Lincolnshire Lakes, Scunthorpe: Geoarchaeological Assessment

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Abstract

This report presents the results of fieldwork across the Site of Lincolnshire Lakes, Scunthorpe, a proposed mixed development of housing and other infrastructure, including artificial lakes.

A mixture of test-pitting and windowless sample borehole survey demonstrated that the majority of the Site was dominated by aeolian sand deposits mapped regionally by the BGS as the Sutton Sand Formation. This contrasts with the mapping of the BGS which suggested that the Site was dominated by warp deposits, the latter reflecting tidal sedimentation manipulated by human activity using drains and sluices to improve the fertility of the low-lying floodplain landscape.

The Sutton Sand Formation was initially depoSited towards the end of the last glaciation, but these sediments have been reworked during multiple phases of the current postglacial (the Holocene), in response to a combination of natural climate change and anthropogenic activity, particularly associated with agricultural activity. This reworking of the aeolian sands has the potential to bury and mask earlier archaeological remains, though none have been recorded within the Site to date.

Buried and interbedded within the sands, particularly within the upper 2m, though sometimes deeper, are organic-rich peat deposits, which radiocarbon dating has shown to span from the Mesolithic to the Iron Age. These peats do not form a continuous, single unit of sediment; rather, they form discontinuous deposits with broad altitudinal variation. Pollen preservation is generally good and indicates that the majority of sedimentation occurred within an alder carr environment; whilst insect preservation was generally poor, demonstrating slow moving and stagnant waters.

Whilst not on the scale mapped by the BGS, warp deposits are present within the Site, their distribution intimately associated with a series of artificial drains, the largest of which is known as Earl Beauchamp's Drain. As with the aeolian sands, there is the potential for warp deposits to bury earlier archaeological remains, though again none have been found within the Site to date.

The geotechnical information has been used to create a series of deposit models showing the upper surfaces of the key lithostratigraphic units (peat, warp). When augmented by Lidar data, these models allow the 3-dimensional evolution of the landscape to be reconstructed, in turn providing a secure basis for geoprospection across the Site and development of a robust mitigation strategy.

1 INTRODUCTION

1.1 Site background

1.1.1 York Archaeology (YA) were commissioned by BWB Consulting on behalf of Hargreaves Land Ltd to undertake geoarchaeological monitoring and assessment alongside geotechnical investigations (GI) at the prospective development Site of Lincolnshire Lakes, Scunthorpe (NGR SE 86699 09528; Figure 1). In total, the GI works were undertaken across an area of nearly 115 ha.

1.1.2 The proposed development Site is extensive and will comprise the construction of six villages totalling around six thousand homes adjacent to the river Trent. Alongside the homes, recreation facilities, hospitality and commercial buildings will be created in addition to artificial lakes.

1.1.3 This investigation followed the geoarchaeological methodology established within the archaeological Written Scheme of Investigation (WSI) that was produced for the project (YA 2023b).

1.2 Geology and Topography

1.2.1 The Site is located at the western edge of the town of Scunthorpe, centred approximately at NGR SE 86699 09528 (Figure 1). It is situated at the eastern margin of the Trent floodplain and west of the Scunthorpe escarpment. At the time of investigations, the Site comprised uncultivated agricultural fields overgrown by plants typical of waste/disturbed ground.

1.2.2 The M181 motorway forms the western boundary of the Site whilst extant field margins form the southern boundary. The south-eastern boundary of the Site is formed by woodland and residential housing with the north-eastern portion of the boundary being Scotter Road. The northern boundary consists of access tracks in addition to field drains/field boundaries. The Site is also bisected by the east-west aligned Brumby Common Lane (Figure 1).

1.2.3 The following geological information has been taken from the WSI (YA, 2023b) and is summarised below:

1.2.4 The underlying geology of the Site as mapped by the British Geological Survey (BGS) is that of the Triassic Mercia Mudstone Group. Of the three open-access BGS boreholes located within the Site boundary, the bedrock is recorded between depths of 14.00 to 15.95m Below Ground Level (BGL) (-11.30 to -13.43m OD; see Tables 1-3 below). The north-eastern margin of the Site at the foot of the Scunthorpe escarpment is mapped as Penarth Group mudstone.

1.2.5 The superficial deposits of the area are likely to be complex comprising warp, Alluvium, Peat and Sutton Sand Formation.

1.2.6 Detailed palaeoenvironmental survey has been carried out in close proximity to the Site to the south of Flixborough, *c*. 5.50km north of the Site; this work, undertaken as part of the Humber Wetlands Survey, encompassed the entirety of the Trent Valley floodplain (Lille, 1998).

1.2.7 Three open-access BGS boreholes are located within the Site boundary (Figures 2 and 3; Tables 1, 2 and 3).

BGS Interpretation	Simplified Description	Depth Top (m BGL)	Depth Base (m BGL)	Thickness (m)	Elevation Top (m OD)	Elevation Base (m OD)
Soil	-	0.00	1.00	1.00	2.52	1.52
Warp	Silt and clay	1.00	1.40	0.40	1.52	1.12
Peat	Peat	1.40	2.50	1.10	1.12	0.02
Blown Sand	Coarse to fine sand,	2.50	6.00	3.50	0.02	-3.48
Glaciofluvial Deposits	Clay and silty sand	6.00	10.00	4.00	-3.48	-7.48
Sand and Gravel	Coarse to fine sand and gravel	10.00	15.95	5.95	-7.48	-13.43
Mercia Mudstone	Mudstone	15.95	/	/	-13.43	/

Table 1: BGS borehole SE80NE26

BGS Interpretation	Simplified Description	Depth Top (m BGL)	Depth Base (m BGL)	Thickness (m)	Elevation Top (m OD)	Elevation Base (m OD)
Topsoil	Black, silty	0.00	0.20	0.20	2.70	2.50
Blown Sand	Fine sand, well rounded	0.20	9.10	8.90	2.50	-6.40
Glaciofluvial Deposits	Silty clay, laminated in parts	9.10	10.90	1.80	-6.40	-8.20
Sand and Gravel	Medium to fine sand	10.90	14.00	3.10	-8.20	-11.30
Mercia Mudstone	Mudstone	14.00	/	/	-11.30	/

Table 2: BGS borehole SE80NE70

BGS Interpretation	Simplified Description	Depth Top (m BGL)	Depth Base (m BGL)	Thickness (m)	Elevation Top (m OD)	Elevation Base (m OD)
Topsoil	Black, silty	0.00	0.50	0.50	3.27	2.77
Blown Sand	Medium and fine sand	0.50	7.30	6.80	2.77	-4.03
Glaciofluvial Deposits	Calcareous silty clay	7.30	8.85	1.55	-4.03	-5.58
Glaciofluvial Deposits	Medium and fine sand	8.85	9.60	0.75	-5.58	-6.33

BGS Interpretation	Simplified Description	Depth Top (m BGL)	Depth Base (m BGL)	Thickness (m)	Elevation Top (m OD)	Elevation Base (m OD)
Glaciofluvial Deposits	Soft brown silty calcareous clay	9.60	10.00	0.40	-6.33	-6.73
Glaciofluvial Deposits	Firm brown silty calcareous clay	10.00	10.35	0.35	-6.73	-7.08
Sand and Gravel	Medium and fine sand with gravel	10.35	15.10	4.75	-7.08	-11.83
Mercia Mudstone	Mudstone	15.10	/	/	-11.83	/

Table 3: BGS borehole SE81SE31/A

1.2.8 The BGS boreholes indicate that a suite of deposits overly the mudstone bedrock. These appear to comprise of a basal sand with some gravel, which may be fluvial or glaciofluvial in origin. These deposits are overlain by a sequence of silts, sands and clays, which have been also been interpreted in the logs as being glaciofluvial. However, within the locale of the Site, very little work has been done to corroborate the origin of these deposits, largely owing to their depth of burial and lack of exposure. The uppermost sediments within the boreholes comprise a mixture of aeolian sands, peats and warp; whilst the first two are natural accumulations, the latter (warp) is an anthropogenic sediment depoSited across such low-lying landscapes in order to improve soil fertility (Lillie, 1997, 1998).

1.3 Planning Background

1.3.1 The following background is taken from the archaeological WSI (YA, 2023b). At present there is no planning reference number as the GI works and geoarchaeological monitoring were undertaken prior to the submission of a planning application.

1.3.2 Developments of this nature, and their impact upon the historic environment, are addressed by the revised 2021 '*National Planning Policy Framework*' (NPPF) published by the Ministry of Housing, Communities and Local Government (MHCLG), and the NPPF Planning Practice Guide '*Conserving and Enhancing the Historic Environment*' (DCLG, 2014).

1.3.3 Section 16 of NPPF, paragraph 192 states:

Local planning authorities should maintain or have access to a historic environment record. This should contain up-to-date evidence about the historic environment in their area and be used to:

a) assess the significance of heritage assets and the contribution they make to their environment; and

b) predict the likelihood that currently unidentified heritage assets, particularly Sites

of historic and archaeological interest, will be discovered in the future.

1.3.4 In addition, paragraph 194, states that:

In determining applications, local planning authorities should require an applicant to describe the significance of any heritage assets affected, including any contribution made by their setting. The level of detail should be proportionate to the assets' importance and no more than is sufficient to understand the potential impact of the proposal on their significance. As a minimum the relevant historic environment record should have been consulted and the heritage assets assessed using appropriate expertise where necessary. Where a Site on which development is proposed includes, or has the potential to include, heritage assets with archaeological interest, local planning authorities should require developers to submit an appropriate desk-based assessment and, where necessary, a field evaluation.

1.3.5 Furthermore, paragraphs 199 and 205 of the NPPF state:

When considering the impact of a proposed development on the significance of a designated heritage asset, great weight should be given to the asset's conservation (and the more important the asset, the greater the weight should be). This is irrespective of whether any potential harm amounts to substantial harm, total loss or less than substantial harm to its significance. Local planning authorities should require developers to record and advance understanding of the significance of any heritage assets to be lost (wholly or in part) in a manner proportionate to their importance and the impact, and to make this evidence (and any archive generated) publicly accessible. However, the ability to record evidence of our past should not be a factor in deciding whether such loss should be permitted.

2 GEOARCHAEOLOGICAL BACKGROUND

2.1.1 The following geoarchaeological and archaeological background has been taken from the WSI (YA, 2023b):

2.1.2 The most extensive deposit mapped by the BGS is the Sutton Sand Formation, sometimes referred to as Blown Sand on earlier maps and adjacent (BGS map) sheets, as well as coversands in other publications. These deposits are principally mapped across the northern, eastern, and southern margins of the Site, representing accumulations of aeolian material against the Scunthorpe escarpment.

