ARCHAEOLOGICAL SERVICES WYAS

Warren Field
Horkstow
North Lincolnshire

Geophysical Survey

Report no. 2379

July 2012

Client: ECUS Ltd

REGISTERED ORGANISATION IfA

Warren Field
Horkstow
North Lincolnshire

Geophysical Survey

Summary

A geophysical (magnetometer) survey, covering approximately 2 hectares, was carried out on agricultural land known as Warren Field, to the north of Horkstow, North Lincolnshire, in advance of the submission of a planning application for the construction of a single wind turbine and associated infrastructure. No anomalies of obvious archaeological potential have been identified by the survey although linear anomalies due to recent agricultural activity have been noted. On the basis of the survey the site is considered to have a low archaeological potential.

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Report Information

Client:	ECUS Ltd
Address:	3 Blackburn Road, Sheffield, S61 2DW
Report Type:	Geophysical survey
Location:	Warren Field, Horkstow
County:	Lincolnshire
Grid Reference:	SE 9811 1975
Period(s) of activity: represented	Modern
Report Number:	2379
Project Number:	3938
Site Code:	WFH12
OASIS ID:	archaeol11-132645
Planning Application No.:	Pre-determination (Outline)
Museum Accession No.:	n/a
Date of fieldwork:	July 2012
Date of report:	July 2012
Project Management:	Sam Harrison BSc MSc AIfA
Fieldwork:	Christopher Sykes BA MSc Alex Harrison BSc
Report:	Christopher Sykes Alex Harrison
Illustrations:	Alex Harrison Christopher Sykes
Photography:	Alex Harrison

Authorisation for distribution: ---

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1 Introduction

Archaeological Services WYAS was commissioned by Dr Holly Smith of ECUS Ltd to carry out a programme of non-intrusive geophysical (magnetometer) survey over the site of a proposed wind turbine and access track at Warren Field, Horkstow, North Lincolnshire (see Fig. 1). The work was undertaken in accordance with guidance contained within the National Planning Policy Framework (2012) and in line with current best practice. The survey was carried out on July 9th 2012.

Site location, topography and land-use

Horkstow is located approximately 2.8km to the south of South Ferriby (see Fig. 1) and 21km east of Scunthorpe. The site is located to the north of the village, and to the west of the B1204 (see Fig. 2). The survey area lies at about 10m above Ordnance Datum (aOD) and was under a sugar beet crop at the time of survey (see Plates).

Geology and soils

The underlying bedrock comprises Ampthill Clay – mudstone, which is overlain by glaciolacustrine superficial deposits – sand and gravel (BGS 2012). The soils are classified in the Wallasea 1 association being characterised as deep, stoneless, non-calcareous and calcareous, clays. (SSEW 1983).

2 Archaeological background

A number of cropmarks have been recorded in the vicinity of the proposed development area further up the slope upon the Lincolnshire Wolds. These cropmark features are thought to be indicative of Iron Age and Roman period activity.

3 Aims, Methodology and Presentation

The general objective of the geophysical survey was to provide information about the presence/absence, character, extent of any archaeological remnants identified within the specific area to be impacted by the proposed development (wind turbine and access tracks), and to help inform further strategies should they be required.

In order to achieve these aims detailed (recorded) magnetometer survey was carried out over an area of 1 hectare centred on the proposed location of the turbine and along a 20m wide corridor covering an access track leading from an exiting track to the turbine location.

Magnetometer survey

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 map is shown in Figure 1. A large scale (1:2500) site location plan showing the greyscale magnetometer data is shown in Figure 2. The data are presented in greyscale, XY trace plot and interpretation formats in Figures 3 to 8 inclusive at a scale of 1:1000.

