A47 Great Ouse Bridge

Geoarchaeological Monitoring of GI Works

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Summary

Geoarchaeological monitoring of GI works, comprising the recording of a total of six dynamic sample and seven overwater vibrocore boreholes, followed by a programme of deposit modelling, was undertaken in advance of proposed refurbishment of the A47 Great Ouse Bridge, King's Lynn, Norfolk. The geoarchaeological monitoring was undertaken in order to provide information on the archaeological and geoarchaeological resource that might be impacted by the proposed development, and to inform the scope and requirement for any further archaeological and geoarchaeological investigations that may be required.

The sequence of superficial geological deposits at the Site comprises a basal fluvial sand and gravel, overlain by a sequence of freshwater and estuarine alluvium forming under the influence of relative sea level rise during the Holocene to a level of c. 5 m OD. The contemporary River Great Ouse cuts through this alluvial sequence to a river bed level of c. -3 m OD, where modern river bed sediments are recorded overlying a similar sequence of Holocene estuarine alluvium and fluvial sands and gravels.

The basal fluvial sands and gravels were recorded in various boreholes at a depth of c. 8.10 to 13.60 m bgl, with an average thickness of 0.50-0.80 m. This unit generally overlies bedrock, although in places a finer-grained unit was recorded underneath the sands and gravels, potentially representing Pleistocene alluvium. Although their age is currently uncertain, these basal sands and gravels are provisionally interpreted as cold stage fluvial deposits formed within a high energy channel associated with the valley of the Great Ouse. These deposits have broad potential for Palaeolithic archaeology, faunal material and fossiliferous horizons containing palaeoenvironmental and artefactual remains; however, these deposits are deeply buried (present at depths generally greater than 10 m bgl in terrestrial locations and greater than 3.0 m bgl within the river) and are not possible to evaluate using conventional archaeological trial trenching or test pitting.

The fluvial sands and gravels are overlain by a sequence of estuarine alluvial deposits of the River Great Ouse, present at elevations between c. -7.0 and 5 m OD likely forming in a range of different environments including tidal mud flats, salt marshes and semi-terrestrial reed swamps under the influence of rising sea levels during the Holocene. Peat was recorded within the Estuarine Alluvium at elevations between c. 0.0 and -2.0 m OD (c. 5.0 to 11.0 m bgl) with a varying thickness of between 0.2 and 1.0 m. The peat, recorded widely across the Site, is considered to represent a broadly contemporaneous transition to semi-terrestrial conditions on the estuarine floodplain, likely as a response to a reduction in rates of relative sea level rise. These deposits are of high archaeological and palaeoenvironmental potential, on the basis of their potential to preserve Prehistoric waterlogged archaeological remains and palaeoenvironmental records.

Depending on the nature of the design proposals and likely depth of impact on these deposits, a purposive geoarchaeological borehole survey may be appropriate in order to recover samples suitable for a programme of palaeoenvironmental assessment and scientific dating focussed on the peat.

Acknowledgements

Wessex Archaeology thanks Tetra Tech Ltd for commissioning the work detailed in this report. The fieldwork was managed on site by Jasmin Lycett and Richard Payne. Deposit modelling was undertaken by Jasmin Lycett and Dr Daniel Young. The report was compiled by Dr Daniel Young, Jasmine Lycett and Jon Dobbie and reviewed by Dr Alex Brown. Figures were produced by Amy Wright. The project was managed on behalf of Wessex Archaeology by Dr Daniel Young.

A47 Great Ouse Bridge

Geoarchaeological Monitoring of GI works

1 INTRODUCTION

1.1 Project and planning background

1.1.1 Wessex Archaeology has been commissioned by Tetra Tech Ltd (Bristol) ('the client') to produce a report outlining the results of the monitoring of Ground Investigation (GI) works associated with refurbishment works to the A47 Great Ouse Bridge, King's Lynn, Norfolk (the 'Site'). The Site is centred on National Grid Reference (NGR) 556116, 331841 (TF 561160 318415) (**Figure 1**).

1.1.2 A Written Scheme of Investigation (WSI) was produced by Wessex Archaeology (2022) which identified the likely presence of superficial geological deposits within the Site which may have geoarchaeological and archaeological potential. Geoarchaeological potential is defined as the possibility for deposits that preserve paleoenvironmental evidence and/or dating evidence relevant for contextualising prehistoric settlement history.

1.1.3 The geoarchaeological monitoring of the GI works will provide further information on the archaeological and geoarchaeological resource that may be impacted by the proposed development, and facilitate an informed decision with regard to the requirement for, and methods of, any further archaeological and geoarchaeological work that may be required; or the formation of a mitigation strategy (to offset the impact of the development on the archaeological resource) or a management strategy.

1.2 Scope of works

1.2.1 Geoarchaeological recording of the samples arising from the GI works was undertaken at a logging facility in August and October 2022 and January and February 2023. The GI works at the Site comprised:

- 16 dynamic sample boreholes;
- 13 dynamic sample boreholes with rotary follow-on;
- 7 vibrocore and cable percussion boreholes; and
- 21 Piezocone penetration test (CPTu) tests.

1.2.2 Of these GI, a total of six dynamic sample boreholes (ATK-BH05, BH06, BH11, BH11a, BH12 and BH22) and seven overwater vibrocore boreholes (VC07, VC08, VC09, VC10, VC10a, VC19 and VC20) were recorded by a Geoarchaeologist at a logging facility. The logs arising from the remainder of the GI works were reviewed by a Geoarchaeologist.

1.3 Scope of document

1.3.1 To help frame archaeological and geoarchaeological investigations of this nature, Wessex Archaeology has developed a four-stage approach, encompassing different levels of investigation appropriate to the results obtained, accompanied by formal reporting of the

results at the level achieved. The borehole survey reported on here represents Stage 2 of this process (**Table 1**).

1.3.2 In format and content, the work follows the methodology set out within the WSI (2022), and conforms to current best practice, including the guidance in *Management of Research Projects in the Historic Environment* (MoRPHE, Historic England 2015a), the Chartered Institute for Archaeologists' (CIfA) *Standard and guidance for archaeological field evaluation* (CIfA 2014), Historic England's technical guide to Geoarchaeology: Using Earth Sciences to Understand the Archaeological Record (Historic England 2015b) and Deposit Modelling and Archaeology (Historic England 2020).

Table 1 Staged approach to geoarchaeological investigations

Stage 1: Geoarchaeological Desk-based Assessment (GDBA) and deposit modelling	A Geoarchaeological Desk-Based Assessment (GDBA) examines a range of data (published and unpublished ("grey literature"), LiDAR, historic maps) and models existing Ground Investigation (GI) data to inform on the possible Palaeolithic archaeological and geoarchaeological potential of a site. The GDBA may include, dependant on the site and complexity of a site, a Geoarchaeological Landscape Characterisation (GLC) which divides a study area into different zones (Geoarchaeological Characterization Zones – GCZs) based on variations in deposits and potential. The GDBA establishes the requirements for and scope of Stage 2 archaeological and geoarchaeological field elevation. Should Stage 2 evaluation be required, appropriate and proportionate recommendations for each GCZ are provided.
Stage 2: Geoarchaeological monitoring of GI works and/or Geoarchaeological borehole survey	Field evaluation to establish the geoarchaeological and archaeological potential of Quaternary deposits within an evaluation area, which informs on the requirements and scope of further works at Stage 2 (e.g. purposive borehole survey), Stage 3 palaeoenvironmental assessment and/or Stage 4 mitigation. The principal methods of geoarchaeological evaluation are through monitoring of Ground Investigation (GI) works or targeted boreholes. A geoarchaeological evaluation report is produced, which includes deposit modelling (where sufficient data allows) and recommendations for further work at Stage 2 or Stage 3 if required. Further works may include additional interventions (stepped trenches, test pits or boreholes) to retain additional/suitable samples for assessment.
Stage 3: Palaeoenvironmental assessment	Palaeoenvironmental samples recovered during Stage 2 are assessed to inform on the archaeological and geoarchaeological potential of deposits and guide the scope and need for Stage 4 analysis. A report is produced outlining the palaeoenvironmental potential of the deposits including targeted and proportionate recommendations for Stage 4 analysis.
Stage 4: Palaeoenvironmental analysis	Based on the results of the Stage 3 palaeoenvironmental assessment, palaeoenvironmental analysis on selected deposits/samples may be required. In addition to full analysis of suitable samples identified during the assessment. work at Stage 4 may include additional scientific dating where appropriate/required. A final analysis report is provided on completion of mitigation program. Where appropriate, this may include recommendations for publication or other forms of dissemination.

Publication	The scope and location of a publication report will be agreed in consultation with the client and LPA advisor. The publication report may comprise a note in a local journal or a larger publication article or monograph, dependant on the significance of the archaeological and geoarchaeological work.

1.4 Site location and topography

1.4.1 The Site is bounded by Pullover Roundabout to the north-west and the A47 roundabout with High Road, Saddlebow Road and the A148 to the southeast. The boreholes were located along the route of the A47 where it crosses the River Great Ouse, with a series of overwater vibrocores located within the river.

1.4.1 The Site comprises the southern Eau Brink Cut section of the River Great Ouse, where the river was artificially rerouted and straightened to minimize flooding risk in the area. The works on this section of the Eau Brink Cut were initially completed in 1821, with additional work performed later to widen it.

1.4.2 The modern topography of the Site reflects its position within the Fenlands close to The Wash, with the Site lying at a maximum elevation of 6 m above Ordnance Datum (m OD).