2.1.3 Deposits of the Sutton Sand Formation are concentrated in an area between York and Lincoln and were originally depoSited towards the end of the last glaciation during the Last Devensian, although no precise chronology exists with regards to the retreat of the ice front within the Vale of York and wider Humberhead region (Bateman et al. 2015). However, organic sediments underlying the Sutton Sand Formation at Sutton on the Forest, some 60km north-west of the Site, have been dated to 12,879 +/- 168 cal yr BP indicating that the ice sheet front must have retreated to the north of this location by the Late Devensian (Bateman et al. 2015). Locally, west of Scunthorpe, borehole data have shown that the aeolian sands range from 1.50m to 9.00m in thickness and are likely to have been extensively reworked in the Holocene (McIlwaine and McDonnell, 2006), a conclusion supported by multiple Sites regionally (Baker *et al*., 2013; Bateman *et al*., 2000). Detailed investigations as part of the '*North Lincolnshire Coversands Research Project*' (McIlwaine and McDonnell, 2006) at Willow Holt Quarry, Flixborough, indicate that the 'coversands' have been accumulating and reactivating since *c*.11,000 BP. Such reprofiling of the sands has the potential to bury and seal former land surfaces, which may include multi-period archaeological remains including lithic scatters.

2.1.4 The Sutton Sand Formation deposits are complicated by the presence of peat underlying, interbedded, and overlying the sand accumulations. This has been demonstrated to various degrees from previous investigations as part of recent archaeological / geoarchaeological work in adjacent areas, some of which overlap with the Site boundary (YA 2021, YA 2023a).

2.1.5 The results of the radiocarbon age estimates from investigations undertaken by ASWYAS (Archaeological Service West Yorkshire Archaeological Service) and AOC are provided in Table 4 using information replicated from the initial evaluation and post-excavation assessment reports (AOC 2017a; AOC 2017b; YA 2021).

Core / Trench	Sample	C14 Elevation (m OD)	C14 Sample Depth (m BGL)	Radiocarbon Age (BP)	Calibrated Date (95.4%)
AOC Trench 1	Peat (Humic Acid)	1.41	0.67	4676 ± 33	3624-3367 cal BC
ASWYAS Trench 12	*Maloideae* roundwood	0.97	1.06	3710±30	2201 to 2024 and; 1993 to 1983 cal BC
ASWYAS Trench 12	Peat (Humin Acid)	0.77	1.26-1.30	4040±30	2632 to 2469 and: 2663 to 2651 cal BC
AOC Core 1A2	Macroplant	0.76	1.64	268 ± 27	1521-1798 cal AD
AOC Trench 4	Peat (Humic Acid)	0.71	1.69	1434 ± 33	568-657 cal AD
AOC Core 1A2	Peat (Humic Acid)	0.50	1.90	5785 ± 25	4707-4555 cal BC
AOC Trench 7	Peat (Humic Acid)	0.56	1.60	7515 ± 33	6451-6261 cal BC
AOC Core 1A3	Peat (Humic Acid)	0.30	2.10	6723 ± 28	5707-5568 cal BC
ASWYAS Trench 12	Peat (Humin Acid)	0.27	1.76-1.80	8170±30	7194 to 7065 and; 7317 to 7266 and; 7261 to 7226 cal BC
ASWYAS Trench 12	Peat (Humic Acid)	0.27	1.76-1.80	6700±30	5670 to 5605 and; 5600 to 5556 and; 5708 to 5609 cal BC
AOC Core 1A4	Macroplant	-1.03	3.43	6951 ± 31	5902-5741 cal BC

Table 4: Radiocarbon age estimates from AOC (2017a&b) core 1, trenches 1, 4, and 7, and ASWYAS Trench 12. The dates are displayed in descending order of elevation. Note, no laboratory references numbers were provided in the AOC reports and the sample types, sample depths, and elevations have

been reproduced using the information contained within the reports. All sub-samples from which material was dated derives from peat deposits.

2.1.6 Table 4 outlines radiocarbon age estimates from previous locations within the Site boundary. Those dates highlighted in dark grey are likely to be the result of intrusive elements and are therefore deemed unreliable. The single result from AOC Trench 7 in light grey may also be unreliable given that the radiocarbon age / calibrated date does not correspond with the sample elevations. Once these unreliable dates are excluded, the chronological model for the Site appears fairly simple at this stage, though it requires refining in order to test the reliability of the dating. Despite this, it appears apparent that organic accumulations and deposition in the wider area of the Site is consistent with a broad Mesolithic to Early Bronze Age date. Stratigraphically, it should be noted that all the peat deposits recorded in the AOC trenches and cores were sealed by warp.

2.1.7 No peat was recorded in the test pits previously monitored across the southern half of the Site (Allen Archaeology, 2015a). This is surprising, given the relative proximity of TP 6, excavated to 2.60m BGL and TP8, excavated to 3.00m BGL, to AOC Trench 1 / Core 1 and AOC Trench 7 respectively, given that peat was encountered within the same depth range as these nearby interventions. This may point to very localised peat formation in addition to the possibility that peat could be present within or underlying the Sutton Sand Formation deposits within this area and to the east of it.

2.1.8 Peat was also recorded immediately underlying the topsoil to the north of the Site (YA, 2023a). There is also the presence of an intermediate peat, underlying the Sutton Sand Formation, below approximately 6m of sand. This unit has only been recorded in GI logs and was not observed or recovered as part of the current geoarchaeological works. This much deeper unit of peat remains undated and therefore the recovery of such material during the monitoring of the GI is seen as a priority; whilst the construction of housing and other infrastructure is unlikely physically impact such deposits, the creation of artificial lakes may have an impact; furthermore, changing groundwater conditions may impact such deposits. The presence of a shallow, upper peat has also been demonstrated at Keadby (Figure 1), on the left bank of the Trent (YA, 2022) where mid-Mesolithic reworked sands were overlain by Neolithic to Early Bronze Age peat at elevations between 0.28 to 0.67m OD.

2.1.9 The upper sequence of superficial deposits is further complicated by the presence of warp. Warp consists of fine clays and silts, representing a blanketing deposit which was formed within the Lower Trent Valley by deliberate tidal inundation of the low-lying landscape for two principal reasons: (1) to make unproductive peaty and acidic soils workable, and; (2) to reduce the impact of natural seasonal inundations and waterlogging by artificially raising the ground surface level (see Lille, 1997, 1998). This process was largely achieved by the deliberate 'flood-warping' of areas, with material (silts and clays) carried in tidal suspension being allowed to settle and accumulate throughout areas where warping was desirable. The extent of warping is summarised by BGS mapping; '*most of the (Trent) floodplain south of Neap House (to the north-west of the Site) is occupied by flood-warp, which was allowed to run from the levee slopes east towards to the rising blown sand outcrops*' (cf Gaunt 1976, 419, in Lille 1998b). Specifically, the land south of Crosby (the Great Common) to the north of the Site, underwent warping from 1808, with 243 ha of ings, common and moor warped until *c.* 1832 (Lille 1998, 110). A substantial warping drain is located within the north-east half of the Site, continuing to the north / north-west, as well as forming part of the Site's northern boundary (Earl Beauchamp's Warping Drain). Elsewhere within the Lower Trent Valley and Humberhead region, warping deposits have been demonstrated to seal former land surfaces, in addition to smoothing out any subsurface topographic variation (see Lillie, 1997, 1998).

2.1.10 The BGS have mapped warping deposits across the vast majority of the Site (Figure 3) and they were recorded in all the trial pits monitored by Allen Archaeology (2015a) in the southern half of the Site, with the exception of TP6, TP13 and TP14 where Sutton Sand Formation was recorded immediately underlying the topsoil (Figure 2). Warping deposits were recorded as sealing peat or Sutton Sand Formation deposits in all trenches and boreholes undertaken as part of the works by AOC (2017a and 2017b) in the south-west corner of the Site. Warping deposits were also recorded in all the test pits and trenches excavated by ASWYAS within the boundary to the east of the M181 (Figure 2). Approximately 0.40m of warp is also recorded in BGS borehole SE80NE26 but are absent in the two additional boreholes located within the Site boundary (see Tables 1-3). There was a complete absence of warping deposits in a recent evaluation to the north-east of the Site (YA, 2023a), despite the area being mapped as having such deposits.

2.2 Archaeological context

MESOLITHIC (*c.*9500 – *c.*4000 cal BC)

2.2.1 Peat dating from the Later Mesolithic (Table 4) has been recorded in previous investigations within the current Site boundary. This is indicative of a Mesolithic land surface which has been subsequently masked by Post-medieval warp deposits. No Mesolithic findspots are known from within the Site boundary, but this is unsurprising given the blanket of warp covering the majority of the Site. It is possible that further to the east, where warp deposits are less likely to be present, that peat and/or Sutton Sand Formation may be present below topsoil.

NEOLITHIC AND EARLY TO MIDDLE BRONZE AGE (*c.*4000–*c.*1150 cal BC)

2.2.2 Peat accumulations appear to have continued from the Mesolithic into the Neolithic (Table 4). No Neolithic findspots are located within the immediate Site boundary, however chance findspots have been located within 0.50km to the north-east of the Site (HER 1914, 1915). These represent localised and isolated finds and are confined to higher ground where warp accumulations are not present to mask prehistoric land surfaces.

2.2.3 Accumulations of peat have also been demonstrated to continue into the Early Bronze Age within the Site boundary (see Table 4). Additionally, a potential ring ditch (HER 25906) is located at SE 8646 0957 within the Site boundary, to the immediate west of the main warping drain having been identified and interpreted through geophysical survey (Pringle, 2015). There is currently no further evidence to demonstrate the location or extent of Bronze Age settlement within the Site.

EARLY MEDIEVAL (*c.* AD 410–1066)

2.2.4 Brumby derives its name from the Old Norse personal name of 'Bruni' and the Old Norse term 'by', meaning farmstead (Institute for Name-Studies, 2023). The Scandinavian settlement in Lincolnshire took place after over-wintering of the Viking

'Great Army' at Torksey in AD 872 and Repton in AD 873, and their control of Lincoln from AD 876.

HIGH MEDIEVAL (AD 1066–1485)

2.2.5 In the AD 1086 Domesday Survey, Brumby is recorded as 'Brunebi', located in the hundred of Manley, with 14 freemen, 3 men's plough teams and 80 meadow acres to its land and resources (Foster and Longley, 1942, 20).

2.2.6 During the later medieval period the Site formed part of the Brumby Common with the Site record as being 'Heathland' by the North Lincolnshire Historic Landscape Characterisation (HLC) record. This would indicate that the land within the Site was utilized for livestock grazing as opposed to arable uses.

2.2.7 A feature named 'Brumby caucee' was recorded in a Lindsey Court roll in AD 1446 (Peacock, 1889, 101). A 'caucee' or 'causey' was a route "over boggy land, that has been made by raising a bank above the level of the water as it stands in flood time" (Peacock 1889, 100). In that case, Brumby Caucee may have been a name for the part of Frodingham Causeway (HER 25905), which ran within the Manor of Brumby. Should that be the case, the AD 1446 reference would be the earliest documentary evidence for activity within the Site

POST-MEDIEVAL (AD 1485–1750)

2.2.8 An AD 1558 inquisition of Sewers record of 'Brumby causey' states that this feature had "dikes to either side" (quoted in Peacock 1889, 102). This may support the suggestion that Brumby Causeway was Frodingham Causeway, as the part of the causeway identified in the south-western part of the Site during the 2015 geophysical survey has ditches to either side of the raised bank (Allen Archaeology, 2015c, 6-7). Should this be correct, this would indicate that the ditches of Frodingham Causeway remained open in the mid-16th century. The AD 1558 inquisition ordered that the 'dikes' were to be "*sufficiently scowred and cleansed*" (quoted in Peacock 1889, 102). As such, these works may have removed any earlier materials that would have been depoSited within the ditches.

