transgression deposits. The palaeoenvironmental and archaeological potential of any sub-samples can therefore be classified as low.

4.4. UNIT 2: FIRM TO STIFF BROWN (SOMETIMES SPECKLED WHITE) SLIGHTLY SANDY - SLIGHTLY GRAVELLY CLAY

4.5. STAGE 1 RESULTS

4.5.1. In all of the borehole logs the Unit 1 sediment, where present, overlay a stiff sandy or gravelly clay – the Unit 2 sediment. The only exception was core BHL 21, where substantial deposits of Unit 1 sediment directly overlay the chalk bedrock (Unit 4).

4.5.2. The Fugro report (Fugro 2004) assigned Unit 2 to the Bolders Bank Formation, a composite of subglacial and supraglacial deposits dating to the end of the Devensian glaciation.

4.5.3. However, the core log descriptions of the deposit indicated the presence of significant elements of clay within this unit. Clay deposits are usually formed in low energy environments, and thus may represent material deposited during transgression in sheltered parts of the Holocene coastline, or material re-deposited by the Devensian glaciers. Low energy deposition is characteristic of Holocene estuaries, and can be associated with peat formation.

4.5.4. In core BHL28, there was a 2.5m thick silt inclusion within the clay. The silt in the lowermost part of this inclusion was recorded as having an organic odour. Silt is generally formed in higher energy environments than clay. However, the organic odour was characterised as possibly being indicative of the presence of peat within this element of the sequence, suggesting that the deposit formed in what was still a relatively low energy environment.

4.5.5. Due to the level of information available in the borehole logs and the resolution at which the descriptions were provided it was not possible to determine the exact nature of the deposit and it appeared possible that the deposit was in fact more complex. Detailed archaeological recording and assessment was recommended in order to identify elements of the deposit that are of specific archaeological interest.

4.5.6. In general the layers with highest palaeoenvironmental and archaeological potential were identified as probably lying directly below the modern mobile marine sediments and above the glacially deposited Bolders Bank layer. The deposits with the highest archaeological potential are peat and fine-grained sediment formations that allow for the preservation of organic remains. From the descriptions provided it was not possible to determine conclusively whether the upper reaches of Unit 2 contained any such deposits, but if present they would have had high potential for palaeoenvironmental deposits likely to be of high regional and possibly national importance.

4.6. STAGE 2 RESULTS

4.6.1. Between -14.67 and -14.78mOD the core section of BHL21 comprised clay with chalk inclusions (**WA2**), which overlay a layer of coarse sand and gravel between -14.78 and -14.86m OD (**WA3**). Both **WA2** and **WA3** can be described as glacial till belonging to Unit 2. **WA3** probably represents a sandy and gravelly lens within the overall clayey sediment.

4.6.2. The geological log for BHL28 recorded a 2.5m thick silt inclusion within the clay of Unit 2. Two sections of this 'silt' were available for archaeological recording (**WA9** and **WA10**) and this has confirmed that both sections consisted of sandy clay with gravel inclusions (i.e. till) with no visible silty components, but with rare inclusions of very small shell fragments.

4.6.3. The majority of core sections available for archaeological recording came from BHID25 (**WA4-8**). The upper three sections (**WA4-6**) derived from a layer described as slightly sandy and slightly gravelly clay in the geological logs. This description was largely confirmed by the archaeological recording, which described frequent gravel inclusions. As a result, the layer has also been identified as till.

4.6.4. The Fugro report (Fugro 2004) identified a change in the sedimentary sequence of BHID25 at -17.10m OD. This is borne out by the core section from between -17.70 and -17.93m OD (**WA7**) subject to archaeological recording which was found to consist of sandy, slightly silty clay without any visible inclusions and is more homogenous than the upper sections of this core.

Another sediment change was noted in core BHID25 by Fugro (Fugro 2004) at -18.50m OD, where the upper edge of a clay/silt layer with black organic pockets was reported. The archaeological recording of the section between -18.70 and -19.05m OD (**WA8**) evidenced sandy silty clay with no visible inclusions. This sediment was completely crossed by black, possibly organic bands and the palaeoenvironmental and archaeological potential of any sub-samples can therefore be classified as high.

4.7. INTERPRETATION

4.7.1. Till is one of the most variable types of sediment to be found on the earth's surface. It is an unsorted glacial sediment which is deposited directly by glaciers, either at their terminal, lateral, medial or ground moraine. As a glacier melts, large amounts of this till are washed away and deposited as outwash in secondary deposits.

