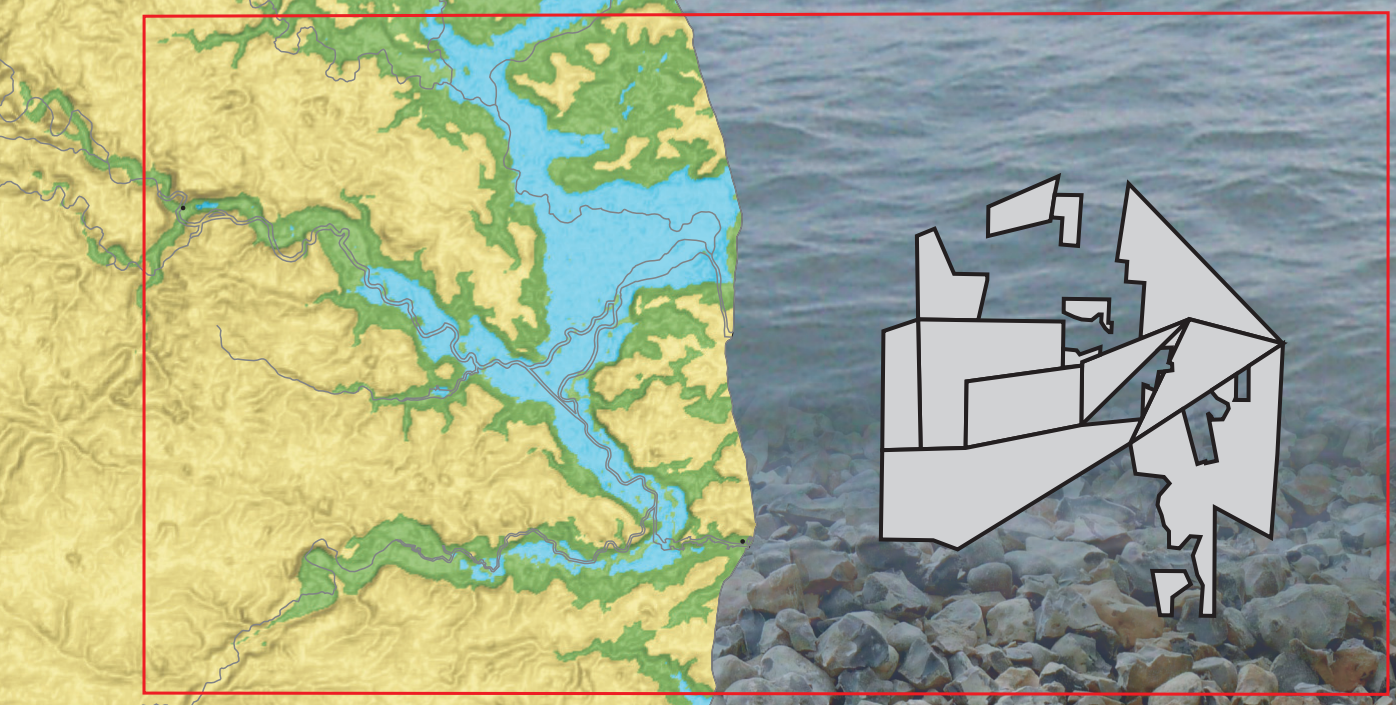
Wessex Archaeology

Palaeo-Yare Catchment Assessment

Technical Report



Ref: 83740.04

January 2013

PALAEO-YARE CATCHMENT ASSESSMENT

TECHNICAL REPORT

Prepared by:

Wessex Archaeology
Portway House
Old Sarum Park
Salisbury
Wiltshire, SP4 6EB

Prepared for:

British Marine Aggregate Producers Association
Gillingham House
38-44 Gillingham Street
London, SW1V 1HU

On behalf of:

The Crown Estate
16 New Burlington Place
London, W1S 2HX

CEMEX UK Marine Limited
Baltic wharf,
Elm Street
Marine Parade
Southampton, SO14 5JF

Hanson Aggregate Marine Limited
Burnley Wharf
Marine Parade
Southampton
Hampshire, SO14 5JF

Tarmac Marine Dredging Limited
UMA House
Shopwhyke Road
Chichester
West Sussex, PO20 2AD

Volker Dredging Limited
Suite A04 Arena Business Centre
Holyrood Close
Poole
Dorset, BH17 7FJ

Ref: 83740.04

January 2013

PALAEO-YARE CATCHMENT ASSESSMENT

TECHNICAL REPORT

Ref: 83740.04

Title:	Palaeo-Yare Catchment Assessment. Technical Report
Principal Author(s):	Louise Tizzard; Andrew Bicket
Managed by:	Euan McNeill
Origination date:	January 2013
Date of last revision:	August 2012
Version:	.04
Wessex Archaeology QA:	Euan McNeill
Status:	Final
Summary of changes:	Minor figure and table edits
Associated reports:	83740.05
Client Approval:	Mark Russell

PALAEO-YARE CATCHMENT ASSESSMENT

TECHNICAL REPORT

Ref: 83740.04

Summary

Wessex Archaeology has been commissioned by the British Marine Aggregate Producers Association on behalf of The Crown Estate, CEMEX UK Marine Limited, Hanson Aggregates Marine Limited, Tarmac Marine Dredging Limited and Volker Dredging Limited, to conduct an assessment of the Palaeo-Yare catchment area, East Anglia. The aim of the project is to delineate, where possible, the regional extents and survival of specific sediment units from which a large number of flint artefacts and faunal remains were recovered. The sediment units and associated finds coincide with a region where long standing production licence areas for marine aggregate dredging have permitted extraction for several decades.

Artefactual material, including handaxes, flakes and cores were recovered, along with faunal remains (including bison, mammoth, horse and reindeer) in 2008 from aggregate extraction Area 240 (licensed to Hanson Aggregates Marine Ltd.), situated approximately 11km off the coast of Great Yarmouth. The place where the finds were recovered is relatively discrete, and the provenance of the artefacts is secure. Once the finds were reported Hanson Aggregates Marine Limited, the licensee, stopped dredging in the immediate area and voluntary implemented a rectangular exclusion zone based on dredger trackplots in accordance with the BMAPA *Protocol for Reporting Finds of Archaeological Interest*.

Further seabed sampling work (funded through the Aggregate Levy Sustainability fund, via English Heritage) and monitoring of dredged material (commissioned by Hanson Marine Aggregate Ltd.) recovered additional flint artefacts. The Middle Palaeolithic Assemblage comprises a total of 124 flint artefacts including 36 handaxes, 9 cores and 79 worked flakes. At least some of the assemblage, including the handaxes, is thought to have been *in situ*. There is also evidence of Levallois technique employed at this site. Interpretation of the geology in Area 240 indicated that the assemblage was most likely recovered from particular floodplain sediments deposited during the early development of the Palaeo-Yare valley.

Given the distribution of artefactual material in Area 240 it was hypothesised that there would be potential in the wider region where there were remnants of Unit 3b deposits. This hypothesis has implications not only for licencing of Area 240 but also licence areas within the wider East Coast region. This was acknowledged by the industry and the aggregate companies. It was also acknowledged that the relationship between the apparently *in situ* archaeological material and the regional context of Unit 3b could not effectively be carried out on a licence by licence area basis. This project was conceived to allow the development of a regional framework which would result in a better understanding of the prehistoric archaeological resource in the region in terms of its distribution, significance and the mitigation effects from dredging.

The aim of the Palaeo-Yare Catchment Assessment project is to map, primarily using existing industry data, the extents of the key Palaeo-Yare deposit (Unit 3b), and to develop hypotheses about the archaeological potential of the region in order to support decisions relating to the assessment and management of future marine aggregate operations.

Specific objectives are as follows:

- Map the extent of the Wolstonian floodplain deposit (Unit 3b) within the offshore aggregate dredging areas;
- Assess the archaeological potential of the offshore catchment area within the offshore aggregate dredging areas;
- Assess the known geology of the Palaeo-Yare onshore and its associations with its offshore extension;
- Assess the available information on the onshore archaeology and its possible associations with the artefacts recovered offshore.

The study area can broadly be defined as encompassing the now onshore, nearshore and offshore reaches of the Palaeo-Yare valley. To the west the study area includes the lower reaches of the Yare, Waveney and Bure rivers from Winterton Ness in the North to Benacre Ness in the South. To the east the study area includes the block of East Coast aggregate dredging licence areas.

Approximately 2,500 line kilometres of sub-bottom profiler data from 22 surveys and 1,171 vibrocore logs were reviewed from 43 separate surveys acquired between 1988 and 2011, the majority of which have been undertaken by the marine aggregate industry. Additionally, approximately 400 onshore borehole logs (supplied by British Geological Survey) were reviewed. Electronic monitoring system data indicating location of dredging within the study area were also assessed. In addition to the geophysical and geotechnical data assessments several sources of cultural heritage data were consulted, primarily to investigate the archaeological record of the onshore region of the study area.

The Palaeo-Yare valley developed at the end of the Anglian Glaciation *c.* 430ka and has continued to develop through to the present day. During cooler periods when sea-levels were lowered sands and gravels were deposited and during warmer climes when the sea-level was higher the lower reaches of the Palaeo-Yare valley was slowly inundated, changing from fluvial, to estuarine and where sea-levels were high enough, shallow marine environments. During these times of high sea-level the upper reaches of the Yare would have remained a river but with some tidal influence.

The main phase of development of the floodplain occurred during the cooling period from MIS 9 interglacial to the MIS 8 glacial (*c.* 300 to 250 ka) and the floodplain continued to develop during this cold phase. It is these sediments, classified as Unit 3b, from which the flint assemblage was dredged in Area 240.

Assessment of the geophysics and geotechnical data indicate that Unit 3b sediments are regionally extensive and are associated with a wide floodplain deposit orientated east-west and 12 km wide (see Executive Summary Figure). Although Unit 3b does not occur throughout the entire block of marine aggregate licence areas, its distribution does extend across a number of individual licence areas within the region. Generally, the floodplain deposits in the west and south are generally thinner than elsewhere, approximately 2 to 4 m thick. Within the channel and to the east the units are generally 2 to 6 m thick.

Archaeologically, the Middle Palaeolithic Assemblage site is important at local, regional and international levels. The assemblage meets several of the criteria set out in the "*Identifying and protecting Palaeolithic remains*" report (English Heritage 1998) in relation to whether Palaeolithic remains have particular importance and can be shown:

- to have remains that are probably undisturbed and in a primary context (prior to dredging);
- to have remains belonging to a period or geographic area where evidence of human presence is particularly rare or previously unknown;

- to have well preserved indicators of the contemporary environment that can be directly related to the remains;
- to have one deposit containing Palaeolithic remains that has a clear stratigraphic relationship with another;
- to comprise abundant artefacts; and
- that the site can be related to the exploitation of a resource, such as a raw material.

Regionally, sites and assemblages of Early Middle Palaeolithic, Levallois technique are a largely absent component of the Palaeo-Yare archaeological record except for the offshore Middle Palaeolithic assemblage. Major sites and lithic assemblages are more prevalent in other areas of England and north-western Europe, during MIS 9, and particularly MIS 8-7. Area 240 is situated to the north of other sites of similar age.

Although the relationship between the distribution of archaeological material and the overall extent of Unit 3b is not known, it is possible that there is the potential for further flint artefacts present in other Unit 3b sediments within the region. However, it is difficult to state how much and where they would be found. Given the extent of Unit 3b, it seems unlikely that archaeological material is distributed evenly across Unit 3b deposits. It is more likely that cultural processes during the Palaeolithic, in combination with than geological process, are responsible for the distribution of the archaeological material.

Natural reworking of Unit 3b sediments by both marine and terrestrial processes are observed in the data and impact the potential for the presence of *in situ* archaeological material. For example, in Areas 319 and west 251 there has been removal of Unit 3b, partly due to dredging, but more due to re-working in the area due to the re-development and development of an Early Holocene channel.

There is evidence on the geophysical data where Unit 3b has been removed or heavily reworked through dredging activity. Modification by dredging activity also impacts potential for the recovery of *in situ* material. Comparison between the remnants of Unit 3b and known dredging activity (1993 – 2011) indicates that there are areas where the unit has been dredged heavily and possibly entirely removed, areas that have been dredged to low or moderate intensity and areas where no known dredging has occurred.

There are also areas where Unit 3b and any potential *in situ* material are preserved from dredging activity. In the east of the region a large bank structure overlying Unit 3b. Unlike elsewhere in the region, the bank is the target aggregate, not Unit 3b.

There are, of course, remaining uncertainties when considering the potential for archaeological material to be located within the region, principally regarding the location of archaeological material and also the extent of Unit 3b from which archaeological material may be recovered due to the age of the assessed datasets and dredging activity.

These uncertainties can only be addressed with further investigation of the region. Although up-to-date geophysics data in some areas may reduce the uncertainty in defining the extents of Unit 3b, this data would not help in assessing the uncertainties regarding the potential for archaeological material. This can only be achieved by further monitoring of the aggregate recovered in the East Coast region.

Based on the results of the Palaeo-Yare archaeological assessment there are a number of key conclusions with reference to the potential for the presence of archaeological material within the wider licence area:

- The Middle Palaeolithic Assemblage is mixed, *i.e.* contains artefacts of *in situ* and secondary context.
- The Middle Palaeolithic Assemblage is primarily associated with Unit 3b within Area 240.
- There is potential for palaeolithic material in secondary context associated with Units 2, 3b, 4, 7, 8 and the bank structures (of unknown age).
- Natural processes throughout transgressions and regressions subsequent to deposition have not completely removed sediment units. With regards to the *in situ* elements of the Middle Palaeolithic assemblage, remnants of *in situ* Unit 3b sediments are present within the region.
- Extensive dredging of the region has not necessarily completely removed Unit 3b sediments within the area.
- There is potential for *in situ* archaeological material to be present elsewhere within the region where remnants of Unit 3b are located.
- Faunal remains and palaeoenvironmental material are likely to be sourced from Units 2, 3b, 4 and 7. These could be *in situ* or secondary context and may be located throughout the region.
- Uncertainties remain due to the data limitations used for the assessment and the degree of dredging undertaken since the geophysics data were acquired.

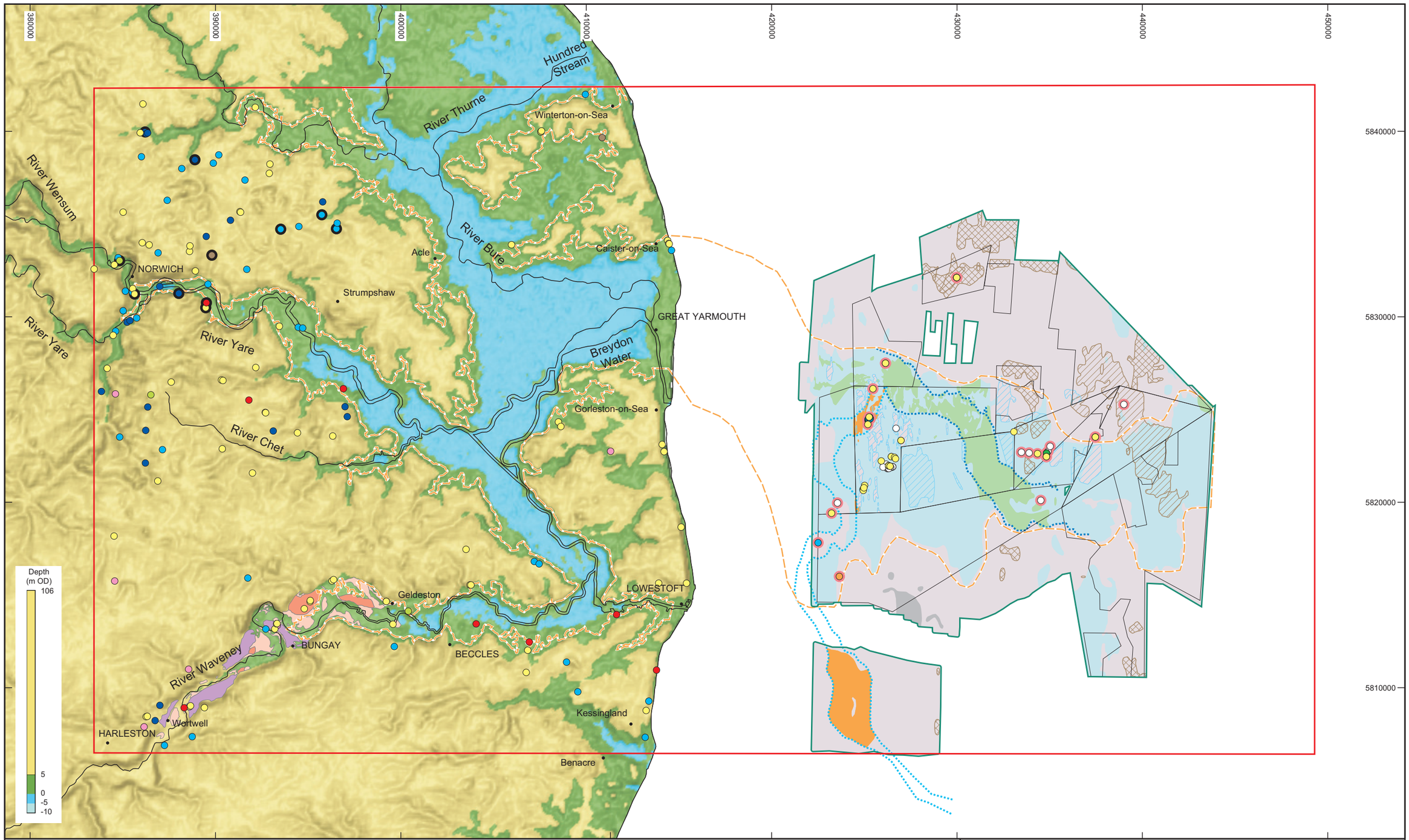
A set of hypotheses have been developed that can be applied to the licence areas within the region in order to test these key conclusions. It is envisioned that these hypotheses will be tested through physical sampling and monitoring of dredge loads from the licence areas as detailed in the *Provisional Written Scheme of Investigations for the Anglian Region*. Certain licence areas will lend themselves to certain hypotheses. For the short-term licence applications the hypotheses are dealt with on a licence area basis and are detailed in the addendum report that accompanies this document (Wessex archaeology 2012a).

Hypotheses:

Inhabitation	**H1a**: Palaeolithic material is recovered only from Unit 3b, which dates to the Wolstonian. **H1b**: Palaeolithic material recovered from Unit 3b is predominantly *in situ*.
Choice and use of location	**H2a**: Palaeolithic material is recovered only from Unit 3b deposits on the margin of Channel A, not within the Channel itself. **H2b**: Palaeolithic material is recovered only from Unit 3b deposits within the limits of the Palaeo-Yare floodplain, and not within the Unit 3b outliers to the north and south of the floodplain **H2c**: The recovery of Palaeolithic material is clustered in relatively large quantities in discrete locations; material is not recovered from otherwise similar locations.
Natural processes	**H3a:** The distribution of recovered Palaeolithic material does not vary according to variations in the sediment structure of Unit 3b. **H3b:** Palaeolithic material is not recovered where Unit 3b appears to have been reworked by natural processes in the past. **H3c**: Palaeolithic material is not recovered where Unit 3b appears to be covered by major bank structures.
Dredging History	**H4a**: Palaeolithic material is not present where the dredging history indicates that a high level of dredging has taken place since the introduction of EMS. **H4b**: Palaeolithic material is not present where geophysical data indicates that a high level of dredging has taken place.

Operation Sampling methods	**H5a**: Palaeolithic material is found at all wharves where Operational Sampling takes place

These hypotheses provide a basis for structured monitoring of aggregate areas within the East Coast Region. The information resulting from these hypotheses will enhance the knowledge of the presence of Palaeolithic material in the area and will inform the continuing monitoring activity in the licence areas.



Study Area (SA)
Licence Dredging Areas
Survey Area

Drawing projection: UTM WGS84 z31N.

Wessex Archaeology

Reworked bank
Bank feature (unknown age)
Unit 7
Unit 4
Unit 3b removed/heavily effected due to dredging

0 10 km

Unit 3b
Unit 2
Unit 1

Extents of Late Anglian channel (Channel A)
Extents of Early Holocene channel (Channel B)
Limits of Palaeo-Yare valley

River terraces:
Floodplain Terrace
Broome Terrace
Homersfield Terrace

Lower Palaeolithic
Middle Palaeolithic
Upper Palaeolithic
Palaeolithic
Palaeolithic / Mesolithic

Early Mesolithic
Mesolithic
Mesolithic / Neolithic
Prehistoric
Unknown
Lithic working sites
Faunal or environmental

Date:	14/08/12	Revision Number:	0
Scale:	1:200,000 @A3	Illustrator:	KJF
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-05-22		

Palaeogeography and known archaeology associated with the Palaeo-Yare

Figure ES

PALAEO-YARE CATCHMENT ASSESSMENT

TECHNICAL REPORT

Ref: 83740.04

Acknowledgements

Wessex Archaeology (WA) has been commissioned by British Marine Aggregate Producers Association (BMAPA) to conduct an assessment of the Palaeo-Yare catchment area, East Anglia. Wessex Archaeology would like to thank Mark Russell (BMAPA) for his assistance throughout the project and Dr Antony Firth of Fjordr Ltd for his contribution.

Wessex Archaeology would particularly like to thank the licensees for their support in providing the data for their respective licences and also providing details on the dredging history of the area. Thanks to Dr Andrew Bellamy (Tarmac Ltd), Will Drake (Volker Dredging Ltd.), Graham Singleton, Dr Rebecca Westlake and Joe Holcroft (CEMEX UK Marine Ltd) and Nigel Griffiths, Emma Beagley, Laura Humphries and Amy Stewart (Hanson Aggregates Marine Limited).

Also, thanks to Royal Haskoning for supplying the Electronic Monitoring System (EMS) data.

Dr Louise Tizzard and Dr Andy Bicket prepared the report with contribution from Nic Bigourdan and Jack Russell. Kitty Foster prepared the illustrations and the project was managed and QA'd by Euan McNeill.

Data Licences

PALAEO-YARE CATCHMENT ASSESSMENT

TECHNICAL REPORT

Ref: 83740.04

Contents

1. INTRODUCTION 1
1.1. PROJECT INTRODUCTION 1
1.2. STUDY AREAS 1
1.3. RATIONALE 1
1.4. AIMS AND OBJECTIVES 5
1.5. DEFINITIONS 5
2. DATA ASSESSMENT METHODOLOGY 6
2.1. INTRODUCTION 6
2.2. DATA AUDIT 6
2.3. GEOPHYSICAL ASSESSMENT 6
Interpretation Methodology 7
2.4. GEOTECHNICAL ASSESSMENT 7
2.5. DREDGING HISTORY 8
2.6. DATA CONSIDERATIONS 10
Geophysical Data 11
Geotechnical Data 11
2.7. INTEGRATION WITH AREA 240 INTERPRETATION 12
2.8. CULTURAL HERITAGE ASSESSMENT 12
Introduction 12
Cultural Heritage Data 13
Summary of Archaeological Material 14
3. OVERVIEW OF PALAEOGEOGRAPHY AND ARCHAEOLOGY 17
3.1. INTRODUCTION 17
3.2. PRE-YARE VALLEY PALAEOGEOGRAPHY 19
Pre-Anglian (MIS 13 upwards; >480 ka) 19
Anglian Glaciation (MIS 12; 480 – 423 ka) 21
3.3. DEVELOPMENT OF THE PALAEO-YARE: PLEISTOCENE (MIS 12 – MIS 2; 430 KA – 13,500 BP) 22
Overview 22
Late Anglian (MIS 12; ~430 ka) 22
Yare Valley Formation and River Terraces 24
Hoxnian (MIS 11; 420 – 380 ka) 25
Wolstonian (MIS 10 – 6; 380 – 130 ka) 26
Ipswichian (MIS 5e; 130 – 110 ka) 27
Devensian (MIS 5d – MIS 2; 110 ka – 13,500 BP) 28
3.4. DEVELOPMENT OF THE PALAEO-YARE: LATE DEVENSIAN (MIS 2; 13,500 BP) AND HOLOCENE (MIS 1) 30
3.5. SUMMARY 33
4. PALAEO-YARE AND THE MIDDLE PALAEOLITHIC ASSEMBLAGE 34
4.1. INTRODUCTION 34
4.2. PALAEOGEOGRAPHY 34
4.3. ARCHAEOLOGY 36
Middle Palaeolithic Assemblage 36

Faunal remains 38
Known and Potential for Palaeolithic Sites in the Upstream Palaeo-Yare Valley 40
Wider Early Middle Palaeolithic (EMP) Context 41
Archaeological Significance of the Middle Palaeolithic Assemblage 42
4.4. POTENTIAL FOR FURTHER ARTEFACTS IN THE EAST COAST DREDGING REGION 43
Potential in original deposition 43
Subsequent modification by natural processes 44
Subsequent modification by human processes; dredging history 44
Target aggregate 45
Remaining uncertainties 45
5. CONCLUSIONS AND FURTHER WORK 46
5.1. KEY CONCLUSIONS 46
5.2. HYPOTHESES 46
Inhabitation 47
Choice and use of location 47
Natural processes 47
Human processes, including dredging history 48
Operational sampling methods 48
6. REFERENCES 49
APPENDIX I: GEOPHYSICS DATASETS 56
APPENDIX II: GEOTECHNICAL DATASETS 62
APPENDIX III: GAZETTEER OF KNOWN ARCHAEOLOGY 68
APPENDIX IV: MIDDLE PLEISTOCENE, LOWER AND MIDDLE PALAEOLITHIC SITE CONTEXT TO AREA 240. 87

Tables

Table 1 Interpretation of geological units identified during the Seabed Prehistory Project (Wessex Archaeology 2011a) **3**
Table 2 Distribution of documentary sources consulted for the terrestrial SA assessment **14**
Table 3 Archaeological Periods associated with documentary sources in the SA **15**
Table 4 Site Types associated with the documentary sources in the SA **15**
Table 5 Geological associations reported for finds in the SA with tentative correlations to the identified offshore units **16**
Table 6 Radiocarbon ages of Breydon Formation (Unit 7) **31**
Table 7 Geological associations reported for finds in the SA with tentative correlations to the identified offshore units (Unit 7) **33**
Table 8 OSL ages of channel and floodplain deposits (Unit 3b) **35**
Table 9 Composition of the Middle Palaeolithic Assemblage **37**
Table 10 Radiocarbon dates of faunal remains recovered from Area 240 **39**

Figures

Executive summary Palaeogeography and known archaeology associated with the Palaeo-Yare
Figure 1 Location map
Figure 2 Overview and schematic illustrating the development of the channel and floodplain (based on Wessex Archaeology 2011a)
Figure 3 Assessed datasets
Figure 4 Table illustrating age of datasets assessed during the project
Figure 5 Dredging analysis based on EMS data
Figure 6 Known archaeology within the SA

Figure 7 Sea-level curve, dating results and overview of the Palaeo-Yare catchment interpretation
Figure 8 Palaeogeographic regional reconstruction: Pre-Anglian
Figure 9 Remains of pre-Anglian sediment units (Units 1 and 2) in the SA
Figure 10 Palaeogeographic regional reconstruction: Late Anglian (MIS 12) to Devensian (MIS 2)
Figure 11 Profile illustrating the base of the Palaeo-Yare valley
Figure 12 Remains of Wolstonian (Unit 3b) sediments in the SA
Figure 13 Remains of early Devensian (Unit 4) sediments in the SA
Figure 14 Palaeogeographic regional reconstruction: Holocene (MIS 1) (after Shennan *et al.* 2000)
Figure 15 Remains of early Holocene channel development and deposits (Unit 7) in the SA
Figure 16 Palaeogeography and known archaeology associated with the Palaeo-Yare
Figure 17 Example of Palaeo-Yare floodplain deposits (Unit 3b)
Figure 18 Example of the relationship between Unit 3b and Unit 4 in the Late Anglian channel (Channel A)
Figure 19 Example of the major bank structure and erosion of Unit 3b
Figure 20 Location of the Middle Palaeolithic Assemblage
Figure 21 Middle Pleistocene, Lower and Middle Palaeolithic Site context to Area 240 site: Sites dating to MIS 8 and 7 are highlighted
Figure 22 Wolstonian sediment (Unit 3b) and known aggregate dredging distribution in aggregate licence areas

PALAEO-YARE CATCHMENT ASSESSMENT

TECHNICAL REPORT

Ref: 83740.04

1. INTRODUCTION

1.1. PROJECT INTRODUCTION

1.1.1. Wessex Archaeology has been commissioned by British Marine Aggregate Producers Association on behalf of The Crown Estate, CEMEX UK Marine Limited (CEMEX), Hanson Aggregates Marine Limited (HAML), Tarmac Marine Dredging Limited (TMDL) and Volker Dredging Limited (VDL), to conduct an assessment of the Palaeo-Yare catchment area, East Anglia. The aim of the project is to delineate, where possible, the regional extents and survival of specific sediment units from which a large number of flint artefacts and faunal remains were recovered in 2007/2008 and artefacts subsequently recovered between 2009 and 2011. The sediment units and associated finds coincide with a region where long standing production licence areas for marine aggregate dredging have permitted extraction for several decades.

1.1.2. Previous work relevant to this assessment includes work conducted in the Aggregate Dredging Licence Area 240 (Wessex Archaeology 2011a) on behalf of English Heritage (EH), funded by Aggregate Levy Sustainability Fund (ALSF) and work commissioned by HAML which involved a programme of archaeological monitoring within Licence Area 240 (Wessex Archaeology 2011b).

1.2. STUDY AREAS

1.2.1. The study area (SA) in question can broadly be defined as encompassing the now onshore, nearshore and offshore reaches of the Palaeo-Yare valley. To the west, the SA includes the lower reaches of the Yare, Waveney and Bure rivers from Winterton Ness in the north to Benacre Ness in the south. To the east, the SA includes the block of aggregate dredging licence areas (current and relinquished). The SA is illustrated in **Figure 1**.

1.3. RATIONALE

1.3.1. In 2007/2008, 88 Palaeolithic artefacts, including handaxes, flakes and cores as well as a series of bones (woolly mammoth, woolly rhino, bison, reindeer and horse) were discovered by Mr Jan Meulmeester in stockpiles of gravel at the SBV Vlissingen (Flushing) Wharf. The finds were identified from stockpiles and reject piles between the 7th December 2007 to the 18th March 2008, dredged from the dredging Licence Area 240 between the 7th December 2007 and 5th February 2008. The fresh condition of some of the handaxes indicated that they came from relatively undisturbed deposits.

1.3.2. The discovery of the finds were reported to English Heritage (EH) and through the BMAPA *Protocol for Reporting Finds of Archaeological Importance* (BMAPA and EH 2005). The place where the finds were dredged was relatively discrete, dredged

specifically for aggregates for SBV Flushing. The correlation between the inspected stockpiles and the source of the aggregate, confirmed by the correspondence between the dates of his visits and the dates of aggregate dredging in Area 240, means that the provenance of the artefacts is secure. Moreover, a review of trackplots of dredging for the relevant dates has established the extent of a quite limited geographical area within which the artefacts are most likely to have been recovered.

1.3.3. Once the finds were reported HAML, the licensee, stopped dredging in the immediate area and voluntary implemented a rectangular exclusion zone based on dredger trackplots in accordance with the BMAPA *Protocol for Reporting Finds of Archaeological Interest* (**Figure 1**).

1.3.4. An assessment of the flint assemblage was carried out by Dr Dimitri De Loecker of the University of Leiden (De Loecker 2011). The assemblage comprised a total of 33 handaxes, 47 complete and fragmented flakes and flake tools, and 8 cores.

1.3.5. The condition and quality of the flint artefacts show that the material originates from several contexts. However, it is likely that some of the flint artefacts were dredged from undisturbed deposits. Generally, accumulated evidence of early human activity (a palimpsest) is suggested (De Loecker 2011). The flint raw material used is homogenous in character and was sourced from exposed gravel bar river deposits (De Loecker 2011).

1.3.6. The assessment of the 33 handaxes revealed that the assemblage is homogenous and show a considerable amount of workmanship. The handaxes are of cordiform or sub-cordiform type and can be described as Acheulean or as Mousterian of Acheulean Tradition (MAT) (De Loecker 2011).

1.3.7. The faunal remains were assessed by Mr Jan Glimmerveen in Holland. Initial radiocarbon dating of a number of bones returned dates of between 31,000 and 43,000 BP and approximately 70 % of the bones recovered have been attributed to this date. The remaining 30 % are heavily fossilised and at the time it was estimated that the majority were thought to be older than 500 ka (J. Glimmerveen, pers. com. 21/07/2010).

1.3.8. Between October 2008 and March 2011 Wessex Archaeology undertook a multi-disciplinary project (*Seabed Prehistory: Site Evaluation Techniques (Area 240)*) with the aim of improving the future management of the potential effects of aggregate dredging on the marine historic environment by developing techniques to evaluate the source of prehistoric artefactual material discovered in the East Coast region. The project included the acquisition and interpretation of geophysical data, geotechnical data, seabed sampling, vibrocoring, palaeoenvironmental assessment, analysis and dating (Wessex Archaeology 2011a).

1.3.9. The assessment of prehistoric character of Area 240 has revealed a complex history of deposition and erosion. Eight sediment units were identified, dating from the Late Pliocene/Early Pleistocene to marine deposits associated with the last transgression in the Holocene (**Table 1**). The area is dominated by two channel features, one dating to the Late Anglian (*c.* 430 ka), the other an Early Holocene shallow meandering channel infilled with peats, deposited as late as *c.*7800 BP. Although two channel features are observed they are effectively part of the same system, interpreted as the offshore extension of the Palaeo-Yare Valley system.

Unit	Interpretation	Age	Description
8	Marine deposits associated with the last transgression in the Holocene	Holocene	Shelly, gravelly medium to coarse sand.
7	Basal fill of a shallow under-filled channel feature (equivocal to onshore lower Breydon Formation)	Early Holocene	Only observed to the northwest of Area 240 and also a small patch in the south western corner. It comprises a basal unit of peat approximately 0.2 m thick overlain by a unit of sandy or shelly clay. Infilling of Channel B.
6	Glaciofluvial alluvium	Possibly mid-Devensian	Sandy gravel.
5	Possibly represents an estuarine or near coastal depositional environment	Unknown, possibly contemporary with unit 6	Slightly gravelly, slightly silty, fine to medium grained sand infilling depressions.
4	Brown Bank Formation	Early Devensian (110 – 75 ka)	Unit 4 is a very distinctive unit generally associated with the buried channel feature in the north of Area 240 interpreted as the infilling of a cut sequence. It is comprised of fine-grained sediments (sands, silts and clays) deposited in a low-energy environment such as river or estuary.
3b	Reworked glaciofluvial outwash	Wolstonian glaciation (380 to 130 ka)	Unit 3b overlies Unit 3a in the channel and directly overlies Unit 2 throughout the central and western area. It is comprised of sands and gravels.
3a	Reworked glaciofluvial outwash	Wolstonian glaciation (380 to 130 ka)	A channel (Channel A) infill deposit that is associated with a channel feature probably cut into Unit 2 during the Late-Anglian glaciation. Unit 3a is the deepest, and oldest, fill primarily associated with the channel feature in the northeast and comprises gravel and sand.
2a/b	Yarmouth Roads Formation	Cromerian period (478 to 787 ka)	Unit 2a generally comprises silty, gravelly, fine to coarse sands. Observed throughout the majority of Area 240 and generally overlies Unit 1.To the south of Area 240 Unit 2b comprises silty sand with very frequent thin beds and laminae of firm to stiff clay and peaty organic clay.
1	Westkapelle Ground Formation	Pliocene/Early Pleistocene	The deepest unit and is observed across Area 240

Table 1: Interpretation of geological units identified during the Seabed Prehistory Project (Wessex Archaeology 2011a)

1.3.10. **Figure 2** is a schematic illustrating the development of the Middle Pleistocene channel (Channel A) and deposition of sediments based on the Area 240 interpretation and a map that illustrates the lateral extent of remnant sediment units within the area. The evidence suggests that Area 240 has been an outer estuarine or coastal location which could have been suitable for use by humans and animals alike, during repeated periods of known occupation.

1.3.11. During the seabed sampling phase of the *Seabed Prehistory* project a further 11 worked flakes were recovered from the southern half of the exclusion zone. The

worked flint were recovered using a clamshell grab with samples acquired from 31 locations along three transects. A total of 19 tons of sediments were processed (sieved to 10mm, with sub-samples sieved to 4mm). Although the number of flints recovered was low due to the methodology, the recovery of worked flint indicated that there was potential for further artefacts and that the sediment containing artefacts had not been completely removed by dredging activities.

1.3.12. During June 2009, prior to the seabed sampling phase of the *Seabed Prehistory* project, a piece of worked flint was recovered from a clamshell grab sample during the East Coast Regional Environmental Characterisation (EC REC) survey (Limpenny *et al.* 2011). The grab targeted sediments within the voluntary exclusion zone and confirmed the potential for further artefacts to be found.

1.3.13. The flint artefacts are interpreted as being principally associated with a specific glaciofluvial sediment Unit 3b. Deposited during the Wolstonian (MIS 8/7), Unit 3b forms a floodplain deposit of Channel A (Wessex Archaeology 2011a).

1.3.14. Further work carried out by WA for HAML comprised a programme of archaeological monitoring of aggregate dredging within dredging licence Area 240 and its subsequent processing in Holland (Wessex Archaeology 2011b). The project was undertaken with agreement with EH with the aims of:

- trialling methods of bulk sampling the seabed using standard aggregate dredging plant with the goal of intercepting artefactual material in industrial processes for the purposes of evaluation;
- evaluating the presence/absence, distribution, character, quality and preservation of Palaeolithic artefacts within the Area 240 and specifically within the established exclusion zone.

1.3.15. Dredged material was assessed on the dredger, on the plant at the sorting table and the oversize stockpile. A total of 24 flint artefacts, including three handaxes, were recovered from the eight dredge loads (*c.* 40,000 tons) and confirmed the association of worked flint with the Wolstonian floodplain deposit. Monitoring of the dredged material indicated that archaeological material were present in the southern half of the exclusion zone and in dredging lanes situated to the east, indicating a possible wider distribution of material, than originally recovered.

1.3.16. The project concluded that in terms of the specific management of Area 240 it would seem appropriate to follow a combined approach of both managed access and monitoring, developed in consultation with EH.

1.3.17. The flint artefacts from the original discovery and the flints recovered during clamshell grab sampling and during the monitoring of dredging activity are, henceforth, referred to as the Middle Palaeolithic Assemblage and are described in more detail in **Section 4**.

1.3.18. Given the distribution of artefactual material in Area 240 it was hypothesised that there would be potential in the wider region where there were remnants of Unit 3b deposits. This is supported by the small number of finds reported through the Marine Aggregate Industry *Protocol for Reporting Finds of Archaeological Interest*. Interpretation of the geology of Area 240 suggested that Unit 3b extended into adjacent licence areas, but it was not known how regionally extensive this unit was.

1.3.19. As such, the presence of the Middle Palaeolithic Assemblage in Area 240 and the association with specific deposits (Unit 3b) has implications not only for licencing of

Area 240 but also licence areas within the wider East Coast region. This was acknowledged by the industry and the aggregate companies.

1.3.20. It was also acknowledged that the relationship between the apparently *in situ* archaeological material and the regional context of Unit 3b could not effectively be carried out on a licence by licence area basis. This project was conceived in order to allow the development of a regional framework which would result in a better understanding of the prehistoric archaeological resource in the region in terms of its distribution, significance and the mitigation effects from dredging.

1.4. AIMS AND OBJECTIVES

1.4.1. The aim of the project is to map, primarily using existing industry data, the extents of the key Palaeo-Yare deposit (Unit 3b), and to develop hypotheses about the archaeological potential of the region in order to support decisions relating to the assessment and management of future marine aggregate operations.

1.4.2. The mapping and assessment of archaeological potential will be based on the primary research carried out in Area 240, but extended into the other licence areas using geophysical and geotechnical data acquired previously on behalf of aggregate companies. In addition, information about the early prehistory of the upper (currently onshore) reaches of the Yare valley will be examined to better understand the archaeological potential of the catchment as a whole.

1.4.3. Specific objectives are as follows:

- Map the extent of the Wolstonian floodplain deposit (Unit 3b) within the offshore aggregate dredging areas;
- Assess the archaeological potential of the offshore catchment area within the offshore aggregate dredging areas;
- Assess the known geology of the Palaeo-Yare onshore and its associations with its offshore extension;
- Assess the available information on the onshore archaeology and its possible associations with the artefacts recovered offshore.

1.5. DEFINITIONS

1.5.1. Difficulties are encountered when attempting to describe a single catchment system which is now situated in both an onshore and offshore context. As such, a number of definitions have been used throughout the report in order to describe and navigate particular areas of the SA.

1.5.2. The SA refers to the area on which the archaeological assessment is focussed. This includes the lower catchment of the Rivers Waveney, Yare and Wensum and Breydon Water extending 30 km west of the coastline between Winterton-on-Sea in the north and Benacre in the south. The SA extends 35 km east of the present-day coastline and encompasses the offshore aggregate licence areas.

1.5.3. A single SA has been employed as the Palaeo-Yare is a single system irrespective of its present-day situation. An onshore SA and an offshore SA has not been utilised as this implies a distinct, but artificial boundary. However, it is difficult to describe the area and not refer to the present-day situation. As such, “onshore” refers to the present-day terrestrial section of the SA. “Offshore” or “now submerged” are terms used to describe the marine SA. “Nearshore” is used to

define the area to the east of the coastline and west of the aggregate dredging areas.

1.5.4. Survey areas and appropriate licence aggregate area numbers are used to describe particular features within the aggregate licence areas.

2. DATA ASSESSMENT METHODOLOGY

2.1. INTRODUCTION

2.1.1. Numerous datasets have been used to assess the palaeogeography and archaeology of the Palaeo-Yare catchment area. Principally, within the aggregate extraction block the data assessed were supplied by the licensees, supplemented by data previously acquired during surveys in the region. The data comprised geophysical data (sub-bottom profiler and bathymetry data) and geotechnical data in the form of vibrocore logs and photographs. The sub-bottom profiler data were interpreted to map the structure of sub-surface features, such as channels and infill sediments, and the vibrocores were integrated into the geophysical interpretation providing details on sediment composition.

2.1.2. The licensee data were supplemented with sediment data from the British Geological Survey (BGS) Onshore Borehole Viewer and details on the geology from secondary sources.

2.1.3. In addition to the known archaeology recovered from part of Area 240, further archaeological records were reviewed to assess the archaeological potential of the Palaeo-Yare catchment area.

2.2. DATA AUDIT

2.2.1. In October 2011 WA submitted a preliminary audit of the available geophysical and geotechnical data available for the SA (Wessex Archaeology 2011c).

2.2.2. The aim of the data audit was to determine and assess the nature, quantity and quality of existing data available to undertake more comprehensive mapping of the Palaeo-Yare and gain a greater insight into the significance of the archaeological deposits within it to inform aggregate licensing.

2.2.3. The audit was informed by various sources, including WA's previous projects in the area, the dredging area licensees, the BGS, BMAPA and EH datasets.

2.2.4. A substantial existing body of geophysical and geotechnical data were identified within areas of aggregate extraction and in the surrounding region, including over 2000 line km of seismic survey data and 528 vibrocores in the SA which have not previously been examined by WA, alongside a number of relevant supplementary datasets and secondary sources.

2.3. GEOPHYSICAL ASSESSMENT

2.3.1. Approximately 2,500 line km of sub-bottom profiler data from 22 surveys were reviewed as part of this assessment. The datasets were acquired between 1989 and 2011.

2.3.2. Approximately 2,900 line km were provided by the licensees for the areas covering the aggregate dredging areas and approximately 2,400 line km were assessed as

part of this project; approximately 500 line km of data were reviewed recently by WA, either as part of the *Seabed Prehistory* project (Wessex Archaeology 2011a) or a recent aggregate area evaluation report conducted for VDL in Area 228 (Wessex Archaeology 2011d).

2.3.3. The sub-bottom profiler data were generally provided to WA as paper rolls. The data were supplemented by the survey reports which provided survey technical specifications.

2.3.4. Additionally, 850 line km of data acquired during the EC REC (Limpenny *et al.* 2011), 120 line km acquired as part of the East Coast Regional Environmental Assessment (EC REA) and 220 line km acquired as part of previous *Seabed Prehistory* projects conducted by WA (Wessex Archaeology 2008a; 2008b) were assessed. These data were provided in digital (seg-y) format.

2.3.5. Additionally, for aggregate surveys areas where the data were not available (Area 228 surveys in 2002 and 2005), WA was provided with the resource reports and interpretation charts which were assessed in the absence of the raw data.

2.3.6. For the majority of the aggregate areas bathymetry data were provided in the form of raw data or as charted data. The bathymetry data were used where appropriate.

2.3.7. **Figure 3** illustrates the areas of survey coverage for data assessed as part of this project and **Figure 4** illustrates the year of acquisition for each dataset and indicates full or partial coverage. Details of the individual surveys are provided in **Appendix I**.

Interpretation Methodology

2.3.8. The digital sub-bottom profiler data were processed using Coda Seismic+ software. This software allows the data to be replayed with user selected filters and gain settings in order to optimise the appearance of the data for interpretation. The software then allows an interpretation to be applied to the data. The interpretation tags were exported as text files and imported to GIS.

2.3.9. The analogue data was interpreted from the paper rolls and the interpretation was input into GIS for geospatial analysis.

2.3.10. The sub-bottom profiler data were interpreted with a two-way travel time (TWTT) along the z-axis. In order to convert from TWTT to depth, the velocity of the seismic waves was estimated to be 1,600 ms^{-1}. This is a standard estimate for shallow, unconsolidated sediments.

2.3.11. All trackplots (digital and analogue) were georeferenced in ArcGIS to allow an assessment of data coverage.

2.4. GEOTECHNICAL ASSESSMENT

2.4.1. A total of 1,171 vibrocore logs were reviewed from 43 separate surveys acquired between 1988 and 2011 (**Figure 3** and **4**, **Appendix II**). Of these, 1,144 vibrocore logs and accompanying photographs were supplied by the licensees. Additionally, 16 vibrocores acquired during the EC REC project and 11 vibrocores acquired as part of previous *Seabed Prehistory* projects (Wessex Archaeology 2008a; 2008b) were assessed.

2.4.2. In order to compare the data spatially, the locations were entered into a database and, where necessary, converted to WGS84 datum UTM z31 projection.

2.4.3. Initially, the vibrocore logs were archaeologically assessed in order to establish the presence and location of sediment units with likely archaeological and palaeoenvironmental potential. The geotechnical data were then integrated with the geophysical data to aid identification of specific sediment units of interest with regards to the development of the Palaeo-Yare.

2.4.4. Additionally, approximately 3,213 onshore borehole logs exist within the 0-5m contour in the SA. Of these, 2,092 are freely available (non-confidential) through the online BGS borehole viewer. Based on documented sources (Arthurton *et al.* 1994) approximately 400 boreholes were reviewed to assess the presence and composition of the Yare Valley Formation and documented river terraces. The geotechnical logs are of varying type and penetration, including trial pits, hand augers to boreholes. Where the Yare Valley Formation and river terrace deposits are not recorded in the logs this may be due to lack of penetration rather than absence of sediment units.

