THE (LONDON GATEWAY PORT) HARBOUR EMPOWERMENT ORDER 2002
HEO INQUIRY

THE PENINSULAR AND ORIENTAL STEAM NAVIGATION COMPANY

and

THURROCK COUNCIL

STATEMENT OF COMMON GROUND ON THE TOPIC OF CULTURAL HERITAGE for the HEO

Prepared in accordance with Annex 3(ii) of DETR Circular 5/2000

Macfarlanes/Faber Maunsell
July 2003
Draft Number 4

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1 INTRODUCTION

1.1 This Statement of Common Ground on the topic of Cultural Heritage has been prepared for The London Gateway Port Harbour Empowerment Order (HEO) 2002 Inquiry following a number of meetings and discussions between P&O and Essex County Council (ECC) acting for Thurrock Council (TC).

1.2 The Statement sets out the facts as accepted between the above parties. The document has been prepared in response to the London Gateway Port Harbour Empowerment Order (HEO) 2002. Also considered is the in-combination application of the HEO with the London Gateway Commercial and Logistics Centre Outline Planning Application (OPA) with Rail, and the Commercial and Logistics Centre OPA without Rail.

1.3 The Statement references items of data relevant to the topic of Cultural Heritage and the methodologies set out in documents listed at Appendix 1. The minutes of meetings between the parties is set out in Appendix 3.

1.4 Where items in the Environmental Statements and or Technical Reports are agreed this is stated, with the relevant document reference.

2 ACCEPTED DATA

HEO

2.1 The parties agree that the data presented in the ES and supporting documents, including the refinement work, fulfil the structure and local plan policy requirement that applicants should provide sufficient information to enable the planning authority to make a decision on the application. These data include the baseline study, the assessment of archaeological impacts and the significance of effects, along with the conclusions reached.

2.2 The parties also agree that Listed Buildings and Conservation Areas would not be directly effected, and their settings would be preserved.

Accepted In-Combination Data: HEO plus and OPA with TWAO

2.3 As 2.1-2.2 above.

Accepted In-Combination Data: HEO and plus OPA without TWAO

2.4 As 2.1-2.2 above.

3 ACCEPTED ASSUMPTIONS AND METHODOLOGIES

HEO

3.1 All parties to this statement agree that the approach and methodologies adopted by the Appellants in the preparation of the Environmental Impact Assessment (EIA) for Cultural Heritage have been appropriate. This agreement encompasses the sources consulted in the study, the methodologies used (including the method used to assess receptor importance, magnitude of change and significance of environmental effect), and the methodologies for more intensive survey work.

3.2 The parties are also agreed that the data presented in the ES and the conclusions derived from them are sufficient to enable the appropriate mitigation to be established, as required by Structure and Local Plan policies.

Accepted In-Combination Assumptions and Methodologies: HEO plus OPA with TWAO

3.3 As 3.1-3.2 above

Accepted In-Combination Assumptions and Methodologies: HEO plus OPA without TWAO

3.4 As 3.1-3.2 above

Other Items not Contained in Technical Statements

3.5 There are no other items.

4 UNRESOLVED ISSUES

HEO

4.1 There are no unresolved issues between the parties.

Unresolved In-Combination Impacts: HEO plus OPA with TWAO

4.2 As Section 4.1 above.

Unresolved In-Combination Impacts: HEO plus OPA without TWAO

4.3 As Section 4.1 above.

5 SOLUTIONS

HEO

5.1 As a result of undertaking the agreed refinement surveys it has been possible to submit updated proposals for mitigation. These proposals are set out in the Archaeological Mitigation Framework (see Appendix 2) and would form the basis of an agreed precondition with Thurrock Council as Local Planning Authority and The Secretary of State, as part of the Harbour Empowerment Order.

In-Combination Solutions: HEO plus OPA with TWAO

5.2 In addition, due to limited land take along the proposed A13 Road Improvements, the parties to this statement have agreed that the most practical option for mitigation of the impacts would be archaeological recording following topsoil stripping, prior to construction.

In-Combination Solutions: HEO plus OPA without TWAO

5.3 As 5.1-5.2 above.

6 CONCLUSIONS

6.1 It is agreed by the parties that the ES is sufficient to promote a precondition. There are no unresolved issues.

7 PRECONDITION

7.1 The parties agree that, if the Appeal is allowed, it should be subject to the following precondition:

"*Within each element of the HEO, no development shall take place until the applicant has secured the implementation of a programme of archaeological work in accordance with a Project Design for the relevant archaeological work, which has been submitted by the applicant and approved by the Planning Authority and which conforms to the Archaeological Mitigation Framework*"

EXECUTION BY PARTIES

Signed on behalf of Appellants

Position

Date

Signed on behalf of Thurrock Council

Position:

Date

APPENDIX ONE

EIA DOCUMENT REFERENCES

OAU (July 2002) *The (London Gateway Port) Harbour Empowerment Order 2002: Assessment of Effects Cultural Heritage* (Vol. 1 Main Report and Vol. 2 Appendices). Oxford Archaeological Unit

OAU (July 2002) *The (London Gateway Port) Harbour Empowerment Order 2002: Archaeological Surveys and Update of Effects: Cultural Heritage in Respect of the Proposed London Gateway Development* (2 Vols.). Oxford Archaeological Unit

OA (Nov 2002) *The (London Gateway Port) Harbour Empowerment Order 2002. Site X Amelioration Area: Cultural Heritage (Archaeology) Desk-based Assessment.* Oxford Archaeology

OA (Nov 2002) *The (London Gateway Port) Harbour Empowerment Order 2002. Site A Amelioration Area: Cultural Heritage (Archaeology) Desk-based Assessment.* Oxford Archaeology

OA (Nov 2002) *The (London Gateway Port) Harbour Empowerment Order 2002. Northern Triangle Amelioration Area: Cultural Heritage (Archaeology) Desk-based Assessment.* Oxford Archaeology

OA (Dec 2002) *The (London Gateway Port) Harbour Empowerment Order 2002. Cultural Heritage Assessment Refinement of Proposed Off-Site Infrastructure Improvements.* Oxford Archaeology.

OA (March 2003) *The (London Gateway Port) Harbour Empowerment Order 2002. Cultural Heritage Assessment Refinement in Respect of the Proposed London Gateway Development* (3 Vols. Technical Reports and Technical Report Appendices). Oxford Archaeology.

Gosney, R (March 2003) *HEO Listed Buildings and Conservation Area Report.*

Documentation relevant to the In-Combination Application

OAU (Jan 2002) *The (London Gateway Commercial And Logistics Centre) Outline Planning Application 2002: Assessment of Effects Cultural Heritage* (Vol. 1 Main Report and Vol. 2 Appendices). Oxford Archaeological Unit

OAU (July 2002) *The (London Gateway Commercial And Logistics Centre) Outline Planning Application 2002: Archaeological Surveys and Update of Effects: Cultural Heritage in Respect of the Proposed London Gateway Development* (2 Vols.). Oxford Archaeological Unit

OA (Dec 2002) *The (London Gateway Commercial And Logistics Centre) Outline Planning Application 2002: Cultural Heritage Assessment Refinement of Proposed Off-Site Infrastructure Improvements.* Oxford Archaeology.

OA (March 2003) *The (London Gateway Commercial And Logistics Centre) Outline Planning Application 2002: Cultural Heritage Assessment Refinement in Respect of the Proposed London Gateway Development* (3 Vols. Technical Reports and Technical Report Appendices). Oxford Archaeology.

Statements of Common Ground: issue dates

Draft 1	20/01/03
Draft 2	05/02/03
Draft 3	02/04/03

APPENDIX TWO

ARCHAEOLOGICAL MITIGATION FRAMEWORK

THE (LONDON GATEWAY PORT) HARBOUR EMPOWERMENT ORDER 2002

Archaeological Mitigation Framework

July 2003

THE (LONDON GATEWAY PORT) HARBOUR EMPOWERMENT ORDER 2002

Archaeological Mitigation Framework

Prepared by	G Andrews, N Shepherd, J Chandler, A Firth & M Bates
Reviewed by	N Shepherd
Approved by	G Andrews

Version: 4.0 Reference: Date: July 2003

THE (LONDON GATEWAY PORT) HARBOUR EMPOWERMENT ORDER 2002

Archaeological Mitigation Framework

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CONCEPT

Underpinning this mitigation strategy is a commitment to a seamless and integrated approach to the archaeological resource, regardless of whether or not it is currently on dry land or beneath the Thames. The scale of this project presents a particular challenge in realising this aim and in order to address this it is intended that the archaeological programme will:

1. be readily understood by all those involved on the project at all stages of its execution;
2. be owned and developed by those executing the archaeological part of the project i.e. be facilitating rather than proscriptive;
3. be applicable to the full range of archaeological deposits which will be encountered in the programme of work;
4. establish a common language by which diverse organisations involved in different aspects of the project are able to communicate about specific issues in terms which are of relevance to all;
5. establish priorities and thus ensure that resources are allocated in a cost-effective manner;
6. disseminate the knowledge gained to the widest possible audience

1 INTRODUCTION

1.1 Planning Background

1.1.1 In July 2002 P&O submitted an application for a Harbour Empowerment Order (HEO) to develop a port at Shell Haven, Essex. The port will comprise container storage areas, berths for docking large ocean-going container ships, a dredged channel extending into the North Sea, and the provision of rail and road links to serve the proposed port. The proposed provision of amelioration areas of tidal marsh will entail the realignment of the sea walls in areas to the west and north east of the development and across the estuary in Kent.

1.1.2 Studies undertaken to date suggest that the development has the potential to impact on nationally important archaeological remains. These studies are set out in Technical Reports supporting the Environmental Statements which have already been published. The Secretary of State's policy on archaeological remains and how they should be preserved or recorded, is set out in Planning Policy Guidance Note 16: Archaeology and Planning (PPG 16). It indicates the need to take account of known archaeology in development proposals and to ascertain the extent of further archaeological remains which may be affected by the proposed development.

1.1.3 The Guidance states that in the case of nationally important archaeological remains the presumption should be in favour of their preservation in situ. Where preservation *in situ* is not justified it advises that it is reasonable for planning authorities to require the developer to make appropriate and satisfactory provision for excavation and recording of remains. This document has been prepared in order to inform the decisions on the appropriate approach to mitigation of the effects of the proposed port development on the archaeological resource.

1.1.4 Since May 2002, maritime archaeology within English territorial waters has been the statutory responsibility of English Heritage. Initial priorities are set out in *Taking to the Water* (EH 2002) and these have been taken into consideration in the preparation of this mitigation framework.

1.2 Role And Structure Of The Mitigation Strategy

1.2.1 The proposed port development area is extensive, including works on the gravel terrace, historic marshland, and the inter-tidal and sub-tidal zones which are likely to encompass a diverse archaeological resource. The purpose of this document is to establish the strategic framework, applicable to all of these zones, within which the London Gateway port archaeological programme will operate.

1.2.2 The archaeological programme offers the opportunity to elucidate the history of the Thames Estuary, one of the great estuaries of Western Europe. The estuary has been a focus for human inhabitation from the

Palaeolithic through to the 20th century and throughout that period changes in the environment and sea levels have profoundly affected patterns of settlement, exploitation of natural resources and the use of the river for transport and trade. It is the history of this dynamic relationship between the changing environment and human inhabitation which this mitigation strategy seeks to address.

1.2.3 The resource deposit model for the archaeology and the mitigation strategy with its academic justification are conceived as operating within a regional framework defined by the Greater Thames estuary. This is considered in Section 2. Section 3 sets out the aims of the archaeological mitigation strategy and the nature of the record which will be produced and disseminated while Section 4 describes the methodology by which that record will be constructed. Section 5 discusses the way in which the archaeological strategy will be implemented within the context of the construction programme. Section 6 describes staffing and quality standards. Health and Safety policy is outlined in Appendix 1. Specific investigation and recording methodologies, to support general policies in Sections 3 and 4 are provided in Appendix 2. A full list of sources consulted is provided in Appendix 3. A bibliography is provided in Appendix 4, which is also available as a digital database that forms part of the project archive.

1.2.4 Once the detail of the construction programme has been finalised, site specific Project Designs will be prepared for each of the areas requiring archaeological investigation in accordance with the principles set out in this Mitigation Strategy. These Project Designs will cover:

1. data collection methodologies;
2. programme;
3. health and safety plans;
4. reporting proposals.

1.2.5 Each Project Design will reflect at a detailed level the archaeological strategy presented in this Mitigation Strategy and any departure from that strategy will be implemented only after agreement with Thurrock Council and English Heritage as appropriate. Before the port development and dredging of any area commences a copy of the Project Design for that area will be sent to Thurrock Council and their advisors and English Heritage as appropriate. Fifteen working days days following receipt of the Project Design will be allowed for consultation and agreement before work commences on site.

1.2.6 Throughout the duration of the archaeological programme reasonable access will be given to representatives of Thurrock Council and English Heritage as appropriate in order for them to satisfy themselves that compliance with this Mitigation Strategy has been achieved, through monitoring site work. The regulators will be informed five working days in advance of the predicted completion of each piece of fieldwork for which a project design has been issued.

1.2.7 Any dispute or difference arising out of or in connection with this [agreement] (including without limitation any question regarding its existence, validity, interpretation, performance or termination) shall be referred to and finally resolved by arbitration under the Rules of the London Court of International Arbitration ("the Rules"), which Rules are deemed to be incorporated by reference into this paragraph. It is agreed that:

1. The number of arbitrators shall be one;
2. The appointing authority for the purposes of the Rules shall be the London Court of International Arbitration;
3. The seat, or legal place, of arbitration shall be London;
4. The language to be used in the arbitration shall be English;
5. The governing law of the agreement shall be the substantive law of England and Wales.

2 THE ARCHAEOLOGICAL RESOURCE

2.1 *Background*

2.1.1 Establishing an appropriate programme of archaeological mitigation is dependant upon a thorough understanding of the nature and survival of the archaeological resource. The proposed port development is situated in the Thames estuary which has been a major artery for communication both within south-eastern Britain and with the world beyond throughout most of human history and which provides the national context for this archaeological programme.

2.1.2 The site lies at the boundary between the inner and outer parts of the estuary within an area known as the London Basin which is bounded to the north by the chalk escarpment of the Chiltern Hills and to the south by the chalk of the North Downs. The resource model for the archaeology has been conceived as operating within a regional framework represented by the Greater Thames estuary, defined as a zone from Clacton in Essex to Whitstable in Kent, and upstream to Tower Bridge (Williams and Brown 1999). A list of sources and a comprehensive bibliography for the region is provided in Appendices 3 and 4 respectively.

2.2 *Geological and palaeo-environmental background*

2.2.1 The geological history of this part of the Thames is complex. It has resulted in the deposition of a number of gravel terraces down through which the river has cut and over which it has flooded during the various glacial and interglacial periods. Some of the terraces are now submerged beneath the estuary and since the end of the last glaciation rising sea-levels have led to the deposition of a deep sequence of alluvial and marine clays and silts across the floodplain.

2.2.2 Fieldwork elsewhere in the Thames Estuary and in coastal and estuarine environments in the UK and across northern Europe has demonstrated the survival of superimposed buried landscapes at such locations dating from the Palaeolithic period onwards. Prior to the end of the last cold stage this area would have seen a succession of conditions when the river would have alternated between phases of fast flow under cold climates and slower flow, sometimes estuarine, during the warmer phases.

2.2.3 Stratigraphic analysis of historic and purposive borehole data has been used to assemble a model of the Pleistocene deposits running from the gravel terrace through the floodplain, into the Thames channel and beyond onto the Kent side. Terrace deposits in this part of the Thames are not well studied and there are considerable differences of opinion regarding their identification and date. The studies undertaken as part of the London Gateway EIA appear to indicate that deposits post-dating 150,000 BP (the final glaciation) are buried beneath the alluvial floodplain with earlier deposits from the penultimate interstadial and the previous glaciation exposed above the floodplain to the west.

2.2.4 Consequently it is reasonable to expect that Palaeolithic remains (and palaeo- environmental material) may exist within the Pleistocene sediments both above the marsh surface as well as below it in almost any units with the possible exception of those associated with the last interglacial.

2.2.5 From the end of the last cold phase fluctuating, but ultimately rising, sea-levels, coupled with deep seated movement of the earth's crust, have created a complex stratigraphy of dry-land, salt marsh and inter-tidal mud flats representing a sequence of rich and varied environments, all capable of having sustained a range of human activities. Successive inundations within the floodplain have caused prehistoric and later landscapes to become buried beneath and within the accumulating alluvium, together with the residues of these activities. Due to waterlogged conditions preservation at such sites can be excellent and the significance of these deposits is now widely acknowledged.

2.2.6 As with the earlier deposits there has been little study of the Holocene sequence in the Shell Haven area, and more generally for the area between Tilbury and the Isle of Grain. There are, however, still clear parallels between the London Gateway results and those of Devoy (1977, 1979) and Long, *et al.* (2000), although it is now clear that those models are oversimplified. At Shell Haven detailed deposit modelling has identified up to 15 m of interdigitated alluvial and marine silts and clays across the floodplain (to the south at Cliffe Marshes these deposits appear to be up to 25 m in depth). Within these units two main peat deposits have been identified, a basal unit at around -12 m O.D. dated to pre-9,000 years BP (Mesolithic) and an upper unit at around –3 to –5 m O.D. dated to 5,800 years BP (Neolithic/Bronze Age). The age estimates indicate the deposits can be equated with Devoy's Tilbury I and Tilbury III peat respectively (Devoy 1977, 1979).

2.2.7 Palaeo-environmental analysis carried out on samples from the peat and the intervening minerogenic silts at Shell Haven demonstrates good survival of pollen and microfauna (diatoms, foraminifera and ostracods). The preliminary analysis indicates a high potential for detailed environmental and landscape reconstruction. Although there was no direct evidence of human activity the presence of vivianite, evidence for burning and evidence for local vegetational change (woodland clearance as shown by the elm decline and later more open conditions and spread of pastoral farming) are all possibly of anthropogenic origin.

2.2.8 Deposit modelling using observations of the stratigraphy from purposive and historic borehole data has enabled a provisional reconstruction of the early Holocene topography, see Figure 1. As well as demonstrating the progressive coastal shift as sea-levels rose this has also identified zones of potential human activity. These are as yet tentative but topographically logical in that they represent areas of high ground within the floodplain, and areas littoral to a potential early palaeochannel running north to south through the floodplain. While other areas were no doubt inhabited, these islands and channel edges provide a primary focus for investigation.

2.3 Prehistoric, Roman, Medieval and Later Settlement

2.3.1 The gravel terraces of the Thames contain evidence of human activity from the prehistoric to the present day. Exploitation of the low-lying floodplain will normally have been organised on the higher drier lands of the terrace or on islands within the floodplain and it is here that both prehistoric and historic settlements are likely to be found. This evidence is rarely deeply buried and as a consequence has frequently been damaged by post-depositional processes such as agriculture, quarrying, recent development and erosion.

2.3.2 Areas at the interface of the gravel terrace and the floodplain are likely to have been the focus for particular types of activity, especially at those points where creeks gave access from the river to the higher ground. Such areas are likely to be partly masked by alluvium.

2.3.3 Evidence for human activity on the floodplain reflects the shifting courses of the river and associated shorelines, so sites and environments that were once terrestrial may be buried by many metres of alluvial and marine silts, that may themselves contain evidence of human activities. These deposits contain the sorts of sites that might be expected on land such as settlement or ritual features, as well as palaeoenvironmental evidence provided by various macro and microscopic materials within the deposits themselves.

2.3.4 The present inter-tidal zone and sub-tidal zones are part of the same stratigraphic continuum as the floodplain and have the potential to reveal the full range of terrestrial sites, as well as more specifically shore-related features such as wharves, wrecks, oyster pits, jetties and sea defences. It is not known at what point our predecessors first used water transport, but it can be reasonably assumed that the Thames emerged as a navigable feature following the late Upper Palaeolithic reinhabitation of Britain. Its navigability would have changed as sea levels rose and a relatively deep estuary developed and there is therefore the potential for channel deposits to preserve the remains of wrecks and debris that found their way to the seabed.

2.3.5 It is likely that the existing creeks preserve a pattern of reclamation which is of some antiquity. They would have provided a focus for traffic and activity throughout all periods, connecting the river and marshes to settlement on the higher ground. Buried former creeks may have attracted settlement to their banks and they represent a significant potential resource for the preservation of archaeological remains associated with the exploitation of the marshes (e.g. bridges and trackways, wharves and platforms) and with maritime transportation. The potential for boat and ship remains within the former marshlands is high.

2.3.6 Medieval and later land reclamation has left its own unique mark on the landscape in the form of sea walls and drainage channels. The dry land has supported built structures in historic times, and the most recent industrial history of the proposal is of some significance.

2.3.7 Figure 2 shows elements of the historic landscape, both natural and artificial, derived from the earliest maps of the area, Chapman and Andre's Map of 1777, the Ordnance Survey 1" map of 1805, and the OS 1st Edition 6" map (surveyed 1863). The main features were identified and included in the Cultural Heritage features mapping of the original assessment, but the main elements, such as settlement, roads, creeks and banks, are presented here in order to provide an overall picture of the historic landscape environment, along with areas of archaeological potential from the later medieval period (and possibly earlier).

2.4 Depositional environments

2.4.1 Elements of the archaeological record, including deposits, in the Greater Thames estuary fall into four categories or **depositional environments** which relate to the geological formation processes and geomorphological agents/processes which have operated there. These depositional environments are:

2.4.2 Middle to Late Pleistocene gravel and sand deposits existing along the valley edges and beneath the fine-grained floodplain of the modern river. These deposits, predominantly formed by the Thames during cold phases in the past, have often been cut through to form terraces in the landscape. Occasionally evidence for fine-grained deposits, potentially containing faunal and floral remains as well as Lower Palaeolithic archaeological material from temperate episodes may occur within these deposits. These deposits and landscapes are largely natural ones, occupied by humans and locally modified and altered by the presence of humans.

2.4.3 Late Pleistocene/Holocene/recent fine grained sands, silts, clays and peats resting beneath the modern floodplain and burying the most recent gravels from the last cold stage. These deposits reflect the changing environments associated with inundation of the landscape resulting from sea level rise after the last glaciation. Typically these bury a landscape likely to have been occupied by Mesolithic and early Neolithic peoples in the early Holocene and form a complex of wetland systems, including relict channels, occupied and exploited by later Prehistoric, Roman and post-Roman groups. These landscapes are a complex of natural landscapes modified extensively by human activity.

2.4.4 Prehistoric and later material cut into the terrace gravels and alluvium. Features and deposits are associated with the use and reclamation of the wetlands including land drainage, creation of drainage ditches and dykes and the building of seawalls resulted in drying of the wetland landscapes, fossilisation of older creek systems and the creation of new ecologies and associated deposits. More recent military and industrial uses are also included. In this case sediments, landforms and ecologies result directly from human activity.

2.4.5 The Thames channel and associated extant fleets/creeks. Within these are exposed deposits of categories 1 and 2 with potential for maritime structures, principally boats, but also other craft, within fine-grained sediments either exposed in the sides or buried at the base.

2.5 Survival of the Archaeological Resource

2.5.1 Consideration of the nature and extent of past impacts forms an important element in any future mitigation programme (see Figure 3). Assessment of archaeological survival is based on information obtained from a variety of sources, comprising air photographs, historic maps, archaeological investigations and site walkovers. Within the area of the former refinery, past impacts are based on a detailed study of engineering drawings held by the Shell Haven Drawing Office. The study is summarised in *Cultural Heritage Refinement Technical Report Appendices* - Appendix P (ES March 2003).

2.5.2 The study of past impacts within the refinery has shown that approximately 10% of the area is occupied by structures which have been piled. The typical piling densities would have resulted in a total impact area of less than 2% for the footprint of most structures, but would have destroyed archaeology at each pile location, and possibly beyond, throughout the entire alluvial sequence and into the underlying gravels. Archaeology in areas of piled buildings will, however, have survived relatively intact between the piles.

2.5.3 In refinery areas where there has been no piling the study has shown that any archaeological deposits at the very top of the alluvial sequence (i.e. later medieval or post-medieval date) are likely to have been partly damaged by subsequent activity. This impact is likely to cover much of the site. There are likely to be other small areas of localised impact but in general archaeology present within everything but the upper levels of the alluvial sequence will have survived intact.

2.5.4 Outside the area of the refinery the floodplain seems to have been principally used as grazing marsh for much of its history and the major impacts on any archaeological deposits are likely to be land drainage which may have damaged archaeological deposits at the top of the alluvial sequence. Possible areas of localised impact from World War II anti-glider ditches and bomb craters have also been noted.

2.5.5 On the floodplain, both within and outside the area of the refinery, the sites of silted or filled-in creeks are likely to survive and could contain important historic and prehistoric organic remains as well as palaeo-environmental material.

2.5.6 On the gravel terrace the major impacts on any archaeological deposits, other than the construction of the Coryton Gas Pipeline in 1999, would have been from arable agriculture, particularly deep ploughing. Such relatively shallow impacts (c. 0.3m) could potentially have had a severe effect as archaeological deposits are typically located directly beneath topsoil.

2.5.7 Beyond the sea wall, the area of proposed reclaim has seen the construction of jetties, wreck clearance and dredging which will have had some localised impact but areas of the seabed may survive intact.

2.5.8 Within the area of the proposed channel dredge recent study (OA March 2003 *Cultural Heritage Refinement Technical Report Appendices* - Appendix Q) has indicated the presence of sites of archaeological interest on the surface of the seabed. These sites are likely to include both maritime anomalies comprising wreck or other ship-related debris (although many of the anomalies will be of no archaeological interest and previous dredging will have had localised impact) and other sites of possible prehistoric and palaeo-environmental interest. There has been dredging in the channel on several occasions from the 1920s onwards with a major capital dredge of the Yantlet channel in the 1960s.

3 AIMS AND OBJECTIVES OF THE MITIGATION STRATEGY

3.1 *Aims and Approaches*

3.1.1 Understanding the potential significance of the surviving archaeological resource, as set out in Section 2 above, facilitates the identification of research objectives and approaches appropriate to mitigating the anticipated impacts of the proposed development. The area of the development covers a diverse archaeological resource and the aim of this project is to move beyond the recovery and description of remains as they are distributed across the landscape and to create an historical understanding of the dynamic relationship between human activity and the changing landscape in relation to its regional, national and international context.

3.2 *Guiding Principles*

3.2.1 The requirement for a single integrated approach that will establish priorities, and facilitate decision-making to a devolved on-site level.

3.2.2 Explicit research objectives will guide each stage in the recovery and interpretation of data from deposit sequences that are identified as being at risk from development impact (5.2.4 and 5.2.5), and which the resource deposit model indicates are relevant to the project research themes (3.5).

3.2.3 Acceptance of the highly fragmentary and partial representation of archaeological materials in a complex matrix of sediments.

3.2.4 The requirement for strategies and methodological procedures which reflect both the archaeological potential of the site and the particular physical conditions in which archaeological remains are found.

3.3 *Geomorphological Frameworks*

3.3.1 The depositional matrix has been determined by the evolving riverine, marine and terrestrial systems operating in the area. The ways these energy systems operate has changed radically through time.

3.3.2 The location of activity will have shifted its position relative to the river, with the encroachment of the sea since the last glacial period.

3.4 *Analysis*

3.4.1 Analysis will require:

1. An adequate modelling of deposition through time as a product of various formation and energy systems (Deposit Model).
2. The identification of a particular theme or themes that unite the history of human occupation with the nature of the changing geographical location and changing depositional processes.

3.5 *Proposed Research Themes*

3.5.1 Research themes are inevitably and intimately related to the different **depositional environments** encountered across the study area (see 2.4 above).

3.5.2 Quaternary environments and Palaeolithic inhabitation – the lower Palaeolithic remains of the Thames valley are important within a European context and have immense potential for the study of environmental change and its relationship to human inhabitation. Deposits, both *in-situ* and derived, may occur within the terrace gravel exposed on the higher ground within the NW of the study area, beneath the alluvial deposits of the floodplain and outcropping in the sides and at the base of the Thames channel.

3.5.3 Holocene palaeo-environment and inhabitation from the Mesolithic to the modern period – fluctuating periods of post-glacial sea-level change have trapped evidence for past environments and activity both on dry land, within the floodplain, and submerged within the Thames channel. Deposits of these dates may also be found cut into the terrace gravels to the NW and truncated by later activity.

3.5.4 Reclamation of the Thames floodplain – as on many UK and European estuaries, the current line of the coast at Shell Haven was established by reclamation of the floodplain prior to the early C19th. It is not clear when reclamation started, or what the phasing was; nor is it known what the implications of reclamation were for local Medieval and Post-medieval populations living on the higher ground but intimately connected to the wetlands. Evidence for reclamation will come principally from the area of the floodplain.

3.5.5 Industrialisation of the waterfront and floodplain – the Thames floodplain has witnessed successive waves of industrial use from the C18th onwards, including railways and docks, live animal importation, explosives manufacture, and oil refining and related industries. The area thus provides scope for the archaeological investigation of both the development of industry, and of the effects of industrial development on earlier archaeological deposits.