2 GEOARCHAEOLOGICAL BACKGROUND

2.1 Introduction

2.1.1 The superficial deposits in the Site may include deposits with geoarchaeological and/or archaeological potential of both Pleistocene and Holocene date. These epochs form parts of the Quaternary, a period covering the last 2.6 Mya, and defined by repeated fluctuations between cold (glacial) and warm (interglacial) climate stages (**Table 2**).

2.1.2 Where age estimates are available for deposits these are expressed in millions of years (Mya), thousands of years (Kya) and within the Holocene epoch as either years Before Present (BP), Before Christ (BC) and Anno Domini (AD). Where radiocarbon dates are included, they are quoted as calibrated (cal.) BC or AD. These dates are supplemented where relevant with the comparable Marine Isotope Stage (MIS) where odd numbers indicate an interglacial period and even numbers a glacial period.

Table 2 British Quaternary chronostratigraphy

Geological Period	Chronostratigraphy		Age (Kya)	MIS
Holocene	Holocene interglacial		11.7 – present	1
Late Pleistocene	Devensian Glaciation	Loch Lomond Stadial	11.7 – 12.9	2 – 5d
		Windermere Interstadial	12.9 – 15	
		Dimlington Stadial	15 – 26	
		Upton Warren Interstadial	40 – 43	
		Early Devensian	60 – 110	
	Ipswichian interglacial		115 – 130	5e
		Unnamed cold stage	130-374	6

Geological Period	Chronostratigraphy		Age (Kya)	MIS
Middle Pleistocene		Avery interglacial		7
		Unnamed cold stage		8
		Purfleet interglacial		9
		Unnamed cold stage		10
	Hoxnian interglacial		374 – 424	11
	Anglian glaciation		424 – 478	12
	Cromerian Complex		478 - 780	13 – 19

2.1.3 The geoarchaeological background relating to Site was assessed in a prior Written Scheme of Investigation (Wessex Archaeology 2022), the results of which are reproduced below. Additional sources of information are referenced, as appropriate.

2.2 Solid Geology

2.2.1 The bedrock geology of the area is mapped by the British Geological Survey (BGS) as Kimmeridge Clay Formation Mudstone, a sedimentary bedrock that formed 152 – 157 Mya in the Jurassic Period in a predominantly shallow marine environment. BGS archive borehole data (TF61NW63 and TF61NW68) shows the bedrock in the vicinity of the Site as a typically firm to very stiff laminated dark grey silty clay with occasional shell fragments (https://mapapps2.bgs.ac.uk/geoindex/home.html).

2.2.2 The upper surface of the Kimmeridge Clay was recorded at 12.95m below ground level (bgl) (-8.83m OD) in borehole TF61NW63 on the west bank of the Great Ouse; 10.5m bgl (-6.46m OD) in TF61NW70 on the east bank and 0.53m bgl (-22.58m OD) on the riverbed in borehole record TF61NW65.

Superficial Geology

2.2.3 The superficial is mapped by the BGS as Tidal Flat Deposits comprised of clay, silt and sand, forming under estuarine influence in the intertidal zone. These estuarine alluvial deposits are recorded as being occasionally interbedded with organic deposits. A 0.6m thick layer of peat was recorded at 4.26m bgl (-0.24m OD) in borehole TW61NW68 on the east bank, and a 0.21m thick layer of peat was recorded at 3.93m bgl (0.21m OD) in borehole TW61NW62/A located on the west bank of the river.

2.2.4 The Site is located towards the northeast of the low-lying Fens, which during the Holocene has been progressively infilled with unconsolidated sediments as a response to sea-level change and local geomorphological processes (Wheeler & Waller 1995). Marine clastic sediments dominate at seaward localities close to the Wash, intercalating with freshwater deposits over the central part of the basin and where they meet the valleys of Rivers draining in to the Wash. Around the landward edge of the basin freshwater deposits dominate, namely organic, fluviatile and lacustrine clastic deposits (Wheeler & Waller 1995).

2.2.5 Peat deposits of Holocene age, referred to as Nordelph Peat but in places including up to three distinct peat units, have been widely recorded across the low-lying Fens (Wheeler & Waller 1995). Where these peat deposits are present they are of high archaeological and palaeoenvironmental potential, and may include material of Mesolithic date onwards.

2.2.6 A comprehensive study of environmental change during the Holocene was undertaken on the alluvial deposits of Fenland as part of The Fenland Project (Waller 1994), with studies in the eastern Fens, including at Wiggenhall St Germans and from boreholes associated with the A17 road scheme and those undertaken by the Great Ouse River Board between King's Lynn and Denver Sluice, providing a useful context for the geoarchaeological investigation of the present Scheme.

2.2.7 Waller (1994) describes the stratigraphy of this part of Fenland, overlying the pre-Holocene deposits, as composed of marine sands in the deeper parts of the basin (below c. -6.0m OD), overlain by intercalated peats and estuarine clays, with evidence for widespread peat formation in the late Neolithic/early Bronze, generally following a consistent sequence of saltmarsh through to fen carr dominated by willow.

2.2.8 In parts of the eastern Fens (e.g. at Wiggenhall and Saddle Bow) peat formation appears to have continued in to the Iron Age and Roman periods, although a renewed phase of estuarine inundation, depositing estuarine silts and clays, appears to have occurred from the Late Bronze Age onwards (Waller 1994).

3 ARCHAEOLOGICAL BACKGROUND

3.1 Introduction

3.1.1 The archaeological and historical background relating to the evaluation was assessed in the WSI (Wessex Archaeology 2022) which considered the recorded historic environment resource within a 1 km study area of the proposed development. A summary of those results is presented below. Additional sources of information are referenced, as appropriate. The historical background includes entries in the Norfolk Historic Environment Record (HER) for the area of the Site and the surrounding area.

3.2 Early Prehistoric (900,000 - 4,000 BC)

3.2.1 At Kings Reach 3.3km to the east of the Site a fen-edge site underwent an archaeological evaluation in 2001 and 2002 with a subsequent phase of excavation in 2004 (NHER 36320). The earliest activity on the site dates from the Late Mesolithic and Early Neolithic periods, with many worked flints of this date recovered from buried soil horizons with many of the flints appearing to represent in situ flint working.

3.2.2 During the Late Neolithic and Early Bronze Age activity appears to have taken place along the edge of a palaeochannel, which environmental evidence indicates was situated within a grassland environment with woodland nearby. Features likely to have been associated with this phase of activity included a burnt mound with an associated trough and clay-lined pit and a nearby cluster of pits containing worked flint and Beaker pottery. A series of medieval ditches and a pit were also excavated, situated on higher ground in the easternmost part of the site.

3.3 Prehistoric (4,000 BC - AD 43)

3.3.1 2.65km to the south east of the Site near Puny Drain a single flint scraper of unknown date was recorded (NHER 23589). 4.5km to the north east of the Site flint flakes, a flint core and a late Neolithic to Early Bronze Age barbed and tanged arrowhead were found in a garden (NHER 35624). 5.25km to the north east of the Site on the west side of Spring wood, flint flakes of an unknown date were recorded (NHER 16831). During the construction of a new housing estate 5km to the north east of the Site in 1974 flint flakes were identified, possibly from an axe production site, and later a scraper were recovered in 1985 (NHER 5548).

3.3.2 5km to the north east of the Site a Bronze Age round barrow (NHER 5489) excavated in the 1930s revealed a Beaker occupation site that was sealed by the barrow. Two poorly-preserved crouched inhumation burials were found, although no trace of a barrow ditch was observed. Several Mid-Late Bronze Age cremations (at least one urn) were also identified; these representing later insertions into the Early Bronze Age barrow mound.

3.3.3 In 2014 the area around the site of the barrow was subject to a programme of archaeological evaluation, one of the aims of which was to establish the exact site of the Reffley Wood barrow. A geophysical survey identified what appeared to be two concentric ring-ditches, although these were some 70m to the north of the site where the barrow was believed to have lain. Subsequent trial trenching demonstrated that these anomalies did indeed correspond with ring-ditches and the nature of the internal features suggests that this was almost certainly the Reffley Wood barrow.

3.4 Roman (AD 43 – AD 410)

3.4.1 671m to the north east of the Site a Roman coin identified as an Ae from the reign of Constantius II (AD 337 – 361) was found in a garden on Wisbech Road (NHER 14483).

3.5 Anglo-Saxon/Early Medieval/Medieval (AD 410 – AD 1540)

3.5.1 320m to the west of the Site nine sherds of Grimston-type Thetford Ware including thumb-impressed rim and spout were found in 1979 (NHER 15487) along with animal bones and shells.

3.5.2 230m to the north of the Site an earthwork (NHER 38321) dating from the medieval to post-medieval period is recorded. It varies in width from 8.5m to 13m. At TF 61284 19681 the earthwork abuts another section of bank running from TF 61275 19546 to TF 61263 19722. The lines of both these banks are depicted on the 2nd edition map (1902-7, 25") (S2).

3.5.3 535m to the southwest of the Site a sea bank (NHER 21808) believed to be medieval was recorded, it has been heavily eroded and was visible for a length of approximately 580m in RAF air photographs from 1948.

3.6 Post-Medieval and Modern (AD 1850 – AD 2000)

3.6.1 460m to the south west of the Site an area of post medieval ridge and furrow (NHER 38245) is recorded. 768m to the south west an undated cannon ball was found in 1981 (NHER 17301).

