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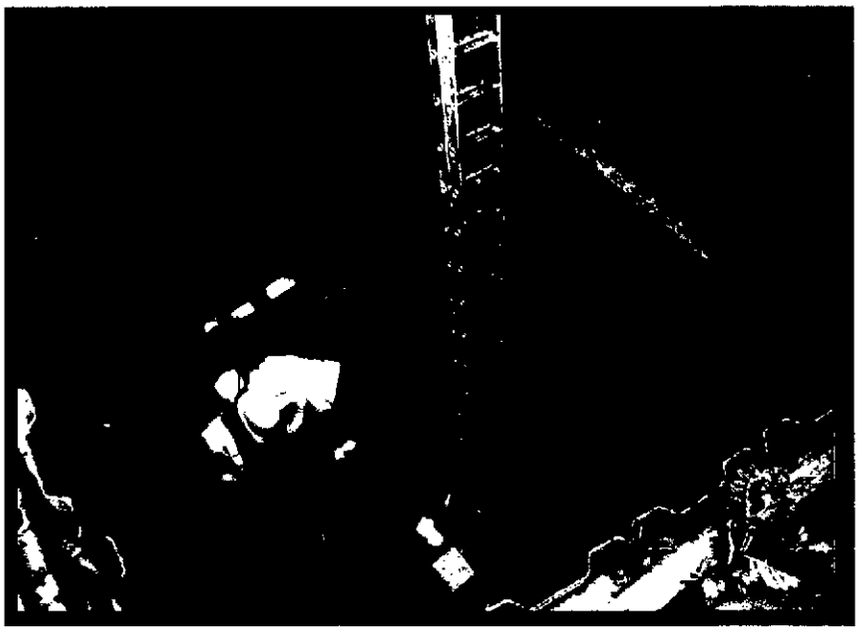
Channel Tunnel Rail Link

New NGC ZR4 pylon location
Post Excavation Assessment Report

October 2000



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Channel Tunnel Rail Link
Union Railways (North) Limited

Project Area 330

NEW NGC ZR4 PYLON LOCATION, EBBSFLEET, KENT
ARC ZR400

SG 211
17434

DETAILED EXCAVATION ASSESSMENT REPORT FINAL

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SUMMARY

As part of an extensive programme of archaeological investigation carried out in advance of the construction of the Channel Tunnel Rail Link (CTRL), the Oxford Archaeological Unit was commissioned by Union Railways (North) Limited to undertake a series of investigations at the site of the new National Grid Company (NGC) Pylon ZR4, which is being erected as part of an overhead line diversion.

The site is in an area known to be of high Palaeolithic significance and lies within the limits of Scheduled Ancient Monument Kent 267a. The field evaluation confirmed that the works would impact significant Palaeolithic archaeological horizons, namely a deep sequence of Pleistocene deposits containing a range of biological evidence including large mammals, small mammals, amphibians, fish, birds, molluscs and ostracods. Charred plant material, plant macro-fossils and pollen evidence were, however, absent.

The significant deposits were only impacted by the two deeper uplift tower footing foundation pits. The mitigating excavation concentrated upon recovering sufficient evidence from these to address the landscape zone priorities for the Palaeolithic, and establish correlations between the deposits at the ZR4 locations and those known from other locations in the Ebbsfleet Valley. These include the nearby British Museum Site A, the Baker's Hole Levalloisian site and Burchell's Temperate Bed site (SAM Kent 267b), the latter two of which contain undisturbed horizons of refitting artefactual material as well as biological evidence. The Pleistocene deposits affected consisted of a fluvial group of sands, silts and clays overlain by a colluvial group of, primarily, laminated sands and silty sands. Most of the significant biological evidence was contained in the fluvial deposits, although some molluscan and small mammalian evidence was recovered from the lowest colluvial deposits.

A total of 50 larger faunal remains were recovered, most of them identifiable. The study of the material recovered from the site can provide a detailed picture of the local changing climate, environment and depositional regimes through the sequence, with the range of different types of evidence from the same horizons providing added precision. The mammalian species diversity and the bio-metric attributes of some larger species such as horse and mammoth are of potential bio-stratigraphic value, allowing correlation with the significant Palaeolithic sites of the Ebbsfleet Valley, as well as others in the region such as at Crayford. The presence of molluscs through most of the sequence allows construction of an amino acid profile, and some of the sedimentary units identified are also suitable for attempting OSL dating. The deep and complex deposits of the Ebbsfleet Valley may provide an unparalleled and relatively complete record of environmental and climatic change through the complex sub-stages of Oxygen Isotope Stage 7, providing for the first time a more complete framework for human occupation of SE England at this critical time in Neanderthal development, when the evolution of full Neanderthal physiognomy must have been beginning, accompanied by the development of Levalloisian knapping approaches and a shift from handaxes to an increased reliance on flake-tools.

The site is clearly of national significance for placing the undisturbed Palaeolithic working floors of the Ebbsfleet Valley in a more secure chrono-stratigraphic and environmental context, for improving understanding of the timing, duration and context of Late Middle Pleistocene human occupation of SE England and for defining the nature of the contemporary geomorphology and environment and its natural changes through time.

1. INTRODUCTION

1.1 Project Background

1.1.1 The Oxford Archaeological Unit (OAU) was commissioned by Union Railways (North) Limited (URN) to conduct a series of investigations on the site of the new NGC ZR4 Pylon location. This work formed part of an extensive programme of archaeological investigations (Table 1) carried out on behalf of URN in advance of the construction of the CTRL.

1.1.2 The construction of the CTRL through the Ebbsfleet Valley required relocation of the existing Pylon ZR4 to a new position within the Palaeolithic Scheduled Ancient Monument Kent 267a (TQ 61180 74410, Figure 1). The new pylon required the excavation of four footing foundation holes 4m x 4m square, two of them 4.5m deep (uplift footings), and two of them 1.8m deep (compression footings). These holes were positioned in a square separated by approximately 15m diagonally and 10m between the faces of adjacent holes (Figure 2).

1.1.3 The OAU was commissioned by URL initially to undertake field evaluation (ARC ZR498) at the new ZR4 site (Table 1). Trial pits excavated in each of the four pylon footings took place in January 1998 and confirmed an impact upon significant Palaeolithic archaeological horizons in the uplift footings.

1.1.4 The detailed excavation took place between 17th April 2000 and 9th May 2000 (on instructions from URN) and further archaeological material was collected during the subsequent watching brief monitoring of the construction of the uplift footings in June 2000.

1.1.5 The archaeological Written Scheme of Investigation (URN 2000) was prepared by Rail Link Engineering (RLE), and agreed in consultation with English Heritage and Kent County Council (KCC), on behalf of the Local Planning Authority.

Table 1: List of fieldwork events

Fieldwork event name	Fieldwork event code	Contractor	Dates of fieldwork
New NGC Pylon ZR4 location evaluation	ARC ZR498	OAU	5/1/1998 - 8/1/1998
New NGC Pylon ZR4 location detailed excavation	ARC ZR400	OAU	17/4/2000 - 5/5/2000
New NGC Pylon ZR4 location watching brief	ARC ZR400	OAU	June 2000

1.2 Geology and Topography

1.2.1 The Ebbsfleet Valley has been severely altered by quarrying for chalk since the mid-19th century. The Ebbsfleet is a small tributary of the Thames, now virtually stagnant, which enters the Thames from the south, cutting through Chalk bedrock and the major east-west trending Boyn Hill/Orsett Heath Pleistocene fluvial terrace formation.

1.2.2 The new NGC pylon is sited on one of the few parts of the Ebbsfleet Valley which has remained unquarried. At this point, a deep sequence of Pleistocene fluvial and colluvial deposits has developed on a chalk bedrock base, which originally rose to the west but has now been quarried away. This remnant part of the original landscape is now both scheduled as an Ancient Monument (Kent 267a) and protected as an SSSI (Baker's Hole). It consists of a sloping piece of ground used for

grazing and allotments over much of the last century, but now generally overgrown with scrub and brambles, although retaining some more open areas. The ground slopes up to the west towards the edge of the quarried area, now landfilled, and down to the southeast and east towards the current Ebbsfleet alluvial floodplain.

1.3 Archaeological and Historical Background

1.3.1 The landscape around the Ebbsfleet Valley is rich in significant Palaeolithic sites. These are mostly associated with the east-west trending Boyn Hill/Orsett Heath Thames fluvial terrace formation laid down between Oxygen Isotope Stages 12 and 10, a period of warm, interglacial climate between c. 425,000 and 350,000 BP, and include the site of Barnfield Pit, Swanscombe c. 1.5km to the west where an early hominid skull showing some traits characteristic of the subsequent Neanderthal population has been recovered, as well as biological evidence and great quantities of lithic artefacts.

1.3.2 The Ebbsfleet Valley has been incised transversely through the Boyn Hill/Orsett Heath deposits, and contains younger Pleistocene sediments dating to subsequent glacial and interglacial periods. These have been shown by research throughout the 20th century to contain significant Palaeolithic archaeological evidence including:

- the nationally important Levalloisian site of Baker's Hole (TQ 615739), discovered and excavated early in the 20th century (Smith 1911; Wenban-Smith 1990, 1992 & 1995);
- the undisturbed late Levalloisian knapping floors and deposits rich in palaeo-environmental biological evidence discovered and excavated by Burchell in the mid-20th century (Burchell 1933, 1935a&b, 1936a,b&c, 1954 & 1957; Wenban-Smith 1995), now the Palaeolithic Scheduled Ancient Monument Kent 267b (Figure 1, Site B);
- the sequence of deposits containing both biological and artefactual evidence discovered by Marston and Carreck (1972) and later investigated by Kerney & Sieveking (1977) and Wenban-Smith (1995), now the SAM 267a area within which the new ZR4 pylon is sited (Figure 1).

1.3.3 These previous investigations showed that the importance of the SAM site Kent 267a lies in the deep sequence of Pleistocene sediments containing a variety of biological and palaeo-environmental evidence including large mammals, small mammals, fish, reptiles, ostracods and molluscs (Wenban-Smith 1995). Artefacts have also been recovered from the more active fluvial sediments at the base of the known sequence. Before works in relation to the ZR4 pylon, these deposits had only been investigated at the western edge of the SAM area where they have been exposed by quarrying at various times since the early 1970s (Carreck 1972; Kerney & Sieveking 1977; Wenban-Smith 1995).

1.3.4 The presence, location, national significance and nature of the Palaeolithic SAM was highlighted in the Assessment of Historic and Cultural Effects (OAU 1994), leading to selection of a route for the CTRL through the Ebbsfleet which avoided it. Nevertheless, it was not possible to avoid some impact on the SAM area due to the consequent necessity of re-siting the NGC pylon ZR4. Therefore a field evaluation (ARC ZR4 98) was carried out to establish the nature and significance of the deposits affected by this works, and to aid in determining a strategy for mitigation of the archaeological impact.

Field evaluation ARC ZR4 98

1.3.5 Test pits were mechanically excavated in one half of each of the footing foundations down to the full depth of the proposed impact (URL 1998, Figure 2) to assess the

nature of the deposits affected and their Palaeolithic archaeological significance, the other half being retained for more detailed mitigating works if necessary. Limited manual access was achieved for purposes of sampling by the use of trench boxes, which were inserted into the trench as mechanical excavation proceeded. The method precluded substantial hand excavation of the Pleistocene deposits and limited exposure of the sections to one side of each trench. The lithostratigraphic sequence of deposits in each test pit was recorded, and sieving for artefactual and biological evidence was carried out, as well as sampling for micro-biological evidence.

1.3.6 Significant deposits rich in biological evidence, mostly fluvial clays and silts, were identified in the bases of the deeper uplift footing test pits (URL 1998, 3423TP and 3424TP) and particularly in 3423TP. The main significance of these deposits was in their abundant micro-biological evidence, including fish, amphibians, reptiles and small mammals, although certain sedimentary units also contained larger mammalian remains. Therefore a programme of mitigation was designed by RLE and agreed with Kent County Council and English Heritage which involved more detailed excavation and sampling of these deposits followed by a watching brief during construction of the new ZR4 pylon.

2. ORIGINAL PRIORITIES, AIMS AND METHODOLOGY

2.1 Landscape Zone Priorities

2.1.1 The Ebbsfleet Valley is part of the Greater Thames Estuary landscape zone defined in the CTRL Archaeological Research Strategy (URL 1997), and was highlighted for its potential contribution to research on prehistoric hunter-foragers, early agriculturalists and towns and their rural landscapes. The area affected by the ZR4 pylon was shown by the field evaluation to only contain evidence relating to prehistoric hunter-foragers. Key research objectives for this period include investigation of:

- the nature of the contemporary landscape encompassing palaeo-topography, palaeo-climate and palaeo-environment
- establishing the chronological and geographical distribution of human occupation in relation to the changing palaeo-landscape
- refining knowledge of the broad palaeo-environmental, climatic and chrono-stratigraphic framework for early human occupation
- the range and nature of human cultural activity, particularly behaviour and palaeo-economy
- the effect of climatic and environmental change on human lifeways and adaptive strategies
- the changes to the organisation of the landscape through time
- the prehistoric landscape division
- the utilisation of natural resources

2.2 Fieldwork Event Aims

2.2.1 The general aims of the mitigating excavation were to:

- record the horizontal and vertical extent and sedimentological character of the Pleistocene sequence in the two deeper uplift footing footprints
- recover direct evidence of human behaviour if present
- gather sufficient relevant data for palaeo-environmental reconstruction through the Pleistocene sequence
- gather sufficient relevant data to date the Pleistocene sequence by correlative biostratigraphy and/or radiometric methods
- carry out an assessment of the potential for analysis of the findings of the works

2.2.2 The specific objectives were to:

- establish correlations of Pleistocene sedimentological units between the two deeper uplift footing foundation pits.
- establish correlations of the sedimentary units in the two deeper foundation pits with those known from previous research in the area, and those revealed during the evaluation of Area 8 immediately to the east of the SAM 267a area.
- provide a more detailed and coherent palaeo-environmental and chrono-stratigraphic context for the significant Palaeolithic artefactual remains recovered from other nearby locations in the Ebbsfleet Valley.

- identify the types, condition and prevalence of biological and artefactual evidence present in each sedimentary unit.

2.3 Fieldwork Methodology and Summary of Excavation Results

2.3.1 The general approach to the mitigating excavation was to achieve direct access to, allowing hand excavation and sampling of, the significant Pleistocene deposits at the base of the deeper uplift footing foundation pits. Mitigating excavation was limited to a 3m x 3m square within each 4m x 4m footprint in order to leave stable pit sides for subsequent engineering works. Thus approximately half of each of the mitigating excavation trenches (3776TP and 3777TP) was backfill from the evaluation trenches (3423TP and 3424TP), leaving the other half for excavation and sampling (Figure 2).

2.3.2 Full details of the excavation methodology are given in the WSI. In summary, each 3m x 3m trench (3776TP and 3777TP, Figure 2) was excavated by mechanical excavator down to the surface of the significant Pleistocene deposits, and steel trench-sheet shoring put in place supported by hydraulic braces. These sheets were subsequently lowered as hand excavation progressed to the required depth.

2.3.3 A vertical series of hand-excavated bulk samples were taken through the significant Pleistocene deposits, as identified in the field evaluation (URL 1998), in each of 3776TP and 3777TP, following the slope of the stratigraphic layering and taking care not to cross stratigraphic boundaries. The usual spit-depth was 10cm, although this was reduced for sedimentary units less than 10cm thick. Samples of at least 100 litres were taken from each spit where there was sufficient sediment - smaller samples were unavoidable from thin sedimentary units - and larger samples generally up to 250 litres in volume were taken from spits within the sediments identified in the evaluation as being particularly rich in micro-palaeobiological evidence. The WSI specified that 500 litres should be collected from the richest evaluation context (313 - excavation context 527). In practise a total of 420 litres were recovered from four spits within the context to allow differentiation between its upper and lower levels (samples 125-127). Sub-samples of *c.* 2 litres from each bulk sample were set aside for molluscan analysis.

