ARCHAEOLOGICAL SERVICES WYAS

West Moor Park
Armthorpe
South Yorkshire

Geophysical Survey

Report no. 2704

December 2014

Client: Prospect Archaeology Ltd

West Moor Park
Armthorpe
South Yorkshire

Geophysical Survey

Summary

A geophysical (magnetometer) survey covering 12.5 hectares was carried out on land south of West Moor Park Industrial Estate, to inform planning proposals for the development of the site. Previous archaeological investigations, undertaken in advance of the development of the industrial estate, revealed features indicative of extensive Late Iron Age industrial and agricultural activity. Ditch features forming part of this landscape appear to extend into the current site. No anomalies of definite archaeological potential have been identified by the survey although faint linear trends to the north-west of the site are on a similar alignment to the Late Iron Age features and therefore may indicate the continuation of the field system; similar weak and fragmentary anomalies were identified by a previous survey carried out to the south of (and partially overlapping) the site. These anomalies are limited to an area of sands and gravels. No anomalies of archaeological potential are recorded on the clay and silt superficial deposits that prevail in the southern and central parts of the site. On the basis of the magnetic survey the archaeological potential of the site is considered to be low, with a moderate potential ascribed to the north-west of the site, although the presence of further, unrecorded features, to the south of the site cannot be discounted.

ARCHAEOLOGICAL
SERVICES
WYAS

Report Information

Client:	Prospect Archaeology Ltd
Address:	Prospect House, Garden Lane, Sherburn-in-Elmet, Leeds, North Yorkshire, LS25 6AT
Report Type:	Geophysical Survey
Location:	Armthorpe
County:	South Yorkshire
Grid Reference:	SE 640 047
Period(s) of activity:	Iron Age?
Report Number:	2704
Project Number:	4306
Site Code:	WMP14
OASIS ID:	archaeol11-202434
Planning Application No.:	n/a
Museum Accession No.:	n/a
Date of fieldwork:	October 2014
Date of report:	December 2014
Project Management:	Alistair Webb BA MCIfA
Fieldwork:	David Harrison BA MSc MCIfA
	Sam Harrison BSc MSc MCIfA
	Dan Waterfall BA
Report:	David Harrison
Illustrations:	David Harrison
Photography:	Sam Harrison
Research:	n/a

Authorisation for distribution: ----------

PO Box 30, Nepshaw Lane South, Morley, Leeds
LS27 0UG
Telephone: 0113 383 7500.
Email: admin@aswyas.com

Contents

List of Figures

List of Plates

1 Introduction

Archaeological Services WYAS (ASWYAS) were commissioned by Prospect Archaeology Ltd (the Client), to undertake a geophysical (magnetometer) survey of land proposed for development at West Moor Park, South Yorkshire (see Fig. 1). 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 (NPPF 2012) and in line with current best practice (David *et al*. 2008). The survey was carried out between October 6th and October 16th 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) is located on the eastern side of Armthorpe, centred at SE 640 04, immediately south of West Moor Park Industrial Estate and west of the M18 motorway. The survey area consists of two arable fields which are bound to the north by Holme Wood Lane, to the east by a sewage treatment facility, to the south by a ditch known as ‘village drain’ and to the west by small fields of pasture on the periphery of Armthorpe village (see Fig. 2).

The site is located on a gentle south-facing gradient being at 7m above Ordnance Datum (aOD) within the north of the PDA and 4m aOD in the south. At the time of the survey the site was under a remnant cereal crop (see plates).

Soils and geology (see Fig 3)

The underlying bedrock comprises sandstone of the Nottingham Castle Sandstone Formation, overlain by superficial deposits of River Terrace Deposits (undifferentiated sand and gravel) in the north; Hemingbrough Glaciolacustrine Formation (clays and silts) in the south-west and Breighton Sand Formation (sands and silts) in the south-east (British Geological Survey 2014). The soils are classified in the Dunkeswick association, characterised as slowly permeable, seasonally waterlogged fine loams and fine loams over clay (Soil Survey of England and Wales 1983).

2 Archaeological Background

The PDA is situated within an extensive Iron Age and Romano British landscape of fields, trackways and enclosures as indicated by cropmarks identified by aerial photographs. Archaeological excavations to the immediate north of the PDA (see Fig. 2) have identified a Late Iron Age agricultural and industrial landscape comprising a ‘brickwork plan’ of field systems and features including hearths, ovens/kilns, a well as well as cremations (Richardson 2008).

The southern part of the application area was previously surveyed (Archaeophysica 2008) as part of an earlier application. The report concluded that 'the survey revealed sufficient to suggest that the field system found north of Holme Wood Lane does continue into the site and that there may be a scatter of related features'. The report also suggested that ploughing may have truncated many features as indicated by the indistinct and discontinuous nature of the anomalies.

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 proposed 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:

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

Magnetometer survey

The magnetometer survey was undertaken using a Sensys Magneto®MXPDA 5 channel cart-based system (see Plate 1) which has five FGM650 fluxgate gradiometers mounted at 0.5m intervals with readings of between 0.1nT and 10,000nT recorded at 20Hz. The fluxgate gradiometers are linked to a Trimble R6 Real Time Kinetic (RTK) differential Global Positioning System (dGPS) allowing for the georeferencing of all measurement points within ±1cm accuracy. The data is recorded by Sensys Magneto®MXPDA software on a rugged Personal Data Assistant (PDA) device and stored on a Secure Digital (SD) memory card within the PDA.

TerraSurveyor V3.0.25.0 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 (1:5000) location plan displaying the processed greyscale magnetometer data and previously recorded archaeological features. Figure 3 is produced at the same scale and shows the magnetometer data and superficial geological deposits reproduced from data provided by the British Geological Survey 2014). An overall

interpretation of the magnetometer data is shown in Figure 5, also at 1:5000). Detailed processed data plots and full interpretative figures are presented, at a scale of 1:1000, in Figures 5 to 8 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.

Archaeological Services WYAS is registered with the Online Access to the Index of archaeological investigations project (OASIS). The OASIS ID for this project is archaeol11-202434. The record is shown in Appendix 4.