3.6.2 The Eau Brink Cut (NHER 13532) was an artificial waterway constructed in 1821 to remove a bend from the Great Ouse River to aid navigation of the waterway. Landowners had been pressurising parliament since 1794 to allow a canal to be dug to remove the dangers of navigating a shallow bend in the river. An Act was obtained in 1795 for improving the drainage of the Middle and South Levels by altering the course of the Ouse from the Eau Brink, in the parish of Wiggenhall St Mary's, to the upper part of the harbour at King's Lynn.

3.6.3 Approximately 500m to the south west of the Site an undated bank 250m long is recorded (NHER 38246). The bank may relate to the course of the river prior to construction of the Eau Brink Cut.

3.6.4 150m to the north east of the Site the Marshland Free Bridge (NHER 41847) was constructed in 1873. The bridge had an ornate iron superstructure that was supported on cylinders of cast iron filled with concrete. The bridge was in use until 1925 and was demolished in 1942, although the piers of the bridge are still in position.

3.6.5 The route of the Midland and Great Northern Joint Railway (NHER 13581) ran through the Site. The section from King's Lynn to Sutton Bridge had stations at South Lynn, Clenchwarton and Terrington and Walpole, and was opened by the Lynn & Sutton Bridge Railway in 1864. The section between King's Lynn and Great Yarmouth had twenty-two intermediate stations and opened under the Yarmouth & North Norfolk Railway from 1877 to 1881, the Lynn & Fakenham Railway between 1879 and 1882, and by the Eastern & Midlands in 1883. The whole network was closed on 2 March 1959, although some sections survive as paths. A number of stations, signal boxes, goods sheds and concrete mileposts also remain.

3.6.6 240m to the north a type 22 pillbox (NHER 38247) was located on the western bank of the River Great Ouse, below Free Bridge. This location was presumably to cover the approach to the bridge from the A47 to the west although it also overlooks the river. The pillbox was probably demolished in around 1961.

3.6.7 To the east of the Site is the location of the Cooper Roller Bearings Factory (NHER 62855), founded in 1894 and a major employer in Kings Lynn.

4 AIMS AND OBJECTIVES

4.1.1 The aims and objectives of the geoarchaeological monitoring follow those outlined within the WSI (Wessex Archaology 2022) and are presented below.

4.2 Overarching aims

4.2.1 The general aims (or purpose) of the geoarchaeological monitoring, in compliance with the CIfA *Standard and guidance for archaeological field evaluation* (CIfA 2014), are:

- provide information about the archaeological and geoarchaeological potential of the Site;
- consider the possible significance of any archaeological and geoarchaeological evidence present, or potentially present, in the context of national and regional research priorities and agendas (e.g. EH 2008a, East of England Research Framework (EERF), and
- inform either the scope and nature of any further archaeological and geoarchaeological work that may be required; or the formation of a mitigation strategy (to offset the impact of the development on the archaeological resource); or a management strategy.

4.3 Site-specific aims and objectives

4.3.1 Following consideration of the archaeological and geoarchaeological background to the Site (**Section 2**), the following site-specific aims and objectives of geoarchaeological monitoring have been identified:

4.3.2 The overarching aims and objectives of the geoarchaeological monitoring are as follows:

- Gain information about the superficial deposits within the area of the proposed bridge refurbishment;
- Provide detailed information regarding the likely date, character, extent, integrity and degree of preservation of the superficial geological deposits;
- Mitigate against impacts on archaeology and superficial deposits with geoarchaeological potential;

- Inform requirements for and scope of further archaeological and geoarchaeological investigations;
- Place the results of the borehole survey within its local, regional, and national, archaeological and geoarchaeological context.

5 METHODS

5.1 Introduction

5.1.1 Health and safety override archaeological considerations in all works since, as stated in CIfA guidance, *Health and Safety regulations and requirements cannot be ignored no matter how imperative the need to record archaeological information; hence Health and Safety will take priority over archaeological matters* (CIfA 2014a, 11).

5.1.2 All works were undertaken in accordance with the detailed methods set out within the WSI (WA 2022). Any significant variations to these methods were agreed in writing with Norfolk County Council's Historic Environment Advisor and the client, prior to being implemented. The fieldwork was carried out under the supervision of an experienced geoarchaeological specialist.

5.2 Geoarchaeological monitoring of GI works

5.2.1 A total of six dynamic sample boreholes (ATK-BH05, BH06, BH11, BH11a, BH12 and BH22) and seven overwater vibrocore boreholes (VC07, VC08, VC09, VC10, VC10a, VC19 and VC20) were recorded by a Geoarchaeologist at the Tetra Tech logging facility in King's Lynn. In addition, the GI logs arising from the remainder of the boreholes were reviewed by a Geoarchaeologist prior to inclusion in the deposit model (see **6.4**).

5.2.2 The attending geoarchaeologist recorded, described and interpreted the sequence of deposits encountered in order to allow an assessment of likely geoarchaeological potential using the criteria outlined below. Where appropriate and where there were no conflicts with the geotechnical requirements for the cores, selected samples from the cores were retained as part of the sedimentary archive against which further works will be recommended.

5.3 Sediment description

5.3.1 The boreholes were recorded using Wessex Archaeology's pro-forma digital recording system. For each stratigraphic unit descriptions and interpretations of the deposits are provided, as shown in **Appendices 1 and 2**. Descriptions of deposits included information such as:

- *Depth*
- *Texture*
- *Composition*
- *Colour*
- *Inclusions*
- *Structure*
- *Shape and nature of contacts between deposits*

5.3.2 Interpretations included, where possible, probable depositional environments and formation processes.

5.3.3 A full photographic record was made using a digital camera equipped with an image sensor of not less than 10 megapixels. This recorded both the detail and the general context of the principal lithological and stratigraphic features, and the evaluation area as a whole.

5.3.4 Digital images were subject to managed quality control and curation processes which will embed appropriate metadata within the image and ensure long term accessibility of the image set. Photographs were taken of all areas, including access routes, to provide a record of conditions prior to and on completion of the borehole survey.

5.4 Deposit modelling

5.4.1 A series of geoarchaeological deposit models were constructed for the site using a total of 50 stratigraphic records, including the 39 new boreholes (of which 13 were recorded for geoarchaeological purposes) and 11 British Geological Survey (BGS) online archive boreholes (http://mapapps.bgs.ac.uk/geologyofbritain/home.html).

5.4.2 Only those stratigraphic records with sufficiently detailed descriptive terminology and location data (including surface elevation) were included in the model. The deposit modelling was undertaken following the guidelines in Historic England (2020).

5.4.3 All available data points were entered into industry standard geological utilities software (Rockworks™ 23). Each stratigraphic unit was given a colour and pattern allowing cross correlation and grouping of the different sedimentary units. The grouping of these deposits is based on lithological descriptions, which define distinct depositional environments referred to as ‘stratigraphic units’ (e.g. estuarine/tidal alluvium, peat etc.).

5.4.4 Sedimentary units from the boreholes were classified into eight stratigraphic units: (1) Topsoil, (2) Made Ground, (3) Modern River Alluvium, (4) Estuarine Alluvium, (5) Organic Alluvium, (6) Peat, (7) Sands and Gravels and (8) Bedrock. The classified data for groups 1 to 6 were then input into a database within the RockWorks 17™ program.

5.4.5 A two-dimensional stratigraphic profile (‘transect’) of selected interventions across the Site was generated using Rockworks™ 23. Transect 1 (**Figure 4**) shows the main stratigraphic units and their lateral and vertical variability across the area of the site.

5.4.6 The key aims of the modelling were to interpret the data, identify the probable depositional environments represented, and determine areas of higher and/or lower geoarchaeological potential where further work may be required (e.g. deposits with potential for the recovery of significant archaeological and palaeoenvironmental remains).

6 RESULTS

6.1 Introduction

6.1.1 This section summarises the results of the monitoring of GI works, integrating the results of the geoarchaeological deposit modelling. A total of 13 boreholes (**Appendices 1 and 2**) were recorded as outlined in **Section 6.2**, with a programme of geoarchaeological deposit modelling integrating the results of the GI works and a review of relevant BGS archive boreholes. The results of the geoarchaeological deposit modelling are shown in **Figure 4**.

6.2 Stratigraphic sequence

6.2.1 The full sequence of superficial geological deposits recorded during the monitoring of the GI works, and forming the basis of the deposit modelling, comprises:

- Topsoil (modern)
- Made Ground (modern)
- River Alluvium (modern)
- Estuarine Alluvium (Holocene)
  - Organic Alluvium
  - Peat
  - Sands and Gravels
- Fluvial Sands and Gravels (Pleistocene)
- Bedrock (Jurassic)

6.2.2 More detail on the variability and composition of these deposits is described below, with a consideration of their geoarchaeological and archaeological potential outlined in **Section 8**.

Bedrock

6.2.3 The bedrock, recorded as a fissile, laminated, and fossiliferous blueish grey mudstone (Kimmeridge Clay) was recorded in all boreholes across the Site except for BH26 and BH28, generally at elevations between -6.50 to -8.00m OD (**Figure 4**).

6.2.4 Fossil elements as observed on site were small shelly fossils paler than the matrix and visually identified to be predominantly bivalves in an apparent death assemblage. Elements of selenite were also identified in weathered horizons and immediately above weathered horizons. Subordinate limestone bands were identified in some boreholes.

