# Great Yarmouth Third River Crossing

## Application for Development Consent Order

# Document 6.2: Environmental Statement Volume II: Technical Appendix 9C: Borehole Log Review and Deposit Modelling Report

**Planning Act 2008**

**The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 (as amended) (“APFP”)**

APFP regulation Number: 5(2)(a)

Planning Inspectorate Reference Number: TR010043

Author: Norfolk County Council

Document Reference: 6.2 – Technical Appendix 9C

Version Number: 0 – Revision for Submission

Date: 30 April 2019

# Great Yarmouth Third River Crossing

Borehole log review
and deposit modelling report

Ref: 204901.01
September 2018

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## Document Information

| | |
|---|---|
| Document title | Third River Crossing, Great Yarmouth |
| Document subtitle | Geoarchaeological borehole review and deposit modelling |
| Document reference | 204901.01 |
| | |
| Client name | WSP UK Ltd |
| Address | 3 White Rose Office Park<br>Millshaw Park Lane<br>Leeds LS11 0DL |
| | |
| Site location | Great Yarmouth |
| County | Norfolk |
| National grid reference | 652500 305920 (TG 52500 05920) |
| Statutory designations | |
| Planning authority | Norfolk County Council |
| | |
| WA project name | Great Yarmoth Third River Crossing |
| WA project code | 204901 (204900) |
| Project management by | Dave Norcott |
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| Graphics by | Nancy Dixon |

**Quality Assurance**

| Version & issue date | | Status | Author | Approved by |
| --- | --- | --- | --- | --- |
| V1 | 07/09/2018 | External draft | CLM | DRN |

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**Summary**

Wessex Archaeology was commissioned by WSP Ltd. to undertake a geoarchaeological assessment of geotechnical borehole data collected as part of ground investigation works in support of the proposed Third River Crossing, Great Yarmouth.

The proposed scheme will provide a new bridge and associated transport links across the River Yare, which bisects the town. Construction activities include the installation of pile foundations to support the bridge structure, and ground works and landscaping associated with the new strategic road network.

Previous archaeological investigations identified deposits of potential geoarchaeological significance within the proposed scheme boundary (WSP 2018; Wessex Archaeology 2018). These comprise peat and alluvium of the Breydon Formation, deposited in semi-terrestrial wetland environmental under the influence of post-glacial rising sea levels.

To assess the distribution, depth and significance of the geoarchaeological resource, and therefore the possible impact of construction activities, a geoarchaeological review of 48 geotechnical borehole logs has been undertaken and the results used to construct a deposit model for the scheme area.

Based on the borehole review, the stratigraphy of the site is characterised by London Clay overlain by Crag Group deposits, both of which pre-date human occupation and thus have no geoarchaeological potential. Sands and gravels of the Happisburgh Glacigenic Formation overlie Crag Group deposits, but as these were deposited during the Anglian glacial period, they have low geoarchaeological potential.

The most geoarchaeologically significant deposits within the proposed scheme belong to the Breydon Formation. These deposits comprise peat and alluvium and were mapped on the western side of the River Yare. Peat deposits have high geoarchaeological potential as they may preserve palaeoenvironmental as well as archaeological material. These deposits are located at depths between -4 m OD and -10.35 m OD. Alluvial deposits overlie the peat and can be found at depths between -0.23 m OD and -10 m OD. These deposits have a lower organic content but the potential to preserve inorganic microfossils and are judged to be of medium geoarchaeological potential.

On the eastern side of the River Yare, North Denes Formation is present where Breydon Formation is absent. North Denes Formation comprises sand and gravel that was deposited as part of a coastal spit/ barrier that developed from AD 500 onwards. The geoarchaeological potential of these deposits is low, although it is possible that they may contain evidence of occasional archaeological activity.

Modern Alluvium is present in boreholes located within the River Yare channel and directly adjacent to its margins; elsewhere across the proposed scheme Made Ground comprises the uppermost deposits. Collectively, these deposits have low geoarchaeological potential, although the Made Ground could include any near-surface archaeological features or layers.

Taking into account construction activities and the location of the buried resource – in particular the Breydon Formation – it is likely the only impacts of significance would be associated with the construction of the road network to the west of the River Yare. Even here, unless construction impact penetrates more than 5 metres below current ground level, the deposits should be unaffected.

If construction works are to impact the area of proposed road construction to the west of the River Yare, then it is recommended a purposive geoarchaeological borehole survey be undertaken, with palaeoenvironmental and dating works to follow on core samples if appropriate.

**Acknowledgements**

This work was commissioned by WSP UK Ltd. Alex Grassam of WSP is thanked for their assistance in the production of this report. The report was compiled by Claire Mellett with contributions from Andy Shaw. The deposit modelling was undertaken by Holly Rogers. Illustrations were prepared by Nancy Dixon. Quality control and project management was provided by Dave Norcott.

# Third River Crossing, Great Yarmouth

## Geoarchaeological borehole review and deposit modelling

## 1 INTRODUCTION

### 1.1 Project background

1.1.1 Wessex Archaeology have been commissioned by WSP Ltd. to undertake a geoarchaeological assessment of geotechnical borehole data collected as part of ground investigation works in support of the proposed Third River Crossing, Great Yarmouth (herein referred to as the proposed scheme).

1.1.2 The proposed scheme will provide a new bridge and associated transport links across the River Yare which bisects the town of Great Yarmouth in Norfolk. The Third River Crossing will provide new linkages between South Denes Road to the east of the River Yare, and key transport networks to the west via the A47 Harfreys roundabout (**Figure 1**).

1.1.3 Any impacts on the geoarchaeological or archaeological resource are expected to occur during the construction phase through the installation of pile foundations to support the bridge structure, and ground works and landscaping associated with the new strategic road network.

### 1.2 Site location and geology

*Site Location*

1.2.1 The proposed scheme is located ~800 m south of the town centre in Great Yarmouth, Norfolk. Great Yarmouth lies at the mouth of the River Yare which is one of the principle navigable waterways, connecting the Norfolk Broads to the North Sea at Gorleston-on-Sea (**Figure 1**).

1.2.2 The proposed scheme will provide a new crossing over the River Yare connecting the isolated South Denes peninsular on the eastern side of the river, with the rest of the town and major transport links on the western side of the river.

1.2.3 The proposed scheme site boundary is presented on **Figure 1** centred at approximately National Grid Reference TG 52500 05920.

*Geology*

1.2.4 The solid and superficial geology of Great Yarmouth has been mapped by the British Geological Survey (BGS) (Arthurton et al. 1994) and is summarised below. Where age estimates are available these are either in millions of years ago (MA), thousands of years ago (ka), or years before present (BP). These dates are supplemented, where known, with the relevant Marine Isotope Stage (MIS).

1.2.5 The solid geology comprises blue-grey calcareous silty clays, London Clay Formation (Eocene), overlain by dark green to weathered brown marine sands and gravels of the Crag Group, laid down between approximately 0.5 to 5 MA during the late Pliocene and Early Pleistocene epochs.

1.2.6 The superficial geology of Great Yarmouth mostly covers the last 480,000 years of geological time, extending across the Middle Pleistocene (781-126 ka), Late Pleistocene (126-11.7 ka) and Holocene (11.7 ka–present) epochs. Together these epochs form part of the Quaternary, a period covering the last 2.588 MA characterised by repeated fluctuations between cold (glacial) and warm (interglacial) climate stages.

1.2.7 Extensive deposits of sand, and sand and gravel have been mapped to the north and south of Great Yarmouth. These deposits are members of the Happisburgh Glacigenic Formation thought to be glacial outwash deposits associated with the Anglian glaciation (MIS 12, 423–480 ka)

1.2.8 Less extensive deposits of glacial till occur to the north and south of Great Yarmouth, predominately comprising sandy till deposits of the Happisburgh Glacigenic Formation with localised patches of chalky sandy till of the Lowestoft Formations, both deposited during the Anglian Glaciation (MIS 12, 423–480 ka).

1.2.9 Yare Valley Formation, comprising alluvium and river terrace deposits, overlies glacial deposits and Crag Group, extending as far as the River Ant to the North and the Waveney Valley to the south. These deposits also extend offshore within River Yare palaeochannels that formed during periods of lower sea level (Tizzard et al. 2015). The precise age of these deposits is unknown but thought to date from the late Anglian (MIS 12) to Devensian (MIS 5-2) (Tizzard et al., 2015).

1.2.10 BGS boreholes located in the vicinity of the proposed scheme boundary have recorded sand and gravel underlying Breydon Formation. Given their lithology, these deposits may correlate to sand and gravel members of the Happisburgh Glacigenic Formation, or to Yare Valley Formation.

1.2.11 The Yare Valley Formation is overlain by Holocene (MIS 1, 11.7 ka to present day) sediments of the Breydon Formation and North Denes Formation (Arthurton et al. 1994).

1.2.12 The Breydon Formation comprises a variable lateral and vertical sequence of estuarine clays and silts with subordinate sands (alluvium), interbedded with peat. The Breydon Formation are deposits that formed under the influence of mid-Holocene rising sea-levels. Alluvium represents mudflat and saltmarsh environments deposited during periods of sea-level rise with peat forming during periods of stable and/or falling sea level when semi-terrestrial plant communities (e.g. tall herb swamp, fen woodland) encroached into the wetland. Breydon Formation alluvium is extensive to the west of the River Yare with pockets of peat fringing the alluvium.