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

The geophysical survey methodology, report and any recommendations comply with guidelines outlined by English Heritage (David *et al.* 2008) and by the Institute for Archaeologists (IfA 2010). 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

Ferrous anomalies, either as individual 'spikes' or more extensive areas of magnetic disturbance, are typically caused by ferrous (magnetic) debris, either on the ground surface or mixed in with the plough-soil. Little importance is normally given to such anomalies, unless there is any supporting evidence for an archaeological interpretation, as ferrous debris is common on rural sites, often being present as a consequence of manuring or tipping/infilling. There is no clustering to these anomalies and they are therefore assumed to be due to the random distribution of ferrous debris.

Two parallel bands of 'over range' readings have been recorded aligned broadly east/west across the northern part of the access track corridor. This is caused by the electromagnetic field produced by the low-hanging overhead power cables which cross the survey corridor at these two points (see Fig. 2). The wires from a second power line do not hang as low and therefore have not had the same effect on the data.

A small area of magnetic disturbance in the south-eastern corner of the access track survey area is due to the tipping or accumulation of building rubble in the corner of the field, probably tipped to improve drainage.

Throughout the survey area linear trend anomalies are identified. These are predominantly aligned north/south, parallel with the field boundary marking the eastern site boundary. These anomalies are due to recent ploughing. A few other trends on differing alignments are also noted. These are also assumed to have an agricultural origin. A much stronger linear anomaly, **A**, aligned east/west locates a former field boundary.

Several short linear and discrete anomalies (areas of magnetic enhancement) have also been identified. None has definite archaeological potential but this possibility cannot be discounted. Two strong anomalies, **B**, on the western edge of the turbine base area, are considered most likely to have a geological origin, being due to variation in the glaciolacustrine superficial deposits. Other much weaker, broader, anomalies in the immediate vicinity are also interpreted as due to geological variation. Three other discrete anomalies, **C**, **D** and **E**, probably also have a geological origin although these probably have slightly more archaeological potential than anomaly **B**.

5 Conclusions

The geophysical survey has not identified any anomalies of obvious archaeological potential. Nevertheless, several anomalies are noted where an archaeological cause cannot be discounted. However, on the balance of probability it is considered likely that all the anomalies identified by the magnetic survey are due to recent agricultural activity or variation in the composition of the soils and superficial deposits. Therefore, on the basis of the geophysical survey, the site is considered to have a low archaeological potential.

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.

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 it 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 survey grid was laid out using a Geodimeter 600s total station theodolite and tied in to permanent landscape features and to temporary reference objects (survey marker pins) that were established and left in place following completion of the fieldwork for accurate geo-referencing. The locations of the temporary reference points are shown on Figure 2 and the Ordnance Survey grid co-ordinates tabulated below. The survey grids were then super-imposed onto a base map 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.

Station	**Easting**	**Northing**
A	498063.4773	419409.8049
B	498324.1813	419488.9031

Archaeological Services WYAS cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party or for the removal of any of the survey reference points.

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 North Lincolnshire Historic Environment Record).

Bibliography

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Soil Survey of England and Wales, 1980, Soils of Northern England Sheet 1

