ORDE/14

OLD RIVER DON WIND FARM

Geophysical survey conducted at a site near to Crowle, North Lincolnshire

commissioned by REG Windpower

February 2015

HEADLAND ARCHAEOLOGY

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project info

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Old River Don Wind Farm

Geophysical survey conducted at a site near to Crowle, North Lincolnshire

SUMMARY

This geophysical survey is to form part of an archaeological field evaluation of a proposed wind farm site near Crowle, Lincolnshire, in order to assist in the characterization of the buried topographic features and assess the archaeological potential of the site. The survey results are consistent with variations in the thickness of peat deposits across the site. These results suggest that in combination with ground truthing it may be possible to identify and avoid areas with the potential to contain buried archaeological remains related to human activity within Thorne Moors.

A Lancaster Bomber is reported to have crashed in the area in 1945. The survey detected no evidence for a crash site within the survey area.

INTRODUCTION

Headland Archaeology (UK) Ltd was commissioned by REG Windpower to conduct a Terrain Electrical Conductivity survey (TEC) using Geonics EM-31-MK2 conductivity meter at a site near to Crowle, North Lincolnshire, within the proposed construction footprint of five of the six turbines of the proposed development in order to assist in the characterization of the subsurface geomorphology. The areas covered by the survey are mapped by the British Geological Survey as being covered by peat and warp deposits; other areas, including Turbine 6 and the proposed site compound area, have been subject to gradiometer survey (reported in Appendix 9.5 of the Environmental Statement)

As ground conductivity is influenced by soil moisture content, it was hypothesised that survey using EM31 would be able to identify areas of sub-warp peat and alluvium based on its presumed elevated water content (and hence higher conductivity) relative to that of the underlying geological horizon. This would help to define the former physical topography of the survey area by identifying former channels or basins in the sub-peat landscape. Identifying these features would help to define areas of archaeological potential within the proposed development area.

Site Location, Description and Setting

The site is centred at NGR 475000, 413000 near to Crowle, North Lincolnshire. The location and character of the site are described in detail in the Written Scheme of Investigation for the project which was prepared by Headland Archaeology for REG Windpower and are only summarised below.

Geology

The British Geological Survey records the underlying solid geology as Triassic Sherwood Sandstone overlain, to the east of a line running north/south from Goole to Sandtoft, by Mercia Mudstone, also of Triassic age. The floodplain of the Old River Don is covered by alluvial deposits of sand, gravel, clay and silt.

Further to the north-west the superficial geology consists of peat, overlain by 'warp' deposits: silt deposited by channelling tidal floodwaters into embanked compartments, to raise the surface of the fields and improve their agricultural productivity (data from British Geological Survey: http://www.bgs.ac.uk).

Archaeological and Historical Background

The area to be covered by the geophysical survey is located on the Thorne Moors raised mire. This peat bog dates from the Neolithic period, but has been heavily affected by post-medieval peat cutting and drainage works. Large areas were also converted for agricultural use by the deliberate introduction of tidal sediments, known as 'warping'. This has resulted in approximately 1m of silt cover over surviving peat and other deposits within the survey area. Nevertheless, the buried raised mire has the potential to contain evidence for human activity related to exploitation of the wetlands, and for settlement on areas of higher ground amongst the peat basins.

GEOPHYSICAL METHODS

A Geonics EM-31-MK2 conductivity meter was used to perform a terrain electrical conductivity survey. The instrument is a non-intrusive frequency-domain electrical conductivity measuring device that records the spatial variations of apparent ground conductivity (the reciprocal of apparent ground resistivity); differences in deposits – principally variations in thickness between deposits with different conductivities - can produce spatial variations in the conductivity readings.

The instrument has various environmental applications and its data can be used to map landfills, buried metal objects, and shallow groundwater contamination, as well as geotechnical applications such as measuring soil thickness.

A survey grid was set out at the required locations (the turbine micro-siting areas) and subdivided into 8m traverses over a total area of 2 hectares per turbine base, tied to the Ordnance Survey National Grid (OS NGR) using a differential GPS system to provide 0.1m or greater accuracy. The survey data is therefore geo-referenced, and OS coordinates defining the boundaries of the turbine bases are given in Table 1. The areas surveyed are shown in Figure 1.

The EM31-MK2 provides measurements in units of milliSiemens/metre (mS/m). The Siemen is the international unit of measurement for volume electrical conductance and is the equivalent to an Ampere/Volt.

The system provides two measurements, Quadrature (apparent conductivity) and In-phase data (metallic response) and soil conditions permitting has an effective operating depth of approximately 6.0m; the bulk of the conductivity response is derived from sediments at a depth range of 1-3m below ground level. The survey was targeted on those parts of the proposed development where deeply buried deposits of palaeoenvironmental and archaeological potential could be affected by deep construction impacts (primarily turbine base construction).

The data was digitally recorded and periodically down-loaded to a field computer for quality assurance and preliminary interpretation.