2.5. DREDGING HISTORY

2.5.1. Dredging history of the aggregate areas is an extremely important consideration in aiding the interpretation of the geotechnical and geophysical data given that many of these licence areas represent long standing interests that have been actively worked for 30 years or more. The available datasets vary in age and in most if not all cases dredging in the area has continued since the survey took place. As such, detail on the dredging history was required in order to adequately assess the geophysical data with regards to the likely presence or absence of the sediment units under consideration.

2.5.2. In order to address the dredging activity issue a series of meetings with the individual licensees were organised in order to discuss the issue of past and ongoing dredging within the aggregate dredging areas. These meetings took place during January and February 2012.

2.5.3. Additionally, Electronic Monitoring System (EMS) data was provided for the East Coast region based on a year-on-year basis from 1993 to 2011.

2.5.4. In 1993 the Crown Estate deemed it compulsory that all vessels dredging on their licence areas should be fitted with an EMS. The EMS automatically records the date, time and position of all dredging activity and every month this information is supplied to The Crown Estate (The Crown Estate and BMAPA 2010).

2.5.5. It was the interrogation of the EMS data that allowed the area from which the handaxes where dredged to be determined and formed the basis for the creation of the exclusion zone (**Figure 1**).

2.5.6. The wider dredging history demonstrates that dredging occurred in many of the licence areas for several decades prior to 1993 but the EMS data have allowed a certain amount of qualitative analysis of dredging activity within specific aggregate areas.

2.5.7. The EMS data were provided as a series of 19 shapefiles, one for each year (1993 – 2011). Each shapefile comprises the tracks defined by 50m cells for the particular year. Each cell has a code, as follows:

- 1 – dredging for <15 minutes
- 2 – dredging between 15 minutes and 1 hour and 15 minutes
- 3 – dredging for > 1 hour and 15 minutes

2.5.8. The division of the data in such a way made the assessment of total dredging activity for the 19 years difficult. The time dredged does not equate to volume of sediment dredged and there is a weighted bias in the way the groups have been allocated. However, it does provide a proxy for intensity of effort based on total time spent dredging per unit area. Although no quantitative analysis can be made a certain amount of useful qualitative trend analysis can be undertaken.

2.5.9. Using ArcView GIS the shapefiles were processed into a single file using the "Union" process. This creates a single shapefile with each area dredged represented as an individual feature. Further statistics can then be calculated. For the purpose of analysis the gridcodes 1, 2 and 3 have been treated as low, medium and high intensity, respectively.

2.5.10. With regards to this project the key issue of the dredging data is when, where and how much dredging has occurred. The timing of the dredging is important in terms of assessing the state of the seabed at the time of the acquisition of the geophysical data and relatively how much dredging took place since the data acquisition.

2.5.11. **Figure 5a** and **5b** illustrates the cumulative number of years in which dredging has taken place at any one time. **Figure 5c** illustrates the area (km^2) dredged during each year, divided by low, medium and high intensity.

2.5.12. Only a small area of the seabed measuring 1.515 km^2 has been dredged continuously over the 19 years of records. The general trend is that the largest area of seabed has been dredged for the least time in term of number of years (<=4). **Figure 5a** illustrates the distribution of the cumulative years dredged and indicates that certain areas (254, 240, 228, 319, 361, 296 and 212) have been dredged in 11 or more years between 1993 and 2011.

2.5.13. The greatest amount of dredging in terms of area dredged (not tonnage) occurred between 1993 and 1999, there was generally a reduction in dredging between 2000 and 2003 and a further reduction since 2003 (**Figure 5c**). This reduction in area dredged over time largely reflects a change in emphasis by the licensees with increased efficient management of the remaining resource in the licence area. In each year approximately 70 to 75% of the area is dredged at the lowest intensity and between 5 and 10% is dredged at the highest intensity.

2.5.14. The data were then analysed to assess the cumulative intensity of dredging over the 19 years based on the data provided. After statistical analysis of the data and consultation with BMAPA and the licensees, it was decided that a qualitative approach was the most appropriate. Due to the inherent bias/weighting of the original data any classification based on statistical analysis of frequency and area distributions would be flawed. However, a qualitative assessment allows a sense of dredging intensity to be achieved.

2.5.15. For each feature within the shapefile the numbers of years dredged for low (gridcode 1), medium (gridcode 2) and high (gridcode 3) intensity were calculated. The cumulative intensity over the 19 years was then classified as follows:

- Very low cumulative intensity – based on consultation (pers. com. M. Russell, May 2012) this group is defined as low intensity dredging (gridcode 1) for up to 5 years only;
- Low cumulative intensity – low level dredging (gridcode 1) for greater than 5 years, medium intensity (gridcode 2) for up to 5 years and no years of high intensity (gridcode 3);
- Medium cumulative intensity – Medium dredging (gridcode 2) for greater than 5 years and high intensity for less than 5 years;
- High cumulative intensity – areas dredged at high levels (gridcode 3) for greater than 5 years, irrespective of low or medium level dredging.

2.5.16. It is clear that this is an arbitrary scale and there are other ways of classifying this data. However, the aim is to show a qualitative cumulative increase in the intensity of dredging. The very low and high classifications are easier to define. However, the boundary between the low and medium classifications is more arbitrary. The footprint of dredging in the area (based on the original 50m cell size) is 226 km^2.

2.5.17. **Figure 5d** and **5e** illustrate the cumulative intensity within the dredging areas.

2.5.18. The general trend of the model indicates a greater footprint area of seabed dredged as very low and low intensities compared to medium or higher intensities. The model illustrates approximately 70 km^2 only dredged for less than 5 years at low intensity. Of this 38 km^2 has been dredged at low level for one year only. Only 1.2 km^2 has been dredged cumulatively at high levels for 5 years or more. Based on this classification approximately 100 km^2 of seabed is cumulatively dredged at low intensity and 50 km^2 at cumulative medium intensity.

2.5.19. The areas with the lowest cumulative dredging (classified as very low) are observed around the edges of more intensely dredged areas and stray single lines within areas of little or no aggregate resource.

2.5.20. The areas of highest cumulative intensity occur in Areas 228, 361, 360 and 401/2 in the east and Areas 202 (now fully relinquished) and 254 in the west. With the exception of Area 254 and 360 the areas with highest cumulative intensity are no longer active dredging areas.

2.5.21. Additionally, the EMS data were assessed in direct conjunction with the survey data. For each geophysical survey area the presence/absence of known dredging were assessed up to, and including, the year of the survey. This allowed the EMS data to be used in conjunction with the geophysical data to assess whether the absence of particular sediment units was due to natural environmental reasons or due to the effects of dredging in the area.

2.5.22. The EMS data has also allowed an assessment on the likely survival of the sediment units based on cumulative intensity of dredging that has taken place since the survey data were acquired.

2.6. DATA CONSIDERATIONS

2.6.1. There are numerous considerations in assessing a large number of datasets coupled with the history of dredging over time. It is necessary to discuss any limitations and how this affects the confidence of the interpretation.

Geophysical Data

2.6.2. The large number of geophysical datasets acquired between 1989 and 2011 vary in quality. Generally the data is of good quality; however, some datasets are adversely affected by weather. Where more than one geophysical dataset was available for a particular area the dataset of better quality was used. Where there was no alternative the data has been interpreted and it is accepted that in certain areas certain units are undifferentiated where clear boundaries cannot be observed. This is particularly pertinent in areas where dredging has further complicated the interpretation. Variations in data quality and type are illustrated in **Figures 17**, **18** and **19**, which illustrate different features associated with the Palaeo-Yare palaeogeography.

2.6.3. Predominantly, the sub-bottom profiler surveys were acquired using a boomer source. However, two surveys in Area 254 (1993 and 1999) were acquired using a pinger system. Pinger data is very useful in assessing any fine-grained units (Unit 4), however does not fully resolve coarse-grained sediments (Unit 3b). Due to the number of surveys in Area 254 a combination of boomer and pinger data has been used for the assessment.

2.6.4. There is generally an overlap in the survey data relating to different years. This can result in initial discrepancies in the interpretation either due to differences in the data quality, differences in the data type or effects of dredging between the acquisition of the two surveys. These discrepancies have been rectified, wherever possible, and generally the most recent interpretation has been used.

2.6.5. The majority of the licensee geophysical data were provided as paper rolls. The data was effectively processed prior to printing. This means that in some datasets the data range is not optimized, i.e. the range is set to penetrate 50m sub-seabed and as such, the upper 5m of interest to this study is not clearly resolved. As such, subtle, shallow features identified in digital data where the range can be adjusted, such as Units 5 and 6 in Area 240, cannot be identified on the paper rolls.

2.6.6. Although the paper roll data cannot be re-processed the main units under consideration in this report were identified and mapped.

2.6.7. The datasets were acquired at varying lateral resolutions. Although the interpretation is treated as almost 100% coverage of the area (**Figure 3**) the interpretation is based on a range of line spacing (detailed in **Appendix I**). Typically the licensee data varies between 100 m line spacing to 300 m line spacing with cross-lines acquired at greater intervals (typically 500 m or 1 km). The regional REC and REA data are based on single line acquisition or a corridor approach. As such, there is a certain amount of interpolation between the lines which, in places, affects the resolution of the interpretation. Also, in some datasets, certain lines were missing and as such the interpolation between lines could exceed the line spacing distance.

2.6.8. The difference in the resolution of the interpretation between digital data acquired at 100 m line spacing and analogue data at 300 m spacing is apparent within the overall interpretation. However, the best overall interpretation has been made based on the best available data.

Geotechnical Data

2.6.9. The offshore geotechnical data comprised a number of logs acquired during numerous surveys during different years (**Figure 4**). Correlation between these

datasets based on vibrocore logs and photographs is complicated by a number of factors, discussed below.

2.6.10. The logs were completed at different times by different companies and the recording of the information in the logs can differ. For example, the degree of sorting, sedimentary structure, and gravel type are either not recorded or recorded intermittently within the logs, thus increasing the difficulty when comparing logs.

2.6.11. The sediment incorporated within more recent sandwaves and lag deposits are likely to have been originally transported to the SA by shallow marine/fluvial/glacial processes and sediments from these sources are difficult to differentiate in photographs. Also, the mode of deposition of sand and gravel either by marine, coastal, fluvial and/or glacial processes cannot be determined by only reviewing geotechnical vibrocore logs.

2.6.12. The vibrocore data is more often than not provided without water depth information. Normally this is not necessarily a problem if the vibrocores were acquired at the same time as a geophysics survey whereby the bathymetry data can be used as a datum for the top of the vibrocore. However, many vibrocores were acquired during periods between the geophysical surveys and the previous bathymetry is not suitable as a datum due to intervening dredging in the area. This does not mean that the geotechnical data cannot be integrated with the geophysical data, just that care is required when referring to depth and thickness of sediment units.

2.6.13. Dredging activity has likely disturbed the top *c.*2 m of sediment in some areas and this is not always obvious from the vibrocore log descriptions or photographs.

2.7. INTEGRATION WITH AREA 240 INTERPRETATION

2.7.1. For the interpretation of the Palaeo-Yare catchment area, the same interpretation scheme as the Area 240 interpretation has been employed. Any differences to the interpretation and additional units and features are discussed in **Section 3**.

2.7.2. The interpretation of Area 240 was based on a single geophysics dataset with no reference to any geophysics in the surrounding area. With the benefit of additional data the initial interpretation from Area 240 has been revisited and there have been a few revisions, particularly to the channel limits in the north-east and the sediment units in the east of Area 240.

2.8. CULTURAL HERITAGE ASSESSMENT

Introduction

2.8.1. Large numbers of stone, typically flint, early prehistoric artefacts and faunal remains have long been found in sediments associated with river channels (Pettitt and White 2012, Wymer 1999), either in modern floodplain sediments or relict floodplains (terraces) preserved above the modern valley floor following periods of uplift and river incision (Lewin and Gibbard 2010, Bridgeland 1994, Bridgeland and Westaway 2008). In the Yare and Waveney valleys, within sand and gravel layers or associated fine-grained sediments and peats, a broad range of archaeological periods are represented. Lower Palaeolithic handaxes to Mesolithic human remains and microliths have been recovered; many associated with river terraces (Wymer 1999).

2.8.2. The recovery of Palaeolithic stone artefacts and Pleistocene faunal remains from the southern North Sea has a long history predominantly associated with the fishing

industry and, more recently, the dredging industry (Godwin and Godwin 1933; Glimmerveen *et al.* 2004; Mol *et al.* 2006) and reinforces the flux in palaeogeography of Britain between an island and a peninsula during the Pleistocene.

2.8.3. Numerous mammal remains have also been reported from a relatively restricted area in the southern North Sea between the Brown Bank area and the Norfolk coast, which have yielded Early and Middle Pleistocene mammal fossils (van Kolfschoton and Laban 1995; De Wilde 2006). Isolated finds of artefacts such as flints, bone spearheads, and reworked or carved fossil mammal bones are also documented (Long *et al.* 1986; Coles 1998; Flemming 2002). Artefacts and faunal remains continue to be reported from the North Sea aggregate dredging areas via the Marine Aggregate Industry *Protocol for Reporting Finds of Archaeological Interest.*

2.8.4. Finds may be recovered in primary context from river terraces with the archaeological material *in situ*. Alternatively, material may be eroded and reworked from primary contexts and incorporated into other sedimentary deposits such as river floodplains further downstream (and subsequently terraces if further incision and / or uplift occur) (Wymer 1999). In a particular location - onshore or (now) offshore – there may then be a mixture of archaeological materials of various periods and of various provenance reworked within sedimentary units.

2.8.5. The broad range of artefactual and environmental material found in these contexts is of high value for understanding the earliest prehistory of Britain and the North Sea basin (English Heritage 2008, Hosfield and Chambers 2004).

Cultural Heritage Data

2.8.6. In addition to the geophysical and geotechnical data assessments several sources of cultural heritage data were consulted, primarily to investigate the archaeological record of the onshore region of the SA. These sources included:

- National Record of the Historic Environment (NRHE);
- Suffolk Historic Environment Records (HERs);
- Norfolk Historic Environment Records (HERs);
- The English Rivers Palaeolithic Project (TERPS) records;
- BMAPA Protocol for Reporting Finds of Archaeology Interest;
- Secondary documentary sources.

2.8.7. The NRHE database and the Suffolk and Norfolk HERs were consulted for all Palaeolithic and Mesolithic finds and sites relating to the SA.

2.8.8. TERPS[1]: a considerable database of Palaeolithic and Mesolithic sites with known provenance from river valleys around Eastern and Southern England compiled by the late Dr John Wymer (Wymer 1999) was consulted for sites within the SA.

2.8.9. A series of filters was applied to the various datasets. This took into account the chronology and dating of artefacts (where available). Hence, exclusively records dating from the Mesolithic (with potential for correlation to Unit 7), and/ or Palaeolithic periods (with potential for correlation with Unit 3b) were kept for further

[1] http://archaeologydataservice.ac.uk/archives/view/terps_eh_2009/index.cfm; http://archaeologydataservice.ac.uk/archives/view/wymer_eh_2008/index.cfm?CFID=25213&CFTOKEN=22E934B2-A1B6-4E8D-B8E923C547D93181 (last accessed 03/02/2012)

consideration. Additionally, records suggesting an adequate and relevant date but without being formally dated were taken into account.

2.8.10. A final selective factor was considered in order to exclude records without a clear geological relationship *e.g*. surface finds and/or records for which the nature and location of the finding was uncertain. The main database holding this contextual information is TERPS, where Dr John Wymer has ascribed a geological source unit to the finds. In some cases it may be possible to assign a geological context to other sources such as the NHRE or HERs but many do not record sufficient information to make a secure judgement and as such this additional interpretation has not been undertaken with these datasets.

2.8.11. Secondary documentary sources were also consulted to provide archaeological and geomorphological context to the cultural heritage datasets. Site locations associated with the finds recovered from grab sampling and archaeological monitoring or dredging activity is also included in the assessment.

Summary of Archaeological Material

2.8.12. The initial classification and filtering process for documentary sources focused the number of relevant records for the period and location under investigation from several thousand records to just 280 locations (**Table 2**). These consist of Mesolithic and Palaeolithic records that have potential for correlation to the offshore units of archaeological interest (**Figure 6 and Appendix III**).

Archive source	Unfiltered	Filtered* (SA, terrestrial, period)	Environmental Association
NHRE	2762	6	0
Norfolk HER	658	120	0
Suffolk HER	304	24	0
TERPS	44	43	34
PastScape	8	6	0
BMAPA	116	43	0
Other sources	38	38	36
Total	**3930**	**280***	**70**
* A find or site may have several records across the various databases. Due to some positional uncertainty a minority of records' positions have been averaged between two or three duplicate points leading to 228 individual record locations. A location may also consist of many constituent finds.			

Table 2: Distribution of documentary sources consulted for the terrestrial SA assessment

2.8.13. Of the 280 filtered locations in the gazetteer, in the upper catchment of the Yare valley, eight specifically refer to Acheulean tools, or attributed to "Lower Palaeolithic" technology. Of the total 280, 77 refer to identifiable or potentially "Mesolithic" material, with four "Upper Palaeolithic" records. There are 105 generic references to "Palaeolithic" material, and six to "Prehistoric" material (**Table 3**). Based upon this documentary evidence it is difficult to ascribe much detail to diagnostic archaeological periods within the terrestrial SA.

Archaeological Period	Number of Features
Palaeolithic	105
Lower Palaeolithic	8
Middle Palaeolithic	1
Middle Palaeolithic; Upper Palaeolithic	1
Upper Palaeolithic	2

Archaeological Period	Number of Features
Upper Palaeolithic; Early Mesolithic	1
Palaeolithic; Mesolithic	1
Palaeolithic or Mesolithic	2
Early Mesolithic	5
Mesolithic	48
Mesolithic ; Neolithic	10
Mesolithic or Neolithic	10
Prehistoric	6
Unknown	28
Total	**228**

Table 3: Archaeological Periods associated with documentary sources in the SA.

2.8.14. Of the lithics recovered from Area 240 (**WA 2147**) and additional flints and flakes recovered from the region (by grab sampling and monitoring: **WA 2193 - 2227**), there is a mix of Lower and Middle Palaeolithic production methods from *in situ* and near *in situ* contexts (de Loecker 2011). The patterns of artefactual material in the onshore and the now offshore areas of the Palaeo-Yare catchment indicate both a significant reworking of artefacts across a broad region of Palaeo-Yare floodplain and interfluves as a whole but also indicate a few discrete, major lithic producing centres that may be primary sources of dispersed, out-of-context artefacts downstream.

2.8.15. The documentary sources also provide limited information on site types (**Table 4**). Where there are clusters of finds that have been reported as “Lithic Working Sites”, (n = 11) these tend to lie at the margins of river valleys or interfluves (**Figure 6**). Most are listed as “Mesolithic” or “Mesolithic – Neolithic”. Of the specifically “Lower Palaeolithic” working sites, Whitlingham (**WA 2059**) (Sainty 1927) is the only example in the SA. There are two records of “Palaeolithic”, “Lithic Working Sites”, one being Carrow Road (**WA 2019**) (Sainty 1933, Wymer 1999), the other in the vicinity of Whitlingham (**WA 2057**) (which may be referring to the same site with some positional inaccuracy and insufficient documentation to clarify further).

Site Types	Number of Features
Findspot	174
Human Remains	2
Lithic Working Site	11
Faunal	28
Environmental	13
Total	**228**

Table 4: Site Types associated with the documentary sources in the SA

2.8.16. The distribution of archaeological materials from identified sedimentary contexts is very mixed with few finds from a defined period deriving from a sedimentary unit of equivalent age or with a reported archaeological context other than “Palaeolithic” (**Table 3**).

2.8.17. Due to the lack of geological context in most of the documentary sources, only 70 can be attributed to a particular sedimentary source based upon the TERPS dataset, contextual information from the BMAPA reporting protocol and archaeological assessments carried out in the area (**Table 5**).

2.8.18. Of these records with geological context, 53 could be assigned to a primary context *i.e.* a specific formation or unit; 17 records relate to secondary contexts such as head deposits or glacial sands and gravels.

Geological Context	Number of Features	Associated Finds (Arch. Periods)	Associated Offshore Unit
-	158	Lower Palaeolithic; Palaeolithic; Upper Palaeolithic; Early Mesolithic; Mesolithic; Neolithic; Unknown	-
Alluvium	1	Lower Palaeolithic	7?
Blown Sand	1	Palaeolithic	
Boulder Clay	2	Palaeolithic	
Corton Formation (Sand clay of Corton Formation)	3	Palaeolithic	
Cromer Till	1	Palaeolithic	
Edge of Crag and Alluvium	1	Palaeolithic	2,7
Edge of River Deposits of Terrace 1	1	Palaeolithic	7?
Glaciofluvial / Glacial Sand(s) and Gravel(s)	10	Palaeolithic	
Head	1	Palaeolithic	
Junction of Norwich Crag and Till (Lowestoft)	1	Palaeolithic	2?
Kesgrave Sands and Gravels	1	Lower Palaeolithic	
Peat	1	Lower Palaeolithic	7
River Deposits of Terrace 1 (Floodplain)	3	Palaeolithic	7?
River Deposits of Terrace 2 (Broome)	1	Palaeolithic	3
River Deposits of Terrace 3 (Homersfield)	2	Palaeolithic	3
River Terrace Deposits Undifferentiated	2	Lower Palaeolithic	
Till (Lowestoft)	1	Palaeolithic	
Edge of Alluvium and Glacial Sand and Gravels	1	Palaeolithic	
Unit 3	35	Unknown	3
Unit 5	1	Unknown	1
Total	**228**		

Table 5: Geological associations reported for finds in the SA with tentative correlations to the identified offshore units.

2.8.19. The distribution of “Palaeolithic” material encompasses a very wide range of sediments and geological units highlighting the reworking of this material. Reworked or mobile sediments such as blown sand, glaciofluvial sands and gravels, and tills

are arguably less likely to contain *in situ* material, although the presence of sites cut into these deposits cannot be ruled out. Glacial sediments such as the Corton Formation units, tills and marine sediments such as Crag are also less likely to contain *in situ* artefacts but again the archaeological context for any associated finds is not clear.

2.8.20. In summary, throughout the SA there are relatively few diagnostic finds that have diagnostic environmental or geological associations. This highlights the value of the Area 240 Middle Palaeolithic Assemblage having a confined lateral and vertical extent in addition to having been examined in some detail for palaeoenvironmental, geological and archaeological purposes.

2.8.21. The documented archaeological sites are discussed, in more detail, with reference to the palaeogeography in **Sections 3** and **4**.

3. OVERVIEW OF PALAEOGEOGRAPHY AND ARCHAEOLOGY

3.1. INTRODUCTION

3.1.1. Today, the lower reaches of the River Yare and Waveney flow into Breydon Water, the remnants of an outer estuary (**Figure 1**). The water flows east from Breydon Water and then south into the North Sea. To the north and south of Great Yarmouth the region is shaped by its rivers and the Norfolk Broads (remnants of peat removal between the 12th and 14th Century and since flooded). The coastline to the north comprises a cliffline that is generally less than 10 m high that continues to erode at a rate of, on average, 0.9 m per year (Clayton 1989).

3.1.2. To the south of Great Yarmouth the eroding coastline is cut by the River Waveney at Lowestoft, a man-made river cut from the Waveney 5 km inland to the coast in 1827[2] in order to increase trade to the coast and to supplement the harbour at Great Yarmouth.

3.1.3. Nearshore, the seabed is dominated by a series of large sandbanks formed since the last marine transgression. These banks, such as Cross Sands, Scroby Sands and Caister Shoal, are up to 25 m high and are composed of material generated from the eroding coastline to the north and erosion of localised seabed sediments (D'Olier 2002).

3.1.4. The banks possibly originally formed as banner or headland banks from the northern Caister/Winterton Upland. Banner banks are long banks of sand that lie with one end almost connected to the coast at headlands.

3.1.5. Beyond the banks lies a gently sloping seabed deepening to *c.* 40 mbOD (metres below Ordnance Datum) water depth before deepening to *c.* 50 mbOD at an apparent break of slope 40 km from the coast. The seabed morphology continues to change with mobile sandwaves affected by seabed currents and new bedload material transported into the nearshore area from the north.

3.1.6. A group of aggregate licence areas are situated between 8.5 and 30 km from the coast. The area has been dredged since the 1970s and the dredging has changed the seabed morphology in this area. Water depths in the licence areas are generally between 20 and 35 mbOD, excluding effects of mobile sandwaves.

[2] http://www.lowestoftmaritimemuseum.org.uk/sea_to_river.htm

3.1.7. These morphological features represent the latest in a continuously-changing environment. During the past 900,000 years since the earliest known occupation in the area there has been a period of fluctuating climate with corresponding oscillations in sea-level (Bridgeland 2002). During interglacial periods sea-levels were relatively high, sometimes comparable to the present-day, whereas at the climax of glacial periods the sea-level fell to more than 100 m below present levels. During these multiple cycles of transgressions and regressions various areas of the southern North Sea have been repeatedly exposed. It is generally agreed that when sea-levels rise above 40 mbOD then Britain was an island (Pettitt and White 2012).

3.1.8. **Figure 7** provides an approximate indication of relative sea-level variations in the southern North Sea during the last one million years. Major archaeological periods and periods of known occupation are included to illustrate the relationship between these periods and the relative sea-level stands. The sediment units identified in the archaeological assessment are shown with reference to the sea-level curve.

3.1.9. During the multiple cycles of transgression and regression, sediments would have been reworked, primarily through the repeated combination of fluvial action, glacial and permafrost melts, followed by marine transgression. Moreover, glacial cycles did not follow a regular pattern and within the transition from glacial to interglacial, with its progressive warming of the environment, there would have been short periods of cooling. As a consequence, the pattern of inundation and exposure would have occurred irregularly at varying rates, within an overall transgression or regression trend.

3.1.10. Consequently, deposits have been truncated and sequences of earlier deposits have been isolated. The present-day stratigraphy does not necessarily represent a complete chronological sequence as deposits may have been completely or partially eroded before subsequent deposition (**Figure 7**). As well as the possibility of some periods of deposition not being represented in the sedimentary record, some deposits may have been reworked and modified.

3.1.11. For a large percentage of the Middle and Late Pleistocene, rivers have extended beyond present-day shorelines onto the continental shelf during periods of low sea-level (Bridgeland 2002). These extensions of existing rivers, enlarged by confluences that are now submerged, and swollen by glacial meltwater, would have been drainage systems of considerable size (Bridgeland 2002).

3.1.12. The following palaeogeographic reconstruction is based on broad timescales. The evidence from the assessment of geophysical and geotechnical data and existing studies is relatively small and localised. Therefore, there is a need to relax the time-constraints and assess the area based on large time intervals in order to achieve coverage and provide an overview of the general trends of regression and transgression throughout the period under consideration (Funnell 1995). Although this study is focussed on the development of the Palaeo-Yare valley and its tributaries it is necessary to take a brief step back in time and assess the older landscape in order to provide geological context. For the purpose of the palaeogeographic reconstruction the time period assessed goes back as far as the early Pleistocene around 2 Ma as this is the earliest identified unit in the SA. However, the focus is placed on the periods throughout which human occupation is known (*c.* 900 ka).

3.1.13. The palaeogeographic development of the area is focussed on three periods:

- palaeogeography prior to the development of the Palaeo-Yare valley which encompasses Pleistocene to the end of the Anglian Glaciation;
- the development of the Palaeo-Yare valley from the late Anglian through to the late Devensian;
- Holocene development of the valley and the final marine transgression.

3.1.14. The following section details the environment of the SA during these periods based on the known geology of the now onshore area and the remnants of the sediments identified on data in now submerged areas.

3.2. PRE-YARE VALLEY PALAEOGEOGRAPHY

Pre-Anglian (MIS 13 upwards; >480 ka)

3.2.1. During the majority of the Pliocene (*c.* 5.3 to 2.3 ma) Britain was surrounded by warm temperate seas (Funnell 1995). The SA was a shallow marine environment with the coastline situated approximately 50 km west of the current coastline (**Figure 8a**). Then, commencing around 2.3 ma BP the first major sea-level falls associated with northern hemisphere glaciation occurred.

3.2.2. A series of marine transgressions and regressions throughout the Early Pleistocene resulted in the deposition of the Crag group in a shallow shelf and intertidal environment comprising sands, silts and clays with occasional gravels (Moorlock *et al.* 2000). From around 2.3 ma to 1.7 ma there was an overall trend of northward regression (**Figure 8a**, Cameron *et al.* 1992) and the development of a northward progressing delta. Although a regressive trend, during this time the sea transgressed and regressed several times (Funnell, 1995). By 1.7 ma progressive deltaic northward progradation continued and the Ur-Frisia delta top linked Britain to mainland Europe excluding all marine influence from the southern North Sea Basin between approximately 1.7 ma and 500 ka. The Ur-Frisia delta was fed by the Bytham, Thames, Rhine, Meuse and northern German rivers to the coastline situated north of Aberdeen at 57°N (Funnell 1995).During this period Britain was a peninsula of northwest Europe, even during periods of high sea-level.

3.2.3. On the landward side of the delta top there was a hiatus in major influx of sedimentation accompanied by widespread soil formation throughout southeast East Anglia. Two major rivers flowed through the landscape during this period. The Bytham River flowed eastwards from the Midlands through East Anglia and into the North Sea. The ancestral form of the River Thames flowed from its source in the Cotswolds along its present day course to Reading and then flowed northeast to the north Norfolk coast (**Figure 8b**). At Happisburgh Site 3 a series of channel sediments and associated overbank alluvium belonging to the ancestral River Thames has been mapped and are thought to be either MIS 25 (*c.* 970 ka) or MIS 21 (*c.* 850 ka) (Parfitt *et al.* 2010).

3.2.4. By *c.* 700 ka the Bytham had changed its course and flowed through Pakefield into the North Sea (Parfitt *et al.* 2005, **Figure 8c**). The earliest known occupation of the SA is at Pakefield (**WA 2135**) where artefacts have been recovered from floodplain deposits dated to *c.* 700 ka (Parfitt *et al*. 2005; Lee *et al*. 2006).

3.2.5. The assemblage at Pakefield comprises 32 worked flints, including a simple flaked core, a crudely retouched flake and a quantity of waste flakes (Parfitt *et al*. 2005). The artefacts were all found in clear stratigraphical contexts relating primarily to the interglacial infill of a channel, comprising extensive deposits of organic muds and clays (Cromer Forest-bed Formation) incised into late Pliocene and Early Pleistocene marine Crag deposits. These organic sediments have also yielded a

rich fauna of elephants, deer and other large mammals (Wymer 1999).The Cromer Forest-bed Formation are overlain by the terraced river deposits of the Bytham sands and gravels (Rose *et al.* 2002).

3.2.6. Remnants of the early marine sediments are observed onshore in the form of Crag deposits with the western limit of the Crag Group marking the westernmost limit of the coastline at 2.3 ma. The remnants of two delta-top deposits are observed in the submerged SA (**Figure 9**). The Westkapelle Ground Formation, termed Unit 1, partially equivalent to the upper Crag deposits, was deposited in a prodelta-environment and generally comprises silty clays with partings of sand passing upwards into predominantly mud-free sands (Cameron *et al.* 1992).

3.2.7. The top of Unit 1 is observed throughout the licence areas and generally deepens to the east. Unit 1 is generally observed as comprising silty, clayey, shelly sand and is generally overlain by younger Pleistocene deltaic sediments of the Yarmouth Roads Formation (Unit 2). However, Unit 1 is observed to sub-crop the marine post-transgression sediments in the south of Area 251 where the overlying Unit 2 thins and the Unit 1 is exposed (**Figure 9**).

3.2.8. As part of the Ur-Frisia delta plain the Yarmouth Roads Formation (Unit 2) were deposited between 2.3 ma and 480 ka; the later deposits equate, in part, to the Cromer Forest-bed Formation which have been associated with archaeological material at Pakefield.

3.2.9. Palaeoenvironmental material from vibrocores taken in Area 240 (Wessex Archaeology 2011a) indicates that these sediments were deposited in a cold climate, shallow marine or outer estuarine environment. OSL dating of this unit returned a date of 735 ± 134 ka (MIS 19; GL 10040)[3] which is considered to be a minimum age estimate indicating a Cromerian Complex age (Wessex Archaeology 2011a: **Appendix II**) and are comparable to the age of Yarmouth Roads Formation in the Dutch sector at similar latitudes (Zagwijn 1983). The Yarmouth Roads Formation is known to comprise a complex delta-top sequence consisting of sands with pebbles (including chalk), abundant plant debris and peat clasts (Cameron *et al.* 1992).

3.2.10. The Yarmouth Roads Formation (Unit 2) is generally observed throughout the survey areas, with the exception of small areas in the northwest of Area 240 and to the south of Area 251 (**Figure 9**). In the western survey areas Unit 2 is observed as an easterly thickening blanket deposit generally comprising silty sand or clayey silty sand. To the north (Area 296 and 454) and the east (Area 328, 242, 361 and 401/2) the unit thickens and becomes more complex with internal channel structures observed.

3.2.11. A further two known archaeology sites have possible attribution to Unit 2 sediments (**Figure 6**). In both cases the artefacts are likely to be in secondary context. **WA 2064** is a Palaeolithic handaxe found in the Junction of the Norwich Crag (partial equivalent of Unit 2) and Lowestoft Till. **WA 2021** is a Palaeolithic handaxe recovered from the edge of Crag (partial equivalent to Unit 2) and alluvium (equivalent to Unit 7).

[3] Due to a relatively low environmental dose rate received by sample GL 10040 from the surrounding sediments, saturation of quartz dosimeters has not occurred, extending the dateable range of this material (Wessex Archaeology 2011a: Appendix II).

Anglian Glaciation (MIS 12; 480 – 423 ka)

3.2.12. The Anglian glaciation represents the most extensive glaciation of the British Middle Pleistocene, with ice sheets reaching down as far as the north Cornish coast and the Thames Valley (Wymer 1999). The trapping of water within the extensive Anglian ice sheets resulted in a fall in sea-level thought to be the lowest recorded around the British Isles and estimated at 130 m below the present level. The Anglian Glacial maximum occurred around MIS 12.2 (*c.* 434 ka).

3.2.13. Extensive remodelling of the landscape took place, with old river courses such as the Bytham River destroyed or buried (Rose 2009) and the Thames and its tributaries were diverted southwards to approximately its present-day position.

3.2.14. There is much debate about the landscape within the region of the SA during the Anglian Glaciation. There is a general consensus of the presence of a large ice-dammed lake which developed in the southern North Sea - directly to the south of the ice-front - into which the Thames and other major European rivers flowed (Gibbard 1988; 2001).The extent of the this lake is important with regards to the subsequent development of the Palaeo-Yare valley.

3.2.15. One palaeogeographic reconstruction (Gibbard 1995; reconstructed by Parfitt *et al.* 2010) (**Figure 8d**) indicates that the SA would have been predominantly covered in ice and to the west of an ice-dammed lake. To the south of the lake a spillway was established over a topographic low between Dover and Calais and created new valleys that persistently diverted the River Thames (Gibbard 1988; Gupta *et al.* 2007, Hijma *et al.* 2012).

3.2.16. Areas immediately to the north of the ice front would have been dominated by till plains, peppered with newly exposed glacial landforms such as kettle holes and over-deepened glacial valleys, the latter often forming the basis for new drainage systems (Wymer 1999; Pettitt and White 2012). Till deposits belonging to the expansive Corton Till Formation and overlain by the Lowestoft Till Formation are observed in East Anglia and probably extended offshore and it is the erosion of these till deposits which forms the source of sediment contributing to the series of large sandbanks observed nearshore (D'Olier 2002). However, recent work (Murton and Murton 2012) have indicated that the ice-dammed lake was much more extensive extending up to 20 km into onshore East Anglia. In this hypothesis the entire SA would have been covered by lake water during the height of the glaciation. No direct evidence of lake deposits are preserved within the SA.

3.2.17. Moreover, recent work has indicated that the limit of the ice may in fact be further south than originally thought (Emu Ltd 2009) which would have implications for the size and situation of the ice-dammed lake.

3.2.18. Although there are varying theories, it is certain that re-working and remodelling of the land surfaces would have occurred in the SA during this period. It is probable that younger Cromerian Complex deposits (the younger Yarmouth Roads Formation) were eroded during this time and that tills would have been deposited throughout the majority of the SA. However, there is no direct evidence of the tills surviving in the offshore area and it is likely that any such material was eroded during subsequent periods of high sea level, in particular the Hoxnian (MIS 11) and Ipswichian (MIS 5e) interglacial stages. Based on current rates of cliffline erosion it has been surmised that around 10,000 years ago the "cliffline" was situated approximately 8 km east of the present-day coastline and has since been eroded away under marine conditions (D'Olier 2002).

3.2.19. It was onto this crag and till covered landscape that the Palaeo-Yare valley cut and developed.

3.3. DEVELOPMENT OF THE PALAEO-YARE: PLEISTOCENE (MIS 12 – MIS 2; 430 KA – 13,500 BP)

Overview

3.3.1. The Palaeo-Yare valley initially formed at the end of the Anglian Glaciation and then continued to develop through to present-day. The Yare valley has been active since its inception to the present-day throughout a number of oscillations from glacial to interglacial conditions. During cold periods subsequent to the formation in the Late Anglian, when sea-levels were lowered, sands and gravels were deposited on the valley floor and formed terraces. During warm periods the sea-levels rose and the Yare valley became increasingly affected by tidal conditions becoming an estuary and in the eastern extremes shallow marine conditions prevailed.

3.3.2. The Palaeo-Yare valley is discussed in terms of the development between the end of the Anglian glaciation (MIS 12) and the end of the Devensian Glaciation (MIS 2) which encompasses the series of cooling and warming events until the end of the last Glaciation. The Holocene (MIS 2 – 1) development of the valley is discussed in **Section 3.4** which encompasses the climatic amelioration and rising sea-levels which eventually flooded the lower reaches of the valley and forced tidal conditions on the upper reaches of the valley.

3.3.3. An overview of the regional palaeogeography for the development of the Palaeo-Yare through the Pleistocene is presented in **Figure 10** and is discussed further in the following sections.

Late Anglian (MIS 12; ~430 ka)

3.3.4. When the Anglian ice started to melt after the glacial maximum (*c.* 434 ka) the present-day drainage pattern developed on a predominantly till-covered landscape. Some rivers, such as the upper reaches of the Waveney, broadly re-occupied their pre-glacial channels, while other utilised the new topography of meltwater channels (Moorlock *et al.* 2000; Gibbard and Clark 2011).

3.3.5. It is likely that the Palaeo-Yare valley developed during this time and covered much the same area as is observed today with the Rivers Wensum, Yare and the Waveney flowing into a wide floodplain (now Breydon Water) and the flowing east to the lower reaches of the Yare valley which are now submerged (**Figure 10a**).

3.3.6. The initial incision of the channel and valley would have been deeper than observed now due to the subsequent sediment infill. However, the profile of the valley floor is particularly gentle. **Figure 11** illustrates a west – east profile of the base of the Palaeo-Yare valley based on the base of the infill sediments. There are relatively few onshore boreholes that penetrate the base of the valley infill units. As such, the profile is based on interpolation between known points. The profile shows a gentle slope (approximately 0.04% gradient) from 8.5 mbOD at the confluence of the Rivers Yare and Wensum to 38.5 mbOD at the easternmost limit of the SA. The change in profile at 45 km indicates a deepening (0.25% gradient) of the valley floor.

3.3.7. To the east of the present-day coastline there is little evidence to suggest the northern and southern limits of the valley area due to the presence of large sandbanks. In the geophysical data it is not possible to confirm the presence of the Palaeo-Yare valley deposits, partly due to penetration issues and partly due to the

nature of the sediments and the similarity with the underlying basement sediments (probable Unit 1). However, an assessment of the base of a series of sandbanks in the nearshore area compared to the projected profile of the base of the valley indicates that there is potential for sediments to exist beneath the sandbanks, *i.e.* the base of the sandbanks has not eroded to a level below the projected valley floor (**Figure 11**).

3.3.8. To the east of the sandbank complex the base of the valley floodplain and a channel feature are observed in the survey data (**Figure 12**). The base of the floodplain is broadly flat and gently dipping to the east. A distinct channel (Channel A) is observed towards the north of the floodplain which flows southeast through Areas 254, 240 and 228 before heading east through Area 251. The channel edges are not clearly observed in Area 401/2 however, it is likely that the channel would have continued to the east through this area. In Area 240 and 228 the channel is observed up to 6 m deep. This channel was probably cut during the earliest phase of development.

3.3.9. To the north of the floodplain, the upland area comprising till overlying crag between Winterton Ness and Benacre possibly extended north-eastwards as far as the Newarp Banks, extending under Cockle Shoal, Winterton Overfalls and North Cross Sand, with tributaries from this upland supplying the Yare (**Figure 10a**). It is likely that small waterways such as the Hundred Stream and the Thurne River flowed southwestward toward the River Bure from higher ground that was once situated offshore (D'Olier 2002). D'Olier (2002) also postulated that parts of the deep channels of Barley Picle and Caister Road between these banks were the location of streams that once ran off southwards from the higher ground into the River Yare.

3.3.10. On reviewing the geophysical data that were acquired within the area of Barley Picle in 2006 (Wessex Archaeology 2008a) there is some evidence of a very minor cut and fill of sediments between the sandbanks in the south of the area. However, it is not possible to ascertain whether this is related to a Middle Pleistocene river or associated with post-transgression erosion and re-deposition of sediments.

3.3.11. Tills would have extended to the south of the floodplain with an east-west aligned watershed that extended through the high ground north of Kessingland. Small streams probably ran north or northeast from this upland into the River Yare. There is a possibility that the Waveney River ran directly to the east rather than joining up to the Yare (at Breydon Water) though the lowland area observed today. It is possible that valleys at Lowestoft and to the southeast of Lowestoft are tributaries to the now submerged Palaeo-Yare (**Figure 10a**).

3.3.12. At the end of the Anglian Glaciation the Palaeo-Yare may have flowed into the remaining ice-dammed lake with an upland area to the north and the south.

3.3.13. During the initial development of the Palaeo-Yare floodplain sands and gravels would have been deposited. However, there are no sediments definitively dated to the late Anglian. In the upper reaches of the Palaeo-Yare (onshore) the sediments infilling the valley are either classified as the Yare Valley Formation or as river terrace sands and gravels. There are no definitive dates for the Yare Valley Formation. However, characteristics of the early deposits indicate a possible Late Anglian age (Arthurton *et al.* 1994) with upper deposits suggested as Devensian (Coxon 1979) or Late Devensian (Cox *et al.*1989). Arthurton *et al.* (1994) supposes at least some of the deposits to be Late Devensian/early Holocene age. It is considered that at least the basal deposits of the unit may have been deposited during the Late Anglian Glacial.

3.3.14. Although the Yare Valley Formation was deposited from the Late Anglian to the late Devensian, the Yare Valley Formation and river terraces are described below. Sediment units that can be ascribed to specific ages are discussed in more detail below.

Yare Valley Formation and River Terraces

3.3.15. The Yare Valley Formation (Arthurton *et al.* 1994) is observed throughout the river valleys to the north of Kessingland as far as the River Ant to the north of the SA. Over most of the onshore section the Yare Valley Formation predominantly overlies crag deposits (pre-Anglian). Nearshore, gravelly sediments assigned to the Yare Valley Formation have been recorded in valleys to the east of Newtown, Great Yarmouth, resting on Crag.

3.3.16. The thickness of Yare Valley Formation is up to 11m near Great Yarmouth and comprises fine to coarse gravel with variable amounts of fine- to coarse-grained sand. The gravel is mostly flint and silty gravel is observed in some cores. Formally, the unit is defined according to a borehole (no. 8) situated at Runham/Yare, adjacent to the banks of the River Yare outflow from Breydon Water. The Formation is 5.2 m thick with a maximum depth of 24 mbOD. It comprises grey, silty, fine to coarse gravel passing in the topmost metre to grey-brown gravelly medium grained sand.

3.3.17. The Yare Valley Formation is known to extend into the Waveney Valley, in the south of the SA, however, lack of borehole evidence means that the full extent is unknown (Moorlock *et al.* 2000).

3.3.18. There are few terraces associated with the Wensum/Yare Rivers. Onshore boreholes indicate the presence of terrace deposits in the upper reaches within the SA. **Figure 12** indicates the onshore boreholes that contain Yare Valley Formation or river terrace gravels. The terraces form flat or gently sloping features, generally 1 to 3 m above the alluvium. Sub-angular and angular flints with some quartz or quartzite pebbles are found on the surface of the terraces. The age of the terrace deposits is uncertain and Cox *et al.* (1989) thought that there was some evidence to suggest a late Hoxnian age (Arthurton *et al.*1994).

3.3.19. In the Waveney Valley three terrace sets are identified (**Figure 12**). The terraces have mainly been mapped in the western areas and are absent further downstream. The third (and highest) is the Homersfield terrace which forms a distinct irregular topographic bench typically 6 m above the present floodplain. Environmental evidence suggests deposition in a cold post-Anglian period.

3.3.20. The sands and gravels of the Broome Terrace (terrace 2) are thought to have been deposited in cold climate during the Wolstonian, based on re-worked Hoxnian interglacial pollen and that the terrace is stratigraphically higher that than nearby Ipswichian deposits at Wortwell. The youngest terrace deposits of the first 'floodplain' terrace are documented as late Devensian in age.

3.3.21. Sand and gravel working within the Waveney Valley indicate that the river terrace deposits contain large flint nodules (0.3m) clearly not transported far from the chalk source (Moorlock *et al.* 2000). The gravel content of the terraces varies between 29 and 59 % (average 41 %) and comprises mainly flint, quartz, quartzite and rare chalk (Moorlock *et al.* 2000).

3.3.22. Throughout the Palaeo-Yare Valley system these underlying floodplain sand and gravel deposits are overlain by Holocene post-glacial deposits belonging to the Breydon Formation. These are discussed in **Section 3.4**.

3.3.23. Interestingly, there is a somewhat clearer pattern of deposition in the now submerged Palaeo-Yare. The assessment of geophysical and geotechnical data, combined with environmental and dating techniques have allowed detailed assessment of the sediment units. The development of the Palaeo-Yare throughout the Middle Pleistocene is described in more detail below set against the regional context.

Hoxnian (MIS 11; 420 – 380 ka)

3.3.24. At the end of the Anglian Glaciation the climate warmed and the Hoxnian interglacial followed. Initially, sea-levels rose rapidly and by 400 ka were around 10 mbOD. During the latter parts of the interglacial, Britain is likely to have been a peninsula of north-western Europe.

3.3.25. The Palaeo-Yare became increasingly estuarine and then shallow marine environment as the sea-level continued to rise. The upland areas of till to the north and south of the floodplain would have formed the coastline and probably would have undergone at least some degree of erosion (**Figure 10b**).

