Managing the Essex Pleistocene

Final Project Report

September 2015

Essex County Council

6639
MANAGING THE ESSEX PLEISTOCENE PROJECT

PROJECT REPORT

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Frontispiece: Marks Tey Brickpit, Essex (Courtesy of Rosalind Smith)

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Executive summary

This report presents the results of an English Heritage project concerned with the development of a methodology and creation of a predictive model of the Palaeolithic resource at a county-wide scale. Managing the Essex Pleistocene (MEP) builds on previous work, in particular the Medway Valley Palaeolithic Project (MVPP, 2007), the Tendring Geodiversity Characterisation Project (2009) and on earlier ALSF funded projects carried out within Essex. The projects have all been GIS-based (Geographical Information Systems), which allows for greater functionality, distribution and updating of the data.

This project is one of several commissioned by English Heritage in 2013 to "ensure that the significance of early prehistoric deposits and their palaeoenvironmental context is recognised appropriately, and to improve their consideration within the planning process" (EH 2012).

The purpose of the project has been to determine whether a methodology can be created on a County-wide scale utilising existing data sets that are readily available and be used by heritage professionals to inform on the potential for Palaeolithic archaeological sites to exist within a particular area. The main aim is to facilitate the delivery of consistent and considered responses to development proposals from Historic Environment Officers/ Local Authority planning archaeologists, and to offer advice on management of the archaeological resource.

The project was carried out by staff from Essex County Council and external specialists.

1 INTRODUCTION

1.1 Introduction to the project

The project, *Managing the Essex Pleistocene*, has developed and applied a methodology to create a predictive model by which the potential for the survival of Palaeolithic archaeology and Pleistocene faunal or floral remains within any part of Essex can be quickly assessed, and the nature and significance understood in order to influence pro-actively strategic plan-making and respond to individual development schemes.

This project is one of several commissioned by English Heritage in 2013 to “ensure that the significance of early prehistoric deposits and their palaeoenvironmental context is recognised appropriately, and to improve their consideration within the planning process” (EH 2012).

It follows a recent period of significant discoveries that have pushed back the timing of the known occupation of Britain, and the termination of funding from government bodies for archaeological fieldwork and research in areas impacted upon by the aggregates industry.

The location, landscape and geology of Essex make it a suitable candidate for applying a test methodology as it has a significant wealth of geological deposits in which Palaeolithic material has been shown to be present. The evidence for this has been derived largely through the consequences of past industrial activities such as quarrying. These deposits have also been the subject of much scientific research enabling a greater understanding not only of the environments under which they were deposited but of the relationship between the deposits and the archaeological material that they contain.

The Aggregates Levy Sustainability Fund (ALSF) was established in 2002 by the government to provide funds to tackle a wide range of problems in areas affected by the extraction of aggregates. ALSF funded projects within the county of Essex have included:

- The Middle Thames Northern Tributaries Project;
- The Medway Palaeolithic Project, and
- The Aggregates Survey of the Thames

These ALSF projects have provided detailed information within their relative study areas within Essex, largely in a stand-alone, GIS based format.

The sites of Palaeolithic potential that were identified within the Aggregates Survey of the Thames were added to the HER. The sites were limited to the polygons that originated from the existing mineral working sites GIS layer, as provided by ECC Minerals and Waste Team, and so were restricted to existing mineral working areas and their immediate environs.

Aggregates Survey of the Thames – *The archaeological survey of mineral extraction sites around the Thames Estuary (Essex County Council and Kent County Council 2004) included extant and former mineral sites in the Thurrock/Dartford area. The outputs of this project included a range of GIS layers, incorporating the results of specialist studies (including geology, Palaeolithic archaeology and industrial archaeology). The survey considers the importance and potential of the resource in and around the extraction sites.*

The GIS shapefiles that were produced as a result of the Medway Valley Palaeolithic project could be loaded separately into an ArcView GIS project with HER data and interrogated. A separate excel spreadsheet provided descriptive information on the various zones and provided an indication of the methods of mitigation that could be used according to the significance and potential of the zone for Palaeolithic archaeological remains.

The Medway Valley Palaeolithic project – *The project , which covered much of the districts of Tendring and Southend , aimed to develop a Medway Region Palaeolithic Research Framework, and involved the characterisation and predictive modelling of the Palaeolithic resource in the Medway region, specification of appropriate evaluation/excavation methodologies, and enhancement of respective HERs*

The Middle Thames Northern Tributary project was a pilot project and so was limited in extent to within the Lea Valley area and was largely focused on the valley bottom Holocene deposits.

The Middle Thames Northern Tributaries Project – *The project covered the area along the western boundary of the county, along the Lea Valley. The project was both desk and field-based to assess the potential of interpreting borehole data into a geoarchaeological layer in GIS. The results were the identification of 19 zones each with unique characteristics according to the nature of their sediments, age, and likely archaeology and also where peat and palaeoenvironmental data might be found*

The total area covered by ALSF funded work in Essex equates to around 15% of the total area of the county. This reveals an obvious gap in our coverage for information on the Palaeolithic potential in those areas beyond the scope of the existing ALSF projects.

The ALSF projects were restricted to areas affected by past and present quarrying. For Essex this centred on the gravel deposits where, although many finds of Palaeolithic date have been recovered from the complex stratigraphic terrace sequences, they are not the only source of potential Palaeolithic archaeology. This project aims to assess all known geological deposits of Pleistocene date in Essex, as mapped by the BGS up to the year 2013.

A key objective of the project is to provide complete spatial data as well as descriptive data on the Pleistocene deposits found within Essex with an indication of the nature of the archaeological, geological and palaeoenvironmental evidence within these areas.

1.2 Project area and current development pressures

The project area covers the whole of the county of Essex, located in the East of England (Figure 1). The county of Essex is located to the north east of London, and is bordered to the east by the North Sea and to the south by the River Thames. The County's northern boundary is delineated by the River Stour for much of its length, adjoining Suffolk, and to the west the boundary is defined by the River Lea for much of its length, adjoining Hertfordshire.

FIGURE 1. Location map of Essex

The county of Essex contains some of the most significant sites of national importance for the correlation of Pleistocene history across Europe.

The Pleistocene deposits of the lower reaches of the River Thames and its tributaries are of international significance; they form a framework for this part of the geological record in Britain, and they have important links with the glacial stratigraphy of East Anglia, the fluvial stratigraphy of the Rhine and Seine and the terrace sequence can be correlated with the global climatic stratigraphy.

Further north along the coast, the Clacton Channel deposits are hugely important, not least because Clacton is the international type site for the Clactonian Industry, a technological attribution that is also used outside Britain. The site has well provenanced evidence of lithic artefacts, fossil mammalian remains and other palaeoenvironmental evidence from deep sequences including undisturbed occupation horizons. It contained one of Britain's very few non-lithic artefacts of this era, a wooden spear.

Essex shares both a county boundary and coastline with Suffolk and beyond to Norfolk where recent finds at Pakefield and Happisburgh have provided some of the earliest evidence for human activity in northern Europe (possibly *c*.950,000 BP), Both sites have considerable implications for our understanding of the earliest colonization of Europe and the types of environment in which early humans could survive.

The county of Essex contains 19 areas designated as geological SSSIs, many of which contain Pleistocene geological sequences with evidence for Palaeolithic archaeological remains.

Developmental pressures on the County's Pleistocene resource arise primarily due to its location, the characteristics of its landscape and drift geology, specifically the presence of extensive areas of glacial/fluvial gravels and the accessibility of these for mineral extraction and supply.

***Population and Economy**- (source Essex Mineral Local Plan 2014)*

• Essex is one of the largest counties in England in terms of land area and has a resident population of 1,393,600 persons and growing (ONS, 2011 Census).

• There are three national growth areas in Essex: the Thames Gateway, Haven Gateway and West Essex Alliance respectively; and four growth centres at Basildon, Chelmsford, Colchester, and Harlow.

• The revisions to the East of England Plan (March 2010) proposed the construction of 100,000 new homes in Essex from 2011 to 2031.

• There is a substantial employment base including major manufacturing enterprises, service sector functions, logistics and international transport gateways.

Environment

• 70% of the 369,394ha land area of Essex is productive farmland. Half of this land is graded as Grade 1, 2 or 3a under the Agricultural Land Classification, meaning it is of a high quality.

• Much of the 180 mile long coastline is of international/ national biodiversity importance

• 29 species and 15 habitats are classed as vulnerable or in need of protection or safeguarding.

• There are 14,000 Listed Buildings, 296 Scheduled Monuments, 37 Historic Parks & Gardens and 21,000 recorded archaeological sites.

The Essex Mineral Local Plan (MLP) was adopted in July 2014. It is predicted that Essex will need to provide 40.67 million tonnes of aggregate from the preferred sites identified within the MLP, the majority of which are sand and gravel. The plan is due to last until 2029. Many of the preferred sites lie beyond the scope of the existing ALSF project boundaries. Almost all minerals planning applications have significant historic environment implications. The Historic Environment Consultants at Essex County Council are therefore consulted at an early stage in the development process and continue to be involved throughout the application process where there is perceived to be an impact on the historic environment.

Due to the abolition of Regional Spatial Strategies, the Draft Revision to the East of England Plan (March 2010) represents the most recent proposal for future dwelling provision prepared on a consistent basis across Essex and the East of England region. For Greater Essex the Draft Revision proposed an annual average provision of 6,230 dwellings a year between 2011 and 2031. This strategic pattern of growth is, and continues to be, planned for through the Local Plans/Local Development Framework documents prepared by each Essex district/borough/ city authorities.

The Historic Environment Consultants at Essex County Council act as advisors to the County Council, as the Minerals and Waste planning authority, and to most of the local planning authorities in the County, and maintain Service Level Agreements with them for the provision of historic environment advice on planning applications and strategic planning. This may take the form of a consultation by the local planning authority on individual planning applications where there is anticipated to be an historic environment impact, or through the checking of weekly planning application lists where all planning applications may be assessed. In this way there is the potential for identification of developments that may have an impact on the historic environment.

The Historic Environment Consultants rely on data available in the Essex Historic Environment Record (HER) to provide advice both in response to mineral applications and local planning applications. For Palaeolithic archaeological records this usually comprises findspot data and occasionally PAS (Portable Antiquity scheme) data which has recently been incorporated into the Essex HER. However by their nature, finds of Palaeolithic material are often discovered out of their primary context, or may have been transported some distance by natural processes and the accuracy of the records can be lacking both in location information and in identification and provenance of the finds.

1.3 Research context

The 1999 *Research Frameworks for the Palaeolithic and Mesolithic of Britain and Ireland* focused upon three strategic research themes:

- colonisation and recolonisation; settlement patterns and settlement histories; social organisation and belief systems, field and survey projects (subdivided into surveys, assessments and publication of key sites) and
- education, display and information exchange.

It identified a series of specific research questions and priorities including 'Predictive computer modelling of present and future distribution patterns'. The development and utilisation of computer modelling programmes such as geographic information systems (GIS) over the last 10-15 years has aided much research and facilitated in the attempt to investigate the possibility of achieving this research theme.

The revised framework (Prehistoric Society & EH, 2008) identified four primary research themes and eight strategic research and conservation themes. Of direct relevance is '**Theme 4. Curation and conservation'** which the primary objectives of this project aim to achieve. This will be achieved specifically by: facilitating the liaison between Palaeolithic and geological specialists and providing, through a GIS based system, the information required to the county HER to enable informed decisions to be made regarding the Palaeolithic potential of areas which may have otherwise been considered as 'archaeologically sterile'

Strategic Research and Conservation Themes

4. Curation and conservation

Strategies are needed for the collation, archiving, long-term protection and preservation of the resource. The planning process has been recognised elsewhere as an important tool for the curation and conservation of the Palaeolithic archaeological resource. The Working Group recognises that despite increasing understanding and awareness within local authority services of the potential for Palaeolithic archaeology, following the English Rivers Palaeolithic Survey and the Welsh Lower Palaeolithic Survey, there remains a lack of specialist knowledge of the Palaeolithic amongst local authority archaeological curators and decision-makers in land development. Areas of impact outside the planning system (or any regulatory framework), such as agriculture or coastal erosion, may also have significant impacts on the resource but are more difficult to recognise and manage.

Recognition of the potential impact of development and other land-use change in order to protect and conserve the diminishing Palaeolithic resource. The process of informing decision makers within local authorities of this potential must continue. Local authority planning archaeologists are in an appropriate position to do this but need to be better informed themselves about the potential of deposits they often regard as 'archaeologically sterile'. Regional or county based Sites and Monuments Records/Historic Environments Records are fundamental to the planning process, yet are only as good as the information put into them. There is clearly a role for Palaeolithic specialists here. Most SMR/HERs now have, or are developing, digital data within standardised databases linked to Geographical Information Systems, which provide appropriate contexts for liaison between Palaeolithic specialists and local authorities.

Liaison between Palaeolithic specialists and local authority curators should provide sound academic justification for why archaeological investigation should be funded by developers. Information and support is required to justify the archaeological evaluation of areas of as-yet undefined Palaeolithic potential.

In 2000 the Eastern Counties research framework (Brown & Glazebrook, 2000) identified that:

"***Research strategies need to be developed to enable the study of Palaeolithic archaeology to be more strategic and proactive in its approach rather than the present situation which is ad hoc and reactive.***"

The revised framework (Medlycott, 2011) assessed the results of the projects which had taken place since 2000 and attempted to address this research strategy. The revised framework highlights the need to place these surveys within the wider regional landscape and utilise the predictive models that had been created. As part of the future research topics it identified a need for "better understanding of the nature, sequence and extent of Pleistocene deposit" and the need for HERs to include geological and palaeoenvironmental data to help ensure that threats to the resource can be met with an appropriate response.

"**If possible the HERs should aim to characterise the sediments and identify areas of high potential**."

Research and Archaeology Revisited: a revised framework for the East of England

Assessment of progress on research topics proposed in 2000

The National Ice Age Network project and the Ancient Human Occupation of Britain project have done sterling work in collating and furthering the study of the Pleistocene and the Palaeolithic in Britain. Progress has been made on many of the broad research topics identified by the original Research Agenda and Strategy. In particular the English Rivers Palaeolithic Survey, together with the Middle Thames Northern Tributaries project, the Medway Valley project, the Wash Rivers and Over Landscapes projects, and the survey of mineral extraction sites around the Thames Estuary, have all provided both quantitative and qualitative assessments of the resource.

The Greater Thames Estuary Historic Environment Research Framework (Heppell, 2010) highlights the significance of the Thames Estuary during the Pleistocene in contributing to our understanding of the social and cultural strategies of early human populations in relation to changes in environment and climate (Framework Objective 1A). Within the proposals for specific areas of research that could address this objective fieldwork, investigation and mapping areas of extant superficial deposits (classified in terms of their likely temporal and spatial characteristics) are considered primary methods in providing a framework for geoarchaeological interpretation and identification of further areas of potential significance.

1.4 Integration/collaboration with other projects

The project was carried out in close collaboration with Kent County Council (EH Project 6637) with whom the findings will be presented at a seminar to English Heritage specialist staff including science advisors, Kent and Essex curators (both County Council and others e.g. Canterbury), local authority development control teams, Palaeolithic and geoarchaeological specialists, and archaeological contractors. In addition, following on from the successful collaboration of the Medway Valley Palaeolithic Project, curatorial advice and management will be developed and shared.

Other on-going research projects that complement the project include:

Norfolk County Council (Project 6623) have carried out a systematic update of their HER for the recording of Palaeolithic and Mesolithic finds. The project highlighted the complexities of searching for Palaeolithic records within their HER and the paucity of detail recorded for current HER records of Palaeolithic and Mesolithic finds. The project resulted in an increase from 1800 to c.4700 records with a significant increase in the level of detail of individual finds. Due to the recent finds of the earliest Palaeolithic flint tools along the Norfolk coast the accurate location and provenance of these finds and their relationship to the Pleistocene geology could enhance the Essex project along the adjacent coastal regions.

Worcestershire Archive and Archaeology Service have enhanced the HER with previously unrecorded Palaeolithic sites as well as over 2000 faunal records. These were plotted against Quaternary geology to create a map of known and potential Palaeolithic activity. Working with Quaternary geologists and archaeologists they classified the BGS mapped river terraces into dated groups, making the geology more accessible to non-specialists, a fundamental aim reflected in the Essex project. This method allowed 21 separate areas of Palaeolithic potential to be identified. Worcester has previously developed a GIS map as a result of both the National Ice Age Network project and its predecessor. Comparison of the results, specifically with the HER enhancement will be of significance in refining the Essex methodology.

Both the West Berkshire (Project 6633) and Kent County Council project involved predictive modelling with input from fieldwork to refine the Pleistocene geological mapping. A comparison of the results between a purely desk-based approach compared with a fieldwork-based element will be of significance in determining the validity of the Essex project in attempting to cover a larger geographical area where fieldwork would prove prohibitive in terms of time, cost and access.

2 AIMS AND OBJECTIVES

2.1 Research Aims

1 To enhance our understanding of the Pleistocene in Essex and to ensure the proper management of the Palaeolithic resource

2 To develop a methodology by which Palaeolithic potential can be quickly assessed and the nature and significance understood in order to pro-actively influence strategic plan-making and respond to individual development schemes

3 To develop a predictive model identifying areas of Palaeolithic-related geology and an indication of varying Palaeolithic potential that can be used by non-specialists

4 To enhance the Essex Historic Environment Record with interpretative data on the Palaeolithic archaeological potential within the county.

2.2 Research Objectives

1 To provide an up-to-date comprehensive background on the Palaeolithic related geology and Palaeolithic archaeology of Essex

2 To simplify the BGS 50k geology digital layer mapping to create a GIS layer of Pleistocene deposits of Essex for use by a non-specialist.

3 To provide a detailed characterisation of each lithological unit mapped within Essex with a non-specialist description and indication of Palaeolithic potential.

4 To create a basic stratigraphic model for the main lithological units from BGS borehole data

5 To map all known sites of Palaeolithic archaeology

6 To map all existing and future potential mineral extraction sites to assess the impact on the Palaeolithic resource

7 To integrate and synthesise information about the Palaeolithic resource from existing ALSF GIS based projects within Essex

8 To digitally map potential Local Geological Sites (LoGS) of Pleistocene/Palaeolithic potential and make the data compatible with the developing biological record centres in Essex.

9 To identify areas of distinct geoarchaeological characteristics and create a GIS layer of ‘areas’ of varying Palaeolithic potential with attached attributes.

10 To disseminate the methodology and results of the project in a final report and as a GIS layer. Opportunities will be sought to disseminate the report through the web-sites of partner organisations and other interested forums

11 To provide guidance on the application and use of the project products and results

12 To enhance the HER through the updating of the Historic Environment Characterisation Projects with information on Palaeolithic potential.

13 To indicate possible approaches to investigation of areas of high Palaeolithic potential in collaboration with Kent CC

14 To facilitate the delivery of a consistent and considered response to development applications from Historic Environment Officers/ Local Authority planning archaeologists and offer advice on management of the archaeological resource.

3 PROJECT CONTEXT

3.1 Geological and Palaeolithic archaeological background in Essex

The geology of Essex is dominated by the effects of the major Anglian glaciation, which occurred approximately 478,000 – 424,000 years BP (Before Present) (**Table 1**). The ice sheet associated with this glacial period expanded into Essex from the north, reaching approximately as far south as the A12 trunk road. This area is thus largely covered by Anglian till (boulder clay) laid down under the ice sheet (**Figure 2**). The till buried earlier Quaternary deposits (**Table 1**), principally the Sudbury and Colchester Formations of the Kesgrave Sands and Gravels, laid down by an early course of the Thames flowing in a broad curve from west to north-east through the county towards the North Sea. (See figure 13 and figure 16). The buried Kesgrave deposits are exposed where valleys cut through the till, and the younger Colchester Formation beds of the Kesgraves also outcrop in the Colchester area and on the Tendring plateau. South of the till sheet, some hilltops in western and central Essex are capped by outcrops of old Quaternary gravel (Stanmore Gravels) from the Early Pleistocene, and eastern Essex is dominated by higher level gravels laid down by the pre-Anglian course of the Medway (High-level East Essex Gravel). The Anglian ice blocked the Kesgrave Thames and the river was diverted to its modern valley, though north of its present course, to join the Medway in the Southend area. This route is marked by the extensive spreads of terrace gravels in the Lower Thames and, at lower levels on the eastern fringes of the Dengie and Rochford peninsulas, by gravels laid down by the combined Thames-Medway following diversion of the Thames by the Anglian ice (Low-level East Essex Gravel).

The nature of the Quaternary deposits in East Anglia is such that it is difficult to classify some of them using the accepted stratigraphic procedures. Consequently there is divided opinion about which sedimentary bodies should be classified at the 'Formation' level. The Kesgrave Sands and Gravels are classified at the Formation level by some, while others have the sub-divisions of the KSG as the Sudbury Formation and Colchester Formation. In this report, the terms 'Kesgrave Sands and Gravels' and 'Sudbury Formation' and' Colchester Formation' are used as the last two are strongly embedded in the local literature.

Prior to the Anglian, Britain was connected to the continent by an extensive land bridge, so there was no physical barrier to human migration. The Straits of Dover were created during the Anglian and thereafter migration could occur only during colder periods when sea-level was lower.

For this report, the county has been divided into Lithological Units (LUs) (Section 4.4) which correspond to the geology as it relates to the Palaeolithic archaeology shown in Table 1, broadly following in chronological sequence. LU 1 (Stanmore Gravel) and LU 2 (Sudbury Formation) cover the early Kesgrave Thames, and the older part of LU 6 (High-level East Essex Gravel) cover the early Medway as it crossed eastern Essex. So far these have no Palaeolithic history, but finds on the East Anglian coast at Happisburgh indicate a possibility of finds in the future. LU 3 and 4 (Colchester Formation), LU 5 (Woodford Gravel) and the later part of the LU 6 cover later Kesgrave Thames deposition, of the Colchester Formation, and its equivalents in the Roding Valley, the Woodford Gravel, and early Medway in coastal Essex. Palaeolithic material has been recovered from Westcliff (LU6) and Wivenhoe (LU 3) Clacton and Wrabness (LU 4). LU 7 examines the Anglian glacial deposits (mostly till and outwash), which would seem to represent an inhospitable environment, but in fact has a record of Palaeolithic finds. This contradiction is discussed. LU 8 considers the lacustrine deposits that were common immediately following the melting of the ice, particularly at Marks Tey and Copford. LU 9 and 11 cover the post-Anglian terraces of the Lower Thames and LU 10 their continuation across eastern Essex as the Low–level East Essex Gravels. The brickearth deposits of the Lower Thames are described in LU 12 and of eastern Essex in LU13. Finally tufa deposits are examined in LU14.

Essex is a county rich in Palaeolithic remains. There are over 200 findspots recorded within the Essex HER and 13 Portable Antiquities Scheme (PAS) records. (**Table 2**). These include numerous records from surviving terrace sequences with Palaeolithic remains from two of Britain's major rivers, the pre-Anglian Thames and the post-Anglian Thames-Medway system. There is also a diversity of other deposits containing Palaeolithic remains, mostly accumulated on the impermeable surface of the wide spread of Anglian glacial till (boulder clay) that covers much of the northwestern half of the county.

There was human occupation of Britain prior to the Anglian, with some of the most important sites along the coast at Happisburgh, Norfolk and Pakefield, Suffolk in deposits thought broadly equivalent to those of the Kesgrave Sands and Gravels. However little good evidence is so far known from Essex, although there are some well-provenanced findspots associated with pre-Anglian deposits, particularly the

Colchester Formation of the Kesgrave Sands and Gravels (LUs 3 and 4) and the High-level East Essex Gravels (LU 6) (**Table 2**). HER findspots apparently linked to the earlier Stanmore Gravel and the Sudbury Formation of the Kesgrave Sands and Gravels (LUs 1 and 2) are not well-provenanced, and probably relate to residual material found on the surface of these deposits. Nonetheless, it is possible that important pre-Anglian remains survive within the extensive Kesgrave Sands and Gravels, the High-level East Essex gravels, or perhaps the relatively minor outcrops of the Woodford Formation.

Essex (and indeed Britain as a whole) was largely unoccupied during the periods of extreme cold of the Anglian glaciation. The majority of the Palaeolithic interest in the county lies therefore in the younger deposits that have developed above or beyond the extensive till and glaciofluvial deposits of the Anglian glaciation (**Table 1**). Britain was rapidly occupied after the end of the glaciation as the climate warmed, and then remained occupied (with occasional hiatuses) for much of the remaining Pleistocene. Consequently there has been a long association between Palaeolithic archaeology and post-Anglian Pleistocene deposits in Essex, especially with fluvial deposits laid down by the various courses of the Thames and the Medway in Essex. As can be seen (**Table 2**) from an overview of how Palaeolithic findspots in the Essex HER relate to Pleistocene lithological units, the great majority of findspots (n=109, or nearly 56%) are associated with post-Anglian river terrace deposits of the Lower Thames (LU 9), the Thames-Medway (LU 10) and other Essex rivers (LU 11).

A significant number of HER findspots (n=42, or nearly 20%) are apparently associated with glacial till and glaciofluvial sands and gravels (LU 7). Since we can be confident that Britain was unoccupied during the period of actual glaciation when these deposits were being laid down, this must either represent surprisingly abundant reworked evidence of earlier pre-Anglian occupation, or evidence of post-Anglian occupation in unmapped deposits of various types. The latter is more likely, and highlights the potential of these areas for the recovery of further Palaeolithic remains.

Some seemingly-hospitable environments for human occupation have a poor record of lithic finds, such as the brickearths of the Lower Thames (which have a rich mammalian record), lakes of glacial origin that persisted into the Hoxnian Interglacial and tufa deposits that have yielded palaeoenvironmental information in the adjoining counties of Suffolk, Kent and Hertfordshire. However, this probably reflects that deposits of these categories are of very limited spatial extent, compared to the large areas of river terrace deposit for instance, and that where they are sufficiently well developed to be mapped they represent wet environments of deposition unconducive to hominin activity. The tufa deposits in Essex are furthermore thought to have formed entirely in the Holocene so would not in any case contain any Palaeolithic remains (apart from perhaps Long Blade evidence from the final Upper Palaeolithic at their very base).

Nonetheless, there are several findspots in the Essex HER associated with the lithological units that cover deposits other than river terrace gravels. There are nine findspots associated with spreads of Devensian brickearth (LU 13). However all of these are probably derived remains from earlier in the Palaeolithic, or remains associated with unmapped outcrops of lacustrine or head deposits. There are eight finds associated with Hoxnian lacustrine deposits (LU 8), although only one is accurately provenanced. However, lakes would not be good environments for hominin habitations and activity, so most (and the most important) Palaeolithic archaeological evidence would be likely to be found in unmapped zones around the edges of mapped lacustrine outcrops. There are seven findspots associated with interglacial deposits (LU 4). These include the rich evidence associated with the MIS 11 Thames-Medway channel deposits at Clacton-on-Sea, and finds near a mapped outcrop of LU 4 at Wrabness. Finds have also been made from within interglacial horizons of the Kesgrave deposits (Colchester Formation), but these are included as part of the latter (LU 3).

A high number (n=105, or nearly 50%) of Palaeolithic findspots in the Essex HER are not associated with any Pleistocene LUs but with other superficial deposits such as head, alluvium or beach deposits, or with solid deposits such as Chalk, Thanet Sand or London Clay (**Table 2**). The head deposits of Essex are mostly thought to have formed in post-Palaeolithic times, and so have no potential for pristine Palaeolithic material, but may contain reworked material. However, it is likely that older head deposits are present in the county, and these may contain (or seal) contemporary Palaeolithic remains of importance. Unfortunately it is not known where any such outcrops are most likely to occur, if present. In addition to this, mapped head outcrops may contain unmapped elements of other deposit types, such as lacustrine deposits, river terrace deposits or plateau brickearth.

Alluvial deposits, being post-Palaeolithic, have the potential for the recovery of derived material from the Lower/Middle Palaeolithic. However, undisturbed sites dating to the final Upper Palaeolithic, associated with the end of the last cold stage and the transition to the Holocene may be present at the base of Holocene alluvial sequences. Spreads of present-day alluvium may also overlie productive earlier deposits of different types and ages with important Palaeolithic remains.

Beaches are highly dynamic environments, constantly changing morphology and sediment type, seasonally or following storms. They have no potential for Palaeolithic archaeology within the currently active sand/gravel bodies, which may however contain reworked material. This reworked material may be indicative of nearby exposures with important Palaeolithic remains, for instance outcropping in cliffs abutting the intertidal zone, or occurring under the beach deposits and extending offshore.

Concerning findspots that are associated with solid geological deposits, clearly no Palaeolithic material is going to be present in, or have originated from, these. Many of these records come from general or estimated locations, for which the rough grid co-ordinate happens to fall on an area of pre-Pleistocene geology within an area of Pleistocene deposits that are the likely source of any Palaeolithic material. However it is also the case that some sites have accurately reported locations, but material has been either found in unmapped deposit outcrops or from sediments that have since been removed or extracted.

The important point here is that areas mapped as London Clay, Chalk, Thanet Sand, or other solid beds cannot be ruled out as having potential for Palaeolithic remains. Consideration needs to be given to the Palaeolithic potential of localities where Pleistocene LUs are not mapped, bearing in mind their topographic situation, records of Palaeolithic finds and the presence of any nearby mapped Pleistocene outcrops.

Palaeolithic finds from each lithological unit are discussed in more detailed in the reports for each Lithological Unit.

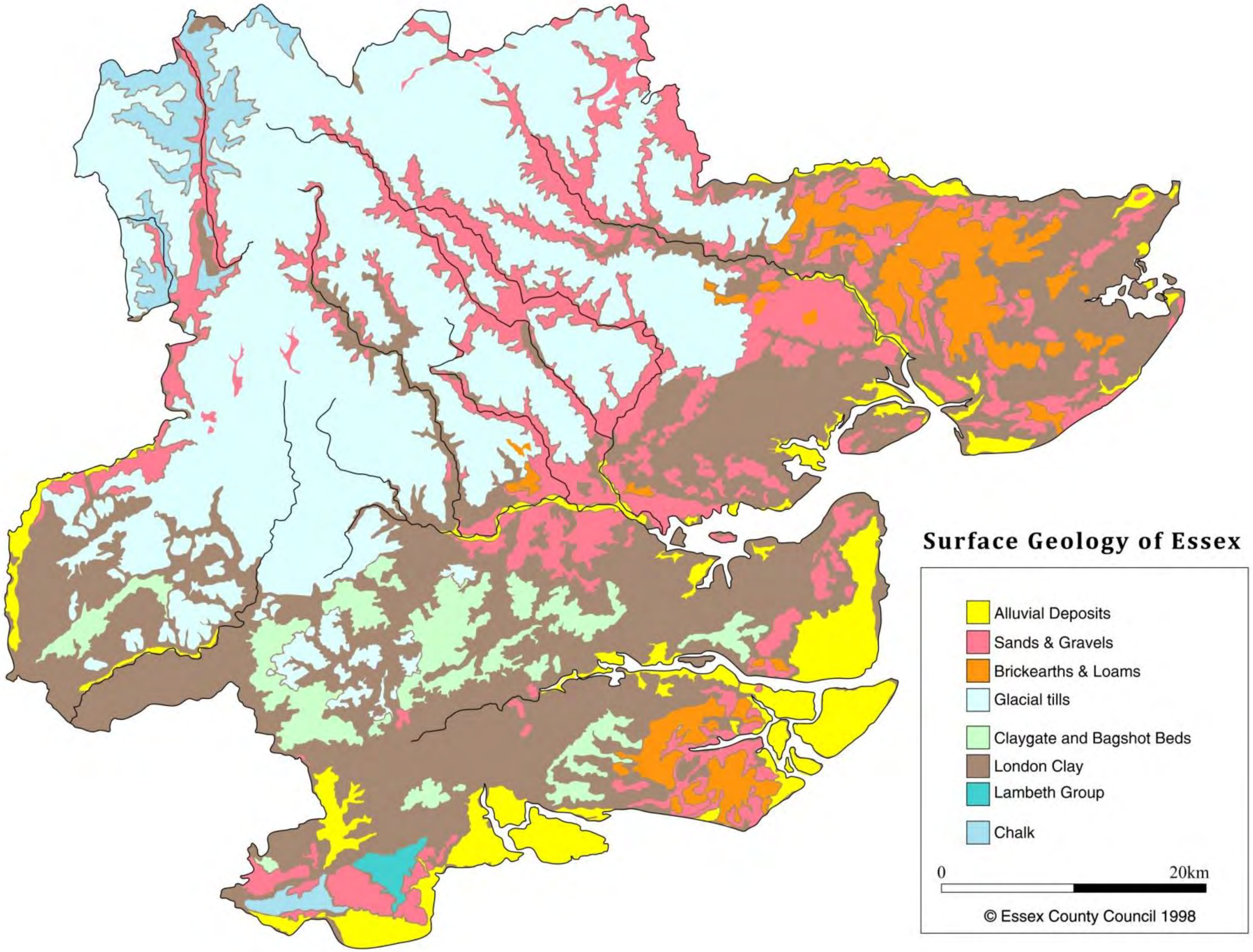

Figure 2 Simplified geology of Essex (ECC)

Table 1 Quaternary stratigraphy of Essex

AGE	*THAMES* FORMATIONS AND MEMBERS			*MEDWAY AND THAMES MEDWAY* FORMATIONS AND MEMBERS		MIS STAGE
Holocene			*Tilbury alluvial deposits {Tufa* ***(LU14)****}*		*Alluvium*	*1*
Devensian			Shepperton Gravel {Brickearth – Tendring *et al.* **(LU13)**}			2
Devensian	Lower Thames Formation **(LU9 + 11)**	(Kempton Park Terrace)	East Tilbury Marshes Upper Gravel	Low-level East Essex Gravel (Thames-Medway) **(LU10)**	Submerged	*5d – 2*
Ipswichian Interglacial			*Trafalgar Square Deposits*		*Submerged*	*5e*
Late Saalian			East Tilbury Marshes Lower Gravel		Submerged	6
Late Saalian		Mucking Gravel (Taplow Terrace)	{Brickearth - Ilford, Grays **(LU12)**}		Submerged and beneath Foulness	6
			West Thurrock Gravel		*Submerged*	*7*
Aveley Interglacial			*Aveley Silts and Sands*		Submerged and beneath Foulness	8
Mid Saalian			Crayford Gravel			
Mid Saalian		Corbet's Tey Gravel (Lynch Hill Terrace)	Botany Gravel		Barling Upper Gravel	8
Purfleet Interglacial			*Purfleet Silts and Sands*		*Shoeburyness/Rochford/Burnham channel deposits*	*9*
Early Saalian			Purfleet Silts and Sands		Shoeburyness Channel Gravel	10
Early Saalian		Orsett Heath Gravel (Boyn Hill Terrace)	Orsett Heath Upper Gravel [Marks Tey lacustrine deposits]		Southchurch/Asheldham/ Mersea Island/Wigborough Gravel	10
Hoxnian			*[Marks Tey lacustrine deposits* ***(LU 8)****]*		*Southend/Asheldham/Clacton Channel deposits*	*11*
Anglian			*Swanscombe deposits*		Southend/Asheldham/Clacton Channel Gravel	12
			Orsett Heath Lower Gravel			
Anglian		Black Park Gravel (Black Park Terrace)	(Buried by Orsett Heath & Southchurch Formations)			12
	Lowestoft Formation **(LU7)**		(Anglian/Lowestoft Till) Outwash gravel = Upper St Osyth Gravel		Upper Holland Gravel	12
	Kesgrave Sands and Gravels	Colchester Formation **(LU3 + 4)**	Lower St Osyth Gravel	High-level East Essex Gravel **(LU6)**	Lower Holland Gravel Chalkwell/Caidge Gravel	12
Cromerian			Wivenhoe Upper Gravel *Wivenhoe interglacial deposits* Wivenhoe Lower Gravel		Canewdon/St Lawrence Gravel	{13} *{13}* {14}
{attributions uncertain}			Ardleigh Upper Gravel *Ardleigh interglacial deposits* Ardleigh Lower Gravel		Belfairs/Mayland Gravel	{14} *{15}* {16}
			Waldringfield Gravel		Ashingdon Gravel	{16}
			{Woodford Gravel} **(LU5)**			
		Sudbury Formation **(LU2)**	Moreton Gravel		Oakwood Gravel	{16}
			Bures Gravel		Daws Heath Gravel	{18}
			Stebbing Gravel		Claydon Gravel	{20}
			Bushett Farm Gravel			
(attribution uncertain)			Stanmore Gravel **(LU1)** (Pebble Gravel, Warley Gravel)			

