

**REPORT**



# Hornsea Project One Offshore Wind Farm

## Stage 1 Intertidal Geoarchaeological Assessment

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## 1. Introduction

Maritime Archaeology Ltd. has been commissioned by DONG Energy Wind Power A/S to provide a Stage 1 assessment of geotechnical boreholes recovered from the intertidal zone relating to the Hornsea Offshore Wind Farm Project One (the Project) (see Figure 1).

The Stage 1 geoarchaeological assessment correlates to the first element in the archaeological assessment of geotechnical data as defined in:

- *Offshore Geotechnical Investigations and Historic Environment Analysis: Guidance for the Renewable Energy Sector* (COWRIE, 2011).

This initial 'Core Log Assessment' comprises a review by a suitably trained archaeologist of the geotechnical core logs produced by the geotechnical contractor, undertaken to determine whether, from the sediment descriptions, there appear to be layers/sediments of archaeological interest. The review assessed all the geotechnical logs and reporting for the intertidal area of Hornsea Project One including a list of retained samples and photographs. Previous geoarchaeological reports covering the Project area were reviewed and recommendations for further Stage 2 work to be undertaken have been included.

## 2. Scheme background

DONG Energy (DE) took over full ownership of Hornsea Offshore Wind Farm Project One (Hornsea Project One) on 4 February 2015 following years of development alongside SMartWind. Hornsea Project One was one of the three projects for which DONG Energy was awarded Final Investment Decision Enabling contracts (Contract for Difference (CfD)) by the UK Government in April 2014. Under this CfD the business will receive a fixed price per MWh of electricity produced by the wind farm for the first 15 years of operation following which DONG Energy will receive the market price.

Hornsea Project One has received final investment decision (February 2016) and DE will develop the project through into construction and operation

Hornsea Project One will consist of 174 wind turbines each 7MW and will be located 120 km off the Yorkshire coast, covering approximately 407 square kilometres. Onshore construction of the project started early 2016 with offshore construction beginning in Q1 2018. Horizontal Directional Drill (HDD) landfall construction is planned for early 2017.

In September 2015, Allied Exploration and Geotechnics Ltd were contracted by the Project to perform ground investigation at Horseshoe Point comprising trial pits and six cable percussion boreholes (Figures 2 and 3). The boreholes demonstrate the presence of beach deposits overlying alluvium, in places recorded with organic inclusions including plant fragments.

Testing of the cores for landfall design purposes is complete and the cores acquired from the cable percussion boreholes are no longer available. Bagged samples, however, have been retained which may assist the archaeological contractor with the identification of sub-surface deposits and their archaeological potential.

Further Stage 1 assessment work is a requirement of the *Intertidal Written Scheme of Investigation (WSI) for Archaeology* (Hornsea, 2016) of this material, which has been submitted to the MMO along with its advisors at Historic England (HE).

The MMO confirmed on 13<sup>th</sup> December 2016 that they were content with the Hornsea Project One Intertidal WSI for Archaeology strategy and that the condition could be discharged in respect of the HDD phase of works as set out below.

*DML 4, Pre-construction plans and documentation 13 (2)(g):*

*A written scheme of archaeological investigation in relation to Wind Farm Area 1 in accordance with industry good practice to include—*

- (i) details of responsibilities of the licence-holder, archaeological consultant and contractor;*
- (ii) a methodology for any further site investigation including any specifications for geophysical, geotechnical and diver or remotely operated vehicle investigations;*
- (iii) analysis and reporting of survey data to be submitted to the MMO within four months of survey completion;*
- (iv) delivery of any mitigation including, where necessary, archaeological exclusion zones;*
- (v) monitoring during and post construction, including a conservation programme for finds;*
- (vi) archiving of archaeological material; and*
- (vii) a reporting and recording protocol, including reporting of any wreck or wreck material during construction, operation and decommissioning of the authorised scheme.*

## **2.1 Previous Geoarchaeological Work**

The previous assessment of offshore geotechnical and geophysical survey data collected in the Project One area revealed the presence of Pleistocene fluvial and estuarine sediments with the potential to contain hominid remains beneath the Devensian glacial till (generally at depths of 15 m or more below the seafloor). Closer to the seabed surface this work identified that Early Holocene 'Upper Botney Cut' channels, generally up to 15 m deep and 80 m wide, are cut into larger late Glacial channels of considerably greater size containing reworked glacial till (Wessex Archaeology 2013:16).

