Trent Valley Geoarchaeology 2002

ADVANCING THE AGENDA IN ARCHAEOLOGY AND ALLUVIUM

Component 4b: DEVELOPMENT OF A GEOMORPHOLOGICAL RISK MAP FOR THE VALLEY FLOOR DEPOSITS OF THE RIVER TRENT

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The requirements of users are to identify the presence of archaeological interests and to access guidance about their implications at an early stage.

Risk mapping of the multi-dimensional archaeological resource in the Trent Valley involves more than the creation of constraint maps based upon known archaeological sites or historic buildings. It will involve the application of models based upon predictions of erosion and land accretion through river movement, geomorphological models, period based settlement and land-use models, and experiential data, to characterise the archaeological resource and historic environment in the Trent Valley and its tributaries, and to attribute values to the various character elements. This component will contain a number of elements from methodological design through to GIS based map production. It is likely that more than one form of map with different degrees of accessibility will be necessary.

(Components 4ab Project Outline May 2002)

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1. INTRODUCTION

The concept of risk management and the development of risk maps have become established tools for environmental specialists managing geotechnical aspects of floodplain management. One of best-known examples of valley floor risk management is provided by the Environment Agency's 'Indicative Floodplain Maps' which provide an overview of flood risk for homeowners and businesses throughout England and Wales. However, despite the demonstrable wealth of cultural and environmental archaeology within alluvial environments (Needham and Macklin, 1992), the concept of risk management and risk mapping has been poorly developed and utilized by the archaeological community, despite the demonstrable threats to archaeological landscapes (Darvill and Fulton, 1998). Where valley floors have been zoned and graded into areas of varying archaeological potential, this approach has been based upon information relating to the geomorphological evolution of the landscape (Passmore and Macklin, 1997; Howard and Macklin, 1999a; Passmore *et al*., 2002). However, the development of risk management strategies must be inclusive, since the definition of risk may vary between the needs of different stakeholder communities. For example, the risk management strategy needed by the aggregates industry may be different to that needed by the heritage management community. The definition and concept of risk related to the archaeological deposits of the Trent Valley is discussed fully by Spence and Bishop (forthcoming). The aim of this report is to provide a conceptual framework for the development of a risk map for valley floor environments based upon the nature of geological substrates and landform assemblages (Trent Valley Geoarchaeology 2002, Component 4b).

1.1. Component Aims & Objectives

Components 4a and 4b were developed in tandem with 4b concentrating on the development of a geomorphological risk map for the valley floor based upon evidence within the physical landscape and the results of discussions concerning the concept of risk developed in Component 4a. The results of Component 4a will be reported separately (Spence and Bishop, in prep.).

- To develop the concept of risk mapping as a tool of archaeological resource management and informing stakeholders in the archaeology of the Trent Valley (4a).

- Identification of the stakeholder community (4a)
- Development of the definition of risk and production of a draft risk management strategy document (4a).
- Production of a provisional conceptual framework and development of a preliminary risk management map for the Trent Valley based on evidence within the physical landscape (4b).

2. THE NATURE OF BRITISH FLOODPLAINS

2.1. Characterising Floodplain Evolution

In the UK, the Holocene fluvial record indicates that prior to large scale drainage and channelisation since the industrial revolution, there were a greater diversity of channel types and floodplain sedimentation styles than found today (Macklin and Needham, 1992). These contrasting river patterns, included braided (laterally mobile multi-channelled rivers with wide and shallow, rapidly shifting channels, that divide and rejoin around sand and gravel bars, and vegetated islands) and anastomosed channel systems (inter-connected networks of low gradient relatively deep and narrow channels of variable sinuosity, characterised by stable, vegetated banks composed of fine-grained silt and clay; Smith and Smith, 1983) which produce different alluvial sedimentary sequences (Brown and Keough, 1992; Passmore *et al.,* 1993).

2.1.2. River Channel and Floodplain Classification

More than a century of study by fluvial geomorphologists has resulted in the classification of rivers and their floodplains on the basis of channel planform and sedimentation processes. Four styles of fluvial channel are commonly recognised; braided, meandering, anastomosing and straight (Leopold & Wolman, 1957; Leopold *et al.,* 1964). All of these channel types have been identified in British Holocene fluvial sedimentary sequences though divided multi-channel river systems (braided or anastomosing) are relatively rare in Britain today. Although these categories are useful, they must be considered as tendencies within a spectrum of channel types. British rivers have been further sub-divided into upland, piedmont, lowland and perimarine systems (Lewin, 1981) on the basis of physiography and basin relief (Macklin and Lewin, 1993).

Howard and Macklin (1999a) utilised a generic classification of floodplains developed by Nanson and Croke (1992) which is based upon stream power (the product of discharge and channel slope) and bank erodibility, within the geomorphic framework proposed for British rivers by Macklin and Lewin (1986, 1993). Such a classification is ideally suited to archaeological applications since it can be used for the investigation of specific sites or short lengths of river valley.

2.2 Characterising the Valley Floor of the River Trent

The River Trent is unique amongst British river in that it flows along the junction of upland and lowland Britain with its north bank tributaries draining the highlands of the Peak District. Therefore, the river displays characteristics of both upland/piedmont and lowland rivers and discharge from the Peak District into its middle reaches has been used to explain its lateral migration tendencies in that part of the valley floor (Brown, 1998).

Certain parts of the upper and middle Trent display the characteristics of a medium energy river system with non-cohesive banks, whereas the lower Trent downstream of Newark is a low energy river with cohesive banks (Figures 1 and 2). The development of this latter area has also been influenced by perimarine processes (Long *et al*. 1998). Archaeological preservation within these contrasting fluvial environments is distinct, though can be characterised on a broad scale (Figures 1 and 2).

The middle reach of the Trent is complicated further by the constriction of the river between Nottingham and Newark through the Trent Trench, an anomalous drainage route which cuts across the dipslope of the Mercia Mudstone (i.e. across the natural drainage of present day relief) and was probably formed during a pre-Ipswichian glacial stage. This feature has restricted the lateral movement of the river and may well have affected channel gradients and erosive forces in this part of the Valley.

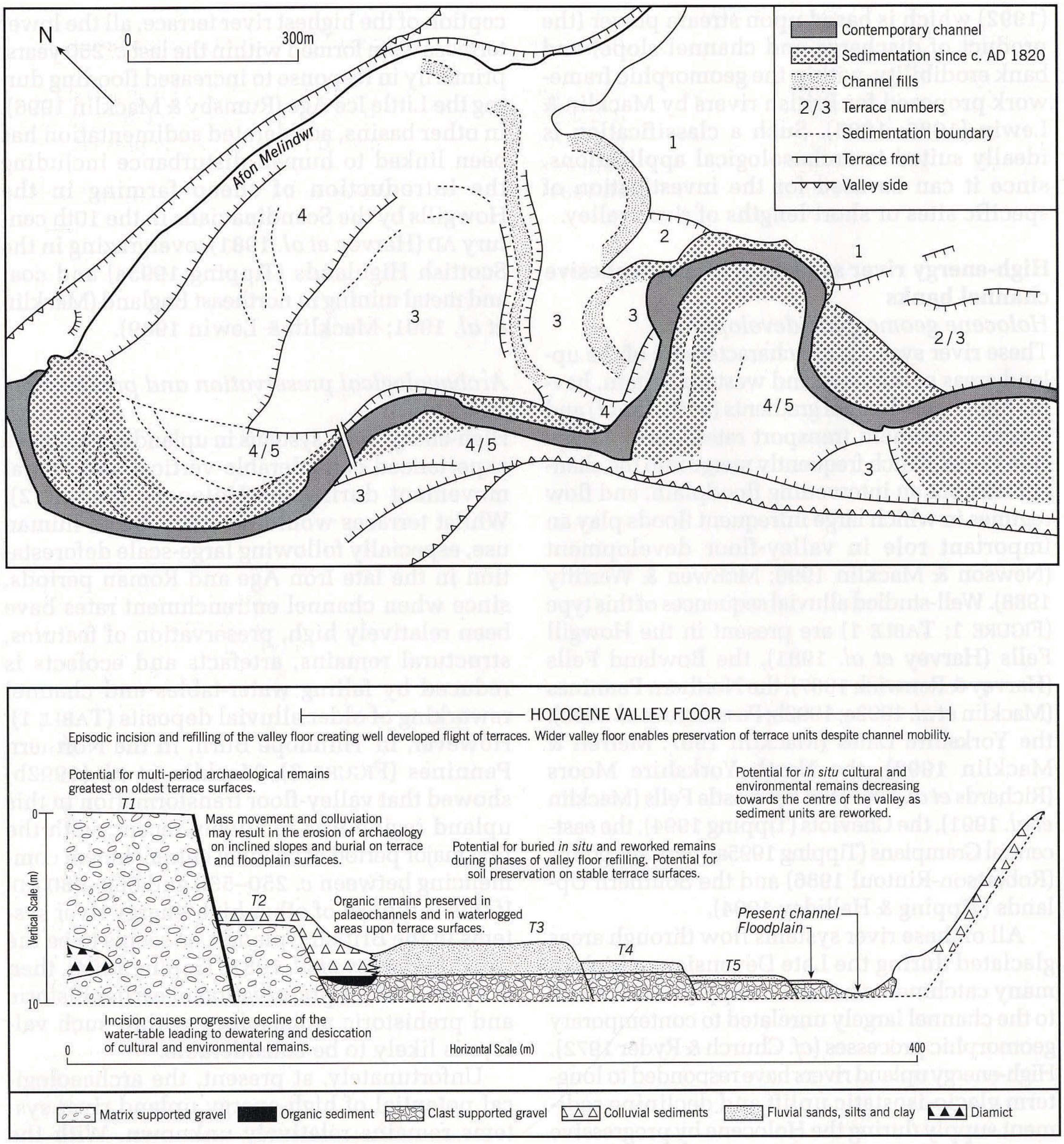


Figure 1. Model of floodplain evolution and issues of archaeological preservation in medium energy river systems (from Howard and Macklin, 1999a).

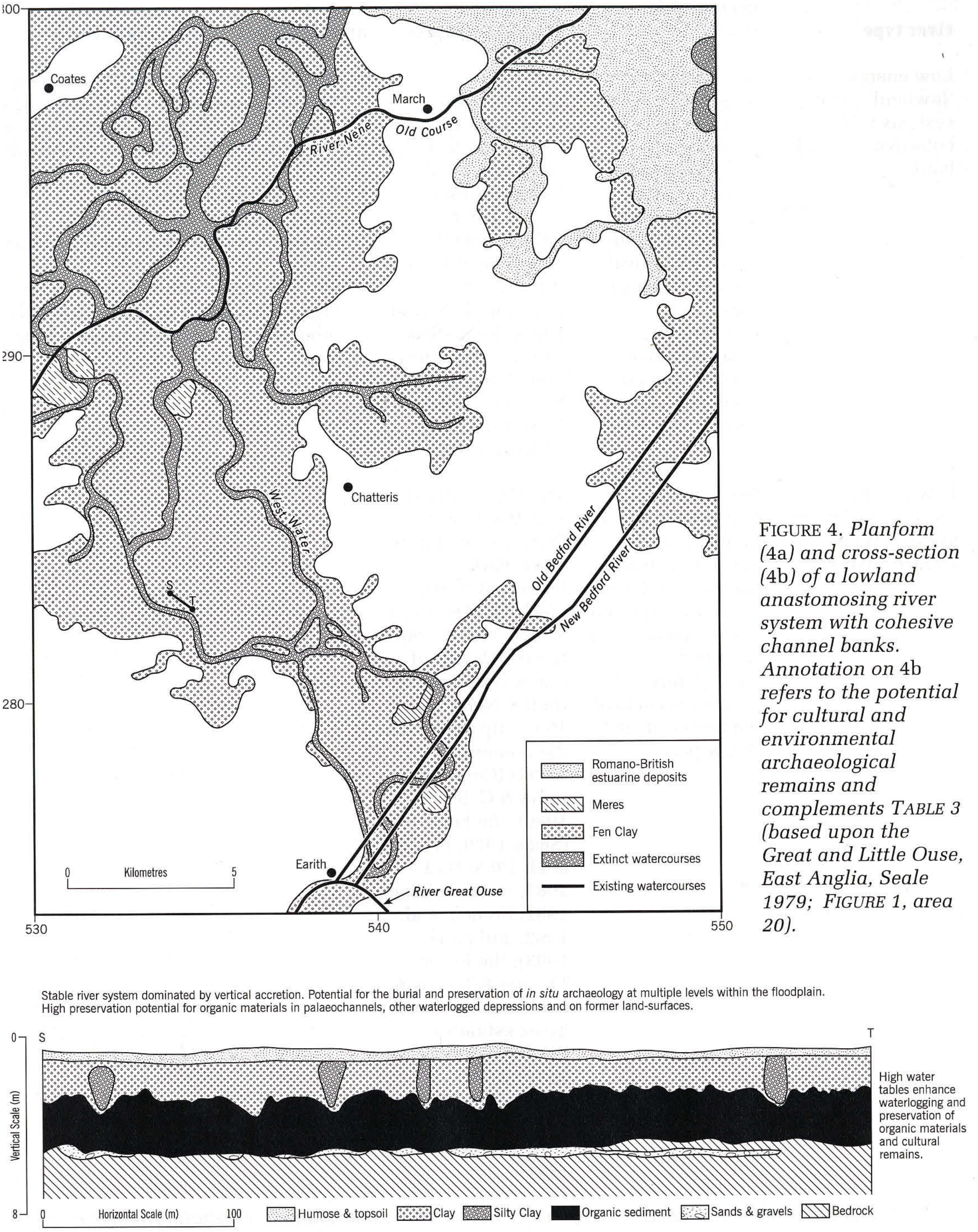


FIGURE 4. *Planform (4a) and cross-section (4b) of a lowland anastomosing river system with cohesive channel banks. Annotation on* 4b *refers to the potential for cultural and environmental archaeological remains and complements* TABLE 3 *(based upon the Great and Little Ouse, East Anglia, Seale 1979;* FIGURE 1*, area 20).*

Stable river system dominated by vertical accretion. Potential for the burial and preservation of *in situ* archaeology at multiple levels within the floodplain. High preservation potential for organic materials in palaeochannels, other waterlogged depressions and on former land-surfaces.

High water tables enhance waterlogging and preservation of organic materials and cultural remains.

Figure 2. Model of floodplain evolution and issues of archaeological preservation in low energy river systems (from Howard and Macklin, 1999a).

2.3. Identifying Landform Elements and Zonation of Floodplains

A number of studies in northern Europe and North America have recognised the role that geomorphological and geological processes can play in determining archaeological patterns observed within the landscape, termed geological filtering by Bettis and Mandel (2002). This information has been used to zone valley floors into areas of high and low archaeological potential and to explain patterns and discrepancies in the archaeological record as well as to aid in the prospection of buried resources (Bettis and Hajic, 1995; Mandel, 1995; Passmore and Macklin, 1997; Howard and Macklin, 1999a; Bettis and Mandel, 2002; Stafford and Creasman, 2002). Whilst many of these models are generic in nature, based upon hypothetical examples derived from empirical studies (e.g. Howard and Macklin, 1999a), a recently published study by Passmore *et al.* (2002) focused on the Milfield basin (Northumbria, UK) provides a useful template for studies in the Trent Valley. Passmore *et al.* (2002) zoned the archaeological potential of the basin on the basis of 'landform elements analysis', dividing the landscape into a series of discrete morphological units such as terraces and palaeochannels etc. (Figure 3, Table 1).