2.3.4 The prime purpose of the bulk samples was to sieve them for the recovery of the small vertebrate evidence whose abundance was determined at the evaluation stage and to sub-sample them for molluscan evidence. Sub-samples of each bulk sample were, however, also taken for pollen, insect and ostracod analysis (Appendix 1). The presence of molluscs had been established during the field evaluation which did not, however, cover pollen, insect and ostracod analysis. Therefore appropriate sampling for these categories of evidence was undertaken as part of the mitigation excavation, and determination of their prevalence and significance, was deferred to the assessment report stage (Section 3.3).

2.3.5 The same sedimentary units identified in the field evaluation were successfully recognised and sampled (Section 3.3), although a different context numbering sequence was allocated for the mitigating excavation (Section 3.1). The upper dark grey clay-silt (context 307 from the evaluation, 516 from the mitigation) was only present in tiny quantities due to the high proportion of trench 3776TP that had been disturbed by the evaluation trenching, but a sample of 150 litres was recovered during the watching brief. A further sample of 100 litres of the brown clay context 528 was also recovered during the watching brief to replace material accidentally discarded in transit to processing.

2.3.6 Larger mammalian remains were common in the top part of the lower brown clay of trench 3776TP (context 314 evaluation/528 mitigation), and present in the immediately overlying grey clay-silts (313/527) and shelly grey sands (312/526). These were in a variety of conditions, ranging from very poor to very good. Each was individually excavated by hand, recorded, lifted and packaged to ensure safe transport off-site. Several large mammalian remains were also salvaged from the lower brown clay during the watching brief from the parts of the footing foundation pit outside the designated mitigation excavation trench.

2.3.7 Several monoliths were taken from trenches 3776TP and 3777TP, covering the major stratigraphic boundaries and the full depth of the finer-grained sediments, in case these were later shown to contain pollen evidence and for more detailed laboratory work on the particle-size and magnetic susceptibility of the sedimentary sequence.

2.3.8 Sediment resistivity readings were taken at intervals of between 2cm and 5cm as appropriate through the full sequence of deposits in both trenches ARC 3776TP and 3777TP. This data was collected in order to assist in interpreting subtle changes in the stratigraphic sequence. Assessment of the results indicate that broad trends in the data are visible that correspond to on-site observations of variation in grain size between the major stratigraphic units.

2.3.9 When the full depth of hand excavation was reached at the base of the footing foundations impact, a screw-type hand auger was used to investigate the underlying sedimentary sequence in each of 3776TP (between depths of 5.10 and 5.36m) and 3777TP (between depths of 5.0 and 5.6m) and to recover samples from it. These will be of use for extending the stratigraphic sequence beyond the excavated deposits.

2.3.10 Five samples were taken for OSL dating from suitably homogenous sandy sediments, three from 3776TP and two from 3777TP (Section 3.4). Background radiation readings were not taken *in situ* but samples were recovered for this purpose from around the location of each OSL sample tube.

2.4 Assessment Methodology

2.4.1 This assessment report was commissioned by URN to the specification produced by RLE and agreed with English Heritage and Kent County Council. This specification follows national guidelines prepared by English Heritage and provides additional information regarding the level of detail required in the report and its format. The assessment report was produced by Dr. Francis Wenban-Smith on behalf of the OAU. Stuart Foreman of the OAU was the Project Manager.

2.4.2 The overall objectives of this assessment are:

- to synthesise the archives from the field evaluation, the mitigating excavation and the watching brief
- to establish the full range of types of biological evidence contained in the samples from the sequences of deposits investigated in trenches ARC 3776 and 3777
- to establish the potential for analysis of the types of evidence present, particularly with respect to the aims and objectives discussed above in Sections 2.1 and 2.2

2.4.3 The data recovered has been assessed for the following categories of evidence:

a) stratigraphy (including sediment resistivity)
b) large mammalian remains
c) small vertebrate remains
d) molluscs
e) ostracods
f) pollen
g) insects
h) OSL samples

2.4.4 The specific method of assessment for each of these types of evidence is discussed in more detail in the appropriate appendices. For the large mammalian remains, the assessment process was a straightforward matter of counting and examining them. For the other types of evidence, it was necessary to a) process a sub-sample of the samples collected in order to establish the presence, prevalence and condition of the types of evidence omitted at the evaluation stage (cf Appendix 1) and b) sort a sample of the bulk-sample residues to establish the variety, richness and potential for analysis of the molluscan and small vertebrate remains in the different bulk samples and sedimentary units (cf Appendix 1). A proportion - usually 20% - of each bulk sample was processed by sieving through a mesh of 0.5mm and the residue examined and sorted; smaller samples had a larger proportion processed and sorted (cf Appendix 1). Processing of the remainder of each bulk sample only proceeded after it had been established that significant evidence was present.

2.4.5 Processing of the bulk sediment samples for small vertebrate remains was carried out at OAU premises. Otherwise the specialist work was undertaken by appropriately qualified external specialists.

Table 2: List of specialists

Specialist	*Organisation*	*Specialism*	*Contribution to assessment report*
Francis Wenban-Smith	Freelance	General Palaeolithic/Quaternary	Preparation of overall assessment report & appendices Overall sampling strategy for assessment report Residue sorting and examination
Martin Bates	St Davids University College, Lampeter	General Quaternary	Lithostratigraphy, Appendix 2
Simon Parfitt	Natural History Museum	Large vertebrates Small vertebrates	Appendix 3 Appendix 4
Mark Robinson	Oxford University	Molluscs and plant macro-fossils	Appendix 5
John Whittaker	Natural History Museum	Ostracods	Appendix 6
Russell Coope	Freelance	Insects	Appendix 7
Rob Scaife	Freelance	Pollen	Appendix 8

3. FACTUAL DATA AND QUANTIFICATION

3.1 The Stratigraphic Record (Appendix 2)

3.1.1 Two profiles were recorded through the sequences exposed during the mitigation works (ZR4 3776TP, and ZR4 3777TP). The stratigraphy present in both sequences can be subdivided into four major groups of sediments:

1. A lowermost group of deposits dominated by coarse flint gravel deposited during the Pleistocene under typically cold climate conditions (contexts 540 and 622).
2. A group of well stratified sands, silts and clays that contains well preserved palaeo-biological evidence including large and small mammal remains, birds, amphibians, fish, molluscs and ostracods (contexts 515, 516, 522, 523, 520, 521, 525, 526, 527, 528, 537, 536, 538 and 539 – 3776TP and 605, 606, 607, 608, 619, 620 and 621 – 3777TP). These deposits are likely to represent sediments deposited on the floodplain of the river under temperate conditions. Evidence exists within the sequence for horizons that may suggest the presence of temporary (land)surfaces within the fluvial sediment stack (e.g. blocky structure within context 527 and secondary precipitate within context 528). The generally coarser nature of the sediments in ZR4 3777TP may indicate closer proximity to an active channel on the floodplain surface.
3. A group of predominantly sandy sediments that exhibit a strong downslope dip to the major external and internal boundaries (contexts 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514 – 3776TP and 610, 611, 612, 613, 614, 615, 604, 603, 602, 601 – 3777TP). These deposits probably derived from the upslope erosion of older Middle Pleistocene sediments and the Thanet Sand bedrock, and were subsequently moved downslope by colluvial processes.
4. An upper group of reddish brown clay-silt units (501, 502, 503 – 3776TP and 616, 617, 618, 609 – 3777TP) exhibiting contacts dipping downslope in a similar fashion to those noted above (see 3 above). These are likely to be Holocene colluvial sediments.

3.1.2 Correlations between these context numbers and those from the evaluation are summarised in Tables 2.4 and 2.5 Appendix 2.

3.1.3 These sequences are similar to others previously recorded within the Ebbsfleet Valley area at site A (Wenban-Smith, 1995). However the altitudes of deposits are different and direct stratigraphic correlation between the sediments investigated here and other previously investigated sequences remains problematic because of the likely considerable altitudinal variation in deposit elevations within fluvial systems..

3.1.4 An extensive suite of Pleistocene sediments exists within the Ebbsfleet Valley at elevations ranging between +17m O.D. to at least –2.5m O.D. (Wenban-Smith, 1995; OAU 1997). Deposits at similar datums exist to the west within the preserved edge of the old pit where excavations by the British Museum and subsequently Wenban-Smith (1995) demonstrated that a sequence of fine grained fluvial sediments exists within this area. These deposits were rich in a wide variety of faunal remains including large and small mammal remains, molluscs and ostracods.

3.1.5 Direct correlation of the sediments preserved within the area of investigation and those present elsewhere within the site is however, difficult. Figure 4 shows the relationship between the profiles exposed in trenches 3776TP and 3777TP and the sequence present within the area of Site A that has been ascribed (Wenban-Smith, 1995) to the penultimate interglacial period (Marine Isotope Stage 7, c240-190ka B.P.). The Site A profile has been selected, for comparative purposes, as representative of the main north-south profile illustrated by Wenban-Smith (1995) from the British Museum excavation works previously described by Kerney and Sieveking (1977). It is noted that a rise in bedrock chalk was seen at the northern end of this profile. However, it should be noted that the correlation of sequences on the basis of height datums of sediments in fluvial situations is not necessarily valid because of the way in which sediments are laid down at different heights in river systems. Other approaches to correlation including the lithological and sedimentological characteristics of the sediment bodies, together with their associated palaeoenvironmental indicators and any amino acid ratios from fossil molluscan material may be appropriate methods for investigation.

3.1.6 Borehole ARC 0021SA (OAU 1997) is also shown for comparison. The sediments in this borehole are thought to date to the last interglacial, on the basis of amino acid ratios from the lower parts of the sequence (OAU 1997) and clear differences in height between these deposits and those of the sites under current investigation can be seen. However, it should be noted that the stratigraphic record preserved within the area is complex and that differences in stratigraphic complexity and sedimentary history probably exist within the area. For example, sediments recovered from the northern end of the transect A (URL, 1997), particularly in borehole ARC 0018SA and ARC 2006TP, probably correlate in part with the sediments examined in this phase of evaluation.

3.1.7 Further work on the samples recovered is justified in order to ascertain the environments of deposition of the sediments and to determine the taphonomic history of the contained fossil material.

3.2 The Artefactual Record

Worked flint (Appendix 2)

3.2.1 A single handaxe was found loose in a small pile of gravel scattered on the groundsurface *c.* 10m to the west of 3776TP and mingled with modern rubbish, topsoil and recently cleared shrub debris. It does not relate to any of the deposits investigated during ARC ZR498 or ARC ZR400, but may have been brought to the surface by geo-technical ground investigations of the lower Pleistocene deposits at the site which underlie those investigated during ARC ZR498 and ARC ZR400. If so, it emphasises the artefact-bearing potential of the deeper fluvial deposits in the general SAM area. Otherwise no artefacts were found.

3.3 The Environmental Record

Large vertebrates (Appendix 3)

3.3.1 A total of 52 large vertebrate remains were recovered from the fluvial sands, silts and clays in the bottom part of 3776TP. Over half of these were identifiable to species, and they include two large water birds - cormorant and duck - as well as mammoth, bison, horse and red deer. Most of the identifiable vertebrate remains came from the top 0.1m of context 528, and preservation of the material from this horizon is considered good.

3.3.2 Study of these faunal remains will help ascertain their taphonomic and depositional history and contribute to establishing the changing local climate and environment through the sequence of deposits. Biometrical comparisons of key species with those from other broadly contemporary sites (cf. Sutcliffe 1995) will form the basis for the biostratigraphic correlation of the sequence. Even single specimens of species such as horse and mammoth can be of biostratigraphic value, although the assemblage includes several specimens of these and other potentially biostratigraphically significant species. Although no lithic artefacts were found, the faunal material may contain cut marks or patterns of breakage indicating human activity. Scanning of the material during the assessment produced no such evidence, but more detailed examination following cleaning and conservation work may do so.

3.3.3 The Ebbsfleet Valley is noted for its rich Pleistocene mammalian fauna. This collection is of critical importance in understanding a complex and poorly understood period of rapid climatic and biotic change during the later part of the Middle Pleistocene in Britain.

3.3.4 Small vertebrates (Appendix 4)

3.3.5 Small vertebrate processing to date has focused upon sampling the bulk samples recovered to establish which of them contain significant evidence and need to have their processing completed. The fluvial deposits at the site are in general notable for the exceptional abundance and good preservational condition of small vertebrate material. Small mammal, amphibian and fish remains are abundant in the fluvial sands, silts and clays in the bottom part of ARC 3776TP, which also contain scarce small bird remains. Small mammal and amphibian remains are also present in the fine-grained fluvial sediments in the base of ARC 3777TP.

3.3.6 The small mammal species recovered to date include a range of voles, shrews and mice; the amphibians include frogs, toads and newts; and the fish include pike and sticklebacks. Completion of processing of the remaining parts of the assessed bulk samples will increase the assemblage diversity and provide information on the relative abundance of different species and orders. This will provide a good indication of the changing local climate, environment and depositional conditions through the sequence of deposits.

3.3.7 Biostratigraphically significant small mammal species recovered so far include watervole, northern vole and extinct mouse. Preliminary results indicate a general Oxygen Isotope Stage 7 date, c. 240,000 to 190,000 BP. Comparison of the small mammal assemblage from the ZR4 site with those previously recovered from other sites in the Ebbsfleet Valley (Wenban-Smith 1995) may establish detailed correlations and relationships at the level of the isotopic sub-stage, enabling more accurate dating of the artefact-bearing working floors known in the Ebbsfleet Valley and a fuller understanding of their climatic and environmental context.

Pollen (Appendix 5)

3.3.8 Eight sediment samples of c. 50g from the fine-grained silts and clays in the base of 3776TP and 3777TP were investigated for pollen. None was found. This was unsurprising in view of the generally calcareous nature of the sedimentary sequence, although pollen can occasionally be preserved in reasonable condition in certain well-sealed calcareous environments.

3.3.9 There is no potential for pursuing further pollen analysis, the most promising looking samples having given a negative result. Previous examination of sediments from Sites A and B has also produced a negative result, indicating that the generally calcareous nature of all Pleistocene deposits investigated to date in the Ebbsfleet Valley has not favoured pollen preservation.

Molluscs (Appendix 6)

3.3.10 The field evaluation showed that molluscs were preserved throughout the fluvial sequence in both trenches, 3423TP and 3424TP although their condition was generally poor with numerous shell fragments and relatively scarce identifiable specimens. Nonetheless enough molluscs were present for useful analysis, so a dedicated series of molluscan samples was taken throughout the full sequence of Pleistocene fluvial deposits up into the base of the colluvial deposits in each of the mitigation trenches ARC 3776 and 3777 TP.

3.3.11 Analysis for this assessment report focused upon identifying the presence of molluscs in contexts not already examined in the evaluation, in order to establish the overall potential for molluscan analysis through the full sequence investigated. The dedicated molluscan samples were not processed or examined, but molluscan preservation was assessed at the same time as sorting residues for small vertebrate remains, the dedicated molluscan samples being sub-samples from the same original bulk sediment samples

3.3.12 In trench 3776TP molluscs are present throughout the fluvial sequence and in the bottom part of the colluvial sequence (Table 6.3). Molluscs were scarce in the colluvial deposits, being limited to occasional specimens of *Pupilla muscorum*, albeit in fairly good condition. Molluscs were more frequent in the fluvial deposits, although many samples were dominated by broken shell fragments.

3.3.13 In trench 3777TP molluscs were found throughout both the bottom part of the colluvial deposits and the underlying fluvial marginal floodplain deposits (Table 6.4). They were generally scarce in the colluvial deposits, and became progressively more frequent with increasing depth down into the fluvial marginal floodplain deposits.

3.3.14 Study of the molluscan sequence has the potential to complement the other forms of biological evidence to reconstruct the changing history of climate, local environment and depositional conditions through the sequences of deposits in trenches 3776TP and 3777TP.

