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**Walland Farm Solar Development
Bideford
Devon**

Geophysical Survey

Report no. 2599

April 2014

Client: Hyder Consulting (UK) Limited



Walland Farm Solar Development

Bideford

Devon

Geophysical Survey

Summary

A geophysical (magnetometer) survey, covering 13 hectares, was carried out on agricultural land south of Walland Farm, near Bideford, Devon in advance of the determination of a planning application for a proposed 3.9MW Solar PV Development. Anomalies have been identified which correspond to the 19th century and later agricultural landscape as depicted on historical mapping including extensive areas of magnetic 'noise' suggestive of attempts to improve the waterlogged land. A former trackway has been identified which is shown on a tithe map of 1841 and may be of local historical interest. On the basis of the geophysical survey, the archaeological potential of the site is thought to be low.



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Report Information

Client: Hyder Consulting (UK) Ltd
Address: The Mill, Brimscombe Port, Stroud, Gloucestershire, GL5 2QG
Report Type: Geophysical Survey
Location: Bideford
County: Devon
Grid Reference: SS 35368 22129
Period(s) of activity: post-medieval
Report Number: 2599
Project Number: 4217
Site Code: WAB14
OASIS ID: archaeol11-176732
Planning Application No.:
Museum Accession No.: n/a
Date of fieldwork: March 2014
Date of report: April 2014
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Photography: Site Staff
Research: n/a

Authorisation for
distribution: -----



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1 Introduction

Archaeological Services WYAS (ASWYAS) were commissioned by Jenny Wylie of Hyder Consulting (UK) Limited (the Client) on behalf of Lightsource Renewable Energy Limited, to undertake a geophysical (magnetometer) survey of agricultural land at Walland Farm, Devon, prior to the determination of a planning application for a proposed 3.9MW Solar PV Development. The work was undertaken in accordance with a Project Design (Harrison 2014) supplied to and approved by the Client, with guidance contained within the National Planning Policy Framework (2012) and in line with current best practice (David *et al.* 2008). The survey was carried out between March 18th and March 21st 2014 in order to provide additional information on the archaeological potential of the site.

Site location, topography and land-use

The Proposed Development Area (PDA) comprises an irregular shaped parcel of land, centred at SS 35368 22129, 10km south-west Bideford, Devon (see Fig. 1). It comprises six fields of improved pasture (see plates) to the immediate south of Walland Farm and the A39 and north of Brooklands Farm. Open farmland extends to the east and west of the site (see Fig. 2). Areas of notably soft ground, characterised by the presence of Soft Rush were observed in Field 2 and Field 3 and the northerly extents of Field 4 and Field 5, indicating sustained waterlogging within these locations. The topography of the site is undulating although generally it lies on an east-facing gradient, being at 196m above Ordnance Datum (aOD) at its westerly extent, dropping to 183m aOD at the eastern extent.

Soils and geology

The underlying bedrock comprises Bude Formation - sandstone. There are no recorded superficial deposits (British Geological Survey 2014). The soils are classified in the Hallsworth 2 association, characterised as slowly permeable, seasonally waterlogged clays, loams and silts (Soil Survey of England and Wales 1983).

2 Archaeological Background

A Cultural Heritage Desk-Based Assessment (Hyder Consulting 2014) identified no archaeological remains within the PDA, although this is thought to be related to its use as farmland since at least the medieval period. Post-medieval agricultural improvements (Heritage Asset 21) are highlighted by the desk-based assessment within Field 3 and possibly Field 2. Evidence from the wider landscape suggests that there is some potential for the presence of unrecorded archaeological remains from the prehistoric period to be present within the site.

3 Aims, Methodology and Presentation

The main aim of the geophysical survey was to provide sufficient information to enable an assessment to be made of the impact of the development on potential sub-surface archaeological remains and for further evaluation or mitigation proposals, if appropriate, to be recommended. To achieve this aim a magnetometer survey covering all available parts of the PDA was carried out.

The general objectives of the geophysical survey were:

- to provide information about the nature and possible interpretation of any magnetic anomalies identified;
- to therefore determine the presence/absence and extent of any buried archaeological features; and
- to prepare a report summarising the results of the survey.

Magnetometer survey

The site grid was laid out using a Trimble VRS differential Global Positioning System (Trimble 5800 model). Bartington Grad601 magnetic gradiometers were used during the survey, taking readings at 0.25m intervals on zig-zag traverses 1m apart within 30m by 30m grids, so that 3600 readings were recorded in each grid. These readings were stored in the memory of the instrument and later downloaded to computer for processing and interpretation. Geoplot 3 (Geoscan Research) software was used to process and present the data. Further details are given in Appendix 1.