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 (Institute for Archaeologists, 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

Generally, a low level of background magnetic variation has been recorded throughout the PDA. However, there is a noticeable variation within this low background and this clearly correlates with the change in superficial deposits from the sands and gravels, which lie across the northern part of the site (where the data has a more 'speckled' appearance), to the much more uniform response recorded across the silts and clays to the south of the site. Despite this low level of variation, several anomalies have been identified by the geophysical survey although the majority are recorded on the sands and gravels to the north. These anomalies are discussed below and cross-referenced to specific examples depicted on the interpretative figures (Figs 5 to 8 inclusive), where appropriate.

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. A high magnitude linear dipolar linear anomaly, **A**, within the east of Field 2 locates the route of a service pipe on a north/south alignment.

Broad areas of magnetic disturbance at the perimeters of the PDA are due to ferrous material within the adjacent field boundaries, whilst the magnetic disturbance along the southern edge of the site is due to the proximity of the 'village drain'.

Agricultural Anomalies

Analysis of historical Ordnance Survey mapping indicates that the layout and division of land within the PDA has been altered, since the publication of the first edition Ordnance Survey map in 1854, by the removal of two field boundaries. Within Field 1, one of these boundaries has been detected as a very faint linear anomaly, **B**, visible on an east/west orientation. The anomaly is due to a soil-filled ditch. The second former field boundary, within Field 2, has not been detected with clarity by the survey but is thought to be located by a vague alignment of ferrous 'spikes', **C**, on a north-south alignment. These anomalies are likely to be caused by an accumulation of debris, including ferrous material, either side of the field boundary, now removed. The lack of clarity in the data in the vicinity of the two former boundaries is suggestive of low magnetic susceptibility within the soils.

Faint parallel linear trends within the south of Field 2, spaced at regular 8m intervals are typical of modern field drains. Elsewhere, more narrowly-spaced linear trends are typical of modern cultivation ridges and, at the perimeters of the fields, ploughing headlands.

Geological Anomalies

A slight variation in background magnetic response can be seen between the north and the south of the PDA. This variation is due to differing superficial deposits across the site. The slightly 'speckled' appearance to the data north of the geological boundary, **D**, is due to sand and gravel River Terrace deposits whilst south of the boundary, the more consistent grey tone to the data is thought to result from the homogenous properties of the clay and silt deposits. Broader, amorphous, areas of magnetic enhancement within the south of the PDA are thought to be due to accumulations or pockets of silts and clays. Within the east of Field 1, a higher magnitude anomaly, **E**, is observed. This may be due to an isolated area of magnetic superficial deposits or possibly an area of localised extraction.

Possible Archaeological Anomalies

No anomalies of obvious archaeological potential have been identified by the geophysical survey. However, several faint trends and fragmented linear anomalies, **F – L** have been identified within the north of Field 1 which are ascribed a possible archaeological origin based on their linear appearance and their east-west orientation, similar to that of the ditches identified in excavations to the immediate north of the PDA. No clear archaeological pattern is discernible but is possible that these faint anomalies indicate ditches, possibly associated

with the agricultural field system excavated to the north of Holme Wood Lane which are of Late Iron Age date.

Within the centre of Field 1 a faint and fragmented linear anomaly, **M**, is identified on an east/west orientation. The anomaly is parallel to the former field boundary, **B**, and may indicate another field boundary removed prior to the publication of the first edition map. However, an archaeological origin is equally plausible and this anomaly may be caused by an earlier ditch.

5 Conclusions

No anomalies of definite archaeological potential have been identified by the magnetic survey. However, within the north-west of the PDA weak and discontinuous linear trend anomalies may be of archaeological interest. The anomalies appear on a similar east/west alignment to the network of Iron Age ditches and trackways to the immediate north of the site. The detection of these anomalies is limited to the area of sands and gravels with no anomalies of archaeological potential recorded on the silts and clays which comprise the majority of the site. It is therefore concluded, using information from excavation and previous geophysical survey of adjacent areas, that the archaeological potential of the current site may be higher than indicated by the survey results. Features may be present but poor magnetic contrast on the silts and clays and the likely adverse impact of modern ploughing have combined to make identification of archaeological features very difficult, even using a cart based magnetometer system. The extent of archaeological activity on this site can only be confidently evaluated by a programme of trial trenching.

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.

