Norwich Western Link

Environmental Statement

Chapter 8: Cultural Heritage

Appendix 8.5: Geoarchaeological Deposit Model

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Executive summary

WSP has been commissioned by the Applicant to provide a geoarchaeological deposit model across the Wensum Valley, in support of the environmental impact assessment (EIA) for the proposed Norwich Western Link in Norfolk. Deposit models are conjectural maps that use existing information to illustrate the distribution of buried deposits across a site or landscape. Models are particularly effective in river valleys in identifying areas of both palaeoenvironmental and archaeological potential where past landforms and channels can be masked by sediment, such as alluvium.

The model provides a non-intrusive way of evaluating the possible impact of proposed piling on the geoarchaeological resource and feeds into project design and delivery to minimise unexpected discoveries. The model uses geotechnical ground investigation and British Geological Survey data to characterise the nature, distribution and depth of superficial geological deposits across the Wensum, identify zones of potential and guide further work.

This report is a risk management tool that can be used to inform planning discussions and to support existing archaeological reports submitted as part of a planning application.

The deposit model comprised cross sections, deposit surface plans and thickness plots to map and interpret the sub-surface stratigraphy across the valley. The investigation identified five landscape positions (different depositional environments) within the modelled area. These are the:

- Valley edge;
- Dry valley;
- Floodplain zone;
- Channel bar; and
- Floodplain channels.

The site has been divided into three ‘Landscape Zones’ (LZs) of varying archaeological and palaeoenvironmental potential derived from examining the location, extent and thickness of sediments and the landscape positions identified in the model.

LZ1 is of low geoarchaeological potential and contains the Pleistocene Till, River Terrace Deposits and Head of the surrounding river catchment surface and valley sides. Any palaeoenvironmental remains would be of medium heritage significance and Palaeolithic remains, if in situ, of high significance due to their scarcity.

LZ2 covers the Holocene channel bars and floodplain belt between deeper channels. There is low to moderate potential for both palaeoenvironmental and archaeological remains of low or medium heritage significance depending on whether remains are in situ or reworked by the river (residual).

LZ3 represents the organic sediment-filled Holocene floodplain channels and has high potential for well-preserved prehistoric or historic (currently of uncertain date) palaeoenvironmental remains of medium heritage significance. At the edges of the floodplain channels, there is low potential for archaeology such as fish traps, revetments or evidence of floodplain management most likely dating from the medieval period onwards. Potential and significance may be attenuated where channel flow or recent modification such as channel cutting, straightening, and management has disturbed floodplain deposits. Archaeological remains would be of medium heritage significance if in original position, otherwise significance would be low.

Palaeoenvironmental and archaeological remains would be entirely removed from within the footprint of each road viaduct pile as the pile is driven downwards. The severity of the impact would therefore depend on the pile size, type and pile density. The pile size and spacing is not currently known but it is assumed that the piles would be large diameter and spaced apart. Augered /continuous flight auger (CFA) piles would minimise the impact whereas vibro-compacted piles are likely to cause additional impact through vibration and deformation of vulnerable surrounding deposits.

It is recommended that a transect of six purposive geoarchaeological boreholes is considered across LZ3 to enhance the model and understanding of the nature and potential of the subsurface deposits. These would be placed to capture continuous sediment samples that represent the floodplain channel sequence. Samples would be assessed off-site for presence/absence of palaeoenvironmental remains and for their potential to understand environmental change, sedimentation chronology and Holocene floodplain evolution in the Wensum. Results would be set in the context of the spread of archaeology across the scheme, as well as compared to regional Holocene sequences.

As part of the archiving requirements, it is recommended that the geoarchaeological deposit model and site stratigraphy information is made accessible to the Historic Environment Record (HER) to build the palaeotopgraphy of the region and contribute to understanding prehistory.

A Written Scheme of Investigation (WSI) for purposive geoarchaeological boreholes would be required and could be added to the Proposed Scheme's WSI for Archaeological Mitigation **Appendix 8.4** (document reference 3.08.04) by addendum.

1 Introduction

1.1 Project background and scope

1.1.1 WSP has been commissioned by Norfolk County Council (NCC) to provide a geoarchaeological deposit model across the Wensum Valley, as a technical appendix to the Environmental Statement (ES) for the Historic Environment, in support of the proposed Norwich Western Link in Norfolk (National Grid Reference/NGR 612000, 314600; **Figure 1,** Section 9, this Appendix). The proposed road crosses a rural landscape of open fields and woodland to the west of Norwich, and includes a viaduct over the River Wensum, an area of palaeoenvironmental and archaeological potential.

1.1.2 The planning application has yet to be determined, but the requirement for a paleoenvironmental deposit model has been agreed in consultation with the Historic Environment Senior Officer (Strategy and Advice) for Norfolk County Council (NCC). Should consent be granted, and dependent on recommendations and consultation with the archaeological advisor, geoarchaeological field investigation may form part of the archaeological mitigation. The presence or potential presence of palaeoenvironmental evidence can constitute a constraint to future development, and producing the model is a non-intrusive method of further assessing archaeological potential and risk to design, planning and programming.

1.1.3 Deposit models use existing information to map the distribution of buried deposits across a site or landscape and produce a baseline assessment of geoarchaeological potential. A model offers a way to evaluate potential within the alluvial zone where thick superficial deposits often mask prehistoric landforms and channels that contain environmental remains. This geoarchaeological model of the Wensum Valley uses geotechnical Ground Investigation (GI) data and British Geological Survey (BGS) information to look at the nature and depth of deposits within the Red Line Boundary where more intrusive survey was not possible due to wet and unstable ground conditions.

1.1.4 Deposit models are most effective in the earlier phases of the planning process at the desk-based stage but can be used or updated throughout the project lifecycle during evaluation, mitigation or off site during post-excavation.

1.1.5 The deposit model is undertaken in line with the method described in the Written Scheme of Investigation (WSI) for Archaeological Mitigation (WSP 2023a) and approved by the County Planning Authority’s Archaeological Advisor (December 2023). The report is not intended to stand alone in support of a planning application and should be considered alongside other archaeological desk based and fieldwork reports.

1.2 Outline of proposals and impact

1.2.1 The Proposed Scheme will cross the River Wensum and its floodplain by means of a viaduct. Excavations for the viaduct piers and for the foundations of the road bridges would entirely remove any archaeological remains within the pile footprints. Pile diameter and spacing is not currently known, but for the purposes of this assessment are assumed to be large in diameter and widely spaced. The viaduct piers would cause a localised impact on any remains in the Wensum within the excavation footprint. For any archaeological remains, the proposed impacts would constitute substantial harm or total loss of significance. For Holocene palaeoenvironmental remains the impacts would result in less than substantial harm.

1.3 Aims and objectives

1.3.1 The aim of the deposit model is to map and interpret the sub-surface stratigraphy across the Wensum Valley within the Red Line Boundary. Using geotechnical ground investigation and geological information, the model will indicate the likely nature and depth of any archaeological remains and palaeoenvironmental deposits. This minimises the risk of unexpected discoveries that could impact project design and delivery, and is achieved through the following objectives:

- Objective 1: Identify the different depositional units within the site and map their location, extent and thickness;
- Objective 2: Map zones of likely geoarchaeological and palaeoenvironmental potential across the site based on the depositional units;
- Objective 3: Provide an indication of the likely nature, depth and significance of buried archaeological deposits within each zone, based on the geotechnical data; and
- Objective 4: Provide recommendations, including making any geoarchaeological deposit model and site stratigraphy information accessible to the Historic Environment Record (HER) to contribute to understanding prehistory in the region, particularly the Palaeolithic to Mesolithic (Medlycott 2011).

1.4 Report layout

1.4.1 The report establishes the geoarchaeological background and terms used (Section 2); outlines the method (Section 3); describes the model (Section 4); divides the site into Landscape Zones of varying geoarchaeological potential (Section 5); concludes and makes recommendations (Section 6).

2 Geoarchaeological background

2.1 Introduction

2.1.1 This section provides a summary of the landscape evolution and associated archaeology in the vicinity of the River Wensum (**Figure 1,** Section 9, Appendix 8.5). It forms the background and context to interpret valley deposit formation and to assess the potential of the alluvial stratigraphic sequence.

2.1.2 The Wensum is a lowland river that drains eastwards across an arable catchment from Whissonsett to Norwich. The landscape was largely formed by the Anglian glaciation (480–430ka) (Table 2.1). The Anglian was the largest onshore glaciation of the Late Pleistocene, and prevailing views consider it created the Fenland Basin and gouged out The Wash (Clayton 2000). The topography was further re-modelled by ice, river and slope process in the subsequent glacial complexes (Wolstonian and Devensian), and although the Wensum catchment has been altered by human agency, (the majority of the twelve water bodies that make up the Wensum are heavily modified) (Environment Agency catchment planning), its sinuous meandering form is still evident.

2.1.3 The Wensum River rises near Whissonsett, is joined by the River Tat at Tatterford and meanders through Sculthorpe Moor and Fakenham. The newly restored meander north of Pensthorpe Nature Reserve and the stretch from Great Ryburgh to North Elmham have undergone a number of restoration phases to improve function and habitat. The Blackwater joins the Wensum near Elmham, and the Reepham Blackwater at Lenwade, before the river curves around Ringland, through the scheme and to the outskirts of Norwich. **Figure 1** shows the centre of the current Wensum channel and catchment as mapped by the Environment Agency (catchment planning). This section of the catchment (Lenwade to Hellesdon) adopts a sinuous meandering formerly multi-threaded channel. The Wensum meets the Tud at Hellesdon Mill and flows through Norwich to meet the Yare at Whitlingham (Broadland catchment partnership) which joins the Broads near Buckenham.

2.1.4 The BGS geological mapping (2023) (**Figure 2**) is useful for geoarchaeological desk based reports as it can provide an indication of suitability for past settlement and the potential for preservation of archaeological and palaeoenvironmental remains. In the Wensum Valley, alluvium is mapped across the floodplain bounded by River Terrace Deposits (RTDs) and Head over Till (described in greater detail in Section 2.3 below). The anaerobic conditions of alluvial clays and peats can preserve both archaeological structures made of wood (such as trackways, fish traps and jetties) and palaeoenvironmental remains (due to waterlogging). Ecofacts such as pollen, plant remains and diatoms have evidential value for reconstructing local and regional environmental and landscape change, in combination with geoarchaeological assessment of the sediments. The potential of alluvial sediments can broadly be considered as follows:

- Minerogenic alluvium – silts, clays and occasionally sands have potential for preservation of snails, diatoms (microscopic algae) and ostracods (bivalve crustacea); and
- Organic alluvium - organic silt, organic clay, peat, and peaty soils can preserve pollen, seeds and plant fragments. Organics (terrestrial plant macrofossils) can also be dated by radiocarbon techniques that can support the establishment of a chronology for the depositional sequence. Peat is a good indicator of a former environment where conditions were dry enough for vegetation to form, and this can therefore also provide an indication of levels of dry-land human activity.