At the conclusion of the survey, the EM-31 data was interpreted and mapped using Surfer 3D version 10, a surface mapping software that allows the EM-31 data to be contoured, and presented in a fashion that will show and allow the interpretation of subsurface features.

Table 1: GPS coordinates defining the study areas [HA3]

Turbine Areas	Easting / Northing	Easting / Northing	Easting / Northing	Easting / Northing
1	474423.687/414033.326	474551.391/414026.984	474561.299/413882.255	474416.694/413888.71
2	474686.234/413597.729	474769.095/416479.766	474651.387/413396.587	474569.005/413514.097
3	474596.355/413250.885	474679.131/413132.503	474562.452/413050.127	474478.474/413167.239

4	474975.585/413220.696	475057.282/413103.206	474939.388/413020.307	474857.028/413137.407
5	472549.354/412990.668	475262.812/412901.998	475174.186/412788.599	475062.751/412875.639

GEOPHYSICAL SURVEY RESULTS-EM31

The survey conducted within the turbine micro-siting areas has benefited from relatively consistent ground conditions due to large areas being historically converted for agricultural use by the deliberate introduction of tidal sediments, known as 'warping' which has resulted in stable silt cover over surviving peat deposits and other natural geology.

The EM31 data is presented in illustrations 2, 3, 4, 5 and 6 and for the purpose of this report only the vertical dipole quadrature (apparent conductivity) data is displayed. The in-phase data (metallic response) proved inconclusive in the identification of any large metallic objects or areas of metallic disturbance or spread within the scope of the surveyed areas. The detail grid reports for both the quadrature data have been included in the results section as individual tables showing maximum and minimum levels of responses and the in-phase data has been included in Appendix 1 for reference purposes.

Turbine 1 (Illus 2)

Turbine Base 1 – Conductivity			
Count	X	Y	Z
Minimum:	640459.985	5942927.094	24.8
Maximum:	640512.635	5943002.542	30.2
Mean:	640478.190047	5942955.62214	27.8428562539

The EM31 vertical dipole quadrature data recorded within the Turbine 1 survey area displays a zone of higher conductivity concentrated towards the north-west corner of the survey area (B) ranging between 24.8 mS/m and 30.2 mS/m and dissipating towards the southwest. Zone B separates two areas of relatively low conductivity (A and C, 27mS/m)

Turbine 2 (Illus 3)

Turbine Base 2 – Conductivity			
Count	X	Y	Z
Minimum:	640700.676	5942502.313	22.18
Maximum:	640816.767	5942639.569	28.48
Mean:	640759.516935	5942569.72359	25.1731190584

The results of the data recorded within Turbine 2 span a constant range with a mean of 25.17mS/m, peaking between 22.18 mS/m and 28.48mS/m, (median 25.2mS/m), suggesting that the underlying landscape reflects a consistent zone of more resistant and presumably drier ground. These measurements are commensurate with high readings under other turbine bases.

Turbine 3 (Illus 4)

Turbine Base 3 – Conductivity			
Count	X	Y	Z
Minimum:	640556.238	5942108.933	23.6
Maximum:	640726.567	5942285.704	33.6
Mean:	640640.658892	5942194.71759	27.5226772837

The data collected from Turbine 3 had a minimum and maximum range of 23.6 mS/m to 33.6mS/m respectively with a mean average of 27.52mS/m. The survey results indicated the possible presence of a channel or wetter area running through F to G, with a possible interconnecting zone (H) forming a division between two areas of more resistant or drier ground represented by zones D and E.

Turbine 4 (Illus 5)

Turbine Base 4 – Conductivity			
Count	X	Y	Z
Minimum:	640910.481	5942065.992	23.23
Maximum:	641111.756	5942266.012	34.4
Mean:	641009.882449	5942166.9253	27.7871534057

The survey results from Turbine 4 revealed a possibly mixed landscape of more resistant or drier ground cut by depressed zones or areas of wetter ground. The data values range from an average minimum and maximum of 23.23mS/m to 34.4mS/m respectively with a mean average of 27.78mS/m similar to the other survey area average readings but comprising of a series of areas of high conductivity (K and L) forming a channel or wetter area containing a zone of very high conductivity (M) at the south west corner of the survey area. A zone of higher conductivity (N) possibly forms a curving depression running between zones L and M, intersecting the areas of more resistant or drier ground I and J. The areas of more resistant or drier ground (I and J) are poorly defined possibly indicating movement in the water table while towards the north-west of zone A; zone O forms an area of higher conductivity and possibly wetter ground that constrains zone I into a spit of more resistant or drier ground between O, L and K.

Turbine 5 (Illus 6)

Turbine Base 5 – Conductivity			
Count	X	Y	Z
Minimum:	641122.693	5941835.979	19
Maximum:	641264.282	5941973.86	26
Mean:	641191.284481	5941905.01425	22.5983404711

The survey results from Turbine 5 indicate a landscape of more resistant or drier ground (P and Q) subdivided by a large linear anomaly (S) aligned approximately north south with a large zone of depression or extremely wet ground (R) located towards the eastern edge of the survey area. The result of the survey data range from a maximum of 26.0mS/m in zones S to a minimum of 19.0mS/m within zone Q, with a mean average of 22.59mS/m.

