ORDE/03

OLD RIVER DON WIND FARM

Geoarchaeological Report

commissioned by REG Windpower

February 2015

HEADLAND ARCHAEOLOGY

REGISTERED CIfA ORGANISATION

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project info

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LOCAL AUTHORITY	North Lincolnshire

project team

PROJECT MANAGER	Mike Kimber
AUTHOR	Emma Tetlow
FIELDWORK	Emma Tetlow, Magnar Dalland, Steve Cox
GRAPHICS	Caroline Norrman, Magnar Dalland
SPECIALISTS	Emma Tetlow – Geomorphology assessment and geological background
APPROVED BY	Mike Kimber – Project Manager

MIDLANDS & WEST
Headland Archaeology
Unit 1, Premier Business Park, Faraday Road
Hereford HR4 9NZ

01432 364 901
midlandsandwest@headlandarchaeology.com

www.headlandarchaeology.com

Old River Don Wind Farm
Geoarchaeological Report

SUMMARY

An auger survey was undertaken on land at Medge Hall, Crowle, as part of a programme of evaluation required as Supplementary Environmental Information further to the cultural heritage assessment presented in an Environmental Statement for the Old River Don Wind Farm, a development of six wind turbines and associated infrastructure. The survey consisted of 7 auger transects, sampling turbine base micro-siting zones and compound area. The aim of the survey was to record the presence or absence of peat deposits across the areas of deep construction impacts, and to investigate the cultural and palaeoenvironmental potential of the area. A further facet was the ground-truthing of a previous geophysical survey, in order to determine the topography of the basement sands and the potential of this deposit as a former occupation horizon.

The coring demonstrated the presence of organic rich deposits at turbines 1-4, comprising a peat deposit of a reasonably uniform 1m thickness, which was overlain by 1m+ of deliberately introduced tidal silts ('warp'). At turbine 5 peat cover appeared reduced or absent. At turbine 6 a raised island or levee rose above the peat and river channel deposits. At the proposed compound area a former channel of the Old River Don was detected.

The peat sequences detected are not considered to be of particular palaeoenvironmental interest, in comparison to other previously studied sequences in the locality. Any archaeological remains in the turbine 1-4 locations would most likely be associated with pre-peat levels, at an average depth of 2m below ground level (average elevation -0.17m OD). Turbine 6 may have some archaeological potential at shallower depths associated with the higher ground. Turbine 5 appears to have limited cover of warp and peat, which may relate to former peat cutting activity. The compound area has limited archaeological potential due to the presence of river channel deposits.

The previous conductivity survey appears to have provided generally reliable information about the thickness of superficial cover at turbines 1-5, but did not directly detect the presence of peat.

INTRODUCTION

REG Windpower has submitted an Environmental Statement in support of a planning application for the construction of six wind turbines with associated infrastructure at Old River Don Wind Farm, Medge Hall, near Crowle, North Lincolnshire. The proposed development area (PDA) sits within an area of potential archaeological significance which has already been subject to limited investigation by the Humber Wetlands Project (Van de Noort and Ellis 1997). A key aspect of this is in relation to multiperiod activity (Mesolithic to the 20th century) and the palaeoenvironmental potential of peat deposits across the PDA. In order to understand the potential impacts on sub-surface heritage assets, the archaeological advisor to the planning authority requested that a programme of evaluation be carried out prior to determination of the planning application.

REG Windpower commissioned Headland Archaeology to agree and undertake a programme of field evaluation, comprising geophysical survey, palaeoenvironmental coring and fieldwalking.

A geophysical survey using an EM-31 conductivity meter was undertaken by Headland Archaeology in September 2014 (Mayes 2014). The objective of the survey was to map the sub-peat topography of turbine bases 1-5, by attempting to differentiate between areas of conductive - presumed wet – ground, and areas of resistant – and presumed drier – ground. The survey demonstrated variations in the conductivity of the deposits across the survey areas but concluded that ground-truthing of the results was needed in order to determine the extent to which variations in peat thickness had influenced the conductivity results.

This component of the pre-determination work comprised targeted hand-auger survey of the turbine base micro-siting zones and compound area (Illus 1). This was designed to provide further information about the presence and thickness of peat deposits and the depth of the sub-peat topography in order to assist in establishing the archaeological potential of the proposed development area. A project design covering the work was agreed with the archaeological advisor to the planning authority (Kimber 2014).

Site Description

The site is located c.2km to the west of Crowle (centred at NGR 474964 413217). The majority of the site comprises Grade 2 agricultural land with a small area of Grade 3 located at the site access from Marsh Road. It is currently managed for arable production. A strip of woodland, aligned roughly northeast-southwest, dissects the centre of the site; however the majority lies outside of the site boundary. The site is drained by numerous drains and ditches.

Thorne Moor Special Areas of Conservation (SAC) and part of the Thorne and Hatfield Moors Special Protection Areas (SPA) border the site on the north-east and north-west. A further four international sites, i.e. Special Areas of Conservation, Special Protection Areas and Ramsar sites are located within 10km of the Site.

The site is located within the Humberhead Levels region of the Humber wetlands, a low-lying region to the southwest of the Humber estuary. The land profile is generally flat, with ground levels lying between 3m Above Ordnance Datum (OD) and 0.7m OD. The old course of the River Don, made redundant by artificial drainage, passes through the south-eastern part of the development area in a broad alluvial floodplain. To the east of the Old River Don, Crowle sits at the northern tip of the Isle of Axholme, an area of higher ground bounded by the former wetlands of the Trent valley to the east and the Don, Idle and Torne to the west. The north-west half of the site lies within Thorne Moors, an area of raised mire wetland which has been considerable reduced and degraded by peat extraction and agricultural drainage.

OBJECTIVES

The objectives of the auger survey were:

- To determine the thickness of any superficial deposits of low archaeological/palaeoenvironmental potential;
- To target particular high-conductivity anomalies/trends and check whether they correspond to buried areas of deep peat;
- To target particular low-conductivity anomalies/trends and check whether they correspond to areas of raised ground within the buried raised mire;
- In the Turbine 6 and compound area; check whether buried ground surfaces with archaeological potential could occur at depths greater than can be detected by a gradiometer survey (0.5-1m);
- In the Turbine 6 and compound areas; locate if possible any former river channels;
- To thereby check the interpretation of the geophysical survey against actual ground conditions and produce a sub-surface deposit model with a high confidence rating;
- To use this information to inform the siting of the proposed wind turbines and other site infrastructure away from areas of archaeological and/or palaeoenvironmental potential;

- To produce and deposit a satisfactory archive and disseminate the results of the work via grey-literature reporting and publication as appropriate.

METHODOLOGY

Fieldwork

The fieldwork methodology was set out fully in the Project Design (Kimber 2014), but in brief, provision was made for the drilling of 70 auger points across the development zone. At several points in Turbines 1-6 the highly compacted nature of the warp deposits hindered borehole recovery. At these locations the resolution of the transects was reduced to target the principal variations in conductivity. These modifications were undertaken in discussion with the monitoring archaeologist. It was rapidly determined that the Compound Area was located within a zone previously occupied by a substantial palaeochannel of the Old River Don, and resolution was reduced here on the recommendation of the palaeoenvironmental specialist as significant sedimentary variation across the channel was unlikely. In total 41 points were drilled on transects across the turbine micro-siting localities. The remaining 3 points were in the compound area. All drilling was undertaken using a Dutch Auger and 6cm gouge auger.

All auger points were located using a Trimble GPS, allowing the construction of a Digital Elevation Model (DEM) and subsurface relief map in a Geographic Information System (SURFER10) representing thickness and depth of the peat deposit.

RESULTS

The auger survey will be discussed in two parts. The first will consist of a characterisation of the sedimentary units found across the site. The Compound Area, Turbine 5 and Turbine 6 will be discussed individually, while the remaining Turbines will be discussed together, due to the relatively homogeneity of the deposits found in these areas. The second part will provide comment on the relationship of the geophysical survey to the depth of the stratigraphy and sedimentology observed at the site.

Full details of all augers taken are given in Appendix 1.

Turbines 1-4

The basement varied across the site: at Turbines 1 (Illus 2 & 3), 2 (Illus 4 & 5) and 3 (Illus 6 & 7) this consisted of clay or a silty, clay rich sand, whilst at Turbine 4 (Illus 8 & 9) the basement deposit was sand. The depth at which this deposit was reached varied between -1.08m OD (Turbine 1) and +0.37m OD (Turbine 2). This disparity probably represents the buried topography of the basement. Overall, the basement depth was generally below sea level, although there were indications of a slight rise at Turbine 2 (Table 1). Deeper measurements, possibly representing topographically significant variations occurred at Turbine 1 (Borehole 70; d=-1.08m OD) and Turbine 4 (Boreholes 39 & 40; d=-0.83 & -0.76m OD).

Where the basement consisted of clay or sandy clay, a sandy deposit overlay the primary unit. This was capped in some areas by further deposits of sand and clay, most notably borehole 65 and 68, Turbine 1; borehole 52, Turbine 2; and boreholes 41 and 43, Turbine 3. Boreholes 52 and 65 were particularly complex with several intercalated layers of sand and clay.

The subsequent unit, which variously consisted of fibrous peat was found across all four turbines, and whilst the base of this deposit varied across them, the overall thickness of the deposit did not often significantly exceed 1m; although at Borehole 70 it was 1.64m thick. In nearly all cases, the peat gave way to further bands of intercalated sands and clays, before giving way to loamy topsoil.

Turbine 5 (Illus 10 & 11)

The basement deposit here was sandy, and generally slightly above sea level, with a maximum elevation of 0.18m OD. Across Profile 10 at Turbine 5 (boreholes 29, 27 25 & 22), the peat was almost entirely absent except at Borehole 27, where a grainy organic peat lay directly beneath the topsoil.

Borehole 21 identified a large hollow, the base of which lay at -1.14m OD. The hollow was filled with 0.67m of organic silt and peat and sealed by approximately 1m of silty clays, sandy silts and topsoil.

In general this location seems to have lost (or never had) peat cover like at Turbines 1-4; and does not seem to have had significant warp cover either.

