Substrata
Archaeological Geophysical Surveyors

An archaeological gradiometer survey

Land at Pond Farm proposed turbine site Bodham, Norfolk

Ordnance Survey (E/N): 613970,338220 (point)

Report: 131129
Ross Dean BSc MSc MA MIfA
24 April 2014

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1 Survey description and summary

Type of survey: twin-sensor fluxgate gradiometer
Date of survey: 15 November 2013
Area surveyed: 0.8ha.
Lead surveyor: Ross Dean BSc MSc MA MIfA

Client
Genatec Ltd, Highland Farm, West Beckham, Holt, Norfolk, NR25 6PL

Planning application summary

Site:	Land at Pond Farm, Bodham
District:	North Norfolk
County:	Norfolk
Nearest Post Code:	NR25 6PL
NGR:	TG 139 382 (point)
Ordnance Survey (E/N):	613970,338220 (point)
Planning reference:	pre-planning
Proposal:	wind turbine and access track
Senior Historic Environment Officer: (Planning):	Ken Hamilton PhD MIfA
Agent:	David Mack, Development Manager, Genatec Ltd, Highland Farm, West Beckham, Holt, Norfolk, NR25 6PL
Archive:	At the time of writing, the archive of this survey will be held by Substrata.
OASIS entry:	substrat1-117691

Summary
This report was commissioned by Genatec Ltd and prepared by Substrata as supporting information for a forthcoming planning application concerning the development of a wind turbine at the above site. The work comprised a field survey by geophysical prospection to determine the extent and significance of subsurface features across the areas under consideration for the construction of an access track, turbine base, substation base and crane platform. The location of the site is shown in figure 5, appendix 1.

As shown in figure 4, appendix 1, not all of the area designated for development could be surveyed, although the base of the turbine and much of the proposed access route were surveyed. Mud and deep tyre ruts prevented surveying around the proposed turning area at the eastern end of the site while the proximity of a telecommunications mast and wire fencing precluded survey at the western end of the site.

The magnetic contrast across the survey areas, while low, was sufficient to be able to differentiate between anomalies representing possible archaeological features and background magnetic responses. With the level of response found on this site, it is likely that most of the larger features will be recorded in the data set but some deeply buried or relatively small potential features such as post-holes, may be missed.

One linear magnetic anomaly group, one irregular group and a dispersed group of three oval anomalies were identified as pertaining to potential archaeology. A natural origin for each group could not be ruled out.

2 Survey aims and objectives

Field boundary changes have been recorded on historical maps, aerial photographs and Google Earth images as discussed below in section 5. These aside, there is a lack of evidence for Prehistorical and Historical activities within the survey area itself. There is, however, evidence for archaeological deposits and finds from a broad range of periods within an approximate 1000m radius of the area. With these conditions in mind, the survey was designed to account for a potentially wide range of archaeological deposits and activities.

Within the revised framework for East Anglian Archaeology there is a call for the further development of GIS as a tool for interpreting landscape trends (Medlycott, 2011: 85, 88). The project was based around a GIS at all stages and the GIS in conjunction with the report comprised the main deliverable.

Aims

1. To cost-efficiently provide a prospection survey to record evidence for the extent and significance of subsurface features.
2. Produce a report containing the geophysical data and the data in interpreted form.
3. Provide the survey data, an assessment of the archaeological character of the recorded anomaly patterns, and accurate positional information so as to inform any further archaeological assessment of the site.

Objectives

1. Complete a gradiometer survey across the survey area at a traverse interval of 1m and a sample interval of 0.25m.
2. Identify any magnetic anomalies that may be related to archaeological deposits, structures or artefacts.
3. Within the limits of the techniques and dataset, archaeologically characterise any such anomalies or patterns of anomalies.
4. Accurately record the location of the identified anomalies.
5. Produce a GIS project with a fully populated database of identified anomalies pertaining to potential archaeological deposits and activities.
6. Produce a report based on the survey and GIS project that is sufficiently detailed to inform any subsequent development on the site about the location and possible archaeological character of the recorded anomalies.

3 Standards

All works will be carried out in full accordance with the appropriate sections of Gurney (2003). The data archive will be prepared in accordance with Archaeology Data Service (undated), formerly available as Schmidt et al, 2001.

In addition, Substrata uses standards and codes of practice produced by the Institute for Archaeologists (2011, 2008, 2009). The document text was written using the house style of the Institute for Archaeologists (Institute for Archaeologists, undated).

4 Site description

Landscape

The survey area comprised part of a field situated southeast of the village of Bodham, North Norfolk. The survey area lies at the southern boundary of the field between approximately 95.5m and 89m O.D. on the eastern slope of Bodham Hill, the second highest hill in North Norfolk, which rises to 98m O.D. (figure 4). The survey area is bounded on three sides by the field and on the southern side by a field boundary of hedges and wire fencing.

Land use at the time of the survey

Cut and removed crops.