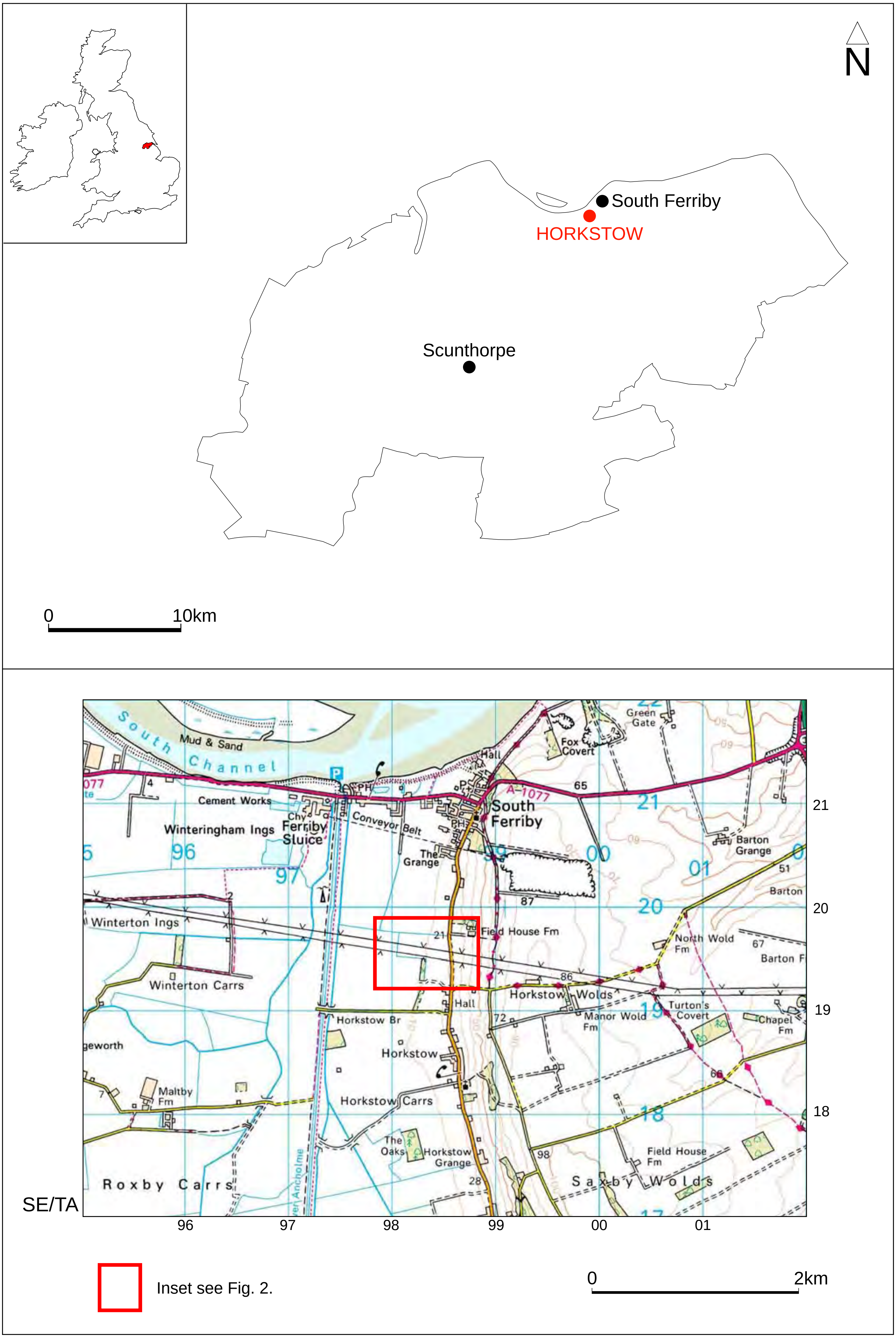

Fig. 1. Site location

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

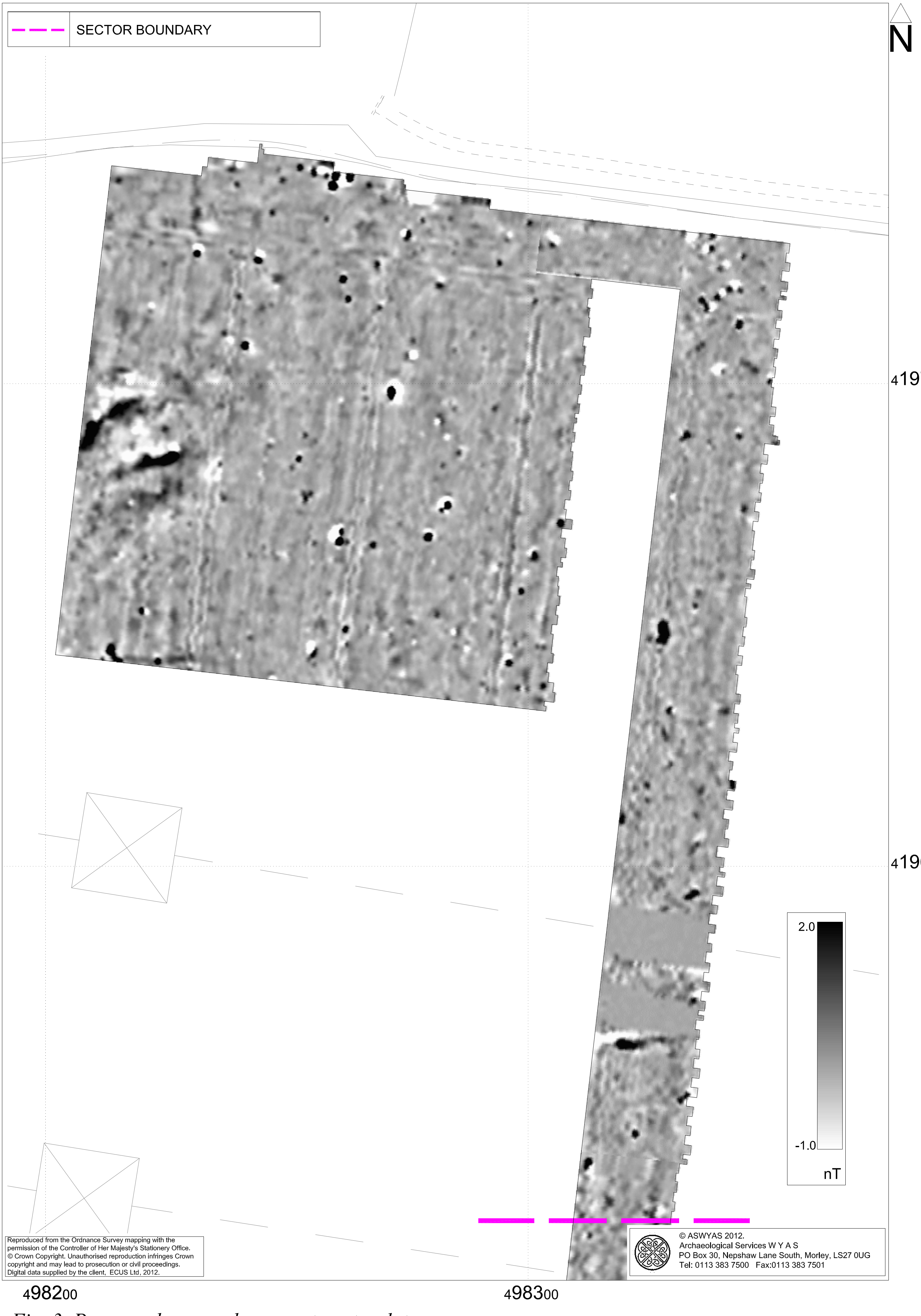

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Fig. 3. Processed greyscale magnetometer data; Northern sector (1:1000 @ A4)

Fig. 4. XY trace plot of minimally processed magnetometer data; Northern sector (1:1000 @ A4)