Pleistocene Sands and Gravels

6.2.5 A basal unit of sands and gravels was recorded in BH01, BH03 BH04, BH05, BH06, BH12, BH14a, BH15, BH16, BH17, BH18, BH23, BH26, VC09, VC10 and VC10a at a general depth of 8.1 to 13.60 m bgl (c. -7.0 to -5.5 m OD) with an average thickness of 0.50-0.80m (**Figure 4**). This unit was described as a dark greyish brown medium to coarse sand and silty sand with common fine to medium subangular to subrounded gravels of mixed lithology.

6.2.6 These deposits are relatively thin and are currently of unknown date, though they may represent a cold stage fluvial deposits associated with the River Great Ouse.

Estuarine Alluvium

6.2.7 A brownish to blueish grey clay, grading in places to medium sand with occasional lithological coarse components of predominantly gravel sized subangular dark grey to black flints with occasional mudstone, was recorded across the Site. This unit is interpreted as Estuarine Alluvium, with an upper surface of between 1.0 and 5.0 m OD north and south of the Great Ouse, and below -3.0 m OD within the channel. The Estuarine Alluvium was variable in thickness, generally between 4.0 and 11.0 m (see **Figure 4**).

6.2.8 Coarse components of detrital organic lenses/inclusions were also noted in places, with units containing such material generally found less than 2 m below ground level (bgl) in overwater vibrocores. This organic material was generally woody, fragmentary, and not orientated. Small gravel sized bivalve shells were also observed occasionally in both overwater and terrestrial boreholes, with valves generally being complete but disarticulated.

6.2.9 These deposits represent sediment accumulating under the influence of rising post-glacial sea-levels, deposited within a range of settings from early Holocene channel systems through to mud flats and salt marsh environments within the succeeding extensive intertidal floodplains of the Ouse Estuary. Organic-rich and peat units were recorded within this sequence of alluvial deposits (see below).

Peat

6.2.10 Peat was recorded within the Estuarine Alluvium at a general depth of 0.0 to -2.0 m OD with a varying thickness of 0.20 to 1.00 m (see **Figure 4**). A slightly higher possible peat unit or buried soil was recorded in BGS archive borehole TF61NW72 (c. 1.5 m OD), excavated in 1968, though on the basis of the depth of the made ground in adjacent boreholes BH32 and BH27 this unit may have since been truncated.

6.2.11 The Peat was generally dark brown to black and amorphous to psuedofibrous. The plant material within the Peat, where identifiable, was generally orientated parallel to ground level and was greyish yellow in colour. The lower boundaries of the peat units were generally sharp to abrupt.

6.2.12 The peat units are indicative of a transition to semi-terrestrial conditions on the estuarine floodplain, supporting the growth of wetland vegetation such as that found growing in reed swamp, sedge fen or fen carr, likely as a response to a reduction in rates of relative sea level rise. The distribution of the peat indicates that they may represent a single broad phase of semi-terrestrial conditions, with their varying depth potentially related to different rates of autocompaction of the alluvial sequence across the Site.

Sands and Gravels

6.2.13 A unit of angular to subangular flint gravel within a brownish grey coarse sand matrix was recorded within the alluvial sequence at variable elevations between c. -5.0 and -1.0 m OD. These deposits are considered to represent Holocene fluvial deposits forming within channels of the River Great Ouse, potentially related to a network of dendritic tidal channels or channel migration across the floodplain.

Organic Estuarine Alluvium

6.2.14 The Organic Estuarine Alluvium was generally similar in composition to the minerogenic Estuarine Alluvium, but includes inclusions or lenses of blackened discontinuous pseudofibrous peat. These pockets are generally 3-5cm in diameter and are orientated parallel to ground level. *Phragmites* remains were common in this unit, along with 1-1.5cm thick woody organic traces running perpendicular to ground level.

6.2.15 These units were present at various depths throughout the alluvial sequence. The organic material in this unit is likely to be detrital in nature and includes material derived from peat deposits in the wider catchment of the river.

Modern River Alluvium

6.2.16 Modern River Alluvium is visually distinct from Estuarine Alluvium, being a soft friable light yellowy brown well sorted medium coarse sand with occasional anthropogenic coarse components, generally fragmentary brick and slag with uncommon plastics. This material becomes more abundant and larger to the base of the unit when present. Bivalve shells are also present within this unit, being life coloured whole but disarticulated valves. This unit is found in most overwater boreholes and is associated with the River Great Ouse, being the uppermost unit in the vibrocore boreholes. This unit is generally massive, with no notable

sedimentary structures. The lower boundary is generally sharp to abrupt with underlying units.

Made ground

6.2.17 Made Ground is common within boreholes on the banks of the River Great Ouse, and is associated with the river embankment and the Eau Brink Cut in this context. It is identified by being an orange sandy clay with frequent anthropogenic coarse components, most frequent plastic, CBM and concrete.

7 DISCUSSION

7.1 Introduction

7.1.1 A programme of geoarchaeological monitoring and deposit modelling, integrating the results of the geoarchaeological recording of selected boreholes with a review of GI logs and BGS archive boreholes, was undertaken in advance of proposed refurbishment of the A47 Great Ouse Bridge, King's Lynn, Norfolk. During the programme of GI works, a total of six dynamic sample boreholes (ATK-BH05, BH06, BH11, BH11a, BH12 and BH22) and seven overwater vibrocore boreholes (VC07, VC08, VC09, VC10, VC10a, VC19 and VC20) were recorded by a geoarchaeologist at a logging facility.

7.1.2 The geoarchaeological monitoring was undertaken in order to provide information about the archaeological and geoarchaeological resource that might be impacted by the proposed development, and to inform the scope and requirement for any further archaeological and geoarchaeological investigations that may be required to mitigate any impacts on those deposits.

7.2 Sedimentary sequence and depositional environment

7.2.1 The sequence of superficial geological deposits at the Site comprises a basal fluvial sand and gravel, overlain by a sequence of freshwater and estuarine alluvium forming under the influence of relative sea level rise during the Holocene to a level of c. 5 m OD. The contemporary River Great Ouse cuts through this alluvial sequence to a river bed level of c. -3 m OD, where modern river bed sediments are recorded overlying a similar sequence of Holocene estuarine alluvium and fluvial sands and gravels.

7.2.2 A discontinuous, basal unit of fluvial sands and gravels was recorded in various boreholes at a depth of c. 8.10 to 13.60 m bgl, with an average thickness of 0.50-0.80 m. This unit was described as a dark greyish brown medium to coarse sand and silty sand with common fine to medium subangular to subrounded gravels of mixed lithology. This unit generally overlies bedrock, although in four sequences (BH01, BH04, BH12 and VC09) a finer-grained unit was recorded underneath the sands and gravels, potentially representing Pleistocene alluvium.

7.2.3 Although their age is currently uncertain, these basal sands and gravels are provisionally interpreted as cold stage fluvial deposits formed within a high energy channel associated with the valley of the Great Ouse. On the basis that the Ouse may have taken a more northerly route towards the Nene prior to reconfiguration during the Late Pleistocene (Boreham 2002), these fluvial deposits are considered likely to be Late Pleistocene (perhaps Devensian, MIS 5d-2; 110-11.7 Kya) in date, although Boreham et al (2010) note the difficulty in differentiating terraces in the lower reaches of the Great Ouse. The Late Devensian (MIS 2) fluvial deposits of the lower valley of the Great Ouse are known as the St. Ives Member, from which radiocarbon dates in the range 18,000–10,000 years BP have been obtained (Boreham et al 2010).

7.2.4 Fluvial sands and gravels of Pleistocene date have broad potential for Palaeolithic archaeology, faunal material and fossiliferous horizons containing palaeoenvironmental and artefactual remains. In general, the potential for such remains is highest in fine-grained or organic-rich units within or below these gravels, or at their surface.

7.2.5 Fine-grained units, potentially representing Pleistocene alluvium or clay/sand rich units of the gravel, are recorded at the base of the sequence in boreholes BH01, BH04, BH12 and VC09. The significance and potential of these units is dependant on their age, but if they are Pleistocene in date, these would be of high scientific dating and palaeoenvironmental potential. In addition, the surface of the fluvial sands and gravels has the potential to contain Late Upper Palaeolithic/Prehistoric archaeological remains. However, these deposits are deeply buried (present at depths generally greater than 10 m bgl in terrestrial locations and greater than 3.0 m bgl within the river) and are not possible to evaluate using conventional archaeological trial trenching or test pitting.

7.2.6 The fluvial sands and gravels are overlain by a sequence of estuarine alluvial deposits of the River Great Ouse, present at elevations between c. -7.0 and 5 m OD likely forming in a range of different environments including tidal mud flats, salt marshes and semi-terrestrial reed swamps under the influence of rising sea levels during the Holocene. More organic units are recorded within the sequence of estuarine alluvium, though the organic component of these is entirely detrital and is considered to be of limited archaeological and palaeoenvironmental potential due to the uncertain source area of this material. Similarly, the geoarchaeological potential of minerogenic alluvium is considered to be low, except where it is directly associated with peat units.

7.2.7 Peat was recorded within the Estuarine Alluvium at elevations between c. 0.0 and -2.0 m OD (c. 5.0 to 11.0 m bgl) with a varying thickness of between 0.2 and 1.0 m. The peat, recorded widely across the Site, is considered to represent a broadly contemporaneous transition to semi-terrestrial conditions on the estuarine floodplain, supporting the growth of wetland vegetation such as that found growing in reed swamp, sedge fen or fen carr, likely as a response to a reduction in rates of relative sea level rise. The peat deposits at the Site are of high archaeological and palaeoenvironmental potential, on the basis of their potential to preserve Prehistoric waterlogged archaeological remains and palaeoenvironmental records.