MODERN (AD 1750 TO PRESENT)

2.2.9 As previously discussed, the wider landscape around the Site started to undergo warping in the early 19th century to transform and elevate the previously waterlogged, low-lying landscape for arable agriculture.

2.2.10 Around AD 1863, further warping works were undertaken, with a large, canalised warping drain being constructed along what is now the Site's northern boundary (HER 24682). Part of this large warping drain continues in the north-eastern half of the Site, extending into the southern half of the Site. In addition, there are two further buried probable warping drains in the southern half of the Site (HER 25977 and HER 24683). These works are likely to form part of the wider warping network (Figure 4).

2.2.11 Monitoring of two trial pits (TP9 and TP10) by Allen Archaeology (2015a) observed features interpreted as a continuation of the large warping drain in the southern half of the Site. It was therefore possible that similar features will be encountered during the monitoring of the proposed trial pits across the Site.

3 PROJECT AIMS AND OBJECTIVES

3.1.1 The aims and objectives of the project were established within the archaeological WSI (YA, 2023b):

3.1.2 The aims of the work were to:

- Provide an assessment of the formation processes responsible for the depositional sequences and their development through time.
- Produce a geoarchaeological deposit model of the Site to detail the sequence and distribution of sub-surface deposits across the area;
- Further refine the chronology of peat accumulation across the Site, particularly that associated with the Sutton Sand Formation deposits.
- Assess the potential for primary and secondary archaeological remains to be associated with buried sediment sequences;
- Determine the location, nature, extent, date, condition, state of preservation, significance and complexity of geoarchaeological and palaeoenvironmental sequences;
- Provide information, within the limitations of the investigation, about the palaeoenvironment and the palaeotopography and place the results into the context of the wider landscape; Aid further evaluation and understanding of the archaeological potential within the Site.

3.1.3 The main objectives of the work were as follows:

- To monitor the GI works undertaken at the Site;
- To recover geoarchaeological samples as appropriate, within the confines of GI monitoring;
- To record the lithology of the deposits and create a deposit model of the Site;
- To undertake palaeoenvironmental assessment and range-finder radiocarbon dating on appropriate postglacial (Holocene deposits), should they be recoverable at this stage;
- To produce a deposit model based on the results of the GI monitoring, augmented by integrating the available results of previous work undertaken within and adjacent to the Site.

Research Questions

3.1.4 The aims and objectives described above for this Site have the potential to address the following topics identified within the East Midlands Research Agenda (http://archaeologydataservice.ac.uk/researchframeworks/eastmidlands/wiki/Main):

3.1.5

2 MESOLITHIC (c.9500 - c.4000 cal BC)
2A - Enhance understanding of the environmental background to Mesolithic activity: 'By comparison with some other areas of the country, the Mesolithic environment of the East Midlands is little known… There is a need to obtain more closely dated pollen sequences from upland, riverine and coastal peat deposits and to extend the investigation of ancient environments to include isotope studies of the organic fractions of coastal and riverine sediments.'
2.6.1 What can analyses of cave deposits, palaeochannel fills, upland peats and other deposits with potential for preserved pollen, charcoal and other organic remains contribute to studies of the earliest stages of woodland clearance and plant domestication?
2.6.2 How can we maximise the potential of palaeochannels, upland or coastal peats and other organically rich deposits as sources of data on Early Holocene landscapes and changes in subsistence strategies and diet?
2H - Investigate the transition from the Mesolithic to Neolithic: 'The issue of changing subsistence strategies and the relationship between Mesolithic and Neolithic lifeways can be addressed in part by consistent sampling of organic material preserved in palaeochannels and other waterlogged or wetland contexts spanning the transition period.'
NEOLITHIC AND EARLY TO MIDDLE BRONZE AGE (c.4000–c.1150 cal BC)
3E - Target Sites with Late Mesolithic and Early organic remains: '…significantly more organically rich contexts of this period need to be targeted for environmental analysis and radiocarbon dating to elucidate patterns of landscape change during this key transitional period. Particular attention should be focused upon Sites preserving organic remains that may be threatened by dewatering, while the information gained from Sites under threat from development should be maximised.'
3.2.3 How may environmental sampling strategies assist in elucidating the transition from later Mesolithic to earlier Neolithic economies?
3.7.2 What ceremonial or ritual roles may rivers or other watery locations have performed and how may this have varied regionally and over time?

3.1.6 The *Lincolnshire Coversands Project* recommended a number of key considerations for future work in the area (McIlwaine and McDonell, 1996). These included elucidating the extent, depth and topography of the coversands.

3.1.7 Additionally, recent work in the development of the national *Mesolithic Research and Conservation Framework* highlights the targeting of research on Sites at risk such as wetland Sites where peat is drying out (Blinkhorn and Milner, 2013, 30). Key themes were identified in relation to prospection of Sites:

S2.2: Broader use of fieldwalking, test-pitting and other low-impact techniques is needed, especially within a developer-led context.

S2.4: Novel methodologies to evaluate the locations of Mesolithic activity should be sought and successes in the field appropriately communicated across all sectors. For instance, these might be grounded in geoarchaeological modelling, or the application of borehole, coring and sieving strategies.

4 GEOARCHAEOLOGICAL METHODOLOGY

4.1 Fieldwork Methodology

4.1.1 All works were undertaken in accordance with the WSI as approved by the County Council Planning Archaeologist and to standards defined by CIfA Guidelines for Recording of Archaeological Sites (2019; 2020a; 2020b).

4.1.2 Geotechnical trial pits were located by an engineer from BWB Consulting and excavated using a JCB excavator up to a maximum depth of 3.00m. However, as mentioned in Section 4.2, this depth was rarely achievable. All 56 trial pits were excavated and geoarchaeologically monitored.

4.1.3 Window sample (WS) boreholes were also being undertaken for GI works simultaneously with the trial pits; however, trial pit monitoring took precedence. Where an opportunity arose, the WS boreholes were monitored, which resulted in geoarchaeological monitoring of three additional locations.

4.1.4 The lithology of the geoarchaeologically monitored boreholes was recorded using the sediment classification system of Troels Smith (1955). The scheme breaks down a sediment sample into four main components and allows the inclusion of extra components that are also present, but that are not dominant. Key physical properties of the sediment layers are darkness (Da), stratification (St), elasticity (El), dryness of the sediment (Sicc) and the sharpness of the upper sediment boundary (UB). A summary of the sedimentary and physical properties classified by Troels-Smith (1955) is provided in Appendix 1.

4.1.5 The descriptive logs (Appendix 2) were supplemented by digital photography carried out using a DSLR with a minimum sensor size of 10 megapixels. All photography adhered to Historic England guidance for Digital Image Capture and File Storage (HE 2015b). Graduated metric scales of appropriate lengths were used, ensuring the use of vertical scales used against deep sections in combination with horizontal scales. Digital photographs intended for archive purposes will comply with AAF and ADS guidance (i.e. high quality non-proprietary raw files (DNG) or TIFF images).

4.1.6 The sampling followed procedures set out within the *Historic England Guidelines for Environmental Archaeology* and *Geoarchaeology* (HE 2011 and HE 2015a). Should waterlogged wood be encountered species identification was carried out with reference to Schweingruber (1990) and Schoch (2004). The consideration of preservation within the deposits was made with specific reference to Historic England's guidance document for *Preserving Archaeological Remains* (HE 2016).

4.1.7 A deposit model was constructed using the results of the monitoring, existing British Geological Survey records and other GI works undertaken at the Site. The modelling followed procedures set out within the *Historic England Guidance for Deposit Modelling and Archaeology* (HE 2020). The data was entered into Rockworks in order to generate 3-D solid models, fence diagrams and cross sections. In addition, surfaces were created to aid visualisation using ArcGis incorporating available Lidar data as digital terrain models with multi-directional hillshading and/or local relief modelling used to aid interpretation.

4.1.8 The data is archived in an excel spreadsheet.

4.2 Fieldwork constraints

4.2.1 Due to the sandy composition of the superficial strata, the trial pits were very unstable and frequently collapsed shortly after 2.00m BGL. This frequently prevented trial pit excavation up to the maximum 3.00m depth.

4.2.2 Although attempts to opportunistically monitor window sample boreholes were made, this was frequently not possible due to trial pitting and borehole drilling occurring simultaneously within different areas of the Site.

5 RESULTS

5.1 Lithology

5.1.1 The earliest deposits recorded during trial pit and WS borehole monitoring were fine sands, which occasionally contained a minor medium sand component. These sands were pale grey throughout much of the sequence, though infrequently they became a more yellow or orange colour towards the upper part of the sequence; this colour change may reflect increased oxidation as a result of recent agricultural activity. The fine sand formed the large majority of all recorded sequences and often composed the entirety of the lithological sequence underlying recent topsoil.

5.1.2 Within this fine sand, peat deposits were recorded at varying depths. Peat was recorded within 30 of the 56 interventions. Where recorded within a trial pit, peat was predominantly present as a single unit. However, within BH12 and TP38, two peat units were recorded. In TP38 this lower peat was a moderately humified, relatively sandy peat with frequent woody fragments, and was recorded between 2.20m and 2.60m BGL (0.03m- -0.37m OD). In BH12 the lower peat was moderately humified, though was distinctly more clay-rich than that from TP38 and contained frequent natural wood inclusions and twigs. It demonstrated a very graduated upper boundary with the overlying sand; likely reflecting gradual aeolian deposition encroaching onto the peat. This lower peat within BH12 was located between 2.88m and 3.00m BGL (-0.15- -0.27m OD).

5.1.3 For the remaining trial pits where peat was located, it was present at a relatively wide variety of depths, predominantly either between 0.30m and 0.60m BGL or between 1.00m and 1.50m BGL. In terms of elevation OD this depth varies more significantly between around 1.00m OD and up to 2.50m OD. This peat was predominantly very sandy and humified, though occasionally demonstrated relatively frequent inclusions of natural woody material and twigs. The peat was also quite herbaceous, where it was not overly-humified. This peat was between around 0.20m and 0.40m thick.

5.1.4 Overlying the fine sand and/or peat within 20 of the 56 interventions was greyish-brown silty clay with occasional yellow mottling. The thickness of this deposit varied, however was generally between 0.20m and 0.50m thick. It was recorded at relatively similar depths BGL at around 0.30m to 0.50m BGL, though in terms of OD elevation it varied somewhat more at between 1.60m and 2.20m OD. This deposit was interpreted as pertaining to warping. Within BH14, TP10, and TP42 the warp sediment differed in that it comprised a soft mid-grey silty clay. This was still present at comparable depths, in similar thicknesses and was interpreted as being the result of the same depositional processes, though at a slightly different phase of deposition.

5.1.5 Overlying the warp was either a relatively thin (*c*.0.40m thick) further layer of fine pale grey or yellow sand, in turn overlain by topsoil. This topsoil was composed of silty sand across much of the Site, though in the south-western fields the topsoil was more clay-rich, becoming a sandy clay. Recent agricultural activity throughout the Site had led to extensive intrusion of modern organic material into the underlying sediment; primarily rooting from extant agricultural crops.