Geology

The site is located on a solid geology of the Pre-Pastonian Age (Early Pleistocene) to Cromerian Age (Middle Pleistocene) Wroxham Crag Formation which comprises a sheet of interbedded gravels, sands, silts and clays. The gravels are dominated by flint (up to c.80%) and by quartz and quartzite (up to c.60%), with far-travelled minor lithogies including Carboniferous chert, Rhaxella chert, Greensand chert, Spilsby Sandstone and felsic volcanic rocks from North Wales. The deposits are interpreted as estuarine and near-shore marine (British Geological Survey, undated).

The superficial geology is comprises the Pleistocene Briton's Lane Sand and Gravel Member of the Briton's Lane Formation which consists of horizontal, massive and low angle planar cross-bedded gravels and cobble gravels with thin seams of horizontal and rippled sand. The lithology has a distinctive high flint content (c.85-89%) of which the majority is of non-chatter marked variety (c.78-85%). The gravels also contain a wide range of far-travelled crystalline erratics including rocks of British and Scandinavian provenance (ibid).

5 Archaeological background

An archaeological desk-based assessment was conducted for Genatec Limited by NPS Archaeology in February 2013 (Sillwood, 2013) in order to appraise the archaeological impact of the creation of a solar farm in the same field as that of the proposed development site. While the conclusions of this assessment were that there was a reasonably low potential for archaeological remains of any date to be present within the proposed solar farm development (Sillwood, 2013: 25), there are a number of Historic Environment Record entries within a 1000m radius of the field as discussed below. These, by their nature and location, imply that the survey area may lie within an area of archaeological potential and that the impact of the development on the significance of heritage assets (both known and as yet undiscovered) cannot be determined by desk-based assessment alone.

This section is a summary of the desk based assessment in relation to the geophysical survey.

The site is located close to one of the highest elevations in Norfolk (second only to Beacon Hill, which is located nearby in north Norfolk).

Prehistoric evidence

Fifteen sites containing prehistoric evidence are recorded in the Norfolk Historical Environment Record (NHER) within a 1000m radius of the field in which the survey was undertaken. There are none within the survey area or in the immediately adjacent fields although there is cropmark evidence for a possible Prehistoric henge or ring ditch approximately 600m to the northeast of the field centre. The area has evidence for several possible Bronze Age funerary monuments in the form of round barrows, the nearest being some 425m to the north of the field. Sillwood suggests that there is unlikely to be much Prehistoric settlement evidence or activity near the top of Bodham Hill itself (ibid: 1, 5-7, 9).

Roman evidence

Fourteen sites containing Roman evidence are recorded in the NHER within a 1000m radius of the field. There are none within the survey area or in the immediately adjacent fields. The focus of Roman activity in the area appears to be located to the southwest of the field, with evidence for settlement recorded here during evaluation and excavation of part of the route of the on-shore pipeline from Sheringham Shoal wind farm. It should be noted that this apparent distribution of activity may simply reflect the pattern of archaeological investigations in the area (ibid: 1, 8 - 10).

Anglo-Saxon evidence

Fieldwalking south-west of the survey area, conducted as part of the Sheringham Shoal pipeline route assessment, uncovered some late Anglo-Saxon pottery. Otherwise, there is no evidence of Anglo-Saxon activity within a 1000m radius of the field. A set of Middle Saxon tweezers (or a page turner) more usually associated with site of ecclesiastical learning and literacy, were found on the Sheringham Shoal pipeline route. The object is important as its inscription contains a previously unknown character from the runic alphabet. The find was unstratified but could be an indication of a Middle Saxon ecclesiastical presence in the area (ibid: 1, 10 - 12).

Medieval evidence

Twelve records of Medieval activity lie within the 1000m radius search area. Two of these, the result of metal detecting and each containing metal assemblages, lie relatively close to the field in adjacent fields to the northwest. Medieval activity within the area of the proposed solar farm is most likely to have been predominantly agricultural, with mainly finds of this date recorded

in the area, and little known occupational activity (ibid: 1, 11 - 14).

Post-medieval evidence

Twenty sites were recorded within the 1000m radius study area around the field. Two are the adjacent metal detection finds sites discussed above and contain a variety of Post-medieval finds including coins. A Post-medieval coin and lead weight were also found approximately 260m to the southwest of the field. Post-medieval activity within the area of the field is most likely to have been predominantly agricultural, with mainly finds of this date recorded in the area, and little known occupational activity (ibid: 1, 13 - 15).

Second World War evidence

Second World War defences had an impact along the north Norfolk coast; there are examples outside of the field but nothing is recorded within the boundary of the site itself.

Cartographic and Aerial Photography evidence

The earliest map, Faden's 1797 map of Norfolk, does not provide significant detail within the study area to facilitate analysis except to say that the field was apparently under open field cultivation at the time. A collection of buildings recorded to the west of the field may be Pond Farm as recorded on later maps. New Road, now on the western boundary of the field was not recorded on this map. By the publication of the 1810 Enclosure Map, New Road is recorded along with many field boundaries, roads and other features that are extant today. Bryant's 1826 map of Norfolk records the name "Mill Hill" close to the survey area which implies an unmapped nearby mill at one time. The 1842 tithe map of Bodham shows the site overlying four fields with Mill Hill to the south of the survey area.