4.7.2. The principal characteristics of a till are a lack of complete sorting which usually means the presence of some pebbles or boulders much larger than the dominant clay, silt or sand matrix. Tills are a homogenous mix of sediment lacking any smooth laminations or regular graded bedding, combined with a mixture of mineral and rock types, some of which may be of distant provenance and not represented in the local strata (Lowe and Walker 1997: 89).

4.7.3. The palaeoenvironmental and archaeological potential of till is comparatively low, because it does not reflect former landsurfaces, but consists instead of re-deposited sediments, which had completely reshaped the landscape by the end of the Devensian period (c. 13,000BP).

4.7.4. The most obvious explanation for the presence of shell debris within the till of BHL28 is the passage of ice across the former seabed (**WA9** and **10**). Isolated and tiny chips identified in **WA9** and **WA10** possibly indicate a greater distance of glacial transport, with shell often being absent from the top metres of exposures due to postglacial weathering and associated decalcification. Till containing chalk, flint, wood, shell and erratics from the North Sea floor, Scotland and Scandinavia is known from Norfolk (www.museums.norfolk.gov.uk/).

4.7.5. The lithostratigraphic subdivision of a glacigenic sequence illustrated in Lowe and Walker (1997: 300 Fig. 6.2) shows that the upper till layers of a formation such as the Bolders Bank Formation are likely to contain not only frequent gravel inclusions, but also sand and silt lenses. This may explain the presence of the silty sediments in **WA7** below the gravelly and clayey till sediments in the upper sections of core BHID25 (**WA4-6**).

4.7.6. However, the black, possibly organic bands crossing the sandy silty clay sediment in **WA8** are an unusual phenomenon within the general sedimentary sequence of bedrock, till and recent seabed deposits in the area. These bands might be remains of varves, i.e. yearly deposits in a proglacial lake (Whitten and Brooks 1972: 470), or they might indicate – possibly in connection with the silty sediment of **WA7** – a sedimentary sequence the origin and evolution of which is unclear so far.

4.7.7. As a result, the archaeologically recorded core sections **WA2-6, WA9-10** and possibly **WA7** can be characterised as glacial till of the Bolders Bank Formation and belong to Unit 2. They come from an absolute depth of between -12.20 and -19.30m OD. **WA1** represents recent seabed sediment consistent with Unit 1, found in a depth of between -14.50 and -14.67m OD. The origin of the deposits within **WA8** is less clear, containing abundant black bands in a depth of between -18.70 and -19.05m OD. The slightly silty character of this core section and the core section above it (**WA7**) furthermore suggests possible deposition in a lower energy estuarine or lacustrine environment.

4.7.8. Regarding the relative stratigraphic position of **WA7-8** between bedrock and glacial till these layers are presumably of Palaeolithic age. According to their absolute depth, they might belong to the Brown Bank, a lower Devensian formation preceding the Bolders Bank Formation, which was deposited in a marine to lacustrine environment (Cameron et al. 1992: 102, 112-113). However, the Brown Bank Formation extends just east of the study area, and an allocation seems problematic. As a consequence, a far older age of these sediments is also possible.

4.8. RECOMMENDATIONS

4.8.1. Questions are raised by the untypical black, possibly organic bands crossing the slightly silty sediments within **WA8**. According to their stratigraphic position, this core section and the slightly silty core section **WA7** are potentially of late Devensian, Early Upper Palaeolithic age. This would imply their deposition in a period when Britain was probably virtually unoccupied by humans (Tolan-Smith 1998: 21-24; Barton 1999: 14-15). If the sediments are older, they could belong to any period within the Lower, Middle and Early Upper Palaeolithic of Britain, which saw the arrival of early hominids, Neanderthals and modern humans.

4.8.2. **WA7-8** can be characterised, therefore, as having a high potential for revealing further information about the palaeoenvironment and the palaeoclimate of the area, and consequently of its archaeological potential. The recorded sediments indicate a low energy deposition, i.e. possibly an estuarine environment, or a proglacial lake, formed either by the damming action of a moraine or ice dam during retreat of a melting glacier, or formed by meltwater trapped against an ice sheet due to isostatic depression of the crust around the ice.