Reporting

A general site location plan, incorporating the 1:50000 Ordnance Survey (OS) mapping, is shown in Figure 1. Figure 2 is a large scale (1:2500) location plan displaying the processed magnetic data. Figure 3 is an overall data interpretation plot at the same scale. Detailed data plots ('raw' and processed) and full interpretative figures are presented at a scale of 1:1000 in Figures 4 to 9 inclusive.

Further technical information on the equipment used, data processing and survey methodologies is given in Appendix 1 and Appendix 2. Appendix 3 describes the composition and location of the site archive.

The survey methodology, report and any recommendations comply with the Project Design (Harrison 2014) and guidelines outlined by English Heritage (David *et al* 2008) and by the Institute for Archaeologists (IfA 2013). All figures reproduced from Ordnance Survey mapping are with the permission of the controller of Her Majesty's Stationery Office (© Crown copyright).

The figures in this report have been produced following analysis of the data in ‘raw’ and processed formats and over a range of different display levels. All figures are presented to most suitably display and interpret the data from this site based on the experience and knowledge of Archaeological Services staff.

4 Results and Discussion (see Figs 4 to 9 inclusive)

Two distinctly different magnetic backgrounds have been recorded across the PDA. To the east (Field 2, Field 3 and part of Field 6) there is minimal variation resulting in a uniform grey tone to the data plot. To the west of the site, predominantly Field 4 and Field 5, the magnetic background is considerably elevated with numerous anomalies and broad areas of magnetic enhancement. The reasons for this disparity are discussed further below. The anomalies identified by the survey fall into three different types and categories according to their origin and these are discussed below and cross-referenced to specific examples and locations within the site.

Ferrous Anomalies

Ferrous responses, either as individual ‘spike’ anomalies or more extensive areas of magnetic disturbance, are typically caused by modern ferrous (magnetic) debris, either on the ground surface or in the plough-soil, or are due to the proximity of magnetic material in field boundaries, buildings or other above ground features. Little importance is normally given to such anomalies, unless there is any supporting evidence for an archaeological interpretation as ferrous debris or material is common on rural sites, often being present as a consequence of manuring or tipping/infilling. Throughout the PDA individual iron ‘spike’ anomalies are not common perhaps being indicative of the land being under pasture for a considerable period of time.

Linear bands of magnetic disturbance around the perimeters of the PDA, and in between fields are due to the close proximity of magnetic material within the adjacent fencing, are high in magnitude and are of no archaeological interest. Areas of magnetic disturbance within Field 1 are likely to be due to areas of dumping close to the adjacent farm buildings.

Agricultural Anomalies

The data from Field 4 and Field 5 is characterised by clusters of high magnitude magnetic anomalies (Field 5 – **A** and Field 4 – **B**) throughout all but the far north of the fields where the enhancement is constrained by fragmented linear anomalies, **C** and **D**. Analysis of historical mapping shows that these linear anomalies (**C** and **D**) locate former field boundaries (soil-filled ditches), which are depicted on the first edition OS map (1886). It is therefore considered likely that the increased magnetic background is agricultural in origin, probably relating to improving the drainage of the land. Similar broad areas of enhancement can be seen within the west of Field 6 (**E**) and, to a lesser extent, the west of Field 1 (**F**). The

cause of the enhancement is unclear. It is possible that magnetic material such as sands and gravels may have been imported to the site to aid drainage, the material being redistributed throughout the field by subsequent ploughing activity. Alternatively, the enhanced responses may be due to fracturing and mixing up of the bedrock with the ploughsoil during the laying of field drains. Several field drains have been identified by the survey, typically manifesting as parallel linear anomalies, for example, **G**. To the east of the site, the field drains manifest as ‘speckled’ linear trends.

To the south of Field 5, an east/west orientated linear anomaly, **H**, also corresponds to a former field boundary depicted on the first edition OS map. The anomaly is due to the contrast between the soil-filled ditch and the surrounding soils. Another possible former field boundary, **I**, is located within the south of Field 4, visible as a clear high magnitude linear anomaly aligned east/west and parallel with the existing field boundaries. However, this anomaly does not appear on any former maps and therefore it may locate another drainage ditch.

Within the north of Field 1, a negative curvilinear anomaly, **J**, has been identified on a north-west/south-east orientation. Given the orientation of this anomaly, heading towards the field entrance at the south of Walland Farm, it is reasonable to assume that this anomaly is due to a modern farm track.

A second trackway is visible as two parallel negative linear trends, **K** and **L**, crossing Field 6 on a north-east/south-west alignment. The trends are thought to indicate ditches flanking the former trackway which is depicted on the first edition OS map and also on the earlier 1841 Woolfardisworthy tithe map where it is labelled as ‘Old Road’. It is worth noting that the areas of enhancement, **F**, appear to respect the line of the trackway.

