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APPENDIX 1 MAGNETOMETER SURVEY

Magnetic susceptibility and soil magnetism

Iron makes up about 6% of the earth's crust and is mostly present in soils and rocks as minerals such as maghaemite and haematite. These minerals have a weak, measurable magnetic property termed magnetic susceptibility. Human activities can redistribute these minerals and change (enhance) others into more magnetic forms so that by measuring the magnetic susceptibility of the topsoil, areas where human occupation or settlement has occurred can be identified by virtue of the attendant increase (enhancement) in magnetic susceptibility. If the enhanced material subsequently comes to fill features, such as ditches or pits, localised isolated and linear magnetic anomalies can result whose presence can be detected by a magnetometer (fluxgate gradiometer).

In general, it is the contrast between the magnetic susceptibility of deposits filling cut features, such as ditches or pits, and the magnetic susceptibility of the topsoil, subsoil, and rock into which these features have been cut, which causes the most recognisable responses. This is primarily because there is a tendency for magnetic ferrous compounds to become concentrated in the topsoil, thereby making it more magnetic than the subsoil or the bedrock. Linear features cut into the subsoil or geology, such as ditches, that have been silted up or have been backfilled with topsoil will therefore usually produce a positive magnetic response relative to the background soil levels. Discrete feature, such as pits, can also be detected.

The magnetic susceptibility of a soil (clay) can also be enhanced by the application of heat. This effect can lead to the detection of heat affected features such as hearths, kilns, or areas of burning.

Types of magnetic anomaly

In most cases anomalies are termed 'positive'. This means that they have a positive magnetic value relative to the magnetic background on any given site. However, some features can manifest themselves as 'negative' anomalies that, conversely, means that the response is negative relative to the mean magnetic background.

Where it is not possible to give a probable cause of an observed anomaly a '?' is appended.

It should be noted that anomalies interpreted as modern in origin might be caused by features that are present in the topsoil or upper layers of the subsoil. Removal of soil to an archaeological or natural layer can therefore remove the feature causing the anomaly.

The types of response mentioned above can be divided into five main categories that are used in the graphical interpretation of the magnetic data:

Isolated dipolar anomalies (iron spikes) These responses are typically caused by ferrous material either on the surface or in the topsoil. They cause a rapid variation in the magnetic response giving a characteristic 'spiky' trace. Although ferrous archaeological artefacts could produce this type of response, unless there is supporting evidence for an archaeological interpretation, little emphasis is normally given to such anomalies, as modern ferrous objects are common on rural sites, often being introduced into the soil during manuring.

Areas of magnetic disturbance These responses can have several causes often being associated with burnt material, such as slag waste or brick rubble or other strongly magnetised/fired material. Ferrous structures such as pylons, mesh or barbed wire fencing and buried pipes can also cause the same disturbed response. A modern origin is usually assumed unless there is other supporting information.

Lightning-induced remnant magnetisation (LIRM) LIRM anomalies are thought to be caused in the near surface soil horizons by the flow of an electrical current associated with lightning strikes. These observed anomalies have a strong bipolar signal which decreases with distance from the spike point and often appear as linear or radial in shape.

Linear trend This is usually a weak or broad linear anomaly of unknown cause or date. These anomalies are often caused by agricultural activity, either ploughing or land drains being a common cause.

Areas of magnetic enhancement/positive isolated anomalies Areas of enhanced response are characterised by a general increase in the magnetic background over a localised area whilst discrete anomalies are manifest by an increased response (sometimes only visible on an XY trace plot) on two or three successive traverses. In neither instance is there the intense dipolar response characteristic exhibited by an area of magnetic disturbance or of an 'iron spike' anomaly (see above). These anomalies can be caused by infilled discrete archaeological features such as pits or post-holes or by kilns. They can also be caused by pedological variations or by natural infilled features on certain geologies. Ferrous material in the subsoil can also give a similar response. It can often therefore be very difficult to establish an anthropogenic origin without intrusive investigation or other supporting information.