5.2 Remote Sensing and Deposit Modelling

5.2.1 A Lidar model for the Site was developed which illustrated the variation in elevation levels throughout the Site (Figure 2). Although the elevation is relatively uniform and essentially flat, the west and south-west parts of the Site are broadly lower (*c*.0.50 m to 1.00m) than the remainder. The Lidar also identifies a slight topographic depression in the north-east of the Site in the vicinity of TP29 to TP33 (Figure 2).

5.2.2 A simple local relief model (SLRM) visualisation of Lidar data was developed for the Site which highlighted a number of warping channels (Figure 4). These channels were focused within the western half of the Site, with a particular concentration being noted within the two south-western fields.

5.2.3 A single, large channel intersects with the Site from the north-west, passing along the line of a modern field boundary towards the south-east, and appears to terminate in the southern portion of the Site. This channel represents Earl Beauchamp's warping drain. Further drains are identified within the south-western quarter of the Site which relate to the HER assets described in Section 2.2.10.

5.2.4 The HER monument of the Frodingham Causeway (MLS 25905) transects the north-western corner of the Site (Sections 2.2.7 and 2.2.8), however no evidence for this causeway was observable on the Lidar models, nor in any of the trial pits or boreholes.

5.2.5 Surface models were developed in QGIS for the peat and warp to illustrate both the location of these deposits and the depth (OD) of their upper boundaries. Figure 6 illustrates the distribution of warp deposits, which are focused within the south-western quarter of the Site, along with a band of warp transecting the centre of the Site on an east-west alignment (from TP06 through to TP13). There is also a discrete accumulation within the north-western part of the Site, focused around BH12, BH14 and TP19.

5.2.6 The model of the peat upper surface demonstrates a much more widespread distribution of peat than the warp, with it being present throughout much of the Site other than within the central-northern portion (Figure 7). The model illustrates the variation in depth (OD) for the peat, where in the south-west it is around 0.50m OD, whereas in the southern and eastern parts of the Site it is as high as 2.00m to 2.50m OD. Relatively isolated deposits were identified within BH12 and TP40; with the latter modelled as being connected to the broader peat deposits. This may be due to an absence of data points between TP40 and TP12. There is a gap in the model in the north-eastern corner of the Site due to an absence of data points.

6 DISCUSSION AND CONCLUSIONS

6.1 Overview of lithological sequence

6.1.1 A large majority of the recorded sequence was composed of fine grey sands, which extended beyond the maximum depths of both boreholes and test pits. These sands were also recorded overlying peat and warp deposits extending upwards to the modern topsoil. These fine sands are interpreted as Sutton Sand Formation deposits, which corroborates BGS mapping across the Site. These sands, which are of aeolian origin, form extensive deposits throughout the Lincolnshire area and have been demonstrated to be up to 9m thick locally.

6.1.2 Overlying fine sands within 30 of the test pits and one of the boreholes was peat. It was recorded at a wide variety of depths, predominantly either between: 0.30m and 0.60m BGL; 1.00m and 1.50m BGL; or around 1.00m OD and up to 2.50m OD. These peats were mostly moderately humified, sand-rich sediments, with no observable botanical macrofossils, except for a small number of interventions where natural woody fragments such as twigs and small branches were recorded.

6.1.3 Within the large majority of interventions, peat was present as a single layer, though within BH12 and TP38 two peat layers were recorded, separated by fine grey aeolian sands. In TP38 this lower peat was a moderately humified, relatively sandy peat with quite common natural woody inclusions; in contrast, the lower peat in BH12 was moderately humified, more clay-rich, and contained frequent natural wood inclusions and twigs. These lower peats were relatively low in elevation at around 0m to -0.40m OD.

6.1.4 Peat was recorded throughout the Site, other than within the central-northern part (Figure 7). There also appears to be a particular concentration within the southern half of the Site; especially within the south-west portion.

6.1.5 Warp was recorded as overlying either the peat deposits (where present) or the grey fine sand within 20 interventions. This warp was predominantly composed of a greyish-brown silty clay with occasional yellow mottling. The thickness of this deposit was predominantly between 0.20m and 0.50m and was recorded at elevations of between 1.60m and -2.20m OD. Within three interventions, the warp was recorded as a soft mid-grey clay. which likely represents the same depositional process (warping) though at a different phase of sedimentation and under a lower energy regime.

6.1.6 Warp deposits were focused within the south-western quarter of the Site, along with a band of warp transecting the central area from TP06 through to TP13 on an east-west alignment. This spatial distribution of warp broadly matches the locations of the warp channels identified by the SLRM Lidar model (Figure 4) in the south-west of the Site. Additionally, the small concentration of warp within the north-west of the Site focused around BH12, BH14, TP19, and TP42 is adjacent to and within the large warp channel identified as Earl Beauchamp's drain.

6.2 Discussion of deposits

6.2.1 The results of this assessment concur with the findings of earlier investigations at the same Site (Allen Archaeology 2015; AOC 2017a; AOC 2017b; Trent and Peak 2021; YA 2023a), with sand-dominated sequences interspersed with peat and warp, notably towards the top of the sequence. These sands represent aeolian deposits of the Sutton Sand Formation (*aka* North Lincolnshire coversands) which are known to be present in significant thicknesses throughout the region spanning an area of around 400km^2 (McIlwaine and McDonnell, 2005). Scunthorpe Edge (*aka* Lincoln Cliff or Lincolnshire Edge) which is at the western edge of the town and around 2km east of the Site, forms a natural barrier to these aeolian deposits, which thin out significantly eastwards of this landform. To the west of the Scunthorpe Edge, where the Site is located, these sands are demonstrated to be up to around 9.00m thick, whereas east of Scunthorpe Edge the sands have a mean depth of 3.70m (James, 1976).

6.2.2 These wind-blown sands were initially depoSited around 11,000 BP based on OSL dating at Willow Holt Quarry, Flixborough (McIlwaine and McDonnell, 2006) or around 12,500 BP (note that these are uncalibrated dates) based on OSL dating at nearby Cove Farm, Westwoodside (Bateman *et al*., 2005). This latter Site contained insect fauna which demonstrated that these aeolian sands initially formed within a cold periglacial environment alongside ice wedge veins exceeding 3.00m in height. Though they were probably once formed as a continuous sheet (McIlwain and McDonnell, 2006), these sands have subsequently undergone repeated and extensive reworking until well into the later Holocene, both as a result of natural climatic fluctuations and anthropogenic impacts. For instance, OSL dating of these sands at Keadby, around 3km to the north-west of the Site yielded dates of the early to mid-Mesolithic period at 5320-3540 cal BC and 7270-5490 cal BC (YA 2022).

6.2.3 These reworked sands have also been demonstrated to overlie archaeological remains, including material of Mesolithic, Neolithic and Bronze Age date (McIlwain and McDonnell, 2006). However, neither this investigation nor any previous investigations at or close to the Site has demonstrated any such remains to be present.

6.2.4 Peat deposits were recorded in the current phase of test pitting within the aeolian sands within 20 interventions (Figure 5). These peat deposits have been encountered within previous investigations (Allen Archaeology 2015a; AOC 2017a; AOC 2017b; Trent and Peak, 2021; YA, 2022) and are known to exist as intermittent, discrete deposits throughout the Site (Trent and Peak, 2021; YA 2023a). This assessment has identified that within most sequences, the peat is present as a single deposit, although within two interventions two discrete peat units were recorded (Section 5.1.2).

6.2.5 Although peat was recorded within many interventions throughout the Site, it is present at variable elevations demonstrating a considerably undulating subsurface topography and is unlikely to represent a single continuous spread throughout the Site. Instead, the peat likely developed as relatively small, localised deposits within depressions in the aeolian sands. Given the spread of radiocarbon dates established for the Site (Table 4; AOC 2017, YA 2022) these small, isolated deposits of peat developed independently over a prolonged period from the Mesolithic through to the Iron Age.

6.2.6 Palaeoenvironmental assessment and radiocarbon dating was undertaken on a column sample of peat recovered from a trial trench during earlier evaluation works (Trent and Peak, 2021), close to TP51 from this assessment (Figure 2). Radiocarbon dating of the peat from this column sample demonstrated an onset of deposition within the later Mesolithic. The exact point for this onset is difficult to determine due to wide variation between dates in this unit likely caused by a mixing of organics, but was likely at some point between around 7300-5500 BC (Table 4). This peat continued to form through the Neolithic and until the early Bronze Age at around 2200-1980 BC (Trent and Peak, 2021).

6.2.7 Pollen preservation and abundance within the peat was good, though diversity was somewhat limited. The pollen assessment suggested an initially very waterlogged, open aquatic setting surrounded by sedges, grasses, birch and willow. This transitions towards alder and hazel, though still within a waterlogged environment; likely an alder carr, which existed for much of the depositional history of the peat unit. Insect remains were poorly preserved and limited in extent, though those present suggested the area was characterised by slow-flowing and stagnant waters (Trent and Peak, 2021).

6.2.8 Modelling of warp deposits suggested that they were broadly focused within the south-western quarter of the Site alongside a band in the north-west of the Site (Figure 6; Sections 5.2.5 and 7.1.6) coinciding with the locations of Lidar SLRM-mapped warping channels (Figure 4). To the south-west a number of channels intersected the area, including Earl Beauchamp's Drain. This latter drain is also the primary source for the warp in the north-west focused around BH 12, BH14, TP19 and TP42 (Figures 4 and 6). Although warp has been mapped by the BGS as encompassing the entire Site, it is less extensive than suggested (as demonstrated in YA, 2023a) and focused within the south west of the Site.

6.2.9 Although warp deposits such as these can cover archaeological remains and significant underlying deposits, no archaeological deposits were encountered within this assessment.

6.3 Potential impact on deposits

6.3.1 The proposed development is planned to be extensive, including significant residential construction, infrastructure development, and the creation of artificial lakes. Although the precise layout of the Site is yet to be determined, impacts on the underlying superficial geology and any associated archaeological remains are likely to encompass the majority (if not entirety) of the Site. Developments that will directly impact the Site are foundation construction, infrastructure development, and piling. However, secondary impacts will likely be created through affecting the sub-surface hydrology of the Site by piling and the remodelling of surface topography as part of flood mitigation strategies and SuDS (Sustainable Drainage System).

6.3.2 Organic deposits (peats) have been demonstrated to be present throughout the Site (Sections 5.1.2 and 5.1.2) and at a range of depths, including relatively close to the surface (within 1.00m BGL, Appendix 2). These deposits are present as intermittent, discrete deposits within the aeolian sands at a variety of elevations and are unlikely to represent a continuous single unit mappable across the Site. Radiocarbon dating undertaken during previous studies has demonstrated that these organic remains span at least the Mesolithic into the Iron Age (Table 4). Previous palaeoenvironmental studies have demonstrated that these deposits can provide insights into past vegetation change, climate and potentially land use (Section 7.2.7); given the range of radiocarbon dates these deposits have the potential to provide palaeoenvironmental data over a prolonged time period.

6.3.3 Since the majority of recorded organic deposits were located within the upper 2.00m of the sequence, they will likely be directly impacted by development, either heavily truncated or removed entirely. Whilst the deeper organic deposits, located over 2.00mbgl within BH12 and TP38, are somewhat more insulated from direct impacts, they may be prone to degradation through alterations to the subsurface hydrological regime associated with the development.