Series of faint parallel linear trends are visible within the south of Field 4 and throughout Field 6. These result from modern ploughing.

Geological anomalies

Across those parts of the survey areas seemingly unaffected by the land improvement activity, occasional discrete, low magnitude, anomalies (areas of magnetic enhancement) have been identified. These are interpreted as geological in origin and are thought to be caused by localised variations in the depth and composition of the seasonally waterlogged soils.

5 Conclusions

No anomalies of obvious archaeological potential have been identified by the magnetometer survey. A broad area of magnetic ‘noise’ covers almost half of the PDA and this is thought to be a result of repeated attempts to improve the waterlogged land either by the importation of

magnetic material or by the disturbance and redistribution of the underlying magnetic bedrock, or a combination of both. Any anomalies of archaeological potential, if present, may be masked within this magnetic background, although based upon the results of the geophysical survey, there is no reason to assume that this is the case on this site. A number of former field boundaries have been identified which relate to the 19th century and later agricultural landscape as depicted on historical mapping, whilst a former trackway within the south-east of the site may have earlier origins and is likely to be of local historical interest.

Therefore, on the basis of the geophysical survey, the archaeological potential of the PDA is assessed as being low.

The results and subsequent interpretation of data from geophysical surveys should not be treated as an absolute representation of the underlying archaeological and non-archaeological remains. Confirmation of the presence or absence of archaeological remains can only be achieved by direct investigation of sub-surface deposits.