Linear and curvilinear anomalies Such anomalies have a variety of origins. They may be caused by agricultural practice (recent ploughing trends, earlier ridge and furrow regimes or land drains), natural geomorphological features such as palaeochannels or by infilled archaeological ditches.

APPENDIX 2 SURVEY LOCATION **INFORMATION**

An initial survey base station was established using a Trimble VRS differential Global Positioning System (dGPS). The magnetometer data was georeferenced using a Trimble RTK differential Global Positioning System (Trimble R8s model).

Temporary sight markers were laid out using a Trimble VRS differential Global Positioning System (Trimble R8s model) to guide the operator and ensure full coverage. The accuracy of this dGPS equipment is better than 0.01m.

The survey data were then super-imposed onto a base map provided by the client to produce the displayed block locations. However, it should be noted that Ordnance Survey positional accuracy for digital map data has an error of 0.5m for urban and floodplain areas, 1.0m for rural areas and 2.5m for mountain and moorland areas. This potential error must be considered if coordinates are measured off hard copies of the mapping rather than using the digital coordinates.

Headland Archaeology cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party.

APPENDIX 3 GEOPHYSICAL SURVEY **ARCHIVE**

The geophysical archive comprises an archive disk containing the raw data in XYZ format, a raster image of each greyscale plot with associate world file, and a PDF of the report.

The project will be archived in-house in accordance with recent good practice guidelines (http://guides.archaeologydataservice. ac.uk/g2gp/Geophysics_3). The data will be stored in an indexed archive and migrated to new formats when necessary.

APPENDIX 4 MAGNETOMETER DATA **PROCESSING**

The gradiometer data has been presented in this report in processed greyscale and minimally processed XY trace plot format.

Data collected using RTK GPS-based methods cannot be produced without minimal processing of the data. The minimally processed data has been interpolated to project the data onto a regular grid and de-striped to correct for slight variations in instrument calibration drift and any other artificial data.

A high pass filter has been applied to the greyscale plots to remove low frequency anomalies (relating to survey tracks and modern agricultural features) to maximise the clarity and interpretability of the archaeological anomalies.

The data has also been clipped to remove extreme values and to improve data contrast.

2025 by Headland Archaeology (UK) Ltd File Name: PTHS23-Report-v8.pdf

APPENDIX 5 OASIS DATA COLLECTION FROM: ENGLAND

OASIS ID (UID): headland1-524151

Project Name: Geophysical Survey, Magnetometry Survey at Peartree Hill Solar Farm, East Riding of Yorkshire

Activity type: Geophysical Survey, Magnetometry Survey, MAGNETOMETRY SURVEY

Sitecode(s): PTHS23

Project Identifier(s): E23-0111

Planning Id: [no data]

Reason for Investigation: Planning: Pre application

Organisation Responsible for work: Headland Archaeology (UK) Ltd

Project Dates: 19-Jul-2023 - 18-Jan-2024

HER: Humber HER

HER: Scheduled Monument Casework

HER: Historic England review
HER: National Trust HBSMR

HER Identifiers: [no data]

Project Methodology:

It is acknowledged that magnetometry has limitations and that certain types of sub-surface remains may, under certain circumstances, be more likely to be identified by other survey techniques such as earth resistance, ground penetrating radar (GPR) or electro-magnetic methods which measure different geophysical properties. However, to achieve the immediate project aims over such a large area constituting the Site, magnetometry was selected as the best general-purpose methodology for assessing the site given the sub-surface remains most likely to be encountered and the project considerations. Magnetic survey methods rely on the ability of a variety of instruments to measure very small magnetic fields associated with buried archaeological remains. A feature such as a ditch, pit or kiln can act like a small magnet, or series of magnets, that produce distortions (anomalies) in the earth's magnetic field. In mapping these slight variations, detailed plans of sites can be obtained as buried features often produce reasonably characteristic anomaly shapes and strengths (Gaffney & Gater 2003). Further information on soil magnetism and the interpretation of magnetic anomalies is provided in Appendix 1. The surveys were undertaken using four Bartington Grad601 sensors mounted at 1m intervals (1m traverse interval) onto a rigid carrying frame. The system was programmed to take readings at a frequency of 10Hz (allowing for a 10-15cm sample interval) on roaming traverses (swaths) 4m apart. These readings were stored on an external weatherproof laptop and later downloaded for processing and interpretation. The system was linked to a Trimble R12 Real Time Kinetic (RTK) differential Global Positioning System (dGPS) outputting in NMEA mode to ensure a high positional accuracy for each data point. MLGrad601 and MultiGrad601 (Geomar Software Inc.) software was used to collect and export the data. Anomaly GeoSurvey v1.12.8 (© 2018 Robbie Austrums) software package (© 2018 Robbie Austrums) was used to process and export the data plots. Subsequent data interpretation and illustration work was undertaken using QGIS v3.28.5.

PEARTREE HILL SOLAR FARM, EAST RIDING OF YORKSHIRE PTHS23

Project Results:

The survey covered all the areas suitable for survey within the Site and has recorded a large number of natural/geological features and anomalies of agricultural origin identifying systematic patterns of field drains, ploughing trends both historic ridge and furrow and modern, and former field boundaries which typify the geographic landscape within which the Site is located. Five separate small pockets of archaeological potential, identified with varying levels of clarity and interpreted confidence, have been recorded within the Site. Areas of locally high archaeological potential consisting of a spread of likely enclosures are recorded east of Riston Carr House and immediately north-east of Wawne Grane where a possible sub-rectangular enclosure, containing two ring ditches with a larger third ring ditch located immediately outside, are recorded. Possible archaeological features comprising of a cluster of linear and curvilinear ditches have been recorded east of the farm at Low Baswick and a broad group of linear and curvilinear ditch-like anomalies of uncertain origin and two discrete anomalies possibly identifying localised burning have also been mapped across multiple fields east of Meaux Lane. These anomalies, which when viewed collectively, could indicate a further area of archaeological potential. A small cluster of magnetically enhanced responses of uncertain origin are also recorded in the location of 'ruins' detailed on historic maps close to the river Hull. The siting of each of these areas of archaeological potential on patches of sand and gravel or till superficial deposits is likely an indication of the suitability of the land for historic occupation rather than a bias in the detection of features present on superficial deposits other than alluvium which is widespread across the Site. No anomalies considered of archaeological potential were identified in several locations where heritage assets are recorded on the Humberside Historic Environment Record (HHER) and therefore the archaeological potential of these areas remains uncertain. This includes the location of Meaux deserted medieval village, to the east and west of Riston Grange where cropmarks of field and ditch systems and enclosures are recorded and just outside the Order Limits at Arnold Carr where cropmarks of a pentagonal enclosure are noted. Outside of the areas of archaeological potential and excluding natural/geological features, findings are limited to several isolated discrete responses of uncertain origin, former field boundaries and a pond detailed on historic mapping, several high magnitude linear anomalies identifying buried services and areas of magnetic disturbance of modern origin. Several fields located to the west and north-west of Meaux Abbey appear to have been spread with varying levels of 'green waste' used as a soil improver. This is judged not to have precluded the identification of anomalies of possible archaeological potential though none were identified. Based on the results of the survey and information detailed in the archaeological desk-based assessment, areas where the archaeological potential is considered locally high are identified east of Riston Carr House and immediately north-east of Wawne Grange and considered of moderate potential east of the farm at Low Baswick and across multiple fields east of Meaux Lane. Outside of these areas however the archaeological potential of the Site is considered low reflecting the historically marginal landscape within which the majority of the Site is located.

Keywords: [no data]

Archive: [no data]

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