Italics – interglacial warm period {nn} – attribution uncertain [xxx] – equivalent stratigraphic position

Table 2. Numbers of Essex HER Palaeolithic findspots in relation to MEP LUs and other geological deposits

LUs			Non-LU deposits								
LU #	**LU name**	**no. of HERs***	Alluvium	Beach	Head	Lambeth Group & Thanet Sand	London Clay	Chalk	Sea	Other	**Total**
14	Tufa	-	-	-	-	-	-	-	-	-	-
13	Brickearth, Devensian	8	1	-	-	-	-	-	-	-	**9**
12	Brickearth, Pleistocene	1	-	-	-	-	-	-	-	-	**1**
11	Terraces of the Essex Rivers	11	4	3	2	-	3	3	-	2	**27**
10	Low-level East Essex Gravels	21	2	3	-	-	3	-	1	1	**31**
9	Lower Thames Terraces	11	5	-	12	-	2	20	-	-	**51**
8	Lacustrine Deposits	2	1	-	2	-	-	2	-	-	**7**
7	Glacial/Glacio-fluvial deposits	39	1	-	-	-	2	-	-	-	**42**
4	Interglacial/ Interstadial deposits	4	-	3	-	-	-	-	-	-	**7**
6	High-level East Essex Gravel	1	-	-	-	-	2	-	-	-	**3**
5	Woodford Gravel	-	-	-	-	-	-	-	-	-	**-**
3	Kesgrave Gravels, Colchester	7	1	-	-	-	5	-	-	-	**13**
2	Kesgrave Gravels, Sudbury	2	-	-	-	-	-	-	-	-	**2**
1	Stanmore Gravel	1	-	-	-	-	-	-	-	-	**1**
Remaining unattributed**			3	2	6	4	2	2	-	-	**19**
Grand total Essex Palaeolithic HERs											**213**

[Column 3 "LUs" gives the number of HERs attributable to each LU category; columns 4-10 give the numbers of HERs spatially associated with non-LU deposits that can however be re-attributed to LUs]

**HERs that are obvious duplicates or non-Palaeolithic records have been omitted from these figures*

*** Number of Palaeolithic HERs from non-LU deposits that have not been reliably re-attributed to LUs*

The Quaternary framework for the Palaeolithic

*The Quaternary Period covers the last 2.6 million years and consisted of over 100 major climatic switches (many more minor oscillations) of alternating cold and warm stages, controlled astronomically by variations in the orbit of the earth around the sun. The sequence of these climatic changes has been elucidated by analysis of oxygen isotopes in Foraminifera from cores through deep ocean trenches where sedimentation was continuous for much of the time period. The relative proportions of the two common isotopes of oxygen, O^{16} and O^{18}, the ratio being about 500:1, can be used to infer climate. Because the O^{18} is the heavier isotope, it tends to become more concentrated in lakes and seas, as compared to the lighter one which is more readily transferred to the atmosphere by processes such as evaporation. In warm stages, the O^{16} quickly returns to the ocean principally through rainfall, but in cold stages it gets trapped in the ice sheets, so diminishing the amount in the oceans and increasing the proportion O^{18}. By measuring the variation in the ratios of the isotopes in fossil Foraminifera, where the oxygen is measured in the calcium carbonate ($CaCO_3$) of the shells, the climate of the time can be deduced, as high amounts of the heavier isotope implies a cold period. The peaks and troughs of this record of palaeoclimate change (known as Marine Oxygen Isotope Stages, or MIS) are numbered from the top (most recent) down, with the warm peaks having odd numbers and the cold troughs having even numbers with the subdivisions being a-c-e, etc for the warm substages and b-d-f, etc for the cold (**Figure 3**). In the early stages, the climatic cycles had a periodicity of c.41 - 44,000 years, but about 0.9 million years ago (MIS 22) this changed to c.100,000 years, with greater fluctuations, sufficient to give periods of extreme cold, with glacial and periglacial activity, contrasting with warm interglacial periods with deciduous forest.*

*This profoundly affected the regimes of rivers and has been thought to lead to the formation of more complex terrace stratigraphy (Bridgland, 2006). Under this model, each terrace spans a cold-warm-cold climatic sequence (**Figure 4**) which in turn can be related to the MIS record (**Table 1**). In effect, if the full sequence is present, there is a 'sandwich' - lower cold stage deposits, usually a gravel - interglacial, finer grained sands, silts and clays often with palaeoenvironmental material - upper cold stage gravels (**Table 1**), as is the case for MIS 15 and later. If the interglacial element of the sequence is missing, due to erosion, it is difficult to separate out the lower and upper gravels. However, the proposed simple association between gravel deposition and cold stage conditions needs more careful consideration and cannot be relied upon as a consistent interpretive framework. There are many examples of the recovery of warm climate faunal remains from gravel-rich horizons, for instance in Thames gravels at Swanscombe (Kent) immediately to the south of Essex. Here, sediments attributed to the Boyn Hill/Orsett Heath Formation are rich in interglacial faunal remains and attributed to the MIS 11 interglacial. The Swanscombe gravels are thought to be lateral equivalents of many outcrops on the north side of the Lower Thames, in Essex.*

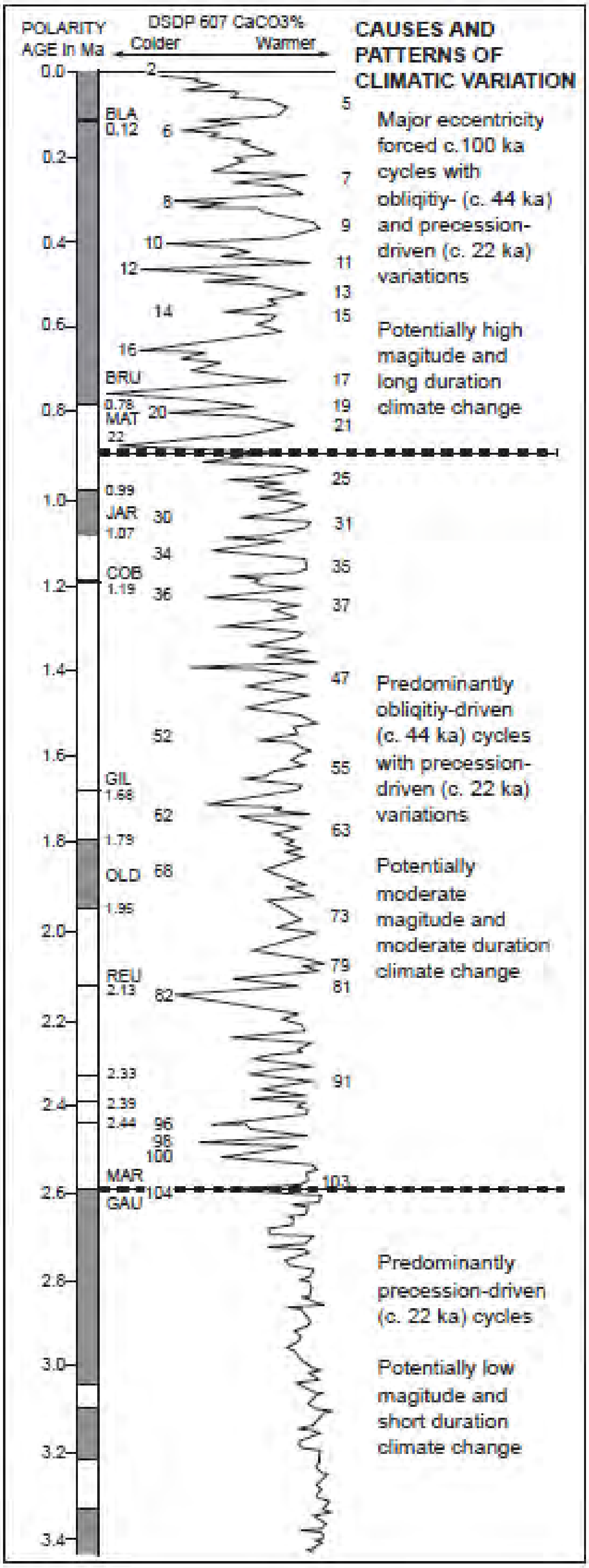

Figure 3. Quaternary climatic change; marine isotope stages (MIS) (Rose, 2010)

The bar indicates geomagnetism/palaeomagnetism, the shaded zones indicate normal geomagnetism (north at North Pole) and the unshaded reversed polarity (south at North Pole)

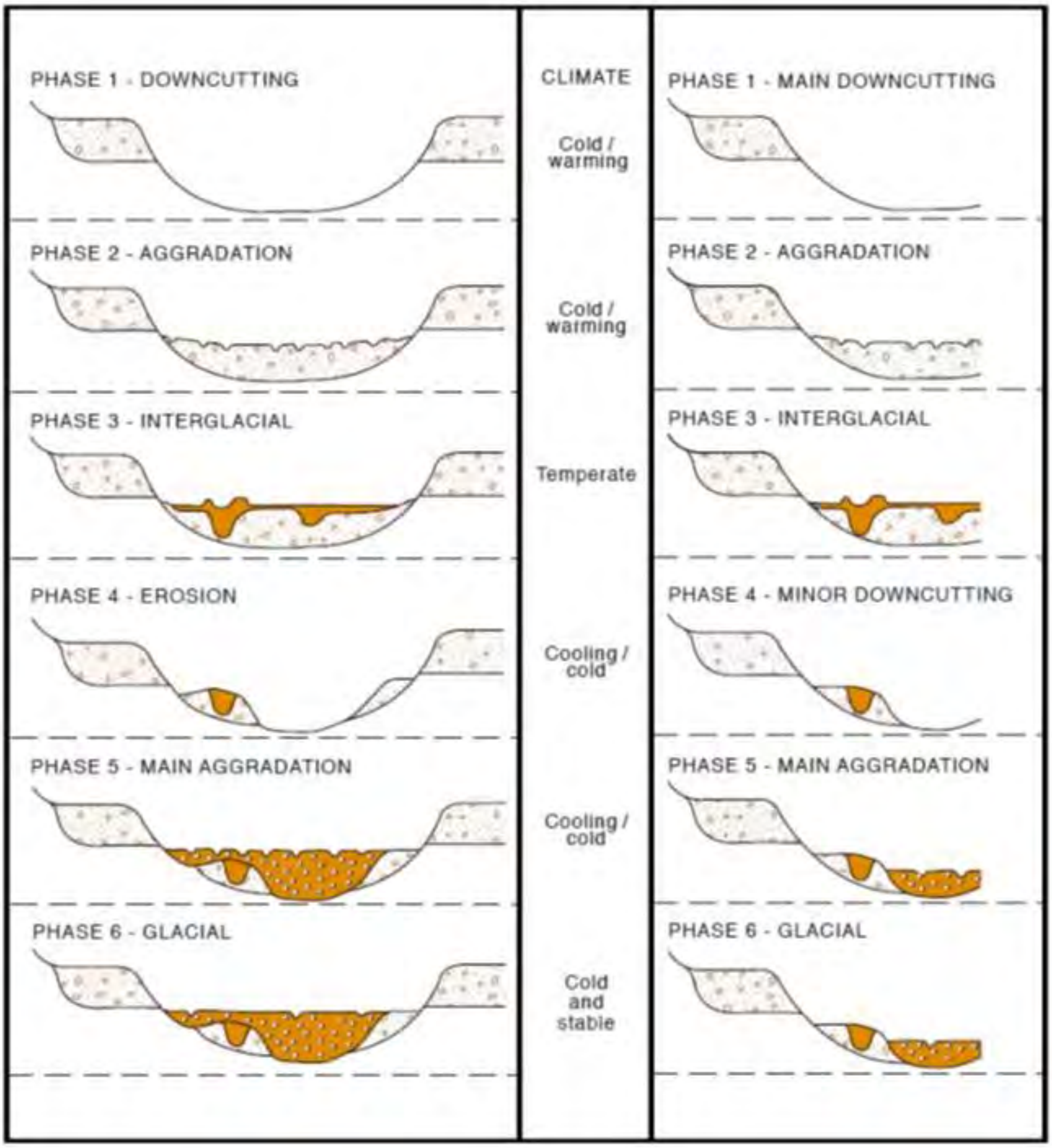

Figure 4. Model of terrace formation in synchrony with glacial-interglacial climatic fluctuation.

Left side, classic model; right side variation, with less aggradation in Phase 5. (after Bridgland, 2014)

3.2 Dating

Dating the stratigraphy of the Essex Quaternary deposits is reasonably robust for the period after the Anglian glaciation (MIS 12; 478 – 424,000yrs BP), though still subject to modification. Prior to that, there is disagreement and much revision of dating. As an example, the switch between the Sudbury to the Colchester Formations was put at MIS 19 (*c.*780,000 yrs BP) by Rose (2010) but at MIS 17-16 (*c.*700 – 625,000 yrs BP) by Westaway (2011). Earlier Westaway *et al*. (2002) and others had put the transition at MIS 22-21 (*c*.850,000 yrs BP).

This becomes particularly significant when comparing the Essex stratigraphy with that of Happisburgh on the north Norfolk coast where the oldest evidence of human occupation was put at either MIS 21 (866-814,000 yrs BP) or MIS 25 (970 – 936,000 yrs BP) (Parfitt *et al*., 2010), suggesting an equivalence with the Sudbury Formation. This however was contested by Westaway (2011) who suggested that although the basal deposits at Happisburgh may be Early Pleistocene, the beds above should be dated to MIS 15c (*c*.600,000 yrs BP), suggesting the equivalence is with the Colchester Formation.

4 METHODOLOGY

4.1 Data sources

Data sources used in this project include information on the superficial and bedrock stratigraphy, known Palaeolithic archaeological sites and findspots, Pleistocene sites of local significance and mineral working information. In addition the information from previous ALSF GIS projects and geodiversity projects were utilised.
The main data sources included:

Geological compiled by the British Geological Survey. The 50k superficial digital information formed the basis of the mapping component of the project. Bedrock data was also used in areas where no superficial geology is mapped.

Borehole data held by the British Geological Survey was used by the geological specialist to supplement Lithological Unit descriptions and significant recorded lithologies were digitally plotted where provided by the specialist.

Essex Historic Environment Records have all recorded archaeological sites available as digital (findspot and polygon) data

Portable Antiquities Scheme have records of Palaeolithic finds reported to the scheme in digital (findspot) data

Minerals data held by Essex County Council. Information concerning past present and future mineral extraction sites in digital form (ESRI polygon shapefiles)

Gazetteer of Pleistocene sites in Essex as compiled by Gerald Lucy was plotted as GIS digital data with background information on many non-statutory sites of geological importance

Geological SSSI (Sites of Specialist Scientific Interest) of Pleistocene significance was supplied and mapped as digital data (ESRI polygon shapefiles) by Natural England

4.2 GIS

The GIS is the prime medium through which the project will present its results to the 'end users' such as EH, the Essex HER and the Essex Historic Environment Consultants who provide advice on planning applications to the Districts and Local Authorities in Essex. The project results will consist of a single ESRI polygon shapefile with attribute data providing information on the zones of Palaeolithic potential and 14 separate LU descriptions which will be hyperlinked to the ESRI shapefile and viewable as word documents within GIS projects.

4.2.1 Metadata and data catalogue

English Heritage requires all metadata to follow the latest version of the UK GEMINI metadata standard – currently this is version 2.1 – to ensure INSPIRE compliance. Metadata for ESRI shape files has been created through ArcCatalog (part of the ArcGIS 10 package). This metadata can be stored alongside the data source as a XML file.

BGS Superficial and bedrock geology mapping is supplied at a scale of 50k. The geological data is not licensed for further distribution; the resultant polygons created do not reproduce the BGS data as it is supplied and has been verified by BGS to be allowed to be distributed onwards.

OS Base mapping was 1: 25k and 1: 10k scale
OS Contours (5m)

A data catalogue will be circulated with the shapefiles which contains a short summary explaining the content, quality, condition, and other characteristics of the data.

4.3 EHER data extraction

A HER Search was conducted using 'Date' as the main search criteria, using the Monument search tab where Monument type = (BLANK) and date =

(PALAEOLITHIC). A total of 1087 records were identified and monument details exported.

The assessment sheets for each record were filtered by using information from the description field. The search had included many non-Palaeolithic records whose date range had been entered using a standardised date range of 'Lower Palaeolithic to Late Bronze Age' where a more accurate date had not been possible (for instance a large number of cropmark sites had been included). These records were reviewed and removed where the description did not state an identified Palaeolithic age flint or find. These records were exported to a separate shapefile in case further information allowed them to be confirmed as of Palaeolithic date.

In addition any findspot records with a non-specific grid reference (i.e. only to parish level or 4 figure) were removed if they could not be more accurately located from the information provided in the description.

The final GIS shapefile (point) of Palaeolithic finds contained 225 records (APPENDIX 1)

4.4 Lithological Unit creation

The Lithological Units are based on the paper and digital BGS 50k mapping supplemented by borehole information and current understanding of significant Pleistocene geologies researched and mapped by geoarchaeological and Quaternary geological specialists. The work was carried out by Dr Peter Allen.

The mapping of geological boundaries of soft rock deposits is often, unavoidably, imprecise. For instance a unit may just peter out, getting thinner and thinner, or patches of a younger overlying deposit may occur beyond the limit of its main outcrop. In these cases it can be difficult to convey the situation with a simple line on a map. With the above proviso, in most cases the boundaries on the map are usually representative to within a few tens of metres.

Over 40 separate superficial lithological categories (attribute LEX-D in digital 50k mapping) are mapped by the BGS within the county of Essex, 32 of these are Pleistocene sediments. These were plotted according to the BGS classification and supplied to the specialist as paper maps. The BGS Pleistocene geologies were then grouped into 14 separate lithological units according to the main characteristics of the sediment(s) (Table 3).

The resultant LU polygons have the same spatial extent as the BGS polygons. Information on the sediment type, origin, size and environment of deposition was provided by the specialist. Each LU had a separate ESRI GIS shapefile which contained only the polygons of the BGS geologies that had been assigned to that LU.

The Lithological Units include:

1_Stanmore Gravel

2_Kesgrave Gravels_Sudbury

3_Kesgrave Gravels_Colchester

4_Terrace Interglacial/Interstadial deposits

5_Woodford Gravel

6_High-Level East Essex Gravel

7_Glacial/Glaciofluvial deposits

8_Glacial/Interglacial Lacustrine deposits

9_Lower Thames terrace gravels

10_Low-Level East Essex Gravel

11_Terraces of the Essex Rivers

12_Brickearth (Pleistocene) on Thames terraces

13_Brickearth (Devensian) across central and eastern Essex

14_Tufa

The Lithological Unit description was provided to the Palaeolithic specialist, Dr Francis Wenban-Smith along with pdf copies of the mapped LU data overlaid with HER and PAS data and supplied with the full HER record description. This allowed an assessment of the LU to be made in terms of its potential for containing or being associated with Palaeolithic archaeological remains.

Table 2 illustrates the approach to the HER data and LU information. The interpretation of the HER data in relation to the LUs is provided in APPENDIX 3.

Table 3. Creation of LUs from BGS categories

BGS NAME	**PARTICLE SIZE**	**LITHOLOGICAL UNIT**	**LU Number**
STANMORE GRAVEL FORMATION	SV	Stanmore gravel	**1**
KESGRAVE CATCHMENT SUBGROUP	SV	KesgraveGravel_Sudbury	**2**
KESGRAVE FORMATION AND LOWESTOFT FORMATION (UNDIFFERENTIATED)	SV	KesgraveGravel_Colchester	**3**
INTERGLACIAL SILT AND CLAY	XCZ	Interglacial/Interstadial	**4**
WOODFORD GRAVEL FORMATION	SG	Woodford Gravel	**5**
RIVER TERRACE DEPOSITS, 4	SV	High-Level East Essex gravels	**6**
GLACIOFLUVIAL DEPOSITS, MID PLEISTOCENE	SV	Glacial-glaciofluvial	**7**
LOWESTOFT FORMATION	DIAMICTON		
LOWESTOFT FORMATION	CZ		
LOWESTOFT FORMATION	SV		
INTERGLACIAL LACUSTRINE DEPOSITS	CZ	Lacustrine Deposits	**8**
GLACIOLACUSTRINE DEPOSITS, MID PLEISTOCENE	CZS		
BLACK PARK GRAVEL MEMBER	SV	Lower Thames Terrace	**9**
HACKNEY GRAVEL MEMBER	SV		
TAPLOW GRAVEL FORMATION MEMBER	SV		
BOYN HILL GRAVEL MEMBER	SV		
KEMPTON PARK GRAVEL FORMATION	SV		
LYNCH HILL GRAVEL	SV		
RIVER TERRACE DEPOSITS, 1	SV	Part Low-Level East Essex Gravels	**10**
RIVER TERRACE DEPOSITS, 1 TO 2	SV		
RIVER TERRACE DEPOSITS, 1 TO 3	SV		
RIVER TERRACE DEPOSITS, 2	SV		

BGS NAME	PARTICLE SIZE	LITHOLOGICAL UNIT	LU Number
RIVER TERRACE DEPOSITS, 1	SV	Terraces of the Essex rivers	**11**
RIVER TERRACE DEPOSITS, 1 TO 3	CZ		
RIVER TERRACE DEPOSITS, 2	CZ		
RIVER TERRACE DEPOSITS, 2 TO 3	CZ		
RIVER TERRACE DEPOSITS, 3	SV		
RIVER TERRACE DEPOSITS, 4 TO 5	CZ		
RIVER TERRACE DEPOSITS, 5	SG		
RIVER TERRACE DEPOSITS (UNDIFFERENTIATED)	SV		
RIVER TERRACE DEPOSITS (UNDIFFERENTIATED)	CZ		
ILFORD SILT MEMBER	SV	Brickearth Pleistocene	**12**
BRICKEARTH	CZS	Brickearth Devensian	**13**
COVERSAND	CZS		
RODING SILT MEMBER	CZ		
TUFA	TUFA	Tufa	**14**

4.5 Creation of areas of Palaeolithic potential (PPAs)

The main aim of the methodology is to identify areas that can be characterised by their potential for the presence and survival of Palaeolithic archaeological remains and/or associated Pleistocene palaeoenvironmental remains (Palaeolithic Potential Areas).

Stage 1- Add GIS datasets and identify direct associations for LUs

Information to be mapped

Lithological Units	Polygon data
HER	Point data
PAS (Portable Antiquities Scheme) data	Point data
Mineral extraction sites	Polygon data
LOGS/Pleistocene sites from Essex Gazetteer	Point data
Geological SSSI's of known Palaeolithic (or Quaternary) potential	Polygon data
Previous ALSF projects	Polygon data
Contour data	Line data
Borehole data (where available)	Point
Tendring Geodiversity Character areas	Polygon

Each LU layer was added to a GIS map separately in order of age with LU 1 deemed to be the oldest stratigraphic unit and LU 14 the youngest.

Each LU was assigned a 'baseline' score based on the LU descriptions as provided by the specialists which had taken into account the nature of the sediment itself and the potential for that sediment to contain and preserve Palaeolithic archaeological evidence and/or Pleistocene environmental evidence.

Each separate layer of Lithological Unit polygons were then overlaid with the GIS datasets above and assessed to identify any spatial correlations between the LUs and the datasets which provide direct or indirect evidence for the presence of Palaeolithic remains within the LU layer.

A GIS search was carried out using ‘Search by location’ which then selected any LU polygons which ‘intersected with the source’ datasets The selected polygons from the LU layer could then be assessed and extracted from the original LU layer into a new shapefile (PPA). The information relating to the GIS datasets was added to the attributes of each PPA.

Due to the number of multiple ‘merged’ polygons associated with BGS mapping this often involved having to ‘explode’ a single LU into its many component parts (polygons), selecting the relevant individual polygons which had been selected according to the search criteria and extracting them from the LU layer to the PPA shapefile.

The remaining polygons from the LU layer which had no direct association with any of the GIS datasets were then merged back into a single multi-polygon feature and added to the PPA shapefile.

Areas known to have been quarried were cut out as separate polygons to enable recognition for potential loss of the Pleistocene resource within former or current mineral extraction areas.

Stage 2- refinement with data from adjoining LU layers

As each PPA polygon was ‘created’ from the source LU layer the relationship to any adjacent polygons was assessed to determine whether the adjoining polygons had an impact on the potential. This would largely be determined by a direct spatial relationship to areas of higher potential where all or part of the polygon boundaries were in direct contact.

In areas where borehole data, either plotted or provided within the Lithological Unit description, or information from the plotting of the LoGs or Geological SSSIs indicated that an adjoining LU of higher potential was likely to lay below the superficial mapped LU then a stratigraphic relationship could be determined within the areas including and surrounding the GIS dataset feature.

Where the added LU was made up of discrete polygons as mapped by the BGS (which was often the case for geologies such as gravel outcrops, interglacial sediments etc.) any polygons which displayed a direct relationship to the adjoining or adjacent LU of higher potential would be selected and 'cut' as a single polygon feature. The full extent of the 'cut' polygon thus acted as a 'buffer'.

Where the LU layer was not mapped as a series of discrete individual polygons but as a large single or spread of polygons, such as the distribution of glacial deposits or brickearth, a defined area of the LU polygon would be 'cut out' around the GIS datasets to indicate the possible presence of an unmapped higher potential LU deposit upon or below the superficial mapped LU. This often exhibited at margins of glacial deposits. The extent of the buffer could be variable according to various topographical features including height, slope, aspect etc. The buffer was up to 500m distance from the source GIS dataset.

Stage 3- adding and analysis of non-LU layers

Once each LU had been added and zones of Palaeolithic potential created non-Pleistocene data was added to the map as separate GIS layers and where possible zones of Palaeolithic potential were identified. Bedrock and non-Pleistocene geologies were taken as having 'zero' potential for the presence of Palaeolithic archaeological evidence and/or Pleistocene environmental remains. Their final score was then a reflection of the potential for the presence of either unmapped Pleistocene geology to be present, possible reworked Palaeolithic or Pleistocene remains to be present or, where it could be demonstrated that Pleistocene LUs of higher potential could be present below later Holocene deposits.

The bedrock geology was cut out in the areas where it was shown by the BGS mapping to be at surface (i.e. where no superficial geology data existed) and added to a GIS map. Bedrock geology that was mapped as being at the surface was assessed according to the above datasets only in order to identify areas where finds have been seen to be recovered despite the source of the finds being unknown. A suitable buffer would be drawn around the concentration or group which would be based on a visual assessment of the extent of the concentration rather than a fixed distance. In practise this often involved assessment of the surrounding topographical features or any characteristics identified from the remaining GIS datasets such as the proximity to a potential source of the findspot. The buffer would be less than 500m from the source GIS dataset.

The more recent, Holocene geologies as identified by BGS were added as layers and, where possible, divided into areas where there may be more potential for underlying Pleistocene deposits to contain Palaeolithic archaeology. This was possible where borehole data or Pleistocene sites identified in the Gazetteer had been plotted or in areas where the Holocene deposits were likely to overlie more significant Pleistocene deposits such as at the boundaries of the two deposits. Again a suitable buffer distance would be drawn along the appropriate margins of the Holocene PPA polygon. This ranged between 50m and 500m depending on the level of information that could be gained from the source GIS datasets.

Stage 4- Integration of ALSF data

Cross referencing with the three ASLF projects was carried out once the polygons had been created based on the available GIS datasets and then refined using the ALSF data. The ALSF id information was added to the attribute data.

Stage 5 - Scoring

Scoring <u>definitions</u>:

Very High- Known association of **LU** with Palaeolithic archaeology and/or significant Pleistocene faunal and/or floral remains (as established through specialist interpretation and description) **<u>and:</u>**

- direct evidence of known archaeological remains (eg accurately sourced and relatively well provenanced HER/PAS data)
- direct spatial association and relationship between other GIS datasets and **LU**

In addition to the above the PPA needs to fulfil the criteria below to be considered VERY HIGH Potential:

- **LU** sediments are deposited under climatic conditions, temperate or cold, suitable for human occupation and current understanding indicates known contemporary occupation

- **LU** sediments are deposited under conditions suitable for good preservation and survival of Palaeolithic archaeology and/or Pleistocene faunal/floral remains
- likelihood for good survival of Palaeolithic remains and/or Pleistocene faunal/floral remains based on the characteristics of the associated **LU**
- potential for retrieval of significant Palaeolithic archaeological remains and/or Pleistocene remains based on the characteristics of the associated **LU**

High- Known association of **LU** with Palaeolithic archaeology and/or significant Pleistocene faunal and/or floral remains (as established through specialist interpretation and description) **and:**

- direct evidence of isolated archaeological remains (such as single findspots) or archaeological remains which are not accurately located (less than 6 figure grid reference) or well provenanced.
- indirect evidence of known archaeological remains, such as being adjacent to and sharing a boundary with a PPA of either very high potential with the equivalent LU or a PPA which has recorded archaeological remains with a different LU. The relationship may be visible between surface (spatial) deposits or be indicated through stratigraphic relationships (temporal)

In addition to the above the PPA needs to fulfil the criteria below to be considered HIGH Potential:

- LU has direct evidence such as borehole data or GIS datasets to demonstrate it is either an unmapped deposit OR it survives at depth
- Sediments are deposited under climatic conditions, temperate or cold, suitable for human occupation
- Sediments are deposited under conditions possibly less suitable for good preservation and survival of Palaeolithic archaeology and/or Pleistocene faunal remains
- Likelihood for reasonable survival of Palaeolithic remains and/or Pleistocene faunal remains

- Potential for reasonable retrieval of Palaeolithic archaeological remains and/or Pleistocene remains

Moderate- Indirect association OR potential for presence of unmapped **LUs** with Palaeolithic archaeology and/or significant Pleistocene faunal and/or floral remains, (as established through specialist interpretation and description) including**:**

- Spatial association (sharing a boundary) of LU to PPAs of high potential
- Areas of Pleistocene geology with isolated or derived Palaeolithic findspot evidence where the source of Palaeolithic material is unlikely to be directly related to the mapped superficial LU
- Areas of pre-Pleistocene bedrock with recorded evidence for Palaeolithic archaeological findspots within close proximity of LUs with Palaeolithic potential
- Areas of Holocene deposits with recorded evidence for Palaeolithic archaeological findspots within close proximity of LUs with Palaeolithic potential

Low- No known direct or indirect association with Palaeolithic archaeology and/or significant Pleistocene faunal and/or floral remains but with some potential for as yet undiscovered remains (as established through specialist interpretation and description). Includes:

- Areas with no known association of LU to Palaeolithic remains at present but within timescale of currently known human occupation of area
- Areas of pre-Pleistocene bedrock with no close proximity to recorded evidence for Palaeolithic archaeological findspots
- Sites known to have had much of the Pleistocene LU extracted or removed due to extraction/development
- LUs deposited under conditions prohibitive to human occupation

- Large areas of Pleistocene geologies with no indications of having bioenvironmental information but adjacent to more significant Pleistocene LUs

Zero - No association with Palaeolithic archaeology and/or significant Pleistocene faunal and/or floral remains (as established through specialist interpretation and description). Includes:

- Areas of total previous extraction of Pleistocene sediments
- Undisputed pre-Pleistocene bedrock with no boundaries to any Pleistocene geological deposits with potential for Palaeolithic archaeological or Pleistocene faunal/floral remains.

Uncertain - Should there be no available data to provide a sound judgement on the Palaeolithic potential then the PPA may be categorised as uncertain

Stage 6 – assigning attributes and hyperlinks

Each PPA will have a polygon and a list of attributes associated with it. There will be a hyperlink to a pdf document of the LU or LUs that the PPA is within which will provide the information about the sediment and the general Palaeolithic potential of the LU or LUs.

5 RESULTS

5.1 Gazetteer of Essex Pleistocene sites

The Gazetteer provided 200 sites (**Fig. 5**) of recorded Pleistocene geology within Essex, some were already designated as SSSIs (19), one is locally listed site of geological interest (LoGS/former RIGS). However the remaining *c.*180 added further information on the Pleistocene deposits within Essex beyond the mapped BGS data. This was possible largely because the data was taken from many historic quarry areas/sites where the Pleistocene geology would have been covered by later deposits and so mapped as such by the BGS. This data is especially useful for trying to categorise the Palaeolithic potential in areas mapped as Head and Alluvial deposits.

The data was plotted according to the main sediment type that the site was recorded for to enable quick assessment for the PPA creation. A basic description of the site was added to the attribute data (**APPENDIX 2**).

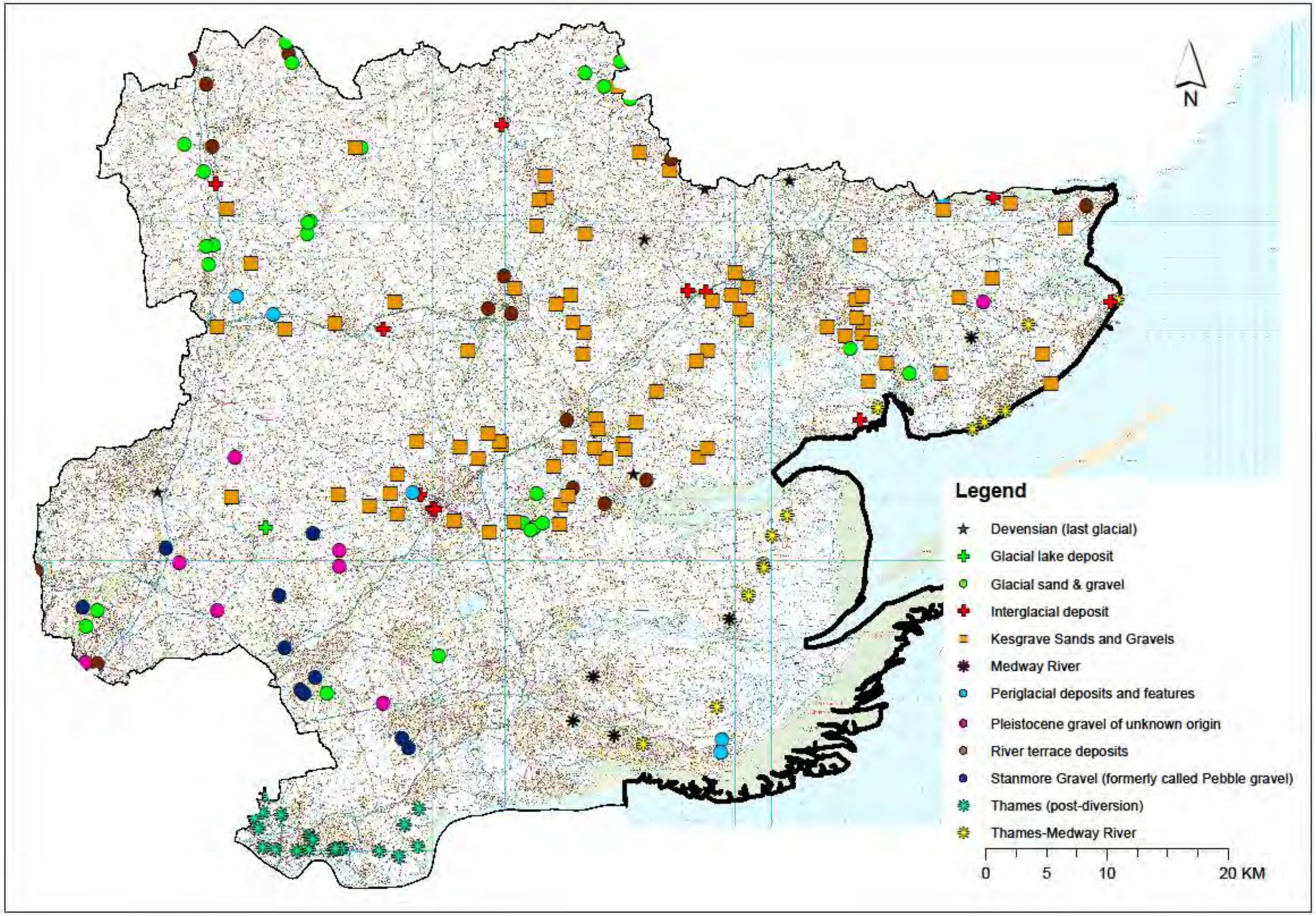

Figure 5. Essex Pleistocene sites (Lucy, G)

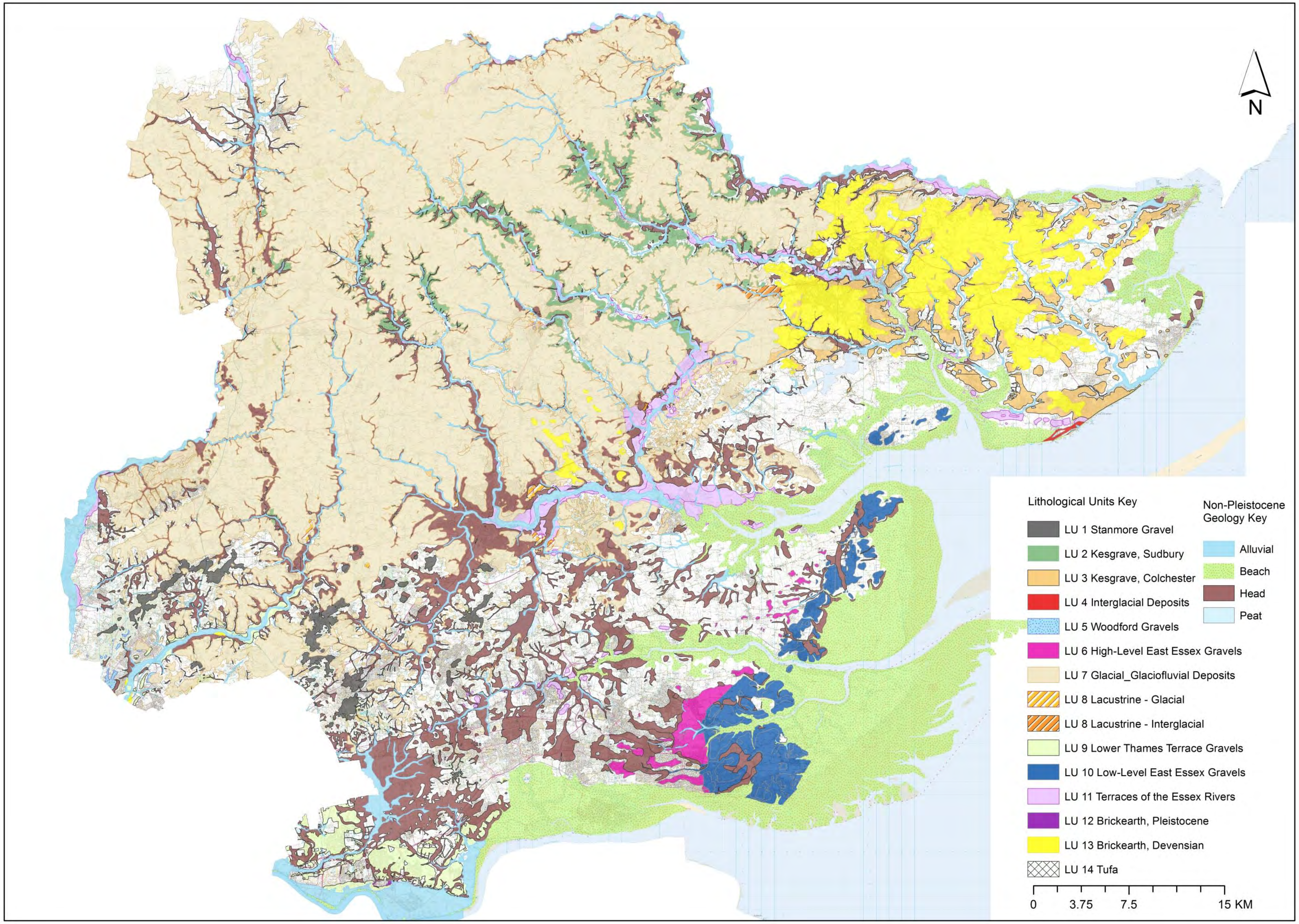

Figure 6 Lithological Units

5.2 Lithological Units descriptions

See **Figure 6**.