The cable corridor crosses some Late Pleistocene and Early Holocene channels on its way to shore lying at variable depth below the surface. The most significant feature to the west of Inner Silver Pit is a large palaeo-feature that extends 4 km from landfall and appears to be a segment of the palaeo-Humber (SMart Wind, 2013).

The likelihood of survival of the remains of Mesolithic activity and settlement in and particularly on the side of these later channels is high (Coles, 1998; Flemming 2004 and Boomer *et al.*, 2007), although there are no known prehistoric terrestrial sites within the Project area. Sampling undertaken during the Humber Regional Environmental Characterisation (REC) study (Tappin *et al.* 2011) has shown that these deposits generally lie close to the surface of the seabed. It is therefore likely that the general area contains important prehistoric archaeological sites and finds and palaeo-environmental evidence.

Boreholes and vibrocores collected and assessed for archaeological potential in the Project area (Figure 1) to date are summarised in Table 1.

**Table 1: Previously undertaken geoarchaeological campaigns.**

| Year      | Samples acquired   | Archaeological report  | Report summary   |
|-----------|--|--|--|
| 2011      | <ul style="list-style-type: none"> <li>28 Near shore zone vibrocores</li> <li>Offshore bagged samples</li> </ul>               | Palaeoenvironmental assessment of near shore and offshore cores from the Hornsea Zone (Krawiec et al. 2011).                               | 28 VC logs examined, 6 cores assessed together with bagged samples from the offshore zone. The samples yielded mixed results, the pollen concentrations were extremely low in some of the samples and assessment counts were not always possible. The accuracy of the radiocarbon dates were questioned and further work was recommended.  |
| 2012      | <ul style="list-style-type: none"> <li>12 boreholes</li> <li>129 vibrocores</li> </ul>   | Round 3 Hornsea Offshore Windfarm Subzone 1 and export cable route Stage 1 and 2 Geoarchaeological Assessment, (Wessex Archaeology, 2013). | 12 borehole locations and 27 vibrocore samples from the export cable route were assessed. Glacial, fluvial, estuarine and coastal sediments relating to former potentially inhabited landscapes were identified Stage 3 samples were recommended to further understand the sequence.   |
| 2014-2015 | <ul style="list-style-type: none"> <li>3BHs</li> <li>5 Wireline Push Samples</li> <li>Downhole push CPT's (drilled)</li> </ul> | Hornsea Project One Offshore Wind Farm Stage 1-2 Updated Geoarchaeological Assessment Report. (Maritime Archaeology, 2016)                 | Three boreholes and five Wireline Push Samples collected in 2014-2015 were assessed in terms of their archaeological and palaeoenvironmental potential.<br><br>The small amount of samples recovered could not enhance the initial interpretation of the project area. It was recommended that further Stage 3 assessment should be undertaken with samples from all previous geoarchaeological campaigns. |

### 3. Project aims and objectives

The aim of this study is to inform the Project and provide continuity of geoarchaeological assessment regarding the archaeological potential development area. This has been achieved by examining the logs for six cores and seven trial pits collected at the intertidal zone at Hornsea Project One.

The objectives of the archaeological Stage One review of the available cores are to:

- Review the core logs and the list of retained, bagged samples and identify samples for further assessment and samples of no further geoarchaeological interest;
- Review previous reporting relevant to the Hornsea Project One intertidal and offshore geoarchaeological assessments;
- Highlight the geoarchaeological potential of certain types of sub-surface geological deposits;
- Clarify the potential for impacts to sub-surface geoarchaeological deposits and buried archaeology from activities at the landfall;
- Assess the potential for further geoarchaeological assessment of retained samples; and,
- Identify further samples that may be acquired as part of a proportionate mitigation strategy during on-site archaeological monitoring.