INTERPRETATION

Turbine 1 (Illus 2)

The results from turbine base 1 can be interpreted as showing an area of high or drier ground (A) located in the south west part of the surveyed area and along the northern edge (C) separated by a zone of wetter ground (B), or segment of channel.

Turbine 2 (Illus 3)

Within the area of the survey conducted at turbine base 2 the results suggest that the underlying landscape remains relatively consistent and forms a large area of undisturbed or higher and subsequently drier ground.

Turbine 3 (Illus 4)

The results have suggested the possible presence of a channel or wetter area running through F to G along the northern edge of the survey area which is commensurate with other channel type anomalies observed elsewhere.

An area of relatively high conductivity (H), which could represent a small channel, divides two areas of lower conductivity, represented by zones D and E, which could represent drier ground.

Turbine 4 (Illus 5)

Within the survey area for Turbine 4 the survey produced a relatively mixed group of data in comparison to the other surveyed areas. Here more resistant zones are cut by zones or areas of conductive ground, with a potential for a warping or drainage channel (N). The zones of lower conductivity represented by areas I and J are relatively small and irregular in shape suggesting irregularities in sub-surface conditions. This could be topographical or variation in the nature of the deposits.

Turbine 5 (Illus 6)

The results from the survey have identified a broad area (P, Q) of stable higher resistant readings subdivided by a conductive linear anomaly (S) aligned north south across the survey area, suggesting a linear channel. No visible indication of this anomaly was observed on the surface during the geophysical survey. Located towards the east corner of the surveyed area an area of high conductivity occurs at anomaly R, suggesting the presence of an area of thicker peat.

CONCLUSION

Headland Archaeology (UK) Ltd was commissioned to conduct a geophysical survey, within the proposed construction footprint of five turbine locations in order to assist in the characterisation of the buried subsurface topography. The results demonstrate variations in deposit conductivity across the survey areas that may be consistent with the presence of underlying peat and alluvial deposits of varying thickness. If present, this variation could be caused by processes such as peat cutting affecting the upper surface of the peat; or by variation in the level of the sub-peat topography. However, the conductivity results are the product of the whole depth of measurement of the instrument and it is not possible to determine the extent to which varying peat thickness has influenced the results without ground-truthing of the survey areas.

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Geoarchaeology: Using Earth Sciences to Understand the Archaeological Record, English Heritage (2007)

Geophysical survey in archaeological field evaluation, English Heritage (2008).

PPS 5 Planning for the Historic Environment: Historic Environment Planning Practice Guide (2010)

IfA Standards and Guidance for archaeological field evaluation (revised October 2008).

APPENDIX 1

Turbine Base 1 – Phase

Turbine Base 1 – Phase			
Count	X	Y	Z
Minimum:	640459.985	5942927.094	-0.7
Maximum:	640512.635	5943002.542	0.74
Mean:	640478.190047	5942955.62214	-0.0740385812072

Turbine Base 2 – Phase

Turbine Base 2 – Phase			
Count	X	Y	Z
Minimum:	640700.676	5942502.313	-0.26
Maximum:	640816.767	5942639.569	0.37
Mean:	640759.516935	5942569.72359	0.0499207786329