3.3.26. The sedimentary record for this period is fragmentary in East Anglia (Arthurton *et al.* 1994). No deposits that can definitely be described as Hoxnian warm stage have been identified, although sands and organic silts infilling a channel cut in the Lowestoft till at Caister-on-Sea, seem likely to be of this age and small outliers of Hoxnian sediments were preserved within deposits on top of the till (Moorlock *et al.* 2000).

3.3.27. There is no evidence of Hoxnian deposits in the offshore aggregate licence areas. Interestingly, an OSL result in the lower floodplain deposits in Area 240 indicates an age of 418 $\pm$ 78 ka (GL 10039) indicating possible deposition associated with late-Anglian channel development prior to the inundation of the area. However, the age distribution of aliquots within this sample (*i.e.* the dating protocol used for this project is based upon 12 sub-samples for each individual date) indicates mixing of significantly older unbleached material of equivalently pre-Anglian age (modes of equivalent MIS 15 and ~25/26) and with a significant modal distribution of younger possibly MIS 8 age, leading to an averaging effect which gives a date between MIS 12 and 11 (Wessex Archaeology 2011a: Appendix II). Similar inter-aliquot averaging effects are exhibited by most of the OSL dates from the site as discussed below.

3.3.28. Any sediment associated with shallow marine deposition or subsequent regression at the start of the Wolstonian period is no longer preserved offshore. Any Hoxnian sediments deposited on top of the upland tills in the offshore area would have been removed by subsequent erosion and re-working of these sediments.

3.3.29. Our understanding of hominid movements and settlement in the Hoxnian interglacial is fragmentary but it is thought that the coastal plain was used for occasional forays into the intertidal marshes and the lower portions of river valleys for fishing and fowling with some sea fishing. It would seem that the potential for recovery of MIS 11 assemblages offshore is greatest in near-shore areas where remnant river terraces or valleys may be buried.

3.3.30. The Lower Palaeolithic sites of the Palaeo-Yare are reported as being particularly implementiferous, with excavations at Whitlingham producing several hundred lithic artefacts (Wymer 1999, Sainty 1927, 1933). The sites of Whitlingham (**WA 2059**) and Carrow Road (**WA 2019**) are located within the SA. The other major Lower Palaeolithic sites within the Palaeo-Yare valley which are situated outside the SA; Hoxne and Keswick Mill Pit[4], indicate a relative richness of significant sites exhibiting Lower Palaeolithic technology. Dating is poor for these sites, based on artefact typology, but it is likely that they date to around MIS 11 - 9.

Wolstonian (MIS 10 – 6; 380 – 130 ka)

3.3.31. The Wolstonian saw alternating periods of warm and cold with fluctuating sea-levels and climatic conditions. **Figure 7** illustrates the three major cold phases (MIS 10, 8 and 6) with two interglacial phases (the MIS 9 (Purfleet) and MIS 7 (Aveley) interglacials).

3.3.32. Cooling into MIS 10 was a slow process with oscillations between cold and warm phases occurring before the onset of more extreme cold conditions during MIS 10. Sea-level at this time was 100 m lower than present-day. During the subsequent warm period (Purfleet interglacial; MIS 9) sea-level was close to present-day level and the eastern Palaeo-Yare would have been a shallow marine environment with the upper reaches of the Yare affected by tidal regimes. Analysis of deposits assigned to the Purfleet interglacial indicates a range of habitats including riparian, woodland and grassland environments with climatic conditions that are thought to be warmer than the present day (Bridgeland 1994). During the high sea-level it is likely that the till coastline continued to erode to some extent. During lowered sea-level the southern North Sea would have been a deltaic environment (**Figure 10a**).

3.3.33. The end of MIS 9 and the climatic deterioration marking the onset of the MIS 8 glaciation began *c.* 300 ka. Although MIS 8 glaciation lasted a long time (*c.* 50,000 years) the climate was less severe than most other Middle Pleistocene glaciations (Tzedakis 2005).

3.3.34. During these cold phases (MIS 10 and 8), when sea-levels were lowered, the sands and gravels were deposited within the Palaeo-Yare. In the west of the SA the Yare Valley Formation continued to develop, the Broome Terrace of the Waveney was formed and the sediments classified as Unit 3 (a and b), identified initially within Area 240 and also identified throughout a large portion of the east coast aggregate licence areas, were deposited (**Figure 11**).

3.3.35. It was from Unit 3b that the Middle Palaeolithic Assemblage in Area 240 were recovered. Details of Units 3a and b including sediment composition, depositional environment, spatial distribution and relation to the Middle Palaeolithic assemblage are discussed in further detail in **Section 4.1**.

3.3.36. As the climate warmed at the start of MIS 7 rising sea-levels led to a marine transgression. Based on sea-level curves it is unlikely that the marine transgression affected the SA as extensive as MIS 9 and 11. The lower reaches of the channel and floodplain are likely to have been an estuarine environment at this time with the upper reaches still fluvial, with maybe some estuarine influence. Following the MIS 7 interglacial Europe entered another glaciation, similar to the severity of MIS 12.

3.3.37. There is much debate over the timing of the Wolstonian Glaciation (MIS 10, 8 or 6; as discussed in Gibbard and Clark 2011). The glacial episode is less well

[4] http://www.heritage.norfolk.gov.uk/SingleResult.aspx?uid=MNF9560 (last accessed 14/05/2012)

represented in the Pleistocene record and has to date been little studied and weakly defined. Gibbard and Clark (2011) suggest that, on balance, the evidence indicates that during the Late Wolstonian (MIS 6) a substantial ice-lobe advanced down the eastern side of Britain and filled the Fenland Basin where it dammed a series of westward-flowing streams to form shallow glacial lakes that coalesced culminating in an extensive proglacial lake. The lake drained westwards to the North Sea via the River Waveney. The Waveney/Yare valley in turn drained into a lake that formed in the southern North Sea analogous to the Anglian, although with smaller coverage (Brusschers *et al.* 2007) (**Figure 9b**).

3.3.38. From the onset of the MIS 6 glacial stage Britain appears to have been uninhabited until *c.* 40,000 years ago (MIS 3).

Ipswichian (MIS 5e; 130 – 110 ka)

3.3.39. The onset of the Ipswichian at MIS 5e was marked by an abrupt climatic transition from the end of the Wolstonian with rapid melting of the glaciers and rapid sea-level rise. The climate was similar of that today, possibly a bit warmer with hot summers and mild winters (Barton 2005). The southern North Sea was submerged during this time with the sea level 5 to 6 m higher than it is today. Similar to the Hoxnian interglacial the influx of sea would have been limited by the tills forming the cliffline and it is likely that these sediments were eroded during this stage (**Figure 10c**).

3.3.40. There is little evidence of Ipswichian interglacial sediments remaining in the Great Yarmouth and Lowestoft areas. Given the rise in the sea-level during this time, much of the coastal areas would have been inundated. At Great Yarmouth and its surrounding areas, of the Pleistocene stages following the Anglian, only the Devensian sediments are considered to be widespread (Arthurton *et al.*1994). To the south in the Lowestoft area, there are Ipswichian deposits at Wortwell, interpreted as having been deposited in a low energy fluvial backwater within the Waveney Valley (Moorlock *et al.* 2000).

3.3.41. There is some limited evidence of this warming period and rise in sea-level in the SA. In Area 254, organic freshwater sands and silts with occasional brackish indicators were OSL dated to 116.7±11.2 ka suggesting an Ipswichian date (Wessex Archaeology 2008a) and the palaeoenvironmental data supported an Ipswichian age. Some indications of increasing salinity were noted amongst the predominantly freshwater faunas indicative of a freshwater pool, lake or oxbow lake, surrounded by a birch and pine woodland.

3.3.42. These possible Ipswichian sediments in Area 254 are observed infilling the deeper section of a shallow channel feature cutting into the underlying Wolstonian sand and gravel sediments (Unit 3b). The presence of this possible Ipswichian fluvial to brackish deposition would indicate a transgression sequence during a sea-level rise which would indicate that the cut of this channel, and any development of freshwater pools *etc.*, occurred during the late Wolstonian and was then infilled during the Ipswichian, continuing to be filled during the early Devensian as the sea-level began to fall (Unit 4) and the channel and floodplain were re-activated.

3.3.43. Similar sediments have not been positively identified elsewhere in the SA. It is possible that some of the sediments identified as early Devensian (Unit 4), may be of this age, at least in their lower parts. Equally, if further freshwater sediments were deposited they may have been reworked or eroded during subsequent deposition during increasingly estuarine conditions during the early Devensian.

Devensian (MIS 5d – MIS 2; 110 ka – 13,500 BP)

3.3.44. The Devensian Glaciation was the last glacial stage to occur before the present climate amelioration. Between MIS 5d and 2 ice sheets waxed and waned reaching their greatest areal extent by 27 ka (Gibbard and Clark 2011) with the southern extent of the ice sheet extending in a line from the Severn to the Wash. The SA would thus have been outside the limits of the ice but within the periglacial zone (**Figure 10c**). At the height of the Devensian, the water locked up in ice sheets caused a lowering of sea-level to approximately 120 m below its current level.

3.3.45. The sea-level curve for the Devensian reflects considerable climatic variability with long periods of relative cold and, overall, a general trend towards ever colder conditions, culminating in the last ice age (**Figure 7**).

3.3.46. During MIS 5d – 5a (110 – 70 ka) there was a general deterioration in climate and is characterised by interstadial (5c and 5a) and stadial (5d and 5b) periods. Periglacial conditions prevailed during the stadials but pollen indicates that this did not limit tree growth altogether (Barton 2005). MIS 4 (75 – 60 ka) marked the onset of very cold conditions in Europe with the advancement of the Scandinavian ice sheet.

3.3.47. Early in the Devensian there was large scale re-development within the area with large scale rivers and lagoons developing on the southern North Sea plain (**Figure 10c**). Within the SA the majority of deposition occurred during the marine regression at the onset of the Devensian glacial stage (MIS 5d). The Yare Valley Formation continued to develop and offshore there was development of the Brown Bank Formation.

3.3.48. The Brown Bank Formation was deposited during the marine regression at the onset of the Devensian glacial stage (MIS 5d) and generally comprises brackish-marine grey-brown silts which are extensively bioturbated with a thin layer of shelly gravelly sand towards the base (Cameron *et al.* 1992; 1989). However, in the western region of the southern North Sea (to the east of the SA) the formation comprises more fluviatile current-bedded silt and finely laminated clays filling late Ipswichian/ early Devensian channels, up to 20 m deep. These channels flow into a shallow lagoon with only limited access to the open sea during late Ipswichian and early Devensian times (Cameron *et al.* 1989). These early channels appear to flow north into the lagoon. However, the presence of a partially filled channel directly to the east of the SA indicates that at some point these channels flowed south and joined with the channel complex in the outer Thames Region (**Figure 10d**). As the climate continued to cool these river systems would have dominated the landscape.

3.3.49. In Area 240 Units 4, 5 and 6 are associated with the Devensian period (Wessex Archaeology 2011a).

3.3.50. Unit 4 is a fine-grained unit generally comprising silty and clayey sands. Palaeoenvironmental evidence from Area 240 indicates deposition in a brackish or estuarine environment. The abundance of deciduous woodland taxa implies that this assemblage is likely to be from an inter-glacial/ stadial warm period and there is also evidence of bilberries, heath and heather which may indicate areas of heathland or mire in the local vicinity. The pollen analysis also implies that this is a pre-Holocene sequence. OSL dating returned dates of 109 ± 11 ka (GL 10037) and 96 ± 11 ka (GL 10041), both correlating to the early-Devensian.

3.3.51. Unit 4 is an infill deposit of a re-cutting of the Wolstonian channel during the end of the Wolstonian or the Ipswichian and is interpreted as deposits belonging to the early Devensian Brown Bank Formation. However, it is not clear from the data how

the channel identified in the SA links with the broader-scale channels identified to the east.

3.3.52. Unit 4 sediments are observed throughout the channel in Area 240, extending through Area 228 and following the channel east in Area 251. No evidence of Unit 4 sediments are observed in Area 401/2, possibly indicating the limit of deposition at this time (**Figure 13**). This limit of deposition may be a change in flow regime rather than a termination of the channel.

3.3.53. The Unit 4 deposits are generally confined to the channel feature or the channel edges and comprise channel infill or overbank deposits.

3.3.54. To the east of the SA in Area 401/2 the western edge of a north-south trending channel is observed which correlated with a larger channel known in the region (Cameron *et al.* 1989; Limpenny *et al.* 2011). There is no direct correlation in the geophysical data between the channel deposits (Unit 4) and the floodplain deposits of Unit 3b. However, two small banks features interpreted as Unit 4 overlie Unit 3b and there is no evidence of erosion.

3.3.55. MIS 3 (60 ka – 25,000 BP) is typified by a sharply oscillating climate – short cooling episodes and milder climatic events are recorded. In Britain, cool dry conditions encourage the development of rich arid grasslands (mammoth steppe) which supported large mammals such as mammoth, woolly rhino, lion, bear etc.

3.3.56. The migration of these animals probably also coincided with the arrival of the Late Neanderthals (Mousterian culture). Anatomically modern humans were active in southern Britain sporadically (in MIS 3: around 38,000 BC at Kent's Cavern, Devon; around 35,000 BC at Beedings, West Sussex). There is evidence of a MIS 4/3 site at Lynford Quarry, Munford, Norfolk where a middle Palaeolithic lithic assemblage (stone tools and debitage) and *in situ* mammoth bones were found within organic fill deposits in a palaeochannel. The infill deposits were dated to MIS 3 cutting into early-Devensian sands and gravels (Boismier *et al*. 2003).

3.3.57. Units 5 and 6 identified in Area 240 as infills of small depressions cut into the underlying Unit 3b and are interpreted as estuarine sediments either deposited or at least exposed during MIS 3 (OSL date of 36 ± 3 ka, GL 10044). These units have not been identified in the surrounding area, possibly due to the resolution of the datasets and the subtle nature of the features.

3.3.58. Subsequently, intense cold all across northern Europe forced human populations to retreat to a few key refuge areas before the last Glacial Maximum around 18,000 BP (Housley *et al*. 1997).

3.3.59. Upstream, there are three Upper Palaeolithic archaeological sites recorded (**WA 2010, 2061** and **2129**). These are recorded as Upper Palaeolithic but it is not clear whether they relate to the Early Upper Palaeolithic (preceding the Last Glacial Maximum: *c.* 40,000 – 27,000 BP) or the Late Upper Palaeolithic (*c.* 14,600 – 11,600 BP). **WA 2010** and **2061** are documented as lithic working sites situated near Norwich and **WA 2129** is a findspot of an Upper Palaeolithic handaxe, probably in secondary context.

3.4. DEVELOPMENT OF THE PALAEO-YARE: LATE DEVENSIAN (MIS 2; 13,500 BP) AND HOLOCENE (MIS 1)

3.4.1. Between 13,000 and 11,000 BP (Windermere Interstadial) the climate was warm and the landscape contained a mixture of light birch woodland, grassy meadow and areas of wetland vegetation, favourable for human occupation. Colder conditions returned between 11,000 and 10,000 BP (Loch Lomond Stadial) when glaciers formed in the Scottish Highlands and colder conditions returned until the climate finally ameliorated with the onset of the Holocene period, approximately 10,000 BP. At the beginning of this period vegetation will have been sparse but, as temperatures rose, both flora and fauna will have become more diverse.

3.4.1. From 10,000 year ago (Pre-Boreal period) the climate saw a marked improvement in climate and then continued amelioration throughout the Boreal period (9,500 – 7,200 BP). Coupled with the warming of climate was a general sea-level rise and gradual shrinking of exposed land. Between 8,700 and 4,500 BP local sea-level rose by between 22 and 26 m, the change being marked by the intrusion of tidal influence much further inland up the valleys (Moorlock *et al.* 2000). **Figure 14** illustrates the regional palaeogeography during MIS 2 and 1.

3.4.2. The SA is likely to have been exposed as dry land throughout this period until the start of inundation *c.* 8,000 to 7,500 BP (Jelgersma 1979; Shennan *et al.* 2000; Shennan and Horton 2002).

3.4.3. Remnants of this exposed landscape are observed as a meandering channel with associated organic sediment unit (Unit 7) in the central region of the SA and to the west observed as the Breydon Formation (**Figure 15**).

3.4.4. The confluence of the Rivers Bure and Yare at Great Yarmouth has resulted in a large complex of alluvium, peat and fen silts adjacent to the coast (Geological Survey of Great Britain, Sheet 12). Peat of freshwater and brackish origins is a major component in the valleys of the River Yare and overlies the Yare Valley Formation gravels (Arthurton *et al.* 1994).

3.4.5. These post-glacial peats are identified as the Breydon Formation, a fill of the buried valley system underlying present-day marshland. The formation is dominated by silt and clay. Associated with the formation are three peat layers: the basal, middle and upper peat. The basal peat unit is comparative with Unit 7 identified offshore; the middle and upper peat were deposited onshore after the inundation of the eastern SA (Boomer and Godwin 1993; Arthurton *et al.*1994).

3.4.6. The basal peat of the Breydon Formation is recorded to have formed 6,600 to 6,240 cal. BC (7,580± 90 BP, HAR 2535) at a depth of around 19 mbOD and is up to 2 m thick (Arthurton *et al.* 1994). Based on seismic data of the near coastal area, the Breydon Formation is thought to be preserved offshore in two distinct areas off Great Yarmouth, approximately 6 km east of the present-day coastline (Arthurton *et al*.1994; **Figure 15**).

3.4.7. Approximately 8 km east of the present-day coastline the remnants of a meandering north-south oriented, partially-filled channel is observed. It is thought that the channel originally flowed east following the same fluvial channels as previously. However, the channel then diverted from its original route continuing east through Area 240, but instead flowed south though Area 319 and 251 (**Figure 15**). The diversion is possibly due to the less erosive early Devensian infill and overbank

structures (Unit 4), with the channel flowing over the Wolstonian floodplain deposits (Unit 3b).

3.4.8. The channel is generally partially filled and only remnants of the channel infill sediments are observed in Area 240, 319 and in the survey area to the south of Area 251 (**Figure 14**); the fills are equivalent to the lower deposits of the Breydon Formation (*i.e.* Unit 7). It is possible that the Breydon Formation deposits were much more extensive in the past but were eroded during, and since, the last transgression. Evidence of rolled and re-worked peat in the offshore region indicates that erosion has continued since the transgression (Wessex Archaeology 2011a). The channel in Area 319 has re-worked, and in places removed, the underlying Unit 3b deposits (**Figure 15**).

3.4.9. The sediment sequence of Unit 7 comprises sediments indicative of a progressively transgressive sequence from intertidal mudflat/saltmarsh deposited in the Early/Mid-Holocene. This is overlain by shallow marine/outer estuarine sand, which is in turn, overlain by a shallow marine lag deposit, formed during the last transgression.

3.4.10. The deposits in Areas 240 and 319 include a peat layer within the unit overlain by transgressive sands and gravels. To the south, the unit generally comprises silts and clays with occasional inclusions of organic matter overlain by sand and gravel.

3.4.11. **Table 6** details the radiocarbon dating of this unit. The dating is also illustrated in **Figure 7**.

Location	Depositional unit	Depth	Age	Reference
Breydon Water	Basal peat of Breydon Formation	19 mbOD	6600 - 6240 cal. BC(7580± 90 BP)	HAR 2535; Arthurton *et al.* (1994)
Area 240	Base of intertidal mudflat/saltmarsh deposit	32.06 mbOD	7710 – 7560 cal. BC (8595±35 BP)	SUERC-32234; Wessex Archaeology (2011a)
Area 240	Top of intertidal mudflat/saltmarsh deposit	31.57mbOD	6730 – 6590 cal. BC (7820 ±30BP)	SUERC-32233; Wessex Archaeology (2011a)
Area 240	Base of intertidal mudflat/saltmarsh deposit	30.80 mbOD	10,710 – 10,280 cal. BC (10,470±35 BP)	SUERC-11978; Hazell (in prep.)
Area 240	Base of intertidal mudflat/saltmarsh deposit	30.05 mbOD	7530 – 7350 cal. BC (8370±25 BP)	SUERC-11975; Hazell (in prep.)
South of Area 251 (REC VC 18)	Upper part of basal gravelly sands	37.55 mbOD	8050 – 7560 cal. BC (9030±35 BP).	SUERC-30759; Limpenny *et al.* (2011)
South of Area 251 (REC VC 18)	Outer estuarine sediments	35.95 mbOD	6490 – 6230 cal. BC (7900±35 BP)	SUERC-30758; Limpenny *et al.* (2011)
South of Area 251 (REC VC 18)		33.53 mbOD	6310 – 5970 cal. BC (7625±35 BP)	SUERC-30754; Limpenny *et al.* (2011)

Table 6. Radiocarbon ages of Breydon Formation (Unit 7).

3.4.12. As inundation continued the coastline continued to retreat and the alluvium and peats continued to develop in the upper reaches of the Yare valley with the Breydon Formation Middle Peat formed between 4,700 and 2,200 BP. The Upper Peat developed around 1,750 BP (Arthurton *et al.* 1994).

3.4.13. To the east of the eroding coastline tidal currents re-developed the nearshore area with the development of the large complex sandbanks offshore and, between these, deep channels were scoured by strong tidal currents. East of these banks within the aggregate dredging area Holocene sediments (Unit 8) generally form a thin veneer over Pleistocene formations. The present-day bathymetry of this area of the North Sea is comparable to the morphology of the pre-Holocene land surface with exceptions where accretion and erosion has occurred (Cameron *et al.* 1992). This is observed where the Early Holocene channel has not been completely infilled, but a veneer of modern sediments is observed throughout the feature.

3.4.14. Within the survey areas the seabed sediments comprise a shelly, gravelly medium to coarse sand lag deposit or shelly sands forming mobile bedforms such as sand ripples and larger sandwaves (up to 6m high in Area 240). Bank features are also observed in Area 494/292 in the north of the SA and in the south of Area 401/2 in the south of the SA (**Figure 15**). These large banks comprise re-worked shelly, sandy gravel. In Area 494/292 these banks are targeted for dredging. Although the age of these banks are unknown, it is considered likely that these formed under shallow marine conditions either during or since the last marine transgression.

3.4.15. Early Mesolithic sites and find spots are often found adjacent to wetlands and estuaries (Oxford Archaeology 2007), indicating a preference by Mesolithic communities for areas in which they could exploit the marine resources available in such environments. In the Early Mesolithic period, the southern North Sea would have comprised undulating lowland drained by a complex of Pleistocene river systems. This extensive lowland would have been attractive for human occupation, not only providing access to both terrestrial and marine resources, but also enabling these early Mesolithic communities to exploit the herds of red deer and other such mammals which migrated into Britain from the Continent as the climate ameliorated (Sumbler *et al.* 1996).

3.4.16. A total of 77 finds of potential Mesolithic material and working sites are recorded within the SA. This includes two records of Mesolithic human remains (**WA 2090** and **2092**) from the marshy floodplain of the Yare between Surlingham and Strumpshaw. The lithic working sites (**WA 2010. 2026, 2045, 2054, 2088, 2096** and **2101**) appear to be concentrated in the northwest of the SA close to Norwich associated with the margins of till and crag overlooking at the margins of the river valleys (**Figure 16**). This trend may simply represent the eroding interfaces between sedimentary units which preferentially permit discovery of archaeological materials rather than a particular locational preference. Documented findspots of Mesolithic artefacts are more dispersed over most of the SA (except in the vicinity of Kessingland). It has been noted that Norfolk in general has few excavated, or palaeoenvironmentally analysed, sites of Mesolithic date (Austin 2011) (**Figure 16**).

3.4.17. Although there is a significant quantity of Mesolithic material in the SA it has been noted that there are few excavated sites or defined patterns of human activity during this period (Hill *et al.* 2008, Austin 2011).

3.4.18. Environmental remains of probable Mesolithic age have been reported through the BMAPA *Protocol for Reporting Finds of Archaeological Importance* (**WA 2148 – 2157, 2164, 2177, 2178**) and are predominantly, with the exception of **WA 2177**

and **2178**, associated within the confines of the early Holocene channel. **WA 2177** and **2178** are probably eroded peat deposits. There are also three (**WA 2179**, **2180** and **2190**) reported finds of faunal remains, which are likely to be in secondary contexts.

3.4.19. Within the overall palaeogeographic context of the Palaeo-Yare valley, during the development of coastal channel in the early Holocene (Unit 7), artefact findspots suggest much of the contemporary human activity was concentrated in the upper reaches of the river valleys. However, the intervening 10 miles between the modern coast and the extent of this north – south orientated channel are characterised by a complex coastal system (now inundated) at the confluence of the Yare and Bure rivers in the vicinity of Great Yarmouth; which may also have been an attractive ecotone of higher potential for Mesolithic human activity (**Figure 16**). Considerable reworking of coastal sediments into significant sand bars have further obscured the early Holocene river system (Royal Haskoning 2009) which is represented by the Breydon Formation in the Yare valley and Unit 7, offshore in Area 240, 319 and to the south of Area 251.

3.4.20. Of the recorded finds within the SA, 18 can be associated with Holocene sediments. The 11 associated with the Mesolithic are environmental remains as detailed above. Additionally, a number of secondary context Lower Palaeolithic and Palaeolithic finds are associated with Early Holocene sediments of the Breydon Formation (**Table 7**).

Geological Context	Number of Finds	Associated Finds (Arch. Periods)	Associated Offshore Unit	WA ID
Unit 7 Holocene channel deposits	11	Mesolithic	7	2148 – 2157, 2164
Alluvium	1	Lower Palaeolithic	7?	2047
Edge of Crag and Alluvium	1	Palaeolithic	2,7	2021
Edge of River Deposits of Terrace 1	1	Palaeolithic	7?	2106
Peat	1	Lower Palaeolithic	7	2114
River Deposits of Terrace 1 (Floodplain)	3	Palaeolithic	7?	2002, 2003, 2019
Total	**18**			

Table 7: Geological associations reported for finds in the SA with tentative correlations to the identified offshore units (Unit 7).

3.5. SUMMARY

3.5.1. Since the initial cut of the Palaeo-Yare valley at the end of the Anglian Glaciation a series of sands and gravels have been deposited during cooler periods when sea-levels were lowered. During warmer climes when the sea-level was higher the lower reaches of the Palaeo-Yare valley was slowly inundated, changing from fluvial, to estuarine and where sea-levels were high enough, shallow marine environments. During these times of high sea-level the upper reaches of the Yare would have remained a river but with some tidal influence.

3.5.2. This general pattern of regression and transgression repeated numerous times over the past 400 ka and during the majority of this time the sea-levels were lowered and the southern North Sea was an exposed landscape.

3.5.3. The Palaeo-Yare valley periodically flowed into glacial lakes (MIS 10 and 6) or joined larger drainage systems either flowing north to the sea or into channels draining south during the later Devensian.

3.5.4. Within the offshore section of the SA the main phase of sediment deposition forming the floodplain and partially infilling the channel occurred during the cooling period from MIS 9 interglacial to the MIS 8 glacial and the floodplain continued to develop during this cold phase. It was these sediments, classified as Unit 3b, from which it is thought the handaxes were dredged.

4. PALAEO-YARE AND THE MIDDLE PALAEOLITHIC ASSEMBLAGE

4.1. INTRODUCTION

4.1.1. This section concentrates on the development of the Palaeo-Yare during the Wolstonian and the associated Middle Palaeolithic Assemblage associated with sediments of this age. The broader context of the Middle Palaeolithic Assemblage and the potential for further artefacts are also discussed.

4.2. PALAEOGEOGRAPHY

4.2.1. An overview of the palaeogeography of the Palaeo-Yare during the Wolstonian was provided in **Section 3.3**. The aim of this section is to provide details of the Wolstonian sediments and their relationship to the Middle Palaeolithic Assemblage.

4.2.2. There are two significant sediment units associated with the Wolstonian (Units 3a and 3b). Unit 3a is observed in Area 240 in the base of the channel feature and the sediments were deposited in a cold, glaciofluvial environment. Unit 3b overlies Unit 3a and forms the floodplain deposits observed throughout the area. Unit 3a has not been identified throughout the other licence areas in the base of the channels as it is indistinguishable from the overlying Unit 3b in the geophysical data.

4.2.3. Unit 3b is an extensive channel infill and floodplain deposit (the remnants of which are illustrated in **Figure 12**). It was Unit 3b from which the handaxes were dredged and as such is the particular focus of this assessment. **Figure 17** illustrates the geophysical nature of the floodplain in the area from which the Middle Palaeolithic assemblage was recovered.

4.2.4. OSL dating of Unit 3b indicates a likely deposition between approximately MIS 8 and MIS 6 with the sediments from which the handaxes were dredged probably dated to the cooling period prior to MIS 8 (**Table 8**). Unit 3a sediments were deposited in a cold environment and are either contemporaneous of MIS 8 deposits or represent deposition in the previous cold stage (possibly MIS 10 or MIS 12).

Location	Depositional unit	Depth	Age	Reference
Area 240 (central floodplain)	Base of Unit 3b – reworked Hoxnian	31.0 mbOD	418± 78 ka (MIS 12/11)	GL 10039; Wessex Archaeology (2011a)
Area 240 (central floodplain)	Unit 3b below level from which handaxes were dredged	28.7 mbOD	243 ± 33 ka (MIS 7)	GL 10038; Wessex Archaeology (2011a)
Area 240 southern floodplain	Base of Unit 3b	31.6 mbOD	283 ± 56 ka (MIS 9/8)	GL 10043; Wessex Archaeology (2011a)
Area 240 channel	Upper channel deposits (Unit 3b)	29.9 mbOD	207 ± 24 ka (MIS 7)	GL 10042; Wessex Archaeology (2011a)
Area 254	Upper Unit 3b sediment - bank structure	40.0 mbOD	175 ± 23 ka (MIS 7/6)	Wessex Archaeology (2008a)
Area 319	Unit 3b – base of bank structure	33.4 mbOD	206.5 ± 29.5 ka (MIS 7)	Limpenny *et al.* (2011)
Area 319	Unit 3b – middle bank structure	32.5 mbOD	222 ± 29 ka (MIS 7)	Limpenny *et al.* (2011)
Area 319	Unit 3b – upper bank structure	31.5 mbOD	188 ± 29 ka (MIS 7/6)	Limpenny *et al.* (2011)

Table 8. OSL ages of channel and floodplain deposits (Unit 3b).

4.2.5. The glaciofluvial nature of Unit 3b indicates deposition during the cold conditions of the Wolstonian glaciation (MIS 8) which is largely confirmed by the OSL dating, however the precision of the dates resolves a window of MIS 9 to 7. When the distribution of OSL dating aliquots is examined it is clear that in most samples there is a mixture of reworked or poorly bleached sediments, some with residual unbleached signals dating to at least MIS 11 (Wessex Archaeology 2011a: **Appendix II**).

4.2.6. On balance, there does appear to be distinct modal distributions of aliquots suggesting the top of Unit 3b, *i.e.* the active dredging surface and likely source of the reported lithic, faunal and floral materials, was deposited by 250 - 200,000 years ago during MIS 8 - 7 (Wessex Archaeology 2011a: Appendix II) which agrees well with the overall site stratigraphy. Marine, fluvial and glacial depositional environments are demonstrably complex for applying OSL sediment dating protocols, particularly of this age (Harding *et al*. In Press, Rendell 1995), but optical luminescence techniques can provide valuable chronological control for interpreting marine stratigraphy (Stokes *et al*. 2003).

4.2.7. Unit 3b is broadly confined to a west-east corridor up to 14 km wide and extending approximately 30 km east of the present-day coastline. The unit within the floodplain area generally comprises a series of laminated sands and gravels with gravel content up between 15 and 30 % in the southern area of the floodplain (RMC Landsearch Exploration Department 1993). The thickness of the unit varies and is difficult to establish due to the dredging of the unit within the area.

4.2.8. Generally, the floodplain deposits in the west and south are generally thinner than elsewhere, approximately 2 – 4 m thick. Within the channel and to the east the units are generally 2 – 6 m thick. Although it is difficult to establish differences in

sediment character on a regional scale, localised differences are apparent. For example, in Area 240 Unit 3b sediments are observed to be coarser grained in the north and finer to the south.

4.2.9. Within Channel A Unit 3b deposits have been eroded and reworked at the onset of the Devensian when the channel was reactivated. Fine-grained Unit 4 sediments were then deposited as bank and fill deposits as illustrated in **Figure 18**.

4.2.10. In the east of the SA there is a large bank deposit orientated southeast to northwest. The bank is up to 6 m high with numerous phases of development and overlies Unit 3b (**Figure 19**). Prior to, or contemporaneous with the development of this bank the northern limit of the floodplain deposits have been eroded away. The bank comprises a series of sand and gravel units as well as an upper unit of fine-grained silts and clays. The age of this feature is unknown but is not to have thought to have formed under marine conditions since the last transgression and may represent an inter-tidal or nearshore deposit formed during a previous rise or fall of the sea-level. The bank is important in that it shows natural erosion of the floodplain deposit (Unit 3b) that has not also been affected by dredging, indicating that in the east the northern limits of the floodplain were more extensive.

4.2.11. To the north of the floodplain small outliers of Unit 3b deposits are observed, generally infilling small depressions in the underlying Unit 2 deposits. The data does not indicate these are re-worked by marine transgression and it is possible that they may represent sediments deposited during sea-level regression or represent remnants of small tributary channels flowing into the floodplain. To the south of the floodplain, in the east, further, more substantial, outliers of Unit 3b are observed. The largest of these features covers an area of 8.6 km^2 and comprises sand and gravel deposits between 2 and 6 m thick. There is a clear cut on the northern side of the feature indicating a channel or large infilled depression feature extending to the southwest beyond the limits of the assessed geophysical data (**Figure 12**).

4.2.12. Within the limits of the floodplain there are areas where the Unit 3b deposits have been removed, or at least, heavily affected by dredging operations (**Figure 12**). Also, in Areas 319 and west 251 there has been removal of Unit 3b, partly due to dredging, but more due to reworking in the area due to the development of the Early Holocene channel (see **Section 3.4**).

4.3. ARCHAEOLOGY

Middle Palaeolithic Assemblage

4.3.1. The Middle Palaeolithic Assemblage comprises a total of 124 pieces of worked flint (**Table 9** and **Figure 20**) recovered from Area 240 during dredging and seabed sampling activities.

Finds	Handaxes	Cores	Flakes	Total
Original discovery (**WA 2147**)	33	8	47	**88**
EC REC (**WA 2206**)	-	-	1	**1**
Seabed Prehistory: Seabed Sampling (**WA 2192** – **2200, 2203** and **2204**)	-	-	11	**11**
Wharf monitoring (**WA 2207** – **2227**)	3	1	20	**24**
Total	**36**	**9**	**79**	**124**

Table 9. Composition of the Middle Palaeolithic Assemblage

4.3.2. The condition and quality of the flint artefacts that make up the Middle Palaeolithic Assemblage show that the material originates from several contexts. However, it is likely that at some of the flint artefacts were dredged from undisturbed deposits. Generally, accumulated evidence of early human activity (a palimpsest) is suggested (De Loecker 2011). The used flint is homogenous in character and that the raw material was sourced from river (exposed gravel bars) deposits (De Loecker 2011).

4.3.3. The assessment of the 36 handaxes revealed that the assemblage is homogenous and show a considerable amount of workmanship. The handaxes are of cordiform or sub-cordiform type and can be described as Acheulean or as Mousterian of Acheulean Tradition (MTA) tradition (De Loecker 2011). Analysis of the three handaxes recovered during monitoring activities, revealed features entirely consistent with the results of the analysis on the original discovery.

4.3.4. Analysis of the flakes reveals that the Levallois technology was definitely involved in the production of some of the flakes; of the original discovery 46 % of the flakes can be described as Levallois *sensu stricto* or as extended Levallois. The eight cores are disc and Levallois *sensu stricto* cores. The majority (86 %) of the cores show remnants of the original outer surface (cortex) of the raw material nodule indicating that the nodules were introduced at the locality without prior preparation or decortication (De Loecker 2011).

4.3.5. The 29 flakes subsequently recovered were largely undiagnostic, and with the exception of two handaxes thinning flakes, may have been derived from either core or core tool manufacture.

4.3.6. No Levallois cores were recovered from the wharf monitoring; however a large tertiary flake (**WA 2209**) and probable broken blade (**WA 2227**), which has a carefully faceted butt, seem likely to have been removed from a prepared core. These finds appear to confirm a Levallois element to the core reduction strategy employed at this site.

4.3.7. The consistency of the artefact composition, especially handaxe form and condition, of the material recovered during wharf monitoring are immediately comparable to those of the original discovery. This supports the argument that the Middle Palaeolithic Assemblage artefacts, both handaxes and flakes, were derived from the same geographical location and sediment deposit (Unit 3b).

4.3.8. The condition of individual artefacts indicates that most of the worked flint assemblage is not from an undisturbed context, specifically an *in situ* land surface, but is unlikely to have moved far from its original point of discard. The fresh unabraided component exists with isolated, more heavily rolled material that may represent older artefacts that have been more extensively reworked in the gravel.

4.3.9. Handaxe typology is an unreliable chronological indicator; however the combination of cordiform hand axes and Levallois technology found together, and in a similar condition, suggests that the components of the assemblage are broadly contemporary. This is compatible with material dating not before MIS 9-8, when it is thought that fully fledged Levallois technology became fully established in Britain after its appearance in MIS 9b (Westaway *et al*. 2006). Although handaxes of this type could typify the 'Mousterian of Acheulian Tradition' (associated with MIS 4-3), given the geological context of the site it is considered that the lithic material is all sourced from Unit 3b sediments dated to the Wolstonian (MIS 8/7).

4.3.10. Further flint artefacts have been reported from Area 240 through the BMAPA *Protocol for Reporting Finds of Archaeological Interest*. In 2007 – 2008 two flints, along with two mammoth teeth, were recovered from the aggregate reject pile at SVB Flushing Wharf (**WA 2159 - 2160**). One of these flints showed possible signs of striking and may have been the waste product during the knapping of a flint tool such as a handaxe (Wessex Archaeology 2008c). Although the exact location of where the flints were dredged is unknown and therefore context is unknown assessment of the geology indicates that the material from which the flakes were dredged was Unit 3b.

4.3.11. A piece of worked flint was recovered from Area 360 along with faunal remains (**WA 2181**) and worked flint was also recovered from an unknown East Coast licence area (**WA 2191**). These finds tentatively suggest that there is potential for the presence of archaeological material within the other East Coast aggregate extraction areas.

Faunal remains

4.3.12. In addition to the lithic artefacts a large number of faunal remains have been recovered from the site. In the original discovery approximately 130 faunal remains (**WA 2146**) were recovered and underwent analysis by Mr Jan Glimmerveen in Holland. Approximately 70 % of the faunal remains were attributed to an age between 43,000 and 31,000 BP based on the radiocarbon dating of 5 of the remains (**Table 10**)[5]. The remaining 30 % of the bones are heavily fossilised, estimated to be older than 500 ka. However, preservation of bones, and the degree of fossilisation may vary within a deposit and between deposits. As it is unknown if the bones were from a single deposit or from many deposits, these dates should not be taken as definitive.

[5] Radiocarbon dating was carried out by Prof. Hans van der Plicht, Centre for Isotope Research, Groningen University, Groningen, Netherlands.

Lab number	Material	RC dates
GrA-39965	Jaw fragment woolly rhinoceros	>45,000 BP
GrA-39962	Cervical vertebra woolly mammoth	37,240 (+280,-260) BP
GrA-39966	Antler reindeer	31,460 (+160,-150) BP
GrA-39964	Metacarpal horse	42,960 (+500,-420) BP
GrA-39518	Metacarpal steppe wisent	39,900 (+850,-650) BP

Table 10. Radiocarbon dates of faunal remains recovered from Area 240.

4.3.13. Additional faunal remains were also recovered from clamshell grab sampling during the *Seabed Prehistory* project (**WA 2201** and **2002**) and also during the wharf monitoring in dredge loads associated with the flint artefacts.

4.3.14. Furthermore, between October 2010 and 2011 faunal remains were recovered at the wharf in Vlissingen by the Natural History Museum of Rotterdam in agreement with the Wharf (Strijdonk *et al.* 2011; 2012). The aggregate from which the faunal remains were recovered was dredged from Area 240. The remains contain an Early Pleistocene to early Middle Pleistocene assemblage comprising terrestrial mammal bones primarily from species of mammoth and moose. These faunal remains are likely to be associated with either Unit 2 or Unit 3b. In addition, an assemblage of faunal remains dated as Late Pleistocene, which includes woolly mammoth, bison, giant deer, woolly rhinoceros and wild horse, are likely to be associated with Unit 4, 5 or 6. A final group dates to the Early Holocene and are likely to be associated with Unit 7 deposits and include red deer and bovid remains.

4.3.15. A further 32 faunal remains have also been reported though the *Protocol for Reporting Finds of Archaeological Interest* from the wider East Anglian aggregate dredging area. The majority of the finds reported in this manner are isolated finds and have little or no context. In many cases the actual location of the find is unknown other than the area from which it was dredged.

4.3.16. Faunal remains have been reported from the aggregate Areas 251, 254, 296, 360 and 361 and Area 430, situated to the south of the main aggregate dredging area region (**WA 2145 - 2192**). All the reported identifiable bones belonged to land mammals, including reindeer, mammoth, deer and auroch. Mammoth teeth were also reported.

4.3.17. An unrolled, probably *in situ* antler fragment from a giant deer (Megaloceros) and Southern Mammoth (*Mammuthus meridionalis*) tooth were recovered from Area 360 (**WA 2184, 2183**) and were thought to have been dredged from an *in situ* deposit. Although it is very difficult to date this material it was considered reminiscent of examples from the early Middle Pleistocene and earlier deposits found on the East Anglian coast (Wessex Archaeology 2009).

4.3.18. The context of the recovered faunal remains is difficult to ascertain. Some of the remains in the original discovery were reported to be in very good condition indicating possible *in situ* remains. However, the majority of faunal remains abraded and rolled, and are likely to be deposited in a secondary context.

4.3.19. Faunal remains, however, are important in terms of assessing environment (marine or terrestrial) and species of animal. Certain species are associated with particular time periods.

Known and Potential for Palaeolithic Sites in the Upstream Palaeo-Yare Valley

4.3.20. The Lower Palaeolithic sites of the Palaeo-Yare are reported as being particularly implementiferous, with excavations at Whitlingham producing several hundred lithic artefacts (Wymer 1999, Sainty 1927, 1933). The sites of Whitlingham (**WA 2059**) and Carrow Road (**WA 2019**) are located within the SA. The other major Lower Palaeolithic sites within the Palaeo-Yare valley just outside the SA; Hoxne and Keswick Mill Pit[6], indicate a relative richness of significant sites exhibiting Lower Palaeolithic technology. Dating is poor for these sites, based on artefact typology but it is likely that they date to around MIS 11 - 9. A poorly contextualised single Levallois flake from Carrow Road, Norwich and a few locations outside of the SA (Wymer 1999) may indicate a contemporary Middle Palaeolithic presence in the vicinity of the Yare / Waveney region but the current evidence is slight (Pettitt and White 2012).

4.3.21. Overall, the large number of excavated (Sainty 1927, 1933) and reported surface finds of Lower Palaeolithic technology in the SA is in direct contrast to the paucity of sites and finds in the Yare valley of Middle Palaeolithic type (either Levallois or Mousterian types of tools) as indicated in the recently analysed TERPS dataset (Pettitt and White 2012); played out on the backdrop of fluctuations in climate, geomorphology (Ashton *et al.* 2006) and island-peninsula palaeogeography between climatic stages throughout the Middle and Late Pleistocene (White and Schreve 2001, Pettitt and White 2012).

4.3.22. Within the now onshore region of the Palaeo-Yare valley the distribution of archaeological materials from identified sedimentary contexts is very mixed with few finds from a defined period deriving from a sedimentary unit of equivalent age or with a reported archaeological context other than “Palaeolithic”.

4.3.23. The distribution of “Palaeolithic” material encompasses a very wide range of sediments and geological units highlighting the reworking of this material. Reworked or mobile sediments such as blown sand, glaciofluvial sands and gravels, and tills are arguably less likely to contain *in situ* material, although the presence of sites cut into these deposits cannot be ruled out. Glacial sediments such as the Corton Formation units, tills and marine sediments such as Crag are also less likely to contain *in situ* artefacts but again the archaeological context for any associated finds is not clear.

4.3.24. Of the geological contexts ascribed to the archaeological finds only ‘Terrace 2’ (the Broome Terrace) and ‘Terrace 3’ (the Homersfield Terrace) of the River Waveney (**Table 10**), within the Palaeo-Yare catchment, between Hoxne and Bungay can be tentatively correlated to Unit 3/3b within Area 240,s*ensu* Moorlock *et al.* (2000), not Wymer (1999) which has attributed the terraces using the Diss district nomenclature after Mathers *et al.* (1993). Moorlock *et al.* (2000) suggests that the Homersfield Terrace is a fluvioglacial deposit of late Anglian age. The Broome Terrace is attributed to the Wolstonian Cold Stage (after Coxon 1984). Of the documentary sources of lithics examined for this project only one is related directly to “Terrace 2” (**WA 2094)**, an *in situ* flake found in a pit and two to the Homersfield Terrace (**WA 2049** and **2085**) found on the edge of old quarry pits (**Figure 16**).

4.3.25. There is some potential for further *in situ* artefacts to be located in the now-onshore area. The Yare Valley Formation is known to exist beneath the Breydon Formation throughout the valley. However, debate over the age of the Formation and being able to identify Wolstonian sediments is difficult within this Formation. Terrace

[6] http://www.heritage.norfolk.gov.uk/SingleResult.aspx?uid=MNF9560 (last accessed 14/05/2012)

deposits speculatively attributed to Wolstonian age *have* been identified within the region suggesting there is potential for locating *in situ* material, but there is little evidence to date that suggests the presence of a site similar to the offshore Middle Palaeolithic Assemblage.

Wider Early Middle Palaeolithic (EMP) Context

4.3.26. The archaeological context within the Yare and Waveney catchment and more widely from Western Europe is summarised in **Appendix IV and Figure 21** encompassing Lower and Early Middle Palaeolithic (EMP) sites typified by Neanderthal humans after MIS 11.

4.3.27. Beyond the Palaeo-Yare catchment in other areas of southern Britain and north-western Europe evidence is much more extensive during (and after) MIS 9 – 7 (**Appendix IV**), with proto-Levallois technology entering the archaeological record from MIS 9 (White and Ashton 2003, Pettitt and White 2012). The overall distribution of EMP sites in England and Wales is spatially very variable with most known activity concentrated in the valleys of the Thames, Great Ouse and Solent rivers (Wymer 1999, Pettitt and White 2012) with other sites more widely distributed across the entire of southern and western Britain and north-western Europe (**Figure 21**).

4.3.28. The frequency of Levallois-type flakes and cores in addition to potentially Acheulean or Mousterian elements in the Area 240 assemblage (de Loecker 2011) suggests a mixed assemblage of potentially Lower and Middle Palaeolithic material; also perhaps indicated by the different states of preservation in the finds. The Levallois flakes and cores probably derive from an eroding palaeosurface context whilst the Acheulean handaxes appear to be from an *in situ* context (de Loecker 2011, Wessex Archaeology 2011a). The presence of the Levallois elements suggest this component of the assemblage was produced between MIS 9 - 7, similar to wider British and north-western European (except in the west) evidence (Pettitt and White 2012, White *et al.* 2006; Scott and Ashton 2011).