5.2.1 LITHOLOGICAL UNIT 1 - Stanmore Gravel

(Warley Gravel, Pebble Gravel)

Age

1.5 million years ago

Summary background

These gravels occur in limited spreads and are usually confined to hill-tops. Their limited outcrops are distributed widely, mostly over Hertfordshire and Essex, and their equivocal sedimentology and lithology makes it difficult to assess their origin and to correlate them. Dines and Edmunds (1925) called them Warley Gravel at Warley and Stock, but Pebble Gravel at High Beach and Westleigh Heights (Basildon). The history of the deposits is discussed in detail by Bridgland (1994) and by Ellison (2004).

Their position in the landscape, above the Kesgrave Sands and Gravels, means they are of great antiquity, possibly dated to1.5 million years ago (e.g. Westaway *et al.*, 2002)

Sediment composition and environment of deposition

The lithology varies between outcrops but frequently rounded flints are dominant, which together with diagnostic surface features on the surface of the sand grains, have led some authors to suggest that the deposits are of marine origin (Wooldridge, 1960; Hey *et al.*, 1971; Ellison, 2004). Ellison noted that the altitudes of the outcrops form a widespread surface that declines to the north-east, reflecting the base of the Red Crag, and suggested that they are of shallow marine origin associated with the retreat of the Red Crag Sea.

Other authors, notably Bridgland (1994), argued that the deposits are fluvial in origin, noting locally that the outcrops can be correlated to indicate that they accumulated on a steep gradient and that they have up to 10% Greensand chert, suggesting that the outcrops are part of a series of linear deposits laid down by rivers from the Weald flowing across Hertfordshire and Essex to an early course of the Thames.

Palaeolithic and palaeoenvironmental potential

The deposits are dated to around 1.5 million years ago, well before the oldest known (to date!) human presence in Britain at Happisburgh, postulated at a maximum of 950,000 years ago. Thus the archaeological potential of the deposit is *a priori* very low indeed. However it is not absolutely inconceivable that hominins might have ventured briefly into Britain at some point contemporary with the presumed formation of these deposits, as early hominins were migrating into western Asia and southern Europe at this time. The likelihood of finding any evidence of such an incursion (which is in any case already very low) further depends upon whether the deposits are regarded as of marine or fluvial origin. In the former case it would be unlikely that marine sediments would contain any evidence; conversely, if the sediments were fluvially laid down, they could (as with fluvial gravels of later periods) contain lithic remains of contemporary early hominin presence. However on present evidence these deposits can be regarded as of very low potential.

Nonetheless, one findspot is associated with LU 1 (**Table 2**). However, the findspot is only generally located and the finds are not well-provenanced. Furthermore, the fact that they constitute handaxes makes it highly unlikely that they relate to occupation more than 1 million years BP [Before Present]. They presumably originate from unmapped LU 7 glacial deposits [in which case they are likely to be derived from pre-Anglian deposits], or from unmapped Head deposits [in which case they could be of any age from MIS 13 through to MIS 8].

A full list of sites where this Unit is or has been exposed is available in the Gazetteer under SITE TYPE – Stanmore Gravel. Some sites listed under - Pleistocene gravel of unknown origin – may be Stanmore Gravel (**APPENDIX 2**)

5.2.2 LITHOLOGICAL UNIT 2 -Kesgrave Gravels (Sudbury Formation)

Age

MIS >30 to MIS 19, from about 1 million years ago to about 780,000 years ago (Rose, 2010)

MIS *c.* 27 to MIS 16-17, from about 1 million years ago to about 650,000 years ago (Westaway, 2011)

Summary background

Trending southwest – northeast in central Essex, mostly beneath the till (boulder clay) cover, extensive linear areas of sands and gravels, the Kesgrave Sands and Gravels, mark very early courses of the Thames, originating from the Midlands or beyond (**Figure 7**). These sands and gravels were deposited over about 300,000 years, covering 10 or more cold – warm cycles. Changes in the proportions of the lithologies and analyses of the gradients of the river indicate that at around MIS 16 - 19 (*c.*700,000 years ago) the extended headwaters were lost and the catchment retracted to within the Cotswold crest. Consequently the Kesgrave Sands and Gravels are divided into the Sudbury (extensive catchment) and Colchester (reduced catchment) Formations. The former is dealt with here.

Within the Sudbury Formation, there are five Members, each representing a buried terrace beneath till (boulder clay) (**Table 1**).

- Moreton Gravel	MIS 16
- Bures/Baylham Common Gravel	MIS 18
- Stebbing Gravel	MIS 20
- Bushett Farm Gravel	MIS >20

There is a mismatch between the morphological and sedimentary evidence of four terraces and the number of climatic cycles, five or more. However, the magnitude of the cycles varies (**Figure 3**) and some may not have been sufficient to trigger the terrace formation process.

The Sudbury Formation Thames was joined by south bank tributaries, the most important being the Medway crossing eastern Essex depositing the High-level East Essex Gravel. The confluence of the Medway and the Thames was offshore of the present coast at the time.

In the western part of Essex, the track of the younger Colchester Formation was within that of the Sudbury Formation so, when downcutting occurred in the time between the two Formations, the Moreton Gravel became isolated from the other Members of the Sudbury Formation (**Figure 7**).

The Kesgrave Thames was over-run by ice during the Anglian glaciation, *c.*450,000 years ago, and diverted into its present valley. Consequently the sands and gravels are mostly covered by till (boulder clay) usually up to 5m thick, and also, in places, by glacial outwash, up to 2m thick. However, the Sudbury Formation is exposed in the sides of the deeper valleys and many quarries penetrate the till (boulder clay) to reach it.

Sediment composition and environment of deposition

Whilst the predominant lithology of the Kesgrave Sands and Gravels is flint from the London Basin, Chilterns and North Downs, minor elements indicate an extensive catchment, with igneous rocks from North Wales, quartzites from the Midlands, vein quartz from the south-east Wales or the southern Pennines, and various cherts from the Pennines and Kent/Surrey. A high proportion of the flints are angular or sub-angular indicating frost shattering, though blunted by subsequent transport by the river, and many show rounded indentations (pots) where frost has caused breakage of the flint surface (lids). The sedimentary structures are dominated by gravel bars separated by channel sands, indicative of periglacial braided river deposition, similar to rivers in the Arctic today.

After deposition, the gravels formed a sequence of flat terrace surfaces in the landscape on which a soil formed, which became complex as it passed through 10 or more warm stages and cold stages. During the warm stages a temperate soil developed, the Valley Farm Soil, now recognised by preservation of its sub-soil B horizon, enriched in iron and clay by the downward passage of groundwater, the iron causing a degree of reddening. This temperate element of the palaeosol is usually disturbed by periglacial involutions, ice-wedge casts and sand wedges, formed in later cold stages as the Barham Soil. As it is the lower horizons of the palaeosol that are preserved, the upper horizons have been eroded, hence reducing the likelihood of finding lithic or bioenvironmental material. As yet no lithic finds or significant bioenvironmental information have been recovered from the Sudbury Formation.

Palaeolithic and palaeoenvironmental potential

If the older age attribution of Parfitt *et al* (2010) is taken, the Sudbury Formation (*c*.MIS 30 to 16 – 19, *c*.1 million to 780 – 650,000 yrs BP) mostly corresponds to the oldest known human occupation of Britain, postulated at a maximum of *c*.950,000 years ago, from discoveries at Happisburgh (Norfolk). Thus it is not inconceivable that hominins might have ventured briefly into Essex at this time and that fluvial deposits of this era might contain lithic evidence of hominin presence. Any such presence would correspond with warmer climatic conditions, so any deposits with evidence of temperate palaeosol formation (such as the Valley Farm soil) could be regarded as of higher potential.

There is some uncertainty at Happisburgh whether the hominin occupation dates to MIS 21 (*c.*850,000 BP) or MIS 25 (*c.*950,000 BP) (Parfitt *et al*, 2010). This means that establishing whether or not there is hominin presence at the time of the Sudbury Formation that cover the age range 950,000 through to 650,000 BP is an important research question that can clarify the known date of the earliest occupation of Britain. Particular attention should be paid to evidence of temperate soil formation in this time range, which might correspond with the Happisburgh occupation. The recovery of palaeoenvironmental and dating information would be important (even in the absence of lithic artefact remains). This could clarify the chronostratigraphic relationship with the Happisburgh evidence, thus helping to improve dating of the latter. It would also contextualise any future recovery of lithic remains from any stratigraphically related deposits.

Two Palaeolithic findspots are associated with LU 2 (**Table 2**). One of these (HER 4609) is accurately located but lacking in good provenance. The reported presence of Levallois flint artefacts and the nearby presence of outcrops of LU 8 (MIS 11 lacustrine deposits) and LU 11 (post-Anglian Essex River terraces) both suggest that this findspot is not good evidence of material from LU 2.

However the other findspot (HER 6318, Hunnable's Gravel Pit) is more promising. There is better provenance to the gravel deposits, and the reported finds include elephant and horse fossils as well as Palaeolithic implements, all of which could be compatible with a very early date. Alternatively, these remains could likewise originate from unmapped post-Anglian deposits (Head or river terrace) in the vicinity.

An ancient land surface is evidenced by the Valley Farm (warm stage) and Barham (cold stage) Soils, which have been recorded in Essex between Ongar and Coggeshall. One might hope to find evidence of occupation associated with the temperate Valley Farm soil in this area, and with other temperate soils that might be present in the wider Kesgrave-Sudbury Formation.

There are relatively few findspots associated with LU 2 in contrast with an abundant finds (Essex HER, n=13) associated with LU 3.

Sites

A full list of sites where this Unit is or has been exposed is available in the Gazetteer under SITE TYPE - Kesgrave Sands and Gravels (Sudbury and Colchester Formations are not separated; insufficient research done to categorise all sites). (APPENDIX 2)

Moreton (pit closed)

?Hallsbridge, Ongar (?pit closed)

Bradwell/Rivenhall, where a clay is recorded within or overlying the Sudbury Formation (BGS MAU BH TL82SW 6, 8156 2146)

Shalford (?pit closed)

Beasley End (?pit closed)

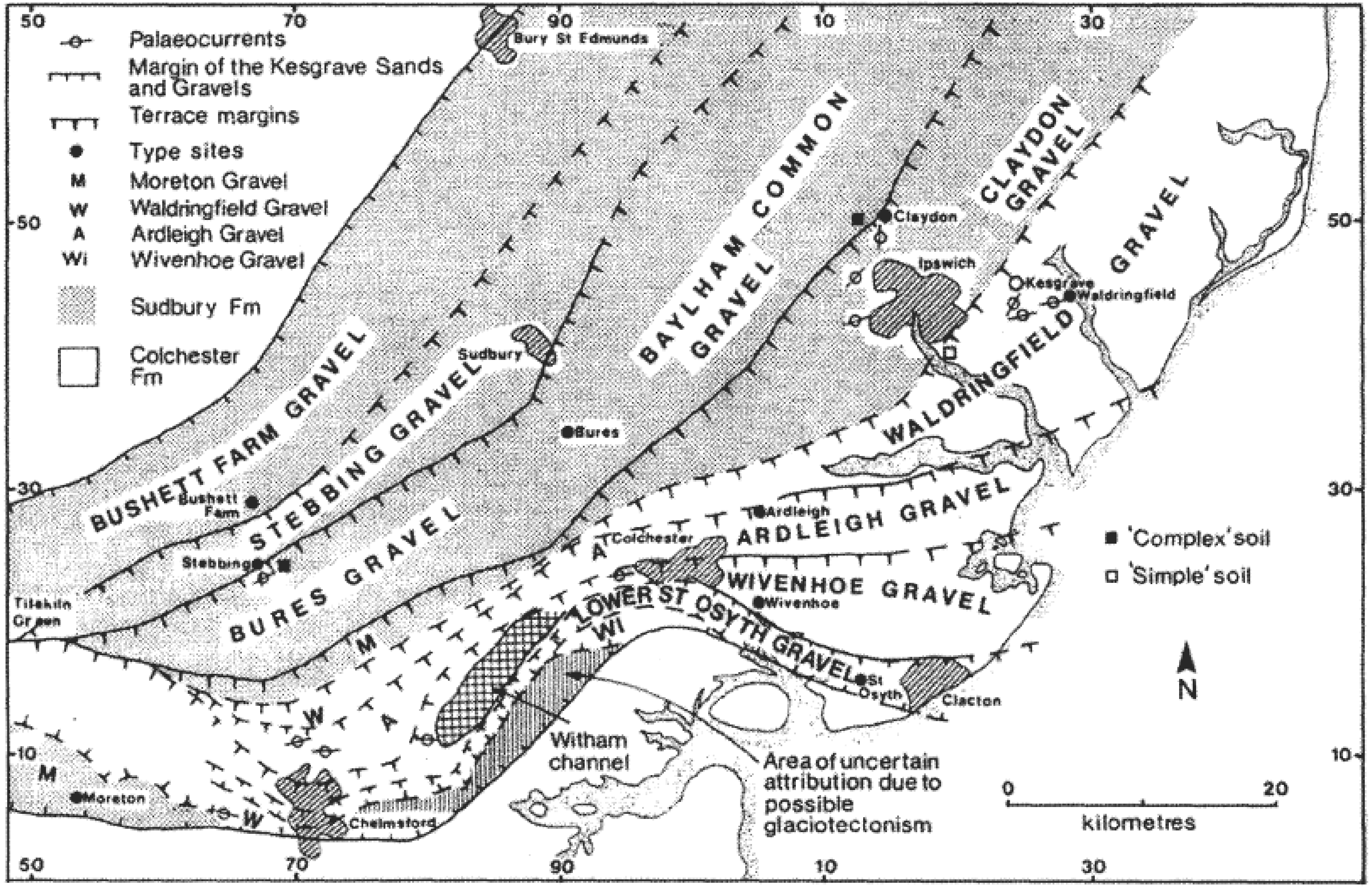

Figure 7. Distribution of the Sudbury and Colchester Formations of the Kesgrave Sands and Gravels (Whiteman, 1992)

5.2.3 LITHOLOGICAL UNIT 3 - Kesgrave Gravels_Colchester Formation

Age

MIS 19, *c.*780,000 BP (Rose, 2010) or MIS 16-17, *c.*650,000 BP (Westaway, 2011) to MIS 12 , *c.*450,00 yrs BP

Summary background

Extensive linear areas of sands and gravels, the Kesgrave Sands and Gravels, trending southwest-northeast across central Essex mark very early courses of the Thames, extending from the Midlands or beyond. Changes in the proportions of the lithologies and analyses of the gradients of the river indicate that at about MIS 19 or 16 - 17 (*c.*700,000 years ago) the extended headwaters were lost and the catchment retracted to within the Cotswolds. These sands and gravels were deposited over a long period time, from MIS 19 or 16-17 (*c.*700.00 years ago) to MIS 12, (*c.*450,000 years ago), representing 6 cold – warm cycles. Consequently the Kesgrave Sands and Gravels are divided into the older Sudbury (extensive catchment) and the younger Colchester (reduced catchment) Formations. The Colchester Formation is dealt with here.

Within the Colchester Formation, there are four Members, each representing a terrace (**Table 1**).

St Osyth Gravel	
St Osyth Upper Gravel	MIS 12 (full glacial)
St Osyth Lower Gravel	MIS 12 (early)
Wivenhoe Gravel	
Wivenhoe Upper gravel	MIS 13
Wivenhoe interglacial deposits	MIS 13
Wivenhoe Lower Gravel	MIS 14
Ardleigh Gravel	
Ardleigh Upper Gravel	MIS 14

Ardleigh interglacial deposits	MIS 15
Ardleigh Lower Gravel	MIS 16
Waldringfield Gravel	MIS 16

As yet no interglacial deposits from MIS 17 have been found within the Waldringfield Gravel. The St Osyth Gravels represent the early part of the MIS 12-11-10 climatic cycle, the interglacial MIS 11 element being represented by the Clacton Channel deposits.

In the western part of Essex, the track of the Colchester Formation was within that of the Sudbury Formation so, when downcutting occurred in the time between the two Formations, the Moreton Gravel became isolated from the other Members of the older Sudbury Formation. In a similar fashion, within the Colchester Formation, the Lower St Osyth Gravel incises into the Wivenhoe Gravel.

West and north of Colchester, the Kesgrave Thames was over-run by ice during the Anglian glaciation, *c.*480,000 years ago, and diverted into its present valley. Consequently the sands and gravels are mostly covered by till (boulder clay) usually up to 5m thick, and also, in places, by glacial outwash, up to *c.*2m thick. However, beyond the till (boulder clay) limit, in the Colchester area and to the south-east, in the Tendring peninsula, the Colchester Formation occurs at or near the present ground surface. The early Medway confluence with the early Thames had by Colchester Formation times migrated to the Tendring peninsula and its changing position is shown in **Figures 8 - 11**.

Sediment composition and environment of deposition

Whilst the predominant lithology of the gravels is flint from the London Basin, Chilterns and North Downs, elements such as cherts from the Pennines and the Weald area of Kent/Surrey indicate a more extensive catchment. There are also minor elements of igneous rocks from North Wales, quartzites from the Midlands, vein quartz from the south-east Wales or the southern Pennines and various cherts from the Pennines, but these occur in lower percentages than in the Sudbury Formation and are taken to be reworked from the older Formation. Reconstructions of the gradients (long profiles) of the river do not clear the lowest col though the

Cotswolds. These factors are taken to indicate that the headwaters had retreated to downslope of the Cotswold crest.

A high proportion of the flints are angular or sub-angular indicating frost shattering, though blunted during subsequent transport by the river, and many show rounded indentations (pots) where frost has caused breakage of the flint surface (lids). The sedimentary structures are dominated by gravel bars separated by channel sands, indicative of periglacial braided river deposition, similar to rivers in the Arctic today. During periods of stability within the cold stages, very occasionally arctic vegetation developed, now marked by peat, as at Ardleigh.

After deposition, the gravels formed a sequence of flat terrace surfaces in the landscape on which a soil formed, which became complex as it passed through 10 or more warm stages and cold stages. During the warm stages a temperate soil developed, the Valley Farm Soil, now recognised by preservation of its sub-soil B horizon, enriched in iron and clay by the downward passage of groundwater, the iron causing a degree of reddening. This temperate element of the palaeosol is usually disturbed by periglacial involutions, ice-wedge casts and sand wedges, formed in later cold stages as the Barham Soil. The palaeosol becomes less complex on the lower terraces as it passed through fewer climatic cycles. As it is the lower horizons of the palaeosol that are preserved, the upper horizons have been eroded, hence reducing the likelihood of finding lithic material.

A detailed assessment of the boreholes penetrating through the Kesgrave Sands and Gravels, particularly the Colchester Formation, will be needed to identify further sites.

Palaeolithic and palaeoenvironmental potential

One might think that there is little potential within the gravels of the Colchester Formation for Palaeolithic archaeology and for palaeoenvironmental information, as the gravels are thought to represent vigorous deposition during a cold environment inhospitable to human colonisation. However, they represent a time period of 200,000 or 300,000 years prior to the onset of the Anglian glaciation during which there was known to be periodic occupation of Britain. This includes a number of rich archaeological sites such as the Caversham Ancient Channel (Berkshire), Pakefield (the Norfolk Coast), High Lodge, Culford, Warren Hill (Suffolk), Boxgrove (West Sussex) and, if the MIS 15c dating of Westaway (2011) is accepted, Happisburgh. So far as is known, occupation was restricted to more-temperate episodes (not just peak interglacials), and Britain was unoccupied during the colder glacial episodes. Thus there is potential within the gravels of this period both for derived occupational evidence in cold climate gravel deposits, and also for the scarce (but very important, if detected) occurrence of less disturbed evidence in fine-grained horizons or buried land surfaces within the Formation that represent interglacial deposits from this time range. Some of these are known and mapped, included here as LU 4.

Interestingly, bearing in mind the presently known history of occupation of Britain (very sporadic before MIS 15, but with more common sites known from the Cromerian complex covering MIS 15 through to the onset of MIS 12, the Anglian glaciation), this pattern is represented in the Essex HER. There are relatively abundant findspots associated with LU 3 in contrast to the very few associated with LU 2. There are 13 findspots that can reasonably, and sometimes definitively, be associated with mapped outcrops of LU 3 (**Table 2**).

One record from LU 3 is that from Wivenhoe quarry, near Elmstead Market, east of Colchester (HER 7252), where Bridgland found two flakes *in situ* in the 2nd youngest terrace (Wivenhoe interglacial deposits). Other potentially good records are those from north of Hall Farm, Weeley (HER 3086) and the nearby Daking's Pit (HER 3352) where material has been recovered *in situ* from pits that seems to have been exploiting Kesgrave deposits. Warren (1933: 24) recovered lithic remains from the pit north of Hall Farm that he regarded as "Clactonian". These would have been cores and flakes, and thus indistinguishable from significantly older material that was technological/typologically similar. It is also worth bearing in mind that handaxes are known to have been in use at pre-Anglian sites such as Boxgrove, so handaxe finds cannot be ruled out as of pre-Anglian age merely on typological grounds. And there are other finds from the vicinity of Thorpe-le-Soken that seem to have been exploiting the same deposits, as well as surface collections of handaxes from the vicinity of Fingringhoe that may have originated from LU 3 deposits.

The other findspots lack good provenance for the Palaeolithic remains, and few are accurately located. Despite the paucity of well provenanced and accurately located findspots for LU 3, the presence of even a few reliable sites is sufficient to indicate the potential of this deposit to contain Palaeolithic remains. Considering their early date, any finds can be regarded as important. The accumulation of less reliable evidence is a further indication that these deposits do contain pre-Anglian lithic remains (and/or unmapped post-Anglian deposits with Palaeolithic potential). They should therefore be considered for Palaeolithic investigations when impacted by development activity.

SITES

A full list of sites where this Unit is or has been exposed is available in the Gazetteer under SITE TYPE - Kesgrave Sands and Gravels (Sudbury and Colchester Formations are not separated; insufficient research done to categorise all sites). (APPENDIX 2)

WIVENHOE

The sequence at Wivenhoe conforms to the cold – warm – cold pattern with:

5 Involuted stony silty-clay, humic but possibly due to reworking from (3) rather being organic in its own right

4 Wivenhoe Upper Gravel, horizontally-bedded gravels with occasional sand lenses (cold stage)

3 Organic silty clay with plant remains scattered pebbles, yielded two struck flint flakes, possibly lacustrine in an old meander cut-off (interglacial)

2 Sands, horizontally- and cross-bedded

1. Wivenhoe Lower Gravel, medium coarse sandy gravel (cold stage)

Bulls Lodge, Boreham, where a humic palaeosol has been recorded (2013) overlying the Colchester Formation (TL 73240 12244). This palaeosol is known to extend to the Broomfield area

Newney Green (pit closed; palaeosol recorded at site)

Roxwell

Broomfield (pits closed; palaeosol recoded at site)

Great Waltham (/pit closed)

Hatfield Peverel (pit closed)

Birch

Stanway

Ardleigh (interglacial and interstadial deposits recorded)

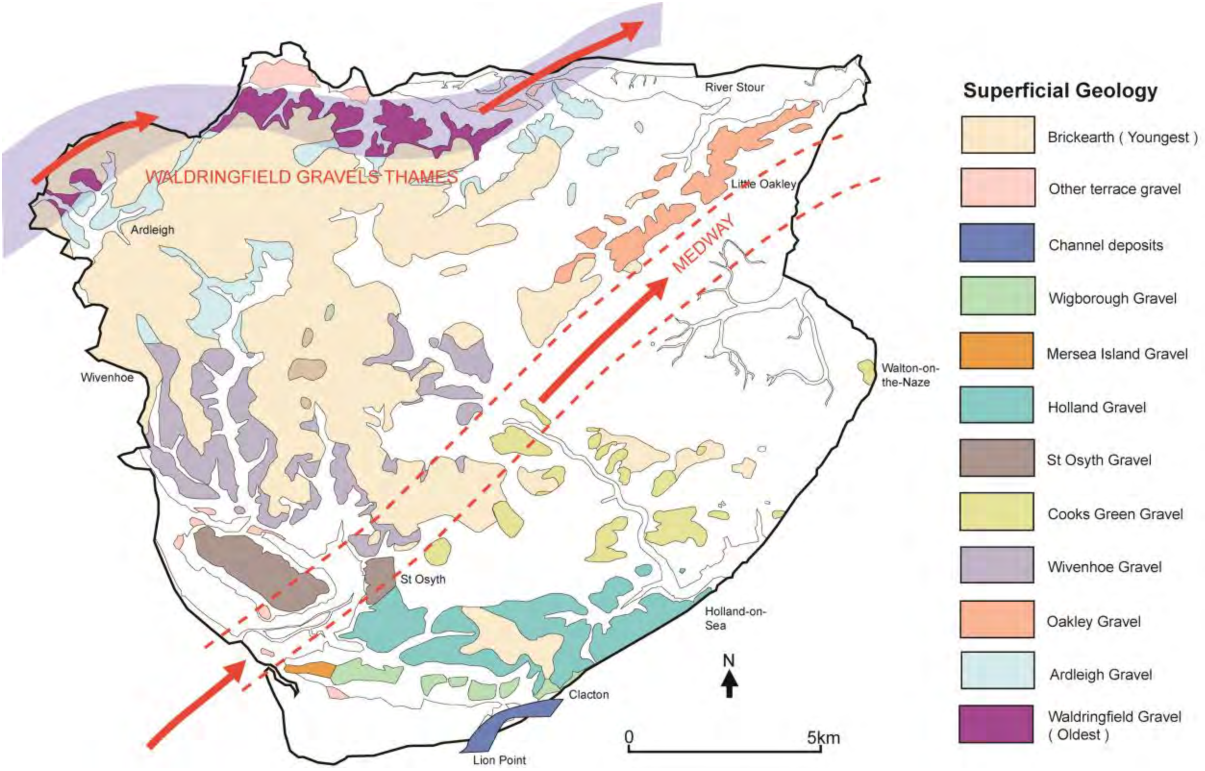

Figure 8 Courses in Tendring of the Colchester Formation Thames and Medway in Waldringfield Gravel times (After Bridgland 1999, based on BGS mapping)

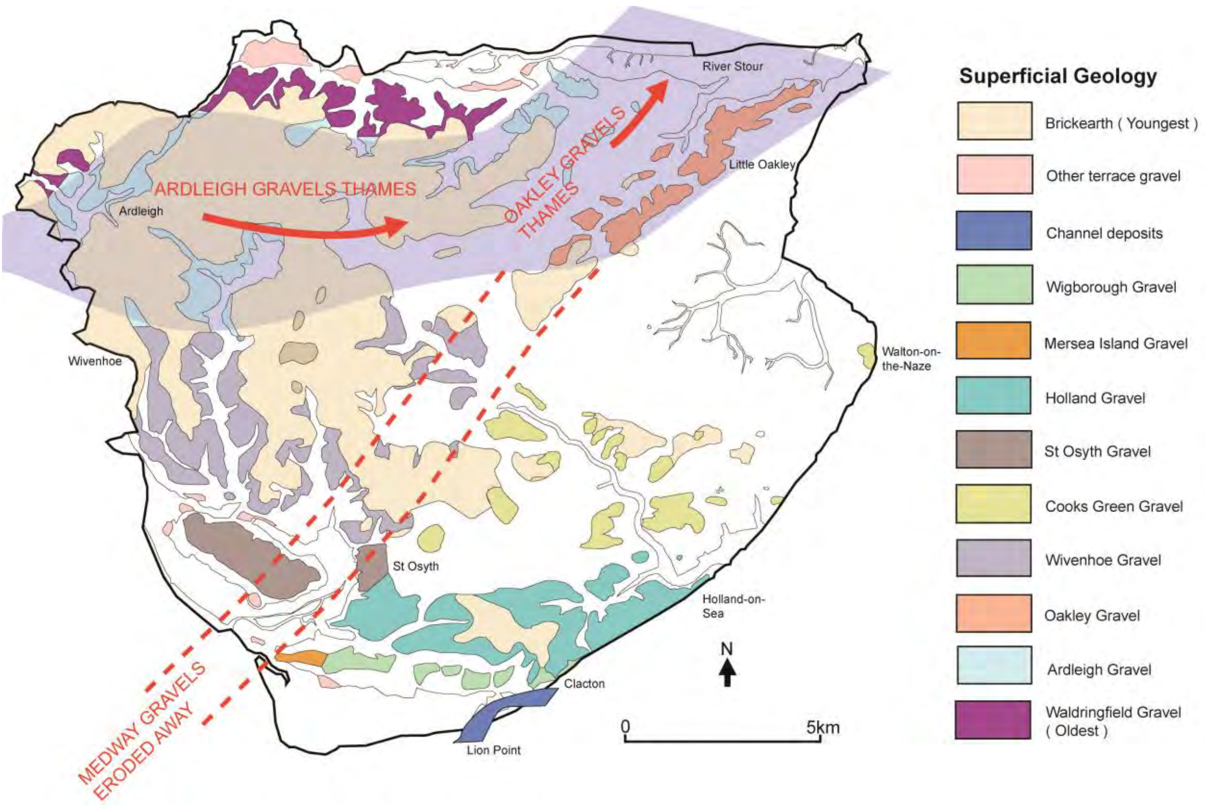

Figure 9 Courses of the Colchester Formation Thames and Medway in Ardleigh and Oakley Gravels times (After Bridgland 1999, based on BGS mapping)

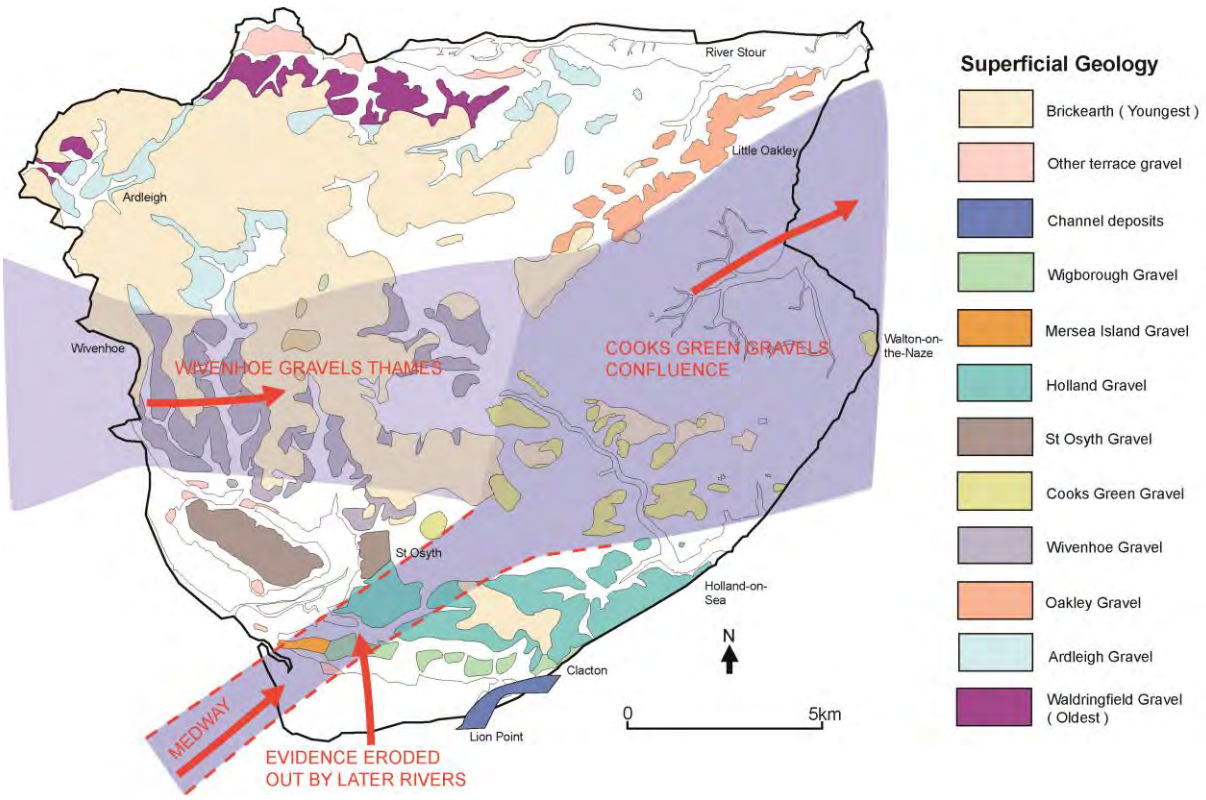

Figure 10 Courses in Tendring of the Colchester Formation Thames and Medway in Wivenhoe and Cooks Green Gravels times (After Bridgland 1999, based on BGS)

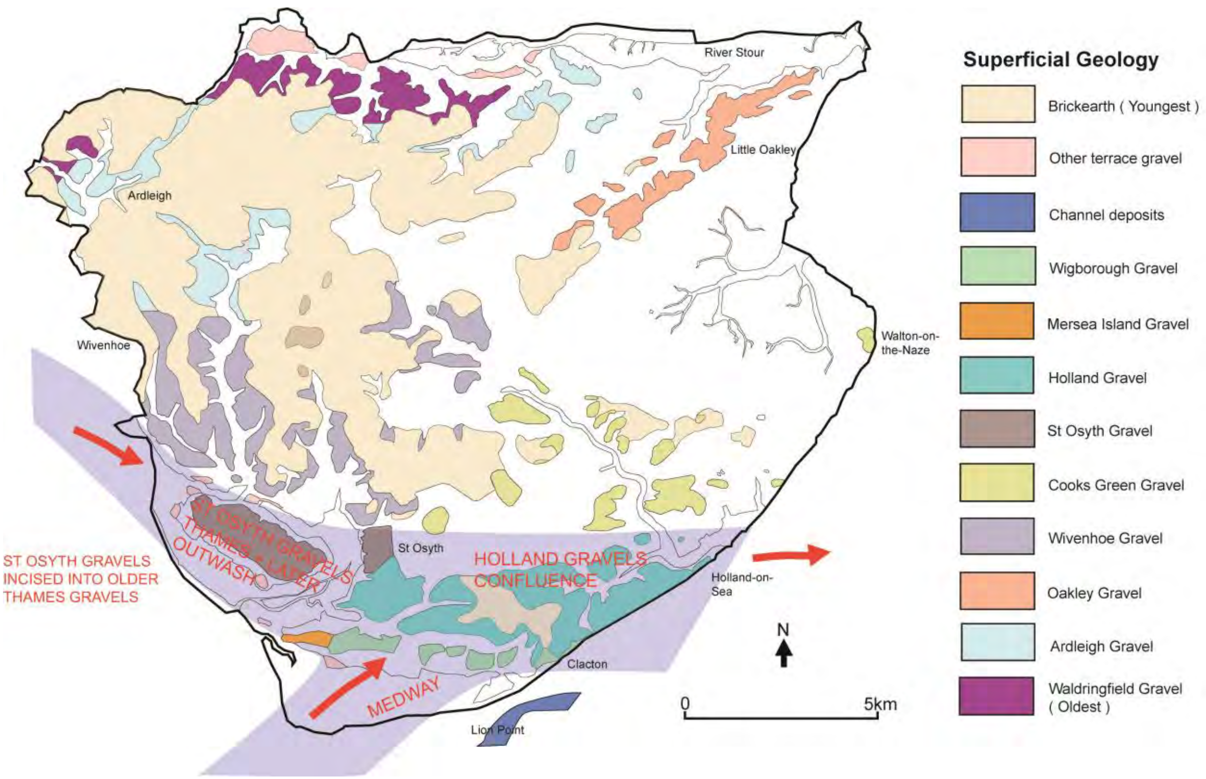

Figure 11 Courses of the Colchester Formation Thames and Medway in St Osyth and Holland Gravels times (After Bridgland 1999, based on BGS mapping)

5.2.4 LITHOLOGICAL UNIT 4 - Terrace Interglacial/Interstadial deposits

Age range

The surface or near-surface outcrops of interglacial deposits are of varying age.

