Geoarchaeological report from Torksey, Lincolnshire

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Contents

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1. *Introduction*

The identification of the site of the Viking overwintering camp at Torksey, Lincolnshire was made by Mark Blackburn through the use of metal detector finds, many reported to the Portable Antiquities Scheme (Blackburn 2011). This identification has led to the investigation of the site by the Universities of Sheffield and York and the British Museum. One avenue of research being followed by the University of Sheffield is the palaeoenvironment and geoarchaeology of the Viking overwintering camp.

This fieldwork completed in 2012 is the follow up to recommendations made after the 2011 fieldwork (Stein 2013). Overall, the intention of this fieldwork was to understand the early medieval landscape of Torksey through various means of palaeoenvironmental investigation, and to provide the wider Torksey Project with a landscape reconstruction.

The area being examined by the Torksey Project covers an area of approximately 32 ha, centred at SK 483460 380342. It lies within the parishes of Torksey and Brampton. The study area rises up to 16m OD, and is bounded to the west by the River Trent and the Trent Valley, to the south by the village of Torksey, and to the east and north by an area of lowlying peat and silt (4m OD).

2. *Geological and archaeological background*

2.1. *Geology*

Torksey is located on the Permo-Triassic outcrop of the Mercia Mudstone Group, previously known as Keuper Marl (BGS lexicon). These mudstones were lain down as an accumulation of red clays, built up in argillaceous facies; these thin layers built up in a desert-like environment 200-250 MYA. The Keuper Marl of micacous sandstones and bedded mudstones up to 1350m thick covers a vast area of Mercia, stretching southwards, and covering 85 sq. mi. Throughout the bedrock, skerries of silts and fine sands occur, and at the margins of the outcrop, the bedrock is mixed with parts of waterstones of the Colwick formation. Other irregularities throughout the Marl include intercalations of green/grey gley beds. Torksey is also in close proximity with the Rheatic Penarth Group to the east, which is composed of grey marine mudstone strata. (Smith *et al*. 1973; Swinnerton and Kent, 1976; Kent 1980; Knight and Howard 2004; Howard *et al*. 2008)

Superficial deposits at Torksey have been a very important part of the sand and gravel industry of the Trent over the past 100 years. On the border of the Coal Measures, this area around the Trent was initially scoured for coal, however it eventually became a major exporter of sand and gravel minerals. These extracted sediments are primarily related to the glacial terrace deposits in the Trent Valley. The aggregates occur on terrace sequences; the settlement of Torksey is located on a present alluvial plain, however the site in question sits atop an outcrop of Holme-Pierrepont Sand and Gravel. Torksey was also used for the rail line and canal system in order to facilitate the sand and gravel extraction; the train station at Torksey is no longer in use (Cooper 2008).

The British Geological Survey (BGS) map indicates that peat deposits are present to the east of the site, as well as local aeolian deposits (part of the Younger Dryas Lincolnshire Coversands) to the east and south. The BGS map (redrawn in appendix 1, figure 4) displays many of the sediments present in the surrounding areas, but does not map sediments that cover less than 1-2m depth, a significant depth in relation to archaeological deposits. This survey will aim to determine what unrecorded aeolian and peat deposits are directly related to the site.

The British Geological Survey (BGS) map indicates that peat deposits are present to the east of the site, as well as local aeolian deposits to the east and south. The BGS map (redrawn in appendix 1, figure 2) displays many of the sediments present in the surrounding areas, but does not map sediments that cover less than 1-2m depth, a significant depth in relation to archaeological deposits. The 2011 fieldwork also aimed to map the general locations of additional superficial geology that was not mapped by the BGS (Stein 2013). These data were used in order to pinpoint areas of further investigation in 2012.

2.2. *Archaeology*

Despite the rich archaeological deposits in the surrounding area (e.g. Roman *Segelocum* at Littleborough (Notts.), Anglo-Saxon royal estate at Stow, early medieval pottery industry at Torksey), there has been very little archaeological investigation within the study area. The excavations completed by Wessex Archaeology in 1997 as part of the Blyborough pipeline project produced a coring sequence across the site, which showed the depth of deposits up to 2.5m, which gave an indication of what was present that was not mapped on the BGS map. Also in this report was a brief palynological study on the peat deposits was completed, including a bi-zonal pollen diagram showing a clear tree decline (probably related to Neolithic clearing), but this sequence does not have associated radiocarbon dates (Wessex Archaeology 1997, Appendix 3, pg. 4)

Besides this report by Wessex Archaeology, the only major archaeological information relating to the immediate site comes from metal detector finds, the majority of which are dated from the Roman and early medieval periods (Blackburn 2011).

3. Objectives and aims

The main aim of this fieldwork was to assess the types and depths of superficial sediments across the site at Torksey, and characterize them using geoarchaeological techniques.

The main objectives were to:

a) complete an auger survey at pre-specified and targeted locations;
b) gather samples of the different sediment types across the site;
c) assess the character of the peat sediments and core for pollen analysis;

d) map the locations of any drift geology not indicated by BGS mapping;
e) complete a walkover survey to address any visible landscape features;
f) carry out geoarchaeological analyses on any samples gathered.

Laboratory analyses depended on the results of sampling during fieldwork, and were limited to techniques including sediment observation, particle size analysis, loss on ignition, magnetic susceptibility, and calcimetry. Other laboratory analyses that will be used include palynology and radiocarbon dating. While most of these analyses are still in progress, this report aims to present the initial findings and implications of the first phases of fieldwork. The walkover survey also aimed to identify any other landscape features that were not previously recorded in the HER or elsewhere.

4. *Methodology*

Auger survey

The core locations of the auger survey were planned prior to arrival on site, with plans to complete up to 20 cores in an evenly spaced transect across the site. Each of the core sites were located while in the field via GPS, but many were in locations where present conditions would not allow for the best results, including over trackways, in flooded land, or in impenetrable dense clay. Where a core was not possible with the available equipment, the location was moved slightly. Often, changes in sediment conditions were visible on the ground where they were not visible from the available maps, so an opportunistic approach was taken, and a core was extracted in areas that would provide the most valuable and informative data set. This resulted in a total of 43 assessment cores taken across the entire site.

A simple 1 meter gouge auger (3 cm diameter) was used to extract samples for profile and sediment examination. Upon retrieving sediment, the depth of any changes in the profile was noted and described (see appendix 2). A full profile was also drawn in the field. Any observations on the profiles were noted, and photographed if possible. Each type of sediment was sub-sampled; if there was no change in sediment from one core to the next, a sample was not always taken. However, if there were no links between similar sediment types (for example, sand at the north part of the site and sand at the south part of the site, with clear gaps in between), similar sediments were sampled multiple times for comparison.

Laboratory analysis

Laboratory analysis was limited to particle size analysis, loss on ignition (organics), magnetic susceptibility, and calcimetry.

Magnetic susceptibility

Magnetic susceptibility, expressed as X_{LF}, is the measure of magnetic minerals present in a sample. Soils and sediments can become magnetized through natural processes or anthropogenic means (Thompson and Oldfield 1986). The matrix materials tested can also affect magnetic susceptibility; quartz and calcite minerals and organic materials are considered diamagnetic, or non-magnetic, and therefore do not exhibit magnetic characteristics. The samples were dried at low temperatures, then tested using a Bartington MS-2/magnetic susceptibility meter.

