Chapter 5

Project Concepts

A Geoarchaeological Framework for the Route Corridor

In order to identify evidence of human activity in areas of thickly stratified sediments and, indeed, to attach significance to the discovery of signals pertaining to human activity during evaluation, a consideration of the nature of the archaeological signals likely to be present in such areas was fundamental to designing the project. In conjunction with an understanding of the nature of the signals is the need to understand the landscape setting and local geomorphology of an area within which human activity of different kinds is more or less likely. For this reason a geoarchaeological model specific to the alluvial corridor was required. Thus the following factors were considered as basic elements within such a model:

- The nature of the archaeological signal;
- The relationship between archaeological signals/sites and sediments (sedimentary facies);
- The concept of palaeolandsurfaces and their identification within the alluvial corridor.

Furthermore approaches to modelling these sequences and the buried surfaces required consideration in order to place the evidence within a palaeogeographical context. These issues are considered below.

The Archaeological Signal

Within urban contexts, where houses, streets, etc are well defined, a site can be clearly isolated and defined, and the presence of such features in the archaeological record identified through clearly visible layers (such as within boreholes or trenches) Within the rural context, where activity is more dispersed, site definition is often less apparent. This is particularly the case for prehistoric sites where evidence of occupation or activity may be ephemeral and difficult to discern even during excavation. Alternatively the structure of the archaeological record may be based on size of archaeological occurrence (Table 3) (eg, see Fokkens 1998). Here occurrences are sub-divided into four classes: points, scatters, groups and systems. Within this four-fold sub-division all likely activity occurrences can be accommodated. It is clear that the different scales of archaeological 'site' will have different properties and their visibility in the landscape and within sedimentary units will vary. Their visibility to differing survey techniques will also vary. Archaeological sites can also be classified on the basis of site function and position in the landscape (Tables 4 and 5). These criteria can be combined and used within the framework of reconstructed landscapes for the range of environments expected to be present within the Lower Thames during much of the Holocene.

Additionally, a further class of archaeological signal in the landscape can be defined: archaeological proxy records. They are indirect records of human activity where activity results in changes in biotic, sedimentological or geochemical conditions within the area surrounding the human activity. For example pollen records showing evidence of woodland clearance and agriculture (Birks *et al* 1988), enhanced phosphate levels in sediment (Lippi 1988) and the results of deforestation and the resulting soil erosion/deposition (Bell and Boardman 1992) are indicative of human activity at varying distances from the point of sampling. However, results from these proxy records, unlike direct physical remains of human activity, are usually only recognisable following costly and time consuming laboratory investigation.

It should be noted that definition of the archaeological resource/signal is likely to depend on the objectives of the investigation project. The signals

Table 3 Size classification of archaeological sites (adapted from Bates 1998)

Unit size	Archaeological characteristics	Examples	Site terminology
<1m	Single artefact/dense scatters	Knapping episode	Point
1–10m	Artefact scatters/single structure/faunal residue scatters	Tent/hut, butchery site	Scatter
10–100m	Groups of scatters, structures	Settlements	Group
>100m	Associations of structural elements, routeways, field systems	Landscape systems	System

Table 4 Site types, site sizes, descriptions and locations within the landscape for the main types of archaeological sites expected in the area

Site	Site size	Site description	Site location	Site type
Find Spot	<1m	Single artefact lost or placed within a 'natural context'	Any point in landscape	Point
Production episode	1–10m	Single knapping episode, tool production point, etc	Anywhere in landscape but often in proximity to raw material source or source of material to be processed	Scatter
Processing episode	1–10m	Single exploitation episode eg, carcass butchery	Anywhere in landscape but often in proximity to water source, channel, etc	Scatter
Boat	1–10m or 10–100m	Hull or dug-out ranging from canoe to large merchant and warships	Within or adjacent to channels on mudflats	Scatter
Trackway	10–100m	Wooden trackway or lithic causeway	Within or on peat units in floodplain environment	Group
Revetment	1–10m, 10–100m	Wooden or stone construction at waters edge	Channel marginal situation	Group
Settlement/ Ritual	10–100m, >100m	Cluster of artefacts, structures including houses/huts, routeways and revetments	Gravel islands, channel margins, 'upland zones'. Floodplain surface, channel edge, shallow lake	Group

considered of archaeological relevance will therefore vary between projects. Additionally, the sampling strategies and methods of investigation employed to detect that signal will also vary and will depend on the 'site' target type/size and the methods at the disposal of the project team.