Aerial photograph evidence shows that in 1946 there was a small rounded area separated off from the field to the south but that this area was no longer apparent in 1988.

6 Results, discussion and conclusions

This survey was designed to record magnetic anomalies. The anomalies themselves cannot be regarded as actual archaeological features and the dimensions of the anomalies shown do not represent the dimensions of any associated archaeological features. The analysis presented below attempts to identify and characterise anomalies and anomaly groups that may pertain to archaeological deposits and structures.

The reader is referred to section 4.

6.1 Results

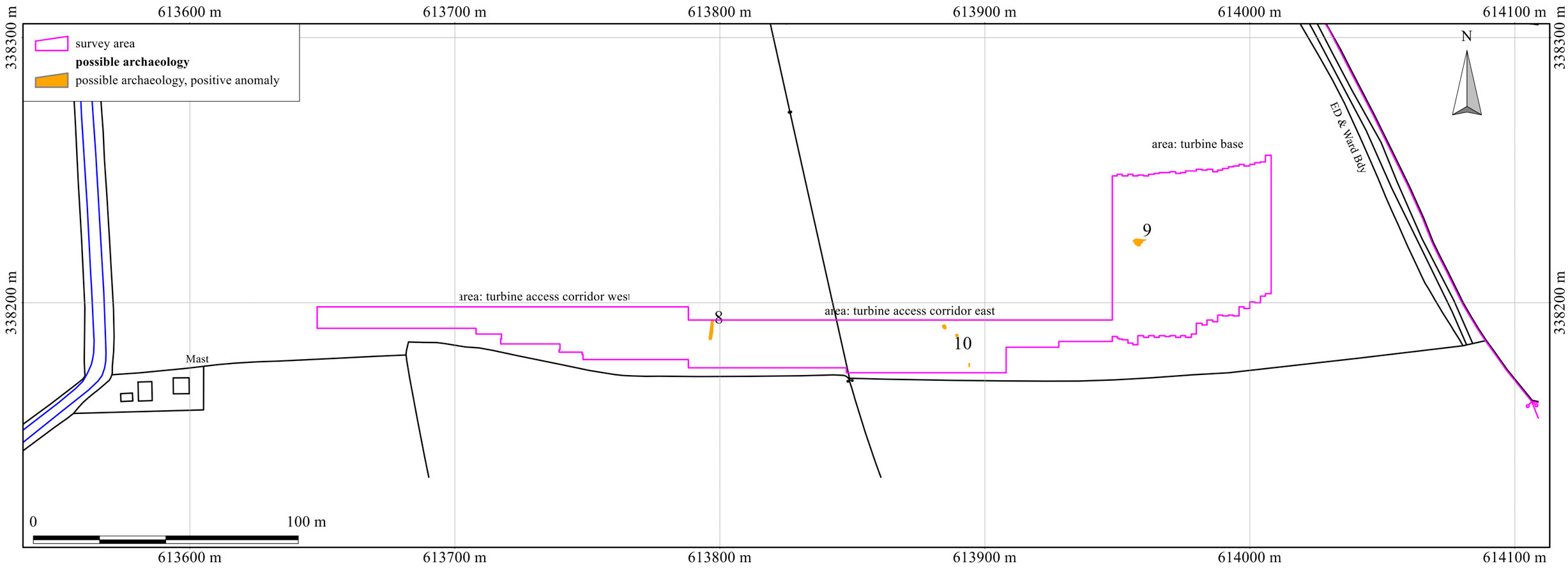
Figure 1 (this section) shows the interpretation of the survey across all survey areas and the following is an extract from a detailed analysis of the survey data provided in the attribute tables of the GIS project on the accompanying CD-ROM.

Group: 8
Class: possible archaeology, positive magnetic anomaly
Form: linear
Comments: anomaly group has a linear pattern indicative of man-made and possibly archaeological deposits. In this case, the group was isolated in the data set and cannot be characterised further. A natural origin can not be ruled out.

Group: 9
Class: possible archaeology, positive magnetic anomaly
Form: irregular
Comments: anomaly group represents deposits disturbed by relatively recent ploughing; a filled hollow is likely but the archaeological provenance is uncertain.

Group: 10
Class: possible archaeology, positive magnetic anomaly
Form: oval
Comments: anomaly groups represent filled hollows but the archaeological provenance is uncertain.

Plots of the processed data are provided in figures 2 and 3, appendix 1.



British Grid
centre X: 613825.10 m, centre Y: 338206.49 m

Scale: 1:1500 @ A3. Spatial Units: Meter. Do not scale off this drawing

Notes:
1. All interpretations are provisional and represent potential archaeological deposits.
2. Anomalies designated "likely archaeology" have supporting evidence e.g. historical maps and or visible earthworks.
3. Anomalies likely to represent geological or other natural deposits are not mapped unless relevant to potential archaeological structures or deposits.

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Figure 1: survey interpretation

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6.2 Discussion

Refer to figures 1 (this section), 2 and 3 (appendix 1).