Calcimetry

Each sample at Torksey was dried and ground using mortar and pestle to break up aggregates, and tested for $CaCO_3$ (Calcium Carbonate). The calcimeter measured the pressure from CO_2 emitted by the dissolving $CaCO_3$ by mixing HCl 3N and the $CaCO_3$ in the sample ($CaCO_{3(s)} + 2\ HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$).

Organic content

Each sample from Torksey was weighed, dried at 100ºC to remove any moisture, weighed again, ignited at 500ºC for one hour, and weighed one last time. At 500ºC, organic matter is incinerated, but the heat does not break down the clay content (Ball 1964; Stein 1984). The organic content of soils is expressed as a percentage, and calculating it is achieved as per the equation below.

$$\%\ Organics\ (L.O.I.) = 100 \times \frac{dried\ sample - incinerated\ sample}{dried\ sample - crucible\ weight}$$

Measuring organic content in soils can be useful in recognizing topsoil or buried soils, since organics tend to accumulate near the surface. In an alluvial environment, organic content may also indicate changes in rate of sediment accumulation or stability of the environment (English Heritage 2007; Stein 1984).

Particle size analysis

Particle size analysis (PSA) is a measure of grain-size distribution in sediment. A measure of determining the energy of deposition, it can be useful in determining agents of deposition, soil formation processes, and anthropogenic, biological, and erosional effects (Reineck and Singh 1980, 132; Canti 1993, 13). PSA was completed using the Horiba LA-950 at the University of Sheffield, Department of Geography. The Horiba LA-950 Laser Diffraction Particle Size Distribution Analyzer uses light diffraction to measure particle size, assuming that light will bounce off each size at a different angle. Using photodiodes, it then collects the scattered light and analyzes the pattern to provide a precise distribution of the particle sizes (http://www.horiba.com/us/en/scientific/).

Each sample from Torksey was dried, any aggregates were then broken up using sodium hexametaphosphate, and were fed into the LA-950. The results were processed using Microsoft Excel.

The results from each of these analyses can be found in 5.1.1 and appendix 3.

Peat sampling

Peat sampling was completed separately, at a location identified during the gouge auger survey. This sampling was completed by digging a small test pit through the dried, moderately humified peat, and a Russian corer was used to extract and preserve the wet, very humified sediment. This sample was stored in the University of Sheffield, Department of Archaeology cold storage. Subsampling and processing for palynology was completed in 2012, with final results pending. Sampling for radiocarbon dating was also completed in 2012 (results in 5.1.2).

Walkover survey

Walkover survey was completed at the same time as the auger survey. Because much of the site is under plough, there is little chance for earthworks to survive; however there were some areas of preserved earthworks on the alluvial plain. Overall, the walkover survey targeted existing natural features, often those interfering with agricultural practices, such as natural boundaries of peat formations, or existing natural sand dunes.

5. *Fieldwork and initial interpretations*

All field numbers referred to in the fieldwork summary and interpretations below are labeled in Appendix 2.

5.1. *Fieldwork*

5.1.1. Sediment types and core profiles

The site at Torksey includes a number of different types of geological depositions. The earliest, and parent material across much of the site, is the pre-Jurassic Keuper Marl, or Mercia Mudstone. This bedrock underlies the entire site; its most common form is red silty-clay, though it also occurs in a grey silty-clay. Mercia Mudstone is an easily weathered parent material that absorbs moisture into the surface, but does not always allow sufficient drainage. Slaking of this parent material creates a layer of red paste-like clay as a gradual boundary between the mudstone and any overlying deposits (below).

Overlying this earliest deposition across much of the site is the Holme-Pierrepont Sand and Gravel (HPSG) member, one of the last members of the Trent Valley Devensian terrace sequence. This sediment can occur in several forms, indicating various phases in its deposition; the deposit only includes well-sorted clay, fine sand, and cobble sized particles, with very few inclusions sized in between. The spatial distribution of the HSPG deposit is scattered across the site (scattered throughout fields C, D, E, F, G).

The Mercia Mudstone and the HPSG are the geological deposits that have remained *in situ*. Each of these deposits were recorded with some accuracy on BGS maps. The following deposits (aeolian coversand, peat, humic clay, and alluvium) overlie these early geological formations.

Aeolian sands blanket much of the site, lying directly on both Mercia Mudstone and HPSG. This sand is the most frequently occurring sediment across the site, ranging from 50 cm to 4 m in depth. The well-sorted medium to coarse sand remained a consistent colour and texture across the site, and was instantly recognisable by a light orangey-brown colour. These aeolian sediments are likely to be part of the Lincolnshire coversands, and their variation in depth is probably due to the original formation sand dunes. The date of initial deposition of the Lincolnshire coversands is debated. Recent studies of the cover sands at the nearby sites including Girton, Twigmore Woods, and Kelsey suggests a pre-boreal deposition (7-10ka), though this research will argue that redeposition of the cover sands has greatly affected archaeological deposits (Baker and Bateman, forthcoming). While the BGS did not map any aeolian sands within the study area, a sand dune at Bunker's Hill Warren borders the site on the east side. This dune is a rare example of an intact sand dune that has avoided major plough damage, probably due to its use as a rabbit warren (as suggested by the place name). Sediment characterization of the sand on the site matched those as BHW, confirming their aeolian origins.

To the north of the site (field A), bounded by the present river course and present drainage channel, greyish-brown humic clay makes coring nearly impossible. Depth of this clay deposit is over 50 cm, but assessment of the true depth was not achieved using the applied coring techniques. This clay overlies the aeolian sands, although at the boundary between the two deposits, ploughing and natural (water and wind) reworking has created a stratigraphy of alternating deposits. The dense clay may imply a pool with little movement, or possibly even a prior lacustrine environment. With gradual spatial transition to the peat deposits to the east, and no clear boundaries with the alluvial silt to the west, it is difficult to determine the dates that this waterlogged environment was present, though it is possibly related to the 19th-century drainage channel to the north of the site and of the deposit.

The peat deposition is present along the entire stretch of the lowlying eastern border of the site (fields A, M, N), and is even evidenced within the present village of Torksey, on the modern golf course (Johnson 1997, 5). This deposit varies in depth, with the sampled core reaching a depth of 125 cm. This deposit overlies well-sorted grey gleyed sand, which varies only slightly in particle size from the exposed aeolian deposits.

Alluvial silt can be found across the entire present Trent Valley, although the coring programme was limited to the east side of the Trent. Alluvium is often well-sorted organic rich silt, with very few inclusions. Alluvial deposits can range from centimeters to meters in depth (Perry *et al*. 2011). This deposit covers the western edge of the site, (fields A, J, I, H, K, L); depositional timescale can vary greatly.

Soil formation across the site varies dependant upon the underlying deposits. Sand prohibits strong soil formation, as the constant aeolian reactivation and re-deposition prevents the formation of established soils. Where soil formation does have a chance to form, it is a weakly formed Alfisol on sand, with more pronounced horizons on alluvium. Where there is no drift geology overlying the Mercia Mudstone, deep ploughing, often cutting into the underlying geology, obscures any permanent soil formation.