3.5.6 Warfare - the Thames corridor has from earliest times been the focus for invasion and defence. These themes will be considered throughout our investigation of the human inhabitation of the area but will be of special significance for the study area from the eighteenth century and particularly for the period of WWII.

3.5.7 Maritime activity – a major highway, the Thames estuary is likely to contain the remains of lost or discarded watercraft dating back to the earliest navigation in the waters around Britain. The remains of boats, ships and their former contents constitute important evidence for people's ability to organise, build and operate systems of economic, social and military contact at every scale from local to global. Evidence for these structures will come not only from the Thames channel but also from existing and filled in fleets and channels across the floodplain.

3.5.8 These broad themes will provide a framework for the development of site-specific Project Designs which will arise out of a consideration of the particular and detailed circumstances of archaeological survival, significance and the proposed impact.

4 METHODOLOGY

4.1 Professional Advice and Services

4.1.1 P&O has taken active steps to ensure that it is appraised of the appropriate requirements for protecting the archaeological heritage and, should the development go ahead, will appoint an Archaeological Liaison Officer (ALO) to be responsible for the provision of archaeological advice and management of the archaeological strategy throughout periods of construction.

4.1.2 The representatives of Thurrock and/or English Heritage, as appropriate, will be responsible for monitoring the programme to ensure that it complies with this mitigation strategy and fulfils curatorial requirements as set out in table 4.1.

4.1.3 On behalf of P&O the ALO will:

1. act as the principal point of contact for the London Gateway Port archaeological programme;
2. liase with Thurrock Council and/or English Heritage as appropriate as set out in table 4.1 below;
3. ensure that appropriate access to the project and its results is available to all relevant parties.

4.1.4 P&O will appoint a Principal Archaeological Contractor, who will be responsible for working alongside the ALO and for executing the London Gateway Port archaeological programme.

4.1.5 The Principal Archaeological Contractor will be responsible for:

1. drawing up the detailed programmes of work (see 1.2.3) which will be based upon this Mitigation Strategy;
2. implementing fieldwork programmes;
3. undertaking analysis and dissemination of results.

4.1.6 Archaeological sub-contractors will where necessary be appointed to provide specialist support to the ALO and Principal Contractor as appropriate.

TABLE 4.1: LONDON GATEWAY ARCHAEOLOGICAL MITIGATION PROGRAMME: CURATORIAL LIAISON

LONDON GATEWAY PROJECT STAGE	PRODUCT FOR CIRCULATION	CURATORIAL LIAISON Thurrock Council [TBC]or English Heritage [EH] as appropriate
	ALL AREAS	
Compile Research Strategy (THIS DOCUMENT)	Archaeological Mitigation Framework (AMF)	Agree AMF
	FOR EACH INDIVIDUAL LG AREA	
Determination of appropriate mitigation strategy	Mitigation Proposal (for preservation in-situ or by record)	Agreement
	FOR PRESERVATION BY RECORD	
Compile Project Design	Project Design	Agree Project Design
Fieldwork investigation through phased sampling strategy (monitoring by ALO)	Project Design Update Notes (as appropriate)	1. Monitoring of fieldwork 2. Consultation where further sampling is not justified 3. Notification of further sampling where required 4. Agreement at the end of fieldwork
Off-site Assessment	Interim Report, including preliminary proposals for further work (Updated Project design UPD)	Agreement
	GROUPED AREAS	
Integrated Assessment	Integrated proposals for Analysis and publication (UPD)	Agreement of UPD Analysis and Dissemination Programme
Methodological Review	Project Design Update Notes	Consultation
Analysis	Publication text	Monitor progress during production of text
	Dissemination (various media)	

4.2 Approaches to Investigation

4.2.1 Four current **physical environments** have been identified within which different sampling strategies will be employed. The physical conditions that now operate in those areas present differing challenges in terms of accessibility to the archaeological resource and therefore demand different methodological approaches. These environments, which are shown on Figure 3, are:

1. the gravel terrace (nominally above 5 m aOD) -material sealed within the terrace gravels or cut into or overlying them and surviving as a truncated surface;
2. the alluvial floodplain (from 5 m aOD to the high water mark) - material sealed beneath and within the alluvium and cut into its surface;
3. the inter-tidal zone (between the high and low water marks) - material sealed beneath and within alluvium and cut into its surface;
4. the Thames channel/sea-bed and existing fleets and creeks - material sealed beneath and within the alluvium, particularly wrecks of boats and other craft.

4.2.2 Appropriate strategies and methodologies for particular areas of the site will be formulated by consideration of the current **physical environment**, the likely **depositional environment** in which archaeological remains are likely to occur (see 2.4) and the principal research themes (see 3.5). For instance methodologies appropriate to Roman and medieval surface cuts and deposits on the terrace will differ from those appropriate to Mesolithic material deeply buried within alluvium or exposed in the inter-tidal zone.

4.2.3 Underpinning these strategies and methodologies will be a commitment to a staged, iterative process of mitigation. A cycle of intervention, feedback and assessment over a number of years is anticipated as the scheme is implemented. A flexible and responsive approach to data collection and analysis will be required in order to fully realise the potential of the archaeological deposits within the agreed constraints of the construction programme as it develops over time, and in a manner which is both cost-effective and maximises archaeological value.

4.3 Techniques

4.3.1 A wide range of possible techniques may be applicable. These are set out in Appendix 2 and are outlined below.

Desk-based study

4.3.2 While this has already been carried out for terrestrial areas some aspects of the maritime resource, notably those anomalies recently identified by marine geophysics (Appendix O, ES March 2003), still require further characterisation from documentary sources. Desk-based study will allow a further refinement in our understanding of the significance of the anomalies and so inform appropriate mitigation strategies.

Detailed non-intrusive surveys (see A2.1)

4.3.3 As a first stage of mitigation it may be appropriate to undertake further non-intrusive survey where access has to date been limited or not possible and may include:

1. Standing building recording
2. Topographical surveys
3. Inter-tidal walkover surveys
4. Field artefact collection
5. Geophysical survey
6. Area-based marine geophysical survey
7. Site-specific marine geophysical survey
8. Metal-detector survey
9. Archaeological diving inspection

Deposit modelling (See A2.2)

4.3.4 A preliminary deposit model which presents the current understanding of the palaeotopography and the palaeoenvironment of the development area has been completed (see ES March 2003 Appendix O). This will be further refined during mitigation.

4.3.5 This refined modelling work will require the collection of additional data and wherever possible the requirements of this study will be co-ordinated with work undertaken for other disciplines.

4.3.6 **Refinement of the deposit model using geotechnical CPT data.** Use of CPT data in the recent palaeoenvironmental investigations (see ES March 2003 Appendix O) has indicated that very detailed reconstructions can be made on the basis of this information. New CPT data collected for geotechnical purposes will enable the further definition and location of features such as gravel ridges and islands, palaeochannels and relict coastlines which in turn will facilitate the implementation of appropriate mitigation measures.

4.3.7 **Sample recovery and micro-artefact survey.** Having further refined the palaeotopography, work will be required to identify the presence or absence of human activity. Proxy indicators of human activity include charcoal, micro-artefacts (flint debitage chips, burnt flint and comminuted pot) and bone. Micro-artefact concentrations are dense within the confines of activity areas and become diffuse away from those areas. Consequently samples from boreholes may be able to trace artefact concentrations across a landscape.

4.3.8 It is proposed that a series of MOSTAP and U100 samples would be used to recover cores. These would be cut into continuous 10cm intervals and sieved. Given sufficient density of boreholes both the vertical and lateral distribution of micro-artefacts may be mapped.

4.3.9 A selection of key samples, will be subject to paleoenvironmental assessment for waterlogged plant remains, insects, pollen, diatoms, ostracods and foraminifera as appropriate. Selected radiocarbon dates will be obtained to provide a chronological framework for the predictive model (sufficient sample material will be retained from key sequences to undertake more comprehensive dating, which may be further refined using Bayesian statististical modelling).

4.3.10 A limited number of shell and auger boreholes will be used to extend the sequence into the Pleistocene gravels as appropriate. The samples from these will be assessed for the presence of faunal remains and molluscs. The stratigraphic, palaeoenvironmental and artefact distribution data recorded will be used to refine the predictive model.

4.3.11 MOSTAP sampling will be undertaken as part of preliminary site investigation. Linear developments will provide opportunities to investigate transects across the landscape and phased development of land parcels will ensure a comprehensive coverage.

Excavation (See A2.3)

4.3.12 Where desk-based studies, non-intrusive survey or borehole work identifies significant archaeological deposits consideration will be given to preservation in-situ. Where this is not appropriate excavation (preservation by record), will be the principal mitigation methodology. A phased approach will normally be taken.

4.3.13 **Phase I.** Initial excavations comprising test pit or trench investigations can be used to further characterise deposits of all dates and the techniques are appropriate to investigate areas identified by the deposit model. The layout of interventions, their density and depth can be varied according to sampling strategies appropriate to the nature of archaeological deposits being investigated and the physical and depositional environments within which they are found. In places, and at an early stage of the project, it may be appropriate to utilise deep engineering works as initial excavations.

4.3.14 **Phase II.** Strip Map and Sample techniques are applicable to shallow and surface deposits on the gravel terrace. Such techniques can also be used as Phase I investigation in place of initial excavations as appropriate. These techniques are particularly useful in response to proposed impacts such as topsoil stripping along infrastructure corridors and across building footprints and can be fully integrated into the early stages of the construction programme. The technique involves removal of non-archaeological surface deposits (topsoil or made ground) under archaeological supervision and the rapid mapping and sample excavation and recording of any archaeological remains identified. The level of sampling is dependent on the nature of the archaeological remains and their significance with reference to the project aims. Strip

Map and Sample may lead to further detailed excavation if appropriate.

4.3.15 **Phase III.** Detailed excavation may be considered where significant remains cannot be adequately recorded or protected during Phases I and II. The level of sampling will depend upon the nature and significance of the identified archaeological remains in relation to the project research objectives (section 3).

4.3.16 Site-specific methodologies for the above techniques would be provided in Project Designs and would be agreed with curatorial archaeologists within the framework of this document.

Monitoring and recording (See A2.8)

Terrestrial

4.3.17 Archaeological monitoring, and recording as appropriate, of engineering works will be undertaken throughout the construction phases of the project. This may form an appropriate mitigation response:

1. where it can be shown that there is a low potential for archaeological remains to survive,
2. where previous phases of mitigation have already been undertaken but some potential for remaining archaeology remains, and
3. where conditions such as the nature of the impact and the accessibility of archaeological remains suggest it is an appropriate technique.

4.3.18 It is anticipated, for example, that monitoring may be undertaken across areas of large-scale topsoil strip where previous survey has already demonstrated low potential. It may also be appropriate during dredging works and during some piling operations.

Marine

4.3.19 Procedures will be implemented to ensure that discoveries made by construction staff, where archaeologists are not present, are adequately reported. This will be of particular relevance during dredging operations.

4.4 Assessment, Analysis and Dissemination

4.4.1 The programme of analysis and dissemination will be dependent upon the construction programme which will extend over a number of years. A number of separate episodes of assessment/analysis and publication are likely to occur.

4.4.2 The extended duration of the project means that methodologies will need to be reviewed and revised at intervals to take account of new research priorities, methods and technology. However, it is essential that up-dated methods do not compromise the consistency of the record.

Methodological Reviews will be undertaken as part of the Project Review procedure. These will be recorded in Project Design Update Notes during the course of fieldwork.

4.4.3 Once a programme of fieldwork has been completed an integrated assessment encompassing the results of all the separate areas/phases of work will take place. The principal purpose of this assessment will be to prepare a costed analysis programme which will result in the production of a report for publication and appropriate dissemination through other media. Throughout the analysis programme the aim will be to use the field data in a targeted and critical manner. This will ensure that the data selected to be worked up for the publication are those which best address the project's research priorities.

4.4.4 The objective of the analysis and dissemination programme will be to produce an accessible and interesting product aimed at a wide audience for the archaeology of South Essex and the Thames Estuary. The stimulation of that interest will contribute to the use of the archive for additional and future work.

4.5 Archive

4.5.1 All context records will be audited and all paper records, finds and samples will be catalogued and indexed. All digital records will be validated and stored in appropriate formats.

4.5.2 The complete project archive will be prepared in accordance with the guidelines set out in Appendix 3 of Management of Archaeological Projects (English Heritage 1991) and with reference to current professional practice.

4.5.3 The project archive, including the finds, will be deposited with the appropriate local museum in accordance with their guidelines. All reports will in addition be lodged with the Essex County Council Heritage Conservation Record. Prior to the commencement of fieldwork, arrangements will be made to ensure agreement between P&O and the appropriate local museum over requirements for archive preparation, storage and conservation.

4.5.4 Additional copies of the archive will be deposited with the National Monuments Record, as appropriate, and a suitable depository for the digital archive will be identified.

5 IMPLEMENTATION: MITIGATION PROPOSALS AND INTEGRATION WITH CONSTRUCTION

5.1 Working Practices in Relation to Development

5.1.1 A robust set of measures will be established both to ensure that sufficient time and resources are provided for any archaeological investigations and that the changing needs of those investigations can be integrated and safeguarded within the construction programme. Such measures will comprise:

1. the appointment of a London Gateway Archaeological Liaison Officer, with authority to resolve any difficulties that may arise in the effective implementation of this Mitigation Strategy and the curatorial liaison set out in Table 4.1;
2. the operation of a "permit to work" system, whereby archaeologically sensitive areas of the site must first be formally signed over to the engineering contractors/dredging contractors before construction work can commence;
3. the demarcation of and controlled access to, any areas either undergoing or due to undergo archaeological excavation, with access only be permitted upon the authorisation of the ALO;
4. the total integration of the ALO, the Principal Archaeological Contractor and the archaeological programme within the London Gateway Project Team and construction programme.

5.1.2 Representatives of Thurrock Council and/or English Heritage as appropriate will monitor the project to review progress and ensure compliance with this mitigation framework. Table 4.1 sets out the points within the programme at which liaison with the regulators must take place.

5.1.3 Thurrock and English Heritage will be kept abreast of academic and methodological developments through the issue of Project Design Update Notes. In addition periodic revisions to this mitigation framework will be made following consultation.

5.2 Construction Impact and Archaeological Mitigation Proposals

5.2.1 The following section sets out the nature of the development proposals within the application site (Figure 4), the anticipated impact of those proposals on the archaeological resource and the proposed archaeological mitigation strategy and curatorial input set out in Table 4.1.

5.2.2 The nature of the archaeological resource which is expected is considered with reference to the depositional and physical environments categorised above (2.4, 4.2) and the anticipated survival of the resource is shown on Figure 5.

5.2.3 Most of the area of proposed development has been identified as an area of high archaeological potential. Figure 5 identifies areas of "higher" potential based on the updated deposit model. Within the area of the floodplain, these include for example, gravel islands, the sides of palaeochannels, which might have attracted settlement and other activity in the early prehistoric period, or economic activities (wharves, boats) in later periods.

5.2.4 Areas where zones of higher potential coincide with areas of development impact will be accorded particular importance during the formulation of mitigation proposals.

5.2.5 The proposed impacts within the London Gateway port development area fall into eight main groups. These are: topsoil stripping; pile foundations; ground reduction; deep soil mixing; ecological mitigation; amelioration areas; wick drains; dredging for berthing; dredging the Thames and Approach Channel.

Topsoil stripping

5.2.6 This is likely to be undertaken prior to any construction activity and will represent a widespread impact across terrace and floodplain areas. The purpose of the procedure is to create a level and firm platform from which construction can take place. Stripping depth will vary depending on the depth of topsoil and any other deposits that may need to be removed (e.g. made ground) but would normally be between 300 and 500 mm. Where they survive all archaeological deposits will be completely removed to the depth of stripping. Archaeological deposits exposed directly beneath the level of stripping will also be disturbed.

5.2.7 The removal of topsoil and other surface deposits will impact upon any archaeological remains at or just beneath the surface. On the terrace this could impact on Palaeolithic material within the upper part of the gravel, and on Holocene deposits (from the Mesolithic to the present day) cut into and overlying the gravel. On the floodplain stripping will impact on the deposits within the upper part of the Holocene alluvial sediments. These will generally date from the beginning of land reclamation in the medieval period although around the margins of the floodplain earlier deposits may also be encountered.

5.2.8 An analysis of past impacts from construction of the refinery has demonstrated that archaeological survival is variable across this area. In places surface deposits have already been removed by structures, while in other areas they are intact, either beyond the footprint of structures or protected beneath a layer of made ground. On the gravel terrace the upper layers of stratigraphy are likely to have been at least partially affected by ploughing. Topsoil stripping in all locations is therefore a potential impact on any archaeological remains present in these areas.

5.2.9 Wherever appropriate topsoil stripping will be carried out under archaeological supervision. If possible archaeological remains will be preserved in situ by putting in place a protective geotextile membrane over a depth topsoil. Where archaeological deposits have to be removed archaeological investigation will take place prior to development.

Piled Foundations

5.2.10 Piled foundations will be used for both structures on the floodplain and for the new quay wall. Foundations would extend down to solid geology beneath the alluvium. Any archaeology within the alluvium and cut into the underlying gravel would be destroyed within the footprint of each pile. The overall impact of the piling upon any archaeology would depend on the size of the individual piles and the piling density. On average the impact of piles within each building footprint will be less than 2%.

5.2.11 Piled foundations in both the floodplain and the inter-tidal zone will impact upon any archaeological remains within the Holocene sequence dating from the early Mesolithic to the present day and upon any earlier deposits at the interface of the alluvium and the gravel.

5.2.12 Pile caps, ground beams and ground floor slabs will be located at a depth of c. 1.0 m within made ground resulting from ground-raising as part of the reclamation works. There is no predicted impact from these works.

5.2.13 The impact of piling within the proposed buildings on the floodplain will be less than 2% it is proposed that mitigation can be achieved through preservation *in situ*.

5.2.14 Study of past impacts in the refinery area (Appendix P of the March 2003 ES) has shown a level of impact similar to the proposed new build meaning that archaeological survival has not been seriously compromised. It is therefore proposed that piling in these areas will not lead to unacceptable levels of impact and that mitigation by preservation in-situ can be achieved.

5.2.15 In the areas of piling in the intertidal zone subject to the results of any further desk-based or non-intrusive survey it may be appropriate to undertake limited archaeological investigation.

Ground Reduction

5.2.16 In the area of the gravel terrace where the new site access road is crossed by the rail corridor (the subject of separate OPA/TWAO applications) there will be reduction of the ground to a maximum of 0.9m below present ground level. Where they survive all archaeological deposits will be completely removed to the depth of ground reduction.

5.2.17 Ground reduction will impact upon any archaeological remains at or just beneath the surface. This could impact on Palaeolithic material within the upper part of the gravel, and on Holocene deposits (from the Mesolithic to the present day) cut into and overlying the gravel.

5.2.18 At detailed design consideration will be given to the possibility of vertical realignment to achieve preservation *in situ* of any archaeological deposits. Should this not be possible mitigation will comprise a phased programme of archaeological investigation involving topsoil stripping under archaeological supervision and further excavation as appropriate.

Deep soil mixing

5.2.19 Deep soil mixing entails mixing cement and/or lime into the alluvium down to the base of the alluvium. Deep soil mixing may be used to provide foundations for rail and road corridors where they cross the floodplain, although this will be subject to further geotechnical investigation to investigate whether the extent of support works to infrastructure can be reduced. Any archaeology within the alluvium would be destroyed within the footprint of the construction and impact upon any archaeological remains within the Holocene sequence dating from the early Mesolithic to the present day is therefore possible.

5.2.20 It is possible that some roads will cross areas which have been previously piled. In such cases the piles will be re-used and deep soil mixing will not be required. In areas where there has been no past piling in the refinery archaeological deposits at the very top of the alluvial sequence (i.e. later medieval or post-medieval date) are likely to have been partly damaged by earlier activity. Elsewhere archaeology within everything but the upper levels of the alluvial sequence will have survived intact.

5.2.21 Mitigation will comprise a phased programme of archaeological investigation involving boreholes and test pits/trenches as appropriate. Where significant deposits are identified further excavation will be undertaken.

Ecological Mitigation

5.2.22 An area of current marshland to the west of the former refinery is to be retained, largely for ecological management and mitigation purposes. This will comprise re-profiling the existing creeks, the creation of new creeks and the construction of one or more c. 4.0 m deep newt ponds.

5.2.23 Ground reduction will impact upon any archaeological remains within the upper part of the alluvial sequence to a maximum depth of 4.0 m, comprising Holocene deposits dating from the Neolithic/Bronze Age to the present day.

5.2.24 The scope of these works are set out in the Ecological Mitigation and Management Plan but the exact location of these works will be determined by an Ecological Advisory Committee. This will be set up post determination and will consider constraints such as archaeology when locating these features. It is understood that there is some flexibility in the location of these works within the area of retained marshland.

5.2.25 Consideration will therefore be given to the possibility of preservation in situ at detailed design. Where this cannot be achieved mitigation will comprise a phased programme of archaeological investigation involving topsoil stripping under archaeological supervision and further excavation as appropriate.

Amelioration Areas

5.2.26 Within Amelioration Areas A and X a programme of managed retreat is proposed in these areas of the floodplain. This will comprise the breaching of the existing sea wall, the construction of a new sea wall inland, the area between being returned to inter-tidal mud flats and salt marsh. Areas to the landward side of the new sea wall will be turned over to freshwater habitat creation with impacts similar to those described above (see Ecological Mitigation).

5.2.27 This work may result in the removal of the historic seawall (if it coincides with the present structure) and exposure of areas currently under grazing to tidal scour effecting the upper levels of the Holocene alluvial sequence.

5.2.28 Mitigation will comprise further non-intrusive survey to enhance the existing desk based study. This will be followed by further archaeological investigation as appropriate.

Wick Drains

5.2.29 Wick drains installation involves the insertion of narrow, vertical drains into alluvium above the gravel at 1.5 - 2.0m centres. They are to be inserted landwards of the existing seawall on the floodplain. Any archaeology within the alluvium would be destroyed within the footprint of the construction and impact upon any archaeological remains within the Holocene sequence dating from the early Mesolithic to the present day is therefore possible.

5.2.30 Analysis of past impacts from construction has demonstrated that approximately 10% of the refinery area has been covered by structures which have been piled. Piling would have destroyed archaeology at each previous pile location, and possibly beyond, throughout the entire alluvial sequence and into the underlying gravels. Archaeology will however, have survived relatively intact between the piles. In refinery areas where there has been no past piling archaeological deposits at the very top of the alluvial sequence (i.e. later medieval or post-medieval date) are likely to have been partly damaged by earlier activity. Elsewhere archaeology within everything but the upper levels of the alluvial sequence will have survived intact.

5.2.31 Mitigation will comprise a phased programme of archaeological investigation involving boreholes and test pits/trenches as appropriate. Where significant deposits are identified further excavation will be undertaken.

Dredging for Berthing

5.2.32 Inter-tidal and sub-tidal areas to the seaward side of the existing seawall will be dredged to up to 16.0m below chart datum. This may remove archaeological deposits sealed within Holocene alluvium where they survive.

5.2.33 Mitigation will comprise further borehole survey to clarify the existing deposit model in this area. Dependant upon results further investigation will take place as appropriate.

5.2.34 Additionally, monitoring schemes will be implemented to address any sites uncovered by dredging for berthing. Monitoring schemes will include provision for reporting protocols and for periodic survey

Dredging the Thames and Approach Channel

5.2.35 Dredging of the Thames and Approach Channel will be undertaken to depths up to 16.0m below chart datum although this will vary along the length of the channel. This work will potentially have an impact on the remains of ships and other craft which may be present on the seabed and also on Holocene and earlier deposits which may outcrop in these areas.

5.2.36 Monitoring schemes will be implemented to address any sites are uncovered by dredging the Thames and Approach Channel. Monitoring schemes will include provision for reporting protocols and for periodic survey

5.2.37 Further non-intrusive survey will be undertaken to confirm the significance of wreck sites and other anomalies indicated by the studies to date and to investigate areas beyond the Yantlet where no survey work has been undertaken. Where sites of potential archaeological interest are identified a phased programme of investigation will be undertaken where appropriate.

5.3 Reporting and Monitoring

5.3.1 Monitoring meetings will be held between P&O's ALO and the Principal Archaeological Contractor. These meetings will review progress in the context of Performance Indicators established by reference to the project design and set by P&O's ALO.

5.3.2 P&O's ALO will be responsible for providing regular progress reports to Thurrock Council and/or English Heritage as appropriate.

5.3.3 At key points in the programme, formal review meetings will be held to ensure that appropriate strategic decisions are made. These meetings will involve P&O's ALO, the Principal Archaeological Contractor and representatives of Thurrock Council and/or English Heritage as appropriate.

5.3.4 Representatives of Thurrock Council and/or English Heritage as appropriate will be given access to visit the site in order to satisfy themselves that compliance with the Mitigation Strategy is being achieved. Thurrock Council and/or English Heritage will be notified in advance of the completion of fieldwork to a timetable to be agreed.

5.3.5 An Essex Heritage Conservation Area Summary Sheet will be completed at the end of each phase of work for which a project design has been issued.

5.3.6 An outline of the procedures and structures for curatorial liaison is provided in paragraphs 4.1.2, 5.1.2 and 5.1.3 and Table 4.1.

6 STAFFING AND QUALITY STANDARDS

6.1 *Professional Codes - The Institute Of Field Archaeologists*

6.1.1 All work will be undertaken in accordance with the Code of Conduct of the Institute of Field Archaeologists (IFA), the Code of Approved Practice for the Regulation of Contractual Arrangements in Field Archaeology, the Standards and Guidance documents of the IFA and any Archaeological Guidance Papers issued by Essex County Council Archaeology Service in their capacity as advisors to Thurrock Council,.

6.1.2 All staff will be employed in line with the IFA's Codes, policy statements and guidance, and will normally be members of the IFA at the appropriate grade.

6.1.3 All archaeological work will be undertaken to agreed project-specific documentation (see 1.2.3), which will set out clearly measurable performance indicators which can be monitored.

6.1.4 Any archaeological contractors appointed to the project will normally be registered with the Institute of Field Archaeologists as archaeological organisations.

6.2 *Professional Guidance – English Heritage*

6.2.1 All archaeological works will follow guidance set out in *The Management of Archaeological Projects* (English Heritage 1991).

6.3 *Quality Management*

6.3.1 The Principal Archaeological Contractor will be expected to conform with appropriate professional practice as outlined above and to demonstrate this through quality management systems and procedures.

6.3.2 Each individual piece of archaeological investigation will be under the direction of a nominated project manager who will be responsible for its successful completion in all aspects. The work of the project managers will be monitored at a corporate level within the contracting organisation.

6.3.3 The Principal Archaeological Contractor will be required to demonstrate that an appropriate level of advice and technical support for the project managers is available from within the parent organisation and from other nominated support managers responsible for teambuilding, computing, report production, finds and archives, palaeo-environmental issues and other areas. A series of guidance manuals will form the basis for all work.

6.3.4 All work will be regularly monitored and checked whilst in progress; all documents will be checked before issue. There will be periodic reviews of progress, and formal progress reports will be issued to Thurrock Council and English Heritage as appropriate.

APPENDIX 1: HEALTH AND SAFETY

A1.1 LONDON GATEWAY: SPECIFIC PROCEDURES

A1.1.1.1 It is anticipated that any Principal Archaeological Contractor will act as a contractor within the meaning of the CDM Regulations 1994.

A1.1.1.2 The detailed safety management procedures for archaeological works at London Gateway will be set out in the Health and Safety Plan assembled by the principle contractor, and will provide for policy, organisation, auditing and measurement/review of performance. It is intended that through the implementation of each of these elements the project will adhere to the principles set out in Successful Health and Safety Management, HSE 1997.

A1.1.1.3 The following section is not intended to be exhaustive, but sets out the principal hazards which have been identified, and which will be addressed through development of the Health and Safety Plan, and by Risk Assessment.

A1.2 PRINCIPAL HAZARDS

A1.2.1 Excavations in Open Ground

- Potential Hazard - excavation collapse (due to poor ground conditions or high water table), overturning of vehicles and plant, falls into excavation, collapse of temporary support system.
- Risk Reduction - thorough investigation of ground conditions, correct method of ground support, correct signage and fencing/barriers, correct methods of plant support, supervision, permit to excavate, induction.

A1.2.2 Contaminated Ground

- Potential Hazard - wound infection, gases inhalation, allergic reaction, hepatitis, Weils disease.
- Risk Reduction - thorough soil analysis, specialist advice as to appropriate PPE, avoid contact with skin, wash-down equipment, availability of first aiders, first aid equipment and procedures, no eating/drinking/smoking within work areas, knowledge of Emergency Services contact procedures.

A1.2.3 Noise

- Potential Hazard - loss of hearing due to prolonged noise from excavators / compressors etc., difficulties in communication between workers, etc.