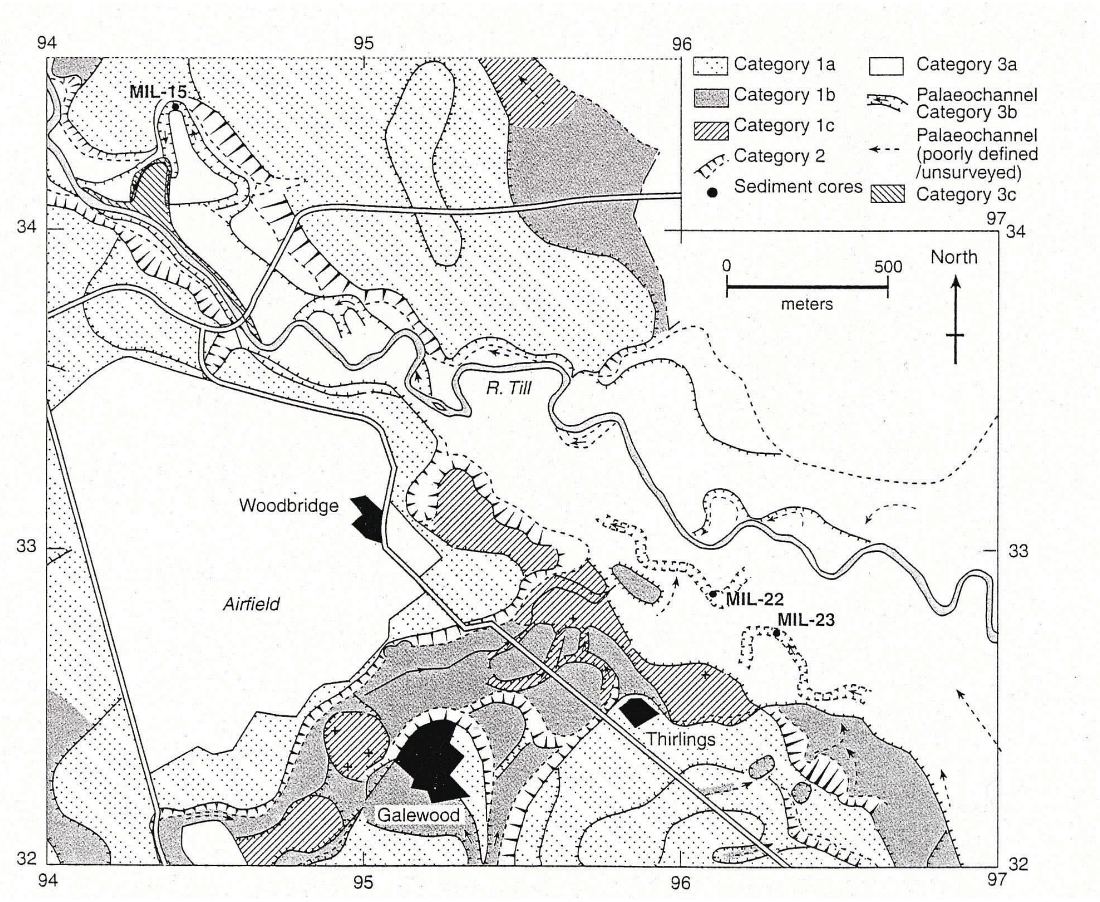
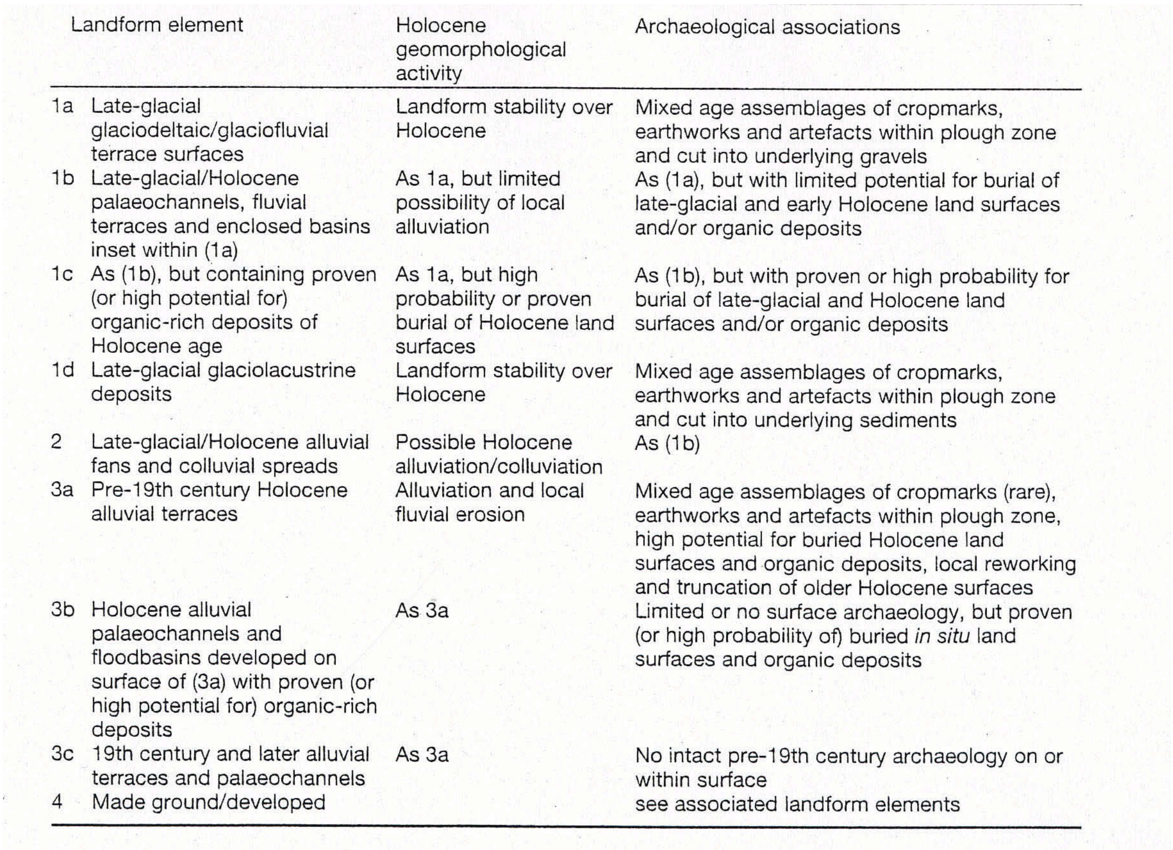


Figure 3. Example of landform elements classification of part of the Milfield Basin (reproduced from Passmore *et al.*, 2002).

Table 1. Landform elements of the Milfield basin and their archaeological potential (reproduced from Passmore *et al*., 2002).



	Landform element	Holocene geomorphological activity	Archaeological associations
1a	Late-glacial glaciodeltaic/glaciofluvial terrace surfaces	Landform stability over Holocene	Mixed age assemblages of cropmarks, earthworks and artefacts within plough zone and cut into underlying gravels
1b	Late-glacial/Holocene palaeochannels, fluvial terraces and enclosed basins inset within (1a)	As 1a, but limited possibility of local alluviation	As (1a), but with limited potential for burial of late-glacial and early Holocene land surfaces and/or organic deposits
1c	As (1b), but containing proven (or high potential for) organic-rich deposits of Holocene age	As 1a, but high probability or proven burial of Holocene land surfaces	As (1b), but with proven or high probability for burial of late-glacial and Holocene land surfaces and/or organic deposits
1d	Late-glacial glaciolacustrine deposits	Landform stability over Holocene	Mixed age assemblages of cropmarks, earthworks and artefacts within plough zone and cut into underlying sediments
2	Late-glacial/Holocene alluvial fans and colluvial spreads	Possible Holocene alluviation/colluviation	As (1b)
3a	Pre-19th century Holocene alluvial terraces	Alluviation and local fluvial erosion	Mixed age assemblages of cropmarks (rare), earthworks and artefacts within plough zone, high potential for buried Holocene land surfaces and organic deposits, local reworking and truncation of older Holocene surfaces
3b	Holocene alluvial palaeochannels and floodbasins developed on surface of (3a) with proven (or high potential for) organic-rich deposits	As 3a	Limited or no surface archaeology, but proven (or high probability of) buried *in situ* land surfaces and organic deposits
3c	19th century and later alluvial terraces and palaeochannels	As 3a	No intact pre-19th century archaeology on or within surface
4	Made ground/developed		see associated landform elements

The approach used in the Trent Valley is modified slightly to include Pleistocene deposits earlier than Late Upper Palaeolithic age (since the Milfield basin was glaciated during the last cold stage, no deposits earlier than this date were considered in their model, although they are conceivably present, buried deep within the Milfield basin).

3. LANDFORM CLASSICATION WITHIN THE TRENT VALLEY

3.1. Available Datasets

3.1.1. Mapping of the British Geological Survey

Comprehensive solid and drift geological survey maps are available for the entire Trent Valley though the date of original survey and additional updates vary widely. This variation in survey date and personnel can result in problems of continuity between individual geology sheets; for example, the Hemington Terrace, a key Holocene lithostratigraphic unit with great archaeological potential is mapped in the Nottingham region (sheet 126), but not on neighbouring geological survey sheets.

3.1.2. Palaeochannel Mapping

As part of Trent Valley Geoarchaeology 2002, comprehensive palaeochannel mapping has been undertaken for the counties of Staffordshire, Derbyshire, Leicestershire, and Lincolnshire (Baker 2003), building on an earlier survey of Nottinghamshire (Malone, 1998). Full details of the methodological approaches and results of these surveys are provided in the respective reports by Baker and Malone and are therefore not discussed here. However, Baker (2003, 19) makes an important point with respect to these palaeochannel surveys:

'*it is highly likely that some features within the database are not palaeochannels and that some palaeochannel features have been excluded. The GIS should be regarded therefore as a starting point for further evaluation, rather than a finished and definitive product*'.

3.1.2.1. LiDAR Imagery

As part of Trent Valley Geoarchaeology 2002, Challis (2004) has evaluated the potential of LiDAR data for terrain modelling of the valley floor. Whilst only a pilot study has been undertaken, the results are impressive identifying sinuous depressions on the valley floor where palaeochannels have not been detected through aerial photographic mapping. The capture and analysis of LiDAR for the entire valley floor offers tremendous potential for future risk mapping projects.

3.1.3. Alluvium Depth and Character Modelling

As part of Trent Valley Geoarchaeology 2002, comprehensive assessment of alluvium depth and character modelling mapping has been undertaken for the counties of Staffordshire, Derbyshire, Leicestershire, and Lincolnshire (Challis, 2003), building on an earlier survey of Nottinghamshire (Challis, 2001). Although the distribution of borehole records is patchy, they do usefully indicate general trends of sediment architecture along the valley and where organic sediments are preserved (Table 2). However, for the majority of the valley, boreholes are not densely enough concentrated to allow detailed modelling of the subsurface stratigraphy and interpretation of archaeological potential. Hence this can only be undertaken during evaluations of individual sites where commissioned borehole studies are used to augment existing datasets.

Table 2. *Summary characteristics of the reaches of the Trent studied by Challis (2003).*

Reach of the River Trent	**Characteristics**
R1. Idle confluence to Humber	• perimarine river • silt & clay deposits up to 19m thick • extensive peat and organic silt units • few palaeochannels at surface • rockhead entrenchment beneath present channel suggests the river has moved within a restricted corridor during the Holocene
R2. The Lower Trent	• mixture of fine grained alluvial sediments deposited during overbank flooding and reworking of Pleistocene sands and gravels in a series of mobile ?braided channels • limited peat and other organic preservation • variable rockhead topography
R3. Trent-Derwent-Soar confluence to the River Dove	• mixture of fine grained alluvial sediments deposited during overbank flooding and reworking of Pleistocene sands and gravels in a series of mobile ?braided channels • limited peat and other organic preservation • variable rockhead topography
R4. River Dove to the River Blithe	• mixture of fine grained alluvial sediments deposited during overbank flooding and reworking of Pleistocene sands and gravels in a series of mobile ?braided channels • limited peat and other organic preservation • substantial depression in rockhead and sands and gravels to the west of the present channel beneath terrace deposits.
R5. The Upper Trent Valley	• Predominantly coarse grained deposition with limited fine grained sedimentation. • limited peat and other organic preservation

3.1.4. Archaeological Data

SMR information was offered towards this study, but trials of these datasets for other components of TVG 2002 suggested that they were of limited use, especially since key information such as whether archaeology was reworked or *in situ* could not be easily extracted from the databases.

4. PLEISTOCENE LANDSCAPE ELEMENTS OF THE TRENT VALLEY

4.1. The Sand and Gravel Terraces

Table 3. *The revised correlation of terrace deposits in the Trent Valley. Modified from work by Brandon and Sumbler (1988, 1991), Howard (1992) and Brandon and Cooper (1997).*

Conventional Quaternary Stage	OIS	Trent (above Nottingham) and lower Dove and Derwent	Trent (Newark to Lincoln)	Approx. age Ky
Holocene	1	Floodplain deposits Hemington Terrace deposits* Ambaston Terrace deposits*	Floodplain deposits	
Devensian	2	Holme Pierrepont Sand and Gravel*	Holme Pierrepont Sand and Gravel*	10 26
	3			65
	4	Allenton Sand and Gravel Beeston Sand and Gravel	Scarle Sand and Gravel *	80
	5d-a			115
Ipswichian	5e	Crown Hill Beds*	Fulbeck Sand and Gravel*	128
	6	Borrowash Sand and Gravel Eggington Common Sand and Gravel	Balderton Sand and Gravel *	195
	7		Thorpe on the Hill Beds *	240
	8	Ockbrook Sand and Gravel Etwall Sand and Gravel	Whisby Farm Sand and Gravel	297
Hoxnian	9-11			330
Anglian	12	Eagle Moor Sand and Gravel Findern Clay Oadby Till Thrussington Till	Eagle Moor Sand and Gravel Skellingthorpe Clay	400

* signifies that the deposit is assigned to an oxygen isotope stage on the basis of biostratigraphy, absolute age determination, detailed stratigraphy, sedimentology or palaeosols. Other deposits are ascribed on the basis of altimetry.

4.1.1. The Pre-Ipswichian Terraces (Oxygen Isotope Stages 6-12 and beyond)

Prior to the last interglacial (Oxygen Isotope Substage 5e), approximately 125,000 before present (BP), suites of sands and gravels were deposited as glacial outwash during at least one and possibly two glacial events. These sands and gravels, known historically as the Hilton Terrace deposits in the Middle Trent, have now been redefined and renamed the Etwall Sand and Gravel and Egginton Common Sand and Gravel (Table 3). In the Lower Trent, north-east of Newark, the lateral equivalents of these deposits are called, in order of decreasing altitude, the Eagle Moor Sand and Gravel, the Whisby Farm Sand and Gravel and the Balderton Sand and Gravel (Brandon and Sumbler, 1991). The Eggington and Etwall deposits in the Middle Trent and the Whisby Farm and Balderton sediments in the Lower Trent have yielded a mixture of rolled and fresh Palaeolithic hand axes, including Levallois material (Armstrong 1939; Wymer, 1999). In recent years, the Balderton Sand and Gravel has yielded an impressive assemblage of large vertebrate remains and organic sediments rich in pollen, macroscopic plant remains, molluscs and insect (Brandon and Sumbler 1991, Lister and Brandon, 1991). Together, this environmental data has provided a high resolution proxy record of climate and the environment in which early humans foraged and hunted.