4.8.3. As a result, sub-sampling for pollen, diatoms, ostracods and foraminifera is recommended for **WA7-8**. Pollen has the potential to inform further on the local and regional environments, the vegetation types, notably terrestrial vs. aquatic environments, and possibly on anthropogenic activity such as the clearance of vegetation. Diatoms, foraminifera and ostracods would have the potential to inform further upon the hydrological regime of the alluvial sediments. In order to obtain a date of the deposits, radiocarbon sampling is also recommended.

4.8.4. Given that not all requested core sections were available, and that other core sections recorded in the geological log showed considerable potential for the survival of palaeoenvironmental and archaeological evidence, it is also recommended that any future cores from the area undergo an archaeological assessment before they are destructively tested.

4.8.5. Sub-bottom profiler marine geophysical data for the Lynn and Inner Dowsing Offshore Wind Farms has not been assessed archaeologically, either during the desk-based assessment (Wessex Archaeology 2002) or as part of the Stage 1 borehole assessment (Wessex Archaeology 2005). The assessment of this data would help to determine whether the area to be impacted by the wind farms contains any submerged river valleys and/or pre-transgression deposits. Such features are generally considered to contain the greatest potential for the presence of palaeoenvironmental material, and their identification would greatly aid this aspect of the archaeological research into the site.

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APPENDIX I: CORE RECORDS

WA ID	Borehole	Depth as labelled (m)	Seabed level below OD (m)	Length of section, (m)	Section below OD (m)	Description	Interpretation / Unit
1	BHL21	1.60	12.90	0.36	14.50 - 14.67	10YR 3/4 Dark yellowish brown coarse sand with small shell and gravel inclusions (<5mm). Very loose, very probably contamination consisting of recent seabed deposits.	Intrusion (seabed deposit) / Unit 1
2					14.67 - 14.78	2.5Y 4/1 Dark grey clay, very firm, stiff, with frequent big chalk inclusions (10-25mm), patch with sand and shell inclusions (<5mm) running from the top corner, probably intrusion from above.	Till / Unit 2
3					14.78 - 14.86	5Y 4/4 Olive coarse sand and gravel (10-65mm), firm and stiff, one black fleck visible at c. 14.79m (organic/mineral?).	Till / Unit 2
4	BHID25	0.50	11.70	0.25	12.20 - 12.45	10YR 3/2 Very dark greyish brown clay, firm and stiff, with frequent chalk (2-10mm) and occasional flint inclusions (10-20mm). Big patch of white chalk at 12.28-12.39, firm and stiff. Big patch of yellowish brown, loose medium sand with big gravel inclusions (40mm) at 12.37-12.45.	Till / Unit 2
5		1.50		0.43	13.20 - 13.63	10YR 3/2 Very dark greyish brown clay, firm and stiff, occasionally slightly sandy, with frequent subrounded gravel inclusions (chalk, flint, red sandstone etc., 4-40mm) and rare tiny black (mineral?) flecks.	Till / Unit 2
6		2.50		0.39	14.20 - 14.59	10YR 3/2 Very dark greyish brown clay, firm and stiff, frequent subrounded gravel inclusions (chalk, flint etc., 5-45mm), rare small black (mineral?) flecks.	Till / Unit 2
7		6.00		0.23	17.70 - 17.93	2.5Y 3/2 Very dark greyish brown sandy silty clay, firm and stiff, well sorted. No inclusions (apart from intrusive small chalk and flint particles at the sides). One brownish sandy band at 17.83-17.84.	Till (?) / Unit 2 (?)
8		7.00		0.35	18.70 - 19.05	2.5Y 3/1 Very dark grey sandy silty clay, completely crossed by slightly arched horizontal black organic(?) bands (c.3mm wide), especially dense between 18.95 and 19.05. Well sorted, firm and stiff, no visible inclusions.	Varves (?) / Unit 2 (?)
9	BHL28	1.50	16.45	0.19	17.95 - 18.14	2.5Y 4/1 Dark grey sandy clay, firm and stiff, medium to coarse sandy patches especially along the sides (intrusive contamination?), frequent gravel inclusions (chalk and flint, 10-50mm), rare very small shell fragments (<3mm).	Till / Unit 2
10		2.50		0.35	18.95 - 19.30	5Y 4/1 Dark grey sandy clay, firm and stiff, with rare small shell inclusions (<3mm). Occasionally brownish sand bands, especially at 19.13, and between 19.20 and 19.30. These sand bands are 2-3cm wide and irregular. They contain frequent small chalk (<6mm) and bigger flint (30mm) inclusions.	Till / Unit 2