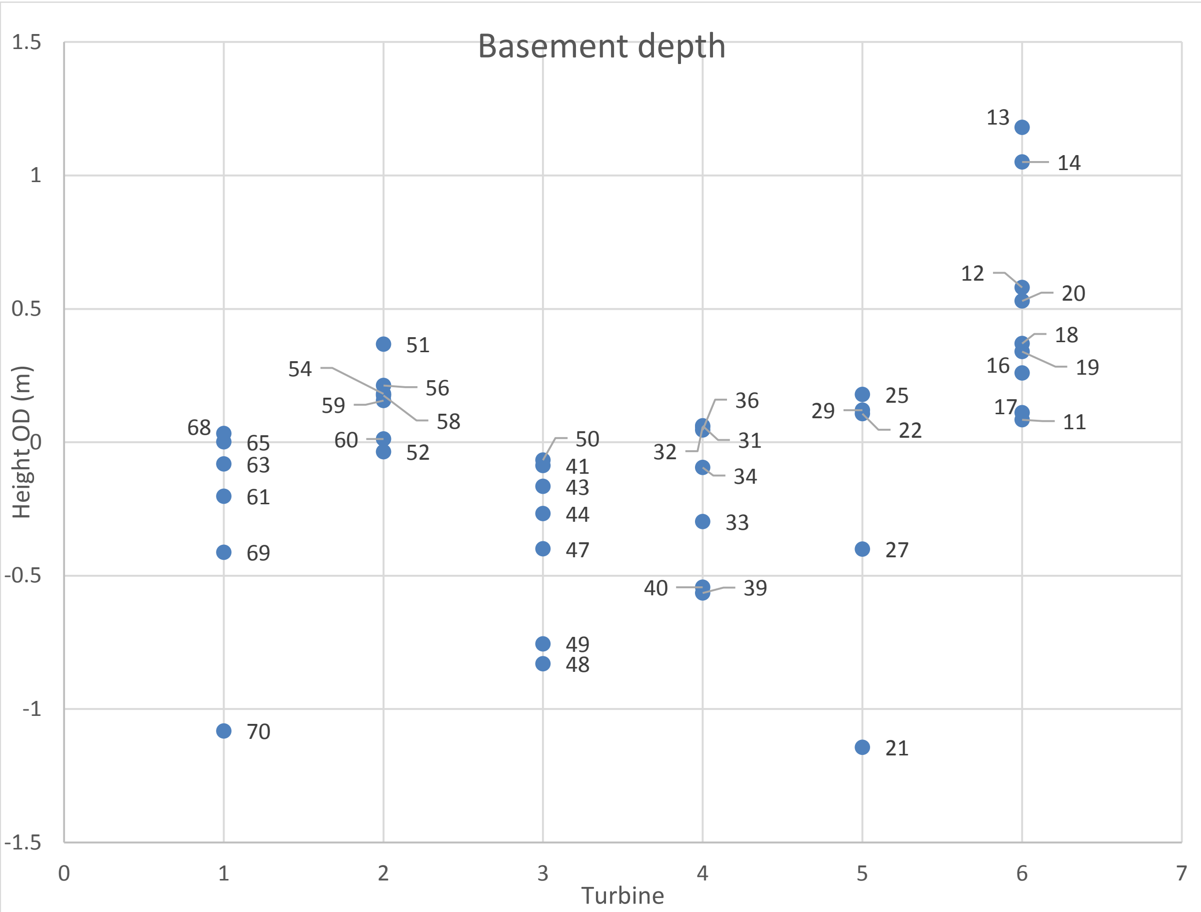

Table 1: Basement depth at Turbines 1-6

Turbine 6 (Illus 12 & 13)

In contrast to Turbines 1-5, the stratigraphy associated with Turbine 6 was relatively shallow and consisted predominantly of basal sand, in some cases sandy clay or clay silt which is overlain variously by silty clays before finally giving way to a clay-rich topsoil. Thin lenses of organic matter were present at some of the borehole locations – notably boreholes 11, 16, 17 & 18 - however these sediments did not seem to represent extensive peat cover, in particular the centre of this area appears clear of peat. The basement topography rose in this area, to 1.18m OD (borehole 13), where a noticeable topographic rise was present.

Compound (Illus 14 & 15)

The stratigraphic sequence in the area of the compound was relatively simple, consisting of a tripartite or bipartite sequence of grey clay, peat and a sandy, clay rich topsoil. Borehole 2 was the deepest found at the site, exceeding four metres and containing in excess of 1.5m of peat. Fragments of wood were also noted within this deposit; borehole 7 was abandoned due to the presence of a large impenetrable piece of wood, whether floodplain detritus or the more substantial remains of an *in situ* tree.

COMPARISON WITH GEOPHYSICAL INTERPRETATION

Turbine 1

The auger transect across Profile 01 in this area supports the suggestion from the conductivity of a wetter or deeper area within the underlying landscape. Overall, the top of the peat in this area was found between 0.77 and 1.58m below ground level (1.05-0.56m OD) with thickness increasing slightly from 0.92-1.64m to the north in line with increased conductivity. The overlying warp also increased in thickness, and the level of the basement sands also fell away towards the north, from -0.20m to -1.08m OD. The geophysics appears to have accurately mapped a buried topographic variation in this area. A similar trend was not observed in Profile 02. The absolute depth of the basement layer and the thickness of the warp and underlying peat did not vary significantly in this area. The general consistency in deposit thicknesses along this transect appears consistent with the low variability in the conductivity readings.

Turbine 2

The peat deposits in this area were less thick than those in Turbine 1. The deeper peat deposits found in boreholes 52 and 58 were associated with reduced conductivity readings compared to the thinner peat deposits in boreholes 56 & 59, when the opposite was expected from the geophysical interpretation. It is likely that there were other influences on the conductivity reading from superficial or bedrock deposits that have overwhelmed any signal from the peat.

In general there was little significant variation in warp cover, peat thickness or basement depth, and this appears to be reflected in the low variation of the conductivity readings. The thickness of total cover was shallowest at Borehole 51 (d=1.16m) and this point was both elevated compared to the other basement levels (0.37m OD) and associated with a reading of reduced conductivity.

Turbine 3

The sedimentology in this area corresponded occasionally with the interpretation of the geophysical survey, particularly in the case of borehole 49, which had 1.5m thick peat within an apparent basin and high conductivity; the evidence at borehole 48 - with very similar stratigraphy but low conductivity – was contradictory of the model. The remaining boreholes in this sequence 41 and 43 are also anomalous, in particular borehole 50 revealed only 0.1m of peat but had a high conductivity. Variation in the thickness of the superficial deposits appears to have been more influential on the conductivity readings.

Turbine 4

Whilst areas of thicker peat were associated with high conductivity values in boreholes 32, 33 & 39, other areas of peat with almost the same thickness were associated with lower conductivity values (e.g. boreholes 34, 36 & 40). There was no clear correlation between peat thickness and conductivity at this location.

Turbine 5

The borehole data at this turbine base supported the geophysical interpretation in part. The variation in conductivity across Profile 10 was reflected in the apparent presence of a peat filled channel. The increased conductivity in the area of borehole 21 was associated with thicker peat than elsewhere at this location, but also with a thicker superficial deposit of warp.

DISCUSSION

The area surrounding the proposed DA and indeed the DA itself has been subject to significant archaeological and environmental investigation since the 1970s (e.g. Buckland, 1979; van de Noort and Ellis, 1997, 1998). It is, nonetheless, the first time predictive modelling has been applied in this area. Such methods have already been applied in a number of areas in the Trent Valley (Brown *et al*. 2007; Carey *et al.* 2006; Challis *et al.* 2007; Gearey and Chapman, 2002).

Auger Survey

The most significant results of this survey are:

- The relatively shallow depth of the peat deposit across the site;
- The presence of a topographic rise or 'island' in the area of Turbine 6;
- The possible location of a former channel of the River Don at the compound area.

When compared to the data from the Adlingfleet transect (Van de Noort and Ellis 1998) the boreholes from Crowle are substantially shallower. Nonetheless, overall, the stratigraphy is strikingly similar: a base of blue grey alluvium, associated with early Holocene sea level rise, overlain by a fine to medium sand of aeolian provenance (Van de Noort and Ellis 1998). These units are overlain by the peat deposit which in most cases is less than 1.2m thick, once again in comparison to the Adlingfleet boreholes, this is relatively shallow.

Peat formation and succession is well understood as a result of the substantial corpus of analytical work undertaken by the Humber Wetlands Project in the mid-1990s. Organic deposition commenced *c*. 5200-2650BP and is indicative of flooding of the lower lying ground and subsequent paludification (Van de Noort and Ellis 1998). In the wider area pollen analysis in the area broadly indicates a succession of reed (*Phragmites)* swamp, mixed Alder (*Alnus)* dominated fen carr woodland before giving way to a further reed dominated episode (Van de Noort and Ellis 1998). In the immediate vicinity of Crowle, previous work suggests a backswamp or riparian mire (Dinnin 1997).

These organic deposits are overlain by the alluvium and sands of warp which was deposited during the 19th century.

Archaeologically, the area of most interest identified by both the auger survey and the geophysics is the raised area, which occupies the footprint of Turbine 6. This feature is expressed as a low, domed topographic rise within the landscape. It is composed of sands and gravels, consistent with an in-channel bar or levee capped by sand and may be associated with the early/mid Holocene proto Don. It is the most likely area to contain any evidence of prehistoric or Romano-British activity in the area.

The location of Turbine 5 may also be of archaeological potential, because of the apparent absence of peat from much of this area. The sub-peat ground surface is at a similar level to that at Turbines 1-4, and it is possible that any peat cover in this area was fully removed by peat cutters and that the area was not subsequently warped.

Finally, within the compound area, it is possible that the boreholes in this area have identified deeper areas of alluvium and organics associated with a palaeochannel of the Old River Don. In the borehole 2 location it seems that a backswamp area similar to that at turbines 1-4 was overlain by later alluvial sedimentation deriving from the channel. A southern channel of the Don at Crowle was subject to intensive palaeoenvironmental investigation by Dinnin (1997). After the development of a carr woodland and floodplain mire 7500-5000BP, this was also replaced by tranquil backswamp or floodplain mire (Dinnin 1997).

Geophysics and the stratigraphic sequence

The auger survey has revealed a relatively homogeneous band of peat which varies from approximately 0.6-1.6m in thickness at Turbines 1-4, but was absent from Turbines 5 & 6. In several areas, most notably Turbines 1, 4 & 5, high conductivity areas were associated with real features of substantial depth and containing a more significant peat deposit than observed across the rest of the area. In contrast, the results for Turbine 2 indicated reduced conductivity, even where the sedimentology clearly indicated a substantial depth of peat (e.g. boreholes 59 and 60).

It was originally hoped that the geophysics would indicate the overall thickness of the peat across the site. However, there was only a slight correlation between peat thickness and conductivity readings (Table 2). There does appear to be a stronger correlation between the thickness of superficial cover and increased conductivity (Table 3). This suggests that the properties of the overlying warp deposits exerted a dominant effect on the readings taken by the conductivity meter, save in areas of gross variation in the sub-peat topography. This may be because the marine derived warp deposits contain a higher concentration of dissolved salts than the groundwater fed peat, which could lead to higher conductivity readings where thicker deposits of warp are present (A Boucher pers comm).

The base of the warp also appears to reflect the solid geology of the basement itself. This is likely to be a result of peat compression across the site, the weight of the warp and overlying sediments, which will be highly variable, causing downward movement in the peat where the basement is deeper. This effect will be enhanced by the composition of the peat itself, for example, in areas where the peat is composed of a tougher material such as wood, the effects of compression will be less. In areas of less resistant material, such as sedges, reeds or even areas which may once have been open water, this effect will be enhanced. This effect and the associated problems and the ramifications for archaeology and palaeoenvironmental analysis, particularly chronological issues has been well documented by a number of authors, e.g. Allen 1999, 2004; Haslett *et al*. 1998; Long *et al*. 2006. Whilst these are examples exploring intertidal environments, when warp formation is considered, such examples provide ideal parallels.

A further consideration, which may explain the nature of the stratigraphy and its relationship to the geophysical results, particularly in the case of Turbine 2, is the depth of the water table and its effects on the moisture content of the peat. The geophysical survey was undertaken during the early autumn of 2014, at the end of one of the driest summers in recent years. This would have had a direct effect on the water table in the area, which could be assumed to be lower than usual and also the moisture content of the peat, which could be considered to be reduced. Other factors may include better drainage in this particular area, greater permeability of the bedrock or subtle variations in the depth of the peat itself.