5.1.2. *Peat core sampling*

A peat core was taken at a location where gouge auger coring identified the deepest peat deposit. The purpose of this core was to sub-sample for a radiocarbon date, in order to identify the beginning of peat formation, as well as to check for pollen presence, and complete palynological sequence for the local environment. The sediment profile showed that the top 50 cm was extremely dry, and likely to have been disturbed by earlier ploughing. Previous OS maps confirm that this area was once under plough for a short period of time before being abandoned in favour of woodland development. A plastic shotgun shell was recovered at 45cm depth, confirming the disruption of this sediment. However, the bottom 75cm provided very humified peat, which was sampled, submitted for radiocarbon dating, and subjected to pollen processing and analysis. A profile drawing of the peat sediment can be found in appendix 4.

5.1.3. *Walkover survey*

As the majority of the site is under the plough, there are not many opportunities for the survival of visible archaeology. There is evidence of ridge and furrow in fields J and I (currently under pasture), indicating a lack of recent alluvial deposition or cultivation in this area. There is also evidence of potential earthworks in field J; these form a vague S-shape, with a small mound to the immediate south west. Coring evidence shows this mound is only alluvial silt, however, in conjunction with the ridge and furrow, this may be a post-medieval feature.

In addition to these features in field I, just south of the detectable ridge and furrow, lies another faint earthwork, which, upon closer inspection, appeared to be concealing bricks in a linear formation. This may also be evidence of an unrecorded post-medieval building.

The wooded landscape at the southeast corner of field A may provide preserved archaeological evidence. There is no indication that this area had ever been ploughed; it is recorded as unused wetland on the 1856 OS map, and subsequently was occupied by a residential building. Since the demolition of the building on this land, a small birch scrub has been permitted and encouraged to grow. This area alone has evaded the plough since drainage in the 19th century.

In field B lies the Blyborough/Cottam Pipeline (Wessex Archaeology 1997), which, on a dry day, is a clearly visible linear feature indicated by a change in topsoil colour. Also notable in this field is evidence of the erosion of sand dunes due to agricultural practices; this is evidenced through the difference in height of the hedge row against the present ground surface. The hedgerow rises at least 1 meter above the surrounding surface, demonstrating the ease of movement and erosion of the sand dunes that have no vegetation.

The two structures that were present on the site in the post-medieval/industrial period, Sand House (south west field E) and Pottery Farm (south east field F), are visible in surface sediment changes only. Sand Farm is filled in with pebble sized imported carbonate sediment, and stands out greatly from the local surrounding sandy topsoil. Local residents have indicated that the area of Pottery Farm (Exley 1970) was in-filled with imported sediments in the 20th century, though slight change in top soil composition, as well as a concentration of 19th-century material waste in the south-west corner of the field F indicates that the signature of the building still exists.

Apart from these features, the only visible changes across the fields are probaby natural in formation, including two depressions in field E, which in wet weather become saturated and form large ponds within the field. While this is not a feature that can be attributed to human actions, it is important in considering the palaeolandscape and previous features that would have affected this area.

To the east of the A156 (fields M, N, and fields further the south) lies a peat deposit. A drainage channel runs along to the east of the deposit. According to aerial/satellite photography from the past two decades (Google Earth), as well as evidenced by the sediment profile, the fields containing peat (M, N) were once entirely under the plough. In recent years, agricultural practices have been abandoned in the eastern half of the fields, and birch woodland encouraged to grow. Two artificial ponds are also recent installations, making the most of existing natural depressions.

The most striking feature on this side of the A156 is Bunker's Hill Warren (BHW). The only obvious and preserved sand dune in the area, there is little to no information available about this feature. Rising about 2m above the surrounding agricultural peat and sand deposits, this standing sand dune still fulfills the function indicated by its place name, with established (but unmanaged) rabbit warrens dotting the surface. It is possible that it naturally survived so well because it is sheltered by the Scunthorpe Mudstone formation, which rises quickly to 17m OD immediately to the east. BHW's continual function as a naturally formed rabbit warren may have also led to its preservation and protection from ploughing.

5.2. *Initial interpretations*

This fieldwork fulfilled each of the aims set: the sediments across the site were mapped, and each type of sediment was characterized and sampled for further analysis. Additionally, where there was variability in one core, the profile was subsampled for a vertical characterization of sediments. These results can be found in Appendix 3.

5.2.1 *Sediment analysis results*

<u>Particle size analysis</u>

Particle size analysis (PSA) was used to complete simple characterisation of each of the different sediment types. These results can be found in Appendix 3. In addition, PSA served to compare and contrast different sediments, determining the relationship between the sediments across the site.

PSA was used to match the aeolian sands from BHW with the deposits of sands on the western side of the site. These two particle sizes were nearly identical, which means the sands on the site can be confirmed as an aeolian coversand.

The sand particles underlying the peat deposits were much coarser in size, with the bottom few centimeters of peat being composed of about 25% sand (see LOI). This may be attributed to either a different method of deposition (alluvial?) or a different and stronger aeolian episode, resulting in the deposition of a larger particle size.

Loss on ignition (LOI)

Peat deposits showed variability in inorganic content throughout the vertical profile, with the percentages of sand fraction accounting for up to 28.5% in the sediments closer to the underlying grey gleyed sand.

The organics within the aeolian sands were rare, ranging from 0-1%. The presence of organics was often randomly placed throughout the profile, eliminating the possible presence of palaeosols. The occasional organic presence may be due to deep reaching roots, or even the severe disruption and re-deposition of previous surface sand.

Calcimetry

Calcium carbonate levels across the site ranged from 0% to 0.1%, indicating no carbonates mixed in the sand materials, nor in any of the varying terrace deposits. Despite the prevalence of the practice of importing limestone chips to scatter across the local fields, these fields have no indication of any additive limestone chips, nor any indication that $CaCO^3$ has permeated the site by natural deposition.

Magnetic susceptibility

Magenetic susceptibility provided predictably diagenic readings within the sand deposits. The sand ranged from 0 to 20 X_{lf}, low readings congruent only with organic materials, and possibly representative of poorly formed incipient soils within the sand. There were no indications of anthropogenic alteration of the sediment through burning. Some of the naturally deposited sediments had readings up to 65 X_{lf}, but this is probably due to the natural presence of iron within the HPSG deposits.

5.2.2. *Peat core analysis*

The peat along the west side of the site follows the line of a palaeochannel of the Trent of a tributary. The profile has two major components: moderately- to un-humified peat, which remains very dry, from 0-50 cm, and very humified peat with continuous high moisture content from 50 to 125 cm. At the deepest point, the profile was sampled with a

Russian corer, and processed for pollen at the University of Sheffield, Department of Archaeology. There was abundant pollen found throughout the profile, but with much better preservation in the lower 75cm. A full palynological profile is still in progress.

In addition, the peat was radiocarbon dated at the bottom of the peat profile, which dates to 3010± 30 BP (BETA 317584; see appendix 4) in date. This date not only determines the beginnings of the peat formation, but also the abandonment of this area as a channel, which is possibly due to a major environmental change, such as local or regional vegetation clearance, or climatic fluctuation leading to lower water levels.

6. *Recommendations for 2012*

This fieldwork met all the specified goals, primarily characterising the sediments and providing opportunity for identifying potential methods of reconstructing the area. The identification of previously misidentified and missing data about the aeolian sediment on the site will contribute not only to a geological understanding, but also an archaeological chronology.