## 4. Methodology

The assessment of potential archaeological deposits follows the staged approach described in *Model Clauses for Archaeological Written Schemes of Investigation: Offshore Renewables Projects* (The Crown Estate, 2010), COWRIE's *Offshore Geotechnical Investigations and Historic Environment Analysis: Guidance for the Renewable Energy Sector* (COWRIE, 2011), and *Environmental Archaeology: a guide to the theory and practice of methods, from sampling to post excavation* (English Heritage, 2011). This comprises the following elements:

- Stage 1 – Desk Based Assessment: archaeological review of geotechnical logs (this report);
- Stage 2 – Splitting and recording geotechnical cores;
- Stage 3 – Sub-sampling & assessment; and
- Stage 4 – Analysis and dating.

The staged approach is designed to flow sequentially with each stage leading to the subsequent stage of work, or representing the end of the assessment if the findings of any stage show that no further work is beneficial.

### 4.1 Stage 1 Desk Based Assessment: Archaeological review of geotechnical logs

The Stage 1 requirements were met by undertaking four specific tasks as outlined in the Scope of Works (DONG Energy, 2016d) and below:

**Task 1:** Log sheets from six cores and seven trial pits were documented and provided by Allied Exploration and Geotechnics Ltd to Maritime Archaeology Ltd. The documentation included borehole, and trial pit logs, photographic archive from the trial pits and the final report including a logging manual (Allied Exploration and Geotechnics Ltd, 2015). The photographic and documentary evidence was assessed both stratigraphically and sedimentologically for each individual borehole and trial pit. The geoarchaeological information extracted from the core logs was evaluated for archaeological potential and cores containing material anticipated to have archaeological potential were identified.

**Task 2:** The results from Task 1 were reviewed against the current knowledge of the potential Holocene sediments within the development area (Table 1) to improve the understanding of the deposits represented within the cores and to inform the Stage 2 assessment. Based on the information from all geotechnical campaigns, further recommendations have been developed for additional assessment.

**Task 3:** A geoarchaeological assessment report has been provided which addresses the objectives set out in the intertidal WSI (DONG Energy, 2016c) and in Section 3 of this report.

**Task 4:** Draft reports have been provided to Hornsea Project One for review and comment.

## 5. Results

The review of the pre-recorded individual core logs was undertaken to a detailed level. Table 2 lists the cores assessed for archaeological potential and summarises their content.

The sequence in the cores shows a relatively homogenous stratigraphy with a base of till, a very stiff brown gravelly clay with inclusions of chalk laid down after the last glacial maximum with a minimal potential for geoarchaeological potential, the till is in some cores overlaid by Holocene alluvium presenting a short time of stability where grasses and plants had time to grow before the area was inundated by the sea, this deposit is of the highest potential to yield material of archaeological importance. The Holocene alluvium is overlain by a sandy seabed/intertidal sediment probably marine or fluvial which is not of geoarchaeological potential, however larger fossils commonly found in the submerged context might be present within the sandy seabed/intertidal sediment.