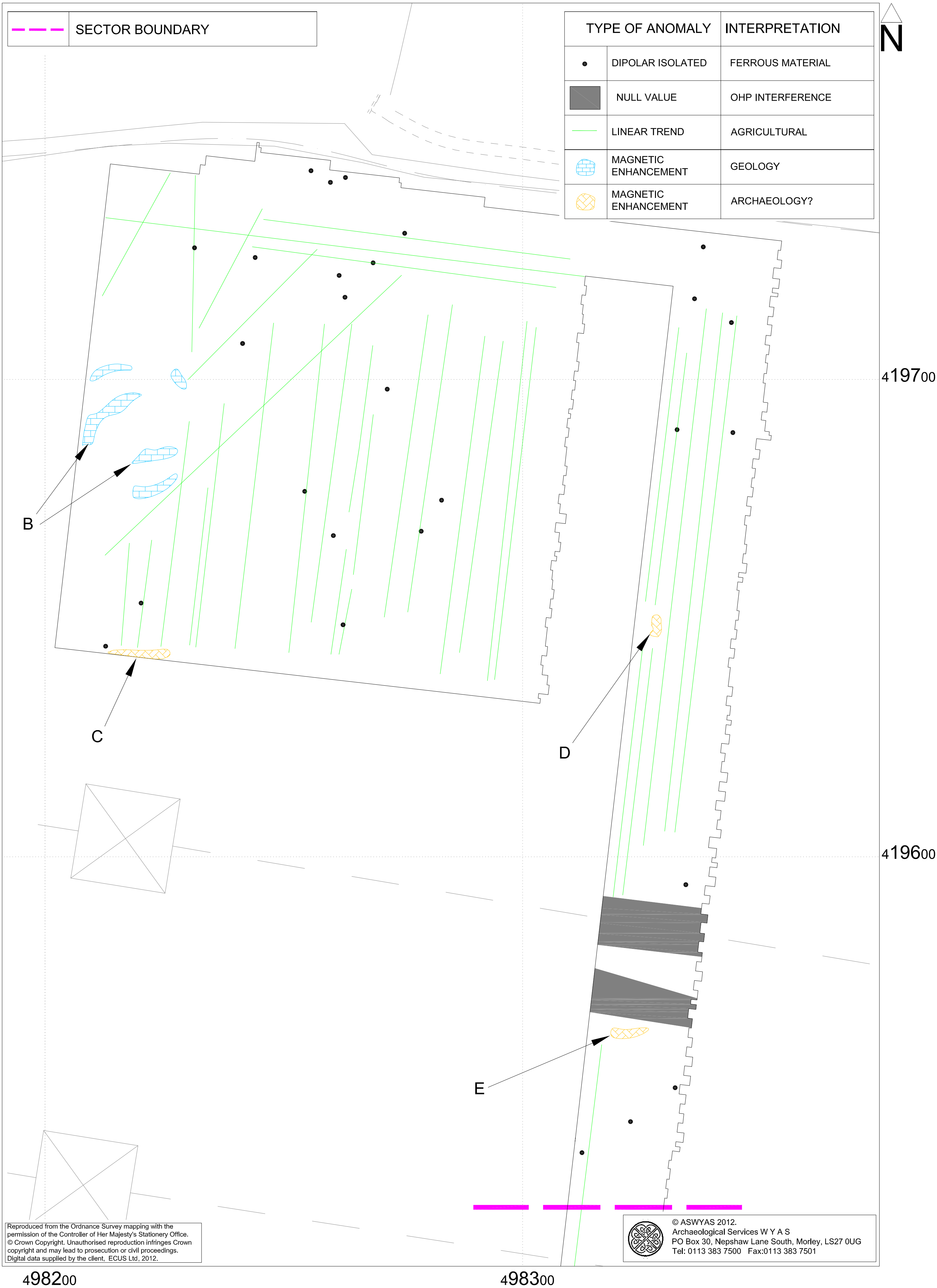

Fig. 5. Interpretation of magnetometer data; Northern sector (1:1000 @ A4)

0 50m

Fig. 6. Processed greyscale magnetometer data; Southern sector (1:1000 @ A4)

Fig. 7. XY trace plot of minimally processed magnetometer data; Southern sector (1:1000 @ A4)