- Risk Reduction - use of ear defenders, use of communications equipment, thorough survey of noise conditions.

A1.2.4 Vehicle Movements

- Potential Hazard - overturning of vehicles, strike to pedestrians from vehicles, equipment damage from collision, strike from materials transported, collision of vehicles with other roads users.
- Risk Reduction - knowledge of vehicle movements around site, observing speed restrictions and direction signage, adequate fencing/barriers/earth bunding to work areas, lighting around excavation (dusk working), correct use of vehicles and plant, use of banksmen, agree routes and parking supervision.

A1.2.5 Buried Services

- Potential Hazard - cable strike - burns, shock, etc., damage to services - potential loss of supplies users, environmental impact of ruptured fuel lines, falls into excavations.
- Risk Reduction - thorough investigation of services, check with Shell/P&O, statutory undertakers, local authorities etc., hand-digging, correct identification of uncovered services, supervision, permit to excavate, familiarity with emergency procedures.

A1.2.6 Materials Storage

- Potential Hazard - environmental damage due to leaks (chemical cleaners, diesel etc.)
- Risk Reduction - storage of materials away from work place, bunded storage areas, knowledge of the Control of Substances Hazardous to Health (COSHH).

A1.2.7 Excavating Process

- Potential Hazard - overturning of plant, strike to personnel by plant (strike by bucket, run-over, strike by falling excavated material), strike to personnel by hand-tools.
- Risk Reduction - supervision, induction, use of banksmen, correct use of plant, correct methods of plant support, Personal Protection Equipment (PPE), i.e. hard hats etc., correct use and maintenance of hand-tools.

A1.3 EXTERNAL STANDARDS AND ADVICE

A1.3.1.1 All work will be carried out according to the requirements of all relevant legislation and guidance, including, but not exclusively: *The Health and Safety at Work etc. Act 1974, The Management of Health and Safety Regulations 1992*, the SCAUM (Standing Conference of Archaeological Unit Managers) H & S manual *Health and Safety in Field Archaeology 1991*, and the *Construction (Design and Management) Regulations 1994*, and *Construction (Health, Safety and Welfare) Regulations 1996*. In addition maritime work will be carried out in accordance with the *Diving at Work Regulations 1997*, and Commercial Diving Project inland/inshore approved Code of Practice (HSE).

APPENDIX 2: GENERAL INVESTIGATION AND RECORDING METHODS

A2.1 NON-INTRUSIVE SURVEY

STANDING BUILDING RECORDING

A2.1.1.1 Recording of any remaining significant buildings or structures may take place.

A2.1.1.2 The level of recording will be commensurate with the significance of the remains, and will be carried out in accordance with RCHME guidelines (RCHME 1999).

A2.1.1.3 Standard reference:

RCHME, 1999, *Recording Historic Buildings: A Descriptive Specification*, Royal Commission on the Historical Monuments of England, 1999
IFA, 2001 *Standard and Guidance for Archaeological Desk-based Assessment*, Institute of Field Archaeologists, compiled 1994, revised 2001
IFA, 2001 *Standard and Guidance for Archaeological Investigation and Recording of Standing Buildings and Structures*, Institute of Field Archaeologists, published 1996, revised 2001

TOPOGRAPHICAL SURVEY

A2.1.1.4 Targeted topographical survey may be carried out to record and analyse earthworks, field boundaries and other up-standing components of the historic landscape. Topographical surveys will only be undertaken following detailed historic map regression, so that the survey is informed by a clear understanding of the key landscape components.

A2.1.1.5 The level of detail recorded will be appropriate to the nature of the remains. Recording levels will be defined by RCHME guidance (1999).

A2.1.1.6 Standard reference: RCHME, 1999, *Recording Archaeological Field Monuments: A Descriptive Specification*, Royal Commission on the Historical Monuments of England, 1999

INTER-TIDAL WALKOVER SURVEY

A2.1.1.7 Inter-tidal walkover survey will be carried prior to reclamation in order to identify any new sites within intertidal areas. Only those elements of the foreshore that are safely accessible on foot will be surveyed.

A2.1.1.8 The results of walkover surveys will be documented in a text report. Any new features exposed in the inter-tidal zone will be subject to immediate topographical survey using GPS equipment. The level of recording will be commensurate with the significance of the remains, in accordance with RCHME guidelines (RCHME 1999).

A2.1.1.9 Standard reference: RCHME, 1999, Recording Archeological Field Monuments: A Descriptive Specification, Royal Commission on the Historical Monuments of England, 1999

FIELD ARTEFACT COLLECTION SURVEY

A2.1.1.10 Surveys will be carried out using a systematic linear transect sampling method. Artefacts will be separated into major categories (divided by period) including flint, pottery, Ceramic Building Materials (CBM) and metalwork.

A2.1.1.11 All surveys will comply with relevant guidance from Essex and Kent County Councils as appropriate.

GEOPHYSICAL SURVEY

A2.1.1.12 Detailed guidance on the selection of methods and sampling strategies can be found in the English Heritage Guideline paper 'Geophysical survey in archaeological field evaluation' (EH 1995). The advice of a specialist will be obtained before determining any geophysical survey evaluation strategy.

A2.1.1.13 A method statement will be submitted to the Thurrock Council or English Heritage as appropriate. A suitably qualified contractor specialising in archaeological surveyt will undertake the work.

A2.1.1.14 Standard reference: EH, 1995 'Geophysical survey in archaeological field evaluation'. *Research and Professional Guideline Paper No 1*, English Heritage.

AREA-BASED MARINE GEOPHYSICAL SURVEY

A2.1.1.15 Area-Based Geophysical Survey will comprise bathymetric, sidescan sonar, magnetometer and/or sub-bottom survey to identify potential archaeological sites in areas to be dredged not previously covered by such survey.

A2.1.1.16 Survey layout and system settings will be determined by prevailing seabed conditions and archaeological requirements.

A2.1.1.17 Data will be acquired digitally in tandem with GPS positioning and tidal records.

A2.1.1.18 Data will be post-processed to provide geo-referenced results.

A2.1.1.19 Geophysical survey results will be interpreted by a competent and suitably experienced archaeologist.

SITE-SPECIFIC MARINE GEOPHYSICAL SURVEY

A2.1.1.20 Site-Specific Geophysical Survey will comprise multibeam bathymetry, sidescan sonar, magnetometer and/or sub-bottom survey to establish the extents of buried/ferrous material and quantify the site prism (e.g. volume of hull).

A2.1.1.21 Survey layout and system settings will be determined by prevailing seabed conditions and archaeological requirements.

A2.1.1.22 Data will be acquired digitally in tandem with GPS positioning and tidal records.

A2.1.1.23 Data will be post-processed to provide geo-referenced results.

A2.1.1.24 Geophysical survey results will be interpreted by a competent and suitably experienced archaeologist.

METAL DETECTOR SURVEY

A2.1.1.25 Metal-detector survey will be used in conjunction with surface artefact collection survey and excavation as appropriate.

A2.1.1.26 Any involvement by amateur metal-detector users will be carried out under the supervision of a suitably experienced professional archaeological contractor, who will record the location of the artefacts and undertake specialist artefact identification, conservation and reporting.

ARCHAEOLOGICAL DIVING INSPECTION

A2.1.1.27 Archaeological inspection will comprise direct observation by a competent and suitably experienced archaeologist, by means of diving and/or remotely operated vehicle (ROV).

A2.1.1.28 Archaeological inspections will be positioned using a combination of GPS and acoustic techniques. Observations will be recorded using an integrated GIS-based structured recording system. Video and/or still images will be captured digitally or by conventional methods and incorporated in the recording system.

A2.2 DEPOSIT MODELLING

CONE PENETRATION TESTING (CPT)

A2.2.1.1 The CPT is performed with a cylindrical penetrometer with a conical tip (cone) penetrating into the ground at a constant rate of penetration. During the penetration, the forces on the cone and the friction sleeve are measured. The measurements are carried out using electronic transfer and data logging, with a measurement frequency that can provide detailed information about the soil conditions.

A2.2.1.2 The results from a cone penetration test can in principle be used to evaluate:

- stratification
- soil type
- soil density and in situ stress conditions
- shear strength parameters

A2.2.1.3 The equipment may be mounted on mobile rigs to 23 tonne tracked trucks. Equipment and test procedures will be in accordance with

BS1377.

MOSTAP SOIL SAMPLING

A2.2.1.4 MOSTAP sampling enables undisturbed soil samples to be recovered at depths, using a CPT rig. The available sample diameters are 35mm and 65mm, with sample lengths of 1m, 1.5m and 2m. This method is suitable for recovering column samples for geoarchaeological and palaeoenvironmental purposes and soil samples for micro-artefact sieving.

A2.2.1.5 MOSTAP sampling will be the preferred method for refining the deposit model in areas with suitable ground conditions. The main limitation of the method is that it can only be used to penetrate soft, fine-grained deposits such as alluvial silts and peats (it can be applied in areas of hard standing by first excavating a starter hole to the top of the alluvial deposits).

A2.2.1.6 A MOSTAP sampler consists of a cone with a cutting mouth at the base, connected to a sample tube, complete with a lining stocking. This is connected to standard CPT rods and pushed using the Hydraulic Rams to the predetermined depth. A fishing tool is lowered through the hollow rods to release the cone face. The apparatus is then pushed further to take the soil sample, while the released cone stays in the top part of the sample tube. Upon withdrawing the probe, the equipment is dismantled allowing the sample to be retrieved, including the 200mm section in the cutting head. Both of these are labelled to identify location and depth. The equipment is thoroughly cleaned, assembled and is ready for the next sample to be taken.

A2.2.1.7 Storage and handling procedures will follow the guidance set out in Environmental Archaeology Centre for Archaeology Guidelines English Heritage 2002. Logging and processing of samples will be undertaken by a suitably qualified geoarchaeologist.

A2.2.1.8 Where appropriate, and where columns are not required for further environmental sampling or archive purposes, remaining soil will be cut into 100mm lengths and micro artefact sieved.

SHELL AND AUGER BOREHOLES

A2.2.1.9 Shell and auger boreholes will be used to corroborate the results of Cone Penetration Testing and recover intact column samples from key locations. Generally these boreholes will be designed to recover information for geotechnical, contaminated land and archaeological purposes. Where appropriate archaeological purposeful shell and auger boreholes may be drilled to ensure key sampling locations determined on the basis of the preliminary deposit model are targeted, and to ensure adequate sample coverage from all of the main environments of deposition.

A2.2.1.10 Drilling will be monitored in the field by a suitably qualified geoarchaeologist. Boreholes will be drilled with a shell and auger drill rig. Where possible in soft sediments U100 drill cores will be taken continuously down the borehole and individual cores will be wax sealed after removal from the drill shoe. Drill shoe samples will be retained as bulk samples between successive U100 cores. Where ground conditions are unsuitable for U100 sampling bulk or small disturbed samples will be taken.

A2.2.1.11 Boreholes for combined geotechnical, contaminated land and archaeological purposes. will be undertyaken in accordance with the SISG Specification for Ground Investigation (Thomas Telford) and logged to BS5930 by suitably qualified personnel. Stratigraphy will be logged by reference to material recovered from disturbed samples including the drill rig cutting shoe or from the top and bottom of recovered drill cores. All U100 cores will be labelled and assigned depths below ground surface. Individual boreholes will be located in 3-dimensional space by GPS survey to Ordnance Datum and National Grid. On return of cores to the laboratory individual cores will be split lengthways and a face of one half of the core cleaned and photographed (colour print record) by a geoarchaeologist and an integrated borehole description produced from the combined field and laboratory recording.

A2.2.1.12 Where appropriate, and where columns are not required for further environmental sampling or archive purposes, remaining soil will be cut into 100mm lengths and sieved for micro-artefacts.

MARINE BOREHOLES AND VIBRO-CORES

A2.2.1.13 Investigations comprising boreholes and vibro-core sampling will be undertaken across the areas of the proposed dredge for design purposes and specified accordingly. However a suitably qualified geoarchaeologist will be present to log the holes and samples from an archaeological perspective. Samples where possible will be obtained for environmental analysis.

MICRO-ARTEFACT SIEVING

A2.2.1.14 The samples will be extracted and the columns described. Any environmental sub-samples will be taken and the remaining soil will be cut into 100mm lengths, which will be wet sieved through a graded nest of sieves of mesh-sizes 10, 4, 2, 1 and 0.5mm. The residues will be scanned under a low-power binocular microscope, to recover micro-artefacts and any other possible traces of anthropogenic activity (eg, flint, micro-debitage, pottery fragments, charcoal, bone, vivianite).

A2.2.1.15 Any micro-artefacts recovered will be identified (where possible) and divided into major material groups by period. The distribution of the different artefact types will be plotted in plan and section against the topographical model.

DEPOSIT MODELLING: ANALYSIS AND INTERPRETATION

A2.2.1.16 Stratigraphic information from individual logs will be entered into Terrastation II software or equivalent (a specialist geological modelling program) in order to allow borehole cross-sections to be generated and topographical projections of identified surfaces to be constructed (eg Pleistocene gravel surface topography). Information from vibro-cores, geophysical surveys, boreholes, test pits and CPTs will be examined as appropriate and the major stratigraphic units identified. A first stage of modelling has already been undertaken for the London Gateway, and further data will be added to the existing Terrastation II database as it becomes available.

A2.2.1.17 Interpretation of the geological sequence at each stage will be informed by dating information and palaeoenvironmental data, as it becomes available. At each stage of assessment, a summary of the information from the site investigations will be prepared, accompanied by up-dated cross-section illustrations and topographical models with time-depth information (ie illustrating the edge of the floodplain and inter-tidal zones in each major period, incorporating palaeoenvironmental assessment data).

A2.3 EXCAVATION AND RECORDING

GENERAL RECORDING PROCEDURES

A2.3.1.1 In order to facilitate the production of an overall project archive of consistent standard, the following recording procedures will be applied as far as possible to all the types of excavation due to be undertaken.

A2.3.1.2 As a general principle all recording will be based around a unified data collection and management system which will be GIS-based and will automate much of the information tracking, validation, auditing and checking, to reduce the need for manually generated registers and cross referencing. Data will be backed up regularly typically on a 4-week complete/1-week incremental/daily incremental rotation and the system will be regularly monitored. 4-week and 1 week tapes will be stored off-site in fire-proof safes.

A2.3.1.3 Each specific area, site or group of sites identified as sub-projects within a single Project Design will be assigned a unique alphanumeric site code, to be agreed with the recipient museums, which will be used to identify all records, finds and samples relating to that piece of work.

A2.3.1.4 All on-site recording will be undertaken in accordance with the requirements of the appropriate standards as set out in the various methodologies contained in this document which should be unified, modified and developed as necessary to take account of innovations being developed for this project or elsewhere, to take account of its emphasis on on-site interpretation and sophistication in the management of digital data.

A2.3.1.5 A continuous unique numbering system will be operated across the whole project. Written descriptions will be recorded on proforma sheets comprising factual data and interpretative elements. The latter element will be enhanced to maximise on-site understanding of the archaeology, particularly regarding deposition processes. All written descriptive and interpretative data will be entered into the project database which will include automatic validation of terms and generation of cross-referencing to digital drawings and finds data.

A2.3.1.6 Where stratified deposits are encountered a Harris Matrix will be compiled during the course of the excavation if appropriate.

A2.3.1.7 Plans and sections will normally be drawn digitally and may therefore be presented and reproduced at any appropriate scale. Very detailed plans may be hand-drawn and then scanned digitally.

A2.3.1.8 A full black and white and colour (35mm transparency) photographic record, illustrating in both detail and general context the principal features and finds discovered will be maintained. The photographic record will also include working shots to illustrate more generally the nature of the archaeological work. Digital photography will also be used and tied into the digital GIS data sets, allowing photographic images to be rectified and related directly to digital drawing data.

TEST PITS

TEST PITS (SHORED)

A2.3.1.9 Shored test pits may be required to enable manual access to undertake detailed recording of key sequences and recover intact monoliths tin samples and bulk samples from a safe situation in unstable ground at depth.

A2.3.1.10 Shoring methods will vary according to ground conditions and depth of excavation. Hydraulic manhole boxes will used where possible, but alternative shoring methods may be adopted if necesssary. A mechanical excavator, working under close archaeological supervision, will excavate sufficiently to allow appropriate support to be inserted into the pit.

A2.3.1.11 Additional support will added to provide safe person access to the required depth. The full depth of excavation will be achieved by digging and installing support as the excavation proceeds. Dewatering, if required, will be done using an appropriately sized pump which will normally discharge into adjacent areas of vegetation where it can percolate to the water table. Where trench boxes are used the open ends will be closed with light duty trench sheets, leaving a viewing window to permit recording of the section.

A2.3.1.12 Manual access will be by fixed ladder. Personnel entering supported test pits will be trained for work in confined spaces including use of escape sets and gas detection equipment. Gas monitors for hydrocarbon vapours, methane, carbon dioxide and oxygen will be lowered into each trench prior to entry by site staff after initial excavation and at the beginning of each day. Staff working within supported test pits will be supplied with escape kits. No manual access by any means will be permitted at locations with inherently unstable or contaminated ground, such as landfill deposits. Each test pit location will be secured with 2m high Heras fencing or similar, and edge protection will comprise 1m high heras fence barriers or similar held in place by 1.5 m driven wooden stakes.

A2.3.1.13 Supported test pit sections will be cleaned and recorded by the specialist geoarchaeologist. For evaluation purposes, sieving will be carried out as for unsupported test pits, the soil normally being recovered by machine excavation in spits. Intact monolith or other palaeoenvironmental samples may be recovered for laboratory investigation samples.

A2.3.1.14 Where very rich deposits, land surfaces or activity areas such as working floors are identified, mechanical excavation will stop and the test pit will made safe for manual access. Hand cleaning and detailed recording will take place.

A2.3.1.15 Standard reference: IFA, 2001 *Standard and Guidance for Archaeological Excavation*, Institute of Field Archaeologists, compiled 1994, revised 2001

TEST PITS (UNSHORED)

A2.3.1.16 In unshored test pits no manual access will be permitted below 1.2m or less depending on the ground conditions.

A2.3.1.17 The test pit will be excavated by a mechanical excavator, working under close archaeological supervision.

A2.3.1.18 The method of excavation may vary according to the type of deposit being excavated. When investigating Pleistocene gravels for Palaeolithic artefacts, or faunal and floral remains, material will be excavated in spits of no more than 0.2m. Soil from individual spits, each give a separate context number, will be stored separately and labelled with their context number, in preparation for dry-sieving.

A2.3.1.19 When testing the depth of Made Ground, excavation may be undertaken rapidly until undisturbed natural deposits are encountered.

A2.3.1.20 In unsupported pits the general sequence of deposits will be recorded as far as possible by observation and photography from the top of the pit and descriptions of the excavated soil.

A2.3.1.21 Standard reference: IFA, 2001 Standard and Guidance for Archaeological Excavation, Institute of Field Archaeologists, compiled 1994, revised 2001

OPEN AREA EXCAVATIONS

IN SHALLOW SEQUENCES

A2.3.1.22 Extensive open area excavation (including strip, map and sample) is suitable for areas in which archaeological features are buried at a shallow depth, normally in terrace areas or on the floodplain surface /margins. Areas of excavation will be stripped of topsoil and other overburden mechanically. An appropriate machine will always be used. This will normally be a 360° tracked excavator with a 1.5 or 1.8m wide toothless bucket. Lorries or dumpers will be used to move spoil to the storage areas. No machinery will be allowed to cross stripped areas.

A2.3.1.23 All machining will be undertaken under direct archaeological supervision.

A2.3.1.24 All undifferentiated topsoil or overburden will be removed down to the significant archaeological horizon or natural subsoil, whichever is encountered first.

A2.3.1.25 Each archaeologically significant interface will be cleaned by hand using appropriate tools, normally shovels, hoes or trowels.

A2.3.1.26 A site grid covering the area of investigation will be established, related to survey points established for the scheme and to the Ordnance Survey Datum and National Grid. Temporary benchmarks related to main survey points for the scheme will be set up.

A2.3.1.27 The sampling strategy for the excavation of archaeological features will be determined after the initial surface clean, and will normally adhere to the following principles:

1. Structures and specific features of specialised activity: (eg industrial, agricultural processing, ceremonial, funerary) will be fully excavated and all relationships recorded.
2. Ditches and gullies and other linear features (eg walls and robber trenches): all significant relationships will be defined and investigated. All terminals of linear features will normally be excavated. Sufficient length of the feature will be excavated to determine its character over its entire course with consideration given to possible recutting or remodelling. Should specialised deposits (eg. localised refuse dumping, industrial wastes) be discovered, then more extensive excavation may need to take place. Sufficient artefact assemblages will be recovered to assist in dating stratigraphic sequences and for obtaining ceramic assemblages for comparative purposes. Following hand sampling and detailed recording, bulk sample excavation of features by machine may be undertaken to enhance artefact recovery as an addition to the basic sampling where this is archaeologically justified.
3. Pits: An appropriate representative sample will be half sectioned, or in the case of complex intercutting suitably sectioned to elucidate the relationships.. Some pits may be fully excavated where the special nature of deposits or the need to fully recover artefacts in order to fulfil the overall objectives of the excavation (this is typically the case with earlier prehistoric pits and those containing 'special' deliberate deposits).
4. Post and stake holes: where they are thought likely to form a structure 100% (by number) will be half sectioned ensuring that

all relationships are investigated. Where deemed necessary (by artefact or palaeoenvironmental content, or the need to verify the interpretation) a number may require full excavation or specialised sampling.

5 Extensive archaeological deposits and buried soil horizons: where such deposits are of limited extent they may be fully excavated with appropriate palaeoenvironmental sampling. Where they are more extensive they will be sampled to a sufficiently to achieve the aims and objectives of the Project.

6 Working hollows, quarry pits etc: The scale and method of excavation will be determined by the need to define their extent, date and function. All significant relationships will be investigated and one or more hand dug sections cut to establish the character of the fill, floor of the feature and any evidence of method of excavation, and to obtain dating evidence; further investigation will be a matter for the specific cases and on-site judgement. Unless there are specific reasons to expect special deposits or stabilised horizons with evidence of occupation activity in their backfill, a combination of machine excavation following the basic stratigraphy and hand sampling mayl be used for further excavation.

A2.3.1.28 Standard reference: IFA, 2001 *Standard and Guidance for Archaeological Excavation*, Institute of Field Archaeologists, compiled 1994, revised 2001

IN DEEP SEQUENCES

A2.3.1.29 Excavation will be carried out by stepping (and/or battering) or shoring trench sides.

A2.3.1.30 Shoring methods will vary according to ground conditions, depth and area of excavation. A Site Engineer will be appointed to oversee the design and installation of any substantial shoring system. Site specific method statements will be prepared. Close sheeting and hydraulic steel frame shoring methods will be used by preference as this system allows logging of the deposit sequence by removing individual sheets at selected locations.

A2.3.1.31 Manual access will be by fixed ladder. Personnel entering supported test pits will be trained for work in confined spaces including use of escape sets and gas detection equipment. Gas monitors for hydrocarbon vapours , methane , carbon dioxide and oxygen will be lowered into each trench prior to entry by site staff after initial excavation and at the beginning of each day. Staff working within supported test pits will be supplied with escape kits. No manual access by any means will be permitted at locations with inherently unstable or contaminated ground, such as landfill deposits. The excavation area will be secured with 2m high Heras fencing, and edge protection will comprise 1m high hears fence barriers held in place by 1.5 m driven wooden stakes.

A2.3.1.32 Where very rich deposits, land surfaces or activity areas such as working floors are identified, mechanical excavation will stop and the excavation area will made safe for manual access.

A2.4 ARTEFACT RECOVERY AND CONSERVATION

A2.4.1.1 The following provisions will apply as far as reasonably possible to all the types of archaeological investigation proposed. This is likely to prove most effective for excavation, and of more limited application to the other types of investigation.

A2.4.1.2 All artifacts recovered from hand excavated contexts will be retained unless they are of recent origin. In these cases sufficient of the material will usually be retained where it is important to validate the date and establish the function of the feature.

A2.4.1.3 Some categories of finds of limited intrinsic interest may be sampled and recorded on site where their retention is not considered to contribute to the archaeological aims and objectives of the Project *and* they would constitute an excessive storage burden. Examples may be burnt stone or undifferentiated post medieval tile fragments.

A2.4.1.4 Unstratified objects from topsoil or other modern deposits will not normally be retained except where they are collected for a specific purpose (as with test pits) or are of intrinsic interest either in their own right or in contributing to an understanding of the site.

A2.4.1.5 Recovery will normally be by hand, except where bulk samples are taken for other purposes or for special recovery of small items (eg with cremation deposits).

A2.4.1.6 In certain circumstances where unusual or extremely fragile and delicate objects are found, then their recovery will be by appropriate specialists who will be named in the Project Design. Metal objects requiring identification will be x-rayed during the course of fieldwork.

A2.4.1.7 All finds and samples will be treated in an appropriate manner and to standards agreed in advance with the approved recipient museum. These will be exposed, lifted, cleaned, stabilised, marked, bagged and boxed in accordance with the guidelines set out in the United Kingdom Institute for Conservation's (UKIC's) "Conservation Guidelines No. 2".

A2.4.1.8 Any wreck material found in UK territorial waters (to 12 mile limit) must under section 2.36 of the Merchant Shipping Act 1995 be reported to the Receiver of Wreck. This will be undertaken by the Principal Archaeological Contractor who will complete a "Report of Wreck and Salvage Form" and submit it to the Receiver of Wreck at Bay 1/05 Spring Place, 105 Commercial Road, Southampton, SO15 1EG within 28 days.

A2.4.1.9 Standard references: UKIC, United Kingdom Institute for Conservation's (UKIC's) "*Conservation Guidelines No. 2*".

A2.5 WATERLOGGED WOODEN STRUCTURES AND OBJECTS

A2.5.1.1 In the event of the discovery of significant in situ waterlogged timbers, the area will be exposed and cleaned to allow the structure to be identified and characterised. Excavation will aim to establish the extent, depth, orientation, context and preservation of the structure, and its potential to address the Research Aims of the project.

A2.5.1.2 When waterlogged wood is found a specialist in ancient wood-working must be involved to advise on identification, dating, recording and treatment of worked wooden structures. On-site assessment by the specialist should ensure that as much recording as possible is carried out on site. Individual timbers will only be removed from site for specific purposes, such as more detailed recording of technological characteristics, dendrochronological dating or for species identification.

A2.5.1.3 Samples of waterlogged timbers, and bulk soil samples from associated deposits, will be recovered for possible radiocarbon and dendrochronological dating and for palaeoenvironmental analysis. A conservation specialist and specialist in ancient wood-working will advise as necessary. If the date of a structure is in doubt, dendrochronological sampling should be attempted where possible before detailed work is undertaken.

A2.5.1.4 Structures or boats, depending on their date condition and significance, may require lifting in their entirety, either as individual timbers or intact. Ephemeral wattle structures will normally be recorded on site and sampled for species identification and other analytical procedures.

A2.5.1.5 Natural accumulations, potentially including drowned forests, may be a valuable source of palaeoenvironmental evidence, and samples may be taken for dendrochronological dating and species identification, on advice from suitably qualified specialists.

A2.5.1.6 Provision will be made for the conservation and long-term museum storage of waterlogged wooden structures or artefacts of national or regional importance. Alternatives to physical preservation, including detailed 3-dimensional digital scanning, may be considered in some circumstances.

A2.6 PALAEOENVIRONMENTAL SAMPLING

A2.6.1.1 The following general principles will apply as far as reasonably possible to all the types of archaeological investigations. Site specific sampling strategies will be formulated as necessary by the palaeoenvironmental co-ordinator.

A2.6.1.2 Different environmental sampling strategies may be employed according to established research targets and the perceived character, interpretative importance and chronological significance of the strata under investigation. The following gives an outline of the typical sampling strategies likely to be adopted for deposits with particular potential for palaeoenvironmental analysis.

A2.6.1.3 Bulk samples of 20 to 40 litres will be taken for flotation for *carbonised remains* where there is clear indication of good potential for such material.

A2.6.1.4 Bulk samples of 10 litres will be taken from significant datable waterlogged deposits for *insects and macroscopic plant remains*.

A2.6.1.5 Sub-samples or Column samples of waterlogged deposits and sealed buried soils with potential for *pollen* preservation will be taken for analysis if appropriate.

A2.6.1.6 Bulk samples of 1 kg will be collected for *molluscs* if clearly present, and columns of such samples will be taken through deposits where there is clear potential for recovering a datable sequence of environmental information.

A2.6.1.7 Recovery of *small animal bones* will normally be achieved through processing other bulk samples or may be taken specifically to sample particularly rich deposits.

A2.6.1.8 Each deposit in *possible human cremations* will be recovered as described in A2.3.7.7 - A2.3.7.9

A2.6.1.9 Undisturbed monolith tin samplesor column samples of sediments will be taken for *micromorphology* of buried soils where these are likely to shed important light on the environmental development of the area.