In this study an underlying principle of the methodology used considers the landscape to be the template on which human activity occurred and that the landscape forms the basic archaeological resource. While it is a useful exercise to consider the types of sites (points) that may form the focus of archaeological attention, one should remember that human activity is not simply restricted to sites but that humans use the whole landscape and that, therefore, the archaeological site is spatially continuous (Foley 1981; Pollard 1998). Identification and consideration of the landscape properties are, therefore, of prime importance.

Sedimentary Facies and Archaeological Sites

The nature of archaeological signatures has been described previously (Chap 3, *Archaeology*) and links have been implied between the nature of the archaeological signal and the location in the landscape of the archaeological remains (Table 4). This suggests that an association between sedimentary characteristics of these zones (ie, sedimentary facies) and their contained archaeology may be determined (Table 6). Defining the relationships between sedimentary facies and the nature of contained archaeological record can therefore:

1. Provide predictive information on the likely types/focus of occupation/activity within a stratigraphic stack; and
2. Provide predictive information on the likely taphonomic status (and history) of any material present within that stack.

Table 5 Site type and size classification of archaeological sites

Site	<1m	1–10m	10–100m	>100m
Find Spot	✓			
Production episode	✓	✓		
Processing episode	✓	✓		
Boat		✓		
Trackway		✓	✓	
Revetment		✓	✓	
Settlement/ritual			✓	✓

The factors defining the facies within the sedimentary stack are a function of the location of the space occupied by the sediments (ie, the accommodation space) in the environment and the interaction of a range of factors within that accommodation space (Fig 12). These characteristics, related to the nature of the environment of deposition, can therefore be linked to site types known to habitually occur in such environments. Additionally, the nature of the environments of deposition will influence the preservational status of those deposits, ie, whether or not artefacts, etc remain *in situ* after loss/discard.

In order to illustrate the principle involved the following example is provided:

> Locations associated with animal capture/ discovery and subsequent butchery are often in water edge situations, on the slip off slopes on the inside bend of meanders or on floodplain flats. Many archaeological examples of such sites are known, for example, the tool production and butchery areas at the Uxbridge Late Glacial site (Lewis 1991; Lewis and Rackham 2011). Sediments within such areas exhibit grain sizes

Table 6 Environments of deposition, sediment characteristics and archaeological status

Environment zone	Environment of deposition	Dominant grain sizes	Stratigraphic characteristics	Organic content	Archaeological status
Deep gravel bed braided river (Donjek type) (based on Miall 1996)	Gravel bar (GB)	Gravel	Massive, matrix supported gravel (Gm) becoming horizontally crude bedded with planar cross-bedded (Gp) and trough cross-bedded (Gt) gravels	Low – rare reworked bones and shells	Mostly reworked
	Sandy bed (SB)	Sand and gravel	Solitary or grouped trough cross-beds (St) and planar cross-beds (Sp), ripple cross laminae (Sr), horizontal cross laminae (Sh), low-angle cross-beds (Sl) and broad, shallow scours (Ss)	Low – rare reworked bones and shells	Mostly reworked
	Floodplain floor (FF)	Sand, silt, clay	Massive with desiccation cracks (Fm) and fine laminated with very small ripples (Fl)		Larger elements may be *in situ*, smaller elements may be reworked
Meandering River (based on Walker and Cant 1984)	Active channel	Coarse gravels	Indistinct bedding but imbircation of pebbles and cobbles is common (Gh, Gt, Gp) – deposits are thin and discontinuous	Low – occasional waterlogged plan remains	Mostly reworked
	Point bars	Sands fine upwards along bar to silts	Large-scale trough cross-bedded coarse sands (St) in lower part of the bar to small-scale trough cross-beds higher on the bar, cross-beds show dip in downstream direction. Plane bed parallel laminae (Sh) may also be present	Low – occasional waterlogged plant remains and isolated faunal elements	Mostly reworked
	Natural levees	Fine sands and silts	Ripple and horizontally stratified units (Fl) overlain by laminates formed on the concave or steep-bank side of the meander loop adjacent to channel. Deposits are thickest and coarsest nearest to channel	Low to moderate and may include organic plant material	Larger elements may be *in situ*, smaller elements may be reworked
	Floodplains	Fine sands, silts and clays,peat	Fine laminations and ripple structures (Fl) to massive with desiccation cracks (Fm)	Considerable plant debris, faunal remains and showing considerable signs of bioturbation	Larger elements may be *in situ*, smaller elements may be reworked
	Abandoned cut-offs	Fine silt and clay, peat	Commonly well laminated with small ripples (Fl) to massive (Fsm) with desiccation cracks (Fm)	Plant remains, molluscs and other faunal elements common	Larger elements may be *in situ*, smaller elements may be reworked
Tide Dominated Estuary (based on Dalrymple *et al* 1992)	Elongated tidal sand bar zone (Marine dominated zone)	Sand	Cross bedded sand bars seaward of the tidal-energy maximum	Faunal remains and extensive bioturbation	Mostly reworked
	Upper flow regime sand flats (Marine dominated zone)	Sand	Braided channel patterns becoming confined to a single channel headwards	Faunal remains and extensive bioturbation	Mostly reworked, occasional *in situ* elements
	Straight-meandering-Straight (mixed zone)	Sands and silts	Bank attached bars and some mid-channel bars, meanders exhibit symmetrical point bars	Faunal remains may be extensive with common bioturbation	Mostly reworked but local *in situ* material possible
Saltmarsh	Supratidal zone	Silts and clays	Fine laminated beds	Bioturbation common, plant remains present becoming peat in places	Larger elements may be *in situ*, smaller elements may be reworked
	Intertidal zone	Sands, silts	Small-scale ripple cross-stratification and dune bedforms in channels, lenticular, wavy and flaser bedding common. Alternating thin sand and silt beds change higher up to silt with thin sand beds		Mostly reworked but some *in situ*
	Subtidal zone	Sands	Lateral accretion in tidal channels and point bars characterised by dunes and internal cross-bedding showing bimodal directions of forset dip. Mud drapes also present		Mostly reworked