Turbine Base 3 – Phase

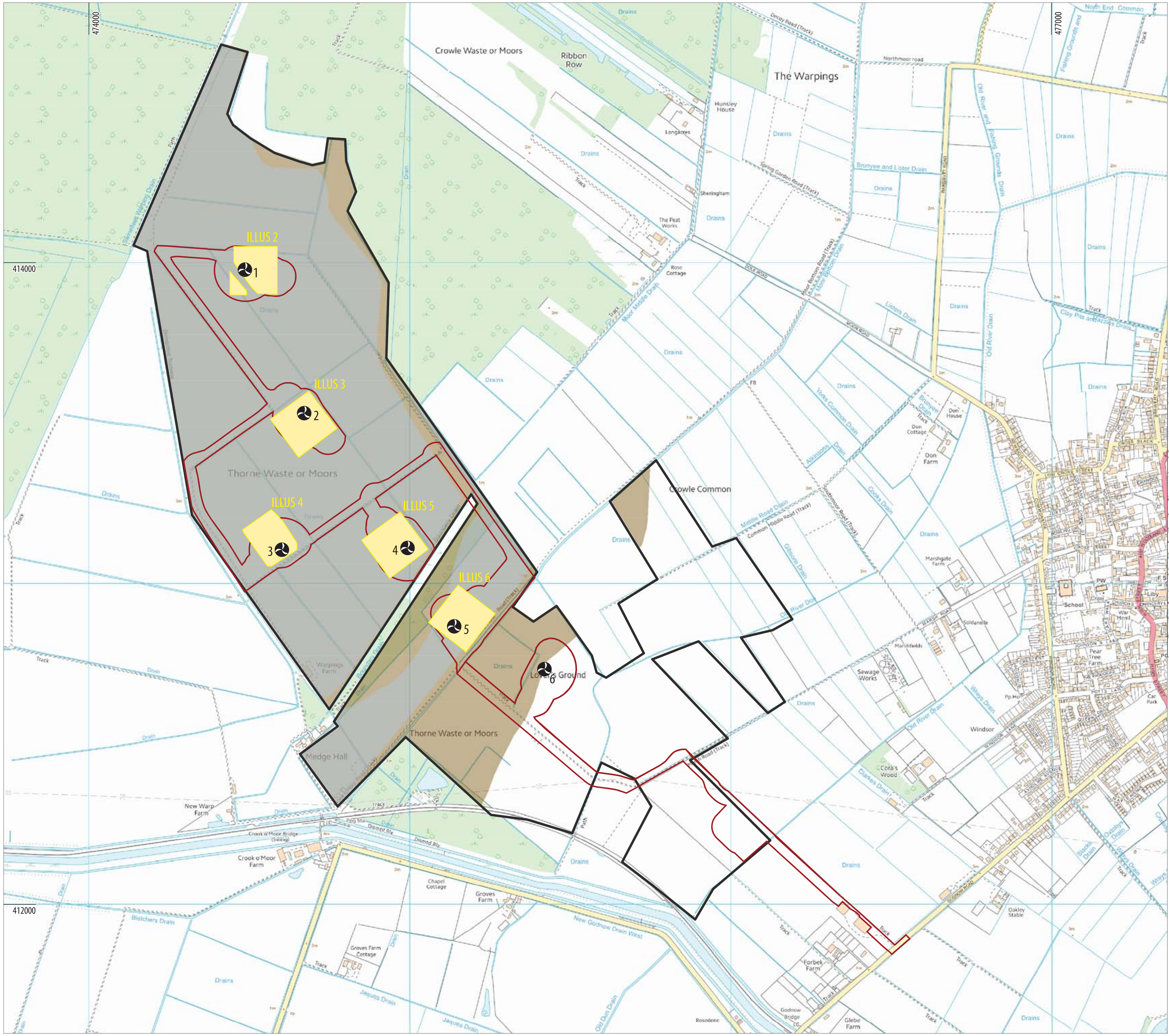
Turbine Base 3 – Phase			
Count	X	Y	Z
Minimum:	640556.238	5942108.933	-0.11
Maximum:	640726.567	5942285.704	0.69
Mean:	640640.658892	5942194.71759	0.104896834936

Turbine Base 4 – Phase

Turbine Base 4 – Phase			
Count	X	Y	Z
Minimum:	640910.481	5942065.992	23.23
Maximum:	641111.756	5942266.012	34.4
Mean:	641009.882449	5942166.9253	27.7871534057

Turbine Base 5 – Phase

Turbine Base 5 – Phase			
Count	X	Y	Z
Minimum:	641122.693	5941835.979	-0.18
Maximum:	641264.282	5941973.86	1.01
Mean:	641191.284481	5941905.01425	0.0256595289079



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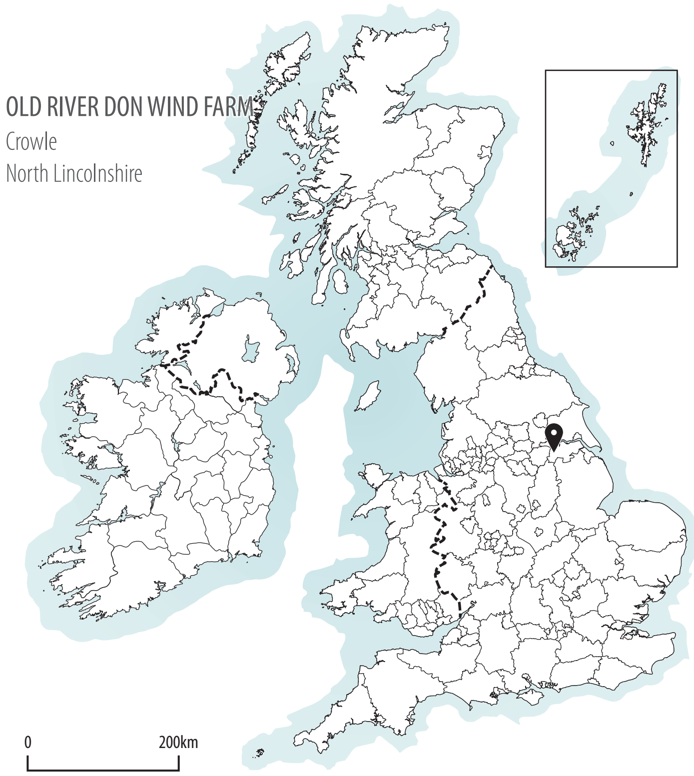