2.1.5 The Historic Environment Desk Based Assessment (**HEDBA Appendix 8.1**) (Document Reference 3.08.01) technical appendix to the ES, describes the site as having moderate or high potential for palaeoenvironmental remains in the Wensum Valley and the Foxburrow Stream (a tributary of the River Tud, also within the Red Line Boundary) (WSP 2023b). Ecofactual remains would be of low or medium heritage significance, derived from their archaeological and historic interest.

2.1.6 The BGS (2023) mapping in Figure 2 does not reveal alluvial thickness or composition, and the alluvium hides the topography of the valley floor. The deposit model, therefore, aims to map and interpret the buried alluvial stratigraphy and to outline the location, depth and palaeoenvironmental potential of deposits (as outlined in Section 1.3).

2.2 Timescales

2.2.1 The Quaternary is the period of Earth history in which humans evolved. It is characterised by series of alternating cold-warm oscillations (glacial-interglacial cycles) named 'Marine Isotope Stages' (MIS), derived from palaeoclimate proxies (such as foraminifera and pollen) from deep sea core samples. Even-numbered stages denote cold phases and odd numbers represent warm stages.

2.2.2 The Quaternary is subdivided into the Pleistocene (c. 2.6 million to approximately 10 thousand years ago / ka) and the Holocene (10ka to the present, MIS1) (Table 2.1). Dates which are given as BP refer to years 'before present' (before 1950). The deposits and archaeology likely to occur on the site are described in chronological order from youngest to oldest.

2.2.3 The Pleistocene (2.6–1.3ka) is largely characterised by long glacial stages when the landscape was shaped by water, wind and ice. Ice Ages were punctuated by shorter, warm interglacials (e.g. the Ipswichian) and times of temperate, but less significant climatic amelioration called interstadials (eg Aveley, Upton Warren and Windemere) (Table 2.1). Sediments and their contained faunal and floral remains enable reconstruction of Palaeolithic environments. Palaeolithic remains therefore form part of the Pleistocene sedimentary record and include artefacts such as stone tools and faunal remains including early humans (hominins). Such remains are rare, but significant for understanding the early human occupation of Britain, a field of study to which sites in Norfolk have made a substantial contribution.

2.2.4 The earliest evidence for human activity yet found in Britain, dated to the mid to latter part of the Quaternary, c. 0.78 million years ago, comes from Happisburgh on the north Norfolk coast (Ashton et al, 2014). The majority of prehistoric archaeology, however, dates to the Holocene (Mesolithic, Neolithic, Bronze Age and Iron Age) and it is this recent epoch that forms the focus of this deposit model.

2.3 Pre-quaternary geology

2.3.1 The bedrock mapped by the British Geological Survey (2023) across the entire Proposed Scheme comprises a range of Chalk Formations: Lewes Nodular Chalk, Seaford Chalk, Newhaven Chalk, Culver Chalk and Portsdown Chalk. This sedimentary bedrock formed between 93.9 and 72.1 million years ago during the Cretaceous period, before humans evolved. Chalk deposits therefore have no archaeological potential although flint, the raw material for prehistoric tools, derives from this bedrock, and chalklands provide an internationally important dataset for the Lower and Middle Palaeolithic (Blundell 2016).

2.4 Quaternary geology

Pleistocene geology

2.4.1 British Geological Survey (BGS 2023) digital data (**Figure 2**) show the majority of the route to lie on the sands and gravels of the Sheringham Cliffs Formation (SHCF). This is a glacial deposit (otherwise referred to as Till, Boulder Clay or diamicton) that crops out widely across north Norfolk between Bacton Green, Dereham and Swaffham forming a highly variable succession of glacial lake sediments (glaciolacustrine marls), sands and rhythmically bedded silts and clays (Lee et al 2015). Two distinctive diamictons are evident within the formation: a lower sandy diamicton (the Bacton Green Till Member), and an upper chalky diamicton (the Weybourne Town Till Member). The Bacton Green Till Member can be observed in coastal sections between Bacton Green and Sheringham. It was deposited during an advance of ice into north Norfolk from the North Sea to the north and north-west and comprises a consolidated brown sandy diamicton (a subglacial facies) and a stratified complex of beds of greyish brown sandy diamicton, waterlain sand and clay.

2.4.2 This part of the River Wensum is likely to cut through the Weybourne Town Till Member (referred to as 'Marly Drift'), known to be lithologically variable, reflecting extensive sediment reworking. Recent studies suggest two separate phases of deposition, difficult to differentiate due to similarities in appearance, by ice masses from the west (older) and north (younger) (Lee et al 2015). It is probable that the site lies on the western-derived facies that crops out widely across western and central Norfolk, thinning progressively eastwards. These are either Middle Pleistocene deposits, that overlie the famous and regionally extensive Lowestoft Till (Anglian Glaciation approximately 0.5 million years old, MIS12), attributed to the Wolstonian Glacial Complex (MIS10-6) spanning the Lower Palaeolithic to Middle Palaeolithic transition (see Table 2.1); or deposited by oscillating North Sea ice lobes during MIS12. Either way, the archaeological and palaeoenvironmental potential of the SHCF is limited.

2.4.3 The Wensum is bordered by fragments of River Terrace Deposits (RTD) on the valley sides. These are mapped by the BGS as the first terrace and assumed to be Devensian in date (MIS4-2) on the basis of elevation and lithology. The Devensian ice sheet reached the margins of The Wash and the north-west Norfolk coast (Lee et al 2015), and the site would have been in the periglacial zone. RTD consist mainly of coarse material, generally gravel or sand, representing the bed load of rivers deposited in active river (fluvial) channels. Soil horizons (palaeosols) and prehistoric land surfaces may also be present in fluvial sediment sequences, and Palaeolithic remains can be associated with RTD. The potential for palaeoenvironmental remains within Devensian RTD is low, although cold climate flora (mosses, dwarf birch and willow) have been found in exposures of Devensian gravels dated to just before the last glacial maximum (c 28 to 20 ka) as in the case of the Lea Valley Arctic Beds. Frozen blocks were probably eroded out, transported and redeposited within the gravel bed during Lateglacial downcutting (Corcoran et al 2011).

2.4.4 Fluvial sediments provide critical records of past and present geologic processes and terrestrial environments (Aslan 2007). RTD have been extensively studied and dated in the UK (eg Bridgland et al 2019; Boreham et al 2010) and gravel terraces are distinguished lithologically by stratigraphy and altitudinal position. The stratigraphy of RTD can be complex, reflecting the variety of depositional settings in the fluvial environment and the potential for both rapid and long-term change in its spatial arrangement.

2.4.5 Lobes of Head are mapped by the BGS joining the floodplain from the valley sides. Head is typically mapped in relict or dry valleys on chalky slopes, and on the Wensum Valley sides it infills Anglian (MIS12) and Wolstonian (MIS8-6) stage dry valleys under periglacial conditions (Ehlers et al 1991) (Table 2.1). Head is a slope deposit that consists of poorly sorted eroded bedrock and superficial geological material moved downhill by gravity and often redistributed freeze-thaw and wind. It can be deposited by mass movement (such as solifluction) or slope-wash (creep) and weathered in situ. Lateral continuity of individual beds is generally limited and difficult to trace. In previous glacial stages, the Wensum valley slopes would have been steeper due to lower baselevels (with Devensian global sea levels up to 140m lower than present-day), exacerbating slope process and runoff which would have significantly remodelled the landscape. In rare circumstances, Head can be stratified and yield sub-fossil evidence for past environments and, as with colluvium, in some situations slope sediments can mask archaeological horizons.

Holocene geology (MIS1)

2.4.6 Alluvium comprises deposits of sands, silts and clays laid down in low-energy environments in river valleys, tidal creeks, on floodplains, backwaters, abandoned channels and ponds. Organic sediment and peat may also be present, and towards the edge of the valley floor, alluvium may interdigitate with slope deposits (colluvium or Head) derived from the valley side.

2.4.7 Alluvial stratigraphy can be complex and reflects a variety of river settings that represent rapid and/or long-term Holocene sedimentation. Sequences often grade upwards from the 'Lateglacial' (Devensian) gravel of the valley floor to early Holocene (Mesolithic) sands and silt/clay flood deposits, intercalated with organic beds that represent former marsh or wetland (Neolithic/Bronze Age) and late Iron Age silt/clay overbank flooding. From the late prehistoric (Iron Age) onwards the climate became wetter and the effects of deforestation, particularly in riparian environments, increased run-off and exacerbated overbank flooding. Historic periods (Roman to post-medieval) are typically characterised by silt/clay overbank flood alluvium as river levels continued to rise. Historic sequences often show signs of weathering (oxidation) and soil formation.

2.4.8 Alluvium can be an important preserving environment for both archaeology and palaeoenvironmental remains, as well as providing evidence of floodplain evolution and river channel change relevant to archaeological time periods.

2.4.9 Interpreting floodplain sediments and soils can inform on river morphology, palaeohydrology, vegetation and ecological change and river level variation. Within managed floodplains alluvium can preserve evidence of basic flood farming, centralised irrigation systems and land drainage. Historical flood magnitude and frequency can also be mapped in certain circumstances.

2.4.10 On site, the British Geological Survey (BGS) maps alluvium infilling the Wensum Valley. The alluvial architecture is not visible, and the deposit conceals the underlying valley floor and its topography.