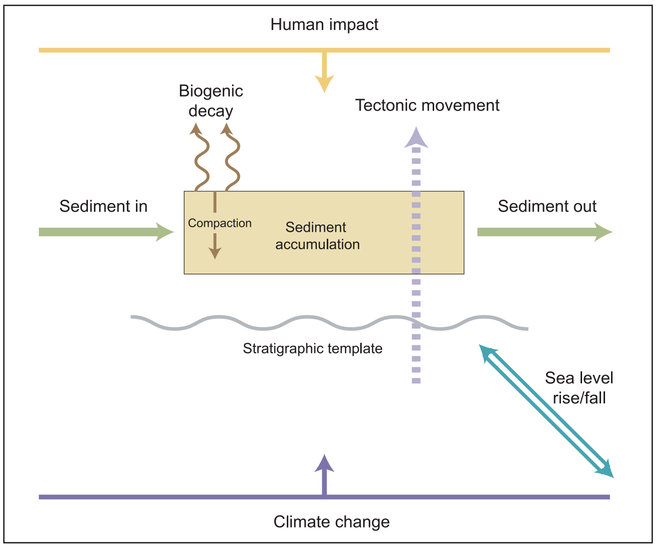

Figure 12 Schematic to show major factors controlling sediment accumulation patterns in a depositional basin

from gravels to fine silts that can be used to identify facies types associated with these situations in field sections or borehole data. This information can be used to indicate the presence of contexts within which evidence of past human activity may be found. Consideration of the grain size relative to the size/status of any contained artefacts will provide information on any potential for reworking within the deposit. For example gravel substrates, deposited under high-energy conditions, indicate a high likelihood that any contained artefacts will be reworked. Artefacts such as axes, contained within finer grained sediments, are less likely to have been reworked (Brown 1997), as supported by the often fresh condition of these, indicating a lack of rolling and transportation. Table 7 describes the properties of the major identified geomorphological zones within the Thames Estuary and their likely archaeological status.

Buried Surfaces and the Archaeological Record

The recognition of buried surfaces (used here to refer to presently buried former landsurfaces) is of critical importance not only within archaeology but also within geology and geomorphology. The identification of buried surfaces within stratigraphic sequences has been used to divide up stratigraphies into packages of sediments (contexts) considered to display genetically and temporally related features. The surfaces identified may be the result of changes in the nature of sedimentation, breaks or hiatuses in sedimentation or represent phases of erosion. The identification of buried surfaces within the stratigraphic stack can be considered as an element of a greater set of attributes within the stack that can be used to reconstruct the landscape (Widdowson 1997). Typically integration of a range of geological and geomorphological data within a conceptual model containing palaeosurface information is often the objective of geoarchaeologists tasked within placing the archaeological site/area of investigation within a (pre)historical context.