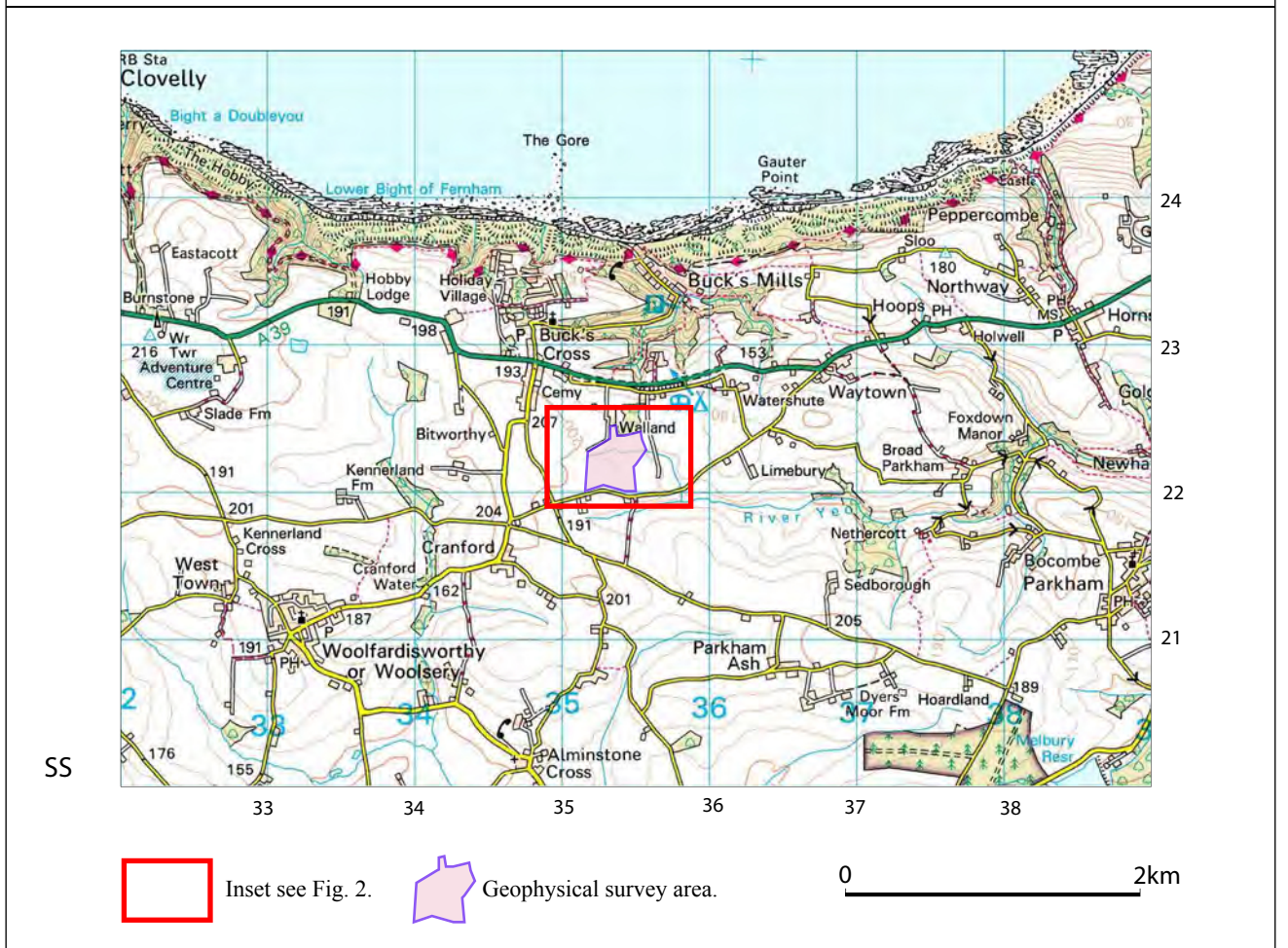
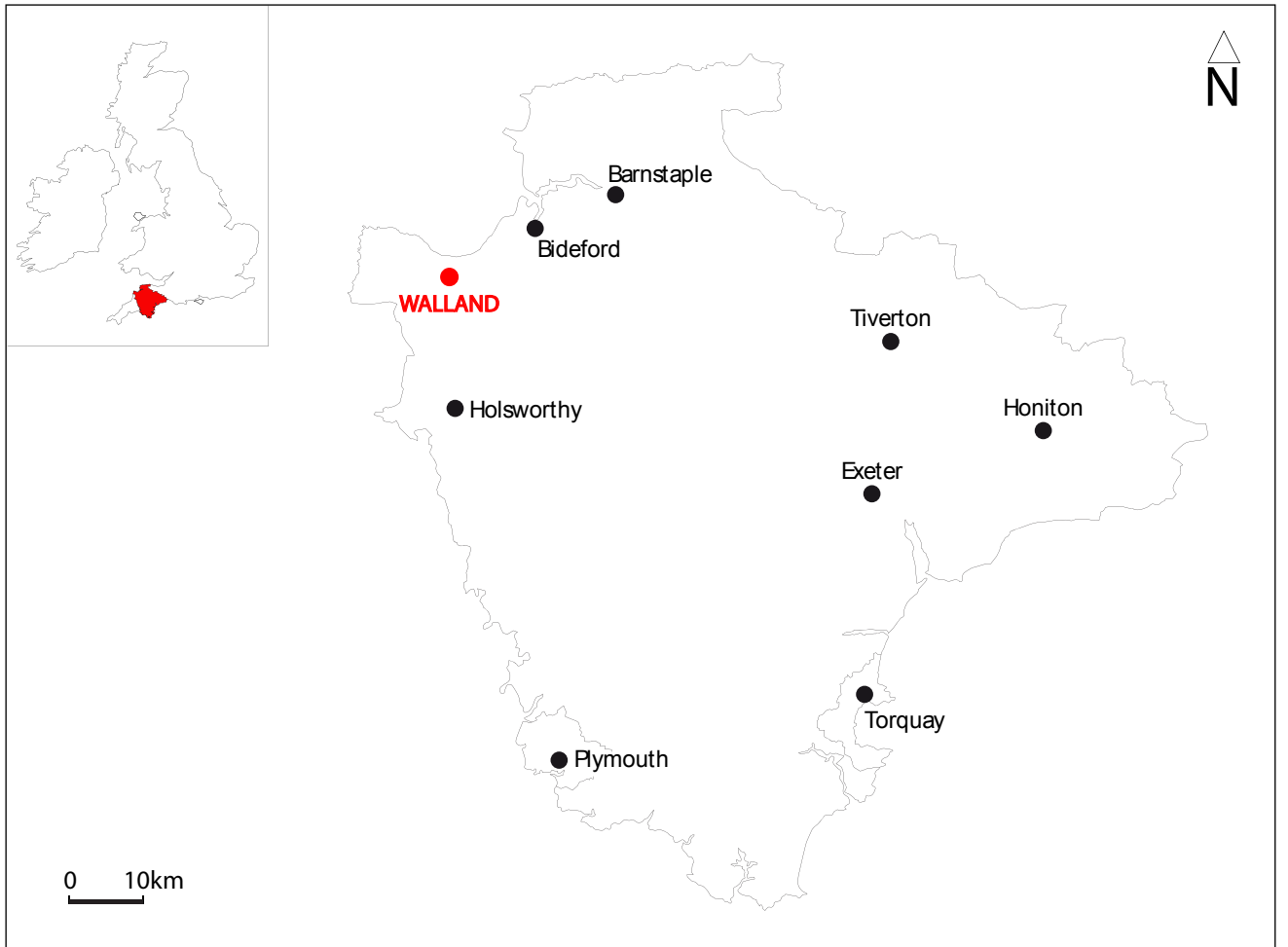