Little Oakley – MIS 15

Walton-on-the-Naze – MIS 13

Clacton Channel Deposits – MIS 11

Wrabness – MIS 7

Summary background

During the long timespan over which the sands and gravels of the various terraces were deposited, there were periods of climatic amelioration, either to fully temperate interglacial conditions with deciduous mixed oak forest or a lesser tundra-like interstadial climate.

Most of the interglacial deposits in Essex are either specifically MIS 11 lake deposits (LU 8) or are subsidiaries of other LU categories such as LU 9 (Lower Thames terraces), LU 10 (Low-level East Essex gravels) or LU11 (post-Anglian Essex rivers), and have been mapped as such. Only four outcrops of interglacial deposits have been identified as being superficial deposits within Essex (a) a series of three small patches at Little Oakley (MIS 15), (b) a small patch of deposit overlying Red Crag at Walton-on-the-Naze, largely sealed under a wide spread of head deposits (MIS 13), (c) the early Hoxnian interglacial channel at Clacton-on-Sea (MIS 11) and (d) a small patch of land at Wrabness, on the south side of the Stour (MIS 7). Only the Clacton and Wrabness sites have produced associated Palaeolithic finds.

Sediment composition and environment of deposition

During interglacial periods, the temperate climate provided a more even supply of water to rivers through the year, further regulated by the vegetation that led to flow discharges associated with the deposition of sand silt and clay. These have the potential for preserving the full range of temperate biota, such as Mollusca and vertebrates (large and small), microfossils such as pollen and Ostracoda and upon which a range of geochemical analyses can be carried out such as isotopic analysis of carbonates, amino acid racemisation and other techniques such as optically stimulated luminescence. The sand was laid down mostly on the edge of the main stream and the silt and clay in quiet side waters, such as embayments, abandoned channels and ox-bows. Increasingly we are finding that gravels could also be laid down in temperate interglacial conditions, so the simple connection between gravel and cold stage conditions needs caution and re-examination.

The interstadial deposits can be rich in organic remains, often with recognisable plant macrofossils, such as leaves, cones, stems, twigs or even short lengths of tree trunk, possibly with beetle elytra (the hard casing protecting the wings). These represent conditions varying from treeless tundra, to coniferous forest in a boggy landscape or even mixed woodland and temperate fauna.

Palaeolithic and palaeoenvironmental potential

Such conditions are both favourable to colonisation by plants and animals, including humans, and conducive to preservation of less disturbed archaeological and palaeoenvironmental evidence, and so are of high Palaeolithic potential.

Along the coast the Clacton Channel deposits are hugely important as Clacton is the international type for the Clactonian Industry, the term being used outside Britain. The site has well provenanced evidence of lithic artefacts, mammalian dietary remains and other palaeoenvironmental evidence from deep sequences including undisturbed occupation horizons. Highlights include recovery of a wooden spear point - one of Britain's very few non-lithic artefacts of this era - from deposits near the shoreline west of Clacton Pier (HER 17686) and the rich occupation horizon of the Golf Course excavation (HER 2950), excavated in 1969 and 1970 (Singer *et al.* 1973). These deposits are all of high Palaeolithic potential. Although their distribution and depth are thought to be well-understood, there may be unmapped deposits in the vicinity.

The small patch of land at Wrabness also has a reliable record of likely associated Palaeolithic remains (HER 13721). It is considered to date to MIS 7.

In addition to these mapped LU 4 areas, there is evidence for buried interglacial channels at Cudmore Grove along the south shore of East Mersea, between *c.*TM 053136 and TM 070147 (mapped as LU 10). There are good records here of buried interglacial channels thought to be of MIS 9 and MIS 5e age with rich mammalian and other palaeoenvironmental remains.

The most likely part of a terrace to be archaeologically and environmentally productive is the landward edge, which marks the river bank, where human activity would be most likely to occur (as at Purfleet and Aveley for example) and where animals would come for water, as well as providing a rich environment for plants, animals and invertebrates such as Mollusca and insects.

Human presence can be deduced not only by the presence of artefacts but also by cut marks on bones and their breakage patterns. Fossil material and the nature of the sediments further build up a picture of the environment the humans lived in, enabling a reconstruction of the landscape, its vegetation (through pollen and plant macro-material), its animal population (through shells, bones, beetle elytra, etc.) and the climatic environment (rainfall, summer and winter temperatures). This information can be further extended by geochemical and geophysical analyses (optically stimulated luminescence, amino acid racemisation, oxygen isotope analysis of carbonate nodules).

Sites

Little Oakley (MIS 15) (TM 223294)

Environmental information, particularly from molluscs, has been recovered from interglacial sediments within a channel cut into the Oakley Gravel at Little Oakley. The infill comprises up to 4 m of fine sand, silt and clay, with occasional pebbles, overlain by up to 3 m of colluvium. The infill sediments are highly fossiliferous, including pollen, molluscs, ostracods, invertebrates (mammals and fish). No lithic artefacts have been recovered.

Walton-on-the-Naze (MIS 13) (TM 266236)

A complex sequence occurs at Walton above the Red Crag (Bowden *et al.,* 1995):

(Top)	1	Brickearth (aeolian, periglacial)
	2	Pebble Bed (lag deposit)
	3	Silts and gravels (upper channel infills)
	4	Cooks Green Gravels, with fragments of mammoth tusk (periglacial)
	5	Silts
	6	Clayey silt (lower channel infill, polleniferous, temperate)
	7	Palaeosol (temperate)
	8	White sands
	(Red Crag)	

Unit 6 has been interpreted as Early Pleistocene Chillesford Clay, but later pollen analysis disproved this as the presence of 'Type X' pollen was taken to indicate a Hoxnian age. However, the clast content of Unit 4 ties in with the Cooks Green Gravel of MIS 13 age, making Unit 6 of MIS 13 age or earlier. The channel sediments are principally a basal sand followed by laminated silty clay and are interpreted as the infill of a meander. No lithic artefacts have been recovered.

Clacton (MIS 11)

The most important site in Essex, of international status, is arguably Clacton, with its wide range of finds and its international status as the type-site for the Clactonian Industry. Between Jaywick and West Cliff at Clacton, a complex of three channels is infilled with freshwater and estuarine beds (Lower and Upper Freshwater Beds and Clacton Estuarine Beds) comprising a basal clayey gravel followed by sands, silts and clays. These beds have produced a wide range of molluscs and vertebrate bones, including lion, narrow-nosed rhinoceros and straight-tusked elephant, as well as flint implements, and a wooden spear. Pollen shows the deposits to belong to the Hoxnian Interglacial (MIS 11). A fourth channel, on the foreshore at Jaywick (Channel IV), still under investigation, has revealed palaeontology (vertebrates and molluscs) and geochemistry (amino acid racemisation) indicating deposition in a later interglacial, the Ipswichian (MIS 5e). Thus the cliff and foreshore geology is more complex than previously thought, increasing the need to preserve the deposits.

Wrabness (MIS 7)

At Wrabness, interglacial deposits mapped by the British Geological Survey include beds of brickearth and sand, topped by cryoturbated sand and gravel. Faunal remains include *Corbicula fluminalis* (mollusc), *Equus ferus* (horse), *Cervus elaphus* (red deer), *Bos* or *Bison* (aurochs or bison), *Palaeoloxodon antiquus* (straight-tusked elephant), *Mammuthus primigenius*/*Mammuthus trogontherii* (mammoth); several flint Palaeolithic artefacts have been found including Acheulian handaxes and Levallois flakes (George, W.H. 2010)

5.2.5 LITHOLOGICAL UNIT 5 - Woodford Gravel

Age

MIS 19, *c*.780,000 BP (Rose, 2010) or MIS 16-17, *c*.650,000 BP (Westaway, 2011) to MIS 12 , *c*.450,00 yrs BP

Summary background

The Woodford Gravel occurs in relatively limited patches either side of the River Roding in Woodford, Buckhurst Hill and Chigwell at a height of 50 - 80 mOD. Little detailed research has been carried out on the Gravel, but its height is comparable to the Dollis Hill Gravel (60 – 80 mOD) and Westmill Gravel (60 – 70 mOD), both in Hertfordshire, which have been studied more deeply and are recognised as south-bank tributaries to the Colchester Formation of the Kesgrave Thames.

Sediment composition and environment of deposition

Descriptions of the sediments are lacking, but gravel counts show 97% flint and 1% each of quartz and Lower Greensand chert. No boreholes were found securely on the outcrop, though several were on the mapped boundary in Woodford.

Palaeolithic and palaeoenvironmental potential

As the Woodford Gravel is thought to be equivalent of the Colchester Formation of the Kesgrave Sands and Gravels, there is similar potential for Palaeolithic remains as reviewed for LU 3. It represents a time period of almost up to 400,000 years prior to the onset of the Anglian glaciation during which there was known to be periodic occupation of Britain. This includes a number of rich archaeological sites such as the Caversham Ancient Channel (Berkshire), Pakefield (the Norfolk Coast), High Lodge (Suffolk), Boxgrove (West Sussex) and possibly Happisburgh. So far as is known, occupation was restricted to more temperate episodes (not just peak interglacials), and Britain was unoccupied during the colder glacial episodes. Thus there is potential within the gravels of this period both for derived occupational evidence in cold climate gravel deposits, and also for the scarce (but very important, if detected) occurrence of less disturbed evidence in fine-grained horizons or buried land surfaces within the Formation that represent temperate climate deposits from this time range. Although no sites are known for the Woodford Gravel, the moderately abundant records of sites and temperate buried land surfaces from their Kesgrave-Colchester equivalent (as reviewed for LU 3) indicate their potential importance. They should therefore be considered for Palaeolithic investigations when impacted by development activity.

Sites

One site is listed in the Gazetteer under SITE TYPE - Pleistocene Gravel of Unknown Origin – BuckhurstHill, Lord's Bushes (APPENDIX 2)

5.2.6 LITHOLOGICAL UNIT 6 –High-level East Essex Gravels

Age

>MIS 19/16-17 to MIS 12, from about 700,000+ years ago to about 480,000 years ago

Summary background

The early Thames that crossed central Essex, depositing the Colchester Formation of the Kesgrave Sands and Gravels, had a southern tributary from Kent, the Medway, which extended across eastern Essex, depositing the High-level East Essex Gravel (HEEG) before joining the Thames offshore or within the Tendring peninsula (Figures 12, 13). The gravels form a sequence of terraces occupying the hill tops in eastern Essex, from the Thames around Rayleigh, to the Blackwater, in the region of St Lawrence. The confluent interaction been the HEEG and the Colchester Formation is clearly demonstrated in Tendring (Figures 8 – 11). The High-level East Essex Gravels and their Colchester Formation equivalents are listed in Table 4.

Sediment composition and environment of deposition

The predominant lithology of the Medway gravels of eastern Essex is flint from the North Downs and London Basin, but with a high proportion of Kentish Lower Greensand chert (pinhole chert) and Wealden sandstones. A high proportion of the flints are angular or sub-angular indicating frost shattering, though blunted during subsequent transport by the river, and many show rounded indentations (pots) where frost has caused breakage of the flint surface (lids). The sedimentary structures are dominated by gravel bars separated by channel sands, indicative of periglacial braided river deposition, similar to rivers in the Arctic today.

Palaeolithic and palaeoenvironmental potential

As the High-level East Essex Gravel is thought to be equivalent to the Woodford Gravel (LU 5) and the Colchester Formation of the Kesgrave Sands and Gravels (LU 3), there is similar potential for Palaeolithic remains as reviewed these deposits. One might think that there is little potential within the High-level East Essex Gravel for Palaeolithic archaeology and for palaeoenvironmental information, as the gravels are thought to represent vigorous deposition during a cold environment inhospitable to human colonisation. However, they represent a time period of up to 300,000 years prior to the onset of the Anglian glaciation during which there was known to be periodic occupation of Britain. This includes a number of rich archaeological sites such as the Caversham Ancient Channel (Berkshire), Pakefield (the Norfolk Coast), High Lodge (Suffolk), Boxgrove (West Sussex) and possibly Happisburgh. So far as is known, occupation was restricted to more temperate episodes (not just peak interglacials), and Britain was unoccupied during the colder glacial episodes. Thus there is potential within the gravels of this period both for derived occupational evidence in cold climate gravel deposits, and also for the scarce (but very important, if detected) occurrence of less disturbed evidence in fine-grained horizons or buried land surfaces within the Formation that represent interglacial deposits from this time range.

Four Palaeolithic findspots can be related to outcrops of LU 6 (**Table 2**). One of these (not yet in the HER) is a flint flake that is reliably provenanced to an outcrop of Canewdon/Clinch Street gravel, found during gravel-sieving for the Medway Valley Palaeolithic Project in 2005 (Wenban-Smith *et al.* 2007). The other three find spots are less reliably provenanced, and cannot be confidently regarded as originating from LU 6, although this cannot be ruled out.

Despite the unreliability of most of these records, the firm record of the flake from Westcliff in conjunction with the moderately abundant records of sites and temperate buried land surfaces from their Kesgrave-Colchester equivalent (as reviewed for LU 3) indicate their potential importance. They should therefore be considered for Palaeolithic investigations when impacted by development activity.

Key to Figure 12

HEEG – Claydons/Daws Heath/Oakwood/Ashingdon/Belfairs-Mayland/Canewdon-St Lawrence/ Chalkwell-Caidge Lower Thames Formation – Boyn Hill/Lynch Hill/Taplow-Mucking/Kempton Park-East Tilbury Marshes LEEG – Southchurch-Asheldham-Mersea Island/Barling-Dammer Wick/ (Bridgland, 2014)

Figure 12. Distribution of the Lower Thames Formation, High-level and Low-level East Essex Gravels *(Bridgland, 2014)*

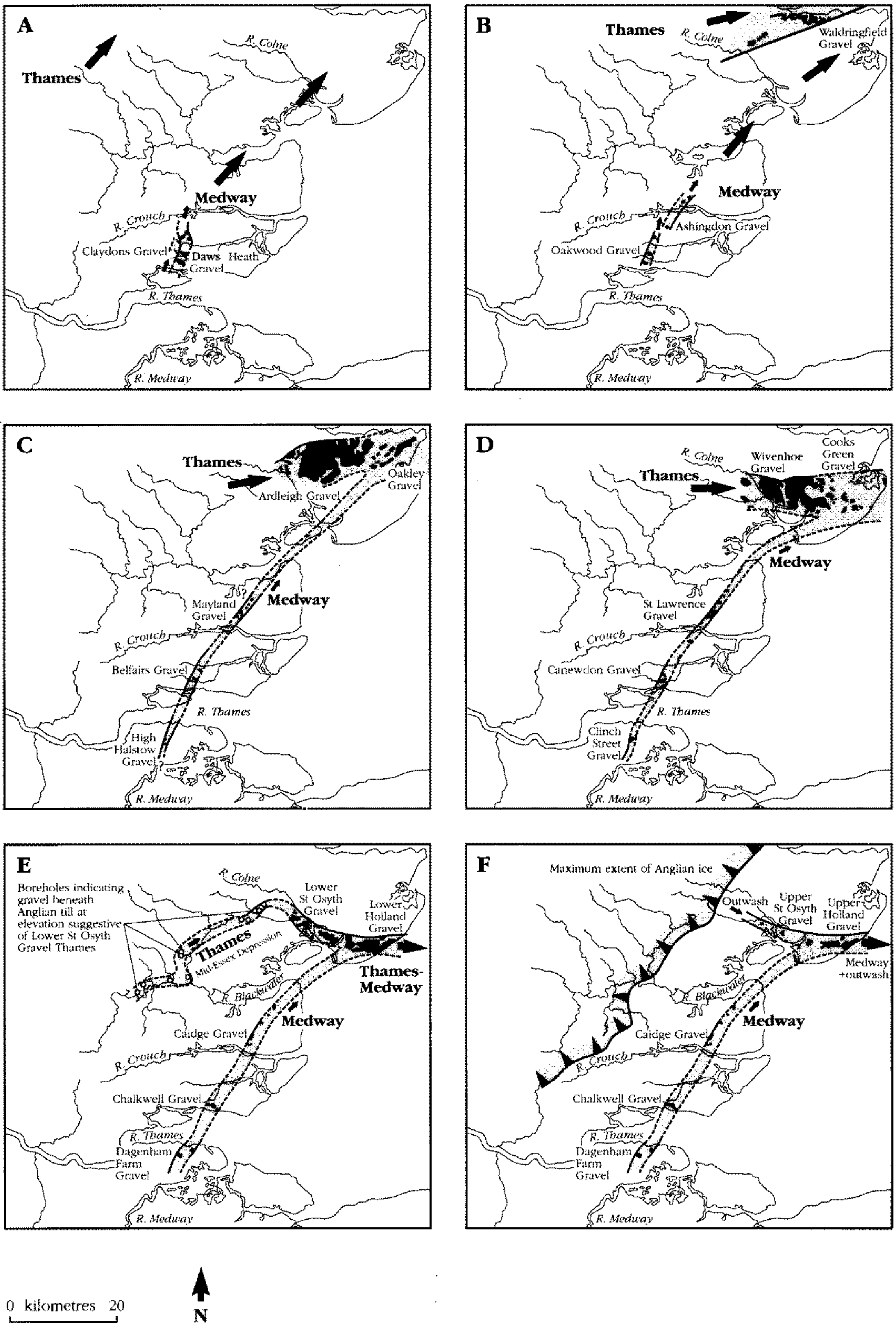

Figure 13 The Medway in Essex (High-level East Essex Gravel) (Bridgland, 1994)

Table 4 Eastern Essex, Quaternary Stratigraphy: Pre-Anglian and Anglian					
HIGH-LEVEL EAST ESSEX GRAVEL				KESGRAVE S & G COLCHESTER FORMATN	CONFLUENT HEEG+COLCH FORMAT
Postulated MI Stage	**Southend area**	**Dengie Peninsula**	**Mersea Island**	**Tendring Peninsula**	**Tendring Peninsula**
MIS 12 (Anglian Ice)	**Chalkwell Gravel**	**Caidge Gravel**		**Upr St Osyth Gravel**	**Upr Holland Gravel**
MIS 12 (early)				Lwr St Osyth Gravel	Lwr Holland Gravel
MIS 13 *MIS 13* MIS 14	**Canewdon Gravel** (MIS 13b)	**St Lawrence Gravel**		**Wivenhoe Upper Gravel** *Wivenhoe Interglac deps (MIS13c)* Wivenhoe Lower Gravel	**Cooks Green Gravel**
MIS 14 *MIS 15* MIS 16	**Belfairs Gravel** **Ashingdon Grv** (MIS 15b+d)	**Mayland Gravel**		**Ardleigh Upper Gravel** *Ardleigh I'glacial deps* Ardleigh Lower Gravel	**Colluvium** *Lt Oakley Silts & Sands* Oakley Gravels
MIS 16	**Oakwood Gravel**			**Waldringfield Gravel**	(Offshore)
MIS 18	**Daws Heath Gravel**				(Offshore)
MIS 20/22	**Claydon Gravel**				(Offshore)

Italic = Interglacial deposit **Bold = Surface deposit**

5.2.7 LITHOLOGICAL UNIT 7 - Glacial/Glaciofluvial deposits

Age

The Anglian cold stage occurred about 478,000 – 424,000 years ago.

Summary background

The Anglian ice-sheet covered Essex about 450,000 years ago, reaching approximately to the line of the A12 trunk road. Whilst representing a cold environment, there could have been large herds of, for example, reindeer, as well as other cold-adapted plants and animals around, but preservation may have been so poor that our knowledge is sparse. The glacier released little debris in the form of outwash and most of that occurs in valleys, suggesting that the meltwater was exiting primarily along specific conduits such as pre-existing valleys, most of which were over-deepened by the meltwater, forming tunnel valleys.

Sediment composition and environment of deposition

The glacier deposited till (boulder clay) directly from the ice body. The till is characteristically a clay deposit with many stones (and some boulders), many of which are foreign to Essex, brought in from further afield by the ice. The basal part of the till may show shearing and banding, due to friction with the substrate as the glacier passed over it. The body of the till is characteristically a grey colour, though the upper part may be weathered to light grey or brown. A scientific coverage of the till of Essex is provided by Whiteman in Allen *et al.* (1991).

The outwash is usually dominated by coarse gravel bar deposits separated by channel sands, indicative of pro-glacial braided river deposition, not too dissimilar to the braided river deposits of the Kesgrave Sands and Gravels. Stone counts may well be close to those of the Kesgrave, but angular flint is more common and exotics such as *Rhaxella* chert help identify it as outwash rather the Kesgrave Gravel.

Palaeolithic and palaeoenvironmental potential

One might expect the Palaeolithic potential of LU 7 to be very poor, because there would have been no human occupation during the glaciation and very little material was present in older deposits to be picked up by the ice. In fact, contrary to this prior expectation, LU 7 deposits are one of the most abundant sources of Palaeolithic findspots in the Essex HER. There are 47 separate sites that correspond spatially with mapped outcrops of LU 7 (**Table 2**), mostly the clayey sub-glacial till, rather than fluvio/glacial outwash sand/gravel deposits. The likely explanation for this is that, while the actual LU 7 sediments themselves do not contain Palaeolithic remains (apart possibly from rare and not-very-useful instances of derived material from pre-Anglian occupation), they have high potential to contain Palaeolithic material in minor unmapped deposit accumulations on the surface of LU 7 spreads. These minor unmapped outcrops could have been formed by a range of processes, including lacustrine, aeolian, slopewash and combinations thereof. They would be likely to contain Palaeolithic remains that have been rapidly buried and minimally disturbed. They would also be likely to contain well-preserved associated mammalian fossils and other palaeoenvironmental remains. In addition to these deposits, spreads of LU 7 might also contain unmapped outcrops of fluvial terrace gravel LU 11, representing the development of post-Anglian fluvial systems across them.

Sites

Most findspots from LU 7 are not accurately located. Finds have been made across the spreads of till and sand/gravel. However there seem to be slight concentrations at the western side of Essex, in the basins of the upper Cam/Granta and the Pincey Brook, and in a band along the southeast side of the till, associated with the basins and interfluves of the Ter, Chelmer, Brain and Blackwater. There is also a concentration of sites broadly in the vicinity of the A12, where glaciofluvial sands and gravel occur. More-accurately located sites with better-provenanced material include near Quendon (HER 394), Acreland Green (HER 1097),Tiptree Churchyard (HER 8326), White Notley Hall (HER 5987) and Kelvedon (Portable Antiquities Scheme 101411). These mostly represent handaxe finds, with shapes of varying forms, including pointed, ovate and twisted ovate.

Unspecified "possible Palaeolithic implements" were found during late 19th century excavations at White Notley Hall, at depths ranging from the surface to c.2m deep. And the find of a "probably late Palaeolithic long pointed flint flake" from Tiptree Churchyard is of interest. If Upper Palaeolithic, this may be a rare instance of early human occupation during the later part of the last Ice Age or perhaps at its very end. If not, it may perhaps be an example of Levalloisian blade production from the Middle or early Lower Palaeolithic.

5.2.8 LITHOLOGICAL UNIT 8 – Glacial-Interglacial Lacustrine deposits

Age

Lacustrine deposition was important following the Anglian Glaciation;
late Anglian to Hoxnian, MIS 12 – 11, about 400,000 years ago

Summary background

Within the lacustrine deposits of Essex, there are known important sites for lithic recovery and for palaeoenvironmental information for the Hoxnian warm stage (MIS 11), at Marks Tey, Rivenhall and Newport (Turner, 1970, 1973a; Baker, 1971). Thus there is potential at a number of other sites where lacustrine sediments have been recorded in boreholes, temporary exposures and brick pits.

During the Anglian cold stage (MIS 12), glaciers deposited till (boulder clay) over most of Essex, the A12 trunk road broadly marking its southern limit. The surface of the till sheet, whilst forming a plateau-like landscape, would have had depressions, such as kettle holes where residual blocks of ice were slower to melt, and would have been dissected by rivers, now existing as the Cam-Stort, Chelmer, *et al*. Some of the lakes would have continued in existence into the Hoxnian temperate stage. Prime examples can be found at Marks Tey (Essex) in a deep plateau surface depression and Harlow and Fyfield on valley sides. Artefacts tend to be recovered from associated gravels.

Sediment composition and environment of deposition

The lacustrine sediments are primarily clay or silty clay, sometimes laminated, reflecting the quiet water environment of the lake. Within the sequences, white laminae or beds of *Chara* marl are often noted. Boreholes records or descriptions of exposures often mention a white, creamy, buff or light grey clay, sometimes thought to be chalky. It is likely that these are *Chara* marls. Not infrequently there are interbeds of sand or even gravel indicating when high discharges into the lake occurred. These are usually confined to the sides of the lake and may be in the form of small deltas and so can be significant in helping identify the lake margin zone where humans would have lived or visited, and animals would have come to drink.

The sequence is often capped by a gravel or head (soliflucted gravel, sand, clay, silt) due to surface processes in cold periods subsequent to the Hoxnian.

Chara is a green algae of the family Characeae, with stem-like and leaf-like structures, covered in calcium carbonate. They are found in fresh water, particularly in limestone areas throughout the northern temperate zone, where they grow submerged, attached to bottom-muds. They prefer less-oxygenated and hard water. These characteristics would be in keeping with lakes forming in depressions in the post-glacial land surface. Calcium carbonate would be available from the chalk in the till. The preference for less oxygenated water indicates quiet rather than flowing water and a muddy substrate would form on the clay of the till. The preference for temperate conditions is indicative of an interglacial climate. The marl may well contain ostracods, as at Hitchin and at Marks Tey, with potential for providing palaeoenvironmental information.

The calcium carbonate-rich environment would also encourage colonisation of Mollusca and the preservation of shells and bones.

Palaeolithic and palaeoenvironmental potential

The palaeoenvironmental potential of LU 8 deposits is high as lakes are comparatively quiet environments with limited chance of reworking or other disturbance of fossil material. The lake margins are particularly significant. Any archaeological or palaeontological material on the margins would be gently covered by sediments when water levels rose, thereby facilitating preservation. The deeper parts of the lake would be less likely to yield artefacts, apart from odd cases such as the Marks Tey handaxe that appears to have been thrown into the lake.

Furthermore, the calcareous environment of lacustrine deposits overlying the Anglian till will favour preservation of a diversity of faunal remains, including mammalian, molluscan and other micro-palaeontological remains such as ostracods. The quality of geochemical analyses can be high, if suitable material is found that has not been affected by diagenesis or contamination.

To date, recovery of archaeological material has been limited from mapped lacustrine outcrops. This might seem rather surprising, as a lake would appear to be a hospitable site for human occupation or visitation. However, the mapped outcrops correspond to larger recognised bodies of lacustrine sediment. While the margins of such bodies might be expected to be a favourable location for hominin occupation/activity, the lakes themselves would of course have been rather an unfavourable and wet location, so it is not surprising that limited evidence has been found from lacustrine sediments, whose quiet nature would not usually have facilitated transport of Palaeolithic evidence from their margins into areas of deeper water. Thus the focus of Palaeolithic potential is in zones near, and beyond, the edge of mapped outcrops, where shallow marginal deposits with Palaeolithic evidence are more likely to be present.

The Essex HER contains just one site that is accurately located in LU 8 deposits. This (HER 11818) is within the brickworks north of Marks Tey, and represents the findspot of a handaxe. An important site not in the HER is located at *c.*591200 224200, and represents the area of seminal work by Charles Turner in the 1960s (Turner 1970) developing a detailed chronological and palynological framework for the Hoxnian interglacial based on the lacustrine sequence at Marks Tey. In addition to these two locations, five further findspots in the HER are in locations where lake or lake-margin deposits might be likely to be present (**APPENDIX 3-TABLE FWS-8**). Two of these (HER 388 and 493) are on Chalk bedrock in northwest Essex, although these could also represent finds from Head or terrace deposits. Two of them (HER 46035 and 8840) are from areas mapped as Head, in the vicinity of Rivenhall at the southwest edge of the sheet of glacial till. Test pit investigation at the former of these sites in 2005 confirmed the presence of Hoxnian lake sediments rich in palaeoenvironmental remains. Surface finds of handaxes and flake tools have been made from the surrounding field area, but no archaeological remains have yet been found *in situ*. However this is clearly an area of high potential.

Finally, a rich collection of mammalian fossil remains (including Bos/bison, beaver (*Trogontherium cuvieri*), red deer, mammoth, horse and hippopotamus) has been reported from the vicinity of Copford Place (HER 46833), where the older LU8 deposits are cut through by the alluvium-filled channel of the Roman River. This variety of faunal remains includes both cold-climate (mammoth) and full interglacial species (hippo), and clearly represents material from different horizons. As well as LU 8, deposits of the Kesgrave Colchester Formation (LU 3), Essex river terraces (LU 11) and interglacial deposits of varying type/age (LU 4) could also be present at this location. This is an area of high potential, and further investigation is required to relate faunal material more precisely to specific horizons, to understand the range and relationships of any Pleistocene deposits better, and to ascertain whether they also contain evidence of early human activity.

Notable Sites

Marks Tey

Marks Tey is the Hoxnian parastratotype, arguably with a more complete record than the stratotype, Hoxne. The site is of international importance.

Around Marks Tey there is an extensive area, including Copford and Stanway, of lacustrine deposits. The sequence within the basin is typically:

Topsoil

Gravel, variable thickness, typically 0.5 to 1.0 m or more

Clay with occasional large flints and seams of sand and of shells, 1.5 – 3.0 m thick

Laminated clays, sometimes brecciated and faulted, becomes sandy towards base, over 30 m maximum depth. The lower part is interglacial (Hoxnian, MIS 11) but the upper sediments represent the onset of the ensuing cold stage (MIS 10)

Gravel

A more-or-less complete pollen record for the Hoxnian Interglacial has been recovered, showing that it lasted 17-20,000 years (Turner, 2014). The Hoxnian provides a close analogue to the interglacial we live in today (Candy & Horne, 2014). Currently work is being undertaken on the detailed sedimentology of the laminated clays (Sherriff *et al*., 2014) and ostracods (Horne *et al*., 2014) to understand more fully the palaeoenvironment of the lake.

Several artefacts have been recovered from the upper gravel and from the surrounding area, but none from laminated sediments.

During the 19th century, Copford brick pit yielded faunas of Mollusca, ostracods and vertebrates, the last including elephant (*Elephas*), bison (*Bos)*, red deer (*Cervu*s)*, bear* (*Ursus*) and giant beaver (*Trogontherium*). Although investigations are incomplete, Hoxnian pollen has been recovered by Turner (1973b). *Trogontherium* became extinct during the Middle Pleistocene. The presence of this species, in association with a post-Anglian context is sufficient to demonstrate an age within MIS 11 (Schreve, 2001). The sediments are up to 24m thick and comprise clays, sometimes sandy or gravelly with peats.

SITES

One site, Shelley (aka Fyfield) is listed in the Gazetteer under SITE TYPE_Glacial Lake Deposit, and two sites under SITE TYPE_Periglacial Deposits and Features; Tye Green and Writtle. (APPENDIX 2)

Borehole locations indicating lacustrine deposits:

Marks Tey – Copford
The deposit was dated by pollen to the Hoxnian (Turner, 1970, 1973a, b), but arguably, the evidence from mammalian biostratigraphy is more important, since pollen from MIS 11 and 9 cannot be reliably differentiated (Thomas, 2001).

(TL 910 243, 933 242, 905 245, 935 242, 898 250, 9052 2457, 9087 2447, 9251 2416, 9242 2506, 9319 2500, 9347 2489, 9251 2416, 9251 2417, 9320 2415)

Rivenhall End
Boreholes and temporary exposures indicate that the presence of lacustrine deposits between *c*.22.0 and 13.0 mOD over a more extensive area than mapped. Wood fragments and shells occur in some of the boreholes. Preliminary pollen analysis dates the deposits to the Hoxnian (Turner, 1970).

Boreholes indicate more extensive presence than mapped
(TL 8343 1623, 8367 1636, 8385 1631, 8402 1634, 8403 1637, 8400 1655, 8395 1665, 8426 1686, 8484 1724, 8503 1783 to 8506 1779, 8519 1784)

Witham
Boreholes and temporary exposures indicate the presence of lacustrine deposits between *c*.21.0 and *c*.11.0 mOD over a far more extensive area than mapped, especially to the west. The deposits have not been dated, but are presumed to be Hoxnian by analogy with Rivenhall and Marks Tey. Bristow (1985) reports boreholes or exposures at:
(TL 8244 1534, 8250 1544, 8260 1534, 8275 1524 to 8282 1520, 8280 1466, 8280 1442 to 8270 1426, 8294 1442)

The extent of the lake is greater than shown on the BGS mapping. Boreholes near Witham railway station record silts and clays, sometimes calcareous, as well as sands and some gravel. This area could well mark the edge of the lake and so be a potential site for early human occupation. Wymer (1985) records that 32 handaxes, two rough-outs and several flakes were found during excavation of a Roman site and speculates that they could have come from the area of lacustrine deposits here or at Rivenhall.

Witham Station, Chipping Hill, High Street
(TL 8289 1576, 8301 1568, 8299 1586, 8307 1559, 8307 1569)

<u>Chelmsford</u>
Extensive area of lacustrine deposits,proved in BHs
(TL 7199 0623, 7174 0606, 7213 0635, 06317135 0621)
Of uncertain age
(TL 680 080, 6875 0688, 7075 0640, 7199 0623, 7199 0631, 7135 0621, 7199 0623, 7174 0605, 7213 0635, 7207 0631, 7135 0621)

<u>Sandon</u>
Boreholes and temporary exposures indicate the presence of lacustrine deposits between *c*.30.0 and *c*.10.0 mOD infilling a sub-glacial channel. These deposits are not dated and it is assumed that the infill occurred mostly during the Hoxnian.