For upcoming fieldwork, sampling and coring the aeolian sediments at higher resolution is recommended to understand the extent of the sand deposits. A programme of optically stimulated luminescence (OSL) is recommended to date the deposition and potential redeposition of the sand deposits. Test pits will be excavated through the sand in order to provide OSL sampling sites, as well as to characterize any pedological or archaeological features that occur within the sediment.

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Acknowledgements

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This fieldwork was aided by Hannah Brown (University of Bradford), geophysicist on the Torksey Project, and Dr. Jose Christobal Caravjal Lopez. Permission for land access was provided by land owners Roger Brownlow and Derek Small.

APPENDIX 1
MAPS AND FIGURES

Figure 1. Location of Torksey in Lincolnshire

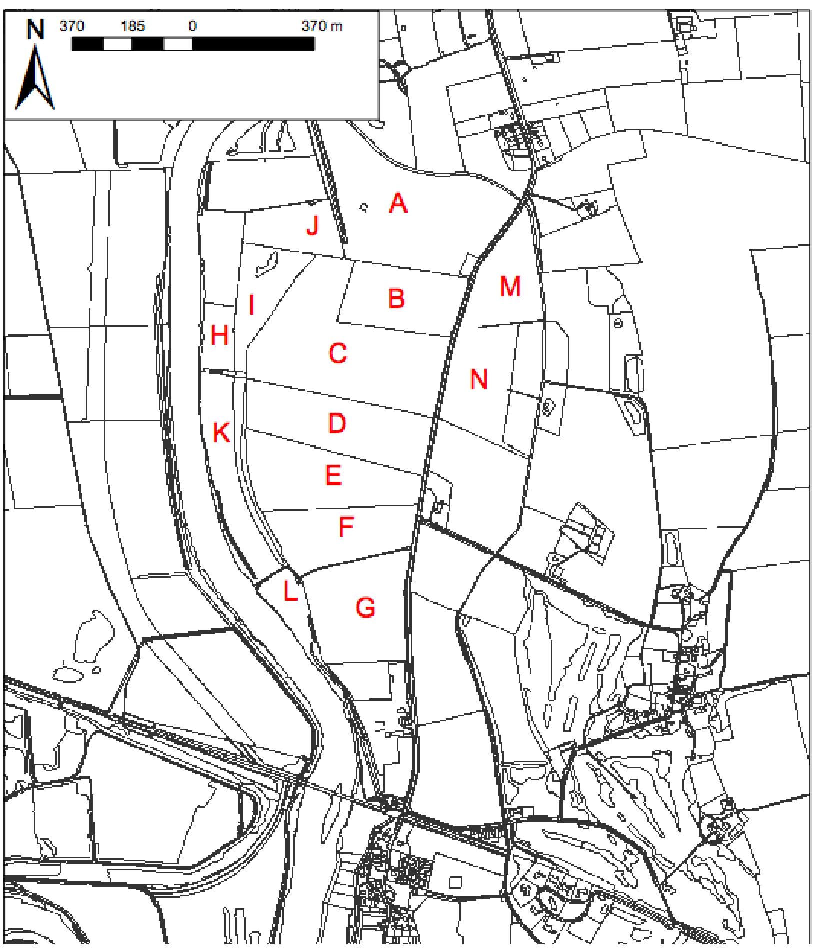

Figure 2: Field numbers referred to throughout the text. Drawn by Hannah Brown. © Crown copyright/database right 2012. An Ordnance Survey/EDINA supplied service

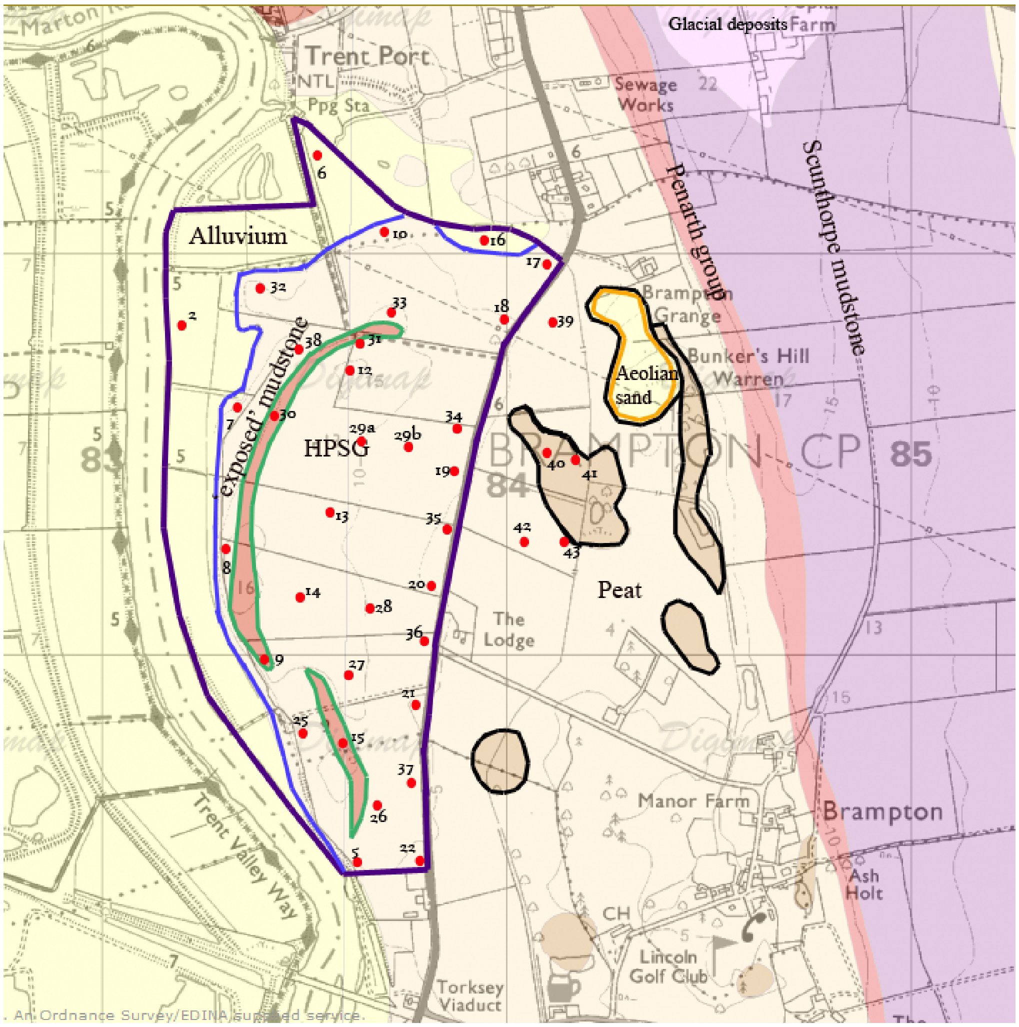

Figure 3: Core locations and numbers in relation to the existing BGS map. Samples were also taken from BHW, labeled as aeolian sand on this first map. © Crown copyright/database right 2012. An Ordnance Survey/EDINA supplied service