7.2.8 The age of the peat deposits at the present Site is currently uncertain. However, peat deposits of Holocene age, referred to as Nordelph Peat but in places including up to three distinct peat units, have been widely recorded across the low-lying Fens (Wheeler & Waller 1995). Waller (1994) describes evidence for widespread peat formation in the late Neolithic/early Bronze, generally following a consistent sequence of saltmarsh through to fen carr dominated by willow. In parts of the eastern Fens (e.g. at Wiggenhall and Saddle Bow) peat formation appears to have continued in to the Iron Age and Roman periods, although a renewed phase of estuarine inundation, depositing estuarine silts and clays, appears to have occurred from the Late Bronze Age onwards (Waller 1994).

8 CONCLUSION AND RECOMMENDATIONS

8.1 Conclusion

8.1.1 A programme of geoarchaeological monitoring of GI works and subsequent deposit modelling has helped to refine understanding of the nature and distribution of superficial geological deposits across the area of the proposed works. The geoarchaeological deposit model integrates the results of the geoarchaeological recording, GI works and nearby BGS archive boreholes and has enabled a reconstruction of the distribution, thickness and

topography of these deposits, and provided information on the evolution of the prehistoric landscape in this area.

8.1.2 Deposits of high geoarchaeological potential are present within the sequence of Quaternary superficial deposits at the Site. These include fluvial sands and gravels and underlying alluvium of uncertain, but potentially Pleistocene date, and peat deposits, potentially of Neolithic/early Bronze date, within the sequence of Holocene alluvium.

8.1.3 The fluvial sands and gravels and underlying finer-grained deposits have broad potential for Palaeolithic archaeology, faunal material and fossiliferous horizons containing palaeoenvironmental and artefactual remains. However, these deposits are deeply buried (present at depths generally greater than 10 m bgl in terrestrial locations and greater than 3.0 m bgl in the river) and are not possible to evaluate using conventional archaeological trial trenching or test pitting.

8.1.4 The peat deposits are of high archaeological and palaeoenvironmental potential, and are present at depths between c. 5.0 and 11.0 m bgl. Again, these are not possible to evaluate using conventional archaeological trial trenching or test pitting, but any impact on these deposits can be mitigated through a programme of palaeoenvironmental assessment to determine their age and potential for reconstructing past environments and ecofactual evidence for human activity and landscape impact.

8.2 Recommendations

8.2.1 Depending on the nature of the design proposals and likely depth of impact on these deposits, a purposive geoarchaeological borehole survey may be appropriate in order to retain samples suitable for a programme of targeted palaeoenvironmental assessment and scientific dating focussed on the peat. The peat is generally thickest in the area of boreholes BH30 and BH32, where it is present at depths between c. 9.0 and 10.0 m bgl.

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APPENDIX

Appendix 1 Sediment description logs – dynamic sample boreholes

Site Code: 267370	Site Name: A47 Great Ouse Bridge	Borehole ID: ATK-BH05
Coordinates (NGR) X: 561069.98	Coordinates (NGR) Y: 318475.22	Level (top): 5.15 m OD
Length:	Width:	Depth: 35.23 m

Context Number	Description	Interpretation	Depth m bgl	Depth m OD	Samples
5001	Orange brown occasionally gravelly sandy clay with fragments of plastic	Made ground	0.00-1.40	5.15	
5002	Soft grey silty clay, occasional organic patches (phragmites?)	Organic Estuarine Alluvium	1.40-7.00	3.75	
5003	Soft dark grey sandy clay	Sands and Gravels	7.00-8.00	-1.85	
5004	Firm dark grey sand with occasional SA/SR gravels, common shell fragments	Sands and Gravels	8.00-8.25	-2.85	
5005	Soft to firm dark grey silty clay with common shell fragments	Estuarine Alluvium	8.25-10.56	-3.10	
5006	Dark grey brown sand with occasional SA/SR gravels and shell fragments	Sands and Gravels	10.56-11.30	-5.41	
5007	Firm to stiff dark grey silty clay	Bedrock	11.30-13.54	-6.15	
5008	Dark grey mudstone	Bedrock	13.54	-8.39	

Site Code: 267370	Site Name: A47 Great Ouse Bridge	Borehole ID: ATK-BH06
Coordinates (NGR) X: 561091.17	Coordinates (NGR) Y: 318494.41	Level (top): 5.08 m OD
Length:	Width:	Depth: 13.90 m

Context Number	Description	Interpretation	Depth m bgl	Depth m OD	Samples
6001	Grey brown gravelly clay with fragments of brick and concrete	Made ground	0.00-0.90	5.08	
6002	Soft dark grey silty clay	Estuarine Alluvium	0.90-2.00	4.18	
6003	soft grey brown clay, occasional small organic patches	Organic Estuarine Alluvium	2.00-5.00	2.18	
6004	Dark grey brown fibrous silty clay	Peat	5.00-5.20	-0.82	
6005	Soft to firm grey brown silty clay	Estuarine alluvium	5.20-7.30	-1.02	
6006	Firm grey sandy gravel SA/SR occasional shell fragments	Sands and Gravels	7.30-9.00	-3.12	

6007	Grey silty clay, slightly gravelly (SA) with occasional organic patches	Organic Estuarine Alluvium	9.00-10.00	-4.82	
6008	Firm light brown gravelly sand, gravel is SA/SR	Sands and Gravels	10.00-11.56	-6.32	
6009	Stiff finely grey laminated and occasionally fossiliferous silty clay	Bedrock	11.56-13.90	-7.38	
6010	Dark grey laminated mudstone	Bedrock	13.90+	-9.72	

Site Code: 267370	**Site Name: A47 Great Ouse Bridge**	**Borehole ID: ATK-BH11A**
Coordinates (NGR) X: 561188.82	**Coordinates (NGR) Y: 318361.68**	**Level (top): 4.07 m OD**
Length:	**Width:**	**Depth: 13.35 m**

Context Number	Description	Interpretation	Depth m bgl	Depth m OD	Samples
1101	Gravelly clay with fragments of brick	Made ground	0.00-0.40	4.07-3.67	
1102	Firm grey brown silty clay with occasional organic patches	Organic Estuarine Alluvium	0.40-4.00	3.67-0.07	
1103	Firm dark brown fibrous silty clay	Peat	4.00-4.60	0.07--0.53	
1104	Soft dark grey silty clay with occasional small organic patches	Organic Estuarine Alluvium	4.60-13.35	-0.53--9.28	
1105	Stiff grey finely laminated mudstone	Bedrock	13.35+	-9.28+	

Site Code: 267370	**Site Name: A47 Great Ouse Bridge**	**Borehole ID: ATK-BH11**
Coordinates (NGR) X: 561200.03	**Coordinates (NGR) Y: 318374.50**	**Level (top): 4.46 m OD**
Length:	**Width:**	**Depth: 12.70 m**

Context Number	Description	Interpretation	Depth m bgl	Depth m OD	Samples
1101	Gravelly clay with fragments of flint, brick and concrete	Made ground	0.00-0.65	4.46-3.81	
1102	Soft grey silty clay with occasional small organic patches	Estuarine alluvium	0.65-5.20	3.81--0.74	
1103	Dark brown fibrous organic clay	Peat	5.20-5.55	-0.74--1.09	
1104	Soft dark grey silty clay with common organic patches and occasional thin sandy laminations	Estuarine alluvium	5.55-6.35	-1.09--1.89	
1105	Firm grey occasionally mottled sandy gravel becoming gravelly clay with depth	Alluvium	6.35-7.85	-1.89--3.39	
1106	Soft dark grey slightly sandy silty clay with occasional organic patches, becoming finely laminated with depth	Estuarine alluvium	7.85-12.70	-3.39--8.24	

1107	Stiff grey laminated mudstone	Bedrock	12.70+	-8.24+	

Site Code: 267370	**Site Name:** A47 Great Ouse Bridge	**Borehole ID:** BH12
Coordinates (NGR) X: 561214	**Coordinates (NGR) Y:** 318404	**Level (top):** 4.93
Length:	**Width:**	**Depth:** 8.00

Context Number	Description	Interpretation	Depth m bgl	Depth m OD	Samples
1201	Topsoil over brown silty clay with a blocky prismatic structure becoming grey brown with depth	Topsoil	0.00 - 1.20	4.93-3.73	
1202	Firm dark grey silty clay, finely laminated with depth, abundant fine black flecking. Unit becomes grey brown with depth Gradual lower boundary	Organic Estuarine Alluvium	1.20 - 4.50	3.73-0.43	
1203	Soft /firm dark grey brown fine textured (silty clay) herbaceous peat.	Peat	4.50-5.38	0.43--0.45	
1204	Dark grey silty clay, finely laminated frequent small organic patches	Organic Estuarine Alluvium	5.38 - 7.74	-0.45--2.81	
1205	firm grey brown gravelly silty clay	Sands and Gravels	7.74 - 8.00	-2.81--3.07	
1206	Dark grey, compact slightly friable silty clay, laminar structure	Bedrock	8.00+	-3.07+	

Site Code: 267370	**Site Name:** A47 Great Ouse Bridge	**Borehole ID:** BH22
Coordinates (NGR) X: 561060	**Coordinates (NGR) Y:** 318459	**Level (top):** 4.89
Length:	**Width:**	**Depth:** 9.20 m