Within the stratigraphic stacks key zones of considerable archaeological importance are those indicating the presence of former landsurfaces. The inundation or burial of landsurfaces on which human activity has taken place can result in the sudden, *in situ* burial of human and animal remains. Amongst the best known examples of buried landsurfaces are those buried by the volcanic eruption of Vesuvius in AD 79 (Jashemski 1979) or the eruption of the volcano responsible for the deposition of the Laacher See pumice in the Neuweid Basin in the Central Rhineland (Street 1986; Ikinger 1990; Baales and Street 1996), another example is the well known buried surface at Boxgrove in Sussex (Roberts and Parfitt 1999). Other less spectacular landsurfaces are commonly found in the archaeological record and provide archaeologists with important time-slice views of the past (Brown and Keogh 1992a; 1992b).

Table 7 Main identified zones within the Thames Estuary and the likelihood of archaeological occurrences

Environment of deposition	**Find spot**	**Production episode**	**Processing episode**	**Boat**	**Trackway**	**Revetment**	**Settlement/ ritual**
Gravel bar	✓	✓	✓	✓	x	x	x
Sandy bed	✓✓	✓	✓	✓	x	✓	x
Floodplain floor	✓✓✓	✓✓	✓✓	✓	✓✓	✓	✓✓
Active channel	✓	✓	✓	✓	x	✓	x
Point bars	✓	✓	✓	✓	x	✓	x
Natural levees	✓✓	✓✓✓	✓✓	✓✓	✓✓	✓	✓✓
Floodplains	✓✓✓	✓✓	✓✓	✓	✓✓	✓	✓✓
Abandoned cut-offs	✓✓✓	✓✓	✓✓	✓✓	✓✓	✓	x
Supratidal zone	✓✓	✓✓	✓✓	✓✓	✓	✓	✓✓
Intertidal zone	✓	✓	✓✓	✓✓	x	x	x
Subtidal zone	✓	x	x	✓✓	x	x	x

x Not present ✓ Low likelihood of occurrence ✓✓ Moderate likelihood of occurrence ✓✓✓ High likelihood of occurrence

Identifying and determining the lateral distribution of buried palaeolandsurfaces is of critical importance in the archaeological evaluation of an area. These features represent positions within the stack at which *in situ* assemblages of material may occur in the context of the landscape in which they were used. They may be identified by a series of features that can be used singly or in combination to determine the presence of a buried landsurface:

- In the absence of a clearly defined erosional contact, sudden changes in lithology within a core profile (Pl 4) either seen as a sudden change in sediment types or shifts in properties such as loss-on-ignition and total phosphates (Barham 1995);
- The presence of a palaeosol;
- The presence of zones of weathering, rooting horizons or enhancement of magnetic susceptibility signals (Allen 1987; Barham 1995) (Pl 4);
- The presence of major bedding planes.

The presence of these features may imply the location of a landsurface. However, in order to determine the significance of these features their lateral extent needs to be determined through the identification and correlation of these features within a number of boreholes. This is most easily achieved using the principles of facies analysis and the construction of a sub-surface stratigraphical model (Bates 1998). For example extensive buried landsurfaces have been identified and mapped in Pleistocene sediments on the West Sussex Coastal Plain (Bates *et al* 1997; 2000b).

Modelling Buried Surfaces

At an early stage in the development of the project it was realised that considerable importance would be attached to the use of borehole and other forms of geotechnical data for which there was abundant information from both ground investigations associated with the project and previous works associated with construction on the floodplain. Consequently, the rationale for the use of such point specific data (boreholes and test pit information) needed clarification in order to understand how it would contribute to sub-surface modelling to allow the geometry and topography of these sub-surface sediment bodies to be described and its limitations (Chew 1995). Building confidence in these models was crucial because we were unlikely to have a complete knowledge of the systems either across space or through time (Bowden 2004) and the conclusions from such work were likely to have far reaching impacts on works programming and costs.