1.2.13 The North Denes Formation overlies Breydon Formation and is mapped by the BGS to the east of the River Yare, comprising beach sands and gravels, flanked to the east towards the present coastline by blown sand and marine beach deposits. These deposits relate to a coastal barrier and spit that is reported to have developed ~2000 yrs BP (Arthurton et al., 1994).

1.2.14 The early Holocene geomorphology of the Great Yarmouth area has recently been modelled by Jordan et al. (2016) using 467 borehole records held by the BGS. The base of the early Holocene deposits in Great Yarmouth ranged between -30.46 m OD to +7.61 m OD, but within the proposed scheme boundary, this varies between topographic lows of -12 m OD (northern limits of the site on the line of the A1243) and -6 m OD to -8 m OD (western limits of the site at the A12 and William Adams Way), to highs of -2 m OD to 0 m OD within the centre of the proposed scheme. This suggests that any Holocene deposits of

Breydon Formation and/or North Denes Formation within the proposed scheme boundary should not exceed thickness of 12 m.

## 1.3 Summary of previous geoarchaeological work

1.3.1 Cultural heritage was assessed in the Environmental Impact Assessment Scoping Report for the proposed scheme (WSP 2018). The majority of heritage assets within 500 m of the proposed scheme are post-Medieval to Modern in age, with the exception of buried urban and riverfront remains dating to the Medieval and a single Neolithic find (WSP 2018).

1.3.2 However, previous archaeological investigations found evidence of buried medieval shorelines on which fragments of boats were preserved (WSP 2018), thus highlighting the geoarchaeological potential of deposits within and along the margins of the River Yare. The scoping report outlined a mitigation strategy that included a comprehensive review of available geological data to understand the potential and significance of the geoarchaeological resource.

1.3.3 Subsequently, a geoarchaeological feasibility study was undertaken by Wessex Archaeology to assess the geoarchaeological resource and recommend a strategy for further works to mitigate the impact of the proposed scheme on deposits with geoarchaeological potential (Wessex Archaeology 2018).

1.3.4 Of the geological units present beneath the proposed scheme, peat and organic rich alluvium of the Breydon Formation are of geoarchaeological interest due to their potential to preserve palaeoenvironmental material. Sands and gravels of the Yare Valley Formation were also highlighted as being of interest due to their potential to contain thin organic layers and/or Palaeolithic artefacts.

1.3.5 The mitigation strategy recommended a geoarchaeological review, and if appropriate, sub-sampling and palaeoenvironmental assessment of ground investigation boreholes acquired in support of the proposed scheme.

## 1.4 Scope of document

1.4.1 To help frame geoarchaeological investigations of this nature, WA has developed a five-stage approach, encompassing different levels of investigation appropriate to the results obtained, accompanied by formal reporting of the results. The stages are summarised below (**Table 1**).

1.4.2 This report outlines the results of a Stage 1 geoarchaeological review of ground investigation logs collected in support of the proposed scheme, accompanied by deposit modelling, as detailed in **Table 1**, with recommendations made for further geoarchaeological work if deemed necessary.

**Table 1** Stages of geoarchaeological assessment and recording

| Stage | Method | Description |
|---|---|---|
| 1 | Geoarchaeological Review | A desk-based archaeological review of the borehole, vibrocore and CPT logs generated by geotechnical contractors. Aims to establish the likely presence of horizons of archaeological interest and broadly characterise them, as a basis for deciding whether and what Stage 2 archaeological recording is required. The Stage 1 report will state the scale of Stage 2 work proposed. |

| Stage | Method | Description |
|---|---|---|
| 2 | Geoarchaeological Recording | Archaeological recording of selected retained or new core samples will be undertaken. This will entail the splitting of the cores, with each core being cleaned and recorded. The Stage 2 report will state the results of the archaeological recording and will indicate whether any Stage 3 work is warranted. |
| 3 | Sampling and Assessment | Dependent upon the results of Stage 2, sub-sampling and palaeoenvironmental assessment (pollen, diatoms and foraminifera) may be required. Subsamples will be taken if required. Assessment will comprise laboratory analysis of the samples to a level sufficient to enable the value of the palaeoenvironmental material surviving within the cores to be identified. Subsamples will also be taken and/or retained at this stage in case scientific dating is required during Stage 4. Some scientific dating (e.g. radiocarbon or Optically Stimulated Luminescence (OSL)) may be undertaken at this stage to provide chronological context. 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 any Stage 4 work is warranted. |
| 4 | Analysis and Dating | Full analysis of pollen, diatoms and/or foraminifera assessed during Stage 3 will be undertaken. Typically, Stage 4 will be supported by scientific dating (e.g. radiocarbon or OSL) of suitable subsamples. Stage 4 will result in an account of the successive environments within the coring area, a model of environmental change over time, and an outline of the archaeological implications of the analysis. |
| 5 | Final Report | If required Stage 5 will comprise the production of a final report of the results of the previous phases of work for publication in an appropriate journal. This report will be compiled after the final phase of archaeological work, whichever phase that is. |

# 2 GEOARCHAEOLOGICAL BACKGROUND

## 2.1 Lower Palaeolithic (800 – 243 ka)

2.1.1 Great Yarmouth is located within the Crag Basin, a structural depression resulting from downwarping of the crust due to the weight of Neogene sediment in the North Sea Basin (Gibbard et al. 1991; 1998). Within this basin marine, intertidal and fluvial sediments are preserved that reflect changing sea levels and climatic oscillations through the Pliocene to early Middle Pleistocene. These deposits are overlain by a series of glaciogenic deposits.

2.1.2 The pre-glacial sediments reflect a broad transition from shallow marine, to estuarine and fluvial deposits (West 1980, Gibbard et al. 1991; 1998). The marine sediments are assigned to the 'Crag Group' and reflect climatic and paleoenvironmental change, ranging from relatively stable shallow marine deposition during the Pliocene (Coralline Crag Formation) to the more pronounced climatic oscillations during the Early and early Middle Pleistocene (Red Crag, Norwich Crag and Wroxham Crag formations), which included periods of arctic conditions. These predominately marine sediments are post-dated by units reflecting fluvial deposition (Hill House Formation (HHF) and Cromer Forest-bed Formation (CF-bF), with deposition in a complex of floodplains, tidal channels and rivers draining land to the west (West 1980). The units have long been famous for their rich palaeooenvironmental records (Newton 1882, Reid 1882, Stuart 1996), but over recent decades have also produced a steadily growing number of Lower Palaeolithic archaeological sites relating to the earliest occupation of Britain and northern Europe (Parfitt et al. 2005; 2010; Ashton et al. 2008, 2014).

2.1.3 The two key Lower and early Middle Pleistocene localities in the region are Happisburgh 3 (Parfitt et al. 2010; Ashton et al. 2008, 2014). and Pakefield (Parfitt et al. 2005).

2.1.4 At Happisburgh 3 archaeological and palaeoenvironmental evidence has been recovered from gravels, sands and interbedded sands and silts of the Hill House Formation (HHF), which are within channels cut within marine deposits belonging to the Norwich Crag Formation. The HHF accumulated in the lower reaches of a large river system, attributed to the River Thames, most probably in the central or upper part of its estuary (Parfitt et al. 2010). The HHF deposits at Happisburgh 3 have produced a small number of lithics artefacts and extensive associated paleoenvironmental indicators; the latter are indicative of hominin activity during boreal conditions (Parfitt et al. 2010). Bio-stratigraphic indicators and palaeomagnetic data indicate that this hominin presence dates to >0.78 Myr ago (Parfitt et al. 2010); it is therefore the earliest known hominin presence in northern Europe. Additionally, hominin footprints have been identified at Happisbugh within laminated clays that are correlated with the HHF (Ashton et al. 2014); this is the oldest known hominin footprint surface outside Africa.

2.1.5 At Pakefield lithic artefacts have been recovered from four different contexts within CF-bF deposits which are within a channel incised into marine sediments of the Norwich Crag. Here, CF-bf deposits are overlain by marine sands, glaciofluvial sediments and Lowestoft Till. These CF-bF deposits are equated with the floodplain of the lower reaches of the erstwhile Bytham River that drained the English Midlands at this time (Parfitt et al. 2005). Associated paleoenvironmental indicators suggest hominin occupation at Pakefield occurred during interglacial conditions associated with a warm, seasonally dry Mediterranean climate; lithostratigraphy, palaeomagnetism, amino acid geochronology and biostratigraphy, indicate a minimum age of 700 ka for these occupations (Parfitt et al. 2005).

2.1.6 There is a rich record of Middle Pleistocene Lower Palaeolithic locales in East Anglia (Wymer 1999). These date to both prior and post to the Anglian glaciation (478-428 ka), a period when ice sheets fundamentally altered the palaeogeography of the region.

2.1.7 Known Middle Pleistocene deposits in the study area are found within the modern lower reaches of Yare Valley river system, which drains the Rivers Yare, Wensum and Waveney. These deposits belong to the Yare Valley Formation deposited by the Palaeo-Yare river. They consist of up to 11 m of sands and gravels (Arthurton et al. 1994) that form a stacked fluvial sequence deposited over multiple glacial-interglacial cycles. Definitive age estimates are lacking, but they have been suggested to include late Anglian (MIS 12) and Devensian (MIS 5d-2; 109 – 14 ka) deposits (Coxon 1993, Cox et al. 1989). This implies that they have the potential to contain Lower, Middle and Upper archaeology, along with associated palaeoenvironmental datasets. Lower Palaeolithic artefacts have been recovered from fluvial deposits of the Palaeo-Yare river, most notably at Whitlingham (Sainty 1927, Wymer 1999).