Table 2-1 Late quaternary chronology and British archaeological periods

Period	Marine Isotope stage (MIS)	Approximate date (thousands of years ago)	Epoch	Epoch (Division) or British Stage (Division)	British archaeological period	Climate	Glacial/ Interglacial
Late Quaternary	1	0.5	Holocene	Late Holocene. Historic	Post medieval	Warm	Interglacial
Late Quaternary	1	1	Holocene	Late Holocene. Historic	Medieval	Warm	Interglacial
Late Quaternary	1	2	Holocene	Late Holocene. Historic	Roman	Warm	Interglacial
Late Quaternary	1	3	Holocene	Late Holocene. Prehistoric	Iron Age	Warm	Interglacial
Late Quaternary	1	4	Holocene	Mid Holocene. Prehistoric	Bronze Age	Warm	Interglacial
Late Quaternary	1	6	Holocene	Mid Holocene. Prehistoric	Neolithic	Warm	Interglacial
Late Quaternary	1	12	Holocene	Early Holocene. Prehistoric	Mesolithic	Warm	Interglacial
Late Quaternary	2	13	Late Pleistocene	Devensian 'Late glacial'. Loch Lomond stadial	Upper Palaeolithic	Cold	Glacial (last cold stage)
Late Quaternary	2	14	Late Pleistocene	Devensian 'Late glacial'. Windemere interstadial	Upper Palaeolithic	Warmer	Interstadial (last cold stage)
Late Quaternary	2	20	Late Pleistocene	Devensian 'Late glacial'. Dimlington stadial (Late glacial maximum)	Upper Palaeolithic	Cold	Glacial (last cold stage)
Late Quaternary	3	58	Late Pleistocene	Middle Devensian. Upton Warren interstadial	Middle Palaeolithic	Warmer	Interstadial (last cold stage)
Late Quaternary	4	75	Late Pleistocene	Early Devensian	Middle Palaeolithic	Cold	Glacial (last cold stage)
Late Quaternary	5a	79	Late Pleistocene	Early Devensian. Brimpton interstadial	Middle Palaeolithic	Warmer	Interstadial (last cold stage)

Period	Marine Isotope stage (MIS)	Approximate date (thousands of years ago)	Epoch	Epoch (Division) or British Stage (Division)	British archaeological period	Climate	Glacial/ Interglacial
Late Quaternary	5b	96	Late Pleistocene	Early Devensian	Middle Palaeolithic	Cold	Glacial (last cold stage)
Late Quaternary	5c	103	Late Pleistocene	Early Devensian. Chelford interstadial	Middle Palaeolithic	Warmer	Interstadial (last cold stage)
Late Quaternary	5d	115	Late Pleistocene	Early Devensian	Middle Palaeolithic	Cold	Glacial (last cold stage)
Late Quaternary	5e	125	Late Pleistocene	Ipswichian	Middle Palaeolithic	Warm	Interglacial (last warm stage)
Late Quaternary	6	190	Late Middle Pleistocene	Wolstonian glacial complex	Middle Palaeolithic	Cold	Glacial
Late Quaternary	7	220	Late Middle Pleistocene	Aveley interglacial	Middle Palaeolithic	Warm	Interglacial
Late Quaternary	8	315	Late Middle Pleistocene	Wolstonian glacial complex	Middle Palaeolithic	Cold	Glacial
Late Quaternary	9	325	Late Middle Pleistocene	Purfleet interglacial	Lower Palaeolithic	Warm	Interglacial
Late Quaternary	10	390	Late Middle Pleistocene	Wolstonian glacial complex	Lower Palaeolithic	Cold	Glacial
Late Quaternary	11	400	Late Middle Pleistocene	Hoxnian interglacial	Lower Palaeolithic	Warm	Interglacial
Late Quaternary	12	475	Late Middle Pleistocene	Anglian glaciation	Lower Palaeolithic	Cold	Glacial

2.5 Human activity

2.5.1 The archaeology across the site is understood through the HEDBA (**Appendix 8.1** (Document Reference 3.08.01), the geophysical survey (Magnitude Surveys 2021) and a trial trench evaluation (Oxford Archaeology, 2023). Past investigations are identified on either side of the Wensum: at Old Hall Farm, Fakenham Road evaluation revealed Neolithic/early Bronze Age pottery (Gaz 10, Figure 3, WSP 2023b), and fieldwalking found prehistoric flint tools near Low Farm (Gaz 29, Figure 3 WSP 2023b) (**Figure 3 in section 9 of this Appendix**).

2.5.2 Trial trench evaluation (246 trenches across 22 fields) ‘ground-truthed’ crop marks and geophysical anomalies and, in the vicinity of the Wensum identified early medieval settlement activity on the east bank (TT22, Figure 2, WSPb 2023) (**Figure 3**). This archaeology is closest to the river (130m to the northeast) although it is noted that two fields at the west edge of the Wensum could not be accessed and have not been evaluated (TT21 and TT24, near Gaz 29) (Figure 2, WSP 2023a). Iron Age and Romano British activity is recorded to the west of the Wensum (TT20), further away from the valley (860m west).

3 Sources and methodology

3.1 Data sources and collection

3.1.1 To build the model, the following Site Investigation Borehole and Window Sample data were examined:

- British Geological Survey (BGS 2023) digital maps and online resources describing the characteristics of the bedrock and drift;
- Geotechnical Investigation 2022 - 70041922-WSP-GE-DWG-001- P06;
- Reading Agricultural Consultants (RAC) (2022). Norwich Western Link: Soil Resource Survey; and

- Geotechnical Investigation 2019-2020 Ringland A47-A1067 Western Link road (CES Highways Projects).

3.1.2 The above surveys were carried out solely for engineering purposes and did not involve any archaeological consultation or input.

3.1.3 In addition to the archaeological information discussed above (WSP 2023b; Magnitude Surveys 2021; WSP 2023a; Oxford Archaeology 2023), the sources listed in Table 3.1 were consulted.

Table 3-1 Data sources consulted

Source	Data	Comment
British Geological Survey (BGS)	Drift and solid geology digital map; online historical geological and geotechnical borehole and trial pit data. BGS memoirs in support of mapping.	Characteristics of the bedrock and superficial deposits of the site, which can provide an indication of landscape evolution, palaeoenvironmental potential and suitability for early settlement.
Client	Project acquired geotechnical data, General Arrangements and viaduct impacts	Indicates the main deposits within the site, including deposit depth and thickness. Geoarchaeological review can determine landscape processes, likely nature and geoarchaeological / palaeoenviromental potential.
English Nature	Research Report, Number 685	Geomorphological appraisal of the River Wensum Special Area of Conservation (SAC).
Environment Agency	Catchment Planning website	Characteristics of present-day Wensum catchment.

Source	Data	Comment
Historic England (HE)	Deposit Modelling and Archaeology Guidance HEAG272; Regional Research Frameworks	Best practice guidance for modelling and East of England research questions.
Internet and Academic Community	Relevant published literature found in national and international journals	Information on past archaeological and palaeoenvironmental investigations.
Natural England	Technical Information Note TIN201	River Wensum Special Area of Conservation Evidence Pack.
Quaternary Research Association (QRA)	Regional Field Guides	Norfolk and Suffolk Regional Field Guide (Lewis et al 2000) providing Quaternary geological context.
WSP	Heritage topic technical appendices to the Environmental Statement in support of the planning application	Planning background and archaeological context provided by the Historic Environment Desk Based Assessment and archaeological field surveys (Geophysical survey and Trial Trench evaluation).

3.2 Methodology

3.2.1 To create the deposit model across the Wensum channel, geotechnical ground investigation data were entered into a digital database (gINT v8i); boreholes with the prefix 'BH', window samples with 'WS' and test pits with ‘TP’. The numbers of each data type entered into the model were as follows:

- Geotechnical boreholes (BH) entered: 48 (22 Rotary and 26 Cable Percussion)

- Geotechnical test pits (TP) entered: 18
- Geotechnical window samples (WS) entered: 12

3.2.2 Deposit descriptions (texture, sorting, structure, colour and inclusions) were examined, and a major and minor component ascribed (eg clay, silty; gravel, sandy). A series of 'working transects' or cross-sections were drawn to illustrate sediment sequences relative to height above Ordnance Datum (OD) across the valley, positioned according to spacing on the ground. Horizontal and vertical deposit relationships were examined, and with reference to BGS mapping and the literature, sediment descriptions were grouped, and correlations made to build a stratigraphic sequence.

3.2.3 The gINT data were transferred to a Geographic Information System (ArcGIS v.10.8.1) to visualise thickness of key deposits and deposit horizon height relative to OD.

3.2.4 Where present, significant ancient landscape features, such as palaeochannels (ancient watercourses, that can be peat-filled) and 'islands' of higher gravels beneath flood alluvium are identified and illustrated. A key horizon surface is the base of the Holocene sequence, which can be correlated between logs to represent the inherited Lateglacial/early Mesolithic topography. This 'early Holocene surface' was the template that influenced later sediment deposition.

3.3 Limitations of the data

3.3.1 Robust deposit models rely on good data, and therefore models may not accurately represent ground conditions. A deposit model is a decision-making tool that provides a conceptual framework of the sub-surface that relies on high quality ground investigation (minimal sediment disturbance), evenly distributed and numerous data, and consistent logging descriptions to support good interpretations. Models can be refined and strengthened by additional data.

3.3.2 The data used here are derived from geotechnical engineering, and not visually inspected by a geoarchaeologist. The descriptions in the logs do not as a consequence contain all the information that a geoarchaeologist or archaeologist would want clarity on. For example, 'made ground' in GI logs might be categorised by an archaeologist as either modern, containing identifiably modern inclusions such as plastic and concrete but not brick or tile, and 'undated' made ground which might contain remains of archaeological interest.

4 Deposit model

4.1 Introduction

4.1.1 The geoarchaeological deposit model comprises a representative cross section of subsurface deposits through the valley (**Figures 3 and 4**) and a series of thickness and elevation plots illustrating the distribution and extent of deposits (**Figures 5 and 6**) and their potential to hold archaeological and/or palaeoenvironmental information (**Figure 7**; Section 5).

4.1.2 The **Figure 4** cross section shows the site stratigraphy with sediments of archaeological interest and potential divided by the Early Holocene Surface into Pleistocene and Holocene superficial deposits (Section 2.2). The Early Holocene Surface illustrated in plan (**Figure 5**) shows the valley sides descending from 26m OD to the floodplain beneath the alluvium (at 4.5m OD). This represents the base of the Holocene sequence and the topography that influenced sediment deposition from the Mesolithic onwards.

4.1.3 Examining the buried sediments across the valley using a series of cross sections, horizon surface and deposit thickness plots has enabled stratigraphic interpretation and comment on floodplain evolution. The key depositional units are as follows, although it is acknowledged that in a number of boreholes minerogenic alluvium underlay organic alluvium and in a few, organic-rich sediment was sandwiched between alluvial layers:

- Topsoil (TS);

- Alluvium (minerogenic) (ALV);
- Alluvium (organic/peat) (PT);
- River Terrace Deposits (RTD);
- Head (HD);
- Sheringham Cliffs Formation (SHCF); and
- Chalk bedrock (CK).

4.2 Deposit Description (lithology)

4.2.1 The HEDBA summarised the geotechnical information (WSP 2023b, Table 4-1). Selected boreholes of palaeoenvironmental interest are tabulated here to describe the stratigraphy in more detail and to illustrate the main depositional units across the Wensum (Table 5.1). Descriptions are made from ground level down to the base of the sedimentary sequence.

Holocene Stratigraphy (MIS1)

Topsoil and made ground

4.2.2 Descriptions show that topsoil is generally peaty or clayey with gravelly inclusions (Table 5.1; **Figure 4**). Soil profiles were investigated across the site in a soil resource survey (RAC 2022) to describe the composition of soil to a depth of 1.2m below ground level (bgl). Profiles were described and soil categorised into two types: a peat loam or loamy peat and, less frequently, a variably organic sandy clay loam or loamy sand. Made ground is clearly noted in only one location (WS202).