Today it is increasingly common to visualise these bodies using geological modelling systems which allow the construction of integrated 3D models that provide the user (and reader) with pictorial images of the sub-surface (Culshaw 2005). The 3D geological models consist of a structural framework of 2D surfaces representing stratigraphic boundaries, chronostratigraphic horizons, etc that aim to produce a 3-dimensional representation of sub-surface deposits allowing the researcher the opportunity to investigate the relationships between deposits and the ability to predict sequence occurrence away from known data positions (Jones 1992). Images produced from the models implies a robustness with respect to the 'hardness' of the surfaces being created as well as the reliability of the relationship between data points when, in fact, our understanding of these surfaces and correlations are based upon often inadequate sampling intervals (of boreholes) and interpretations of sequences based on the application of facies models to the stratigraphies coupled with the surface expression of the associated sediment bodies.

Plate 4 Thin section of landsurface beneath peat, Slade Green Relief Road, Bexley (width *c* 80mm)

One of the major outcomes of sub-surface modelling are the 2D/3D surfaces that may be used (where appropriate) to reconstruct palaeogeographies for areas of the landscape for which surface sediment expression bears little or no relationship to those buried at depth. Within the framework of archaeological investigations associated with development/destruction of sites such an approach has considerable practical use due to its ability to enable the user to identify buried landsurfaces and reconstruct local or regional palaeogeographies through a multi-disciplinary palaeoenvironmental investigation that allows a sequence of palaeogeographic maps to be