## 2.2 Middle Palaeolithic (243 – 36 ka)

2.2.1 An internationally significant early Middle Palaeolithic submerged site lies ~8 km east of Great Yarmouth in the southern North Sea, within an aggregate dredging zone known as Area 240. Here, a total of 88 flint lithics, including handaxes and Levallois artefacts (the latter often equated with the early middle Palaeolithic), along with some 130 faunal remains including woolly mammoth, woolly rhinoceros, bison, reindeer and horse, were recovered during dredging operations (Tizzard et al. 2015).

2.2.2 This site is not located within the proposed scheme boundary, or within the search buffer adopted during the cultural heritage assessment (WSP 2018). However, it is of relevance to the proposed scheme as these key archaeological finds are associated with the offshore extension of the Palaeo-Yare river (Tizzard et al. 2015), and similar assemblages may be preserved within Yare Valley Formation deposits preserved onshore.

2.2.3 Indeed, Levallois artefacts have been reported from onshore fluvial deposits of the Palaeo-Yare at Keswick Mill Pit (Wymer 1985, 1999), Carrow Road, Norwich (Sainty 1927) and Lenwade Pits at Great Witchingham on the River Wensum (Wymer 1985, 1999). However, correlating Palaeo-Yare deposits between marine and terrestrial settings is problematic, both logistically, due to challenges surveying the nearshore coastal zone, but also stratigraphically as the sequence and age of Yare Valley Formation onshore is difficult to resolve (Arthurton et al. 1994).

2.2.4 Devensian deposits have been suggested to be present within the Yare Valley Formation (Coxon 1993, Cox et al. 1989). Such deposits would have the potential to preserve late Middle Palaeolithic artefacts and ecofacts. Regionally, the key late Middle Palaeolithic find spot is Lynford Quarry (Boismier et al. 2012). Here, Upper Pleistocene deposits were identified within a small oxbow lake formed in the course of the river Wissey, which produced minimally disturbed late Middle Palaeolithic artefacts. These are associated with a mammalian faunal assemblage and a range of paleoenvironmental indicators. Optical stimulated luminescence (OSL) age estimates on the associated sediments date hominin activity at the locale to the interval ~65-57 ka.

## 2.3 Early Upper Palaeolithic (36 – 13 ka)

2.3.1 No early Upper Palaeolithic (~30,000-26,000 BP) archaeology has been recovered from the study area, although a possible terminal Middle/early Upper Palaeolithic leaf point has been identified from the Holmes Housing Estate, Gorleston, Great Yarmouth (TG 5200030; Wymer 1985). Additionally, deposits belonging to this period may be present within Yare Valley formation (Coxon 1993, Cox et al. 1989).

2.3.2 There appears to exist major hiatus in the British archaeological between 26,000 and 13,000 BP, which may reflect human absence from Britain (Jacobi and Higham 2011).

## 2.4 Late Upper Palaeolithic to Medieval (13,000 BC – AD 1500)

2.4.1 Great Yarmouth is located in a low-lying basin where the River Yare and River Bure become confluent, flowing through Breydon Water towards the North Sea. Post glacial sea-level rise during the Holocene would have flooded the valleys transforming the rivers into estuaries with marshlands forming along the margins. These Holocene environments are represented by alluvium and intercalated peats of the Breydon Formation.

2.4.2 There are three peat layers associated with the Breydon Formation; the basal, middle and upper peat.

2.4.3 The basal peat is recorded to have formed 6,600 to 6,240 cal. BC (Mesolithic) at a depth of around -19 m OD and is up to 2 m thick (Arthurton et al. 1994). The Mesolithic record in and around Yarmouth is relatively sparse with only 12 Mesolithic findspots located within 10 km of the town (www.archiuk.com).

2.4.4 This may reflect the small number of excavated sites and palaeoenvieonmental records of Mesolithic date within Norfolk in general (Austin 2011). It may also be related to the distribution of Mesolithic findspots, as most of them are restricted to the upper reaches of river valleys within the Norfolk Broads (Wessex Archaeology 2013).

2.4.5 The middle peat is generally 2-4 m thick and occurs within the range of -4 m to -9 m OD. Dates from this peat range from ~4700 BP to 2000 BP (uncalibrated) (Arthurton et al. 1994) suggesting peat formation occurred from the Neolithic to Iron Age. Records of Neolithic to Iron Age activity in and around Great Yarmouth are also poor, with only 31 findspots within 10 km (www.archiuk.com).

2.4.6 The upper peat developed sometime after AD 500, most likely in response to the growth of the Great Yarmouth coastal barrier/spit which would have created a back-barrier marshland allowing peat to form (Boomer and Godwin 1993). North Denes Formation are the deposits associated with the Great Yarmouth barrier and they are expected to be of a similar date.

## 3 AIMS AND OBJECTIVES

3.1.1 The principle aims of the geoarchaeological borehole review and deposit modelling are as follows:

- Review geotechnical borehole logs to identify deposits of potential archaeological interest, assigning high, medium and low priority status;
- Interpret the probable environments represented;
- Model the distribution and depth of deposits across the site using a representative selection of boreholes, considering all available geotechnical data;
- Determine the importance of the deposits, with regard to their archaeological and palaeoenvironmental potential, and;
- Make recommendations for additional work, if required.

## 4 METHODOLOGY

### 4.1 Geotechnical data

4.1.1 Geotechnical data acquired during Ground Investigation (GI) works in support of the proposed scheme was provided by WSP, and included;

- Borehole logs (digital), and;
- Borehole coordinates and elevations.

4.1.2 Samples were recovered from the shallow subsurface using either a percussive window sampling (WS) rig (Dando), or a cable percussion rig (BH). Boreholes located within the River Yare were acquired by cable percussion from a barge (MB)

4.1.3 Where a cable percussion rig was used, samples recovered were typically disturbed and collected in bags. Intermittently, in cohesive strata, a 100 mm length open sampling tube was used to collect an undisturbed sample. However, these samples were subsequently tested by geotechnical contractors and are now disturbed.

4.1.4 The window sampling rig was used to collect near continuous undisturbed samples in cylindrical tubes. These tubes were sealed on site and transported to the geotechnical laboratory for further analysis. These samples are no longer undisturbed due to subsequent geotechnical testing.

4.1.5 To aid interpretations, GI data were supplemented by publicly available records including;

- Borehole records held by BGS, and;
- BGS superficial deposits and bedrock geology maps.

## 4.2 Review of geotechnical data

4.2.1 A total of 48 geotechnical logs were reviewed by a trained geoarchaeologist to determine the geoarchaeological and palaeoenvironmental potential of deposits recovered.

4.2.2 A summary of each borehole is itemised in **Appendix 1**, and includes the following:

- Borehole location;
- Borehole elevation (m below Ordnance Datum [OD]);
- Description of deposits;
- Depths of boundaries between deposits, and;
- Interpretation of stratigraphy.

4.2.3 Boreholes where assigned either a high, medium or low priority status based on their perceived geoarchaeological significance and potential to preserve palaeoenvironmental material, as itemised in **Appendix 1**.

4.2.4 Of greatest geoarchaeological potential are sediments from former terrestrial depositional environments, as well as certain features or inclusions of possible archaeological and palaeoenvironmental interest, specifically:

- Peat layers;
- Deposits containing other organic material such as wood fragments and roots etc.;
- Clay or silt deposits, especially those containing laminated features such as lacustrine varves or tidal rhythmites;
- Inorganic fossils (such as molluscs);
- Concentrations of charcoal;
- Individual artefacts such as pieces of flint or pottery (though finding these within core samples is rare), and;
- Any other feature that may indicate a terrestrial depositional environment.

## 4.3 Deposit modelling

4.3.1 Given the linear nature of the proposed scheme, i.e. a bridge and associated transport links across the River Yare, a two-dimensional section diagram showing the nature, extent and thickness of deposits was considered the most appropriate method of deposit modelling (**Figure 2**).

4.3.2 A transect ~0.6 km in length, running broadly east to west across the proposed scheme was selected for the cross section (**Figure 1**). A total of 14 representative boreholes are included in the cross section in **Figure 2**.

4.3.3 As part of the deposit modelling processes, any borehole records held by BGS that were located within the boundary of the proposed scheme were reviewed and considered for incorporation into the model. However, the level of detail recorded on BGS logs was not considered sufficient enough to improve the quality of the model output. Therefore, only boreholes acquired as part of the GI for the proposed scheme were included.

# 5 RESULTS

## 5.1 Review of geotechnical logs

5.1.1 A total of 48 geotechnical borehole logs were reviewed as part of the borehole review, with the aim of identifying deposits of potential geoarchaeological significance. Outline descriptions based on preliminary geotechnical logs are presented in **Appendix 1**, accompanied by an interpretation of the deposits.

5.1.2 Bedrock comprised of London Clay was encountered in seven of the 48 boreholes (BH10, BH10a, BH11, BH12, BH12b, BH13 and BH13a).