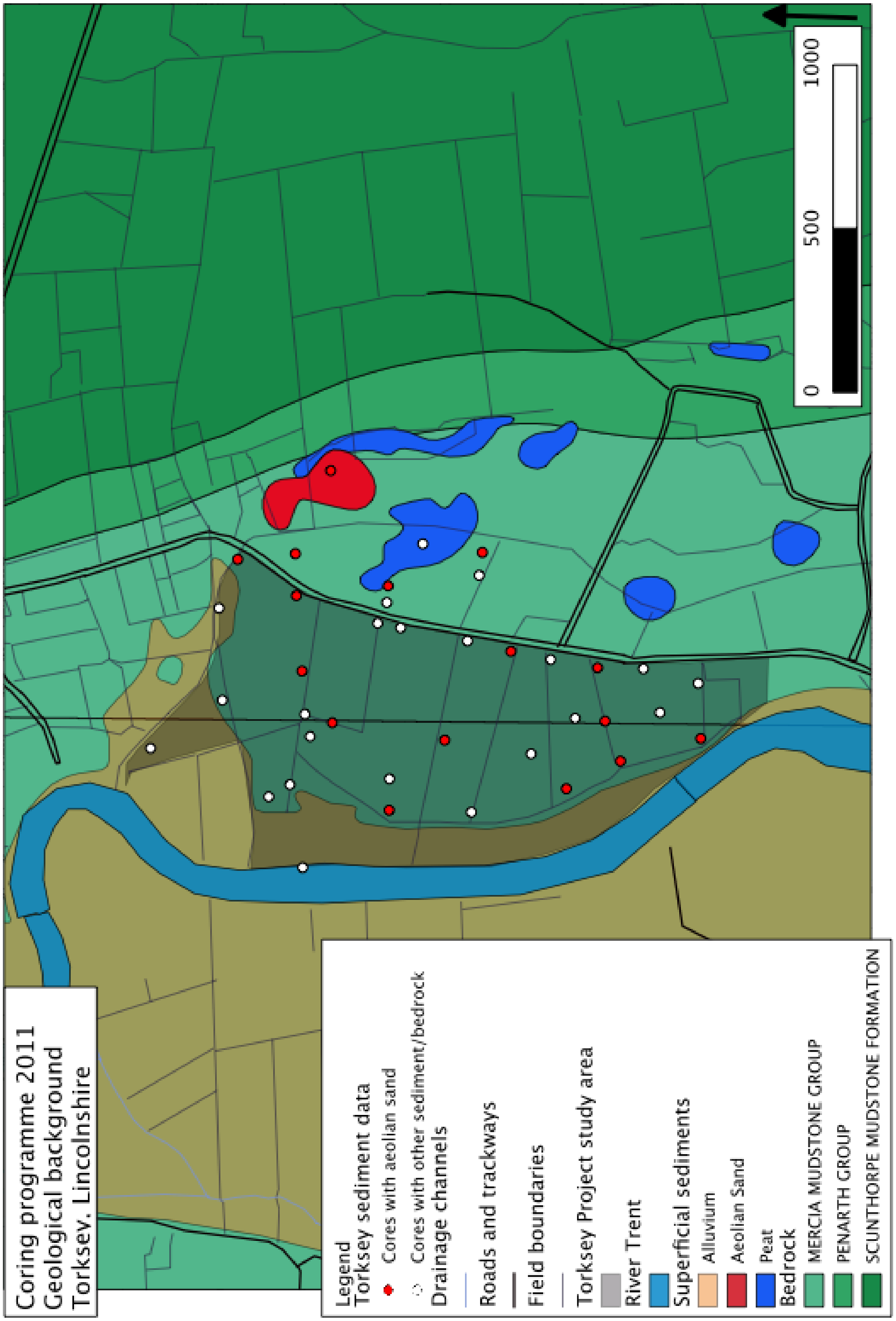

Figure 4: Cores with sand ranging up to a meter depth. With this survey, it has been possible to identify areas with deep sand deposits. Further study will aim to identify the size and depth of these natural features. Map drawn by author.

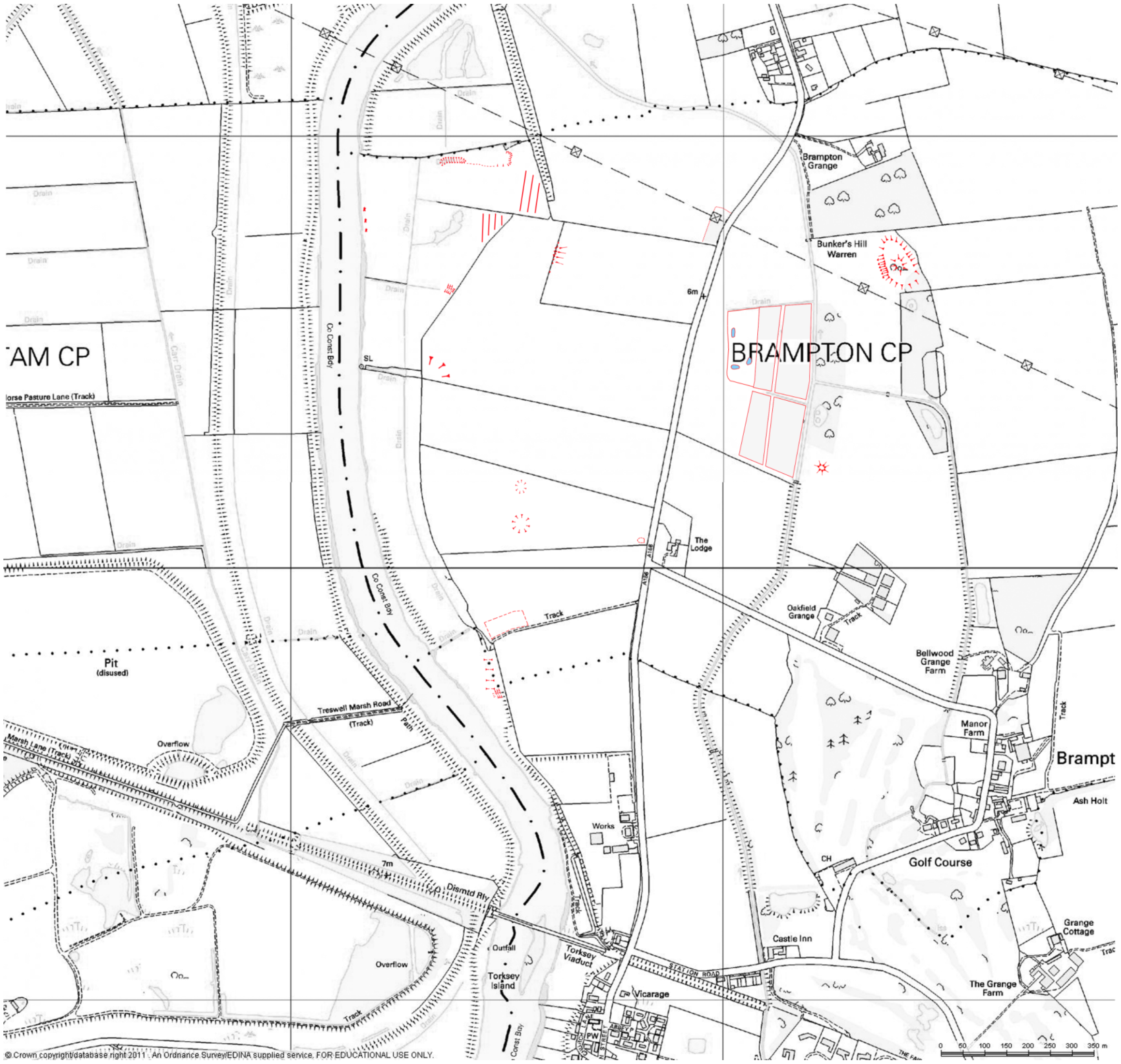

Figure 5: Results of the walkover survey. Red hachures indicate observed landscape features that are not indicated on the present OS map. These features are described in the text. © Crown copyright/database right 2012. An Ordnance Survey/EDINA supplied service

Appendix 2
Descriptions of Sediments
Auger Survey, Oct. 2011

Core 2
83163 80798

No core taken; present floodplain, with exposed section.
Alluvial silt in this location is dark reddish brown with very fine sand fraction. Monic with weakly columnar peds (based on exposed section near river).