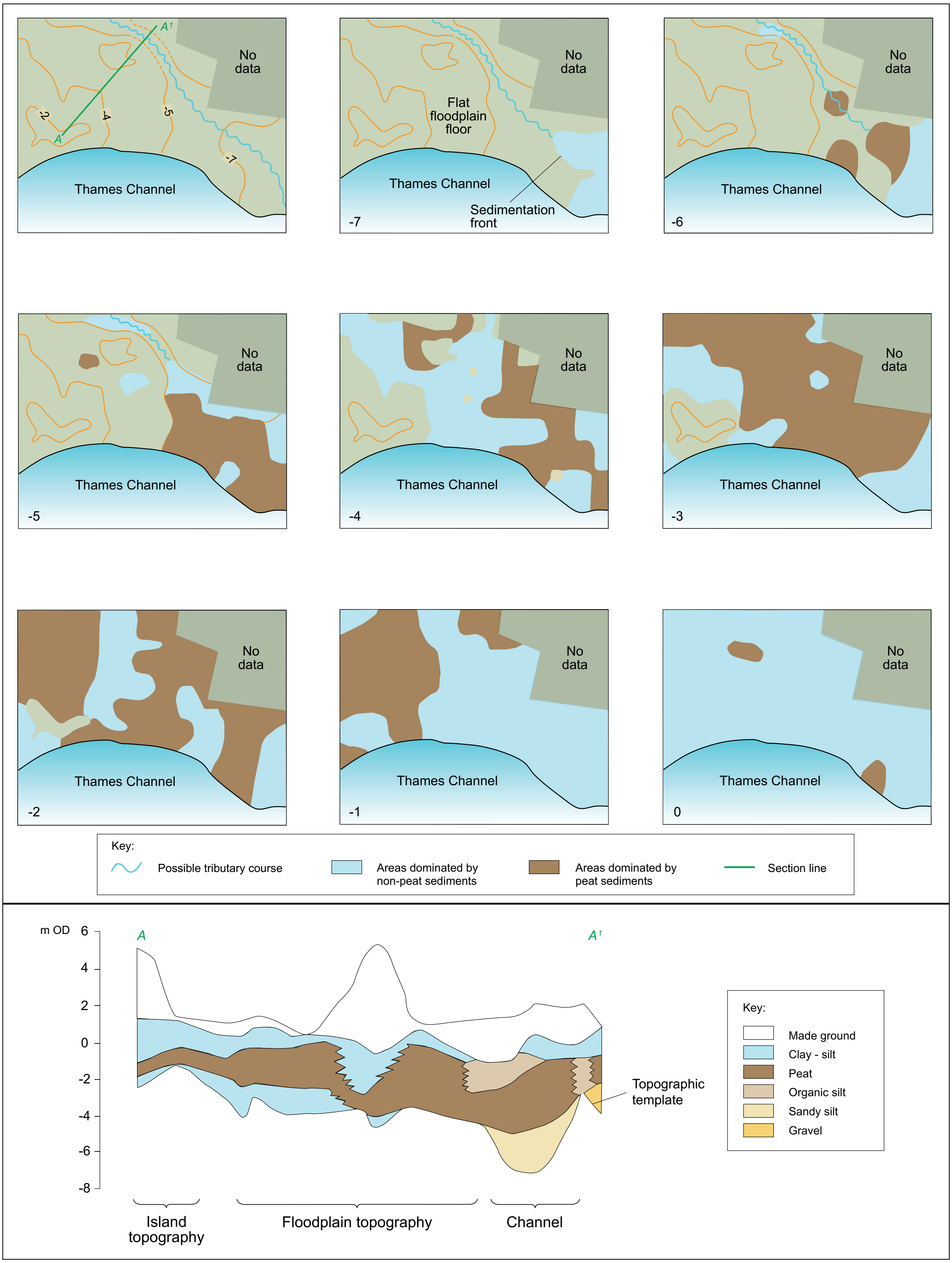

Figure 13 Barking Reach modelled surfaces and local palaeogeographical maps created from geotechnical data held by the GMU (from Bates 1998)

constructed. Examining these maps with knowledge of the preferred loci of human activity allows those locations at which such evidence may exist to be identified (Deeben *et al* 1997; Bates *et al* 2000b; Corcoran *et al* 2011). Other studies have a more geological objective (Chen *et al* 1996; Berendsen and Stouthamer 2001; Culshaw 2005; Bertrand and Baeteman 2005).

In the course of many archaeologically orientated projects correctly predicting the distribution of certain sub-surface deposits with a high archaeological potential has considerable financial implications for the developers. Unexpected archaeological finds may cost construction projects tens of thousands of pounds per day in project down-time while excavation proceeds and consequently the need to 'best guess' the archaeological significance of sites is paramount. However, it has been found that to achieve the goals of sub-surface modelling applying only borehole based surveys is often an inadequate response in many situations. This is particularly the case where approaches need to be flexible and vary from site to site depending on the geological conditions as well as project budgets and practical limitations imposed by ground conditions and the site infrastructure. Additionally, extra information may often be required from areas of the site between sample (borehole) locations and consequently it has been necessary to use not only boreholes but other approaches such as Cone Penetration Testing (CPT) as well as surface and sub-surface geophysics to meet the requirements at individual sites and fill in gaps between boreholes.

Similar arguments have been made by those involved in geotechnical studies associated with engineering construction activities (Lenham *et al* 2005; Culshaw 2005). Characterisation of the ground conditions in order to determine appropriate construction methods generally occurs in the initial stages of project development and may involve a range of techniques including borehole, CPT and geophysical techniques. However, it is recognised (Zhu *et al* 2003) that ground behaviour cannot be established and forecasted with 100% accuracy and that, in order to minimise uncertainties of ground conditions, careful consideration should be given to understanding the limitations of the information sources and the ways in which the information is combined to formulate models and interpretations. The limitations of a typical ground investigation survey are discussed in detail by Salvany *et al* (2004).

In many cases an integrated approach to archaeological investigation using a range of geological, geomorphological and palaeoenvironmental perspectives derived from direct and indirect observations of sub-surface stratigraphies is desirable prior to developing a conceptual model containing palaeosurface information. In some cases this information can be then used to place the archaeological site/area of investigation within a (pre)historical context as well as defining areas in which evidence of *in situ* activity by past human groups/environments may occur. In individual cases the mixed method approach needs to be structured in order to address the needs of the site/problem and an important element of the investigation is the clear articulation and discussion of the methodologies used. In particular, the limitations of the sampling approaches and the impact that that approach may have on the interpretation derived from the investigation (ie, the confidence limits that may be placed on the conclusions of the investigation that relate to the location of sample points and correlations made between sample points) need to be articulated in order for confidence to be placed in the conclusions drawn. Discussion of this kind is rarely seen in the published literature however, this is of particular importance where complex frameworks for site and sequence correlations may be based on individual classes of data (eg, small mammals, etc).

An example of a modelled surface is shown in Figure 13 from the Barking Reach area (taken from Bates 1998; the location of the study is shown on Fig 5).

Palaeogeography and the Archaeological Record

The contextualisation of archaeological remains within the physical landscape, contemporary with human occupation, remains a key objective of many site and regional based archaeological projects. The study of palaeogeography entails the reconstruction of patterns of the earth's surface at a given time and through time. In particular it focuses on the ancient sedimentary environments and the contemporary ecological conditions. Such investigations can fix the location of shorelines, position of rivers and source areas of raw material (ie, for human use).