6.3.4 The warp and reworked aeolian sands have the potential to overlie deposits of archaeological significance, making them relatively invisible to traditional techniques of archaeological prospection (e.g. fieldwalking, air photography, test pitting). However, no such deposits have been encountered at the Site despite numerous previous archaeological excavations (Allen Archaeology, 2015; AOC, 2017a; AOC, 2017b; Trent and Peak, 2021; YA, 2023a).

6.4 Consideration of research aims

6.4.1 This investigation has worked towards achieving the original aims of the investigation. The formation processes responsible for the deposits recorded on Site were predominantly aeolian sedimentation of fine-grained Sutton Sand Formation deposits, initially depoSited towards the end of the last glaciation but subsequently reworked in response to both climate change and human impact during multiple phases of the postglacial; organic-rich (peaty) sediments are buried and interbedded within these sand deposits reflecting times of sediment stability and climatic amelioration. The remainder of the deposits identified across the Site are silts and clays interpreted as anthropogenic warp, laid down by human influence of tidal inundation processes in order to improve agricultural fertility of these low-lying wetlands.

6.4.2 Surface modelling of warp and peat deposits has provided insights into the spatial distribution of these sediments. The modelling has also demonstrated that peat was present through the majority of the Site and warp deposits were focused predominantly towards the south-western area, albeit with some deposits to the north-west. Additional investigation through Lidar modelling identified that this warp coincides with the presence of infilled artificial channels (drains) which are particularly visible through the SLRM visualisation (Figure 4).

6.4.3 This investigation corroborates the results of previous studies in the area (Allen Archaeology, 2015; AOC, 2017a; AOC, 2017b; Trent and Peak, 2021; YA, 2023a) which identified that organic sediments accumulated as localised deposits across the Site, over a prolonged timeframe (Section 6.2.5).

6.4.4 Although the deposits identified within the Site have the potential to contain and mask archaeological remains, no such remains were encountered, supporting the conclusions of earlier investigations of the Site.

6.5 Conclusions

6.5.1 This assessment has demonstrated an aeolian, sand-dominated stratigraphy which represent deposits of Sutton Sand Formation of BGS mapping. These wind-blown sediments extended beyond the maximum depth reached in any intervention across the Site and frequently formed the entirety of the sub-topsoil sequence. These sediments originally formed within the very late Pleistocene, though were heavily reworked throughout the current postglacial (the Holocene). This conclusion contrasts with BGS mapping, which suggests that warp deposits constitute the majority of the Site.

6.5.2 Within the aeolian sands, deposits of organic-rich sediment were recorded at a variety of heights from 1.00m OD and up to 2.50m OD. This peat was mostly moderately humified and sand-rich, with no observable plant macrofossils, though for a minor number of interventions woody, less humified peat with moderate quantities of woody fragments, twigs, and branches were recorded. Within two interventions (BH12 and TP38), peat was recorded at deeper depths at around 0.00 to -0.40m OD (2mbgl).

6.5.3 Modelling of the organic sediment (peat) demonstrated that it was present throughout the Site other than within the central-northern portion (Figure 07). It appears to be particularly concentrated within the southern half of the Site; especially within the south-west. Warp deposits were focused predominantly towards the south-western portion of the Site which coincided with the presence of infilled channels which included Earl Beauchamp's Drain.

6.5.4 Although the deposits identified within the Site have the potential to contain and overlie archaeological remains, no such remains were encountered. This supports the conclusions drawn by previous investigations at the Site (Allen Archaeology, 2015; AOC, 2017a; AOC, 2017b; Trent and Peak, 2021; YA, 2023a).

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APPENDIX 1 – TROELS-SMITH

Darkness	
nig.4	black
nig.3	
nig.2	
nig.1	
nig.0	white

Degree of Stratification	
strf.4	well stratified
strf.3	
strf.2	
strf.1	
strf.0	no stratification

Degree of Elasticity	
elas.4	very elastic
elas.3	
elas.2	
elas.1	
elas.0	no elasticity

Degree of Dryness	
sicc.4	very dry
sicc.3	
sicc.2	
sicc.1	
sicc.0	water

	Sharpness of Upper Boundary
lim.4	< 0.5mm
lim.3	< 1.0 &> 0.5mm
lim.2	< 2.0 &> 1.0mm
lim.1	< 10.0 &> 2.0mm
lim.0	> 10.0mm

	Sh	Substantia humosa	Humous substance, homogeneous microscopic structure
I Turfa	Tb	T. bryophytica	Mosses +/- humous substance
	Tl	T. lignosa	Stumps, roots, intertwined rootlets, of ligneous plants
	Th	T. herbacea	Roots, intertwined rootlets, rhizomes of herbaceous plants
II Detritus	Dl	D. lignosus	Fragments of ligneous plants >2mm
	Dh	D. herbosus	Fragments of herbaceous plants >2mm
	Dg	D. granosus	Fragments of ligneous and herbaceous plants <2mm >0.1mm
III Limus	Lf	L. ferrugineus	Rust, non-hardened. Particles <0.1mm
IV Argilla	As	A.steatodes	Particles of clay
	Ag	A. granosa	Particles of silt
V Grana	Ga	G. arenosa	Mineral particles 0.6 to 0.2mm
	Gs	G. saburralia	Mineral particles 2.0 to 0.6mm
	Gg(min)	G. glareosa minora	Mineral particles 6.0 to 2.0mm
	Gg(maj)	G. glareosa majora	Mineral particles 20.0 to 6.0mm
	Ptm	Particulaetestaemolloscorum	Fragments of calcareous shells

Physical and sedimentary properties of deposits according to Troels-Smith (1955)

APPENDIX 2 – Borehole and trial pit logs

Borehole Number	Depth (m) upper	Depth (m) lower	Da	St	El	Sicc	UB	Troels-Smith Texture	Description
BH12	0	0.1	3	2				Ga2, Ag2	Mid brown silty sand topsoil
BH12	0.1	0.64	2	4			4	Ga4	Fine, pale yellow sand
BH12	0.64	1.1	3	3			3	As2, Ag2	Dark yellow/brown silty clay
BH12	1.1	1.3	4	2			4	Th2, Dl1, As1	Dark brown moderately humified lignous peat
BH12	1.3	2.88	1	4		4	4	Ga2, Gs2	Very pale grey fine/medium sand
BH12	2.88	3	4	2		1	1	Dl2, Tl1, As1	Dark brown moderately humified, slightly clayey peat. Relatively frequent wood inclusions and twigs. Very graduated upper boundary with fine sand
BH12	3	5	3			4		Ga3, Gs1	Grey fine/medium sand
BH14	0	0.4	3	2				Ga2, Ag2	Mid brown silty sand topsoil
BH14	0.6	1.4	3	4			4	As3, Ag1	Grey silty clay- warp
BH14	1.4	3	2	4		4	4	Ga2, Gs2	Grey fine/medium sand. Distinct deposit of brownish organic content between 2.70-2.80. This organic portion is extremely sandy and organic content is relatively slight.
BH24	0	0.55	3	2				Ga2, Ag2	Mid brown silty sand topsoil
BH24	0.55	4	2	4		4	4	Ga2, Gs2	Yellowish grey fine/medium sand. Becoming pale grey by 1.70m
TP01	0	0.4	3	3				As2, Ga2	Mid brown sandy clay topsoil

TP01	0.4	0.8	3	4			4	As3, Ag1	Grey ish brown silty clay- warp
TP01	0.8	1.3	4	2			4	Th2, Sh1, Ga1	Dark brown herbaceous slightly sandy peat
TP01	1.3	2.8	3	3			4	Ga3, Gs1	Pale grey fine/medium sand
TP02	0	0.2	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP02	0.2	2	3	3			3	Ga2, Ag2	Dark yellow/brown silty fine sand. Mixed with irregular deposits of pale grey fine sand
TP03	0	0.3	3	3				As2, Ga2	Mid brown sandy clay topsoil
TP03	0.3	0.55	3	4			4	As3, Ag1	Greyish brown silty clay- warp
TP03	0.55	0.6	4	2			4	Th2, Sh1, Ga1	Dark brown herbaceous slightly sandy peat
TP03	0.6	2.5	3	3			4	Ga3, Gs1	Pale grey fine/medium sand
TP04	0	0.35	3	3				As2, Ga2	Mid brown sandy clay topsoil
TP04	0.35	0.7	3	4			4	As3, Ag1	Greyish brown silty clay- warp
TP04	0.7	0.95	4	2			4	Th2, Sh1, Ga1	Dark brown herbaceous slightly sandy peat
TP04	0.95	2.8	3	3			4	Ga3, Gs1	Pale grey fine/medium sand
TP05	0	0.4	3	3				As2, Ga2	Mid brown sandy clay topsoil
TP05	0.4	0.9	3	4			4	As3, Ag1	Greyish brown silty clay- warp
TP05	0.9	2.8	3	3			4	Ga3, Gs1	Pale grey fine/medium sand
TP06	0	0.4	3	3				As2, Ga2	Mid brown sandy clay topsoil
TP06	0.4	1.3	3	4			4	As3, Ag1	Greyish brown silty clay- warp

TP06	1.3	1.7	4	2			4	Th2, Sh1, Ga1	Dark brown herbaceous slightly sandy peat. Wooden fragments noted
TP06	1.7	3	3	3			4	Ga3, Gs1	Pale grey fine/medium sand
TP07	0	0.3	3	3				As2, Ga2	Mid brown sandy clay topsoil
TP07	0.3	2	3	3			4	Ga3, Gs1	Pale grey fine/medium sand
TP08	0	0.45	3	3				As2, Ga2	Mid brown sandy clay topsoil
TP08	0.45	0.95	3	4			4	As3, Ag1	Greyish brown silty clay- warp
TP08	0.95	1.25	4	2			4	Th2, Sh1, Ga1	Dark brown herbaceous slightly sandy peat.
TP08	1.25	2.9	3	3			4	Ga3, Gs1	Pale grey fine/medium sand
TP09	0	0.3	3	3				As2, Ga2	Mid brown sandy clay topsoil
TP09	0.3	1	4	2			4	Th2, Sh1, Ga1	Dark brown herbaceous slightly sandy peat
TP09	1	2.9	3	3			4	Ga3, Gs1	Pale grey fine/medium sand
TP10	0	0.3	3	3				As2, Ga2	Mid brown sandy clay topsoil
TP10	0.3	1.4	3	4			4	As3, Ag1	Greyish brown silty clay- warp
TP10	1.4	1.7	3	4			4	As3, Ag1	Grey silty clay- warp
TP10	1.7	2.9	3	3			4	Ga3, Gs1	Pale grey fine/medium sand
TP11	0	0.4	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP11	0.4	0.5	4	2			4	Th2, Sh1, Ga1	Dark brown herbaceous slightly sandy peat
TP11	0.5	2.3	3	3			4	Ga3, Gs1	Pale grey fine/medium sand
TP12	0	0.4	3	2				Ga2, Ag2	Mid brown silty sand topsoil