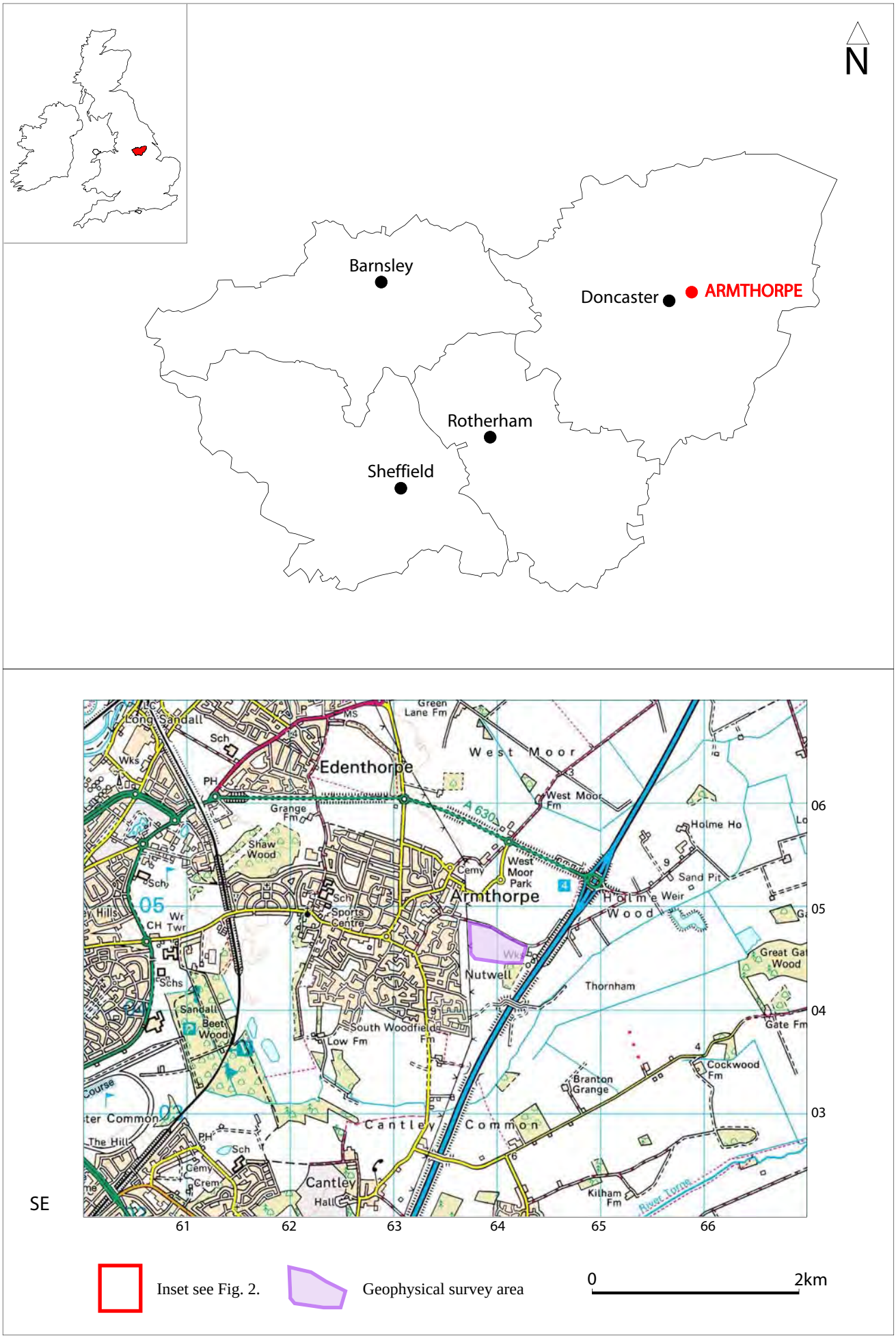

Fig. 1. Site location

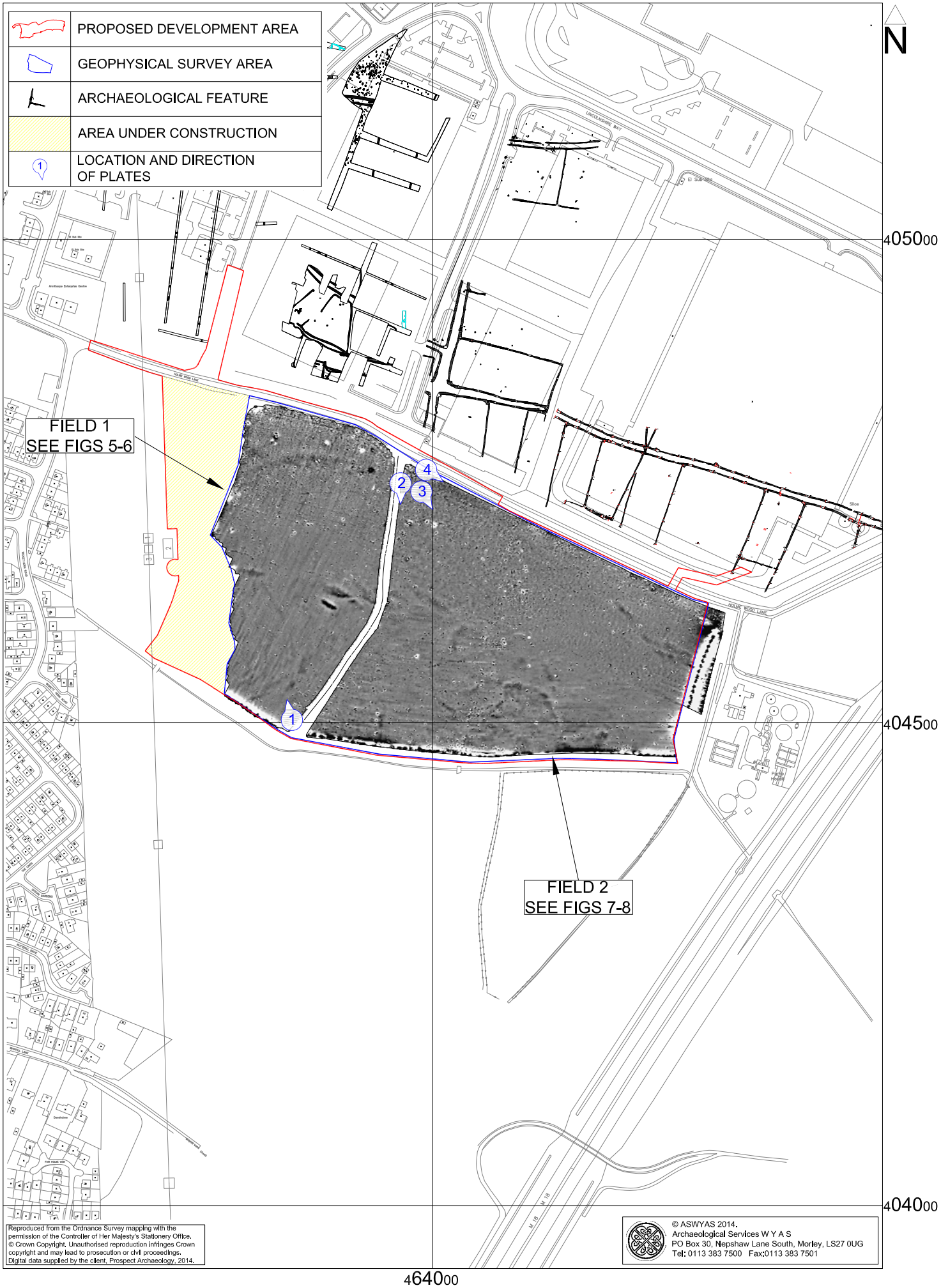

Fig. 2. Survey location showing greyscale magnetometer data and previously recorded archaeological features (1:5000 @ A4)