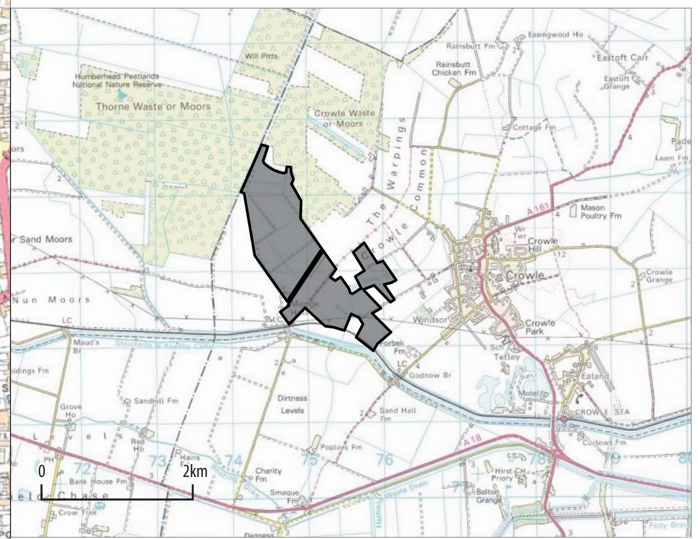

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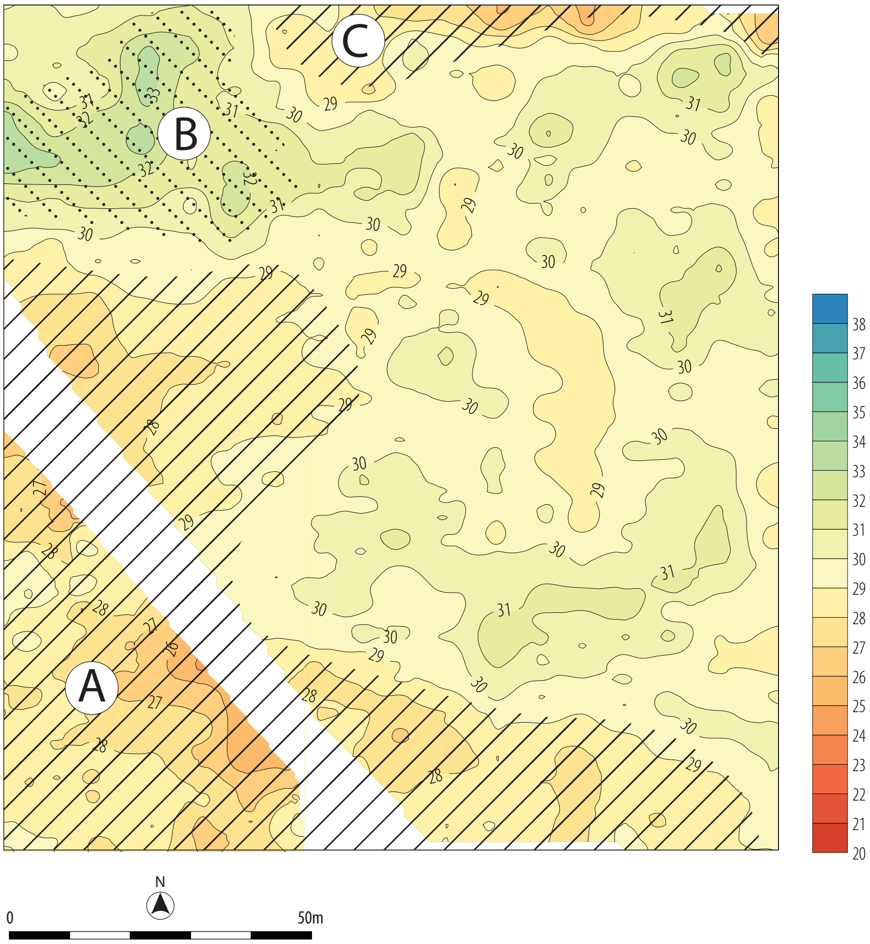
KEY
- application boundary
- inner study area
- proposed turbine location
- survey area