3.3.15 The presence of molluscs throughout the sequence also presents high potential for application of amino acid dating because this is a technique of dating specifically applicable to molluscs, and of proven value in the distinction of sediments from different isotopic stages of the later Middle and Upper Pleistocene (Bowen *et al.*, 1989). This technique may clarify several key issues, namely

i) the extent of the chronological hiatus between the bottom of the colluvial and the top of the fluvial sequences in each of trenches 3776TP and 3777TP,

ii) whether the time-depth within the fluvial sequences of these trenches includes more than one isotopic stage,

iii) correlations of units between the trenches 3776TP and 3777TP at the level of isotopic stage,

iv) correlations at the level of isotopic stage of units from trenches 3776TP and 3777TP with the mollusc-bearing units from Sites A and B, the former of which has an amino acid determination to Isotope Stage 7 (Wenban-Smith 1995) and

v) correlations at the level of isotopic stage of units from trenches 3776TP and 3777TP with amino acid determined Middle and Upper Pleistocene deposits in both South-east England and East Anglia which have similar diagenetic temperature histories.

Insects (Appendix 7)

3.3.16 Sediment samples of c. 1 litre from the fine-grained silts and clays in the base of 3776TP were investigated for the preservation of insect remains. None was found in the most likely looking sediments (contexts 516, 519 & 527) and visual inspection of the other clayey sediments (contexts 515, 528 & 537) suggested that these were too unlikely to contain insect remains for further analysis to be worthwhile. The lack of remains is probably due to the sediments having been oxidised despite originally having been waterlain under, presumably, generally anaerobic conditions.

Ostracods (Appendix 8)

3.3.17 50 samples from the full range of deposits identified in both 3776TP and 3777TP were investigated for the preservation of ostracods. These were found to be present in moderate abundance in 3776TP in the upper fluvial clays and silts, the middle fluvial sands and the lower fluvial clay silts, and in 3777TP in the floodplain deposits.

3.3.18 All of the ostracods identified belong to freshwater species. One of them is extinct in the present-day although it is known from British sites from the second half of the Middle and through the Upper Pleistocene. This is compatible with the presumed late Middle Pleistocene date of the deposits, but does not refine it further to a specific oxygen isotope stage or climatic cycle within this period.

3.3.19 Further study of the changing ostracod population in different sedimentary units through the sequence should provide detailed information on changing depositional conditions and fluvial flow regimes.

3.4 Dating

OSL dating

3.4.1 A number of OSL samples were collected, along with control samples to provide background radiation readings. Two samples (155 and 233) have been submitted for assessment on the basis of the stratigraphic assessment, selected to assess the suitability of the deposits for OSL dating and provide preliminary radiometric dates for key deposits.

3.4.2 The assessment method involves carrying out initial sample processing and taking preliminary readings to establish the suitability of the deposits for undergoing the full dating process.

3.4.3 The samples appear well-suited for OSL dating. The preliminary determinations are as follows:

Sample 155, context 525: c. 127,000 +/- 12,500 BP

Sample 233, context 606: c. 51,000 +/- 7,500 BP

3.5 Archive Storage and Curation

3.5.1 The material recovered from the site has been stored according to the United Kingdom Institute for Conservation conservation guidelines.

3.5.2 The faunal remains will require remedial and reconstructive conservation measures (See Appendix 3). The Natural History Museum is recommended as the most appropriate repository for the faunal remains and other archival material.

3.5.3 Selected samples not used in the assessment or analysis may be stabilised and retained as part of the permanent archive.

3.5.4 The archive index table has been updated and is shown below (Table 2).

Table 3: Archive index table

ITEM	**NUMBER OF ITEMS OR BOXES OR OTHER**	**NUMBER OF FRAGMENTS/ LITRES**	**CONDITION** (no. of items) (W=washed; UW=unwashed; M=marked; P=processed; UP=unprocessed; D=digitised; I=indexed)
Contexts records	40	-	I
A1 plans	1	-	I
A4 sections	2	-	I
A1 sections	2	-	I
Films (monochrome) S=slide; PR=print	4	-	I
Films (Colour) S=slide; PR=print	7	-	I
Lithics	1 size 4	1	W
Animal Bone		52	W
Soil samples (bulk bags/boxes)	393	c. 4000 l	P (proportion retained)
2kg samples (exc. sub-samples from bulk samples)	27	-	UP
Monoliths	17	-	P (proportion retained)
OSL samples (inc controls)	11	-	P (proportion retained)

Key to box sizes

Size 1 = Bulk box	391mm x 238mm x 210mm	0.02 m^3
Size 4 = Eighth box	213 mm x 102 mm x 80 mm	0.002 m^3

4. STATEMENT OF POTENTIAL

4.1 The Stratigraphic Record

4.1.1 The stratigraphic recording was specifically intended to record the horizontal and vertical extent and sedimentological character of the Pleistocene sequence in the two deeper uplift footing footprints. Detailed understanding of the formation processes of deposits at this location is of direct relevance to all of the Fieldwork Event Aims. The assessment aimed to identify the potential of these sequences for revealing new data regarding the nature of the environments of deposition of the sediments. Variations in grain size through the profile were noted during the field investigation as well as zones of potential weathering and pedogenesis.

4.1.2 In order to investigate these sequences and trends a fully detailed investigation of the sedimentology of the individual undisturbed samples will be required. Specifically, investigation should focus on determining a detailed history of sedimentation from monoliths 152, 147, 142 and 143 from section 103, trench 3776TP. The following laboratory testing should be undertaken:

1. Loss-on-ignition in order to determine organic values on samples at 2cm intervals. Objective: to examine changes through profile in order to enhance understanding of the nature of potential breaks in deposition and location of pedogenic horizons.
2. Magnetic susceptibility on samples at 2cm intervals. Objective: to examine the potential of sediments for containing buried soil profiles (comparisons to be made between areas identified on morphological criteria (e.g. blocky structure (context 527) and secondary precipitate (context 528)) to contain potential buried soils and those areas of the stratigraphic stack for which no features indicative of pedogenic activity have been noted).
3. Carbonate determinations at 2cm intervals. Objective: to determine variations in carbonate values that may aid in understanding of the taphonomy and the preservational status of included fossil material.
4. Phosphate determinations at 4cm intervals. Objective: to examine the potential of sediments for containing buried soil horizons within which phosphate values may be expected to increase (comparisons to be made between areas identified on morphological criteria (e.g. blocky structure (context 527) and secondary precipitate (context 528)) to contain potential buried soils and those areas of the stratigraphic stack for which no features indicative of pedogenic activity have been noted).
5. Grain size determinations of selected samples from key stratigraphic units in order to determine trends in grain size within two major cycles seen within the fine grained fluvial sequences (contexts 515, 516, 522, 523, 520, 521, 525, 526, 527, 528, 537, 536, 538, 539) (maximum 20 samples). Resistivity measurements taken on site will be used to assist in this analysis. Assessment of the readings indicates a broad correlation with visual field observations of variations in grain size between the major stratigraphic units.

4.2 The Artefactual Record

4.2.1 There is minimal artefactual potential. No artefacts were found in context, and nothing is known of the depositional history of the broken handaxe found out of context. It may originate from deeper-lying Pleistocene sediments recovered during geo-technical investigations at the site. Therefore it should be described as part of

the post-excavation report as a possible indication of the artefactual potential of the more deeply buried deposits at the ZR4 location.

4.3 The Environmental Record

Introduction

4.3.1 Several different types of biological/palaeo-environmental evidence were recovered from the Pleistocene deposits at the ZR4 site. These included large mammals, birds, small mammals, amphibians, fish, molluscs and ostracods. In combination, this diversity of evidence has high potential to contribute to reconstruction of the changing local palaeo-climate, environment and depositional conditions during formation of the sedimentary sequence.

4.3.2 The environmental evidence can form the basis of dating the deposits, establishing correlations with the occupation floors known from other locations in the Ebbsfleet Valley, and providing the climatic, environmental and chronological context for the early Neanderthal activity known both from the Ebbsfleet Valley and from the wider southeast English region.

4.3.3 Previous research at other locations within the Ebbsfleet Valley has suggested that several of the known Pleistocene deposits date to Stage 7, between *c.* 240,000 and 190,000 BP. This is a complex stage with at least five major climatic fluctuations but no one yet has provided an analysis of which deposits known from that general period might date to specific sub-stages within Stage 7 and how such sub-stages might be differentiated in terms of specific climatic and environmental conditions as well as small vertebrate assemblage structures and species characteristics. Study of the environmental evidence from the various deposits in the Ebbsfleet Valley could provide, for the first time, a detailed record of the climatic and environmental fluctuations and accompanying faunal changes though a single isotopic stage. Besides being of national significance for providing a more secure framework for understanding and interpreting the pattern of the early Neanderthal occupation of the Ebbsfleet Valley and the SE English region generally, such work would be of international significance in providing a template for the potential degree of variability within a single stage of the isotopic signature, with implications for the current grouping of terrestrial Middle and Upper Pleistocene deposits into the isotopic framework.

Large vertebrates

4.3.4 Study of the assemblage will help establish its taphonomic and depositional history, and help reconstruct the changing climate and environment through the sequence of deposits. Biometrical comparisons of key species with those from other broadly contemporary sites (cf. Sutcliffe 1995) will form the basis for the biostratigraphic dating of the sequence. The Ebbsfleet Valley is noted for its rich Pleistocene mammalian fauna. The ZR4 collection is of particular value since it comes from secure contexts in association with other biological evidence. This collection, therefore, has high potential to contribute to understanding a complex and poorly understood period of rapid climatic and biotic change during the later part of the Middle Pleistocene in Britain, by providing a fuller picture of changing large vertebrate faunas in relation to other climatic and environmental indicators.

Small vertebrates

4.3.5 Complete recovery and analysis of the small vertebrate material is central to achieving the landscape zone priorities and research aims and objectives of the project, namely investigation of the palaeo-climate and palaeo-environment and

establishing the chronology and duration of early human occupation in relation to changing climate, environment and palaeo-landscape. The relative prevalence through the sequence of terrestrial, amphibious and aquatic species can provide an essential aid to determining the depositional conditions under which each context was laid down. Several species of small mammal, fish and amphibian are very specific in their niches and study of the changing assemblage structure of these types of evidence through the sequence should give a good indication of changing climate and local environment. Analysis of the body part representation can also clarify the taphonomic history and integrity of the assemblages from each sedimentary unit.

4.3.6 It has become apparent over the last decade that small mammals can play a key role in dating deposits from the Middle and Upper Pleistocene. Dating Pleistocene deposits plays a key part in achieving the CTRL research aim of investigating the chronology and duration of early human occupation in relation to changing climate, environment and palaeo-landscape. Not only is there a high turnover of species giving rise to a rapidly changing assemblage structure, but genera such as Arvicola and Microtus evolve certain dental characteristics rapidly through this period, making them suitable for correlative biostratigraphic work.

4.3.7 Two species already identified in the sample examined for the assessment report, northern vole and watervole, are particularly suitable for such work, and large numbers of specimens of these species are also available for study from the key comparative locations within the Ebbsfleet Valley (Burchell's Levalloisian site and the British Museum excavation), as well as from the important Middle Palaeolithic site at Crayford.

4.3.8 Therefore analysis of the small mammal assemblages from the ZR4 sedimentary sequences and comparison with the assemblages from these other locations which have produced sizeable small mammal assemblages provides a key means of correlating the sequences with each other, in the absence of any direct stratigraphic connections. Thus it should be possible from the small mammals to date the ZR4 deposits to at least specific Oxygen Isotope Stages within the Middle Pleistocene, and to ascertain whether the various sites in the Ebbsfleet Valley come from the same or different Oxygen Isotope stages and, if different, which are older and which younger.

Pollen

4.3.9 No pollen preservation was found, and there is no potential for further pollen work.

Molluscs

4.3.10 Study of the molluscan sequence has the potential to complement the other forms of biological evidence to reconstruct the changing history of climate, local environment and depositional conditions through the sequences of deposits in trenches 3776TP and 3777TP.

4.3.11 The presence of molluscs throughout the sequence has high potential for application of amino acid dating. This technique may clarify several key issues, namely

i) the significance of the chronological hiatus between the bottom of the colluvial and the top of the fluvial sequences in each of trenches 3776TP and 3777TP

ii) the presence of a significant time-depth within the fluvial sequences of these trenches

iii) correlations of units between the trenches 3776TP and 3777TP, iv) correlations of units from trenches 3776TP and 3777TP with units from Sites A and B, and

v) correlations of units from trenches 3776TP and 3777TP with amino acid determined Middle and Upper Pleistocene deposits in both SE England and East Anglia with similar diagenetic histories

Insects

4.3.12 No insect remains were found, and there is no potential for further insect analysis.

Ostracods

4.3.13 Ostracods are preserved in low-medium quantities in several of the fluvial horizons through the Pleistocene sequences in 3776TP and 3777TP. Interestingly, the horizons of better ostracod preservation often coincide with the horizons of the least molluscan and small vertebrate preservation in both trenches. This is presumably a function of the taphonomic history of the deposits and possibly the post burial diagenetic history of the sequence.

4.3.14 Further analysis to recover more specimens from the ostracod-bearing horizons can provide sufficient material to give an indication of prevailing local environmental and depositional conditions, particularly in relation to questions such as waterflow regime. Sufficient quantities of specimens may also be produced to investigate the population structure and determine whether the assemblages are primarily autochthonous or allochthonous.

4.3.15 The ostracods provide a valuable complement to the molluscan and small vertebrate evidence in that they can

i) provide more sensitive information on the local environmental and depositional conditions for the horizons in which ostracod and other environmental evidence co-occurs, and

ii) they provide the sole source of such information in several horizons whose interpretation would otherwise be problematic. Thus further processing and analysis of the ostracod evidence is essential in building up as complete a picture as possible of the changing local palaeo-climate, environment and depositional history through the sequences of Pleistocene deposits investigated at the ZR4 site.

4.4 Dating potential

Radiometric

4.4.1 Five samples and associated sets of background samples were taken for attempting Optically Stimulated Luminescence (OSL) dating (Appendix 2, Table 2.3). The dating of the sequence, at least to the correct isotopic stage, is an important for all of the Landscape Zone Priories and Fieldwork Event Aims but will specifically address the aim of gathering sufficient relevant data to date the Pleistocene sequence by correlative biostratigraphy and/or radiometric methods.

4.4.2 The samples have equal potential on sedimentary grounds for achieving a successful date, but preliminary analysis to confirm or negate their potential for dating was restricted to three samples on grounds of economy. Similar deposits have in the past produced useful results and the 10% accuracy range of the technique (Schwenninger pers. comm.) should be sufficient to provide a useful complement to the other dating approaches discussed below, and to date the deposits under investigation to an isotopic stage.

4.4.3 The three samples being examined currently were chosen as representing the major stratigraphic groups observed in the excavations at ZR4. Preliminary analysis of two of these (155 and 233) has shown that they are suitable for successful production of

a date, following further analysis. If the third sample currently under study shows a lack of potential, another samples from the same stratigraphic group should in turn be assessed for its potential, and a date produced if possible.

Amino acid

4.4.4 Molluscs are present in sufficient abundance throughout the sequence for all the main groups of deposits to undergo amino acid dating. This will enable identification of any significant stratigraphic hiatuses within the sequences at each of 3776TP and 3777TP, as well as allowing comparisons

i) between the sequences in each trench with each other

ii) between the sequences in each trench with Site A, and

iii) between the sequences in each trench with other sites in south-east England

Bio-stratigraphy

4.4.5 The range of mammalian species already identified is dominated by horse, mammoth, deer and northern vole. These species are known to co-occur in Isotope Stage 7. All of these species also show morpho-metric change through the Middle and Upper Pleistocene which is becoming increasingly well understood, leading to increasing potential for the use of these fossils as bio-stratigraphic indicators.

4.4.6 Comparison of the faunal material from 3776TP and 3777TP with that from Sites A and B in the Ebbsfleet Valley may clarify whether the complex sequence of deposits within the Ebbsfleet Valley could be related to sub-stages within Isotope Stage 7. If so, this would be a major contribution to Palaeolithic archaeology, providing for the first time a more detailed picture of the climatic and chrono-stratigraphic framework for the sporadic occupation of Britain at this time, at this critical stage in the evolution of Neanderthals, when new knapping strategies were developing at the same time probably as the classic Neanderthal physiognomy.