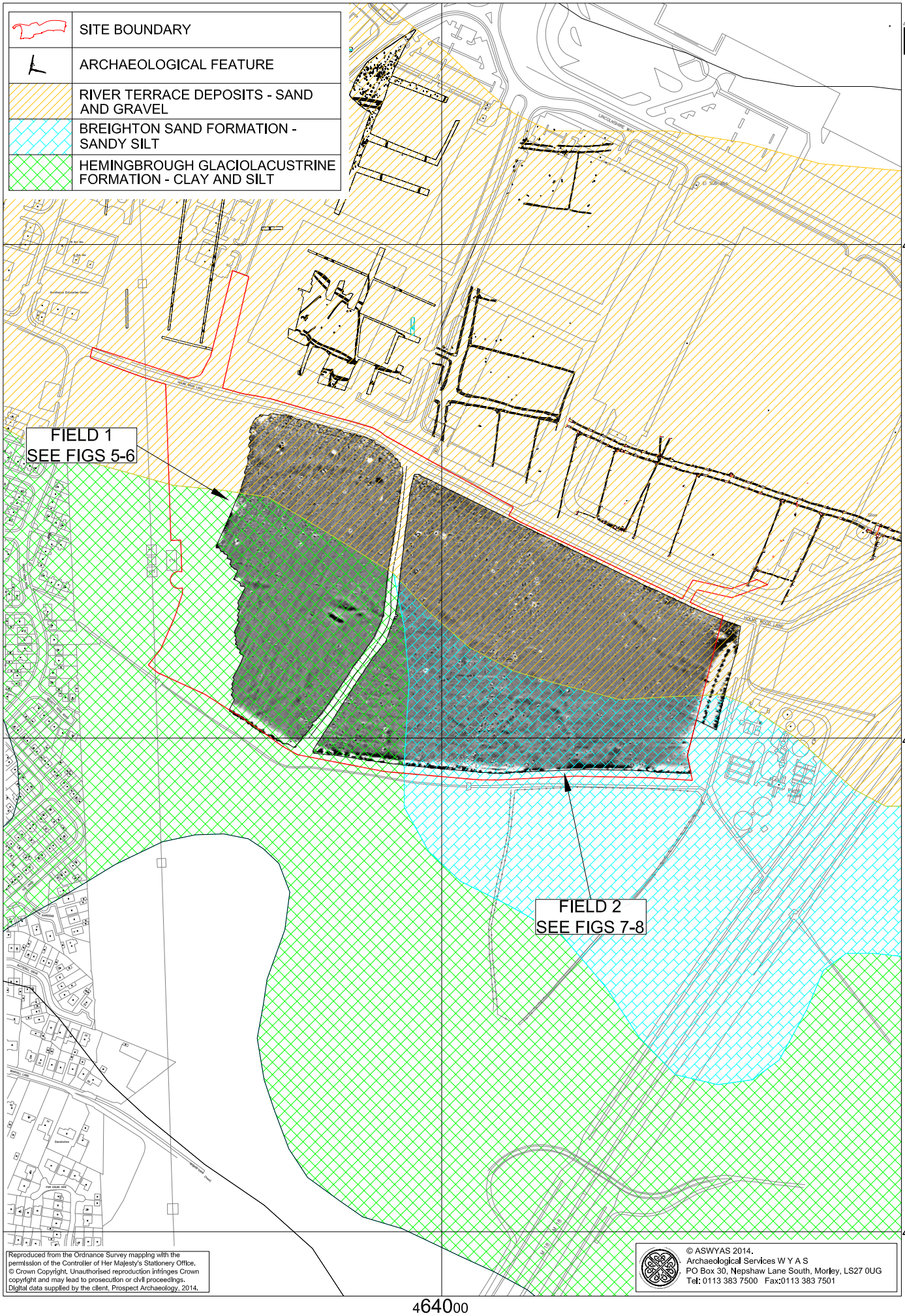

Fig. 3. Survey location showing greyscale magnetometer data and superficial deposits (1:5000 @ A4)