Core 5
83557 79578
0-40 cm: Silty sand, dark brown topsoil
    Compacted and cohesive with high silt fraction (40%)
40-100 cm: Medium to coarse quartz aeolian sand: 7.5YR 4/6, no inclusions. (Same description for every aeolian sand deposit, unless otherwise stated)

Core 6
83527 81264
0-15 cm: Topsoil
    Sandy silt
15-20 cm: Compacted topsoil
20-30 cm: Compact alluvial silty clay, no inclusions. Greyish brown.

Core 7
83338 80533
1-37 cm: Silty sand topsoil 10YR 3/4
    50% sand (medium), 50% very fine sand-silt
37-43 cm: Coarser aeolian sand, decreasing silt
43-80 cm: Aeolian sand, no inclusions
80 cm: Gradual boundary to:
80-95 cm: Red (Mercia Mudstone) sandy clay, 5YR 4/4

Cores 8a and 8b
8a
83306 80271
On present trackway
0-5 cm: O horizon
5-40 cm: A horizon, brown silty sand
    Very compact
    10YR 3/4
    Medium quartz sand
40 cm: Sand is lighter, 5YR 3/4, gradual boundary
40-58 cm: Reddish clayey sand (similar to [core 7], though with more sand)
8b
Further from cliff, nearer to hedge
83332 80281
0-15 cm: Very loose sand (<10% sand)
    10YR 4/3

15-27 cm: As above, 7.5YR 4/6
27-41 cm: Reddish clayey sand (as at [7] and [8a])

Core 9
83399 79970
0-15 cm: Silty sand topsoil, with higher silt content than previous coring sites. 7.5 3/4
15-30 cm: Remains of abattoir waste injection- chemical layer with burnt plant material
30-52 cm: Reddish sandy clay (as in [7 and 8]), though with higher clay content
 Gradually decreasing clay content into sand
52-95 cm: Clay and silt disappear into aeolian sands

Core 10
83674 381044
0-15 cm: Topsoil
 Brown silt, 10% sand, <1% pebbles-cobbles
15-18 cm: Compacted topsoil
18-20 cm: Iron pan
20-35 cm: Fe and Mn mottling in clay
35-55 cm: Grey clay with sand and gravel inclusions.
 Munsell: Gley I, 5/N (grey), with Fe mottling.
 50% Clay, 45% Sand, 5% Gravel
 Rounded gravel (pebbles), some broken abraded pebbles (sub-angular)

Core 12
83605 80707
This core begins at the *bottom* of the hedgerow exposure, as to get the deepest profile available. These depths are an additional 70cm below the surface level when the hedges were originally planted.
0-31 cm: Silty sand, <25% silt; 10YR 3/4
31-50 cm: Lighter aeolian sand; light brown silty sand
 <15% silt; 7.5YR 4/6
 Clear boundary
50-58 cm: Clayey reddish sand
 30-40% clay; 5YR 4/4
 Charcoal inclusions
50-62 cm: Same as 31-50 cm
62-86 cm: Clayey reddish sand (same as 50-58 cm), gradually changes to less clay, and with increasing sand
86-100 cm: Light brown fine to medium sand, 7.5YR 4/6 (Same as 31-50cm; 58-62 cm)

Core 13
83552 80363
0-32 cm: Sitly sand topsoil; 10YR 3/4
32-100 cm: Abrupt boundary
 Fine to coarse tan sand, <20% silt; 7.5YR 5/6
 Slightly ligher in colour towards last 10cm

Core 14
83510 80098
0-100 cm: Sand, with slightly silty topsoil, though only up to 40%. At 60cm, becomes aeolian sand

Cores 15a and 15b
15a
83610 79871
0-25 cm: Silty sand topsoil (as [22])
25-35 cm: Well sorted very fine orange brown sand
35-45cm: Mottled red clay, dry very compact, with green gley amongst red clay.

15b
83605 79889
0-40 cm: Silty sand topsoil
Clear boundary
40-80 cm: medium brown fine to coarse sand
Lighter in colour with increasing depth
Large stone inclusion at 78 cm; 7.5 4/6
80-90 cm: Clear boundary to green grey clay

Core 16
83955 81054
0-25 cm: Very sandy top soil (40-50%), with 50% silt
25-43 cm: Aeolian sand.
43-54 cm: Dark brown silty clay
Alluvial deposit

Core 17
84104 80997
0-25 cm: Silty sand topsoil
25-40 cm: Sub-soil with Fe mottling
40 cm: Iron pan
40-68 cm: Aeolian sand
Clean sand, no inclusions, no mottling. Slightly brighter orange than [16]
68-70 cm: Charcoal layer (surface deposit?)
70-74 cm: Aeolian sand, blackened towards the top
Gradual boundary, cleaner with depth
74-75 cm: Aeolian sand, blackened towards the top
Abrupt above boundary, gradual boundary below
75-100 cm: Aeolian sand/ dark brown silt and sand

Both phases about 5 cm with abrupt boundaries to the top and blackened top merging into dark/black silt with 80% quartz sand. Between these layers is a thin film of dense orange clay.

Core 18
83993 80817
0-30 cm: Silty sand topsoil
30% silt with some pebble inclusion (<1%)
30-47 cm: Silty sand, no inclusions
47-81 cm: Abrupt boundary at 47cms to medium brown fine- medium sand
81-100 cm Clayey sand with flecks of charcoal

Core 19

83895 80498
0-35 cm: Topsoil, abattoir waste, as before
35-55 cm: Sand with 30-40% medium to tan brown clay, with occasional pebble inclusions
Gravel (HPSG) at 55 cm

Core 20
83823 80160
0-10 cm: Limestone flecked clay, calcite rich, clearly artificial fill
10-39 cm: Silty sand topsoil, as before (though with lighter moisture with brick inclusions)
Clearly a disturbed area (brick at 24cm)
39-41 cm: Thin band of pure, medium brown sand
41-44 cm: Silty sand *as above*
44-46 cm: Pure sand *as above*
46-62 cm: Silty sand *as above*
62-80 cm: Diffuse boundary to tan/medium brown fine to medium sand, no inclusions
80-100 cm: Tan medium sand mixes at 85 with light tan fine sand with <20% clay content

Core 21
83773 79894
0-30 cm: Silty sand topsoil <30% silt
30-50 cm: Gradual boundary to sand at 50 cm with decreasing brown silt, and increasing tan sand
50-90 cm: Medium brown to light tan sand, medium to fine
90-100 cm: Clear ferrous concretion (secondary?)
Evidence of burning? Darker silt throughout this portion of profile