4.5 Overall Potential

4.5.1 The overall potential of the site archive relates to the use, in combination, of the different types of environmental and sedimentological evidence to:

- reconstruct the changing regional palaeo-climate and local palaeo-environment through the time period represented by the deposition of the sedimentary sequences excavated in 3423/3776TP and 3424/3777TP
- reconstruct the changing history of depositional conditions and waterflow regime through the time period represented by the deposition of the sedimentary sequences excavated in 3423/3776TP and 3424/3777TP
- correlate and date the sequence of deposits excavated in 3423/3776TP and 3424/3777TP in relation to:

  i) each other

  ii) the undisturbed early Neanderthal working floors excavated previously in other parts of the Ebbsfleet Valley

  iii) other Late Middle and Early Upper Pleistocene Palaeolithic sites in the south-east English region

  iv) the broader north-west European climato-, litho- and chrono-stratigraphic framework

- provide a detailed record of climatic and environmental change through the sub-stages of a single complex Oxygen Isotope Stage

4.5.2 The site is clearly of at least national significance in contributing to a chronological, environmental and climatic context for the significant archaeological sites of the Ebbsfleet Valley, and improving understanding of the pattern of human occupation of England in relation to the Pleistocene chronological and environmental framework.

4.5.3 If the potential of the environmental evidence is fully realised, the ZR4 data will contribute significantly to understanding of the Pleistocene deposits in the Ebbsfleet Valley, which collectively are of international significance. The data has the potential to contribute to knowledge of early Neanderthal settlement and cultural change in relation to landscape evolution and environmental and climatic change through the complex fluctuations of a single Oxygen Isotope Stage.

Realisation of priorities and aims

4.5.4 The landscape zone priorities outlined in Section 2.1 can only be partially addressed due to the lack of artefactual evidence at the ZR4 site. It is not, therefore, possible to directly investigate human behaviour and palaeo-economy, unless further study of the large mammalian assemblage reveals evidence of human cut marks or breakage. Some insight might be gained into the effect of climatic and environmental change on human lifeways and adaptive strategies if the sequences investigated at ZR4 are successfully related to the Early Neanderthal occupation sites at other nearby locations in the Ebbsfleet Valley. However, the recovery of a full range of biological evidence and sedimentary studies should enable the other priorities to be fully addressed as outlined in Section 4.6.1 above.

4.5.5 The general fieldwork event aims of the mitigation excavation outlined in Section 2.2 were fully met with the exception of the recovery of direct evidence of human behaviour, which was not present, although might be revealed by further study of the large mammal assemblage following cleaning and conservation.

4.5.6 The types, condition and prevalence of biological and artefactual evidence was successfully established, but achievement of the other specific fieldwork event objectives outlined in Section 2.2 depends to a large extent on the completion of the post-excavation analyses of the different categories of evidence recovered from the site.

4.6 Additional research potential

4.6.1 Previous research in the Ebbsfleet Valley (Wenban-Smith 1995) has suggested that the bulk of the Pleistocene deposits date to Stage 7, between c. 240,000 and 190,000 BP. This is a complex stage with at least five major climatic fluctuations but no one yet has provided an analysis of which deposits known from that general period might date to specific sub-stages within Stage, 7 and how such sub-stages might be differentiated in terms of specific climatic and environmental conditions and mammalian assemblage structures and bio-metric characteristics. Study of the environmental evidence from the ZR4 site could provide, for the first time, a detailed record of the climatic and environmental fluctuations and accompanying faunal changes though a single isotopic stage. Besides being of national significance for providing a more secure framework for understanding and interpreting the pattern of the pre-Neanderthal occupation of the Ebbsfleet Valley and the SE English region generally, such work would be of international significance in providing a template for the potential degree of variability within a single stage of the isotopic signature. This could potentially result in a reinterpretation of the

current grouping of terrestrial Middle and Upper Pleistocene deposits into the isotopic framework.

4.7 Popular Presentation

4.7.1 So little survives that the site has little in the way of photogenic finds to contribute to a popular presentation. However, the discovery of extinct large mammal remains often attracts a great deal of press and public interest at a local and national level (for example, recent investigations at Aveley in Essex on the A13 Road Improvement Scheme, which also uncovered faunal remains with no associated archaeology, attracted considerable national press coverage). In addition, the study provides a chronological starting point for any overview of the CTRL archaeology, estimated at c. 240,000 to 190,000 BP.

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APPENDIX 1 - PALAEO-ENVIRONMENTAL SAMPLES

by Dr. Francis Wenban-Smith

1.1 Introduction

1.1.1 Sub-samples for investigation and processing for molluscan remains were taken from each bulk palaeo-environmental sample, apart from those recovered by auger which were too small for molluscan analysis. Sub-samples for investigation of pollen, ostracod and insect remains were also taken as specified in tables 1.1 and 1.2 below. The sub-samples were processed by the respective specialists as described in the respective appendices covering each type of evidence. The remainder of the bulk samples were sieved by direct spraying with a fine water mist through a graded series of sieves of mesh sizes 10mm, 4mm, 2mm, 1mm and 0.5mm. The sediments were not dried prior to sieving and the more clayey and silty sediments were soaked in water for up to 3 days to aid breakdown of the sediment to pass through the sieves.

*Table 1.1: bulk sediment samples from 3776TP processing summary for assessment report (*auger samples of c. 250g), samples in stratigraphic order*

Sample	*Context*	*Sample size, litres*	*Processed for ass. rep. 0.5mm mesh, litres*	*50g extracted & processed for ostracods*	*50g extracted for pollen, (*processed)*	*1 litre processed for insects*
Bottom of colluvial deposits						
113	533	50	10	Yes	Yes	-
114	534	50	10	Yes	Yes	-
115	514	50	10	Yes	Yes	-
Upper fluvial clay/silt bands/laminations						
101	515	20	10	Yes	Yes*	-
116	515	10	-	-	-	-
102	516	50	10	Yes	Yes	Yes
117	516	20	-	-	-	-
123	516	10	-	-	-	-
160	516	150	-	-	-	-
103	518	20	10	Yes	Yes	-
104	519	40	10	Yes	Yes	Yes
Middle fluvial sands						
118	522	30	10	Yes	Yes	-
119	523	40	10	Yes	Yes	-
124	520 upp.	30	10	Yes	Yes	-
120	520 low.	20	10	Yes	Yes	-
121	530 521	20	10	Yes	Yes	-
105	522 523 520 530	100	-	-	-	-
106	520 530 521 525 upp.	100	-	-	-	-
122	521 low.	30	10	Yes	Yes	-

Sample	*Context*	*Sample size, litres*	*Processed for ass. rep. 0.5mm mesh, litres*	*50g extracted & processed for ostracods*	*50g extracted for pollen, (*processed)*	*1 litre processed for insects*
107	525 i	100	20	Yes	Yes	-
111	525 ii	100	20	Yes	Yes	-
112	525 iii	100	20	Yes	Yes	-
109	525 iv	100	20	Yes	Yes	-
110	529	10	10	Yes	Yes	-
108	526	250	40	Yes	Yes	-
Lower fluvial clays/silts						
125	527	120	-	-	-	-
128	527	100	-	-	-	-
126	527 upp.	100	20	Yes	Yes*	Yes
127	527 low.	100	20	Yes	Yes	Yes
161	528 i	100	-	-	-	-
129	528 i	150	20	Yes	Yes*	-
130	528 iia	150	20	Yes	Yes	-
132	528 iib	50	10	Yes	Yes*	-
131	528 iii	150	20	Yes	Yes	-
134	537	40	10	Yes	Yes*	-
135*	537	.25	-	-	-	-
Lowest fluvial sands/silts						
133	536	100	20	Yes	Yes*	-
136*	536 i	.25	-	-	-	-
137*	536 ii	.25	-	-	-	-
138*	536 iii 538 i	.25	-	-	-	-
139*	538 ii	.25	-	Yes	Yes*	-
140*	539	.25	-	Yes	Yes	-
141*	540	.25	-	Yes	Yes	-

*Table 1.2: bulk sediment samples from 3777TP processing summary for assessment report (*auger samples of c. 250g), samples in stratigraphic order*

Sample	*Context*	*Sample size, litres*	*Processed for ass. rep. 0.5mm mesh, litres*	*50g extracted & processed for ostracods*	*50g extracted for pollen, (*processed)*	*1 litre processed for insects*
Bottom of colluvial deposits						
201	601 i	100	20	Yes	Yes	-
202	601 ii	100	20	Yes	Yes	-
203	601 iii	100	20	Yes	Yes	-
204	601 iv	100	20	Yes	Yes	-
Marginal floodplain deposits						
205	605 i	100	20	Yes	Yes	-
206	605 ii	100	-	-	-	-
207	605 iii	100	20	Yes	Yes	-
208	605 606	100	-	-	-	-
209	605 606	250	40	Yes	Yes	-
210	605 606	250	-	-	-	-
211	607 i	250	40	Yes	Yes	-
212	607 ii	100	20	Yes	Yes	-

Sample	*Context*	*Sample size, litres*	*Processed for ass. rep. 0.5mm mesh, litres*	*50g extracted & processed for ostracods*	*50g extracted for pollen, (*processed)*	*1 litre processed for insects*
213	607 iii	100	20	Yes	Yes	-
214	608 i	150	30	Yes	Yes	-
215*	608 ii	.25	-	Yes	Yes	-
216*	608 iii	.25	-	Yes	Yes	-
217*	608 iv	.25	-	Yes	Yes	-
218*	619 i	.25	-	Yes	Yes	-
219*	619 ii	.25	-	Yes	Yes	-
220*	620 i	.25	-	Yes	Yes	-
221*	620 ii	.25	-	Yes	Yes	-
222*	620 iii	.25	-	Yes	Yes	-
223*	621	.25	-	Yes	Yes*	-
Gravel						
224*	622	.25	-	Yes	Yes	-

APPENDIX 2 - STRATIGRAPHY

by Dr. Martin Bates

2.1 Introduction

2.1.1 Investigation of the stratigraphy of the exposed sequences involved visits to the site to i) log sequences, ii) advise on procedures for sampling and, iii) undertake sampling of using monolith and soil kubiena tins where appropriate.

2.1.2 Where section logging was required standard geological terminology was used to record sequences as described below. As part of this work a number of samples were recovered to allow for further specialised investigation.

2.1.3 The aims and objectives of the geoarchaeological input to this phase of works focused on identifying and interpreting stratigraphy and buried soil horizons within the sequences that had previously been examined during evaluation works (OAU 1998).

2.2 Methodology

2.2.1 This report focuses on the description and interpretation of two sequences revealed during the course of archaeological investigation of the footings for two of the four pylon feet within the area. Detailed profile descriptions and interpretations are presented for two investigation areas (ZR4 3776TP and ZR4 3777TP) that were recorded in the field by the specialist geoarchaeologist (Tables 2.4 and 2.5).

2.2.2 Sequences were recorded down-profile using standard geological terminology used in Quaternary science (Jones *et al.*, 1999). All measurements on sequences are given relative to the top of the profile.

2.3 Trench 3776TP

2.3.1 The sequence of sediments recovered trench 3776TP can be sub-divided into four groups of sediments:

2.3.2 **Group 1:** 0.00 - 1.20m [11.27-10.07m O.D.] (contexts 501, 502, 503). These deposits consist of silts and some sands. Typically these deposits are similar to deposits found commonly throughout the Ebbsfleet area that were deposited during the Holocene as slope wash sediments laid down as sheets blanketing the valley sides.

2.3.3 **Group 2:** 1.20 – 3.30m [10.07 – 7.97m O.D.] (contexts 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514). These deposits consist of bedded sands and silts. The sand and silt units can be seen to clearly dip downslope, parallel with the existing valley side profile. Locally these units are slightly calcareous and may contain molluscs. Thin flint gravel bands exist within the profile. These deposits are likely to be colluvial slope wash sediments of probable Pleistocene age.

2.3.4 **Group 3:** 3.30 – 5.36m [7.97 – 5.91m O.D.] (contexts 515, 516, 522, 523, 520, 521, 525, 526, 527, 528, 537, 536, 538, 539). This group of sediments forms a complex sequence of sands and clay-silt units that are rich in micro and macrofossils. The sequences are typically similar to those expected in floodplain situations in areas adjacent to active channels. In many places the upper parts of the sequence show evidence of complex faulting. This faulting probably occurred after downcutting by the river and may have been contemporary with the earliest phases of colluvial slope wash activity (faulting occurring as a result of cambering of the

sediments on the valley side). Although precise determination of the environments of deposition of these sediments remains to be determined it is interesting to note that two cycles of sands to clay-silts can be seen in the sequence:

- Lowermost sands (539, 538, 536) – Lower clay-silts (537, 528, 527)
- Upper sands (526, 529, 525, 521, 520, 523, 522) and Upper clay-silts (519, 518, 516, 515).

2.3.5 These deposits are of Pleistocene date.

2.3.6 **Group 4:** 5.36m – [5.91m O.D. -] (context 540). This unit is a gravel that was only discovered through augering through the base of the trench. It is difficult to determine the precise nature of the sediment but deposits such as this gravel are likely to have been deposited under cold climate conditions during the Pleistocene.

2.4 Trench 3777TP

2.4.1 The sequence of sediments recovered from trench 3777TP can also be sub-divided into four groups of sediments:

2.4.2 **Group 1:** 0.00 - 1.25m [10.456-9.206m O.D.] (contexts 616, 617, 618, 609). These deposits consist of silts and some sands. Typically these deposits are similar to deposits found commonly throughout the Ebbsfleet area that were deposited during the Holocene as slope wash sediments laid down as sheets blanketing the valley sides.

2.4.3 **Group 2:** 1.25 – 3.70m [9.206 – 6.756m O.D.] (contexts 610, 611, 612, 613, 614, 615, 604, 603, 602, 601). These deposits consist of bedded sands and silts. The sand and silt units can be seen to clearly dip downslope, parallel with the existing valley side profile. Locally these units are slightly calcareous and may contain molluscs. Thin flint gravel bands exist within the profile. These deposits are likely to be colluvial slope wash sediments of probable Pleistocene age.

2.4.4 **Group 3:** 3.70 – 5.55m [6.756 – 4.906m O.D.] (contexts 605, 606, 607, 608, 619, 620, 621). This group of sediments forms a complex sequence of sands and sandy-silts that contain some fossiliferous material. The sequences are typically similar to those expected in floodplain marginal situations adjacent to active channels. These deposits are of Pleistocene date.

2.4.5 **Group 4:** 5.55m – [4.906m O.D. -] (context 622). This unit is a gravel that was only discovered through augering through the base of the trench. It is difficult to determine the precise nature of the sediment but deposits such as this gravel are likely to have been deposited under cold climate conditions during the Pleistocene.

2.5 Sample summary - lithostratigraphy, sediment micromorphology and OSL

2.5.1 Tables 2.1 and 2.2 list the contexts present in both trenches and indicate monolith, kubiena tins and Optically Stimulated Luminescence (OSL) samples related to contexts.