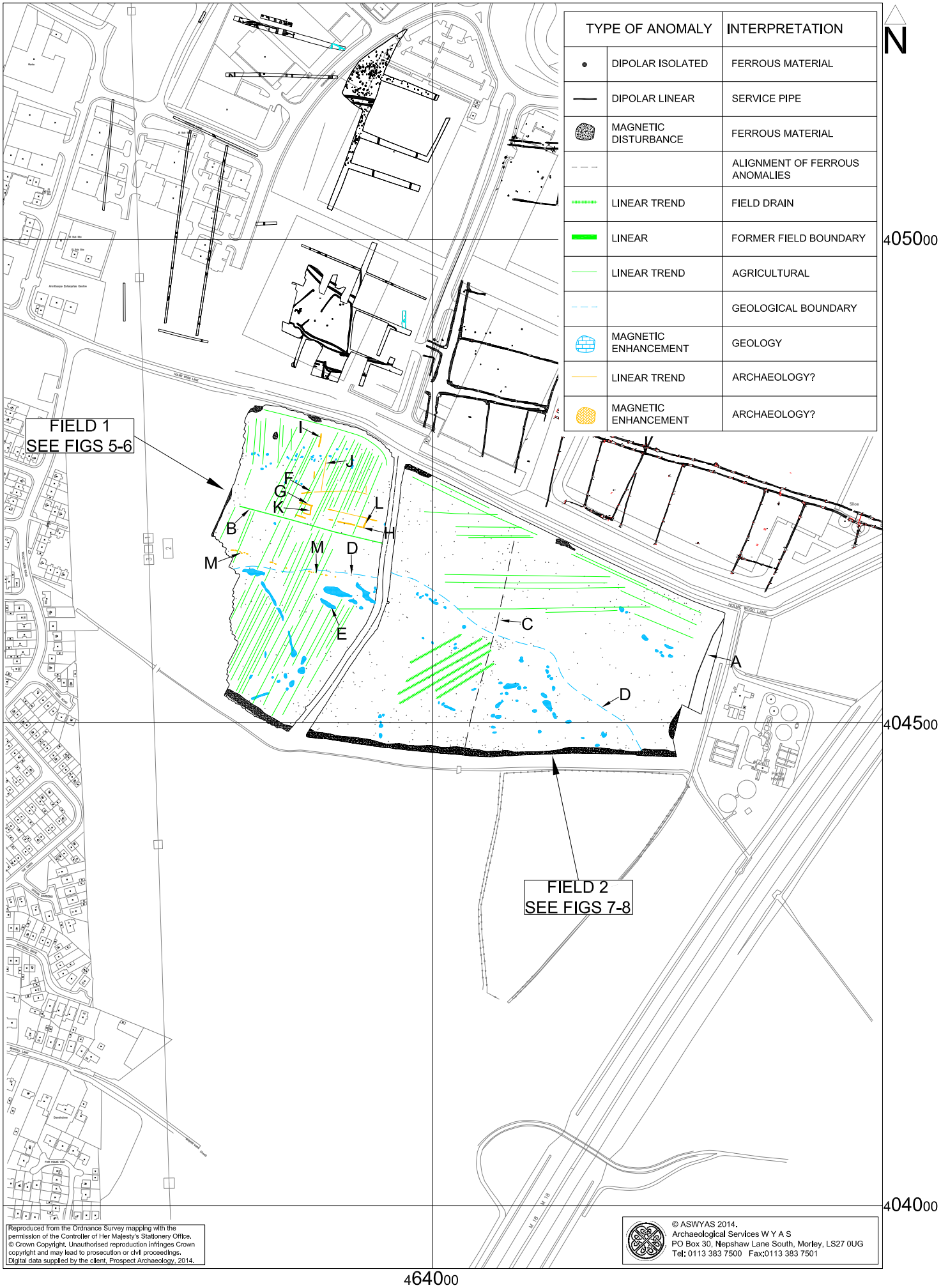

Fig. 4. Overall interpretation of magnetometer data (1:5000 @ A4)

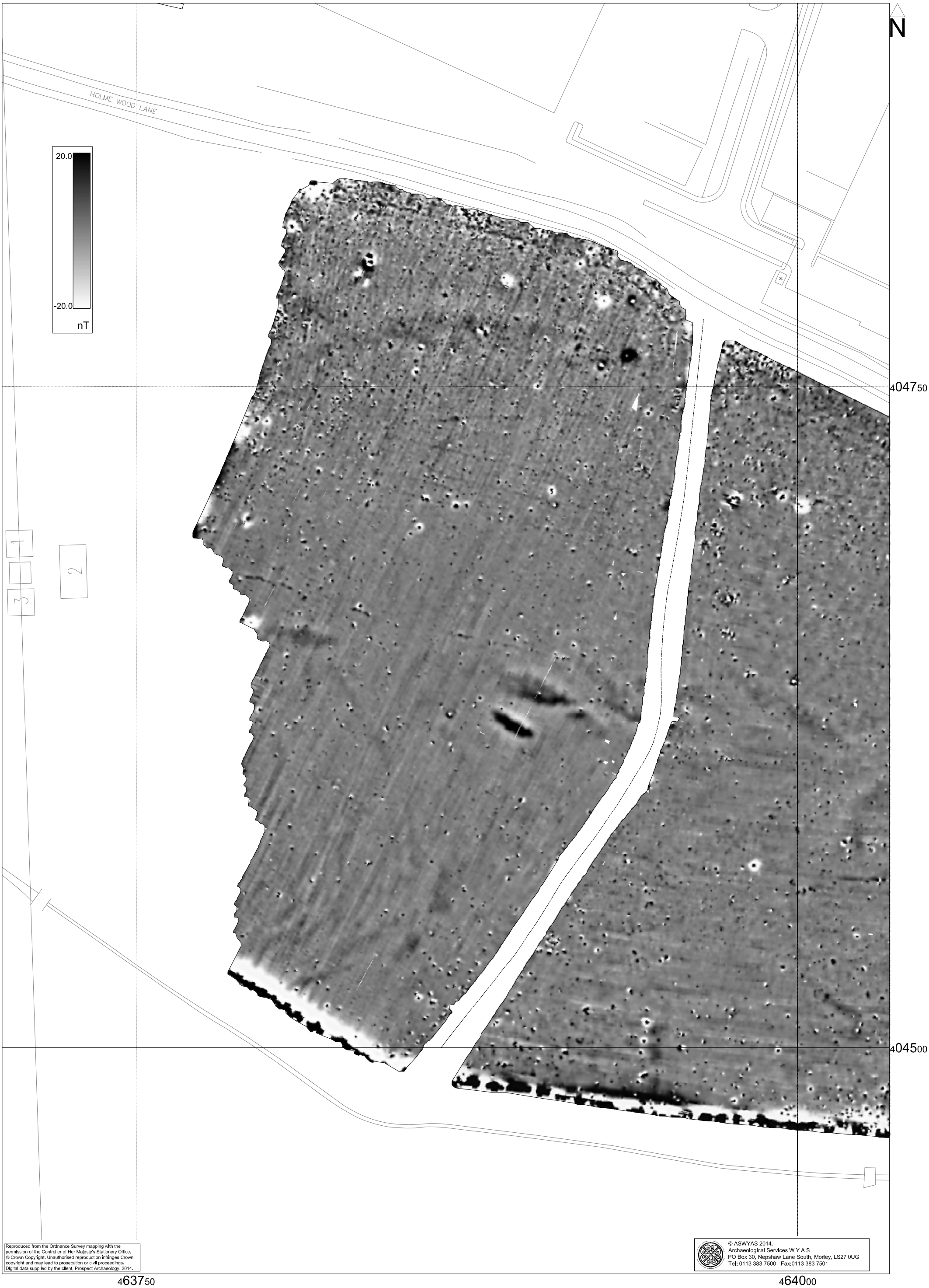

Fig. 5. Processed greyscale magnetometer data; Field 1 (1:1000 @ A3)