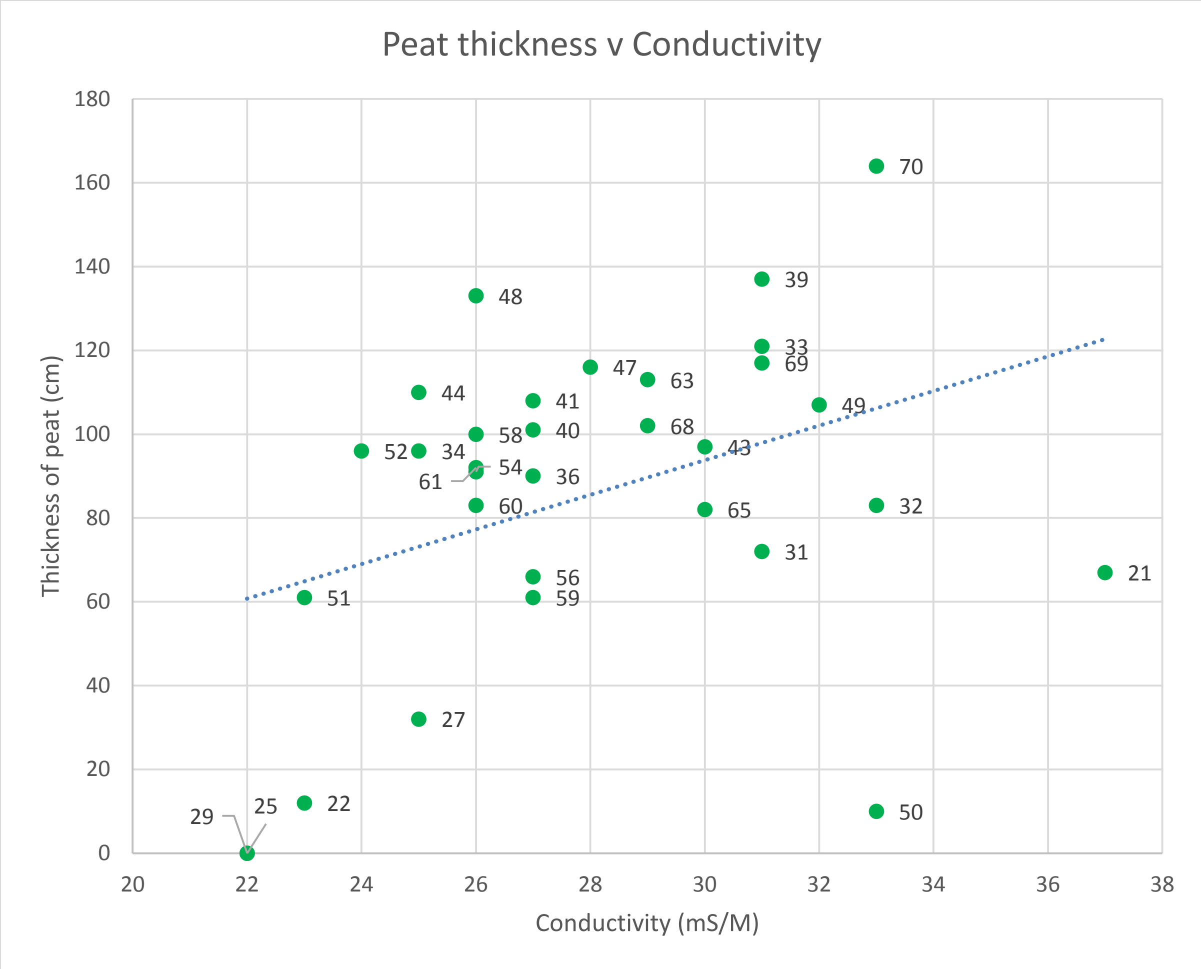

Table 2: Peat thickness versus conductivity

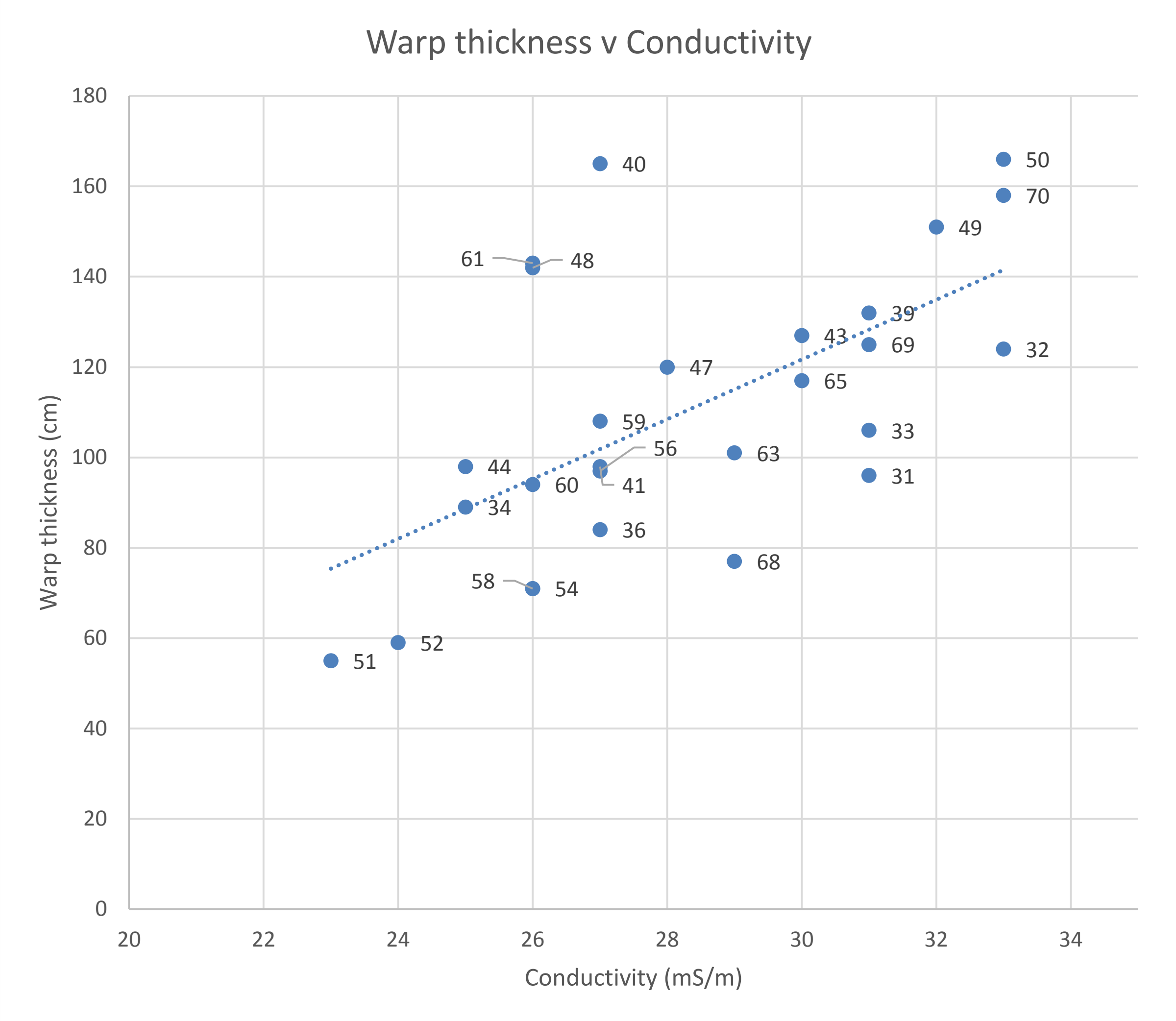

Table 3: Warp thickness versus conductivity

CONCLUSIONS

The auger survey has demonstrated that there is generally no more than a 1m undulation in the level of the sub-peat topography across Turbines 1-5, at or around 0m OD. At each turbine site the undulation is generally limited within a range of 0.5m. This suggests a relatively level flood-plain landscape existed prior to peat formation. In general the variations in the sub-peat topography seem to be too minor to have registered on the conductivity survey, having been generally swamped by the responses from the overlying warp deposits.

The gross exceptions to this – deeper basin features at Turbine 1 (borehole 70); Turbine 3 (borehole 49) and Turbine 5 (borehole 21) appear to have been detected as conductive responses by the geophysical survey, although the readings appear to reflect the thicker warp within these hollows, rather than thick peat. Their presence is suggestive of low points in the pre-peat landscape. The gradient of these features is not steep – being around 0.5m deeper than their next-nearest auger points – and they are likely to simply represent a slight exaggeration in the general topographic undulation rather than indicating substantial landscape features such as river channels.

The auger survey was successful in mapping the stratigraphic sequence at the survey locations. The evidence from this survey supports the previous evidence that the floodplain was covered by a mire or backswamp during the Neolithic and Bronze Age. This evidence reduces the likelihood of human activity in the immediate area of Turbine 1, 2, 3, 4 & 5; it is well recognised that for much of prehistory, human occupation was associated with the drier periphery of the floodplain (Van de Noort and Ellis 1998 p 292). In this case, this area of the floodplain of the Old

River Don during much of Neolithic/Bronze age was dominated by fluvial wetlands and would have been too wet for permanent or prolonged human activity. The exception is Turbine 6 which appears to occupy a former island or area of higher ground within the floodplain.

The compound area appears to be within a former channel of the Old River Don. This channel may have become inactive by the later prehistoric period. Gradiometer survey of this area did not indicate the presence of any archaeological remains.

In terms of palaeoenvironmental potential, the peat does not represent a particularly substantial deposit when considering the rest of this part of the Humberhead Levels and the extensive nature of previous work. If further work was required post-consent, the most productive method of analysis would be the acquisition of material for radiocarbon dating from the top and bottom of the deposit. This would constrain the period of formation and place the deposit within the existing chronology and model for vegetative succession/development, providing a minor addition to the existing body of data.

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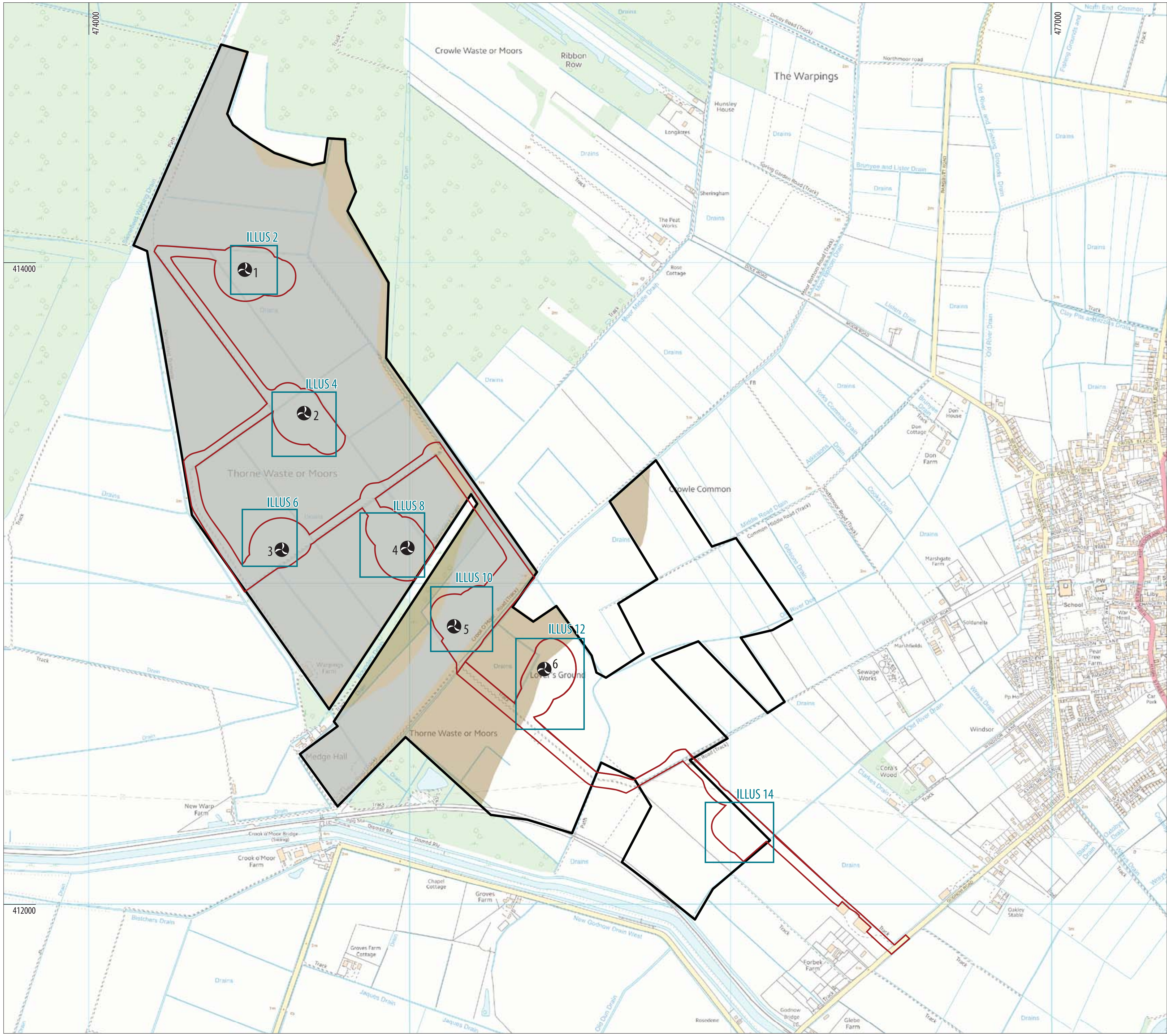