*Table 2.1: context numbers and sample details: ZR4, section 103, 3776TP (OSL samples undergoing preliminary assessment marked *)*

Context	*Sample Number*	*Sample type*
514	152, 151	Monolith (152), Kubiena (151)
515	152, 151	Monolith (152), Kubiena (151)
516	152, 151	Monolith (152), Kubiena (151)
524	152	Monolith (152)
522	152, 147	Monolith (152, 147)
523	152, 147	Monolith (152, 147)
520	147	Monolith
530	147	Monolith
121	147, 150	Monolith (147), Kubiena (150)
122	147, 150	Monolith (147), Kubiena (150)
525	147, 142, 143, 153, 155	Monolith (147, 142, 143), OSL (153/154) & (155/156)*
526	143, 146, 148	Monolith (143, 148), Kubiena (156)
527	143, 146, 148, 149	Monolith (143, 148), Kubiena (156, 149)
528	143, 144, 145, 148, 149	Monolith (143, 148), Kubiena (144, 145, 149)
537	143	Monolith (143)
525	148	Monolith
536	148, 157	Monolith (148), OSL (157/158)*

*Table 2.2: context numbers and sample details: ZR4, section 203, 3777TP (OSL samples undergoing preliminary assessment marked *)*

Context	*Sample Number*	*Sample type*
603	225	Monolith
602	225	Monolith
601	225	Monolith
605	225, 227, 226, 228	Monolith (225, 226), Kubiena (227, 228)
606	226, 228, 229, 233	Monolith (226), Kubiena (228, 229), OSL (233/235)*
607	226, 230, 234	Monolith (226), Kubiena (230), OSL (234/236)
608	226, 230	Monolith (226), Kubiena (230)

2.6 Provenance

2.6.1 The stratigraphy present within the two trenches examined is similar to that observed during the previous evaluation phase of works and has some similarities with the stratigraphy noted previously in the vicinity of the British Museum excavations (Wenban-Smith, 1995). The contexts described fall into four groups of sequences:

1. A lowermost group of deposits dominated by medium-coarse flint gravel deposited during the Pleistocene under typically cold climate conditions (contexts 540 and 622)

2. A group of well stratified sands, silts and clays that may contain well preserved fossil material including large and small mammal remains and molluscs (contexts 515, 516, 522, 523, 520, 521, 525, 526, 527, 528, 537, 536, 538 and 539 – 3776TP and 605, 606, 607, 608, 619, 620 and 621 – 3777TP). These deposits are likely to represent sediments deposited on the floodplain of the river under temperate conditions. Evidence exists within the sequence for horizons that may suggest the presence of temporary surfaces within the fluvial stack. The generally coarser nature of the sediments in ZR4 3777TP may indicate closer proximity to an active channel on the floodplain surface.

3. A group of predominantly sandy sediments that exhibit a strong downslope dip to the major external and internal boundaries (contexts 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514 – 3776TP and 610, 611, 612, 613, 614, 615, 604, 603, 602, 601 – 3777TP). These deposits are likely to be sediments moved downslope under colluvial processes that are derived from the erosion of older Pleistocene sediments upslope or the erosion of bedrock Thanet Sand.
4. An upper group of reddish brown clay-silt units (501, 502, 503 – 3776TP and 616, 617, 618, 609 – 3777TP) exhibiting contacts dipping downslope in a similar fashion to those noted above (see 3 above). These are likely to be Holocene colluvial sediments.

2.7 Conservation

2.7.1 A number of undisturbed sediment samples and samples for Optically Stimulated Luminescence Dating (OSL) exist from the trenches (Table 8).

Table 2.3: samples from ZR4 investigation

Sample type	*3776TP*	*3777TP*
Monoliths	152, 147, 142, 143, 148	225, 226
Kubiena Tins	151, 150, 156, 149, 145	227, 228, 229, 230
OSL samples	153, 155, 157	233, 234

2.7.2 These samples are currently stable and are being held under controlled climate conditions in a cold store. The absence of extensive organic remains, such as plant fragments, within the sediments indicates that degradation of the samples will only occur slowly even within a drying environment. However, desiccation of these samples will occur over time.

2.8 Comparative material

2.8.1 An extensive suite of Pleistocene sediments exists within the Ebbsfleet Valley at elevations ranging between +17m O.D. to at least –2.5m O.D. (Wenban-Smith 1995; OAU 1997). Deposits at similar datums exist to the west within the preserved edge of the old pit where excavations by the British Museum and subsequently Wenban-Smith (Wenban-Smith, 1995) demonstrated that a sequence of fine grained fluvial sediments exists within this area. These deposits were rich in a wide variety of faunal remains including large and small mammal remains, molluscs and ostracods.

2.8.2 Correlation of the sediments preserved within the area of investigation and those present elsewhere within the site is difficult in the absence of direct stratigraphic evidence. Figure 4 shows the relationship between the profiles exposed in trenches 3776TP and 3777TP and the sequence present within the area of Site A that has been ascribed (Wenban-Smith, 1995) to the penultimate interglacial period (Marine Isotope Stage 7, c240-190ka B.P.). This clearly shows that height differences exist between these two sets of deposits making correlation between them on stratigraphic and topographical grounds difficult.

2.8.3 Borehole ARC 0021SA (OAU 1997) is also shown for comparison. The sediments in this borehole are thought to date to the last interglacial, on the basis of amino acid ratios from the lower parts of the sequence (OAU 1997) and clear differences in height between these deposits and those of the sites under current investigation can be seen. This evidence suggests that while the deposits within trenches 3776 and 3777TP are likely to correlate broadly with those preserved higher on the slope within the vicinity of Site A this remains to be demonstrated and further work would be needed to establish this correlation. Available avenues of analysis, a combination of which may lead to relatively secure correlation between deposits, include lithology, sedimentology, biostratigraphy and amino acid geochronology.

2.9 Success of the geological investigation

2.9.1 Detailed records were produced describing the vertical and horizontal extent and nature of the deposits in both trenches. This was achieved both as a written record (Tables 2.4 and 2.5), as a drawn record and as a series of electrical conductivity measurements (a approximate indication of sediment grain size). Accompanying the paper record were a series of undisturbed monolith and kubiena tin samples as well as samples for dating (see Tables 2.1, 2.2 and 2.3 above).

2.9.2 Considerable complexity in stratigraphic sequence was noted both within and between trenches. Broad correlation of the units, within the context of a laterally varying floodplain environment, is indicated on altitudinal criteria (Figure 3) however, detailed correlation between individual units between trenches cannot yet be achieved. Correlation beyond the immediate vicinity of the area of investigation (both up and downslope) has been discussed and remains problematic.

2.9.3 The samples recovered reflect the sequence complexity and have been directly linked to the bulk sample sieving exercise. These undisturbed samples (Tables 2.1, 2.2 and 2.3) therefore represent the prime source of evidence for examining the sedimentary sequence in detail and defining, more precisely the palaeoenvironmental conditions during sediment accumulation (including definition of both the geological mechanism of sediment accumulation and part of the taphonomic history of any contained fossil material).

2.10 Additional work and resource estimates

2.10.1 Investigation of the sediments described here aimed to focus on the potential of these sequences for revealing new data regarding the nature of the environments of deposition of the sediments. Variations in grain size through the profile were noted during the field investigation as well as zones of potential weathering and pedogenesis. In order to investigate these sequences and trends a fully detailed investigation of the sedimentology of the individual undisturbed samples will be required. Specifically, investigation should focus on determining a detailed history of sedimentation from monoliths 152, 147, 142 and 143 from section 103, trench 3776TP. The following laboratory testing should be undertaken:

1. Loss-on-ignition in order to determine organic values on samples at 2cm intervals. Objective: to examine changes through profile in order to enhance understanding of the nature of potential breaks in deposition and location of pedogenic horizons.
2. Magnetic susceptibility on samples at 2cm intervals. Objective: to examine the potential of sediments for containing buried soil profiles.
3. Carbonate determinations at 2cm intervals. Objective: to determine variations in carbonate values that may aid in understanding of the taphonomy and the preservational status of included fossil material.

4. Phosphate determinations at 4 cm intervals. Objective: to examine the potential of sediments for containing buried soil horizons within which phosphate values may be expected to increase (comparisons to be made between areas identified on morphological criteria (e.g. blocky structure (context 527) and secondary precipitate (context 528)) to contain potential buried soils and those areas of the stratigraphic stack for which no features indicative of pedogenic activity have been noted).

5. Grain size determinations of selected samples from key stratigraphic units in order to determine trends in grain size within/between two major cycles seen with the fine grained fluvial sequences (contexts 515, 516, 522, 523, 520, 521, 525, 526, 527, 528, 537, 536, 538, 539) (maximum 20 samples).

2.10.2 It is estimated that this programme of analysis requires 40 person days of laboratory time followed by 10 person days of data processing and report writing.

2.11 Stratigraphy

2.11.1 Contexts 538-540 in ARC 3776 TP and contexts 619-622 in ARC 3777TP were only investigated by auger.

Table 2.4: ARC ZR400 3776TP

Context Number	*Depth*	*Stratigraphic description*	*Equivalent evaluation context - "?" shows probable but uncertain correlation ranges*
Top of profile: 11.27m O.D.			
501	0.00 – 0.26	10YR 3/1 very dark grey slightly sandy clay-silt. Structureless and massive. Unconsolidated and containing occasional well rounded flint clasts (<3cm). Extensive modern roots.	301-303?
502	0.26 – 0.49	5YR 3/6 yellowish-red sandy silt to silty ands. Occasional flint clasts (<1cm to 4cm), sub-angular to rounded. Common large (5mm wide) black stained root canals (sub-vertical orientation). Structureless and massive.	301-303?
503	0.49 – 1.20	10YR 5/8 yellowish brown firm sand with some silt. Possibly crude bedded with thin (5-6cm) thick beds. Moderately firm and compact. Large sub-vertical root canals (5mm wide and black stained) continue from above. Zone of white precipitate material at base of unit.	301-303?
504	1.20 – 1.30	10YR 6/8 brownish yellow medium sand with some silt. Massive and structureless. Very small flints (1-2cm) are occasionally present. Modern root present.	304-306?
505	1.30 – 1.33	7.5YR 3/8 strong brown fine sand with some silt. Massive and structureless. Cohesive.	304-306?
506	1.33 – 1.52	10YR 6/8 brownish-yellow medium sand with occasion diffuse zones of white precipitate. Modern roots still penetrate unit. Firm and compact.	304-306?
507	1.52 – 1.70	7.5YR 5/8 strong brown medium sand with some silt. Common white precipitate throughout unit in vertical root canals. Relatively looser and less consolidated that above.	304-306?
508	1.70 – 1.93	7.5YR 5/8 strong brown with 10YR 6/8 brownish yellow medium sand and silty sand. Thin beds of clay-silt are present (<5mm thick). Beds are broadly sub-parallel and dipping with no preferred orientation. Occasional diffuse white precipitate patches.	304-306?
509	1.93 – 2.07	10YR 6/8 brownish yellow medium to fine sand with very small white flecks (shell?). Coarse bedded with beds 5vcm thick. Soft and unconsolidated. Beds sub-parallel and sub-horizontal.	304-306?
510	2.07 – 2.10	10YR 5/8 yellowish brown fine sand with very common flint clasts (<4cm of sub-angular shape. Occasional white flecks. Loosen and	304-306?

Context Number	*Depth*	*Stratigraphic description*	*Equivalent evaluation context - "?" shows probable but uncertain correlation ranges*
		unconsolidated.	
511	2.10 – 2.23	10YR 6/6 brownish-yellow medium sand and some silt. Massive and structureless. Firm and cohesive	304-306?
512	2.23 – 2.48	10YR 5/8 yellowish-brown very well laminated fine sandy-silt. Common <5mm thick undulating and wavy laminate. Occasional white precipitate flecks. Dense and very compact. Occasional small sub-angular flint clasts (<1cm).	304-306?
513	2.48 – 2.67	7.5YR 5/8 strong brown medium to fine sand bedded with 10YR 3/6 yellow sand. Units are 2-6cm thick. Dense and compact. Black flecks and very rare flint clasts (<5mm).	304-306?
514	2.67 – 3.03	10YR 6/8 yellowish-brown silt. Massive and structu8rless. Moderately firm and compact. Contain occasional small (<1cm) flint clasts (Angular and shattered) and larger <3cm rounded chalk clasts.	304-306?
515	3.03 – 3.06	10YR 4/3 dark brown silty clay. Dense and very compact and firm. Shiny sheen on broken surfaces.	307
516	3.06 – 3.10	10YT 6/3 pale brown silt. Dry and friable. Common shell fragments. Possibly fine bedded. White decayed chalk or precipitate patches. Soft diffuse black patches. Zones of 10YR 5/2 greyish brown colour.	308
522	3.10 – 3.23	10YR 7/4 very pale brown very fine sand with 10YR 7/6 yellow silt. Common rounded chalk clasts (<4mm). Black point staining. Very dense and compact.	309-311
523	3.23 – 3.32	10YR 8/3 very pale brown fine sand. Common black point stains and white chalk or precipitate flecks. Structureless and massive. Some 10YR 6/8 brownish yellow mottles.	309-311
520	3.32 – 3.43	2.5Y 7/4 pale yellow and 10YR 6/8 brownish yellow mottles. Massive, structureless and moderately compact. Top of zone of major faulting. Occasional black point stains. Occasional white precipitate and chalk fragments. Possible mollusc remains.	309-311
521	3.43 – 3.69	10YR 8/3 very pale brown fine sand. Generally structureless and massive but with occasional thin clay-silt laminae (<10mm, undulating). Faulting continues through this unit.	309-311
525	3.69 – 4.11	10YR 8/3 very pale brown fine sand bedded with 10YR 6/8 brownish yellow very fine san. Possibly coarsens downwards with depth. Laminae are 2-5mm thick, wavy and sub-parallel and undulating. Some laminate are made of silt. Unit is heavily micro-faulted wit throws of <1cm. Shell and bone fragments are present.	309-311
526	4.11 – 4.21	2.5Y 7/2 light grey fine sand with common gravel clasts (<2cm, sub-angular to sub-rounded). Possibly very crude bedded . Loose and unconsolidated.	312
527	4.21 – 4.41	2.5Y 6/4 light yellowish-brown clay-silt. Slightly blocky structure. Moderately dense and compact. Shell fragments are present. Unit is massive at top becoming finely laminated (wavy, sub-parallel) with depth. Black point staining along laminae in places.	313
528	4.41 – 4.76	2.5Y3/4 light olive brown clay-silt to silty clay. 7.5YR 3/6 strong brown point staining and white precipitate patches. Dense and compact. With depth becoming 10YR 5/2 greyish-brown slightly sandy-clay. Very dense, firm and compact. Black structure in places. 7.5YR 4/4 dark brown point staining. Common shell fragments, small mammal bones (fresh) and large mammal bone. Thin lenses of coarser sand in patches suggesting some remnant bedding. Large soft black patches of staining.	314
537	4.76 – 4.88	7.5YR 6/2 pinkish grey silt. Dense and compact and firm. Shell fragments and occasional small <1cm, flint clasts.	-
536	4.88 – 5.10	2.5Y 7/2 light grey structureless sand to sandy-silt. Occasional diffuse concretion patches.	-
538	5.10 –	5Y 6/1 light grey sandy-silt becoming silty sand with depth.	-

Context Number	*Depth*	*Stratigraphic description*	*Equivalent evaluation context - "?" shows probable but uncertain correlation ranges*
	5.28	Moderately firm and compact. Occasional shell fragments.	
539	5.28 – 5.36	7.5YR 5/6 strong brown medium to fine sand with some clay-silt and occasional small (<1cm(sub-angular flints.	-
540	5.36 -	7.5YR 5/6 strong brown sandy gravel. Clasts are typically <4cm, sub-angular to well rounded. Unit is loose and unconsolidated.	-
		---base of recorded sequence 5.36m---	

Table 2.5: ARC ZR400 3777TP

Context Number	*Depth*	*Stratigraphic description*	*Equivalent evaluation context*
Top of profile 10.46m OD			
616	0.00 – 0.35	10YR 3/1 very dark grey slightly sandy-silt. Loose and unconsolidated, structureless and massive. Common large (2-5cm) rounded to angular flint clasts. Modern roots.	401-403
617	0.35 – 0.52	5YR 4/8 yellowish-red slightly clayey silty fine sand. Moderately compact and firm. Massive and structureless. Very occasional rounded flint clasts (<5cm) and large black filled modern root canals (5—10mm wide).	401-403
618	0.52 – 0.88	5YR 4/6 yellowish-red slightly silty sand. Massive and structureless compact and firm. Modern roots penetrate from above.	401-403
609	0.88 – 1.25	10YR 5/8 yellowish-brown fine to medium sand with some silt. Common flint clasts (<2cm and sub-angular shape). Relative loose and unconsolidated, structureless and massive. Modern root continues from above.	401-403
610	1.25 – 2.16	10YR 5/8 yellow-brown sandy-gravel. Clasts are typically <2cm, rounded to sub-angular in shape. Occasional chalk clasts. Crude being with 20-30cm thick beds. Diffuse bands of relatively clast-free sand also present. Occasional carbonate patches and precipitate along fractures and root canals. Relatively loose and unconsolidated.	404-405?
611	2.16 – 2.30	10YR 5/6 yellowish-brown medium to fine sand. Coarse and structureless. Precipitate present throughout unit. Unit dips downslope. Occasional small (<1cm) flint clasts.	404-405?
612	2.30 – 2.40	10YR 5/6 yellowish-brown medium to fine sandy-gravel. Predominantly well rounded flint clasts (<3cm).	404-405?
613	2.40 – 2.50	10YR 5/6 yellow-brown medium to fine sand. Structureless and massive.	404-405?
614	2.50 – 2.54	10YR 5/6 yellow-brown sandy-gravel with well rounded clasts (<3cm).	406?
615	2.54 – 2.66	10YR 6/6 yellow-brown medium to fine sand. Possible remnant beds present with some discontinuous clay-silt bands present. Loose and unconsolidated.	407-411?
604	2.66 – 2.76	10YR 6/6 brownish-yellow medium to fine sand with common small gravel clasts (sub-angular, <1cm). Loose and unconsolidated.	407-411?
603	2.76 – 3.20	10YR 6/6 brownish-yellow medium to fine sand with some coarse sand lenses or discontinuous bands. Occasional shell fragments. Occasional black point staining. Some coarse beds (5-6cm thick) dipping downslope. Moderately firm and compact.	407-411?
602	3.20 – 3.25	10YR 6/6 brownish-yellow sandy-gravel. Gravel clasts are <2cm and sub-angular in shape.	407-411?
601	3.20 – 3.70	10YR 6/6 brownish yellow fine sand. Discontinuous beds becoming laminae with depth (between 2and 5cm thick at top thin to 1-2cm with depth). Individual units are wavy, sub-parallel and included downslope. Shell fragments are present within units. Moderately firm and compact. Possible increase in silt content with depth.	407-411?
605	3.70 – 4.00	10YR 6/6 yellow-brown to 10YR 4/4 dark yellow brown bedded sands and clay-silts. Beds are wavy, sub-parallel and sub-horizontal	407-411?