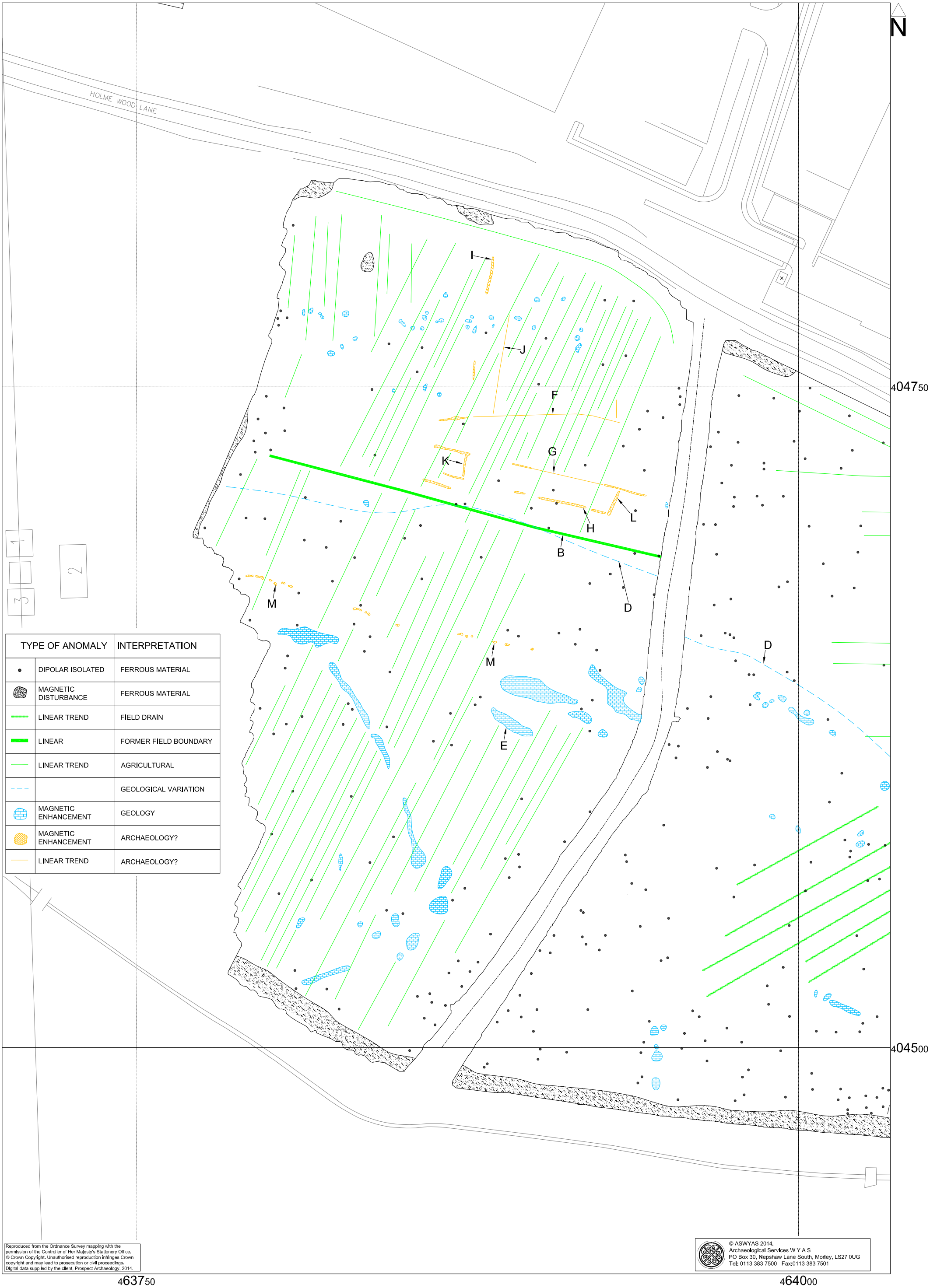

Fig. 6. Interpretation of magnetometer data; Field 1 (1:1000 @ A3)