Not all anomalies or anomaly groups identified in the survey dataset are necessarily discussed below. All identified anomaly groups are recorded in the GIS project on the accompanying CD-ROM. Those anomaly groups possibly representing archaeological deposits are included in data analysis table 1.

General points
Trends in the data running approximately east-west are related to relatively recent ploughing (figures 2 and 3).

There is a broad, diffuse anomaly group trending approximately northeast-southwest at the eastern end of the survey area (figure 2). It is likely to represent a natural deposit such as a palaeochannel.

There is one relatively large positive anomaly group on the line of a power cable at the southern boundary of the survey area (figures 2 and 3). This anomaly pattern is likely to reflect modern ferrous materials adjacent to the field boundary and associated with the power cable.

As can be seen in figure 4, not all of the area designated for development could be surveyed, although the base of the turbine and much of the proposed access route were surveyed. Mud and deep tyre ruts prevented surveying around the proposed turning area at the eastern end of the site while the proximity of a telecommunications mast and wire fencing precluded survey at the western side of the site.

Data related to historical maps and other records
No anomaly groups were associated with features recorded on historical maps or in other records.

Data with no previous provenance
Anomaly group **8** has a linear pattern indicative of man-made and possibly archaeological deposits. In this case, the group was isolated in the data set and cannot be characterised further. A natural origin could not be ruled out.

Group **9** represents deposits, probably a filled hollow, disturbed by relatively recent ploughing. The archaeological provenance is uncertain; possible origins include (as examples) a natural filled hollow, a sink hole or a large archaeological pit.

Group **10** is likely to represents three filled hollows. While an archaeological origin such as former pits or large postholes cannot be ruled out, no obvious pattern is discernable and so it is equally possible that the anomalies represent natural features.

6.3 Conclusions

The magnetic contrast across the survey areas, while low, was sufficient to be able to differentiate between anomalies representing possible archaeological features and background magnetic responses. With the level of response found on this site, it is likely that most of the larger features will be recorded in the data set but some deeply buried or relatively small potential features such as post-holes, may be missed.

One linear magnetic anomaly group, one irregular group and a dispersed group of three oval anomalies were identified as pertaining to potential archaeology. A natural origin for each group could not be ruled out.

7 Disclaimer and copyright

The description and discussion of the results presented in this report are the authors, based on his interpretation of the survey data. Every effort has been made to provide accurate descriptions and interpretations of the geophysical data set. The nature of archaeological geophysical surveying is such that interpretations based on geophysical data, while informative, can only be provisional. Geophysical surveys are a cost-effective early step in the multi-phase process that is archaeology. The evaluation programme of which this survey is part may also be informed by other archaeological assessment work and analysis. It must be presumed that more archaeological features will be evaluated than those specified in this report.

8 Acknowledgements

Substrata would like to thank David Mack, Development Manager, Genatec Ltd, for commissioning us to complete this survey.

9 Bibliography

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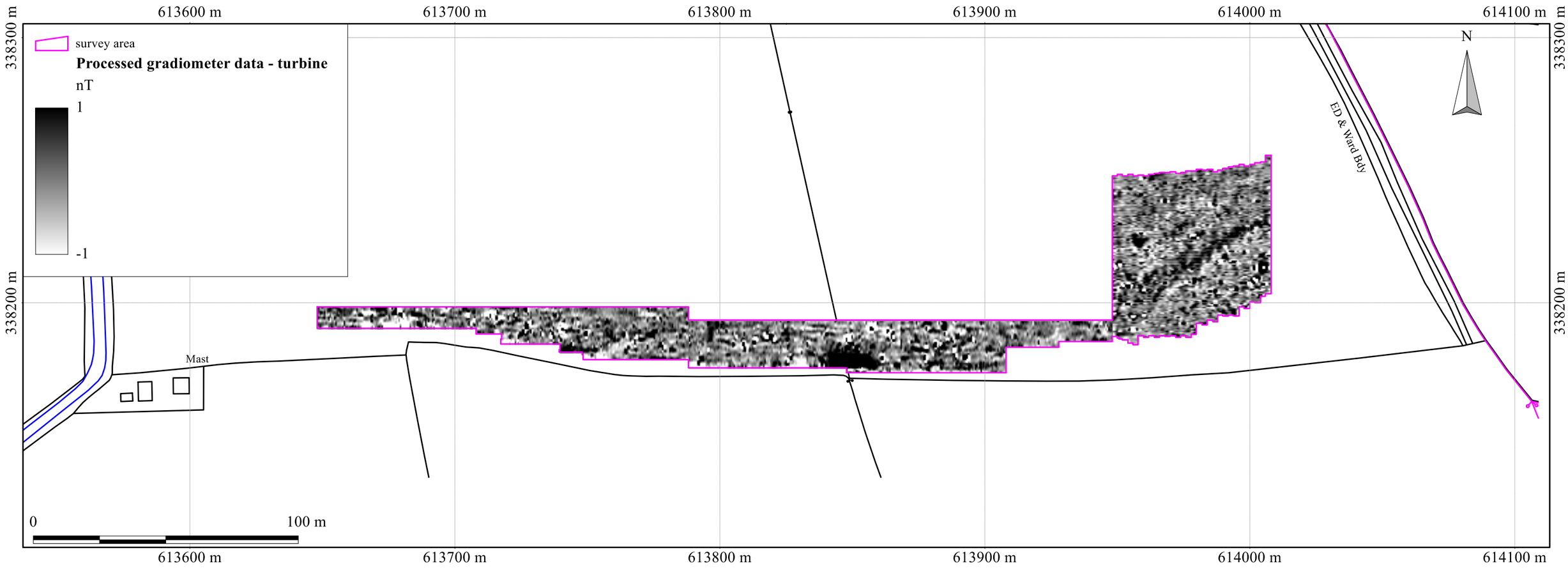
Appendix 1 Supporting plots