5.1.3 Overlying bedrock, deposits associated with Crag Group were recovered, forming the most extensive and thickest sequences (>40 m at BH11) across the site. Crag is characterised by silty sand that is occasionally gravely with shell, interbedded with discrete beds of firm to stiff silty clay. Crag Group deposits were recovered in 34 of the 48 boreholes reviewed and were only absent from the boreholes when they terminated at shallow depths.

5.1.4 In seven of the boreholes, Crag Group was overlain by gravelly sand (BH4, BH4a, BH4d and BH6) and sandy gravel (BH8, BH9 and BH15) interpreted to be deposited in a glaciofluvial environment as part of the Happisburgh Glacigenic Formation. These deposits can be distinguished from the underlying Crag Group as they are coarser-grained and do not comprise shells.

5.1.5 Breydon Formation was recovered in 19 boreholes (WS1, WS3, WS4, WS6, WS7, WS9, BH1, BH2, BH4, BH4a, BH5, BH5a, BH6, BH7, BH4BU, BH8, BH9, MB01 and BH4A3), comprising peat (BF-p) and/or alluvium (BF-a). Where both peat and alluvium are present in the same borehole, the peat is overlain by alluvium, but can be intercalated as is the case in BH2. The peat deposits range in thickness from 0.6 m (BH2) to 2.3 m (WS7), whereas the overlying alluvium can reach thicknesses in excess of 6 m (BH1). The alluvium is fine-grained silts and clays that can be organic rich or comprise discrete organic lenses.

5.1.6 In seven of the boreholes, North Denes Formation was recovered (BH13, BH13a, BH14, BH15, BH16, BH17 and BH18). This deposit, although younger than Breydon Formation, directly overlies Crag Group and is characterised by coarse grained sands and gravels with occasional silt, often forming thin laminae. These deposits are part of the coastal barrier system that presently lies between Caster-on-Sea and Gorleston-on-Sea.

5.1.7 The youngest deposits recovered in all boreholes, with the exception of MB04a, MB07, MB09 and MB10, are characterised by Made Ground and Modern Alluvium.

5.1.8 Modern Alluvium is restricted to those boreholes located within and along the margins of the River Yare (MB01, MB01a, MB03, MB05, MB06, BH10, BH10a, BH11, BH12, BH12a, BH12b, BH13, BH14, BH16, BH17 and BH18) and comprises soft silty clay which is occasionally sandy and gravelly. Made Ground is present in the remaining boreholes and is characterised by a heterogenous mixture of sand and gravel including concrete and brick. The thickness of Made Ground and Modern Alluvium varies from 0.10 m (MB08) to 5.95 m ( BH12a).

## 5.2 Deposit modelling

5.2.1 Given the linear nature of the proposed scheme, a two-dimensional cross section has been created providing an outline model of the stratigraphy and deposits across the site (**Figure 2**).

5.2.2 The cross section runs broadly perpendicular from the A12 on the western side of the River Yare, to Sutton Road on the east (**Figure 1**).

5.2.3 The deposit model comprises a total of 14 boreholes **Figure 2**. The deposit model captures the stratigraphy within 50 m of the present ground level which includes the full depth potentially impacted by pile foundations associated with the bridge structure.

5.2.4 Bedrock is expected to be reached at depths greater than 40 m below OD but Crag Group is the dominant geology at depth across the site, with the top of Crag Group deposits present at elevations between -7 and -12 m OD.

5.2.5 Within the River Yare channel, Crag is present at, or within 1 m of the river bed. Elsewhere, along the margins of the River Yare, Crag is overlain by up to 15 m of Pleistocene and/or Holocene sediments.

5.2.6 Deposits interpreted to be Happisburgh Glacigenic Formation are present on the western side of the River Yare where they appear to thin towards the west from 3.75 m (BH9) to 2.00 m (BH6). They are no longer present west of BH5a (**Figure 2**).

5.2.7 Peat deposits of the Breydon Formation (BF-p) are present to the west of BH5a. They are located at elevations between -4 m OD (WS7) and -6.85 m OD (BH2) and reach a maximum depth of -10.35 m OD (BH2). In BH2, there are two discrete beds of peat separated by a thin (0.6 m) lens of alluvium. This is the only location where two discrete peats are identified. Peat is not present in boreholes to the east of the River Yare.

5.2.8 Overlying Breydon Formation peat and Happisburgh Glacigenic Formation, are Breydon Formation alluvial sediments (BF-a). These deposits only occur to the west of the River Yare and are not present to the east. The alluvium is extensive and is present between depths of -0.23 m OD (WS3) and -1.95 m OD (BH2), reaching a maximum depth of -10 m OD (BH2).

5.2.9 To the east of the River Yare, Crag Group is overlain by deposits interpreted to be part of the North Denes Formation. These deposits are present at elevations between -0.10 m OD (BH18) and -12.60 m OD. North Denes Formation is not present to the west of the River Yare. It appears the river channel limits the extent of these coastal deposits.

5.2.10 Modern Alluvium is present in boreholes located within the River Yare channel and directly adjacent to its margins. Modern Alluvium deposits appear to thicker on the eastern side of the River Yare where they overlay North Denes Formation. The thickness of Made Ground deposits broadly varies from 0.40 m (WS3) to 3.50 m (BH2).

# 6 DISCUSSION

## 6.1 Geoarchaeological potential

6.1.1 The stratigraphy of the deposits within the proposed scheme boundary is summarised in **Table 3**, and the geoarchaeological potential of each of these deposits is outlined below.

**Table 2** Stratigraphy of deposits with the proposed scheme

| WA Unit No | Unit Name (age) | Sediment Characteristics | Depositional history | Geoarchaeological potential |
|---|---|---|---|---|
| MG/MA | Modern Alluvium and Made Ground (Modern) | Silt and clay or heterogeneous clay, silt, sand and gravel inc. concrete and brick | Influenced by human activity post-medieval | Low – although Made Ground may include near-surface archaeology |
| ND | North Denes Formation (Holocene) | Sand with subordinate layers of gravel and thin layers of silty clay. | Coastal barrier/spit that has developed from AD 500 to present day | Low - but may contain archaeology |
| BF-p | Breydon Formation – peat (Holocene) | Peat comprised of partially decomposed organics matter | Deposited in and around the valleys of the River Yare and associated tributaries during the Holocene under the influence of rising sea level. | High - preservation of palaeoenvironmental material likely |
| BF-a | Breydon Formation – alluvium (Holocene) | Silt and clay, occasionally organic rich with shelly marine fauna. Sand is generally subordinate but may be substantial locally. | Deposited in the valleys of the River Yare and associated tributaries during sea-level rise when the area became an estuary with associated saltmarsh and mudflats. | Medium - preservation of palaeoenvironmental material is possible. |
| HGF | Happisburgh Glacigenic Formation – sand and gravel (Anglian) | Sands and gravels | Glaciofluvial deposits | Low – landscape not suitable for occupation |
| Crag | Crag Group - Wroxham Crag Formation (Pleistocene) | Sands interbedded with silt and clay | Deposited in shallow marine-estuarine setting on the edge of the North Sea Basin. | Low – predates occupation |
| Bedrock | London Clay (Eocene) | Silt and clay | Marine | Low – predates occupation |

6.1.2 The geoarchaeological potential of the solid geology London Clay is low as these deposits pre-date hominin occupation.

6.1.3 Crag Group deposits are Pliocene to Pleistocene in age. The Crag Group deposits within the proposed scheme boundary are generally fine to medium sand which are occasionally laminated and interbedded with beds of clay and silt. These most likely belong to the

Wroxham Crag Formation, which are the youngest of Crag Group deposits dating to the Middle Pleistocene/Lower Palaeolithic.

6.1.4 The earliest evidence of hominin occupation in north-west Europe was discovered at Happisburgh ~30 km to the north of Great Yarmouth on the Norfolk coast (Parfitt et al. 2005; 2010; Ashton et al. 2008, 2014). The archaeological and palaeoenvionmental discoveries were associated with deposits from Cromer Forest-bed Formation which overlies Wroxham Crag. Cromer Forest-bed was not identified within the proposed scheme boundary.

6.1.5 Given that Wroxham Crag predates the known occupation history of Britain, and that is contains shells suggesting deposition in a shallow marine environment, the geoarchaeological potential of Crag Group deposits within the proposed scheme boundary is considered low.

6.1.6 Happsiburgh Glacigenic Formation sediments were deposited during the Anglian glacial period approximately 450,000 years ago. The geoarchaeological potential of these deposits is low.

6.1.7 Of all the deposits within the proposed scheme boundary, Breydon Formation peat and alluvial deposits have the greatest geoarchaeological potential. These deposits represent a freshwater-brackish low-lying marshland that formed in and around the River Yare throughout the Holocene.

6.1.8 The peat deposits of Breydon Formation have high geoarchaeological potential due to their potential to preserve paleoenvironmental material e.g. pollen, and macrofossils suitable for radiocarbon dating. In comparison, the alluvium has medium potential due to a lesser organic matter content, although these deposits have potential to preserve other environmental proxies such as diatoms and foraminifera.

6.1.9 Collectively, the intercalated nature of alluvium and peat deposits may reflect changing sea-levels with evidence for multiple transgressions from the Mesolithic to Anglo-Saxon period in the area. Changes in landscape (wetland/estuarine/marine environments) and proximity to marine resources driven by fluctuating sea levels would have influenced land-use and associated industries such as fishing and peat cutting.