Fig. 1. Site location



Fig. 2. Site location showing greyscale magnetometer data (1:2500 @ A3)



Fig. 3. Overall interpretation of magnetometer data (1:2500 @ A3)



Fig. 4. Processed greyscale magnetometer data; Sector 1 (1:1000 @ A3)



Fig. 5. XY trace plot of minimally processed magnetometer data; Sector 1 (1:1000 @ A3)



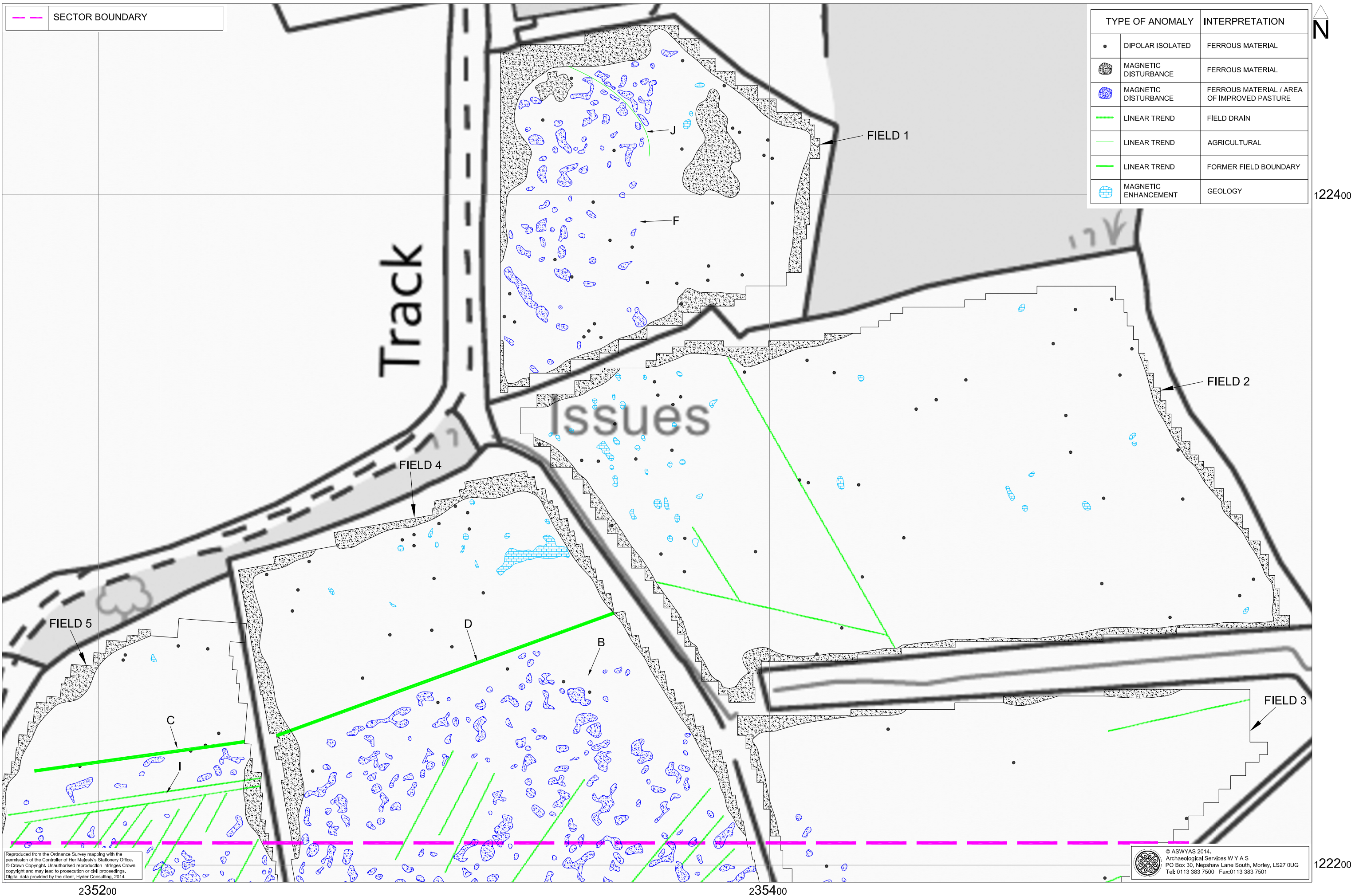


Fig. 6. Interpretation of magnetometer data; Sector 1 (1:1000 @ A3)