General Guidance

The anomalies represented in the survey plots provided in this appendix are magnetic anomalies. The apparent size of such anomalies and anomaly patterns are unlikely to correspond exactly with the dimensions of any associated archaeological features.

A rough rule for interpreting magnetic anomalies is that the width of an anomaly at half its maximum reading is equal to the width of the buried feature, or its depth if this is greater (Clark, 2000: 83). Caution must be applied when using this rule as it depends on the anomalies being clearly identifiable and distinct from adjacent anomalies. In northern latitudes the position of the maximum of a magnetic anomaly will be displaced slightly to the south of any associated physical feature.



British Grid
centre X: 613825.10 m, centre Y: 338206.49 m

Scale: 1:1500 @ A3. Spatial Units: Meter. Do not scale off this drawing

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Figure 2: shade plot of processed data

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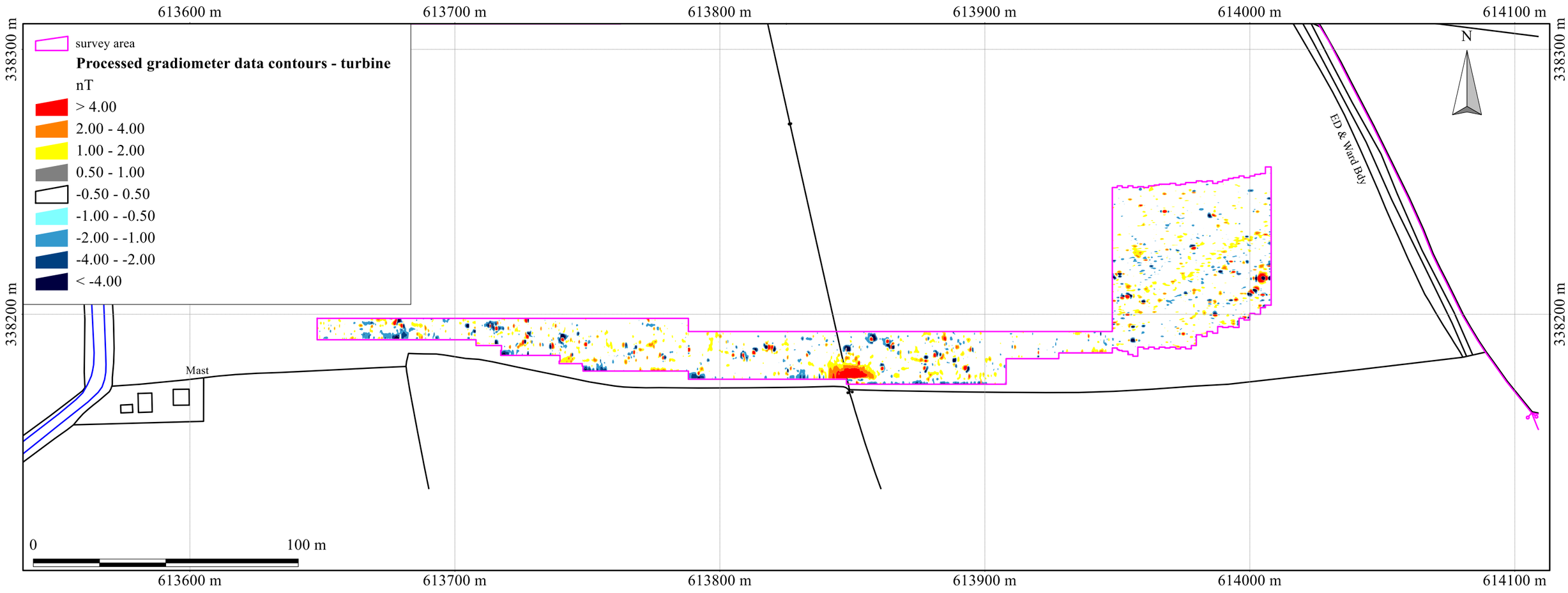

British Grid
centre X: 613825.10 m, centre Y: 338206.49 m

Scale: 1:1500 @ A3. Spatial Units: Meter. Do not scale off this drawing

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Figure 3: contour plot of processed data