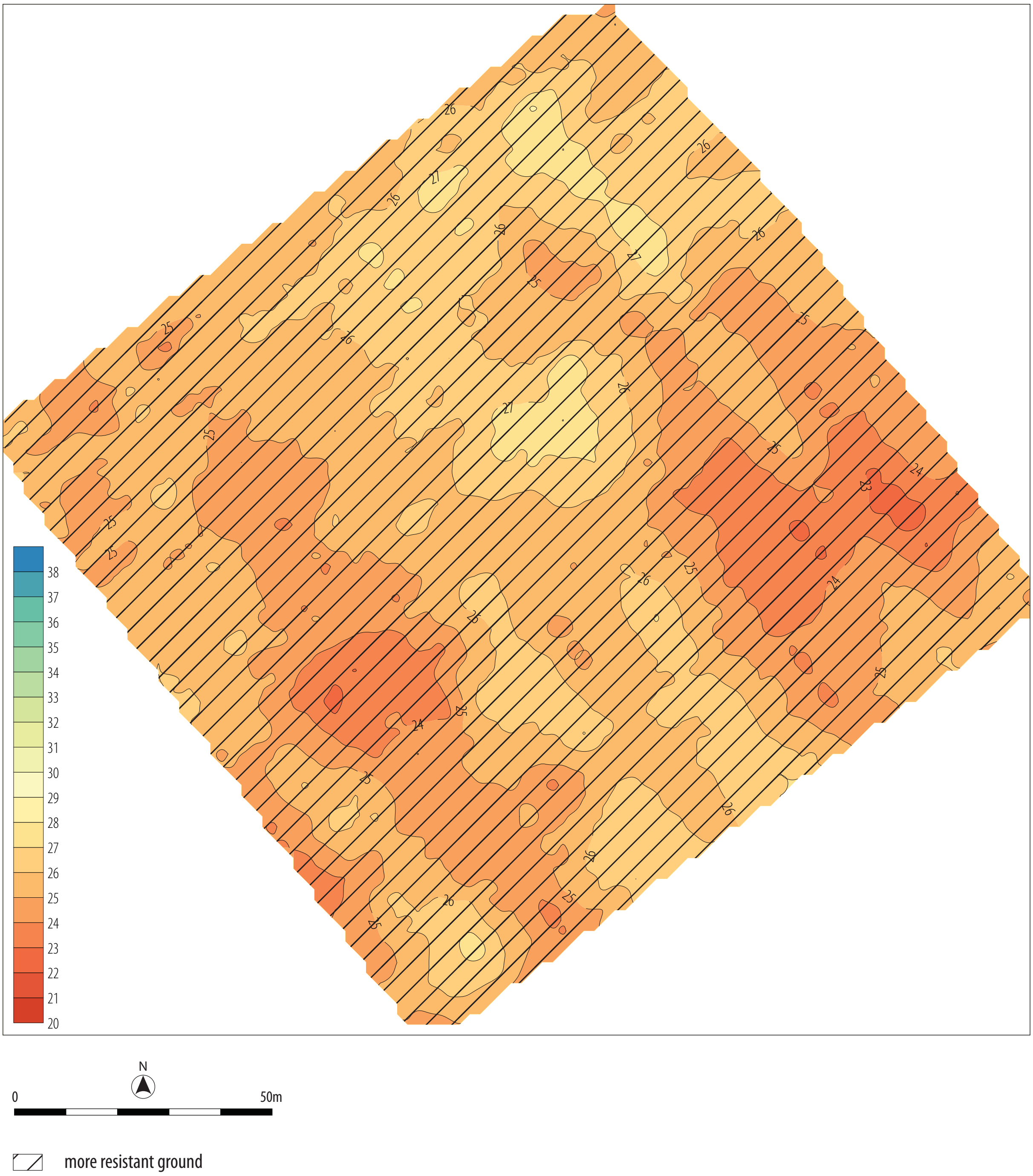
N
0 500m
scale 1:12,500 @ A3

ILLUS 1
Site location



zone of higher conductive response
more resistant ground

ILLUS 2
Turbine 1