Context Number	*Depth*	*Stratigraphic description*	*Equivalent evaluation context*
		orientations. Some indication of cross-bedding in places. Black point staining.	
606	4.00 – 4.27	10YR 7/5 yellow with 10YR 6/3 pale brown alternating fine sand and clay-silt laminae. Laminae are wavy, sub-parallel and undulating. Laminae are between 4 and 10mm thick with more diffuse and disrupted laminae towards the base of unit. Moderately firm and compact. Root canals are occasionally present (filled with precipitate).	407-411?
607	4.27 – 4.68	10YR 7/5 yellow sand with some 10YR 6/3 pale brown laminations. Fine laminae occur towards the base of the unit and are nearly cross-bedded in place. The upper part of the unit contains more diffuse laminae with a tendency towards massive bedding. Occasional large flint clasts (5cm, sub-angular) resting on laminae surfaces. Horizontal orientation to laminae.	407-411?
608	4.68 – 5.00	10YR 5/6 yellowish-brown fine sand with poorly developed bed structures. Relatively compact and firm. Small shell and bone fragments noted.	407-411?
619	5.00 – 5.20	7.5YR 5/4 brown slightly sandy-silt. Cohesive and apparently structureless.	407-411?
620	5.20 – 5.50	10YR 5/3 brown fine sand. Probably crude bedded with beds 1-3cm thick. Occasional beds of medium sand. Small shell fragments throughout unit. Moderately cohesive and firm.	407-411?
621	5.50 – 5.55	10YR 6/3 pale brown sandy-silt. Massive and structureless. Shell fragments are present.	407-411?
622	5.55 -	10YR 6/4 pale brown fine flint and chalk gravel. Clasts are typically <2cm, rolled and sub-angular.	412
		---base of profile 5.60m---	

APPENDIX 3 - LARGE VERTEBRATES

by Dr. Simon Parfitt, Dr. John Stuart & Dr. Francis Wenban-Smith

3.1 Introduction

3.1.1 A total of 52 large vertebrate bones and teeth were recovered from secure geological contexts from trench 3776TP. More than half of these are identifiable to body part and/or taxon. Recovery methods employed during the excavation have ensured that the remains represent an unbiased sample of the fossil assemblage. They are therefore of critical importance and, together with study of the rich small vertebrate collection, they will provide information pertaining to the palaeoenvironmental reconstruction and dating of the Pleistocene deposits.

3.2 Methodology

3.2.1 Most of the large mammal remains were recovered by manual excavation. In addition, fragmentary and indeterminate large mammal remains were recovered from some of the bulk samples. Although a number of the larger more fragile bones were crushed in-situ, the majority of the bones were well preserved. Significantly, the surfaces of most of the bones and teeth are intact and there is minimal post-deposition loss of surface features.

3.2.2 Analysis of the remains will involve identification to body-part and taxon, biometrical analysis of the mammoth, horse and deer remains, and a detailed taphonomic analysis. The latter will involve study of surface modifications and bone damage patterns together with refitting of faunal remains to elucidate site formation processes. The bones will also be examined for cut marks or hominid-induced breakage.

3.3 Provenance and quantification

3.3.1 A total of 52 large vertebrate faunal remains were recovered from 5 contexts (Table 3.1). Two of them, both from context 528, were from medium sized birds, and the remainder were mammalian. Most of the identifiable specimens came from context 528, the lower fluvial clay. The species recovered include horse, mammoth, red deer, bison, duck and cormorant. Although many bones have cracks due to the weight of the overlying sedimentary sequence, their condition is generally good. Most of the bones from context 528 came from a specific horizon consisting of the top 10cm of the context, where larger faunal remains were abundant. The preservation of material from this horizon is also particularly good.

Table 3.1: quantification of large vertebrate remains from 3776TP

Context	*No. identifiable*	*No. unidentifiable*	***Total***
516	1	0	1
526	4	17	21
529	1	0	1
527	2	0	2
528	22	5	27
Total	**30**	**22**	**52**

3.4 Conservation

3.4.1 It is recommended that the faunal collection should be retained and conserved. Conservation of the larger faunal remains will involve careful mechanical cleaning of the bones under a low-magnification binocular microscope. Consolidants will be applied where necessary, and crushed or broken pieces will be reconstructed. The bones should be marked with provenance information and individually stored in labelled acid-free boxes. The material recovered has been stored according to the United Kingdom Institute for Conservation guidelines.

3.4.2 It is recommended that the material is deposited at an collecting museum appropriate for Pleistocene remains, which has yet to be agreed.

3.5 Comparative material

3.5.1 Several other collections of large vertebrates exist from previous research in the Ebbsfleet Valley, notably by R.A. Smith (1911), Burchell (1935a,b, 1954 & 1957), Carreck (1972) Kerney & Sieveking (1977) and Wenban-Smith (1995). This material is mostly stored at the Natural History Museum and is mostly accompanied by good documentation. Large vertebrate material from other Thames Valley Late Middle Pleistocene sites such as Crayford, Grays and Purfleet is also relevant for comparative study.

3.6 Potential for further work

3.6.1 Study of the assemblage will help establish its taphonomic and depositional history, and help reconstruct the changing climate and environment through the sequence of deposits. Biometrical comparisons of key species with those from other broadly contemporary sites (cf. Sutcliffe 1995) will form the basis for the biostratigraphic dating of the sequence. The Ebbsfleet Valley is noted for its rich Pleistocene mammalian fauna. This collection is of critical importance in understanding a complex and poorly understood period of rapid climatic and biotic change during the later part of the Middle Pleistocene in Britain. Integration of the results obtained from the CTRL faunal collection with that from previous excavations at the site is essential to interpret the site more fully.

3.7 Additional work and resource estimates

- Conservation: 5 days
- Identification and comparative study (mammals): 5 days
- Identification and comparative study (birds): 1 day
- Report-writing, modification following review, proof correction (mammals): 10 days
- Report-writing, modification following review, proof correction (birds): 1 day

APPENDIX 4 - SMALL VERTEBRATES

by Dr. Francis Wenban-Smith & Dr. Simon Parfitt

4.1 Introduction

4.1.1 Small vertebrate remains were shown in the evaluation to be abundant in the fluvial deposits in the deeper test pits 3423TP and 3424TP at the NGC Pylon ZR4 site. Therefore a series of bulk sediment samples was recovered from the fluvial deposits in the mitigating excavation trenches 3776TP and 3777TP for sieving for small vertebrate remains (Tables 1.1 and 1.2). These samples were sampled for this assessment report to establish which deposits had which types of small vertebrate evidence in what degree of abundance (Table 4.1 and 4.2). Analysis of the residues from this sample of the bulk samples demonstrated that most of the fluvial contexts contained small vertebrate material. The deeper fluvial sequence in 3776TP contained more contexts with small vertebrate material than the lesser depth of fluvial deposits sampled in 3777TP.

4.2 Methodology

4.2.1 A proportion of each of the bulk sediment samples from each context was processed for the assessment report. This proportion was typically in the range 10-20%, but a higher proportion of smaller samples was examined (Tables 4.1 and 4.2). Samples were selected for assessment to ensure complete coverage of the full sedimentary sequence in both trenches 3776TP and 3777TP. Samples were processed by sieving with a fine water spray through a graded nest of sieves with mesh sizes 10mm, 4mm, 2mm, 1 mm and 0.5mm. These residues were then dried at room temperature and sorted for small vertebrate remains. The smallest grade of residue (0.5-1.0mm) was not examined for the purposes of assessment, since material in the other grades would be sufficient to establish the variety and abundance of small vertebrate material.

4.3 Provenance and quantification

4.3.1 Small vertebrate remains consisting of small mammals, amphibians and fish were present in abundance in many of the samples investigated, and small avian remains were also found in context 527, trench 3776TP (Tables 4.1 and 4.2).

4.3.2 In trench 3776TP small mammal remains were found in the basal colluvium, although these were probably derived from stratigraphically earlier fluvial deposits seen to be truncated by the colluvial sequence in the trench section. Small mammals and fish were quite common and amphibians very abundant in the upper fluvial silts and clays (contexts 515, 516, 519). The upper middle fluvial sands (contexts 522, 523, 520, 530, 521 and the upper part of 525) were, interestingly, devoid of small vertebrate material apart from a single, probably derived or intrusive, small mammal remain at the top in context 522. The lower middle fluvial sands (context 525 lower, 529, 526) were, however, rich in small mammals, amphibians and fish with a noticeable increase upward in the proportion of small mammal remains. The lower fluvial clays, silts and sands (contexts 527, 528, 537, 536) all contained small mammal, amphibian and fish remains in abundance, as well as some small bird remains from context 527.

4.3.3 In trench 3777TP small vertebrate remains were entirely absent from the lower colluvial deposits investigated (context 601). They were also entirely absent from the upper marginal floodplain deposits (contexts 605 and 606). Small mammals and

amphibians were, however, abundant in the lower marginal floodplain deposits investigated (contexts 607 and 608), but despite the abundance of small vertebrate material in these deposits, they contained no fish remains.

4.3.4 The species of small mammal recovered include northern vole (*Microtus oeconomus*), extinct mouse (*Apodemus maastrichtiensis*), watervole (Arvicola sp.), pygmy shrew (*Sorex minutus*) and watershrew (Neomys sp.). The species of amphibian recovered include frog, toad and newt. The species of fish recovered include pike and stickleback.

4.3.5 Some material may have been derived from local underlying deposits during fluvial activity, but the fragile small vertebrate material cannot survive much exposure and/or reworking so the great majority of it is very probably contemporary with its containing sedimentary unit, which are generally clays and silts reflecting low energy fluvial depositional conditions with little erosive energy. The condition of the material is generally very good, although individual bones are generally incomplete. Variations in colour of some material within the same context may indicate varying taphonomic histories, a point which will be addressed in more detail during analysis. The small mammal material from the lower colluvial context 534 is particularly pale, in contrast to that from the other fluvial contexts which is generally pinkish or purplish brown, and may be derived from the fluvial clay silts (context 515, 516) truncated at that point by the colluvial sequence.

4.4 Conservation

4.4.1 The sorted small vertebrate material requires no special conservation, but should be kept in dry conditions at room temperature. The sorted residues should be retained at this stage in case clast lithological analysis becomes desirable, or in case a new technique of study is developed to interpret the numerous sedimentary and calcareous concretions contained in the residues. The residues also contain numerous molluscan specimens, potentially usable for identification and/or amino acid analysis if the smaller dedicated molluscan samples produce insufficient material.

4.5 Comparative material

4.5.1 Small vertebrate remains were reported from the previous work of Burchell (1935a,b & 1936a,b,c) and Carreck (1972) in the Ebbsfleet Valley, but none of the specimens they recovered are now extant. Wenban-Smith's research in the area in the early 1990s involved large-scale sampling for small vertebrates (Wenban-Smith 1995), leading to the recovery of large small vertebrate assemblages from Burchell's Temperate Bed site sequence (Site B, SAM Kent 267b) and from the British Museum site sequence (Site A, SAM Kent 267a). Small vertebrate material has also been recovered from sites such as Crayford in the Lower Thames region. Most of the relevant material is stored at the Natural History Museum, or in the personal collection of F.F. Wenban-Smith.

4.6 Potential for further work

4.6.1 Complete recovery and analysis of the small vertebrate material is central to achieving the landscape zone priorities and research aims and objectives of the project. The relative prevalence through the sequence of terrestrial, amphibious and aquatic species can provide an essential aid to determining the depositional conditions under which each context was laid down. Several species of small mammal, fish and amphibian are very specific in their niches and study of the changing assemblage structure of these types of evidence through the sequence

should give a good indication of changing climate and local environment. Analysis of the body part representation can also clarify the taphonomic history and integrity of the assemblages from each sedimentary unit.

4.6.2 It has become more apparent over the last decade that small mammals can play a key role in dating deposits from the Middle and Upper Pleistocene. Not only is there a high turnover of species giving rise to a rapidly changing assemblage structure, but genera such as Arvicola and Microtus seem to evolve certain dental characteristics rapidly through this period, making them suitable for correlative biostratigraphic work. Two species already identified in the sample examined for the assessment report, northern vole and watervole, are particularly suitable for such work, and large numbers of specimens of these species are also available for study from the key comparative locations within the Ebbsfleet Valley, as well as from Crayford. Thus it should be possible from the small mammals to date the deposits to at least a specific Oxygen Isotope Stage within the later Middle Pleistocene.

4.6.3 Previous research at other locations within the Ebbsfleet Valley has suggested that the bulk of the Pleistocene deposits date to Stage 7, between c. 240,000 and 190,000 BP. This is a complex stage with at least five major climatic fluctuations but no one yet has provided an analysis of which deposits known from that general period might date to specific sub-stages within Stage 7 and how such sub-stages might be differentiated in terms of specific climatic and environmental conditions as well as small vertebrate assemblage structures and species characteristics.

4.6.4 Study of the various deposits in the Ebbsfleet Valley could provide, for the first time, a detailed record of the climatic and environmental fluctuations and accompanying faunal changes though a single isotopic stage. This is of direct relevance to several of the Fieldwork Event Aims and CTRL Landscape Zone Priorities, most specifically for refining knowledge of the broad palaeo-environmental, climatic and chrono-stratigraphic framework for early human occupation.

4.6.5 Such work would also contribute to providing a more secure framework for understanding and interpreting the pattern of the pre-Neanderthal occupation of the Ebbsfleet Valley and the SE English region generally. Such work would be of international significance in providing a template for the degree of variability within a single stage of the isotopic signature, potentially leading to a reinterpretation of the current grouping of terrestrial Middle and Upper Pleistocene deposits into the isotopic framework.