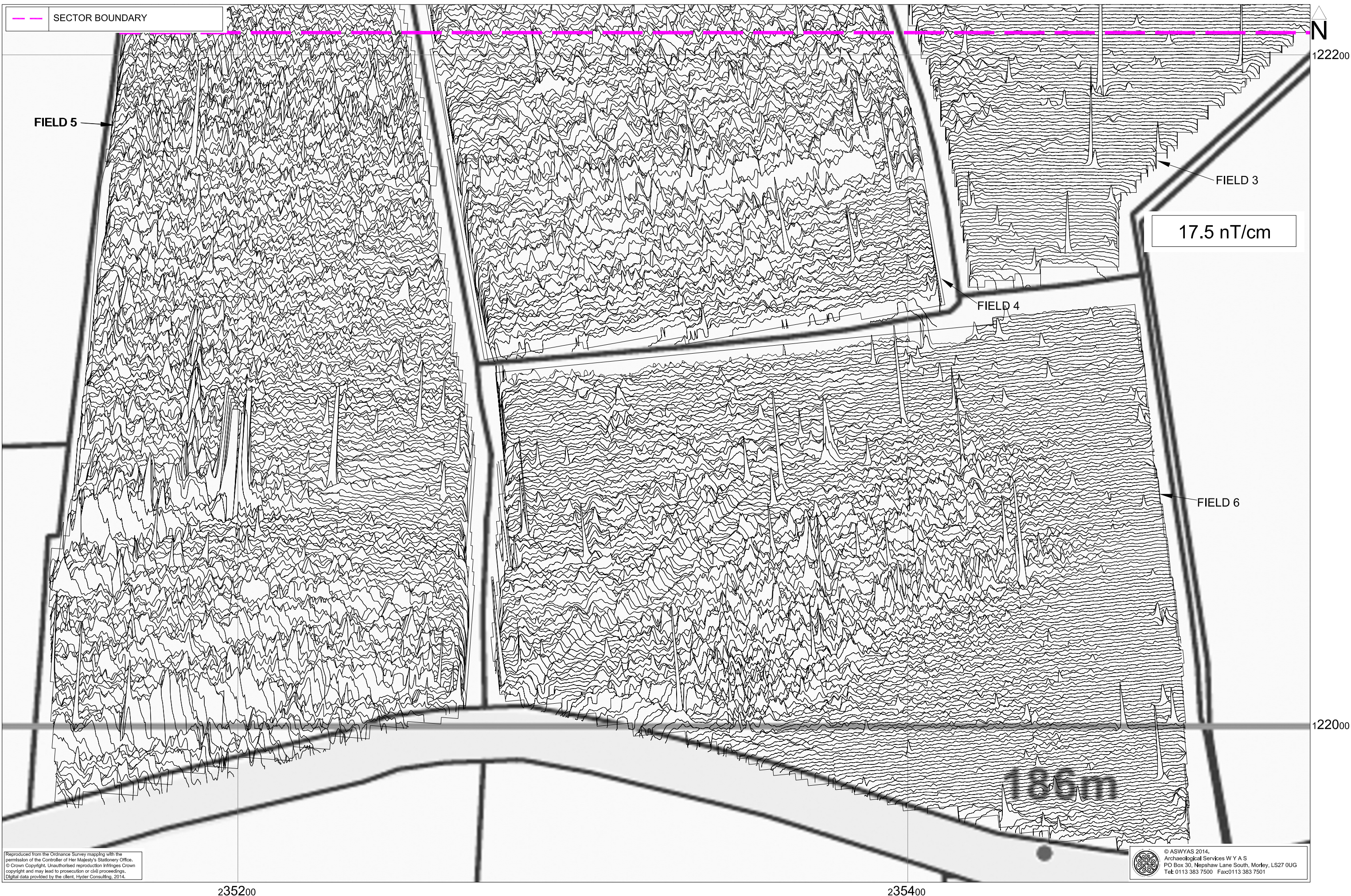


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Fig. 7. Processed greyscale magnetometer data; Sector 2 (1:1000 @ A3)



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Fig. 8. XY trace plot of minimally processed magnetometer data; Sector 2 (1:1000 @ A3)