4.1.2. The Ipswichian Terraces (Oxygen Isotope Substage 5e)

The presence of vertebrate remains of Hippopotamus in organic rich channels in the Allenton Sand and Gravel of the River Derwent immediately south of Derby (Bembrose and Deeley 1898; Jones and Stanley 1974) and the Fulbeck Sand and Gravel near Ancaster in Lincolnshire (Brandon and Sumbler 1988) provides evidence of interglacial environments and fauna and flora of the Trent catchment, approximately 125,000 years ago. Whilst Ipswichian faunal remains, characterised by the diagnostic presence of Hippopotamus, are relatively common within the fluvial terraces of southern and midland Britain, the evidence for human activity is unforthcoming; this has led to a number of researchers to suggest that Britain was not colonized by humans during the Ipswichian and that they did not/could not return until around 60,000 years ago (Currant and Jacobi 1997).

4.1.3. The Post-Ipswichian Terraces (Oxygen Isotope Stages 5d-2)

Following the last interglacial, the British climate started to deteriorate and cool around 115,000 years BP. However, unequivocal evidence for ice incursion into the East Midlands is not recorded in the terrestrial record until Oxygen Isotope Stage 2 (the Dimlington Stadial, Rose 1985). Although ice did not enter the entire Trent Valley, it encroached into the Uttoxeter area in the Upper Trent (King 1966) and blocked the Humber Estuary in the Lower Trent (Gaunt 1981). Meltwater issuing from the ice front in the Upper Trent resulted in the deposition of outwash sands and gravels across the valley floor named the Holme Pierrepont Sand and Gravel (previously called the Floodplain Sand and Gravel and Floodplain Terrace). Extensive quarrying of these deposits in the Middle Trent has led to the recovery of a rich mammalian faunal assemblage dominated by woolly mammoth and occasional handaxes (Wymer, 1999).

Incision of the river into the Holme Pierrepont deposits towards the end of the Dimlington Stadial, probably around 13,000 years BP led to the creation of a terrace surface above the Holocene valley floor. Close to the valley floor, yet beyond the risk of all but the highest flood events, this surface became attractive to Upper Palaeolithic hunter-gathers as demonstrated by the Late Upper Palaeolithic site at Farndon near Newark (Garton, 1993) and continued to remain the focus of settlement and other human activities throughout the Holocene.

In the Lower Trent Valley, drainage impediment of the Humber led to the creation of proglacial Lake Humber, which stretched across a large part of the Vale of York and extended for an unknown distance up the Trent Valley. At present the shoreline positions of this lake are uncertain although there identification in the future is a priority.

Despite the presence of glacial ice only during Oxygen Isotope Stage 2, cold conditions prevailed for the majority of the period preceding the Dimlington Stadial. Therefore, the valley floor of the Trent and its tributaries were characterised by a braided channel network depositing sheets of sands and gravels across the valley floor. These deposits are now called the Beeston, Allenton and Scarle Sands and Gravels (Table 3) and may have temperate channels of Ipswichian date in their basal parts.

4.2. The Nature of Preservation in the Pleistocene Sands and Gravels

The majority of the sands and gravels laid down during the Pleistocene are outwash deposits associated with cold climate, high energy braided river environments. Such environments are characterised by extensive reworking of fluvial sediments and hence the preservation of *in situ* archaeological material within such environments is likely to be low. In the Trent Valley, this is confirmed by the heavily rolled condition of the majority of both faunal and artefactual remains (Armstrong, 1939; Brandon and Sumbler 1988; Lister and Brandon 1991; Wymer, 1999). However, despite the absence of secure contexts for this material, such faunal and artefactual assemblages provide valuable information of the extent and nature of human activity within the landscape (Ashton and Lewis 2002). Further, the identification of *in situ* palaeolandsurfaces and associated archaeology in the Trent Valley, as demonstrated by the significant Middle Palaeolithic site within and adjacent to a palaeochannel at Lynford, Norfolk (Boismier, 2003), should not be discounted.

As demonstrated by the recovery of large temperate vertebrate remains from the Allenton Terrace close to Derby, organic-rich interglacial sediments, usually infilling discrete channels within and beneath the cold climate sands and gravels are recorded in valley floor contexts. Although not extensively recognised or analysed within the Trent Valley, studies in other river valleys such as the Welland at Deeping St James (Keen *et al.*, 1999) clearly indicate the potential of these temperate sediments for environmental reconstruction.

Within the Trent Valley, the majority of pre-Devensian sand and gravel deposits are restricted to relatively small, heavily dissected remnants, capping the interfluves and valley sides of the Middle Trent around Derby. This patchy distribution reflects not only the antiquity of the sediments, but also their deposition within a landscape whose drainage configuration bears little relationship to that of the present day (Figure 4). Between Newark and Lincoln (though outside the study area), more extensive pre-Devensian outwash deposits are recorded, marking former courses of the Trent to the North Sea via the Lincoln Gap.

The spread of probable Ipswichian deposits (and early post-Ipswichian sediments which may include basal temperate deposits) are also restricted to the Middle Trent Valley (Figure 5), although Ipswichian estuarine deposits have been recorded at depth in both the Humberhead Levels and Idle Valley (Gaunt *et al.*, 1972; Gaunt *et al.*, 1974).

In contrast, late Devensian outwash deposits of the Holme Pierrepont Sand and Gravel are extensive throughout the valley floor (Figure 6) and are particularly important as the focus of human activity and settlement from earliest post-glacial times, as well as preserving Pleistocene faunal and artefactual remains internally.

In the lower parts of the Trent Valley, palaeoshorelines associated with Lake Humber may be buried beneath the surface and these may have formed important foci for Late Palaeolithic and early post-glacial hunter gatherers since the area may have formed an important wetland well into the early Holocene. Therefore, the identification of these features should be a future research priority.

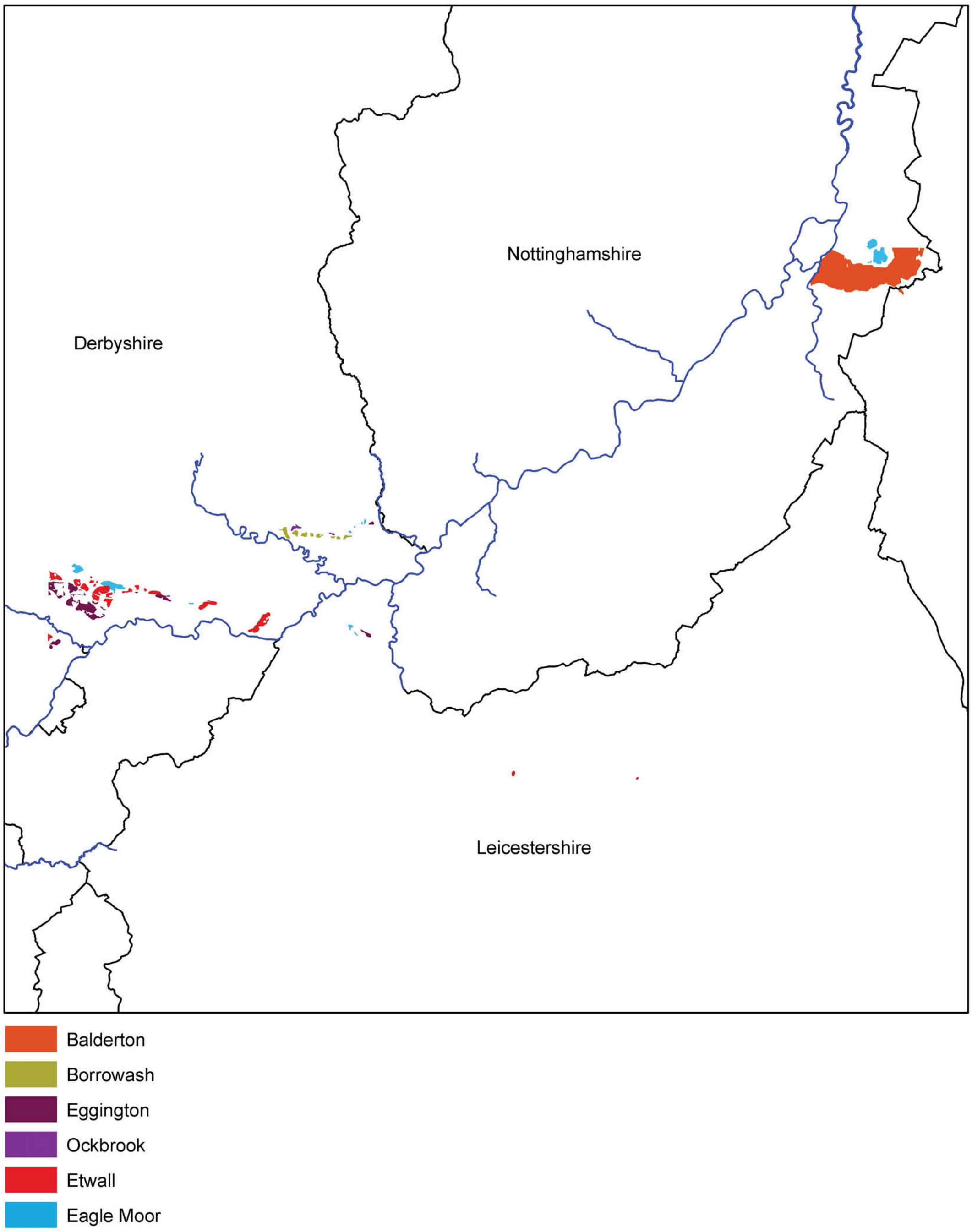


Figure 4. Distribution of pre-Devensian outwash sediments in the Trent Valley.

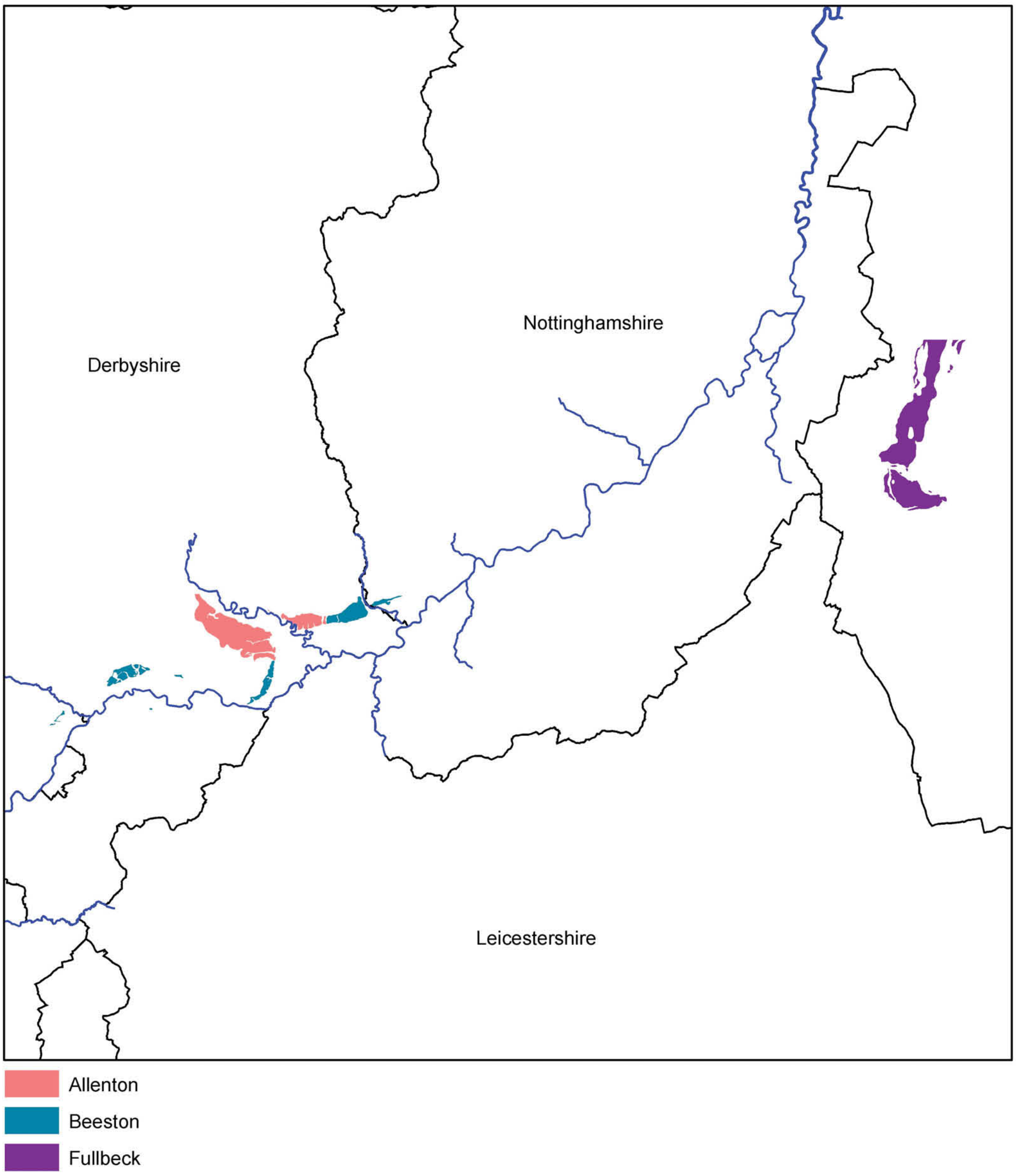


Figure 5. Distribution of deposits in the Trent Valley of probable Ipswichian and early post-Ipswichian age.