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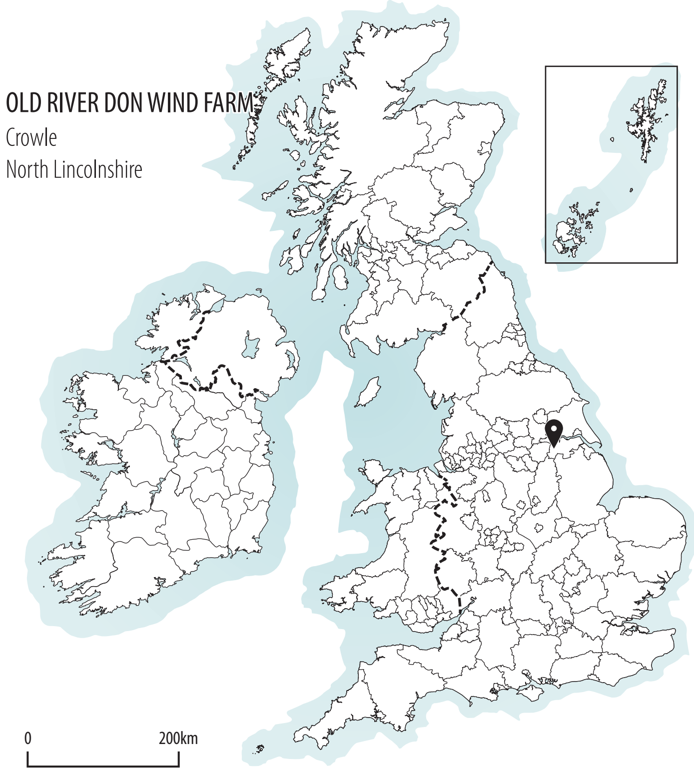
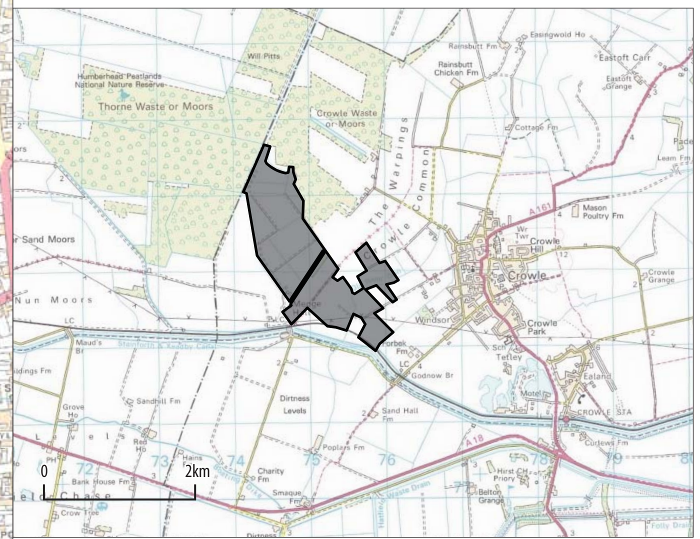


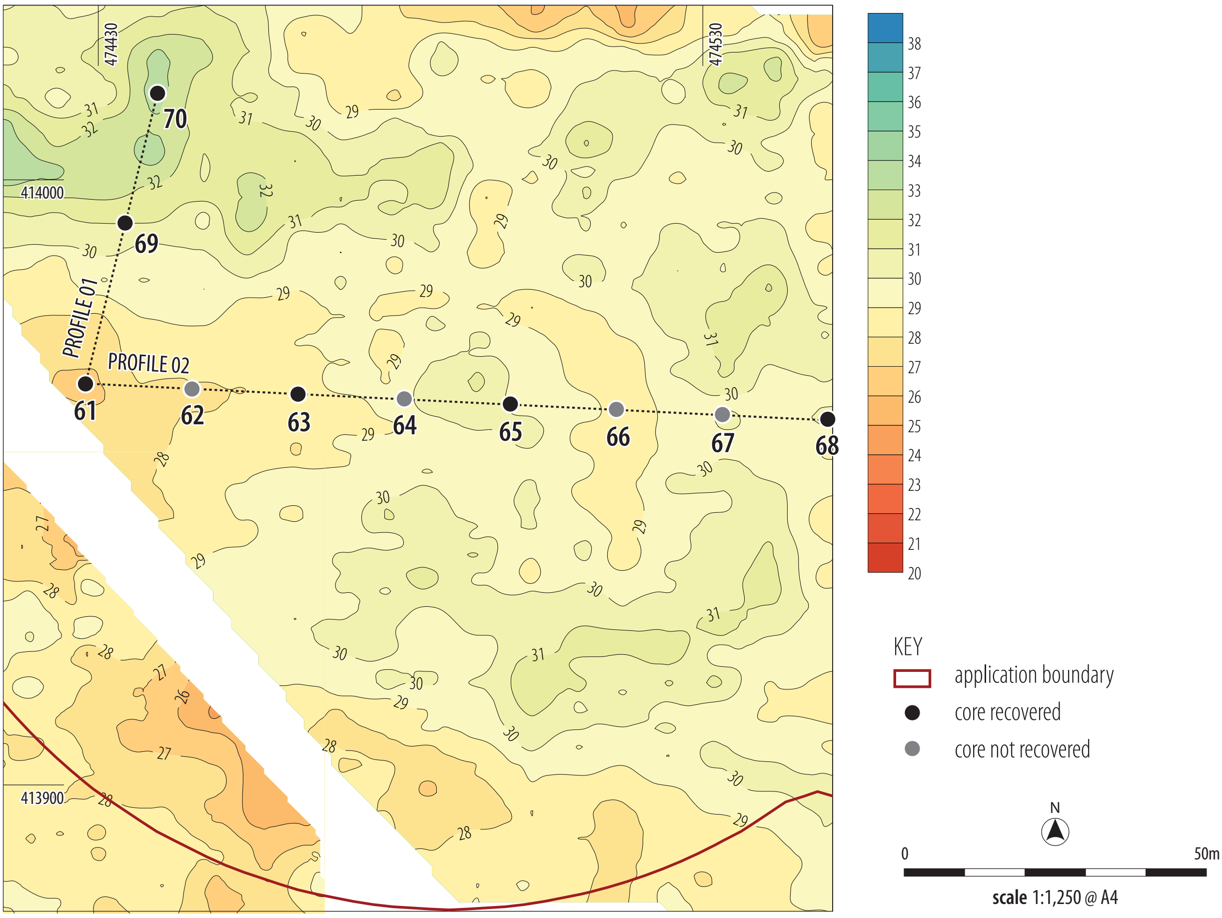


HEADLAND ARCHAEOLOGY
MIDLANDS & WEST
Unit 1, Premier Business Park
Faraday Road
Hereford HR4 9NZ
01432 364 901
www.headlandarchaeology.com