**Table 2: cores assessed for archaeological potential and the broad content**

| Core/Trial pit ID | Depth (BGL) | Sediment recorded   | Stratigraphy                              | Depth of Holocene deposits (BGL) |
|-------------------|-------------|---|---|----------------------------------|
| HOWBH08           | 0-20.00     | Made ground overlying firm to stiff sandy CLAY.   | Made ground, till.                        | n/a                              |
| HOWBH14           | 0-26.00     | Brown clayey SAND overlying sandy organic CLAY and SILT on top of very stiff gravelly CLAY. | Seabed sediment, Holocene alluvium, till. | 8.80- 11.60                      |
| HOWBH15           | 0-25.00     | Brown clayey SAND overlying silty organic CLAY on top of firm and stiff CLAY.               | Seabed sediment, Holocene alluvium, till  | 9.20- 12.00                      |
| HOWBH16           | 0-25.00     | Brown clayey SAND overlying SILT on top of firm and stiff CLAY.                             | Seabed sediment, Holocene alluvium, till  | 6.30- 12.00                      |
| HOWBH17           | 0-26.00     | Brown clayey SAND overlying SILT on top of firm and stiff CLAY.                             | Seabed sediment, Holocene alluvium, till  | 6.20- 16.00                      |
| HOWBH18           | 0-25.00     | Brown clayey SAND overlying silty organic CLAY on top of firm and stiff CLAY.               | Seabed sediment, Holocene alluvium, till  | 11.60- 14.60                     |
| HOWTP-01          | 0-3.00      | Brown fine to coarse SAND and grey clayey fine SAND.  | Seabed sediment.                          | n/a                              |
| HOWTP-02          | 0-1.50      | Brown fine to coarse SAND overlying sandy SILT.   | Seabed sediment.                          | n/a                              |
| HOWTP-03          | 0-1.50      | Brown fine to coarse SAND overlying sandy SILT.   | Seabed sediment.                          | n/a                              |
| HOWTP-04          | 0-1.50      | Brown fine to coarse SAND and grey clayey fine SAND.  | Seabed sediment.                          | n/a                              |
| HOWTP-05          | 0-1.00      | Brown fine to coarse SAND.  | Seabed sediment.                          | n/a                              |
| HOWTP-06          | 0-1.50      | Brown fine to coarse SAND and grey clayey fine SAND.  | Seabed sediment.                          | n/a                              |
| HOWTP-33          | 0-3.70      | Made ground overlying gravelly stiff CLAY.  | Made ground, till.                        | n/a                              |

## 6. Recommendations

The Stage 1 review has shown that it is possible to recover material that may contain preserved macro and micro fauna of archaeological interest from the retained samples. Table 3 lists the samples that should be retained and recorded during the Stage 2 geoarchaeological assessment, as outlined in section 4.

A layer of organic clay and silt is present in four cores where the deposits have been retained in jars and bulk samples. These should be assessed during Stage 2 where sub-sampling should be undertaken and recommendations for assessment for pollen, diatoms, ostracods, foraminifera and macro fossils with the aim to identify material suitable for C14 dating should be made.

The results from a previous geoarchaeological assessment undertaken in the nearshore zone yielded mixed results but demonstrated that there is potential in the deposits from the intertidal zone to contain environmental indicators of geoarchaeological interest. Three cores from the nearshore zone were assessed. CR1A2 where pollen characterised by tree and shrub taxa, and a C14 date of Cal BC 11,140 to 10,800 (Cal BP 13090 to 12750) was obtained; Pollen samples from CR1A8 showed a mixed woodland habitat with a few herbaceous taxa and C14 dates ranging from Cal BC 6350 to Cal BP 8020; The third core from the nearshore zone CR12 came back with a C14 date of Cal BC 16,050 to 15,810 (Cal BP 18000 to 17760) and no results from the pollen assessment (Krawiec *et.al.*, 2011).

As the samples recommended for Stage 2 assessment will be collected from disturbed samples it is recommended that future assessments should focus on deposits where micro- and macro-fossils are more likely to survive i.e. fine grained material such as silt and clay, and to only undertake C14 if suitable material is recovered where minimal disturbance to the sedimentary sequence has occurred.

**Table 3: Samples recommended to be retained for further assessment.**

| Core             | Sample type | Sample | Depth |
|------------------|-------------|--------|-------|
| HOW BH-14        | 4030 Jar    | 5      | 3.00  |
| HOW BH-14        | 4030 Jar    | 7      | 4.50  |
| HOW BH-14        | 4030 Jar    | 9      | 6.00  |
| HOW BH-14        | 4030 Jar    | 11     | 7.50  |
| HOW BH-14        | 4030 Jar    | 15     | 9.50  |
| HOW BH-14        | 4030 Jar    | 19     | 12.50 |
| HOW BH-14        | 4030 Jar    | 25     | 17.00 |
| HOW BH-14        | 4030 Jar    | 28     | 18.50 |
| HOW BH-14        | 4030 Bulk   | 13     | 8.90  |
| HOW BH-14        | 4030 Bulk   | 18     | 12.00 |
| <b>HOW BH-15</b> | 4030 Jar    | 5      | 2.50  |
| <b>HOW BH-15</b> | 4030 Jar    | 7      | 3.50  |
| <b>HOW BH-15</b> | 4030 Jar    | 9      | 4.50  |
| <b>HOW BH-15</b> | 4030 Jar    | 11     | 5.50  |
| <b>HOW BH-15</b> | 4030 Jar    | 14     | 7.70  |
| <b>HOW BH-15</b> | 4030 Jar    | 15     | 8.50  |