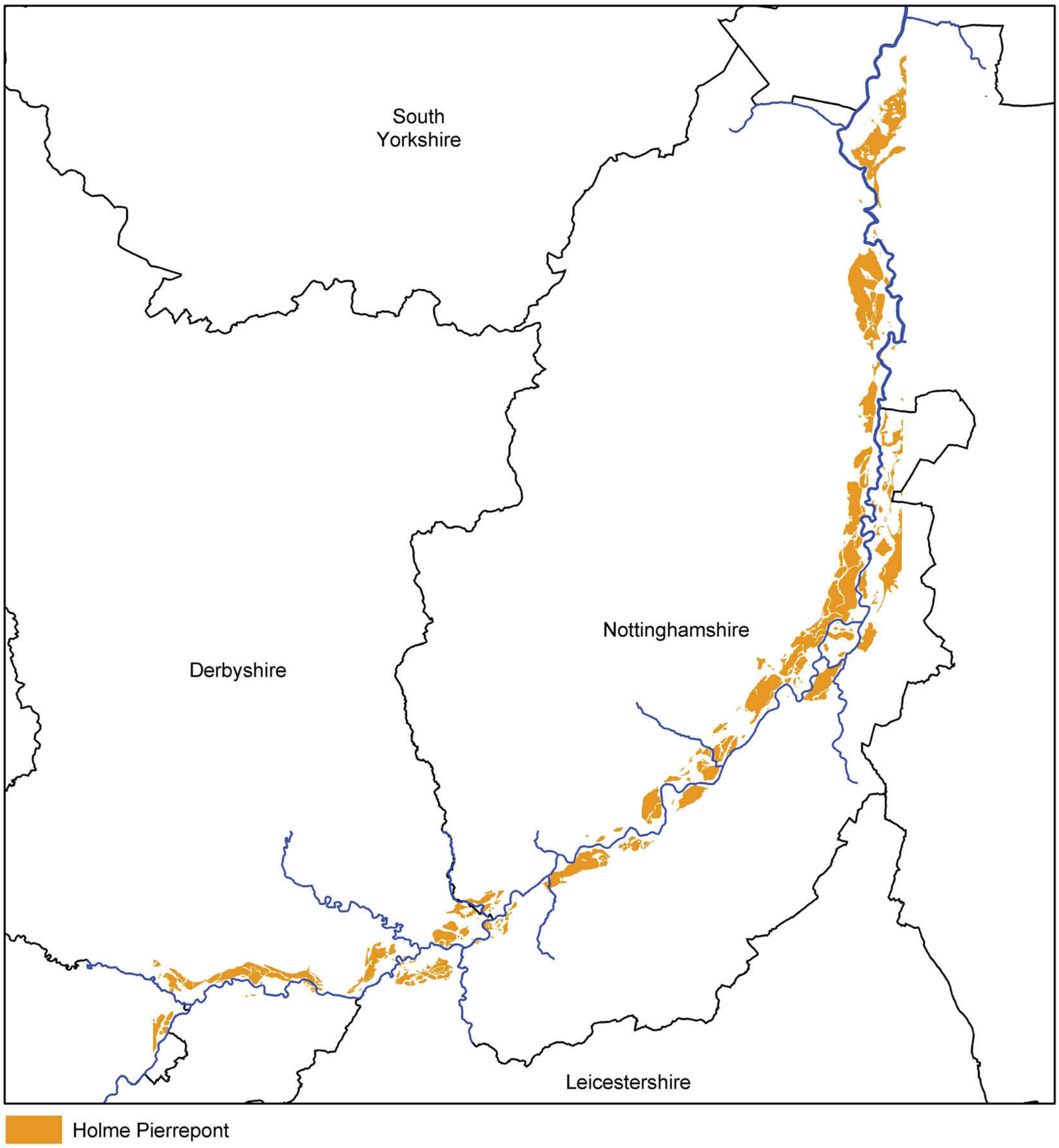


Figure 6. Distribution of the late Devensian Holme Pierrepont Sand and Gravel along the Trent Valley.

5. HOLOCENE LANDSCAPE ELEMENTS OF THE TRENT VALLEY

5.1. The Hemington Terrace – Reworked Sands and Gravels

In contrast to other river systems in midland and southern Britain where the amelioration of climate during the Holocene and increasing input of fine grained sediment to the valley floor as a consequence of deforestation has led to a progressive stabilisation of river systems, the Trent has remained energetic, particularly in its middle reaches, migrating back and forth across its floodplain, reworking Pleistocene sands and gravels, and burying and reworking archaeology in its path (Salisbury *et al.*, 1984; Salisbury, 1992; Brown *et al.*, 2001). Brown (1998) has linked this instability to the input of large quantities of water draining into the Middle Trent from the uplands of the Peak District, via the Rivers Derwent and Dove. These reworked sediments have been classified by the British Geological Survey (BGS) as the Hemington Terrace deposits. Indistinguishable lithologically from the Pleistocene parent material from which the sediment is derived, the deposit is only identified by the presence of post-glacial archaeological material, large tree trunks and the absence of ice wedge casts (which are often recorded truncated in the basal parts of the deposit). Although the unit is only identified by the BGS in the Middle Trent around Derby and Nottingham (as a consequence of recent remapping), geoarchaeological fieldwork has identified the unit north of Newark, where it is/has been quarried at Langford (Howard *et al.*, 1999b) and Besthorpe (Howard, 1992).

5.1.1. The Nature of Preservation in the Hemington Terrace Deposits

Monitoring of quarries in the Middle Trent Valley around Colwick, Holme Pierrepont and Hemington has demonstrated the immense potential for the preservation of archaeological remains including fishweirs, revetments, anchor stones, bridges and mill dams within these sands and gravels (Salisbury *et al.*, 1984; Clay, 1992; Salisbury, 1992, Cooper *et al.*, 1994; Brown *et al.*, 2001; Cooper, 2003). At Langford Quarry in the Lower Trent Valley, finds have included late Neolithic human remains (Howard *et al.*, 1999b).

Although many of these remains are not *in situ*, Salisbury (1992) has demonstrated how accurate recording of the spatial position of individual structures and artefacts over prolonged periods of extraction can provide valuable information on the nature of floodplain hydrology.

Despite the energetic nature of the fluvial system, these high energy sediments can also yield important palaeoenvironmental datasets (Howard *et al*., 1999b; Smith, 2000).

As stated earlier, the Hemington Terrace has only been defined lithostratigraphically in the Derby to Nottingham region as a result of detailed remapping and reinterpretation of the valley floor deposits (Figure 7). However, the lateral continuation of the Hemington Terrace can be identified downstream of Newark in exposures at Langford and Besthorpe (by the recognition of large tree trunks, archaeological remains and the absence of ice wedge casts). It seems likely that many areas currently mapped as Holme Pierrepont Sand and Gravel may in fact represent Hemington Terrace deposits, though it should be possible to distinguish the two on the basis of detailed geomorphological/geological mapping and the analysis of borehole records and exposures. Therefore, the identification of this rich, mappable archaeological unit should be a future research priority.

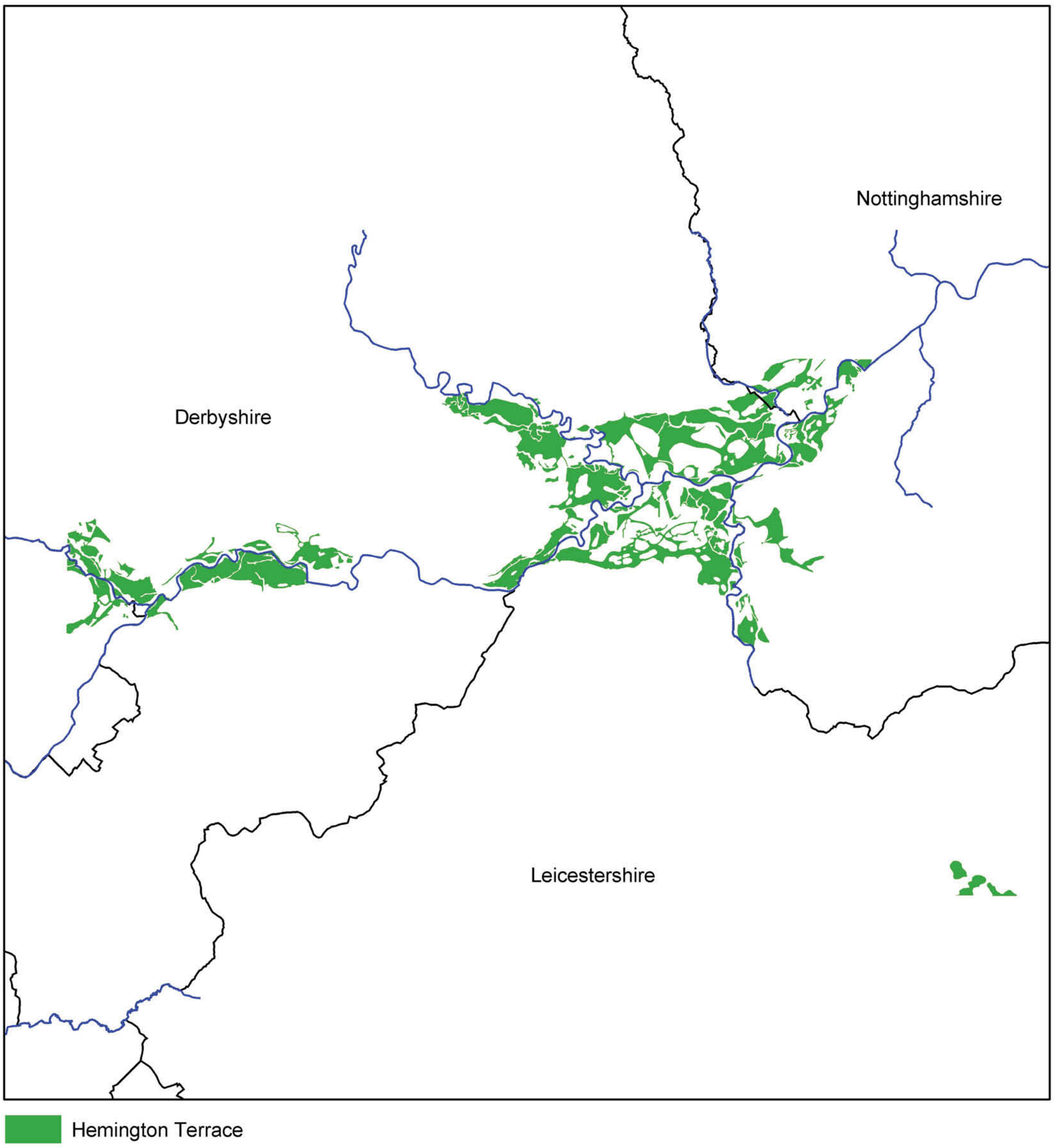


Figure 7. Distribution of the Hemington Terrace deposits in the vicinity of Derby and Nottingham.

5.2. Areas of Fine-Grained Alluviation

In the wide floodplain of the Trent, particularly downstream of Newark, extensive fine grained alluviation has occurred. In the Lower Trent, Challis (2003) notes that these deposits are up to 19 m thick, although upstream of Newark, these deposits are considerably thinner, sometimes less than 0.5 m thick (Elliott and Knight, 1998, 1999). Enhanced fine grained alluviation can be demonstrated from the Romano-British period (Buckland and Sadler 1984), but probably has its origins in the Late Neolithic and Bronze Age during the first large scale forest clearances of the catchment (Knight and Howard 1995). In a number of areas of the Trent Valley where available borehole records or commissioned studies have resulted in a dense spread of stratigraphic records, attempts have been made to model the subsurface topography of these areas in order to produce strategies for targeted prospection of palaeochannels and buried gravel islands (Figure 8 & 9).

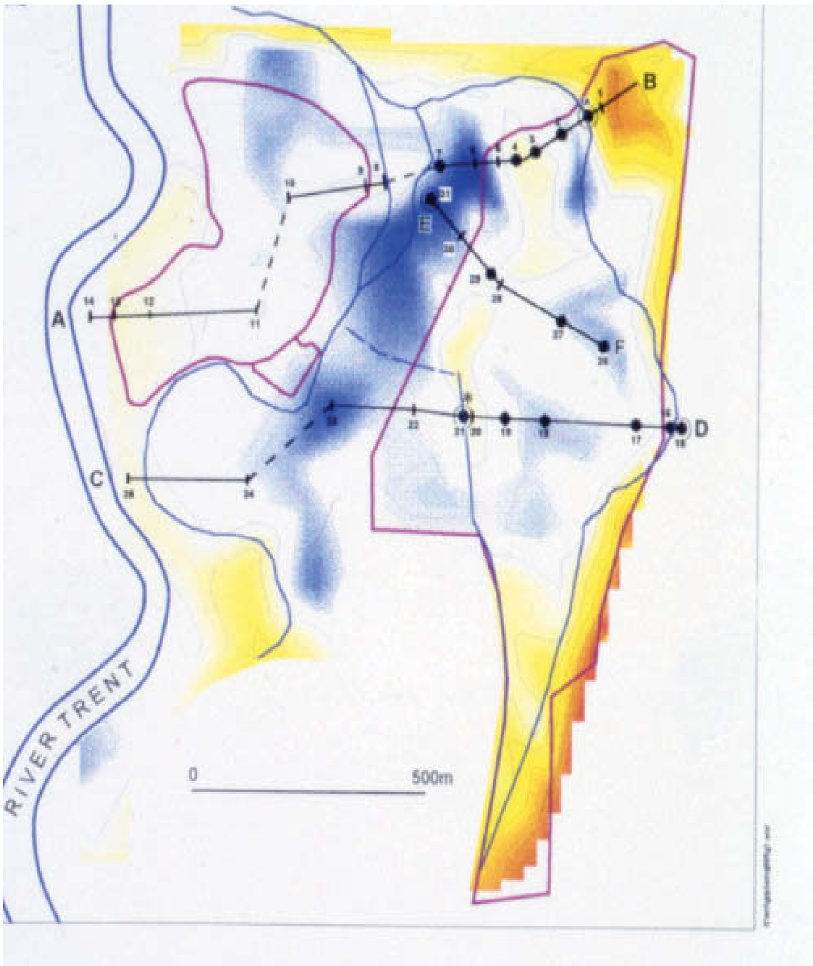


Figure 8. Subsurface topography of the floodplain north of Girton revealing deeper areas of alluvium (blue) and areas of higher ground (yellow to orange).

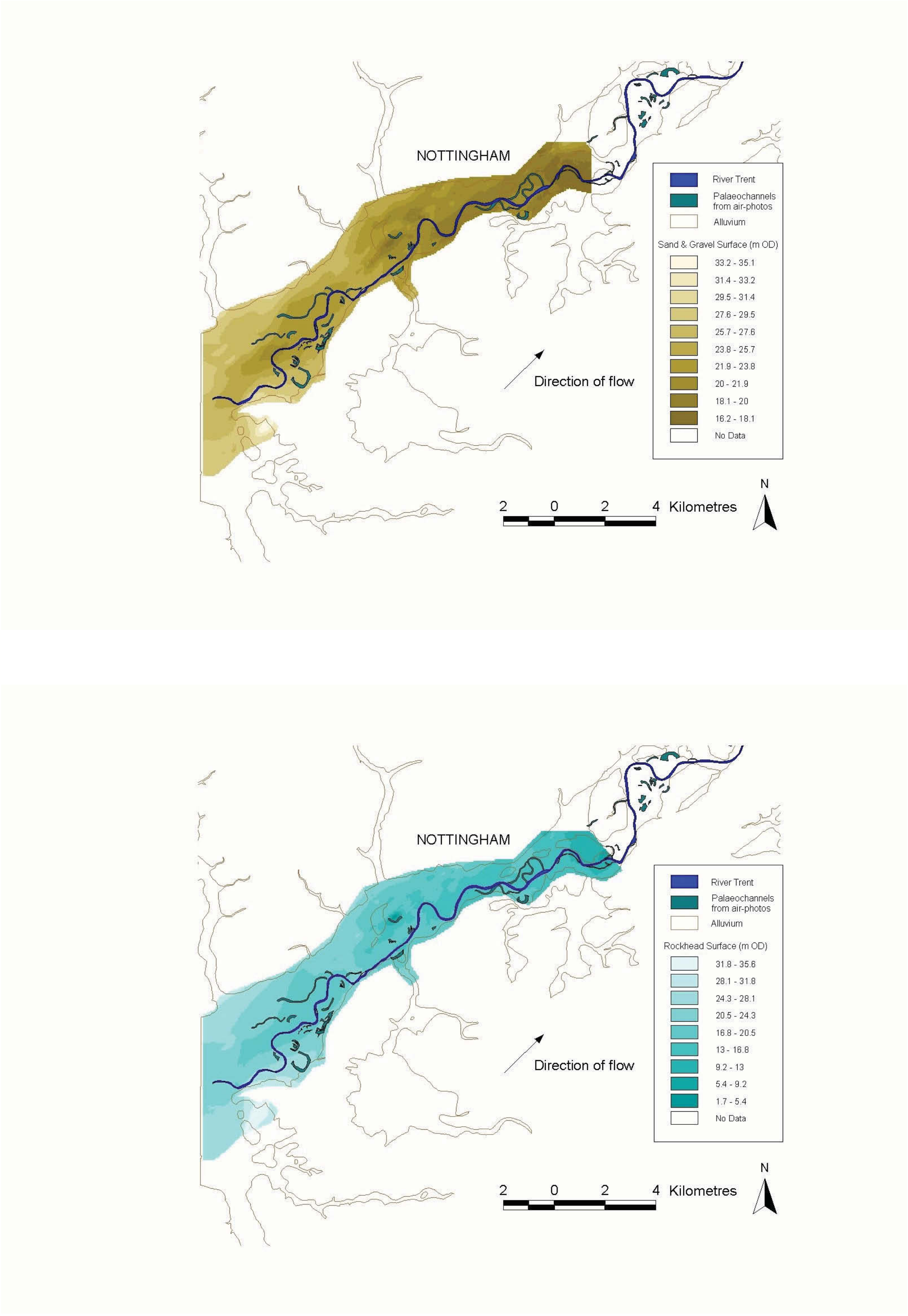


Figure 9. Modelling of the sand and gravel and rockhead surfaces in the Middle Trent Valley (reproduced from Challis and Howard, 2003).