6.1.10 Within the proposed scheme boundary, there is at least one, but possibly two distinct peat deposits preserved on the western side of the River Yare. The Breydon Formation is expected to have three distinct peat bodies separated by estuarine alluvium, with each peat representing a different time periods as follows (Boomer and Godwin 1993);

- Upper peat – post AD 500 (Anglo-Saxon to Early Medieval);
- Middle peat – 2,700 BC to AD 0 (Neolithic to Iron Age), and;
- Lower peat – pre- 5,500 BC (Mesolithic)

6.1.11 It is not possible to establish which of these peats are present within the proposed scheme without further paleoenvironmental works. Based on their depth and thickness, they may be part of the middle peat forming at some point between the Neolithic and Iron Age. It is anticipated the upper peat has been removed due to extensive peat extraction for fuel between 12$^{th}$ and 15$^{th}$ centuries AD (Lambert and Jennings 1960).

6.1.12 The North Denes Formation deposits are associated with a coastal barrier system that extends from the present-day coast to the River Yare. These deposits are younger than Breydon Formation and documentary evidence supports the existence of the barrier from 500 AD onwards (Arthurton et al. 1994). Given its age, there is potential for the deposits to contain archaeological material, although the presence of significant layers or occupation is unlikely. Given the coarse-grained nature of these deposits, their geoarchaeological potential is considered low.

6.1.13 The potential of Modern Alluvium is considered low. Made Ground is also considered to be of low potential, although it is important to note that should any near-surface archaeological remains be present, they would be included within this designation.

## 6.2 Potential impact

6.2.1 Within the proposed scheme, Breydon Formation are the only deposits identified as having high and medium geoarchaeological potential. These deposits are located on the western side of the River Yare (**Figure 2**) at depths between -0.23 m OD (WS3) and -10.35 m OD (BH2).

6.2.2 Any impact on these deposits will likely occur during construction of the road network and associated landscaping on the western side of the River Yare.

6.2.3 The Breydon Formation peat, which has the highest geoarchaeological potential, is located at depths typically between 5 m and 10 m below ground level. Any ground works at these depths will impact the peat. At shallower depths, between 1 m and 5 m below ground level, the Breydon Formation alluvial deposits may be impacted during construction.

6.2.4 The installation of piles to support the bridge structure within and along the margins of the River Yare, will not impact deposits with high to medium geoarchaeological potential. However, if pile structures are used elsewhere on the western side of the River Yare, these may impact the deposits depending on their penetration depth.

# 7 RECOMMENDATIONS

7.1.1 Based on the results of the borehole review and deposit modelling, Breydon Formation deposits interpreted to have high (peat) and medium (alluvium) geoarchaeological potential, were identified with the proposed scheme site boundary to the west of the River Yare. There is potential for these deposits to be impacted during the construction phase of the road network associated with the Third River Crossing bridge, depending on the depth of ground works.

7.1.2 Due to the geotechnical testing schedule, samples from these deposits have been disturbed and are no longer suitable for geoarchaeological recording and sub-sampling for palaeoenvironmental assessment.

7.1.3 If the depth of impact exceeds 5 m below ground level, it is recommended a dedicated geoarchaeological borehole survey is undertaken to recover undisturbed core samples from the Breydon Formation deposits. Drilling a single borehole to a maximum depth of 15 m in close proximity to BH2 should capture the most extensive sequence of deposits. Depending on the nature of deposits recovered, further paleoenvironmental works may be recommended.

7.1.4 Alternatively, if the depth of impact associated with construction of the road network is less than 5 m below ground level, it is unlikely the peat deposits will be impacted, and no further works are recommended.

## REFERENCES

### Bibliography

Arthurton, R S, Booth, S J, Morigi, A N, Abbott, M A W and Wood, C J 1994. *Geology of the County around Great Yarmouth* HMSO, London.

Ashton, N, Lewis, S G, Parfitt, S A, Penkman, K E H and Coope, G R 2008 New evidence for complex climate change in MIS 11 from Hoxne, Suffolk, UK *Quaternary Science Reviews* 27, 652–668.

Ashton, N, Lewis, S G, De Groote, I, Duffy, S M, Bates, M, Bates, R, Hoare, P, Lewis, M, Parfitt, S A, Peglar, S, Williams, C, and Stringer, C, 2014 Hominin Footprints from Early Pleistocene Deposits at Happisburgh, UK. *PLoS ONE* 9 (2), e88329.

Austin, L, 2011 Palaeolithic and Mesolithic In, Medleycott, M (Ed). *Research and Archaeology revisited: a revised framework for the East of England*, East Anglian Archaeology Occasional Paper No.24, ALGAO East of England.

Boismer, W A, Gamble, C and Coward, F 2012 *Neanderthals Among Mammoths; Excavations at Lynford Quarry, Norfolk*. English Heritage, Swindon.

Boomer, I, Godwin, M 1993 Palaeoenvironmental Reconstruction in the Breydon Formation, Holocene of East Anglia. *Journal of Micropalaeontology* 12: 35 –46.

Cox, E C, Gallois, R W and Wood, C J 1989 *Geology of the Country Around Norwich*. Memoir of the Geological Survey of Great Britain, London.

Coxon, P 1993 The geomorphological history of the Waveney Valley and the Interglacial deposits at Hoxne. In Singer, R, Gladfleter BG and Wymer, J (Eds) *The Lower Palaeolithic site at Hoxne, England* 67—73. University of Chicago Press, Chicago.

Gibbard, P L, West, R G, Zagwijn, W H, Balson, P S, Burger, A W, Funnell, B M, Jeffery, D H, de Jong, J, van Kolfschoten, T, Lister, A M, Meijer, T, Norton, P E P, Preece, R C, Rose, J, Stuart, A J, Whiteman, C A, and Zalasiewicz, J 1991 Early and early Middle Pleistocene correlations in the southern North Sea Basin *Quaternary Science Reviews* 10, 23–52.

Gibbard, P L, Mathers, S J and Zalasiewicz, J A 1998 Stratigraphy of the Late Pliocene to Early Pleistocene of East Anglia *Mededelingen Nederlands Instituut voor Toegepaste Geowetenschappen* 60, 239–262.

Jacobi R M and Higham T F G 2011 The British earlier Upper Palaeolithic: settlement and chronology. In: Ashton N, Lewis S, Stringer C (Eds*) The ancient human occupation of Britain*. Elsevier, Amsterdam, pp 181–222.

Jordan, H, Holbrook, H and Lawley, R 2016 Early Holocene geomorphology of the Great Yarmouth area, Norfolk, UK. *Journal of Maps* 12, 122-130.

Lambert, J, M and Jennings, J N 1969 Stratigraphical and associated evidence. In Lambert, J M, Jennings, J N, Smith, C T, Green, C and Hutchinson, J N (Eds) *Memoir of the Royal Geographical Society*, No. 3.

Newton, E T 1882 *The Vertebrata of the Forest Bed Series of Norfolk and Suffolk*. Memoirs of the Geological Survey, London.

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, and Stuart, A J 2005 The earliest record of human activity in northern Europe, *Nature* 438, 1008–1012.

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, 229–33.

Reid, C 1882. *The Geology of the Country around Cromer*. Memoirs of the Geological Survey, London.

Sainty, J E 1927. An Acheulean Palaeolithic workshop site at Whitlingham, near Norwich. With geological notes by Professor P.G.H. Boswell. *Proceedings of the Prehistoric Society of East Anglia* 4, 177–213.

Stuart, A J 1996 Vertebrate faunas from the early Middle Pleistocene of East Anglia. In Turner, C (ed), *The early Middle Pleistocene in Europe*, 9-24. Balkema, Rotterdam.

Tizzard, L, Bicket, A and De Loecker, D 2015 *Seabed Prehistory: Investigating the Palaeogeography and Early Middle Palaeolithic Archaeology in the Southern North Sea*. Wessex Archaeology Report 35. Wessex Archaeology, Salisbury.

Wessex Archaeology 2018 *Third river Crossing, Great Yarmouth, Geoarchaeological Feasibility Study*. Report No 204900.01, Salisbury.

Wessex Archaeology 2013 *Palaeo-Yare Catchment Assessment*. Report No 83740.04, Salisbury.

West, R G 1980 *The pre-glacial Pleistocene of the Norfolk and Suffolk Coasts*. Cambridge University Press, Cambridge.

WSP 2018 *Great Yarmouth Third River Crossing Environmental Impact Assessment Scoping Report*. Report No 70041951-ENV-EIA-SCOPING, WSP.

Wymer, J J 1985 *The Palaeolithic sites of East Anglia*. Geo Books, Norwich.

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

**Websites**

British Geological survey (BGS) (August 2018) Geology of Britain Online Viewer. http://mapapps.bgs.ac.uk/geologyofbritain/home.html

http://archiuk.com (September 2018).