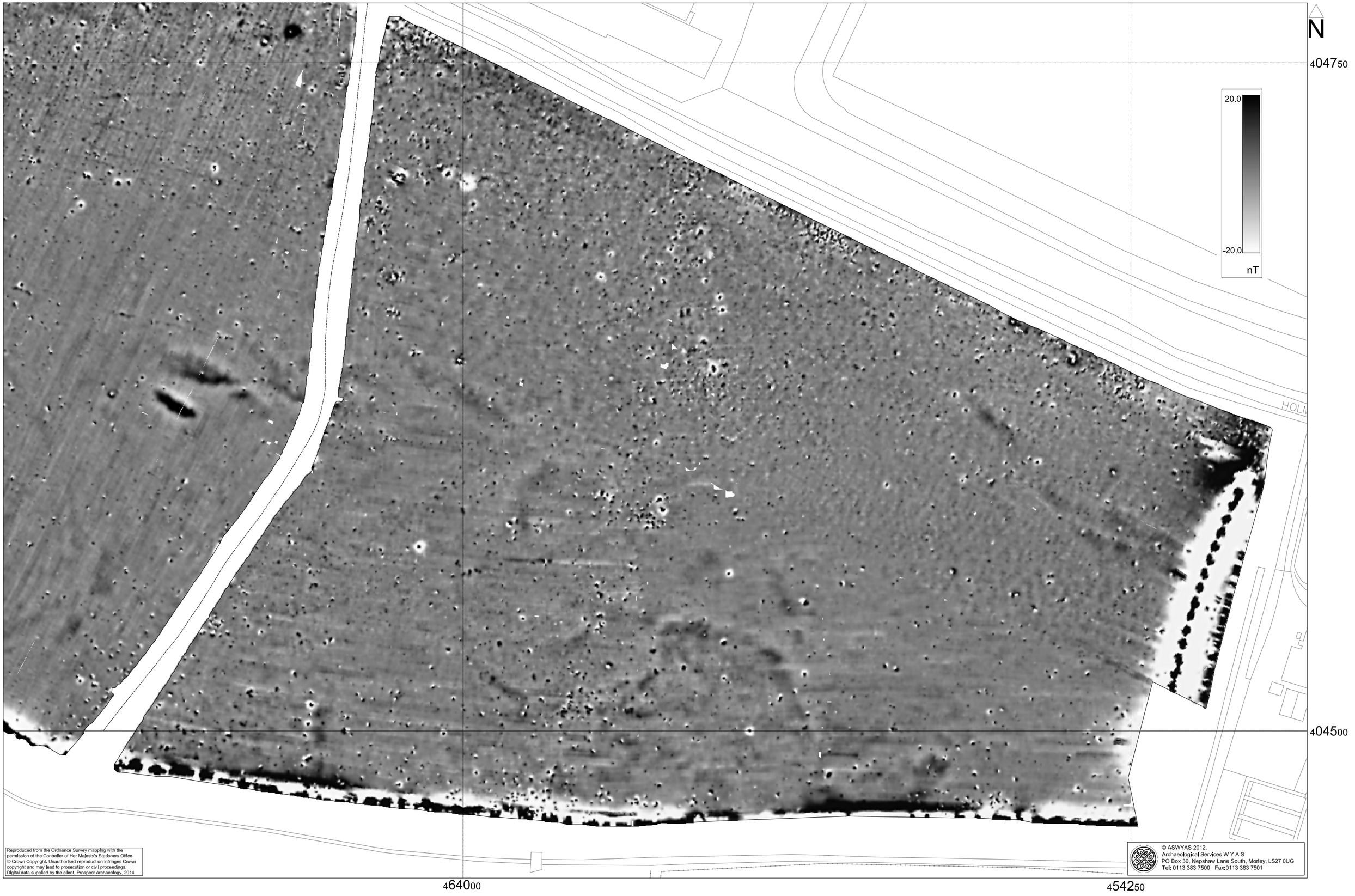

Fig. 7. Processed greyscale magnetometer data; Field 2 (1:1000 @ A3)

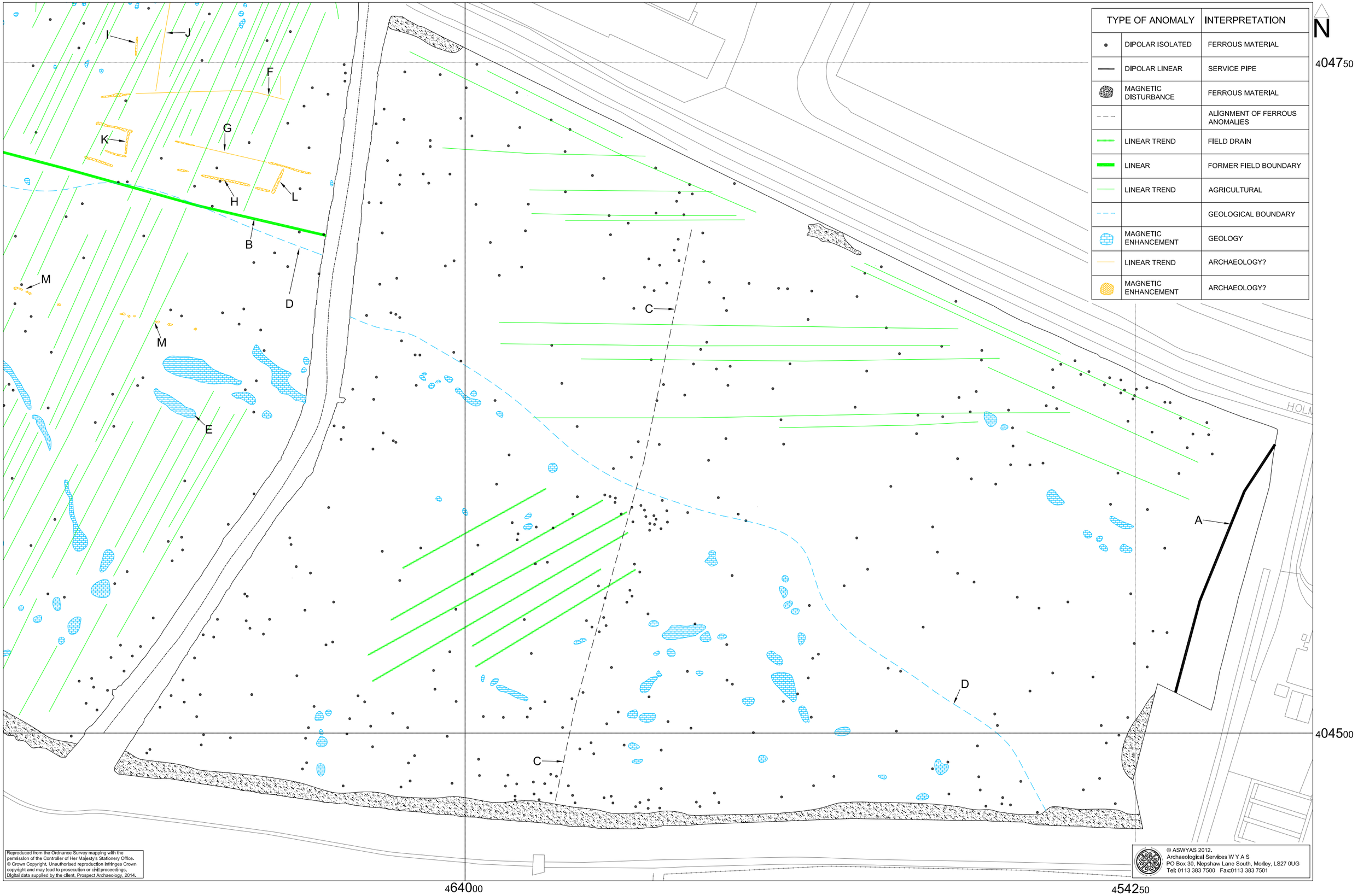

Fig. 8. Processed greyscale magnetometer data; Field 2 (1:1000 @ A3)

Plate 1. General view of Field 1, looking north-west

Plate 2. General view of Field 2, looking south

Plate 3. General view of Field 2, looking south-east

Plate 4. General view of Field 2, 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. Areas of human occupation or settlement can then be identified by measuring the magnetic susceptibility of the topsoil because 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.