4.3.29. However, as De Loecker (2011:20) states, "*the analysis of artefacts collections found at Ebbsfleet (Kent), Lion Tramway Cutting at West Thurrock (Essex), Pontnewydd Cave (Clwyd, Wales), Harnham (Wiltshire) and Broom (Devon) suggests that Levallois and Acheulean handaxe technologies co-existed in separate assemblages during MIS 8 and 7."* Several of the sites indicate a move towards Levallois technique from late MIS 9 and during MIS 8 / 7 which may provide direct context for discussing the Area 240 assemblage. The cold-cool climate and evidence of Acheulean *and* Levallois artefacts are broadly analogous to other British and European sites such as Mesvin IV and Purfleet which develops across northwestern Europe during MIS 8 and 7 (**Appendix IV**).

4.3.30. Contemporary MIS 8 sites are highlighted in **Figure 21** and described **Appendix IV**. The sites reflect the variations in lithic technology apparent at various sites across Britain and NW Europe (as discussed by White *et al.* 2006 and Scott and Ashton 2011). The dominance of cold, open environments and riverine environments developing during MIS 8 similar to that at the Middle Palaeolithic Assemblage site is a notable feature of the dataset.

4.3.31. The assemblage appears to represent the northern hinterland of the Wolstonian archaeological landscape of north-western Europe not under ice (or at least not under prohibitively periglacial conditions) at this time. This location makes the *in situ* elements of the lithics assemblage all the more significant.

4.3.32. The amelioration of the climate during early MIS 7 and the associated rising of sea level and flooding of the English Channel led to critical changes in palaeogeography and the human landscape (Toucanne *et al.* 2009). In Britain, the diminishing quantity and quality of artefact assemblages at the end of MIS 7 (White *et al.* 2006; Scott and Ashton 2011) (**Table 8**) has been argued to represent being cut off from the broader continent which had a serious, deleterious impact upon British Neanderthal groups inducing population collapse. Archaeological evidence for Neanderthal activity is then absent until the Devensian (MIS 3) (Boismier *et al.* 2003, Pettitt and White 2012).

4.3.33. Internationally, the known distribution of Middle Pleistocene, submerged archaeological sites is extremely rare globally, with evidence for preserved land surfaces and *in situ* handaxes recently reported from South Africa (Werz and Flemming 2001).

Archaeological Significance of the Middle Palaeolithic Assemblage

4.3.34. The Middle Palaeolithic Assemblage is of considerable importance and meets several of the criteria set out in the "*Identifying and protecting Palaeolithic remains*" report (English Heritage 1998) in relation to whether Palaeolithic remains have particular importance. Based on the set criteria, the Middle Palaeolithic Assemblage located in Area 240 can be shown:

- to have remains that are probably undisturbed and in a primary context (prior to dredging);
- to have remains belonging to a period or geographic area where evidence of human presence is particularly rare or previously unknown;
- to have well preserved indicators of the contemporary environment that can be directly related to the remains;
- to have one deposit containing Palaeolithic remains that has a clear stratigraphic relationship with another;
- to comprise abundant artefacts; and
- that the site can be related to the exploitation of a resource, such as a raw material.

4.3.35. The assemblage is also significant with relation to specific Middle Palaeolithic archaeology. Within the context of the *in situ* Acheulean and Levallois assemblage the condition suggests different elements have been recovered from a primary context and eroded from a palaeolandscape surface, both associated with Unit 3b. As such, hominin activity at the Middle Palaeolithic Assemblage site likely occurred within a period incorporating the cooling limb of MIS 9 through MIS 8 and the warming limb of MIS 7e, a period roughly dating to 330 – 240,000 years ago. Existing OSL dating (Wessex Archaeology 2011a) suggests Unit 3b may have been deposited by 250-200,000 years ago but further chronological analysis is required to fully clarify a more precise date.

4.3.36. Terrace deposits speculatively attributed to Wolstonian age *have* been identified within the SA suggesting there is potential for locating *in situ* material (the reported Levallois find at Carrow Road suggests some existing, but perhaps reworked, archaeological evidence, *e.g.* **WA 2019**), but focussed field-based research and an absolute chronology is required to constrain the actual distribution of relevant EMP-bearing deposits on land in a similar manner to the pioneering work at Area 240 (Wessex Archaeology 2011a).

4.3.37. What is particularly clear is that within the Palaeo-Yare catchment as a whole there is a dearth of EMP sites and artefacts dating to MIS 8, *except* for the offshore Middle Palaeolithic Assemblage. As has been noted by a number of authors reviewing the region, the distribution of known material from this period is very limited (Wymer 1999, Pettitt and White 2012, Austin 2011, Hill *et al.* 2008). This is partly due a lack of research focussed on the period (the focus being on Lower Palaeolithic sites). Onshore aggregates extraction of sedimentary deposits of archaeological interest still occurs in the region suggesting EMP material may be a finite resource if present and preserved (Hill *et al.* 2008).

4.3.38. There is some evidence from Britain and Europe for coeval lithic assemblages of Acheulean and Levallois technique during MIS 9 - 7 (Ashton *et al*. 2011, Scott and Ashton 2011, De Loecker 2011), similarly suggested by the dating and provenance of the mixed lithic assemblage at Area 240. Major Acheulean sites in the Palaeo-Yare, are poorly dated, except arguably at Hoxne (MIS 11), and a general absence of provenance data on findspots means that excluding an MIS 9 date for some of the Acheulean or many 'palaeolithic' finds from the Palaeo-Yare catchment is problematic. However, the noticeable lack of Levallois assemblages in the SA beyond the Middle Palaeolithic Assemblage site appears to be robust with the available data.

4.4. POTENTIAL FOR FURTHER ARTEFACTS IN THE EAST COAST DREDGING REGION

Potential in original deposition

4.4.1. Based on the work carried out in Area 240 (Wessex Archaeology 2011a) the Middle Palaeolithic Assemblage was dredged from Unit 3b. Although the relationship between the distribution of archaeological material and the overall extent of Unit 3b is not known, it is possible that there is the potential for further flint artefacts present in other Unit 3b sediments within the region.

4.4.2. Although there is potential for further artefacts it is difficult to state how much and where they would be found. Given the extent of Unit 3b, it seems unlikely that archaeological material is distributed evenly across Unit 3b deposits. It is likely that cultural processes during the Palaeolithic, in conjunction with geological process are responsible for the distribution of the archaeological material. It may be that the area to the southwest of the channel was more preferable to the banks to the north or southeast. Indeed, it is difficult to say whether the site location was more preferable to the areas further upstream and whether there are potential for, as yet not found sites elsewhere within the catchment area. It seems likely that the Middle Palaeolithic Assemblage represents discrete hotspots of archaeological material within the overall extent of Unit 3b.

4.4.3. On a regional scale the assessed vibrocore data does not indicate any significant changes in the sand and gravel layers of Unit 3b throughout the area; the unit appears relatively consistent, within the limits of the data, and comprises sand and gravel layers with an occasional silty component. Some localised variations are noted. At present, however, it is not possible to associate any changes in sediment character with the potential for the recovery of archaeological material.

4.4.4. Due to vibrocore methodology very little coarse (>100mm) material is recovered that would have been the source material for the handaxes. However, the material dredged from Area 240 and deposited in the outsize pile at SVB Flushing Wharf certainly indicates that there is source material present in Unit 3b. Also, occasional flint up to 110 mm were observed in the clamshell grab samples in Area 240 (Wessex Archaeology 2011a) from Unit 3b and the clamshell grab sample for the

EC REC survey (**WA 2207**) comprised gravelly sand with occasional flint and quartz cobbles (Limpenny *et al.* 2011).

4.4.5. To the north and the south of the floodplain there are outliers of Unit 3b sediments (**Figure 12**). The relationship of these features to the main floodplain is not known but the sediments are likely to be contemporaneous with the floodplain deposits. Based on sediment deposition there is potential for archaeological material within these sediments.

4.4.6. A series of sandbanks are situated to the west of the survey areas. Geophysical data from Area 436 (to the west of Area 254, now relinquished) and the EC REA data indicate that the eastern edge of the sandbank overlies Unit 3b for 500m before Unit 3b peters out and is not present. However, based on the profile of the base of the valley floodplain (**Figure 11**) it is possible that some Unit 3b sediments are preserved under the sandbanks, and as such may preserve archaeological material.

Subsequent modification by natural processes

4.4.7. Although the data indicates that some of Unit 3b sediments remain *in situ*, a certain amount will have been reworked by natural processes subsequent to deposition. This modification of sediments may also have impacted any archaeological material associated with these sediments.

4.4.8. Modification will have been due to terrestrial processes, such as the reworking of sediments as channels are reactivated (Channel A) or new channels forming (Channel B) cutting through and reworking underlying sediments. Marine processes also cause a considerable amount of reworking particularly during regressions and transgressions.

4.4.9. To the north of the floodplain aggregate dredging targets a sand and gravel lag deposit and reworked bank sediments. It is likely that at least some of these sediments originated from the floodplain and have been re-worked by marine transgressions.

4.4.10. Similarly, Unit 8, the uppermost unit which is observed throughout the area comprises shelly, sands and gravels, the composition of which will include sediments from underlying units, such as Unit 3b, as well as sediment imported into the area through marine processes.

4.4.11. Archaeological material associated with terrestrial processes may comprise secondary context material reworked from primary contexts, or *in situ* material associated with the period in which the sediments were deposited.

4.4.12. Any archaeological material associated with the marine sediments is likely to be preserved in a secondary context.

Subsequent modification by human processes; dredging history

4.4.13. The effects of dredging also need to be taken into account when assessing the potential for artefacts within Unit 3b. The geophysical data indicate areas where the Unit 3b has been heavily affected and possibly dredged out. Due to the disturbance caused by the dredging it is not always clear on the geophysical data if Unit 3b has been completely removed or just heavily disturbed, this is particularly an issue in Areas 254 and 228. **Figure 22a** illustrates the remnants of Unit 3b within the aggregate dredging areas.

4.4.14. **Figure 22b** and **c** illustrate the occurrence of dredging since monitoring began (1993). Within the floodplain area, the majority of the areal coverage of Unit 3b has been dredged to some extent, with the exception of Area 251 and 401/2. Unit 3b also remains around the edges of some aggregate licence areas. However, as proven in Area 240, dredging in an area does not mean that there is no potential for flints to be recovered. Area 240 has been classified as low - medium cumulative intensity dredging (based on the analysis outlined in **Section 2.5**) and yet it is from these sediments from which the artefacts were recovered. This, of course, is dependent on the classification used to analyse the EMS data. However, it is fair to say that with the possible exception of where Unit 3b has been heavily dredged or removed, the potential for the unit to contain artefacts cannot be discounted.

Target aggregate

4.4.15. In addition to the potential for a particular sediment unit to have potential for archaeological material the potential for accessing this material also needs to be taken into account. As detailed above, Unit 3b is considered the principal unit that has the potential for Palaeolithic archaeological material. However, Unit 3b is not always the aggregate target.

4.4.16. **Figure 22** illustrates the presence of Unit 4 sediments and the large bank structure in Area 401/2, 242 and 328. Unit 4 sediments overlie Unit 3b within the channel area. Although Unit 3b sediments are protected from dredging in these areas it is considered less likely for the potential of artefacts as they are considered that there is lower potential within the channel compared to the floodplain.

4.4.17. Unit 3b sediments are observed partially beneath the large bank feature in the east (**Figure 22**). Although dredging has occurred in this area the target aggregate is the sands and gravels of the bank feature and therefore Unit 3b is preserved. As such, any *in situ* Palaeolithic material within Unit 3b is likely to be preserved.

Remaining uncertainties

4.4.18. There are, of course, remaining uncertainties when considering the potential for archaeological material to be located within the region, principally regarding the location of archaeological material and also the extent of Unit 3b from which archaeological material may be recovered.

4.4.19. As discussed above, the relationship between the archaeological material, particularly *in situ* artefacts, is presently unknown. Previous work carried out in Area 240 has demonstrated that geophysical and geotechnical techniques are not capable of identifying potential discrete assemblages. Further sampling, in large volumes, is considered the only way to address this issue.

4.4.20. There are also uncertainties associated with the age of the geophysical and geotechnical data used to assess the palaeogeography of the region.

4.4.21. It is important to note that the interpretation does not necessarily indicate the present-day coverage. The interpretation is based on the geophysics at the time of acquisition and cannot take into account the amount of dredging that has taken place subsequent to data acquisition. For example, in Areas 319, 251 and 361 the data were acquired prior to known dredging (pre-1993 monitoring). There is some evidence of dredging in the geophysical data at the time of acquisition, however, the majority of dredging has occurred since the geophysics acquisition. Although the EMS data can indicate where dredging occurred since acquisition, it is not possible to how much of the target aggregate has been removed during this time and as such how much remains.

4.4.22. These uncertainties can only be addressed with further investigation of the region. Although up-to-date geophysics data in some areas may reduce the uncertainty in defining the extents of Unit 3b, this data would not help in assessing the uncertainties regarding the potential for archaeological material. This can only be achieved by further monitoring of the aggregate recovered in the East Coast region.

5. CONCLUSIONS AND FURTHER WORK

5.1. KEY CONCLUSIONS

5.1.1. Based on the results of the Palaeo-Yare catchment assessment there are a number of key conclusions with reference to the potential for the presence of archaeological material within the wider licence area.

5.1.2. Within the following section the Middle Palaeolithic Assemblage refers to the flint artefacts as detailed in **Table 9**; Palaeolithic material refers to all Palaeolithic material including worked flint, faunal remains and palaeoenvironmental material. Although the focus of this project has been the flint artefacts, other material is as important when assessing the archaeological potential of a region.

5.1.3. The key conclusions are as follows:

- The Middle Palaeolithic Assemblage is mixed, *i.e.* contains artefacts of *in situ* and secondary context.
- The Middle Palaeolithic Assemblage is primarily associated with Unit 3b within Area 240.
- There is potential for palaeolithic material in secondary context associated with Units 2, 3b, 4, 7, 8 and the bank structures (of unknown age).
- Natural processes throughout transgressions and regressions subsequent to deposition have not completely removed sediment units. With regards to the *in situ* elements of the Middle Palaeolithic assemblage, remnants of *in situ* Unit 3b sediments are present within the region.
- Extensive dredging of the region has not necessarily completely removed Unit 3b sediments within the area.
- There is potential for *in situ* archaeological material to be present elsewhere within the region where remnants of Unit 3b are located.
- Faunal remains and palaeoenvironmental material are likely to be sourced from Units 2, 3b, 4 and 7. These could be *in situ* or secondary context and may be located throughout the region.
- Uncertainties remain due to the data limitations used for the assessment and the degree of dredging undertaken since the geophysics data were acquired.

5.2. HYPOTHESES

5.2.1. A set of hypotheses have been developed that can be applied to the licence areas within the region in order to test these key conclusions and address the remaining uncertainties. The hypotheses are predominantly focussed on the potential for artefacts within the Palaeo-Yare floodplain deposits (Unit 3b).

5.2.2. It is envisioned that these hypotheses will be tested through physical sampling and monitoring of dredge loads from the licence areas as detailed in the *Provisional Written Scheme of Investigations for the Anglian Region*. Certain licence areas will lend themselves to certain hypotheses. For the short-term licence applications the hypotheses are dealt with on a licence area basis and are detailed in the addendum report that accompanies this document (Wessex archaeology 2012a).

5.2.3. The hypotheses have been divided into 5 groups relating to specific issues, and are detailed below.

Inhabitation

5.2.4. These hypotheses are intended to test if the Palaeo-Yare floodplain was inhabited and if the evidence of inhabitation dates only to the Wolstonian period. These hypotheses primarily assess if archaeological material is *in situ* and associated with the Unit 3b deposits. The assessment of whether the material is *in situ* or recovered from a secondary sediment source will be based on the character and quality of flint material recovered combined with the known geology in the location of the dredge load being monitored.

H1a: Palaeolithic material is recovered only from Unit 3b, which dates to the Wolstonian.

H1b: Palaeolithic material recovered from Unit 3b is predominantly *in situ*.

Choice and use of location

5.2.5. Although there is potential for further artefacts it is difficult to state how much and where they would be found. There is likely to be a cultural element to the use of the landscape and it may be that the area to the southwest of the channel was more preferable to the banks to the north or southeast.

5.2.6. These hypotheses are intended to test whether people inhabited the area represented by Unit 3b according to spatial preferences; and whether activity was focussed or dispersed.

H2a: Palaeolithic material is recovered only from Unit 3b deposits on the margin of Channel A, not within the Channel itself.

H2b: Palaeolithic material is recovered only from Unit 3b deposits within the limits of the Palaeo-Yare floodplain, and not within the Unit 3b outliers to the north and south of the floodplain

H2c: The recovery of Palaeolithic material is clustered in relatively large quantities in discrete locations; material is not recovered from otherwise similar locations.

Natural processes

5.2.7. Although the data indicates that certain areas of Unit 3b have remained undisturbed since their original deposition and contain *in situ* artefacts, some areas of Unit 3b appear to have been heavily reworked. This reworking is due to terrestrial processes such as the development of Early Holocene channel in the west of the area that would have significantly reworked underlying Unit 3b sediments. Also, the erosion and deposition of a large reworked bank in the east of the area have been shown to cause natural reworking of Unit 3b deposits.

5.2.8. Marine processes also cause reworking of sediments during regression and transgression. During transgressions and periods of high sea-level the upper portions of Unit 3b sediments have been reworked and re-deposited with a marine component. Unit 8 which is identified throughout the area as either a veneer or as seabed bedforms will contain sediments eroded and reworked from the underlying sediments.

5.2.9. Hypotheses H3a and H3b are intended to test whether taphonomic processes affect the distribution of Palaeolithic material, where such processes are indicated by changes in the sand/gravel composition of Unit 3b. Changes in the composition of Unit 3b are difficult to assess on a regional scale as the differences are subtle. However, on a localised licence area scale changes in composition are apparent. For example, in Area 240 Unit 3b sediments in the north are noticeably coarser and more gravelly than those in the south.

H3a: The distribution of recovered Palaeolithic material does not vary according to variations in the sediment structure of Unit 3b.

H3b: Palaeolithic material is not recovered where Unit 3b appears to have been reworked by natural processes in the past.

5.2.10. Hypothesis H3c is intended to test whether Palaeolithic material is protected from dredging impacts where the target aggregate is the reworked sediments of bank features.

H3c: Palaeolithic material is not recovered where Unit 3b appears to be covered by major bank structures.

Human processes, including dredging history

5.2.11. Dredging activity has taken place within the East Coast region over the several decades. Known levels of dredging have been recorded since 1993. This EMS data has been modelled to provide a qualitative assessment of cumulative dredging activity throughout the region (**Section 2.5**) and evidence of dredging is observed in the geophysics data in localised areas. The aim of these hypotheses is to test whether evidence for previous dredging, identified through geophysical or EMS data, can be used to indicate an absence of Palaeolithic material.

H4a: Palaeolithic material is not present where the dredging history indicates that a high level of dredging has taken place since the introduction of EMS.

H4b: Palaeolithic material is not present where geophysical data indicates that a high level of dredging has taken place.

Operational sampling methods

5.2.12. In May 2012 WA carried out, on behalf of HAML with agreement from EH, a successful programme of archaeological monitoring of the processing at Frindsbury Wharf, Kent, of aggregate dredged from within dredging licence Area 240 (Wessex Archaeology 2012b). Monitoring was carried out by a team of three archaeologists who monitored *c.* 1500 tons aggregate dredged from a known location. The 40-100mm fraction was observed on a conveyor, prior to being crushed, which was stopped by archaeologists by means of triggering the metal detector whenever pieces with archaeological potential were seen. A piece of bovid animal bone and two items of relatively fresh worked flint in the form of two flakes consistent with previous finds from the area were recovered. These flakes have not been included in the assemblage as this work is still ongoing.

5.2.13. The methods employed during this phase of work proved to be a viable methodology at this particular wharf. However, as all wharves have different set-ups

this may not be viable at all wharves. This hypothesis aims to test whether the methodology is effective at all wharves were it is deployed.

H5a: Palaeolithic material is found at all wharves where operational sampling takes place.

5.2.14. These hypotheses provide a basis for structured monitoring of aggregate areas within the East Coast Region. The information resulting from these hypotheses will enhance the knowledge of the presence of Palaeolithic material in the area and will inform the continuing monitoring activity in the licence areas.

5.2.15. The addendum report, which accompanies this volume, details the palaeogeography, archaeology and mitigation on a licence basis specifically for those areas under short-term licence conditions.

6. REFERENCES

Arthurton, R.S., Booth, S.J. Morigi, A.N., Abbott, M.A.W., Wood, C.J., 1994,Geology of the country around Great Yarmouth, London: HMSO, pp 138.

Ashton, N., Lewis, S.G., Parfitt, S., White, M., 2006, 'Riparian landscapes and human habitat preferences during the Hoxnian (MIS 11) Interglacial', Journal of Quaternary Science 21: 497-505.

Ashton, N., Lewis, S.G., Hosfield, R., 2011, 'Mapping the Human Record: Population Change in Britain During the Easrly Palaeolithic. In Ashton, N., Lewis, S.G., Stringer, C. (eds) The Ancient Human Occupation of Britain. Developments in Quaternary Sciences, volume 14, 39 – 51.

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

Barton, N., 2005,'Ice Age Britain', London, Batsford and English Heritage.

BMAPA and English Heritage, 2005,Marine Aggregate Dredging and the Historic Environment, English Heritage, pp18.

Boismier, W., Schreve, D. C.,White, M. J., Robertson, D. A., Stuart, A. J., Etienne, S., Andrews, J., Coope, G. R., Field, M., Green, F. M. L., Keen, D. H. Lewis, S. G., French, C. A., Rhodes, E., Schwenninger, J-L., Tovey, K., O'Connor, S., 2003, 'A Middle Palaeolithic site at Lynford Quarry, Mundford, Norfolk: interim statement', Proceedings of the Prehistoric Society 69: 314-324.

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

Bridgeland, D, 1994, 'The Pleistocene of the Thames. In Bridgeland D (eds). Quaternary of the Thames'. Geological Conservation Review Series No. 7. London: Chapman and Hall

Bridgeland, D.R., 2002,'Fluvial Deposition on periodically emergent shelves in the Quaternary: example records from the shelf around Britain'.Quaternary International 92: 25 – 34.

Bridgland, D and Westaway, R. 2008. 'Climatically controlled river terrace staircases: A worldwide Quaternary phenomenon'. Geomorphology, Vol.98, 285–315.

Brusschers, F. S., Kasse, C., van Balen, R.T., Vandenberghe, J., Cohen, K.M., Weerts, H.J.T, 2008. 'Late Pleistocene evolution of the Rhine-Meuse system in the southern North Sea Basin: imprints of climate change, sea-level oscillation and glacio-istostacy. Quaternary Science Review, 26, 3216 – 3248.

Cameron, T.D.J., Crosby, A., Balson, P.S., Jeffery, D.H., Lott, G.K., Bulat, J., Harrison, D.J., 1992,The geology of the southern North Sea. British Geological Survey, United Kingdom Offshore Report, London HMSO.

Cameron, T.D.J., Schuttenhelm, R.T.E., Laban, C., 1989,'Middle and Upper Pleistocene and Holocene stratigraphy in the southern North Sea between 52° and 54°N, 2° to 4°E',In: Henriet, J.P and de Moor, G. (Eds.)The Quaternary and Tertiary Geology of the Southern Bight, North Sea. Ministry of Economic Affairs – Belgian Geological Survey, 119 – 136.

Clayton, K.M., 1989,'Sediment input from the Norfolk cliffs, Eastern England – a century of coast protection and its effect', Journal of Coastal Research 5: 433 – 442.

Coles, B., 1998,'Doggerland: a speculative survey',Proceedings of the Prehistoric Society,64: 45-81.

Cox, F.C., Gallois, R.W.,Wood, C.J., 1989,Geology of the Country around Norwich. Memoir of the British Geological Survey, Sheet 161 (England and Wales). London: HMSO.

Coxon, P., 1979,'Pleistocene Environmental History in Central East Anglia', Unpublished PhD thesis, University of Cambridge.

Coxon, P., 1984, 'The Waveney Valley', in Allen, P. (Ed.), 'Field Guide (revised edition) to the Gipping and Waveney Valleys, Suffolk. May 1982', Quaternary Research Association, p78–107.

Crown Estate and BMAPA, 2010, Marine Aggregate Terminology: A Glossary, pp 93.

D'Olier, B., 2002,'Southern North Sea Sediment Transport Study Phase 2 Sediment Transport report. Appendix 10: A geological background to sediment sources, pathways and sinks', HR Wallingford unpublished report,Ex4526 ver 2.

EMU Ltd., 2009,'Outer Thames Estuary Regional Environmental Characterisation'. Unpublished report, pp129. Available from http://www.marinealsf.org.uk/

English Heritage, 1998, 'Identifying and Protecting Palaeolithic Remains: archaeological guidance for planning authorities and developers'. London: English Heritage.

English Heritage, 2008, 'Research and conservation framework for the British Palaeolithic'. London, English Heritage and The Prehistoric Society.

Flemming, N.C., 2002,'The Scope of Strategic Environmental Assessment of North Sea areas SEA 3 and SEA 2 in regard to prehistoric archaeological remains: Technical Report SEA3_TR014', Department of Trade and Industry.

Funnell, B.M, 1995,'Global sea-level and the (pen-)insurality of late Cenozoic Britain'. In: Preece, R.C. (Ed.). Island Britain: a Quaternary perspective. Geological Society Special Publication No. 96. p3 – 14.

Gibbard, P, L., Clark, C.D., 2011,'Pleistocene Glaciation Limits in Great Britain', In: Ehlers, J. Gibbard, P.L and Hughes, P.D. (Eds.) Quaternary Glaciations - Extent and Chronology A Closer Look, Developments in Quaternary Sciences Volume 15, 75 – 93.

Gibbard, P., 2001,History of the northwest European rivers during the past three million years,http://www.qpg.geog.cam.ac.uk/research/projects/nweurorivers/

Gibbard, P.L., 1988, 'The history of the great north-west European rivers during the past three million years'.Philosophical Transactions of the Royal Society of London, B318, 559-602.

Gibbard, P.L., 1995,'The formation of the Strait of Dover'. In: Preece, R.C. (Ed.). Island Britain: a Quaternary perspective. Geological Society Special Publication No. 96. p15 – 26.

Glimmerveen, J., Mol, D., Post, K., Reumer, J.W.F., van der Plicht, J., de Vos, J., van Geel, B., van Reenen G., and Pals, J.P., 2004. 'The North Sea project. The first palaeontological, palynological and archaeological results', In: Flemming N.C. (Ed.) Submarine Prehistoric Archaeology of the North Sea. CBA research report 141.

Godwin, H.,Godwin, M. E., 1933,'British Maglemose Harpoon Sites'. Antiquity 7: 36-48.

Grün R., Schwarcz H.P. 2000. 'Revised open system U-series/ESR age calculations for teeth from Stratum C at the Hoxnian Interglacial type locality, England'. Quaternary Science Reviews, 19:1151–1154.

Gupta, S., Collier J.S., Palmer-Felgate, A., Potter G., 2007,'Catastrophic fl ooding origin of shelf valley systems in the English Channel', Nature 448: 342–345.

Harding, P., Bridgland, D.R., Allen, P., Bradley, P., Grant, M.J., Peat, D., Schwenninger, J-L., Scott, R., Westaway, R., White, T.S., In Press, 'Chronology of the Lower and Middle Palaeolithic in NW Europe: developer-funded investigations at Dunbridge, Hampshire, southern England', Proceedings of the Geologists' Association (2012), doi:10.1016/j.pgeola.2012.03.003.

Hazell, Z.J., (in preparation),'Area 240, off Great Yarmouth, North Sea: Analyses from an Offshore Peat Layer Recovered by Vibrocore', English Heritage Research Department Report.

Hijma, M.P., Cohen, K.M., Roebroeks, W., Westerhoff, W.E., Busschers, F.S., 2012,'Pleistocene Rhine-Thames landscapes: geological background for hominin occupation in the southern North Sea region', Journal of Quaternary Science 27, 17 – 39.

Hill, T., Fletcher, W., Good, C., 2008, 'The Suffolk Valleys River Project: a review of published and grey archaeological and palaeoenvironmental literature', The Suffolk Valleys River Project ALSF 4772, Birmingham University. Doi: 10.5284/1000077

Hosfield, R.T., Chambers, J.C., 2004,'The Archaeological Potential of Secondary Contexts', English Heritage Project Report (Project No. 3361), English Heritage Archive Report: London.

Housley, R. A., Gamble, C. S., Street, M., and Pettitt, P., 1997. Radiocarbon Evidence for the Lateglacial Human Recolonisation of Northern Europe. *Proceedings of the Prehistoric Society,* 63, 25–54.

Jelgersma, S., 1979,'Sea-level changes in the North Sea Basin' In Oele, E, Schuttenhelm, R.T.E., Wiggers, A.J. (Eds.),The Quaternary History of the North Sea, Acta Universatis Upsaliensis: symposium Universitatis Upsaliensis Annum Quingentesimum Celebrantis 2.

Koehler H. 2008, 'L'apport du gisement des Oisiers à Bapaume (Pas-de-Calais) au début sur l'émergence du Paléolithique Moyen dans la Nord de la France'. Bulletin de la Société Préhistorique Française 105, 709-736.

Kolfschoten, T. van and C. Laban 1995, 'Pleistocene terrestrial Mammal faunas from the North Sea Area'. Mededelingen Rijks geologische Dienst 52, 135-151.

Lee, J.R., Rose, J., Candy, I, and Barendregt, R.W., 2006, 'Sea level changes, river activity, soil development and glaciation around the western margins of the southern North Sea Basin during the Early and early Middle Pleistocene: evidence from Pakefield, Suffolk, UK', *Journal of Quaternary Science* 21: 155-179.

Lewin, J., Gibbard, P.L., 2010, 'Quaternary river terraces in England: Forms, sediments and processes', Geomorphology 120: 293-311.

Limpenny, S.E., Barrio-Froján, C., Cotterill, C, Foster-Smith, R.L., Pearce, B., Tizzard, L., Limpenny, D.L., Long, D., Walmsley, S., Kirby, S., Baker, K., Meadows, W.J., Rees, J., Hill, J., Wilson, C., Leivers, M., Churchley, S., Russell, J., Pacitto, S., and Law, R., 2011,'The East Coast Regional Environmental Characterisation', Cefas Open report 08/04.

De Loecker, D., 2011, 'Great Yarmouth dredging licence Area 240, Norfolk, United Kingdom. Preliminary report on the lithi artefacts', Unpublished report, University of Leiden.

Long, D., Wickham-Jones, C.R.,Buckley, N.A., 1986,'A flint artefact from the northern North Sea'in Roe, D.A. (Ed.), Studies in the Upper Palaeolithic of Britain and Northwest Europe, BAR International Series 296.

Mathers, S.J., Horton, A., Birstow, C.R., 1993, 'Geology of the Country around Diss'. Memoir of the British Geological Survey, Sheet 175 (England and Wales).

Mol, D., Post, K., Reumer, J.W.F., van der Plicht, J., de Vos, J., van Geel, B., van Reenen, G., Pals, J.P., Glimmerveen, J., 2006,'The Eurogeul – First Report of the Palaeontological, Palynological and Archaeological Investigations of this part of the North Sea'. Quaternary International 142-143: 175 – 185.

Moorlock, B.S.P., Hamblin, R.J.O., Booth, S.J., Morigi, A.N., 2000,'Geology of the Country around Lowestoft and Saxmundham',London: HMSO, p 114.

Murton, D.K., Murton, J.B., 2012,'Middle and Late Pleistocene glacial lakes of lowland Britain and the southern North Sea Basin'. Quaternary International 260: 115 – 142.

Oxford Archaeology, 2007. England's Historic Seascapes Pilot Study: Southwold-to-Clacton final project report, unpublished report.

Parfitt, S.A., Barendregt, R.W., Breda, M., Candy, I., Collins, M.J., Coope, G.R., Durbidge,P., Field, M.H., Lee, J.R., Lister, A.M., Mutch, R., Penkman, K.E.H., Preece, R.C., Rose, J., Stringer, C.B., Symmons, R., Whittaker, J.E., Wymer J.J. and Stuart, A.J., 2005. The earliest record of human activity in northern Europe, *Nature* 438:1008-1012.

Parfitt, S.A., Ashton, N.M., Lewis, S.G., Abel, R.L., Russell Coope, G., Field, M.H., Gale, R., Hoare, P.G., Larkin, N.R., Lewis M.D., Karloukovski, V., Maher, B.A., Peglar, S.M., Preece, R.C., Whittaker, J.E., Stringer, C.B., 2010,'Early Pleistocene human occupation at the edge of the boreal zone in northwest Europe',Nature466: 229 - 233.

Penkman, K., Collins, M., Keen, D., Preece, R., 2008, 'British Aggregates: An Improved Chronology Using Amino Acid Racemization and Degradtion of Intracrystalline Amino Acids (IcPD), Scientific Dating Report', English Heritage, ALSF.

Pettitt, P., White, M., 2012, ';The British Palaeolithic: Human societies at the edge of the Pleistocene world', Routledge, Abingdon, pp 587.

Rendell, H.M.1995, 'Luminescence dating of Quaternary sediments'. Geological Society, London, Special Publications 89, 223-235.

RMC Landsearch Exploration Department, 1993, 'Lowestoft Vibrocore Survey Production Licence 251, 360, 319 and Prospect Licences 251 south and 251 east', Geological Report.

Rose, J., 2009,'Early and Middle Pleistocene landscapes of eastern England', Proceedings of the Geologists Association, 120: 3 -33.

Royal Haskoning, 2009, 'Suffolk SMP2 Sub-cell 3c, Appendix C: Coastal Processes', Unpublished Report ref: /RCP1/301164/PBor.

Ryssaert C., 2006,'Lithische technologie te Mesvin IV: selecticriteria voor geretoucheerde werktuigen en hum relatie met Levalloiseinproducten',Anthropologica et Praehistorica 117 : 13-34.

Sainty, J.E., 1927,'An Acheulian Palaeolithic Workshop Site at Whitlingham, Near Norwich. With geological notes on the Acheulian site at Whitlingham, Norfolk by Professor P.G.H. Boswell', Proc. Prehist. Soc. E. Anglia. 5:177-213.

Sainty, J.E., 1933, 'Some Norfolk Palaeolithic discoveries. With an appendix on Implementiferous gravels in East Anglia by Dr J.D. Solomon', Proc. Prehist. Soc. E. Anglia 7(2), 171–6.

Sainty, J.E. and Halls, H.H., 1927 'An Acheulian Palaeolithic workshop site at Whitlingham, near Norwich. With geological notes on the Acheulian site at Whitlingham, Norfolk by Professor P.G.H. Boswell', Proceedings of the . Prehistic Society of East Anglia, 5, 177–213.

Santonja, M.,Villa, P., 2006,'The Acheulian of Western Europe' in Goren-Inbar, N., Sharon, G., (Eds.), Axe Age: Acheulian Tool-making from Quarry to Discard, Equinox, London, p429-478

Schreve, D. C., Harding, P., White, M. J., Bridgland, D. R., Allen, P., Clayton, F., Keen, D. H., Penkman, K. E. H., 2006, 'A Levallois knapping site at West Thurrock, Lower Thames, UK : its quaternary context, environment and age.', Proceedings of the Prehistoric Society 72: 21-52.

Scott, B., Ashton, N., 2011, 'The Early Middle Palaeolithic: The European Context'. In Ashton, N., Lewis, S.G., Stringer, C. (eds) The Ancient Human Occupation of Britain. Developments in Quaternary Sciences, volume 14, 91 – 112.

Shennan, I., Horton, B., 2002, 'Holocene land- and sea-level changes in Great Britain', Journal of Quaternary Science 17: 511 – 526.

Shennan, I., Lambeck, K., Flather, R., Horton, B., McArthur, J., Innes, J., Lloyd, J., Rutherford, M., Kingfield, R., 2000,'Modelling western North Sea palaeogeographics and tidal changes during the Holocene'in Shennan, I.,

Andrews, J.E., (Eds.), Holocene Land – Ocean Interaction and Environmental Change around the North Sea, 299-319.

Singer, R., Gladfelter, B.G. Wymer, J.J., 1993,'The Lower Palaeolithic site at Hoxne, England', Chicago, Univ. Press.

Soriano, S., 2000, 'Outillage bifacial et outillage sur eclat au Paleolithique ancien et moyen. Coexistence et interaction'. PhD dissertation, Universite de Paris X-Nanterre, Nanterre.

Stokes, S., Ingram, S., Aitken, M.J.,Sirocko, F.,Anderson, R.,Leuschner,D.,2003,'Alternative chronologies for Late Quaternary (Last Interglacial–Holocene) deep sea sediments via optical dating of silt-sized quartz', Quaternary Science Reviews 22, Issues 8–9: 925-941.

Strijdonk, H., Post, K., Mol, D, Ras, B., 2011,'Report of identifications of fossil mammal remains which have been collected in sediments at the premises of SBV (Sorteerbedrijf Vlissingen) dredged from the North Sea bottom off the coast of East Anglia', Unpublished Report.

Strijdonk, H., Post, K., Mol, D, Ras, B., 2012,'Report #2 of identifications of fossil mammal remains which have been collected in sediments at the premises of SBV (Sorteerbedrijf Vlissingen) dredged from the North Sea bottom off the coast of East Anglia', Unpublished Report.

Sumbler, M.G. (Ed.) 1996. *British Regional Geology: London and the Thames Valley*. 4th Edition. London HMSO for the British Geological Survey.

Toucanne, S., Zaragosi, S. Bourillet, J.F., Cremer, M., Eynaud, F., van Vilet-Lanoe, B., Penaud, A., Fontanier, C., Turion, J.L., Cortijo, E., Gibbard, P.L.,2009, 'Timing of the massive 'Fleuve Manche' discharges over the last 350 kyr : insights into the European ice-sheet oscillations and the European drainage netweork from MIS 10 to 2',Quaternary Science Reviews 28: 1238-1256, doi :10.1016/j.quascirev.2009.01.006.

Tuffreau A., 1972,'Les Industries de l'Acheuléen supérieure de Bapaume'in Tuffreau, A., (Ed.), Quelques aspects du Paléolithique dans le Nord de la France (Nord et Pas de Calais), Numéro spécial du Bulletin de la Société Préhistorique du Nord 8, 33-54.

Tzedakis, P.C., 2005, 'Towards an Understanding of the Response of Southern European Vegetation to Orbital and Suborbital Climate Variability', Quaternary Science Reviews 24: 1585-1599

Wenban-Smith, F. 2004: Handaxe typology and Lower Palaeolithic cultural development: ficrons, cleavers and two giant handaxes from Cuxton. In: M. Pope and K. Cramp (eds.) Lithics 25 (Papers in Honour of R.J. MacRae), 11-21.

Wessex Archaeology, 2008a,'Seabed in Prehistory: Gauging the Effects of Marine Aggregate Dredging. Final Report, Volume IV, Great Yarmouth', Unpublished report ref. 57422.34.

Wessex Archaeology, 2008b,'Seabed in Prehistory: Gauging the Effects of Marine Aggregate Dredging. Final Report, Volume VII, Happisburgh and Pakefield Addendum', Unpublished report ref. 57422.37.

Wessex Archaeology, 2008c. *Protocol for reporting finds of archaeological interest. Annual Report to BMAPA 2007-2008*, pp70. Available from http://www.wessexarch.co.uk/projects/marine/bmapa/docs.html

Wessex Archaeology, 2009,'Protocol for reporting finds of archaeological interest. Annual Report to BMAPA 2008-2009', pp78. Available from http://www.wessexarch.co.uk/projects/marine/bmapa/docs.html

Wessex Archaeology, 2011a,'Seabed Prehistory: Site evaluation techniques (Area 240) – Synthesis', Unpublished Report, ref: 70754.04.

Wessex Archaeology, 2011b,'Licence Area 240 Archaeological Monitoring of Dredging Activity', Unpublished Report, WA ref: 77860.02.

Wessex Archaeology, 2011c,'Palaeo-Yare Data Audit', unpublished report.

Wessex Archaeology, 2011d,'Aggregate Dredging Licence Application Area 228. Archaeological Assessment', Unpublished Report, ref: 78670.02.

Wessex Archaeology, 2012a,'Palaeo-Yare Catchment Assessment. Addendum Report', Unpublished Report, ref: 83740.05.

Wessex Archaeology, 2012b,'License Area 240. Archaeological Mitigation: Frindsbury Wharf Methodological Trial', Unpublished Report, ref: 77860.04.

Westaway, R., Bridgland, D., White, M., 2006a. The Quaternary uplift history of central southern England: evidence from the terraces of the Solent River system and nearby raised beaches. Quaternary Science Reviews 25, 2212-2250

Werz, B., Flemming, N.C., 2001. Discovery in Table Bay of the oldest handaxes yet found underwater demonstrates preservation of hominid artefacts on the continental shelf. South African Journal of Science 97, 183–185.

White, M. J., Ashton, N. M, 2003, 'Lower palaeolithic core technology and the origins of the Levallois method in North-Western Europe', Current Anthropology 44(4): 598-609.

White, M. J., Schreve, D. C., 2001, 'Island Britain-Peninsula Britain: palaeogeography, colonisation and the Lower Palaeolithic settlement of the British Isles', Proceedings of the Prehistoric Society 66:1-28.

White, M.J, B. Scott and N.M. Ashton 2006, 'The Early Middle Palaeolithic in Britain: archaeology,settlement history and human behaviour'. Journal of Quaternary Science, 21-5, 525 -541.

de Wilde, B. 2006. '*Caprovis savinii* (Bovidae, Mammalia) rediscovered: horn core finds of an Early Pleistocene antelope from the North Sea floor'. *Netherlands Journal of Geosciences*, 85, 239-243.

Wymer, J.J., 1999,'The Lower Palaeolithic Occupation of Britain', Wessex Archaeology and English Heritage, doi:10.5284/1000063.

Zagwijn, W.H., 1983,'Sea-level changes in the Netherlands during the Eemian' Geologie en Mijnbouw 62: 437 – 450.

APPENDIX I: GEOPHYSICS DATASETS

Area	Year	Licensee	Survey contractor	Vessel	Survey dates	Equipment	Nominal line spacing	Data format	Reference
Areas 360, 319, 228, 251, 251 East and 251 South	1989	CEMEX	Gardline Ltd.	*M.V Profiler*	May 19th – June 12th 1989	Boomer system; single-beam echosounder	200/400m	Paper rolls	Gardline Ltd. (1989)
Areas 360, 319, 251, 251 East and 251 South	1993	CEMEX	RMC Landsearch Exploration Department			Resource report based on vibrocore surveys conducted in 1989, 1991 and 1993		Paper copy	RMC Landsearch Exploration Department (1993)
Area 202/436	2000	HAML	Andrews Survey	*Bon Accord*	12th – 14th March 2000	Odom Echotrac, dual freq. single-beam echosounder: EG&G Uniboom sub-bottom profiler	202: N-S:200m; E-W:500m; 436: N-S100m; E_W: 500m	Paper rolls	Andrews Survey (2000a)
Area 212	1999	HAML	Andrews Survey	*Bon Accord*	17 – 19th June 1999	Single-beam echosounder; Boomer sub-bottom profiler	N-S: 200m; E-W: 1000m	Paper rolls	Andrews Survey (1999a)
Area 212	2008	HAML	EMU Ltd.	*RV Discovery*	18th February 2008	Reson 8101 MBES; Applied Acoustics Boomer System	N-S: 100m	Paper rolls	EMU Ltd. (2008)

Area	Year	Licensee	Survey contractor	Vessel	Survey dates	Equipment	Nominal line spacing	Data format	Reference
Area 240	2005	HAML	Andrews Survey	*Unknown*	2005	Single-beam echosounder; Sub-bottom profiler; Reson 8101 MBES; Applied Acoustics Boomer System	N-S: 100m; E-W: 1000m	Txt; sgy	
Areas 242/361/328	2010	HAML	Emu Ltd	*Victor Hensen*	April 2010	Reson 8101 multibeam echosounder; Applied Acoustics surface-tow boomer system	N-S: 100m; E-W: 1000m	Charts; Paper rolls	Emu Ltd (2010)
Area 328	1999	HAML	Andrews Survey	*Bon Accord*	June and July 1999	Single-beam echosounder; Boomer sub-bottom profiler	N-S: 200m; E-W: 1000m	Paper rolls	Andrews Survey (1999b)
Area 361	1999	HAML	Andrews Survey	*Bon Accord*	June and July 1999	Single-beam echosounder; Boomer sub-bottom profiler	N-S: 200m; E-W: 1000m	Paper rolls	Andrews Survey (1999c)
Area 401/2	2000	HAML	Andrews Survey	*Bon Accord*	Jun-00	Single-beam echosounder; Boomer sub-bottom profiler	N-S: 150m; E-W: 500m	Paper rolls	Andrews Survey (2000b)

Area	Year	Licensee	Survey contractor	Vessel	Survey dates	Equipment	Nominal line spacing	Data format	Reference
Area 254	1992	TMDL	Andrews Hydrographics Ltd.	*Unknown*	May – June 1992	Boomer	N-S: 200m; Plus two crosslines (NW-SE and SW-NE)	Paper rolls	
Area 254	1993	TMDL	Andrews Hydrographics Ltd.	*Unknown*	23rd – 24th May 1993	Pinger	E-W: 100m; N-S: 200m	Paper rolls	
Area 254 Cross Sands	1999	TMDL	Andrews Survey	*Unknown*	3rd – 5th September 1999	Echo Sounder: Odom Hydrotrac, single frequency; Sub-bottom profiler EG&G Uniboom; Pinger: Oretech 3010	N-S: 200m	SBES: digital txt; Paper rolls	Andrews Survey (1999d)
Area 254	2000	TMDL	Gardline Surveys Ltd.	*MV Elinor TH*	Jul-00	EG&G surface-tow boomer system	N-S: 150m in east; N-S: 300m in west	Paper rolls	Gardline Surveys Ltd. (2000)
Area 296	1991	TMDL	Geoteam	*Unknown*	Jun-91	Boomer	N-S: 300m	Paper rolls	
Area 296 and 494	2007	TMDL	GardlineLankelma	*Nat West II*	16th – 23rd June 2007	MBES: GeoAcoustics GeoSwath Plus (250kHz); EG& G Uniboom surface-tow boomer	N-S: 200m; NE-SW: 450m	MBES: Chart; SBP: paper rolls	GardlineLankelma (2007)

Area	Year	Licensee	Survey contractor	Vessel	Survey dates	Equipment	Nominal line spacing	Data format	Reference
Area 228	2002	VDL	Andrews Survey	*Unknown*	Apr-02	Single-beam echosounder; Sub-bottom profiler	N-S: 150m	Paper charts only	Andrews Survey (2002a)
Area 228	2005	VDL	Andrews Survey	*Unknown*	Jul-05	Single-beam echosounder; Sub-bottom profiler	N-S: 100m	Paper Charts only	Andrews Survey (2005a)
Area 228	2011	VDL	Gardline Environmental Ltd.	*M.V. Ivero*	22nd to 24th April 2011	Applied Acoustics surface-towed boomer; Kongsberg Simrad EM3002D 300kHz swathe system with a Seapath motion reference unit	N-S: 100m; E-W: 1000m	STB: SEG-Y file format; MBES: xyz format	Gardline Environmental Ltd. (2011)
Catchment Area	2009		CEFAS	*Cefas Endeavour*	May-09	Echo sounder: Kongsberg Simrad EM3000/ 3002; Sub-bottom profiler: Applied Acoustics CSP-D.	Grid corridors 2.7km spacing (100m line spacing within corridors)	Txt files; Cod files/ SEG-Y files	Limpenny *et al.* (2011)

Area	Year	Licensee	Survey contractor	Vessel	Survey dates	Equipment	Nominal line spacing	Data format	Reference
Area 254	2005		Titan Environmental Surveys Ltd.	*Titan Explorer*	August – October 2005	Echo Sounder: Odom Hydrotrac, single frequency; Sub-bottom profiler: Applied acoustics surface-tow boomer; Probe 5000 pinger	E-W: 50m; N-S: 100m; Single prospection lines	Txt files; Cod files/ SEG-Y files	Wessex Archaeology (2008a)
Catchment Area	2006		Wessex Archaeology	*Wessex Explorer*	Jun-06	Echo sounder: Knudsen 320M singlebeam; Sub-bottom profiler: Edgetech 3100P chirp and Applied Acoustic Engineering AA200 surface-tow boomer	Various	Txt files; Cod files/ SEG-Y files	Wessex Archaeology 2008b)
Catchment Area	2010		Gardline Environmental Ltd.	*Melanie D*	Surface-tow boomer data: 26th March to 17th April. Multibeam echosounder: 23rd to 26th April 2010.	Surface-tow boomer (based on EG&G 230); Kongsberg EM3002 swathe system	8 lines E-W from coast to aggregate licence block	STB: SEG-Y; MBES: xyz (1m grid)	Gardline Environmental Ltd. (2010)

*equipment refers only to data that was assessed as part of this project. It does not list all equipment types

References

Andrews Survey, 1999a. Area 212 – Norfolk Aggregate Licence. Unpublished report ref: 0222/A212/RA(01).