A2.6.1.10 Column samples or monolith tins samples may be sub-sampled for assessment of *microfauna* and *diatoms*.

A2.6.1.11 Soil chemistry samples will comprise 1kg of soil, which is sufficient to undertake the full range of tests including *particle size, magnetic susceptibility, phosphate/ nitrate analysis* and *loss-on-ignition*.

A2.6.1.12 Standard Reference: English Heritage 2002, Environmental Archaeology; A guide to the theory and practice of methods, from sampling and recovery to post-excavation.

A2.7 EXCAVATION AND RECORDING OF HUMAN REMAINS

BURIAL LICENCES

A2.7.1.1 IFA Technical Paper No. 11 on the Law and Burial Archaeology outlines the legal requirements where human remains are encountered (Garrett-Frost et al 1993). Home Office licenses are required for the removal of buried human remains unless covered by Faculty or the Disused Burials Ground Act

UNCREMATED HUMAN REMAINS

A2.7.1.2 All excavation and recording will be undertaken in accordance with the requirements and the recommendations of IFA Technical Paper No.13 (McKinley and Roberts). IFA Technical Paper No. 3 on crypt clearance and post-medieval remains may be relevant (Cox 2001).

A2.7.1.3 Processing: All skeletons, with the exception of samples chosen for DNA analysis, will be washed, dried, placed in clear plastic bags and stored in archivally acceptable cardboard boxes. Skulls and post-cranial elements will normally be boxed separately and cross-referenced.

A2.7.1.4 All articulated skeletons will be numbered with permanent ink. It will not be necessary to mark disarticulated bone.

A2.7.1.5 Post-Excavation Assessment and Analysis: Assessment and analysis will be undertaken by reference to published guidelines (Mays 2002) and draft guidelines to be published jointly by BABAO and the IFA (numerous authors forthcoming).

A2.7.1.6 Standard osteological techniques will be used in the establishment of age at death, (Miles 1962, 1963; Lovejoy et al 1985; Buikstra and Ubelaker 1994). Standard osteological techniques will be used in the multi-factorial assessment of biological sex (Steele and Bramblett 1988; Buikstra and Ubelaker 1994). Individuals will be assigned to probable male, probable female or unknown categories where incompleteness, poor preservation, or ambiguous results prohibit definitive assignment to either sex. Stature will be calculated for adult individuals (Trotter 1970). Pathology will be recorded and interpreted by references to standard texts (eg; Ortner and Putschar 1981; Buikstra and Ubelaker 1994, Roberts and Manchester 1995)

CREMATED HUMAN REMAINS

A2.7.1.7 Excavation and recording: All cremation burials will be subjected 100% sampling. Undisturbed urns should be lifted intact and where possible their contents should be excavated in a series of 20 mm spits by the osteo-archaeologist in order to identify bone as it is removed. A specialised cremation recording sheet should be used for this purpose. There are standard recommendations available for the excavation, recording, assessment and analysis of cremated human bone (eg McKinley 1994). These will be adhered to at all times.

A2.7.1.8 Processing: All bulk samples will be processed by mechanical flotation in a modified Siraf machine for the recovery of charred plant remains, with the sample held on a 500 μm and the flot collected on a 250 μm mesh. The remaining clean residues will be wet-sieved by washing through sieves sized 10 mm, 4 mm, 2 mm and 0.5 mm. Residues will be sorted to 4 mm for bones and artefacts and the fine residues to 0.5 mm will be retained for assessment. The flots and fine residues will be air-dried and scanned under a binocular microscope at x10 and x20 magnification. The presence of any seeds and chaff will be noted and an estimate of abundance made. Fragments of charcoal will be randomly extracted, fractured and examined in transverse section. The potential of the small fragments of cremated bone will be assessed.

A2.7.1.9 Post-excavation assessment and analysis: Assessment and analysis will be undertaken by reference to published guidelines (Mays 2002) and draft guidelines to be published jointly by BABAO and the IFA (numerous authors forthcoming).

HEALTH AND SAFETY WHEN HANDLING HUMAN REMAINS

A2.7.1.10 Funerary archaeology can present a specific and complex range of hazards, particularly in the context of post-medieval human remains. All staff will wear protective clothing if required and site-specific risk assessments will be produced as required.

A2.7.1.11 Where wooden coffins were used there may be an increased risk of infection due to occasional good preservation of bodies and other materials. The highest risk category is from sealed lead coffins. If any soft tissue remains the hazard presented will be treated as potentially severe and suitable protective systems will be used. There is a risk of increased lead levels in the blood of workers dealing with lead coffins, particularly in confined spaces. In such circumstances monitoring of blood lead levels of staff is required.

DNA ANALYSIS

A2.7.1.12 DNA samples will be collected by appropriately qualified staff who must wear protective clothing in order to avoid contamination with modern DNA. Sealed containers for the samples and a freezer capable of storage of samples at below – 20 degrees centigrade will be provided.

ISOTOPE ANALYSIS

A2.7.1.13 Where sampling for trace element analysis is to be undertaken it will be necessary to take soil samples from around the skeleton to provide a check for the effects of diagenesis.

A2.7.1.14 Standard references:

Cox, M 2001 Crypt archaeology: an approach, *IFA Technical Paper No. 3*

Garratt-Frost, S, Harrison, G and Logie, J G 1993 The Law and Burial Archaeology, *Institute of Field Archaeologists: Technical Paper No. 11*

McKinley, J I and Roberts, C 1993 Excavation and Post-Excavation Treatment of Human Remains, *Institute of Field Archaeologists: Technical Paper No. 13*

Mays, S 2002 Human bones from archaeological sites. Guidelines for producing assessment documents and analytical reports, Centre for Archaeology, English Heritage

A2.8 ARCHAEOLOGICAL MONITORING AND RECORDING

TERRESTRIAL MONITORING

A2.8.1.1 Monitoring and Recording will comprise, observation, investigation and recording of excavation works carried out in connection with the main construction programme, which may be used to obtain preliminary data.

A2.8.1.2 Standard reference: IFA, 2001 Standard and Guidance for Archaeological Watching Brief, Institute of Field Archaeologists, published 1994, revised 2001 A3.n

MARINE MONITORING

DISPERSAL/CLEARANCE WITHOUT RECORDING

A2.8.1.3 Material considered to be of no archaeological interest will be subject to dispersal/clearance without further archaeological recording, using methods appropriate to construction/engineering requirements.

DISPERSAL/CLEARANCE WITH RECORDING

A2.8.1.4 Material of archaeological interest whose permanent curation is not warranted will be subject to limited archaeological recording in the course of dispersal/clearance by methods appropriate to construction /engineering requirements.

A2.8.1.5 Recording will be carried out in accordance with the methods and standards applied to recording on land, subject to the adoption of working practices appropriate to environmental conditions and risks.

REPORTING MECHANISM

A2.8.1.6 Reporting mechanisms will comprise protocols and guidance to be applied by marine construction staff in order to bring archaeological attention to any sites uncovered during construction. Reporting mechanisms will include provision for archaeological supervision, training for construction staff and feedback mechanisms to ensure the effectiveness of the monitoring scheme

PERIODIC INSPECTION

A2.8.1.7 Periodic inspections will be carried out on the base and section of recently–cut areas to identify any hitherto unrecognised archaeological material that has become exposed.

A2.8.1.8 Periodic inspection will comprise direct observation by a competent and suitably experienced archaeologist, by means of diving and/or remotely operated vehicle (ROV). The methods set out above in respect of Archaeological Inspection will apply.

PERIODIC GEOPHYSICAL SURVEY

A2.8.1.9 Periodic Geophysical Survey will be carried out on areas and sites subject to dredging to identify any hitherto unrecognised archaeological material that has become exposed.

A2.8.1.10 Periodic Geophysical Survey will be carried out using the methods set out above in respect of Area-Based and Site-Specific Geophysical Survey.

A2.9 POST-EXCAVATION ASSESSMENT METHODS

PREPARATION OF PROJECT ARCHIVE AND REVIEW

A2.9.1.1 The post excavation procedures will follow those set out in The Management of Archaeological Projects (MAP2 English Heritage 1991)

A2.9.1.2 The site archive (paper, digital and photographic record, artefacts and environmental samples) will be prepared for long-term storage in accordance with *Guidelines for the preparation of excavation archives for long term storage* (Walker 1990 - UKIC) and Standards *in the Museum Care of Archaeological Collections* (Museums and Galleries Commission 1992), to a standard from which post excavation assessment may proceed in a format agreed in advance with the recipient museum.

A2.9.1.3 The receiving Museum will be further consulted about their conditions for long term conservation and storage of the archives and excavated material.

A2.9.1.4 On completion of each main stage of the excavations and monitoring and recording the same procedure as above will be adopted.

GENERAL ASSESSMENT PROCEDURES

A2.9.1.5 Post-excavation assessment will be undertaken in stages governed by the development programme and the results of fieldwork.

A2.9.1.6 The final post-excavation assessment will conclude on completion of the reviews of the last purposive archaeological works, and will include the results from all archaeological investigations. The results of additional work will be added as revisions to the post- excavation assessment as the programme allows.

A2.9.1.7 Site archives will be security copied and a copy deposited with the NMR before post-excavation analysis begins or as soon thereafter as can be conveniently arranged. Digital data will be the subject of a regular programme of security copying.

A2.9.1.8 A summary report will be prepared on completion of a site archive. This will include:

- A re-assessment of the research aims of the fieldwork and an illustrated summary of results to date indicating to what extent the aims were fulfilled or extended.
- A list of the project aims as understood in the light of the results of fieldwork and post-excavation assessment.
- An explanation of the methods which will be used to achieve the research aims (these should be explicitly linked to aims).
- A list of all the main tasks involved in using the stated methods to achieve the aims and produce a report and research archive in the stated format, wherever possible linking each task explicitly to the relevant method statement and indicating the personnel

and time in days involved in each task. Allowance will be made for general project-related tasks such as monitoring, management and project meetings, editorial and revision time.

- A provisional report synopsis, broken down into chapters, section headings and subheadings, with approximate word lengths and numbers and titles of illustrations per chapter. The structure of the report synopsis should explicitly reflect the research aims of the project.
- A list of the personnel involved indicating their qualifications for the tasks undertaken.
- A cascade or Gantt chart indicating tasks in the sequence and relationships required to complete the project.
- Provisional publication options indicating potential publisher(s) and report format.

A2.9.1.9 Assessment will include baseline recording of artefact and environmental assemblages, which will be undertaken concurrently with the fieldwork, to allow constant feedback and inform the developing research strategy. Where relevant, material will be sorted and re-boxed by context groups in the course of the assessment. Where possible specialist databases will be designed so that any further recording can build directly on the assessment data. Recording will be undertaken in accordance with the methods detailed below.

ARTEFACT ASSESSMENT

CERAMICS

A2.9.1.10 All ceramic material will be recorded to a consistent baseline level at the assessment stage. Any further analysis will consider selected contexts only. Assessment level data will comprise quantification by sherd count and weight per context. Form, fabric and Estimated Vessel Equivalent (EVEs strictly rim equivalents - REs - for rim sherds) will also be recorded where relevant. The assessment will recommend selected contexts for further detailed recording in the analysis stage. Residue analysis will be recommended if it has the potential to contribute significantly to the project research aims. Form and fabric identifications for local wares will follow existing regional typologies as far as possible.

A2.9.1.11 Brick, tile and structural fired clay assessment level recording will comprise quantification by context, artefact category, with comment on assemblage composition and date (loomweights and other fired clay objects will be separated out and assessed with the small finds).

A2.9.1.12 Standard References:

Darling, M, 1994 (ed) *Guidelines for the archiving of Roman pottery*, Study Group for Roman Pottery Guidelines Advisory Document 1, London

PCRG, 1997 The Study of Later Prehistoric Pottery: General Policies and Guidelines for Analysis and Publication, Prehistoric Ceramics Research Group

RFG & FRG 1993 *Roman Find Group and Finds Research Group AD 700-1700, 1993*. The guidelines for the preparation of site archives and assessments for all finds other than fired clay vessels

Slowikowski, A, Nenk, B, and Pearce, J, 2001 *Minimum standards for the processing, recording, analysis and publication of post-Roman ceramics*, Medieval Pottery Research Group Occ Paper No 2

WORKED FLINT

A2.9.1.13 All worked flint material will be recorded to a consistent baseline level at the assessment stage. Any further analysis will consider selected contexts only. Baseline recording will comprise quantification by context, artefact category and summary comments on assemblage composition, technological characteristics, use-wear and date.

A2.9.1.14 Numbers of burnt and broken pieces and the weight of cores will also be recorded, to allow the general condition of the material to be compared across the development area. Burnt unworked flint will be recorded by number, weight and general appearance.

SMALL FINDS

A2.9.1.15 This category includes artefacts made from worked stone (including shale, amber and precious stones) fired clay (objects, but not structural fired clay, which is assessed under the Ceramics heading), worked bone, glass (including frit), organics/textiles, metalwork (including gold, silver, copper alloy, iron and lead) and slag/metalworking debris.

A2.9.1.16 Stabilisation conservation will be undertaken where urgent attention is required, in the field if necessary. X-radiography of all metalwork and archive recording of all objects will be carried out as part of standard artefact processing procedures.

A2.9.1.17 Small finds will be assessed in accordance with the Roman Find Group and Finds Research Group AD 700-1700, 1993 guidelines (RFG & FRG 1993). Assessment level recording will comprise baseline catalogue information including Small Find Number, context, material, artefact category and date. The assessment catalogue will note any further conservation requirements for long-term storage and the potential for further analysis, including investigative conservation, metallurgy, petrology, further X-rays, Scanning Electron Microscopy and X-Ray fluorescence.

A2.9.1.18 Metal-working residues will be examined, weighed and recorded by context. Smithing hearth bottoms will be individually weighed and measured. Gridded sub-samples from metal-working sites will be examined for hammerscale and other micro-slags by running a magnet through the contents.

A2.9.1.19 Standard reference: RFG and FRG, 1993, *Roman Find Group and Finds*

Research Group AD 700-1700, 1993 guidelines

PALAEOENVIRONMENTAL AND PALAEOECONOMIC ASSESSMENT

CHARRED PLANT REMAINS

A2.9.1.20 Charred plant remains are generally recovered from archaeological features and derive mainly from economic activities, such as crop-processing or metal-working, or ritual activities such as human cremation.

A2.9.1.21 The on-site sampling strategy will usually focus on secure, dated contexts with high potential for charred remains and the capacity to contribute to the project research aims. It is therefore expected that all samples collected for charred plant remains will be processed and assessed.

A2.9.1.22 Samples will be processed by bulk water flotation and flots will be collected onto 250μm mesh sieves. Residues will be retained on 1mm sieves. The assessment level data will record the volume of material processed from each sample, the flot size and the number of samples for each feature type, divided by phase. All flots will be scanned by a palaeobotanist and estimates of abundance will be made for each species present. Summary information will be presented, indicating abundance of grain, chaff, weed seeds and charcoal by context. *New flora of the British Isles* (Stace1991) will be used to obtain the up-to-date taxonomy for the different plants.

A2.9.1.23 Estimates of abundance will be made on a five-point scale:

+ = 1-10 items
++ = 11-50 items
+++ = 51-100 items
++++ = 101-1000 items
1000+ = >1000 items

A2.9.1.24 The identification of the plant material will be carried out with the aid of a botanical reference collection housed at the Museum of London Specialist Services, Mortimer Wheeler House, London. Reference manuals will also be consulted for identification purposes, eg. Berggren (1969, 1981), Anderberg (1994), Beijerinck (1947).

A2.9.1.25 The assessment of charcoal will normally comprise a scan of flots by a charcoal specialist, noting wood species identification, feature type and estimated abundance by context. Charcoal assessment and any further analysis will normally be closely focussed on specific objectives, such as fuel use in human cremation pyres or on metal-working sites. Nomenclature and taxonomic order follows Clapham, Tutin and Moore (1989).

A2.9.1.26 Standard References:

Anderberg A-I. 1994 *Atlas of Seeds* volume 4
Beijerinck, W, 1947 Zadenatlas der Nederlandsche Flora
Berggren G. 1969 *Atlas of Seeds*, volume 2
Berggren G. 1981 *Atlas of Seeds*, volume 3

Stace C, 1991 New flora of the British Isles. Cambridge

WATERLOGGED PLANT REMAINS

A2.9.1.27 Waterlogged conditions provide exceptional preservation conditions for organic materials that do not usually survive in an archaeological context. Waterlogged seeds, branches and sometimes whole trees, preserved in riverine, coastal or peat bog environments, provide a much more complete record of the environment of deposition than charred plant remains, as naturally occurring and cultivated species are preserved without bias.

A2.9.1.28 Sub-samples, normally of 200g, will be processed using a simple wash over technique and both flots and residues will be collected onto 250µm mesh sieves. Assessment is conducted by scanning the flots under a binocular microscope at x10 to x20 magnification. Any waterlogged seeds or other items are provisionally identified and an approximation of abundance is made. Nomenclature and taxonomic order follows Clapham, Tutin and Moore (1989). Estimates of abundance are made on a three-point scale:

A2.9.1.29 + = present

A2.9.1.30 ++ = common

A2.9.1.31 +++ = abundant

A2.9.1.32 Standard reference: Clapham AR, Tutin,TG and Moore DM 1989, *Flora of the British Isles*, 3rd edition. Cambridge University Press

DIATOMS

A2.9.1.33 Diatoms are unicellular algae that have cell walls of silica instead of cellulose. These silica cell walls, which can be identified to species, survive after the algae die and accumulate at the bottom of bodies of water. The composition of an assemblage reflects the habitat, alkalinity, salinity and nutrient status of the water. Diatoms are particularly useful for tracing changes in sea-level or coastline.

A2.9.1.34 Diatom assessment is usually undertaken at the same time as the pollen assessment. The assessment will normally check for presence or absence, although estimates of abundance will be made where possible.

A2.9.1.35 Diatom preparation follows standard techniques (Battarbee 1986). Hydrogen peroxide is used for removal of organics from samples of 2ml. Residues are mounted in mounting medium. Examination is carried out at x400 and x1000. For assessment purposes, estimates of abundance will be made using the following scale:

~ A minimal trace.

* A small number are present but possibly not enough to give statistical counts, although the assemblage may have diagnostic taxa from which environmental deductions might be made.

** to *** Good numbers of diatoms which should enable some counts to be made.

A2.9.1.36 Diatom species' salinity preferences will be classified using the halobian groups of Hustedt (1953, 1957: 199) summarised below:

- Polyhalobian: >30 g l-1
- Mesohalobian: 0.2-30 g l-1
- Oligohalobian - Halophilous: optimum in slightly brackish water
- Oligohalobian - Indifferent: optimum in freshwater but tolerant of slightly brackish water
- Halophobus: exclusively freshwater
- Unknown: taxa of unknown salinity preference.

A2.9.1.37 Standard reference: Battarbee, RW, (1986). Diatom analysis. In Berglund, BE (Ed)

POLLEN

A2.9.1.38 Pollen grains are identifiable by species and can be used to reconstruct past natural environments, and sometimes to detect human influences on the landscape and understand site formation processes. Comparison between pollen sequences from different locations can identify major changes in climate and vegetation at a regional level. Pollen samples are usually taken from intact soil columns (monoliths) recovered from waterlogged sequences, although pollen can sometimes be preserved in dry site conditions.

A2.9.1.39 The samples will be prepared by the specialist using standard pollen extraction techniques, as detailed in Moore and Webb (1978) and Moore *et al.* (1991). Pollen grains are identified using a microscope, typically at a magnification of 400x with critical identifications being made at 1000x magnification. For analysis purposes the slides are systematically scanned, initially either to 100 total land pollen (TLP) or 5 traverses, normally reduced to 1 traverse per slide for assessment purposes. Pollen identifications are made in accordance with standard reference works including Moore, Webb and Collinson (1991) Reille (1992) and reference type slide collections. Nomenclature follows Bennett (1994) and Bennett, Whittington and Edwards (1994).

A2.9.1.40 If required at assessment stage, the data will be presented in standard pollen diagram form with the pollen of dry-land taxa calculated as a percentage of their sum. Marsh types and spores are as a percentage of the dry land sum+the sub-group. Diagrams will be plotted using Tilia and Tilia Graph.

A2.9.1.41 Standard References:

Bennett, KD 1994, *Annotated catalogue of pollen and pteridophyte spore types of the British Isles*. Unpublished manuscript, Department of Plant Sciences, University of Cambridge

Bennett, KD, Whittington, GW and Edwards, KJ (1994) Recent plant nomenclatural changes and pollen morphology in the British Isles. *Quaternary Newsletter* 73, 1-6

Moore PD, Webb JA and Collinson ME 1991, *Pollen analysis.* Second edition, Blackwell, Oxford, 216pp

Reille M 1992, *Pollen et spores d'Europe et d'Afrique du Nord*, Laboratoire de Botanique historique et Palynologie, Marseille, 520pp

Handbook of Holocene Palaeoecology and Palaeohydrology. Chichester: John Wiley and Sons, pp 527-570

OSTRACODS, FORAMINIFERA AND OTHER MICROFAUNA

A2.9.1.42 Microfauna are microscopic animal remains which can be used for palaeoecological reconstruction in the same way as plant remains. Interpreting the combination of species present in a particular deposit indicates the likely environment of deposition. The changing combination of species through a single monolith reflects changes in environmental conditions at that location. Ostracods (crustaceans) and foraminifera (single-celled organisms) are particularly relevant for tracing changes in sea-level and coastline through time, as different species are adapted to freshwater, brackish and saltwater environments.

A2.9.1.43 Ostracods and foraminifera will normally be extracted from 200g sub-samples, from monoliths and incremental columns. As a rule, one sample will be taken from each context of organic and minerogenic sediments. Where the context is over 20cm thick, one will be taken from the top and one from the bottom. Where it is 60cm to over 1m thick, then a sample will be taken at the top, in the middle and at the bottom.

A2.9.1.44 Samples are first thoroughly dried in ceramic bowls in an oven before soaking in hot water. They are then each washed through a 75 micron sieve with hot water and decanted back into the ceramic bowl before again being dried in an oven. The dried residue is put into a labelled, plastic bag and later sorted through under a binocular microscope for its microfaunal content.

A2.9.1.45 As an aid to ecological reconstruction, the ostracods will be divided into freshwater, brackish and marine.

A2.9.1.46 In addition to ostracods and foraminifera, the presence of other microfauna with ecological significance will be noted in the course of the assessment, where relevant. The following are particularly relevant to Thames Estuary sequences as indicators of freshwater, brackish or saltwater conditions.

A2.9.1.47 Earthworm granules: Found in flood-plain soils. Can tolerate some (freshwater) logging but intolerant of salinity. Because of their shape, they can be redeposited.

A2.9.1.48 Charophytes: The oogonia (reproductive organs) of the stonewort, which have a calcareous outer layer and chitinous inner layer. Because of the reducing nature of much of the Thames sediments, it is only the inner chitinous lining of the oogonia which are usually preserved. Usually freshwater, but can tolerate very low salinities.

A2.9.1.49 Cladocerans: "Water-fleas". The flexible carapaces of these freshwater Crustacea are sometimes preserved but are difficult to distinguish from decalcified freshwater ostracods. More often, it is the chitinous egg-cases (ephippia) that are seen, sometimes very commonly in many of these organic-rich decalcified sediments.

A2.9.1.50 Selected references:

De Rijk, S 1995 Agglutinating Foraminifera as Indicators of Salt Marsh Development in Relation to Late Holocene Sea Level Rise. Doctoral Dissertation, Vrije Universiteit, Amsterdam, 188pp

Murray, JW 1979 British nearshore foraminiferids, in Kermack, DM & Barnes, RSK (eds), Synopses of the British Fauna (New Series), no 16 Academic Press, London, etc (for The Linnean Society of London and The Estuarine and Brackish-Water Sciences Association), 68pp

Boyd, PDA 1981, The micropalaeontology and palaeoecology of medieval estuarine sediments from the Fleet and Thames in London, in Neale, JW & Brasier, MD (eds), *Microfossils from Recent and Fossil Shelf Seas.* Ellis Horwood Ltd, Chichester, for the British Miropalaeontological Society, 274-292

MOLLUSCA

A2.9.1.51 Each snail species is restricted to a limited range of habitats and their presence in a particular deposit, in conjunction with other species, can provide a general picture of vegetation cover at the time the deposit was laid down. Molluscs are particularly useful because shells are often preserved in environments where other organic materials are not, for example in dry valley soil sequences, or Pleistocene sediments.

A2.9.1.52 Bulk sediment samples, typically of 10-20 litres, taken from potentially suitable finer-grained sediments, will be sieved through a graded nest of sieves of mesh-sizes 10, 4, 2, 1 and 0.5mm. The residues will be dried at room temperature and then sorted for any molluscan remains, using a low-powered binocular microscope for the smaller size-grades of residue. 100% of all the residues greater than 2mm will normally be sorted, 50% of residues in the size-grade 2–1mm will normally be sorted, and 10% of the residues of the grade 1–0.5mm will be scanned.

A2.9.1.53 When a section has been sampled by a vertical series of samples from the same context, these may not all need to be sorted at the assessment stage, but may be sampled at regular intervals (usually alternately).

A2.9.1.54 Assessment level recording will comprise scanning of residues in order to estimate the abundance and condition of molluscs per sample. It is not normally necessary to provide a breakdown by species at this level, but comments on the range of species present and the environmental implications will be provided by sample. Abundance and condition will be assessed using the following scale:

/ Unsorted sample
– None/condition not applicable
+ Sparse/poorly preserved

* Moderately common/occasionally well-preserved, generally poor,

** Abundant, common/generally well-preserved)

A2.9.1.55 Selected reference: Kerney M P, 1963 'Late glacial deposits on the chalk of south-east England'. *Philosophical Transactions of the Royal Society of London*. 246, 203-54

INSECTS

A2.9.1.56 Sub-samples collected for waterlogged plant remains may also be assessed for the presence of insects, which can provide detailed ecological information, particularly when combined with other evidence.

A2.9.1.57 Where macroscopic plant remains are noted in a sub-sample while it is being scanned, it will be subjected to paraffin flotation onto a 0.25mm mesh. The flots are washed in detergent and scanned under a binocular microscope for insect remains. The species present in each sample are recorded and an interpretation of the likely depositional environment is made. The ecological nomenclature for Coleoptera follow Kloet and Hincks (1977).

A2.9.1.58 Standard reference: Kloet, GS and Hincks, WD 1977 *A check list of British insects, 2nd edition (revised): Coleoptera and Strepsiptera* (Royal Entomological Society of London; Handbook for the Identification of British Insects 11, pt 3). London: Royal Entomological Society.

MACROFAUNAL REMAINS

A2.9.1.59 Faunal Remains (including bones of large and small mammals, fish, bird and amphibian) provide information on past human diet and economy (if the assemblage is large enough). Small animal species in particular can also be a useful environmental indicator. In Paleolithic investigations, the range of species present in a sequence of Pleistocene deposits may help to indicate the interglacial episode in which the deposits were laid down.

A2.9.1.60 Assessment of faunal remains will include quantification by species using the total fragment method. It is essential that bone assemblages are quantified by period at assessment level. In addition, notes will be made on the potential for detailed metrical analysis including number of identifiable bones and number of bones with useful measurements, ageing data, butchery marks etc, possible origin of the assemblage (e.g. mixed domestic refuse, butchery waste; unusual depositions).

GEOARCHAEOLOGICAL ASSESSMENT

GENERAL METHODS

A2.9.1.61 The aim of the geoarchaeological analysis is to examine how the deposits recorded in each location accumulated and were subsequently transformed ('site formation processes') and thus to determine what environment (man-made, natural or both) they represent. This information will contribute to:

1 The interpretation of various features, which the deposits fill or form

2 better understanding of the taphonomy of pollen and other environmental inclusions recovered from the deposits (ie: the processes by which living communities formed death assemblages). Stratigraphic integrity and bioturbation issues will also influence the strategy employed for pollen sampling (or whether it is carried out at all) and C^{14} sample choices.

3 The reconstruction of the changing environment.

A2.9.1.62 Geoarchaeological analysis is closely related to the pollen, diatoms, soil micromorphology and microfaunal remains. These disciplines are either based on sub-samples taken from the geoarchaeological monoliths or are directly concerned with the interpretation of site formation processes. Work on these disciplines will normally be co-ordinated by a geoarchaeologist with detailed knowledge of site stratigraphy and formation processes, and knowledge of existing palaeoenvironmental data from the region.

MONOLITH DESCRIPTION

A2.9.1.63 Where monolith description has not already been undertaken, the monoliths will be described, generally in accordance with Jones et al. (1999). Descriptions will include the following information:

- Depth
- Texture
- Composition
- Colour
- Clast orientation
- Structure (bedding, ped characteristics etc)
- Contacts between deposits

A2.9.1.64 A full description of any profile targeted for further analysis and those previously assessed and referred to in the text, though not taken to analysis, will be summarised for the site archive.