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 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: Gradiometer Survey

The magnetometer survey was undertaken using a Sensys Magneto®MXPDA 5 channel cart-based system (see Plate 1). The system has 5 FGM650 fluxgate gradiometers mounted at 0.5m intervals with readings of between 0.1nT and 10,000nT recorded at 20Hz. The fluxgate gradiometers are linked to a Trimble R6 Real Time Kinetic (RTK) differential Global Positioning System (dGPS) allowing for the georeferencing of all measurement points within

±1cm accuracy. The data is recorded by Sensys Magneto®MXPDA software on a rugged Personal Data Assistant (PDA) device and stored on a Secure Digital (SD) memory card within the PDA.

The gradiometer data has been presented in this report in processed greyscale format. 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.

TerraSurveyor V3.0.25.0 was used to compensate (destripe) interpolate and clip the data. The same program was used to produce the greyscale images. All greyscale plots are displayed using a linear incremental scale.

A sample of data was collected using a Bartington Grad601-2 magnetic gradiometer (see Appendix 5). The instrument 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 regular intervals and calibrated as necessary. The drift from zero was not logged.

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 2: Survey location information

An initial survey station was established using a Trimble VRS differential Global Positioning System (Trimble R6 model). The cart data was geo-referenced using the geo-referenced survey station with a Trimble RTK differential Global Positioning System (Trimble R6 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). The report will be made available for consultation in the South Yorkshire Historic Environment Record.

Appendix 4: OASIS form

OASIS DATA COLLECTION FORM: England

List of Projects | Manage Projects | Search Projects | New project | Change your details | HER coverage | Change country | Log out

Printable version

OASIS ID: archaeol11-202434

Project details

Project name	West Moor Park, Armthorpe
Short description of the project	A geophysical (magnetometer) survey covering 12.5 hectares was carried out on land south of West Moor Park Industrial Estate, to inform planning proposals for the development of the site. Previous archaeological investigations, undertaken in advance of the development of the industrial estate, revealed features indicative of extensive Late Iron Age industrial and agricultural activity. Ditch features forming part of this landscape appear to extend into the current site. No anomalies of definite archaeological potential have been identified by the survey although faint linear trends to the north-west of the site are on a similar alignment to the Late Iron Age features and therefore may indicate the continuation of the field system; similar weak and fragmentary anomalies were identified by a previous survey carried out to the south of (and partially overlapping) the site. These anomalies are limited to an area of sands and gravels. No anomalies of archaeological potential are recorded on the clay and silt superficial deposits that prevail in the southern and central parts of the site. On the basis of the magnetic survey the archaeological potential of the site is considered to be low, with a moderate potential ascribed to the north-west of the site, although the presence of further, unrecorded features, to the south of the site cannot be discounted.
Project dates	Start: 06-10-2014 End: 16-10-2014
Previous/future work	No / Yes
Any associated project reference codes	4306 - Contracting Unit No.
Any associated project reference codes	WMP14 - Sitecode
Type of project	Field evaluation
Site status	None
Current Land use	Cultivated Land 4 - Character Undetermined
Monument type	N/A None
Monument type	N/A None
Significant Finds	N/A None
Significant Finds	N/A None
	"Geophysical Survey"

Methods & techniques	
Development type	Extensive green field commercial development (e.g. shopping centre, business park, science park, etc.)
Prompt	National Planning Policy Framework - NPPF
Position in the planning process	Pre-application
Solid geology (other)	Nottingham Castle Sandstone Formation
Drift geology	SAND AND GRAVEL OF UNCERTAIN AGE OR ORIGIN
Techniques	Magnetometry

Project location

Country	England
Site location	SOUTH YORKSHIRE DONCASTER ARMTHORPE West Moor Park, Armthorpe
Postcode	DN3 3FF
Study area	12.50 Hectares
Site coordinates	SE 640 047 53.534801762 -1.03426638671 53 32 05 N 001 02 03 W Point

Project creators

Name of Organisation	Archaeological Services WYAS
Project brief originator	Prospect Archaeology Ltd
Project design originator	Archaeological Services WYAS
Project director/manager	Webb, A.
Project supervisor	Harrison, S
Type of sponsor/funding body	Developer

Project archives

Physical Archive Exists?	No
Digital Archive Exists?	No
Digital Media available	"Geophysics"
Paper Archive Exists?	No
Paper Media available	"Report"

Project bibliography 1

Publication type	Grey literature (unpublished document/manuscript)
Title	West Moor Park, Armthorpe; Geophysical Survey
Author(s)/Editor (s)	Harrison, D.
Other bibliographic details	Report No. 2704
Date	2014
Issuer or publisher	ASWYAS
Place of issue or publication	Morley
Description	A4 blue comb-bound report
Entered by	David Harrison (dharrison@aswyas.com)
Entered on	3 February 2015

Bibliography

British Geological Survey, 2014. www.bgs.ac.uk/discoveringGeology/geology OfBritain/viewer.html . (Viewed December 19th 2014)

David, A., N. Linford, P. Linford and L. Martin. 2008. *Geophysical Survey in Archaeological Field Evaluation: Research and Professional Services Guidelines (2nd edition)* English Heritage

Harrison, S., 2014 *West Moor Park, Armthorpe, South Yorkshire: Geophysical Survey Project Design* Unpublished ASWYAS document

Institute for Archaeologists. 2013. *Standard and Guidance for archaeological geophysical survey.* CIfA

Richardson, J. 2008. *The Late Iron Age and Romano-British rural landscape of Gunhills, Armthorpe, South Yorkshire*. Archaeological Services WYAS Publications 10

Roseveare, M. 2008. Holme Wood Lane, Armthorpe, South Yorkshire: Geophysical Survey Unpublished Client Report No. HWL081

Soil Survey of England and Wales, 1983. Soil Survey of England and Wales: Soils of Northern England, Sheet 1