4.2.3 Unlike sediment, soils have undergone transformation and developed through time (time-transgressive), sometimes over centuries and understanding soil development chronology can be problematic. While buried soils can signify episodes of past land use (such as medieval drainage and flood management) in general, although organic topsoils will have palaeoenvironmental potential, they are of limited heritage significance, representing recent conditions that can be better researched if warranted (e.g.

in landscapes of high heritage significance) by sampling or using climate, environment and historical records.

Alluvium – Clay, Silty, Peat and Sand

4.2.4 The GI shows the floodplain to be characterised predominantly by gravelly, silty clay minerogenic alluvium (Section 2.1.4). Deeper floodplain sequences are dominated by organic-rich sediment (such as BH209, Table 5.1), and in shallower zones at the floodplain edge (BH224) or on raised areas within the channel belt (BH251; BH215), sediments are characteristically coarse, mixed with sands and gravels. In places the alluvial stratigraphy alternates between organic (described as peats) and silt/clay (minerogenic) deposits, for example BH212 and TP242 where spongy black slightly sandy fibrous ‘peat’ was sandwiched by alluvial sand (brownish black slightly gravelly very silty very organic fine and medium sand, with angular to sub-rounded fine and medium flint gravel) (**Figure 4**). In several boreholes minerogenic alluvium underlay ‘peat’ (BH215, BH217, BH218, BH224 and TP250).

4.2.5 The minerogenic alluvium ranges from organic sands as described in 5.2.3, to gravelly silty fine to coarse sand (BH257, **Figure 4,** Table 5.1), occasionally described as gravelly sandy clay (BH208).

4.2.6 A soil depth probing survey (WSP 2021) measured peaty loam/loamy peat thickness ranging from 0.2m to 2.2m, and thicknesses in GI boreholes range from 0.2 to 2.8m, with greatest depths focusing around BH208 to BH211; BH255, BH256 and TP241. Peat is described as spongy dark brown slightly sandy clayey pseudo-fibrous with frequent medium and coarse decaying wood fragments. The deeper organic deposits are localised in two areas of the floodplain. The cross section (**Figure 4**) and alluvial thickness plot (**Figure 6**) show these localised areas of thicker peaty loam/loamy peat: one on east and on the west side of the floodplain where the base of alluvium descends to a height of approximately 6m OD (e.g. BH210, 6.3m OD and BH221, 6.1m).

Late Pleistocene Stratigraphy (MIS2-8) – River Terrace Deposits (RTD), Head (HD) and Sheringham Cliffs Formation (SHCF)

River Terrace Deposits

4.2.7 River Terrace Deposits are coarse, minerogenic deposits sterile of organic material typically described as dense brown and greyish brown very gravelly fine to coarse sand, with sub-angular to rounded fine to coarse flint gravel (BH222). RTD are mapped at their thickest in the centre of the floodplain (c.10m thick) for example in BH215 (**Figure 4**) and rise from c. 6-8m OD to 18-20m OD on the valley sides.

Head

4.2.8 Head deposits are principally sandy, described as medium dense brown gravelly silty fine to coarse sand (e.g. BH227) similar in description to the SHCF and RTD, and difficult to distinguish from GI descriptions. Head deposits are assumed to infill older Anglian (MIS12) and Wolstonian (MIS8-6) dry valleys, deposited as colluvium/hillwash under periglacial conditions (see Section 2.3.3). The GI reveals no evidence of stratification, although this could be a feature of the drilling and collection method.

Sheringham Cliffs Formation

4.2.9 The Till on the higher valley sides (SHCF) is probably the oldest Pleistocene deposit on site, described as a light brown very gravelly, coarse sand with fine to medium sub-angular flint gravel. These deposits are either MIS10-6 or MIS12: the Lower Palaeolithic to Middle Palaeolithic transition (Section 2.3.2, Table 2.1).

4.3 Deposit Interpretation (stratigraphy)

4.3.1 The modelling exercise reveals the palaeotopography of the Wensum Valley and the distribution of floodplain sediments, with a focus on Holocene organic deposits. Five different landscape positions or depositional environments of varying geoarchaeological potential (Table 5.1) are identified:

- high valley edge (WS206);

- head-filled dry valley descending to the floodplain (TP205; BH228; BH227);
- floodplain zone (BH257);
- raised floodplain channel bar (BH215); and
- areas of deeper floodplain channels (BH209, BH210, BH221).

4.3.2 This section describes these landscape positions and comments on the geoarchaeological (archaeological and palaeoenvironmental) potential.

Valley Edge

4.3.3 The RTD outcrop at elevations of 18–20m OD on the valley sides and are attributed to the first terrace, dating to the last glacial period (Devensian, MIS5d to MIS2) glacial 'complex' (Table 2.1). By the end of this period Britain was occupied by modern humans, and Neanderthals phased out to extinction (White and Pettitt 2011). At Lynford Quarry in the Brecklands, important evidence of Neanderthals and the British Middle Palaeolithic (dated to c 65-57ka, at the transition between MIS4 and 3) was preserved within the organic sediments of a palaeochannel (mammoth remains and bout-coupé handaxes) (Boismier et al 2012). The RTD in the Wensum, by contrast, are considered of low palaeoenvironmental potential, devoid of organics and with no evidence of fine-grained palaeochannels. Although it is possible that the RTD contain ex-situ contemporary Palaeolithic tools (made in the late Middle Palaeolithic by Neanderthals or Upper Palaeolithic modern humans) or artefacts reworked from older deposits, sites and findspots are rare. On this basis RTD are considered of low archaeological potential. The palaeoenvironmental potential of RTD is also low due their coarse, gravelly nature: a poor preserving environment.

4.3.4 The valley side and catchment surface are characterised by the SHCF 'Marly Drift', thought to be the Weybourne Town Till Member (Section 2.3.2). Regardless of whether this glacial Till was deposited during MIS10-6 or MIS12, the geoarchaeological potential of the SHCF is limited. The potential of finding artefactual material such as Acheulean or Mousterian handaxes is extremely low given the location of the ice mass in Norfolk at the time and likely geographic extent and low density of hominin populations. The palaeoenvironmental potential is also low due to the subglacial depositional environment, lack of organic matter, poor preserving environment and age of deposits.

Head-filled Dry Valley

4.3.5 Many of the dry valley forms in the Wensum were formed under periglacial conditions during the Anglian and Wolstonian glacials (Natural England 2022) (Section 2.3.3), and because Head is difficult to distinguish from SHCF and RTD, interpretations are guided by BGS mapping. Head is considered of low archaeological potential due to the deposit type (coarse and minerogenic), climate (cold-stage conditions when human populations were sparse) and depositional environment (slope deposits, reworked by gravity). Artefactual material would be ex-situ.

4.3.6 The palaeoenvironmental potential of Head is low due to sediments lacking evidence of stratification, organic matter and being coarse (fossil content likely to be abraded), free draining (a poor preserving environment) and ancient (any possible fossil content is likely to be seriously degraded).

Floodplain Zone, Floodplain Channel and Channel Bar

4.3.7 Over the course of the Holocene the Wensum would have migrated across the floodplain within the bounds of the valley sides: the flanking Devensian RTDs and Till controlled the movement of the channel. Historic mapping (Faden’s map of 1797 and Bryant’s map of Norfolk of 1826) appears to show the line of maximum depth (thalweg) in a more westerly position than on later Tithe maps (WSPb 2023 Figures 9-11), and at least by the 1880s (1st Ordnance Survey) the channel took its present sinuous meandering course along the eastern edge of the floodplain. Today, the thalweg on the eastern side of the floodplain is linked by perpendicular drainage cuts to a straighter, parallel channel on the west of the floodplain (**Figure 1**).

4.3.8 The model identifies two deep zones of organic accumulation on the east and west of the floodplain (Section 5.2.6). The eastern area of organic sediment aligns with the present day and historically mapped channel, and the western area aligns with the parallel channel. These zones are interpreted as floodplain channels, separated by a raised channel bar (at a height of approximately 9.5m OD). On the channel bar, alluvial horizons are minerogenic or in some cases (e.g. in BH251) topsoil directly overlies the RTD (**Figure 4**).

4.3.9 Channels and bars are floodplain features consistent with braided and anastomosing river patterns where several channel threads branch around higher gravel islands. Given that braiding can be associated with climatic deterioration and severe flooding, typically the floodplain topography is a vestige of Late Devensian glacial outwash, ice melt and/or increase in bedload that promoted channel incision. Thick gravels in the centre of the floodplain (Section 5.2.7) are likely to represent the pre-Holocene buried valley. As the climate ameliorated in the Holocene and bedload reduced, channel threads coalesced and an anastomosing channel pattern is likely to have developed. It is noted that planform changes to braided systems can also take place in Holocene rivers, owing to shifts in climate (wetter e.g. in the Iron Age), land use change (deforestation and increased run-off e.g. in the Neolithic) although this is not common (Passmore et al 1993) and is more characteristic of cold-climate rivers.

4.3.10 The deeper channels in the Wensum, particularly on the west of the floodplain, contain fibrous peaty loam/loamy peat' that may preserve evidence of Holocene vegetation history and have high potential for palaeoenvironmental remains (Section 2.1.4). At the edges of these channels, there is low potential for archaeology such as fish traps, revetments or evidence of floodplain management most likely dating from the medieval period onwards. However, historic modification such as channel cutting, straightening and management (dredging and over-deepening) to drain the surroundings will have impacted the natural geomorphology, and floodplain deposits are likely to be partially disturbed. It is therefore uncertain whether the organic deposits recorded by GI are of a recent, historic or prehistoric date.

4.3.11 The Wensum stratigraphy can be compared to the 'standard' Holocene sequence for the Broads in the lower Yare (Coles and Funnell 1981). The Yare shows evidence of two episodes of marine transgression, represented by estuarine lower and upper clay horizons, sandwiched between freshwater lower (Mesolithic freshwater), middle (Bronze Age fen wood) and upper peat (Romano-British, mainly removed by post-medieval extraction). The lower clay corresponds to the Neolithic (c.4500 BP) and the upper clay dates to the late prehistoric to Romano-British period (at c.2000 BP). Yare deposits are significantly thicker at the seaward limit and elevations are lower (c15m) than in the Wensum. The Neolithic marine transgression, however, extended 20km inland (Murphy 2014), and the effects of sea and river level rise are likely to have been experienced in the river valleys upstream of the Broads. With Neolithic deforestation, increased sediment run-off caused rivers to back-up and fen carr peat to develop in the Bronze Age. On site, the deeper channels may preserve Bronze Age peat, between Neolithic minerogenic alluvium beneath and overlying Iron Age and later deposits.

4.3.12 The Floodplain zone comprises the channel belt between bars and channels. Sediments might be peat-rich or clayey at the channel margins but are predominantly silty or sandy, as indicated by the soil erodibility map in the recent geomorphological appraisal (English Nature 2022) and verified by the GI. The floodplain zone has low to moderate potential for both palaeoenvironmental and archaeological remains, as sediments are mainly minerogenic, shallow, coarse and free draining (i.e. less waterlogged and a poor preserving environment) (Section 2.1.4).