Sandon (BHs at TL 7463 0485, 7400 0522, 7419 0522, 7430 0460)
Sandon (augering at TL 7536 0446, 7553 0446, 7543 0457)
Sandon (BHs at TL 7571 0457, 7618 0511)
Sandon (abandoned pits at TL 7575 0500, 7600 0545, 7605 0569)
Sandon Bridge (TL 7566 0533, 7647 0790, 7435 0658, 7443 0636, 7445 0599, 7443 0690, 7412 0723, 7414 0764, 7405 0799)
Downstream of Sandon, also part of the infill of a sub-glacial, channel (TL 7647 0790, 7435 0658, 7443 0636, 7445 0599, 7443 0690, 7412 0723, 7414 0764, 7405 0799)
Many further boreholes along the line of the A120 confirm the presence of the lake.

<u>Fyfield</u>
Valley-side lacustrine deposits up to 12.8 m thick, comprising laminated clays, silts and sands in the central area and cream or pale grey clays, silts and fine sands at the margins, revealed in boreholes. The lacustrine deposits are mostly

unfossiliferous, but a part tusk of woolly mammoth was recovered in 1983, in keeping with a late Anglian, now in the Chelmsford and Essex Museum.
(TL 5667 0660, 571 083, 573 076, 5725 0764, 5645 0593, 5594 0508, 5622 0554, 5667 0628)

Harlow

Silts, sands and clays, at times laminated, are argued to be deposits of a large pro-glacial lake, Lake Hertford, extending from an Anglian ice front to the east of Harlow into the Vale of St Albans and Finchley Depression, with a lake surface height of c.70 mOD (Clayton and Brown, 1958). The borehole coverage for Harlow is too dense to elaborate here, but can be summarised that the lake deposits are on the north side of the town, e.g. in the Netteswell area, but till (boulder clay is at the ground surface in the central and southern area.

Minor outcrops

(often recognised in a single borehole)

Great Tey
Wendens Ambo (TL 5153 3713, 5163 3645)
North Hall, Quendon (TL 5243 3031)
Bishops Stortford Bypass (TL4942 2299)
Morrice Green (TL415 354)
Braintree, Perry Childs Farm (TL7289 2444)
Braintree, Clap Bridge (TL741 229)
Braintree – Rayne (TL7475 2202)
Gosfield, Gosfield Hall (759 299, 7933 3621, 7730 3621)
Epping, Spellbrook (TL 484 168, 4846 1681)
New Hall, Roding Valley (TL 5812 1639)
Shelley – Clatterford End (TL 5667 0660, 5645 0593, 5594 0508 to 5622 0505, 5642 0554, 5650 0637, 5650 0637)
Writtle, Warren House Farm (TL 680 085, 6835 0759)
Blackmore (TL 6099 0291, 6135 0319, 5933 0070)
High Easter (6634 1608)
Osea Island (TL 9077 0640, 9034 0645, 9038 0636)
Boreham House (TL 7541 0890, 7386 0892, 7475 0931, 7626 0857, 7668 0911)
Ter Valley (TL 7604 1289)
Scarlett's Farm (TL7680 1095)
High Wych (TL 4627 1552)

Crix Farm (TL 7752 1056)
Warren Farm (TL 680 080)
Can Valley (TL 6875 0688)
Great Canfield (TL 5865 1739)
Hall Street (TL 7075 0640)
Stoneham's Lock (TL 7472 0810, 7540 0858)
Huskett's Mill (TL 7664 0893, 7839 0931)
Cardfield Farm (TL 7909 0945, 7908 0903)
Kelvedon (TL 8556 1829)
Tolleshunt D'Arcy- Tollesbury (small outcrops mapped as London Clay may be interglacial lacustrine clay (TL 9745 0312, 9762 0322)
Blackwater valley (TL 8556 1829, 8666 1823, 8588 1852, 8615 1864, 8710 1926, 8713 1940, 8635 1985)
Southminster gravel pits (TL 955 982)
Tillingham (TL 982 040)

5.2.9 LITHOLOGICAL UNIT 9 - Lower Thames terrace gravels

Age

Anglian glaciation (MIS 12, *c.*478,000 – 424,000 years ago) to the Devensian Cold Stage (MIS 2, *c.*10,000 years ago).

Summary background

The Anglian ice over-ran the Kesgrave Thames in central Essex and diverted it into its present valley, though initially on a course north of its present trace, marked by sands, gravels and interglacial deposits of the Lower Thames Formation. In the Southend area, the diverted Thames was confluent with the Medway and a combined Thames-Medway flowed northwards across eastern Essex, depositing the Low-level East Essex Gravels (LEEG).

Since the Anglian glaciation, there have been four climatic cycles controlling the cold and warm stages, with a periodicity of *c.*100,000 years. These were more extreme than earlier cycles and consequently the rivers of Essex often have a complex history. This is particularly well illustrated by the Lower Thames which is flanked by flat terrace surfaces (landforms), underlain by a sequence of terrace deposits (sediments) (Figure 15). These have often been regarded as having formed as a 'sandwich' of: gravel (cold stage) / sands, silts, clays (warm stage) / gravel (cold stage) (Figures 4 and 14). However, this model remains to be confirmed by palaeoenvironmental evidence through complete terrace sediments, and there are several proven exceptions to this framework, for instance the 4th terrace (Boyn Hill) sequence at Swanscombe (on the south bank of the Lower Thames, in north Kent) which includes numerous interglacial gravels. This model was until recently presumed to be applicable to the 3rd terrace (Lynch Hill) sequence at Purfleet in Essex, although it is now being suggested that the upper silty clay in this latter sequence may also be of interglacial origin. The terraces mark the height of the river at the time the sediments were deposited, but episodically over time the river cut down, so the terraces form 'staircases' down the valley side, becoming successively younger down the staircase. The 'sandwich' represents climate changes during the period of the formation of each terrace. The downcutting is currently thought to be primarily in response to ongoing tectonic uplift of inland Britain, but the rivers have sufficient power to downcut only at certain times, usually during the transition from cold to warm stages, hence its episodic nature. There are three north-bank Thames terraces outcropping in southern Essex and a further one above ground in central London, but beneath the Thames marshes in Essex, due to the downstream drop in altitude of the deposits (Figure 12):

- Boyn Hill Terrace, Orsett Heath Gravel, Fourth Terrace (Southend area) (MIS 12-11-10)

- Lynch Hill Terrace, Corbets Tey Gravel, Third Terrace (Southend area) (MIS 10-9-8)

- Taplow Terrace, Mucking Gravel, Second Terrace (Southend area) (MIS 8-7-6)

- Kempton Park Gravel, East Tilbury Marshes Gravel, First Terrace (Southend area) (MIS 6-2)

The interglacial equivalents of the Swanscombe deposits within the Boyn Hill/Orsett Heath Gravels in east Essex are the Southchurch – Asheldham Channel and Clacton Channel deposits.

The gradient of the Kempton Park/First Terrace falls below the present Thames floodplain east of Woolwich (Ellison *et al.,* 2004) and is noted not to be exposed in the Southend area (Lake *et al*., 1986). However, two small exposures are indicated in BGS mapping supplied to ECC in the Mucking Marshes. These are mapped as Taplow Gravel/Second Terrace on the published BGS Sheets 257 and 258/259.

Sediment composition and environment of deposition

The cold stage upper and lower gravel components of the 'sandwich' are dominated by flint, some freshly eroded, but much is reworked from the Kesgrave Sands and Gravels, so the proportion of sub-angular gravel is high. Again, many show rounded indentations (pots) where frost has caused breakage of the flint surface (lids). The proportions of quartz, quartzites and cherts tend to be lower than in the Kesgrave Sands and Gravels. The sedimentary structures are dominated by gravel bars separated by channel sands. The assemblage is indicative of periglacial braided river deposition, akin to rivers in the Arctic today.

Interglacial deposits can be found within the gravel sequence (see LU 4). Gravel-rich members have generally been hitherto presumed to be associated with more active cool climate depositional environments. However, as indicated above, this can no longer be presumed for deposits lacking faunal evidence, considering the increasing faunal evidence for deposition under warm conditions.

Palaeolithic and palaeoenvironmental potential

Essex is rich in Palaeolithic findspots associated with post-Anglian Thames terrace deposits of south Essex (**Table 2**). Interestingly, the majority of these findspots are not associated with mapped outcrops, but are re-attributed from locations associated with other deposits such as head, Chalk and alluvium. The Thames terrace deposit of south Essex are generally thought to conform to the tripartite model outlined above (cold stage gravels / interglacial silts and sands / cold stage gravels) and contain evidence, rich in places, from throughout the later Middle Pleistocene. Within the terrace sequences, fine-grained deposits representing quiet deposition during or after hiatuses in active deposition are important as Palaeolithic material might be found *in situ* or close to its place of origin and may also be associated with environmental information, biological or geochemical. A particularly good example of the former is the Lion Pit Tramway Cutting SSSI at West Thurrock, where artefacts including refits were found indicating human presence at the bottom of a chalk cliff overlooking the Thames estuary of the time. An example of the latter occurs at Purfleet where a complex of quarry sites (Bluelands, Greenlands, Botany Pit, Esso Sports Ground) generally thought to cover the period of MIS 10-9-8 have been studied in great detail (Bridgland et al., 2013). The cold stage MIS 10 deposits comprise coombe rock, due to periglacial weathering of the chalk river bank, and river gravels, which contain scarce flakes and cores but no evidence of handaxe manufacture. The warm stage MIS 9, Purfleet Interglacial, laminated clays and sandy shell beds have yielded an impressive list of land and aquatic vertebrates and molluscs, freshwater and marginally saline ostracods, supported by geochemical analyses of the amino-acids of molluscan opercula and isotopic analyses of reprecipitated carbonate nodules. The laminated clays and the shell beds are succeeded by a largely unfossiliferous gravel of late interglacial or early post-interglacial age which has yielded an Acheulian handaxe and thinning flakes, as well as flakes and core. The uppermost gravels, MIS 8, contain Levallois artefacts.

In total there are 52 HER records for Palaeolithic findspots in Essex associated with post-Anglian Thames terraces (**APPENDIX 3-TABLE FWS-9**). Remarkably, only 7 of these are accurately located to sites on mapped LU 9 outcrops, one of these being the Lion Pit Tramway Cutting sequence (HER 45420), which however is notable for the thickness of presumed fluvial brickearth deposits and the presence of a deeply-buried Levalloisian knapping floor, and is relatively lacking in terrace gravel deposits. However the majority of the remainder are reliably associated with Thames terrace deposits. For instance, the numerous important well-recorded and accurately-located sites in the vicinity of Purfleet are technically located on Chalk bedrock, due to their point locations being within old chalk quarries, namely the Bluelands and Greenlands Pit sequences (HER 5040 and 45425), Botany Pit (HER 5008 and 45426) and Esso Pit (HER 45421 and 45424). Numerous findspots (n=12) are recorded as being from head deposits. However, these all are spatially close to mapped LU 9 outcrops, and the artefacts found can be confidently regarded as either having been derived from terrace deposits, or as being from unmapped terrace deposits underlying superficial head deposits. Likewise the two sites recorded as from London Clay, the quarries at Moor Hall Farm, Rainham (HER 45418) and Buckles Lane, South Ockendon (HER 45419). One site (Globe Pit, Little Thurrock, HER 45417) comes out as mapped onto older brickearth deposits of LU 12; however the Palaeolithic remains from this site are firmly associated with gravels (presumed to be fluvial, although it has been suggested they might include significant slopewash elements) just beyond the northern margin of the brickearth deposits.

In terms of spatial distribution, all of the LU 9 findspots are in the Thurrock area of south Essex, on the north side of the Lower Thames valley. About a third of the findspots represent finds associated with deposits of the Ockendon loop, upstream of the point where the ancient course of the Thames curved back on itself around the west end of the Purfleet chalk anticline (Beacon Hill) and headed east/north-east out towards the North Sea. Besides the Purfleet complex of sites (mentioned above), another notable site in this area is Sandy Lane Quarry, Aveley, where an elephant and a mammoth skeleton were found at the same spot, spatially superimposed (with the mammoth above the elephant) but stratigraphically divided by a thin deposit of sediment that nonetheless is thought to represent a significant time gap, maybe thousands of years. Whether this is just a remarkable coincidence, or whether there is some site formation aspect that encouraged the demise and preservation of elephants (in the loose familial sense) remains to be resolved. Another notable site in this area is the Belhus Park cutting (TQ 575811), where an interglacial channel deposit has been noted, within a sequence rich in diverse palaeoenvironmental remains and with associated lithic artefacts, some of which are in fresh condition and therefore thought to represent contemporary occupation.

Downstream of Beacon Hill, there are slightly more numerous (n=26, 50% of the total for LU 9) north bank palaeo-Thames Palaeolithic findspots. There are numerous findspots associated with the uppermost Boyn Hill/Orsett Heath terrace, although none of them rich concentrations. Perhaps the best of these sites are the locale south of Herringham School, Chadwell St. Mary (HER 1729) where a reliably provenanced handaxe was found, and Socketts Heath Pit, Thurrock (HER 1703) where a handaxe was found in association with lithic artefactual remains. Generally speaking, the Boyn Hill/Orsett Heath deposits north of the Thames would benefit from much more thorough and systematic investigation in advance of any future developments.

There are also several sites associated with (the spatially less extensive) outcrops of the lower Lynch Hill and Corbets Tey terraces in this area. Notable sites include Globe Pit, Little Thurrock (HER 1704), which has a parallel with Purfleet and occurs in the same gravel body, as mapped by Bridgland, where Clactonian-looking artefacts have been found in gravels attributed to MIS 9. This was once seen as anomalous, there having been dispute over whether the artefacts are reliably associated with the gravel, or whether the gravel is indeed an MIS 9 fluvial gravel as is widely presumed. Another notable site is the Lion Pit Tramway Cutting (HER 45420), where the deposits are predominantly fine-grained, and attributed mostly to MIS 7. Here, substantial spreads of equivalent deposits extend east and west of the deep north-south cutting, and these need to be recognised as having high potential for Palaeolithic and palaeoenvironmental remains in the event of proposed development. The Cutting has already yielded a rich fauna, including steppe mammoth (*Mammuthus trogontherii*), elephant, narrow-nosed rhinoceros (*Stephanorhinus hemitoechus*), Merck's rhinoceros (*Stephanorhinus kirchbergensis*) and red deer (*Cervus elaphus*).

Further northeast there are two handaxe findspots (HER 5227 and 1846) and a findspot of a presumed Palaeolithic flake (HER 7246) likely to be associated with the mapped LU 9 deposits. However the location of all these findspots is vague, and their provenance not reliably recorded, so further systematic investigations are required in this area to establish the locations and context of Palaeolithic remains, and to relate any palaeo-Thames deposits to the established Lower Thames framework.

Finally, there are a few sites (n=4) associated with the wide spread of alluvium at Tilbury. One of these (HER 1710) is recorded as two handaxes and one flake dredged from the Thames at Tilbury Dock. One (HER 1730) is recorded as a pointed handaxe found in 1967. And the other two (HER 1784 and 1669 respectively) are merely recorded as Palaeolithic "implement" or "implements", the former found in

1913 at Tilbury Fort, and the latter possibly a duplicate record of HER 1710. None of them have good provenance. They are mostly likely to be derived from older deposits and incorporated in Devensian terrace gravels underlying the alluvium, or introduced into the alluvium by slopewash processes.

Notable Sites

Gravels are widely found in south Essex where mapping by the British Geological Survey shows to cover much of the ground, mostly south of the A127 trunk road.

A full list of sites where this Unit is or has been exposed is available in the Gazetteer under SITE TYPE – Thames (post-diversion)(APPENDIX 2)

Lower Thames

MIS 11

Orsett Heath Gravel/Boyn Hill Terrace

Clacton (LU 4)

MIS 9

Corbets Tey Gravel/Lynch Hill Terrace

Purfleet

Belhus

Little Thurrock (Globe Pit)

Upminster/Corbets Tey

MIS 7

Mucking Gravel/Taplow Terrace

Aveley (Sandy Lane and Purfleet Road)

West Thurrock (Lion Pit Tramway Cutting)

MIS 5e

East Tilbury Marshes Gravel

Under Lower Thames marshes, e.g. East Tilbury, Thurrock, Rainham

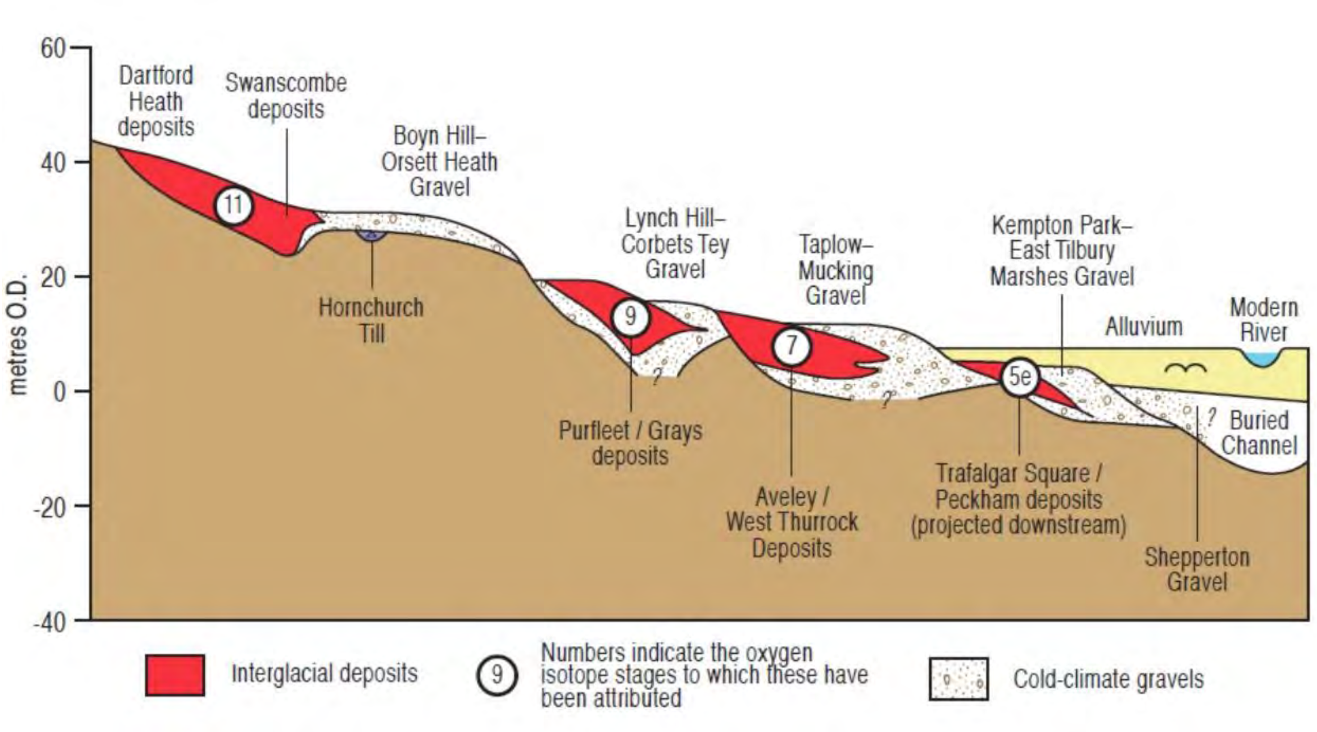

Figure 14. Idealised terrace sequence in the Lower Thames (Bridgland 2014)

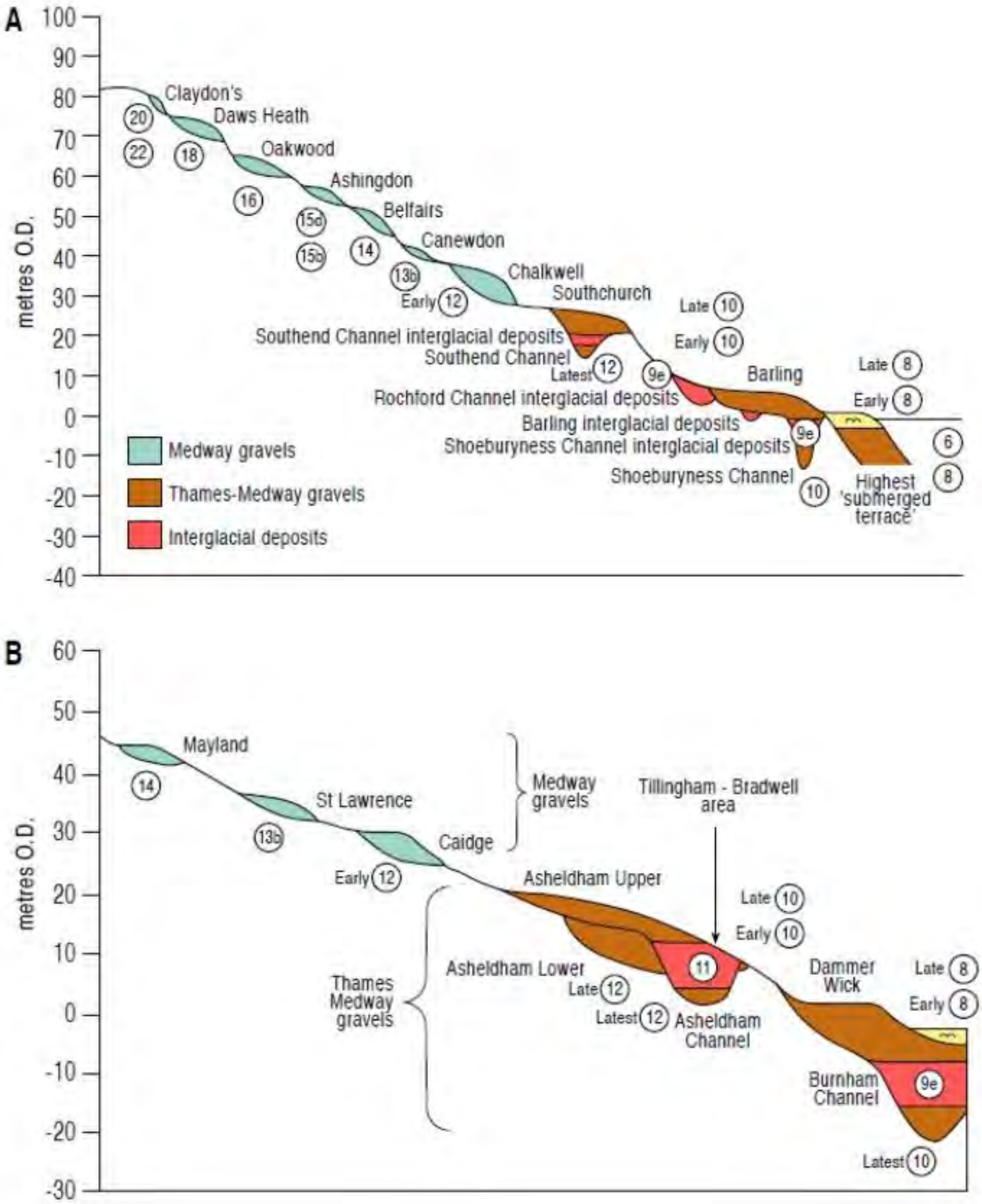

Figure 15. Idealised terrace sequences in the Rochford peninsula (A) and Tendring peninsula (B) (Bridgland 2014)

5.2.10 LITHOLOGICAL UNIT 10 – Low-level East Essex Gravels

Age

Anglian glaciation (MIS 12, *c*.478,000 – 424,000 years ago) to the Ipswichian Interglacial (MIS 5e, *c*.120,000 years ago).

Summary background

With the blockage and diversion, by the Anglian glacier, of the early (Kesgrave) Thames, it changed from its course across central Essex to its present valley. The post-Anglian Thames joined the Medway in the Southend area and the confluent Thames-Medway flowed across eastern Essex to the Clacton area, depositing the Low-level East Essex Gravels (Figures 12, 16, **Table 5**).

The Low-level East Essex Gravels continue the sequences of the Lower Thames, with equivalent interglacial material (Figure 14). The Boyn Hill Terrace is represented by the Southchurch – Asheldham – Mersea Island – Wigborough Gravels, with MIS 11 (Hoxnian) interglacial material within buried channel deposits at Tillingham and foreshore and onshore deposits at Clacton. The Lynch Hill Terrace is represented, in a more complex way, by the Shoeburyness Channel + Rochford and Barling Gravels – Dammer Wick Gravel – Cudmore Grove Channel and Cudmore Grove Gravels, with MIS 9 (Purfleet) interglacial deposits in the foreshore and cliffs. Represented in London at Trafalgar Square, but not in south Essex, MIS 5e (Ipswichian) deposits occur as foreshore deposits at Cudmore Grove at the Hippopotamus Site and at the Restaurant Site (both of these south-west of the MIS 9 deposits) and possibly offshore at Clacton (Channel IV).

These Low-level Gravels can be divided into Members and because the coastal area is broken by the Crouch, Blackwater and Colne, each land area has its own nomenclature (**Table 5**)

Sediment composition and environment of deposition

The predominant lithology of the gravels is flint from the North Downs and London Basin, but with a proportion of Greensand chert (pinhole chert) and sandstones from the Weald and of more exotic material, such as vein quartz and quartzites, contributed by the Lower Thames. A high proportion of the flints are angular or sub-angular indicating frost shattering, though blunted by subsequent transport by the river, and many show rounded indentations (pots) where frost has caused breakage of the flint surface (lids). The sedimentary structures are dominated by gravel bars separated by channel sands, indicative of periglacial braided river deposition, similar to rivers in the Arctic today.

Palaeolithic and palaeoenvironmental potential

Mapped LU 10 deposits are concentrated in Southeast Essex including outcrops on Mersea Island. They contain abundant records of Palaeolithic finds, often well-provenanced. There are more than 30 records (*c.*15% of Palaeolithic findspots in the HER) of artefact finds, mostly well-provenanced, from these map areas (**APPENDIX 3-TABLE FWS-10**). Most of these finds are from deposits attributed to Barling terrace, although several are also attributed to Southchurch/Asheldham terrace. Particularly important locales in the Barling Gravel include the Barling Gravel Pit (HER 11344) and Baldwin's Farm (HER 11047). At the former site there are good records of gravel deposits (Barling Gravel) containing Palaeolithic artefacts, and overlying a buried channel with fine-grained deposits dating to MIS 9. Other work in another part of the Barling Gravel Pit by the Medway Valley Palaeolithic Project in 2005 (HER 46924) identified artefact-bearing gravel deposits with faunal remains and sparse pollen preservation at a significantly lower level. These were dated by OSL to MIS 6, and thus possibly represent a different, younger terrace than the main Barling terrace. Three handaxes are reported from Baldwin's Farm, so this seems to be an area that would benefit from more systematic investigation.

There are fewer sites associated with Southchurch/Asheldham gravel deposits than with Barling deposits, but a higher proportion of the Southchurch/Asheldham sites are well-provenanced and accurately located. Notable sites are Roots Hall Gravel Pit (HER 9593), a gravel pit near Prittlewell Church (HER 9597) and Goldsands Pit, Southminster (HER 48080). This latter site is worthy of emphasis because the current HER record notes the site as "having potential", but does not mention the proven record (Wymer, 1985, Bridgland, 1994) of the recovery of two handaxes *in situ* during cleaning of a single section in 1983. This would suggest that deposits at the site may contain a rich concentration of artefactual remains. More systematic investigation and recovery of a larger artefact assemblage from this site could provide sufficient material to characterise the lithic industry and compare it with those thought to be broadly contemporary from other parts of the country, particularly the well-known Lower Thames region.

There are extensive spreads of LU 10 on the south side of the Blackwater estuary, but from which no artefact finds have been reported. There seems no reason why deposits in this area should be lacking in evidence, compared to other spreads of LU 10. This is therefore likely to be nothing more than due to their relative lack of investigation.

On the north side of the Blackwater estuary, there are several gravel terrace outcrops attributed to LU 10 on Mersea Island. However none of the artefact finds from this area are reliably provenanced to these deposits. Artefacts have mostly been found loose on the beach (PAS 58360) or are associated with the underlying Cudmore Grove Channel interglacial deposits, which occur in a cliff face and on the foreshore.

The MIS 11 channel deposits at Clacton-on-Sea are an extremely important example of Low-level East Essex river deposits, being the type-site of the Clactonian Palaeolithic Industry and rich in diverse faunal remains. However these particular deposits have been included under LU 4 (Interglacial deposits). A limited number of flakes and handaxes are associated with the Barling, Dammer Wick and Cudmore Grove Gravels. Possibly the low number of finds is a reflection of less investigation in this area, and the inaccessibility of many of the deposits of greatest potential.

Sites

A full list of sites where this Unit is or has been exposed is available in the Gazetteer under SITE TYPE Thames-Medway River (all entries relate to Low-level East Essex Gravel). Appendix 2

MIS 12 + 10

Asheldham Quarry

MIS 11

Tillingham
East Hyde

Barling (buried channel)
(Clacton)

MIS 9
Cudmore Grove, East Mersea (see below)

MIS 7
Shoeburyness (buried channel)
Burnham (buried channel)

MIS 5e
Restaurant site, East Mersea (see below) (River Blackwater)

East Mersea

Interglacial material is found at depth in channels, cut through the Low-level East Essex Gravels by a tributary. This has been investigated by Roe and Preece (2011) (Figure 16). There is limited potential from surface or near-surface outcrops, except on Mersea Island. At Cudmore Grove outcrop of MIS 9 material occurs in a cliff face and in a channel on the foreshore. In the nearby cliff and at Restaurant site a rich MIS 5e fauna has been found.

<u>Cudmore Grove, East Mersea</u>

Gravel and sand
Organic clay with wood fragments
Shelly detritus mud, richly fossiliferous
Clayey silt with estuarine Mollusca
Gravel
(London Clay)

<u>Restaurant site, East Mersea (River Blackwater)</u>

Clayey silt
Sandy silt with bones and shells
Gravels with mammal bones
(London Clay)

Finds include hippopotamus (*Hippopotamus amphibius*), straight-tusked elephant (*Palaeoloxodon antiquus*), narrow-nosed rhinoceros (*Stephanorhinus hemitoechus*), Bison (*Bison priscus*), giant deer (*Megaloceros giganteus*) and spotted hyaena (*Crocuta crocuta*).

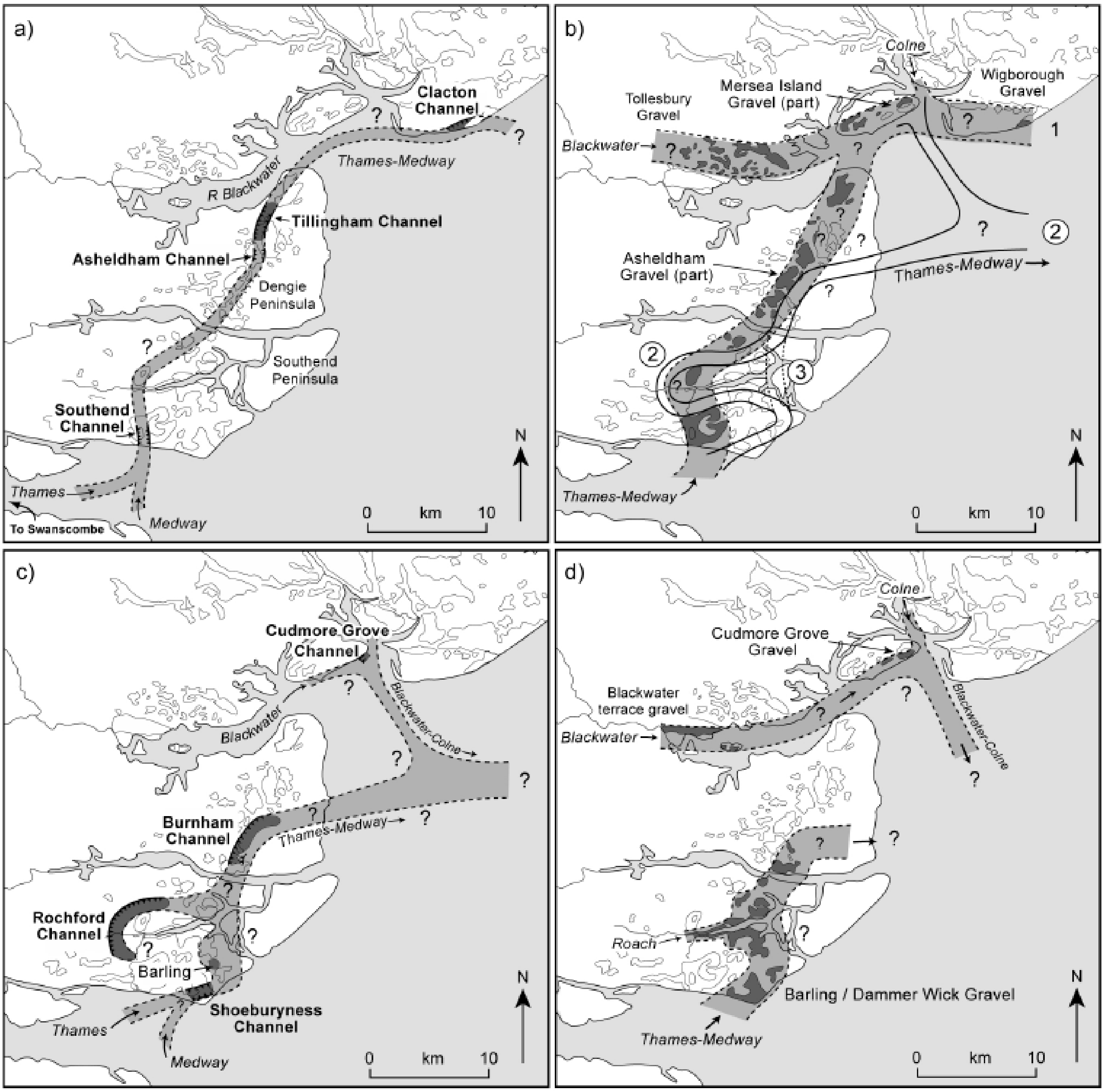

Figure 16 Palaeodrainage maps of eastern Essex during the interval between MIS 11 and MIS 8. (Based on Roe and Preece, 2011)

a) Thames-Medway drainage during the Hoxnian (MIS 11).

b) Possible palaeodrainage at the time of the Asheldham (Upper) Gravel aggradation during MIS 10.

c) Palaeo-estuary inferred for the MIS 9 interglacial.

d) Palaeodrainage at the time of the Barling Gravel aggradation (MIS 8).

The dark shading on map (a) and (c) show the distribution of channel-fill sediments of estuarine character that have been examined for pollen and other microfossils

Table 5 Eastern Essex, Quaternary Stratigraphy: Late Anglian and Post-Anglian

LOW-LEVEL EAST ESSEX GRAVELS				**KESGRAVE S & G COLCHESTER FORMATN**	**CONFLUENT LEEG+COLCH FORMAT**
Postulated MI Stage	**Southend area**	**Dengie Peninsula**	**Mersea Island**	**Tendring Peninsula**	**Tendring Peninsula**
MIS 8 *MIS 9* MIS 10-9 *(tr)*	**Barling Upper Gravel** *Shoeburyness Channel Deps* *Rochford Channel Deposits* Shoeburyness Channel Grav	**Dammer Wick Gravel** *Burnham Channel Deps* Burnham Channel Gravel	**Cudmore Grove Gravel** *Cudmore Gr Channel Deps* Cudmore Gr Channel Grav		
MIS 10 *MIS 11* MIS12-*11(tr)* MIS 12 (late)	**Southchurch Gravel** *Southend Channel Deposits* Southend Channel Gravel	**Asheldham Upper Gravel** *Tillingham Clay* *Asheldham Channel Deps* Asheldham Channel Grav Asheldham Lower Gravel	**Mersea Island Gravel**	**Wigborough Gravel** *Clacton Channel Deps* Clacton Channel Gravel	

Italic = Interglacial deposit **Bold = Surface deposit** (tr) = Downcutting and aggradation occurs during cold to warm transition

5.2.11 LITHOLOGICAL UNITS 11 - Terraces of the Essex Rivers

Age

Hoxnian (MIS 11) to Devensian (MIS 2)

Summary background

Essex was over-run by ice during the Anglian glaciation, broadly as far south as the alignment of the A12 road. Thus virtually all of the intra-Essex river systems post-date the Anglian (MIS 12).