5.2.1. The Nature of Preservation under Fine Grained Alluvium

Figure 10 illustrates that fine grained alluvium is mapped valley wide and a number of studies in the Trent Valley have demonstrated the presence of well preserved features beneath alluvium. For example around Hoveringham in the Middle Trent, Elliott and Knight (1998, 1999) recorded features buried beneath a thin blanket of alluvium which were invisible to conventional techniques of archaeological prospection and only identified through monitored topsoil stripping. Aerial photography of the lower Trent has demonstrated the presence of features disappearing beneath alluvium at terrace edges (Whimster 1989) and it seems likely that the thick sequences of alluvium in the lower valley contain buried land surfaces, as well more extensive organic surfaces and constrained channel deposits (Challis, 2003). Whilst studies in the Middle Trent Valley (Figure 9) demonstrate the potential of boreholes to allow the mapping of subsurface depressions and other features invisible on the ground surface, both the spatial density and quality of borehole records, as well as the modelling algorithms used, can severely affect the nature of the interpolated palaeosurfaces (see Challis, 2003; Challis and Howard, 2003). Therefore, whilst subsurface modelling is a useful additional tool for the geoarchaeologist, at the reach scale, it should be used broadly rather than to place definitive boundaries around lithostratigraphic units. However, at the site-specific scale, it can be used with greater confidence to model the surface and subsurface topography and to identify areas for assessment using targeted trial excavation and other methods of prospection (Howard and Knight, 2001).

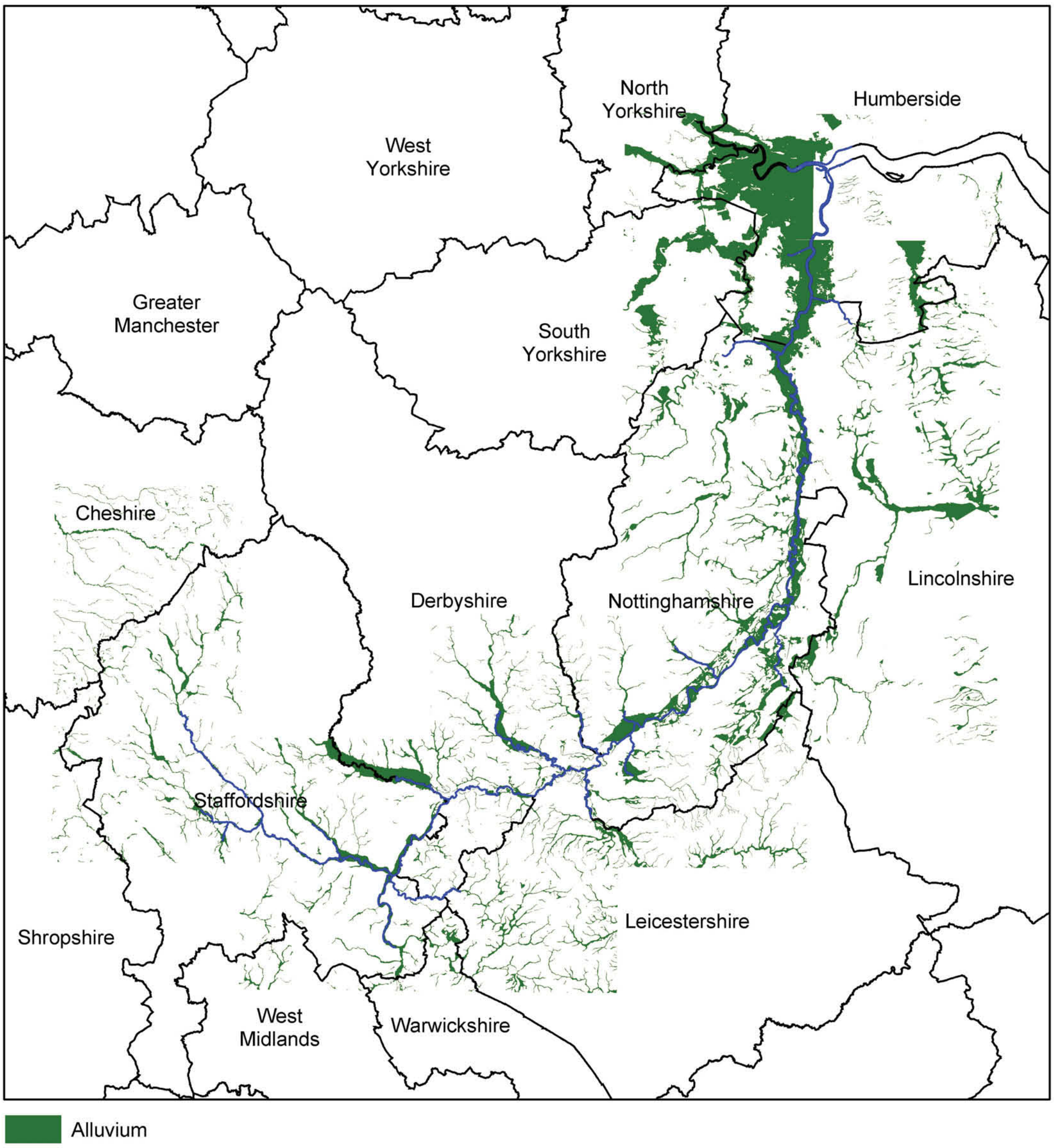


Figure 10. The distribution of fine grained alluvium throughout the Trent Valley.

5.3. Areas of Aeolian Sedimentation

Extensive deposits of aeolian sand, termed Coversand, are a notable feature of the lower Trent, north of Newark, where they blanket the Holme Pierrepont terrace deposits on the eastern margin of the valley floor (Figure 11). The majority of this sand was deposited initially during the Loch Lomond Stadial, an intense cold event between 11-10,000 years BP when strong winds eroded fine sands deposited by meltwaters associated with Dimlington Stadial ice. Although deposited during the late Pleistocene, it is likely that these fragile deposits may have been reworked in the Trent Valley on a number of occasions during the Holocene, as in the Vale of York (Matthews, 1970), although with the exception of Mesolithic and post-Medieval reworking around Tiln in the Idle Valley (Bateman *et al.*, 1997; Howard *et al.*, 1999c), this remains to be demonstrated widely.

In addition to the valley floor braided river sands, blown sands could also have originated from the friable soils of the Sherwood Sandstone to the west of the Trent which were extensively cultivated during the Romano-British period.

5.3.1. The Nature of Preservation under Coversands

Although few archaeological sites in the Trent Valley have been excavated on areas of coversand, the potential for reworking of these sediments provides for both burial and erosion of archaeology upon these deposits. At Tiln, in the Idle Valley, extensive spreads of Mesolithic flintwork were recorded both upon and buried within a layer of coversand approximately 2 m thick, blanketing a late Pleistocene river terrace of the Idle (Howard *et al.*, 1999c). Elsewhere at Tiln, late Medieval-post Medieval ditches were recorded buried beneath coversands (Bateman *et al.*, 1997).

Thin peat beds are also a characteristic feature of coversand deposits in eastern England (Bateman, 2001; Murton *et al.*, 2001) and therefore the potential of these deposits for palaeoenvironmental reconstruction should not be underestimated

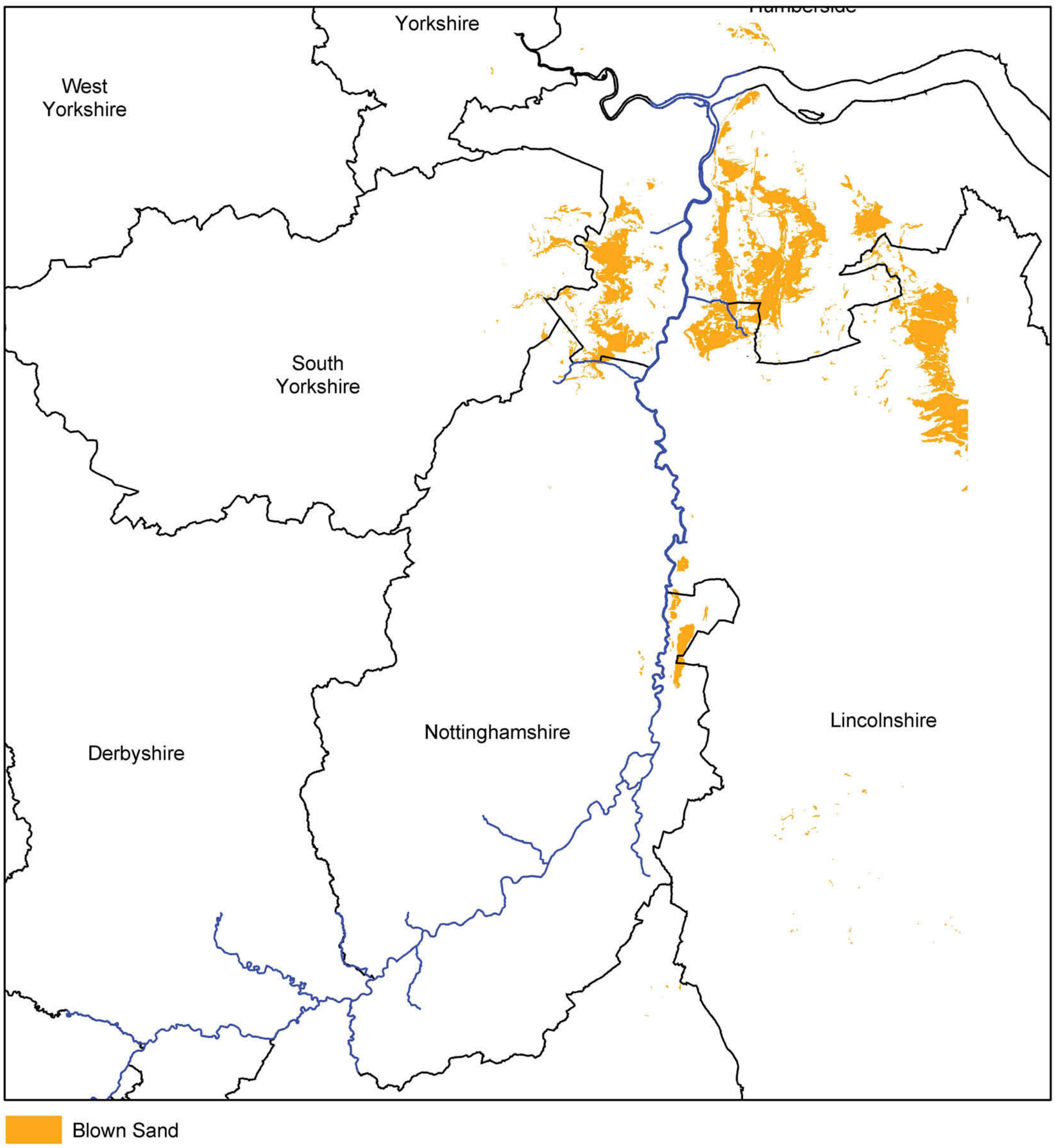


Figure 11. Distribution of coversand deposits in the Trent Valley and adjacent areas.

5.4. Areas of Colluviation

Despite the lack of obvious relief within the contemporary valley floor, which may in part be due to fine-grained alluviation, the slopes of some terraces and gravel islands may have been steep enough in earlier periods to allow the movement of material through gravity. This is demonstrated in the lower Trent by interdigitating colluvial and alluvial sediments recorded at Collingham (Knight, 1994) and Kelham (Knight and Priest 1998).

5.4.1. The Nature of Preservation under Colluvium

Sedimentation at landform edges has the potential to bury archaeological remains and to rework artefacts from upslope. Although examples from the Trent Valley are rare, Iron Age features have been recorded sealed beneath colluvial deposits at Foxcovert Farm, Aston-on-Trent (Hughes 1999) and at Kelham, near Newark (Knight and Priest 1998). Unfortunately, unless landforms typical of increased slope channel coupling are evident within the landscape, for example, alluvial fan cones, this type of geomorphic process and the associated sedimentary evidence usually remains undetected within the landscape and is rarely mapped. Certianly within the Trent Valley, it is not mapped by the British Geological Survey.

5.5. Areas of Alluvial Landform Development

5.5.1. Areas of Preservation - Organic-rich Palaeochannels

Systematic mapping of the valley floor by Malone (1997) and Baker (2003) has demonstrated that extensive suites of palaeochannels are preserved on the Holocene floodplain (Figure 12). This data has the potential to be augmented by mapping using LiDAR (Challis, 2004).