## APPENDIX 1

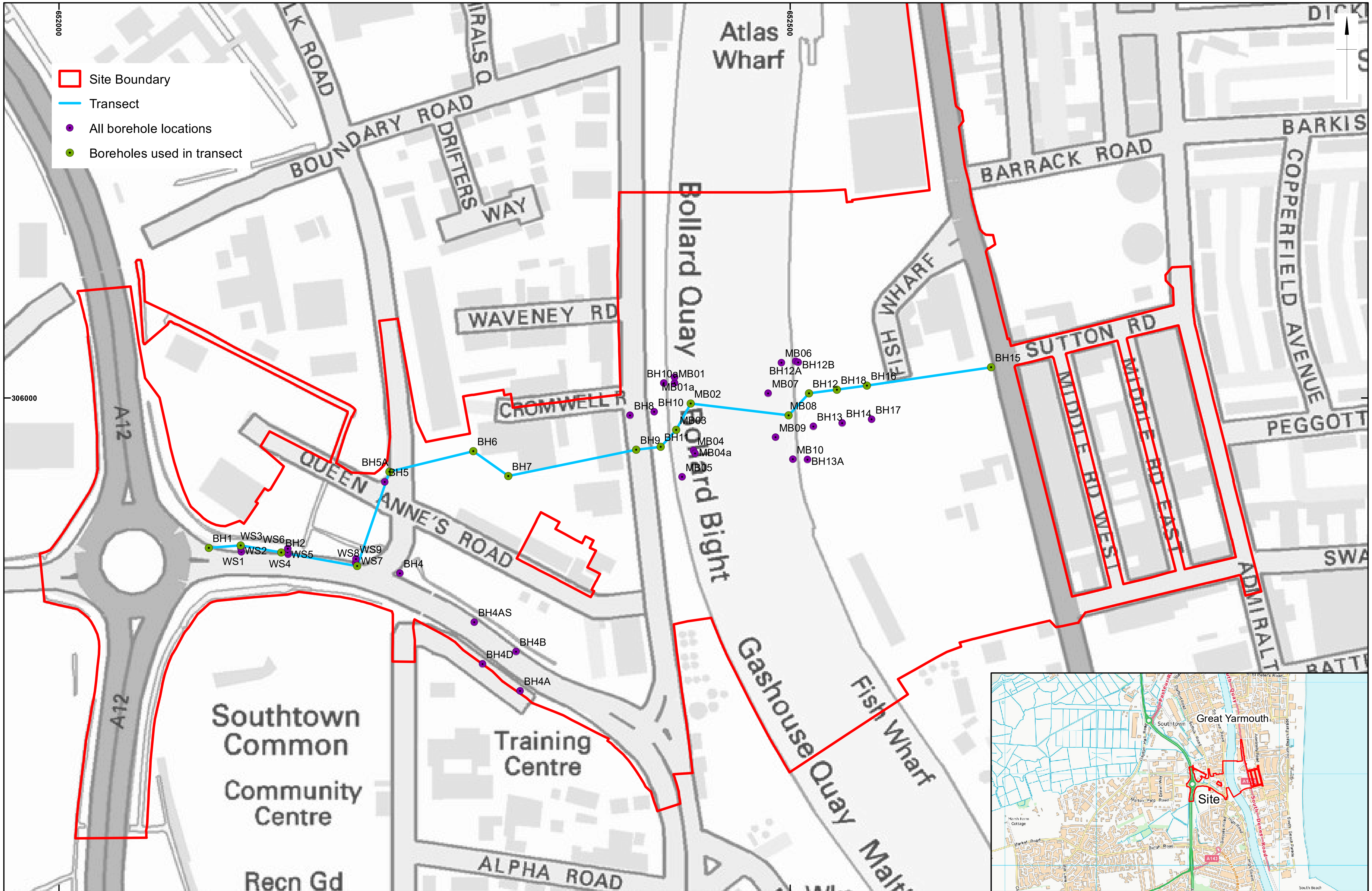
| id | Description | Potential | Easting (m) | Northing (m) | Elevation m (OD) |
|---|---|---|---|---|---|
| MB01 | loose sand and gravel (0.80 m) (MA) firm laminated clay (1.70 m) (BF-a) gravelly sand (3.60 m) (Crag) mottled brown sand (4.00 m) (Crag) | Low | 652421 | 306010 | -6.59 |
| MB01a | soft silty sandy clay (1.40 m) (MA) silty sand with occasional shell and fine gravel (20.60 m) (Crag) firm silty clay (23.7 m) (Crag) silty sand with occasional shell (25.00 m) (Crag) | Low | 652421 | 306014 | -7.88 |
| MB02 | soft silty gravelly clay (1.00 m) (MA) sand and gravel with occasional shell (Crag) (2.00 m) silty slightly gravely sand with occasional shell (20.80 m) (Crag) firm silty clay (23.20 m) (Crag) silty slightly gravelly sand with occasional shell (35.40 m) (Crag) silty sand with clay laminations (36.40 m) (Crag) stiff silty clay (4.00 m) (Crag) | Low | 652432 | 305996 | -7.87 |
| MB03 | soft mottled silty sandy clay (1.30 m) (MA) silty sand with occasional shell and fine gravel (19.70 m) (Crag) stiff silty sandy clay (20.50 m) (Crag) sand with clay laminations (25.00 m) (Crag) | Low | 652422 | 305978 | -7.67 |
| MB04 | clay, sand and gravel of concrete (1.00 m) (MG) | Low | 652434 | 305964 | -8.1 |
| MB04a | gravelly sand (2.30 m) (Crag) silty sand with occasional fine gravel and shell (18.30 m) (Crag) silty sand with clay laminations (20.40 m) (Crag) firm silty sandy clay (24.30 m) (Crag) silty sand with occasional shell (38.20 m) (Crag) stiff silty clay (41.70 m) (Crag) | Low | 652435 | 305962 | -7.99 |
| MB05 | soft silty clay and sandy silt (1.00 m) (MA) silty sand with occasional fine gravel (20.30 m) (Crag) clayey silty sand (22.40 m) (Crag) firm silty clay (24.40 m) (Crag) silty sand (25.00 m) (Crag) | Low | 652426 | 305946 | -5.77 |
| MB06 | silty sand (2.40 m) (MA) silty sand with occasional fine gravel and shell (Crag) firm sandy clay (22.60 m) (Crag) | Low | 652494 | 306024 | -6.56 |
| MB07 | silty gravelly sand (1.30 m) (Crag) sand with occasional fine gravel and shell (18.90 m) (Crag) clayey silty sand (19.5 m) (Crag) firm sandy clay (22.20 m) (Crag) silty sand (37.40 m) (Crag) stiff silty clay (40.00 m) (Crag) | Low | 652485 | 306003 | -6.85 |
| MB08 | soft silty clay (0.10 m) (MA) silty slightly gravelly sand (13.50 m) (Crag) stiff clay (18.80 m) (Crag) clayey silty sand (21.00 m) (Crag) stiff silty clay (23.30 m) silty slightly gravelly sand (25.00 m) (Crag) | Low | 652499 | 305988 | -6.7 |
| MB09 | slightly gravelly sand (1.30 m) (Crag) silty sand with occasional gravel and shell fragments (19.50 m) (Crag) silty sand with clay laminations (21.20 m) (Crag) firm silty clay (24.30 m) (Crag) silty sand with occasional shell fragments (37.40 m) (Crag) stiff silty clay (37.70 m) (Crag) gravelly sand ( 38.00 m) (Crag) silty clay (40.00 m) (Crag) | Low | 652490 | 305973 | -6.13 |

| id | Description | Potential | Easting (m) | Northing (m) | Elevation m (OD) |
|---|---|---|---|---|---|
| MB10 | silty sand (3.70 m) (Crag) silty slightly gravelly sand (14.40 m) (Crag) hard claystone (14.55 m) (Crag) silty sand with occasional gravel (14.55 m) (Crag) silty sand with clay laminations (19.70 m) (Crag) clayey silty sand (22.00 m) (Crag) stiff silty clay (22.33 m) (Crag) slightly gravelly sand with shell fragments (25.00 m) (Crag) | Low | 652502 | 305958 | -5.87 |
| BH4AS | sand and gravel (0.50 m) (MG) soft silty clay (2.20 m) (BF-a) peat (3.20 m) (BF-p) sand with occasional gravel (4.80 m) (Crag) | High | 652283.975 | 305846.552 | 2.128 |
| BH4B | gravel and sand (1.40 m) (MG) | Low | 652312.473 | 305826.346 | 1.831 |
| WS1 | slightly gravelly sand (3.90 m) (MG) soft clay (5.00 m) (BF-a) | Low | 652124.658 | 305894.619 | 1.547 |
| WS2 | silt (0.10 m) (MG) gravelly sand becoming sand and gravel with depth (2.00 m) (MG) | Low | 652124.438 | 305896.963 | 0.854 |
| WS3 | gravelly clay (0.40 m) (MG) clayey sandy silt (1.60 m) (BF-a) black organic clay (5.00 m) (BF-a) | Medium | 652124.299 | 305899.154 | 0.178 |
| WS4 | gravelly sand (4.90 m) (MG) soft clay (5.00 m) (BF-a) | Low | 652156.628 | 305892.961 | 1.592 |
| WS5 | slightly gravelly sand becoming sand and gravel with depth (1.10 m) (MG) | Low | 652156.195 | 305894.429 | 1.092 |
| WS6 | silty sand (0.60 m) (MG) silty clay (1.50 m) (BF-a) sand (2.50 m) (BF-a) soft black organic clay (5.00 m) (BF-a) | Medium | 652156.473 | 305896.786 | 0.135 |
| WS7 | sand and gravel (3.30 m) (MG) black silty clay (5.70 m) (BF-a) peat (8.00 m) (BF-p) | High | 652203.884 | 305884.993 | 1.701 |
| WS8 | sand (0.40 m) (MG) | Low | 652202.85 | 305887.222 | 0.874 |
| WS9 | sand and gravel (1.30 m) (MG) clayey silt (3.50 m) (BF-a) peat (5.00 m) (BF-p) | High | 652203.029 | 305889.802 | 0.271 |
| BH1 | slightly gravelly silty sand (1.70 m) (MG) slightly gravelly silty clay with lenses of organic matter (8.50 m) (BF-a) peat (11.40 m) (BF-p) organic silt and sand (13.00 m) (BF-a) silty sand with occasional shell and fine gravel (26.10 m) (Crag) laminated silty sandy clay (28.80 m) (Crag) silty sand with occasional clay laminations (30.45 m) (Crag) | High | 652102.434 | 305897.297 | 1.7 |
| BH2 | sand and gravel (3.50 m) (MG) silty clay with organic lenses (4.30 m) (BF-a) slightly gravelly clay (8.40 m) (BF-a) peat with organic clay lenses (9.00 m) (BF-p) peat (10.90 m) (BF-p) silty sand (11.5 m) (BF-a) peat (11.90 m) (BF-p) silty sand (14.00 m) (Crag) silty gravelly sand (19.35 m) (Crag) clayey silty sand (27.00 m) (Crag) laminated silty clay and sandy silt (30.00 m) (Crag) | High | 652152.032 | 305894.197 | 1.556 |
| BH4 | sand and gravel (3.30 m) (MG) soft silty clay (4.30 m) (BF-a) peat (6.00 m) (BF-p) silty gravelly sand with occasional organic fragments inc. wood (8.50 m) (BF-a) gravelly sand with thin beds of sand (9.45 m) (HGF) sand (18.00 m) (Crag) gravelly sand (19.00 m) (Crag) silty sand with clay laminations (24.45 m) (Crag) sand with occasional shell fragments (29.50 m) (Crag) laminated silty clay (30.45 m) (Crag) | High | 652233.11 | 305879.934 | 1.769 |