The major rivers, the Lea, Roding, Chelmer, Blackwater, Colne and Stour have terraces or valley-side gravel spreads, some with notable find sites. Because of the complexity of dating and correlating the terraces of the minor rivers, as explained below, individual terraces will not identified, but the terrace sequences for each river will be treated as one.

Correlating the terraces of the Essex rivers is particularly difficult as few have organic remains by which they can be dated. The numbering of the terraces is by counting up from the present flood-plain within each of the major river valleys, so that terraces carrying the same number can differ in age from valley to valley. There are also other inconsistencies. This is well illustrated by the Blackwater Terrace 3. Hoxnian (MIS 11) lacustrine deposits overlie Terrace 3 gravels at Rivenhall (Turner, 1970), meaning that the underlying gravel is Anglian (MIS 12). However, Terrace 3 gravels on Mersea Island overlie MIS 9 deposits at Cudmore Grove (Bridgland, pers. comm.) and so must be MIS 8 in age or later. Another example is that Terrace 2 of both the Chelmer and Blackwater merge at their confluence at Langford (Geological Survey 1:50 000 Sheet 241, Chelmsford). Terrace 2 of the Blackwater has Devensian (MIS 2) organic deposits at Great Totham (Bridgland, 1994) but the numerically younger Terrace 1 of the Chelmer has older, Ipswichian (MIS 5e), deposits at Moulsham in Chelmsford. At Moulsham, Terrace 1 covers only a small area and the interglacial deposits come from former brickpits in an adjacent area mapped as London Clay, only a small patch of which has a covering of brickearth.

Sediment composition and environment of deposition

The terrace sediments of the smaller rivers in Essex are highly variable, from beds of relatively coarse gravel, often clayey, through sands to silts and clays, some of which are described as lacustrine (as at Moulsham on the Chelmer).

In the Essex rivers, the gravels reflect higher-energy river flows that are usually associated with cold periods, and the finer-grained sands, silts and clays quieter flows usually associated with warm stage interglacial periods. The more frequent occurrence of silty or clayey gravels suggests inputs from the local slopes. The larger rivers such as the Thames, creating wider terraces, would have had the space and power to separate out the silts and clays. The smaller rivers would have been less able to so do. It also seems that some the lesser rivers, or stretches along them, may not always have crossed the power threshold to cut down during the cold stages, affecting their ability to create terraces and helping explain the mismatches between the various river basins.

Palaeolithic and palaeoenvironmental potential

Artefacts are commonly found in river terrace gravels, sometimes in great abundance. Gravel bodies are an important part of the Palaeolithic heritage, with high potential for the recovery of evidence that makes an important contribution to national and regional research priorities.

Furthermore, mapped terrace bodies presumed to consist primarily of gravel may well contain unpredictably located sealed horizons of finer-grained material, and these may contain gently buried undisturbed Palaeolithic artefact remains, and a diversity of well-preserved palaeoenvironmental evidence.

The relatively small-scale terrace outcrops of the intra-Essex post-Anglian river system attributed to LU 11 can be important in providing a good understanding both of broad technological/typological variation through the Palaeolithic, and details of any regional variations.

A surprisingly large number (n=28) of finds in the current HER can be broadly associated with LU 11 (APPENDIX 3-TABLE FWS-11). Twelve findspots are associated with mapped outcrops, and a further 16 findspots are in locations where the grid locations indicate a different substrate (mostly Chalk, London Clay or head), but where their topographic situation makes it likely that unmapped Essex river terrace deposits are present. However, relatively few of these findspots are accurately located or well-provenanced.

In the Roding valley, between Woodford and Passingford Bridge, BGS mapping supplied to ECC shows Kempton Park Gravel, but published mapping (1:50 000 Sheet 257, Romford) shows the same outcrops as Roding Silt. There is no record of artefacts.

In the Lea Valley, published BGS mapping (1:50 000 Sheet 240, Epping) shows outcrops of Flood Plain Gravel, associated with the Lea Valley Arctic Plant Bed, flanking the Lea Valley. The Arctic Bed comprises peats and clays which have yielded a variety of fauna, such as mammoth, woolly rhinoceros, horse, reindeer, bison and rodents, including the collared lemming. Artefacts are sparse, mostly rolled handaxes, and some of Levallois type. The peats are dated between 21,530 and 28,000 BP. The grid references for the Arctic Bed are sometimes (e.g. Nazeing and Stratford) on the alluvium of the River Lea, indicating that the Kempton Park Gravel is below the modern flood plain. However, there are inconsistencies. Geological mapping supplied to ECC shows these outcrops as Kempton Park Gravel and Taplow Gravel.

Accurately-located sites from earlier in the Palaeolithic include Beauchamp's Farm, Wickford (HER 7532), Hoemill Gravel Pit (HER 7996) and Kelvedon (HER 8289). At Beauchamp's Farm a handaxe was found in head deposits, just beside a Crouch terrace outcrop that was probably its source. At Hoemill Gravel Pit, a large ficron handaxe in fresh condition was found at a spread of terrace gravel on the south side of the Chelmer. At Kelvedon, several handaxes have been found in association with spreads of Blackwater Terrace 3. However in this latter case, there is also the possibility that material originates from unmapped outcrops of Hoxnian lake-bed sediments that might be present in the area. Walton-on-the-Naze is also an area of high potential, where unmapped river deposits might be present in the inter-tidal and offshore zones. There are reports of a mammoth skeleton being found here.

There are several findspots that probably relate to the recovery of material from Devensian gravels, for instance Paper Mill Bridge (HER 5593) where cold-climate faunal remains were recovered from below the alluvium. Two sites are particularly important, possibly being nationally rare examples of Upper Palaeolithic material. There is a report from Chappel Farm, Little Totham (HER 46254) of an Upper Palaeolithic burin from a wide spread of T2 on the north side of the Blackwater. This find is most likely to originate not from the terrace gravel itself, but from below alluvium (or perhaps aeolian/colluvial brickearth) accumulated on the terrace surface. It therefore may represent a location where minimally disturbed material might be present, and perhaps with different concentrations of activity spread over a wide area. The other potentially important Upper Palaeolithic site is White Colne

Gravel Pit (HER 47301). Here, a leaf point was recovered from an outcrop of Colne terrace 1, on the north side of the current river channel, in association with faunal remains.

Sites

A full list of sites where this Unit is or has been exposed is available in the Gazetteer under SITE TYPE – River Terrace Deposits (APPENDIX 2)

Moulsham

River Chelmer

Terrace 1

MIS 5e Ipswichian

(TL 708 608)

Of particular interest from the Moulsham area, Chelmsford, was the finding of bones of hippopotamus (*Hippopotamus amphibious*), aurochs (*Bos primigenius*), woolly mammoth (*Mammuthus primigenius*), woolly rhinoceros (*Coelodonta antquitatis*), shells (*Limnaea palustris*, *L .pereger*, *L. truncatula*, *Planorbis marginatus*, *P. spirorbis*, *Pupilla muscorum*, *Succinea elegans* and *S. oblonga*) and wood. These record the waning stages of the Ipswichian interglacial. This fossil material was from a series of silts, gravels and brickearth (silt/clay) of the First Terrace. This is in keeping with the Ipswichian terraces of the Lower Thames and southern East Anglia which have a strong record of yielding biotic material, e.g. from Trafalgar Square (Thames), Hackney (Lea) and Bobbitshole (Ipswich; Belstead Brook/Orwell) (West, 1957; Preece, 1999; Green *et al.,* 2006). The gravels of this terrace are the equivalent of the Kempton Park Terrace, underlain by the East Tilbury Marshes Gravels of the Thames (Bridgland, 1994; Gibbard, 1994; Mitchell, 1995). No artefacts are associated with the site.

Dovercourt

At Dovercourt, a former gravel working known as Gants Pit (or by the name of the former farm, Pounds Farm) occurs on a mapped outcrop of LU 3 (Colchester Formation). However the site is regarded as an unmapped terrace outcrop of post-

Anglian Essex Rivers (LU 11). This emphasises the potential for mapped outcrops of LU 3 to contain different, unmapped deposits of Palaeolithic potential.

This is the richest source of Palaeolithic artefacts in the county and the richest source of handaxes (208 in number) in Essex (Roe, 1968; Wymer, 1985, 1999). It was also known to be a source of mammal fossils; Wymer (1985) listed beaver (*Trogontherium*), rhinoceros (*Rhinoceros*), fallow deer (*Dama dama*), red deer (*Cervus elaphus*), aurochs (*Bos primigenius*) and straight-tusked elephant (*Palaeoloxodon antiquus*). Warren (1933), who did much work at the site, confidently asserts that the Palaeolithic material came from a gravel deposit that overlay and abutted the gravel now recognised as the Colchester Formation and that it is part of a terrace of the Stour.

Great Totham

River Blackwater

Terrace 2

MIS 2 Devensian

Lofts Farm Pit (TL 866 092)

At Great Totham, Lofts Farm, during gravel working, a rich organic clay, 2.6 m thick was revealed approximately 3 m below the ground surface. The clay yielded wolf (*Canis lupus*), hyaena (*Crocuta crocuta*), reindeer (*Rangifer tarandus*), giant deer (*Megalocer*os), Bison/*Bos*, woolly rhinoceros (*Coelodonta antiquitatis*), horse (*Equus ferus*), woolly mammoth (*Mammuthus primigenius*), beetles, molluscs, ostracods.

Great Chesterford

Cam

Terrace 3

?MIS 7

Bordeaux Pit (TL 513 413)

The former Bordeaux gravel pit, at Little Chesterford, yielded mammoth, ?hippopotamus, rhinoceros and molluscs. A few worked flints are thought to have come from the base of the gravel, but most cannot now be traced or provenanced.

Other sites

River Stour

MIS 7 Aveley Interglacial

Wrabness (TM 165320)

See LU 4

River Lea

Flood Plain Gravel

MIS 2

Nazeing Lock (TL 373043)

5.2.12 LITHOLOGICAL UNIT 12 - Brickearth (Pleistocene) on Thames Terraces

Reworked aeolian deposits
Ilford Silt, Grays Brickearth

Age

MIS 10-8 (*c*.300,000 years ago) and MIS 8-6 (*c*.200,000 years ago).

Summary background

The term brickearth is used to cover deposits of various origins that are predominantly silty or clayey, with the potential to make bricks. Brickearth is usually associated with aeolian deposition in a cold stage and reworking later in that stage and in the subsequent warm and cold stage(s). Two periods of Brickearth accumulation are known to have occurred during the earlier Pleistocene period, *c*.300,000 years ago and *c*.200,000 years ago.

These periods of deposition are associated with the Lynch Hill Terrace (Purfleet Interglacial, MIS 9) and the Taplow Terrace (Aveley Interglacial, MIS 7) resulting in the Ilford Silt (Grays Brickearth). The two are conflated by the British Geological Survey. A further isolated outcrop of Aveley Interglacial age occurs at Wrabness, on the Essex bank of the Stour, dealt with in LU 11.

Sediment composition and environment of deposition

Much brickearth is initially of aeolian origin, deposited during cold periods when vegetation cover was sparse and the wind could pick up the finer particles (fine sand, silt and clay) from the ground surface. This material would be deposited widely over the landscape. Being deposited as a loose surface accumulation, much if not most was worked into the soil, by frost, rain, worms and so on, and it is recognised in present-day soils by a silty or clayey element that cannot be related to the local bedrock parent material. Where deposits were thicker, they were quickly reworked by surface wash from rain and snowmelt, so very little brickearth shows aeolian characteristics and can be characterised as true loess. Many areas mapped as Brickearth have sediments that are predominantly alluvial, rather than aeolian/colluvial.

The thicker brickearth spreads would tend to accumulate on flatter ground, such as the Taplow and Lynch Hill Terraces of the Thames particularly at Ilford, Dagenham and Grays (Ilford Silt/Grays Brickearth).

At Ilford and Thurrock the brickearth is underlain and overlain by gravel, thereby having a similar depositional sequence to the fluvial terrace sequences and so may be of fluvial rather than Aeolian origin.

The brickearths at Ilford and Thurrock have a rich fauna of Mollusca and vertebrates. The species list from the MIS 8-7-6 Lion Pit Tramway Cutting in the Taplow Terrace is indicative of interglacial conditions (rhinoceros, elephant, aurochs) and slow flowing or stagnant water (tench, roach, stickleback, carp), indicating the complex history of the deposit. The accompanying archaeology is from the surface of the underlying Crayford Gravel, with a Levallois knapping site. Of the same age, the brickearth at Ilford has few associated palaeoliths. The older Grays Brickearth spread abutting the Globe Pit, Little Thurrock (MIS 10-9-8) in the Lynch Hill Terrace shows an interglacial MIS 9 fauna.

Palaeolithic and palaeoenvironmental potential

In principle the earlier (pre-Late Devensian) Pleistocene Brickearth deposits attributed to LU 12 have high Palaeolithic potential. They are deposits that formed rapidly and would have quickly buried any Palaeolithic artefactual and/or faunal remains. In practice, many brickearth spreads prove to be relatively sterile, and so brickearth deposits are often regarded as of lower Palaeolithic potential. However, the principle remains sound. Some of Britain's most important Palaeolithic sites come from within brickearth deposits, such as the undisturbed knapping scatters at Caddington (Hertfordshire) and Crayford (northwest Kent). The Palaeolithic remains are often deeply buried towards the base of the brickearth, and the more acid nature of much brickearth may often not favour faunal preservation, so these factors may make the Palaeolithic potential of brickearth harder to recognise. In addition, the minimal disturbance of any archaeological remains may lead to any such remains being preserved as isolated concentrations in relatively large areas of sterility, again reducing the ease of recognition of high potential. In the case of predominantly alluvial spreads of brickearth, there is an enhanced potential for mammalian and other faunal remains to be preserved, in conjunction with artefactual remains on any short-lived land surfaces periodically exposed during the build-up of alluvial sediment.

In Essex, the thicker deposits of the Ilford Silt/Grays Brickearth (usually 1-3 m thick, but up to 6m in places), attracted heavy use for brick making. There is thus a rich archaeological and palaeoenvironmental record from brickearth deposits at Ilford and Grays. Unfortunately these deposits were heavily exploited in the 19th century, so much important material was collected then without sufficiently good provenance records for it to contribute to improving present day understanding of the Palaeolithic and Quaternary. Bones from this brickearth were collected before artefacts were widely recognized, but they have cut marks, suggesting that there must have been artefacts (Parfitt, in: Bridgland, 2013).

Only the Grays brickearth spread lies within the project area, on the north side of the Lower Thames. There are just two HER findspots associated with this brickearth (APPENDIX 3-TABLE FWS-12), Whitehall Lodge (HER 14578) and the Globe Pit, Little Thurrock (HER 45417). No Palaeolithic remains are known from Whitehall Lodge, but it is in the HER as one of the rare locations where spreads of the Grays brickearth survive, and therefore meriting investigation in the event of development impact. The Globe Pit, Little Thurrock contains a sequence of deposits at the extreme north edge of the east-west trending spread of the Grays brickearth. It has produced rich lithic remains of Clactonian aspect (flakes, cores and simple flake-tools) from presumed fluvial gravel deposits at the northern fringe of the brickearth spread, but few (if any) from the brickearth itself.

Sites

MIS 10–8 (Lynch Hill Terrace, Corbets Tey Gravel; Purfleet Interglacial)
Globe Pit, Little Thurrock (TQ 625783)
and surrounding area, mapped as Ilford Silt

MIS 8-6 (Taplow Terrace, Mucking Grave; Aveley Interglacial)
Lion Pit Tramway Cutting, West Thurrock (TQ 598783)
and surrounding area, e.g. Sandy Lane Cemetery
(possibly not mapped as brickearth)

5.2.13 LITHOLOGICAL UNIT 13 - Brickearth (Devensian) across central and Eastern Essex

Reworked aeolian deposits
Brickearth, Coverloam, Roding Silt

Age

MIS 2 Devensian/Late Glacial Maximum (*c.*15-20,000 years ago)

Summary background

The term brickearth is used to cover deposits of various origins that are predominantly silty or clayey, with the potential to make bricks. Brickearth is usually associated with aeolian deposition in a cold stage and reworking later in that stage and in the subsequent warm and cold stage(s). Three periods of Brickearth accumulation are known to have occurred, at *c*.300,000, at *c*.200,000 years ago and at *c*.15-30,000 years ago. The last is dealt with here.
During MIS 2 (Devensian cold stage/Late Glacial Maximum) – MIS 1 (Holocene), about 30,000 – 15,000 years ago, brickearth was deposited:

- on the till plateau lands of Essex (mostly north of the A12)
- between Prittlewell and Burnham-on-Crouch
- on the Tendring peninsula, mapped as coverloam
- on the Taplow and Kempton Park Gravels at Woodford in the Roding Valley (Roding Silt)
- as Enfield Silt associated with the alluvium of the River Lea between Roydon and Cheshunt.

Sediment composition and environment of deposition

Much brickearth is initially of aeolian origin, deposited during cold periods when vegetation cover was sparse and the wind could pick up the finer particles (fine sand, silt and clay) from the ground surface. This material would be deposited widely over the landscape, therefore at varying heights. Being deposited as a loose surface accumulation, much if not most was worked into the soil, by frost, rain, worms and so on, and it is recognised in present-day soils by a silty or clayey component that cannot be related to the local bedrock parent material. Where deposits were thicker, they were quickly reworked by surface wash from rain and snowmelt, so very little brickearth shows aeolian bedding structures.

More extensive brickearth spreads occur on flatter ground, such as the terraces between Prittlewell and Burnham, and on the Tendring Peninsula (often mapped as coverloam). There are residual patchy spreads on the till plateau, such as on the hill tops either side of the Ter Valley between Boreham and Witham and on the east side of the Lea Valley around Roydon (mapped as Enfield Silt).

The Enfield Silt associated with the Lea Valley alluvium may be part of a fluvial aggradational sequence, overlying gravel and underlying a veneer of alluvium. The Silt has not been recorded on the Essex side to date, but the potential could be there. To the south of the study area, the gravels include the Lea Valley Arctic Bed, dated to 21,000 to 28,000 ago. The Arctic Beds provide environmental information, but have a poor archaeological record.

Palaeolithic and palaeoenvironmental potential

The brickearth of the Roding and Ter valleys and the Tendring Plateau tends to be thin, less than 2 m, and has a poor archaeological record, probably reflecting the relatively few brick-pits using the resource. The poor record of archaeological and palaeoenvironmental finds suggests these areas have a poor potential.

The deposits of brickearth in the Prittlewell – Burnham area, are thicker, reaching 10 m or more at Eastwood. Again, there appears to be no record of finds associated with the brickearth despite its thickness.

For the Enfield Silt flooring the Lea Valley, Wymer (1985) notes ‘with one important, rare exception, the archaeological evidence from these Devensian deposits are sparse and uninformative’.

Deposits attributed to LU 13 are concentrated in north-eastern Essex, with a major spread (described as "coverloam") in the lower Colne valley, in the vicinity of Colchester. There are twelve findspots in the Essex HER that are spatially associated with LU 13 (APPENDIX 3-TABLE FWS-13), most of them associated with the spread of coverloam at Colchester. However none of these findspots are accurately located or stratigraphically well-provenanced, and it is unlikely that any of them represent material that is actually associated with Devensian brickearth. Rather, they are thought likely to be of older age, either associated with (or derived from) unrecognised outcrops of older post-Anglian/pre-Devensian head or lacustrine deposits sealed below the Devensian coverloam, or originating from the spread of Kesgrave-Colchester Formation deposits (LU 3) that occurs deeper down across this area.

Four of the findspots (HER 11593, 11619, 46834 and 12522) are not too far (within 3km) to the east of the Marks Tey Hoxnian lake. Besides Palaeolithic implements, one of these sites (Stanway Manor, HER 46834) is reported as producing a number of large bones, including vertebrae and tibia, however the context in which these were found is unknown. It is possible that unmapped lake-marginal sediments are present under the mapped coverloam, and that these contain Palaeolithic material, with faunal preservation. If so, these deposits would be of high importance. Alternatively, if these finds originated from deeper-lying Kesgrave deposits, they would also be of high importance. If they come from glaciofluvial or post-Anglian head deposits they would probably be of less importance, but their provenance is presently entirely uncertain.

Three findspots are associated with areas of LU 13 away from the Colchester concentration. One is on the north side of the Colne (HER 11870), one further north towards the Stour (HER 2702), and the third further east on the south side of the Stour. As for the finds in the Colchester area, their provenance is entirely uncertain. It is less likely (but still possible) that unmapped lacustrine and lake-marginal deposits are present in these areas, and perhaps slightly more likely that they come from glaciofluvial or head deposits of less importance.

In summary, LU 13 has produced a reasonably high number of Palaeolithic remains. However, their provenance is poorly understood. It is possible that the quantity of finds in the Colchester area merely reflects the greater degree of activity and investigation here, leading to a greater likelihood of recovering Palaeolithic finds. It is likely that areas attributed to LU 13 contain a range of different (and unmapped) outcrops of other deposit types, and that these contain Palaeolithic remains, some of which might be important. Thus it is necessary to carry out a systematic array of further work to improve understanding of these arrays, in order to help future curatorial decision-making in conjunction with development proposals.

<u>Sites</u>

There does not appear to be a record of Palaeolithic archaeology associated with brickearth in Essex, but nearby in Kent there is a significant record, from Crayford, Wansunt Pit, Ebbsfleet and Sittingbourne. This warrants a need to put notice on the Essex brickearths for their potential to yield palaeoliths.

Several site locations duplicate those from LU 8, Glacial- Interglacial Lacustrine deposits, as the lacustrine clays are often suitable for brick-making and the deposits are not mapped consistently in one or the other designation.

Three sites where this Unit is or has been exposed is available in the Gazetteer (APPENDIX 2) under SITE TYPE – Periglacial Deposits and Features – Great Wakering, Mistley Heath, North Shoebury

Southend Area

Eastwood (TL 8350 8998
Sutton (TL 9074 8741)
Cherry Orchard Lane (TL 851 894)
Hawkwell (TL 852 927)
Stroud Green (TL 855 910)
Bournes Green (TL 905 875)

Chelmsford Area

Ter Valley (TL 7604 1289, 7815 1350, 784 130, 788 128, 7781 1298)
Scarlett's Farm (TL 7470 1432 to 7496 1425)
Springfield – Boreham (TL 7680 1095)
Crix Farm (TL 7752 1056, 7706 0991 to 7738 1003)
Brackey Wood (TL 772 097) – may have been brick pits
Witham bypass (TL 8100 1284)
Sandford's Farm (TL 810 120)
Butlers (TL 8100 0987)
Oak Farm/Warren Farm (TL 810 060)
Chelmer Valley (TL 780 094; Ulting Hall, Langford Park)
Hatfield Wick (TL 7770 1235, 7784 1212, 7800 1145, 7885 1065, 795 100)
Rivenhall End (TL 834 162, 844 155)
Tyndales – Royal Oak (TL 806 045, 8070 0515)
Cock Clarks (TL 807 027, 8135 0255)
Ulting (TL 810 102, 803 100, 8084 0965)

Extensive outcrops are mapped in the following areas:
Boreham – Russell Green
NW and SW of Witham
Ulting
Woodham Walter
Tendring

5.2.14 LITHOLOGICAL UNIT 14 - Tufa

Age

Holocene, Hoxnian

Summary background and environment of deposition.

Tufa usually consists of soft porous calcium carbonate precipitated around calcareous springs. The tufa often coats grasses and other vegetation and stones adjacent to the spring. In Essex, chalk is not a surface or near-surface deposit except in small areas in the very south-west or north-west of the county, so there is little potential for extensive tufa deposits. Such deposits as do occur are associated with the modern springs issuing from the calcareous Anglian till (boulder clay).

Although springs may seem attractive areas for human occupation or visitation, there is no record in Essex of associated artefacts or palaeoenvironmental information, unlike the examples of Hoxnian (MIS 11) tufas reported from Hertfordshire at Hitchin, Oughtonhead Lane (TL 172 299) associated with Mollusca, but no artefacts. However in this instance Chalk is a surface or near-surface deposit and so is not a good analogy for Essex. A better analogy is from Suffolk at Beeches Pit, West Stow (TL 798 719), where both Mollusca and artefacts were found in tufa associated with till (boulder clay), though there is Chalk nearby.

Palaeolithic and palaeoenvironmental potential.

The known Essex tufas are Holocene in age, and therefore have no known Palaeolithic potential. There is a very limited potential for Hoxnian tufa development in the extreme south-west or north-west of the county. One should however take care when encountering any Holocene tufas, to verify whether or not any final Upper Palaeolithic material from the Devensian/Holocene transition is present at the base of the tufa.

Sites

Tufa is sporadically reported, the largest outcrops, albeit still of very limited extent, being in the Ter Valley, near Terling, and Brain Valley, near Witham, in some cases associated with peat (Bristow, 1985). Smaller patches occur in the Dunmow area at Martels (TL 638 197) (Lake and Wilson, 1990). The tufa is related to modern spring seepage. No detailed examination of the tufa is reported.

5.3 Non-Pleistocene geologies descriptions, and finds from areas without mapped Pleistocene deposits

5.3.1 HEAD

Head comprises slope deposits reworked under periglacial conditions as solifluction. The process involves surface deposits of the slope moving as mudflows in saturated ground conditions during periods of ground-ice melting.

The head deposits of Essex are mostly thought to have formed late in the Pleistocene, in post-Palaeolithic times, and so have no potential for pristine Palaeolithic material, but may contain reworked material. However, it is likely that older Head deposits are present in the county, and these may contain (or seal) contemporary Palaeolithic remains of importance. Unfortunately it is not known where any such outcrops are most likely to occur, if present. In addition to this, mapped Head outcrops may contain unmapped elements of other deposit types, such as lacustrine deposits, river terrace deposits or plateau brickearth.

A reasonably high number (n=24) of Palaeolithic findspots in the Essex HER are associated with Head outcrops. However seventeen of these were re-attributable to other LUs, with most (n=12) re-attributions to LU 9, Lower Thames terrace deposits. Notable re-attributions that exemplify the problems in relying entirely on matching the grid co-ordinate in the HER with geological mapping (for which the outcrop boundaries are rarely going to be precisely correct) are:

- HER 46035, the field south-west of Durward's Hall, Rivenhall, where field investigations have confirmed the presence of Hoxnian lacustrine sediments (LU 8)

- HERs 19471 and 47220, Pleistocene deposits at Sandy Lane, Aveley, the latter being the location of the exceptional find of a mammoth and an elephant overlying each other at the same spot, in alluvial Thames deposits (LU 9) dated to MIS 7

- HER 7532, handaxe find from near a mapped Crouch terrace outcrop (LU 11)

5.3.2 ALLUVIUM

Alluvium comprises mostly sands, silts, clays and occasional gravels, usually small, deposited on river floodplains during periods of overbank flooding. The alluvium of the present Essex rivers is associated with their present courses and floodplains, and is of recent origin, probably from the late Devensian through to today. There are also dry valley tributary systems associated with Essex rivers, that are filled with alluvium but in which water doesn't currently flow.

The deposits, being post-Palaeolithic, have potential for derived material from the Lower/Middle Palaeolithic and handaxes are fairly often recovered. However, undisturbed sites dating to the final Upper Palaeolithic, associated with the end of the last Ice Age and the transition to the Holocene may be present at the base of Holocene alluvial sequences. Spreads of present-day alluvium may overlie productive Palaeolithic deposits of different types and ages, for instance as at Moulsham (see LU 11, Terraces of the Essex Rivers).

A reasonably high number (n=21) of Palaeolithic findspots in the Essex HER are associated with mapped alluvial bodies. Fifteen of these were re-attributable to a wide range of other LUs, with most re-attributions to LU 9 (Lower Thames terrace deposits, n=5) and LU 11 (Essex river terraces, n=4). Other re-attributions were made to LUs 3, 7, 8, 10 and 13. Notable re-attributions that exemplify the problems in relying entirely on matching the grid co-ordinate in the HER with geological mapping (for which the outcrop boundaries are rarely going to be precisely correct) are:

- HER 3352, discovery of abundant lithic remains from gravel at Daking's Pit, Hillhouse Farm, thought most likely to be attributable to the Kesgrave Colchester Formation (LU 3)

- HER 46924, Pleistocene fluvial deposits under alluvium at Barling Gravel Pit, dated to MIS 6 and containing pollen, mammalian remains and lithic artefacts, attributed to Low-level East Essex terrace deposits (LU 10)

- HER 46833, a rich and diverse collection of large mammalian fossils including Bison, Bos, beaver, red deer, mammoth, horse and hippopotamus recovered from presumed lacustrine (LU 8) and/or fluvial deposits (LU 11) at Copford Place

5.3.3 BEACH: SALT MARSHES, BLOWN SAND AND BEACH SAND AND GRAVEL

The salt marshes of Essex are of very recent origin, forming in quiet estuarine inter-tidal zones. Clay and silt particles carried downstream by freshwater rivers meet salt water in the estuarine area and combine (flocculate) to form larger particles that are deposited between the high and low water marks. Following initial deposition plants become established forming a marsh. From this stage, the salt marsh can grow more quickly as the vegetation slows the water flow and traps more sediment. Because of their recent origin, they have no potential for pristine Palaeolithic archaeology, though during periods of sea-level fall (regression) the salt flats became habitable and may have more recent archaeology buried within them.

Blown sand comprises uncemented sand, usually moved off a beach by onshore winds and deposited nearby. It is usually ephemeral in the geological record and are of very recent origin, mostly developed in the last millennium at their oldest. Because of their recent origin, they have no potential for pristine Palaeolithic archaeology within them, though they may cover unmapped Pleistocene deposits of Palaeolithic importance.

Beaches are highly dynamic environments, constantly changing morphology and sediment type, seasonally or following storms. They have no potential for Palaeolithic archaeology within the currently active sand/gravel bodies, which may however contain reworked material. This reworked material may be indicative of nearby exposures with important Palaeolithic remains, for instance outcropping in cliffs abutting the intertidal zone, or occurring under the beach deposits and extending offshore.

A moderate number (n=11) of Palaeolithic findspots in the Essex HER are associated with beach environments, all bar two of which were re-attributable to other LUs, with re-attributions evenly divided between LU 4 (Interglacial deposits), LU 10 (Low-level East Essex gravels) and LU 11 (Essex river terraces). Notable re-attributions that exemplify the problems in relying entirely on matching the grid co-ordinate in the HER with geological mapping (for which the outcrop boundaries are rarely going to be precisely correct) are:

- HER 19600 and 17628, beach finds of material from unmapped sub-surface interglacial channel deposits (LU 4) at Cudmore Grove, East Mersea, and Clacton-on-Sea

- HER 2803, reports of rich faunal remains deriving from presumed Essex river fluvial deposits (LU 11) in and above the intertidal zone, including a mammoth skeleton

5.3.4 LONDON CLAY

A reasonably high number (n=20) of Palaeolithic findspots in the Essex HER are not associated with any Pleistocene LUs but with London Clay bedrock of Tertiary date. Clearly no Palaeolithic material is going to be present in, or have originated from, this deposit. Many of these records come from general or estimated locations, for which the rough grid co-ordinate happens to fall on an area of London Clay within an area of Pleistocene deposits that are the likely source of any Palaeolithic material. However it is also the case that some sites have accurately reported locations, but material has been found in unmapped deposit outcrops, or that they are from old pits where London Clay is now exposed in the pit floor, but Palaeolithic remains were recovered from deposits prior to their extraction or from pit faces where deposits are still preserved.

The important point here is that areas mapped as London Clay (or indeed Chalk, Thanet Sand, or other Solid geological beds) cannot be ruled out as having potential for Palaeolithic remains. Consideration needs to be given to the Palaeolithic potential of localities where Pleistocene LUs are not mapped, bearing in mind their topographic situation, records of Palaeolithic finds and the presence of any nearby mapped Pleistocene outcrops.

All bar three of the HER findspots associated with London Clay were re-attributable to other LUs. The greatest number (n=5) of re-attributions was to LU 3 (Kesgrave Colchester Formation). Three re-attributions were made to each of LU 10 (Low-level East Essex gravels) and LU 11 (Essex river terraces). Two were made to each of LU6 (High-level East Essex Gravel), LU 7 (Head/lacustrine deposits overlying glacial-glaciofluvial till/sand/gravel) and LU 9 (Lower Thames terrace deposits). Notable re-attributions that exemplify the problems in presuming that areas mapped as London Clay do not have any Pleistocene/Palaeolithic potential are:

- HER 7252, recovery of two flakes in situ from pre-Anglian interglacial deposits within the Kesgrave-Colchester Formation (LU 3)

- HERs 9876, 11071and 11135, recovery of several handaxes from various localities with Barling Gravel (LU 10), especially Baldwin's Pit (HER 11135)

5.3.5 LAMBETH GROUP DEPOSITS AND THANET SAND

A few (n=4) Palaeolithic findspots in the Essex HER are not associated with any Pleistocene LUs but with Lambeth Group or Thanet Sand bedrock of Tertiary date. Clearly no Palaeolithic material is going to be present in, or have originated from, these deposits.

All four of these records represent unprovenanced material from vague general or estimated locations. None of them were re-attributable to a Pleistocene deposit. Nonetheless, it is important to remember that areas mapped as Lambeth Group, Thanet Sand (or other Tertiary beds) cannot be ruled out as having potential for Palaeolithic remains. Consideration needs to be given to the Palaeolithic potential of localities where Pleistocene LUs are not mapped, bearing in mind their topographic situation, records of Palaeolithic finds and the presence of any nearby mapped Pleistocene outcrops. For instance at Swanscombe in Kent, a substantial area to the south of the mapped outcrop of Boyn Hill terrace (LU 9) that underlies the village is mapped as Thanet Sand, but has been proven to contain numerous nationally important Palaeolithic remains, including the undisturbed Clactonian butchery site of the Ebbsfleet elephant (Wenban-Smith 2013).

5.3.6 CHALK

A high number (n=30) of Palaeolithic findspots in the Essex HER are not associated with any Pleistocene LUs but with Chalk bedrock of Cretaceous date. Clearly no Palaeolithic material is going to be present in, or have originated from, this deposit, however access to fresh raw material from exposed Chalk would have been very important. Many of the HER records come from general or estimated locations, for which the rough grid co-ordinate happens to fall on an area of Chalk bedrock near Pleistocene deposits that are the likely source of any Palaeolithic material. However some sites represent finds from unmapped Pleistocene deposits, or are from old pits where Chalk is now exposed in the pit floor, but Palaeolithic remains were recovered from Pleistocene deposits prior to their extraction or from pit faces where Pleistocene deposits are still preserved.

The important point here is that areas mapped as Chalk (or indeed London Clay, Thanet Sand, or other Solid geological beds) cannot be ruled out as having potential for Palaeolithic remains. Consideration needs to be given to the Palaeolithic potential of localities where Pleistocene LUs are not mapped, bearing in mind their topographic situation, records of Palaeolithic finds in the vicinity and the presence of any nearby mapped Pleistocene outcrops.

All bar four of the HER findspots associated with Chalk were re-attributable to other LUs. The great majority (n=21) of re-attributions was to LU 9 (Lower Thames terrace deposits). Three re-attributions were made to LU 11 (Essex river terraces) and two were made to LU 8 (lacustrine interglacial deposits dating to MIS11). Notable re-attributions that exemplify the problems in presuming that areas mapped as Chalk do not have any Pleistocene/Palaeolithic potential are:

- the complex of sites in the vicinity of Purfleet (eg. HERs 5040, 18007 and 45422) where numerous important sites such as Armor Road, Bluelands/Greenlands Pit, Botany Pit and Esso Pit have locations that are associated with chalk bedrock. Even though these sites (and the numerous other HER findspots in the vicinity) are mostly quarried down to the Chalk, small but important areas of unmapped and unquarried deposit survive, and these need to be sought and investigated in the event of any development plans in this area, and in other analogous areas.

- HERs 388 and 493, reports of Palaeolithic flints from near where patches of interglacial post-Anglian MIS 11 lacustrine deposits (LU 8) outcrop along the Cam headwaters east of Audley Park and along the Debden-Saffron Walden road.

5.4 Distribution of Areas of Palaeolithic archaeological Potential (PPAs)

In total ***419*** areas of Palaeolithic potential were categorised through the process of applying the project methodology. The PPAs are illustrated by District (Figures 17 – 29) and the attributes are held in a table in **APPENDIX 4**

10 polygons of 'very high potential' have been identified through the project methodology. These zones of very high potential will be sites which have known evidence for Palaeolithic archaeology and so should be known to Historic Environment Consultants through the HER. The creation of the zones allows an understanding of the nature of the deposits from which the material may have been derived and extend the area of potential to those areas where the LU may extend either at the surface or be shown to be present below later Holocene deposits such as head or alluvium.