0 50m

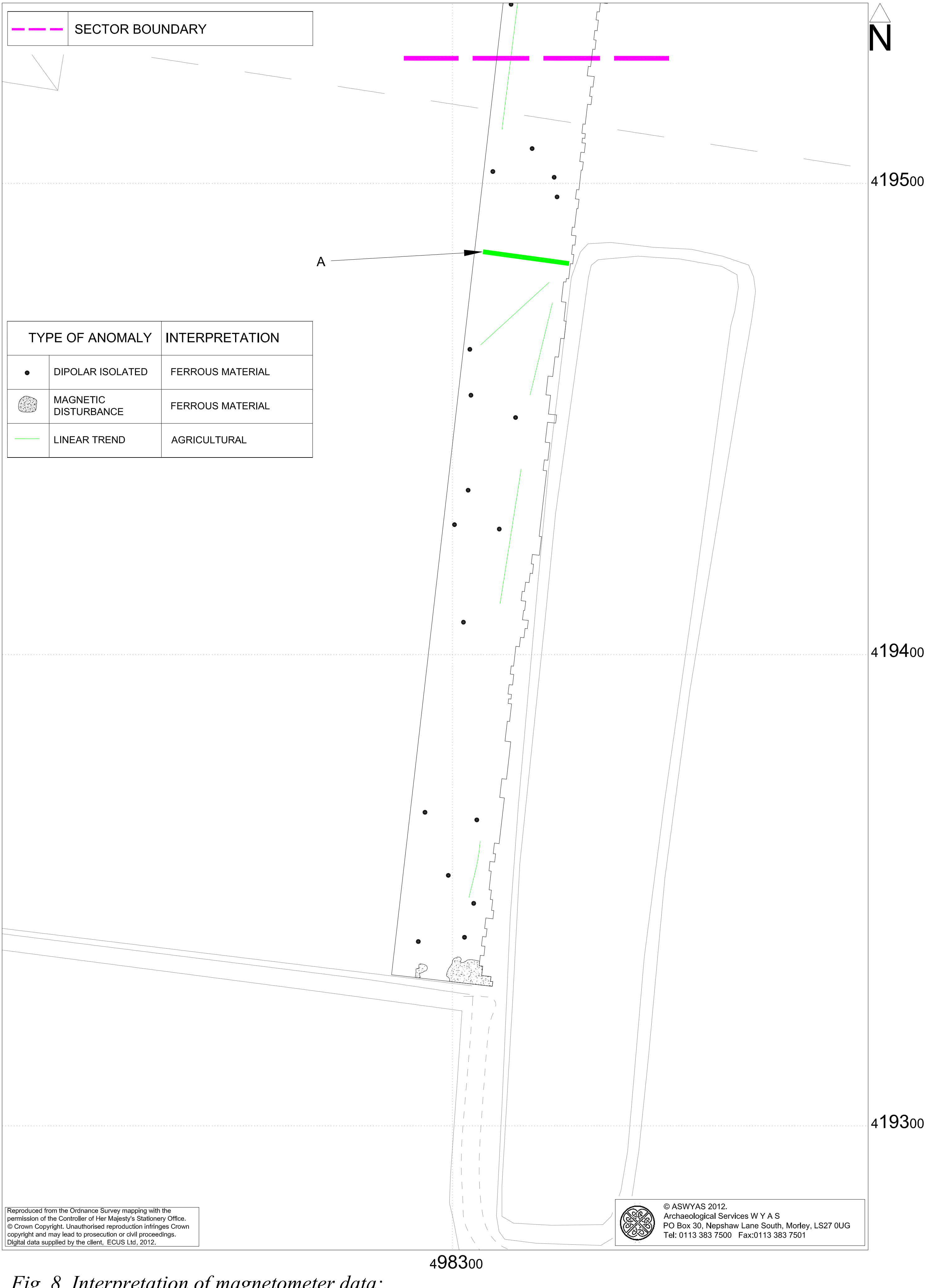

Fig. 8. Interpretation of magnetometer data; Southern sector (1:1000 @ A4)

Plate 1. General view of survey area, looking south

Plate 2. General view of survey area, looking north