A2.9.1.65 Sub-samples for pollen, additional sedimentary techniques and, in some cases, thin section analysis will be taken from the monoliths. Illustrations (in schematic section/profile form) will be prepared relating the location of sub-samples (eg: for pollen and further sedimentological techniques) to the monolith samples and showing the relationship of the monolith units to the site stratigraphy and to OD heights. The monolith samples will also be located on a plan of the site.

A2.9.1.66 The geoarchaeologist responsible for the description and sub-sampling of the monoliths will integrate the results of any sub-samples taken from and in association with the monoliths (pollen, radiocarbon dating, soil micromorphology etc) as appropriate.

SAMPLE SELECTION AND PREPARATION

A2.9.1.67 Scientific testing of soils will not will not normally be undertaken at assessment level. However, where visual inspection or the context indicates potential for these types of analysis, this will be indicated in the Post-excavation Assessment Report. A pilot study may be required to establish potential in some cases. Where the potential is indicated, samples will be prepared for archive deposition as a minimum, to permit study by future researchers. Samples will only be analysed as part of the project if such methods can contribute significantly to the specified research aims.

A2.9.1.68 Sub-samples for pollen, magnetic susceptibility and loss-on-ignition will be collected as 1cm splits, generally from every other centimetre. Sub-samples for soil micromorphology, where not taken as separate monolith tin samples, will be cut from the monoliths. The depth measurements will be recorded on the monolith description sheets and in the sample database.

A2.9.1.69 The following techniques can be used to characterise the deposit sequence in detail, to allow scientific comparison with datasets from comparable sequences, and allow more accurate interpretation of the environment of deposition:

- Soil micromorphology (sample composition and structure)
- X-radiography (sample composition and structure)
- Particle size analysis (environment of deposition)
- Magnetic susceptibility (burning, weathering)
- Loss-on-ignition (organic content)
- Chemical analysis (concentration and types of phosphate reflecting inputs of bone, dung etc, pH and carbonate - inputs of ash and secondary carbonate)

SOIL MICROMORPHOLOGY

A2.9.1.70 The microstratigraphic analysis will include soil micromorphology, microprobe and chemical analyses (as appropriate). Where thin sections have not already been manufactured, samples will be air-then oven-dried at 40°C, consolidated with crystic resin, cured and slabbed into thin-section sized blocks, which will be made into thin sections. The thin sections will be cleaned and polished using 1,000 grade carborundum paper. The slides will be left uncovered in case they need to be studied by microprobe etc.

A2.9.1.71 The thin sections will be examined at magnification from x1 to x400, under plane polarised light, crossed polarised light, oblique incident light, and fluorescence microscopy. The latter in order to search for autoflourescent materials, such as recent root material and calcium phosphate ('apatite'), in the form of bone, mineralised coprolites and secondary mineral accumulations such as hydroxyapatite. Observations will be made regarding the biological and anthropogenic inclusions, fabric types and features indicative of depositional and post-depositional processes. Interpretations will be based upon Bullock *et al* 1985, Kemp 1995, Courty *et al* 1989 and previous experienced gained from the study of similar deposits.

A2.9.1.72 .*Numerical soil micromorphological analysis:* Thin sections can be studied at two levels. Often soil micromorphological description provides sufficient data to allow an interpretation of a past soil's history. On the other hand, description can be followed by numerical analysis of the described features and components, in order to more accurately resolve questions of site formation processes.

X-RADIOGRAPHY

A2.9.1.73 The plastic lined samples will be x-rayed using an x-ray machine and KODAK Pb contact film. Tests will be undertaken to determine the best exposure rates. Methods and interpretation will follow those outlined in Barham 1995.

PARTICLE SIZE

A2.9.1.74 The samples will be dried, weighed and disaggregated in water. The suspension will be poured through a nest of sieves from 4mm down to 63microns, the residues air-dried, weighed and the silt+clay fraction (ie < 63 microns) calculated by sub-traction. The data will be expressed as percentages and displayed in histogram form. The texture of the silt+clay fraction will be refined by additional 'finger-texturing' as appropriate (Canti 1991).

MAGNETIC SUSCEPTIBILITY

A2.9.1.75 Magnetic susceptibility will be obtained using a dual frequency Bartington MS 2B meter. Sub-samples will be air dried and sieved to <2mm, then weighed to exactly 5g. Measurements for each sample will be taken at both low (0.43kHz) and high (4.3kHz) frequencies. Low frequency magnetic susceptibility (*lf*) measures the ease with which a sample can be magnetised and is proportional to the concentration of ferrimagnetic minerals (e.g. magnetite, maghaematite) in a sample. All measurements will be given on a mass specific basis (m3 kg-1). The high frequency (*hf*) measurements will be taken in order to assess frequency dependant susceptibility (fd), calculated as (lf - hf / lf) x 100. fd measures the extent to which susceptibility varies with the frequency of the applied magnetic field and is related to the percentage of fine magnetic grains at the stable single domain/superparamagnetic boundary (c.0.05μm). Such grains are commonly produced by pedogenesis (Gale and Hoare 1991). All measurements are given on a percentage basis. Data will be logged in a database and interpreted according to the principles outlined in Walden *et al* 1999.

LOSS-ON-IGNITION

A2.9.1.76 Methodologies will follow those outlined in Gale and Hoare 1991. The sub-samples will be placed in a drying cabinet at 40°C to remove all moisture, ground using a pestle and mortar, sieved through a 2mm mesh to remove larger particles, placed in numbered crucibles and weighed using an electronic balance (to 2 decimal places). The crucibles plus sample will be fired to 550 °C in a muffle furnace for four hours. The samples will be cooled in the sealed furnace and then re-weighed. It is assumed the weight loss reflects the organic carbon content. The pre- and post-firing weights will be added to the database. Carbonate measurement may be done if considered appropriate. This would involve re-firing to 1100 degrees and then re-weighing each sample.

CHEMICAL ANALYSIS

A2.9.1.77 Prior to impregnation bulk samples will be taken from the samples in case it proves necessary to carry out some additional tests. This might include bulk chemical analysis: concentration and types of phosphate (reflecting inputs of bone, dung etc), pH and carbonate (inputs of ash and secondary carbonate).

GEOARCHAEOLOGY REPORTS

A2.9.1.78 Reports will contain diagrams of all geoarchaeological analysis schemes, showing sampling positions superimposed onto section drawings or maps, along with descriptions clarifying how the chosen technique answers the questions posed by the stratigraphy. Analytical results will be presented visually as well as verbally, e,g,

A2.9.1.79 Particle size diagrams (curves, histograms or ternary plots)

A2.9.1.80 Plots of variables such as magnetic susceptibility, where possible shown alongside each other in relation to the lithostratigraphy to allow comparison.

A2.9.1.81 Micrographs to show evidence from micromorphology

A2.10 DATING

INTRODUCTION

A2.10.1.1 Establishing a chronological framework will be essential to the predictive model. A range of scientific dating methods could potentially be used on the Thames Gateway project, but the main emphasis will be on radiocarbon dating (AMS and high precision, as appropriate) and dendrochronology. OSL dating may be applicable for dating key deposits which do not contain suitable material for radiocarbon, potentially including Pleistocene deposits. Archaeomagnetic dating may be applied to suitable contexts, although radiocarbon dating will be used by preference where suitable material exists.

SAMPLE AND LABORATORY SELECTION

A2.10.1.2 The reliability of all scientific dating methods is dependent on careful sample selection and rigorous procedures both on- and off-site to avoid sample contamination. Specialist advice will be sought before undertaking programmes of dating. In selecting the samples, choosing methods, and determining the number of dates to be obtained, careful consideration should be given to the objectives and importance of the dating programme. The major sources of error in radiocarbon sampling in the field are:

A2.10.1.3 As a general rule, samples should be:

- from secure, well-understood depositional contexts
- large enough items to minimise the chance of having been reworked into earlier or later contexts (eg hazelnut shells rather than grain where possible)
- large enough for the dating method proposed (this varies according to the material being dated (large samples are required for high precision radiocarbon dating)
- from fast growing material such as twigs or hazelnut shell, where possible, rather than oak heartwood for example (unless as part of a programme of tree-ring dating). There are many factors that could affect sample reliability, which may not be obvious. For example oak bark does not renew itself annually, so could contain material as much as 100 years older than the felling date. Samples should therefore be taken from sapwood where present.

A2.10.1.4 It is essential that samples are carefully treated to minimise the chances of contamination after sampling, and that as much information as possible on potential sources of contamination is provided to the laboratory. This may mean providing a sample of groundwater if chemical contamination is suspected, for example.

A2.10.1.5 A single co-ordinator (normally the project geoarchaeologist or environmental coordinator) will be responsible for the collection and transport of samples, choice of laboratories and liaison with the relevant EH scientific advisors. The laboratories may be selected on the basis of the error margin required for a particular purpose, cost and speed of turnaround, depending on circumstances.

A2.10.1.6 For example, a spot date required urgently to determine whether a find is of prehistoric or Saxon date, does not require very precise dating to achieve the purpose. For the Roman and medieval periods generally, high precision dates may be the only way to achieve a higher level of resolution than the artefactual evidence. To be worth undertaking at all, large numbers of dates may be needed and in such cases it may be judged that artefactual dating is adequate to address the Research Aims.

ACCELERATOR MASS SPECTROMETRY RADIOCARBON DATING

A2.10.1.7 Radiocarbon dating is by far the most commonly used dating technique in archaeology. C^{14} in the atmosphere is passed on uniformly to all living things through carbon dioxide. (Plants take up Carbon dioxide during photosynthesis. They are eaten by herbivores, who are in turn eaten by carnivores). When an organism dies the C^{14} absorbed by the organism during its lifetime decays at an (almost) constant rate (C^{14}

has a half-life of 5730 years). The age of dead plant or animal tissue can be calculated by measuring the amount of radiocarbon left in a sample.

A2.10.1.8 AMS radiocarbon dating is likely to be the principal dating method used on the Thames Gateway project. AMS dating counts the atoms of C^{14} in a sample directly, which means that measurements can be obtained from very small samples.

HIGH PRECISION RADIOCARBON DATING

A2.10.1.9 High precision radiocarbon dates can be obtained from a number of laboratories, using a variety of methods, usually achieved by high resolution counting and additional chemical testing to eliminate error factors, or combining multiple measurements from a single sample to reduce the margin of error. The main limitations of high precision dating is the large sample size required, the high cost and long processing time.

BAYESIAN MODELLING

A2.10.1.10 Bayesian modelling is a statistical method which can be used to increase the precision of radiocarbon dates by comparing a series of dates which can be placed in a known sequential order, in order to eliminate areas of probability. The stratigraphic relationships used must be completely reliable, for example, a series of samples from a single monolith.

A2.10.1.11 Advice should always be sought from a specialist advisor on radiocarbon dating before using these methods, to ensure that the selection of samples is rigorous.

DENDROCHRONOLOGY

A2.10.1.12 Dendrochronology is a science of precise dating, by the accurate counting of annual tree growth-rings, which allows dating of wooden items, potentially to the season of felling. The pattern of annual tree-rings differs each year, depending upon the growing conditions at the time. Dendrochronology uses the variations in the thickness of annual growth rings in living trees as well as old timbers to date wooden objects and buildings, by counting tree-rings back from the present on very old trees and then by successively overlapping even older timbers further back through time. Selected timbers must meet the following criteria:

- Timbers must be oak.
- They must be long lived. That is, they should have many growth rings.
- They must be derived from an area for which an oak master chronology exists.

A2.10.1.13 All three of these conditions are likely to be met for any substantial structures found on the Thames Gateway Project. Oak has been a preferred building timber since prehistoric times and it occurs regularly on waterlogged archaeological sites. Oak is, as a rule, long lived and timbers with several hundred growth rings are not uncommon. In addition, long master chronologies exist in England (to 5012BC) based in part on material from the Lower Thames Marshes.

A2.10.1.14 In practice it is preferable to sample as many timbers as are available in a structure in order to date it. This increases the chances of obtaining a date although, as with any scientific method, there is no guarantee that analysis will be successful.

A2.10.1.15 Samples should be about 0.05m thick and taken from the widest part of the timber or, if present, through the part which contains sapwood (greater precision is possible if sapwood and bark are present, as the missing outer rings do not then have to be estimated). They should be labelled, sealed in clear polythene and sent to the laboratory for assessment. On-site assessment by the specialist may be required, particularly in situations where there are large numbers of potentially suitable timbers, or sensitive structures in which sampling has to be carefully targeted.

A2.10.1.16 The presence of sapwood may allow the sample to be dated very precisely, but it can deteriorate within days to the point where the rings cannot be counted. Waterlogged samples with sapwood should therefore be processed as rapidly as possible.

OPTICALLY STIMULATED LUMINESCENCE DATING (OSL)

A2.10.1.17 OSL samples will normally be collected in the field by the OSL dating specialist, along with control samples to provide background radiation readings. Samples will normally be processed in two stages. The assessment stage establishes the suitability of the deposits for OSL dating purposes and provides preliminary radiometric dates for key deposits (at c. half the cost of the fully processed date). The analysis stage

A2.10.1.18 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 are 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 for radiation attention, and burial depth are assumed as they will not have a large affect on the ages calculated.

ARCHAEOMAGNETIC DATING

A2.10.1.19 This method can be used for dating fired clay structures, such as hearths or ovens, which can preserve a record of the alignment of the earth's magnetic field at the time of firing. This can be compared against records of known fluctuations in the earth magnetic field, which is constantly changing in both intensity and direction, in order to arrive at an estimate of age. An archaeomagnetism specialist will normally take magnetic measurements in the field.

A2.11 POST-EXCAVATION ANALYSIS AND REPORTING

GENERAL METHODS

A2.11.1.1 Methods to be adopted in post-excavation analysis and reporting will be determined on the basis of an integrated post-excavation assessment, which will act as a supplement and up-date to this document. The English Heritage guidance in MAP2(1991) will be followed.

POST-EXCAVATION ANALYSIS

A2.11.1.2 As a minimum it is expected that sufficient post-excavation analysis will be undertaken to resolve the site chronological and stratigraphic sequence and address key objectives of the Research Strategy.

A2.11.1.3 It is envisaged that assessment level recording for all datable artefact assemblages will be carried out to a baseline level, sufficient as an archive record and for resolving the site chronological sequence. Any further analysis will therefore consider only selected context assemblages, that are capable of addressing the key objectives of the Research Strategy.

A2.11.1.4 Palaeoenvironmental assessment will be carried out to a sufficient level to characterise changing environmental conditions through time (without undertaking detailed quantification). Any further analysis will therefore focus on the detailed quantification of data from key sequences, to provide a sound scientific basis for the overall palaeoenvironmental interpretation.

REPORTING

A2.11.1.5 Interim Reporting: Interim publication of results may include web-based articles, summaries and topic-specific articles submitted to national and regional journals.

A2.11.1.6 Archaeological Report: As a minimum the fieldwork evidence and final results of analysis will be presented in the form of an integrated, illustrated landscape narrative (Archaeological Report). It is intended that the report will be an accessible, interpretative summary of the site sequence, incorporating key supporting evidence and including, where relevant, the summary results and interpretation of specialist analyses.

A2.11.1.7 The level of descriptive detail provided for particular site components will be commensurate with the significance of the evidence and its ability to address the questions posed in the Research Strategy. The Archaeological Report will be cross-referenced to project-wide Specialist Reports and the Digital Archive Database. The Specialist Reports will form part of the digital archive and include detailed results of specialist analyses and summary interpretative overviews of artefactual and palaeoenvironmental evidence. The Digital Archive Database will contain detailed feature and interpretative group descriptions and documentation of phasing decisions.

A2.11.1.8 The final Archaeological Report format will be determined during the final stage post-excavation assessment, in the light of current and future trends in archaeological publication and available technology.

ARTEFACT RETENTION/ DISCARD

A2.11.1.9 Selection policies will be implemented during the fieldwork and assessment stage to ensure that only that material which can contribute to the projects research aims will be collected, processed and retained.

A2.11.1.10 Standard reference: IFA, 2001 Standard and Guidance for the Collection, Documentation, Conservation and Research of Archaeological Materials, Institute of Field Archaeologists, published 2001

GENERAL REFERENCES

A2.11.1.11 RCHME, 1993 *Recording England's Past: A data standard for the Extended National Archaeological Record*, Royal Commission on the Historical Monuments of England/Association of County Archaeological Officers.

APPENDIX 3: SOURCES CONSULTED

A3.1 KEY REFERENCE TEXTS

A3.1.1 Management and research frameworks

- Bedwin, O (ed), 1996 *The archaeology of Essex: proceedings of the 1993 Writtle conference*, Essex County Council, Chelmsford
- Brown, N and Glazebrook, J (eds), 2000 *Research and archaeology: a framework for the eastern counties, 2. Research agenda and strategy*, East Anglian Archaeol Occ Paper **8**
- English Heritage and RCHME, 1996 *England's coastal heritage: a policy statement*, English Heritage and RCHME
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- Fulford, M G, Champion, T C and Long, A, 1997 England's coastal heritage: a survey for English Heritage and the Royal Commission on the Historical Monuments of England, English Heritage Archaeological Reports **15**
- Glazebrook, J (ed), 1997 *Research and archaeology: a framework for the eastern counties,* 1. Resource assessment East Anglian Archaeol Occ Paper 3
- JNAPC, 1989 *Heritage at sea: proposals for the better protection of archaeological sites underwater*. Joint National Archaeological Policy Committee, National Maritime Museum, London
- MoLAS, 2000 *The archaeology of Greater London*, MoLAS, London
- Van de Noort, R, Fletcher, W, Thomas, G, Cartairs, I and Patrick, D (eds), 2002 *Research into Monuments at Risk in England's Wetlands*, English Heritage/University of Exeter
- Roberts, P and Trow, S, 2002 *Taking to the Water: English Heritage's initial policy for the management of maritime archaeology in England,* English Heritage
- Williams, J and Brown, N (eds), 1999 *An archaeological research framework for the Greater Thames Estuary*, Essex County Council, Chelmsford

A3.1.2 Methodology

- Bates, M R, 1998 Locating and evaluating archaeology below the alluvium: the role of sub-surface stratigraphic modelling, *Lithics* 19, 4-18
- Bates, M R and Bates, C R, 2000 Multidisciplinary approaches to the geoarchaeological evaluation of deeply stratified sedimentary sequences: examples from Pleistocene and Holocene deposits in southern England, United Kingdom, *Journal of Archaeological Science* 27, 845-858
- Bates, M R, Barham, A J, Pine, C A and Williamson, V D, 2000 The use of borehole stratigraphic logs in archaeological evaluation strategies for deeply stratified alluvial areas, in *Interpreting stratigraphy: site evaluation, recording procedures and stratigraphic analysis* (ed S Roskams), BAR Int Ser 910, Archaeopress, Oxford, 49-69
- Bridgland, D R, Allen, P and Haggart, B A (eds), 1995 *The Quaternary of the lower reaches of the Thames: field guide*, Quaternary Research Association, Cambridge
- Brown, A G, 1997 Alluvial geoarchaeology: floodplain archaeology and environmental change, Cambridge University Press, Cambridge
- Fenwick, V and Gale, A, 1998 Historic shipwrecks. Discovered, protected and investigated, Tempus Publishing, Stroud

A3.1.3 Recent projects

- Allen, M J and Gardiner, J, 2001 Our changing coast: a survey of the intertidal archaeology of Langstone Harbour, Hampshire, CBA Res Rep 124
- Bell, M, Caseldine, A and Neumann, H, 2000 Prehistoric intertidal archaeology in the Welsh Severn Estuary, CBA Res Rep 120
- Cowell, R W and J B Inness, 1994 *The wetlands of Merseyside*, NWWS 1, Lancaster Imprints 2, Lancaster
- Davidson, A (ed), 2002 *The coastal archaeology of Wales*, CBA Res Rep 131
- Eddison, J, 2000 *Romney Marsh. Survival of a Frontier.* Tempus
- Eddison, J (ed), 1995 *Romney Marsh, The Debatable Ground* OUCA Monogr 41
- Goudswaad, B, 2000 Archaeological assessment within the Betuweroute cargo Line project, in *Archaeological evaluation strategies in Belgium (Flanders and Wallonia), England, France and the Netherlands* (eds K Evans and J Williams), Kent County Council (Planarch), Maidstone

- Hall, D, Wells, C and Huckerby, E, 1995 *The Wetlands of Greater Manchester.* NWWS 2
- Hodgkinson, D, Huckerby, E, Middleton, R and Wells, C, 2001 *The Lowland Wetlands of Cumbria.* NWWS 6
- Leah, M., Wells, C., Appleby, C. and Huckerby, E, 1997 *The Wetlands of Cheshire,* NWWS 4
- Leah, M, Wells, C, Stamper, P, Huckerby, E. and Welch, C, 1998 *The Wetlands of North Lancashire.* NWWS 3
- Nayling, N, 1998 *The Magor Pill Medieval Wreck,* CBA Res Rep
- Nayling, N and Caseldine, A, 1997 *Excavations at Caldicot, Gwent: Bronze Age Palaeochannels in the Lower Nedern Valley.* CBA Res Rep 108
- Needham, S, 2000 The passage of the Thames: Holocene environment and settlement at Runneymede, British Museum Press, London
- Pederson, L, Fischer, A and Aaby, B (eds), 1997 *The Danish Storebaelt since the Ice Age - man, sea and forest,* A/S Storebaeltsforbindelsen, Copenhagen
- Rippon, S, 1996 *Gwent Levels: the Evolution of a Wetland Landscape.* CBA Res Rep 105
- Rippon, S, 1997 *The Severn Estuary: Landscape Evolution and Wetland Reclamation.* Leicester.
- Sidell, J, Wilkinson, K, Scaife, R and Cameron, N (eds), 2000 The Holocene evolution of the London Thames: archaeological excavations (1991-1998) for the London Underground Limited Jubilee Line Extension Project, MoLAS Monogr 5
- Wilkinson, T J and Murphy, P, 1995 The archaeology of the Essex Coast, Volume 1: The Hullbridge Survey, East Anglian Archaeol 71

A3.2 WEBSITES

A3.2.1 Curatorial

- Association of Local Government Archaeological Officers - maritime sub-committees: www.algao.org.uk/cttees/maritime/
- *English Heritage*: Wetlands strategy framework: www.english-heritage.org.uk/archaeology/wetlands
- Policy towards the management of maritime archaeology in England: www.english-heritage.org.uk/archaeology/maritime_archaeology
- Essex County Council: www.essexcc.gov.uk/
- Maritime and Coastguard Agency: www.mcga.gov.uk/

- *Planarch*: www.planarch.org
- Research into Monuments at Risk in England's Wetlands (report): www.exeter.ac.uk/marew

A3.2.2 Current and recent projects

- Channel Tunnel Rail Link (CTRL): www.ctrl.co.uk/
- Fenland Archaeology: www.lincsheritage.org/
- *Humber Wetlands*: www.hull.ac.uk/wetlands
- *Poole harbour*: www.poolemaritime.org/
- Severn Estuary Levels Research Committee: www.selrc.dial.pipex.com/
- *Severn Estuary (Reading University)*: www.rdg.ac.uk/archaeology/research/severn_estuary/
- North Somerset Archaeological Project coastal survey: www.hildich.demon.co.uk

A3.2.3 Related organisations

- British Geological Survey bathymetry project: www.bgs.ac.uk/products/digbath250
- Centre for Maritime Archaeology: http://cma.soton.ac.uk
- Environmental Change Research Centre (ECRC): www.geog.ucl.ac.uk/ecrc
- *Exeter Centre for Wetland Research:* www.exeter.ac.uk/schools/geoarch/wetlandresearch
- Hampshire and Wight Trust for Maritime Archaeology: www.soc.soton.ac.uk
- Institute of Maritime Archaeology, Denmark: www.ils.unc.edu/maritime/nautarch
- Quaternary Environment Research Group: ww.geog.plym.ac.uk/research/quatern/
- Ramsar Convention on Wetlands: http://ramsar.org
- Sea Level Research Unit: www.dur.ac.uk/
- *Seafloor Imaging and Processes Group* (Thames Estuary-related projects): www.huxley.ic.ac.uk/geophysics/
- *Sub-Aqua Association:* www.saa.org.uk/index/archaeology
- University College London (UCL) Coastal research group: www.ucl.ac.uk/ine/coasts

A3.2.4 Specialists consulted

- Dr Jane Sidell, Institute of Archaeology, University College, London
- Dr Martin Bates, Department of Archaeology, University of Wales, Lampeter
- Professor John Barrett, Department of Archaeology, University of Sheffield

APPENDIX 4 : BIBLIOGRAPHY

Author	Year	Title	Key word	Notes
Adams, J, van Holk, A F L and Maarleveld, ?	1990	*Dedgers and archaeology: shipfinds from the Slufter*, Rotterdam	Dredging	
Allen, M J and Gardiner, J	2001	*Our changing coast: a survey of the intertidal archaeology of Langstone Harbour, Hampshire*, CBA Res Rep **124**	Intertidal	
Barham, A J and Bates, M R	1994	*Strategies for the use of boreholes in archaeological evaluations: a review of methodologies and techniques*, Georchaeological Sevice Facility Technical Report 94/01, Institute of archaeology University College London, London	Boreholes	Technical review of current methodologies
Barham, A J and Bates, M R	1994	*A geoarchaeological strategy employing geotechnical data in archaeological evaluation and mitigation measures on the Channel Tunnel Rail Link*, OAU / Union Railways Ltd	CTRL	
Bates, M R	1999	*A geoarchaeological evaluation of the Thames/Medway alluvial corridor of the Channel Tunnel Rail Link*, OAU / Union Railways (North/South) Ltd (unpub)	CTRL	Describes archaeological/geological background to alluvil area of CTRL route corridor in Thames/Medway region
Bates, M R	1998	Locating and evaluating archaeology below the alluvium: the role of sub-surface stratigraphic modelling, *Lithics* **19**, 4-18	Alluvium	Useful summary of Thames Valley geology and techniques for site detection
Bates, M R and Bates, C R	2000	Multidisciplinary approaches to the geoarchaeological evaluation of deeply stratified sedimentary sequences: examples from Pleistocene and Holocene deposits in southern England, United Kingdom, *Journal of Archaeological Science* **27**, 845-858	Geoarchaeol ogy	Discussion of geoarchaeologcal evaluation approaches to alluvial sites, presenting Norton Farm, West Sussex and Ebbsfleet Valley as case studies
Bates, M R, Barham, A J, Pine, C A and Williamson, V D	2000	The use of borehole stratigraphic logs in archaeological evaluation strategies for deeply stratified alluvial areas, in *Interpreting stratigraphy: site evaluation, recording procedures and stratigraphic analysis* (ed S Roskams), BAR Int Ser **910**, Archaeopress, Oxford, 49-69	Boreholes	Borehole strategies focusing on practical techniques for evaluating and predicting sub-surface stratigraphies. Southwark and Medway Valley presented as case studies
Bates, M R and Whittaker, K M	Forth-comin g	Landscape evolution in the Lower Thames Valley: implications for the archaeology of the earlier Holocene, in *Recent research on the neolithic of south-east England* (eds S Cotton and D Field), CBA Res Rep	Holocene	
Bedwin, O (ed)	1996	*The archaeology of Essex: proceedings of the 1993 Writtle conference*, Essex County Council, Chelmsford	Framework	Standard outline of archaeological resource
Bell, M	2000	Introduction to the Severn Estuary and its archaeology, in Bell *et al* 2000, 1-11		
Bell, M	2000	Skull deposition at Goldcliff in the Severn Estuary, in Bell *et al* 2000, 64-72		
Bell, M	2000	Boat planks of c 1170 BC, in Bell *et al* 2000, 74-82		
Bell, M	2000	Trackways and other linear structures at Goldcliff, in Bell *et al* 2000, 136-158		
Bell, M	2000	Discussion and conclusions, in Bell *et al* 2000, 322-350		
Bell, M, Caseldine, A and Neumann, H	2000	*Prehistoric intertidal archaeology in the Welsh Severn Estuary*, CBA Res Rep **120**	Intertidal	Major interdisciplinary investigation of intertidal zone
Boggs, S	1995	*Principles of sedimentology and stratigraphy*, Prentice Hall, New Jersey	Methodology	
Bray, R N, Bates, A D and Land, J M	1997	*Dredging: a handbook for engineers*, London	Dredging	
Bridgland, D R	1994	*Quaternary of the Thames*, Chapman and Hull, London	Quaternary	Describes Pleistocene deposits of the Thames terrace system
Bridgland, D R, Allen, P and	1995	*The Quaternary of the lower reaches of the Thames: field guide*, Quaternary Research	Quaternary	