Table 4-1 Lithology and stratigraphy for Ground Investigation (GI) points representing five different landscape positions (depositional environments) within the site: valley edge (WS206), head-filled dry valley descending to the floodplain (TP205), floodplain (BH257), channel bar (BH215) and floodplain channel (BH209)

GI ref. (height OD) and landscape position	Deposit thickness (m)	Lithology (description)	Stratigraphy (interpretation)
WS206 (20m) Valley edge	0.4	Brown slightly gravelly fine to coarse SAND. Gravel is sub-angular to sub-rounded fine to coarse flint. Occasional rootlets <2mm	Topsoil
WS206 Valley edge	1.6	Loose orangish brown gravelly fine to coarse SAND. Gravel is sub-angular fine to coarse flint	SHCF
WS206 Valley edge	0.5	Very loose orangish cream gravelly fine to coarse SAND. Gravel is rounded fine to coarse chalk	Bedrock
WS206 Valley edge	>0.5	Structureless CHALK composed of cream gravelly SILT.	Bedrock
TP250 (9m) Dry valley to floodplain	0.5	Grass over spongy dark brown slightly sandy slightly gravelly clayey pseudo-fibrous PEAT with low cobble content. Gravel is sub-angular medium and coarse flint. Cobbles are sub-angular flint.	Topsoil
TP250 Dry valley to floodplain	0.2	Firm grey mottled brown sandy gravelly CLAY. Gravel is sub-angular to sub-rounded fine to coarse flint.	Alluvium
TP250 Dry valley to floodplain	0.15	Firm orangish brown mottled grey and brown slightly gravelly very sandy CLAY. Gravel is sub-angular to sub-rounded.	Alluvium

GI ref. (height OD) and landscape position	Deposit thickness (m)	Lithology (description)	Stratigraphy (interpretation)
TP250 Dry valley to floodplain	0.35	Firm grey occasionally mottled brown slightly sandy gravelly CLAY. Gravel is sub-rounded fine chalk.	Head
BH257 (9m) Floodplain	0.2	Dark brown gravelly slightly clayey fine to coarse SAND. Gravel is sub-angular to sub-rounded fine to coarse flint. Occasional rootlets.	Topsoil
BH257 Floodplain	0.5	Plastic dark brown to dark grey slightly gravelly slightly clayey pseudo-fibrous PEAT. Strong organic odour.	Alluvium (organic)
BH257 Floodplain	0.6	Dark grey slightly gravelly silty fine to coarse SAND. Gravel is sub-angular to sub-rounded fine to coarse flint. Weak organic odour	Alluvium (minerogenic)
BH257 Floodplain	7.3	Orangish brown very sandy sub-angular to sub-rounded fine to coarse GRAVEL with low cobble content. Gravel and cobbles are flint.	Devensian RTD beneath the floodplain
BH257 Floodplain	>0.5	Structureless CHALK.	Bedrock
BH215 (9m) Floodplain channel bar	0.25	Dark brown gravelly clayey fine to coarse SAND. Gravel is angular to sub-rounded fine to coarse flint and quartzite. Frequent rootlets <3mm.	Topsoil
BH215 Floodplain channel bar	0.35	Brownish grey gravelly very clayey fine to coarse SAND. Gravel is angular to sub-rounded fine to coarse flint and quartzite.	Alluvium of channel bar

GI ref. (height OD) and landscape position	Deposit thickness (m)	Lithology (description)	Stratigraphy (interpretation)
BH215 Floodplain channel bar	0.6	Grey fine to coarse SAND and angular to sub-rounded fine to coarse GRAVEL of flint and quartzite.	Alluvium of channel bar
BH215 Floodplain channel bar	10.6	Medium dense orangish brown fine to coarse SAND and angular to sub-rounded fine to coarse GRAVEL of flint and quartzite with occasional chalk.	Devensian RTD beneath the floodplain
BH215 Floodplain channel bar	>0.2	Structureless CHALK.	Bedrock
BH209 (9m) Floodplain channel	0.18	Soft dark brown slightly sandy slightly gravelly organic CLAY. Gravel is sub-rounded fine to coarse flint. Frequent roots <3mm.	Topsoil
BH209 Floodplain channel	2.72	Spongy dark brown slightly sandy clayey pseudo-fibrous PEAT with frequent medium and coarse decaying wood fragments.	Alluvium (thick peaty channel infill)
BH209 Floodplain channel	2.1	Medium dense becoming lose multicoloured sandy angular to rounded fine to coarse GRAVEL of flint. Grading to very loose light brown very gravelly fine to coarse SAND. Gravel is angular to rounded fine to coarse flint.	Devensian RTD beneath the floodplain
BH209 Floodplain channel	>0.5	Structureless CHALK composed of cream to yellowish cream slightly gravelly SILT.	Bedrock

5 Landscape zones

5.1.1 The site has been divided up into ‘Landscape Zones’ of varying archaeological and palaeoenvironmental potential on the basis of the location, extent and thickness of the various deposits identified in the model. The Landscape Zones (LZs) are shown on **Figure 7** and described in Table 6.1. The LZs summarise the geoarchaeological potential, derived from modelling, and the heritage significance (based on professional judgement).

Table 5-1 Landscape Zones with associated geoarchaeological (archaeological and paleoenvironmental) potential and heritage significance

Landscape Zone	Character of zone	Geoarchaeological potential and heritage significance
LZ1 (green)	Sandy and gravelly MIS4 River Terrace Deposits; MIS6-8 or 12 Head deposits and MIS6-8 or 12 diamicton (Sherringham Cliffs Formation)	Pleistocene deposits of low palaeoenvironmental potential of medium heritage significance; and low geoarchaeological potential of high significance (due to rarity)
LZ2 (amber)	Sandy and gravelly Floodplain Channel Bars and Floodplain zone	Holocene deposits of low to moderate palaeoenvironmental and geoarchaeological potential, of medium heritage significance
LZ3 (red)	Organic sediment-filled Floodplain Channels	Uncertain but probably high palaeoenvironmental potential (depending on the extent of historic disturbance) of low or medium heritage significance, derived from their archaeological and historic interest. Low potential for floodplain archaeology

5.2 Landscape Zone 1 (LZ1)

5.2.1 LZ1 encompasses the Pleistocene River Terrace Deposits (Devensian), diamicton (Wolstonian or Anglian Sherringham Cliffs Formation) and Head (Devensian, Wolstonian and/or Anglian dry valley fill) of the catchment surface and valley sides. There is low potential to preserve palaeoenvironmental remains as these sediments were deposited in harsh climatic conditions, lack evidence of stratification, are devoid of organic matter, are coarse (any fossil content is likely to be abraded), free draining (a poor preserving environment) and ancient (fossil content likely to be degraded). Any palaeoenvironmental remains would be of medium heritage significance.

5.2.2 LZ1 has low potential for archaeological remains such as Palaeolithic artefacts (handaxes) or ecofacts (floral and faunal remains) that, if in situ, would be of high heritage significance due to their scarcity.

5.3 Landscape Zone 2 (LZ2)

5.3.1 LZ2 includes Holocene channel bars and the floodplain belt between deeper channels. Deposits are occasionally ‘peat’-rich or clayey, but largely sandy and gravelly and of low to moderate potential for both palaeoenvironmental and archaeological remains as sediments are minerogenic, shallow and free draining (i.e. less waterlogged and a poor preserving environment). Any geoarchaeological (both archaeological and palaeoenvironmental) remains would be of low or medium heritage significance depending on whether remains are in situ or reworked by the river (residual)

5.4 Landscape Zone 3 (LZ3)

5.4.1 Peat should be seen as a heritage asset and a palaeoenvironmental resource, with evidential value for reconstructing local and regional environmental and landscape change (Section 2.1.4). Holocene floodplain channels, particularly on the east of the floodplain, contain fibrous peaty loam/loamy peat that may preserve evidence of the prehistoric and historic vegetation history. LZ3 therefore has high palaeoenvironmental potential for remains of medium heritage significance.

5.4.2 At the edges of the floodplain channels, there is low potential for archaeology such as fish traps, revetments or evidence of floodplain management most likely dating from the medieval period onwards. Potential and significance may be attenuated where the flow of the channel or recent modification (such as channel cutting, straightening and management to drain the surroundings) have disturbed floodplain deposits. Archaeological remains on the floodplain would be of medium heritage significance if in original position, otherwise remains would be of low heritage significance.

6 Impact assessment

6.1.1 The engineering details are not currently available and the pile size and spacing is not currently known. It is assumed that piles would be large diameter and widely spaced. Augered /continuous flight auger (CFA) piles would minimise the impact whereas vibro-compacted piles are likely to cause additional impact through vibration and deformation of vulnerable surrounding deposits.

6.1.2 For any archaeological remains, the proposed impacts would remove evidence from within the footprint of each road viaduct pile as the pile is driven downwards. This would constitute substantial harm or total loss of significance for archaeology. For Holocene palaeoenvironmental remains the impacts would result in less than substantial harm. The severity of the impact would therefore depend on the pile size, type and pile density.

7 Conclusion and recommendations

7.1 Conclusion

7.1.1 The deposit model used geotechnical GI to create cross sections, deposit surface plans and thickness plots to map and interpret the sub-surface stratigraphy across the Wensum Valley within the Red Line Boundary.

7.1.2 The investigation identified the different depositional units within the site and mapped the location, extent and thickness of sediments (objective 1, Section 1.3), interpreted depositional environments and identified five different landscape positions within the modelled area:

- **Valley edge** – surface elevation 10-20m OD, thickness 2-8m
- **Head-filled dry valley** - surface elevation 12-16m OD, thickness c. 4m
- **Floodplain zone** - surface elevation 8-10m OD, thickness up to 1m
- **Channel bar** - surface elevation 9-10m OD, thickness up to c. 0.5m
- **Deeper floodplain channels** – base elevation to c6m OD, thickness up to c. 3m

7.1.3 These were consolidated into three Landscape Zones (LZs) of differing geoarchaeological potential and heritage significance (objective 2, Section 1.3) to assess their suitability for further work given that the proposed viaduct bridge would entirely remove any archaeological remains and locally remove palaeoenvironmental deposits. For any archaeological remains this would constitute substantial harm or total loss of significance, and for Holocene palaeoenvironmental remains the impacts would result in less than substantial harm (objective 3, Section 1.3).

7.1.4 **LZ1** comprises Pleistocene sediments of low potential to preserve palaeoenvironmental remains of medium heritage significance. Sediments were deposited in severe climatic conditions, lack stratification, are devoid of organic matter, are coarse and free draining. LZ1 also has low potential for Palaeolithic artefacts (handaxes) or ecofacts (floral or faunal remains). In general, in situ Palaeolithic remains are of high heritage significance due to their rarity.