Andrews Survey, 1999b. Area 328 – East Norfolk Aggregate Production Licence. Unpublished report ref: 0222/A328/RA(02).

Andrews Survey, 1999c.Resource Assessment Lowestoft. Unpublished report ref: 0222/A361/RA(01).

Andrews Survey, 1999d. Cross Sands Geophysical Survey. Unpublished report ref: 0177\Geo(01).

Andrews Survey, 2000a. Area 202/436 Geophysical and bathymetric survey. Unpublished report ref: 0215/202/436/Bth(01).

Andrews Survey, 2000b. Aggregate Licence Area 401/2 Monitoring Survey. Unpublished report ref: 0324/A401/2/436/MS(01).

Andrews Survey, 2002a. Licence Area 228 Resource Assessment. Unpublished report ref: 0460/RA(01).

Andrews Survey, 2005a. Licence Area 228 Resource Assessment. Unpublished report ref: 0699/RA(00).

Emu Ltd, 2008. Geophysical survey of Area 212. Unpublished report ref: 08/J/1/02/1174/0791

Emu Ltd, 2010. Area 361/242 Geophysical survey 2010. Unpublished report ref: 10/J/1/02/1616/1008

Gardline Ltd, 1989, Survey Report: Geophysical and Seabed Sampling Survey 1989, Lowestoft. Unpublished report 3022

Gardline Environmental Ltd, 2010, Anglian Offshore Dredging Association MAREA Geophysical Survey. Unpublished report 8270(00)

Gardline Environmental Ltd, 2011, Gardline Environmental Ltd, 2011a, License Area 228, Geophysical Survey, Unpublished survey report ref: 8672/Geo(00).

GardlineLankelma, 2007. North Cross Sands – Areas 494 and 296 Geophysical Survey. Unpublished report ref: 0866C/Geo(00)

Gardline Surveys Ltd, 2000. Seismic and Sampling Surveys off Norfolk and Lincolnshire.Survey Report. Unpublished report ref: 5490.

Limpenny, S.E., Barrio-Froján, C., Cotterill, C, Foster-Smith, R.L., Pearce, B., Tizzard, L., Limpenny, D.L., Long, D., Walmsley, S., Kirby, S., Baker, K., Meadows, W.J., Rees, J., Hill, J., Wilson, C., Leivers, M., Churchley, S., Russell, J., Pacitto, S., and Law, R., 2011. The East Coast Regional Environmental Characterisation. Cefas Open report 08/04

RMC Landsearch Exploration Department, 1993, Lowestoft Vibrocore Survey Production Licence 251, 360, 319 and Prospect Licences 251 south and 251 east. Geological Report

Wessex Archaeology, 2008a. Seabed in Prehistory: Gauging the Effects of Marine Aggregate Dredging. Final Report, Volume IV, Great Yarmouth. Unpublished report ref. 57422.34.

Wessex Archaeology, 2008b. Seabed in Prehistory: Gauging the Effects of Marine Aggregate Dredging. Final Report, Volume VII, Happisburgh and Pakefield Addendum. Unpublished report ref. 57422.37.

APPENDIX II: GEOTECHNICAL DATASETS

Area	Year	Licensee	Survey contractor	Vessel	Survey dates	Equipment	Number of vibrocore logs	Reference
Area 251, 319, 360	1991	CEMEX	RMC	*Unknown*	Aug-91	3m Hydraulic corer	61	RMC (1991)
Area 251, 319, 454, 251 South	1993	CEMEX	RMC	*Unknown*	31st January to 4th February 1993	3m Hydraulic corer	85	RMC (1993)
Area 251	1999	CEMEX	RMC	*Unknown*	Jun-99	4m corer	24	RMC (2000)
Area 251	2003	CEMEX	Andrews Survey Ltd for RMC Marine Ltd	*StrilBas*	20th July 2003	Andrews Survey High Powered Vibrocorer	10	RMC Marine Ltd (2004)
Area 251	2005	CEMEX	Andrews Survey Ltd for CEMEX UK Marine Ltd	*MV Franklin*	2nd – 5th May 2005	3m hydraulic corer	26	CEMEX UK Marine Ltd (2008a)
Area 251	2008	CEMEX	Coastline Surveys for CEMEX UK Marine Ltd	*MV Flat Holm*	2nd – 5th May 2008	4m high performance corer	10	CEMEX UK Marine Ltd (2008b)
Area 319	1999	CEMEX	RMC	*Unknown*	Jun-99	4m corer	23	RMC (1999a)
Area 319	2005	CEMEX	Andrews Survey Ltd for CEMEX UK Marine Ltd	*Unknown*		3m hydraulic corer	6	CEMEX UK Marine Ltd (2005)

Area	Year	Licensee	Survey contractor	Vessel	Survey dates	Equipment	Number of vibrocore logs	Reference
Area 319	2008	CEMEX	Coastline Surveys for CEMEX UK Marine Ltd	*MV Flat Holm*	2nd May 2008	4m high performance corer	6	CEMEX UK Marine Ltd (2008c)
Area 319, 360, 251	2009	CEMEX	Coastline Surveys for CEMEX UK Marine Ltd	*MV Flat Holm*	6th – 9th May 2009	5m high performance corer	8	CEMEX UK Marine Ltd (2009a)
Area 360	1999	CEMEX	RMC	*Unknown*	Jun-99	4m corer	24	RMC (1999b)
Area 360	2005	CEMEX	Andrews Survey Ltd for CEMEX UK Marine Ltd	*MV Franklin*	2nd – 4th May 2005	3m vibrocore	15	CEMEX UK Marine Ltd (2009b)
Area 360	2008	CEMEX	Coastline Surveys for CEMEX UK Marine Ltd	*MV Flat Holm*	2nd – 4th May 2008	4m high performance corer	15	CEMEX UK Marine Ltd (2008d)
Area 454	2005	CEMEX	Andrews Survey	*Unknown*	8th September 2005	3m Hydraulic corer	14	Andrews Survey (2008)
Area 202/436	2000	HAML	Andrews Survey Ltd	*Bon Accord*	Mar-00	3m hydraulic corer	23	Andrews Survey (2000c)
Area 212, 361, 242, 401/2, 328, 401/1	1999	HAML	Andrews Survey Ltd	*Bon Accord*	Jul-99	3m and 6m hydraulic corer	149	Andrews Survey Ltd (1999e)
Area 240	1999	HAML	Alluvial Mining	*STM Inspector*	1st July - 3rd July	4m HPCvibrocore	25	Alluvial Mining Ltd (1999)
Area 240	2000	HAML	Andrews Survey	*Bon Accord*	23rd March 2000	3m hydraulic corer	7	Andrews Survey (2000d)

Area	Year	Licensee	Survey contractor	Vessel	Survey dates	Equipment	Number of vibrocore logs	Reference
Area 240	2000	HAML	Andrews Survey	*Bon Accord*	18th – 26th July 2000	3m hydraulic corer	41	Andrews Survey (2000e)
Area 240, 242 and 328	2005	HAML	Andrews Survey	*M/V Franklin*	Sep-05	3m hydraulic corer	38	Andrews Survey (2005b)
Area 240, 242 and 328A	2007	HAML	Lankelma Andrews	*Cameron*	Apr-07	3m hydraulic corer	47	Lankelma Andrews (2007)
Area 328	2001	HAML	Andrews Survey Ltd	*Goosander*	Jul-01	3m hydraulic corer	17	Andrews Survey Ltd (2001a)
Area 328	2003	HAML	Andrews Survey Ltd	*Strilbas*	Aug-03	6m hydraulic corer	10	Andrews survey Ltd (2003a)
Area 361	2000	HAML	Andrews Survey Ltd	*Bon Accord*	Mar-00	3m hydraulic corer	5	Andrews Survey Ltd (2000f)
Area 361 &242	2003	HAML	Andrews Survey Ltd	*Strilbas*	Aug-03	6m hydraulic corer	9	Andrews survey Ltd (2003b)
Area 401/2	2000	HAML	Andrews Survey Ltd	*Bon Accord*	22nd March 2000	3m hydraulic corer	17	Andrews Survey Ltd (2000g)
Area 401/402	2000	HAML	Andrews Survey Ltd	*Bon Accord*	Jul-00	3m hydraulic corer	53	Andrews Survey (2000h)
Area 401/2, 361 and 242	2001	HAML	Andrews Survey Ltd	*Goosander*	Nov-01	3m hydraulic corer	20	Andrews Survey Ltd (2001b)
Area 254	1992	TMDL	-	-	-	-	19	-
Area 254	1995	TMDL	-	-	-	-	23	-
Area 254, Area 296	2000	TMDL	Gardline Surveys Ltd	*Elinor and Sea Profiler*	July – August 2000	3m hydraulic corer	70	Gardline Surveys Ltd (2000)
Area 254	2002	TMDL	Gardline Surveys Ltd	*Ocean seeker*	3rd March 2002	GHpV-1 5m corer	10	Gardline Surveys Ltd (2002)

Area	Year	Licensee	Survey contractor	Vessel	Survey dates	Equipment	Number of vibrocore logs	Reference
Area 254	2002	TMDL	Andrews Surveys Ltd	*Goosander*	Mar-02	3m hydraulic corer	27	Andrews Survey Ltd (2002b)
Area 296	2002	TMDL	Andrews Surveys Ltd	*Goosander*	Mar-02	3m hydraulic corer	25	Andrews Survey Ltd (2002c)
Area 296 and 494A	2008	TMDL	GardlineLankelma	*M/V Flat Holm*	Feb-08	5m vibrocore	38	GardlineLankelma (2008)
Area 228	1988	VDL	Alluvial Mining Limited	*M.V. Tugro*	13th to 15th June 1988	3m AM vibrocorer	18	Alluvial Mining (1988)
Area 228	1996	VDL	Alluvial Mining Limited	*Milbrook Surveyor II*	10th June to 18th June 1996	3m vibrocorer	36	Alluvial Mining Limited (1996)
Area 228	2002	VDL	Andrews survey	*Goosander*	Mar-02	3m Hydraulic corer	39	Andrews Survey (2002d)
Area 228	2004	VDL	Andrews Survey	*Gray Mammoth*	Nov-04	4m Hydraulic corer	26	Andrews Survey (2004)
Area 228	2011	VDL	Gardline	*M.V. Ivero*	June and July 2011	Gardline Geosciences High Power Corer	25	Gardline Environmental Ltd (2011b)
Catchment Area	2009		CEFAS/BGS	*Cefas Endeavour*	May-09	BGS 6m vibrocorer	16	Limpenny et al. (2011)
Catchment Area	2006		Gardline Surveys Ltd	*S/V Flatholm*	Jul-06	5m High Power Corer	8	Wessex Archaeology (2008a)

References

Alluvial Mining Limited, 1988, Production Licence 228 Aggregate Survey for Volker Dredging Limited. Unpublished report.

Alluvial Mining Limited, 1996, Production Licence 228 Aggregate Survey for Volker Dredging Limited. Unpublished report: C6224/228.

Alluvial Mining Limited, 1999. Aggregate Prospecting Survey.Areas 240 and 240B. Unpublished report No. 96524-1.

Andrews Survey, 1999e.Great Yarmouth 1999 Vibrocore Survey Volume 1 - 6 (Factual Report). Unpublished report ref: 0139\GY\Lab(01).

Andrews Survey, 2000c.Area 202/436 Vibrocore Survey. Unpublished report ref: 0215/202/436/Lab(01).

Andrews Survey, 2000d.Area 240 Vibrocore Survey. March 2000. Unpublished report ref: 0215/240/Lab(01)

Andrews Survey, 2000e.Area 240 Vibrocore Survey. July 2000. Unpublished report ref: 0278/240/Lab(01).

Andrews Survey, 2000f.Area 381 Vibrocore Survey. Unpublished report ref: 0215/361/Lab(01).

Andrews Survey, 2000g.Area 401/2 Vibrocore Survey. Unpublished report ref: 0215/401/2/Lab(01).

Andrews Survey, 2000h.Area 401/402 Vibrocore Survey. Unpublished report ref: 0278/401-2/Lab(01).

Andrews Survey, 2001a, Licence Area 328 Vibrocore Survey. Unpublished report ref: 0400/328/Lab(01).

Andrews Survey, 2001b, Licence Area 401-2, 361 and 242 Vibrocore Survey. Unpublished report ref: 0427/Lab(01).

Andrews Survey, 2002b, Licence Area 254 Vibrocore Survey. Unpublished report ref: 0456/254/Lab(01).

Andrews Survey, 2002c, Licence Area 296 Vibrocore Survey. Unpublished report ref: 0456/296/Lab(01).

Andrews Survey, 2002d, Licence Area 228 Vibrocore Survey. Unpublished report ref: 0460/Lab(01).

Andrews Survey, 2003a, Licence Area 328 Vibrocore Survey. Unpublished report ref: 0607/328/Lab(01)

Andrews Survey, 2003b, Licence Area 361/242 Vibrocore Survey. Unpublished report ref: 0607/361-242/Lab(01).

Andrews Survey, 2004, Licence Area 228 (Zone 4, Zone 5 & Zone 8/16)Vibrocore Survey. Unpublished report ref: 0696/Lab(01).

Andrews Survey, 2005b.Areas 240, 242 and 328.Vibrocore Survey. Unpublished report ref: 0748/Lab(01).

Andrews Survey, 2008.Areas 454 Resource Monitoring Assessment 2005. Unpublished report ref: 0665.

CEMEX UK Marine Ltd, 2005, North Lowestoft Area 319 Resource Monitoring Assessment 2005 Report.

CEMEX UK Marine Ltd, 2008a, South Lowestoft 251– 2005 Site Investigation Vibrocore Survey Report.

CEMEX UK Marine Ltd, 2008b, South Lowestoft 251– 2008 Site Investigation Vibrocore Survey Report.

CEMEX UK Marine Ltd, 2008c, South Lowestoft 319 – 2008 Site Investigation Vibrocore Survey Report.

CEMEX UK Marine Ltd, 2008d, East Lowestoft 360 – 2008 Site Investigation Vibrocore Survey Report.

CEMEX UK Marine Ltd, 2009a, North Lowestoft 319, 360– 2009 Site Investigation Vibrocore Survey Report.

CEMEX UK Marine Ltd, 2009b, East Lowestoft 360– 2005 Site Investigation Vibrocore Survey Report.

Gardline Environmental Ltd, 2011b, Licence Area 228 Vibrocore Survey. Unpublished report ref: 8672/Lab(00).

GardlineLankelma, 2008. Area 496 & 296A North Cross Sands Sampling Survey. Unpublished report ref: 7538/Lab(00).

Gardline Surveys Ltd, 2000.Seismic and Sampling Surveys off Norfolk and Lincolnshire.Survey Report. Unpublished report ref: 5490.

Gardline Surveys Ltd, 2002.Aggregate Site Survey MARCON (Area 254) Aggregate Report.

Lankelma Andrews, 2007. Areas 240, 242, 328A and 328B Vibrocore Survey. Unpublished report ref: 0841/Lab(01).

Limpenny, S.E., Barrio-Froján, C., Cotterill, C, Foster-Smith, R.L., Pearce, B., Tizzard, L., Limpenny, D.L., Long, D., Walmsley, S., Kirby, S., Baker, K., Meadows, W.J., Rees, J., Hill, J., Wilson, C., Leivers, M., Churchley, S., Russell, J., Pacitto, S., and Law, R., 2011. The East Coast Regional Environmental Characterisation. Cefas Open report 08/04

RMC, 1991, Vibrocore logs, Lowestoft .Area 251, 319, 361.

RMC, 1993, Vibrocore logs, Lowestoft .Area 454, 251, 319 and Lowestoft South.

RMC, 1999a, North Lowestoft – 1999 Vibrocore Survey Report.

RMC, 1999b, East Lowestoft – 1999 Vibrocore Survey Report.

RMC, 2000, South Lowestoft – 1999 Vibrocore Survey Report.

RMC Marine Ltd., 2004, South Lowestoft 251– 2003 Site Investigation Vibrocore Survey Report.

Wessex Archaeology, 2008a. Seabed in Prehistory: Gauging the Effects of Marine Aggregate Dredging. Final Report, Volume IV, Great Yarmouth. Unpublished report ref. 57422.34.

APPENDIX III: GAZETTEER OF KNOWN ARCHAEOLOGY

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
2000	383453	5832575	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic flint handaxe, 58 Earlham Road	MNF472
2001	383848	5825975	FINDSPOT	Centrepoint			Mesolithic; Neolithic	Mesolithic and Neolithic flints, Roman to post medieval pottery sherds	MNF13419
2002	384156	5827221	FINDSPOT	Centrepoint	River Gravels of Terrace 1	7?	Palaeolithic	Probably surface finds (including handaxe) inside Venta Icenorum Roman site	MNF9786; TERPS_22634
2003	384480	5829002	FINDSPOT	Centrepoint	River Gravels of Terrace 1	7?	Palaeolithic	Small ovate handaxe found by H B Woodward prior to 1881; Markshall, between the confluence of the Rivers Yare and Tas	MNF9776; TERPS_22654
2004	384530	5818177	FINDSPOT	Centrepoint	edge of Alluvium and Glacial Sand and Gravels	?	Palaeolithic	Palaeolithic handaxe found in garden in gravel at depth of 1.20m during digging of footings for post-war bungalow; Ruslene, Connaught Park	MNF15909; TERPS_22658
2005	384544	5832805	FINDSPOT	Centrepoint			Palaeolithic	Norwich, with no specific provenance	TERPS_22638
2006	384564	5815754	FINDSPOT	Centrepoint			Prehistoric	Mesolithic flint find	MNF29409
2007	384603	5825842	FINDSPOT	Centrepoint			Prehistoric	Possible Mesolithic microlith, prehistoric flint flakes	MNF28431
2008	384614	5829226	FINDSPOT	Centrepoint			Mesolithic	Mesolithic microlith	MNF9580
2009	384751	5833191	FINDSPOT	Centrepoint			Mesolithic	A Mesolithic implement was found during excavations at 79-87 Magdalen Street/8-12 Cowgate in 1974	NMR_1203982
2010	384828	5833029	LITHIC WORKING SITE	Centrepoint			Upper Palaeolithic; Early Mesolithic	Upper palaeolithic or Early Mesolithic occupation activity	MNF61890
2011	384831	5823517	FINDSPOT	Centrepoint			Mesolithic	Mesolithic flint pick	MNF17172
2012	385018	5835641	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic handaxe	MNF17946
2013	385019	5830326	FINDSPOT	Centrepoint			Mesolithic	Mesolithic chipped flint axehead	MNF335
2014	385141	5831382	FINDSPOT	Centrepoint			Mesolithic	Three Mesolithic flint flakes, Carrow Hill	MNF467
2015	385232	5829707	FINDSPOT	Centrepoint			Mesolithic; Neolithic	Mesolithic and Neolithic flint finds	MNF18267

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
2016	385387	5829797	FINDSPOT	Centrepoint			Mesolithic or Neolithic	Neolithic or Mesolithic flaked axehead	MNF40763
2017	385518	5831321	FINDSPOT	Centrepoint			Mesolithic	Mesolithic flint axehead, Carrow Works	MNF465
2018	385536	5831520	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic flint scatter and multi-period finds/features at Norwich City Football Club, Carrow Road	MNF41766
2019	385636	5831226	LITHIC WORKING SITE	Centrepoint	River Gravels of Terrace 1	7?	Palaeolithic	CARROW ROAD: Handaxes and flakes found by J E Sainty in 1926 during excavation of terrace gravels banked up against a chalk cliff, Carrow Works of Messrs Reckitt and Colman Ltd	TERPS_22635
2020	385748	5829935	FINDSPOT	Centrepoint			Mesolithic	Late prehistoric worked flints, Mesolithic blade, Iron Age coin, Roman to post-medieval objects	MNF45179
2021	385940	5839922	FINDSPOT	Centrepoint	Edge of Crag and Alluvium	2,7	Palaeolithic	Handaxe found by R Chamberlain 1987-8 on surface of a ploughed field	MNF_24415; TERPS_22663
2022	386006	5838629	FINDSPOT	Centrepoint			Mesolithic	Mesolithic flint axehead and multi-period metal objects	MNF32216
2023	386050	5833992	FINDSPOT	Centrepoint			Palaeolithic	Two Palaeolithic handaxes and waste flake	MNF471
2024	386088	5841475	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic flint handaxe	MNF18828
2025	386149	5807891	FINDSPOT	Centrepoint			Prehistoric	Small unfinished Palaeolithic handaxe and prehistoric flint core	MNF28628
2026	386204	5839965	LITHIC WORKING SITE	Centrepoint			Mesolithic; Neolithic	Mesolithic to Neolithic flint-working site, Bronze Age spearhead, and medieval and post medieval metal objects	MNF24651
2027	386219	5822116	FINDSPOT	Centrepoint			Mesolithic; Neolithic	Mesolithic and Neolithic flint implements	MNF19510
2028	386237	5823875	FINDSPOT	Centrepoint			Mesolithic or Neolithic	Mesolithic/Early Neolithic scraper.	MNF62604
2029	386260	5808439	FINDSPOT	Centrepoint	Glacial Sand and Gravel	?	Palaeolithic	Handaxe found by M Payne on surface of a field in 1979	MNF16771; TERPS_22698
2030	386271	5839871	FINDSPOT	Centrepoint			Mesolithic; Neolithic	Mesolithic and Neolithic flint implements	MNF24515
2031	386322	5808458	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic handaxe	MNF16771

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
2032	386339	5839913	FINDSPOT	Centrepoint			Mesolithic; Neolithic	Mesolithic and Neolithic flint implements	MNF23810
2033	386346	5825136	FINDSPOT	Centrepoint			Mesolithic or Neolithic	Mesolithic or Neolithic pebble macehead, prehistoric flint, post medieval objects	MNF18119
2034	386422	5833877	FINDSPOT	Centrepoint	Glacial Sands and Gravels	?	Palaeolithic	Hand-axe found by J H Capon about 1935 in shallow gravel workings. Two other hand-axes hand a flake found by L W Burroughs also on the heath	TERPS_22625
2035	386515	5825793	FINDSPOT	Centrepoint			Palaeolithic or Mesolithic	Palaeolithic or Mesolithic long blade core	MNF28430
2036	386743	5808229	FINDSPOT	Centrepoint			Mesolithic or Neolithic	Mesolithic or Neolithic flint tools and reused axehead	MNF25531
2037	386887	5821147	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic flint flakes	MNF11658
2038	386905	5833450	FINDSPOT	Centrepoint			Mesolithic	Fragment of Mesolithic flaked axehead	MNF19829
2039	386994	5831634	FINDSPOT	Centrepoint			Mesolithic; Neolithic	Neolithic and Mesolithic cores	MNF43320
2040	387000	5809052	FINDSPOT	Centrepoint			Mesolithic or Neolithic	Early Neolithic or Mesolithic flaked axehead	MNF49541
2041	387139	5822836	FINDSPOT	Centrepoint			Mesolithic	Mesolithic finds from Shotesham	MNF57300
2042	387250	5806893	FINDSPOT	Centrepoint			Mesolithic	Mesolithic core. Double platform. Bluey white patination. Presumably found whilst fieldwalking.	MSF4477
2043	387397	5836280	FINDSPOT	Centrepoint			Mesolithic	Mesolithic flaked axehead	MNF25453
2044	387611	5826480	FINDSPOT	Centrepoint	Glacial Sand and Gravel	?	Palaeolithic	Handaxe found by Miss Burslem in gravel pit north-east of school. Open, wooded pit used as public amenity area	MNF9884; TERPS_22657
2045	388020	5831260	LITHIC WORKING SITE	Centrepoint			Mesolithic or Neolithic	Mesolithic or Neolithic flint working site	MNF13927
2046	388182	5837992	FINDSPOT	Centrepoint			Mesolithic	Mesolithic flint find	MNF8140
2047	388310	5808920	FINDSPOT	Centrepoint	Alluvium	7?	Lower Palaeolithic	Ovate Acheulian hand-axe in rolled condition and stained. Found 1988, in river bed. Old Mill Race, River Waveney. Post-war house on site of mill	MNF15571; TERPS_22699
2048	388550	5810997	FINDSPOT	Centrepoint			Prehistoric	Mesolithic to Bronze Age pebble macehead	MNF11044

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
2049	388602	5808978	FINDSPOT	Centrepoint	River Deposits of Terrace 3 (Homersfield)	3	Palaeolithic	Found in gravel pit east of the church. Disused flooded pit, landscaped and used as fishing lake	TERPS_22700
2050	388602	5833525	FINDSPOT	Centrepoint	Glacial Sands and Gravel	?	Palaeolithic	Finely made ovate hand axe (Wymer 1968 type K e/v 12cm long) with plano convex section. Very slightly rolled; stained brown found in garden by Mrs D C Clarke; 36 St. Catherine's Road, Norwich. Post-war residential	MNF21658; TERPS_22639
2051	388622	5833824	FINDSPOT	Centrepoint			Palaeolithic	Lithic implement exhibited to Prehistoric Society of East Anglia in 1925	MNF9614; TERPS_22640
2052	388655	5809024	FINDSPOT	Centrepoint			Palaeolithic	Flint hand-axe (? found) 1962 in gravel pit (S1).	MSF9944
2053	388745	5807360	FINDSPOT	Centrepoint			Mesolithic	Four lightly patinated flakes from a blade industry. Found whilst fieldwalking.	MSF1966
2054	388891	5838467	LITHIC WORKING SITE	Centrepoint			Mesolithic; Neolithic	Mesolithic flint-working site and Neolithic, Bronze Age and medieval finds	MNF12630
2055	388917	5832472	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic flint tools, Thorpe Pit	MNF9614
2056	389403	5808926	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic hand-axe found at Homersfield in Norwich Castle Museum is listed by Roe (S1).	MSF823
2057	389473	5830489	LITHIC WORKING SITE	Centrepoint			Palaeolithic	Palaeolithic flint working site and multi-period finds	MNF9663
2058	389500	5834333	FINDSPOT	Centrepoint			Mesolithic; Neolithic	Mesolithic and Neolithic flint implements	MNF14874
2059	389511	5830756	LITHIC WORKING SITE	Centrepoint	River Terrace Deposits undifferentiated	?	Lower Palaeolithic	WHITLINGHAM: Palaeoliths found by H H Halls and J E Sainty in gravel workings in slope to south of sewage works during 1926. Excavations conducted during 1927. Whitlingham, Kirby Bedon Sewage Farm. Rough disturbed ground to south of plant	MNF9663; TERPS_22641
2060	389596	5831759	FINDSPOT	Centrepoint			Mesolithic	Mesolithic flint axehead	MNF11644

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
2061	389804	5833320	LITHIC WORKING SITE	Centrepoint			Upper Palaeolithic	Upper Palaeolithic flint knapping site	MNF55849
2062	389884	5838283	FINDSPOT	Centrepoint			Mesolithic	Mesolithic chipped flint axe; found in a hedge bank	MNF8145; TERPS_132919
2063	390178	5838729	FINDSPOT	Centrepoint			Mesolithic	Mesolithic tranchet axe	MNF31368
2064	390324	5826592	FINDSPOT	Centrepoint	Junction of Norwich Crag and Till (Lowestoft)	2?	Palaeolithic	Handaxe found in arable field	MNF9882; TERPS_22651
2065	390367	5822882	FINDSPOT	Centrepoint			Palaeolithic	Chipped flint palaeolithic handaxe	MNF10129; TERPS_22656
2066	390402	5826566	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic flint handaxe	MNF9882
2067	390809	5835205	FINDSPOT	Centrepoint			Mesolithic or Neolithic	Mesolithic or Neolithic macehead	MNF8169
2068	391318	5835667	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic handaxe	MNF8151
2069	391353	5835638	FINDSPOT	Centrepoint	Sand clay of Corton Formation		Palaeolithic	Handaxe found by Mrs Howland on potato harvester in 1974	MNF8151; TERPS_22646
2070	391590	5837371	FINDSPOT	Centrepoint			Mesolithic	Mesolithic axehead, medieval and post medieval finds	MNF43963
2071	391690	5832559	FINDSPOT	Centrepoint			Mesolithic	Mesolithic axehead	MNF10216
2072	391744	5815914	FINDSPOT	Centrepoint			Mesolithic	Mesolithic flint find	MNF10594
2073	391802	5825508	FINDSPOT	Centrepoint			Lower Palaeolithic	Palaeolithic handaxe	MNF40057
2074	391995.5	5821576	FINDSPOT	Centrepoint	Boulder Clay		Palaeolithic	Found after ploughing by Mr R Seaman in early 1980s; Palaeolithic handaxe, west of Seething Hall	MNF19381; TERPS_22662
2075	392147	5841293	FINDSPOT	Centrepoint			Palaeolithic	Large flint Acheulian Palaeolithic pointed handaxe found in 'area' of Wroxham	MNF8051; TERPS_22527
2076	392174	5827265	FINDSPOT	Centrepoint			Palaeolithic	A Palaeolithic handaxe was found in a field in Rockland St Mary parish by a Miss Burslem.	TERPS_22653
2077	392688	5824845	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic handaxe	MNF10327

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
2078	392706	5824824	FINDSPOT	Centrepoint	Boulder Clay		Palaeolithic	Palaeolithic handaxe found 1959 by Mr Palmer. Arable	MNF10327; TERPS_22655
2079	392714	5813167	FINDSPOT	Centrepoint			Mesolithic	Mesolithic and Roman finds	MNF22243
2080	392902	5837734	FINDSPOT	Centrepoint			Palaeolithic	Clarke refers to a hand-axe being found by a schoolboy at Salthouse	MNF8462; TERPS_22648
2081	392936	5838233	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic flint handaxe	MNF8462
2082	393117	5823843	FINDSPOT	Centrepoint			Mesolithic or Neolithic	Mesolithic or Early Neolithic and prehistoric worked flint, Iron Age, medieval and post-medieval ceramic artefacts	MNF61878
2083	393200	5813168	FINDSPOT	Centrepoint			Palaeolithic	Found in 1861 on Bungay Common. Probably from the same site as hand-axe above (WYN-2, No.8)	TERPS_22702
2084	393295	5813447	FINDSPOT	Centrepoint			Palaeolithic	Late Pal hand axe found while walking on Outney Common. Further possible Pal finds from Outney common (see BUN Misc).	MSF22706
2085	393321	5813460	FINDSPOT	Centrepoint	River Deposits of Terrace 3 (Homersfield)	3	Palaeolithic	Palaeolithic handaxe found on edge of old quarry in 1988 by M Davy on Outney Common. Grass and bushes in open quarry on edge of golf course, with flooded lake on north-east side	TERPS_22701
2086	393328	5813354	FINDSPOT	Centrepoint			Prehistoric	Three unretouched flakes found on edge of cliff near lake (gravel pits).	MSF1006
2087	393446	5829490	FINDSPOT	Centrepoint	River Terrace Deposits undifferentiated	?	Palaeolithic	Sub-cordate handaxe in rolled condition with slight patina found in garden of Lesingham House in 1974 by Prof K Clayton at a depth of about 0.45m	MNF28057
2088	393518	5834723	LITHIC WORKING SITE	Centrepoint			Mesolithic	Mesolithic flint working site	MNF8485
2089	394424	5823744	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic and prehistoric worked flint, Roman, medieval and post-medieval pottery	MNF61920
2090	394466	5829433	HUMAN REMAINS	Centrepoint			Mesolithic	Possibly Mesolithic human remains	MNF10249
2091	394498	5834867	FINDSPOT	Centrepoint			Mesolithic	Mesolithic blades	MNF8484

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
2092	394706	5829394	HUMAN REMAINS	Centrepoint			Mesolithic	Mesolithic human skull	MNF10240
2093	394790	5814260	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic flint flake	MNF10621
2094	395105	5814639	FINDSPOT	Centrepoint	River Deposits of Terrace 2 (Broome)	3	Palaeolithic	Rolled Palaeolithic flake found in situ in gravel at depth of 2.50-3.00m by Dr P Coxon in 1978. Broome Heath, disused gravel pits. Disused flooded pits used by angling club	MNF28074; TERPS_22703
2095	395114	5814704	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic flint flake	MNF28074
2096	395735	5835500	LITHIC WORKING SITE	Centrepoint			Mesolithic	Mesolithic flint working site	MNF8473
2097	395785	5836196	FINDSPOT	Centrepoint			Mesolithic; Neolithic	Mesolithic, Neolithic and Late Prehistoric flints	MNF58519
2098	396285	5815759	FINDSPOT	Centrepoint	Glacial Sands and Gravels	?	Palaeolithic	Acheulean handaxe found by Mrs L Smith in Ellingham Park. Parkland. Aldeby Sands and Gravels of Coxon (1984)	MNF10673; TERPS_22704
2099	396326	5823571	FINDSPOT	Centrepoint	Till (Lowestoft)		Palaeolithic	Palaeolithic handaxe found in school grounds in 1977 by R Webster when gardening, Langley Park. Walled garden of Langley Hall School	MNF10362; TERPS_22665
2100	396372	5815829	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic handaxe	MNF10673
2101	396525	5834748	LITHIC WORKING SITE	Centrepoint			Mesolithic	Mesolithic flint working site and possible medieval pottery works on 13 Acre, 14 Acre and Kator fields	MNF31238
2102	396566	5835049	FINDSPOT	Centrepoint			Mesolithic	Mesolithic axehead	MNF12634
2103	396900	5826124	FINDSPOT	Centrepoint	Kesgrave Sands and Gravels		Lower Palaeolithic	A fragment of an Acheulian handaxe was found in the garden of 42 Langley Green by Mr C K Smith	MNF10339; NMR_133398; TERPS_22664
2104	396988	5825152	FINDSPOT	Centrepoint			Mesolithic or Neolithic	Mesolithic to Early Neolithic and prehistoric worked flint, Roman, medieval and post-medieval pottery	MNF59077
2105	397107	5824615	FINDSPOT	Centrepoint			Mesolithic or Neolithic	Prehistoric and Mesolithic or Neolithic worked flint, undated, medieval and post-medieval ceramic artefacts	MNF61883

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
2106	399214	5814654	FINDSPOT	Centrepoint	Edge of River Deposits of Terrace 1	7?	Palaeolithic	Handaxe found in 1981 by Mr J Meier on pebbly ground, Geldeston village, close to Wherry Inn in residential gardens	MNF17559; TERPS_22706
2107	399214	5814654	FINDSPOT	Centrepoint			Palaeolithic	A Palaeolithic handaxe found close to the Wherry Inn in Geldeston village by J Meier in 1981. The find remain in private possession	NMR_1231602
2108	399574	5813422	FINDSPOT	Centrepoint			Palaeolithic	Large double platform prismatic core. Found in a boat moored on the River Waveney, having been hurled through boat's windscreen. River had been dredged recently and presumably the core came from the dredgings. Probably UPal or EMes.	MSF651
2109	399646	5812220	FINDSPOT	Centrepoint			Mesolithic	Mesolithic Tranchet axe, ex Trapp collection (S1).	MSF1033
2110	400403	5814129	FINDSPOT	Centrepoint			Palaeolithic or Mesolithic	Palaeolithic or Mesolithic flint finds	MNF10728
2111	403516	5817462	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic ovate and flint flakes	MNF14289; TERPS_22709
2112	403730	5815544	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic handaxe	MNF10723
2113	403783	5815540	FINDSPOT	Centrepoint	Glacial Sands and Gravel	?	Palaeolithic	Early finds of hand-axes made by F C J Spurrell, W G Clarke and C Hartley. Further hand-axe found by Mrs C Harden Jones in 1972. Gravel pits of Atlas Aggregates, extended in 1948 and 1988. Usually referred to as Gillingham or Aylmerton. Disused pit	TERPS_22707
2114	404063.5	5813442	FINDSPOT	Centrepoint	Peat	7	Lower Palaeolithic	A Palaeolithic Acheulian handaxe found at Lotman's Carr. Pasture on the west side of Wild Carr, SW corner of Lotmans Carr by Major Danby in 1979. The find remains in private possession	MSF1184; NMR_1231606; TERPS_22708
2115	405969	5833885	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic flake from Stokesby Pit	MNF8591
2116	406762	5810825	FINDSPOT	Centrepoint	Corton Formation		Palaeolithic	Handaxe found by A H F Gothard about 1974; Mutford or Cottage Farm. Arable	MSF9952; TERPS_22710
2117	406845	5812022	FINDSPOT	Centrepoint	Glacial Sands and Gravels	?	Palaeolithic	Find found by Mr A Pye in 1977 on ploughed ground near Covehall Farm	NSF1542; TERPS_22711

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
2118	406926	5812467	FINDSPOT	Centrepoint			Lower Palaeolithic	Late Acheulean almond shaped axe, recorded on OS card.	MSF1542
2119	407197	5816806	FINDSPOT	Centrepoint			Mesolithic	A Mesolithic type of flint knife blade was found in sand from a rabbit hole in 1948.	NMR_392375
2120	407458	5816677	FINDSPOT	Centrepoint			Mesolithic	Mesolithic flint knife	MNF10743
2121	407553	5839972	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic handaxe from the Old Railway Station	MNF8558
2122	407553	5839972	FINDSPOT	Centrepoint			Palaeolithic	A Palaeolithic flint handaxe was found lying on the surface at the disused Railway Station.	NMR_133846
2123	407587	5840019	FINDSPOT	Centrepoint	Cromer Till		Palaeolithic	Flint ovate hand-axe found in yard of old railway station in 1969. Post war residential of Station Close. Possibly imported with stone from Frettenham	MNF8558; TERPS_22537
2124	408500	5824329	FINDSPOT	Centrepoint	Corton Formation		Palaeolithic	Acheulean hand-axe of ovate type found on heathland 200m from the Round Hills and on the opposite side of the old trackway between Belton and Fritton. Golf course	MNF10472; TERPS_22667
2125	408632	5824085	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic axe	MNF10472
2126	408939	5811381	FINDSPOT	Centrepoint			Mesolithic	Tranchet axe found on perimeter of Mutford Big Wood.	MSF1549
2127	409545	5809781	FINDSPOT	Centrepoint			Mesolithic	Mesolithic flint scatter including micro-burin, scrapers. Rushmere Hall	MSF1563
2128	409956	5841988	FINDSPOT	Centrepoint			Mesolithic	Mesolithic axehead	MNF13694
2129	410857	5839662	FINDSPOT	Centrepoint			Upper Palaeolithic	Palaeolithic handaxe from the garden of 34 Martham Road	MNF42041
2130	411315	5822751	FINDSPOT	Centrepoint			Prehistoric	Mesolithic, Neolithic or Bronze Age flint find	MNF10576
2131	411636	5813944	FINDSPOT	Centrepoint			Lower Palaeolithic	Acheulean hand-axe from cart track, probably consolidation material from elsewhere.	MSF1692
2132	413181	5807326	FINDSPOT	Centrepoint			Mesolithic	One broken axe, one other axe, one broken pick, about 80 cores, several hundred flakes, 58 scrapers, burins, microliths, four Thames picks, 11 hammerstones, 6 fabricators, 2 flint sickles, 3 plain knives, 3 spearheads, 37 blades, 1 flint saw, 1 chisel, 1	MSF1618
2133	413231	5808774	FINDSPOT	Centrepoint	Head	?	Palaeolithic	Found by Mr A Collins beside a dyke in gravel probably dredged from it, Top of Kessingland Cliffs. Dyke between arable and garden about	MSF1634; TERPS_22782

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
								200m from cliff	
2134	413376	5809279	FINDSPOT	Centrepoint			Mesolithic	Small tranchet axe, orange-brown flint. Cliff Farm	MSF1645
2135	413791	5810952	FINDSPOT	Centrepoint			Lower Palaeolithic	Internationally important Lower Palaeolithic Cromer Forest-bed deposits of Cromerian (pre Anglian glaciation) date, including finds of fresh in situ flints exposed on foreshore and along base of cliff.	MSF21847
2136	413907	5815639	FINDSPOT	Centrepoint	Glacial Sands and Gravels	?	Palaeolithic	Reported by W A Dutt; One of two pits in field adjoining brickyard, north of road from Lowestoft to Oulton Broad	MSF15229; TERPS_22712
2137	414095	5823115	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic flint finds	MNF10583
2138	414199	5822731	FINDSPOT	Centrepoint	Glaciofluvial Sand and Gravel	?	Palaeolithic	Found in gravel cliff at depth of 1.30m from the surface by C Fenton in 1915, Cliff just south of Gorleston Golf Links. Sea cliff and beach	TERPS_23091
2139	414390	5834114	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic flint flake	MNF11168
2140	414451	5833954	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic flint handaxe	MNF30179
2141	414476	5833931	FINDSPOT	Centrepoint	Blown Sand	?	Palaeolithic	Very rolled handaxe found on beach by L W Burroughs in 1983. Sandy beach in front of dunes	MNF30179; TERPS_22666
2142	414600	5833584	FINDSPOT	Centrepoint			Mesolithic	Mesolithic flint adze	MNF54936
2143	415119	5818660	FINDSPOT	Centrepoint	Glacial Sands and Gravels	?	Palaeolithic	Find recorded as from 'section in cliff of plateau gravel'	MSF_1750; TERPS_22714
2144	415410	5815635	FINDSPOT	Centrepoint			Palaeolithic	Palaeolithic flake reported by W A Dutt at depth of 3.00-3.60m in gravel	TERPS_22713
2145	426683	5822349	FINDSPOT	Centre of N-S orientated dredge lane			Middle Palaeolithic; Upper Palaeolithic	2 sections of de-laminated mammoth tusk recovered from Area 240: Hanson_0126 3 (2007 - 2008)	BMAPA_5103
2146	426460	5822460	FINDSPOT	Centre of dredge tacks in the HAML exclusion zone			Palaeolithic	Mammoth teeth, tusk fragments and antlers. Significant Palaeolithic assemblage. Due to importance not ultimately addressed through implementation service recovered from Area 240: Hanson_0133 3 (2007 - 2008)	

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
2147	426460	5822460	FINDSPOT	Centre of dredge tacks in the HAML exclusion zone		2,3,5/6	Palaeolithic	88 lithic finds, incl. 28 handaxes. Significant Palaeolithic assemblage. Due to importance not ultimately addressed through implementation service recovered from Area 240: Hanson_0133 3 (2007 - 2008)	
2148	425198	5824420	Environmental	Reported position		7	Mesolithic	Large concentrations of peat recovered from Area 240: Hanson_0150 3 (2007 - 2008)	BMAPA_5153
2149	425215	5824442	Environmental	Reported position		7	Mesolithic	Large concentrations of peat recovered from Area 240: Hanson_0150 3 (2007 - 2008)	BMAPA_5153
2150	425197	5824456	Environmental	Reported position		7	Mesolithic	Large concentrations of peat recovered from Area 240: Hanson_0150 3 (2007 - 2008)	BMAPA_5153
2151	425286	5824478	Environmental	Reported position		7	Mesolithic	Large concentrations of peat recovered from Area 240: Hanson_0150 3 (2007 - 2008)	BMAPA_5153
2152	425211	5824491	Environmental	Reported position		7	Mesolithic	Large concentrations of peat recovered from Area 240: Hanson_0150 3 (2007 - 2008)	BMAPA_5153
2153	425239	5824497	Environmental	Reported position		7	Mesolithic	Large concentrations of peat recovered from Area 240: Hanson_0150 3 (2007 - 2008)	BMAPA_5153
2154	425298	5824504	Environmental	Reported position		7	Mesolithic	Large concentrations of peat recovered from Area 240: Hanson_0150 3 (2007 - 2008)	BMAPA_5153
2155	425321	5824512	Environmental	Reported position		7	Mesolithic	Large concentrations of peat recovered from Area 240: Hanson_0150 3 (2007 - 2008)	BMAPA_5153
2156	425319	5824515	Environmental	Reported position		7	Mesolithic	Large concentrations of peat recovered from Area 240: Hanson_0150 3 (2007 - 2008)	BMAPA_5153
2157	425294	5824588	Environmental	Reported position		7	Mesolithic	Large concentrations of peat recovered from Area 240: Hanson_0150 3 (2007 - 2008)	BMAPA_5153
2158	425192	5824198	Faunal	Centrepoint of dredge lane			Palaeolithic	Mammoth tooth recovered from Area 240: Hanson_0169 3 (2007 - 2008)	BMAPA_5196
2159	425260	5824596	Faunal	Centrepoint of dredge lane			Palaeolithic	2 mammoth teeth recovered from Area 240: Hanson_0180 3 (2007 - 2008)	BMAPA_5179
2160	425260	5824596	FINDSPOT	Centrepoint of dredge lane			Unknown	Struck flint, probable waste flake recovered from Area 240: Hanson_0180 3 (2007 - 2008)	BMAPA_5180