TP12	0.4	1	3	4			4	As3, Ag1	Greyish brown with mid brown mottling, silty clay- warp
TP12	1	1.4	4	2			4	Th2, Sh1, Ga1	Dark brown herbaceous slightly sandy peat
TP12	1.4	2.8	3	3			4	Ga3, Gs1	Pale grey fine/medium sand
TP13	0	0.3	3	2				As2, Ga2	Mid brown sandy clay topsoil
TP13	0.3	0.8	3	4			4	As3, Ag1	Grey silty clay- warp
TP13	0.8	2.5	3	3			4	Ga3, Gs1	Pale grey fine/medium sand
TP14	0	0.3	3	2				As2, Ga2	Mid brown sandy clay topsoil
TP14	0.3	0.7	3	2				Ag3, Ga1	Brownish-grey sandy silt- warp
TP14	0.7	0.8	4	2			4	Th2, Sh1, Ga1	Dark brown herbaceous slightly sandy peat
TP14	1.4	2	3	3			4	Ga3, Gs1	Pale grey fine/medium sand
TP15	0	0.5	3	2				Ga3, Ag2	Mid brown sandy topsoil
TP15	0.5	2	3	3			4	Ga3, Gs1	Orange fine/medium sand becoming pale grey by 1.4m
TP16	0	0.5	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP16	0.5	2	3	3			4	Ga3, Gs1	Pale grey fine/medium sand
TP17	0	0.35	3	2				Ga2, Ag2	Mid brown silty sand topsoil. Very small amount of brick
TP17	0.35	0.95	3	4			4	As2, Ag2	Mid grey clayey silt. Warp
TP17	0.95	1.05	4	2			4	Th2, Ga2	Dark reddish-brown slightly organic sand
TP17	1.05	2.5	3	3			4	Ga3, Gs1	Pale grey fine/medium sand
TP18	0	0.4	3	2				Ga2, Ag2	Mid brown silty sand topsoil

TP18	0.4	1.5	2	1			4	Ga4	Pale grey-brown sand. Becoming v. pale yellow at 1.10m
TP18	1.5	1.9	3	4			4	As2, Ag2	Mid grey clayey silt. Warp
TP18	1.9	3	3	3			4	Ga3, Gs1	Pale grey fine/medium sand
TP19	0	0.36	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP19	0.36	1.1	2	1			4	Ga4	Pale grey-brown sand
TP19	1.1	1.3	3	4			4	As2, Ag2	Mid grey clayey silt. Warp
TP19	1.3	1.55	4	2			4	Th2, Ga2	Dark reddish-brown slightly organic sand
TP19	1.55	2.8	3	3			4	Ga3, Gs1	Pale grey fine/medium sand
TP20	0	2	3	2				Ga2, Ag2	Mid brown silty sand. Slightly greyer from 1.20m. Difficult to distinguish from topsoil. Ceramic land drain and 0.90m
TP20	2	2.4	3	4			4	As2, Ag2	Mid grey clayey silt. Warp
TP20	2.4	2.9	2	1			4	Ga4	Fine pale grey sand
TP21	0	0.3	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP21	0.3	2.3	2	1			4	Ga4	Fine pale orange sand becoming pale grey by 1.30m
TP22	0	0.3	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP22	0.3	1.3	2	1			4	Ga4	Fine pale orange sand
TP22	1.3	1.4	4	2			4	Th2, Ga2, Sh+	Dark reddish-brown moderately organic sand
TP22	1.4	3	2	1			4	Ga4	Fine pale grey sand
TP23	0	0.48	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP23	0.48	2.5	2	1			4	Ga4	Fine grey-yellow sand becoming white/grey by 0.70m

TP24	0	0.6	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP24	0.6	2	2	1			4	Ga4	Fine white sand becoming orange sand at 0.80m before becoming very pale yellow and grey by 1.00m
TP25	0	0.3	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP25	0.3	2	2	4			4	Ga4	Fine orange sand becoming very pale yellow and grey by 0.80m
TP26	0	0.3	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP26	0.3	0.95	3	4			4	As2, Ag2	Mid grey clayey silt. Warp
TP26	0.95	1.3	4	2			4	Th2, Ga2	Dark brown well humified sandy peat.
TP26	1.3	2.5	1	4			4	Ga4	Fine pale grey sand
TP27	0	0.5	3	2				As2, Ga2	Mid brown sandy clay topsoil
TP27	0.5	1.2	3	4			4	As2, Ag2	Mid grey clayey silt. Warp
TP27	1.2	1.3	4	2			4	Th2, Ga2	Dark brown well humified sandy peat.
TP27	1.3	2.7	1	4			4	Ga4	Fine pale grey sand
TP28	0	0.35	3	3				As2, Ga2	Mid brown sandy clay topsoil
TP28	0.35	0.5	4	2			4	Th2, Sh1, Ga1	Dark brown herbaceous slightly sandy peat
TP28	0.5	2.9	3	3			4	Ga3, Gs1	Pale grey fine/medium sand
TP29	0	0.4	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP29	0.4	0.8	4	2			4	Th2, Ga2	Dark brown well humified sandy peat.
TP29	0.8	2.5	1	4			4	Ga4	Fine pale grey sand
TP30	0	0.5	3	2				Ga2, Ag2	Mid brown silty sand topsoil

TP30	0.5	2.5	3	4			4	Ga4	Bright orange fine-medium sand. Becomes very pale grey sand abruptly at 0.80m
TP31	0	0.25	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP31	0.25	0.6	4	2			4	Th2, Ga2	Dark brown well humified sandy peat. Pieces of wood and branches present
TP31	0.6	2.5	1	4			4	Ga4	Fine pale grey sand
TP32	0	0.3	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP32	0.3	0.4	4	2			4	Th2, Ga2	Dark brown well humified sandy peat.
TP32	0.4	2.5	1	4			4	Ga4	Fine pale grey sand
TP33	0	0.4	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP33	0.4	0.45	4	2			4	Th2, Ga2	Dark brown well humified sandy peat.
TP33	0.45	2.2	1	4			4	Ga4	Fine pale grey sand
TP34	0	0.4	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP34	0.4	2	2	4			4	Ga4	Fine pale grey sand discontinuous becoming mid orange by around 0.90m and steadily returning to pale grey through the sequence
TP35	0	0.8	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP35	0.8	2.2	2	4			4	Ga4	Fine light brown sand
TP36	0	0.3	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP36	0.3	2	2	4			4	Ga4	Fine pale grey sand
TP37	0	0.3	3	2				Ga2, Ag2	Mid brown silty sand topsoil

TP37	0.3	2	2	4			4	Ga4	Fine orange sand gradually turning pale grey from 0.50m
TP38	0	0.3	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP38	0.3	1	2	4			4	Ga4	Fine, pale yellow sand
TP38	1	1.1	4	2			4	Th2, Dl1, As1	Dark brown moderately humified lignous peat
TP38	1.1	2.2	1	4		4	4	Ga2, Gs2	Very pale grey fine/medium sand
TP38	2.2	2.6	4	2		1	1	Dl2, Tl1, As1	Dark brown moderately humified, relatively sandy peat. Quite frequent wood inclusions and twigs
TP38	2.6	3	3			4		Ga3, Gs1	Grey fine/medium sand
TP39	0	0.3	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP39	0.3	2	2	4			4	Ga4	Fine bright orange sand
TP40	0	0.4	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP40	0.4	0.6	4	2			4	Th2, Ga2	Dark brown well humified sandy peat.
TP40	0.6	2.4	1			4		Ga3, Gs1	Pale grey fine/medium sand
TP41	0	0.3	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP41	0.3	1	2	4			4	Ag2, Ga2	Pale brown sandy silt
TP41	1	1.2	4	2			4	Th2, Ga2	Dark brown well humified sandy peat.
TP41	1.2	2.6	1			4		Ga3, Gs1	Very pale grey fine/medium sand
TP42	0	0.3	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP42	0.3	1.4	2	4			4	Ga4	Fine orange sand
TP42	1.4	1.8	3	5			4	As4, Ag+	Soft grey clay. Occasionally darker bands of very slightly organic clay- warp

TP42	1.8	3	1			4		Ga3, Gs1	Very pale grey fine/medium sand
TP43	0	0.6	3	2				Ga2, Ag2	Mid brown-grey silty sand topsoil
TP43	0.6	0.8	4	2			4	Th2, Ga2	Dark brown well humified sandy peat.
TP43	0.8	2	2	4			4	Ga4	Fine pale orange-grey sand becoming pale grey by 1.00m
TP44	0	0.45	3	2				Ga2, Ag2	Mid brown-grey silty sand topsoil
TP44	0.45	2	2	4			4	Ga4	Fine pale orange-grey sand becoming pale grey by 1.00m
TP45	0	0.3	3	2				As3, Ga1	Mid brown-grey sandy clay topsoil
TP45	0.3	1.1	3	3			4	Ag2, As1, Ga1	Brownish grey sandy clayey silt- warp
TP45	1.1	1.9	4	2			4	Th2, Dl2	Dark brown-black herbaceous and woody peat. Large inclusions of woody detritus including large twigs, branches, and bark.
TP45	1.9	3	2	4			4	Ga4	Fine pale orange-grey sand becoming pale grey by 1.00m
TP46	0	0.35	3	2				As3, Ga1	Mid brown-grey sandy clay topsoil
TP46	0.35	0.8	3	3			4	Ag2, As1, Ga1	Brownish grey sandy clayey silt- warp
TP46	0.8	2.6	2	4			4	Ga4	Fine pale orange-grey sand becoming pale grey by 0.60m
TP47	0	0.35	3	2				Ga2, Ag2	Mid brown-grey silty sand topsoil
TP47	0.35	1.05	2	4			4	Ga4	Fine pale orange-grey sand
TP47	1.05	1.15	4	2			4	Th2, Ga2	Dark brown well humified sandy peat.
TP47	1.15	2.6	3			4		Ga3, Gs1	Light brown fine/medium sand.