Reconstructing palaeolandscapes for key periods in the (pre)historic past is important to enable sense to be made of current distributions of archaeological materials, to make predictions regarding the likely distribution of remains prior to investigation and to contextualise the materials recovered from the fieldwork phase of a project. In such cases consideration needs to be given to understanding the evidence contained in the stratigraphic record pertinent to landscape reconstructions. It may be tempting to suggest that in the absence of direct archaeological evidence from a given area a verdict of no archaeological interest is deduced. However, if one accepts Foley's (1981) argument of spatially continuous use of the landscape then areas devoid of apparent archaeological remains become an integral part of the broader archaeological picture and therefore require investigation.

The processes involved in palaeogeographic reconstruction include all aspects of palaeoenvironmental studies contributing to the palaeoenvironmental reconstruction. When palaeogeographical reconstructions are formulated within the context of an archaeological project the question of the scale of investigation needs to be considered. Both the spatial and temporal scale of the reconstructions requires consideration and need to be framed in relationship to the nature of the archaeological question.

Successful uses of palaeogeographical reconstruction in archaeological studies have been undertaken in Greece (Kraft *et al* 1987; Sturdy *et al* 1997), the North Sea area (Verart 1996; Coles 1998; Gaffney *et al* 2007) and the Netherlands (Fokkens 1998). Within areas of deeply stratified sediments, for example, in the lower reaches of river valleys, considerable problems exist when attempting to investigate the palaeogeography due to the difficulty of access to sediment sequences required to reconstruct palaeogeographies.

Limitations of Past Geoarchaeological Approaches to Alluvial sequences in the Lower Thames Area

Commonly, geoarchaeological investigation of the floodplain area of the Lower Thames is conducted on an opportunistic basis, where section recording has been undertaken and purposive geoarchaeological boreholes have been drilled, and where development has been considered to have a possible impact on the deeply buried sediments (eg, Barham and Bates 1995; Bates and Williamson 1995; MoLAS 1996). These have typically been restricted in spatial extent where the distribution of the investigation is dictated by the size and nature of the construction impact. In many cases these studies have described the lithostratigraphic sequence preserved at the site and assessed the nature of the contained biostratigraphic evidence. However, these investigations have not commonly been pursued to the analysis phase of investigation. Notable exceptions include work undertaken on the Jubilee Line Extension (Sidell *et al* 2000), Silvertown (Wilkinson *et al* 2000; Crockett *et al* 2002), along the A13 (Carew *et al* 2009; Stafford *et al* 2012), and most recently the Olympic Park in the Lower Lea Valley (Powell 2012). Additionally, facies classification of the identified sedimentary units has only been undertaken sporadically and no attempt has been made to integrate this information into a regional lithostratigraphy (the organisation of sediment units into sequences based on their lithological properties) for the Lower Thames area.

Allied to the opportunistic approach to site investigation has been the absence of a framework for investigation. Although now widely acknowledged to be over simplistic and possibly requiring major modification, the only model for floodplain changes remains that of Devoy (1977; 1979) based on the biostratigraphic analysis of selected borehole sequences. This was latterly simplified by Long *et al* (2000) and site specific investigations undertaken by Sidell (2003).

The following limitations of the approach were noted during the early stages of HS1:

- The framework model available for the Thames floodplain is based on the biostratigraphic approach of Devoy (1977, 1979) that has been updated and modified by Long *et al* (2000). This has been shown to be too simplistic and may require reinterpretation (Haggart 1995);
- Current geoarchaeological investigation of the floodplain is opportunistic and sites for investigation are defined by the commercial development rather than archaeological or geoarchaeological criteria;
- Facies ascriptions of sedimentary units described in boreholes and sections are only rarely presented;
- Core material is often assessed for the widest range of contained data (both sedimentological and biostratigraphical) diluting the potential impact of target specific aims and objectives tied to research questions;
- It is relatively rare that analysis phase works are undertaken on recovered and assessed core material;
- No model describing possible 3-dimensional development which integrates lithostratigraphic units, defined facies bodies and contained biostratigraphic and archaeological data exists across the whole area;
- Process of change is rarely examined in detail. While the outcome of change is well known (peat to minerogenic sediments, alder carr to saltmarsh/mudflats) the nature and timing of the change have not commonly been examined in detail;
- There is a tendency to oversimplify the nature of the environment rather than looking at the probable true heterogeneity of the landscape at any one given time;
- The presence of a model for sequence development would provide valuable information regarding the potential importance of development sites and the aims and objectives of assessment works to be undertaken on core material removed from investigation sites.