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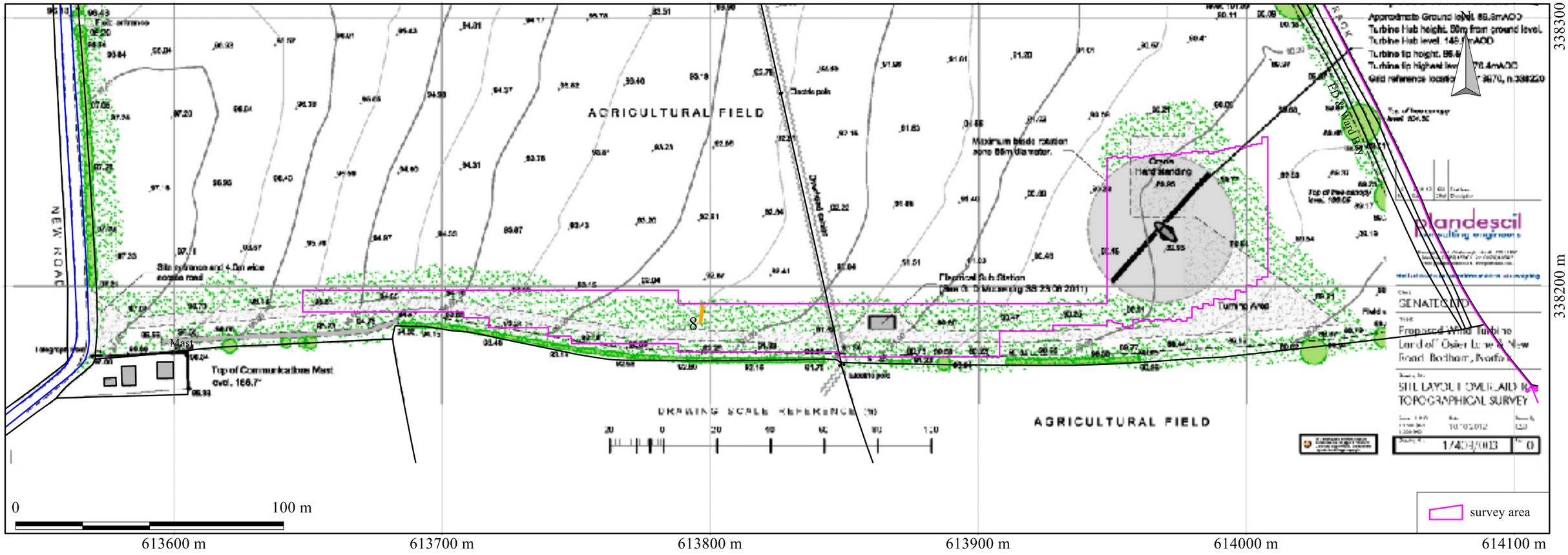

British Grid
centre X: 613825.10 m, centre Y: 338206.49 m

Scale: 1:1500 @ A3. Spatial Units: Meter. Do not scale off this drawing

Figure 4: survey area with the proposed turbine layout

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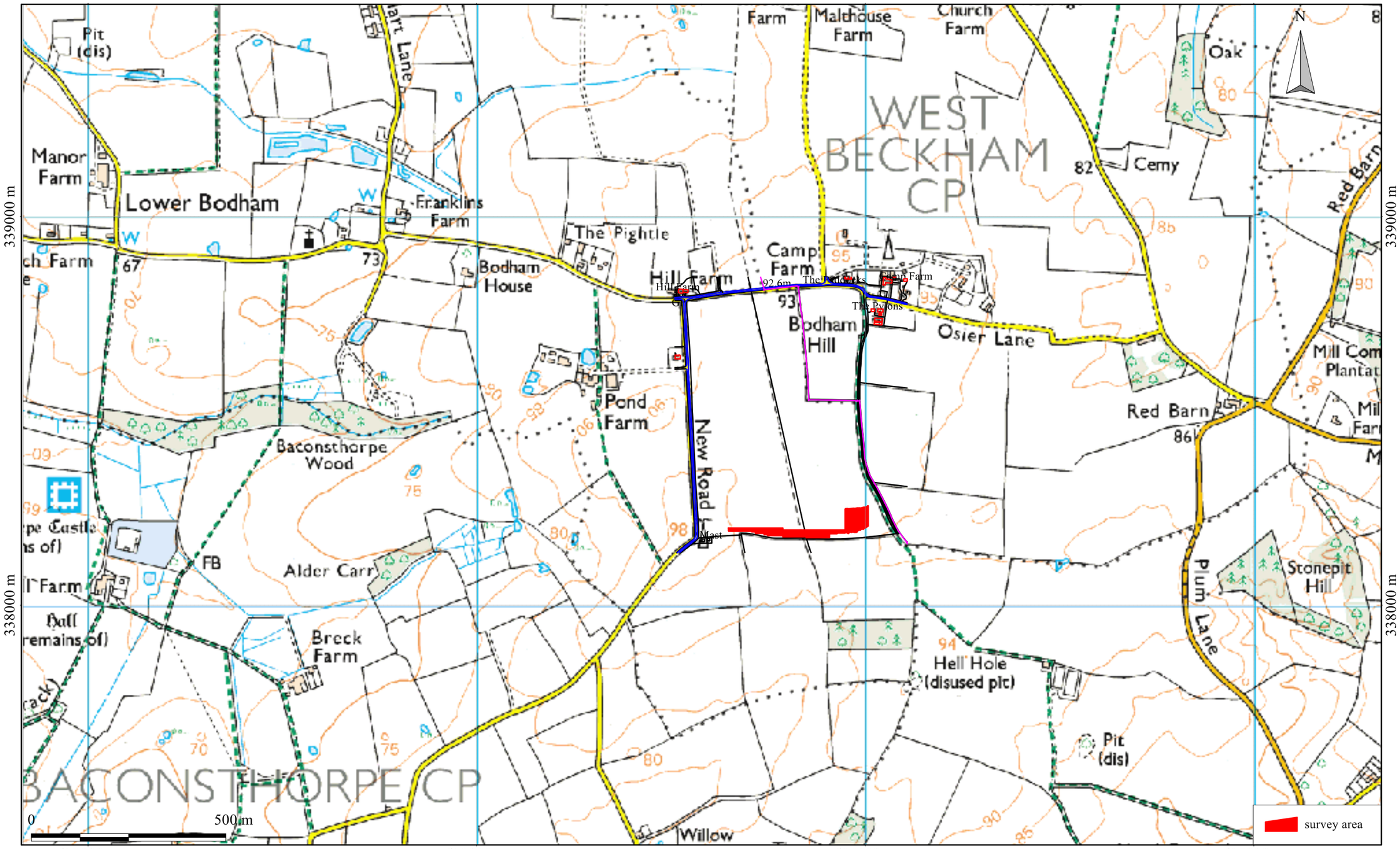