The reclassification of the LUs has identified sediments with differing potential for the survival of Palaeolithic remains, which is not always reflected in the HER findspot count. Sediments in which Palaeolithic and Pleistocene faunal or floral remains are likely to be present and well preserved are those with low energy environments of deposition and low levels of post deposition processes affecting them. For Essex this would include LU 4 Interglacial deposits and LU 8 Lacustrine deposits. However these are not always the sediments in which the majority of Palaeolithic material has been found.

The occurrence of gravels across Essex is widespread. The classification of the gravels into the various LUs has allowed an understanding for the non-specialist of the potential of those gravels to either contain Palaeolithic material within the gravel body itself or within the possible finer grained material within the terrace sequence that the LU encompasses. The creation of the PPAs allows a quick recognition of those gravel bodies which have a higher potential for Palaeolithic remains than others. A high number of the LUs are largely composed of sand and gravel deposits which have yielded Palaeolithic artefacts and which are considered to have a high potential for the retrieval of further artefacts or faunal remains. Five out of eight LUs which are largely gravel bodies have evidence for Palaeolithic archaeological remains, where there is direct evidence for this the LU is considered to have a high potential, however where there is only indirect evidence the potential is reduced due to the reduced potential for finding and retrieving such artefacts from the gravels.

51 separate areas (PPAs) were identified as having a HIGH potential for the presence of Palaeolithic remains and/or Pleistocene faunal or floral remains.

Probably of more significance in terms of applying the methodology to historic environment matters will be those zones identified with a moderate potential, of which there are ***216*** which may have used previously unanalysed data or used proximity and specialist knowledge to advance our understanding of the Palaeolithic potential of an area that has not been previously identified. As stated above, due to the widespread occurrence of gravel bodies across Essex, and the specialists' determination of many of them to be of HIGH potential, the LU polygons which had no direct recorded evidence for Palaeolithic archaeological remains or Pleistocene faunal remains would be considered to be PPAs of MODERATE potential.

Glacial material – although it is clear the there is little chance of human presence during the extreme conditions of the glacial periods there are still a high number of findspots within this material. This is likely to be material which has been eroded from and transported from the underlying Pleistocene deposits by the ice or by water or that has actually come from non-glacial sediments that may lie within or upon the glacial deposits and be currently unmapped. The significance of this material is difficult to quantify and the likelihood of finding further material is difficult to assess. Where findspots of Palaeolithic material have been plotted as coming from areas where glacial sediments have been mapped then the potential of these areas has to be considered as being moderate which may entail a basic assessment of any existing borehole information in the area to determine whether there is a possibility for unmapped sediments of Pleistocene age with a higher potential for Palaeolithic remains to exist.

Many of the large expanses of pre-Pleistocene geologies would be considered to be ZERO potential PPAs, however it was often found that in areas bordering high potential Pleistocene geologies or even in random areas where Palaeolithic findspots had been recovered there was the possibility for the presence of unmapped Pleistocene geologies. Where this could be confidently demonstrated through analysis of the GIS datasets the potential of the areas covered by pre-Pleistocene geologies would be considered to be MODERATE or LOW, dependant on the score of the adjacent PPAs or the strength of the evidence from the other GIS datasets. Out of 417 total polygons only ***137*** areas were categorised as having a low potential for the presence of Palaeolithic archaeological remains and/or Pleistocene faunal/floral remains, however this equates to a relatively large proportion of the county.

Only ***2*** areas could be confidently categorised as ZERO potential, largely due to the possibility of many seemingly ZERO potential LUs having GIS datasets which seemed to indicate some potential for Palaeolithic archaeological or Pleistocene faunal/floral remains. These PPAs categorised as having zero potential are based on our current knowledge and understanding and largely include areas of pre-Pleistocene geologies with no evidence or likelihood to contain unmapped Pleistocene LUs with potential for Palaeolithic archaeology or Pleistocene palaeoenvironmental remains.

The only **3** PPAs of UNCERTAIN potential include the Tufa deposits (LU 14) which, in Essex, has only been identified as Holocene in date which has no known association with Palaeolithic archaeological finds or Pleistocene faunal remains and Stanmore Gravel (LU 1).

MAP OF EACH DISTRICT WITH PPA ZONES IDENTIFIED BY NUMBER

5.4.1 BASILDON

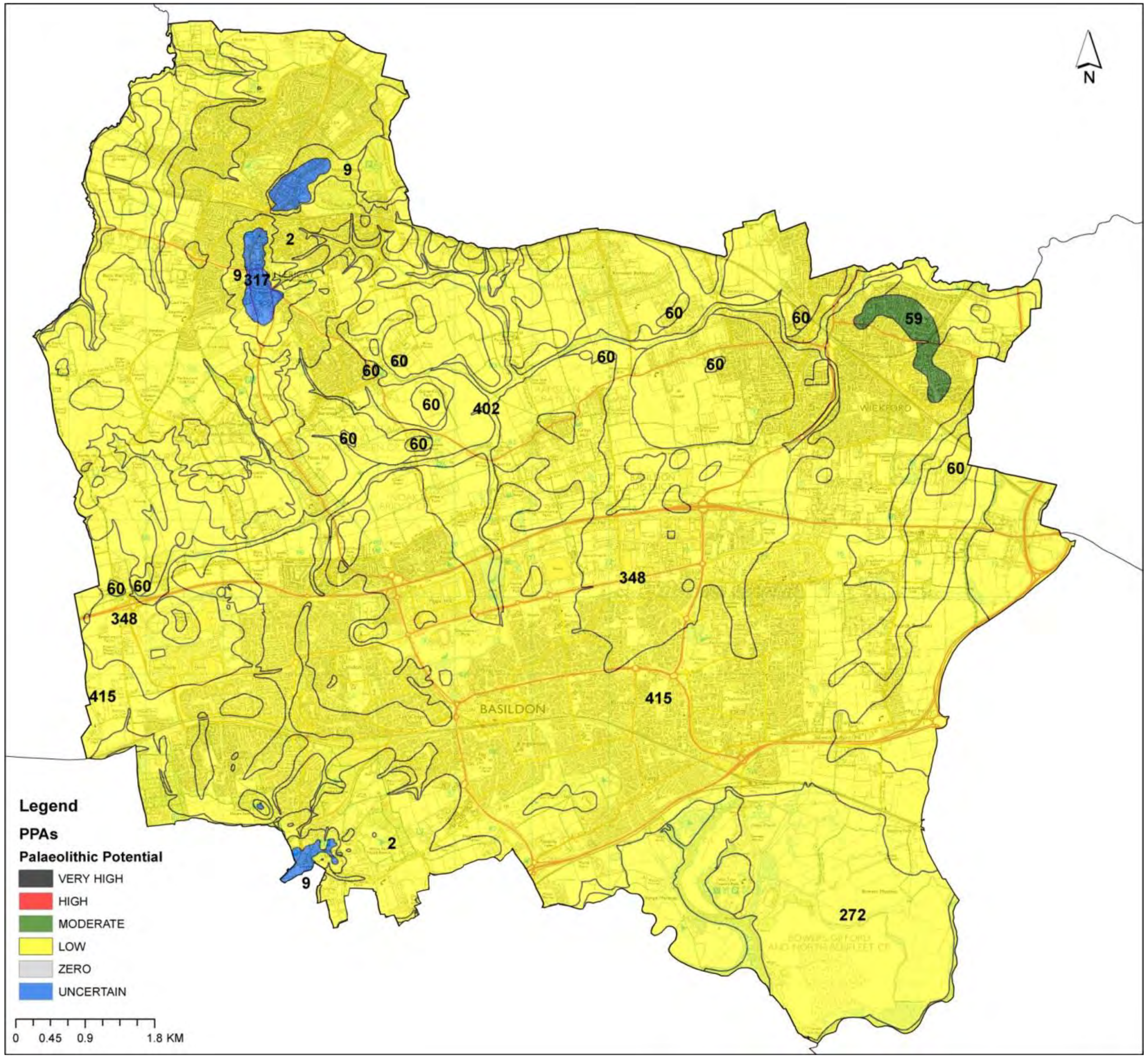

Figure 17 PPAs within the District of Basildon (For illustrative purposes only- not all PPA polygons are labelled)

5.4.2 BRAINTREE

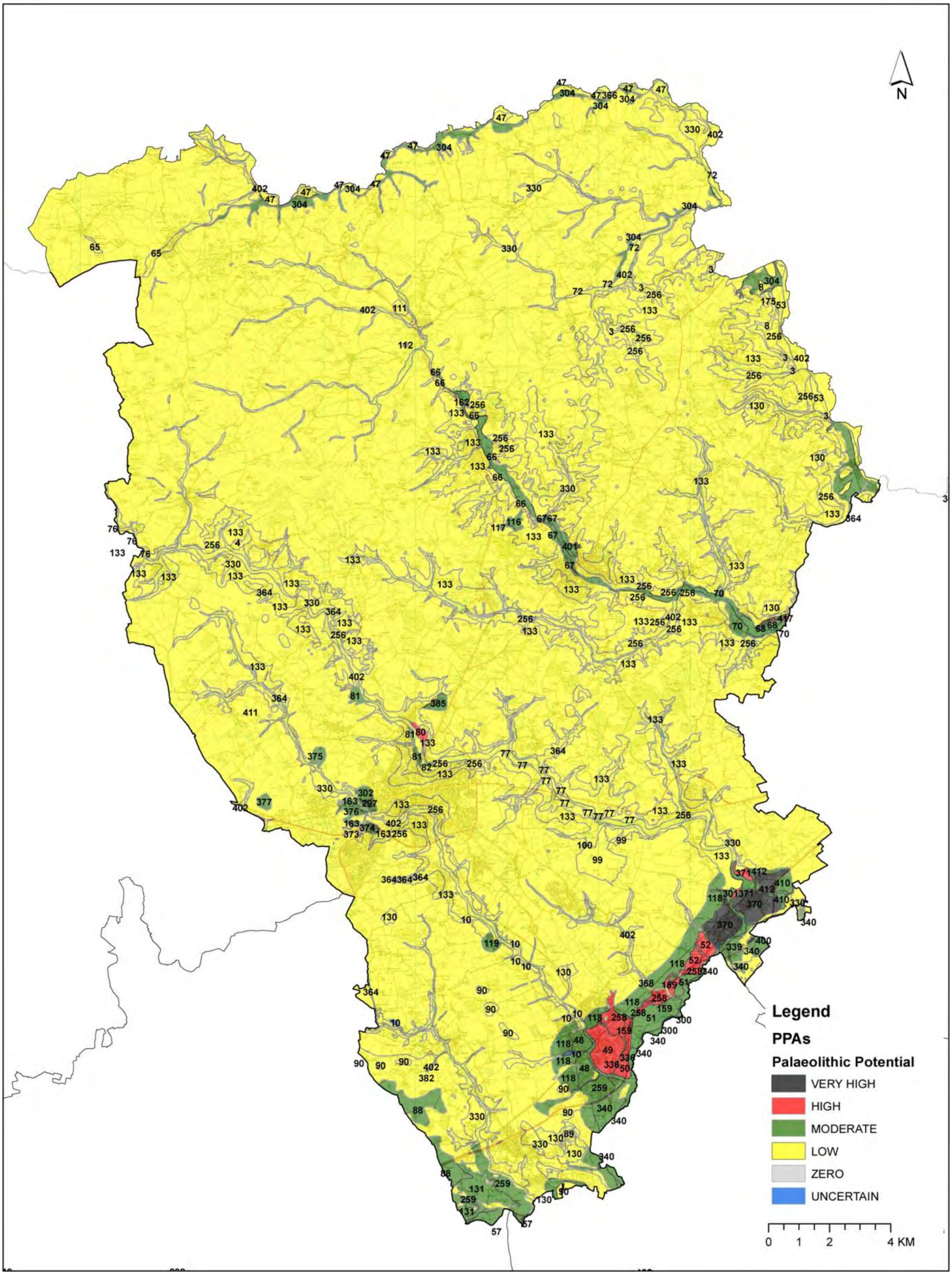

Figure 18 PPAs within the District of Braintree (For illustrative purposes only- not all PPA polygons are labelled)

5.4.3 BRENTWOOD

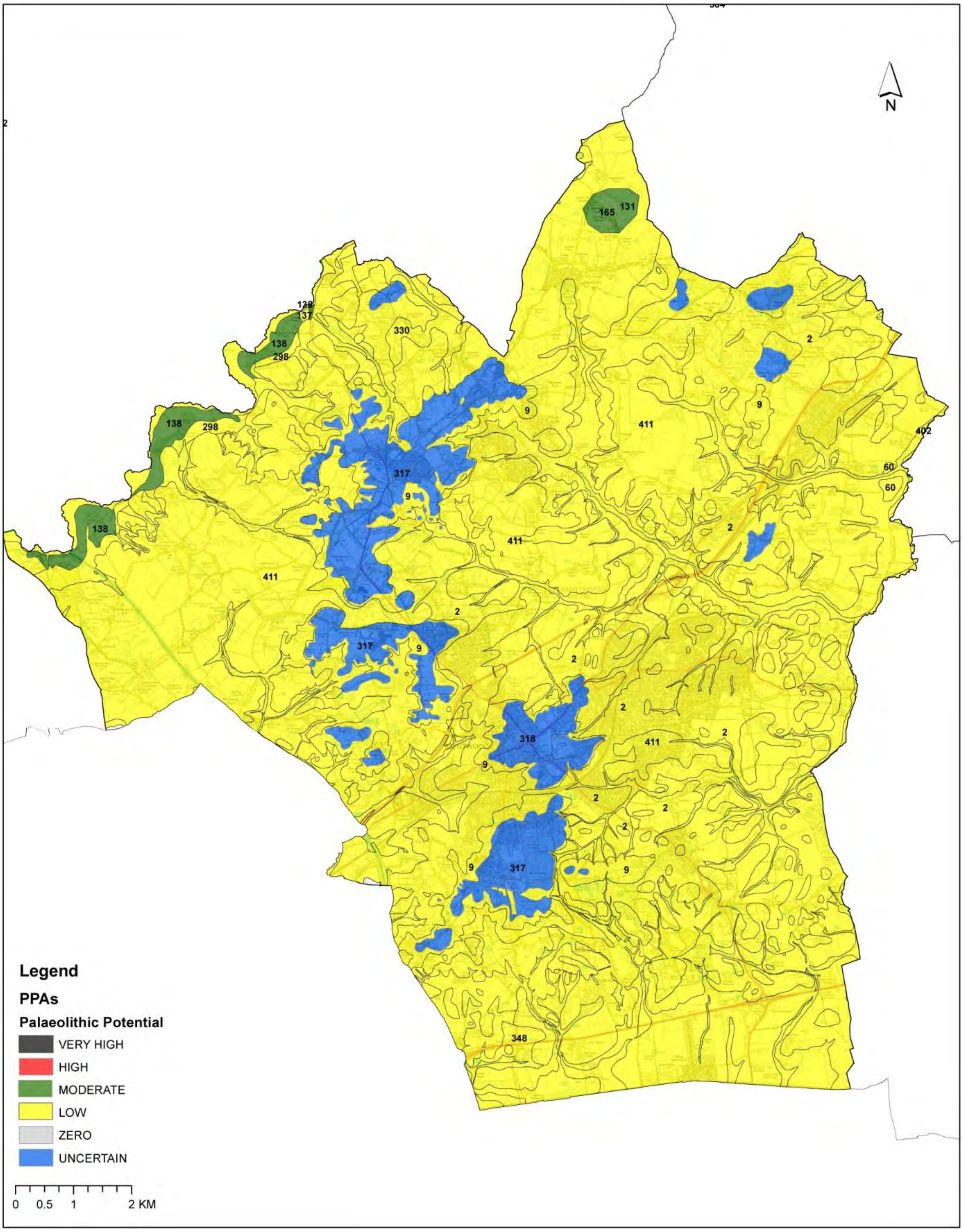

Figure 19 PPAs within the District of Brentwood (For illustrative purposes only- not all PPA polygons are labelled)

5.4.4 CASTLE POINT

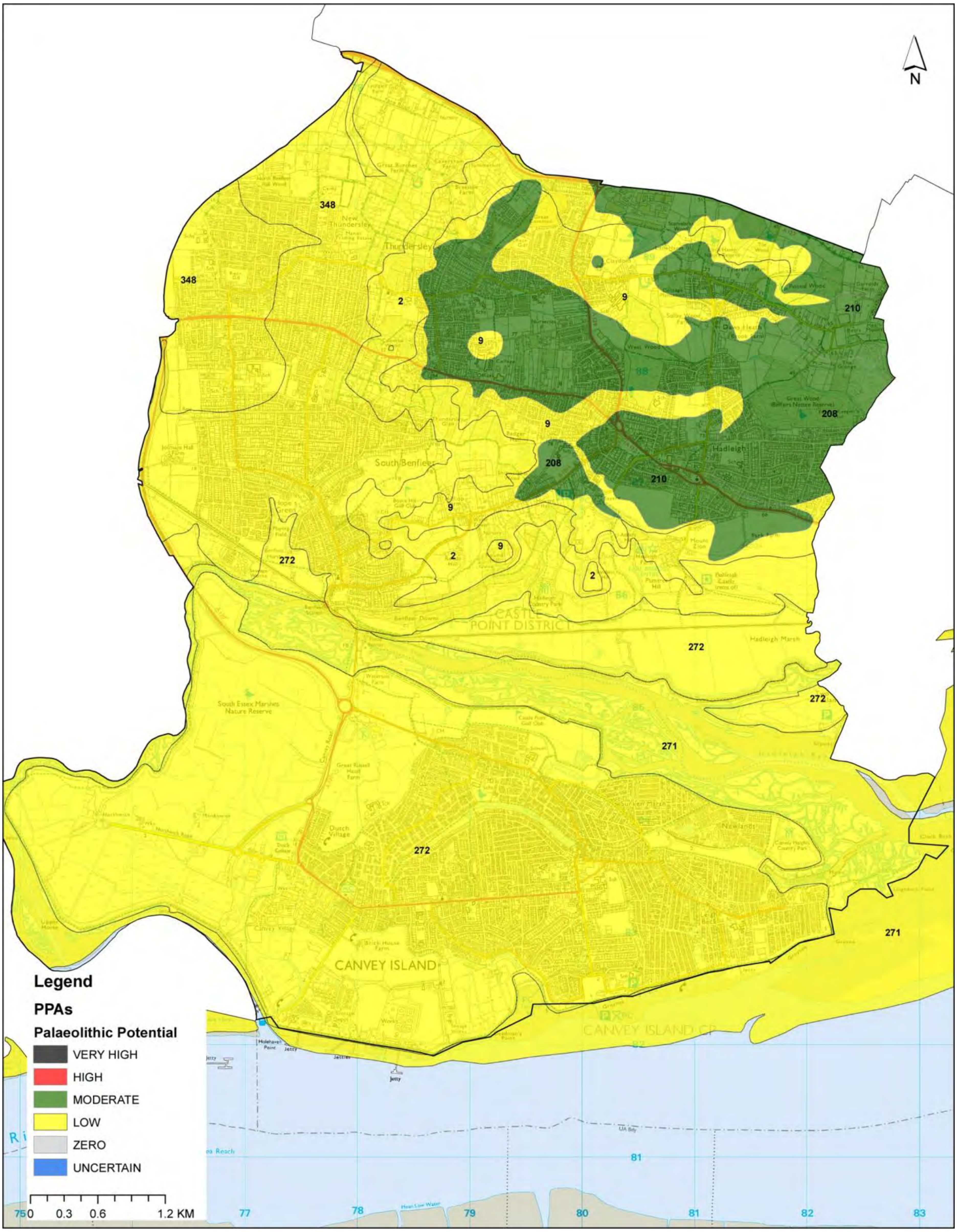

Figure 20 PPAs within the District of Castle Point (For illustrative purposes only- not all PPA polygons are labelled)

5.4.5 CHELMSFORD

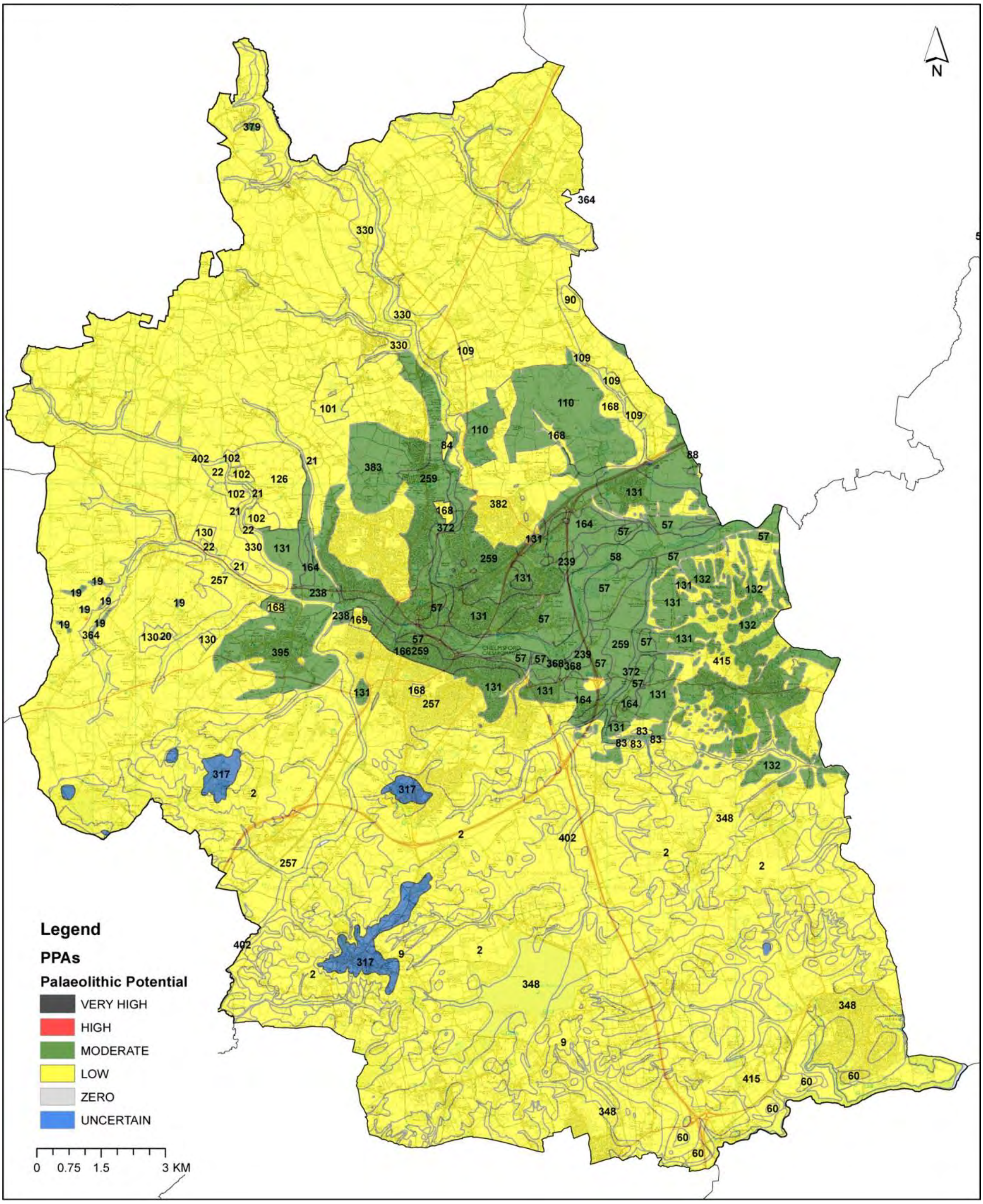

Figure 21 PPAs within the District of Chelmsford (For illustrative purposes only- not all PPA polygons are labelled)

5.4.6 COLCHESTER

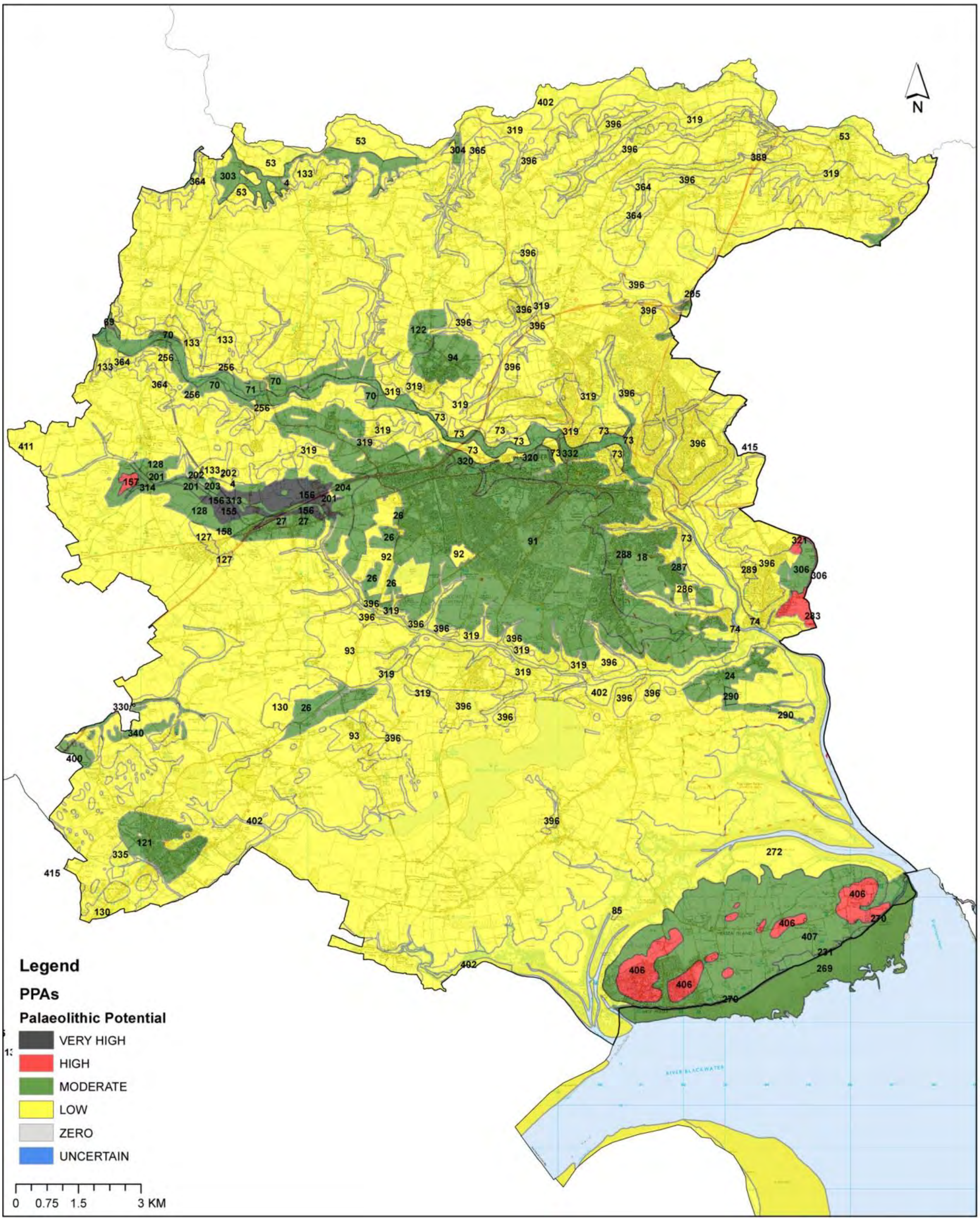

Figure 22 PPAs within the District of Colchester (For illustrative purposes only- not all PPA polygons are labelled)

5.4.7 EPPING AND HARLOW

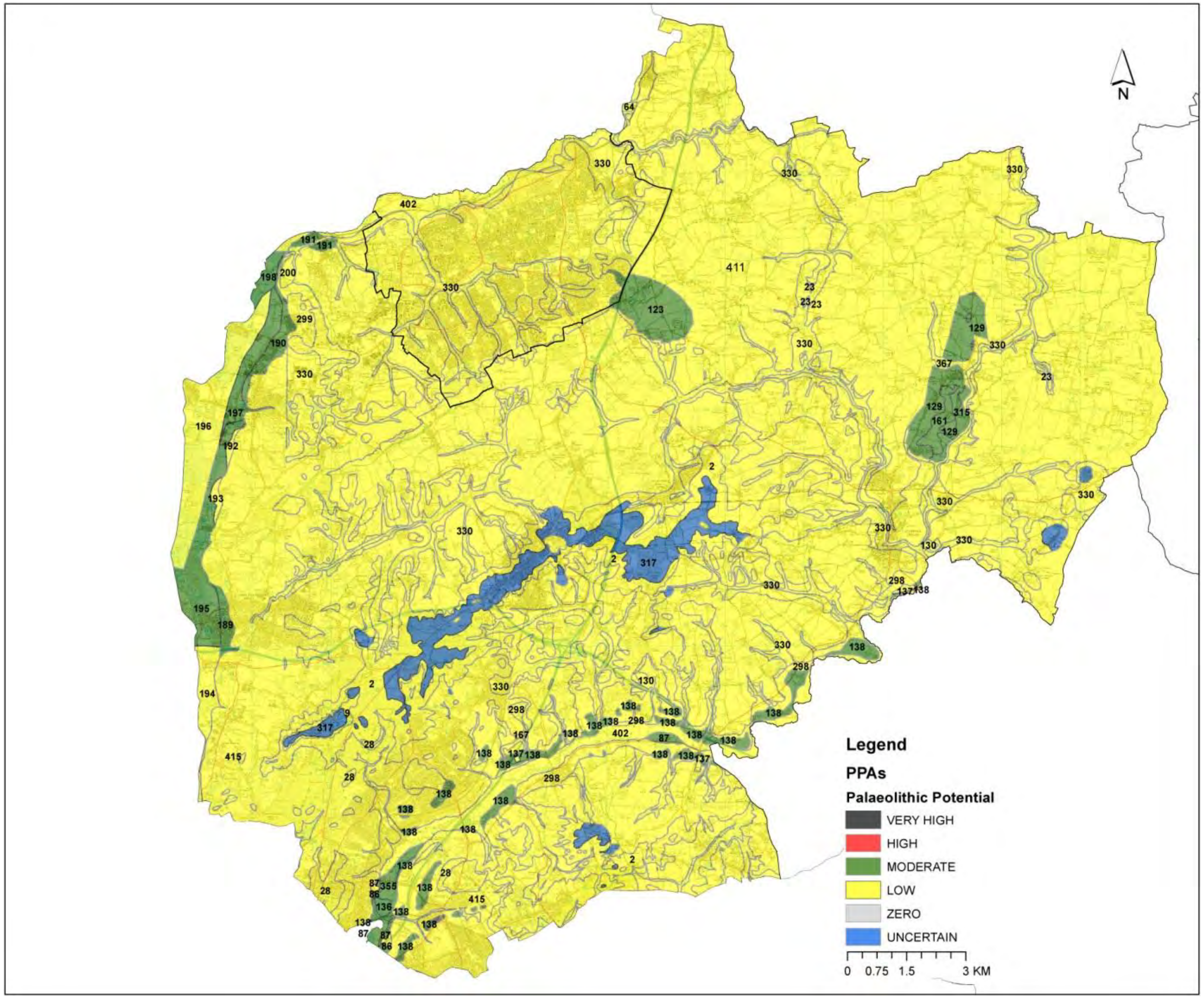

Figure 23 PPAs within the District of Epping and Harlow (For illustrative purposes only- not all PPA polygons are labelled)

5.4.8 MALDON

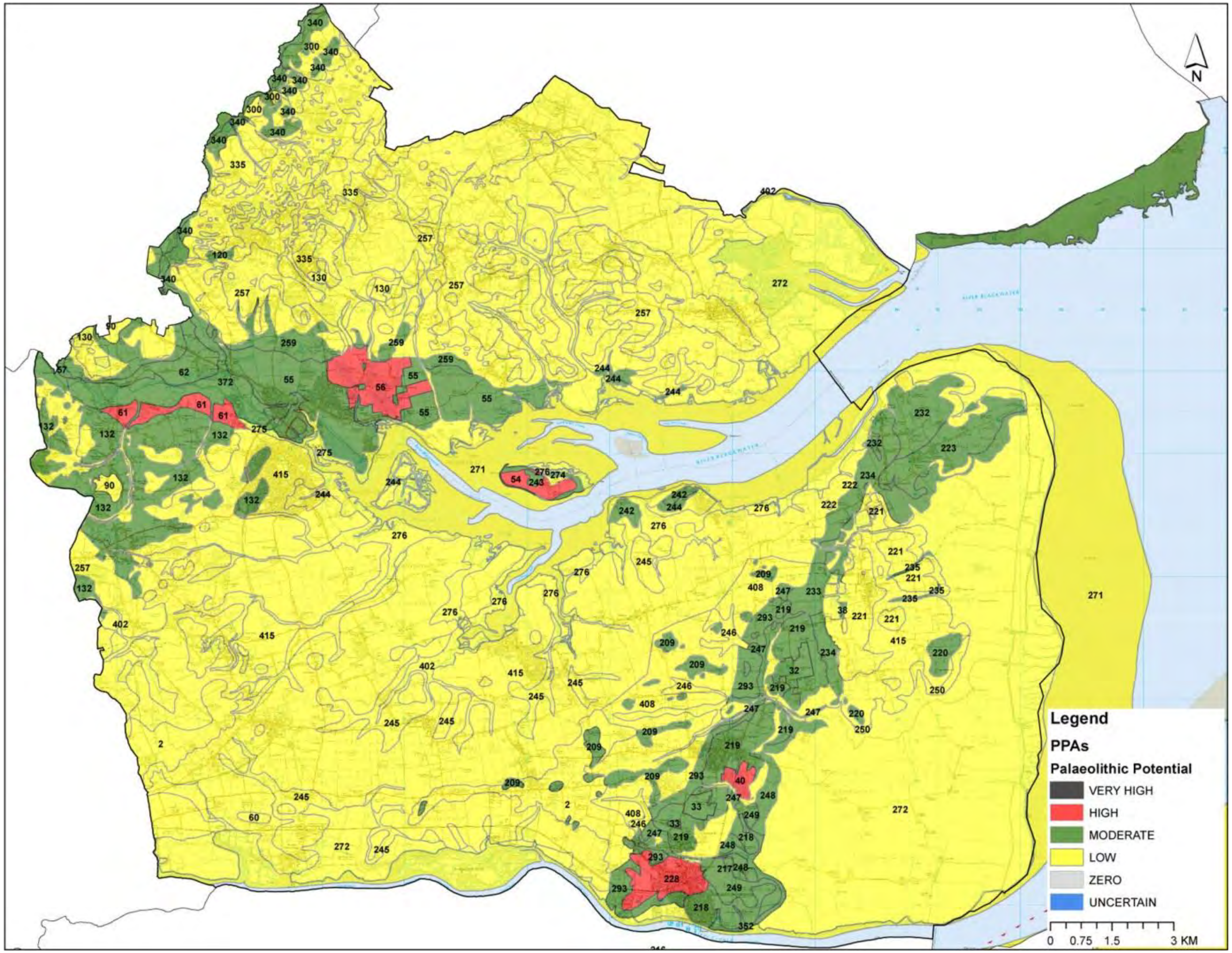

Figure 24 PPAs within the District of Maldon (For illustrative purposes only- not all PPA polygons are labelled)