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
2161	425465	5826119	Faunal	Approximate position of vessel			Palaeolithic	Mammoth tooth recovered from Area 240: Hanson_0268 5 (2009 - 2010)	BMAPA_5336
2162	439002	5825275	Faunal	Centrepoint of dredge lane			Unknown	Fossilised humerus fragment from a large mammal, possibly a mammoth recovered from Area 242_328A_361B_361C_HAML: Hanson_0202 4 (2008 - 2009)	BMAPA_5220
2163	423654	5816000	Faunal	Poor positioning. Could be Area 251 or 102 (Humber)			Middle Palaeolithic	Animal bone, possible hippopotamus (?Ipswichian interglacial) recovered from Area 251: CEMEX_0093 2 (2006 - 2007)	BMAPA_5074
2164	422508	5817821	Environmental	Centrepoint of 1400m N-S track		7	Mesolithic	Peat sample recovered from Area 251: CEMEX_0296 5 (2009 - 2010)	BMAPA_5349
2165	434520	5820104	Faunal	Approximate position of vessel			Unknown	Animal bone, auroch metatarsal recovered from Area 251: CEMEX_0307 5 (2009 - 2010)	BMAPA_5361
2166	434908	5822739	Faunal	Approximate position of vessel			Unknown	Mammoth Bone recovered from Area 360: CEMEX_0340 6 (2010 - 2011)	BMAPA_5394
2167	426144	5827497	Faunal	Centrepoint of dredge lane			Unknown	Fragment of bone, possible deer metatarsus recovered from Area 254: UMD_0041 1 (2005 - 2006)	BMAPA_5016
2168	426144	5827497	Faunal	Centrepoint of dredge lane			Palaeolithic	Upper molar of a woolly mammoth (Mammuthus primigenius). recovered from Area 254: UMD_0045 1 (2005 - 2006)	BMAPA_5024
2169	429984	5832115	Faunal	Centre of Area 296			Unknown	Piece of bone from a large mammal recovered from Area 296: UMA_0076 2 (2006 - 2007)	BMAPA_5062
2170	429984	5832115	Faunal	Centre of Area 296			Palaeolithic	Mammoth tooth, largely unworn so possible milk tooth recovered from Area 296: UMA_0107 2 (2006 - 2007)	BMAPA_5116
2171	429983	5832115	Faunal	Centre of Area 296			Unknown	Femur of a large mammal recovered from Area 296: UMA_0117 3 (2007 - 2008)	BMAPA_5088

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
2172	429984	5832115	Faunal	Centre of Area 297			Unknown	Degraded animal bone, possibly artiodactyl recovered from Area 296: UMA_0160 3 (2007 - 2008)	BMAPA_5161
2173	429984	5832115	Faunal	Centre of Area 298			Palaeolithic	Fragment of an upper cheek tooth of a fossil mammoth, possibly from a relatively young animal recovered from Area 296: Tarmac_0332 5 (2009 - 2010)	BMAPA_5399
2174	429983	5832115	Faunal	Centre of Area 299			Unknown	Mammoth Tooth recovered from Area 296: Tarmac_0354 6 (2010 - 2011)	BMAPA_5426
2175	423232	5819411	Faunal	Approximate position (within 1800m)			Palaeolithic	Fragment of tusk, possibly mammoth recovered from Area 319: CEMEX_0276 5 (2009 - 2010)	BMAPA_5339
2176	423553	5819963	Faunal	Approximate position (within 1200m)			Unknown	Left metatarsus of a large deer, possibly red deer recovered from Area 319: CEMEX_0281 5 (2009 - 2010)	BMAPA_5341
2177	434832	5822648	Environmental	Centrepoint of dredge lane			Early Mesolithic	c 250 large fragments of waterlogged and mineralised wood, eroding peat layer recovered from Area 360: CEMEX_0039 1 (2005 - 2006)	BMAPA_5044
2178	434832	5822648	Environmental	Centrepoint of dredge lane			Early Mesolithic	4 fragments of fibrous herbaceous peat, containing possible fine comminuted charcoal recovered from Area 360: CEMEX_0039 1 (2005 - 2006)	BMAPA_5045
2179	434832	5822648	Faunal	Centrepoint of dredge lane			Early Mesolithic	12 fragments of mineralised bone, probably large herbivore recovered from Area 360: CEMEX_0039 1 (2005 - 2006)	BMAPA_5046
2180	434832	5822648	Faunal	Centrepoint of dredge lane			Early Mesolithic	3 fragments of deer antler recovered from Area 360: CEMEX_0039 1 (2005 - 2006)	BMAPA_5047
2181	434832	5822648	FINDSPOT	Centrepoint of dredge lane			Early Mesolithic	Fragment of worked flint recovered from Area 360: CEMEX_0039 1 (2005 - 2006)	BMAPA_5048
2182	434823	5822459	Faunal	Approximate position			Palaeolithic	Mammoth tooth recovered from Area 360: Cemex_0265 4 (2008 - 2009)	BMAPA_5338
2183	434823	5822459	Faunal	Approximate position			Palaeolithic	Antler, possible Megaloceros (giant deer) recovered from Area 360: Cemex_0265 4 (2008 - 2009)	BMAPA_5338

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
2184	434344	5822621	Faunal	Approximate position			Palaeolithic	Elephant, or possibly mammoth, atlas vertebra recovered from Area 360: CEMEX_0284 5 (2009 - 2010)	BMAPA_5346
2185	433476	5822697	Faunal	Approximate position (within 500m)			Unknown	Fossilised Deer Bone recovered from Area 360: CEMEX_0341 6 (2010 - 2011)	BMAPA_5386
2186	433890	5822660	Faunal	Centrepoint of dredge lane			Unknown	Bones and teeth: 1 claw or tooth; 1 large bone - split in two; 2 pieces of bone - one with remains of marrow; and 1 piece of vertebrate recovered from Area 360: CEMEX_0379 7 (2011-2012)	BMAPA_5445
2187	435025	5823016	Faunal	Centrepoint of dredge lane			Unknown	Fossilised bone recovered from Area 360: CEMEX_0405 7 (2011-2012)	
2188	437463	5823517	Faunal	Approximate position			Palaeolithic	Pieces of mammoth bone recovered from Area 361: Hanson_0018 1 (2005 - 2006)	BMAPA_5011
2189	437463	5823517	Faunal	Centrepoint of dredge lane			Palaeolithic	Pieces of mammoth teeth recovered from Area 361: Hanson_0018 1 (2005 - 2006)	BMAPA_5012
2190	437463	5823517	Faunal	Centrepoint of dredge lane			Palaeolithic; Mesolithic	Possible deer bone recovered from Area 361: Hanson_0018 1 (2005 - 2006)	BMAPA_5013
2191	433070	5823801	FINDSPOT	Centre of East Coast Dredging block			Palaeolithic	Flint flake recovered from Area Unknown: UMA_0182 3 (2007 - 2008)	BMAPA_5182
2192	426340	5821854	FINDSPOT	Centrepoint	Unit 3 grab sample	3?	Unknown	This is a mid-section of a tertiary flake, with well-defined conchoidal rings on the ventral surface. The dorsal surface also has a number of converging negative flake scars. It has a slightly dipping profile. These features, including the way in which it has broken, have been noted on hand axe thinning flakes. Vertebra. Fish. Salmonid?	T1_G22

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
2193	426244	5821816	FINDSPOT	Centrepoint	Unit 3 grab sample	3?	Unknown	Flake similar to that from sample T1_G22 (described above). This flake also lacks the proximal and distal ends, so valuable details of the technology are lost. However, the dorsal surface has a number of residual flake scars, which form a radial pattern. This flake is not as convincing as T1_G22, but is still a probability.	T1_G25
2194	426320	5821851	FINDSPOT	Centrepoint	Unit 3 grab sample	3?	Unknown	This is a stained and patinated primary, hard hammer struck flake. The most convincing feature that indicates human production is the clear striking platform and well positioned point of percussion well back from the edge of the core. Three small flakes, all open to some doubt.	T1_G23
2195	426491	5821890	FINDSPOT	Centrepoint	Unit 3 grab sample	3?	Unknown	A very thin flake in mint condition and unstained. The point of percussion is located at the edge of the flake. It is possible that this flake was removed by natural processes, however the fact that there are apparent traces of platform preparation, that do not represent edge crushing, and other facets suggest that this is a product of debitage. Centrotarsal. Bovine/Cervid. Fossilised and Fossilised unidentifiable bone.	T1_G5
2196	426493	5821897	FINDSPOT	Centrepoint	Unit 3 grab sample	3?	Unknown	A heavily rolled flake with a glossy finish. It is naturally backed. The proximal end is missing, having been chipped by recent damage; however the presence of clear conchoidal rings on the ventral surface and similar well defined traces on the dorsal surface, indicating a previous removal, suggest that this flake is genuine. 2x unidentifiable small bone fragments. Fossilised.	T1_G5a
2197	426361	5821859	FINDSPOT	Centrepoint	Unit 3 grab sample	3?	Unknown	This is an elongated hard hammer struck flake. It is unstained and unpatinated. The argument that it is a genuine artefact relates to the presence of other flake scars, which suggest that it is product of deliberate, systematic debitage.	T1_G21a

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
2198	426537	5821915	FINDSPOT	Centrepoint	Unit 3 grab sample	3?	Unknown	This is a primary flake that is both patinated and stained. It is hard hammer struck. There is always potential for doubt with a flake of this type; however the striking platform is plain and the point of percussion is well positioned on the striking platform and not a glancing blow.	T1_G6
2199	426529	5821916	FINDSPOT	Centrepoint	Unit 3 grab sample	3?	Unknown	Clearly hard hammer struck and is part of a 'compound' removal, where a flake was removed with this one at the same time and the same blow. While not certain, it is probably due to human workmanship. Small flint is principally cortical and not convincing.	T1_G9
2200	426286	5821832	FINDSPOT	Centrepoint	Unit 3 grab sample	3?	Unknown	A small patinated and rolled primary flake, open to some doubt.	T1_G7
2201	426299	5821840	FINDSPOT	Centrepoint	Unit 3 grab sample	3?	Unknown	Unidentifiable small bone fragments. Recent.	T1_G8
2202	426427	5821879	FINDSPOT	Centrepoint	Unit 3 grab sample	3?	Unknown	2x bone pieces. The internal structure is mammalian, possibly a terrestrial mammal.	T1_G27
2203	426178	5822054	FINDSPOT	Centrepoint	Unit 3 grab sample	3?	Unknown	Technically a flake, although open to some doubt.	T2_G1b
2204	426010	5821898	FINDSPOT	Centrepoint	Unit 3 grab sample	3?	Unknown	Small flake that may well be a product of gravel abrasion.	T2_G5
2205	426715	5823985	FINDSPOT	Centrepoint	Unit 3 grab sample	3?	Unknown	Vertebra. Aquatic mammal ?dolphin. Recent.	T3_G5
2206	426326	5821823	FINDSPOT	Centrepoint	Unit 3 grab sample	3?	Unknown	During the East Coast REC survey (Limpenny et al. 2011) a flint artefact, identified as a broken secondary flake, was identified during onboard processing of a clamshell sample at station CG6, which is situated to the west of the HAML exclusion zone. The artefact is a broken secondary flake. The surviving dimensions of the piece are approximately 60 x 43 x 9 mm, although a transverse break means that the piece was originally considerably longer.	CG6

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
2207	426312	5821970	FINDSPOT	Approximate position: mixed load from transect 1A and 1B	Unit 3 target	3?	Palaeolithic	Mixed wharf. Large, mainly cortical flake, unpatinated, unstained, 3 points of impact, hard, slightly rolled, 1 inverse removal; dubious piece primarily thermal and stained but with three negative alternate removals (probably regard as reject)	77860_0000
2208	426312	5821970	FINDSPOT	Approximate position: mixed load from transect 1A and 1B	Unit 3 target	3?	Palaeolithic	Mixed. Cordiform on flake blank, ventral surface flaked sufficient to thin butt, dorsal covering flaking, lightly stained, sharp, 135x95x39mm	77860_1000
2209	426312	5821970	FINDSPOT	Approximate position: mixed load from transect 1A and 1B	Unit 3 target	3?	Palaeolithic	Mixed. Large tertiary flake, hard hammer, plain butt, lightly stained, partially radial flake scars, possibly from Levallois flake core. 95x107x19mm	77860_1002
2210	426312	5821970	FINDSPOT	Approximate position: mixed load from transect 1A and 1B	Unit 3 target	3?	Palaeolithic	Mixed. Large primary flake, unpatinated/unstained, mint/sharp, could be modern on condition but included due to well-placed point of impact 137x106x37mm	77860_1006
2211	426312	5821970	FINDSPOT	Approximate position: mixed load from transect 1A and 1B	Unit 3 target	3?	Palaeolithic	Trip 1 mixed Large flake, stained, sharp/slightly rolled, some modern edge damage. 102x103x23 mm	77860_1007
2212	426312	5821970	FINDSPOT	Approximate position: mixed load from transect 1A and 1B	Unit 3 target	3?	Palaeolithic	Mixed. 1 large primary flake, thermal dorsal surface, cortical butt, stained, slightly rolled/rolled	77860_1008

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
2213	426312	5821970	FINDSPOT	Approximate position: mixed load from transect 1A and 1B	Unit 3 target	3?	Palaeolithic	Mixed. Stained secondary, hard hammer struck flake, slightly rolled/rolled, cortical butt, clumsy crushed impact 86x82x23mm	77860_1009
2214	426312	5821970	FINDSPOT	Approximate position: mixed load from transect 1A and 1B	Unit 3 target	3?	Palaeolithic	Mixed (wharf). Hand axe with plano-convex cross section, probably made on flake. Both sides with covering flaking. Lightly stained, slightly rolled, tip absent. 113x80x23mm	77860_1011
2215	426312	5821970	FINDSPOT	Approximate position: mixed load from transect 1A and 1B	Unit 3 target	3?	Palaeolithic	Mixed wharf. Core fragment with a pot lid fracture, but with relict flake scars (2 deeply invasive and 1 alternate) that are rolled suggesting the recently formed pot lid may have come from a humanly modified block.	77860_1012
2216	426312	5821970	FINDSPOT	Centrepoint of track 1B	Unit 3 target	3?	Palaeolithic	1 tertiary flake, punctiform butt, possibly natural; rolled secondary flake, butt damaged, rolled, stained, dist part broken; tertiary flake, cortical butt, lightly rolled/rolled, lightly patinated.	77860_1018
2217	426391	5821942	FINDSPOT	Approximate position: mixed load from transect 2A and 2B	Unit 3 target	3?	Palaeolithic	Mixed wharf. Large tertiary flake, stained, slightly rolled/rolled, plain butt, uncertain mode, from flake core 77x114x55mm	77860_1038
2218	426391	5821942	FINDSPOT	Approximate position: mixed load from transect 2A and 2B	Unit 3 target	3?	Palaeolithic	Mixed wharf. Large primary hard hammer struck flake, rolled stained, plain butt 97x112x21mm	77860_1039
2219	424933	5820703	FINDSPOT	Centrepoint of track 2A	Unit 3 target	3?	Palaeolithic	Flake linear butt, mint ventral, unpatinated, unstained, modern; broken thinning/shaping flake, opposed scars, linear butt.	77860_1024
2220	426391	5821942	FINDSPOT	Centrepoint of track 2B	Unit 3 target	3?	Palaeolithic	Both flakes might be anthropogenic	77860_1025

WAID	UTM31N Easting	UTM31N Northing	Site type	Position accuracy	Geological Context	Assoc. Offshore Unit	Arch. Period	Description	Sources
2221	424944	5820639	FINDSPOT	Centrepoint of track 4A	Unit 3 target	3?	Palaeolithic	Large hard hammer secondary flake. Possibly represents a stage of hand axe roughing out/shaping. 3 unidirectional flake scars. Good flint, unstained, slightly rolled, unpatinated. Plain butt, no preparation	77860_1045
2222	426978	5823332	FINDSPOT	Approximate position: mixed load from transect 5A and 5B	Unit 3 target	3?	Palaeolithic	Mixed oversize pile. Hand axe. Ovate/cordiform. Tip absent, well executed bifacial covering flaking, lightly stained, sharp, 87x92x23mm	77860_1085
2223	425017	5820908	FINDSPOT	Centrepoint of track 5A	Unit 3 target	3?	Palaeolithic	Bulk. Tertiary, slightly rolled, lightly stained, no preparation, possible signs of soft percussion	77860_1054
2224	426978	5823332	FINDSPOT	Centrepoint of track 5B	Unit 3 target	3?	Palaeolithic	Broken hard hammer secondary flake, light differential staining, sharp. Unidirectional flaking, plain butt 68x57x22mm; rolled primary flake, probably collision	77860_1058
2225	424979	5820780	FINDSPOT	Centrepoint of track 7A	Unit 3 target	3?	Palaeolithic	Broken flake thermal dorsal, unconvincing butt, probable accidental impact; Flake stained sharp, opposing dorsal scar patterns; flake stained sharp clear butt, hinged dist end	77860_1087
2226	426632	5822423	FINDSPOT	Centrepoint of track 7B	Unit 3 target	3?	Palaeolithic	Broken flake matt, near mint, smashed butt, accident; lightly stained flake, butt unclear, transverse dorsal scars may be anthropogenic; rolled flake with parallel flaking scars lightly patinated. Possibly represents hand axe thinning	77860_1088
2227	425915	5822227	FINDSPOT	Centrepoint of track 8B	Unit 5 target	3?	Palaeolithic	Faceted butt, sharp, lightly patinated, hard, dist tip absent but almost certainly blade, possibly retouched	77860_1096

APPENDIX IV: MIDDLE PLEISTOCENE, LOWER AND MIDDLE PALAEOLITHIC SITE CONTEXT TO AREA 240

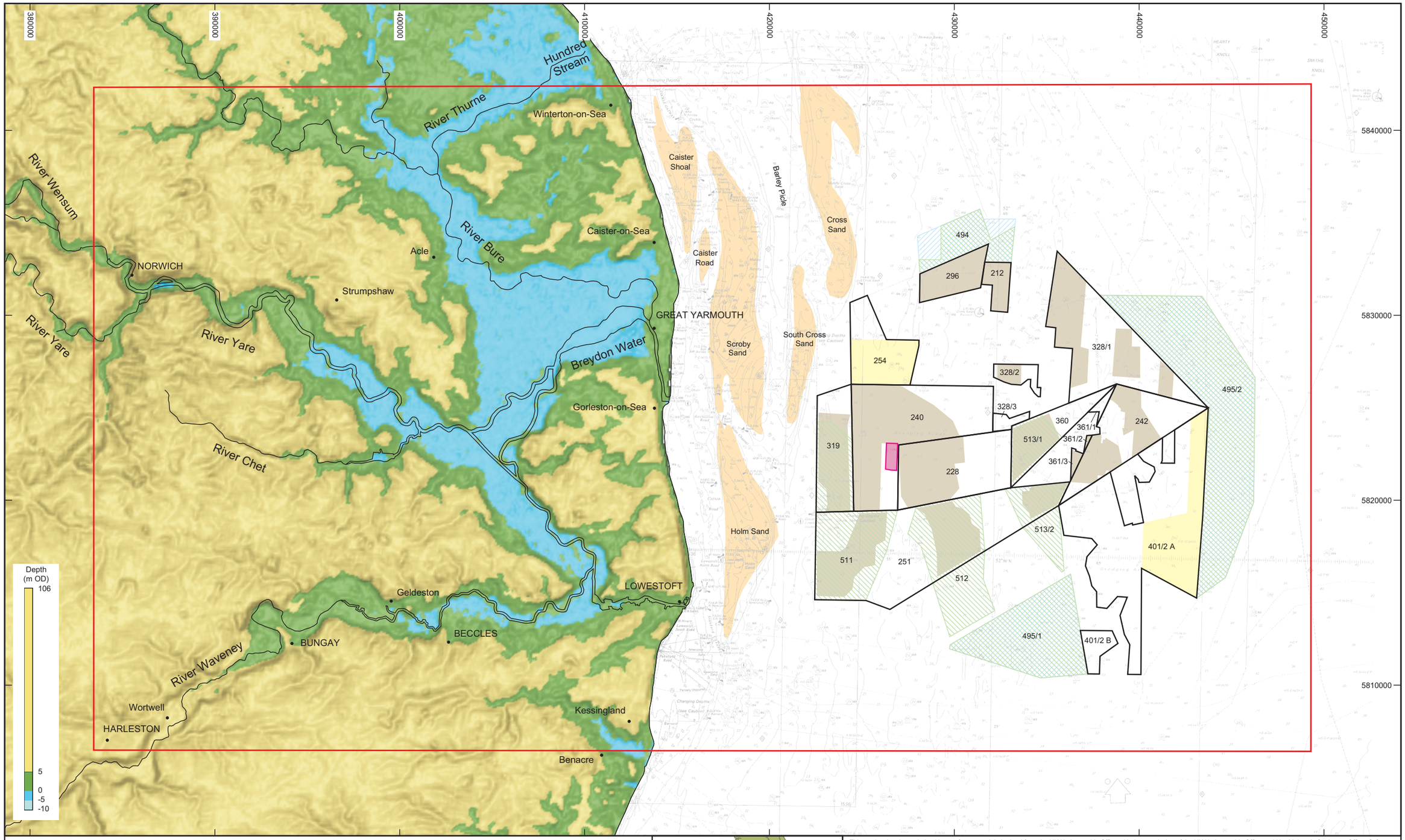
MIS	Stage Name	Date (ka)	Site	Technology	Assemblage Type	Environment	References
11/9	Hoxnian – Purfleet Interglacial	MIS 11 (AAR)	Swanscombe	Clactonian - Acheulean	Home Base	Riverine, Warm – Cooling	Wymer (1999)
11	**Hoxnian**	**404±33 437±38; AAR indicates MIS 11, (Biostratigraphy indicates MIS 9)**	**Hoxne**	**Acheulean: ovate & cordate handaxes (Lower Industry); Pointed handaxes, retouched flake (Upper Industry)**	**Workshop? 3 phases of industry**	**Warm, Cold; Lacustrine**	**Singer *et al.* 1993; Wymer (1999); Penkman *et al.* (2008); Ashton *et al.*, (2006); Grün and Schwarcz (2000)**
?11-9	**Hoxnian - Wolstonian**	**(>300?)**	**Whitlingham**	**Acheulean Handaxes, flakes, cores**	**Workshop**	**Riverine?**	**Wymer (1999); Sainty and Hall (1927); Pettitt and White (2012)**
?11-8	**Hoxnian - Wolstonian**		**Keswick Mill Pit**	**Handaxes, flakes, scrapers, (Levallois flakes)**	**Workshop?**	**Riverine?**	**Wymer (1999); Sainty (1933)**
9	Purfleet Interglacial	296±53	Cagny l'Epinette	Levallois			Santonja and Villa (2006); Pettitt & White (2012)
Late 9/Early 8?	Purfleet Interglacial – Wolstonian		Purfleet, Botany Pit	proto-Levallois / handaxes	Workshop?	Riverine, cool-cold	White *et al.* (2006); Ashton *et al.* (2011)
Late 9/ Early 8?	Purfleet Interglacial – Wolstonian		Mesvin IV	proto-Levallois / handaxes	Workshop	Open/cold	De Loecker (2011); White *et al.* (2006) Ryssaert (2006), Ashton *et al.* (2011)
?Early 8	Wolstonian		Cuxton	proto-Levallois		Riverine	White *et al.* (2006); Wenban-Smith (2004)
8	Wolstonian		Ariendorf I	Cores, flakes	Butchery	Open, Cool	Scott and Ashton (2011)
8	Wolstonian		Achenheim	Levallois		Open, Cool	Scott and Ashton (2011)

MIS	Stage Name	Date (ka)	Site	Technology	Assemblage Type	Environment	References
9-7?	Wolstonian		Broom	Handaxes			Ashton *et al.* (2011); Hosfield and Chambers (2004)
8?	Wolstonian		Kessalt-Op de Schans	Discoidal cores	Workshop		Scott and Ashton (2011)
8?	Wolstonian		Gouzeaucourt (G,H,I)	Handaxes			Scott and Ashton (2011)
Late 8?	**Wolstonian**		**Carrow Road, Norfolk**	**Handaxes/ (Levallois flake)**		**Cool**	**Wymer (1999); Sainty (1933)**
Late 8	Wolstonian		Northfleet (Coombe Rock)	Levallois	Workshop?	Riverine, Cold, open	White *et al*. (2006)
Late 8 / Early 7	**Wolstonian**	**250 – 200**	**Area 240**	**Handaxes / Levallois**		**Riverine, estuarine, cold**	**This volume**
Late 8 / Early 7	Wolstonian – Aveley Interglacial		West Thurrock	Levallois	Workshop?	Riverine. Cool; open? Wooded fully temperate deposits immediately above archaeology	Scott and Ashton (2011); White *et al.* (2006); Schreve *et al.* (2006)
Late 8 / Early 7	Wolstonian – Aveley Interglacial		Harnham	Handaxes		Open, Cool	Scott and Ashton (2011)
Late 8 / Early 7	Wolstonian – Aveley Interglacial		Ebbsfleet	Levallois	Workshop	Open, cool and temperate	Scott and Ashton (2011)
Late 8 / Early 7	Wolstonian – Aveley Interglacial		Pucheuil (A/C)	Levallois	Workshop	Open, Cool?	Scott and Ashton (2011); Soriano (2000)
Late 8 / Early 7?	Wolstonian – Aveley Interglacial		West Drayton / Yiewsley	Levallois			Scott and Ashton (2011)
Late 8 / Early 7	Wolstonian – Aveley Interglacial		Creffield Road	Levallois	Equipping		Scott and Ashton (2011)
Early 7	Aveley Interglacial		Aveley interglacial sands	Flakes		Riverine, possible estuarine influence. Warm heavily wooded	White *et al.* (2006)
Early 7	Aveley Interglacial		Ebbsfleet fluviatile gravel	Levallois	Workshop?	Riverine, Warm; open grassland, woodland present	White *et al.* (2006)

MIS	Stage Name	Date (ka)	Site	Technology	Assemblage Type	Environment	References
Early 7	Aveley Interglacial		Ranville	Handaxes / (Levallois)	Butchery	Open, wooded	Scott and Ashton (2011)
Early / Mid 7?	Aveley Interglacial		Pontnewydd	Levallois / biface handaxes	Home-base	Cave/river. Warm/cold; still or slow-moving water nearby.	Ashton and Scott (2008); White *et al.* (2006)
7	Aveley Interglacial		Maastricht-Belvedère	Levallois / discoidal cores	Workshop, butchery	Woodland and open areas, temperate	Scott and Ashton (2011)
7	Aveley Interglacial		Tourville-La-Rivière	Blade production	Workshop, butchery	Woodland and open areas, temperate	Scott and Ashton (2011)
7	Aveley Interglacial		Rheindalen (B1, B3 and B4)	Levallois / (handaxe) / blade production			Scott and Ashton (2011)
Later 7	Aveley Interglacial		Aveley interglacial silts	Levallois		Riverine. Warm; open with marshy areas	White *et al*. (2006)
Later 7			Brundon	Levallois	Workshop?	Riverine. Warm; open grassland, woodland present	White *et al.* (2006)
Late 7	Aveley Interglacial		Therdonne	Levallois	Workshop, hearths?	Open, cool	Scott and Ashton (2011)
Later 7	Aveley Interglacial		Holbrook Bay	Levallois		Riverine. Warm. Open grassland, woodland present	White *et al*. (2006)
Mid-Late 7	Aveley Interglacial		Stanton Harcourt	Flakes. Cores	Reworked context	Riverine. Warm; open grassland, deciduous woodland present	White *et al.* (2006); Penkman *et al.* (2008)
Later 7	Aveley Interglacial		Selsey	Levallois	Possibly reworked	Riverine. Warm; open grassland with woodland present	White *et al.* (2006)
Later 7	Aveley Interglacial		Stoke Tunnel and Maidenhall, Suffolk	Levallois	Possibly reworked	Riverine. Warm; open grassland, woodland present	White *et al.* (2006)
Early 7?	Aveley Interglacial – MIS 6 cold stage	AAR 6/7	Crayford	Levallois	Workshop	Riverine. Warm/cold ; open grassland, sparse woodland	White *et al.* (2006); Penkman *et al*. (2008)
Flooding of Channel due to subsidence of North Sea Basin then breaching of Weald-Artois ridge in late MIS 7 & 6 (c. 155 ka), respectively: Difficulties in access to Britain, diminishing population leading to abandonment until Late Devensian							
7,6	Aveley Interglacial – MIS 6 cold stage		La Cotte de St Brelade	Levallois / (handaxes)	Home-base	Open, temperate and cool	Scott and Ashton (2011)

MIS	Stage Name	Date (ka)	Site	Technology	Assemblage Type	Environment	References
7/6	Aveley Interglacial – MIS 6 cold stage		Biache	Levallois	Butchery, workshop	Open, cool and temperate	Scott and Ashton (2011)
7/6	Aveley Interglacial – MIS 6 cold stage		Pucheuil (B)	Levallois / (handaxes ?)	Workshop	Open, cool ?	Scott and Ashton (2011)
7/6	Aveley Interglacial – MIS 6 cold stage		Bapaume-les-Osiers	Levallois / (handaxes)			[Tuffreau (1972); Koehler 2008)]; see De Loecker (2011:20)
6	MIS 6 cold stage		Schweinskopf, Tönchesberg, Wannen	Undiagnostic (imported Levallois)	Workshop, butchery	Open, cool	Scott and Ashton (2011)
6	MIS 6 cold stage		Ariendorf 2	Undiagnostic	Butchery	Open, cool	Scott and Ashton (2011)
6	MIS 6 cold stage		Achenheim	Levallois		Open, cool	Scott and Ashton (2011)

British sites are highlighted in GREY, Yare Valley sites are highlighted in DARK GREY.
References are in **Section 6**.



Study Area (SA)
Active Dredging Areas under Short Term Licence Applications
Active Dredging Areas
Licence Dredging Areas
Licence Application Areas
Licence Option Areas
Area 240 exclusion zone
Sandbanks

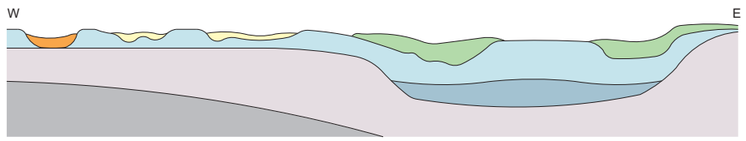
Drawing projection: UTM WGS84 z31N.
Admiralty chart 1543 (dated 2000)

Wessex Archaeology

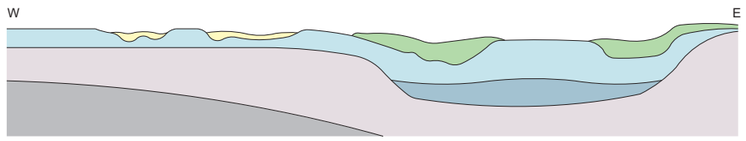
Date:	22/05/12	Revision Number:	0
Scale:	1:200,000 @A3	Illustrator:	KJF
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-05-22		

Location map

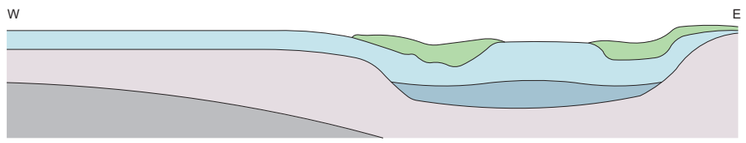
Figure 1



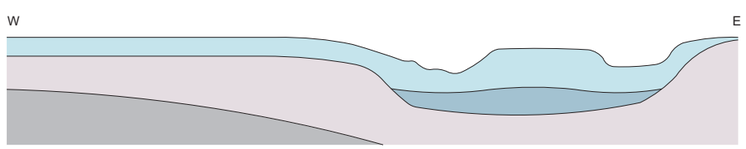
Development of early-Holocene Channel B and partial infill (Unit 7)



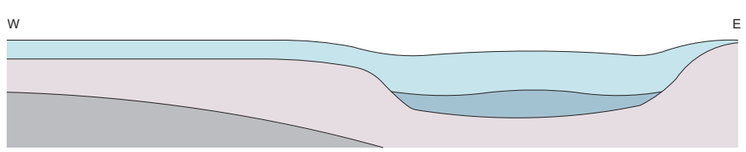
Estuarine sediment (Units 5 and 6) deposited during the mid-Devensian



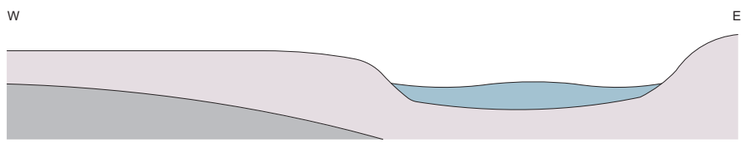
Infill of Channel A (Unit 4) during the early-Devensian



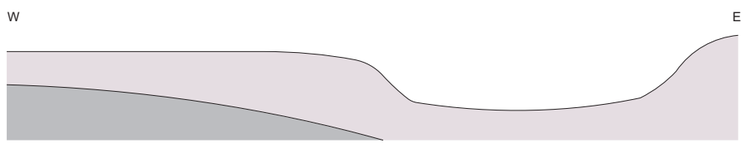
Re-activation of Channel A during the early-Devensian



Channel A infill and development of the floodplain (Unit 3b) during the Wolstonian



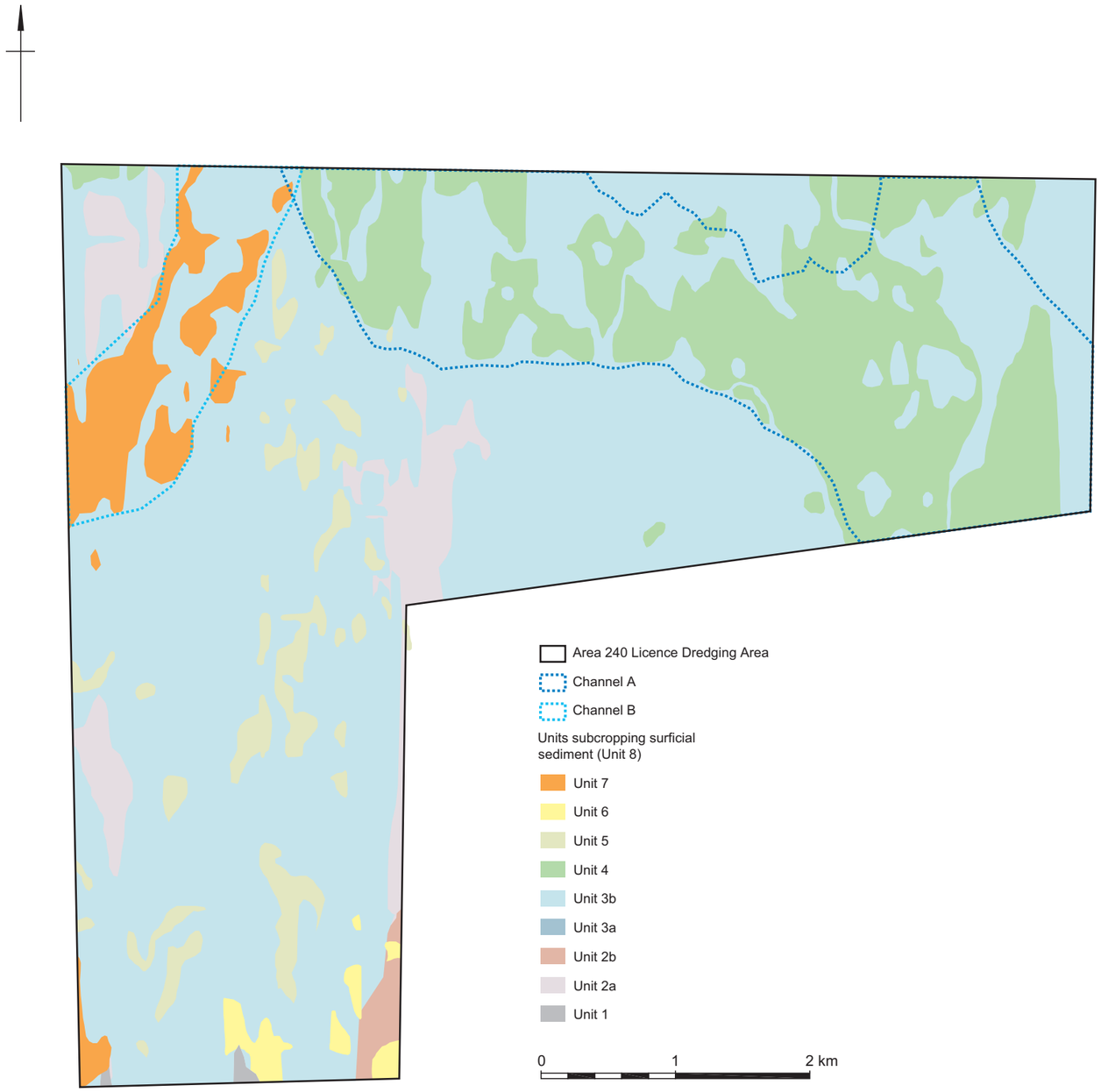
Deposition of channel deposits (Unit 3a) during the Wolstonian



Late-Anglian development of Channel A cut into underlying Cormerian deposits (Unit 2a and 2b)

Units subcropping surficial sediment (Unit 8)

- Unit 7
- Units 5 and 6
- Unit 4
- Unit 3b
- Unit 3a
- Unit 2
- Unit 1

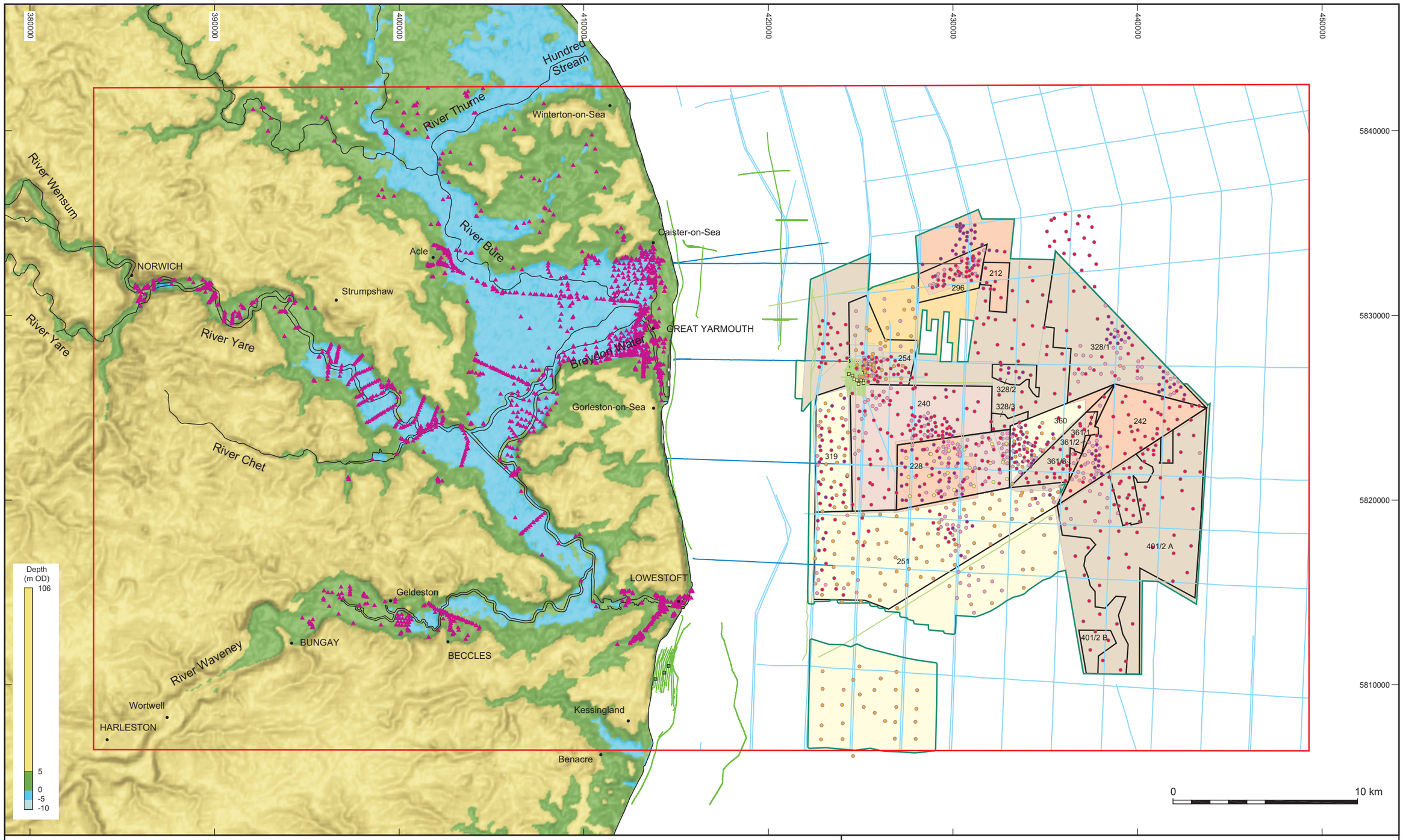


Wessex Archaeology

Date:	14/08/12	Revision Number:	0
Scale:	Plan 1:40,000 @A3	Illustrator:	KJF
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-05-22		

Overview and schematic illustrating the development of the channel and floodplain (based on Wessex Archaeology 2011a)

Figure 2



Study Area (SA)
Licence Dredging Areas
Survey Area
Drawing projection: UTM WGS84 z31N.