British Grid
centre X: 613578.25 m, centre Y: 338464.48 m

Scale: 1:10000 @ A3. Spatial Units: Meter. Do not scale off this drawing

An archaeological gradiometer survey
Land at Pond Farm turbine site, Bodham, Norfolk
Ordnance Survey (E/N): 613650,338500 (point)
Report 140328

Figure 5: location map

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Appendix 2 Methodology Summary

Table 1: methodology summary	
Documents Survey methodology: Dean (2013)	
Methodology 1. All works were carried out in full accordance with the appropriate sections of Gurney (2003). The data archive was prepared in accordance with Archaeology Data Service (undated), formerly available as Schmidt et al, 2001. 2. The geophysical (gradiometer) survey was undertaken with reference to standard guidance provided by the Institute for Archaeologists (2011) and Archaeology Data Service/Digital Antiquity Guides (undated). 3. The survey grid location information and grid plan was recorded as part of the project in a Manifold GIS system. 4. Data processing was undertaken using appropriate software, with all anomalies being digitised and geo-referenced. The final report included a graphical and textual account of the techniques undertaken, the data obtained and an archaeological interpretation of that data and conclusions about any likely archaeology.	
Grid *Method of Fixing:* DGPS set-out using pre-planned survey grids and Ordnance Survey coordinates. *Composition:* 30m by 30m grids across the turbine base, turning area and crane base. 20m by 20m grids across the access track. *Recording:* Geo-referenced and recorded using digital map tiles. *DGPS used:* Spectra Precision PM5V2 GPS with external antenna and survey pole and DigiTerra Explorer 7 as the survey control program.	
Equipment *Instrument:* Bartington Instruments grad601-2 *Firmware:* version 6.1	**Data Capture** *Sample Interval:* 0.25-metres *Traverse Interval:* 1 metre *Traverse Method:* zigzag *Traverse Orientation:* turbine base: GN0 access corridor: GN90
Data Processing, Analysis and Presentation Software DigiTerra Explorer 7 IntelliCAD Technology Consortium IntelliCAD 7.2 DW Consulting TerraSurveyor3 Manifold System 8 GIS Microsoft Corp. Office Excel 2013 Microsoft Corp. Office Publisher 2013 Adobe Systems Inc Adobe Acrobat 9 Pro Extended	