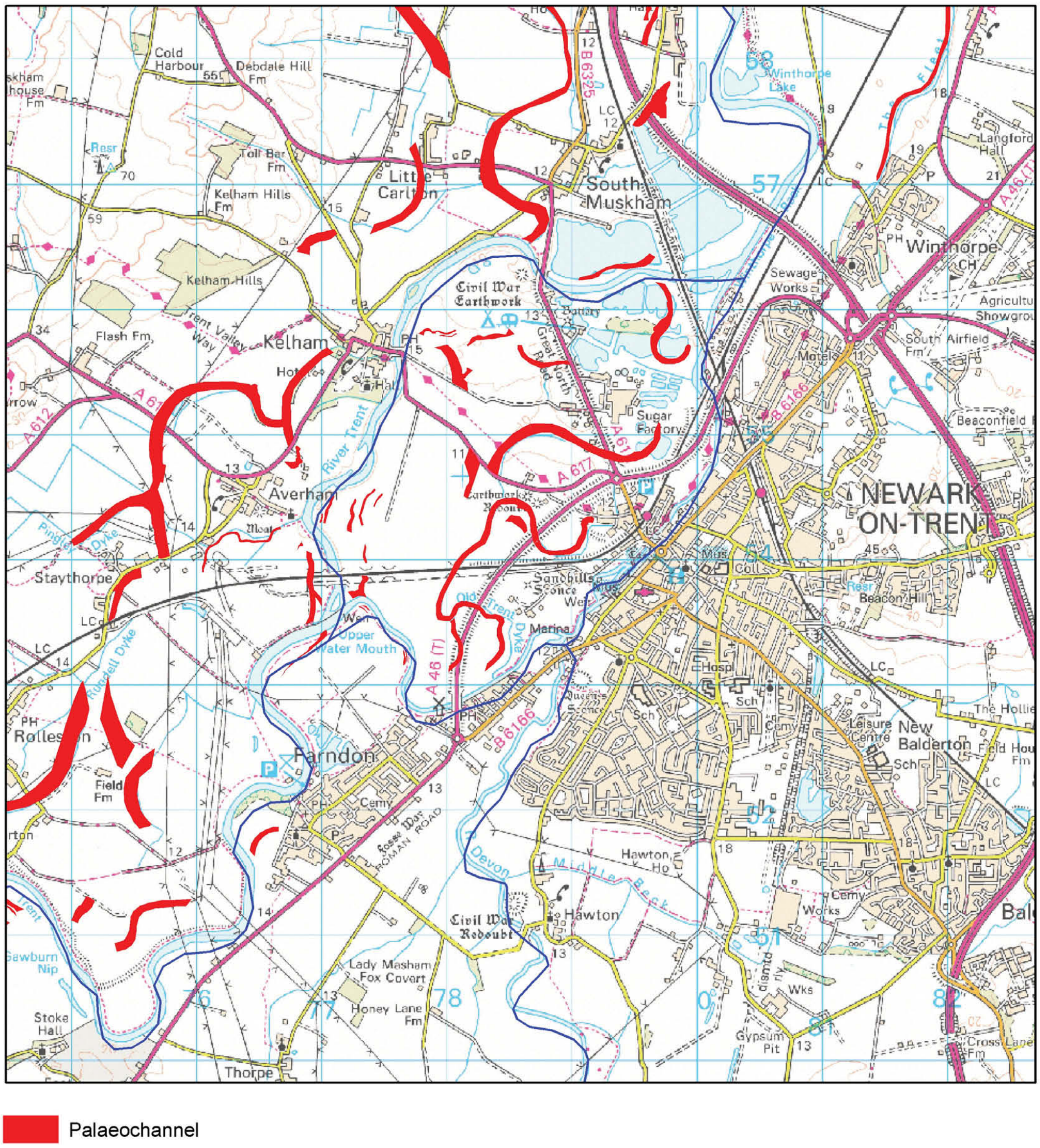


Figure 12. Palaeochannels mapped on the valley floor near Newark (based on Malone, 1997).

In combination with borehole data (Challis, 2003), it is evident that many of these are infilled with peat and other organic-rich sediments capable of providing proxy records of climate and landuse. In general, these organic deposits thicken progressively downstream (Figures 13 and 14), reflecting the lower channel gradients (and hence energy levels) and widening of the floodplain (and hence greater preservation potential).

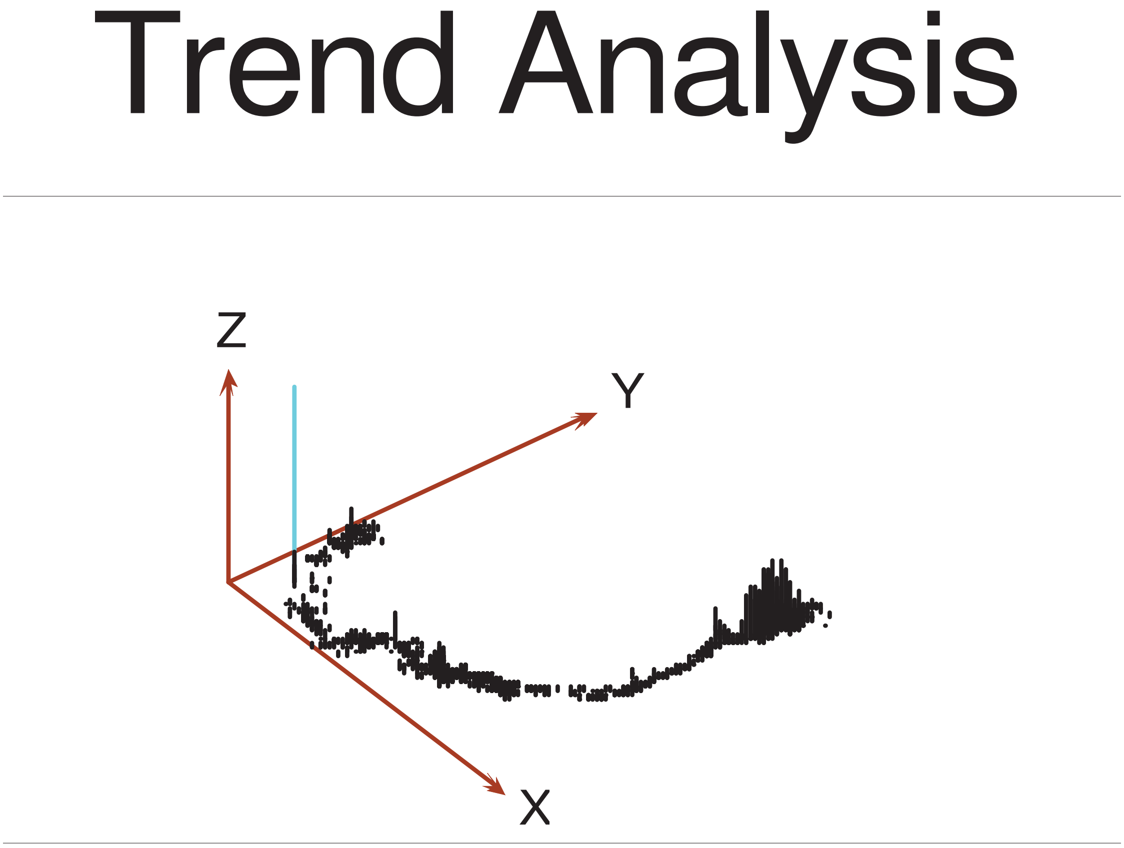


Figure 13. Trend analysis illustrating the increasing thickness of organic sediment towards the lower Trent and Humber Estuary.

However, in the lowest reaches of the Trent Valley, thick organic sequences do not correlate with palaeochannel features mapped on the surface (Figure 15), which suggests that channels and other organic rich surfaces may also be buried beneath thick sequences of fine grained alluvium (see Challis, 2003; Howard and Knight, 2001).

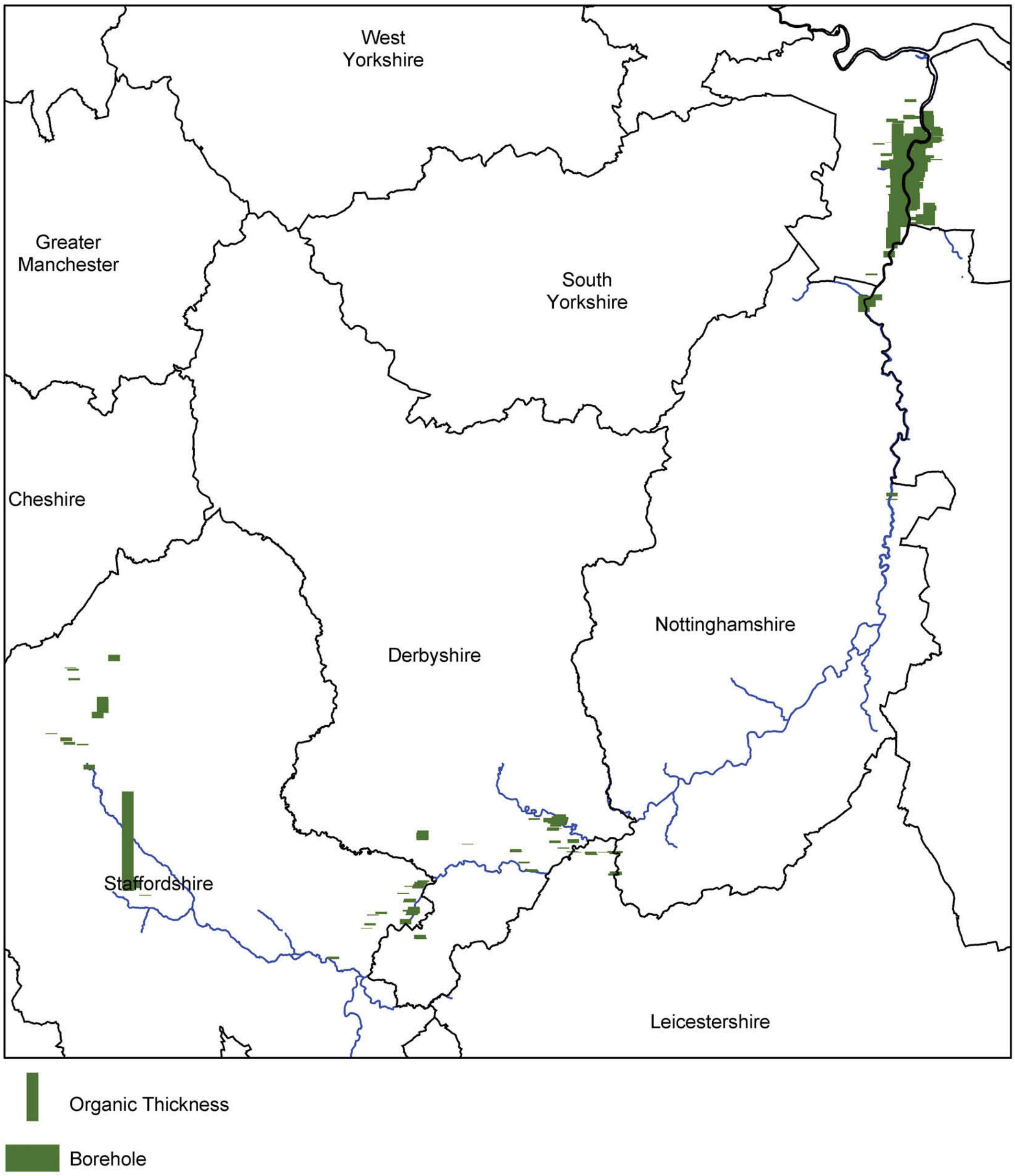


Figure 14. Map showing the increasing thickness of organic materials downstream along the Trent.

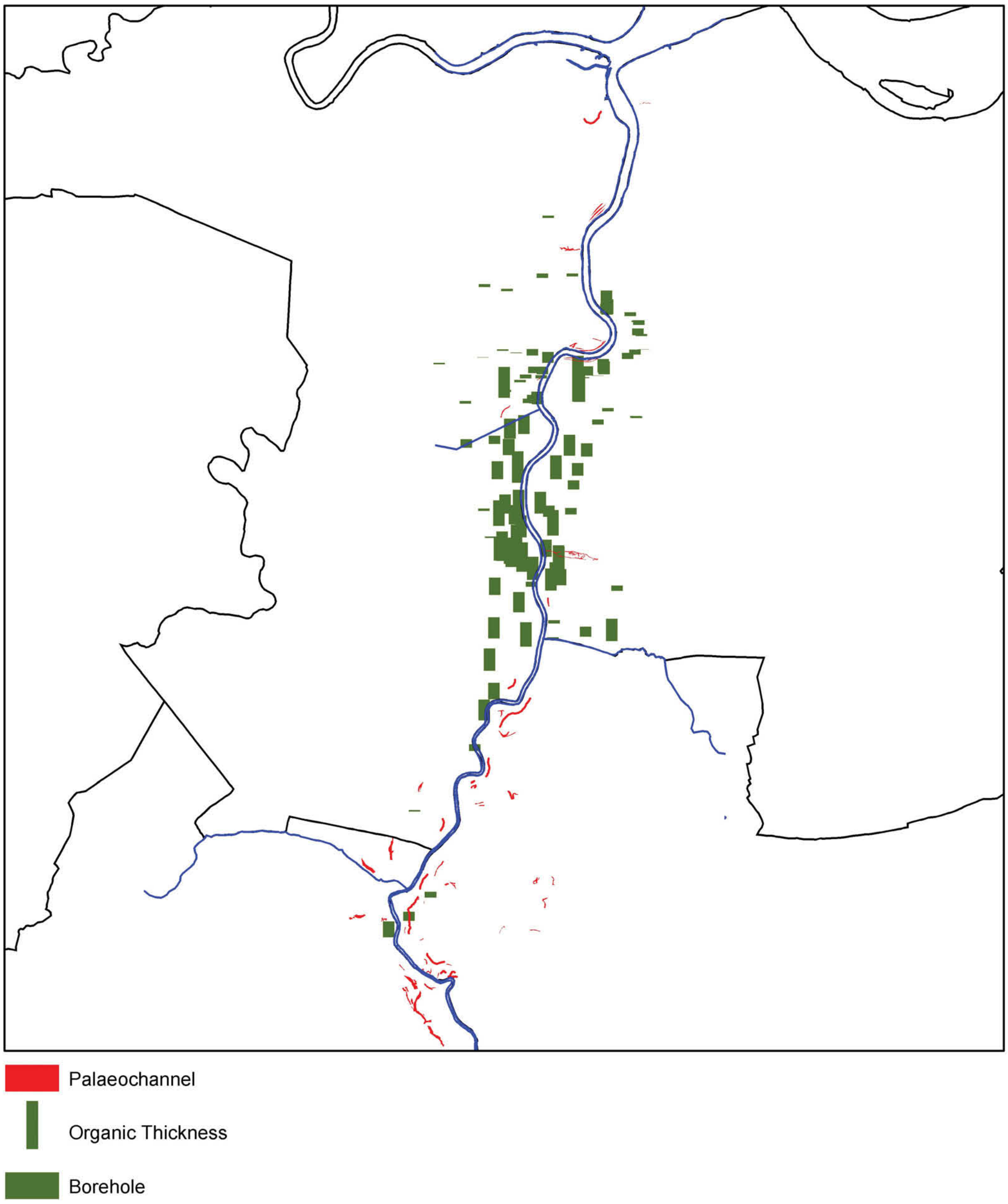


Figure 15. Thick sequences of organic sediments in the lower Trent Valley unrelated to surface palaeochannel features probably indicate extensive, buried palaeolandsurfaces.

5.5.1.1. The Nature of Preservation within Palaeochannels

The potential for palaeochannels and other organic-rich landsurfaces to yield a range of biological material including pollen, insect and macroscopic plant remains, capable of providing high resolution records of climate and land-use is well demonstrated in the Trent Valley (Brayshay and Dinnin, 1999; Smith *et al.*, 2001) and therefore their identification is of paramount important.

As well as yielding organic remains, a number of human activities and structural remains appear to be intimately associated with former channels, for example, burnt mounds (Beamish and Ripper, 2000).

The palaeochannels mapped along the Trent comprise a variety of morphological from small linear features to well developed classic meander loops in the lower Trent around Bole Ings (Table 4; Figure 16). The degree of preservation is clearly related to channel energy and valley width, with greater potential for preservation with increasing distance downstream.