0 40m

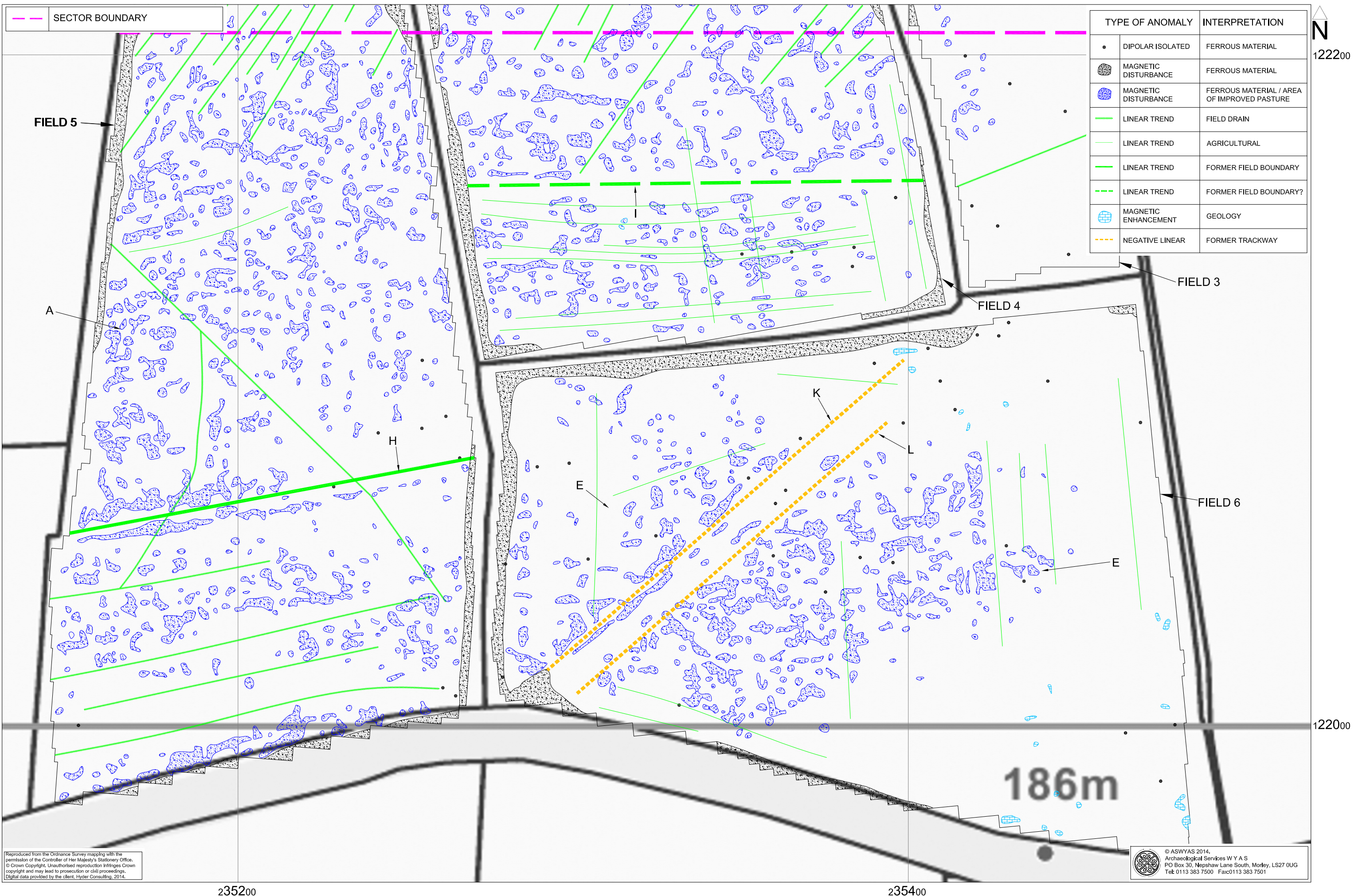


Fig. 9. Interpretation of magnetometer data; Sector 2 (1:1000 @ A3)





Plate 1. General view of Field 1, looking north



Plate 2. General view of Field 2, looking east



Plate 3. General view of Field 3, looking north-east



Plate 4. General view of Field 4, looking south-east



Plate 5. General view of Field 5, looking north-east



Plate 6. General view of Field 6, looking east

Appendix 1: Magnetic survey - technical information

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 haemetite. 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 topsoils, subsoils and rocks 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 can also be enhanced by the application of heat and the fermentation and bacterial effects associated with rubbish decomposition. The area of enhancement is usually quite large, mainly due to the tendency of discard areas to extend beyond the limit of the occupation site itself, and spreading by the plough. An advantage of magnetic susceptibility over magnetometry is that a certain amount of occupational activity will cause the same proportional change in susceptibility, however weakly magnetic is the soil, and so does not depend on the magnetic contrast between the topsoil and deeper layers. Susceptibility survey is therefore able to detect areas of occupation even in the absence of cut features. On the other hand susceptibility survey is more vulnerable to the masking effects of layers of colluvium and alluvium as the technique, using the Bartington system, can generally only measure variation in the first 0.15m of ploughsoil.