4.7 Additional work and resource estimates

- Completion of processing of samples shown by assessment to contain evidence: 10 days
- Sorting of fraction of residues 0.5-1mm: 20 days
- Sorting residues from remainder of samples: 25 days
- Identification and comparative studies: 15 days
- Analysis/interpretation of results, graphic representations: 10 days
- Report writing: 10 days

*Table 4.1: small vertebrate recovery 3423/3776 TP (- not processed, 0 absent, * present, ** abundant)*

Sample	*Context*	*Litres processed*	*% of sample*	*Small Mammals*	*Amphibians*	*Fish*	*Birds*
Bottom of colluvial deposits							
113	533	10	20	0	0	0	0
114	534	10	20	**	0	0	0
115	514	10	20	0	0	0	0
Upper fluvial clay/silt bands/laminations							
1	307 [515]	20	100	*	**	*	0
101	515	10	50	*	**	*	0
116	515	-	-	-	-	-	-
2	308 upp. [516]	10	100	*	**	*	0
3	308 low. [516]	10	100	*	**	*	0
102	516	10	20	0	**	*	0
117	516	-	-	-	-	-	-
123	516	-	-	-	-	-	-
160	516	-	-	-	-	-	-
103	518	10	50	0	*	0	0
104	519	10	25	0	**	*	0
Middle fluvial sands							
118	522	10	33.33	*	0	0	0
119	523	10	25	0	0	0	0
124	520 upp.	10	33.33	0	0	0	0
120	520 low.	10	50	0	0	0	0
121	530 521	10	50	0	0	0	0
105	522 523 520 530	-	-	-	-	-	-
106	520 530 521 525 upp.	-	-	-	-	-	-
122	521 low.	10	33.33	0	0	0	0
107	525 i	20	20	0	0	0	0
111	525 ii	20	20	0	0	0	0
112	525 iii	20	20	**	0	0	0
109	525 iv	20	20	**	*	*	0
14	311 [525,529]	20	100	**	*	*	0
110	529	10	100	**	*	*	0
4	312 [526]	30	100	**	**	**	0
108	526	40	16	**	**	**	0
Lower fluvial clays/silts							
5	313 upp. [527]	28	100	**	**	*	*
6	313 low. [527]	18	100	*	**	*	0
125	527	-	-	-	-	-	-
128	527	-	-	-	-	-	-
126	527 upp.	20	20	**	**	**	*

Sample	*Context*	*Litres processed*	*% of sample*	*Small Mammals*	*Amphibians*	*Fish*	*Birds*
127	527 low.	20	20	**	**	**	*
8	314 [528]	9	100	*	**	0	0
161	528 i	-	-	-	-	-	-
129	528 i	20	13.33	**	**	**	0
130	528 iia	20	13.33	**	**	**	0
132	528 iib	10	20	**	**	**	0
131	528 iii	20	13.33	**	**	**	0
134	537	10	25	**	**	**	0
Lowest fluvial sands/silts							
133	536	20	20	**	**	**	0

*Table 4.2: small vertebrate recovery 3424/3777TP (- not processed, 0 absent, * present, ** abundant)*

Sample	*Context*	*Litres processed*	*% of sample*	*Small mammals*	*Amphibians*	*Fish*	*Birds*
Bottom of colluvial deposits							
201	601 i	20	20	0	0	0	0
202	601 ii	20	20	0	0	0	0
203	601 iii	20	20	0	0	0	0
204	601 iv	20	20	0	0	0	0
Marginal floodplain deposits							
205	605 i	20	20	0	0	0	0
206	605 ii	-	-	-	-	-	-
207	605 iii	20	20	0	0	0	0
208	605 606	-	-	-	-	-	-
209	605 606	40	16	0	*	0	0
210	605 606	-	-	-	-	-	-
20	410 [607]	2	100	*	*	0	0
211	607 i	40	16	0	0	0	0
212	607 ii	20	20	0	*	0	0
213	607 iii	20	20	**	**	0	0
214	608 i	30	20	**	**	0	0

APPENDIX 5 - POLLEN

by Dr. Francis Wenban-Smith and Dr. Rob Scaife

5.1 Introduction

5.1.1 Despite a previous lack of success in isolating pollen grains from the Pleistocene deposits of the Ebbsfleet Valley, a selection of eight samples from the finer-grained clays and silts from trenches 3776TP and 3777TP were investigated for pollen preservation (Table 5.1).

5.2 Methodology

5.2.1 Samples were selected for study by visual appearance and grain size. Greyer and finer-grained deposits were chosen. Large samples of 10ml were processed using standard techniques with slight modifications to concentrate sparsely pollen grains - namely micromesh sieving at 10 microns with some decanting of coarser material.

5.3 Results

5.3.1 No vestige of pollen was found in any of the samples examined (Table 5.1). This is attributed to extreme oxidation and high alkalinity of the site. No pollen was found during previous examination of samples from both Sites A and B in the Ebbsfleet Valley so the prevalence of local Chalk Bedrock is probably creating too calcareous an environment for pollen preservation in the overlying Pleistocene deposits.

Table 5.1: pollen analysis

Trench	*Sample*	*Context*	*Pollen*
3776TP	101	515	None
3776TP	126	527	None
3776TP	129	528	None
3776TP	134	537	None
3776TP	133	536	None
3776TP	139	538	None
3777TP	223	621	None

5.4 Potential for additional work

5.4.1 There is no potential for any additional work.

APPENDIX 6 - MOLLUSCS

by Dr. Francis Wenban-Smith & Dr. Mark Robinson

6.1 Introduction

6.1.1 Samples of waterlain Pleistocene sediment through the sequences from trenches 3423TP and 3424TP were examined for molluscan preservation as part of the field evaluation (OAU 1998). This showed (Tables 6.1 and 6.2) that molluscs were preserved throughout the fluvial sequence in both trenches, although their condition was generally poor with numerous shell fragments and relatively scarce identifiable specimens. Nonetheless enough molluscs were present for useful analysis, so a dedicated series of molluscan samples was taken throughout the full sequence of Pleistocene fluvial deposits up into the base of the colluvial deposits in each of the mitigation trenches 3776TP and 3777TP (Tables 6.3 and 6.4).

6.2 Methodology

6.2.1 Analysis for this assessment report focused upon identifying the presence of molluscs in contexts not already examined in the evaluation, in order to establish the overall potential for molluscan analysis through the full sequence investigated. The dedicated molluscan samples were not processed or examined, but molluscan preservation was assessed at the same time as sorting residues for small vertebrate remains, the dedicated molluscan samples being sub-samples from the same original bulk sediment samples. Each sample was sieved through a graded nest of sieves of mesh-sizes 10mm, 4mm, 2mm, 1mm and 0.5mm mesh by a fine water spray, and then dried at room temperature. Use of oven-drying and chemical decoagulants was avoided.

6.3 Provenance and quantification

6.3.1 In trench 3776TP molluscs are present throughout the fluvial sequence and in the bottom part of the colluvial sequence (Table 6.3). Only one of the fluvial samples and one of the colluvial samples failed to produce any molluscan evidence. Molluscs were scarce in the colluvial deposits, being limited to occasional specimens of *pupilla muscorum*, albeit in fairly good condition. Molluscs were more frequent in the fluvial deposits, although many samples were dominated by broken shell fragments, and identifiable molluscs were never very abundant. Although the sedimentary sequence is calcareous, the relative abundance of Bithynia operculae indicates a loss of molluscan material due to partial decalcification, since these are made calcite, which is more robust than the aragonite of the shells.

6.3.2 In trench 3777TP molluscs were found throughout both the bottom part of the colluvial deposits and the underlying fluvial marginal floodplain deposits (Table 6.4). They were generally scarce in the colluvial deposits, and became progressively more frequent with increasing depth down into the fluvial marginal floodplain deposits. As for 3776TP, some decalcification and loss of molluscan material has clearly taken place, exemplified by the abundance of Bithynia operculae and the lack of Bithynia shells.

6.4 Conservation

6.4.1 The dedicated molluscan samples need to be stored at a cool temperature, although not below freezing, ideally below 10 degrees Centigrade. Processing should involve a fine spray of cold water, followed by drying at room temperature. The use of chemical decoagulants and oven drying should be avoided. The existing, and future,

residues from the small vertebrate sorting also need to be kept dry and at a cool room temperature.

6.5 Comparative material

6.5.1 Burchell (1935a,b, 1954 &1957) published detailed assemblage lists from molluscan analysis of deposits at Site B, his Temperate Bed site, and Carreck (1972) published details of the molluscan assemblage from fluvial deposits at Site A, adjacent to the ZR4 location. Molluscan analysis of deposits from Sites A and B was also carried out by Kerney and remains unpublished in the British Museum archive from Sieveking's work at the site (cf. Kerney & Sieveking 1977). Some molluscan analysis was also carried out by Wenban-Smith in the early 1990s on the same deposits at Site A investigated by Carreck, Kerney and Sieveking, but details of this also remain unpublished, other than the amino acid dating result which suggested an Isotope Stage 7 date (Wenban-Smith 1995).

6.5.2 The whereabouts of the shells recovered by Burchell, Kerney and Carreck is unknown, although discovery of any shells from Site B would be highly significant in allowing amino acid dating of the Temperate Bed itself, the un-decalcified parts of which have not been found since Sieveking's investigation of the late 1960s.

6.6 Potential for further work

6.6.1 Study of the molluscan sequence has the potential to complement the other forms of biological evidence to reconstruct the changing history of climate, local environment and depositional conditions through the sequences of deposits in trenches 3776TP and 3777TP.

6.6.2 The presence of molluscs throughout the sequence has high potential for application of amino acid dating. This technique may clarify several key issues, namely i) the significance of the chronological hiatus between the bottom of the colluvial and the top of the fluvial sequences in each of trenches 3776TP and 3777TP, ii) the presence of a significant time-depth within the fluvial sequences of these trenches, iii) correlations of units between the trenches 3776TP and 3777TP, iv) correlations of units from trenches 3776TP and 3777TP with units from Sites A and B, and v) correlations of units from trenches 3776TP and 3777TP with amino acid determined Middle and Upper Pleistocene deposits in both SE England and East Anglia which have probably had reasonably similar temperature histories.

6.7 Additional work and resource estimates

- Sample processing and sorting (n =50) need to be processed and sorted: 15 days
- Report writing: 5 days
- Amino Acid dating: at least six determinations on up to three suitable species from approximately 5 units in each of trenches 3776TP and 3777TP

Table 6.1: field evaluation molluscan analysis 3423TP (Present, 0 Absent) after Robinson (Appendix 1 in URL 1998)*

Context	307/515	308/516	310/521	311/525, 529	312/526	313/527	314/528
Sample/s	1	2, 3	13	14	4	5, 6	8
Aquatic species							
Bithynia tentaculata	0	0	0	0	*	0	0
Bithynia sp.	0	*	0	0	*	*	*
Bithynia sp. Operculae	*	*	0	0	*	*	*
Valvata cristata	0	*	0	0	0	0	0

Context	307/515	308/516	310/521	311/525, 529	312/526	313/527	314/528
Sample/s	1	2, 3	13	14	4	5, 6	8
Valvata piscinalis	0	0	0	0	*	0	0
Valvata sp.	0	*	0	0	*	*	0
Planorbis corneus	0	0	0	0	0	*	0
Pisidium sp.	0	0	*	0	*	0	0
Lymnaea sp.	0	*	*	0	0	*	0
cf. Planorbis sp.	*	*	0	0	0	0	0
Anisus cf. Leucostoma	0	0	*	0	0	*	*
Terrestrial species							
Pupilla muscorum	*	0	*	0	*	0	0
Vallonia sp.	0	0	*	0	0	0	0

Table 6.2: field evaluation molluscan analysis 3424TP (Present, 0 Absent) after Robinson (Appendix 1 in URL 1998)*

Context	408	410	411
Sample/s	18	20	17, 19
Aquatic species			
Bithynia sp. Operculae	0	*	*
Valvata cristata	0	0	*
Valvata sp.	0	0	*
cf. Hippeutis complanatus	0	0	*
Pisidium sp.	0	0	*
Lymnaea sp.	0	0	*
cf. Planorbis sp.	0	0	*
Anisus cf. Leucostoma	0	0	*
Terrestrial species			
Pupilla muscorum	*	0	*
Vallonia sp.	0	0	*
Limax/Deroceras sp.	0	*	0

*Table 6.3: molluscan recovery 3776 TP (- not processed, 0 absent, * present)*

Sample	*Context*	*Litres processed*	*% of sample*	*Molluscs*
Bottom of colluvial deposits				
113	533	10	20	*
114	534	10	20	*
115	514	10	20	0
Upper fluvial clay/silt bands laminations				
101	515	10	50	*
116	515	-	-	-
102	516	10	20	*
117	516	-	-	-
123	516	-	-	-
160	516	-	-	-
103	518	10	50	*
104	519	10	25	*
Middle fluvial sands				
118	522	10	33.33	*
119	523	10	25	*
124	520 upp.	10	33.33	*
120	520 low.	10	50	*
121	530 521	10	50	*
105	522 523	-	-	-

Sample	*Context*	*Litres processed*	*% of sample*	*Molluscs*
	520 530			
106	520 530 521 525 upp.	-	-	-
122	521 low.	10	33.33	*
107	525 i	20	20	0
111	525 ii	20	20	*
112	525 iii	20	20	*
109	525 iv	20	20	*
110	529	10	100	*
108	526	40	16	*
Lower fluvial clays/silts				
125	527	-	-	-
128	527	-	-	-
126	527 upp.	20	20	*
127	527 low.	20	20	*
161	528 i	-	-	-
129	528 i	20	13.33	*
130	528 iia	20	13.33	*
132	528 iib	10	20	*
131	528 iii	20	13.33	*
134	537	10	25	*
Lowest fluvial sands/silts				
133	536	20	20	*

*Table 6.4: molluscan recovery 3777TP (- not processed, 0 absent, * present)*

Sample	*Context*	*Litres processed*	*% of sample*	*Molluscs*
Bottom of colluvial deposits				
201	601 i	20	20	0
202	601 ii	20	20	*
203	601 iii	20	20	*
204	601 iv	20	20	*
Marginal floodplain deposits				
205	605 i	20	20	*
206	605 ii	-	-	-
207	605 iii	20	20	*
208	605 606	-	-	-
209	605 606	40	16	*
210	605 606	-	-	-
211	607 i	40	16	*
212	607 ii	20	20	*
213	607 iii	20	20	*
214	608 i	30	20	*

APPENDIX 7 - INSECTS

by Prof. Russell Coope and Dr. Francis Wenban-Smith

7.1 Introduction

7.1.1 Eight sediment samples from fine-grained clays and silts thought likely to potentially contain insect remains were submitted for investigation (Table 7.1). Samples 102, 104, 126 and 127 were investigated initially as they appeared most likely to have remained unoxidised, being paler grey and less ferruginous coloured.

7.2 Methodology

7.2.1 Approximately 1 litre of sediment from each sample was wet-sieved through a mesh of 0.25mm, which would have been sufficient to retrieve any fossils of Coleoptera present.

7.3 Results

7.3.1 No insect remains were found. These could have been expected to have been originally present, but must have been lost by subsequent decomposition. They are readily attacked by fungi and bacteria in the presence of oxygen. The other samples were not investigated since it was clear from visual inspection that they were unlikely to contain Coleopteran fossils, being generally darker and brownish coloured, indicating oxidation.

7.4 Potential for further analysis

7.4.1 There is no potential for further insect analysis.

7.5 Additional work and resource estimates

7.5.1 No further work is necessary.

Table 7.1: samples submitted for investigation for insect remains

Sample	*Context*	*Investigated*	*Results*
101	515	No	-
102	516	Yes	No insects
104	519	Yes	No insects
126	527	Yes	No insects
127	527	Yes	No insects
129	528	No	-
132	528	No	-
134	537	No	-

APPENDIX 8 - OSTRACODS

by Dr. John E Whittaker, Natural History Museum

8.1 Introduction

8.1.1 Approximately 50 samples, each of approximately 50g weight, from trench 3776TP and 3777TP were submitted for specialist analysis of the ostracod faunas, selected from key Pleistocene stratigraphic units.

8.2 Methods

8.2.1 All samples were first dried, sodium carbonate added to disperse the clay fraction and they were then washed with hot water through a 75 micron sieve, the resulting residues being oven-dried. These residues have been picked for their ostracod content, their presence being shown by an asterisk (*) in Tables 8.1 and 8.2 below. The presence of charophytes from the aquatic plant stonewort is also shown. Many of the samples also contained (often) abundant reworked microfaunas (ostracods and foraminifera) from the Chalk.