Context Number	Description	Interpretation	Depth m bgl	Depth m OD	Samples
2201	Topsoil over brown silty clay with a blocky prismatic structure becoming grey brown with depth	Topsoil	0.00 - 1.20	4.89-3.69	
2202	abundant fine black flecking. Unit becomes grey brown with depth Gradual lower boundary	Estuarine alluvium	1.20 - 4.00	3.69-0.89	
2203	Dark grey silty clay, finely laminated frequent small organic patches, becoming frequently more organic with depth. may have included peat layers but heavily disturbed from the geotechnical recording.	Estuarine alluvium	4.00 - 9.20	0.89--4.31	
2204	Dark grey, compact slightly friable silty clay, laminar structure	Mudstone bedrock	9.2m+	-4.31+	

Appendix 2 Sediment description logs – vibrocore boreholes

Site Code: 267370	Site Name: A47 Great Ouse Bridge	Borehole ID: VC7
Coordinates (NGR) X: 561111.2498	Coordinates (NGR) Y: 318447.2459	Level (top): -0.59mOD
Length:	Width:	Depth: 5.2 m

Context Number	Description	Interpretation	Depth m bgl	Depth m OD	Samples
701	Modern	Modern River Alluvium	0.00-0.05	-0.59--0.64	
702	Mid dark neutral grey fine to medium SAND with abundant localised plant flot material. Slight "saline" smell, with lighter and darker patches down sequence. Sand matrix is moderately well sorted, plant matter is not, generally gravel sized and in life shape. Branch parts, life coloured, not dyed, easily pulled apart and wet throughout. Matrix has dark streak and is soft and friable. Soggy. Rare small gravel sized angular clasts of ?mudstone. Light brown at very top of sequence for approx 5cm. No recovery after 1.6.	Estuarine Alluvium	0.00-1.60	-0.64--2.19	1m.

Site Code: 267370	Site Name: A47 Great Ouse Bridge	Borehole ID: VC8
Coordinates (NGR) X: 561138.0041	Coordinates (NGR) Y: 318467.5044	Level (top): -0.89mOD
Length:	Width:	Depth: 5.68m

Context Number	Description	Interpretation	Depth m bgl	Depth m OD	Samples
801	Mid light greyish brown SAND, fine to medium, well sorted. Soft and friable, some resistance to being stabbed with trowel. No coarse components noted - massive.	Modern River Alluvium	0.00-1.00	-0.89--1.89	

802	Dark neutral grey SAND, fine to medium, moderately well sorted matrix. Soft and friable, quite wet. Seaside smell. Localised woody flot material, life shaped and coloured - not dyed by matrix. Poorly sorted wood, gravel to large gravel sized, wood wet throughout. Soggy, black streak. Some sub-angular vitreous chert clasts, gravel to coarse gravel sized appearing at base. Sharp boundary with 801. Lightens and darkens in sequence from near black to a mid dark brownish grey - transgressional?	Estuarine Alluvium	1.00-1.80	-1.89 -2.69	
803	Dark greyish black GRAVEL of subangular subrounded chert in a dark grey SAND matrix, 70:30. Chert has black outside, lighter innards, very vitreous outsides (almost looks like true glass) - smashed nodules? Some shards have curved edges on one side. Moderately poorly sorted. Matrix is as 802. Sharp boundary with 802. Apparently not far away from a chalk formation: ?local rock clasts.	Sands and Gravels	1.80-2.00	-2.69--2.89	
804	Mid dark brownish grey SAND, fine to medium, moderately well sorted. No lith coarse components, but some small gravel sized bivalve shells at base of unit (sampled one). Boundary not seen with 803. Very similar to 802 - identical except for shells.	Sands and Gravels	2.00-2.75	-2.89--3.64	2.75m
805	Mid dark blueish grey CLAY with no seen coarse components. Firm end of soft, plastic and easily moulded. Not sticky or claggy, moulding clay consistency. Tears rather than stretches. No notable smell. Firms with depth, firm to stiff by boundary with 806. Abrupt upper boundary with 804.	Estuarine Alluvium	2.75-3.65	-3.64--4.54	
806	BEDROCK - weak fissile laminated mudstones. Fossilferrous - marine shell, fragmentary. Some shells have mother of pearl lustre - apatite?	Bedrock	3.65-4.10	-4.54--4.99	

Site Code: 267370	Site Name: A47 Great Ouse Bridge	Borehole ID: VC9
Coordinates (NGR) X: 561155.2988	Coordinates (NGR) Y: 318404.0023	Level (top): -2.82mOD
Length:	Width:	Depth: 6m

Context Number	Description	Interpretation	Depth m bgl	Depth m OD	Samples
901	Mid light greyish brown SAND, fine to medium, well sorted. Soft and friable, some resistance to being stabbed with trowel. No coarse components noted - massive. Plastic in it - white bag wrap. Undulate diffuse boundary with 902 - upwelling of black up to 40cm, marbled.	Modern River Alluvium	0.00-0.65	-2.82--3.47	
902	Dark neutral grey SAND, fine to medium, moderately well sorted matrix. Soft and friable, quite wet. Seaside smell. Localised woody flot material, life shaped and coloured - not dyed by matrix. Poorly sorted wood, gravel to large grabel sized, wood wet throughout. Some leaves also. Soggy, black streak. Disarticulated but whole bivalve shells in sequence. Life coloured. Rare lith coarse components - mudstone, tabular angular gravel sized. Abrupt boundary with 903.	Sands and Gravels	0.65-2.00	-3.47--4.82	1.2, 1.3m
903	Mid dark blueish grey CLAY with no seen coarse components. Firm end of soft, plastic and easily moulded. Not sticky or claggy, moulding clay consistency. Tears rather than stretches. No notable smell until 2m, then slightly organic smelling. Abrupt upper boundary with 902. Getting increasingly organic with depth with peaty material after 2m. Organic material orientated parallel and perpendicular to ground level.	Estuarine Alluvium	2.00-2.80	-4.82--5.62	2.2, 2.3, 2.4, 2.5,

904	Mid dark greyish brown CLAY with extremely abundant plant matter, generally seaweed-y looking leaves orientated parallel to ground level. Weak organic smell. Plant matter drained greyish yellowy green, very thin. Some plant matter more fragmentary than others. No lith coarse components. Mouldable, but tends to crack with pressure. Soft end of firm, ripple texture on inside when snapped. Gradual boundary with 903. No lower boundary seen, but must be fairly sharp due to vanishing between runs.	Peat	2.80-3.00	-5.62--5.82	
905	Mid dark brownish grey SAND, coarse, with common subangular subrounded GRAVEL of gravel size, generally vitreous chert with black outsides. No orientation or sorting seen. Sharp boundary with 906.	Sands and Gravels	3.00-3.30	-5.82--6.12	
906	Mid dark blueish grey CLAY with no seen coarse components. Firm end of soft, plastic and easily moulded. Not sticky or claggy, moulding clay consistency. Tears rather than stretches. No notable smell until 2m, then slightly organic smelling. Firms with depth, firm to stiff by boundary with 907.	Estuarine Alluvium	3.30-3.95	-6.12--6.77	
907	BEDROCK, weak fissile fossiliferous mudstone. No recovery after 4.04.	Bedrock	3.95-4.04	-6.77--6.86	

Site Code: **267370**	**Site Name:** **A47 Great Ouse Bridge**	**Borehole ID:** **VC10a**
Coordinates (NGR) X: **561176.217**	**Coordinates (NGR) Y:** **318432.4444**	**Level (top):** **-0.13mOD**
Length:	**Width:**	**Depth:** **5.4 m**

Context Number	**Description**	**Interpretation**	**Depth m bgl**	**Depth m OD**	**Samples**
10101	Mid light greyish brown SAND, fine to medium, well sorted. Soft and friable, some resistance to being stabbed with trowel. No coarse components noted - massive. Sharp boundary with 10102.	Modern River Alluvium	0.00-0.55	-0.13--0.68	

10102	Dark neutral grey black SAND, fine to medium with a strong sulphurous smell. Contains disarticulated bivalve shell, CBM (brick) and mortar/firebrick. Coarse components are not orientated but are localised at top of unit. Very wet. Woody flot material appearing at 1m, very common, no apparent orientation. Becoming sandy clay texture, black. Might be different unit.	Made Ground	0.55-1.25	-0.68--1.38	1.1, 1.15, 1.2
10103	Dark greyish black GRAVEL of subangular subrounded chert in a dark grey SAND matrix, 70:30. Chert has black outside, very vitreous outsides (almost looks like true glass) - smashed nodules? Some shards have curved edges on one side. Moderately poorly sorted. Chert is easy to remove from matrix but hollow closes up after due to wetness of matrix. Can't smell it due to 10102 stripping my nose out. Gradual boundary with 10104 - gravel sinking into lower unit ?flame structures.	Sands and Gravels	1.25-1.60	-1.38--1.73	
10104	Mid dark blueish grey CLAY with no seen coarse components. Firm end of soft, plastic and easily moulded. Not sticky or claggy, moulding clay consistency. Tears rather than stretches. No notable smell, but might have been overpowered by 10102 smell. Organic material starts appearing at 2.1, perpendicular to ground level, ?rooting. Firms with depth. Gradual boundary with 10105	Estuarine Alluvium	1.60-2.75	-1.73--2.88	
10105	Mid dark greyish brown silty CLAY with highly abundant plant matter and an organic smell. Moderately firm. Plant matter is matting matrix slightly, and generally appears to be parallel to ground level. Plant matter is orangey brown and rooted. Not plastic, snaps not bends. Snaps apart, doesn't stretch. Sharp boundary with 10106.	Peat	2.75-2.90	-2.88--3.03	