7.1.5 **LZ2** includes Holocene channel bars and the floodplain belt between deeper channels. Sediments are mainly minerogenic and of low to moderate potential for both palaeoenvironmental and archaeological remains. Any remains would be of medium heritage significance.

7.1.6 Within **LZ3,** Holocene floodplain channels contain fibrous 'peat' with high potential for palaeoenvironmental remains of medium heritage significance. Organic sediments may preserve evidence of the prehistoric and historic vegetation change, although there is uncertainty as to the extent of historic disturbance associated with floodplain management. At the edges of the LZ3 floodplain channels, there is low potential for archaeology such as fish traps, revetments or evidence of floodplain management most likely dating from the medieval period onwards. Archaeological remains would be of medium heritage significance.

7.2 Recommendations

7.2.1 Understanding environmental and vegetation change in the Wensum Valley is of relevance to archaeological mitigation for the Proposed Scheme to build the palaeotopgraphy of the region and contribute to understanding the landscape. It is recommended that a series of purposive geoarchaeological borehole samples is considered within LZ3 (near BH209 or BH210) during archaeological mitigation to contribute to Holocene environmental research and the regional research agenda (objective 4, Section 1.3; Medlycott 2011).

7.2.2 The borehole method would ensure continuous sediment samples representing the floodplain channel sequence are collected for off-site investigation. A short transect of six boreholes across the floodplain channel using a percussive rig to collect sleeved windowless samples may be appropriate. A Written Scheme of Investigation for purposive geoarchaeological boreholes would be required and could be added to the Archaeological Mitigation WSI (WSP 2023a) by addendum.

7.2.3 Results would be set in the context of the spread of archaeology across the scheme and in the vicinity (Section 2.1.7 and 2.1.8; WSP 2023a; WSP 2023b), as well as compared to regional Holocene sediment sequences such as the 'standard' Yare material.

7.2.4 Samples could be collected pre-construction, during archaeological mitigation to avoid delays to programme. Boreholes would retrieve a sediment sequence that could be studied during post excavation. Samples would be assessed for presence/absence of palaeoenvironmental remains and for their potential to understand environmental change, chronology and Holocene floodplain evolution in the Wensum.

7.2.5 As part of the archiving requirements, it is recommended that the geoarchaeological deposit model and site stratigraphy information is made accessible to the Historic Environment Record (HER) to build the palaeotopgraphy and contribute to understanding prehistory in the region, particularly the Palaeolithic to Mesolithic (Medlycott 2011).

7.2.6 To maximise the return of data it is important that fieldwork and reporting is undertaken by a trained geoarchaeologist, ideally familiar with the Broads and surrounding environment.

8 References

8.1 Published and documentary sources

- Ashton. N, Lewis. SG., De Groote I., Duffy SM., Bates M., Bates R., Hoare P., Lewis M., Parfitt SA., Peglar S., Williams C., Stringer C. 2014 Hominin Footprints from Early Pleistocene Deposits at Happisburgh, UK *PLoS ONE* 9(2): e88329. [accessed 13-06-2023]
- Aslan A. 2007 'Fluvial Environments' In Elias SA. (ed) *Encyclopaedia of Quaternary Science* Elsevier Ltd pp 672-685
- Boismier, WA. Gamble, C. Coward, F. (eds.) 2015 *Neanderthals Among Mammoths, Excavations at Lynford Quarry, Norfolk,* Swindon: English Heritage.
- Boreham S., White TS., Bridgland DR., Howard AJ., White MJ 2010 The Quaternary history of the Wash fluvial network, UK *Proceedings of the Geologists' Association,* 121, 4, pp. 393-409.
- Bridgland, DR., Briant, RM., Allen, P., Brown, EJ., and White TS. (eds.), 2019 *The Quaternary Fluvial Archives of the Major English Rivers Field Guides,* London: Quaternary Research Association.
- Broadland Catchment Partnership [accessed 13-06-2023]
- Blundell, L. 2016 Hominin activity on the Chalk uplands of southeast Britain: a geomorphological perspective on the archaeological record, *Lithics: The Journal of the Lithic Studies Society,* 37, pp. 55–65.
- CIfA [Chartered Institute for Archaeologists] (2020a) *Standards and guidance for commissioning work or providing consultancy advice on archaeology and the historic environment*: Reading.
- CIfA [Chartered Institute for Archaeologists] (2020b) *Standards and guidance for historic environment desk-based assessment*: Reading

- CIfA [Chartered Institute for Archaeologists] (2020c) *Standards and guidance for the archaeological investigation and recording of standing buildings or structures*: Reading
- Coles, BPL., Funnell, BM. 1981 'Holocene Palaeoenvironments of Broadland, England' in S.-D. Nio, R. T. E. Shüttenhelm, Tj. C. E. Van Weering., (eds.) *Holocene Marine Sedimentation in the North Sea Basin,* Wiley, pp. 123-131.
- Clayton, KM., 2000 'Glacial erosion of the Wash and Fen basin and the deposition of the chalky till of eastern England', *Quaternary Science Reviews*, 19, pp. 811-822.
- Corcoran, J., Halsey, C., Spurr, G., Burton, E., and Jamieson, D. 2011 *Mapping past landscapes in the lower Lea valley: a geoarchaeological study of the Quaternary sequence*, MOLA, Monograph Series 55.
- Ehlers, J., Gibbard, P., and Rose, J., (eds.) 1991 *Glacial Deposits in Great Britain and Ireland,* Balkema: Rotterdam.
- English Nature 2006 *Geomorphological appraisal of the River Wensum Special Area of Conservation* English Nature Research Reports, Number 685
- Environment Agency Catchment Planning [accessed 13-06-2023]
- Historic England 2020 *Deposit Modelling and Archaeology. Guidance for Mapping Buried Deposits*, Swindon: Historic England.
- Natural England (2022) *Technical Information Note TIN201 River Wensum Special Area of Conservation – Evidence Pack* [accessed 25-06-2023]
- Lee J R, Woods MA and Moorlock BSP (eds) 2015 *British Regional Geology: East Anglia* (Fifth edition). (Keyworth, Nottingham: British Geological Survey

- Lewis SG, Whiteman CA, and Preece RC (eds) 2000 *The Quaternary of Norfolk and Suffolk: Field Guide*. Quaternary Research Association London
- Magnitude Surveys 2021, Norwich Western Link: Geophysical Survey Report.
- Medlycott, M. (ed.) (2011) ‘Research and Archaeology Revisited: A Revised Framework for the East of England’ in *East Anglian Archaeology Occasional Papers* 24,
- Murphy, P., (2014) *The Archaeology of the Broads: a review,* Norfolk County Council, Historic Environment Service & the Broads Authority [accessed 25-06-2023]
- Oxford Archaeology 2023, Norwich Western Link Archaeological Evaluation Report
- Passmore, DG., Macklin, M., Brewer, PA., Lewin, J., Rumsby, BT. and Newson, MD. 1993 ‘Variability of late Holocene braiding in Britain’ In Best, JL., and Bristow, CS. (eds.) *Braided Rivers Geological Society Special Publication Classics*, London: Geology Society London
- Reading Agricultural Consultants (RAC) 2022 *Norwich Western Link: Soil Resource Survey*.
- White, MJ., and Pettitt, PB. 2011 The British Late Middle Palaeolithic: An interpretative synthesis of Neanderthal occupation at the northwestern edge of the Pleistocene World, *Journal of World Prehistory*, 24 (1). pp. 25-97.
- WSP (2021) *Soil Depth Probing Survey*
- WSP (2023a) *Norfolk County Council Norwich Western Link Written Scheme of Investigation for Archaeological Mitigation Works*
- WSP (2023b) *Document 3.08.01 Environmental Statement Cultural Heritage* ***Chapter 8: Cultural Heritage – Appendix 1***

8.2 Other sources

- British Geological Survey (BGS) Webapp [accessed 16-05-2023]
- Historic Environment Record (HER)
- Historic England designation data

8.3 Cartographic sources

- Faden’s map of Norfolk of 1797
- Bryant’s map of Norfolk of 1826
- Tithe map of Ringland of 1841
- Ordnance Survey 1st edition 6”:mile map of 1882

9 Figures

9.1.1 The following chapter includes figures showing the deposit model mapping within the Red Line Boundary of the Proposed Scheme where it crosses the River Wensum, and the borehole cross section through the valley. These seven figures form the model and accompany the text.

Figure 1 Site location with centre line and catchment as mapped by the Environment Agency