Appendix 3 Data processing

Table 2: gradiometer survey - processed data metadata (see figure 1 for survey areas)	
SITE Instrument Type: Bartington Grad 610 Units: nT Direction of 1st Traverse: 0 deg Collection Method: ZigZag Sensors: 2 @ 1.00 m spacing. Dummy Value: 32702 PROGRAM Name: TerraSurveyor Version: 3.0.22.1	
<u>Turbine base</u> Stats Max: 158.12 Min: -157.83 Std Dev: 2.75 Mean: 0.08 Median: 0.00	Processes: 5 1 Base Layer 2 Move (Area: Top 0, Left 0, Bottom 1, Right 65) to X 54, Y 0 3 Clip at 4.00 SD 4 De Stagger: Grids: All Mode: Both By: -2 intervals 5 DeStripe Median Sensors: All Note: exporting the processed data from TerraSurveyor into Manifold GIS for analysis imposes an 'x matches y' interpolation on the data which is reflected in the processed data figures.
<u>Turbine access corridor west</u> Stats Max: 10.55 Min: -10.41 Std Dev: 1.36 Mean: 0.03 Median: 0.00	Processes: 7 1 Base Layer 2 Search & Replace From: -3000 To: 3000 With: Dummy (Area: Top 17, Left 319, Bottom 19, Right 400) 3 Search & Replace From: -3000 To: 3000 With: Dummy (Area: Top 8, Left 0, Bottom 16, Right 240) 4 Clip at 4.00 SD 5 DeStripe Median Sensors: All 6 De Stagger: Grids: All Mode: Both By: -1 intervals 7 Clip at 4.00 SD Note: exporting the processed data from TerraSurveyor into Manifold GIS for analysis imposes an 'x matches y' interpolation on the data which is reflected in the processed data figures.
<u>Turbine access corridor east</u> Stats Max: 13.01 Min: -11.63 Std Dev: 1.51 Mean: 0.17 Median: 0.00	Processes: 7 1 Base Layer 2 Search & Replace From: -3000 To: 3000 With: Dummy (Area: Top 17, Left 319, Bottom 19, Right 400) 3 Search & Replace From: -3000 To: 3000 With: Dummy (Area: Top 8, Left 0, Bottom 16, Right 240) 4 Clip at 4.00 SD 5 DeStripe Median Sensors: All 6 De Stagger: Grids: All Mode: Both By: -1 intervals 7 Clip at 4.00 SD Note: exporting the processed data from TerraSurveyor into Manifold GIS for analysis imposes an 'x matches y' interpolation on the data which is reflected in the processed data figures.

Appendix 4 Geophysical surveying techniques

1 Introduction

Substrata offers magnetometer and earth resistance surveying. We also provide other archaeology-specific geophysical surveys such as ground penetrating radar and resistivity. The particular method or combination of methods used depends on local soil conditions and the survey requirements. These methods are capable of delivering fast and accurate assessments of the archaeology of both large and small sites.

Further details can be found on our website at www.substrata.co.uk

2 Magnetometer surveying

Standard magnetometer surveys are the workhorse of archaeological surveying when speed and cost-effectiveness are important. Identifiable archaeological features include areas of occupation, hearths, kilns, furnaces, ditches, pits, post-holes, ridge-and-furrow, timber structures, wall footings, roads, tracks and similar buried features.

Magnetometer surveying is used to detect and map small changes in the earth's magnetic field caused by concentrations of ferrous-based minerals within the soil and subsoil, and by magnetised materials buried beneath the surface. While most of these changes are too small to affect a compass needle, they can be detected and mapped by sensitive field equipment. During surveys the different magnetic properties of top-soils, sub-soils, rock formations and archaeological features are recorded as variations against a background value. Subsequently magnetic anomalies resulting from potential archaeology can be identified and interpreted.

Bartington grad601-2 gradiometers

A gradiometer is a type of magnetometer and is sensitive to relatively small changes in the earth's magnetic field. Our primary surveying instruments are Bartington Grad601-2 (dual sensor) fluxgate gradiometers with automatic data loggers. They are specifically designed for field use by archaeologists. The Bartington gradiometers provide proven technology in archaeological magnetic surveying and offer fast, accurate set-up and survey rates. They are sensitive to depths of between 0 and 1.5m below ground level, with optimum sensitivity at depths of 1m or less.

Multiple sensor arrays

A technique relatively new to commercial archaeological surveying but well understood in academic circles involves the use of multiple magnetometer sensors towed behind a quad bike or similar vehicle. With multiple sensors and the use of on-board GPS units, it is possible to achieve faster survey rates at competitive commercial rates when compared to the use of multiple instruments and the techniques discussed above provided the ground is suitable for the vehicle and array. Substrata is pleased to announce that we now offer this service on suitable larger sites

3 Earth resistance surveying

Earth resistance surveying is an excellent tool for detecting buried archaeology. Its relatively slow rate of survey compared to magnetometer surveys means that it usually employed in commercial surveys when a detailed understanding of buried building remains is required. This technique measures changes in the electrical resistance of the ground being surveyed. In practice, the recording of differences in the electrical resistance of near-surface deposits and structures allows the detection and interpretation of masonry and brick foundations, paving and floors, drains and other cavities, large pits, building platforms, robber trenches, ditches, graves and similar buried features.

Resistance to electrical current flow in the ground depends on the moisture content and structure of the soil and other materials buried beneath the surface. For example, the higher the moisture content of a soil, the less resistant it is to electrical current flow. A ditch completely buried beneath the present ground surface is likely to have an infill soil different to that surrounding the ditch in terms of compactness and composition. As a result, the soil filling the buried ditch will retain moisture in a different way to the surrounding soil which means it will

have an electrical resistance at variance with the surrounding environment. By passing a small current through the ground it is possible to detect, record, plot and interpret such changes in electrical resistance.

For earth resistance surveying Substrata uses the Geoscan Research RM15 series multi-probe resistance meters and purpose-built automatic data-loggers. The Geoscan MPX15 multiplexer is an integral part to the instrument configuration and facilitates multi-probe arrays which speed up survey area coverage rates and, if required, facilitate simultaneous multiple-depth data collection.