Wessex Archaeology

Palaeo-Yare Licensee Geophysical Survey Coverage :
- <1989
- 1990-1995
- 1996-2000
- 2001-2005
- 2006-2011

Palaeo-Yare licensee vibrocore locations:
- <1989
- 1990-1995
- 1996-2000
- 2001-2005
- 2006-2011

- BGS boreholes (non-confidential)
- Seabed Prehistory: Great Yarmouth vibrocores
- Seabed Prehistory: Happisburgh and Pakefield vibrocores
- EC REA trackplot
- EC REC trackplot
- Seabed Prehistory: Great Yarmouth trackplot
- Seabed Prehistory: Happisburgh & Pakefield trackplot

Date:	22/05/12	Revision Number:	0
Scale:	1:200,000 @A3	Illustrator:	KJF
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-05-22		

Assessed datasets

Figure 3

Survey Event Timeline

Area/Dataset		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Area 251	CEMEX		1		3		3						3				3		3			3	3		
Area 251 - South	CEMEX		1				3						3												
Area 319	CEMEX		1		3		3						3						3			3	3		
Area 360	CEMEX		1		3								3						3			3	3		
Area 454	CEMEX		1				3												3						
Area 202/436	HAML													1 3											
Area 212	HAML												1 3									1			
Area 240	HAML												3	3					1 3		3				
Area 242	HAML												3	3	3		3		3		3			1	
Area 328	HAML												1 3				3		3		3				
Area 361	HAML												1 3	1 3	3		3								
Area 401/2	HAML												3	3	3										
Area 254	TARMAC					1 3	2		3				2	2 3		3									
Area 296	TARMAC				1									3		3					2	3			
Area 494	TARMAC																				1	3			
Area 228	VDL	3								3						1 3		3	2					2	3
EC REC																							2 3		
Area 254 - Seabed Prehistory																			2 3						
Happisburgh & Pakefield																				2					
EC REA																								2	

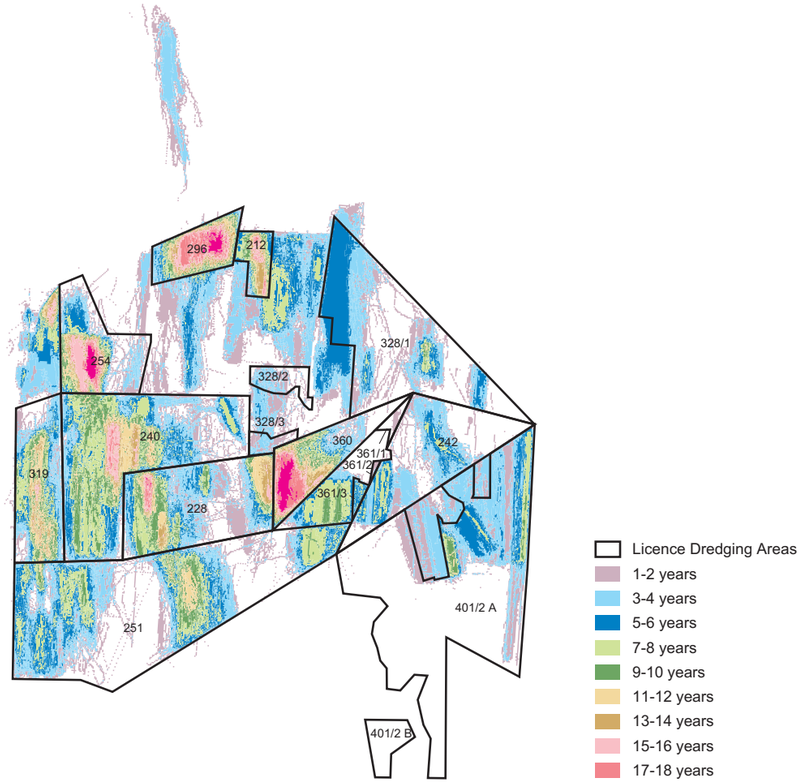
1 Geophysical survey full coverage
2 Geophysical survey partial coverage
3 Geotechnical survey

Date:	22/05/12	Revision Number:	0
Scale:	N/A	Illustrator:	KJF
Path:	W:\Projects\83740\DO\Report figs\Technical report 2012\12-05-22		

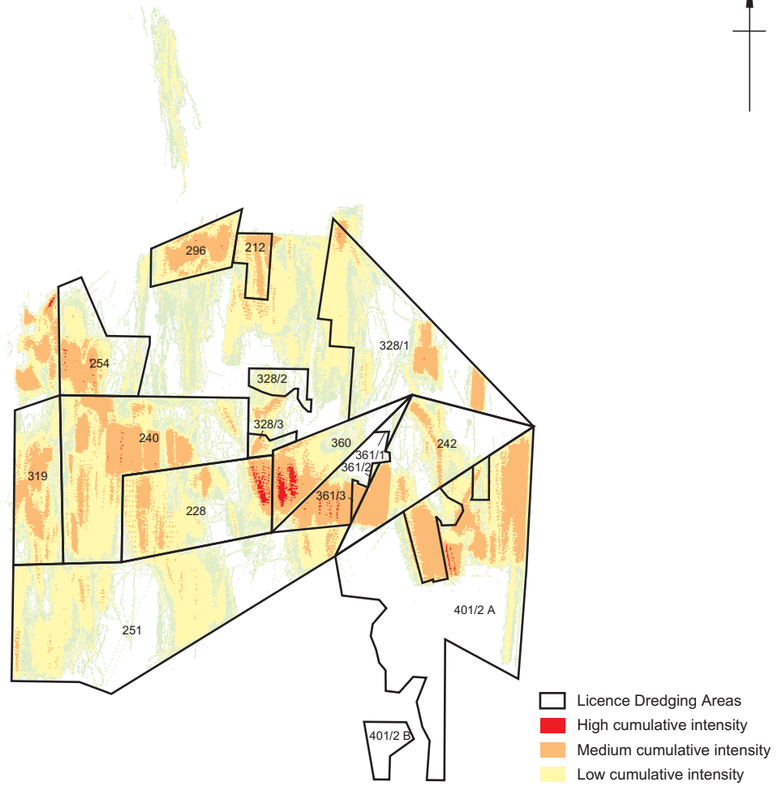
Table illustrating age of datasets assessed during the project

Figure 4

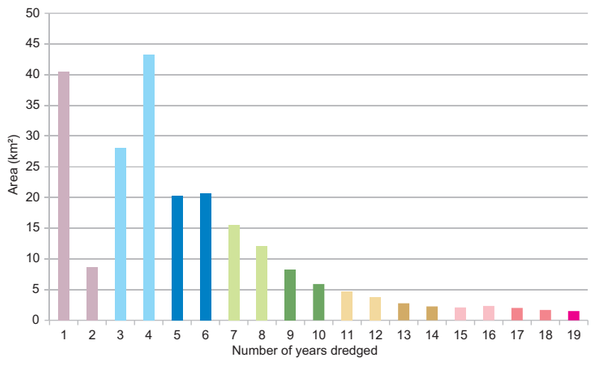
A. Number of years the seabed has been dredged (1993 - 2011)



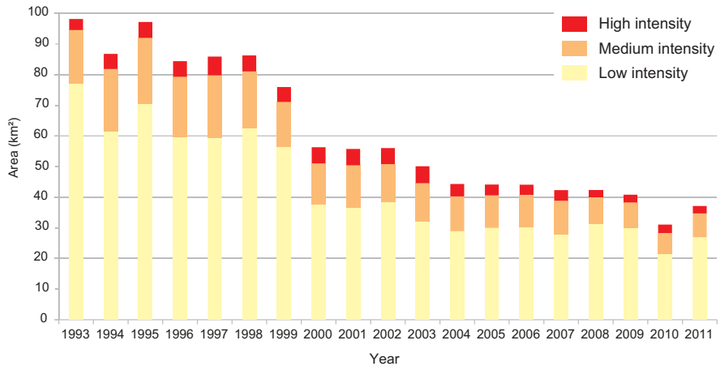
D. Cumulative intensity (1993 - 2011)



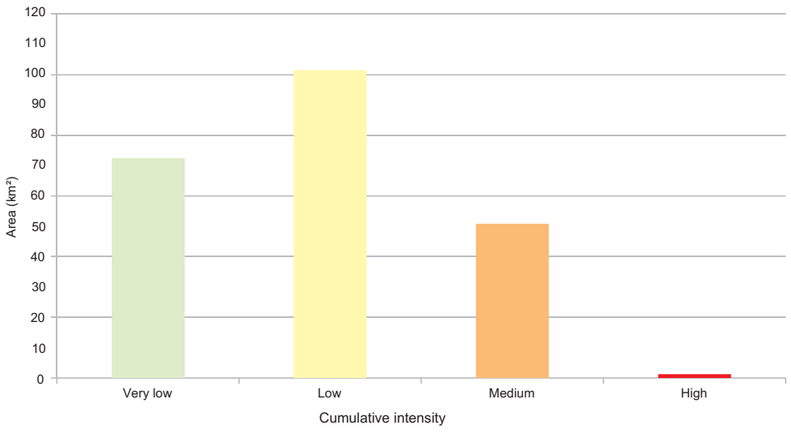
B. Graph illustrating area (km²) of seabed plotted against cumulative years dredged



C. Graph illustrating area (km²) dredged each year (1993 - 2011) divided by intensity values



E. Graph illustrating area (km²) dredged plotted against cumulative intensities



Wessex Archaeology

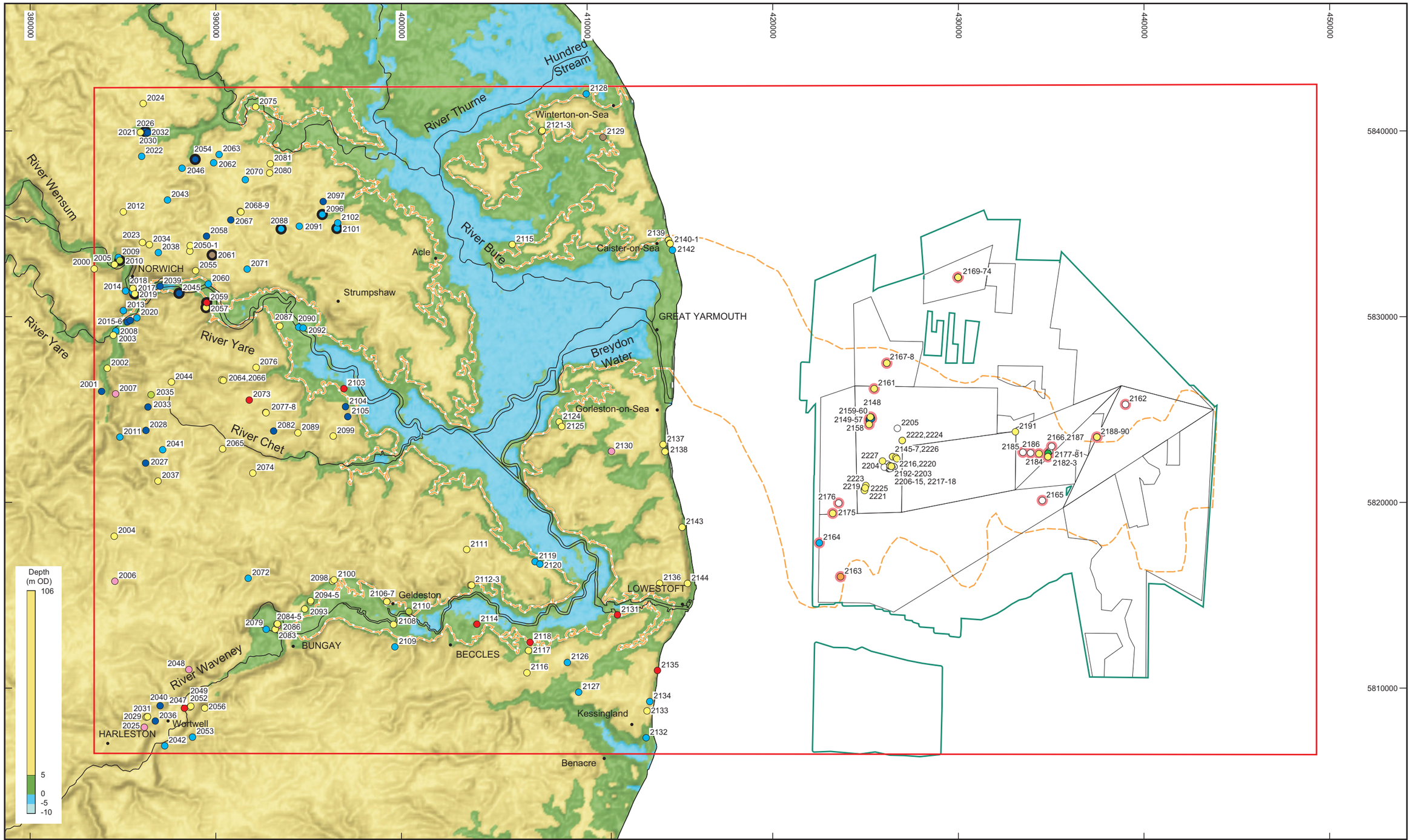
0 10 km

Drawing projection: UTM WGS84 z31N.

Date:	18/06/12	Revision Number:	0
Scale:	1:250,000 @A3	Illustrator:	KJF
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-05-22		

Dredging analysis based on EMS data

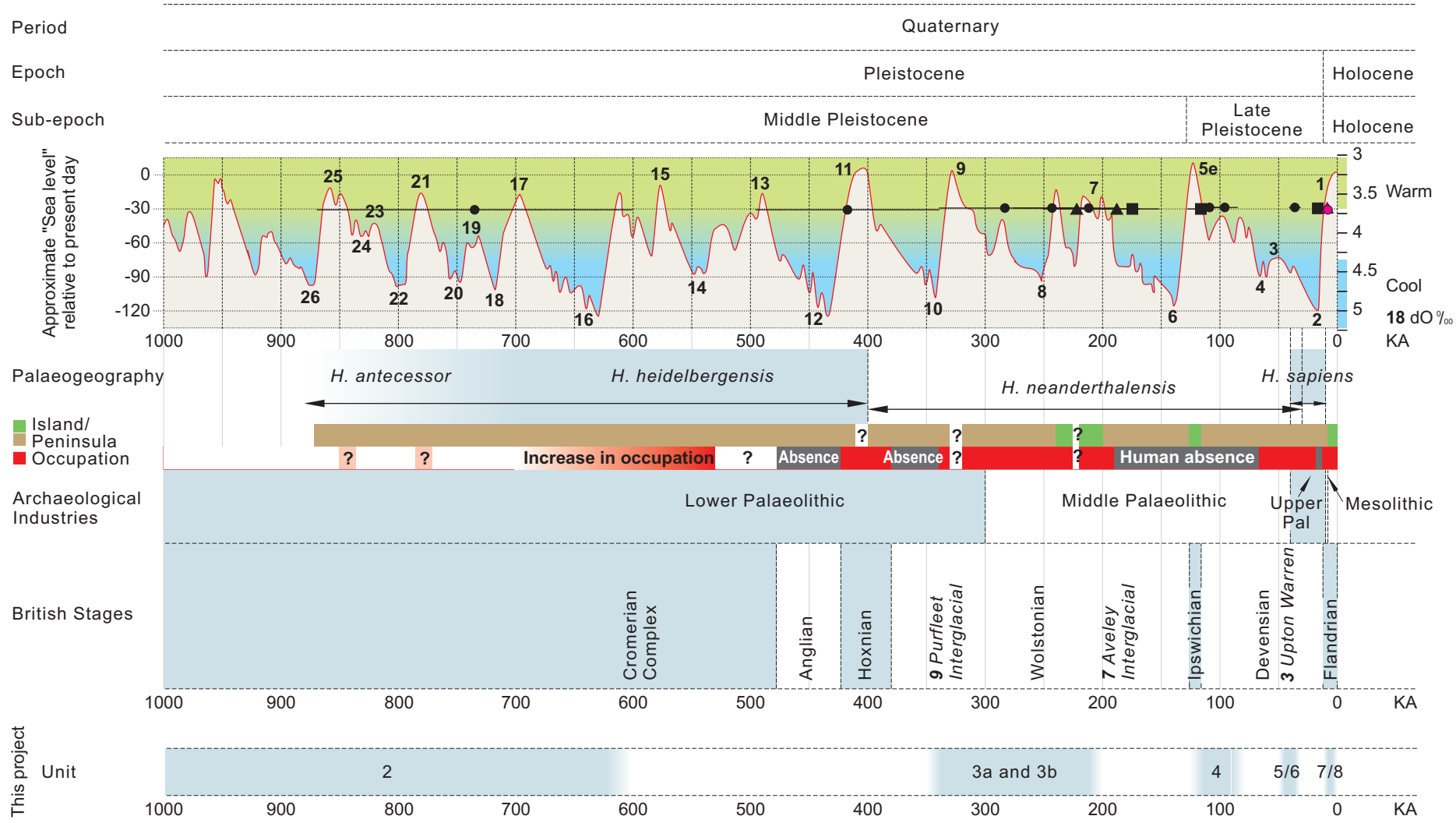
Figure 5



Date:	14/08/12	Revision Number:	0
Scale:	1:200,000 @A3	Illustrator:	KJF
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-05-22		

Known archaeology in the SA

Figure 6

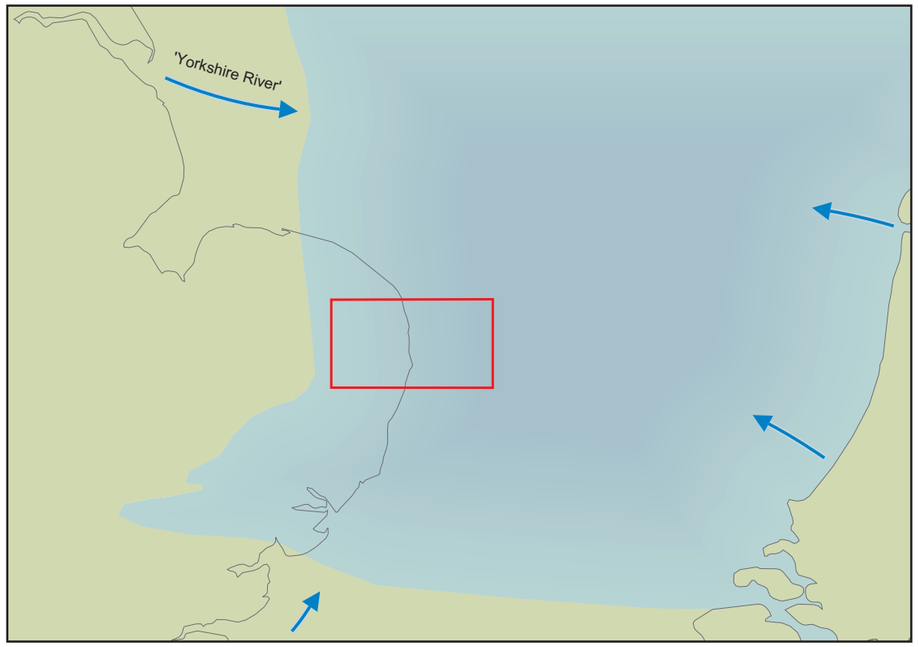


OSL age with error bar (Wessex Archaeology 2008a)
OSL age with error bar (Wessex Archaeology 2011a)
Radiocarbon age (Wessex Archaeology 2011a)
OSL age with error bar (Limpenny *et al.*, 2011)
Radiocarbon age (Limpenny *et al.*, 2011)

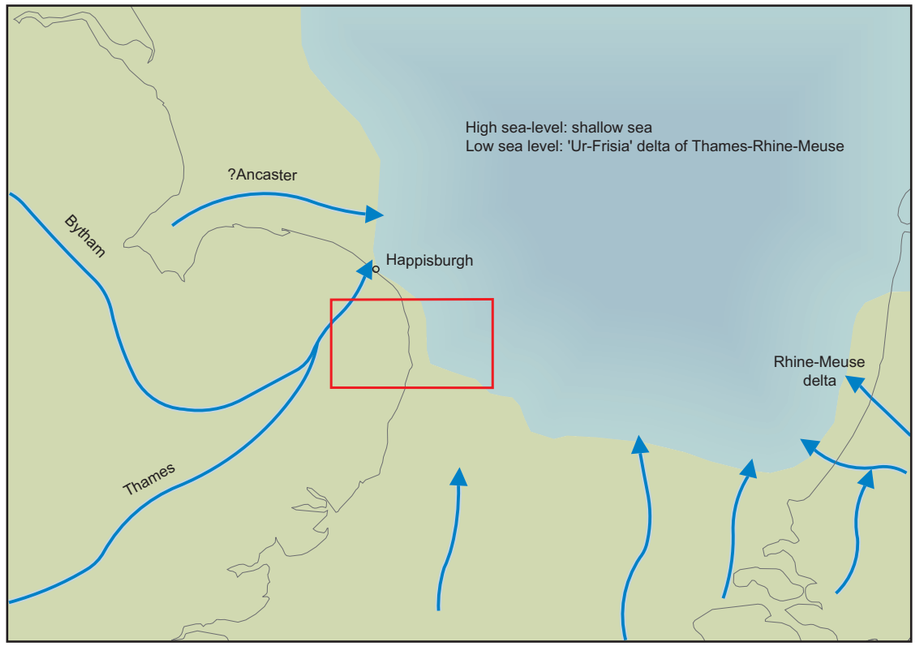
Date:	18/06/12	Revision Number:	0
Scale:	N/A	Illustrator:	KMN/KJB
Path:	W:\Projects\83740\Drawing Office\Report figs\Techl report 2012\12-05-22		

Sea-level curve, dating results and overview of Palaeo-Yare catchment interpretation

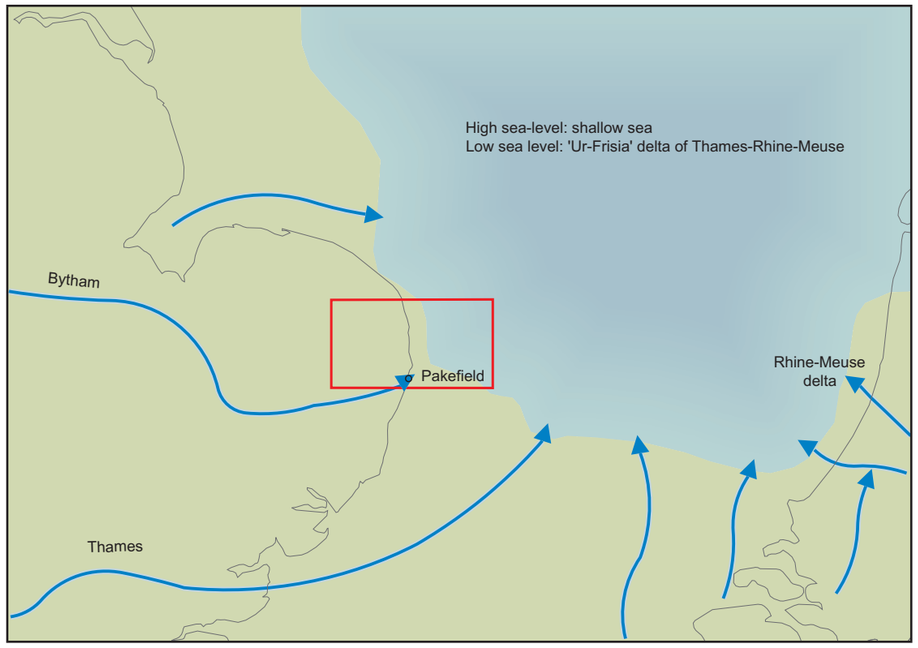
Figure 7



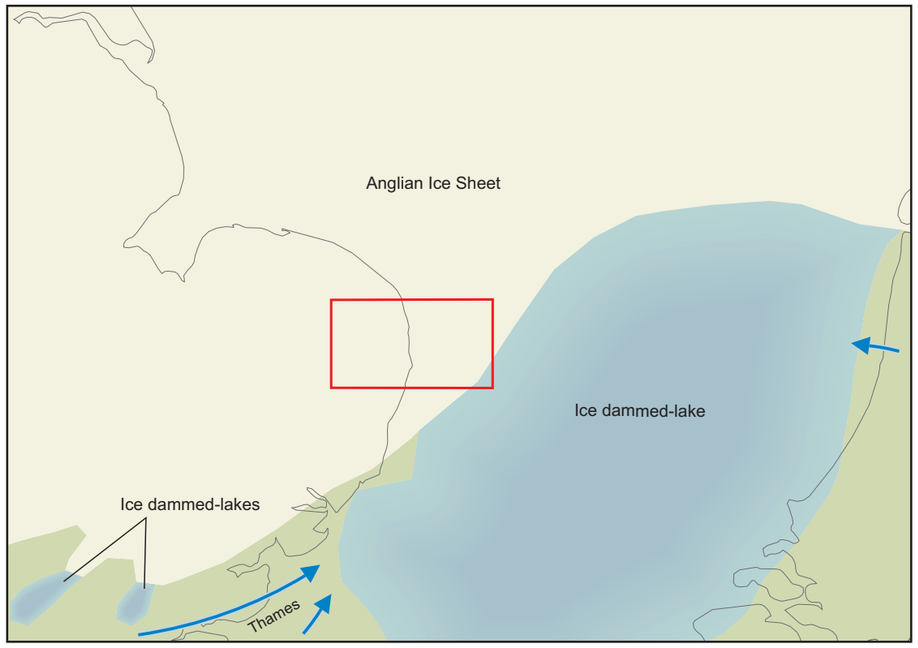
A. Approximate coastline 2.3 ma (after Cameron *et al*. 1992)



B. Generalised palaeogeography of the Middle Pleistocene illustrating the coastline and major rivers c. 1 ma (after Cameron *et al*. 1992; Parfitt *et al*. 2010; Hijma *et al*. 2012)



C. Generalised palaeogeography of the Middle Pleistocene illustrating the coastline and major rivers c. 750 ka (after Cameron *et al*. 1992; Parfitt *et al*. 2010; Hijma *et al.* 2012)



D. Generalised palaeogeography at the Anglian Glacial maximum (Gibbard 1995)

Wessex Archaeology

Study Area (SA)

Major rivers / sediment supply

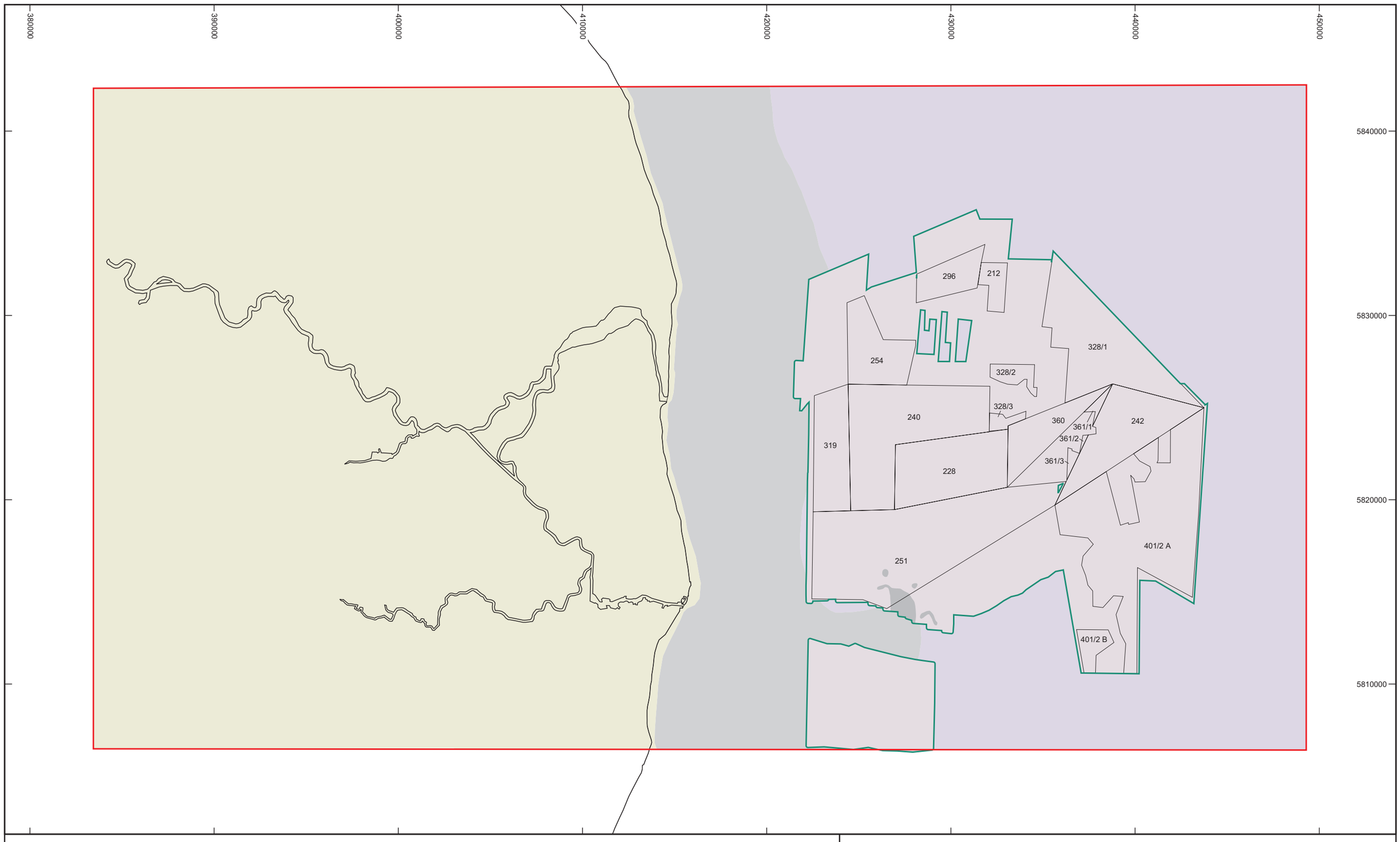
0 100 km

Drawing projection: UTM WGS84 z31N.

Date:	18/06/12	Revision Number:	0
Scale:	1:2,500,000 @A3	Illustrator:	KJF
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-05-22		

Palaeogeographic regional reconstruction: Pre-Anglian

Figure 8



Study Area (SA)
Licence Dredging Areas
Survey Area
Unit 2
Unit 1

Documented formations (after BGS):
Yarmouth Roads Formation
Westkapelle Ground Formation
Crag deposits

0 10 km

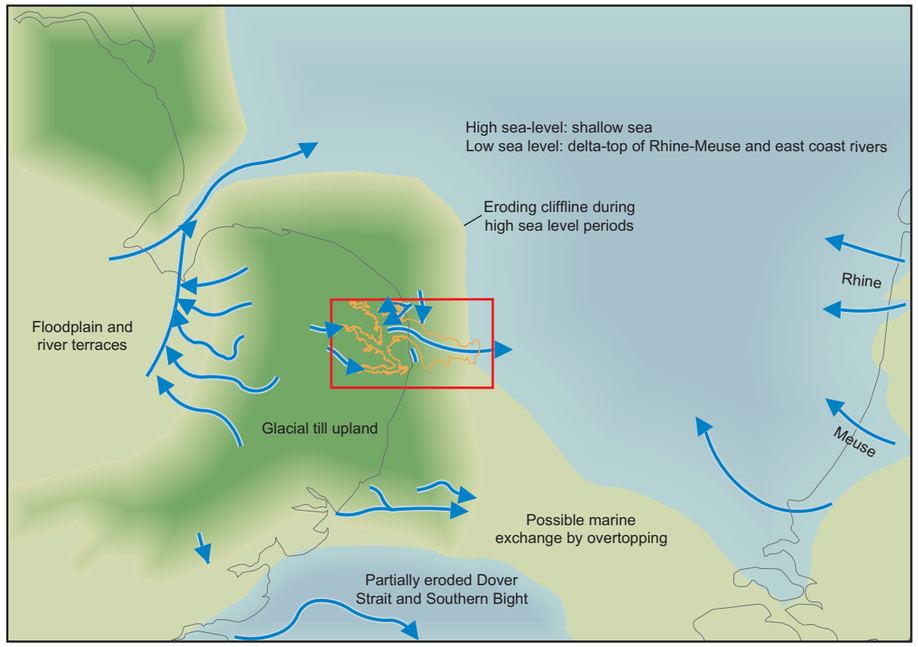
Drawing projection: UTM WGS84 z31N.

Wessex Archaeology

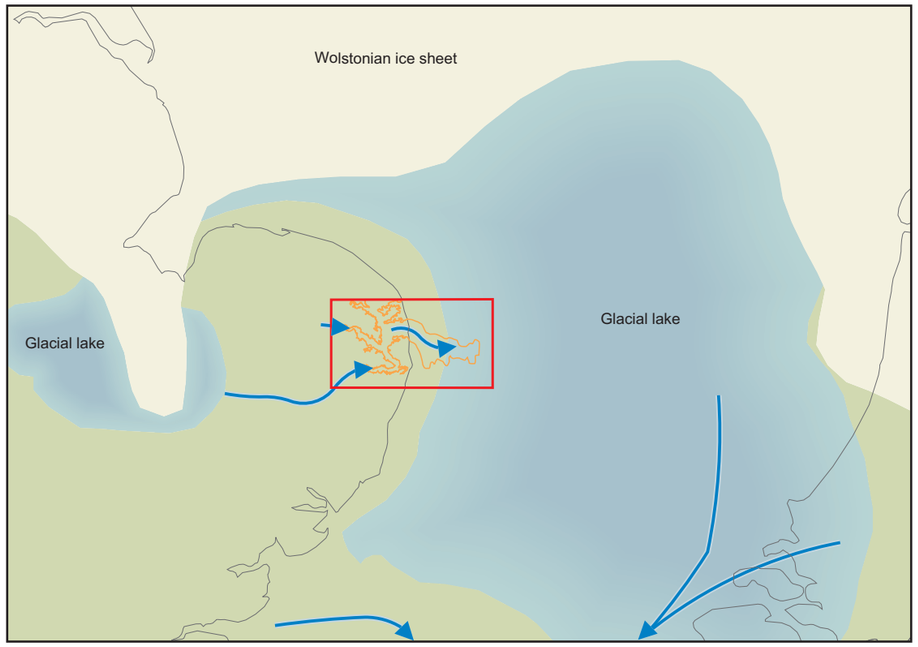
Date:	15/01/13	Revision Number:	1
Scale:	1:200,000 @A3	Illustrator:	KJF
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-05-22		

Remains of pre-Anglian sediment units (Units 1 and 2) in the SA

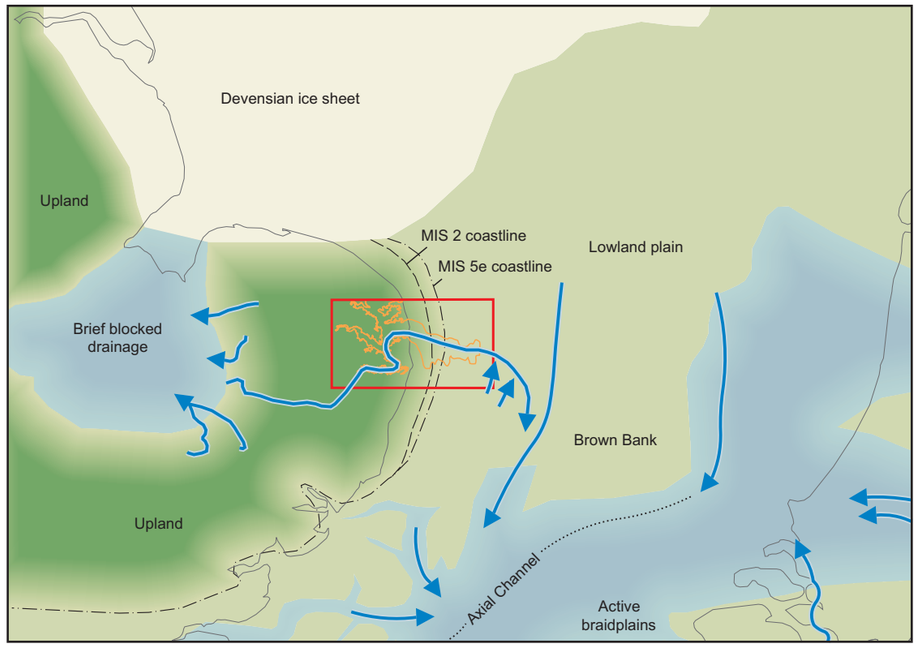
Figure 9



A. Generalised palaeogeography from the late-Anglian Glaciation (MIS 12) to Wolstonian Glacial (MIS 6) (after Limpenny *et al*. 2011; Hijma *et al*. 2012)



B. Generalised palaeogeography during the Wolstonian Glacial (MIS 6) (after Murton and Murton 2012)



C. Generalised palaeogeography between the Ipswichian Interglacial (MIS 5e) and Late Devensian (MIS 2) (after Limpenny *et al*. 2011; Hijma *et al*. 2012)

Wessex Archaeology

Study Area (SA)
Limits of Palaeo-Yare valley
Major rivers / sediment supply

0 100 km

Drawing projection: UTM WGS84 z31N.

Date:	18/06/12	Revision Number:	0
Scale:	1:2,500,000 @A3	Illustrator:	KJF
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-05-22		

Palaeogeographic regional re-construction: late Anglian (MIS 12) to Devensian (MIS 2)

Figure 10

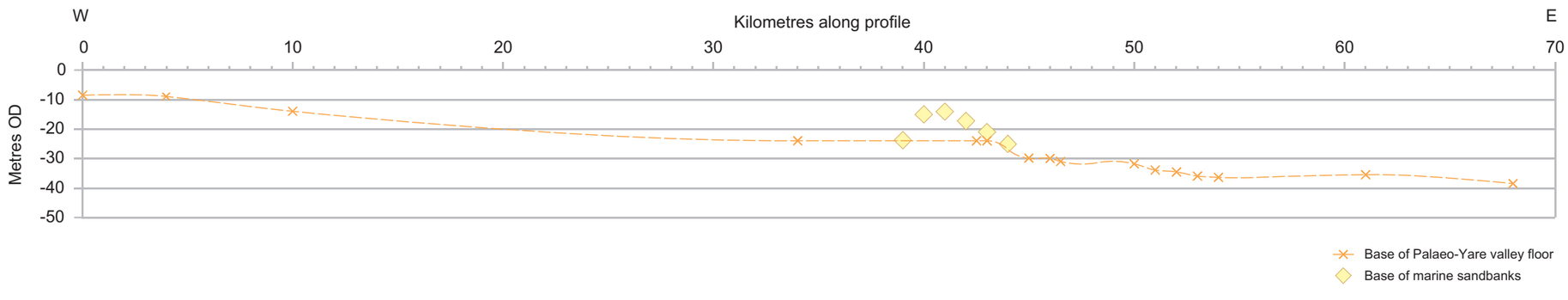
Wessex Archaeology

Caister Shoal
Barley Pickle
Cross Sand
Caister Road
Scroby Sand
South Cross Sand
Holm Sand

Depth (m OD)
106
5
0
-5
-10

Study Area (SA)
Licence Dredging Areas
Extents of Late Anglian channel
Limits of Palaeo-Yare valley
Sandbanks
Palaeo-Yare valley transect
Palaeo-Yare valley transect kilometre point (KP)

0 10 km

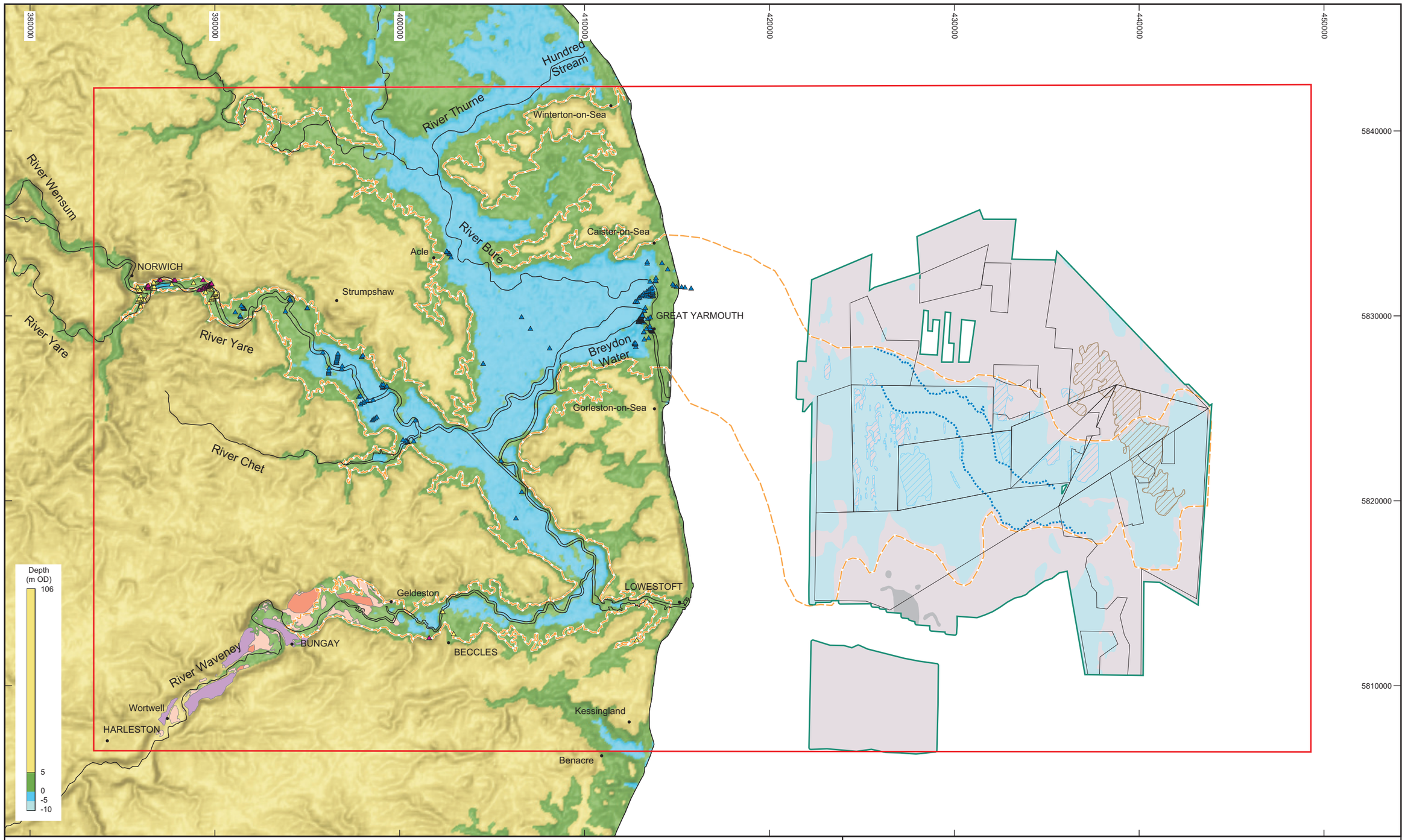


Drawing projection: UTM WGS84 z31N.

Revision Number:	0
Illustrator:	KJF
Date:	19/06/12
Scale:	Plan and graph (x axis)1:250,000 @A3
Path:	W:\Projects\83740\Drawing Office\
Report figs\Technical report 2012\12-05-22	

Profile illustrating the base of the Palaeo-Yare valley

Figure 11



Study Area (SA)
Licence Dredging Areas
Survey Area

Drawing projection: UTM WGS84 z31N.

Wessex Archaeology

Bank feature (unknown age)
Unit 3b removed/heavily effected due to dredging
Unit 3b
Unit 2
Unit 1

Extents of Late Anglian channel (Channel A)
Limits of Palaeo-Yare valley

River terraces:
Floodplain Terrace
Broome Terrace
Homersfield Terrace

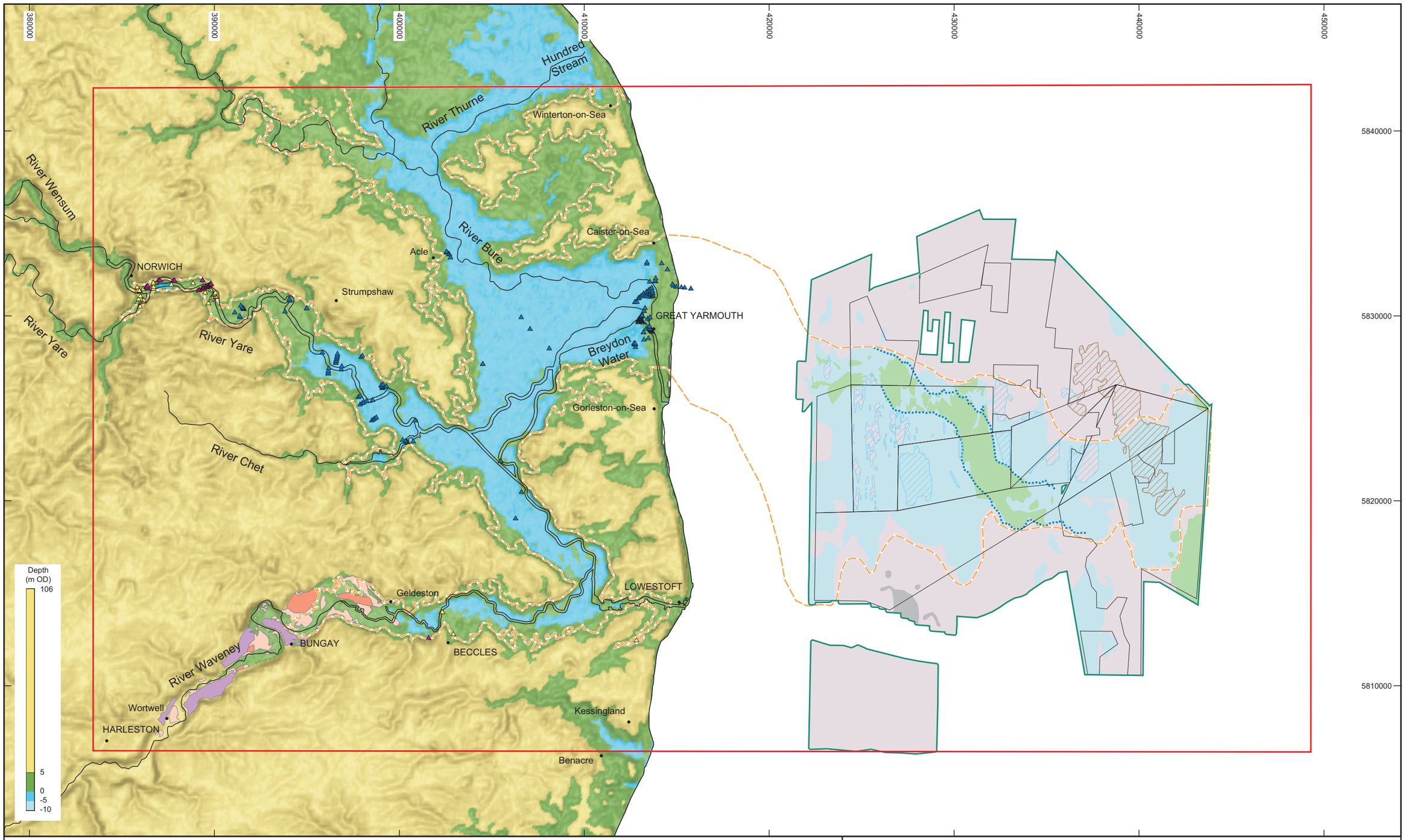
Onshore boreholes:
River terrace sand and gravel
Sub-alluvial sand and gravel (possible Yare Valley Formation)
Yare Valley Formation

0 10 km

Date:	22/05/12	Revision Number:	0
Scale:	1:200,000 @A3	Illustrator:	KJF
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-05-22		

Remains of Wolstonian (Unit 3b) sediments in the SA

Figure 12



Study Area (SA)
Licence Dredging Areas
Survey Area

Drawing projection: UTM WGS84 z31N.

Wessex Archaeology

Bank feature (unknown age)
Unit 4
Unit 3b removed/heavily effected due to dredging
Unit 3b
Unit 2
Unit 1

Extents of Late Anglian channel (Channel A)
Limits of Palaeo-Yare valley

River terraces:
Floodplain Terrace
Broome Terrace
Homersfield Terrace

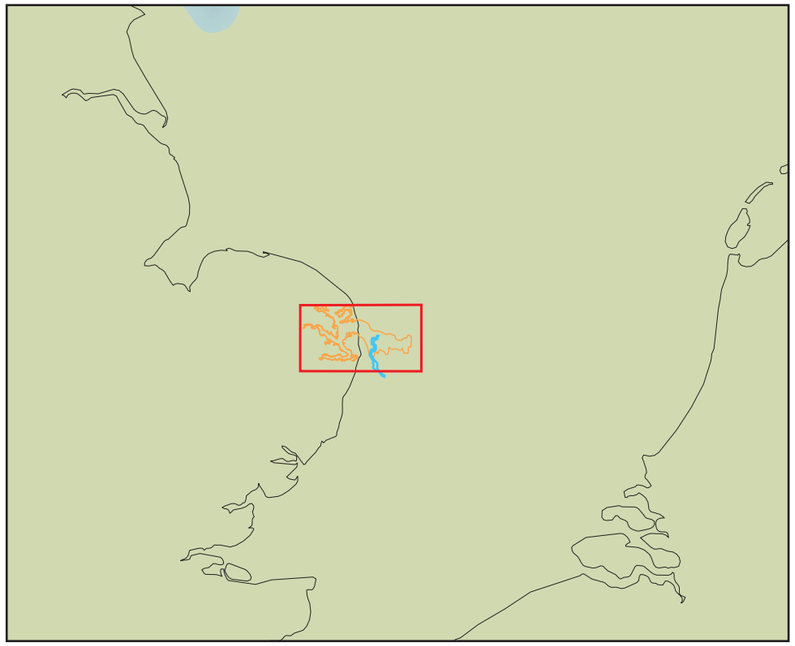
Onshore boreholes:
River terrace sand and gravel
Sub-alluvial sand and gravel (possible Yare Valley Formation)
Yare Valley Formation

0 10 km

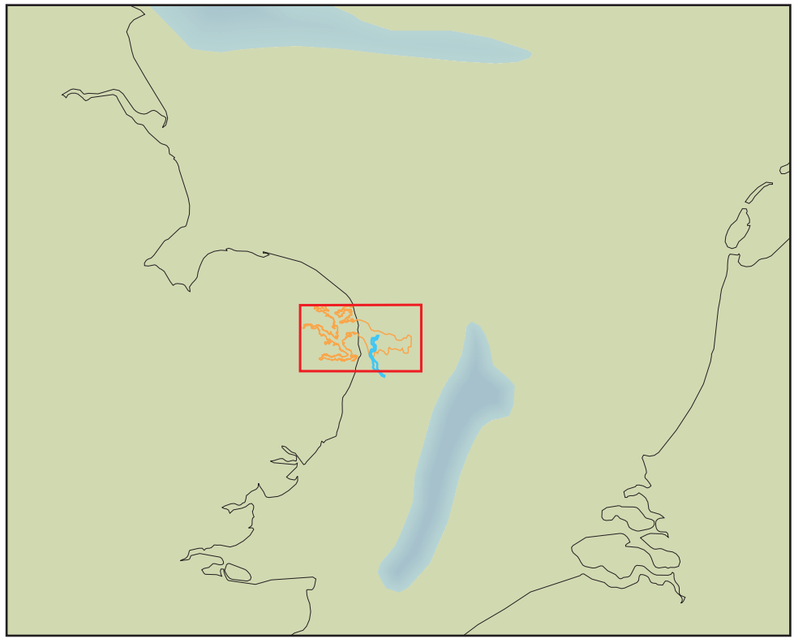
Date:	22/05/12	Revision Number:	0
Scale:	1:200,000 @A3	Illustrator:	KJF
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-05-22		

Remains of Early Devensian (Unit 4) sediments in the SA

Figure 13

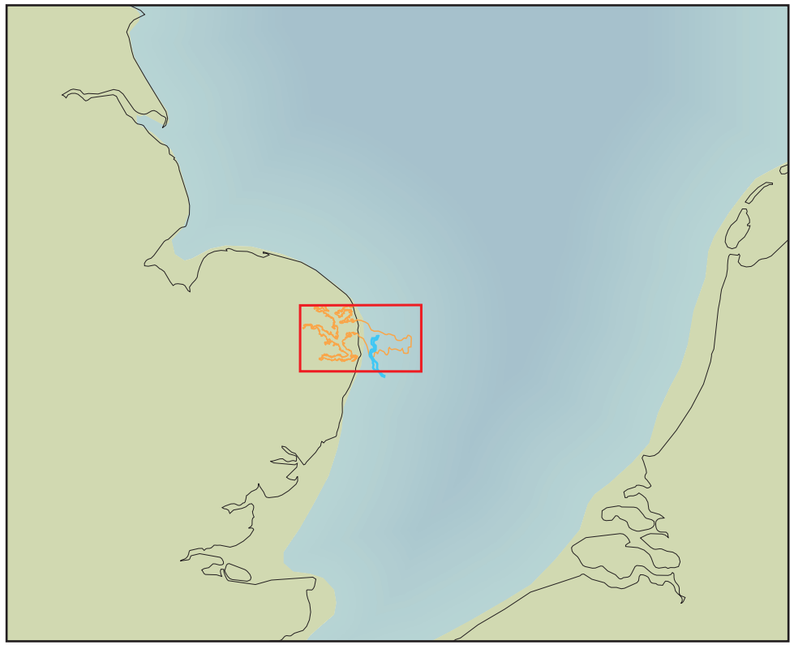


A. 10,000 BP



B. 9000 BP

C. 8000 BP



D. 7000 BP

Wessex Archaeology

Study Area (SA)
Limits of Palaeo-Yare valley
Extents of Early Holocene channel (Channel B)

0 100 km

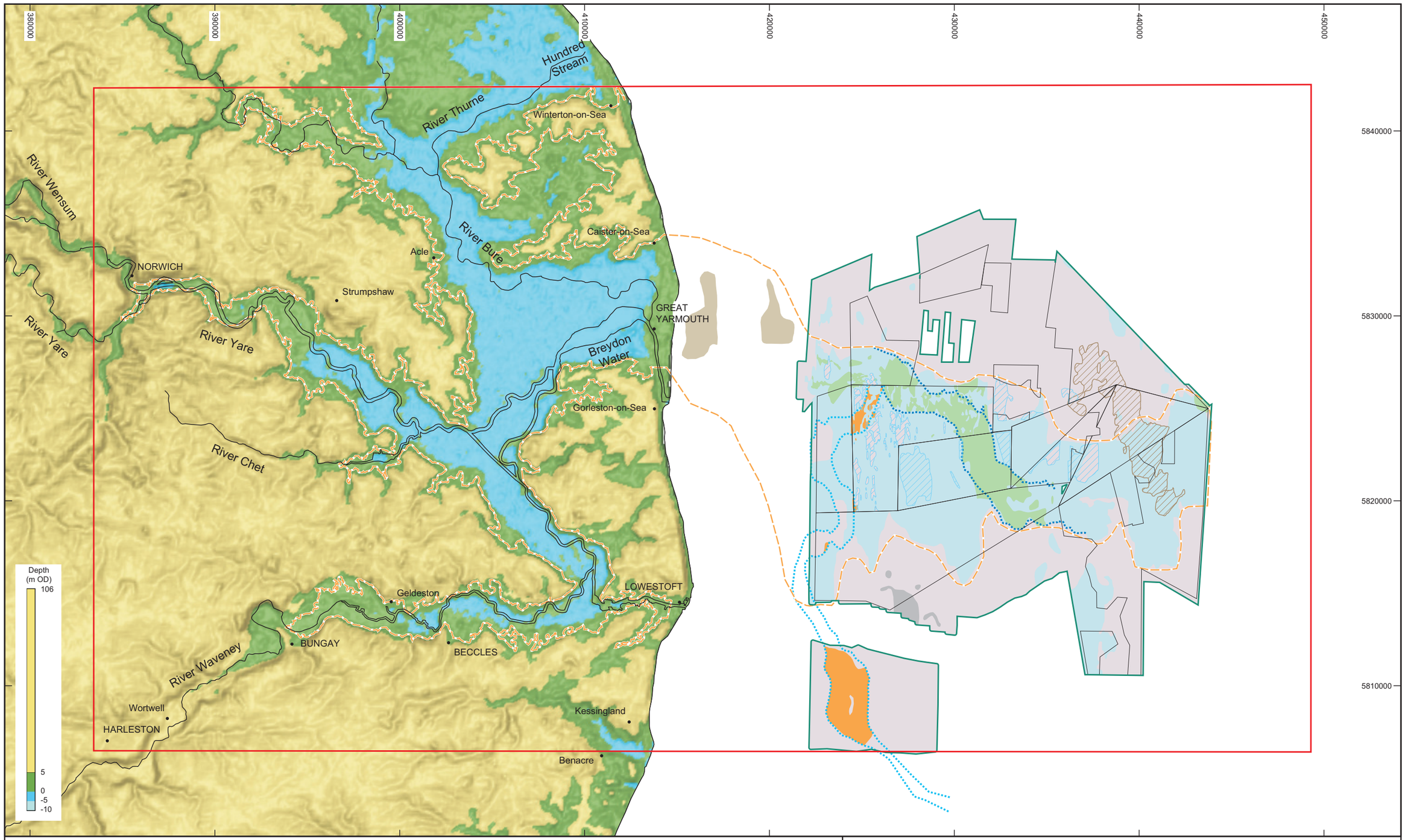
Drawing projection: UTM WGS84 z31N.