Haggart, B A (eds)		Association, Cambridge		
Bridgland, D R and Harding, P	1994	Globe Pit, Little Thurrock, in Bridgland 1994, 228-237	Quaternary	
Bridgland, D R and Harding, P	1994	Lion Pit Tramway Cutting (West Thurrock), in Bridgland 1994, 237-251	Quaternary	
Brown, A G	1997	*Alluvial geoarchaeology: floodplain archaeology and environmental change*, Cambridge University Press, Cambridge	Alluvium	Textbook on alluvial archaeology
Brown, N	2001	Essex Final report, in Cuming *et al* 2001, 43-51	Planarch	Hullbridge survey revisited
Brown, N and Glazebrook, J (eds)	2000	*Research and archaeology: a framework for the eastern counties, 2. Research agenda and strategy*, East Anglian Archaeol Occ Paper **8**	Framework	Research strategy for Essex
Brown, N, Murphy, P, Ayers, B, Bryant, S and Malim, T	2000	Research themes, in Brown and Glazebrook (eds) 2000, 44-48	Framework	
Brunning, R	2001	The Somerset Levels, in *Current Archaeology* **172**, February, 139-143	Somerset	
Carter, G A	1999	*Excavations at the Orsett Cock enclosure, Essex, 1976*, East Anglian Archaeol **86**	Essex	Excavation of gravel site in south Essex
Cameron, N	1995	Diatom analysis from the Wantsum Channel, in Hearne *et al*, 1995,	Diatoms	
Coard, R	2000	Large mammal bone assemblage, in Bell *et al* 2000, 48-53		
Coles, J M and Goodburn, D M (eds)	1991	*Wet site excavation and survey*, MoL/WARP/Nautical Archaeologial Survey	Methodology	
Corfield, M, Hinton, P, Nixon T and M Pollard (eds)	1997	*Preserving archaeological remains in situ: proceeding of the conference of 1st-3rd April 1996, Museum of London* Museum of London/University of Bradford	Management	
Cowell, R W and J B Inness	1994	*The wetlands of Merseyside*, NWWS **1**, Lancaster Imprints **2**, Lancaster	NW wetlands	Multidisciplinary investigation of peat deposits
Cressey, Bunting, M J, Dawson, A, Dawsaon, S, Long, D and Milburn, P	2001	Sea-level changes and palaeoenvironment at Newbie Cottages, near Annan, Upper Solway Firth, South-West Scotland, in Raftery and Hickey eds) 2001, 257-270	Sea-level	
Cuming, P, Evans, K and Williams, J (eds)	2001	*The Planarch Project in Belgium (Flanders and Wallonia), England, France and the Netherlands*, Kent County Council, Maidstone	Planarch	Summaries of projects undertaken in coastal areas
Dalrymple, R W, Zaitlin, B A and Boyd, R	1992	Estuarine facies models, conceptual basis and stratigraphic implications, *Journal of Sedimentary Petrology* **62**, 1130-1146	Facies	
Davidson, A (ed)	2002	*The coastal archaeology of Wales*, CBA Res Rep **131**	Framework	Summary account of coastal surveys
Deeben, J, Hallewas, D P, Kolen, J and Wiemar	1997	Beyond the crystal ball: predictive modelling as a tool in archaeological heritage management and occupation history, in *Archaeological heritage management in the Netherlands* (eds W J H Willems, H Kars and D P Hallewas), Van Gorcum, Amersfort, 76-118	Netherlands	Describes predictive mapping to plot potential sites
Delgado, J P (ed)	1997	*Encyclopaedia of underwater and maritime archaeology*, London	Maritime	
Department of the Environment	1992	*Planning and policy guidance, note 20: coastal planning*	Framework	
Department of the Environment	1990	*Planning and policy guidance, note 16: archaeology and planning*	Framework	
DETR	1998	*Government view: new arrangements for the licensing of minerals dredging*, Department of Environment, Transport and the Regions, London	Framework	
Devoy, R J N	1982	Analysis of the geological evidence for Holocene sea level movements in Southeast England, *Proceedings of the Geologists' Association* **93**, 65-90	Sea-level	
Devoy, R J N	1979	Flandrian sea-level changes and vegetational history of the Lower Thames Estuary, *Philosophical Transactions of the Royal Society of London*, Series B, **285**, 355-407	Sea-level	
Devoy, R J N	1977	Flandrian sea-level changes in the Thames Estuary and the implications for land	Sea-level	

		subsidence in England and Wales, *Nature* **220**, 712-15		
Doyle, P and Bennett, M R (eds)	1998	*Unlocking the stratigraphical record: advances in modern stratigraphy*, John Wiley and Sons, Chichester	Stratigraphy	Geological text-book
Dunbar, J S, Webb, S D and Faught, M	1992	Inundated prehistoric sites in Apalachee Bay, Florida, and the search for the Clovis shoreline, in *Palaeoshorelines and prehistory: an investigation of method* (ed Johnson, L L), CRC Press, Boca Raton, 117-146	Sea-level	
Eddison, J	2000	*Romney Marsh. Survival of a Frontier*. Tempus	Romney	
Eddison, J (ed)	1995	*Romney Marsh, The Debatable Ground* OUCA Monogr **41**	Romney	
Eddison, J Gardiner, M and Long, A (eds)	1998	*Romney Marsh, Environmental Change and Human Occupation in a Coastal Lowland* OUCA Monogr **46**	Romney	
Eddison J and Green, C (eds)	1988	*Romney Marsh, Evolution, Occupation, Reclamation* OUCA Monogr **24**	Romney	
Emery, D and Myers, K J	1996	*Sequence stratigraphy*, Blackwell Science, Oxford	Stratigraphy	
English Heritage	1997	*English Heritage Archaeology Division research agenda*, Draft (unpub)	Framework	National agenda
English Heritage and RCHME	1996	*England's coastal heritage: a policy statement*, English Heritage and RCHME	Framework	EH response to Monuments at Risk (wetlands) survey
English Heritage	1991	*Exploring our past: strategies for the archaeology of England*, English Heritage, London	Framework	
Faught, M K and Donoghue, J F	1997	Marine inundated archaeological sites and paleofluvial systems: examples from kast-controled continental shelf setting in Apalachee Bay, northeastern Gulf of Mexico, *Geoarchaeology* **12**, 417-458	Sea-level	
Fenwick, V and Gale, A	1998	*Historic shipwrecks. Discovered, protected and investigated*, Tempus Publishing, Stroud	Shipwrecks	
Ferring, C R	2001	Geoarchaeology in alluvial landscapes, in Goldberg *et al* 2001, 77-106	Alluvium	
Fischer, A (ed)	1996	*Man and the sea in the Mesolithic*, Oxford Monogr **53**, Oxford	General	
Firth, A	1995	Archaeology and coastal management, in *Managing ancient monuments: an integrated approach* (A Q Berry and I W Brown, eds), 155-167	Framework	
Firth, A	1993	The management of archaeology underwater, in *Archaeological resource management in the UK: an introduction* (J Hunter and I Ralston, eds), Alan Sutton Publishing, Stroud, 65-76	Framework	
Fokkens, H	1998	*Drowned landscape: the occupation of the western part of the Frisian-Drentian Plateau, 4400 BC-AD 500*, Rijksdienst voor het Oudheidkundig Bodemonderzoik, Van Gorcum & Comp BV, Assen	Netherlands	Statistical analysis of finds distribution to assess cultural responses to rising sea-level and transgression/regression episodes
Fulford, M G, Champion, T C and Long, A	1997	*England's coastal heritage: a survey for English Heritage and the Royal Commission on the Historical Mnuments of England*, English Heritage Archaeological Reports **15**	Framework	Wide-ranging survey of coastal archaeology with summaries of principal research approaches
Gibbard, P L	1994	*Pleistocene history of the lower Thames valley*, Cambridge University Press, Cambridge	Thames Valley	
Giffords	2002	*A13 Thames Gateway preliminary archaeological investigations: Movers Lane - further archaeological works report*, Gifford Report B329A.R09 revision B, January 2002	A13	
Glazebrook, J (ed)	1997	*Research and archaeology: a framework for the eastern counties, 1. Resource assessment* East Anglian Archaeol Occ Paper **3**	Framework	
Goldberg, P, Holliday, V T and Ferring, C R (eds),	2001	*Earth science and archaeology*, Kluwer Academic, New York	Methodology	
Gorham, L D and Bryant, V M	2001	Pollen, phytoliths and other microscopic plant remains in underwater archaeology, *J Nautical Archaeol* **30**.2, 282-298	Methodology	
Goudswaad, B	2000	Archaeological assessment within the Betuweroute cargo Line project, in *Archaeological evaluation strategies in Belgium (Flanders and Wallonia), England, France and the Netherlands* (eds K Evans and J Williams), Kent County Council	Netherlands	Large scale infrastucture project through alluviated squences

		(Planarch), Maidstone		
Green, L S (ed)	1999	*The Essex landscape: in search of its history*, Essex County Council, Chelmsford	Essex	Poplar introduction to the Essex landscape
Hall, D, Wells, C and Huckerby, E	199A.	*The Wetlands of Greater Manchester.* NWWS **2**	NW wetlands	
Hallam, A	1998	Interpreting sea level, in Doyle and Bennett 1998, 420-440	Sea-level	
Hearne, C M, Perkins, D R J and Andrews, P	1995	The Sandwich Bay wastewater treatment scheme archaeological project, 1992-1994, *Archaeologia Cantiana*, **105**		Multi-disciplinary project on Kent marshland
Van Heeringen, R and Theunissen, L	2001	Netherlands final report, in Cuming *et al*, 2001, 91-108	Planarch	
Hodgkinson, D, Huckerby, E, Middleton, R and Wells, C	2001	*The Lowland Wetlands of Cumbria.* NWWS **6**	NW wetlands	
Howard, A J and Macklin, M G	1999	A generic geomorphological approach to archaeological interpretation and prospection in British river valleys: a guide for archaeologists investigation (sic) Holocene landscapes, *Antiquity* **73**, 527-541	Methodology	
JNAPC	1995	*A code of practice for seabed developers*	Framework	
JNAPC	1989	*Heritage at sea: proposals for the better protection of archaeological sites underwater*. Joint National Archaeological Policy Committee, National Maritime Museum, London	Framework	
Jones, A P, Tucker, M E and Hart, J K	1999	*The description and analysis of Quaternary stratigraphic field sections*, Quaternary Research Association Technical Guide **7**	Quaternary	
Juggins, S	1992	Diatoms in the Thames Estuary, England: ecology, palaeoecology, and salinity transfer function. *Bibliotheca Diatomologica* **25**	Diatoms	
Kemble, J	2001	*Prehistoric and Roman Essex*, Tempus Publishing, Stroud	Essex	
Leah, M., Wells, C., Appleby, C. and Huckerby, E.	1997	*The Wetlands of Cheshire.* NWWS **4**	NW wetlands	
Leah, M, Wells, C, Stamper, P, Huckerby, E. and Welch, C	1998	*The Wetlands of North Lancashire.* NWWS **3**	NW wetlands	
Long, A J	1992	Coastal responses to changes in sea-level in the East Kent Fens and southeast England, UK over the last 7500 years. *The Proceedings of the Geologists' Association* **103**, 187-199.	Sea-level	
Long, A J, Gunn, A C, Goulty, N and Bedlington, D	1992	Mapping the pre-Holocene surface of an infilled valley in the East Kent Fens with a shear-wave refraction survey. *The Holocene* **2**, 57-62.	Sea-level	
Long, A J and Innes, J B	1995	A palaeoenvironmental investigation of the 'Midley Sand' and associated deposits at the Midley Church Bank, Romney Marsh, in Eddison (ed) 1995, 37-50	Palaeoenviron ment	
Long, A J and Innes, J B	1995	The back-barrier and barrier depositional history of Romney Marsh, Kent, UK, *Journal of Quaternary Science* **10**, 267-283.	Sea-level	
Long, A J and Innes, J B	1993	Holocene sea-level and coastal sedimentation in Romney Marsh, southeast England, UK, *The Proceedings of the Geologists' Association* **104**, 223-237	Sea-level	
Long, A J and Hughes, P	1995	Evolution of the Dungeness foreland during the last 4000 years, *Marine Geology* **124**, 253-271.	Sea-level	
Long, A J, Plater, A J, Waller, M P and Innes, J B	1996	Holocene coastal sedimentation in the eastern English Channel: new data from the Romney Marsh region, United Kingdom, *Marine Geology* **136**, 97-120.	Sea-level	
Long, A J and Roberts, D	1997	Sea-level change, In Fulford *et al* 1997, 25-49.	Sea-level	
Long, A J and Scaife, R	1995	Radiocarbon dates from Weatherlees Hill WTW - implications for relative sea-level movements, in Hearne *et al*, 1995, 320-322	Sea-level	
Long, A J, Scaife, R G and	1999	Pine pollen in intertidal sediments from Poole Harbour, UK: implications for late-	Sea-level	

Edwards, R G		Holocene sediment accretion rates and sea-level rise, *Quaternary International* **55**, 3-16.		
Long, A J and Shennan, I	1993	Holocene sea-level and crustal movements in southeast and northeast England, UK. *Quaternary Proceedings* **3**, 15-19	Sea-level	
Long, A J and Tooley, M J	1995	Holocene sea-level and crustal movements in Hampshire and Southeast England, United Kingdom, *Journal of Coastal Research Special Issue* **17**, 299-310.	Sea-level	
Maritime and Coastguard Agency	nd	*Where to turn when you've turned something up*	Shipwrecks	
Maritime and Coastguard Agency	nd	*Notes of wreck law*	Shipwrecks	
Maritime and Coastguard Agency	nd	*Notes for the guidance of intending salvors*	Shipwrecks	
MAFF	1995	*Shoreline management plans: a guide for operating authorities*, MAFF Publications PB 1471	Framework	
Meddens, F	1996	Sites from the Thames estuary wetlands, England and their Bonze Age use, *Antiquity* **70**, 325-334	Thames estuary	
Miall, A D	1996	*The geology of fluvial deposits: sedimentary facies, basin analysis and petroleum geology*, Springer, Berlin	Methodology	
Miall, A D	1992	Alluvial deposits, in Walker and James 1992, 119-142	Alluvium	
Middleton, R, Tooley, M and Innes, J	2001	*The Wetlands of South West Lancashire.* NWWS **7**	NW wetlands	
Middleton, R, Wells, C, and Huckerby, E	1995	*The Wetlands of Shropshire and Staffordshire.* NWWS **5**	NW wetlands	
Murphy, P and Brown, N	1999	The archaeology of the coastal landscape, in Green (ed) 1999, 11-19	Essex	
Nayling, N	1998	*The Magor Pill Medieval Wreck*, CBA Res Rep	Shipwrecks	
Nayling, N and Caseldine, A	1997	*Excavations at Caldicot, Gwent: Bronze Age Palaeochannels in the Lower Nedern Valley.* CBA Res Rep **108**	Alluvium	Good environmental evidence
Neale, K	1987	*An Essex Tribute*	Essex	
Needham, S	2000	*The passage of the Thames: Holocene environment and settlement at Runneymede*, British Museum Press, London	Alluvium	Environmental data that provide the 'anchor' for research at Runneymede
Needham, S	1991	*Excavation and Salvage at Runnymede Bridge 1978: The Late Bronze Age waterfront site*, British Museum London.	Alluvium	
Needham, S and Macklin, M G (eds)	1992	*Alluvial archaeology in Britain*, Oxbow Monogr **27**, Oxbow Books, Oxford	Alluvium	State of alluvial archaeology in late '80s, early '90s
Van de Noort, R, Fletcher, W, Thomas, G, Cartairs, I and Patrick, D (eds)	2002	*Research into Monuments at Risk in England's Wetlands*, English Heritage/University of Exeter	Framework	
van de Noort, R and Ellis, S (eds)	1995	*Wetland Heritage of Holderness*	Humber	
van de Noort, R and Ellis, S (eds)	1997	*Wetland Heritage of the Humberhead Levels.*	Humber	
van de Noort, R and Ellis, S. (eds)	1998	*Wet/and Heritage of the Ancholme and Lower Trent*	Humber	Accounts of regional surveys
van de Noort, R and Ellis, S (eds)	1999	*Wetland Heritage of the Vale of York.*	Humber	
Van de Noort, R, Lillie, M	2000	*Wet/and Heritage of the Hull Valley.*	Humber	

and Ellis (eds)				
van de Noort, R and Ellis, S (eds)	2001	*Wetland Heritage of the Lincolnshire Marsh.*	Humber	
North Kent Study	1991	*North Kent Marshes study, historical and cultural resources: the archaeology and historical significance of the North Kent Marshes*	North Kent	
Oxford Archaeological Unit	2001	*Ebbsfleet Sports Ground, Northfleet, Kent, ARC ESG00: Phase II evaluation archaeological works fieldwork report - final*, unpublished client report, December 2001	CTRL	
Oxford Archaeological Unit	2001	*Goresbrook Diversion, Dagenham, ARC GOR00: Archaeological evaluation fieldwork report - final*, unpublished client report, April 2001	CTRL	
Oxford Archaeological Unit	2001	*South Thames-Side Development Route Stage 4 archaeological works: method statement*, OAU May 2001	STDR4	
Oxford Archaeology	2001	*CTRL Contract 342 archaeological works in the Ebbsfleet Valley: method statement for additional geoarchaeological ground investigation*, OA June 2002	STDR4	
Pearson, P N	1998	Evolutionary concepts in biostatratigraphy, in Doyle and Bennett 1998, 123-144	Biostratigraphy	
Pederson, L, Fischer, A and Aaby, B (eds)	1997	*The Danish Storebaelt since the Ice Age - man, sea and forest*, A/S Storebaeltsforbindelsen, Copenhagen	Denmark	Multi-disciplinary survey of marine enviromnment
Plater, A J, Long, A J, Spencer, C D and Delacour, R A P	1999	The stratigraphic record of sea-level changes and storms during the last 2000 years: Romney Marsh, southeast England, *Quaternary International* **55**, 17-27	Sea-level	
Pirrie, D	1998	Interpreting the record: facies analysis, in Doyle and Bennett 1998, 395-420	Facies	
Priddy, D and Buckley, D G	1987	An assessment of excavated enclosures in Essex together with a selection of cropmark sites, in *Excavations at Woodham Walter and an assessment of Essex enclosures* (ed J Hedges), East Anglian Archaeol **33**, 48-77	Essex	Assessment and useful distribution map of cropmark sites in Essex
Pye, K and Allen, J R L (eds)	2000	*Coastal and estuarine environments: sedimentology, geomorphology and gearchaeology*. Geological Society Special Publication, London	Facies	
Quinn, R, Cooper, A J A G and Williams, B	2000	Marine geophysical investigation of the inshore coastal waters of Northern Ireland, *J Nautical Archaeol* **29**. 2, 294-298	Shipwreck	
Rackham, D J	1994	Prehistory in the Lower Thames floodplain, *London Archaeology* **7**, 191-196	Alluvium	
Rapp, G and Hill, C L	1998	*Geoarchaeology: the earth-science approach to archaeological interpretation*, Yale University Press, New Haven	Geoachaeology	
Raftery and Hickey, J (eds)	2001	*Recent developments in wetland archaeology*, Department of Archaeology, University College Dublin Monogr Ser **2**	Wetlands	
Reading, H G	1996	*Sedimentary environments: process, facies and stratigraphy*, Blackwell, Oxford	Facies	
Redknap, M	1990	Surveying for underwater archaeological sites: signs in the sands, *The Hydrographic Journal* **58**, 11-16	Maritime	
Ricklis, R A and Blum, M D	1997	The geoarchaeological record of Holocene sea level change and human occupation of the Texas Gulf coast, *Geoarchaeology* **12**, 287-314	Sea-level	
Rippon, S	1996	*Gwent Levels: the Evolution of a Wetland Landscape.* CBA Res Rep **105**	Alluvium	Survey of archaeological/historical sequence
Rippon, S	1997	*The Severn Estuary: Landscape Evolution and Wetland Reclamation.* Leicester.	Severn	
Rippon, S	2000	*The Transformation of Coastal Wetlands*	Essex	Conceptual frameworks, Roman to Medieval
Roberts, P and Trow, S	2002	*Taking to the Water: English Heritage's initial policy for the management of maritime archaeology in England*, English Heritage	Framework	
RCHME	1996	*The national inventory of maritime archaeology for England*, Swindon	Framework	

RCHME	1995	*Thames Gateway: recording historic buildings and landscapes on the Thames Estuary*	Thames estuary	
Scaife, R G and Long, A J	1995	Evidence for Holocene sea-level changes at Caldicot Pill, the Severn Estuary, in Archaeology in the Severn estuary 1994 (ed M Bell), *Annual report of the Severn Estuary Levels Research Committee*, 81-86.	Sea-level	
Shackleton, J C and van Andel, T H	1980	Prehistoric shell assemblages from Franchthi Cave and the evolution of the adjacent coastal zone, *Nature* **288**, 357-359	Shells	
Shennan, I, Tooley, M J, Davies, M J and Haggart, B A	1983	Analysis and interpretation of Holocene sea-level data, *Nature* **302**, 404-6	Sea-level	
Sidell, J, Cotton, J, Raynor, L and Wheeler, L	2002	*The prehistory and topography of Southwark and Lambeth*, MoLAS Monogr **14**	Thames Valley	
Sidell, J, Wilkinson, K, Scaife, R and Cameron, N (eds)	2000	*The Holocene evolution of the London Thames: archaeological excavations (1991-1998) for the London Underground Limited Jubilee Line Extension Project*, MoLAS Monogr **5**	Thames Valley	Key sedimentary sequences of the Thames
Smith, B M	2002	*A palaeoecological study of the raised mires in the Humberland levels*, BAR Brit Ser **336**, Archaeopress, Oxford	Humber	
Spencer, C D, Plater, A J and Long, A J	1988	Rapid coastal change during the mid- to late-Holocene: The record of barrier estuary sedimentation in the Romney Marsh region, south-east England, *The Holocene* **8** (2), 143-163	Sea-level	
Stafford, C R	1995	Geoarchaeological perspectives of paleolandscapes and regional subsurface archaeology, *Journal of Archaeological Method and Theory* **2**, 69-104	Methodology	
Strachan, D	2001	Tidal fish-weirs in Essex: integration of aerial, ground and sonar survey, in Raftery and Hickey (eds), 2001, 309-10	Essex	
Strachan, D	1998	Inter-tidal stationary fishing structures in Essex: some C14 dates, *Essex Archaeol Hist* **29**, 274-82	Essex	
Stright, M J	1990	Archaeological sites on the North American continental shelf, in *Archaeological geology of North America* (eds N P Lasca and J Donahue (or Donoghue?)), Geologocal Society of America Centennial Special Volume **4**, 439-466	Geophysical survey	
Stright, M J	1986	Evaluation of archaeological site potential on the outer continental shelf using high-resolution seismic data, *Geophysics* **51**, 605-622	Seismic	
Sumbler, M G	1996	London and the Thames Valley, *British Regional Geology* (4th edition), British Geological Survey, Keyworth	Thames Valley	
Thomas, C	1985	*Exploration of a drowned landscape: archaeology and the history of the Isle of Scilly*, London	General	
Thomas, G	2001	The Humber Estuary: tracks and traps of the Middle Bronze Age, *Current Archaeology* **172** February, 166-7	Humber	
Walker, R G and James, N P (eds)	1992	*Facies models, response to sea level change*, Geological Association of Canada	Sea-level	
Wallis, S and Waughman, M	1998	*Archaeology and the landscape in the Lower Blackwater Valley*, East Anglian Archaeol **82**	Essex	
Ward, J	1987	"Richer in land than inhabitants" south Essex in the Middle Ages in Neale 1987, 97-108	Essex	
Wells, L E	2001	A geomorphological approach to reconstructing archaeological settlement patterns based on artifact distribution, in Goldberg *et al* 2001, 107-141	Methodology	
Whittaker, A	1998	Borehole data and geophysical log stratigraphy, in Doyle and Bennett 1998, 243-274	Boreholes	
Widdowson, M (ed)	1997	*Palaeosurfaces: recognition, reconstruction and palaeoenvironmental interpretation*, Geological Society Special Publication **120**	Methodology	

Wilkinson, T J	1988	*Archaeology and environment in South Essex: rescue archaeology along the Grays By-pass, 1979/80*, East Anglian Archaeol **42**	Essex	Field investigation of gravel terraces in south Essex; pre-dates Hullbridge survey
Wilkinson, T J and Murphy, P	1995	*The archaeology of the Essex Coast, Volume 1: The Hullbridge Survey*, East Anglian Archaeol **71**	Essex	Baseline survey of Essex coast
Wilkinson, T J and Murphy, P	1986	Archaeological survey of an intertidal zone: the submerged landscape of the Essex coast, *Journal of Field Archaeology* **13**, 177-194	Essex	
Wilkinson, T J and Murphy, P	Forth-comin g	*The archaeology of the Essex Coast, Volume II: Excavations at The Stumble*, East Anglian Archaeol	Essex	Long-awaited 'sequel' to Hullbridge survey
Williams, B	2000	Commercial developments and their impact on maritime heritage: the Northern Ireland experience, *J Nautical Archaeol* **30**.1, 5-11	Dredging	
Williams, J	2001	Introduction, in Cuming *et al* 2001, 5-8	Planarch	
Williams, J and Brown, N (eds)	1999	*An archaeological research framework for the Greater Thames Estuary*, Essex County Council, Chelmsford	Framework	Sets out the research priorities
Wymer, J J and Brown, N R	1995	*Excavations at North Shoebury: settlement and economy in south-east Essex 1500BC - AD1500*, East Anglian Archaeol **75**	Essex	Gravel site in south Essex

APPENDIX THREE

MINUTES OF MEETINGS

Minutes of the Working Group Meeting (24/10/02)

Minutes of the Working Group Meeting (06/11/02)

Minutes of the Working Group Meeting (22/11/02)

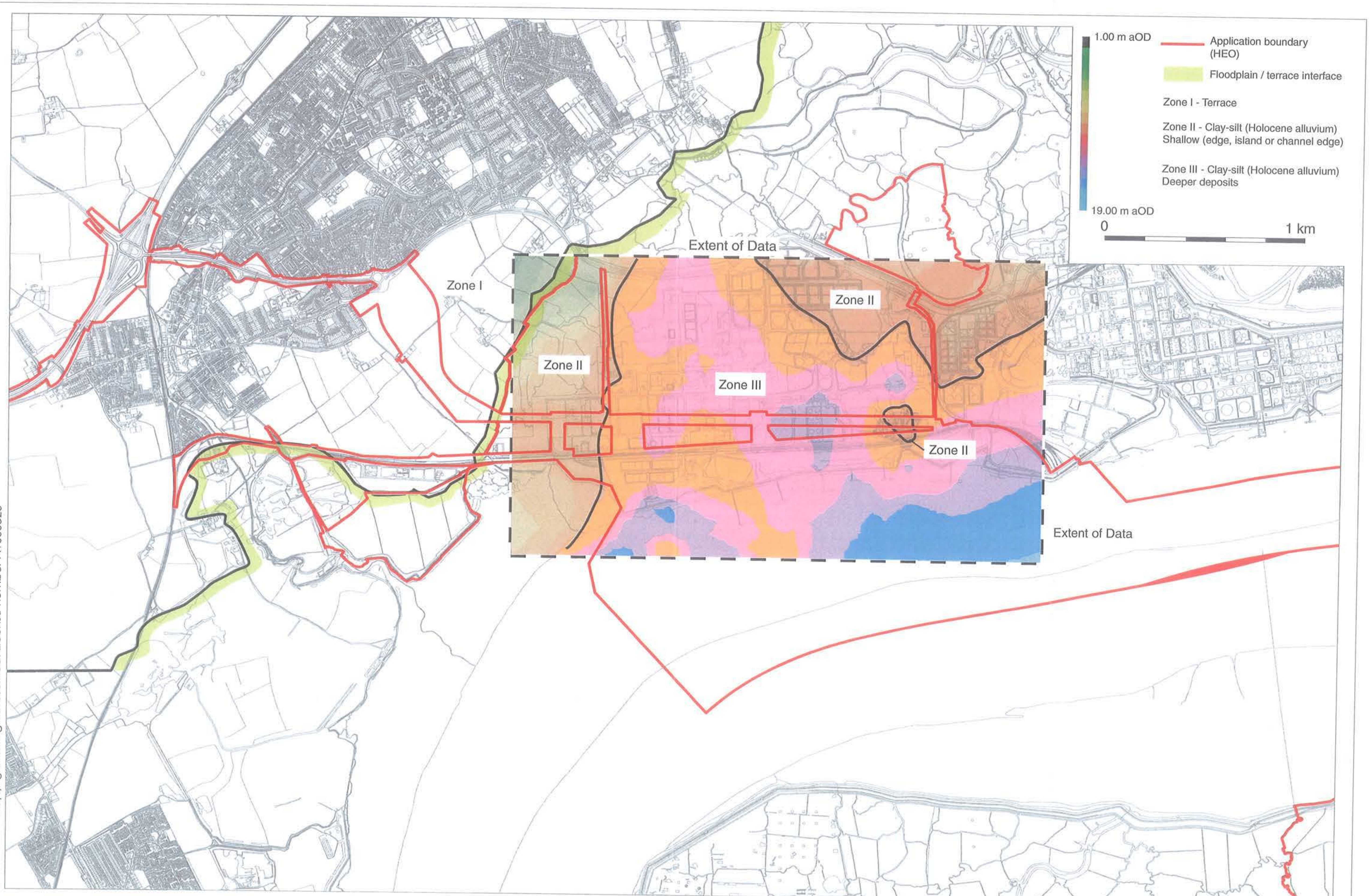
Minutes of the Working Group Meeting (05/12/02)