Although tempting, it is impossible to classify the potential of palaeochannels based on their surface form and their potential can only be assessed through individual evaluations on a site by site basis. Equally, it is impossible to determine the speed at which palaeochannels are abandoned or infilled from surface morphology. This can only be determined through sedimentological analysis on a site by site basis, or in some more recent instances, through the analysis of documentary records (e.g. Large and Petts, 1996).

Table 4. The nature of palaeochannel preservation along the Trent Valley (from Baker, 2003).

Zone	**Valley form and drift geology**	**Land use**	**Frequency of mapped palaeochannels**	**Nature of palaeochannel record**
Upper (above Weston, Staffs.)	Very narrow valley (<1 km) with narrow sinuous channel; narrow alluvial floodplain with no gravel terrace.	Floodplain grassland	No palaeochannels recorded	
Upper Middle (Staffs. below Weston, Derbys., Leics.)	Valley typically 1-3 km wide, expanding to around 6 km at a number of major confluence zones. Sinuous/meandering channel. Dominated by gravel terrace, particularly in confluence zones. Ratio of gravel to alluvium c. 2:1	Predominantly arable, with significant floodplain grassland	Many smaller palaeochannels (3.2 channels/km²)	Cropmarks the largest group (50-60%); floodplain depressions significant (c. 30%)
Lower Middle (Notts., Lincs.)	Valley typically 2-5 km wide with fewer major confluences; sinuous/meandering channel. Dominated by alluvium, with significant gravel terrace; ratio of alluvium to gravel c. 2:1	Arable; some floodplain grassland	Fewer, broader palaeochannels (1.7 channels/km²)	Cropmarks predominate (c. 70%); 10-20% floodplain depressions
Lower and Tidal (North Lincs.)	Broad, sinuous channel with occasional meanders. Very broad and deep alluvial spreads; no gravel terrace	Arable often to channel margins.	Very few channels (0.2 channels/km²)	Cropmarks and field boundaries only

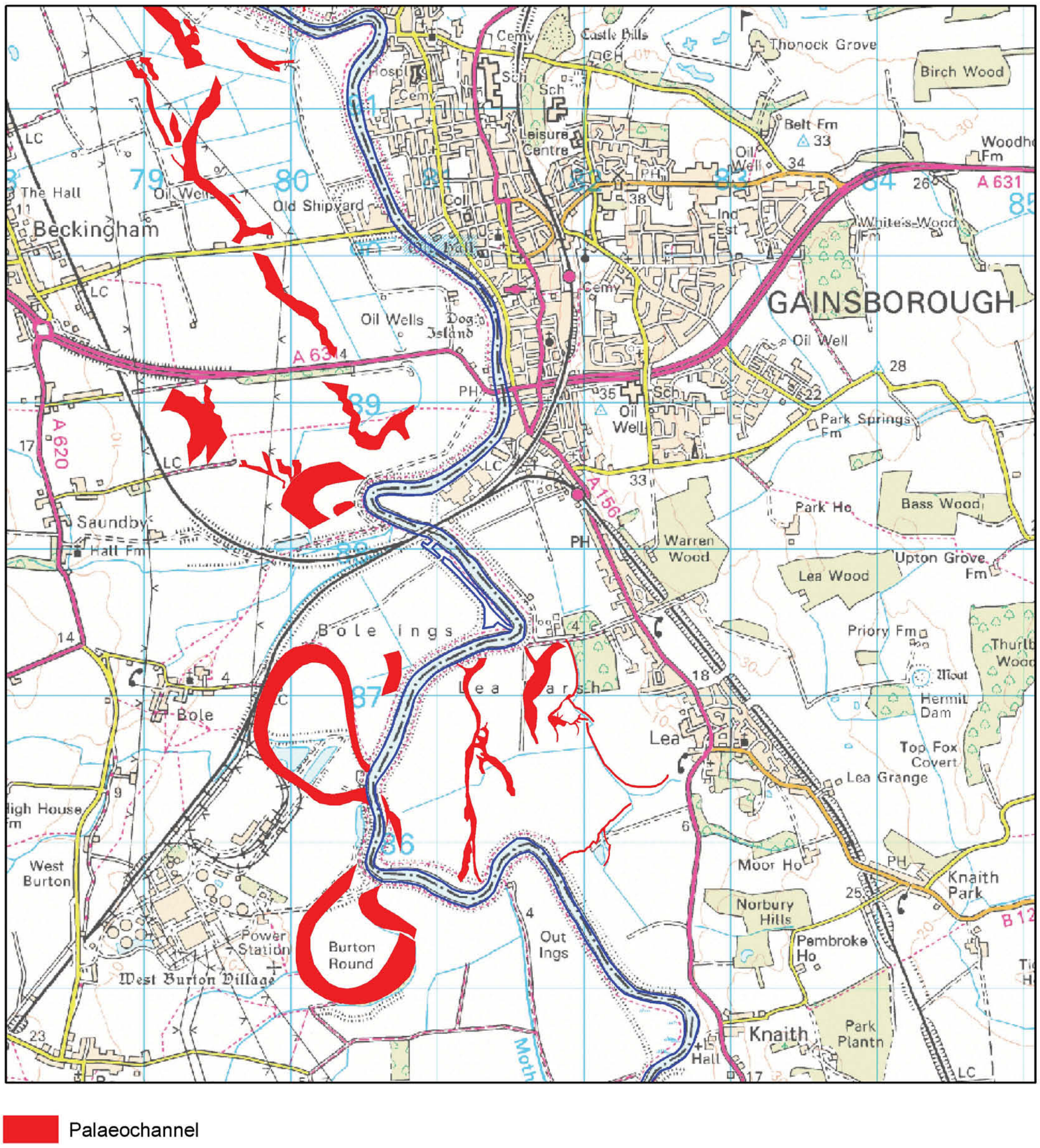


Figure 16. Palaeochannels of varying form on the valley floor near Bole Ings, Gainsborough.

5.5.2. Areas of Destruction – Identification of Scroll Bars

Scroll bars are classic landforms of meandering rivers representing the lateral migration of point bars on river bends. Lateral movement of rivers is a key factor affecting archaeological preservation. Systematic mapping of aerial photographs along the Trent Valley indicates that these landforms are well developed between the Soar and Dove confluences (Figures 17, 18 and 19) and reflect the relatively high stream power of the river in its middle reaches (Brown, 1998). The position of the majority of scroll bars adjacent to the contemporary channel suggest that they are relatively young landforms.

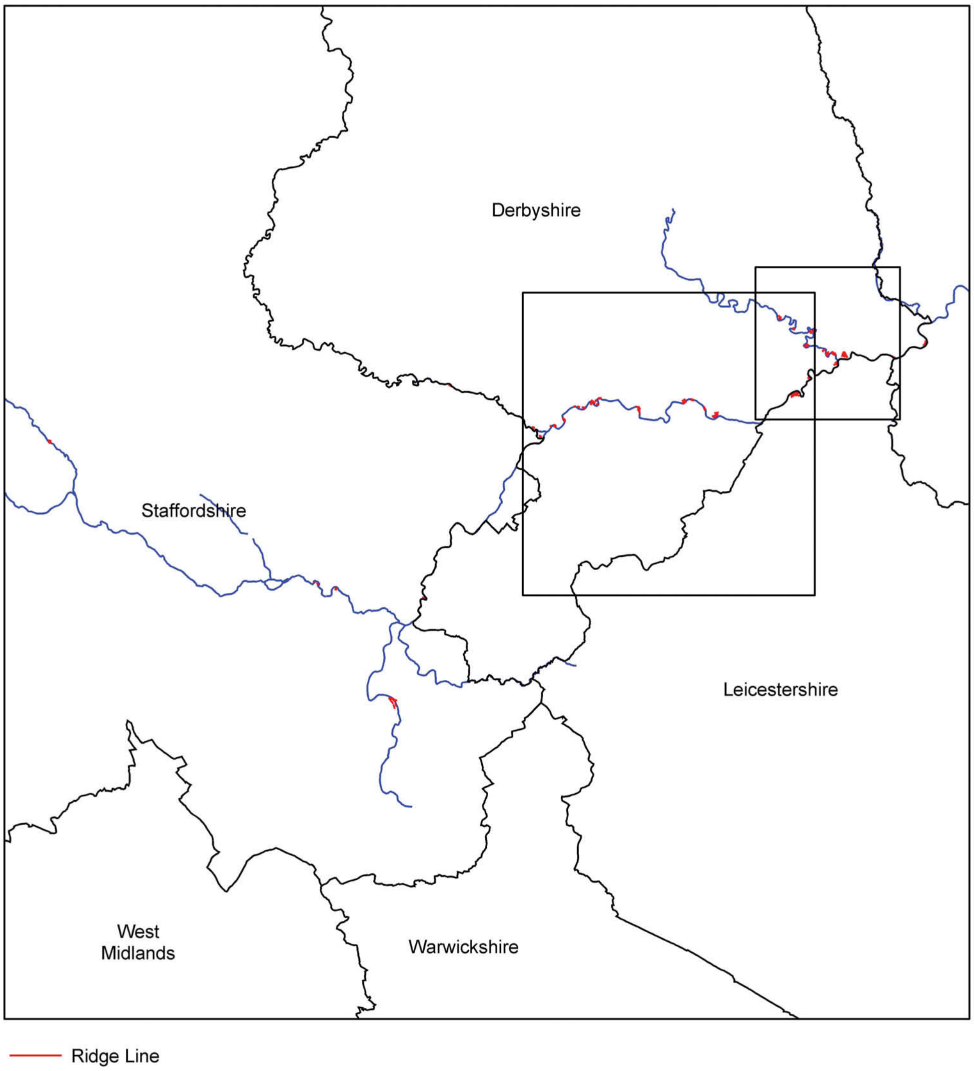


Figure 17. Distribution of scroll bars (termed ridge lines) in the Middle Trent (inset boxes refer to Figure 18 and 19).

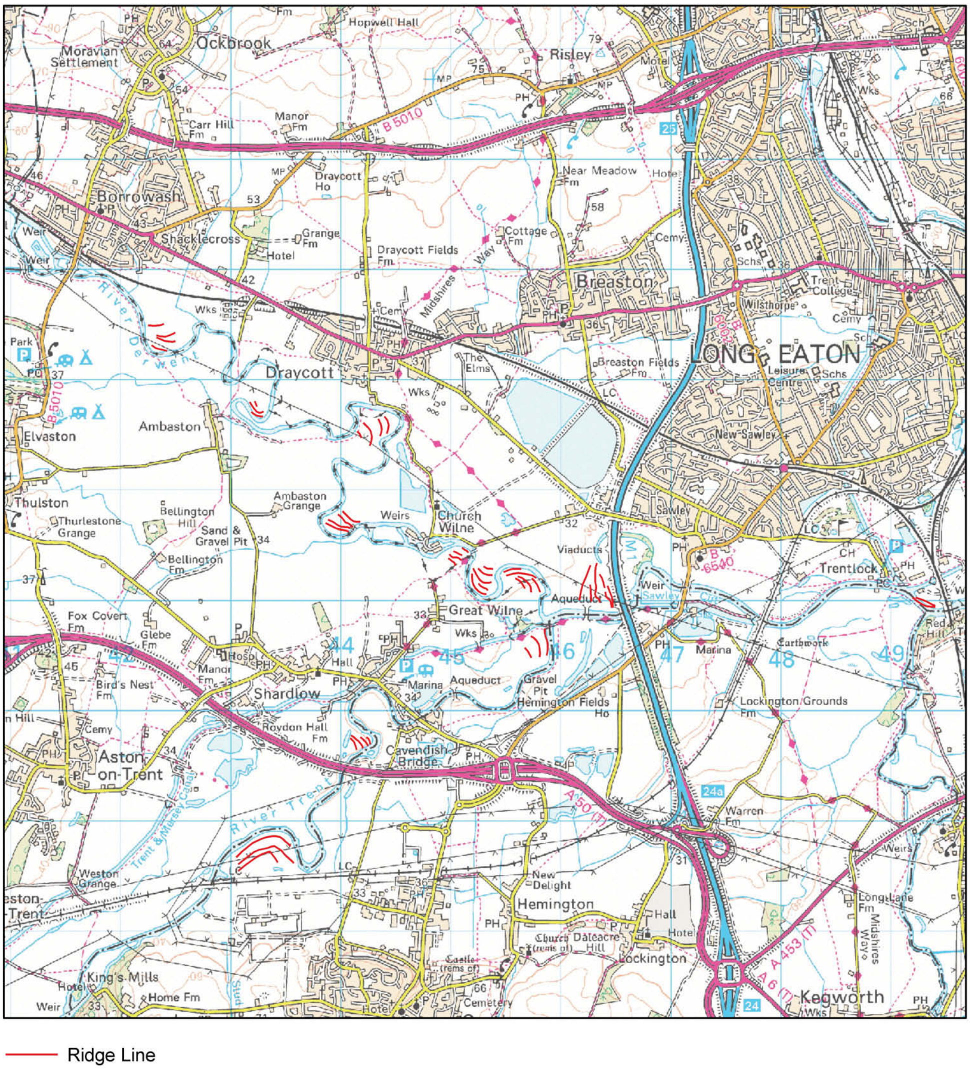


Figure 18. Distribution of scroll bars (termed ridge lines) around the Trent-Derwent confluence.

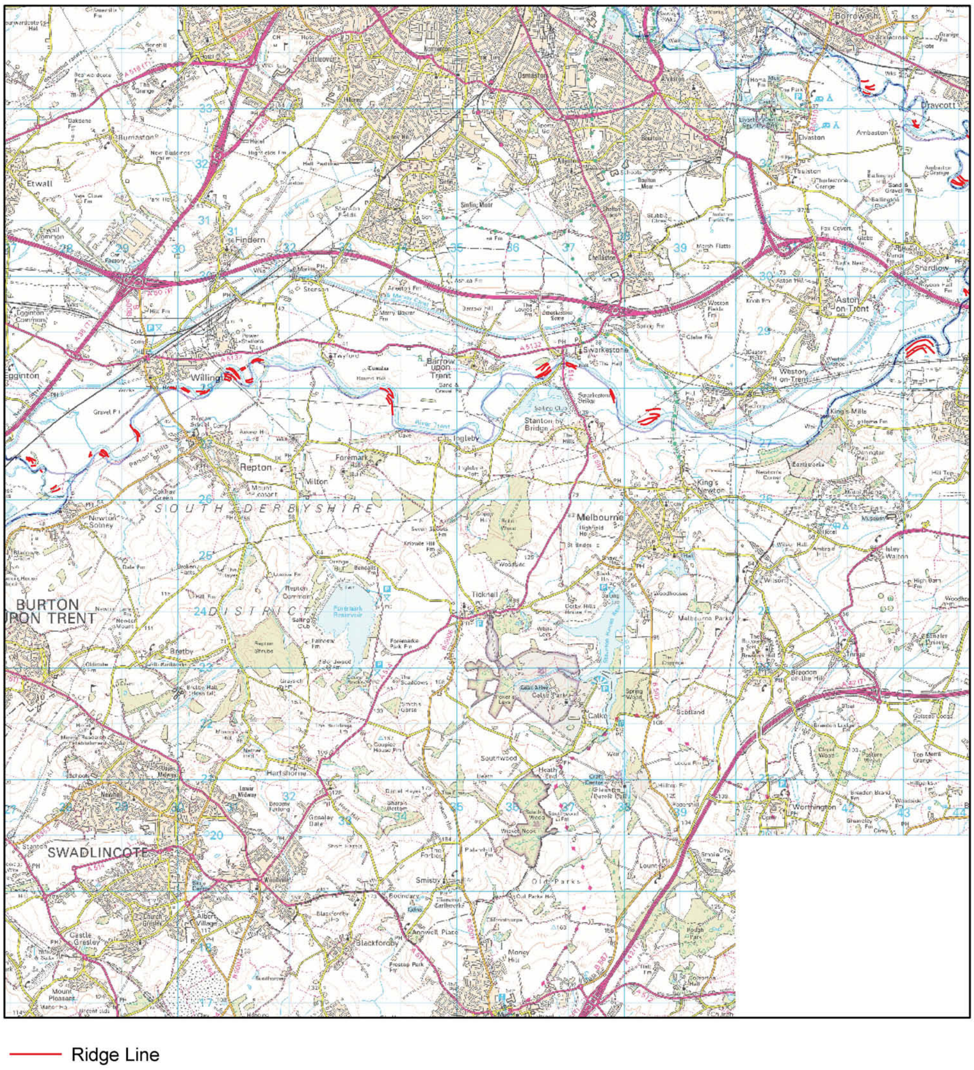


Figure 19. Distribution of scroll bars (termed ridge lines) between the Derwent and the Dove.