| id | Description | Potential | Easting (m) | Northing (m) | Elevation m (OD) |
|---|---|---|---|---|---|
| BH4A | clayey gravelly sand (1.00 m) (MG) laminated clay and silt (BF-a) peat (3.50 m) (BF-p) gravelly sand (5.00 m) (HGF) | High | 652315.409 | 305799.625 | 1.25 |
| BH4D | sand and gravel (4.20 m) (MG) gravelly sand (7.00 m) (HGF) silty gravelly sand with lenses of clay and occasional shell (10.00 m) (Crag) sand (19.45 m) (Crag) laminated silty sand (21.50 m) (Crag) sand with clay laminae (25.00 m) (Crag) laminated silt and clay (26.45 m) (Crag) sand with clay laminations (26.45 m) (Crag) silty clay (30.45 m) (Crag) | Low | 652289.573 | 305817.952 | 1.38 |
| BH5 | sand, gravel silt and clay (1.70 m) (MG) silty clay with peat lenses (2.50 m) (BF-a) organic gravelly sandy silty clay (3.40 m) (BF-a) organic slightly clayey gravelly sand (3.80 m) (BF-a) silty clay with sand laminations (5.00 m) (BF-a) | Medium | 652222.816 | 305942.58 | 0.877 |
| BH5A | sandy gravel and clay (1.70 m) (MG) silty clay with peat lenses (2.40 m) (BF-a) clayey silty sand with peat lenses (3.00 m) (BF-a) sandy gravelly clay with lenses of peat (3.40 m) (BF-a) sandy silty clay (4.80 m) (BF-a) silty sand with clay laminations (5.60 m) (BF-a) gravelly sand (9.70 m) (Crag) silty sand with occasional shell (13.00 m) (Crag) gravelly sand with shell (15.45 m) (Crag) silty sand with shell (25.80 m) (Crag) sandy silty laminated clay (30.50 m) (Crag) | Medium | 652225.894 | 305949.534 | 0.91 |
| BH6 | silty gravel and sand (2.00 m) (MG) organic clayey gravelly sand (3.00 m) (BF-a) clayey sand (4.00 m) (BF-a) slightly gravelly sand (5.00 m) (HGF) sand and gravel (6.00 m) (HGF) slightly gravelly sand (12.50 m) (Crag) silty sand (16.00 m) (Crag) laminated sandy silt and silty clay (17.45 m) (Crag) silty sand with shell (23.00 m) (Crag) clayey silt (24.50 m) (Crag) sand with occasional shell (27.00 m) laminated silty sandy clay (30.45 m) (Crag) | Medium | 652283.411 | 305963.434 | 0.927 |
| BH7 | sandy gravel (1.00 m) (MG) slightly organic clayey sandy silt (1.65 m) (BF-a) silty clay with peat lenses (2.45 m) (BF-a) organic silty clay (3.00 m) (BF-a) sandy silty clay with lenses of peat (4.00 m) (BF-a) slightly gravelly silty sandy clay (6.00 m) (BF-a) | Medium | 652307.183 | 305946.458 | 1.226 |
| BH14 | silty gravelly sand (1.80 m) (MG) sand (2.60 m) (MA) silty sandy clay (3.20 m) (MA) silty sand (9.20 m) (ND) sand and gravel (11.70 m) (ND) gravelly sand (14.70 m) (ND) gravelly sand with occasional shell and fine gravel (27.50 m) (Crag) laminated sandy silt (32.60 m) (Crag) stiff clay (33.20 m) (Crag) sand (40.00 m) (Crag) | Low | 652535.684 | 305982.793 | 1.955 |
| BH15 | gravel (0.35 m) (MG) gravelly sand (5.00 m) (ND) sand and gravel (8.00 m) (ND) silty sand with occasional shell and fine gravel (14.30 m) (Crag) silty clay (14.60 m) (Crag) gravel and sand (15.40 m) (Crag) sand with occasional clay laminae (26.45 m) (Crag) laminated silty clay (30.45 m) (Crag) | Low | 652637.441 | 306020.811 | 1.915 |
| BH16 | sand and gravel (2.00 m) (MG) silty sandy clay (3.00 m) (MA) silty sand (4.00 m) (MA) silty sand with occasional clay laminae (8.00 m) (ND) clayey sand (8.90 m) (ND) sandy gravel (14.30 m) (ND) silty sand with rare shell (37.00 m) (Crag) silty clay (38.90 m) (Crag) silty sand with clay laminations (40.45 m) (Crag) | Low | 652552.53 | 306008.468 | 2.002 |
| BH17 | sand and gravel (1.00 m) (MG) sandy silty clay (1.50 m) (MA) sandy silt (3.00 m) (MA) sand (8.00 m) (ND) clayey silty sand (9.80 m) (ND) clayey gravelly sand (15.60 m) (ND) silty sand (27.00 m) (Crag) clayey silty sand (29.00 | Low | 652555.669 | 305985.372 | 2.047 |

| id | Description | Potential | Easting (m) | Northing (m) | Elevation m (OD) |
|---|---|---|---|---|---|
| | m) (Crag) firm silty clay (31.00 m) sand with clay and silty laminations (36.00 m) (Crag) clayey silty sand (40.45 m) (Crag) | | | | |
| BH18 | sand and gravel (1.50 m) (MG) sandy gravelly silty clay (2.10 m) (MA) clayey sand with shell fragments (4.70 m) (ND) sand becoming silty and gravelly with depth (11.70 m) (ND) sand and gravel (14.6 m) (ND) silty sand with occasional gravel (30.00 m) (Crag) sandy silt with clay laminations (34.00 m) (Crag) silty sandy clay (40.45 m) (Crag) | Low | 652531.997 | 306005.595 | 1.995 |
| BH10 | gravelly silty sand (0.90 m) (MG) gravelly sandy silty clay w/ shell (2.00 m) (MA) slightly sandy silty clay (3.50 m) (MA) slightly organic silty sand (5.00 m) (Crag) laminated sandy silt and clay (11.20 m) (Crag) silty sand (22.40 m) (Crag) sand with lenses of clay (28.00 m) (crag) laminated sandy silty clay (34.00 m) (Crag) sand with shell (45.60 m) silty clay (50.45 m) (bedrock) | Low | 652407.07 | 305990.473 | 2.446 |
| BH10a | sand and gravel (1.30 m) (MG) silty sand with clay lamination (2.30 m) (MA) organic clayey gravelly sand with brick (4.00 m) (MA) organic silty clay and sand (4.30 m) (MA) silty gravelly sand with clay lenses (10.00 m) (Crag) laminated silty sandy clay (12.00 m) (Crag) silty sand (22.40 m) (Crag) silty sand with lenses of clay (28.30 m) (Crag) laminated silty clay (32.00 m) (Crag) sand with shell (45.80 m) (Crag) laminated clay (50.00 m) (bedrock) | Low | 652413.494 | 306009.977 | 2.546 |
| BH11 | sand and gravel (2.80 m) (MG) slightly organic sandy clay with shell (4.50 m) (MA) sand and gravel (6.30 m) (HGF) sandy gravel (6.80 m) (HGF) gravelly sand with shell (7.50 m) (Crag) sand (11.00 m) (Crag) sand with lenses of clay (14.00 m) (Crag) silty sand (21.80 m) (Crag) silty sand with lenses of clay (28.50 m) (Crag) silty sand (29.50 m) (Crag) laminated silty sandy clay (35.50 m) (Crag) silty sand with shell (44.00 m) laminated silty sand and clay (46.45 m) (Crag) silty clay (50.00 m) (bedrock) | Low | 652411.396 | 305966.5 | 2.462 |
| BH12 | silty gravelly sand ( 2.00 m) (MG) sandy clayey silt (3.50 m) (MA) sand with shell (4.00 m) (MA) organic gravelly silty sand (6.50 m) (MA) gravelly silty sand with shell (9.50 m) (Crag) gravelly sand (10.50 m) (Crag) sand with clay an silt laminations (12.50 m) (Crag) silty sand with shell (15.00 m) silty sand with clay laminations (20.50 m) sand (22.50 m) (Crag) slightly gravelly sand with clay laminations (28.70 m) (Crag) laminated silty clay (31.00 m) (Crag) sandy silt and clay (32.50 m) (Crag) laminated sandy silt and clay (34.50 m) (Crag) silty sand (45.50 m) (Crag) silty clay (50.00 m) (bedrock) | Low | 652512.874 | 306003.018 | 2.283 |
| BH12A | sand and gravel (4.80 m) (MG) gravelly sand (5.90 m) (MA) gravel (5.95 m) (MG) | Low | 652503.732 | 306024.912 | 2.368 |
| BH12B | gravelly sand (4.50 m) (MG) organic gravelly sandy silty clay with brick (6.50 m) (MA) laminated sandy silty clay with shell (7.50 m) (MA) organic gravelly sand with brick (6.50 m) (MA) sandy silty clay with shell (7.50 m) (MA) silty sand (11.60 m) (Crag) silty clay (12.20 m) (Crag) silty sand with laminations (29.30 m) (Crag) laminated silty clay (31.80 m) (Crag) silty sand (33.50 m) (Crag) slity gravelly sand (36.50 m) (Crag) silty sand with shell (44.00 m) laminated silty clay (50.00 m) (bedrock) | Low | 652505.498 | 306024.187 | 2.328 |