10106	Dark neutral grey SAND with abundant chert gravel of small gravel size. Quite firm and difficult to stab, but friable. Gravel is subrounded and subangular to subrounded. Brown sand marbling in localized zones. No Recovery after 3.1.	Sands and Gravels	2.90-3.10	-3.03--3.23	

Site Code: 267370	**Site Name: A47 Great Ouse Bridge**	**Borehole ID: VC10**
Coordinates (NGR) X: 561181.9734	**Coordinates (NGR) Y: 318428.8108**	**Level (top): -0.52mOD**
Length:	**Width:**	**Depth: 5.30m**

Context Number	Description	Interpretation	Depth m bgl	Depth m OD	Samples
1001	Mid light greyish brown SAND, fine to medium, well sorted. Soft and friable, some resistance to being stabbed with trowel. No coarse components noted - massive. Rare wood. Abrupt boundary with 1002.	Modern River Alluvium	0.00-0.28	-0.52--0.80	
1002	Dark grey GRAVEL with fine to medium SAND matrix, 70:30. Gravel generally subangular subrounded chert, with one clast of yellow slag near top of sequence. Apparent normal grading, more gravelly at depth. Clasts easily removed from matrix, friable. Seaside smell. Abrupt boundary with 1003.	Sands and Gravels	0.28-0.65	-0.80--1.17	0.4m
1003	Mid dark blueish grey CLAY with no seen coarse components. Firm end of soft, plastic and easily moulded. Not sticky or claggy, moulding clay consistency. Tears rather than stretches. Organic material starting to appear at 1.9m perpendicular to ground level.	Estuarine Alluvium	0.65-2.15	-1.17--2.67	1.9, 2, 2.1
1004	Mid dark greyish brown CLAY with abundant plant matter and a slight organic odour. Material is both parallel and perpendicular to ground level. Soft end of firm, somewhat plastic.	Peat	2.15-2.25	-2.67--2.77	2.15, 2.2

1005	Mid dark gravelly SAND with chert coarse components and abundant flotty plant matter. Coarse sand, moderate sort. Chert is subangular subspheroid. Friable, dark streak. Plant matter is greyish brown. Soft and wet.	Sands and Gravels	2.25-2.35	-2.77--2.87	2.25, 2.35
1006	Mid dark greyish brown medium to coarse SAND with uncommon small gravel coarse components. Moderate sort. Moderately soft to slightly firm, friable. No recovery after 2.93.	Sands and Gravels	2.35-2.93	-2.87--3.45	

Site Code: 267370	**Site Name: A47 Great Ouse Bridge**	**Borehole ID: VC19**
Coordinates (NGR) X: 561102.9252	**Coordinates (NGR) Y: 318434.3206**	**Level (top): -2.78mOD**
Length:	**Width:**	**Depth: 5.39m**

Context Number	**Description**	**Interpretation**	**Depth m bgl**	**Depth m OD**	**Samples**
1901	Mid greyish brown SAND, moderately firm friable fine to medium moderately well sorted with occasional small gravel sized clasts of mortar and brick, subrounded subspherical. Shells in sequence also, disarticulated but whole valves, bivalve life coloured. Diffuse boundary with 1902 texture wise, sharp colour wise.	Modern River Alluvium	0.00-0.55	-2.78--3.33	
1902	Dark grey sandy CLAY, with sandiness varying from clayish sand to clay. Sandier at top of sequence. Sand is fine to medium. Seaside smell. No lith coarse components seen. Wet and sticky, although not claggy, with a dark streak. Plasticity depends on sand content, with sandier material being less plastic. Sand appears marbled rather than layered - sinking down sequence? Probably quite turbid when deposited. Diffuse boundary with 1903	Estuarine Alluvium	0.55-1.00	-3.33--3.78	

1903	Dark grey SAND, fine to medium, well sorted, firm and waterlogged. Water can be pushed down with finger, kind of non-newtonian. Slight marbling of colour in places but marbling still grey. Seaside smell. Dark streak, decently consolidated but probably wouldn't be as well consolidated when dried. No coarse components seen, massive. Sharp to gradual (approx 6cm) boundary with 1904.	Sands and Gravels	1.00-2.35	-3.78--5.13	
1904	Mid greyish yellow brown clayish firm SAND, medium to coarse sand with common to abundant subangular to subrounded gravel of predominantly chert. Quite damp but not as wet as 1903. Gravel appears unsorted. Clay is part of lenses rather than forming a matrix for the sand. Gets more clayish with depth, clay is mid grey. No discernible smell. Gradual boundary with 1905.	Estuarine Alluvium	2.35-2.68	-5.13--5.55	
1905	Dark grey slightly silty firm CLAY. Sticky, slightly claggy, plastic and easily moulded. Tears rather than stretches. No lith coarse component seen. Faint odd smell, not quite organic. Kind of smells like raw potato? Dark streak, consistent colour. Firms to stiff by base. Very rare woody material, small gravel sized, doesn't become anything.	Estuarine Alluvium	2.68-3.20	-5.55--6.07	
1906	Weathered BEDROCK - weak fissile laminated fossiliferous mudstone bands in stiff dark grey clay (like 1905). Bands becoming more abundant by 3.6. No recovery after 4.28.	Bedrock	3.20-5.39	-6.07--8.26	

Site Code: **267370**	**Site Name:** **A47 Great Ouse Bridge**	**Borehole ID:** **VC20**
Coordinates (NGR) X: **561151.2025**	**Coordinates (NGR) Y:** **318393.8088**	**Level (top):** **-0.52mOD**
Length:	**Width:**	**Depth:** **4.57 m**

Context Number	**Description**	**Interpretation**	**Depth m bgl**	**Depth m OD**	**Samples**

2001	Mid greyish brown SAND, fine to medium, well sorted. Firm to the touch but explodes with excessive pressure - well compacted not well consolidated. No notable clasts seen until 1m, no notable smell, massive. Damp but not wet. Becomes very gravelly with subangular subangular chert gravel from Small gravel to coarse gravel sized, increasing in size down sequence (normal grading). Some fragmentary shell in gravel sequence. Very dark grey at base and at base only. Sharp boundary with 2002.	Modern River Alluvium	0.00-1.15	-0.52--1.67	
2002	Mid dark brownish grey CLAY, moderately firm, plastic and sticky, slighly claggy, tears rather than stretches. Very abundant organic material orientated perpendicular to ground level, dark brown. Slight organic smell overpowered by seaside smell. Material is woody, with wood stripes orientated to strike of organic material down sequence. Black streaking becomes apparent at 2m - organic smell becomes stronger. Peaty parts becoming thicker at 2.7m, still orientated down sequence. Sharp boundary with 2003.	Organic Estuarine Alluvium	1.15-3.20	-1.67--3.72	1.3, 1.4, 1.5, 1.5,
2003	Mid dark greyish brown clayish SILT with highly organic matter. Flotty leafy and rooty, quite decomposed. Organic smell. Firm, difficult to get the sample out. Friable, not plastic, crumbles. One clast of angular chert, gravel sized. Taken the 3.25-3.35 portion of the core. Abrupt boundary with 2004.	Peat	3.20-3.35	-3.72--3.87	3.25-3.35m

2004	Mid dark marbled grey clayish SAND. Medium to coarse sand, moderately well sorted. Marbling is greyish brown. No lith clasts noted. Probably worth comparing this and below units to nearby holes to better determine what is going on. Sharp boundary with 2005.	Sands and Gravels	3 35-3.70	-3.87--4.22	
2005	Mid dark grey CLAY, firm to stiff, firmer to base. No clasts seen. Somewhat sticky, plastic and mouldable, snaps rather than stretches. No mudstone banding noted.	Estuarine Alluvium	3.70-4.50	-4.22--5.02	
2006	BEDROCK - fissile fossiliferous mudstone.	Bedrock	4.50-4.57	-5.02--5.09	

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KIMMERIDGE CLAY FORMATION - MUDSTONE