|                  |           |    |       |
|------------------|-----------|----|-------|
| <b>HOW BH-15</b> | 4030 Jar  | 19 | 10.50 |
| <b>HOW BH-15</b> | 4030 Jar  | 20 | 11.50 |
| <b>HOW BH-15</b> | 4030 Jar  | 22 | 12.50 |
| <b>HOW BH-15</b> | 4030 Jar  | 25 | 14.50 |
| <b>HOW BH-15</b> | 4030 Jar  | 31 | 19.50 |
| <b>HOW BH-15</b> | 4030 U100 | 18 | 10.00 |
| <b>HOW BH-15</b> | 4030 Bulk | 16 | 8.50  |
| <b>HOW BH-15</b> | 4030 Bulk | 17 | 9.30  |
| HOW BH-15        | 4030 Bulk | 21 | 11.50 |
| HOW BH-16        | 4030 Jar  | 1  | 0.30  |
| HOW BH-16        | 4030 Jar  | 5  | 2.10  |
| HOW BH-16        | 4030 Jar  | 6  | 2.50  |
| HOW BH-16        | 4030 Jar  | 8  | 3.50  |
| HOW BH-16        | 4030 Jar  | 10 | 4.50  |
| HOW BH-16        | 4030 Jar  | 12 | 5.50  |
| HOW BH-16        | 4030 Jar  | 20 | 11.50 |
| HOW BH-16        | 4030 Jar  | 22 | 12.10 |
| HOW BH-16        | 4030 Jar  | 25 | 13.50 |
| HOW BH-16        | 4030 Jar  | 26 | 14.50 |
| HOW BH-16        | 4030 Jar  | 29 | 16.50 |
| HOW BH-16        | 4030 Jar  | 30 | 17.50 |
| HOW BH-16        | 4030 Jar  | 33 | 19.50 |
| HOW BH-16        | 4030 Bulk | 15 | 6.60  |
| HOW BH-16        | 4030 Bulk | 16 | 7.00  |
| HOW BH-16        | 4030 Bulk | 18 | 8.50  |
| HOW BH-16        | 4030 Bulk | 19 | 10.00 |
| HOW BH-16        | 4030 Jar  | 21 | 11.50 |
| <b>HOW BH-18</b> | 4030 Jar  | 3  | 1.50  |
| <b>HOW BH-18</b> | 4030 Jar  | 5  | 3.00  |
| <b>HOW BH-18</b> | 4030 Jar  | 8  | 4.70  |
| <b>HOW BH-18</b> | 4030 Jar  | 13 | 9.00  |
| <b>HOW BH-18</b> | 4030 Jar  | 15 | 11.00 |
| <b>HOW BH-18</b> | 4030 Jar  | 22 | 15.50 |
| <b>HOW BH-18</b> | 4030 Jar  | 23 | 16.50 |
| <b>HOW BH-18</b> | 4030 Jar  | 29 | 20.50 |
| <b>HOW BH-18</b> | 4030 Bulk | 20 | 14.00 |
| <b>HOW BH-18</b> | 4030 Bulk | 21 | 15.00 |

As the intertidal area has the potential to contain material of geoarchaeological interest in the deposit located between 6.20m and 16.00m BLG, a programme of archaeological monitoring in the intertidal areas during planned works has been agreed as stated in the intertidal WSI (DONG Energy, 2016c). Mitigation for potential impact of the area should also be provided through the *Offshore Renewables Protocol for Archaeological Discoveries* (ORPAD) (The Crown Estate, 2014).