| id | Description | Potential | Easting (m) | Northing (m) | Elevation m (OD) |
|---|---|---|---|---|---|
| BH13 | sand, gravel and clay (2.10 m) (MG) silty clay (2.60 m) (MA) sandy clayey silt (5.00 m) (MA) sand with shell (6.00 m) (ND) gravelly clayey silty sand (9.40 m) (ND) sandy gravel with shell (10.00 m) (ND) gravelly sand (11.00 m) (ND) laminated silty sand with shell (14.00 m) (ND) silty sand with clay laminations (27.70 m) (Crag) sandy clay with laminations (33.00 m) (Crag) clayey silty sand with shell (44.80 m) (Crag) silty clay with laminations (45.20 m) (Crag) clay (50.00 m) (bedrock) | Low | 652515.83 | 305980.383 | 2.269 |
| BH13A | gravelly sand (1.40 m) (MG) sandy silty gravel (2.70 m) (MG) gravelly sandy silty clay (4.90 m) (MG) gravelly sand with shell (5.90 m) (ND) gravelly sand (9.50 m) (ND) gravelly silty clayey sand with laminations (12.00 m) (ND) sand with clay laminations and shell (27.20 m) (Crag) laminated silty sandy clay (31.30 m) (Crag) sand with clay laminations and shell (45.70 m) (Crag) silty clay (46.00 m) (Crag) clay (50.00 m) (bedrock) | Low | 652511.877 | 305957.733 | 2.379 |
| BH4BU | sand and gravel (0.40 m) (MG) silty gravelly sand (1.35 m) (MG) sand and gravel (1.85 m) (MG) silty sand (1.95 m) (BF-a) organic silty clay (2.65 m) (BF-a) gravelly clay with organic lenses (2.85 m) (BF-a) silty gravelly sand (4.00 m) (Crag) sand (5.00 m) (Crag) | Medium | N/A | N/A | N/A |
| BH8 | sand and gravel (1.90 m) (MG) organic sandy silt (2.20 m) (BF-a) peat (2.60 m) (BF-p) gravelly silty sand with peat lenses (3.60 m) (BF-a) sandy gravel (5.00 m) (HGF) sand with shell and clay laminations (27.00 m) (Crag) silty clay (27.70 m) (Crag) sand (29.00 m) (Crag) sand with shell and clay laminations (40.37 m) | High | 652390.553 | 305988.115 | 1.892 |
| BH9 | sand and gravel (1.20 m) (MG) gravelly sandy silty clay (1.80 m) (BF-a) organic sandy gravelly silty clay (2.60 m) (BF-a) sand with rootlets (3.25 m) (BF-a) gravelly sand (6.00 m) (HGF) sand and gravel (7.00 m) (HGF) silty sand with shell and clay laminations (21.80 m) (Crag) silty sandy laminated clay (22.00 m) (Crag) silty sand (27.10 m) silty sand with clay laminations (30.00 m) (Crag) laminated silt and clay (32.00 m) (Crag) gravelly sand (34.00 m) (Crag) sand with clay laminations (38.50 m) (Crag) gravelly sand (40.45 m) (Crag) | Medium | 652394.829 | 305964.55 | 1.827 |

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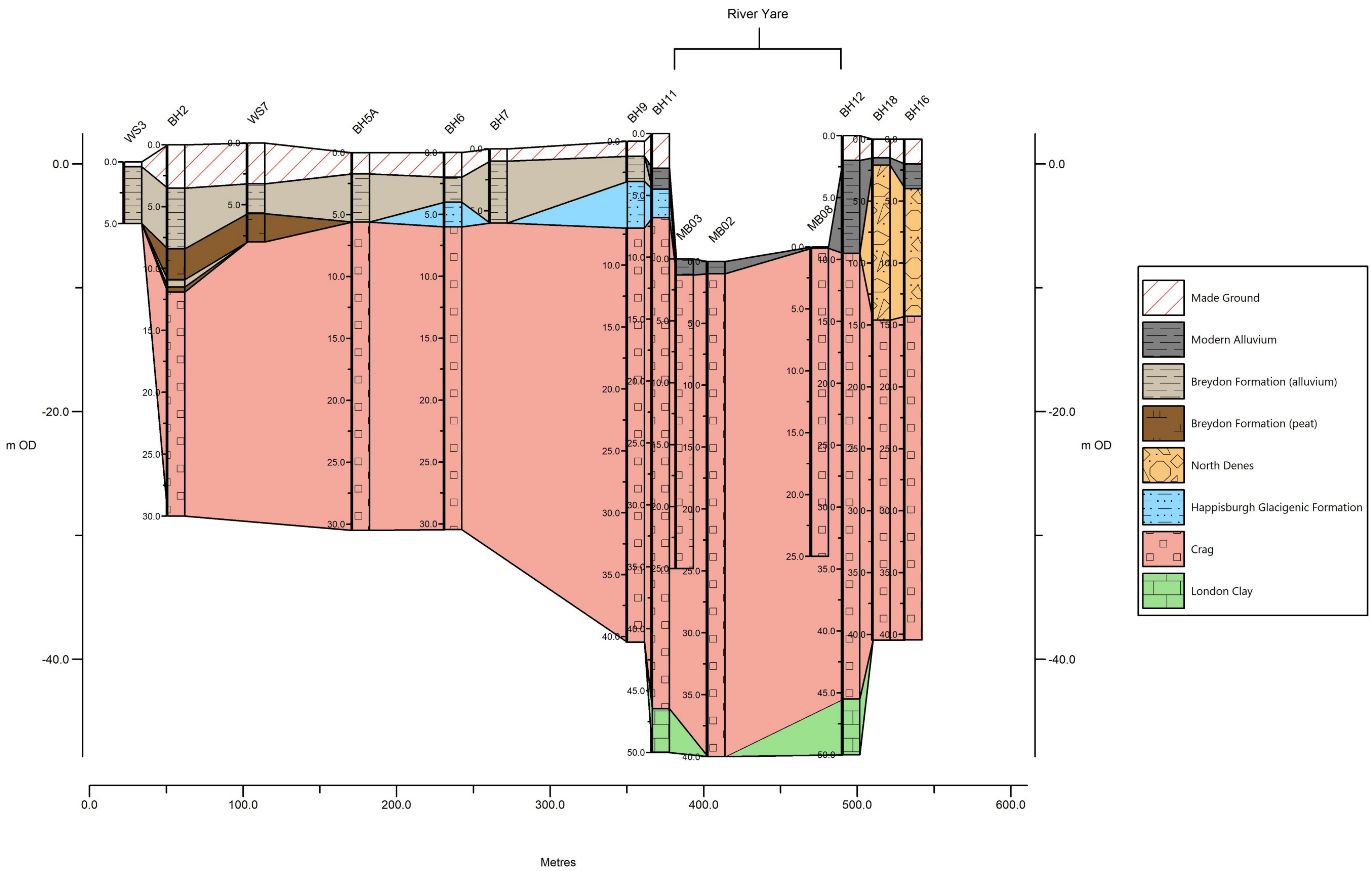
Coordinate system:
OSGB36 (OSTN15/OSGM15)

Site location plan showing transect

Figure 1



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| Scale: | NTS | Illustrator: | ND |
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Sub-surface transect across the Site

Figure 2

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