									Becomes grey at 1.80m
TP48	0	0.4	3	2				As3, Ga1	Mid brown-grey sandy clay topsoil
TP48	0.4	0.5	4	2			4	Th2, Dl1, As1	Dark brown moderately humified lignous peat
TP48	0.5	2	3			4		Ga3, Gs1	Light brown fine/medium sand. Becomes grey at 1.80m
TP49	0	0.4	3	2				Ga2, Ag2	Mid brown-grey silty sand topsoil
TP49	0.4	0.8	2	4			4	Ga4	Fine pale orange-grey sand
TP49	0.8	0.9	4	2			4	Th2, Ga2	Dark brown well humified sandy peat.
TP49	0.9	3.1	3			4		Ga3, Gs1	Light brown fine/medium sand. Becomes grey at 1.80m
TP50	0	0.55	3	2				Ga2, Ag2	Mid brown silty sand topsoil
TP50	0.55	1.34	2	4			4	Ga4	Fine, pale yellow sand
TP50	1.34	1.5	3	3			3	Ga2, Ag2	Dark yellow/brown silty fine sand
TP50	1.5	1.9	4	2			4	Th2, Dl1, As1	Dark brown moderately humified lignous peat
TP50	1.9	2.8	3			4		Ga3, Gs1	Grey fine/medium sand
TP51	0	0.24	3	2				Ga2, Ag2	Mid brown-grey silty sand topsoil
TP51	0.24	1.34	2	4			4	Ga3, Ag1	Fine pale yellow-grey silty sand
TP51	1.34	1.9	4	2			4	Th2, Dl1, As1, Ga+	Dark brown well humified lignous peat. Relatively firm and sandy/silty
TP51	1.9	3	3			4		Ga3, Gs1	Greyish yellow fine/medium sand. Becoming greyer through unit and fully mid-grey by 2.20m

TP52	0	0.4	3	2				Ga2, As2	Mid brown-grey clay sand topsoil
TP52	0.4	1	2	4			4	Ga4	Fine pale orange-grey sand
TP52	1	1.05	4	2			4	Th2, Ga2	Dark brown well humified sandy peat.
TP52	1.05	3	3			4		Ga3, Gs1	Light brown fine/medium sand. Becomes grey at 1.80m
TP53	0	0.55	3	2				As3, Ga1	Mid brown-grey sandy clay topsoil
TP53	0.55	0.9	4	2			4	Th2, Ga2	Dark brown well humified sandy peat.
TP53	0.9	2.2	3			4		Ga3, Gs1	Grey fine/medium sand
TP54	0	0.45	3	2				As3, Ga1	Mid brown-grey sandy clay topsoil
TP54	0.45	0.55	4	2			4	Th2, Ga2	Dark brown well humified sandy peat.
TP54	0.55	2.2	3			4		Ga3, Gs1	Grey fine/medium sand
TP55	0	0.4	3	2				As3, Ga1	Mid brown-grey sandy clay topsoil
TP55	0.4	2	3			4		Ga3, Gs1	Grey fine/medium sand
TP56	0	0.4	3	2				As3, Ga1	Mid brown-grey sandy clay topsoil
TP56	0.4	2.2	3			4		Ga3, Gs1	Grey fine/medium sand