ROXHAM MEMBER AND RUNCTON MEMBER (UNDIFFERENTIATED) - SAND

MINTLYN MEMBER - SAND

LEZIATE MEMBER - SAND

Clenchwarton

West Lynn

South Wootton

Kings Lynn Station

Gaywood

KING'S LYNN

West Winch

North Runcton

Saddle Bow

Wildfields Road

Hall Road

Mill Lane

Ferry Road

Main Road

Black Horse Road

Millennium Way

St Peters Road

Clenchwarton Road

King Street

St James Street

London Road

Vancouver Avenue

Hardwick Road

Gaywood Road

Loke Road

Columbia Way

Wootton Road

Wisbech Road

Saddlebow Road

Mission Drift

Ouse Walk Way

Hansa Road

Oldmeadow Road

Greenyard Way

Scania Way

Queen Elizabeth Way

Constitution Hill

Pullover Road

High Road

Low Road

Main Road

Rectory Lane

Back Lane

A17

A47

A148

A149

B1144

078

560000

562000

564000

320000

318000

316000

Site

NORFOLK

Site boundary

0

1 km

Coordinate system: OSGB 1936 British National Grid

Date: 21/04/2023 | Created by: AW

Scale: 1:20,000 at A3 | Revision: 0

Figure 1: Site location and BGS bedrock geology

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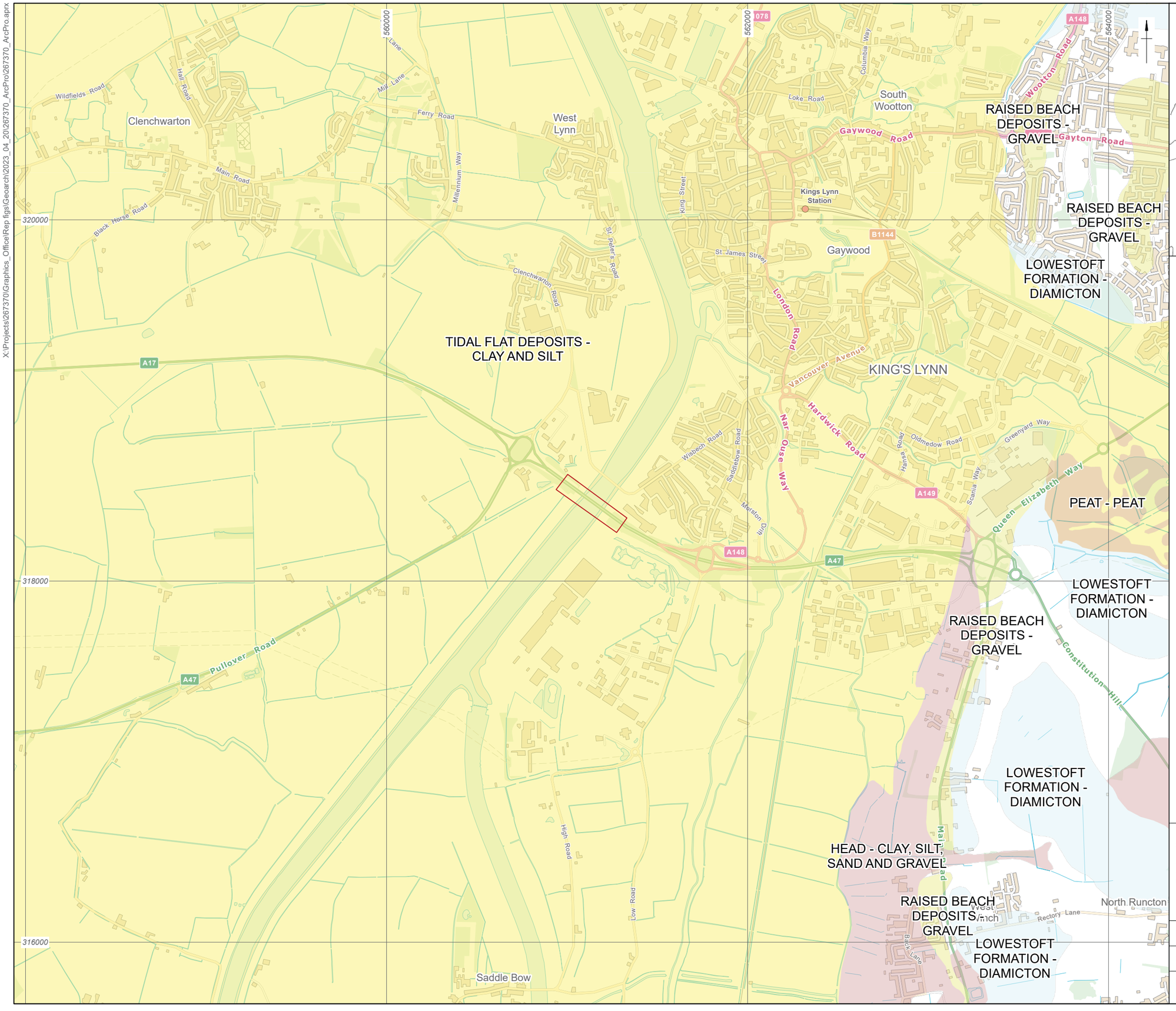

Coordinate system: OSGB 1936 British National Grid

Date: 21/04/2023	Created by: AW	
Scale: 1:20,000 at A3	Revision: 0	

Figure 2: Site location and BGS superficial geology

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318600
318500
318400
318300
561000
561100
561200
561300

BH26
BH02
BH29
BH25
TF61NW61
BH30
BH04
BH06
TF61NW62A
TF61NW62B
BH01
BH03
BH05
BH17
BH21
BH22
VC08
VC07
VC19
VC10a
VC10
TF61NW70
BH12
VC09
TF61NW68
VC20
BH14
BH14a
BH16
BH11
BH13
BH23
BH11a
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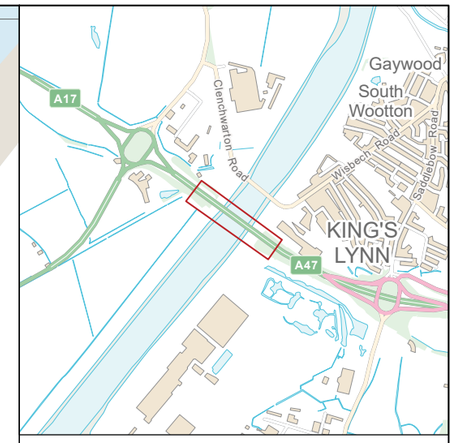
BH35
BH28
BH34
BH33



Site boundary
Boreholes
Transect

0 50 m

Coordinate system: OSGB 1936 British National Grid

Date: 21/04/2023	Created by: AW	
Scale: 1:1,250 at A3	Revision: 0	

Figure 3: Borehole and transect locations

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Stratigraphy Index

- Topsoil
- Made Ground
- Modern River Alluvium
- Estuarine Alluvium
- Organic Estuarine Alluvium
- Peat
- Sands and gravels
- Bedrock
- No Recovery

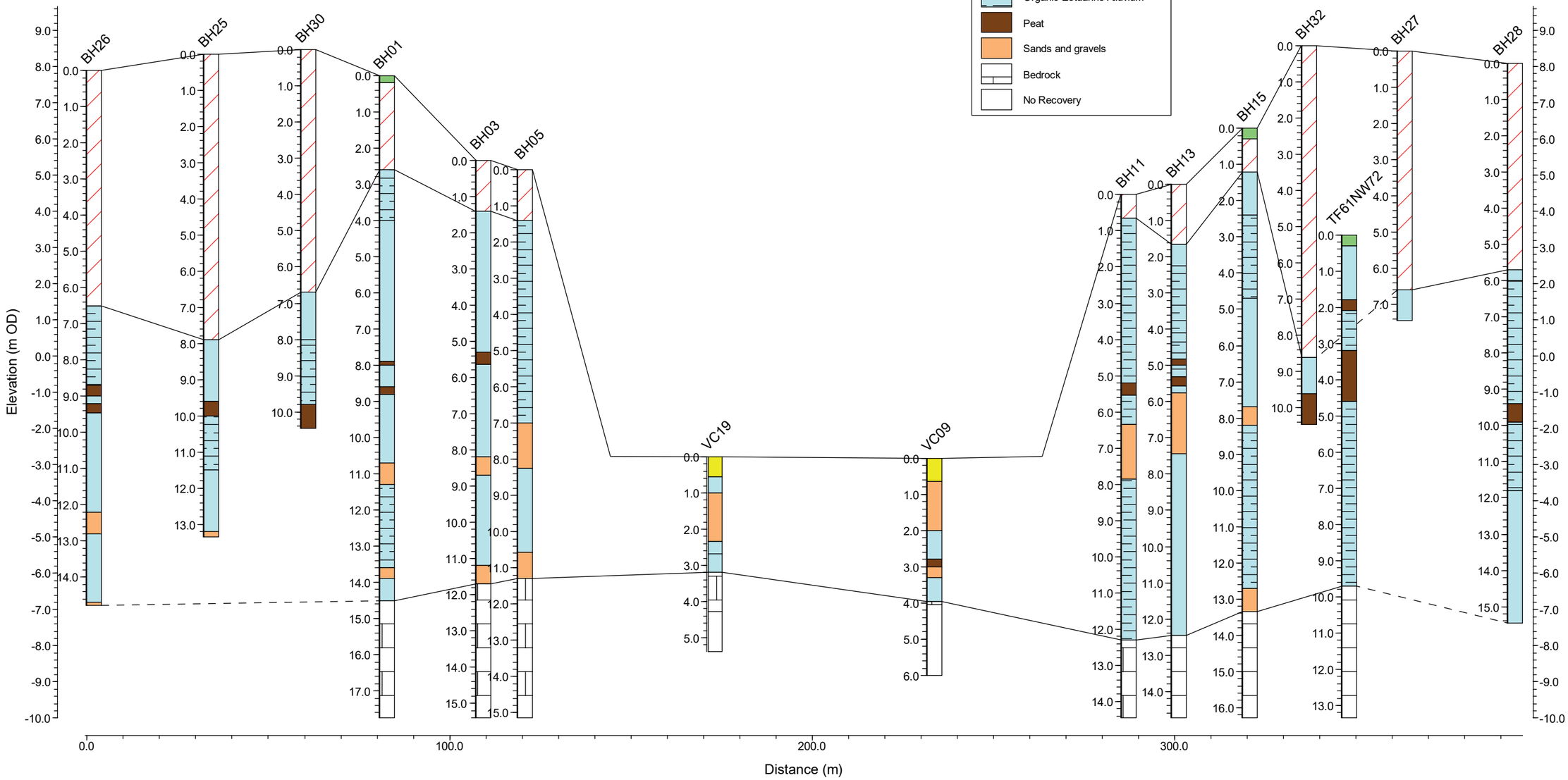

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Figure 4: Transect

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