## 7. References

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## 8. Figures

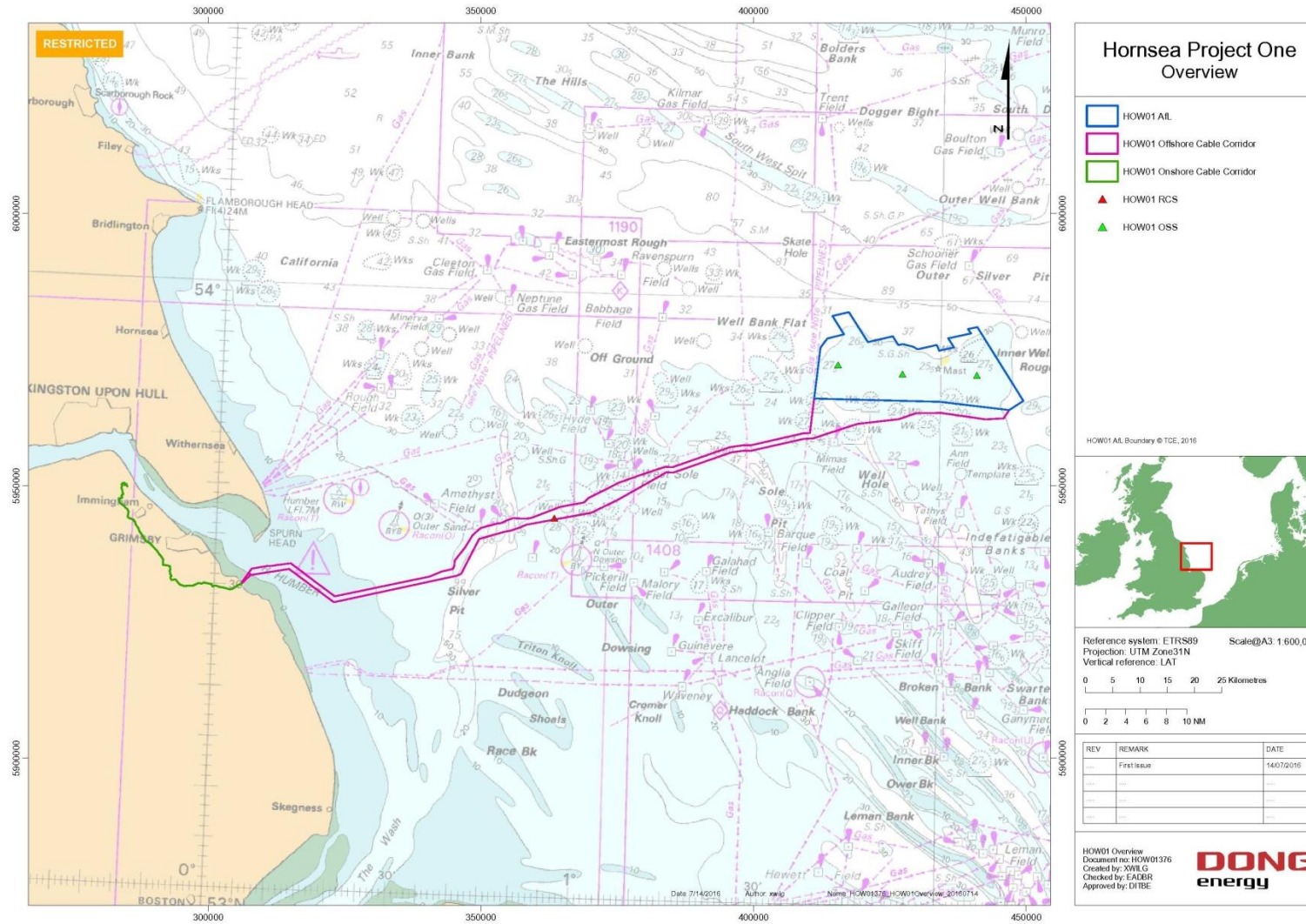


Figure 1 Hornsea One Offshore Wind Farm