APPENDIX 3 – Selected photographs

APPENDIX 4-OASIS FORM

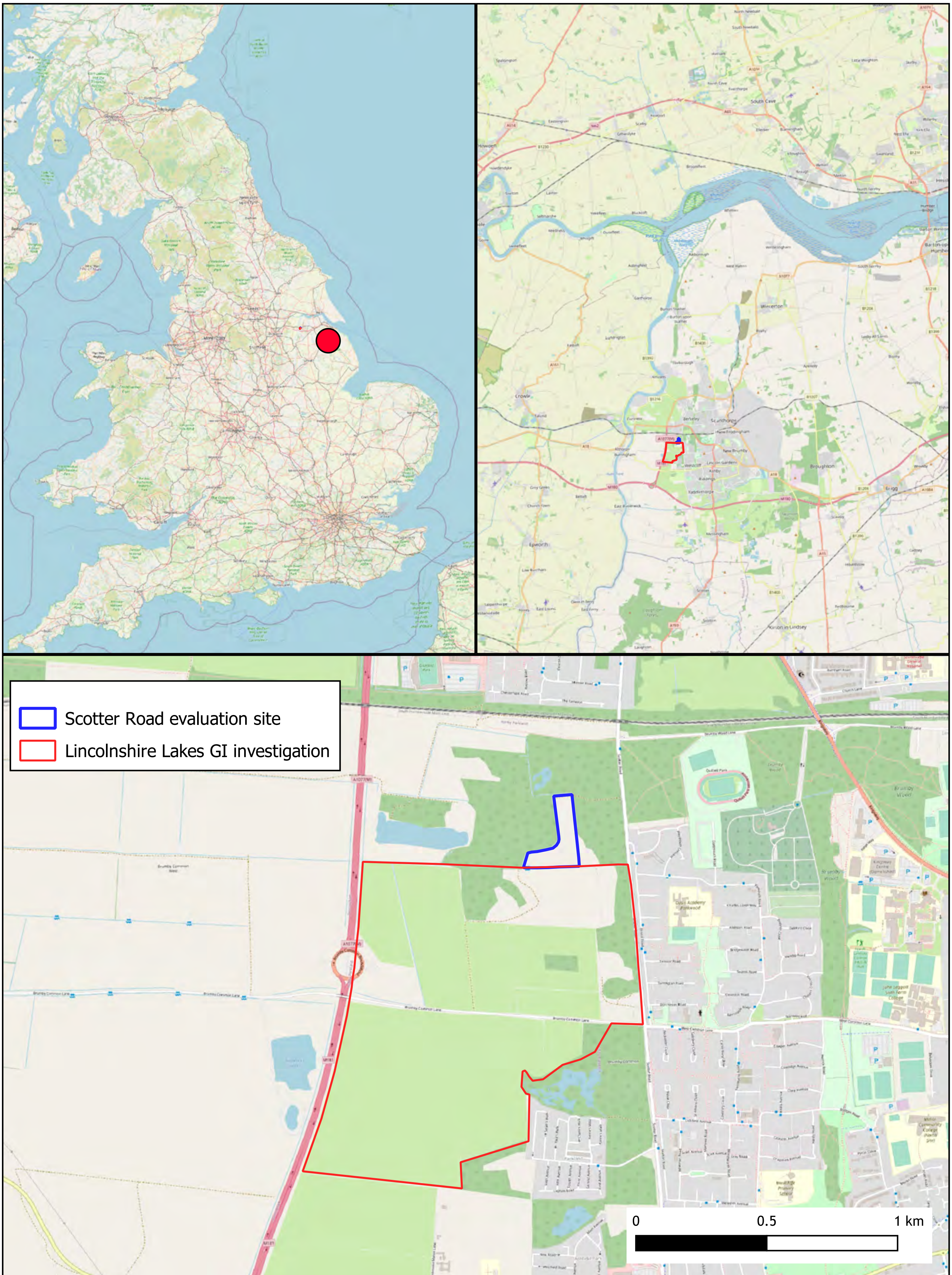

Figure 01 - Site Location

Lincolnshire Lakes Geoarchaeological Assessment

Scale at A4 - Varies

Drawn by: LP

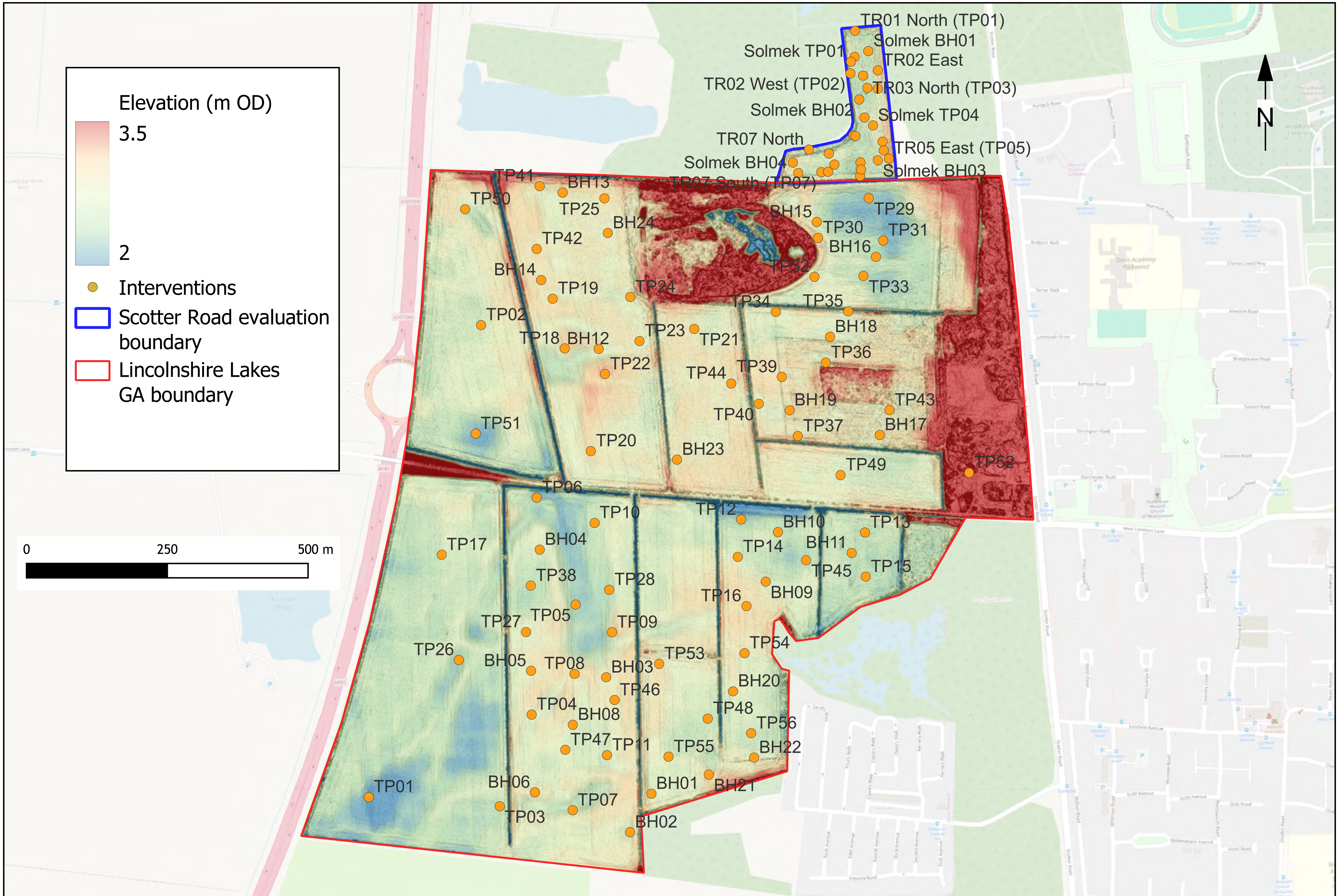

Figure 2. Intervention locations

Lincolnshire Lakes Geoarchaeological Assessment

Scale at A4 - 1:8500

Drawn by: LP

Figure 03- Scotter Road evaluation intervention locations

Lincolnshire Lakes Geoarchaeological Assessment

Scale at A4 - 1:1700

Drawn by: LP

Figure 04 - LiDAR SLRM with warp channels

Lincolnshire Lakes Geoarchaeological Assessment

Scale at A4 - 1:7500

Drawn by: LP

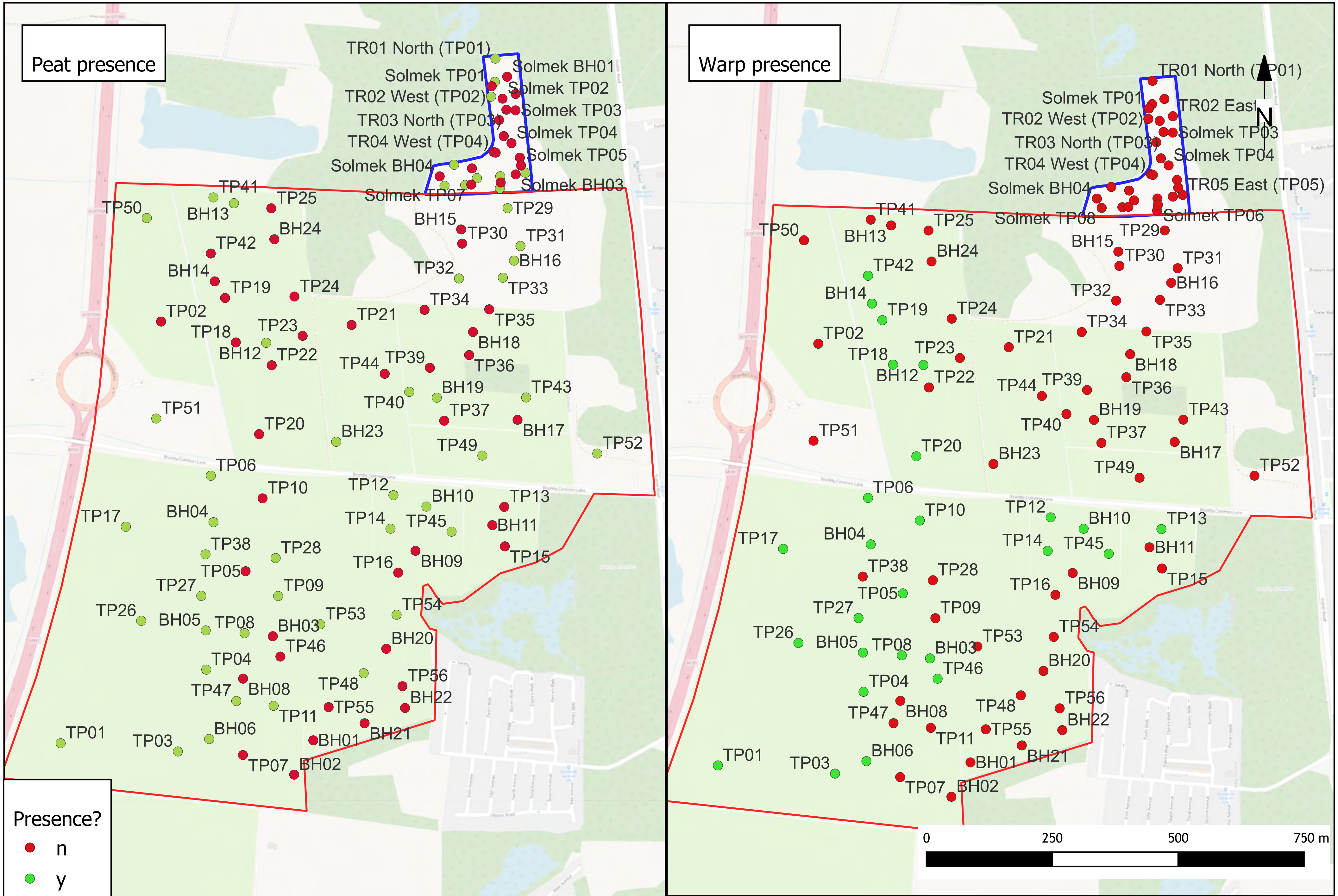

Figure 06. Peat/warp presence/absence

Lincolnshire Lakes Geoarchaeological Assessment

Scale at A4 - 1:9500

Drawn by: LP

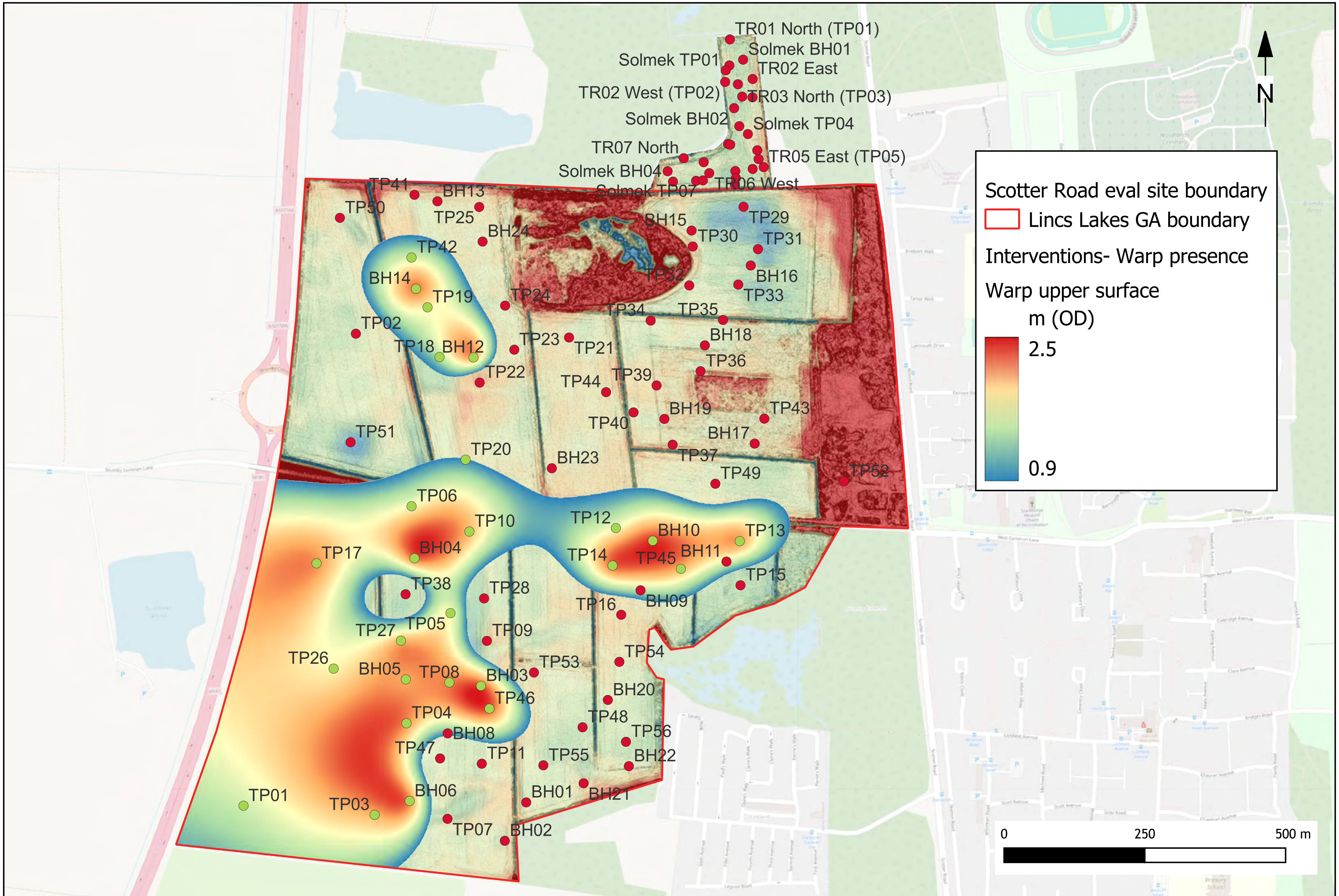

Figure 06 - Modeled warp upper surface

Lincolnshire Lakes Geoarchaeological Assessment

Scale at A4 - 1:8500

Drawn by: LP

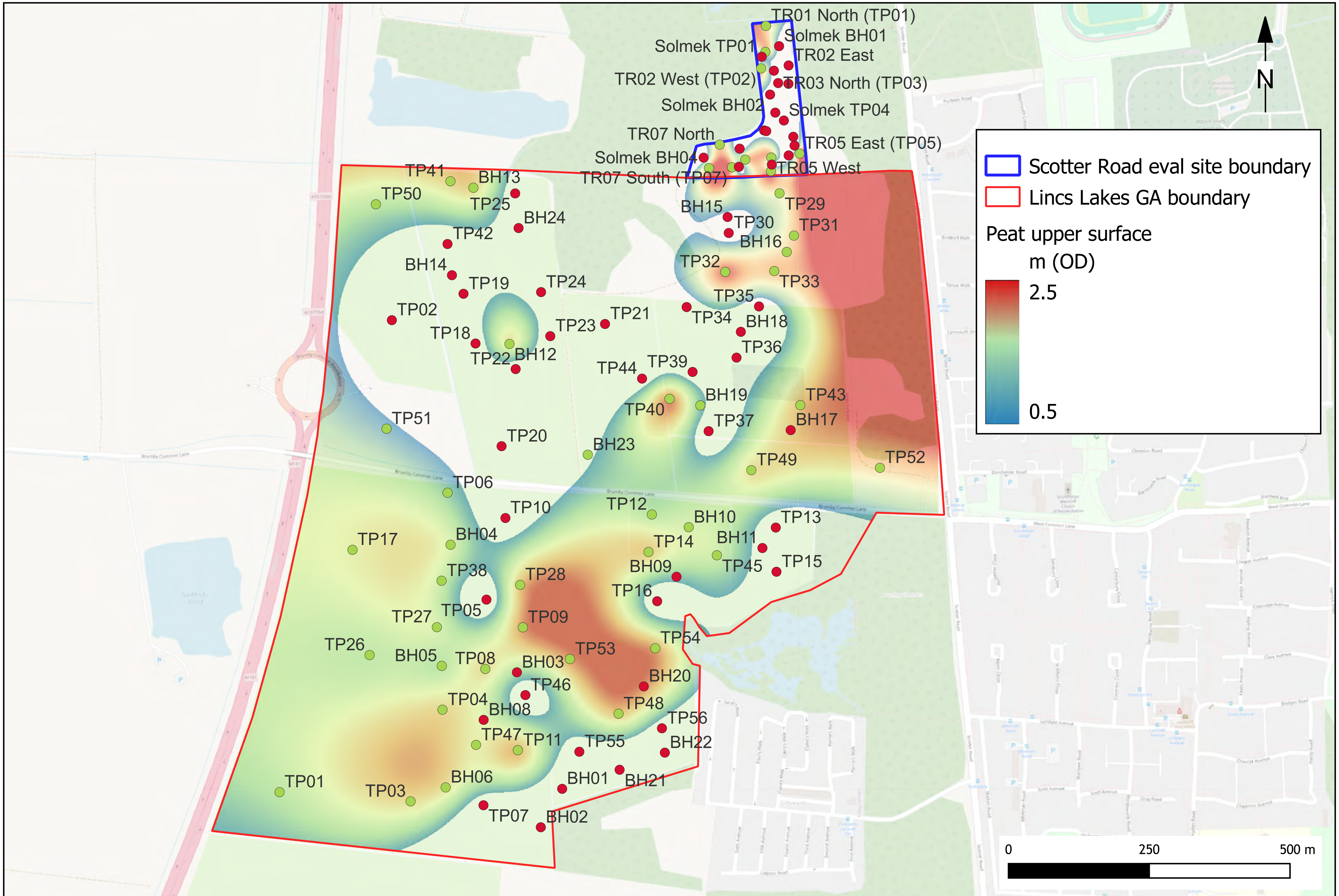

Figure 07- Modeled peat upper surface

Lincolnshire Lakes Geoarchaeological Assessment

Scale at A4 - 1:8500

Drawn by: LP

General shot of deposits in TP05

Collapsed section of TP05

General shot of deposits TP06

Working shot of TP07

Working shot of TP07

General shot of deposits in TP08

Section of deposits prior to collapse in TP08

General shot of deposits in TP09

Section through deposits in TP09

General shot of deposits in TP10

Section through deposits in TP10

General shot of deposits in TP11

Section through deposits in TP11

General shot of deposits in TP28

General shot of deposits in TP35

General shot of deposits in TP38