8.3 Results

8.3.1 The ostracods from 3776TP and 3777TP all belong to freshwater species and are never common. At this stage, only one species (*Limnocythere falcata* Diebel, 1968), which occurred in sample 211 (3777TP), is known to be extinct. It is found in British Pleistocene deposits as far back as various "Hoxnian" sites (including Hoxne, Marks Tey, Trysull and Aldingbourne), through to the Devensian.

8.4 Potential for further analysis

8.4.1 Further more detailed sorting and counting should produce enough specimens to give an indication of prevailing local environmental and depositional conditions, particularly in relation to questions such as waterflow regime. Several samples, however, would benefit from processing of further material which might also produce sufficient quantities of specimens to investigate the population structure and determine whether the assemblages are primarily autochthonous or allochthonous.

8.5 Additional work and resource estimates

8.5.1 Ten further days of specialist time would be required to carry out the further processing and sorting and to produce the final report.

Table 8.1: Ostracod and charophyte presence in 3776TP sequence

Sample	*Context*	*Ostracods*	*Charophytes*
Bottom of colluvial deposits			
113	533	-	-
114	534	-	-
115	514	-	-
Upper fluvial clay/silt bands/laminations			
101	515	-	-
102	516	-	*
103	518	*	-
104	519	-	-
Middle fluvial sands			
118	522	-	-
119	523	*	-

Sample	*Context*	*Ostracods*	*Charophytes*
124	520 upper	*	-
120	520 lower	*	-
121	530/521	*	-
122	521 lower	-	-
107	525 i	-	-
111	525 ii	-	-
112	525 iii	-	-
109	525 iv	-	-
110	529	*	-
108	526	*	-
Lower fluvial clays/silts			
126	527 upper	-	-
127	527 lower	*	*
129	528 i	-	-
130	528 iia	-	-
131	528 iii	-	-
132	528 iib	-	-
134	537	*	-
Lowest fluvial sands/silts			
133	536	-	-
139	538	-	-
140	539	-	-
141	540	-	-

Table 8.2: Ostracod and charophyte presence in 3777TP sequence

Sample	*Context*	*Ostracods*	*Charophytes*
Bottom of colluvial deposits			
201	601 i	-	-
202	601 ii	-	-
203	601 iii	-	-
204	601 iv	-	-
Marginal floodplain deposits			
205	605 i	*	-
207	605 iii	sample missing	sample missing
209	606 i	*	-
211	607 i	*	*
212	607 ii	*	*
213	607 iii	*	*
214	608 i	*	-
215	608 ii	-	-
216	608 iii	-	-
217	608 iv	-	-
218	619 i	-	-
219	619 ii	*	-
220	620 i	-	-
221	620 ii	*	-
222	620 iii	-	-
223	621	-	-
224	622	*	-

APPENDIX 9 - OSL DATING

by Dr.Edward Rhodes

9.1 Introduction

9.1.1 A number of OSL samples were collected, along with control samples to provide background radiation readings. Two samples (155 and 233) have been submitted for assessment in order to establish the suitability of the deposits for OSL dating purposes and provide preliminary radiometric dates for key deposits. Results have yet to be received for a third sample submitted for preliminary processing.

9.2 Methodology

9.2.1 The assessment method involves carrying out initial sample processing and taking preliminary readings to establish the suitability of the deposits for undergoing the full dating process. The samples have been subject to sieving and HF acid treatment. The preliminary dates are based on measuring 4 aliquots of fine sand size quartz from each sample, and use INAA determination of Uranium, Thorium and Potassium to estimate the environmental dose rate. The 'as found' water contents were used (7% for sample 155, 20% for sample 233) for radiation attention, and a burial depth of 3m +/- 1m was assumed for both samples. These latter considerations will not have a large affect on the ages calculated.

9.3 Results

9.3.1 The preliminary determinations are as follows:

Sample 155, context 525: c. 127,000 +/- 12,500 BP

Sample 233, context 606: c. 51,000 +/- 7,500 BP

9.4 Potential for further analysis

9.4.1 There was some variation between the aliquots that were measured. This effect could be better characterised by more complete dating. The samples appear well-suited for OSL dating.

9.5 Additional work

9.5.1 It is recommended that, initially, the two samples so far shown to be suitable for OSL dating should be fully processed. Three further samples were taken, which considered the minimum necessary for dating the sequence. These should be held in reserve and fully processed in a second stage of work, when the dates from the first two samples are known.

Table 7.1: samples submitted for preliminary OSL dating

Sample	*Context*	*Suitable for full processing*	*Preliminary determination*
155	525	Yes	127,000 +/- 12,500
233	606	Yes	51,000 +/- 7,500
158	536	Unknown	Incomplete

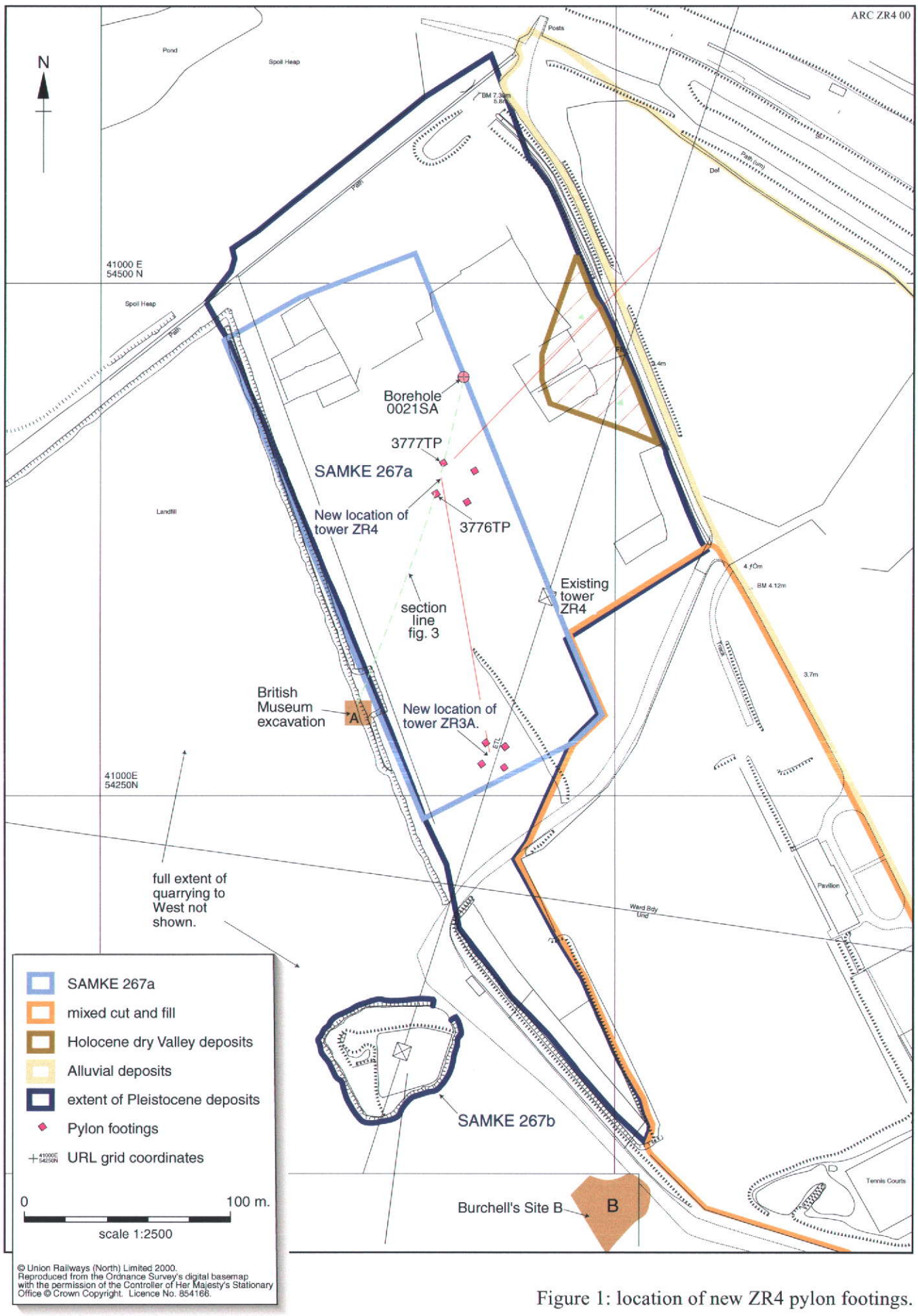

Figure 1: location of new ZR4 pylon footings.

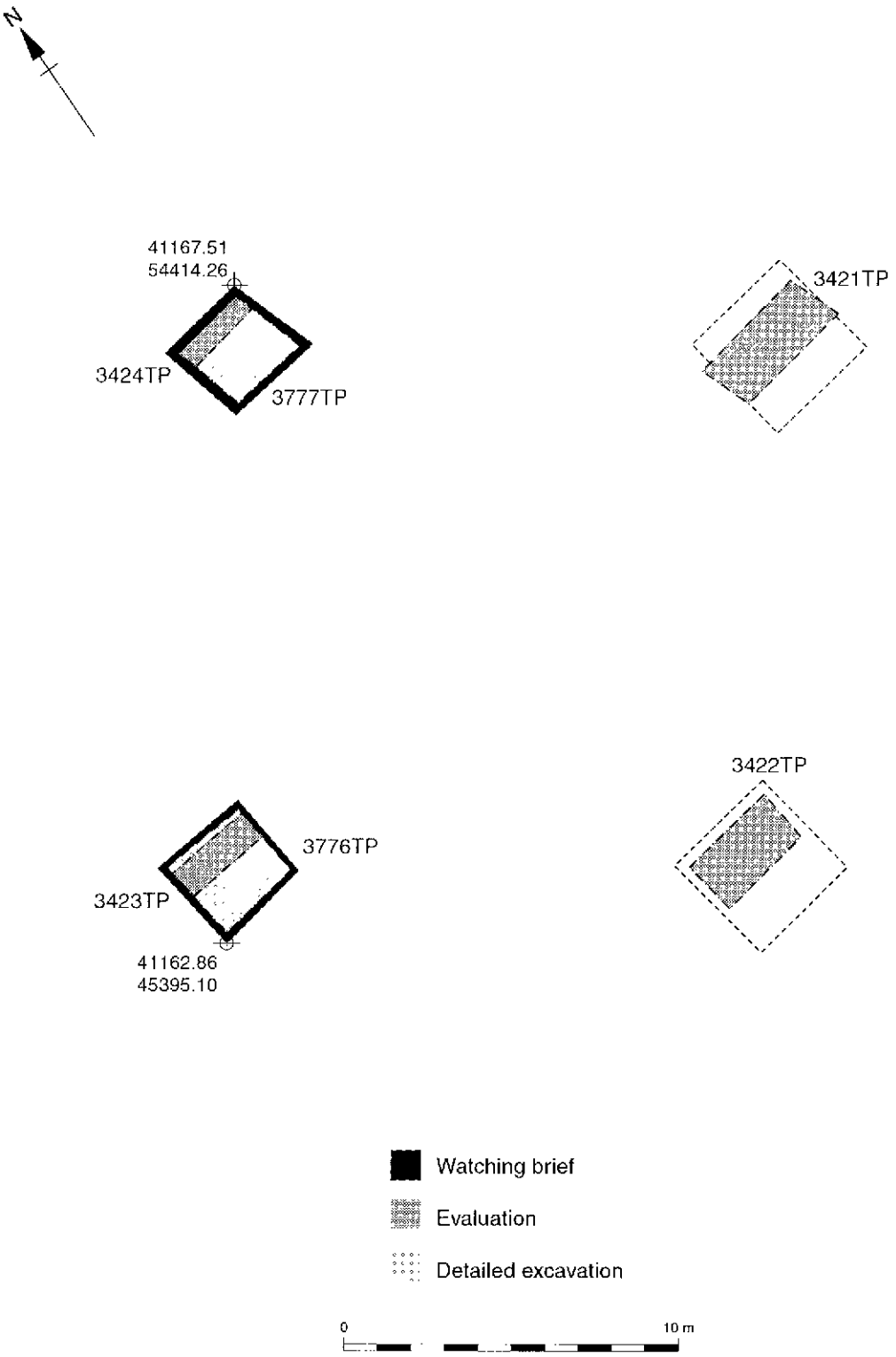

Figure 2: Ebbsfleet Valley Pylon ZR4 (footings).

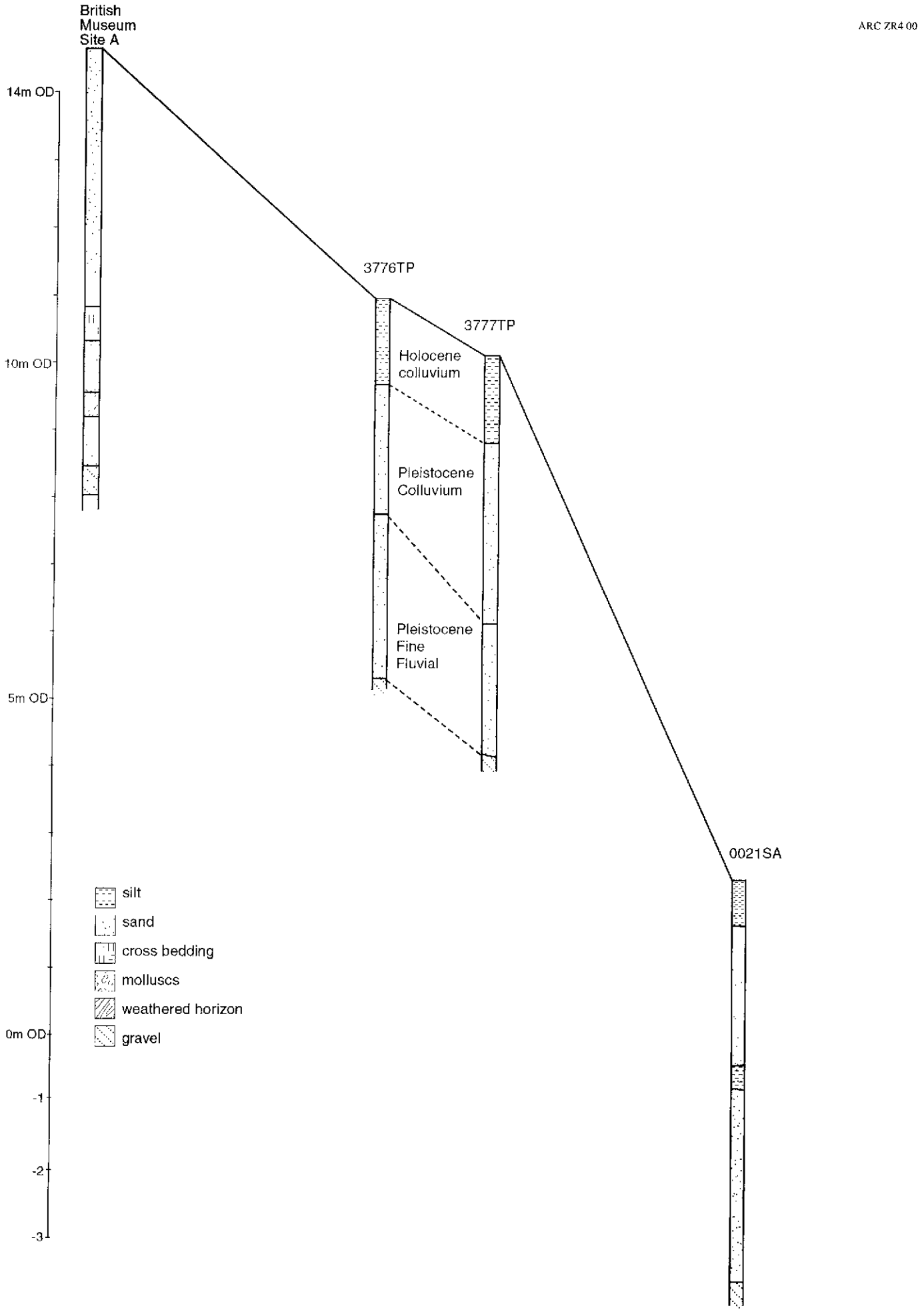

Figure 3: Interpretative section showing relationship of ZR4 sequence with previously recorded sequences (URL 1997 and Wenban-Smith 1995).