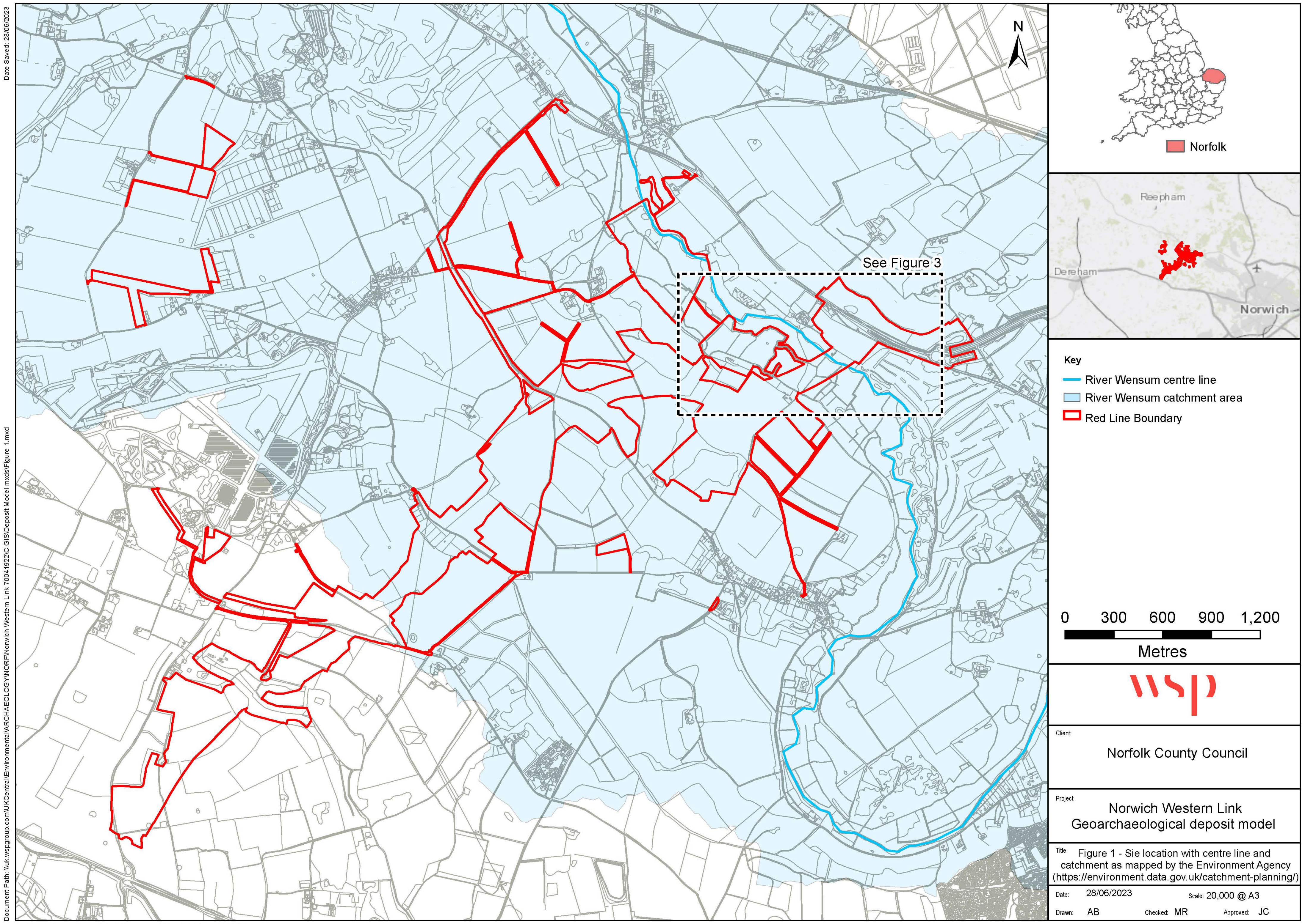

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Figure 2 Geology of the River Wensum with borehole locations

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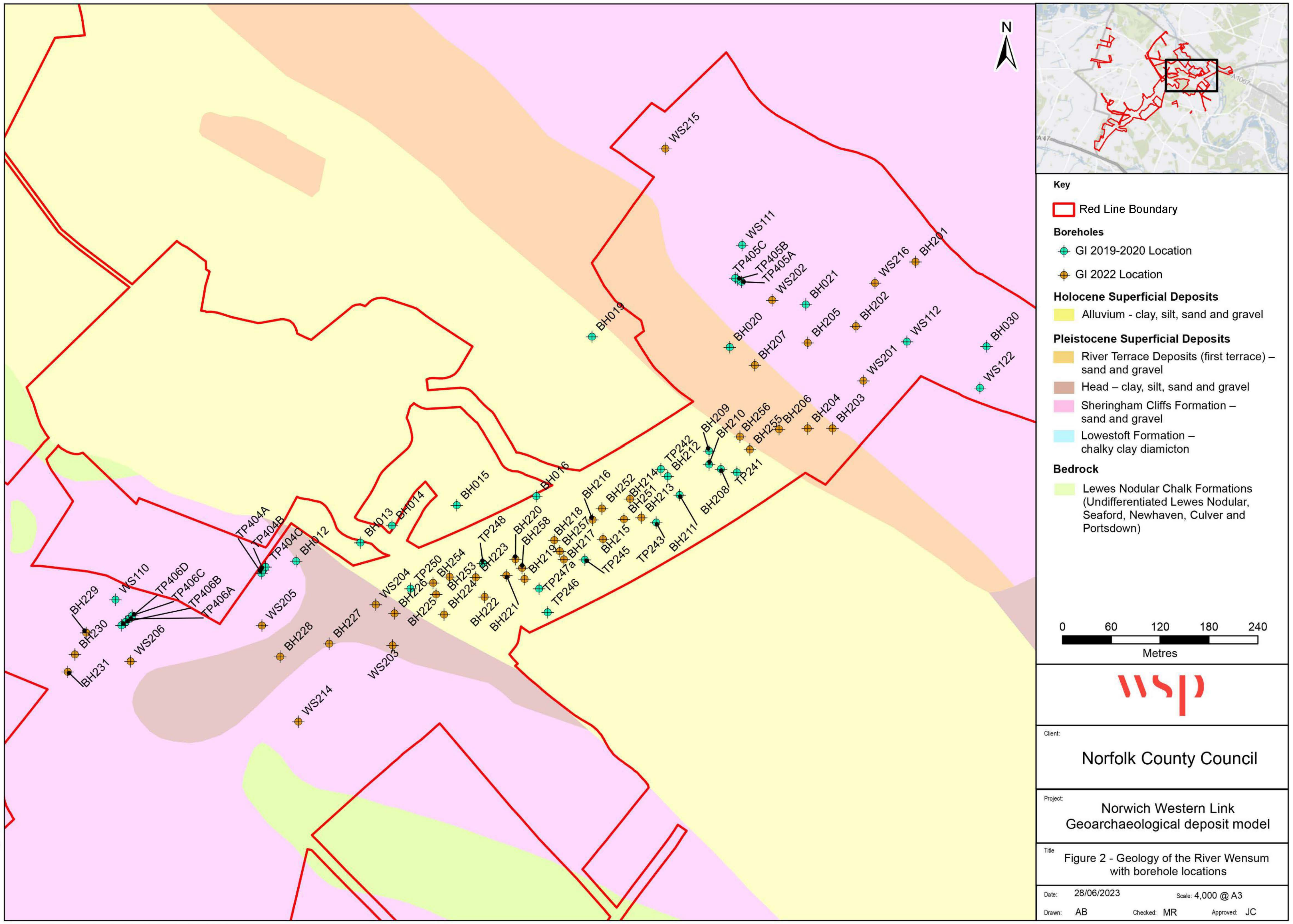

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Figure 3 River Wensum borehole locations, transect plan and local past investigations and proposed SMS mitigation areas