5.5.2.1. The Nature of Preservation Where Scroll Bars are Developed

Scroll bars are indicative of lateral channel migration, and as such, represent areas where archaeological remains are likely to be reworked. However, since the majority of scroll bars are located adjacent to the contemporary channel, this suggests that the features are relatively young, although they could conceivably indicate migration across and reworking of older terrace surfaces. However, as demonstrated by the archaeological remains recorded in the Hemington Terrace deposits, reworking of sediments should not be seen as an entirely negative process.

5.6. Warp

In addition to natural changes in the rate and patterns of deposition throughout the Valley, sedimentation in the lower reaches of the Trent has been manipulated by humans through the process of warping (Gaunt 1994; Lillie 1998). This technique used the natural tidal flow of the lower Ouse, Aire, Don and Trent to introduce fine-grained alluvium across areas of low-lying land in need of agricultural improvement. Sediment rich waters were distributed by a number of artificial drains controlled by sluice gates. Both Van de Noort and Ellis (1999) and Gaunt (1994) illustrate the distribution of warped land, which forms extensive tracts along the banks of the Ouse to the north of Yokefleet, to the west of Goole and around the Ouse-Derwent confluence (Figure 20). The earliest known example of warping is from the 1730s near Rawcliffe on the River Aire with the last recorded evidence from land to the east of Yokecliffe in 1947 (Gaunt 1994).

5.6.1. The Nature of Preservation in Warped Areas

The practice of warping since the post-Medieval period until the very recent past had a significant affect on the distribution and rate of fine grained sedimentation in the Lower Trent Valley. Each warp flood could deposit an average of 2 mm of silt and silty clay across the landscape, with 0.3 m of material accumulating in a single warp season and up to 1.5 m being achieved by sustained warping programmes (Gaunt 1994). Clearly, warping has the potential to bury significant archaeological remains and earlier landsurfaces and may well explain the absence of palaeochannels, but presence of organic sequences in the lower Trent Valley. Whilst attempts have been made to distinguish warp from naturally deposited alluvial materials (e.g. Lillie, 1998), the criteria developed to do this are questionable and warped areas can only confidently be identified through the recognition of structural remains (e.g. sluices) or through detailed documentary research. The difficulty in identifying warp is emphasized by the British Geological Survey who does not distinguish it from other alluvium in their classifications.

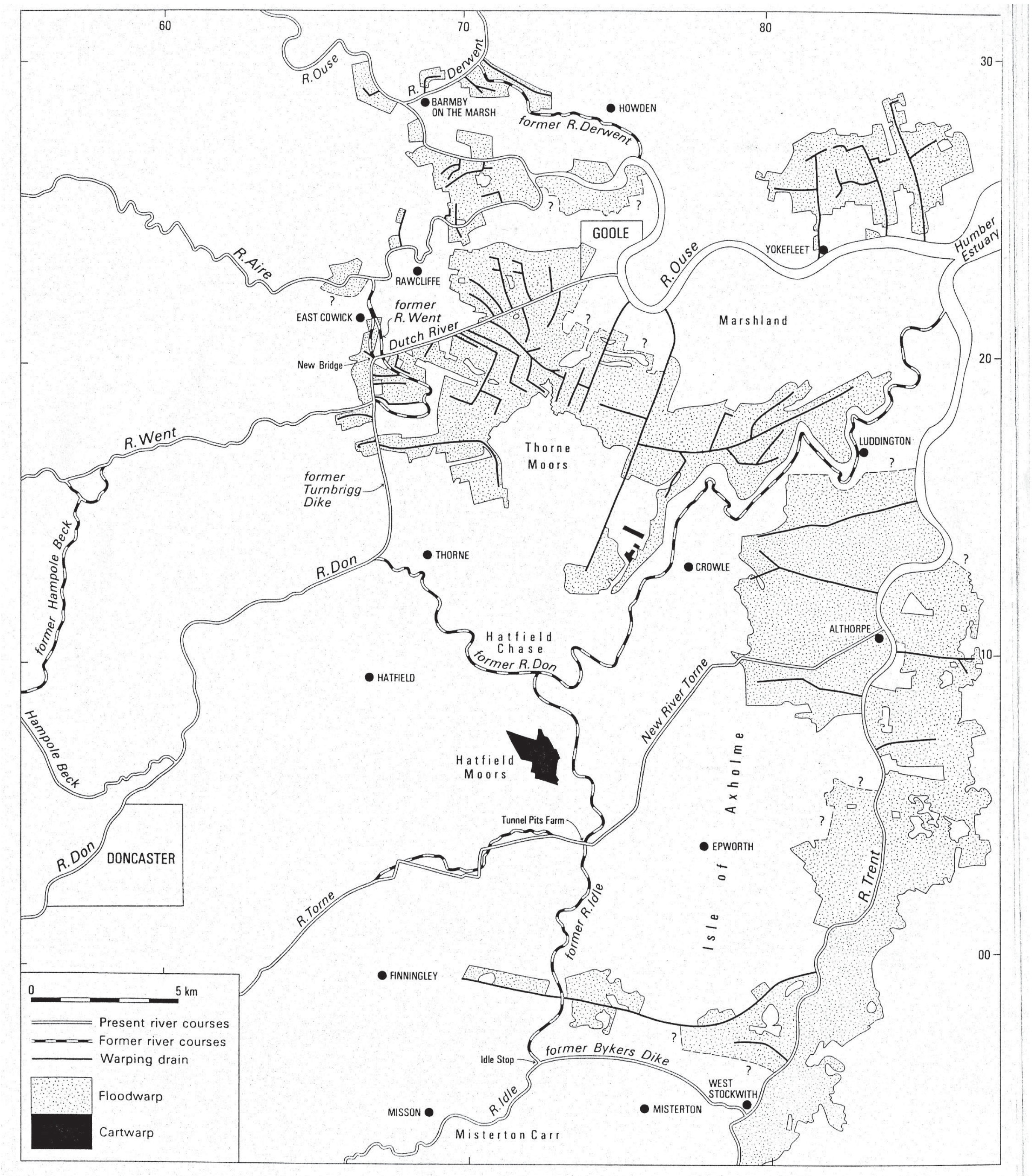


Figure 20. The distribution of Warp in the lower Trent & Humberhead (from Gaunt, 1994).

6. SUMMARY OF LANDSCAPE ELEMENTS IN THE TRENT VALLEY

The landscape elements identified in the Trent Valley and their archaeological potential are summarised in Table 5. Table 6 describes prospection strategies for dealing with deposits of varying risk.

Table 5. *Summary of landform elements identified in the Trent Valley and their importance in considering risk and the archaeological record.*

Landscape Element	**Distribution**	**Geomorphological activity over Holocene**	**Archaeological Potential**
Sands and gravels (Pleistocene)	Occur as terraces flanking the valley and isolated islands within the valley floor	Relatively stable features. Surfaces beyond the impact of flooding	• Multi-period archaeological remains on surfaces • Internally, may yield Palaeolithic artefacts and vertebrate assemblages and temperate sediments
Hemington Terrace (sands and gravels)	Intimately associated with the Pleistocene Sands and Gravels	Reworked since around 4000 BC until early post-Medieval	• Yielded a range of structural remains (e.g. mill dams, bridges, fish weirs, anchor stones, metalwork, human remains) • The surface of the terrace may range from Neolithic to early post-Medieval and can include multi-period remains
Fine-grained alluvium	Throughout the valley but significant thicknesses (around 19m) downstream of Newark	Deposited from the mid to late Holocene period onwards	• Potential to mask archaeological remains from standard techniques of prospection • Potential to conceal multiple palaeolandsurfaces and organic deposits
Aeolian sand	Extensive deposits mapped downstream of Newark and the Idle Valley	Deposited during the late Pleistocene and probably reworked numerous times though the Holocene	• Potential for burial and erosion of archaeology on surfaces • Includes organic sediments for environmental reconstruction
Colluvium	Distribution unknown – likely to form aprons around steeper slopes including terrace edges	Probably deposited from the mid to late Holocene period onwards, though no unequivocal dates known	• Potential to mask archaeological remains at substrate edges and contain reworked archaeological material
Palaeochannels	Distributed across Holocene terraces and floodplain	Abandoned and infilled throughout the Holocene	• Yield palaeobiological indicators of climate and land use • Associated with distinct classes of archaeological remains/artefacts
Warp	Deposited in tidally active areas	Deposited from post-medieval to recent times	• Potential for burial of structural and environmental remains and earlier land surfaces

Table 6. *Prospection strategies for dealing with deposits of varying risk.*

Landscape Element	**Prospection Strategy for deposit**	**Best Practice Regional Examples**
Pleistocene sand and gravels deposits	During the Pleistocene, humans moved in highly mobile groups utilising temporary camps/shelters. Archaeology will be deeply buried and sparsely distributed in the landscape. • Collate and analyse borehole data for deposits, model subsurface topography • Monitor quarry faces at regular intervals and record stratigraphy to identify environment of deposition (cold or temperate) • Identify, sample and analyse organic rich sediments (channels, eroded clasts) • Identify palaeolandsurfaces • Monitor quarry faces and waste tips for mammalian remains (including human) and artefacts (hand axes) • Design and implement dating strategy to provide a chronological framework for deposits	Proposed quarry extension in buried sediments of the Bytham River at Brooksby, Leicestershire (Challis & Howard, 2003). Prospection and excavation of woolly rhinoceros remains at Whitemoor Hayne Quarry, Staffordshire (Buteaux *et al.*, 2003).
Pleistocene terrace surfaces	These terrace surfaces of considerable antiquity and are capable of yielding multi-period archaeological remains • Identify human activity through remote sensing (aerial photography, satellite imagery) • Undertake field walking, geochemical survey, geophysics and trial trenching	Knight (1994).
Hemington Terrace deposits	Deposits of Neolithic to early post-Medieval date. Archaeology likely to be inter-bedded with deposits. • Collate and analyse borehole data for deposits, model subsurface topography • Monitor quarry faces at regular intervals and record stratigraphy to identify environment of deposition (single or multi-channel). • Monitor quarrying and record archaeological remains • Identify, sample and analyse organic rich sediments (channels, eroded clasts) • Identify palaeolandsurfaces • Monitor quarry faces and waste tips for mammalian remains (including human) and artefacts • Identify archaeological hotspots for intensive monitoring from boreholes and desktop survey • Design and implement dating strategy to provide a chronological framework for deposits	Detailed studies undertaken at Colwick and Hemington (Salisbury *et al.*, 1984; Salisbury, 1992; Cooper *et al.*, 1994, Cooper, 2003). Studies at Langford (Howard *et al.*, 1999b).

Landscape Element	**Prospection Strategy for deposit**	**Best Practice Regional Examples**
Fine-grained alluvium	Deposited probably from the Neolithic onwards. Potential for archaeology to be buried and preserved, invisible to standard techniques of archaeological prospection. • Collate and analyse borehole data for deposits, model subsurface topography • Identify palaeolandsurfaces and areas of higher relief (e.g. gravel islands) • Drill additional boreholes to determine stratigraphy • Collect samples for environmental analysis and dating • Undertake geophysical survey • Undertake speculative trial trenching using results of modelling • Undertake targeted trial trenching from known archaeological sites	Proposed quarry extensions at Rampton (Howard & Knight 2001) Collingham (Knight, 1994)
Aeolian sand	Deposited during the late Pleistocene but reworked periodically throughout the Holocene. Potential for burial and reworking of multi-period archaeological remains. • Identify human activity through remote sensing (aerial photography, satellite imagery) • Undertake field walking, geochemical survey, geophysics and trial trenching	**Tiln reports**
Colluvium	Deposited probably from the Neolithic onwards as a consequence of agriculture. Ptential for burial and reworking of archaeological remains • Identify colluvial deposits • Undertaken trenching from known features or speculative trenching	None
Palaeochannels	Deposited throughout Holocene. Contain organic sediments capable of providing high resolution proxy records of climate and land-use. • Identify through remote sensing analysis (aerial photography, satellite imagery) and borehole survey. • Sample and undertake full environmental analysis (pollen, insects, macroscopic plant remains). Integrate with full radiometric dating programme.	Boles Ings (Brayshay & Dinnin, 1999).
Warp	Deposited during post-medieval times. Potential for cultural and environmental remains to be buried beneath warp. • Identify colluvial deposits • Undertaken trenching from known features or speculative trenching	None

Whilst landform elements are important in providing an assessment of risk, the impacts of a number of other factors, which have not been considered in this report, are important when considering the risk associated with discrete landforms. Any further work focusing on landform risk should take these factors into account since they may affect the level of risk attached to individual landform elements.

6.1. Groundwater Conditions

In recent years, a number of studies have demonstrated the significant impacts that quarrying may have on the local water table, and in turn, on the cultural and environmental archaeological record (French *et al*., 1999; French and Heathcote, 2003). To date, no such large-scale studies have been undertaken in the Trent Valley and therefore although a significant number of organic-rich palaeochannels have been identified within the valley floor from aerial photography and borehole assessment, the quality of preservation within many of these features is unknown. Although a number of channels, such as those at Bole Ings (Brayshay and Dinnin, 1999) and Yoxall (Smith *et al*., 2001) have been studied in detail, they provide only a snap-shot of preservation and few insights into the long-term degradation of these deposits.

6.2. Climate Change

Whilst the identification of landscape elements provides one basis for the assessment of risk, the impact of climate change may alter the degree of risk assigned to particular landform elements through time. For example, greater erosion of floodplains as a consequence of increased flood frequency and magnitude may result in the higher potential for the destruction of palaeochannels; increased aridity may cause more wind erosion of coversands. In addition, management policies associated with climate change may have significant implications for archaeology; for example, the concentration of urban development on river terraces. Clearly, the development of a strategy for assessing archaeological risk with respect to climate change is a priority.

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