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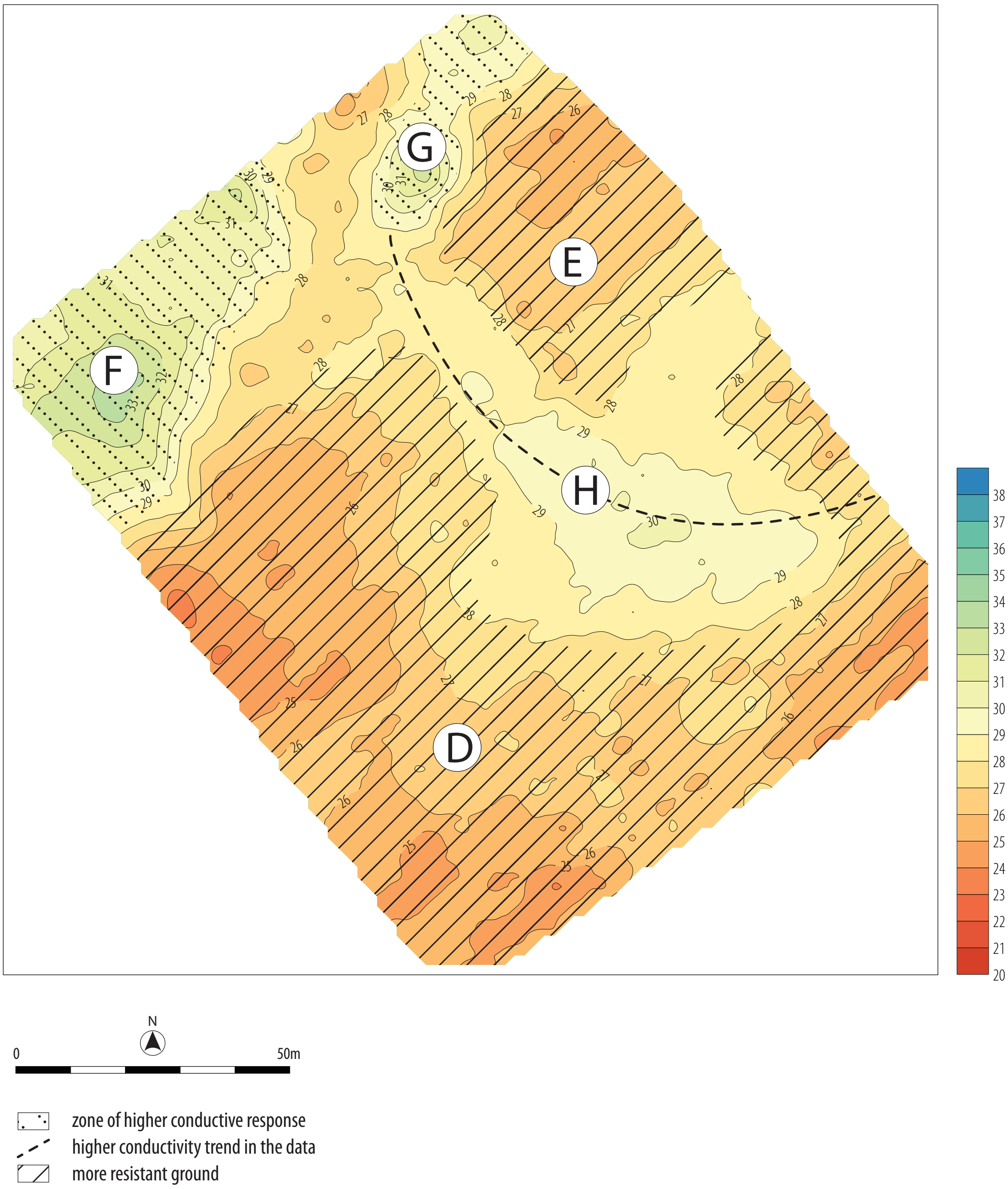
Turbine 2



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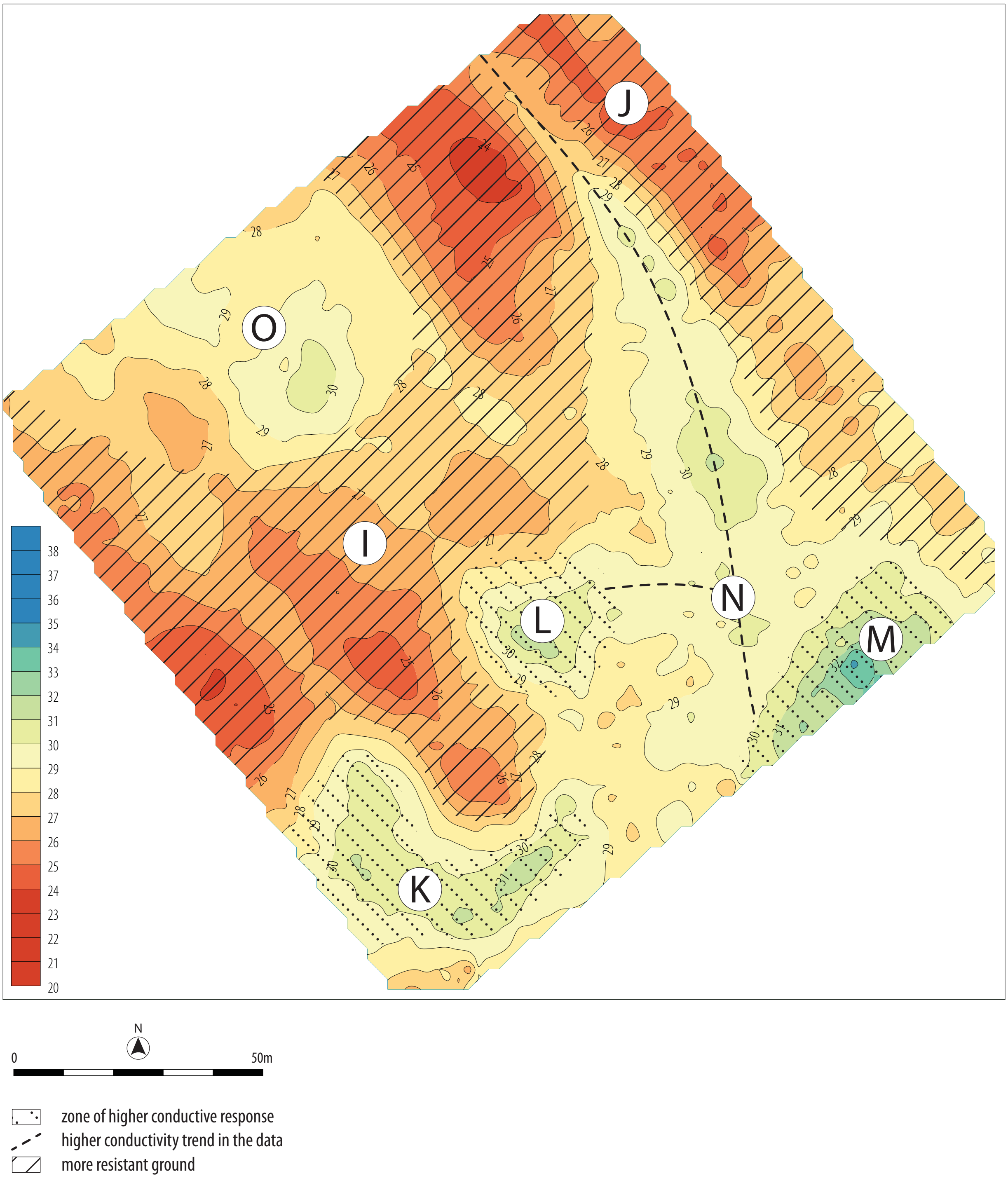
Turbine 3