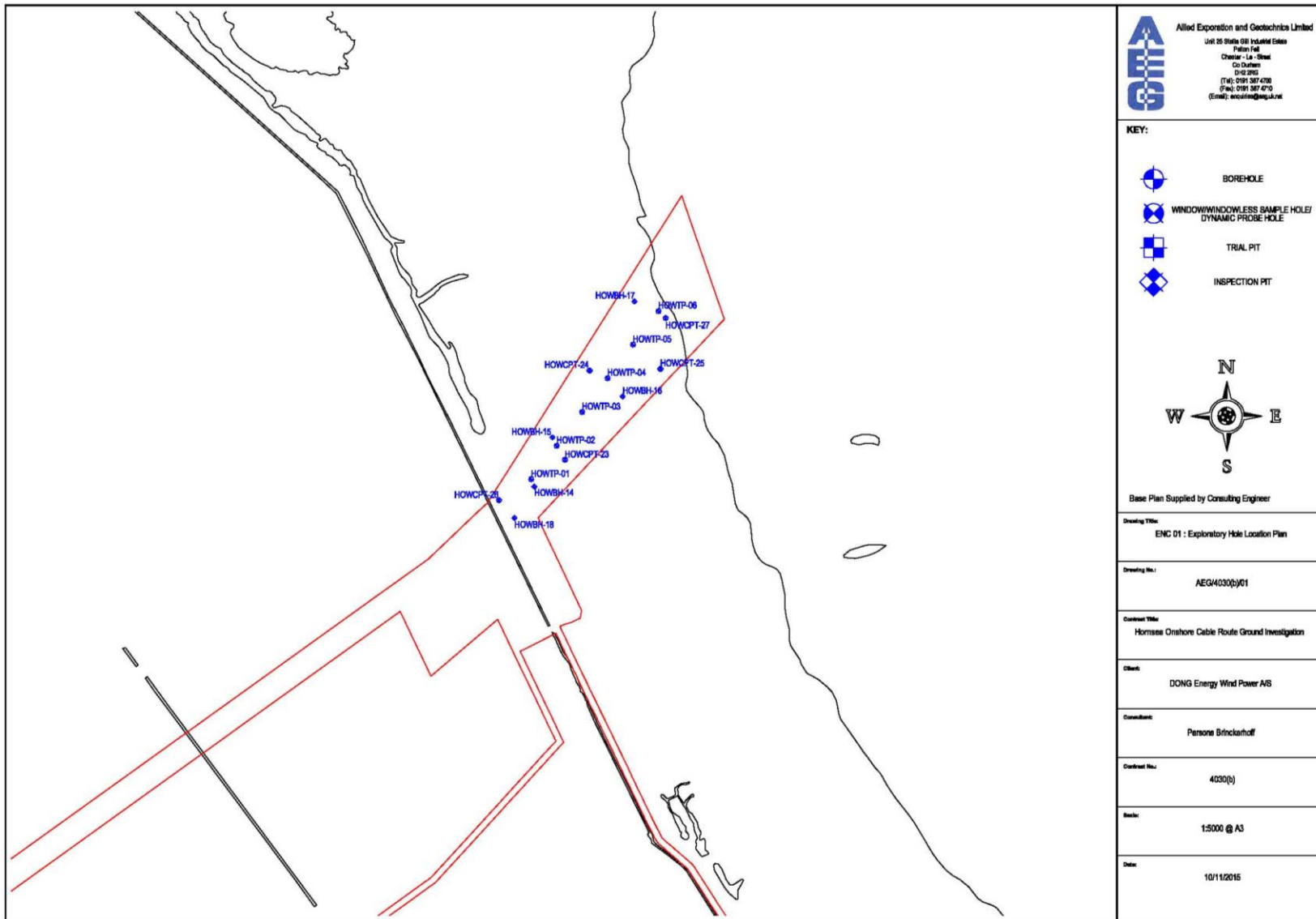


Figure 2 Borehole and trial pit locations (Allied Exploration and Geotechnics Ltd., 2015)