Core 22
83725 79586
0-40 cm: Silty sand topsoil with moderate, well rounded cobbles and pebbles. Noticeable difference in topsoil from rest of the site, from silty sand (and sandy silt) into silty with moderate rounded pebbles and cobbles. All smaller inclusions are well rounded, and any pottery picked up has been abraded. The sediment has clearly formed in at least two, possibly three phases, from a thick silt, adding rounded pebbles and cobbles, finally adding a very small sand fraction and some angular inclusions (especially post-medieval/industrial pottery).
40-41 cm: Diffuse boundary over 1 cm with bright tan sand
40-65 cm: Reddish sandy clay (25-50% sand)
2.5 YR 4/4
Less sand with increasing depth
Impenetrable from 60-65 due to depleted moisture and/or gravel inclusions
Clay at depth was bright red interspersed with greenish gray gley, pockets of orange sand (coarse as in sandstone, *not* aeolian), and pebbles, gravel from HPSG

Core 25
83488 79824
0-40 cm: Silty sand, dark brown topsoil
Compacted and cohesive with high silt fraction (40%)
40-45 cm: Diffuse boundary to tan sand; 7.5 YR 4/3
45-100 cm: Medium aeolian sand; 7.5YR 5/6

Core 26
83636 79703
0-35 cm: Sandy silt topsoil with few cobbles

Diffuse boundary, few changes, lighter colour, less silt
40-70 cm: Sandy with silt, distinctly not aeolian. Cobbles of HSPG at bottom.

Core 27
0-40 cm: Silty sand topsoil
40-100 cm: Aeolian sand

Core 29
29a
83972 80540
0-33 cm: Sandy silt topsoil
30% sand (different from fields to south); 10YR 2/2
33-39 cm: abattoir waste, with limestone cobble inclusion
39-50 cm: Silt, lighter colour than waste above, but with same consistency and smell
Directly overlying terrace gravels.

29b
83706 80517
0-18cm: sandy silt topsoil
18-43 cm: abattoir waste
43-60cm: Sandy silt (as [29a])
60 cm: Terrace gravels.

Core 30
83434 80532
0-30 cm: Silty sand, with moderate pebble inclusions
Rounded, water-worn pebbles
Lighter colour than [29]
10YR 3/4
30-48 cm: Gradual into lighter coloured sand, less silt
10YR 4/4
48-57 cm: Fine to medium sand
7.5YR 4/6
<10% silt
Abrupt boundary
57-65 cm: Bright white sand, very fine to medium with occasional to moderate pebble inclusions
10YR 7/3

Core 31
83631 80791
0-40 cm: Silty sand topsoil
40-100 cm: Light brown sand
7.5YR 4/6
At 100cm depth is the start of gradual boundary to reddish clayey sand, into a sandy clay, as in [12]

Core 32
83379 80902
Despite location on alluvial plain, and being listed as alluvium, this point is located on a slight rise in the topography, with local evidence of natural and archaeological features, including nearby ridge and furrow.

0-2 cm: O horizon- vegetation and roots
2-30 cm: Alluvial silt and sand
Very compact
30-37 cm: B horizon, hint of increased iron.
37-89 cm: Reddish brown clayey sand- mixture of aeolian sediments with underlying degraded mudstone

Core 33
83763 80800
0-44 cm: Sandy silt topsoil
50% sand 50% silt fine fraction
Dark brown, occasional pebble to cobble sized inclusions
44-70 cm: gradually to medium brown sand with <30% silt
70-100 cm: Tan to medium brown sand, very fine to medium

Core 34
83909 80568
0-35 cm: Sandy loam topsoil
30% sand, 40% silt 30% clay
Artificial/import, not locally derived, with abattoir contamination
35-45 cm: Sandy clay with mudstone and grey clay pellet inclusions
Boundary with inclusions: coarse sand (30%)
Occasional pebbles and gravel
45-51 cm: Mottled red and green clay
Gley 1 6/5GY

Core 35
83855 80293
0-47 cm: Silty sand topsoil
As before in beets, towards bottom, compact, up to 40% silt
Gravel at 47 cm

Core 36
83798 80038
0-45 cm: Silty sand topsoil
(28-30 cm, abattoir waste)
45-57 cm: Merging boundary to reddish tan sand
57-100 cm: Reddish tan sand with silt fraction <30%
Moderately compact
No inclusions

Core 37
83761 79754
0-30 cm: Loamy clay topsoil with pebble inclusions
30-45 cm: Gradual boundary between clayey topsoil and red clay subsoil
Decreasing sand with increasing depth
45-60 cm: Red clay with green gley, as [22]

Core 38
83563 80775
0-25 cm: Silty sand topsoil

25-36 cm: beginning of merging boundary;
at 36 cm, thin facies of dark organic material
36-40 cm: Continued mixture of silty topsoil and sand
40-43 cm: Pure sand, medium grains
7.5 4/4 with sharp above boundary
43-45 cm: Silty sand, as above, with slightly more silt
45-49 cm: Light brown fine sand
10YR 5/4
Frequent pebble inclusions; large gravel
Likely same group as [30]

Core 39
84121 80820
0-15 cm: silty clay topsoil, dark brown, <1% sand
15-30 cm: Silty clay, gradually turning to just reddish brown ferrous clay
30-35 cm: Pure reddish brown/ dark brown clay
Some organic inclusion
Very compact
35-55 cm: Moderately humified, very moist organic clay.
55-85 cm: Bright tan and red ferrous medium sand
<5% silt/fine sand
Moisture held in sand
Silt in sand due to silt and clay illuviation

Core 40- PEAT
*Difficult to assess the validity of the depths of cores 40 and 41, due to numerous voids, the very dry nature of the organic material, and the nature of the instrument. For more accurate peat profile, see peat core extraction, Appendix 4.
0-70 cm: Poorly to moderately humified peat
70-80 cm: Bright white sand, very moist

Core 41- PEAT
0-30 cm: Very dry, crumbly, loose organic material.
30- 80 cm: Compact reddish brown humified peat
80-112 cm: Dark peat, very waterlogged.

Core 42
84055 80257
0-30 cm: sandy silt with minute clay fraction
60% silt, 30% sand <5% clay, 5% other
At 30 cm, silt becomes impenetrable.

Core 43
84125 80247
0-36 cm: Dark organic-rich silt with sand, increasing compaction with depth
36-39 cm: White sand, with silt, both bright, same as previous basal sands
39-63 cm: White sand, with less and less inclusions with depth, very moist