Made with Natural Earth. Free vector and raster map data @ naturalearthdata.com.

Date:	03/07/12	Revision Number:	0
Scale:	1:3,000,000 @A3	Illustrator:	KJF
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-05-22		

Palaeogeographic regional reconstruction: Holocene (MIS 1) (after Shennan *et al*. 2000)

Figure 14



Study Area (SA)
Licence Dredging Areas
Survey Area

Drawing projection: UTM WGS84 z31N.

Wessex Archaeology

Bank feature (unknown age)
Unit 7
Unit 4
Unit 3b removed/heavily effected due to dredging
Unit 3b
Unit 2
Unit 1

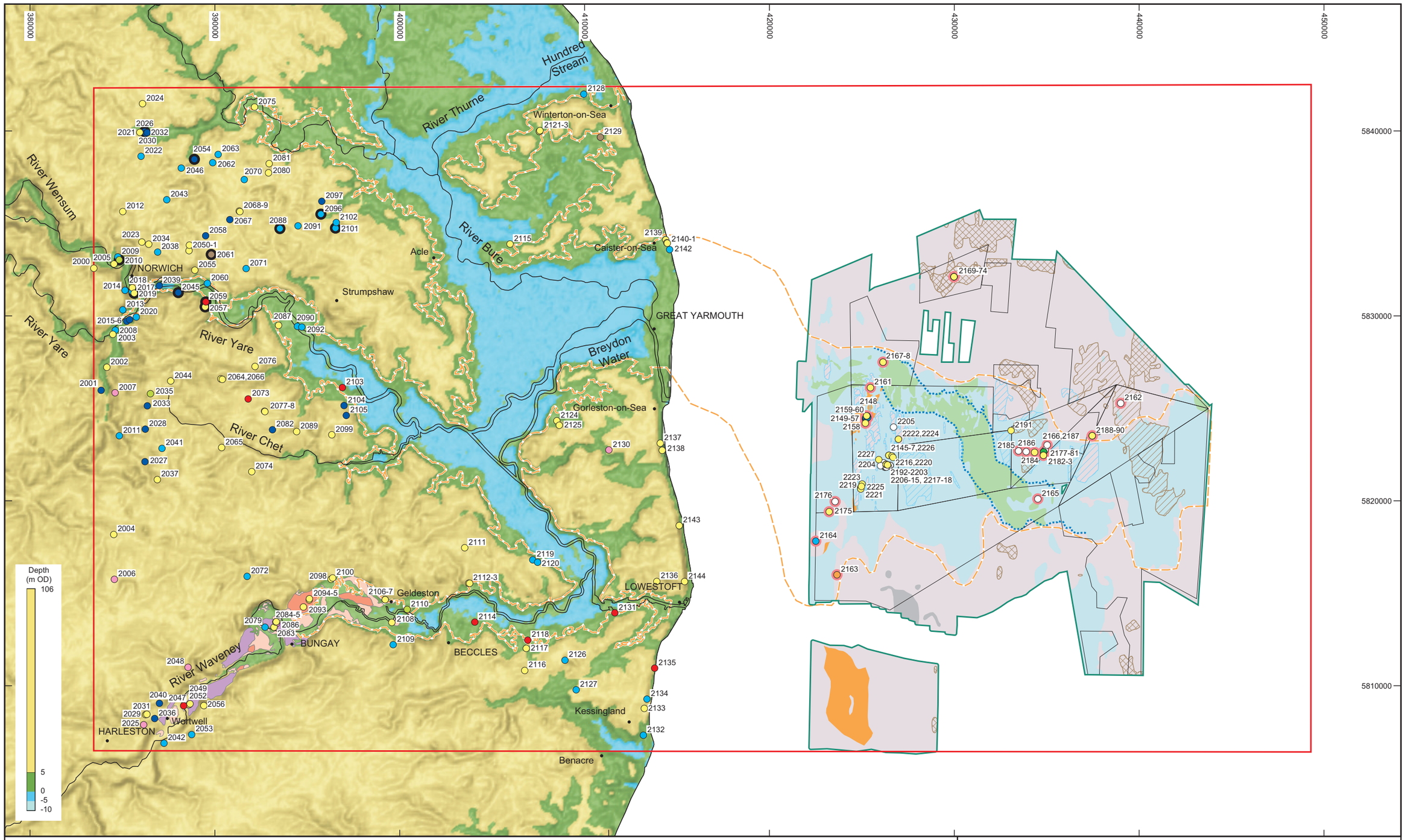
Extents of Late Anglian channel (Channel A)
Extents of Early Holocene channel (Channel B)
Limits of Palaeo-Yare valley
Breydon Formation (Arthurton *et al*. 1994)

0 10 km

Date:	15/01/13	Revision Number:	1
Scale:	1:200,000 @A3	Illustrator:	KJF
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-05-22		

Remains of early Holocene channel development and deposits (Unit 7) in the SA

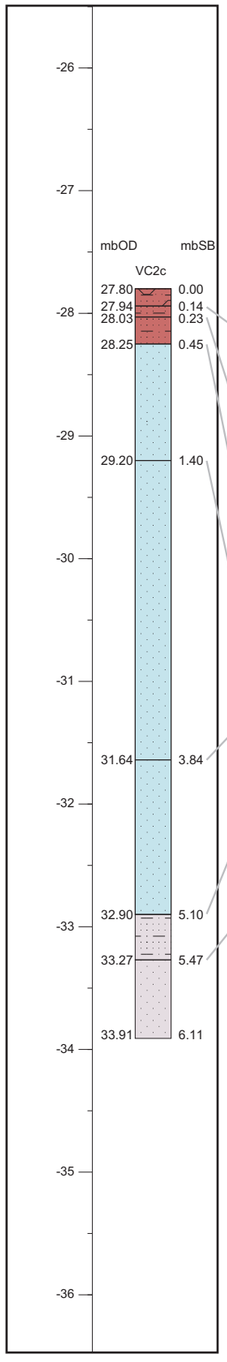
Figure 15



Date:	15/01/13	Revision Number:	1
Scale:	1:200,000 @A3	Illustrator:	KJF
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-05-22		

Palaeogeography and known archaeology associated with the Palaeo-Yare

Figure 16



10YR 6/3 Pale brown gravelly sand. Sand is medium to coarse grained. Gravel is flint, rounded to angular (predominantly subrounded) up to 10mm diameter with occasional small subrounded quartz up to 4mm diameter. Poorly sorted. Abrupt boundary. Disturbed. **Seabed sediment** Unit 8.

2.5Y 7/2 Light grey sand. Sand is fine to medium grained. Very occasional subangular flint up to 40mm diameter. One angular piece of reworked sediment comprising laminated sand and organic black peaty silty sand, 40x65mm diameter. Disturbed. Abrupt boundary. **Seabed sediment** Unit 8.

2.5Y 6/2 Light brownish grey sand. Sand is fine, medium and coarse grained (predominantly medium). Fining upwards. Well sorted. Occasional angular flint up to 5mm diameter. Well sorted. Abrupt boundary. **Seabed sediment** Unit 8.

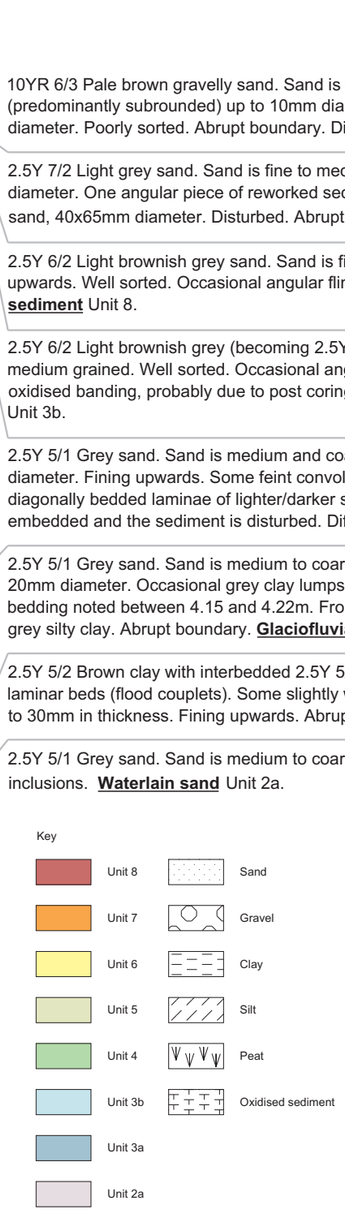
2.5Y 6/2 Light brownish grey (becoming 2.5Y 6/4 Light yellowish brown from 1.00m onwards) sand. Sand is medium grained. Well sorted. Occasional angular flint up to 25mm diameter. Contains some near vertical oxidised banding, probably due to post coring drying of sediment. Abrupt boundary. **Glaciofluvial outwash** Unit 3b.

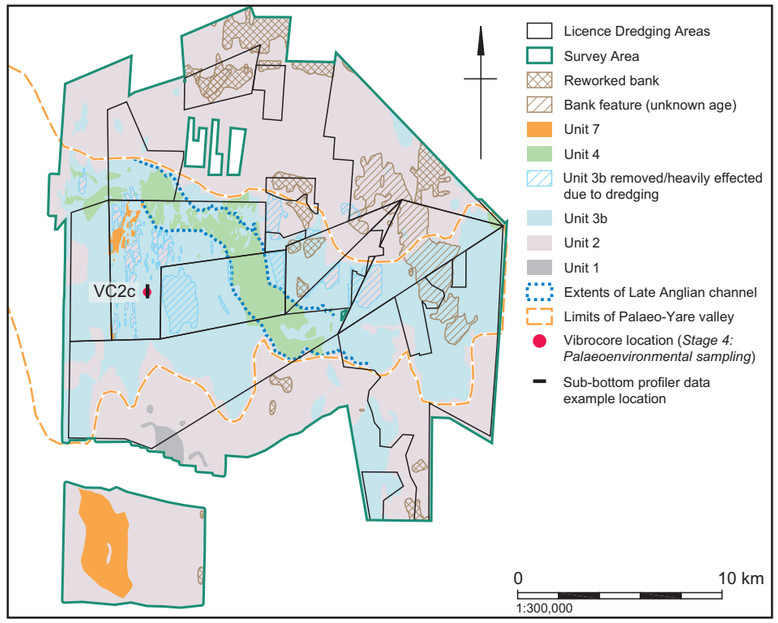
2.5Y 5/1 Grey sand. Sand is medium and coarse grained. Well sorted. Occasional rounded flint up to 12mm diameter. Fining upwards. Some feint convoluted bedding structure apparent between 3.10 and 3.15m and diagonally bedded laminae of lighter/darker sand 3.30 to 3.36m. At 3.53 to 3.60 the metal core catcher is embedded and the sediment is disturbed. Diffuse boundary. **Glaciofluvial outwash** Unit 3b.

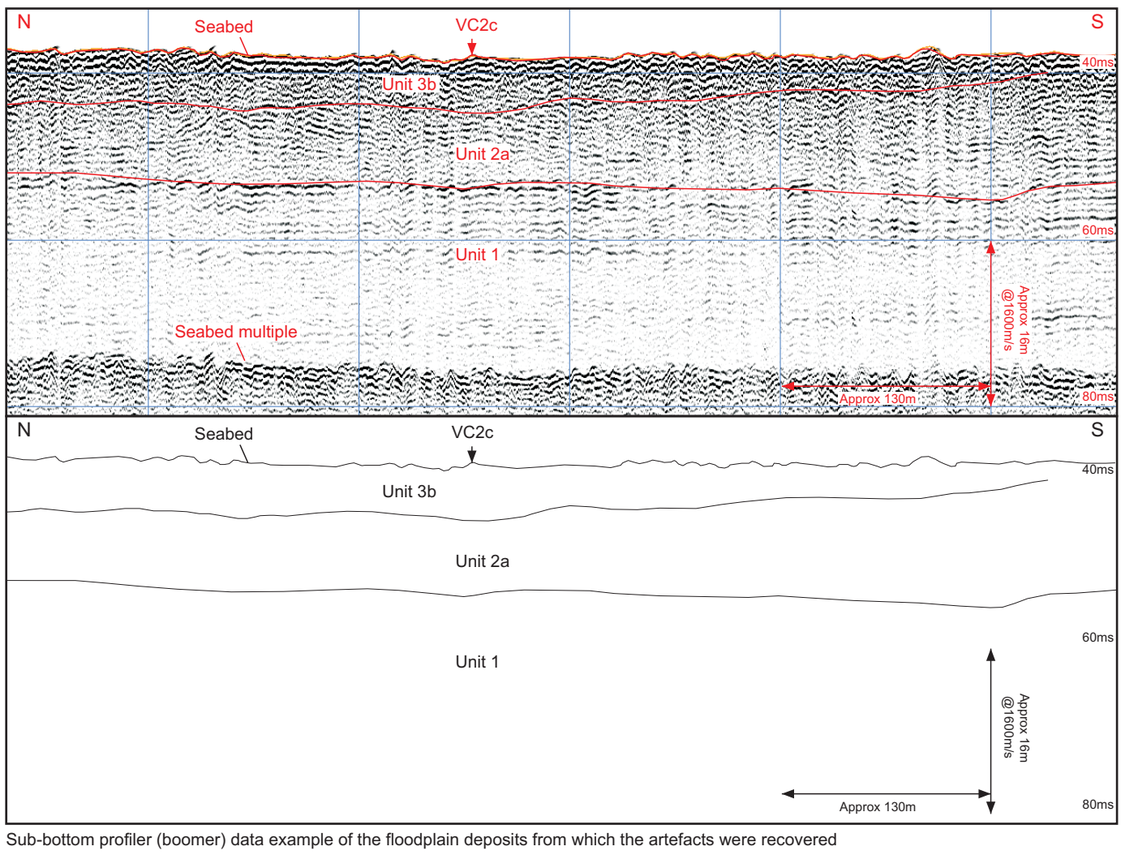
2.5Y 5/1 Grey sand. Sand is medium to coarse grained. Sorted. Occasional subangular to rounded flint up to 20mm diameter. Occasional grey clay lumps up to 35mm diameter at 3.76 and 4.17m. Some laminar horizontal bedding noted between 4.15 and 4.22m. From 4.50 to 4.95m some ?mollusc burrows are noted containing grey silty clay. Abrupt boundary. **Glaciofluvial outwash** Unit 3b.

2.5Y 5/2 Brown clay with interbedded 2.5Y 5/1 grey sorted medium grained sand in predominantly horizontal laminar beds (flood couplets). Some slightly wavy and convoluted bedding is also noted. The clay beds are up to 30mm in thickness. Fining upwards. Abrupt boundary. **Waterlain clay/sand** Unit 2.

2.5Y 5/1 Grey sand. Sand is medium to coarse (predominantly medium) grained. Very well sorted. No inclusions. **Waterlain sand** Unit 2a.





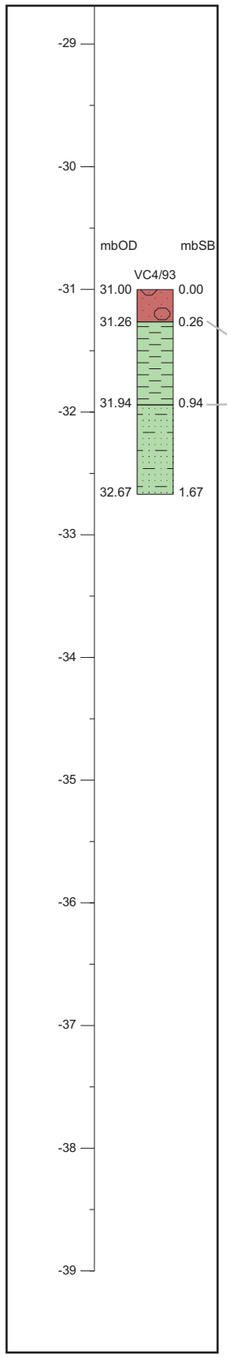


Sub-bottom profiler (boomer) data example of the floodplain deposits from which the artefacts were recovered

Wessex Archaeology

Date:	14/08/12	Revision Number:	0
Scale:	SBP 1:600 vertical	Illustrator:	KJB
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-08-14		

Example of Palaeo-Yare floodplain deposits (Unit 3b)



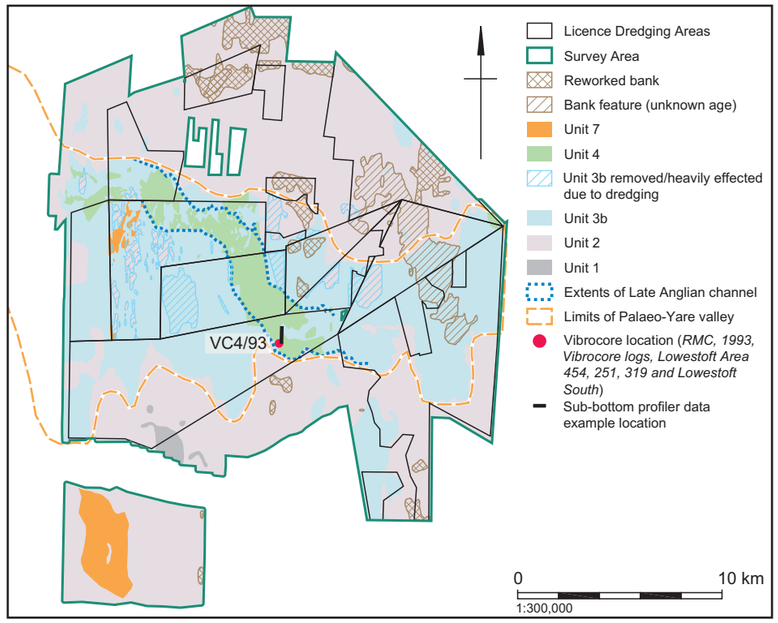
Orange brown sand (mc) and gravel with some shell fragments. Stone is 30mm down; rounded to subangular; brown flint.

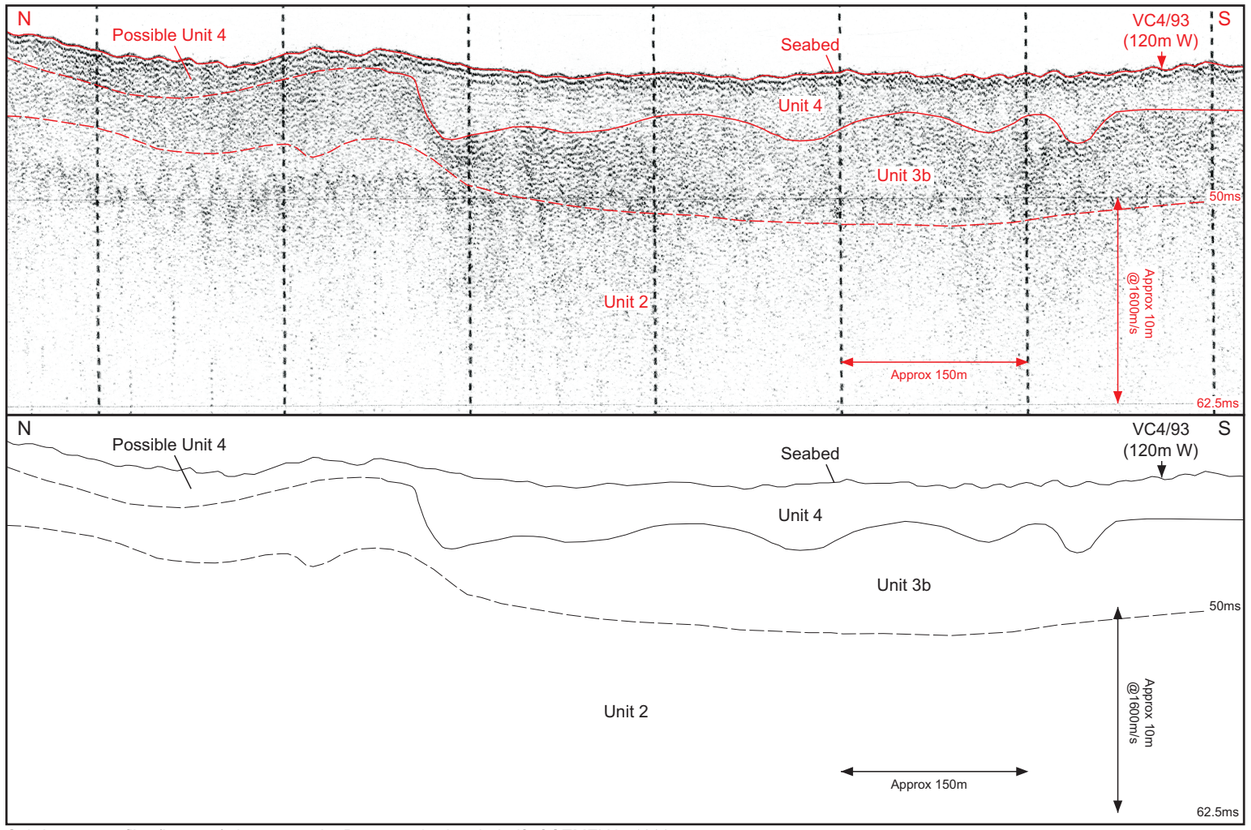
Grey black carbonaceous clay with shelly bands.

Grey sand(f) with silty and clayey bands.

Key

- Unit 8 — Sand
- Unit 7 — Gravel
- Unit 6 — Clay
- Unit 5 — Silt
- Unit 4 — Peat
- Unit 3b — Oxidised sediment
- Unit 3a
- Unit 2a



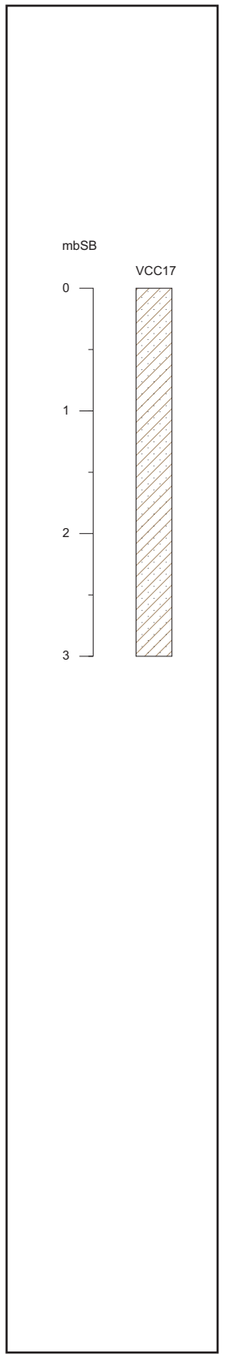


Sub-bottom profiler (boomer) data example. Data acquired on behalf of CEMEX in 1989.

Wessex Archaeology

Date:	14/08/12	Revision Number:	0
Scale:	SBP 1:300 vertical	Illustrator:	KJB
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-08-14		

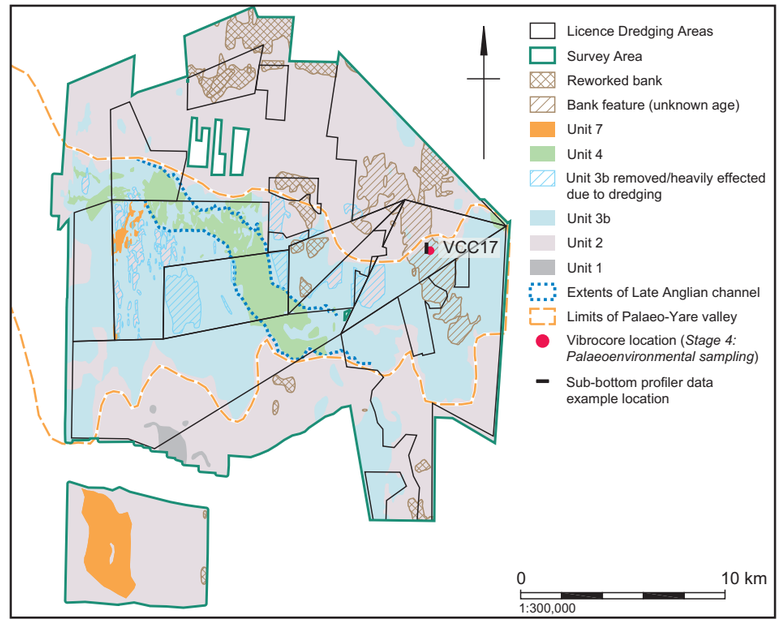
Example of the relationship between Unit 3b and Unit 4 in the Late Anglian channel (Channel A)

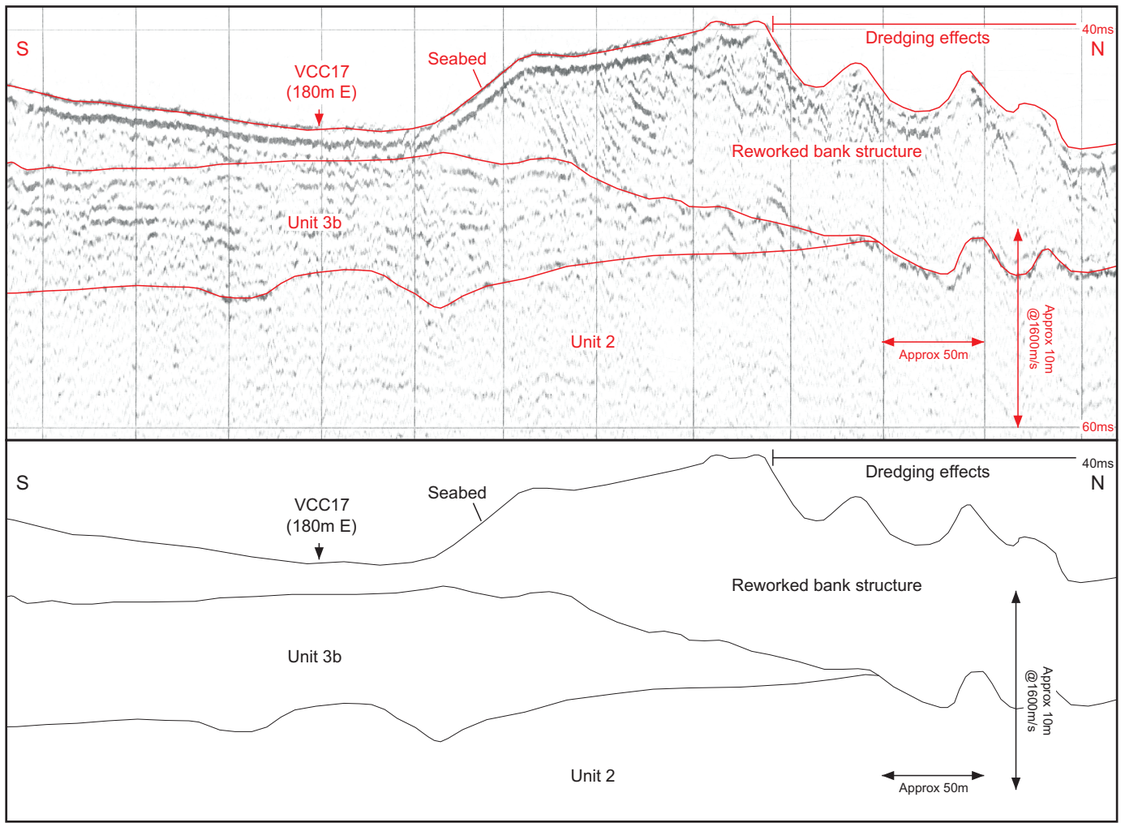


Brownish green slightly shelly slightly silty very gravelly medium to coarse subangular sand (shell fraction is sand to medium gravel sized fragmented bivalves, gravel fraction is fine to coarse subrounded to subangular flint).

Key

- Bank feature (unknown age)
- Unit 8
- Unit 7
- Unit 6
- Unit 5
- Unit 4
- Unit 3b
- Unit 3a
- Unit 2a
- Sand
- Gravel
- Clay
- Silt
- Peat
- Oxidised sediment





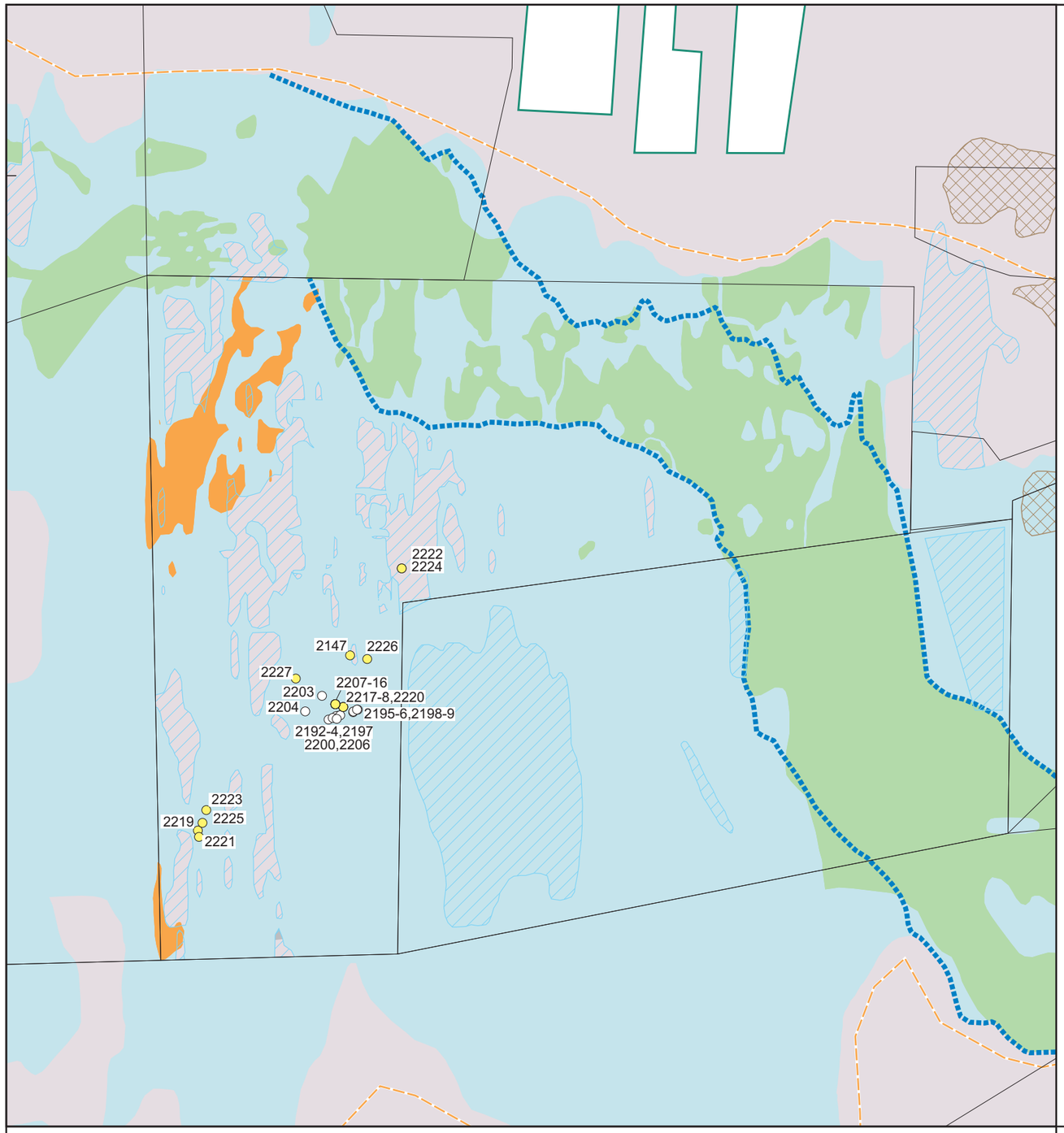
Sub-bottom profiler (boomer) data example

Drawing Projection: UTM WGS84 z31N.			
Date:	14/08/12	Revision Number:	0
Scale:	SBP 1:250 vertical	Illustrator:	KJB
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-08-14		

Wessex Archaeology

Example of the major bank structure and erosion of Unit 3b

Figure 19



A. Handaxe from original discovery (WA 2147)
Not to scale (© SCEZ)

B. Worked flint flake recovered during grab sampling (WA 2194)

C. Handaxe recovered during monitoring of dredge loads (WA 2214)

Date:	14/08/12	Revision Number:	0
Scale:	1:50,000 @A3	Illustrator:	KJF
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-05-22		

Location of the Middle Palaeolithic assemblage

Figure 20

ID	Site Name
1	Aveley, Essex
2	Broom, Devon
3	Brundon, Suffolk
4	Crayford, Kent
5	Creffield Road
6	Cuxton, Kent
7	Ebbsfleet, Kent
8	Harnham, Wiltshire
9	Holbrook Bay, Suffolk
10	Hoxne
11	Whitlingham / Keswick Mill Pit
12	Pontnewydd Cave, Clwydd
13	Northfleet
14	Purfleet, Essex
15	Selsey, West Sussex
16	Stanton Harcourt, Oxford
17	Stoke Tunnel & Maidenhall, Suffolk
18	Swanscombe
19	West Drayton/Yiewsley, London
20	West Thurrock, Essex
21	Carrow Road
22	Abbeville
23	Achenheim
24	Ariendorf
25	Bapaume-les-Osiers
26	Biache
27	Cagny-la-Garenne
28	Cagny l'Epinette
29	Gouzeaucourt
30	Kesselt-Op de Schans
31	La Cotte de St. Brelade
32	Maastricht-Belvedere
33	Mesvin IV
34	Pucheuil
35	Ranville
36	Rheindalen
37	Saint-Acheul
38	Schweinskopf
39	Therdonne
40	Tonchesberg
41	Tourville-la-Rivière
42	Wannen

Study Area (SA)
Licence Dredging Area 240
Palaeolithic sites dating to MIS 8 and 7
Other Palaeolithic sites
Middle Palaeolithic assemblage

0 100 km

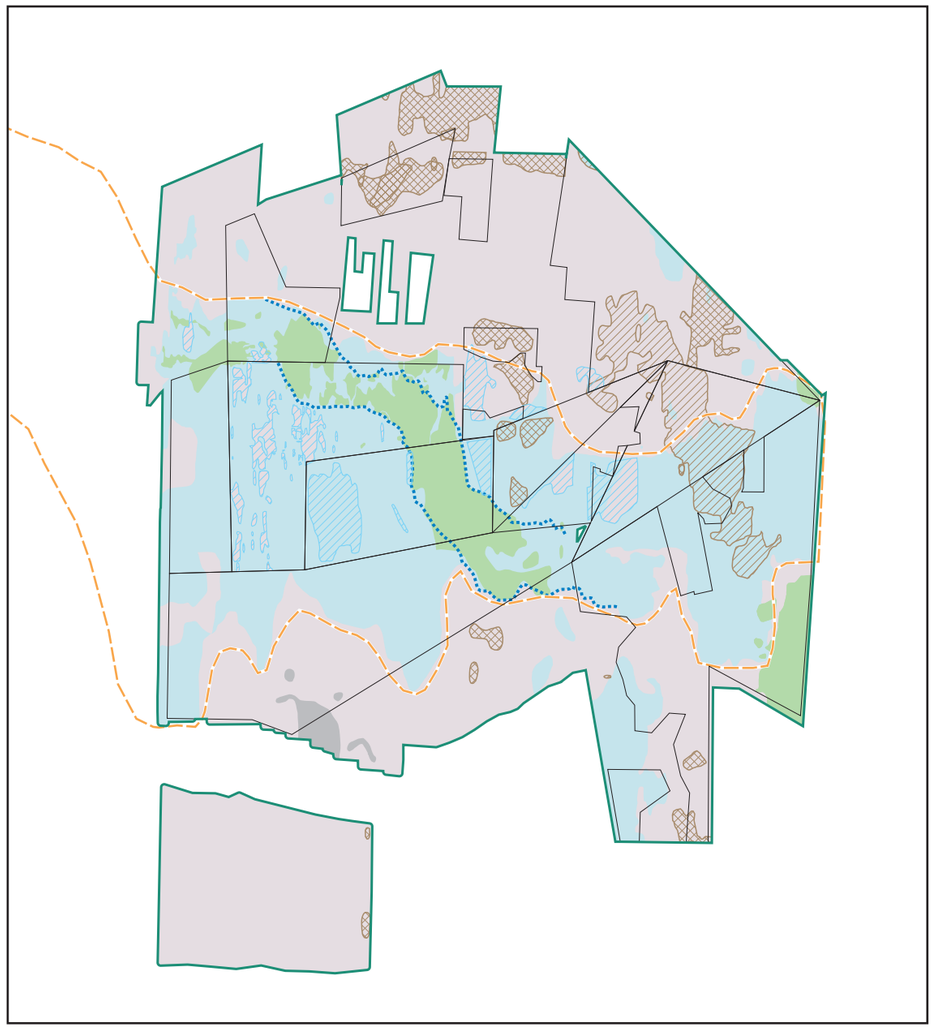
Drawing projection: UTM WGS84 z31N.

Wessex Archaeology

Date:	14/08/12	Revision Number:	0
Scale:	1:2,500,000 @A3	Illustrator:	KJF
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-05-22		

Middle Pleistocene, Lower and Middle Palaeolithic Site Context: Sites dating to MIS 8 and 7 are highlighted

Figure 21



A. Wolstonian sediment (Unit 3b) distribution in aggregate licence areas

B. Cumulative intensity (1993 - 2011)

Licence Dredging Areas
Survey Area

Drawing projection: UTM WGS84 z31N.

Wessex Archaeology

Reworked bank
Bank feature (unknown age)
Unit 4
Unit 3b removed/heavily effected due to dredging
Unit 3b
Unit 2
Unit 1

Extents of Late Anglian channel (Channel A)
Limits of Palaeo-Yare valley

EMS data analysis: cumulative intensity (1993 – 2011)
High intensity
Medium intensity
Low intensity
Very low intensity

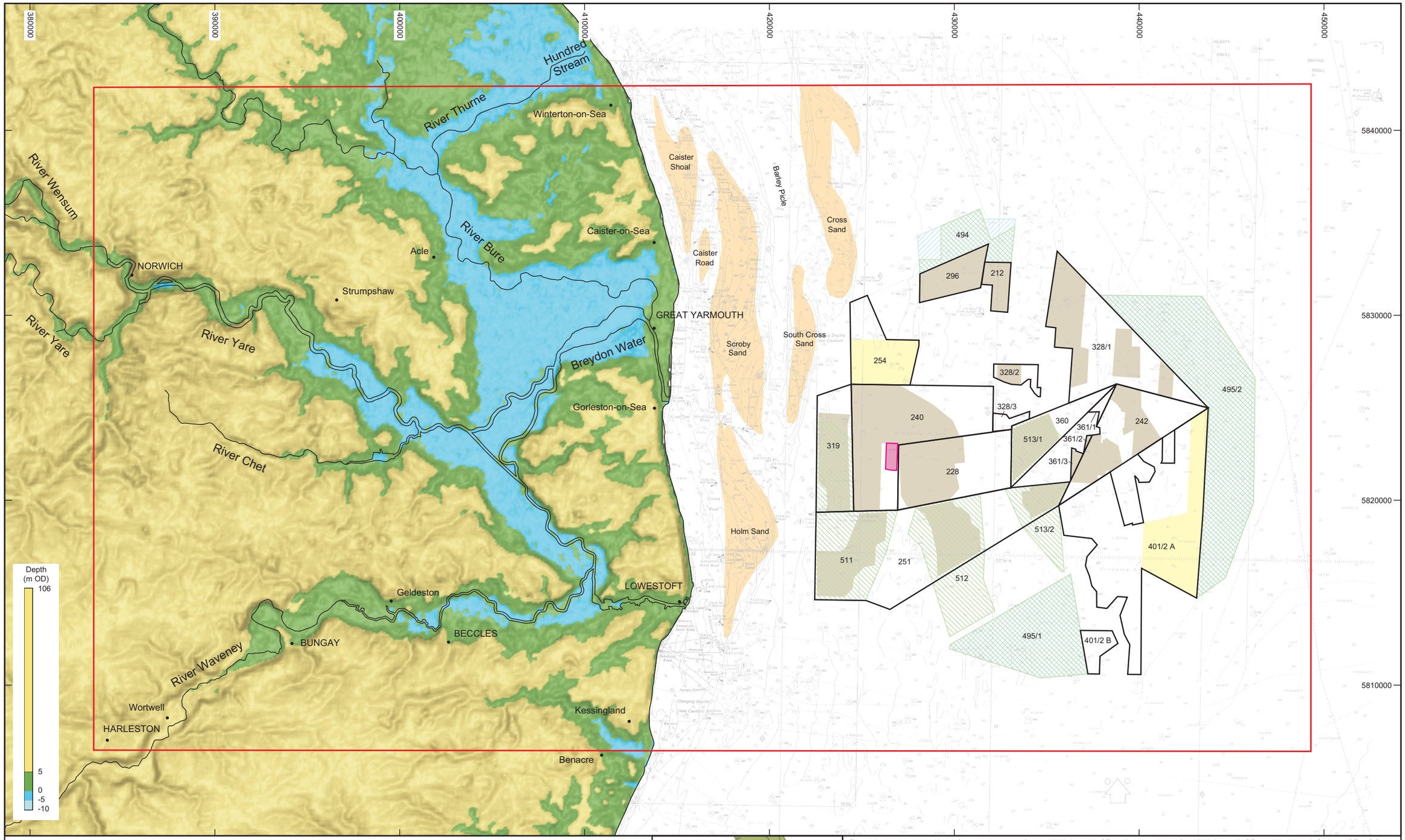
0 10 km

Date:	14/08/12	Revision Number:	0
Scale:	1:200,000 @A3	Illustrator:	KJF
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-05-22		

Wolstonian sediment (Unit 3b) and known aggregate dredging distribution in aggregate licence areas

Figure 22

WESSEX ARCHAEOLOGY LIMITED.
Registered Head Office: Portway House, Old Sarum Park, Salisbury, Wiltshire SP4 6EB.
Tel: 01722 326867 Fax: 01722 337562 info@wessexarch.co.uk
Regional offices in **Edinburgh**, **Rochester** and **Sheffield**
For more information visit **www.wessexarch.co.uk**



Study Area (SA)
Active Dredging Areas under Short Term Licence Applications
Active Dredging Areas
Licence Dredging Areas
Licence Application Areas
Licence Option Areas
Area 240 exclusion zone
Sandbanks

Drawing projection: UTM WGS84 z31N.
Admiralty chart 1543 (dated 2000)

Wessex Archaeology

Date:	22/05/12	Revision Number:	0
Scale:	1:200,000 @A3	Illustrator:	KJF
Path:	W:\Projects\83740\Drawing Office\Report figs\Technical report 2012\12-05-22		

Location map

Figure 1