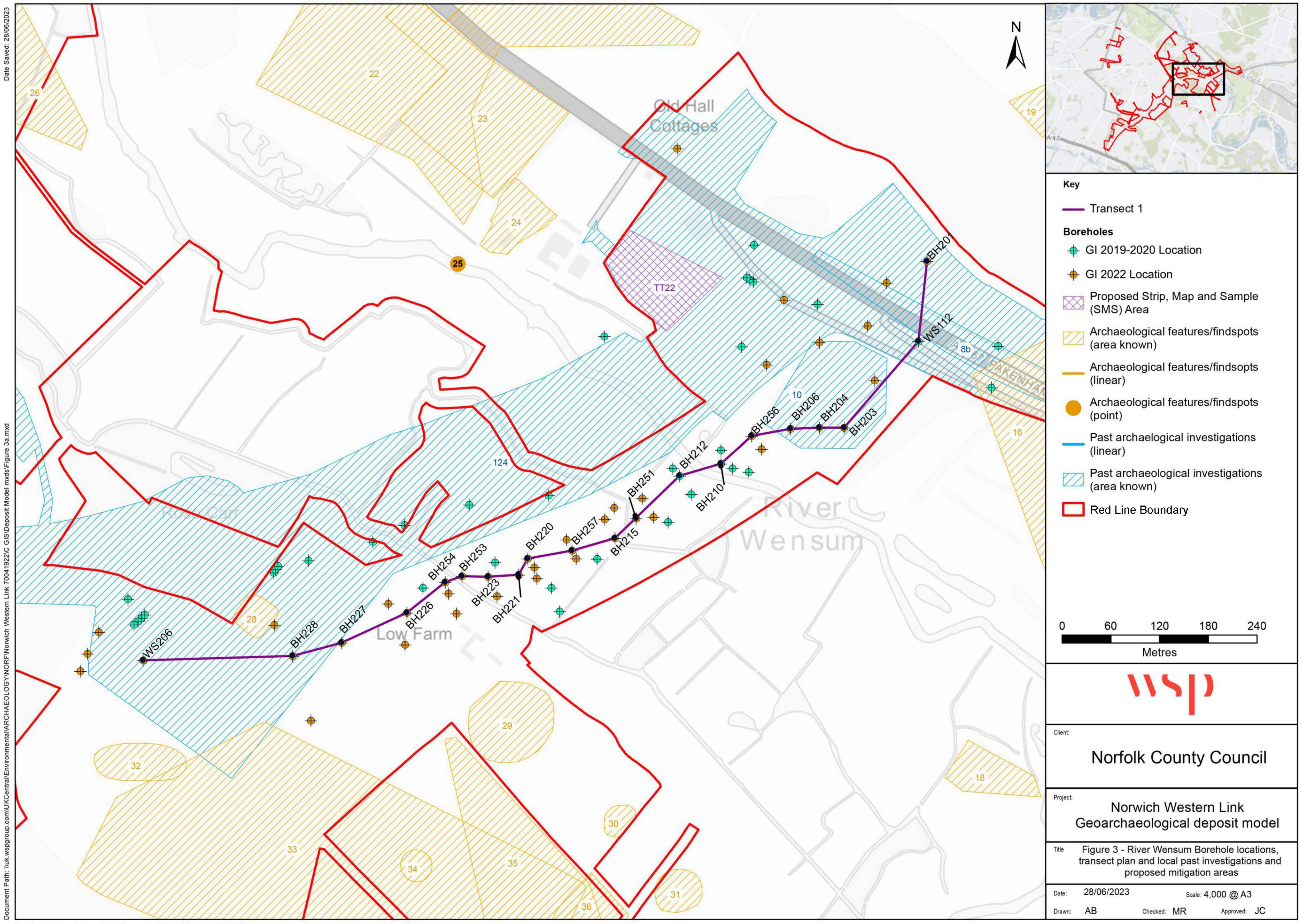

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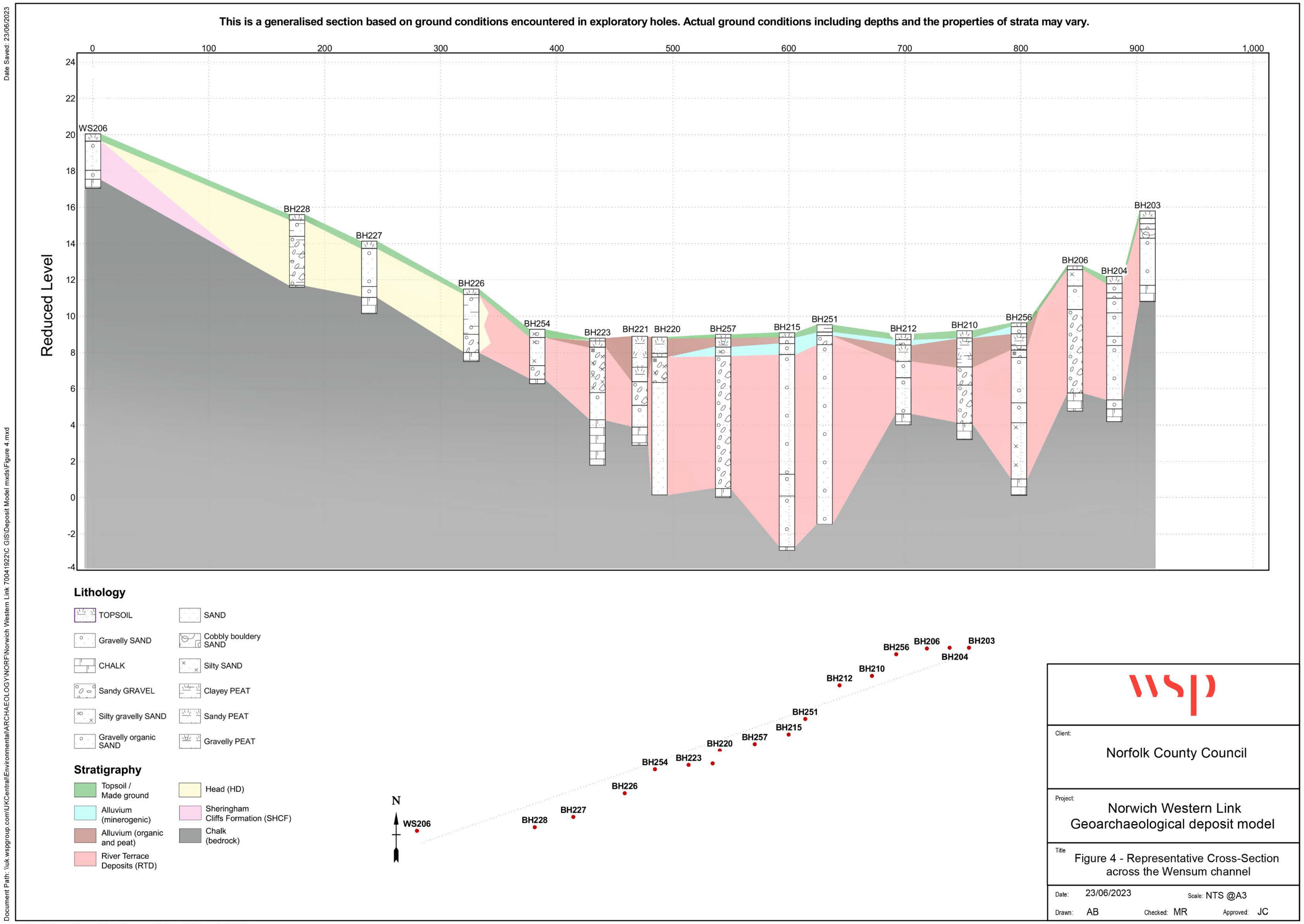
Figure 4 Representative cross-section across the Wensum channel


This is a generalised section based on ground conditions encountered in exploratory holes. Actual ground conditions including depths and the properties of strata may vary.

Client:
Norfolk County Council

Project:
Norwich Western Link
Geoarchaeological deposit model

Title
Figure 4 - Representative Cross-Section
across the Wensum channel

Date: 23/06/2023 Scale: NTS @A3
Drawn: AB Checked: MR Approved: JC

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Figure 5 Surface plot of the Early Holocene surface – base of the Holocene sequence (m OD)

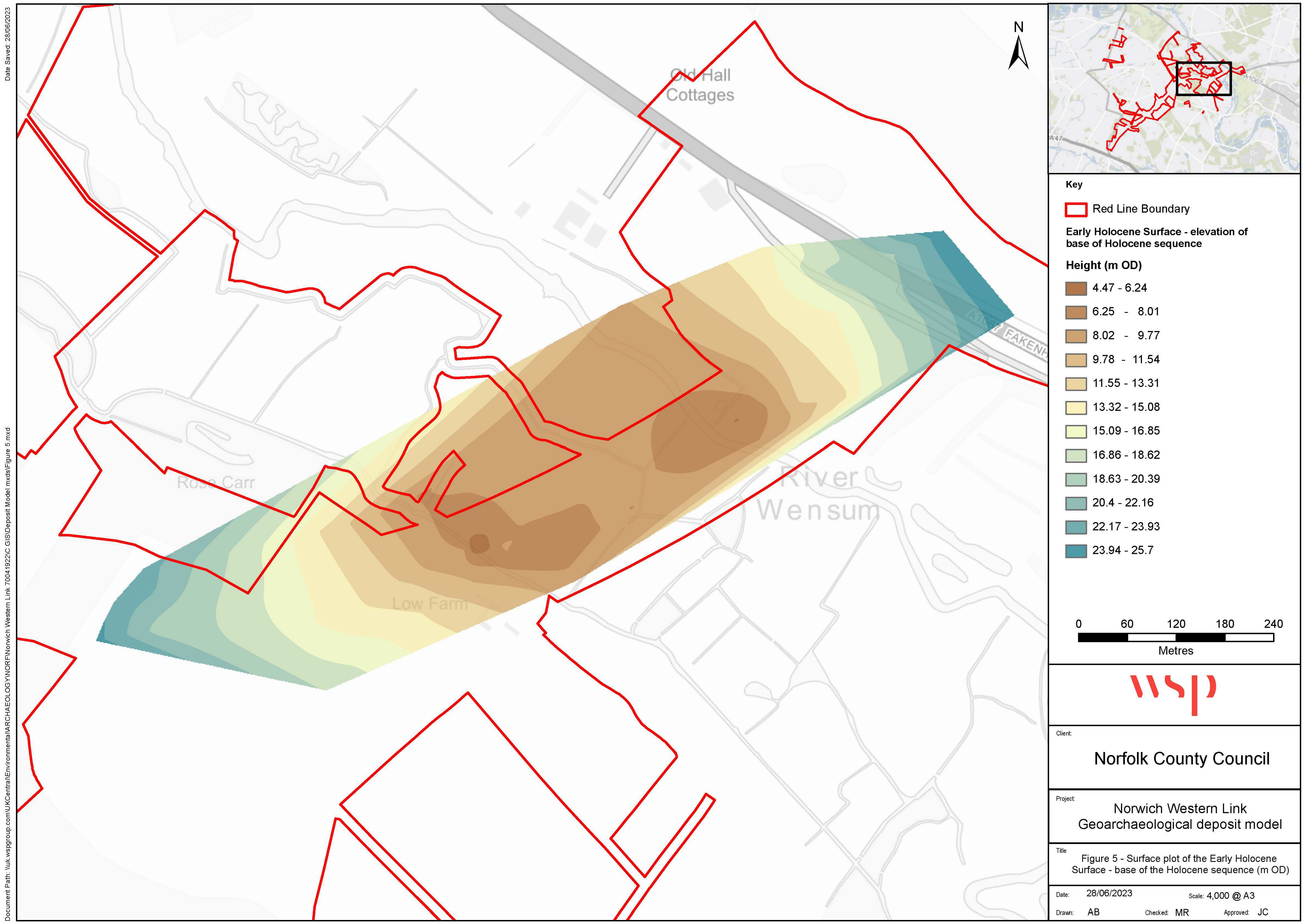

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Figure 6 Thickness and distribution of alluvium and 'peat loam/loamy peat'

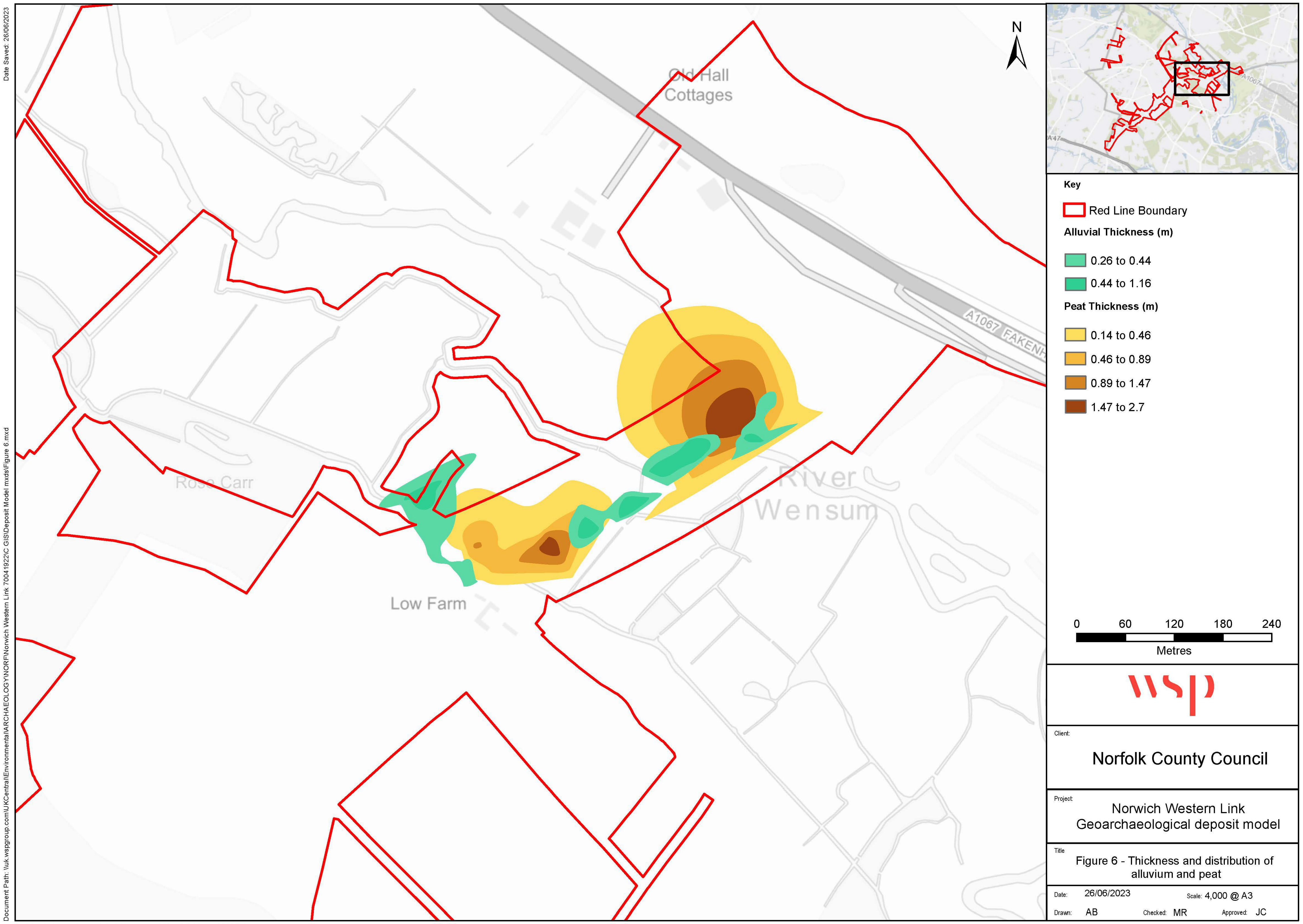

Figure 7 Landscape zones (LZ) of palaeoenvironmental potential

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