KEY
- application boundary
- inner study area
- proposed turbine location

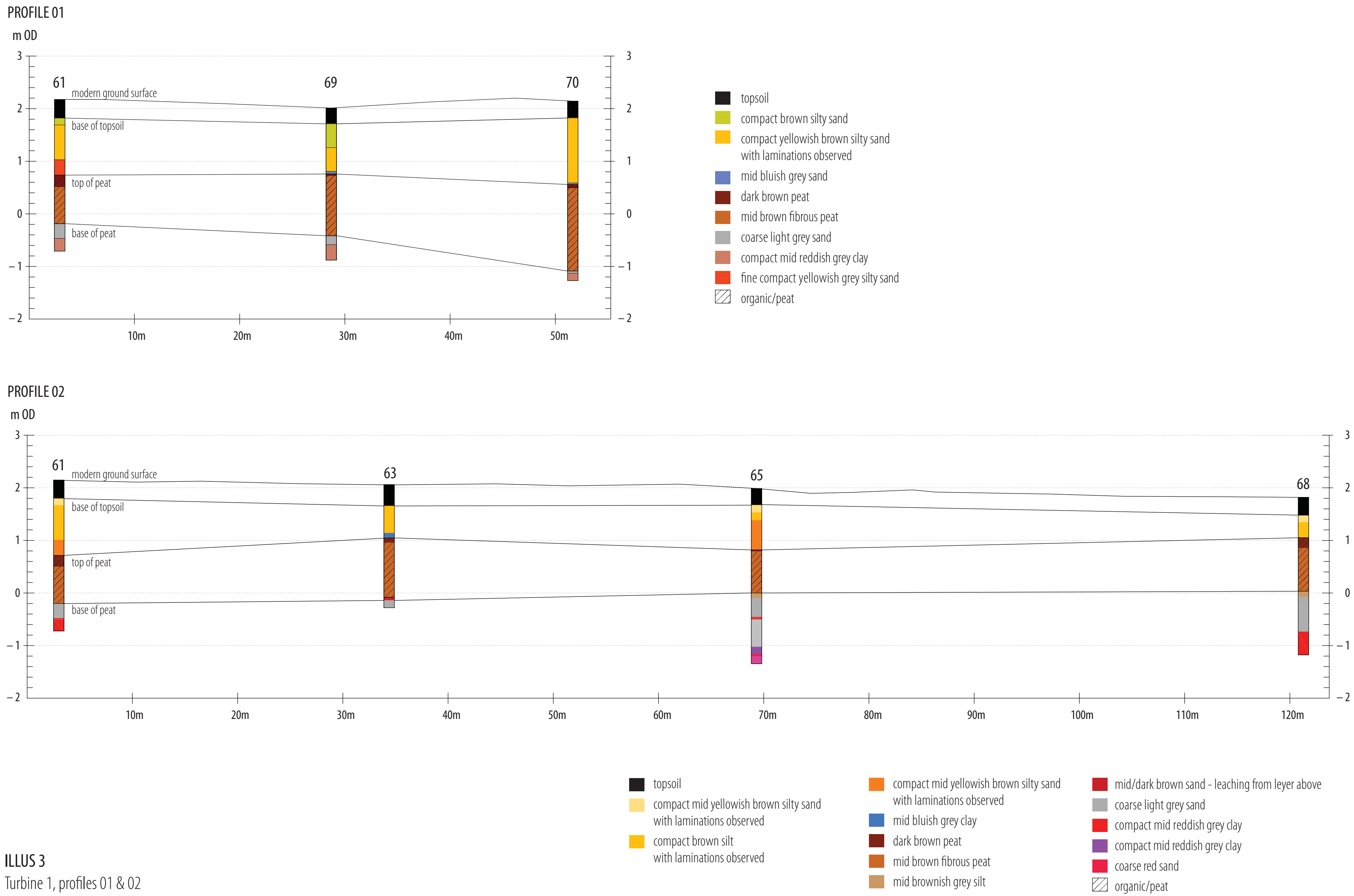
N
0 500m
scale 1:12,500 @ A3

ILLUS 1
Site location



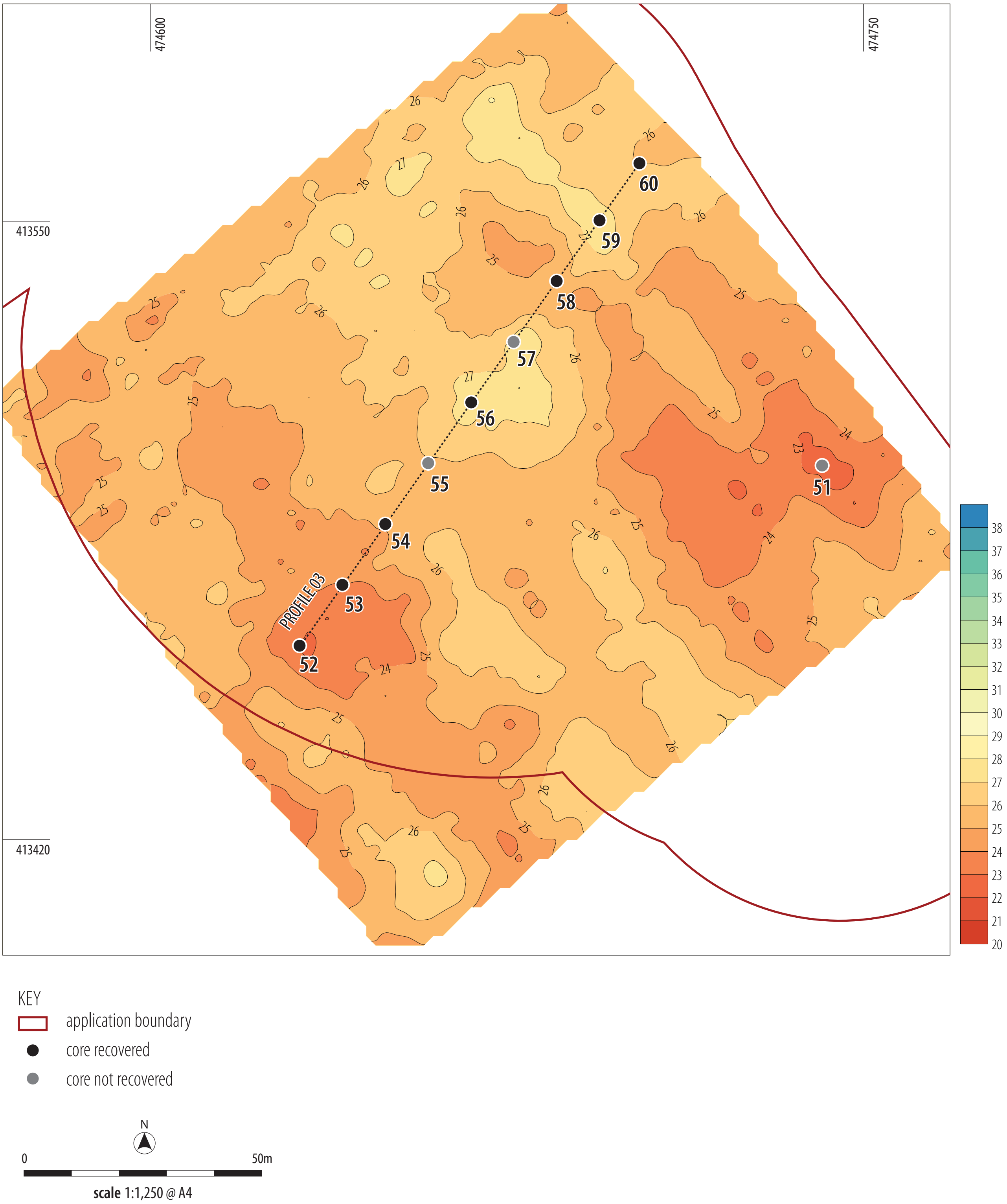
ILLUS 2

Turbine 1, core locations

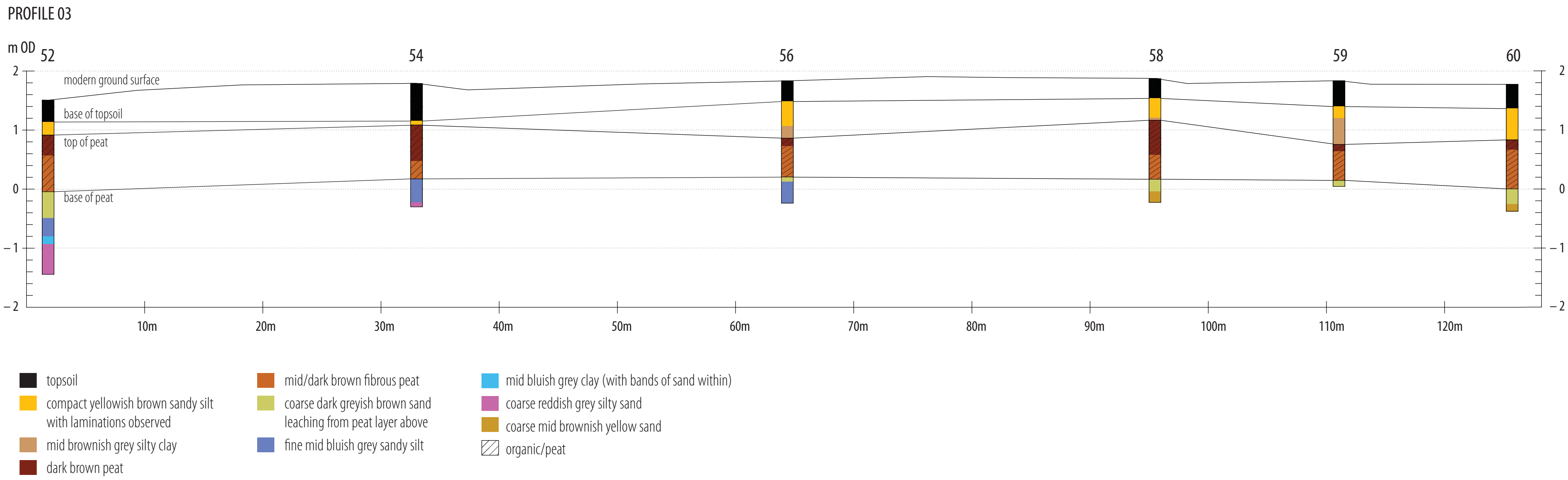


ILLUS 3

Turbine 1, profiles 01 & 02

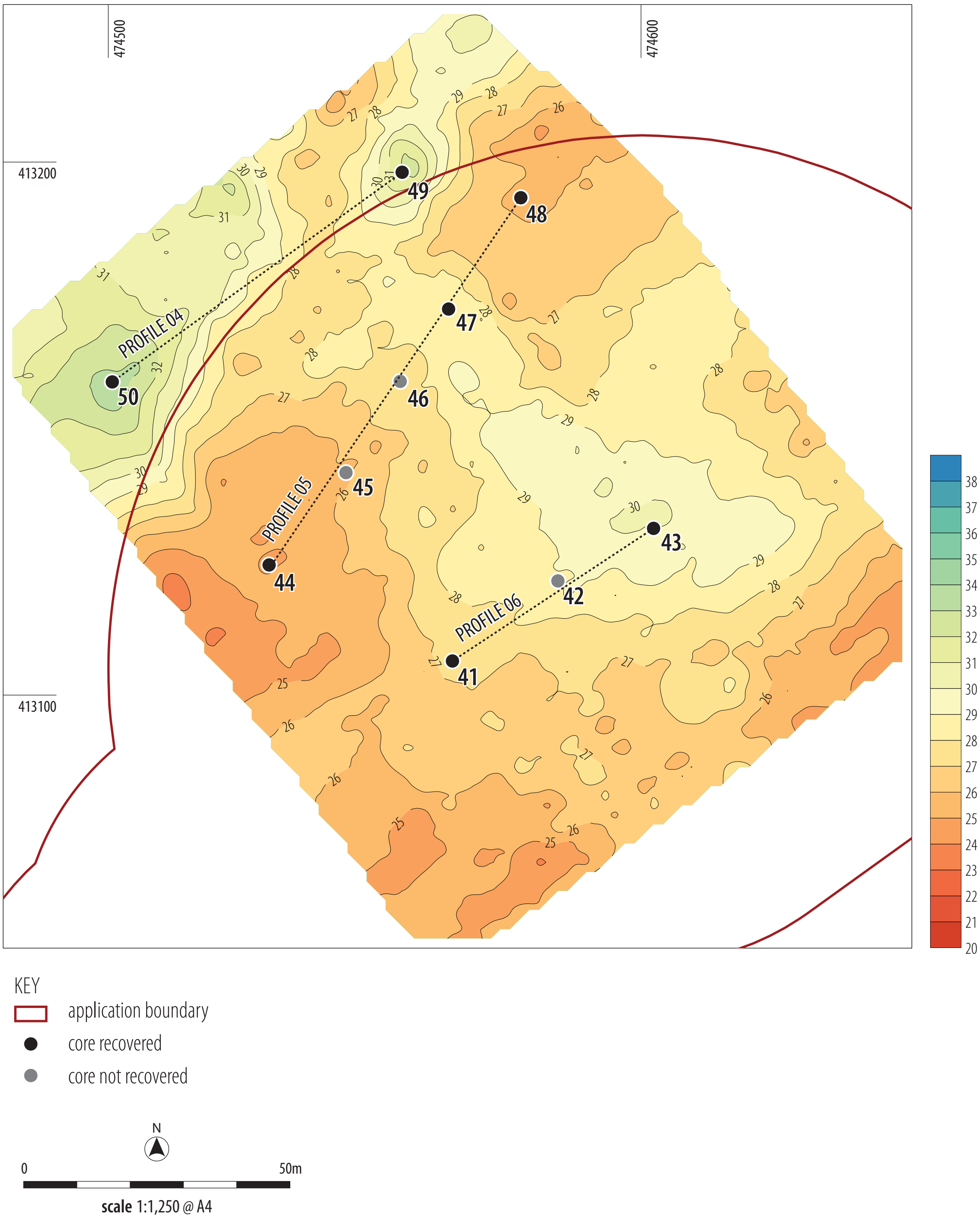


ILLUS 4
Turbine 2, core locations

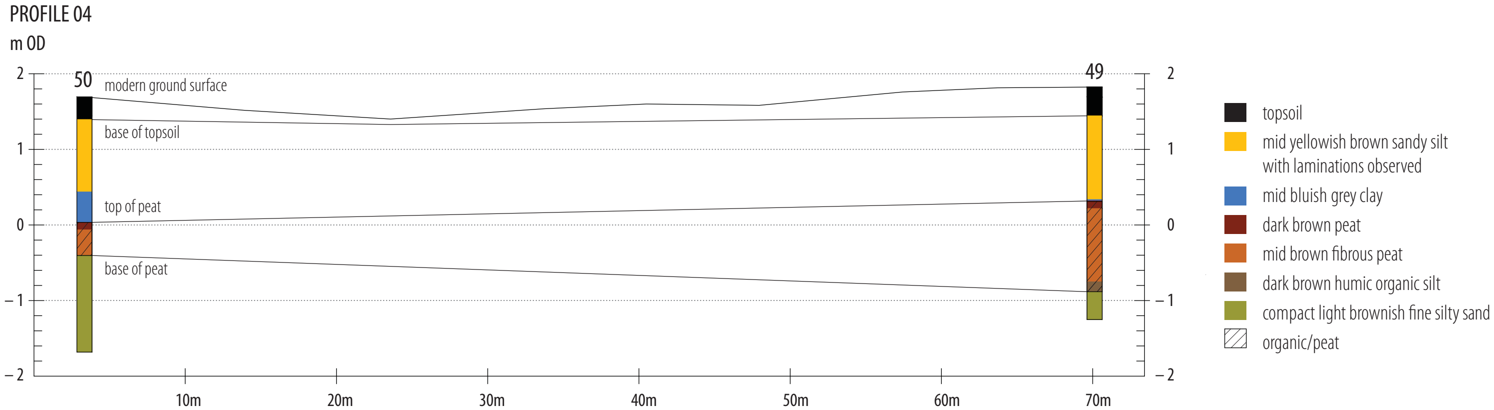