Minutes of the Working Group Meeting (18/12/02)

Minutes of the Technical Group Meeting (05/02/03)

Minutes of the Technical Group Meeting (01/04/03)

Minutes of the Technical Group Meeting (02/04/03)



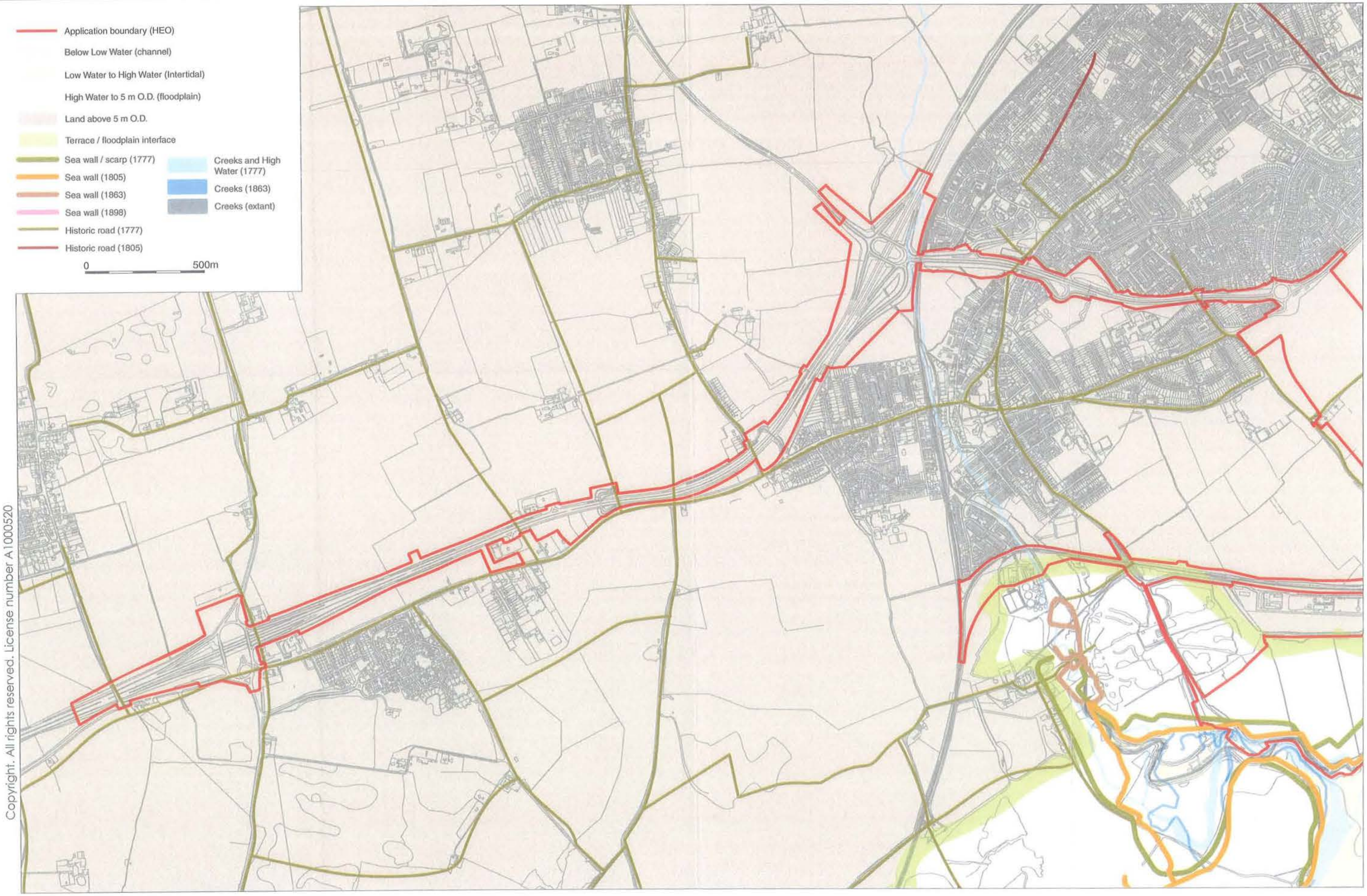
London Gateway

Early Holocene Landscape
(taken from sub-surface deposit model)

Scale: NOT TO SCALE
Date: 03/03/2003

Figure 1

P&O



London Gateway

Post-Medieval and Modern Topography (HEO)

Scale 1:15,000
Date: 05/02/2003

Figure 2a

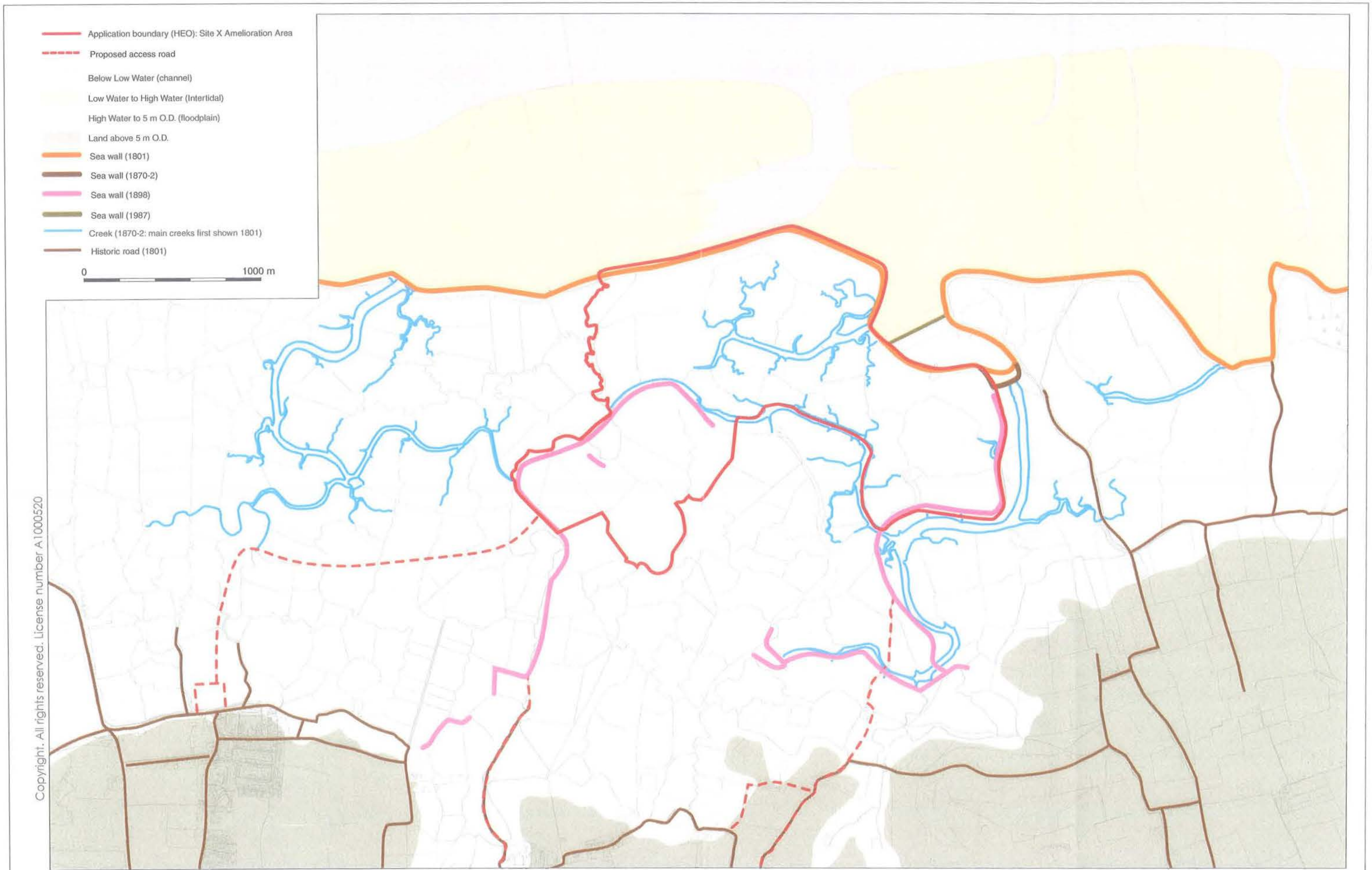
London Gateway

Post-Medieval and Modern Topography (HEO)

Scale: 1:15,000
Date: 05/02/2003

Figure 2b

P&O



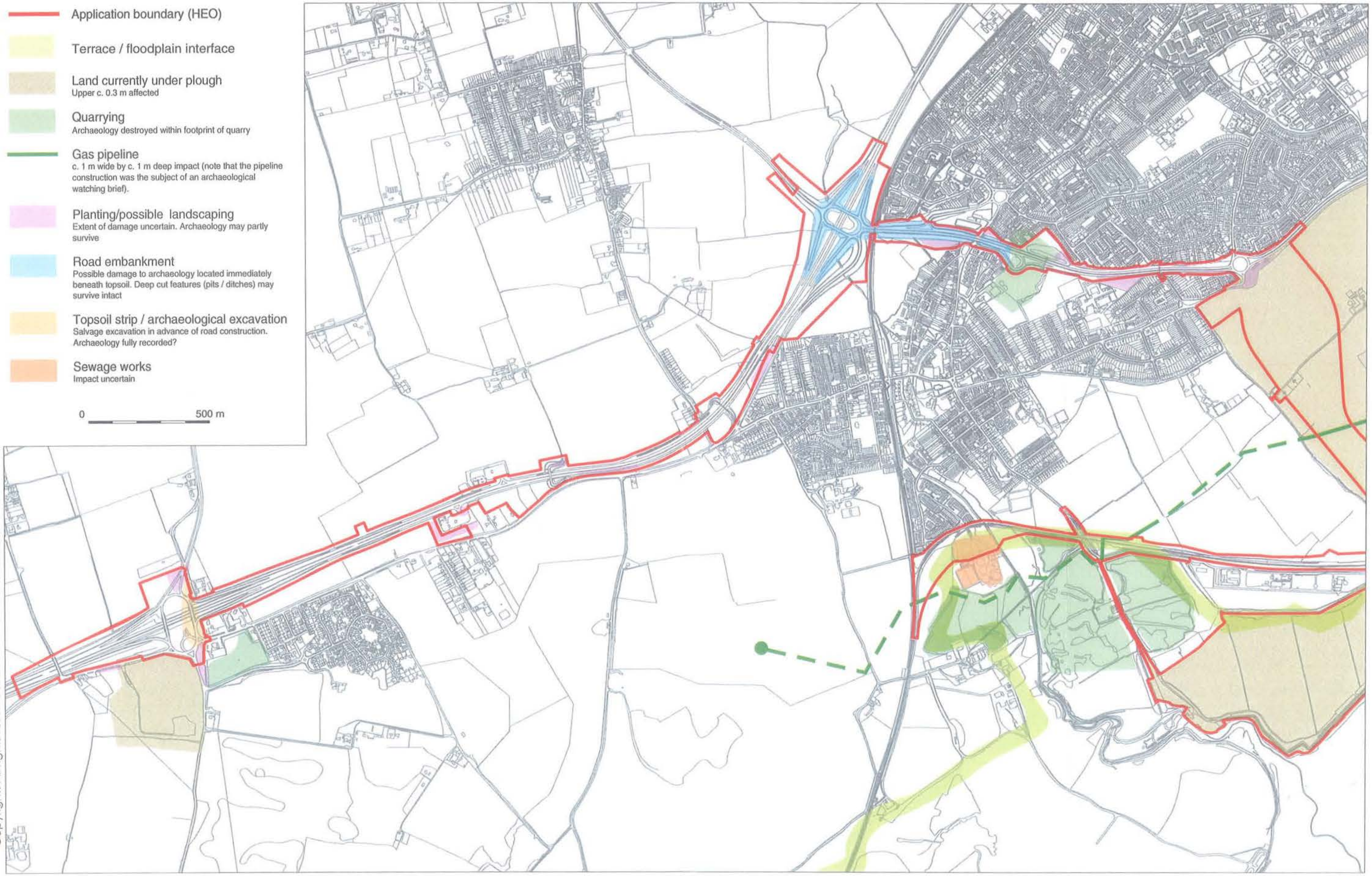
London Gateway

Post-Medieval and Modern Topography (HEO)

Scale: Not to Scale
Date: 05/02/2003

Figure 2c

P&O



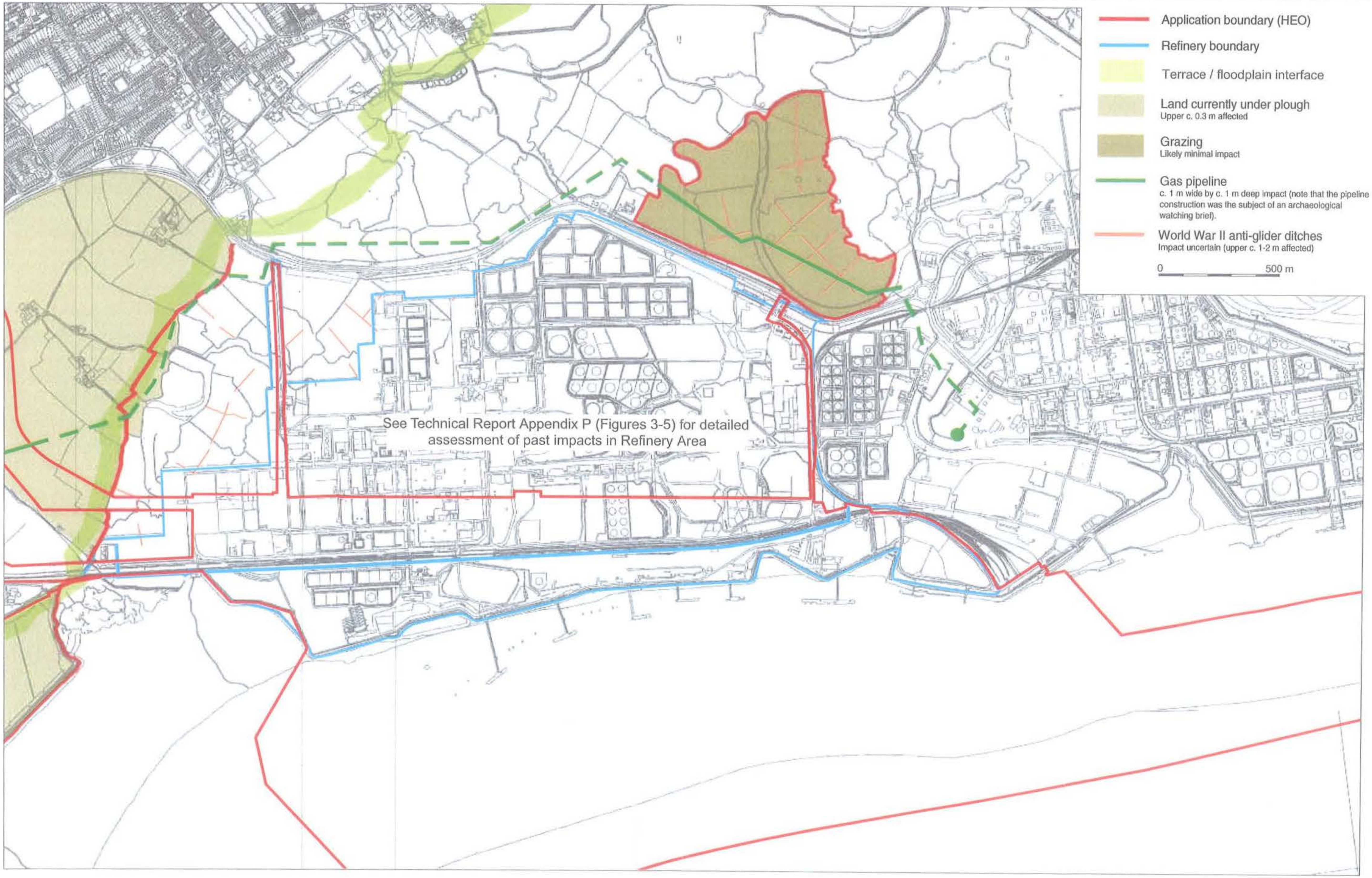
London Gateway

Past Impacts (HEO)

Scale: 1:15,000
Date: 05/02/2002

Figure 3a

P&O



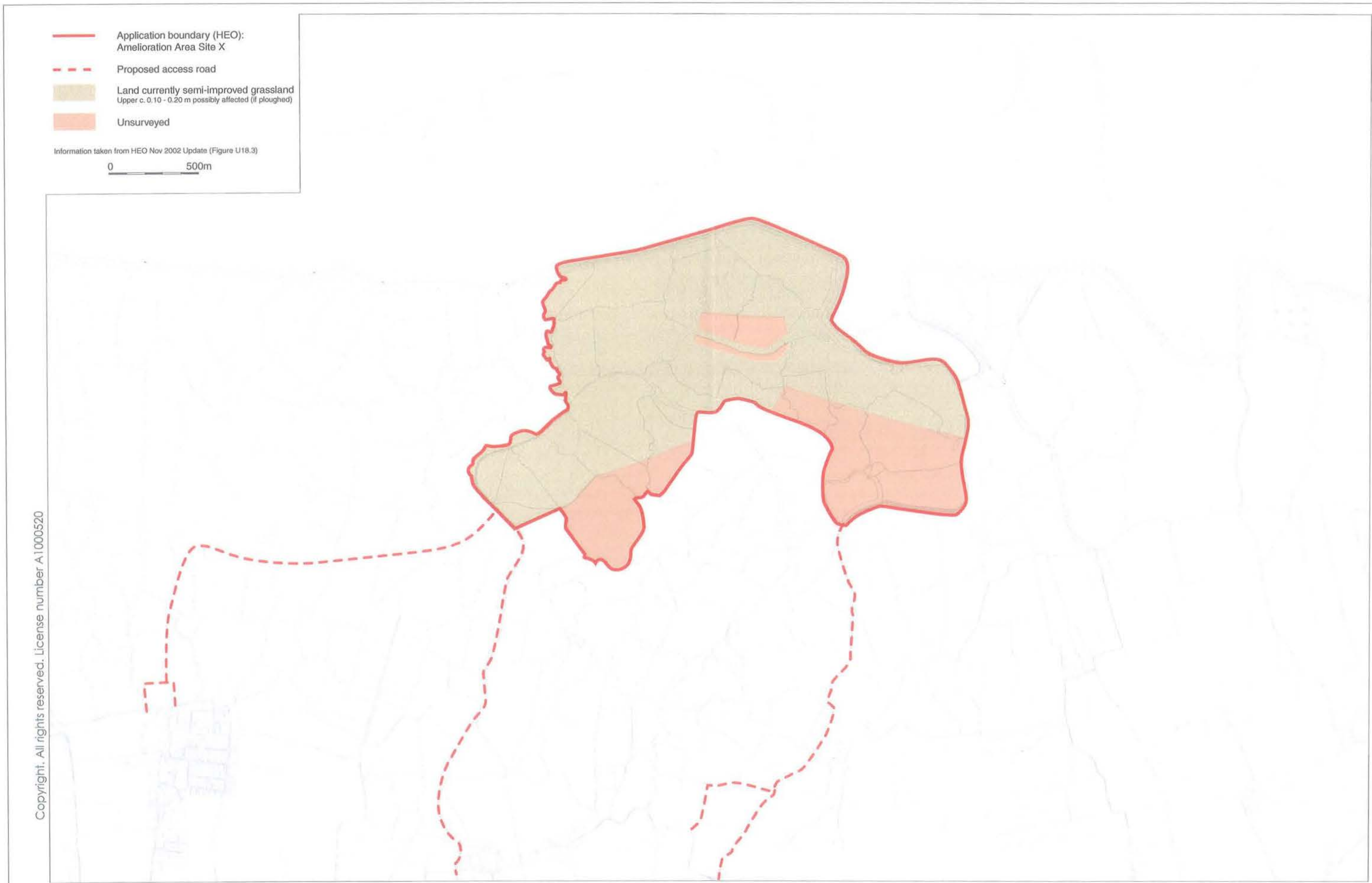
London Gateway

Past Impacts (HEO)

Scale: 1:15,000
Date: 05/02/2002

Figure 3b

P&O



London Gateway

Past Impacts (HEO)

Scale: NOT TO SCALE
Date: 05/02/2003

Figure 3c

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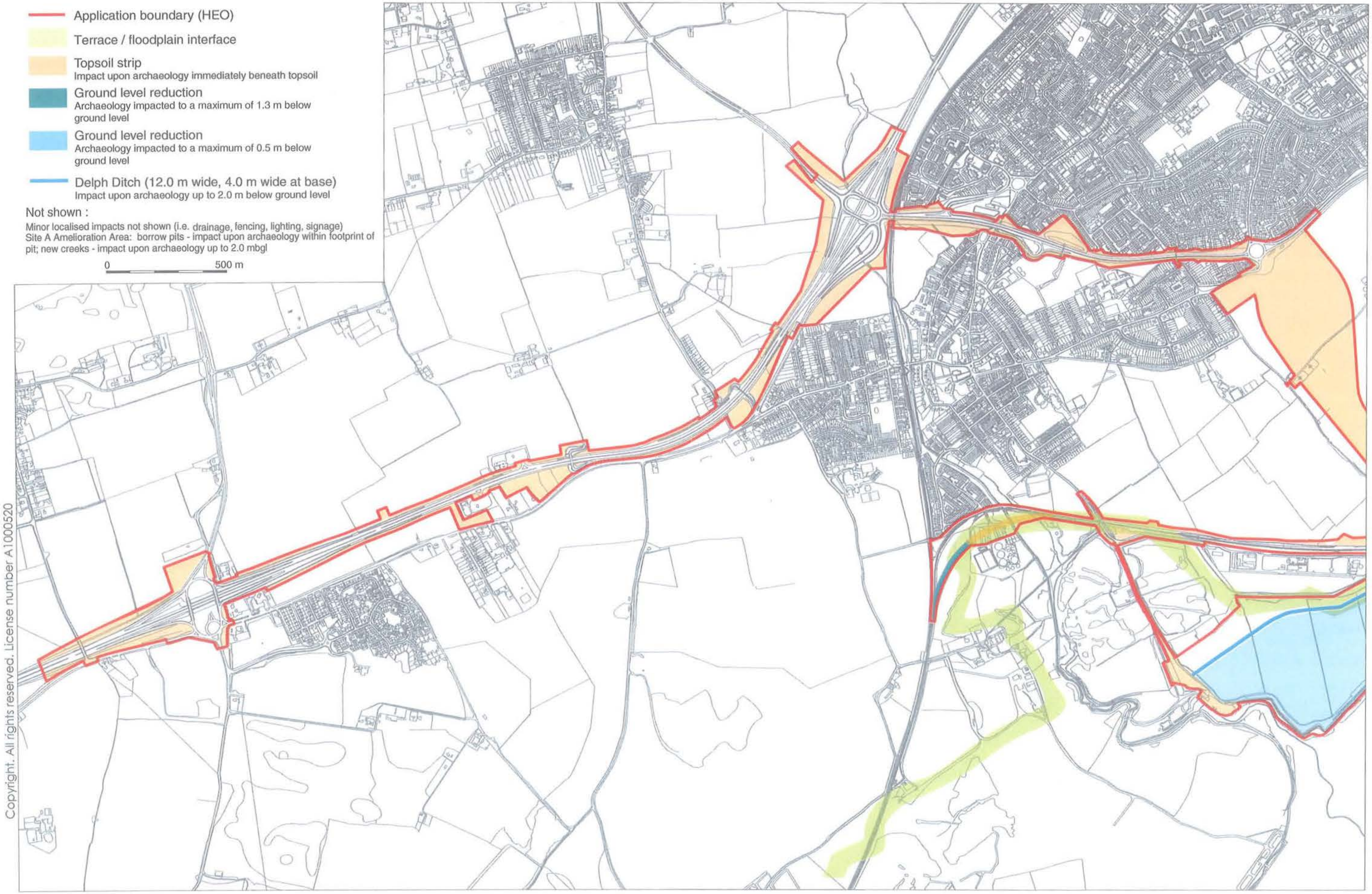


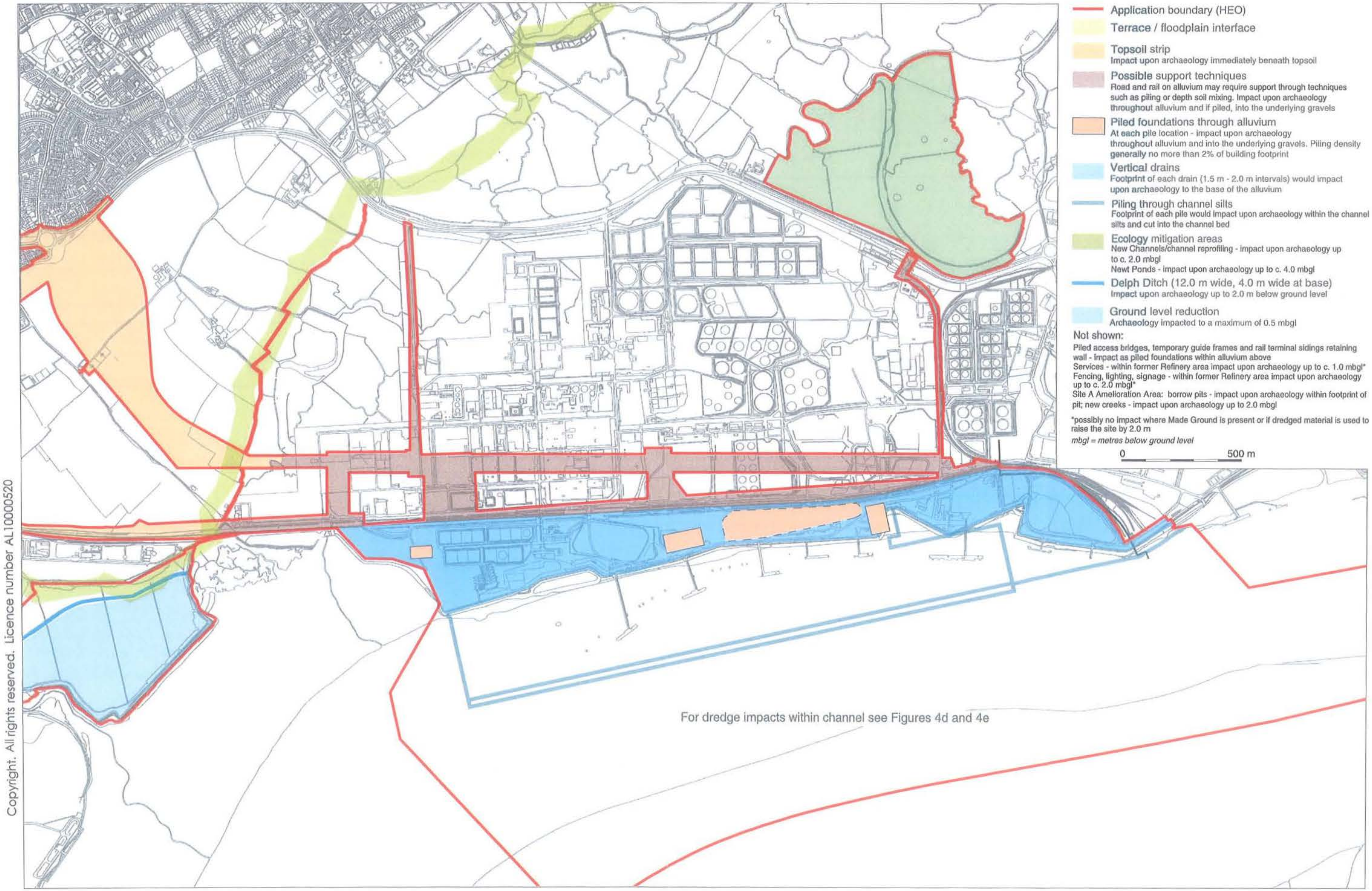
London Gateway

Proposed Impacts (HEO)