Types of Magnetic Anomaly

In the majority of instances 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 present as a consequence of 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.

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.

Methodology: Magnetic Susceptibility Survey

There are two methods of measuring the magnetic susceptibility of a soil sample. The first involves the measurement of a given volume of soil, which will include any air and moisture that lies within the sample, and is termed volume specific susceptibility. This method results in a bulk value that is not necessarily fully representative of the constituent components of the sample. For field surveys a Bartington MS2 meter with MS2D field loop is used due to its speed and simplicity. The second technique overcomes this potential problem by taking into account both the volume and mass of a sample and is termed mass specific susceptibility. However, mass specific readings cannot be taken in the field where the bulk properties of a soil are usually unknown and so volume specific readings must be taken. Whilst these values are not fully representative they do allow general comparisons across a site and give a broad indication of susceptibility changes. This is usually enough to assess the susceptibility of a site and evaluate whether enhancement has occurred.

Methodology: Gradiometer Survey

There are two main methods of using the fluxgate gradiometer for commercial evaluations. The first of these is referred to as *magnetic scanning* and requires the operator to visually identify anomalous responses on the instrument display panel whilst covering the site in widely spaced traverses, typically 10m apart. The instrument logger is not used and there is therefore no data collection. Once anomalous responses are identified they are marked in the field with bamboo canes and approximately located on a base plan. This method is usually employed as a means of selecting areas for detailed survey when only a percentage sample of the whole site is to be subject to detailed survey.

The disadvantages of magnetic scanning are that features that produce weak anomalies (less than 2nT) are unlikely to stand out from the magnetic background and so will be difficult to detect. The coarse sampling interval means that discrete features or linear features that are parallel or broadly oblique to the direction of traverse may not be detected. If linear features are suspected in a site then the traverse direction should be perpendicular (or as close as is possible within the physical constraints of the site) to the orientation of the suspected features. The possible drawbacks mentioned above mean that a 'negative' scanning result should be validated by sample detailed magnetic survey (see below).

The second method is referred to as *detailed survey* and employs the use of a sample trigger to automatically take readings at predetermined points, typically at 0.25m intervals, on zig-zag traverses 1m apart. These readings are stored in the memory of the instrument and are later dumped to computer for processing and interpretation. Detailed survey allows the visualisation of weaker anomalies that may not have been detected by magnetic scanning.

During this survey a Bartington Grad601 magnetic gradiometer was used taking readings on the 0.1nT range, at 0.25m intervals on zig-zag traverses 1m apart within 30m by 30m square

grids. The instrument was checked for electronic and mechanical drift at a common point and calibrated as necessary. The drift from zero was not logged.

Data Processing and Presentation

The detailed gradiometer data has been presented in this report in XY trace and greyscale formats. In the former format the data shown is 'raw' with no processing other than grid biasing having been done. The data in the greyscale images has been interpolated and selectively filtered to remove the effects of drift in instrument calibration and other artificial data constructs and to maximise the clarity and interpretability of the archaeological anomalies.

An XY plot presents the data logged on each traverse as a single line with each successive traverse incremented on the Y-axis to produce a 'stacked' plot. A hidden line algorithm has been employed to block out lines behind major 'spikes' and the data has been clipped. The main advantage of this display option is that the full range of data can be viewed, dependent on the clip, so that the 'shape' of individual anomalies can be discerned and potentially archaeological anomalies differentiated from 'iron spikes'. Geoplot 3 software was used to create the XY trace plots.

Geoplot 3 software was used to interpolate the data so that 3600 readings were obtained for each 30m by 30m grid. The same program was used to produce the greyscale images. All greyscale plots are displayed using a linear incremental scale.

Appendix 2: Survey location information

The site grid was laid out using a Trimble VRS differential Global Positioning System (Trimble 5800 model). The accuracy of this equipment is better than 0.01m. The survey grids 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 co-ordinates are measured off hard copies of the mapping rather than using the digital co-ordinates.

Archaeological Services WYAS cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party.

Appendix 3: Geophysical archive

The geophysical archive comprises:-

- an archive disk containing compressed (WinZip 8) files of the raw data, report text (Microsoft Word 2000), and graphics files (Adobe Illustrator CS2 and AutoCAD 2008) files; and
- a full copy of the report.

At present the archive is held by Archaeological Services WYAS although it is anticipated that it may eventually be lodged with the Archaeology Data Service (ADS). Brief details may also be forwarded for inclusion on the English Heritage Geophysical Survey Database after the contents of the report are deemed to be in the public domain (i.e. available for consultation in the Devon Historic Environment Record).

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