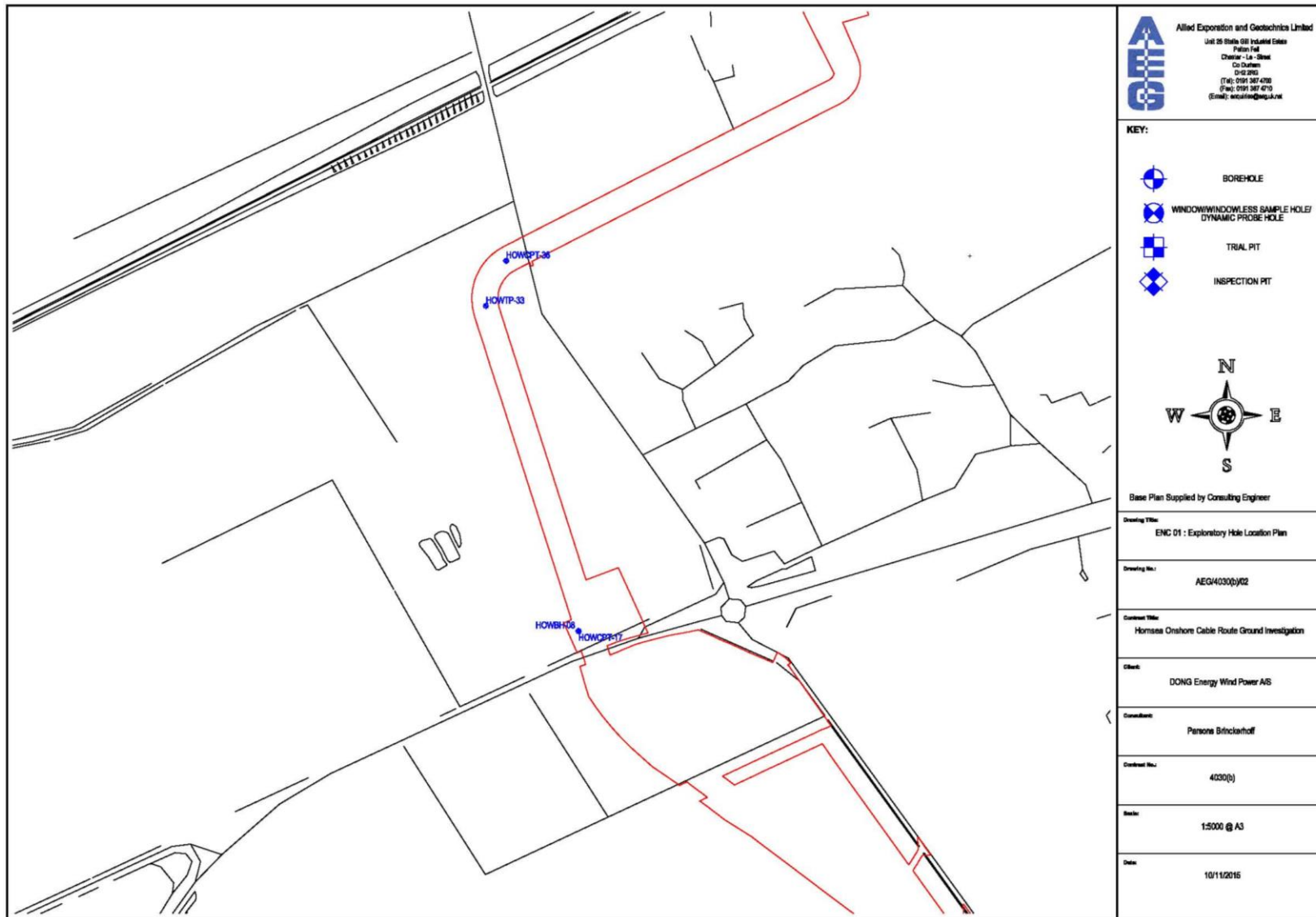


Figure 3 Close up of borehole and trial pit locations (Allied Exploration and Geotechnics Ltd., 2015)