Scale: 1:15,000
Date: 05/02/2003

Figure 4a

P&O



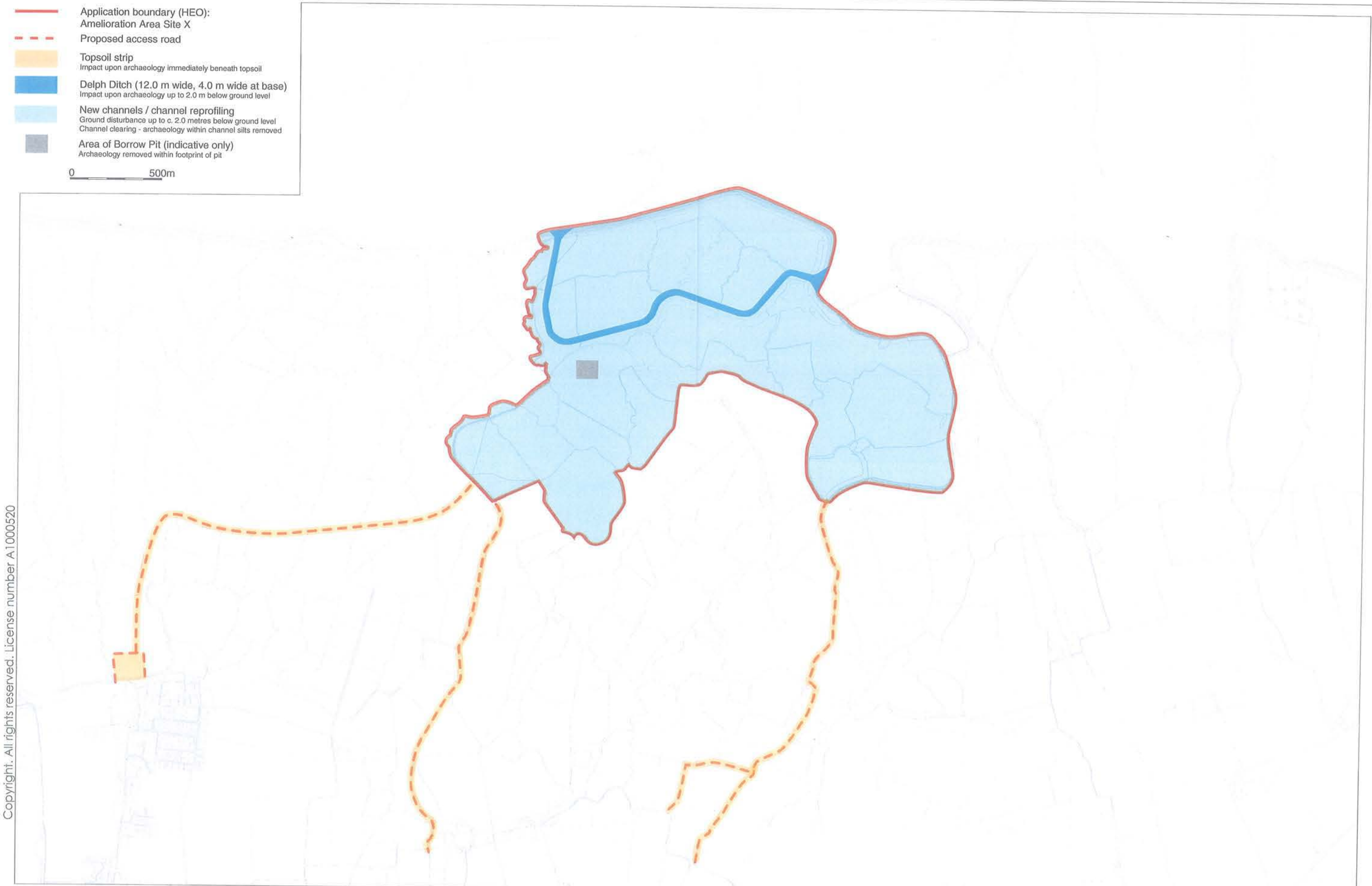
London Gateway

Proposed Impacts (HEO)

Scale: 1:15,000
Date: 05/02/2003

Figure 4b

P&O



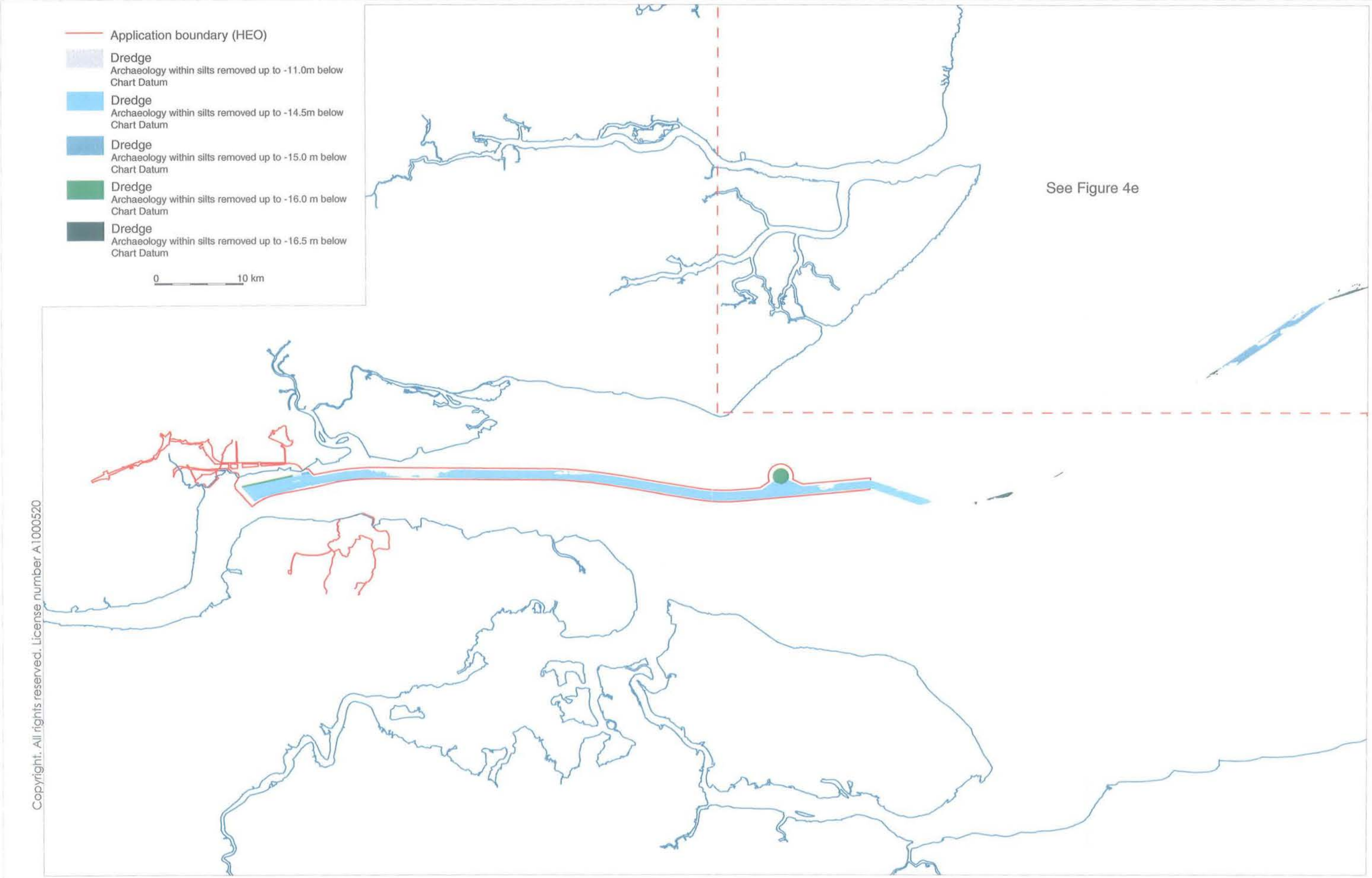
London Gateway

Proposed Impacts (HEO)

Scale: NOT TO SCALE
Date: 05/02/2003

Figure 4c

P&O



London Gateway

Proposed Impacts (HEO)

Scale: 1:200,000
Date: 05/02/2003

Figure 4d

P&O

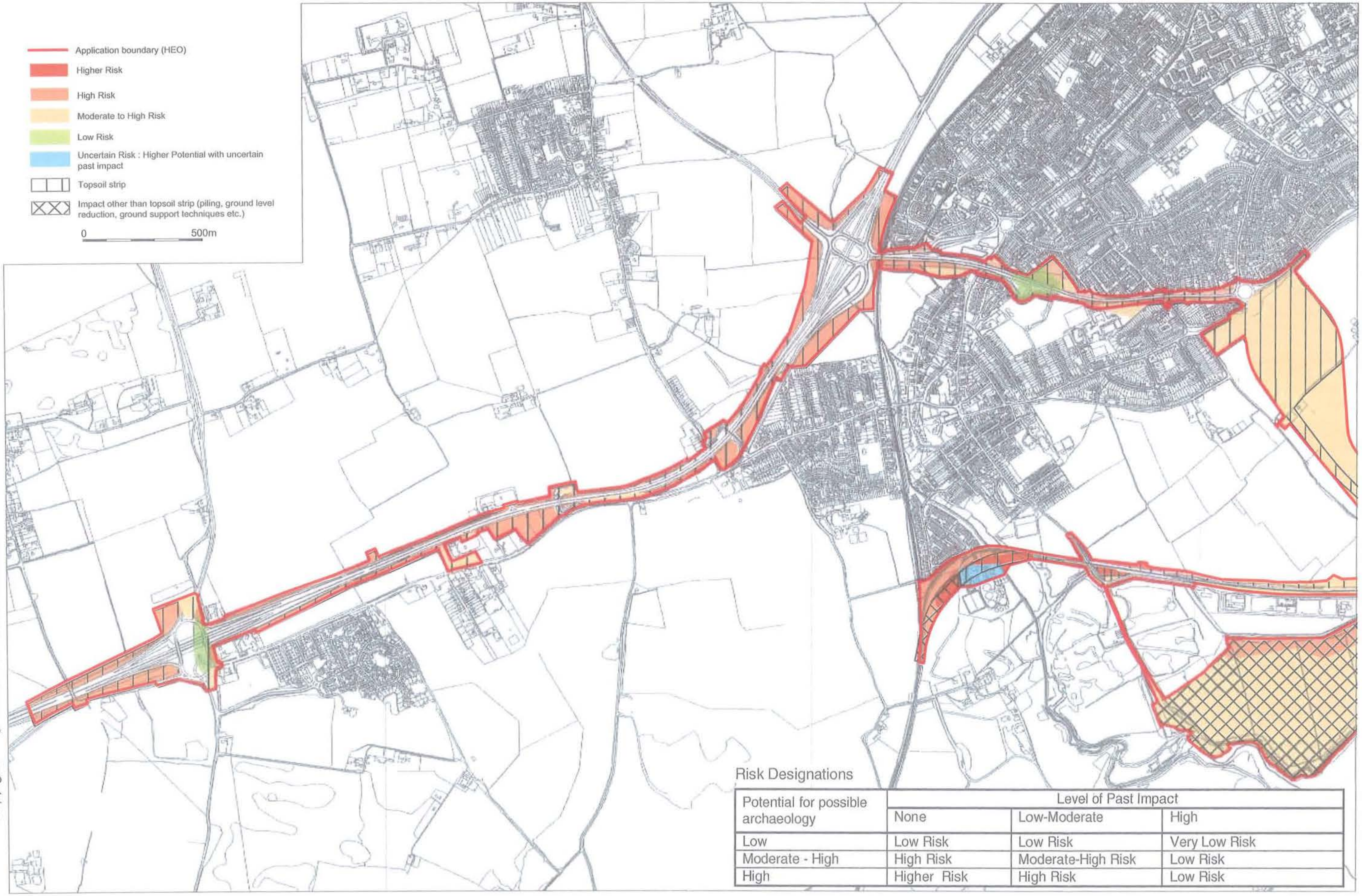
London Gateway

Proposed Impacts (HEO)

Scale: 1:200,000
Date: 05/02/2003

Figure 4e

P&O



Risk Designations

Potential for possible archaeology	Level of Past Impact		
	None	Low-Moderate	High
Low	Low Risk	Low Risk	Very Low Risk
Moderate - High	High Risk	Moderate-High Risk	Low Risk
High	Higher Risk	High Risk	Low Risk

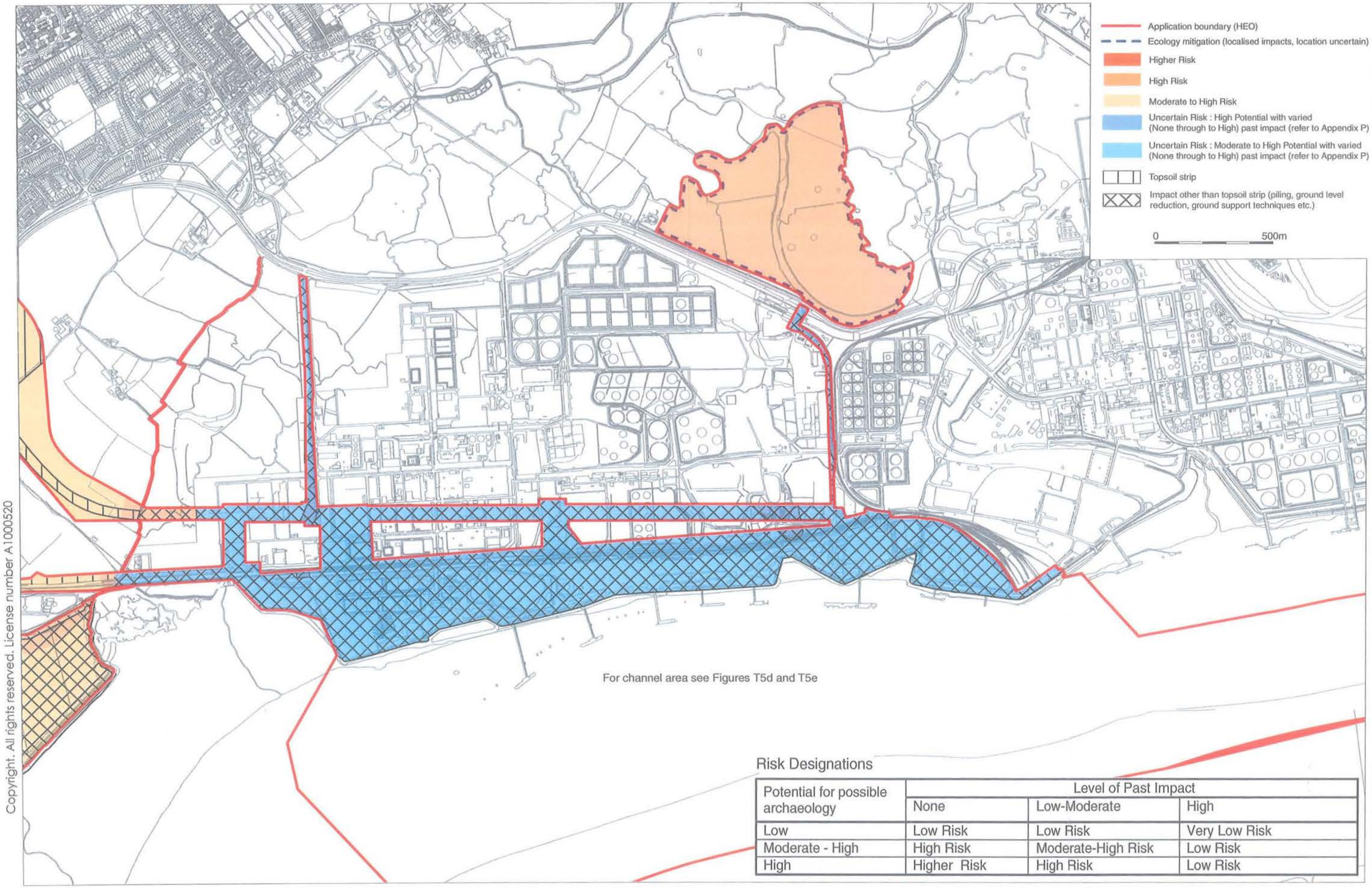
London Gateway

Anticipated Degree of Archaeological Survival (HEO)

Scale: 1:15,000
Date: 05/02/2003

Figure 5a

P&O



Risk Designations

Potential for possible archaeology	Level of Past Impact		
	None	Low-Moderate	High
Low	Low Risk	Low Risk	Very Low Risk
Moderate - High	High Risk	Moderate-High Risk	Low Risk
High	Higher Risk	High Risk	Low Risk

London Gateway

Anticipated Degree of Archaeological Survival (HEO)

Scale: 1:15,000
Date: 05/02/2003

Figure 5b

P&O

Application boundary (HEO):
Amelioration Area Site X

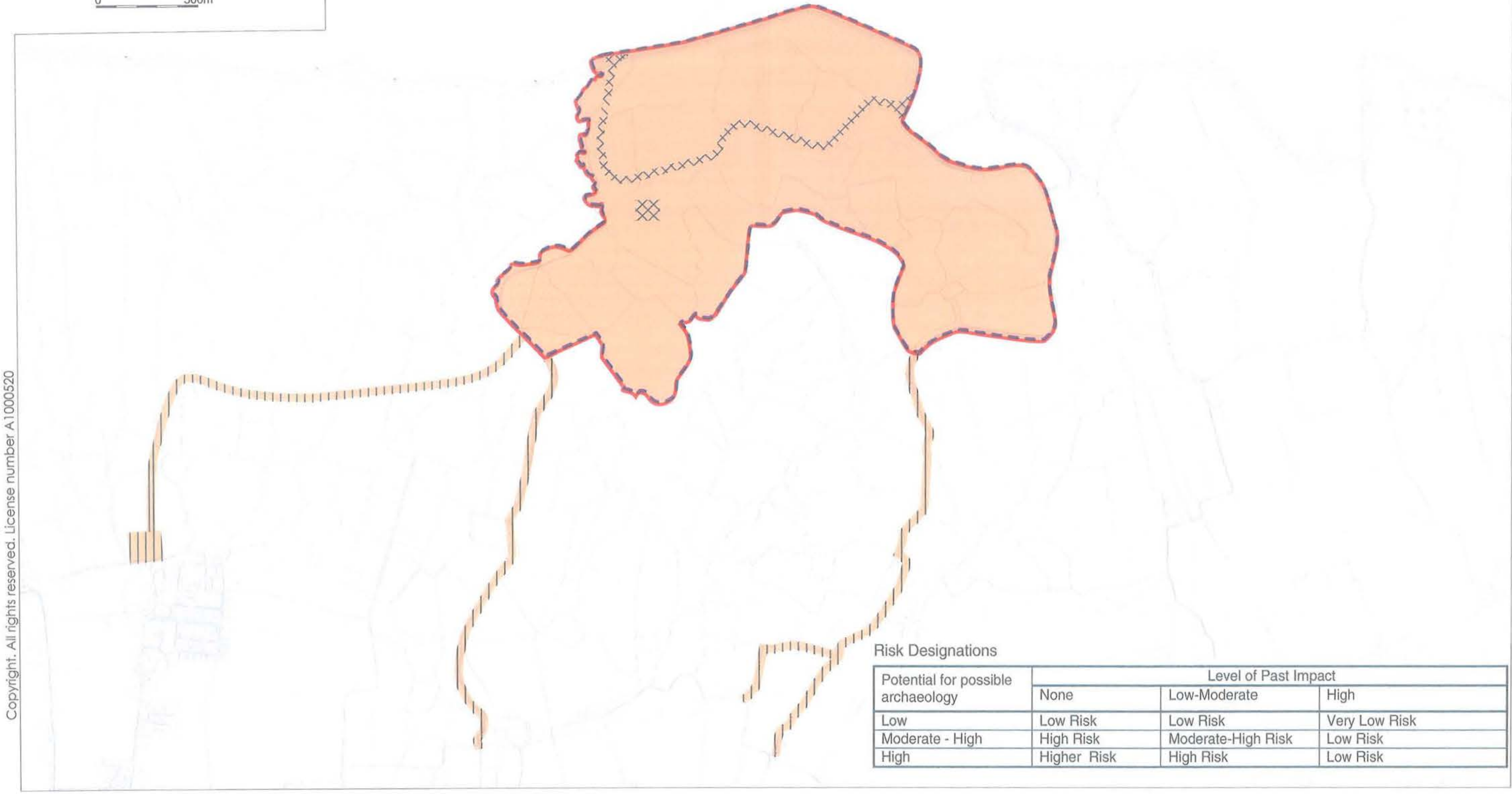
High Risk

Topsoil strip

Impact other than topsoil strip (piling, ground level reduction, ground support techniques etc.)

Localised impacts (topsoil strip and impact other than topsoil strip) location uncertain

0 500m



Risk Designations

Potential for possible archaeology	Level of Past Impact		
	None	Low-Moderate	High
Low	Low Risk	Low Risk	Very Low Risk
Moderate - High	High Risk	Moderate-High Risk	Low Risk
High	Higher Risk	High Risk	Low Risk

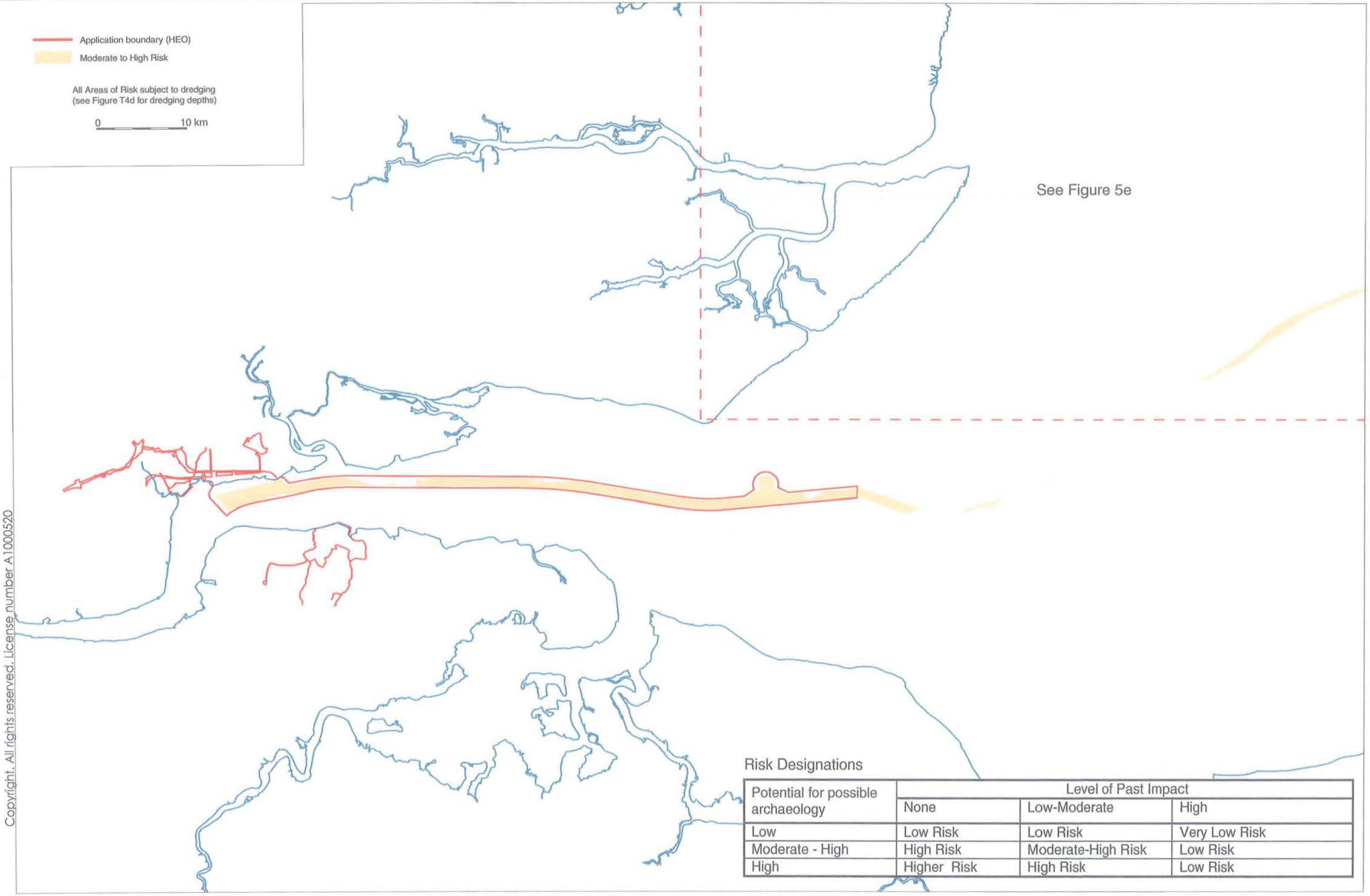
London Gateway

Anticipated Degree of Archaeological Survival (HEO)

Scale: AS ABOVE
Date: 05/02/2003

Figure 5c

P&O



Risk Designations

Potential for possible archaeology	Level of Past Impact		
	None	Low-Moderate	High
Low	Low Risk	Low Risk	Very Low Risk
Moderate - High	High Risk	Moderate-High Risk	Low Risk
High	Higher Risk	High Risk	Low Risk

London Gateway

Anticipated Degree of Archaeological Survival (HEO)

Scale: 1:200,000
Date: 05/02/2003

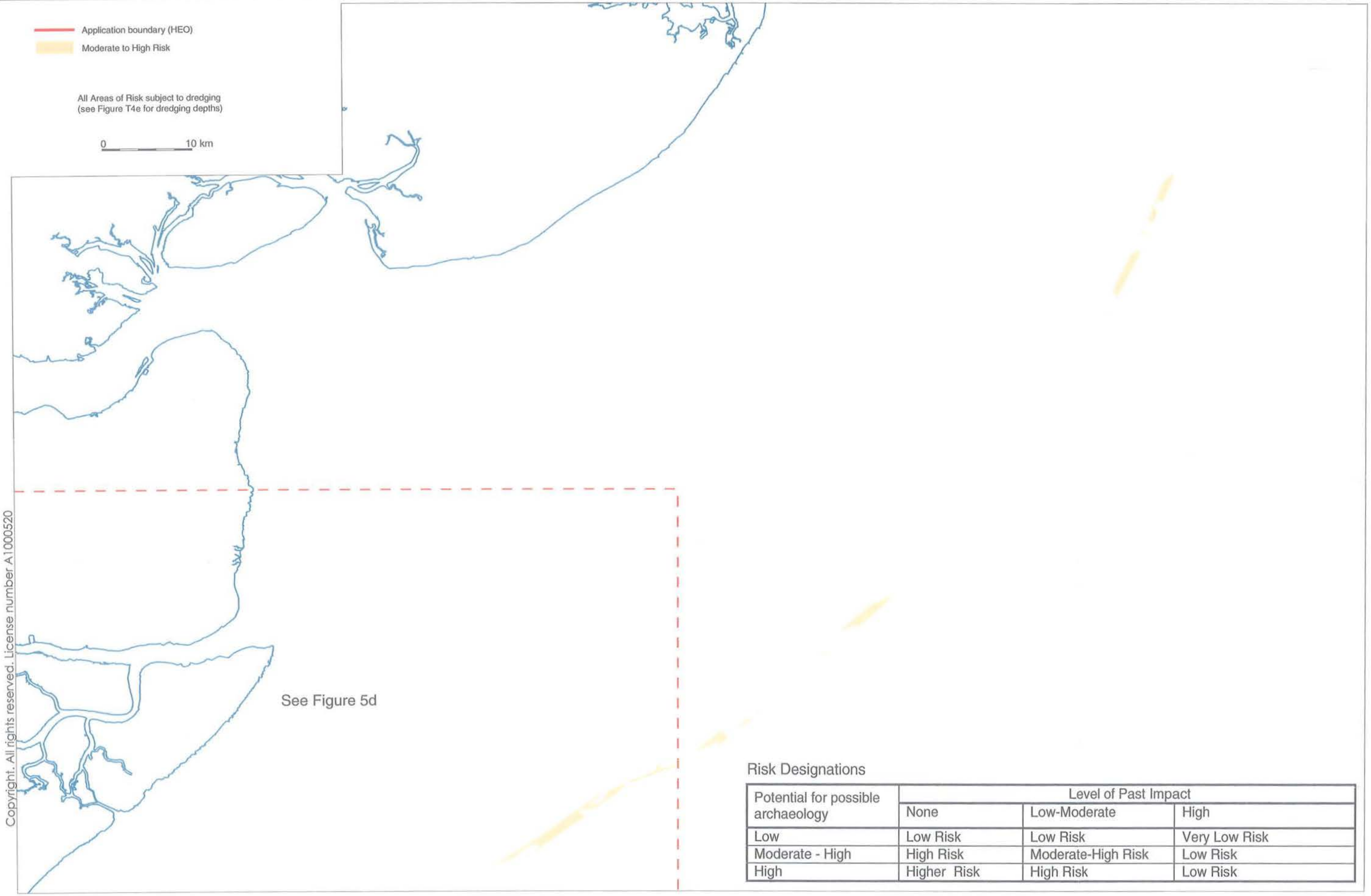
Figure T5d

P&O

Application boundary (HEO)
Moderate to High Risk

All Areas of Risk subject to dredging
(see Figure T4e for dredging depths)

0 10 km



Risk Designations

Potential for possible archaeology	Level of Past Impact		
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London Gateway

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Scale: 1:200,000
Date: 05/02/2003

Figure 5e

P&O