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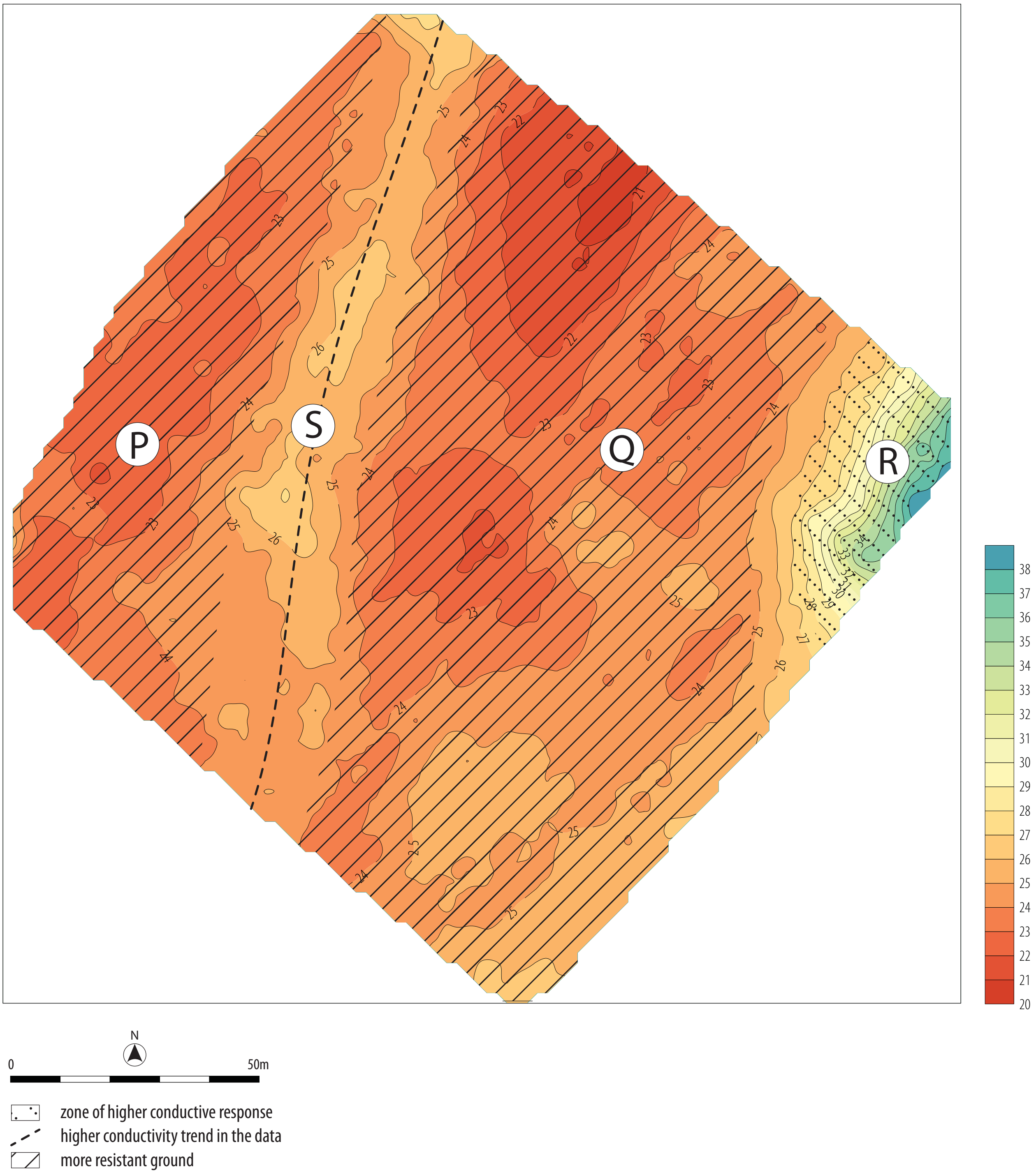
Turbine 4



ILLUS 6
Turbine 5

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