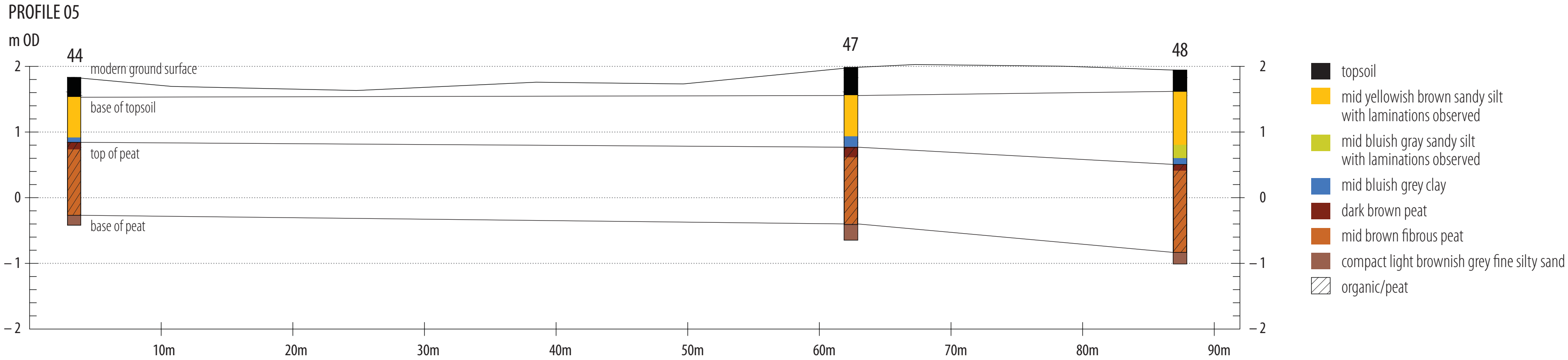
ILLUS 5

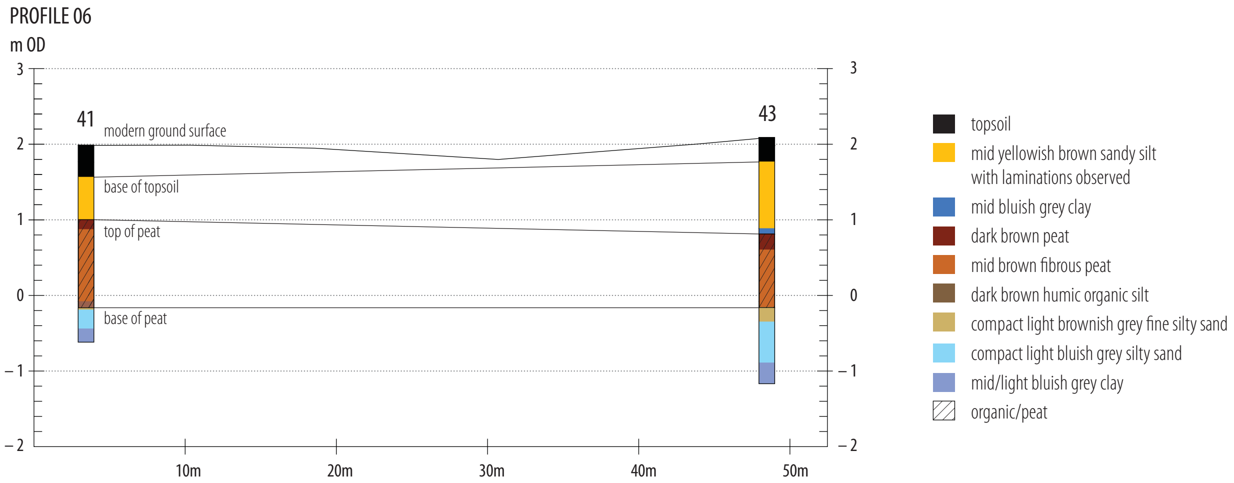
Turbine 2, profile 03



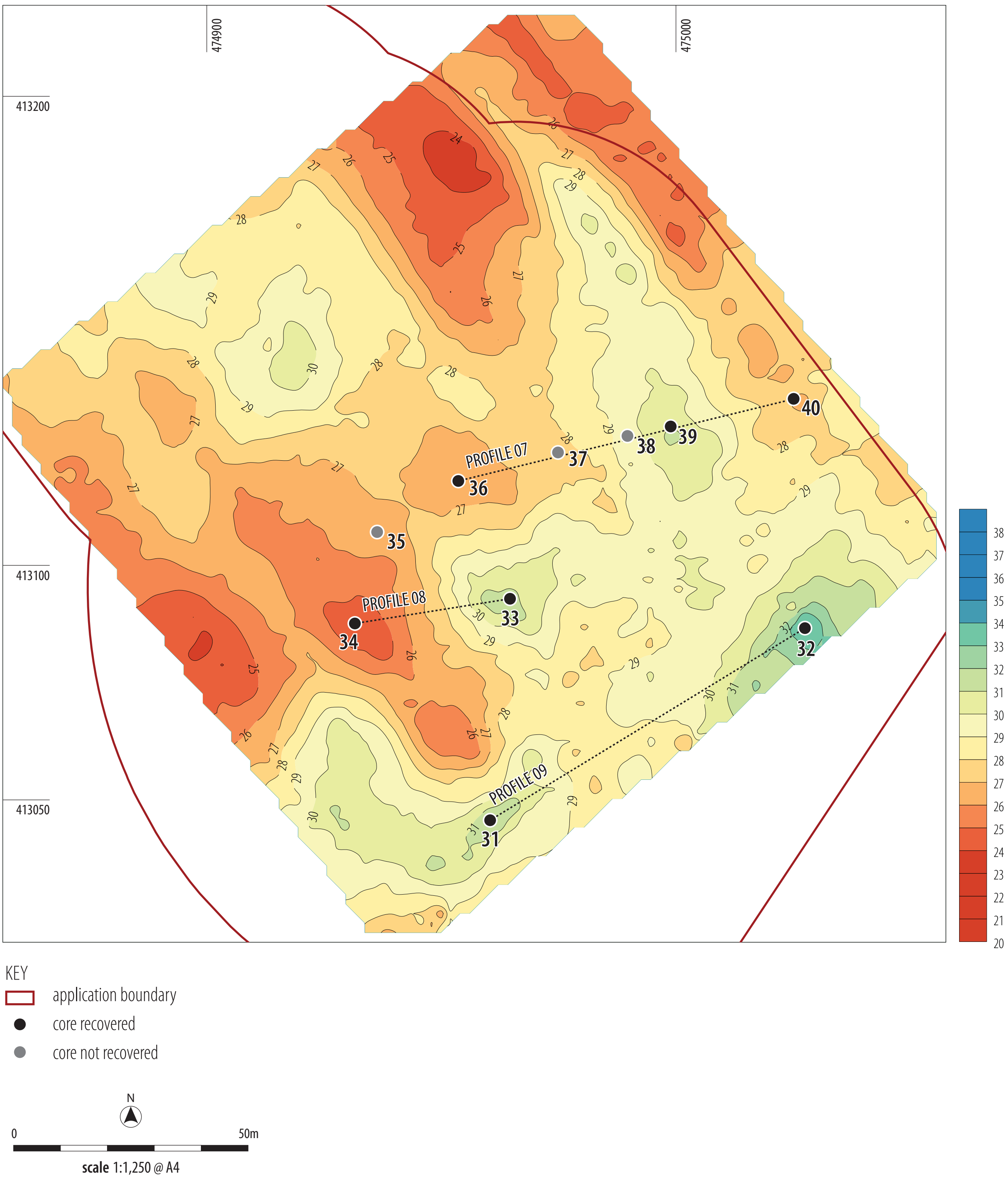
ILLUS 6
Turbine 3, core locations



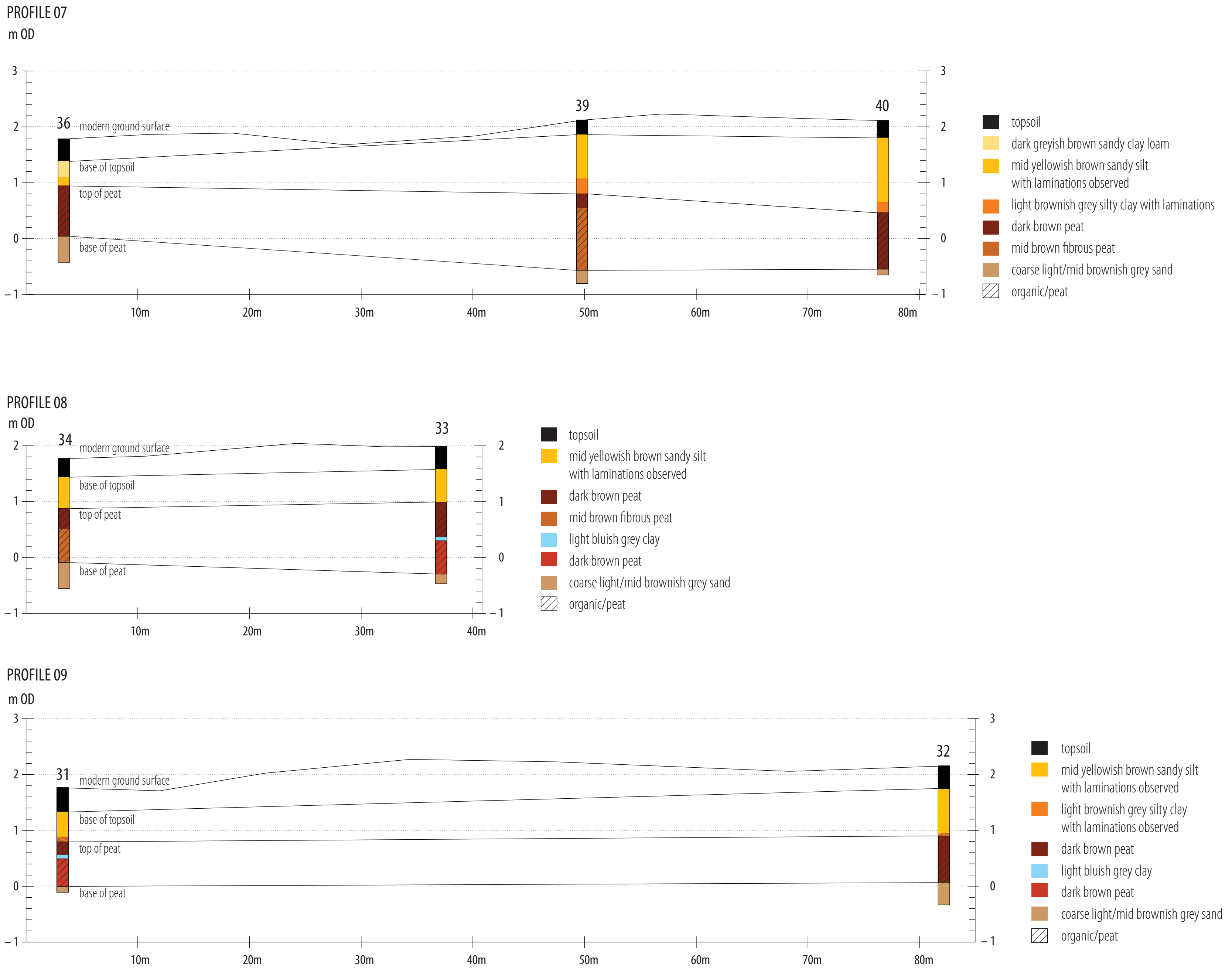




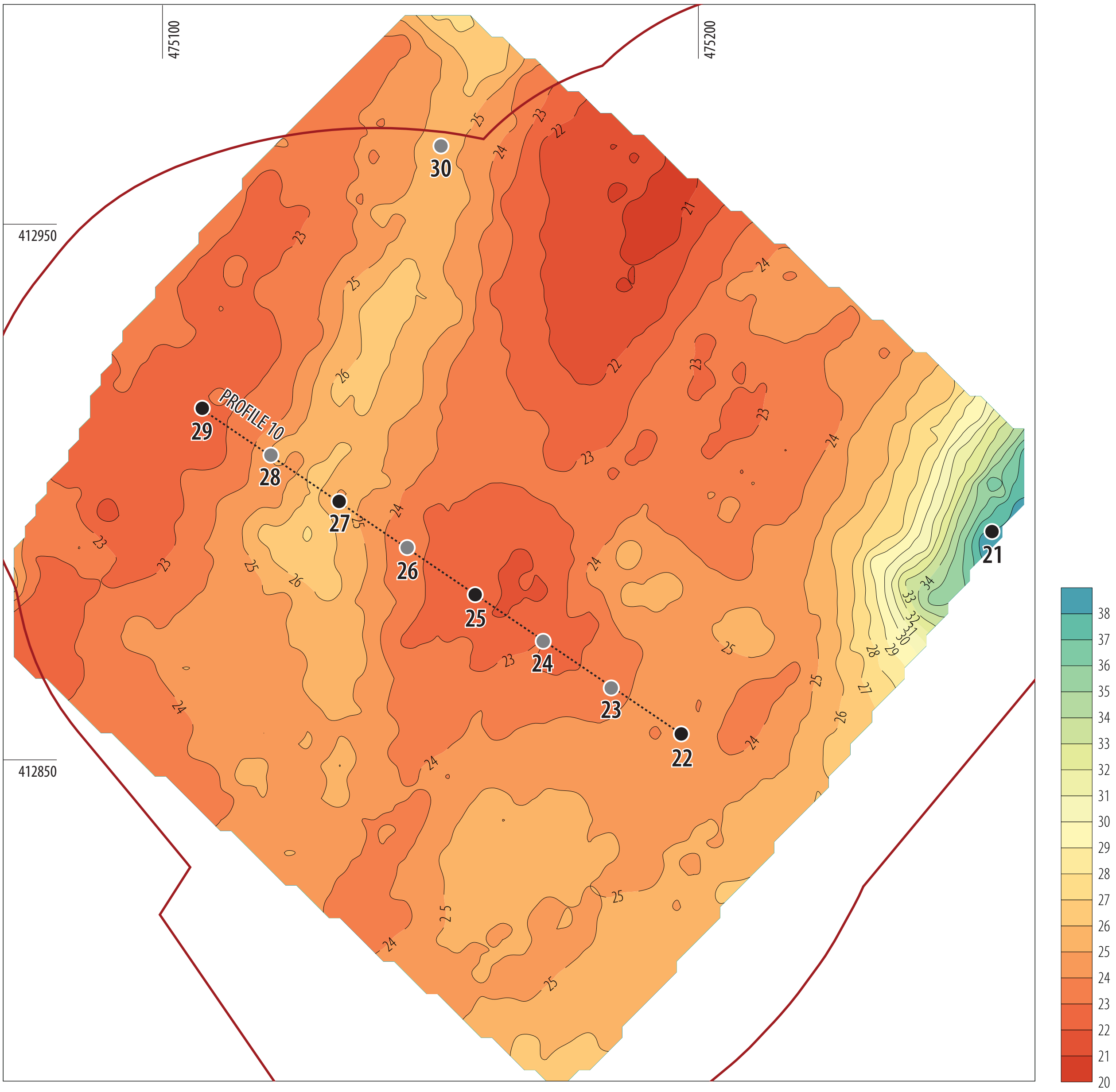
ILLUS 7
Turbine 3, profiles 04, 05 & 06



ILLUS 8
Turbine 4, core locations



ILLUS 9
Turbine 4, profiles 07, 08 & 09



KEY

application boundary

core recovered

core not recovered

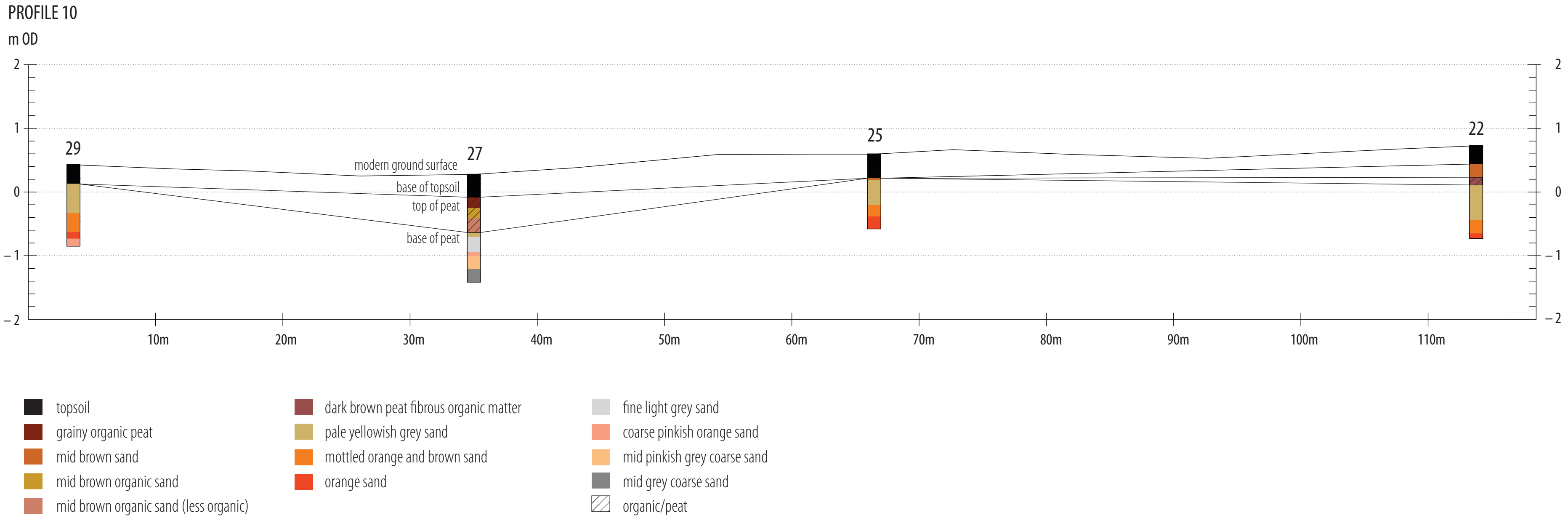