Appendix 3:
Results from Laboratory Techniques

Torksey 2011 Coring Site No.	Unit description	Depth (cm)	LOI (%)	Mag sus (X_{LF})	Mean (M_z)	Sorting (σ_1)	Skewness (SK_1)	Kurtosis (K_G)	Coarse Sand (%)	Medium sand (%)	Fine sand (%)	Silt (%)	Clay (%)
Core 5	Topsoil	0-40											
	Sand	40-100	0.45	4.7	1.89	-0.82	-0.26	1.54	7.4	52.6	34.8	5	0.1
Core 7	Sand	37-80	0.3	2.3	1.51	-1.25	-0.46	3.27	20.3	59.6	11.4	8.1	0.6
	Red marl	80-95	0.99	5.79									
Core 8	Red marl	27-41	1.13	7.8									
Core 9	Topsoil	0-30											
	Red marl	40-52	1.16	8.39									
	Sand	52-64	0.74	4.7	1.93	-1.16	-0.44	2.16	8.8	53	29.5	8.6	0.1
Core 10	Mottled clay	40-50	2.43	5.4									
Core 12	Sand	30-50	0.42	2.34	1.5	-1.24	-0.44	3.19	20.4	59.5	12.1	7.5	0.5
	Sand and charcoal	50-58	0.78	3.33	1.48	-0.95	-0.37	1.7	27.1	51.3	16.1	5.5	0
	Sand	58-62	0.44	1.43	1.48	-0.88	-0.36	1.95	21.9	58.6	14	5.6	0
	Sand and charcoal	62-86	0.44	3.56	1.62	-0.92	-0.38	1.45	21.3	52.9	20.9	4.9	0
	Sand	86-100	0.33	1.84	1.45	-0.84	-0.32	1.99	21.4	60.9	12.5	5	0.1
Core 13	Sand	32-100	0.61	12.31	1.7	-0.95	-0.34	1.96	13.2	57.5	23.4	5.6	0.3
Core 14	Sand	0-100											
Core 15	Marl	35-40	1.49	10.02									
	Sand	40-80	0.58	9.86	1.73	-0.7	-0.21	1.41	10.3	59.6	26	3.7	0.4
	Marl	80-90	2.35	7.94									

Core 16	Sand	25-43	0.66	4.93										
Core 17	Sand	40-68	0.52	3.79	1.58	-0.58	-0.12	1.27	13.1	66.1	18.2	2.6	0
	Sand and charcoal	68-70	19.35	6.1	2.04	-1.53	-0.49	1.82	18.1	44.9	24	12.8	0.3
	Sand	72-80	2.84	3.27	1.52	-0.8	-0.33	1.82	18.3	61.9	15.1	4.8	0
Core 18	Sand	47-81	0.99	2.21	1.69	-0.86	-0.33	1.77	12.9	59.6	21.9	5.5	0.1
	Marl	81-100	1.09	2.06									
Core 20	Sand	80-100	0.8	2.41	1.82	-0.89	-0.33	1.66	10	55.5	28.7	5.6	0.2
Core 21	Sand	30-90	0.48	8.83	1.92	-0.98	-0.38	1.76	5.8	56.8	30.7	6.6	0.1
	Sand with ferrous inclusions	90-100	0.96	7.22									
Core 22	Red Marl	40-65	1.37	6.61	3.23	-2.38	-0.53	0.74	14.6	29.9	24.9	28.4	2.3
Core 25	Sand	45-100	0.47	1.4	1.76	-0.8	-0.27	1.61	10.4	57.8	26.8	4.5	0.5
Core 29	Silty sand (just above HPSG, below abertoire)	39-50	1.34	40.86	2.1	-1.3	-0.47	1.76	9.7	48.3	32.5	10.2	0.3
Core 30	Sand	40-57	0.92	9.06	2.22	-1.42	-0.43	1.73	9.9	40.3	37.7	11.7	0.4
	HPSG sand	57-65	0.2	1.14	2.17	-0.81	-0.02	1.06	7	34.1	55.6	3.2	0
Core 32	Red marl	37-89	1.66	5.5									
Core 33	Sand	70-100	0.11	1.66	1.83	-1	-0.38	2.39	7.4	57.9	28.2	6.3	0.1
Core 34	Grey/green clay	35-51	3.09	14.73	7.23	-2.48	-0.27	1.94	0	2.4	5.4	69.4	22.8
Core 36	Silty sand	57-100	0.29	5.69									
Core 37	Clay	45-60	2	9.1									

Core 38	Sand	45-49	0.48	6.55									
Core 39	Organic silt	35-50	46.51	0									
	Peat	50-55	28.15	3.59									
	Sand	55-70	1.04	0.27									
	Sand	70-85	0.77	0.68	1.83	-1.17	-0.45	2.35	10.7	55.6	25.2	8.1	0.3
Core 40	Peat	0-80											
	Sand	80-100	0.7	0.65	3.14	-2.18	-0.63	0.88	8.1	38.8	24.8	26.5	1.8
Core 41	Peat 0-112												
Core 43	Peat	0-36											
	Sand	36-62	1.28	2.44	2.2	-1.42	-0.49	1.79	8.8	44.5	34.3	12.1	0.3
Bunker's Hill Warren (dune)	Sand		0.92	2.63	1.51	-0.58	-0.12	1.18	17	64.5	16.4	2	0.1

Results from laboratory techniques. Sand highlighted in purple indicates aeolian sand with the same observable characteristics, while those in grey are the gleyed sand from beneath the peat deposits. In the field, both were observed as medium to coarse sand, and it was not clear whether these were members of the same deposit which had undergone different post-depositional processes (well-drained vs. waterlogged).

Initial interpretations of these results can be found in section 5.

Appendix 4
Peat Sampling and Radiocarbon Dating

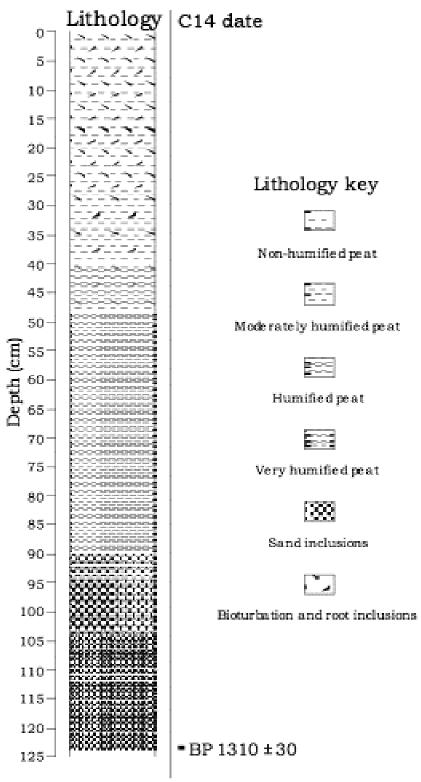

Figure 1. Lithology as identified through gouge auger survey and Russian corer sample. The photograph represents only the first 50cm of the profile, which was too dry to sample with a corer. This may be due to the recent ploughing of this area before it was allocated for woodland development.

Beta	Material pretreatment	Measured age	13c/12c	Conventional Age	2 σ calibration
317584	Acid washes	3090 +/- 30 BP	-29.6 o/oo	3010±30BP	Cal BC 1380 to 1340 (Cal BP 3330 to 3280)/ Cal BC 1320 to 1190 (Cal BP 3270 to 3140)/ Cal BC 1180 to 1160 (Cal BP o 3110)/ Cal BC 1140 to 1130 (Cal BP 3090 to 3080)

Figure 2: BETA Analytic results from radiocarbon dating. Sample was taken at 123cm of the above core. This date represents the date at which this area began to form a wetland environment.

APPENDIX 5
PLATES

Plate 1: Bunker's Hill Warren from the eastern edge of field A

Plate 2: Profile through peat on western edge of site. Humified peat overlying gleyed sand.

Plate 3: Ridge and furrow in field 9

Plate 4: Alluvium build-up (and erosion) on top of aeolian sands. Plastic trapped under the eroding alluvium gives a dating approximation. (scale=1m [red=50cm])


Plate 5: Erosion of sand dune (field B) from ploughing and wind erosion.