5.4.9 ROCHFORD

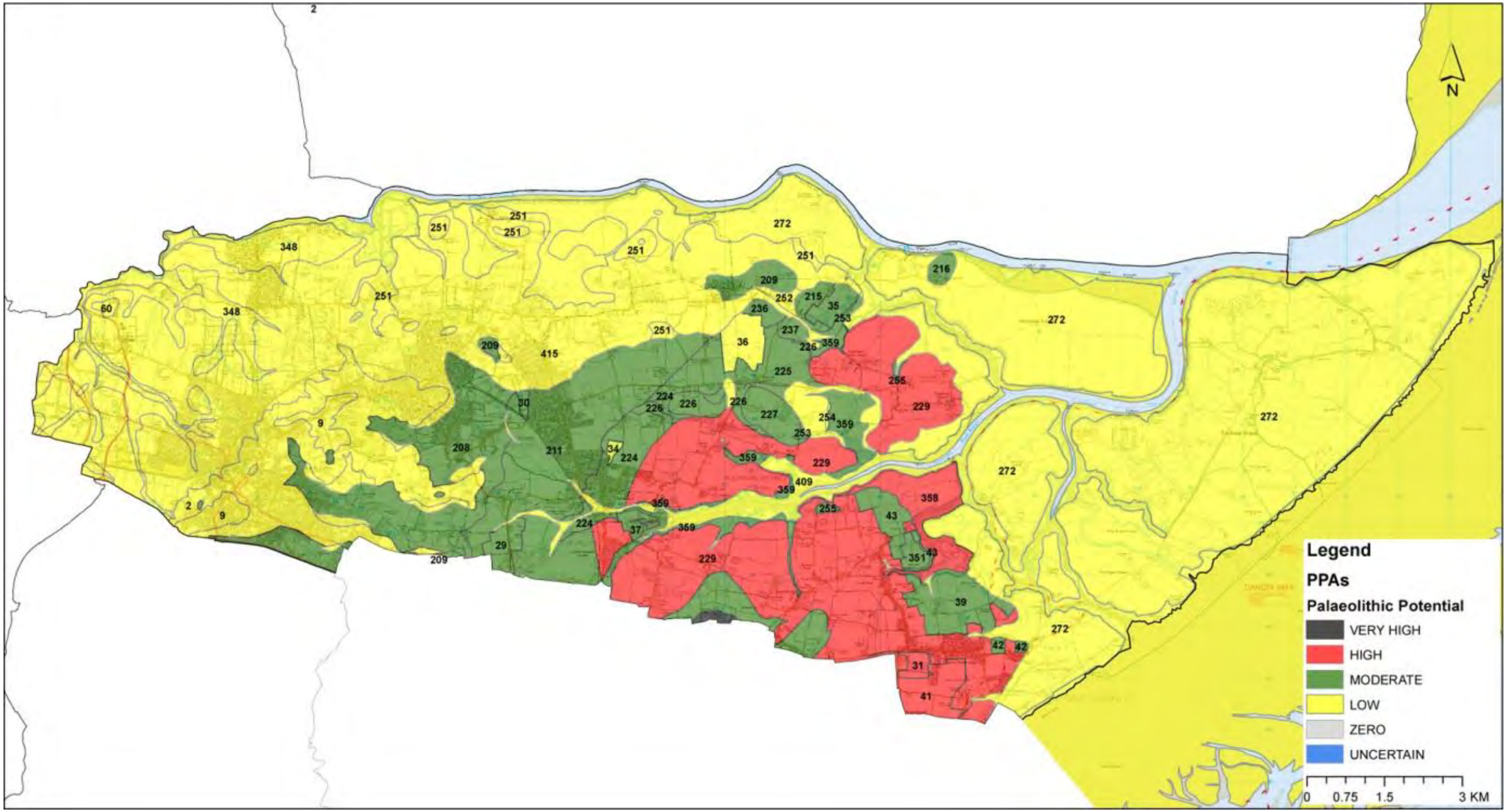

Figure 25 PPAs within the District of Rochford (For illustrative purposes only- not all PPA polygons are labelled)

5.4.10 SOUTHEND

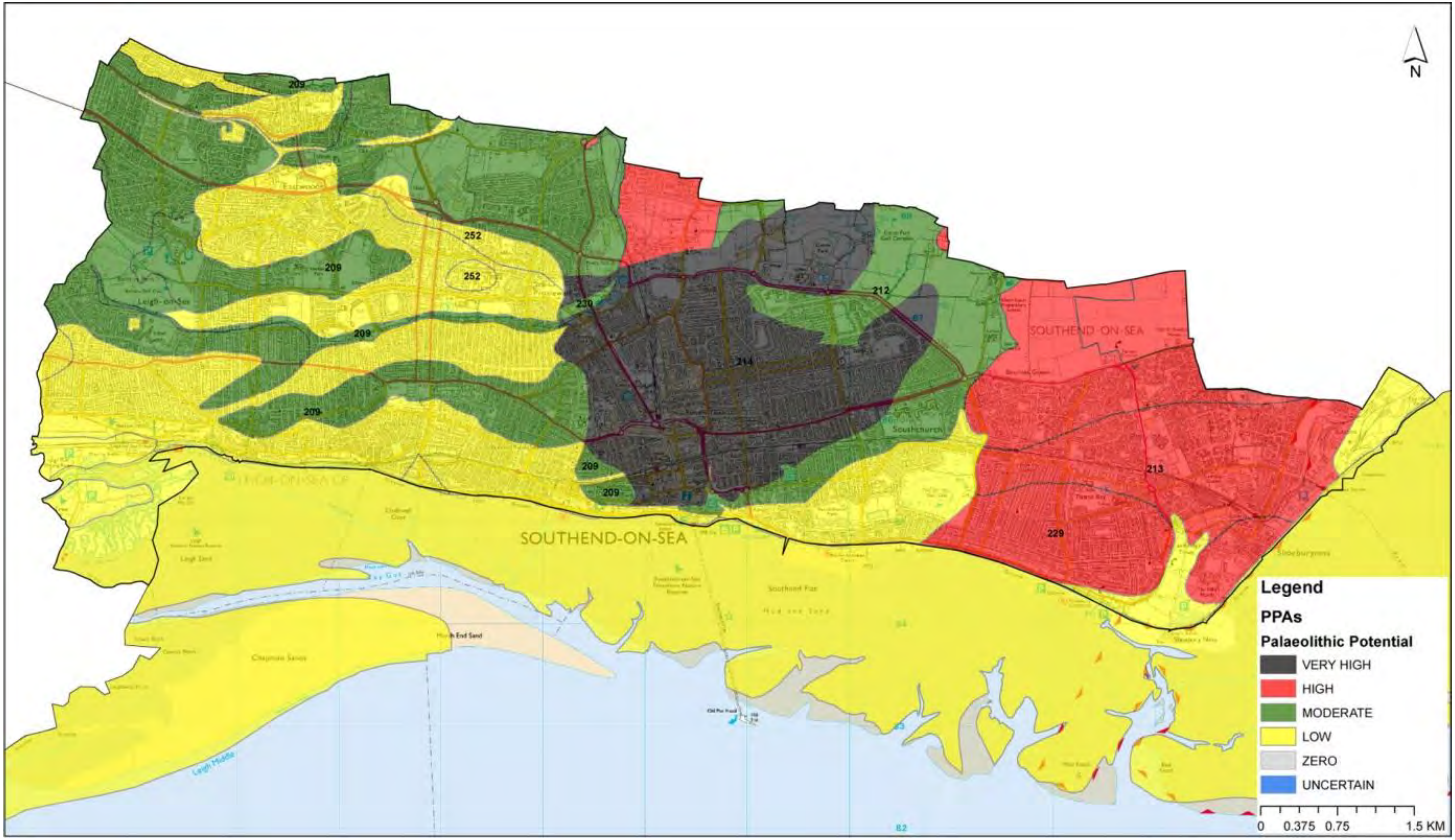

Figure 26 PPAs within the District of Southend (For illustrative purposes only- not all PPA polygons are labelled)

5.4.11 TENDRING

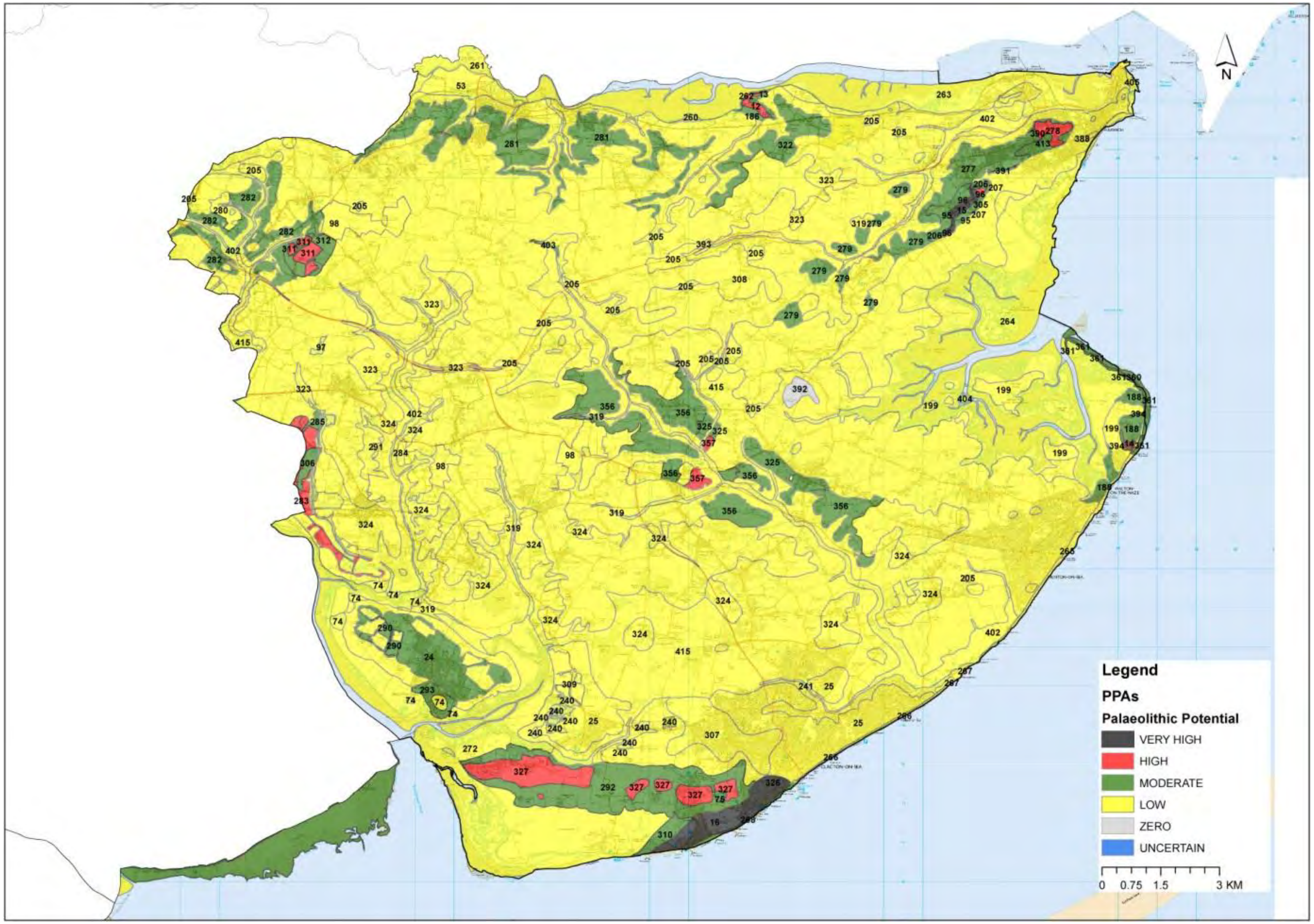

Figure 27 PPAs within the District of Tendring (For illustrative purposes only- not all PPA polygons are labelled)

5.4.12 THURROCK

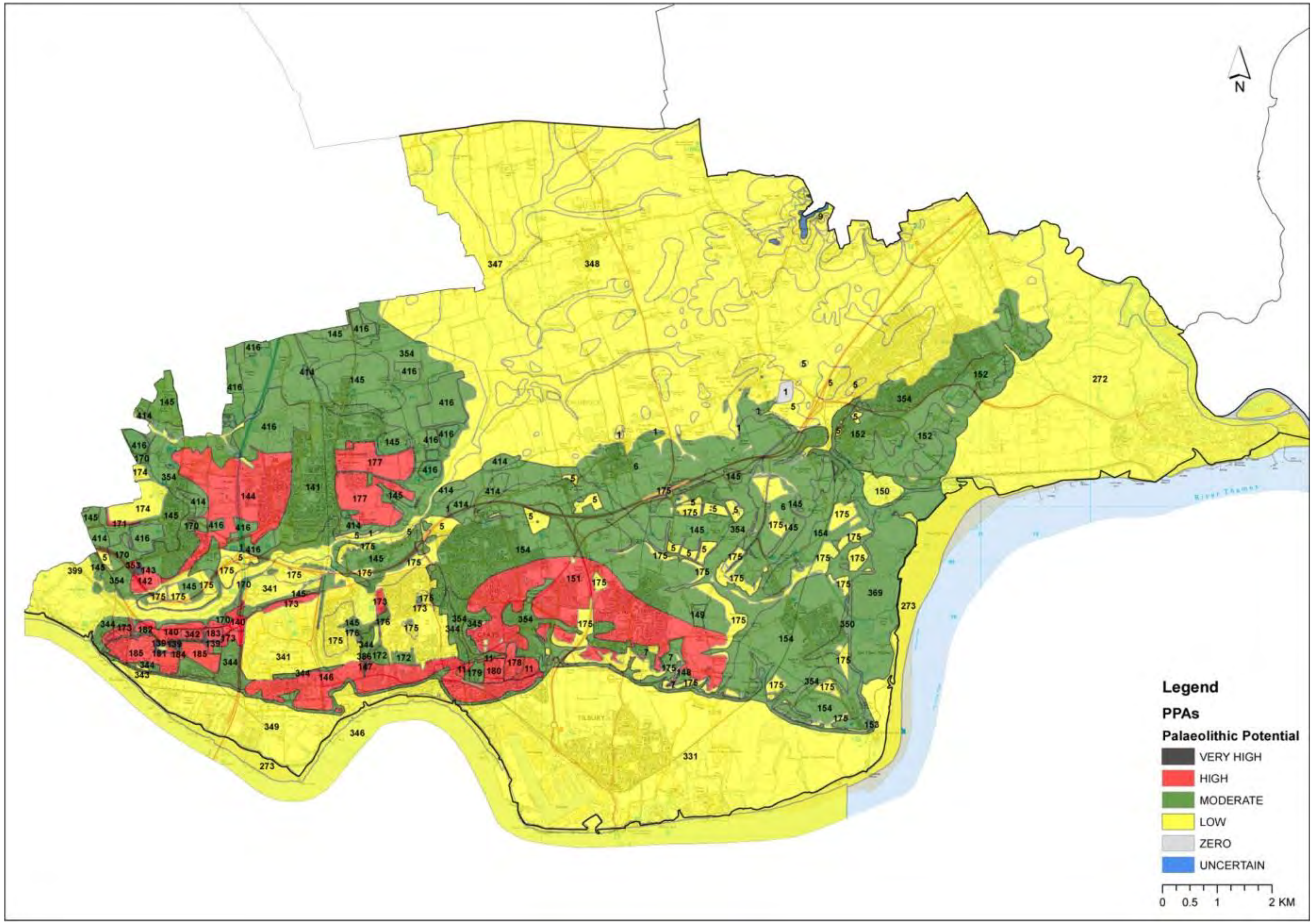

Figure 28 PPAs within the District of Thurrock (For illustrative purposes only- not all PPA polygons are labelled)

5.4.13 UTTLESFORD

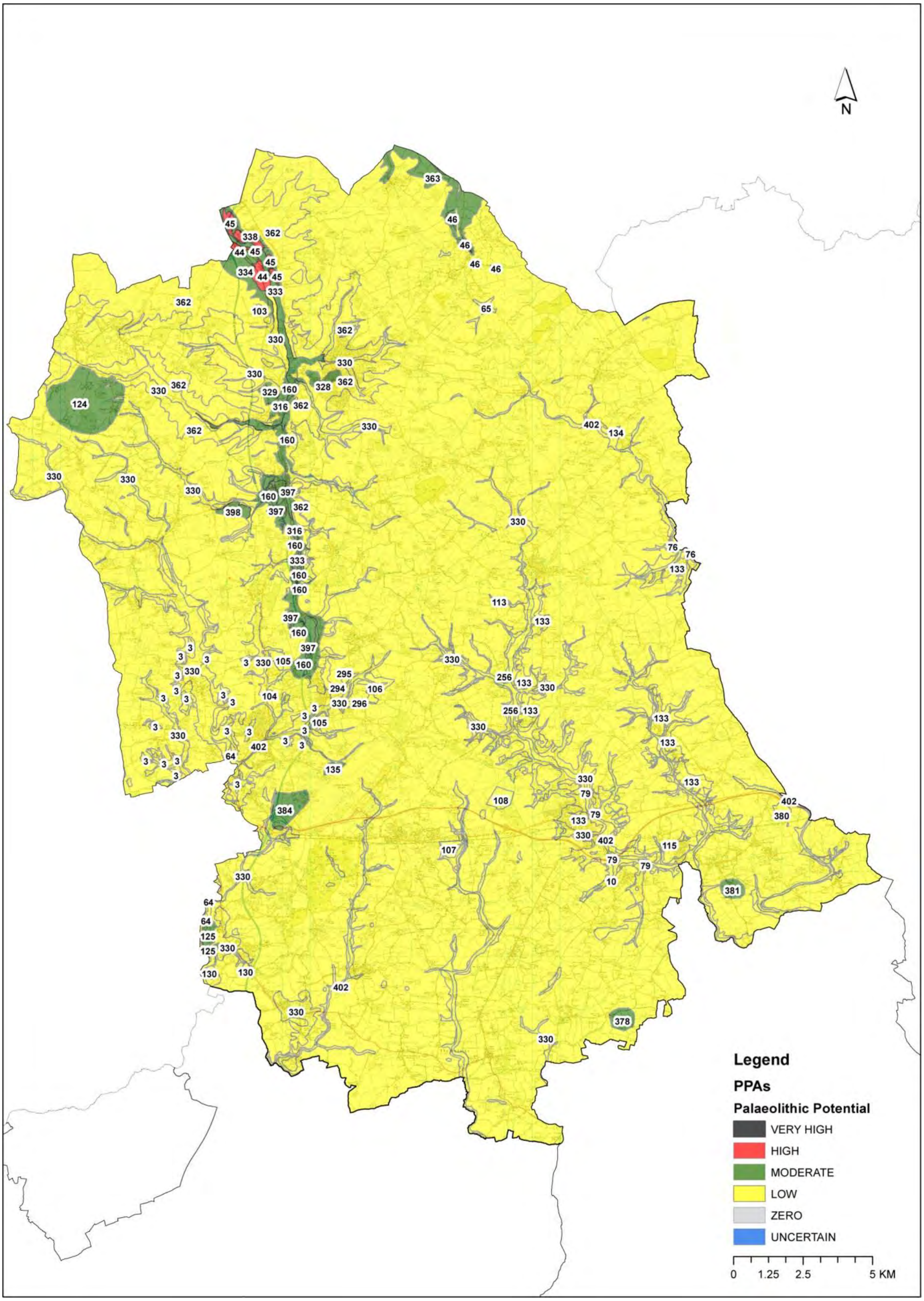

Figure 29 PPAs within the District of Uttlesford (For illustrative purposes only- not all PPA polygons are labelled)

6 DISCUSSION AND ASSESSMENT OF METHODOLOGY AND RESULTS

Our understanding of the Pleistocene in Essex is vital to ensuring proper management of the Palaeolithic resource, especially at this point in time when we are having to re-think some of our ideas for the colonisation of Britain and East Anglia in particular.

The project has addressed many of its objectives by providing an up-to-date comprehensive background on the Pleistocene geology and Palaeolithic archaeology of Essex, presenting a non-specialist but detailed understanding of the nature of the superficial geology that is encountered within Essex, together with a description and explanation of the nature of the Palaeolithic material that it may contain, and identifying the levels of Palaeolithic potential that exist across the whole County. Together these help address the main aim which is to develop a methodology and create a predictive model which will facilitate the delivery of a consistent and considered response to development applications from Historic Environment Officers/ Local Authority planning archaeologists, and to offer advice on management of the archaeological resource.

The LUs were created to present a simplified understanding of the superficial geology that is encountered within Essex. The creation of 14 separate LUs of Pleistocene geology provides the end user with a basic understanding of the sediment type(s) that may be encountered at the superficial geological horizon (the 'natural') and the processes and environment(s) of deposition in which that deposit or deposits were laid down. This should allow a more confident recognition of these geologies in the field and provide an indication of the nature of the deposit that is encountered <u>and what may lie below it</u>.

The creation of the LUs followed a basic process which tried to 'group' deposits of similar characteristics in either date, environment of deposition, mode of deposition etc to allow the description of the likely sediments encountered in the field to be identified and understood. The main problem encountered with this grouping of the LUs was with the interglacial sediments, which had recently been mapped as superficial by the BGS on an updated digital map sheet. The distinction from other deposits that may be seen to be interglacial but not classified as such in the terminology, or not identified as superficial, caused an overlap within the LUs where deposits of a similar nature may be seen to be encountered within more than one

LU. This was largely due to the nature of the formation of terrace sequences over time and the varying nature of the brickearth deposits within Essex. To provide consistency the LUs were based on the current BGS mapping and, although there may be slight overlap in the descriptions, the creation of the PPAs was not affected by this decision.

The methodology employed is based on a basic GIS desk-based assessment utilising existing GIS datasets and based on specialist input. The methodology needs to follow various stages because of the sheer number of polygons that have to be assessed due to the source BGS data. Rather than create new zones which largely encompass areas of perceived Palaeolithic potential the decision to work from the BGS polygons was fundamental to the methodology.

The creation of the LU's was critical to the methodology in that it became a significant GIS dataset to use in areas lacking much information. The LUs description allowed a moderate degree of confidence in classifying polygons where there was no existing HER data by using the potential of the LU itself which was based on specialist knowledge and comparative information on that LU in other areas where information on the Palaeolithic potential had been established. The creation of the LU's took longer than was anticipated due to the scale of the project and complexity of geological mapping, and the need to create hard copies of maps for specialists to work from. This could be made more efficient if all specialists had access to GIS programmes.

The methodology applied is dependent upon specialist input in the first instance, including for the creation of the areas of Palaeolithic potential, which requires an element of understanding of Quaternary stratigraphy and Palaeolithic archaeology. This may not be seen to be a particularly quick or repeatable exercise in terms of applying it to other geographic areas, or updating it. However, as with any data from a County HER there is often a level of specialist understanding required to enable a sound judgement to be made for the potential of any site to contain archaeological remains. The interpretation of findspot data within a HER is especially difficult, as highlighted by the project and illustrated in the tables provided by the specialist (APPENDIX 3) where both accuracy and provenance need to be assessed. The overlaying of the HER data onto the LU units allows this to be assessed to a degree, but often the quality of the source data is not sufficient to allow confident conclusions to be made regarding the areas potential for the possibility of further Palaeolithic finds.

The decision to retain the BGS boundaries was based on the need to provide complete coverage at a County-wide scale; drawing polygons from scratch on this scale would be time-consuming and incur levels of inaccuracy due to the scales of mapping required over a large area. The main advantage of retaining the BGS boundaries is to allow a greater degree of accuracy in assessing that particular LUs potential for containing Palaeolithic archaeological material, and/or Pleistocene remains. In this way the inaccuracies that may be associated with HER findspots may be alleviated as it becomes more possible to identify a likely provenance or source of the recorded Palaeolithic material that may have been found at some distance from a likely Pleistocene deposit or recorded within a general location. In addition, the retention of the BGS boundaries does enable seamless replacement of map sheet data should they be updated in the future by the BGS, requiring only re-assessment of the zones within that map sheet and cross-referencing with the associated LU's. Similarly, if new data becomes available polygons should not need to be re-drawn but may need to be 'cut out' if the LU covers a large area, or individual polygons may need to be re-assessed and their score altered to reflect the new potential.

The use of buffers was often not applied to the Pleistocene LU layers due to the use and retention of the original polygons as plotted by BGS. As each LU layer was formed of many polygons which had a distinct spatial extent each single polygon could be treated as a whole and therefore if any additional GIS dataset(s) were plotted as falling within the extent of a single polygon within a LU layer the whole polygon effectively acted as the buffer for the source GIS dataset feature(s).

Buffers were mainly used in non-Pleistocene areas where there was determined to be no direct relationship between the nature of the mapped geology and the information derived from the GIS datasets. An automated buffer was not applied systematically as this would have been impractical when dealing with irregular shaped polygons and when it would have overlapped onto adjoining polygons. Applying a fixed buffer using GIS methods was also not possible due to the complexity of the polygons. Instead the extent of the buffer required was assessed visually in relation to the relevant GIS datasets and a suitable area of less than 500m surrounding the GIS dataset(s) was cut out of the non-Pleistocene geology polygon. This often involved using topography (contours) and a visual assessment of the spatial distribution of the polygon, therefore the buffer could be irregular in its distance from the originating GIS dataset(s) according to aspects such as slope, height, topographical features etc. This method has the potential to add an element of subjectiveness, however it could be later refined by acquiring borehole information from the surrounding area to try to delimit the area of the buffer.

The methodology adopted within the GIS system has not attempted to employ the use of models or a purely automated approach in the first instance for a number of reasons:

- The methodology is dependent on the accuracy of the existing data and where this is identified as being inaccurate or doubtful it requires the knowledge and experience of a specialist to interpret. In order to attempt to create a model–based approach this data would have needed to be assessed and edited if necessary prior to the incorporation into the model.

- For areas that are not mapped as Pleistocene geologies a number of factors needed to be considered when attempting to identify areas of potential for the presence of Palaeolithic archaeological remains or Pleistocene sediments. This required an element of BGS map interpretation, an understanding of Palaeolithic archaeology and a knowledge of Quaternary stratigraphy that would be difficult to factor into a model:

- For older geologies (bedrock) the possibility that there are Pleistocene geologies present but as yet unmapped needed to be taken into consideration, especially where relevant HER data was recorded;

- For younger (Holocene) geologies an assessment of the likelihood of the mapped deposit to overlie Pleistocene geologies with the potential to contain Palaeolithic material had to be individually assessed according to the spatial distribution of the younger deposits in relation to the adjacent Pleistocene deposits.

- BGS mapping in areas of mineral extraction often shows only bedrock as outcropping and no superficial geologies as surviving. This was more of an issue for assessing an area based on its LU and GIS datasets as it would appear that HER findspots were outcropping on bedrock. Consideration of a wider landscape view, and overlaying the Minerals site GIS layer, allowed these areas to be identified as such but this may be a further confusing factor if trying to 'automate' the procedure;

- Quarried areas which were not mapped as bedrock by BGS were cut out as individual polygons to aid in the recognition for the potential of the Palaeolithic resource to have been either removed or depleted,. However assessment of this for each quarry was not possible within the timeframe and so the score often remained comparable to equivalent areas which had not been quarried. This assumption could be seen to be supported through the results of previous ALSF projects and in the light of such work as High Speed 1, where despite previous extensive aggregate extraction it was demonstrated that patches of sediments can survive and yield potentially significant Palaeolithic archaeological information.

In stark contrast to what was expected in terms of identifying areas of high Palaeolithic potential, the project revealed the significant number of HER findspots that came from LUs, which could otherwise be perceived to be of low potential in containing Palaeolithic material. Most notably was LU7 Glacial and glaciofluvial deposits, which clearly would not contain contemporaneous evidence for human occupation due to the nature of the inhospitable environment under which they were deposited. The likelihood is that these finds have either been picked up from older deposits as the body of the ice sheet has moved over them, and been transported away from the source, or that there are Pleistocene deposits surviving below the glacial sediments that do preserve (possible) contemporary Palaeolithic material. These factors may not be possible to work into a model but need to be factored in to a methodology. If a simple direct correlation between findspots and geology were made then we would be classifying the entire spread of glacial deposits across Essex as being of high potential for Palaeolithic archaeology. This would be difficult to justify under what is considered as fair and reasonable within the planning process, but highlights the many complexities that exist when trying to identify further areas of high Palaeolithic potential.

It is beyond the scope of this project to propose methodologies for investigation for Palaeolithic archaeological remains. However it is anticipated that the recommendations from the Kent project will be adopted in the interests of providing consistent advice (**Table 6 & 7**). A model brief from the Medway Valley Palaeolithic

Project (2007) has been previously used to propose fieldwork and mitigation strategies for a handful of planning applications where there has been demonstrated that the potential for Palaeolithic remains is high. At the very minimum for all cases where the development can be illustrated to be located within an area of moderate to high potential a geoarchaeological desk-based assessment should be requested. This should be carried out by a specialist and a proposal for mitigation should be part of the recommendations of that DBA. A basic template for a geoarchaeological assessment should be created and be available to all historic environment curatorial advisors to promote and enable a consistent approach which can be seen as being fair and reasonable under planning policy.

Table 6 Attribute grades for Likelihood and Importance of Palaeolithic remains (FWS, Stour Basin Palaeolithic Project, with Kent County Council)

Attribution	*Likelihood*	*Importance*
HIGH	High likelihood of Pleistocene deposits with lithic or palaeoenvironmental remains	Undisturbed occupation surfaces or minimally disturbed concentrations; abundant remains from deposits of good stratigraphic and chronological integrity, biological associations; deposits with important lithostratigraphic sequences and relationships
MODERATE	Reasonable likelihood of deposits with remains	Less abundant disturbed artefactual and/or faunal remains from units of reasonable stratigraphic and chronological integrity; deposits with moderate lithostratigraphic sequences and relationship
LOW	Remains are known to occur, but rare	Disturbed remains from deposits of low stratigraphic and chronological integrity; deposits with minimal lithostratigraphic sequences and relationships
VERY LOW	Remains very unlikely to occur	Thought extremely unlikely for there to be any Pleistocene deposits containing remains, any remains found will be residual and reworked
UNKNOWN	Insufficient information on which to assess likelihood	Insufficient information on which to assess importance

Table 7 Matrix for Palaeolithic potential, based on combination of Likelihood and Importance (FWS, Stour Basin Palaeolithic Project, with Kent County Council)

Palaeolithic potential	*Likelihood*	*Likely importance*	*Suggested development control response* *
HIGH	High	High, Moderate	* Pre-condition DBA and field evaluation, retaining option of refusal if important enough remains happen to be found. Refusal would need to be weighed against benefits of thorough mitigation in improving understanding of the resource and addressing current research framework objectives. While clearly a curatorial prerogative, investigation would often be of great academic research benefit, particularly when an impact affects part of a more-extensive resource, and doesn't destroy 100% of a surviving deposit area
	Moderate	High	
MODERATE	High	Low	Post-condition DBA and field evaluation?
	Moderate	Moderate	
	Low	High	
LOW	Moderate	Low	None?
	Low	Moderate	
	Very low	Moderate, High	
VERY LOW	Moderate	Very low	None
	Low, Very low	Low, Very low	
UNKNOWN	Unknown	High, moderate, low or very low	None? This grade is a problem, as it represents the age-old issue of "absence of evidence is not evidence of absence". Furthermore, unexpected Palaeolithic finds in areas of unknown potential could be of high importance. However from a development control viewpoint, grading has to be based on what is known from the HER, and

	High, moderate, low or very low	Unknown	from the specialist consideration of the landscape and likely Pleistocene deposits - but it would be good to target areas that are unknown for further investigation to try and resolve the uncertainties that lead them to be "unknown".

Other than the methodology, LUs and PPA GIS shapefiles other outputs from the project will include:

- guidance on the application and use of the project products and results;
- updates of the Historic Environment Characterisation Projects with information on Palaeolithic potential;
- digital GIS shapefile of potential Local Geological Sites (LoGS) of Pleistocene/Palaeolithic potential
- Guidance notes will be circulated amongst the historic environment specialists of the Place Services team at Essex County Council with in-house training for those who require it. The use of GIS layers is commonplace in most HER's and inclusion of it on the HBSMR mapping will enable the user to consider it when carrying out site assessments and HER searches.
- A GIS shapefile of all known Pleistocene sites extracted from a Gazetteer of Essex Geological sites carried out over a number years by a local geologist, Gerald Lucy, was created. Potential LoGs were identified within the attributes and so could be plotted separately, extracted and provided to the local Geological group (GeoEssex)

7 POTENTIAL FOR REFINEMENT AND FURTHER WORK

The methodology has been successful in applying a set of principles to existing datasets within a GIS format. The results therefore are dependent on the quality and quantity of the information used to predict areas of Palaeolithic potential. The analysis of the HER data by the Palaeolithic specialist revealed some inaccuracies and omissions in the existing record. Where possible this was either corrected or accounted for in any conclusions made. However, it was beyond the remit of the project to verify the accuracy of the details in the HER, and to check that sites mentioned in key primary sources were included in the HER. In light of the fundamental importance of the HER for curatorial decision-making, and as a basis for any further attempts/refinements at predictive modelling of Palaeolithic potential, it should be a priority to invest some resources in checking and updating Palaeolithic records in the HER. It is necessary to check the accuracy of existing records, remove duplicates, check that information from key primary sources is included, particularly regional journals and the key syntheses of: Evans (1897), Roe (1968), and the English Rivers Project Reports 1 and 3 (Wessex Archaeology 1996 and 1997 respectively).

As an adjunct to this, it would be useful to review and update thesauri for lithic artefact terminology, Palaeolithic period terminology and date ranges, and descriptive terms for Palaeolithic sites, Pleistocene deposits and palaeoenvironmental remains.

The analysis of various datasets which can be overlaid onto existing or historic mapping and interrogated within a GIS programme has greatly advanced the quality and quantity of work that can be achieved relatively simply within HERs, or other curatorial institutions. However these systems are not always exploited for their processing abilities, and their employment within a methodology could alleviate many of the more repetitive tasks and help create a more rigorous and repeatable approach. An exploration on the use of the ‘Model building’ application within GIS to allow automated creation and updating of information could be carried out and the results could be compared to the methodology and results generated through this project. In addition, it would be useful to carry out a wider review of various projects over the last decade that have attempted to develop predictive models of Palaeolithic potential, and which have taken an algorithmic approach to greater or lesser degrees. It would be useful to compare the slightly different approaches taken, and to get a curatorial viewpoint on how successful the models have proved, and where they could be improved. It would also be useful to conduct a new study in an as-yet un-modelled area that applied both an expert person and an expertly-informed algorithm, to see how the results compared, and whether any lessons could be learned for expanding Palaeolithic modelling.

The main data source used in this project is the BGS 50k. However 10k mapping is available to buy, and could be used to refine areas of Palaeolithic significance in areas where there is a threat to the potential resource. Mineral operators frequently conduct their own geotechnical bore-hole testing and where possible this should be used to assist and complement the geomorphological analysis for archaeological purposes.

In areas where there is little available information to enable a break up of large PPA polygons of seemingly low potential, freely available borehole information could be sought and reviewed to help model the possible subsurface geologies and refine the PPAs. Some of the borehole information supplied by the specialist for this project has been turned into a GIS layer which identifies the single significant lithology within the borehole sequence. In a trial area that has been classified as 'low' this information could be sought out and interpreted with the aid of a specialist to determine the effectiveness of this dataset in influencing the outcome of the PPA. This would be of significant value in areas mapped with Holocene geologies that are likely to overlie Pleistocene sediments with a higher potential for Palaeolithic archaeological remains, faunal or palaeoenvironmental remains. This could also be used to help determine the presence of unmapped Pleistocene geologies upon large expanses of pre-Pleistocene bedrock.

Further borehole records have been supplied by the specialist, which could be added to the existing GIS dataset and used to further refine the PPAs, or to create new PPAs.

Following the collaboration between Kent and Essex with the presentation of results and integration of mitigation strategies this information could be added into the attribute data of the PPA GIS shapefile to provide a more comprehensive and usable tool. This is especially significant due to the high number of areas identified as having potential for unmapped Pleistocene geologies. The mitigation strategies for determining the presence of unmapped geologies within an area of pre-Pleistocene bedrock or possible buried Pleistocene deposits below mapped Holocene deposits would vary from those used in areas of mapped Pleistocene geologies. This distinction may not be obvious to the curatorial officer from the existing attribute data and so could be added within an attribute field to allow more accurate advice to be given.

The success of any trial desk-based methodology can only be confidently assessed through further investigative work in the form of fieldwork. To this end a trial could be implemented to test the potential of PPAs where areas have been highlighted as having high potential in areas that may not previously have been considered. A fieldwork investigation would provide accurate feedback as to the model prediction but would be limited spatially.

A simple method of recording the impact of the project within the development control process would allow a greater insight into its usefulness and accuracy of prediction. This could be a simple tally of conditions applied from a direct result of using the PPA GIS layer as part of the evidence base for the consideration of planning applications. This could be incorporated into existing databases which record the conditions that are applied to planning applications within Essex. Possibly more usefully, a purpose built database could be created to record the recommendations, including requirements for investigation and results of geoarchaeological investigations including success and failures. This could contain spatial information and be added as a shapefile to a GIS project overlying the PPA shapefile to look for any patterns or relationships between areas where the model works well and areas where it may not be as successful.

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