N

0 50m

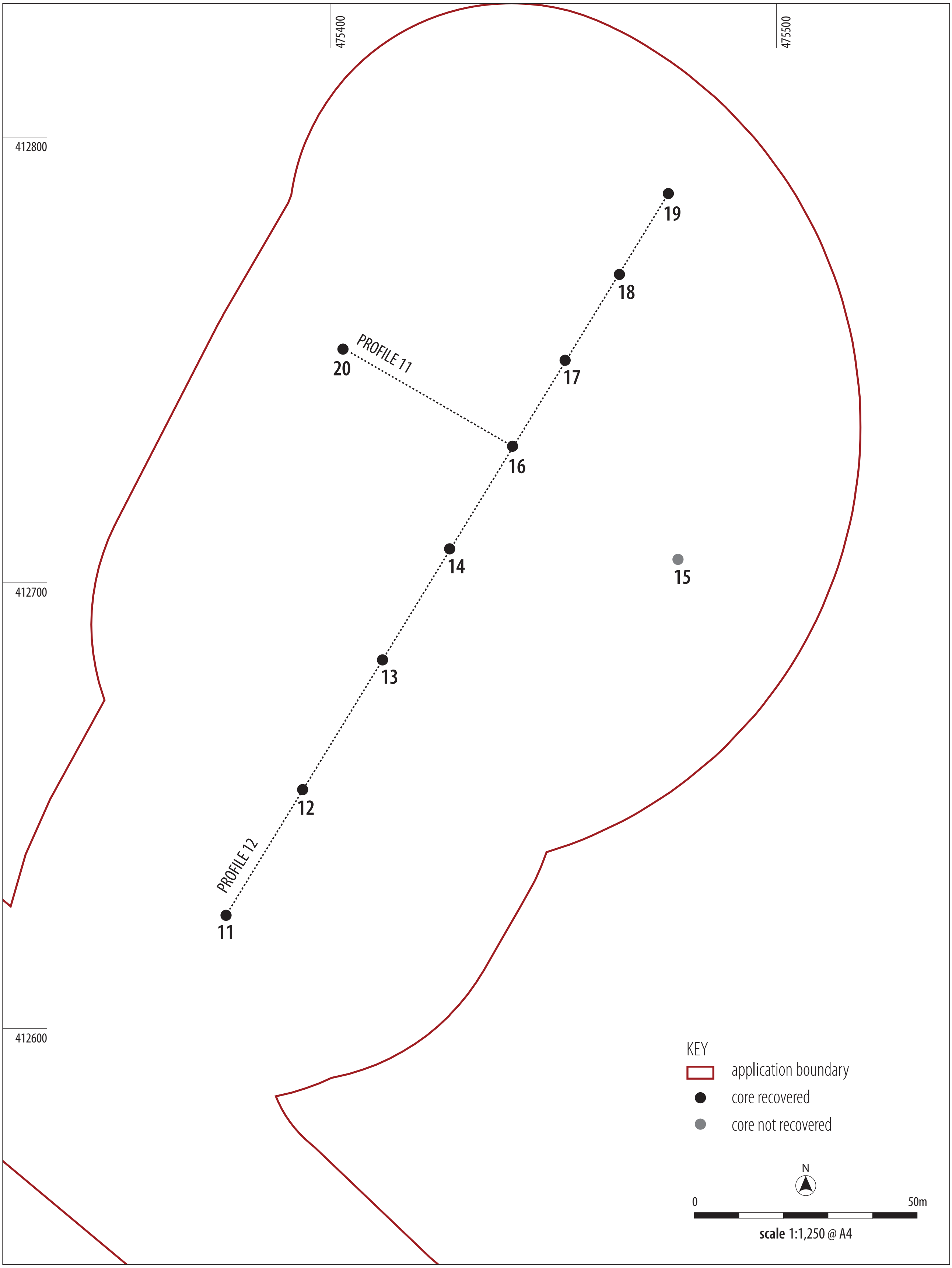
scale 1:1,250 @ A4

ILLUS 10

Turbine 5, core locations

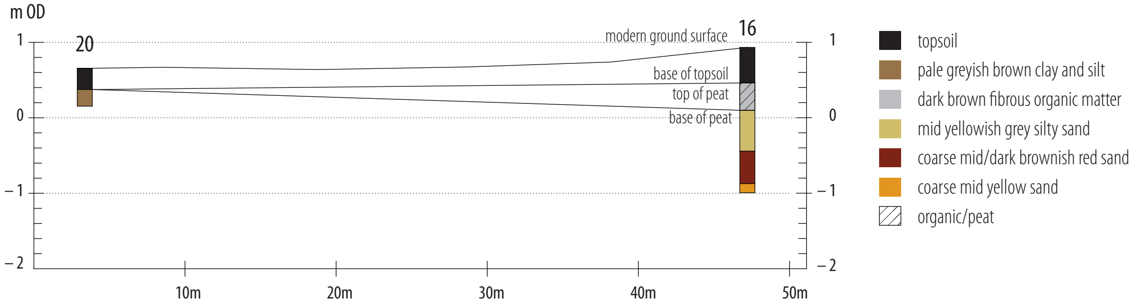


ILLUS 11
Turbine 5, profile 10

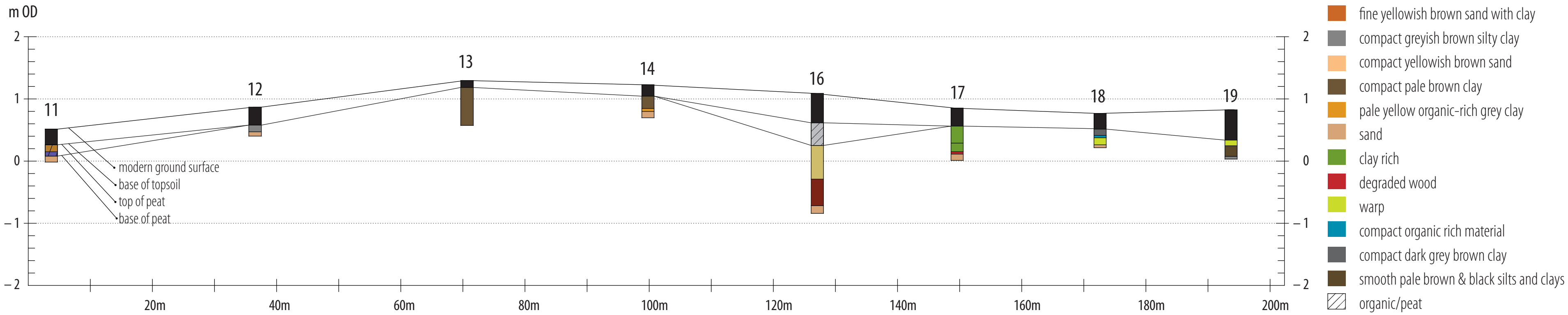


ILLUS 12
Turbine 6, core locations

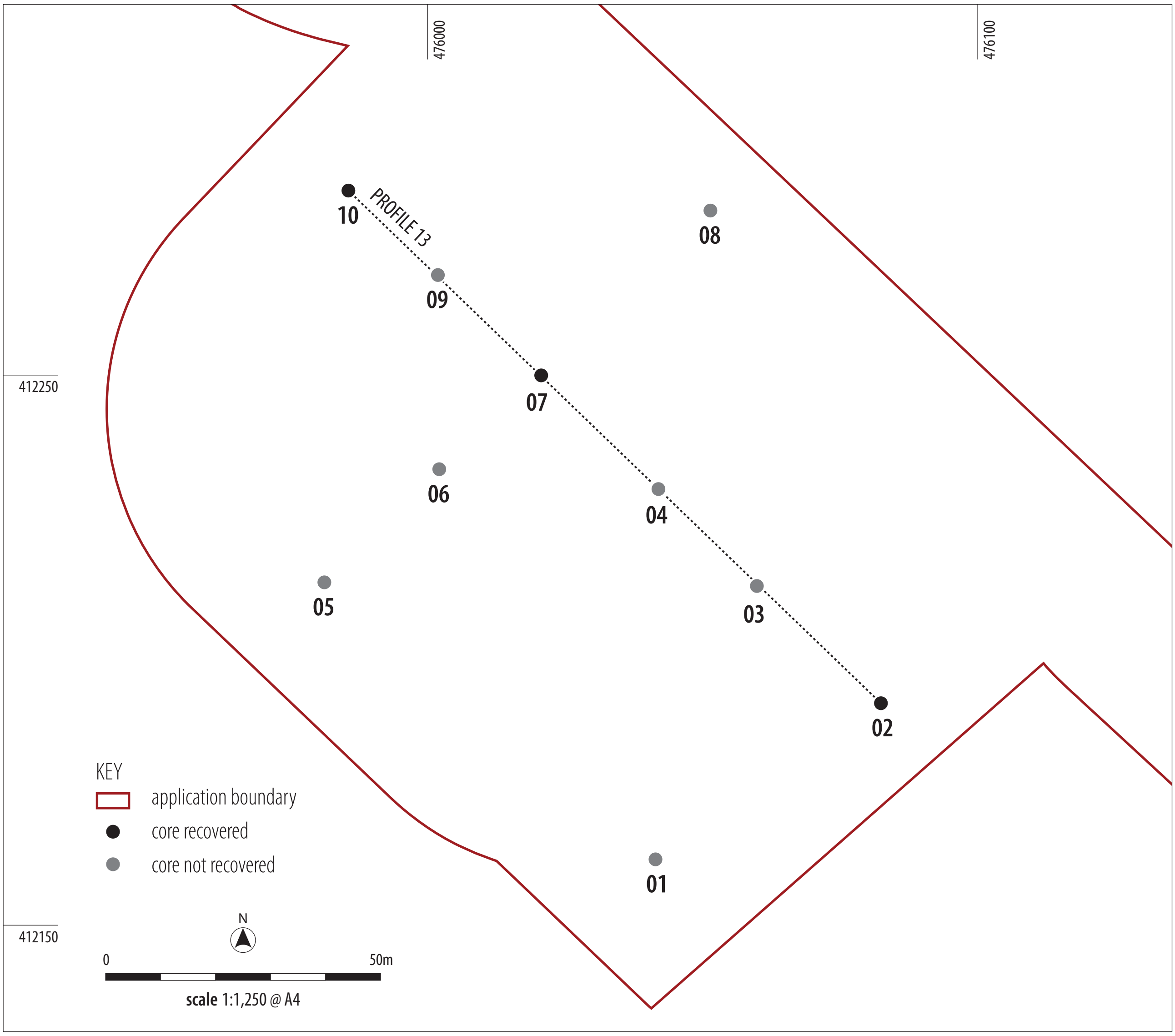
PROFILE 11



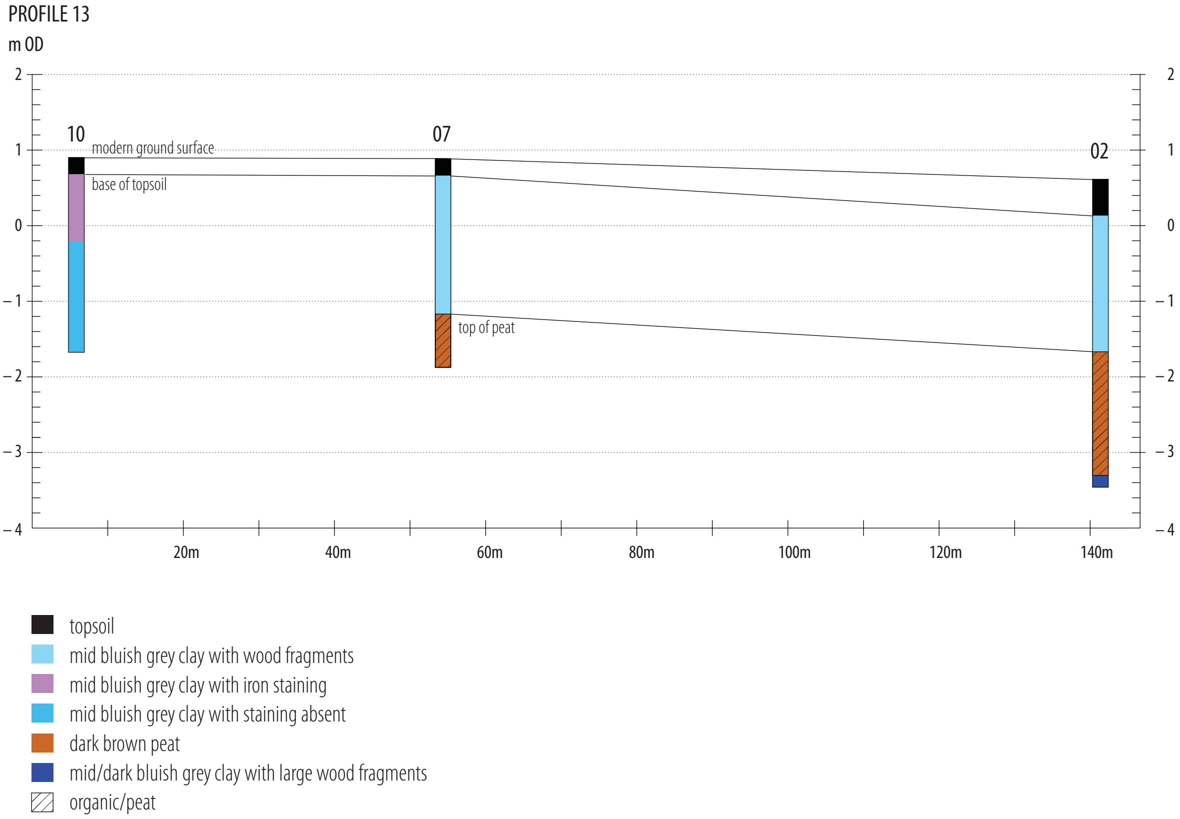
PROFILE 12



ILLUS 13
Turbine 6, profiles 11 & 12



ILLUS 14
Compound, core locations



ILLUS 15
Compound, profile 13

NORTH
Headland Archaeology
13 Jane Street
Edinburgh EH6 5HE

T 0131 467 7705
E north@headlandarchaeology.com

SOUTH & EAST
Headland Archaeology
Building 68C, Wrest Park, Silsoe
Bedfordshire MK45 4HS

T 01525 861 578
E southandeast@headlandarchaeology.com

MIDLANDS & WEST
Headland Archaeology
Unit 1, Premier Business Park, Faraday Road
Hereford HR4 9NZ

T 01432 364 901
E midlandsandwest@headlandarchaeology.com

www.headlandarchaeology.com