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ARCHAEOLOGICAL
SERVICES
WYAS

Land adjacent to Northfields Industrial Estate
Market Deeping
Lincolnshire

Geophysical Survey

March 2006

Report No. 1497

CLIENT
Lincolnshire
in partnership with
JACOBS BABTIE

ELI 6651 SLI 10659 NEGATIVE

Land adjacent to Northfields Industrial Estate

Market Deeping

Lincolnshire

Geophysical Survey

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Summary

A geophysical (magnetometer) survey covering 5 hectares carried out on the north-east edge of Market Deeping has not revealed any anomalies thought to be indicative of archaeological activity. Areas of magnetic enhancement and general magnetic variability are interpreted as being caused by localised variation in the composition of the alluvial drift geology or by modern activity.

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Archaeological Services WYAS

PO Box 30, Nepshaw Lane South, Morley, Leeds LS27 0UG

1. Introduction and Archaeological Background

1.1 Archaeological Services WYAS was commissioned by Jacobs Babtie on behalf of their client Lincolnshire County Council to carry out a geophysical (magnetometer) survey at the site of a proposed light industrial development immediately east of the existing Northfield Industrial Estate in Market Deeping (see Fig. 1). The work was commissioned in compliance with the condition attached to Outline Planning Consent (application no. SO5/0894/56).

1.2 The site, centred at TF 1430 1150, was bounded by the A16 Market Deeping Bypass to the north, the existing industrial estate to the west, arable fields to the east and sports pitches to the south. In total the survey area covered approximately 5 hectares comprising the whole of a single rectangular field (see Fig. 2). A linear strip that will be used for access was not surveyed (see Section 3.1 below). The fieldwork was carried out on February 22nd and 23rd 2006 at which time the field contained a young arable crop approximately 0.1m in height. Once the initial access issues were resolved no problems were encountered during the survey.

1.3 Geotechnical and trial pit data has shown that the site lies on an area of silty clay about 1m in depth. The overlying soils are classified in the Badsey 2 soil association. These soils are characterised as well drained, calcareous, fine loams. Topographically the site was flat and is situated at less than 5m Above Ordnance Datum.

1.4 Research undertaken prior to the geophysical survey, and included in full in the Specification for Geophysical Survey (Jacobs Babtie 2005), has revealed that there are no known archaeological sites within the application area other than the possible vestigial remains of ridge and furrow ploughing, although this may have been truncated or destroyed by recent deep ploughing. However, in the wider area (within 3 kilometres) there is evidence for prehistoric, Roman, post-Roman and medieval activity. In addition the position of Market Deeping close to the edge of the Fens also suggests that there is the potential for preserved palaeoenvironmental remains within the site.

2. Methodology and Presentation

2.1 The general aims of the survey were to obtain information that would contribute to an evaluation of the archaeological significance of the proposed scheme and which would enable further evaluation and/or mitigation measures to be designed.

2.2 More specific aims were:-

- To determine the presence or absence of buried archaeological remains in the survey area;
- To clarify the extent and layout of any remains in the survey area;
- To provide information about the nature and possible interpretation of any geophysical anomalies identified by the survey.

These aims were to be achieved by undertaking detailed magnetometer surveys across the whole of the proposed development area.

2.3 Detailed survey employs the use of a sample trigger to automatically take readings at predetermined points, typically at 0.25m intervals, on traverses 1m apart. These readings are stored in the memory of the instrument and are later downloaded to computer for processing and interpretation. Further details are given in Appendix 1. Detailed survey allows the visualisation of weaker anomalies that may not be identifiable by cruder evaluation techniques such as magnetic scanning or magnetic susceptibility survey.

2.4 A Bartington Grad601 magnetic gradiometer was used during the survey with readings being taken at 0.25m intervals on zig-zag traverses 1m apart within 20m by 20m grids. The readings were stored in the memory of the instrument and later downloaded to computer for processing and interpretation using Geoplot 3 software.

2.5 The survey methodology, report and any recommendations comply with guidelines outlined by English Heritage (David 1995) and by the IFA (Gaffney, Gater and Ovenden 2002). All figures reproduced from Ordnance Survey mapping are done so with the permission of the controller of Her Majesty's Stationery Office. © Crown copyright.

2.6 A general site location plan, incorporating the 1:50000 Ordnance Survey mapping, is shown in Figure 1. Figure 2 shows the processed magnetometer data superimposed onto a digital map base at a scale of 1:4000. The processed (greyscale) and unprocessed (XY trace plot) data, together with an accompanying interpretation diagram, are presented in Figures 3, 4 and 5 at a scale of 1:1250.

2.7 Technical information on the equipment used, data processing and magnetic survey methodology is given in Appendix 1 and the Condition Survey is included in Appendix 2. Appendix 3 details the survey location information and Appendix 4 describes the composition and location of the site archive.

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.

3. Results

3.1 The most obvious feature in the data is the massive magnetic disturbance along the western edge of the site. This was caused by the proximity to the edge of the survey grid of a steel paling fence (see Plate 2) and adjacent factory units. For this reason the linear strip to the south of the main survey area was not surveyed (see Fig. 2). This disturbance has had an adverse affect on the data in places up to 40m into the survey grid and is particularly apparent at the northern end of the field adjacent to the largest of the factory units (see Figs 3 and 4). It is possible that the strong magnetic effect of the fence could mask the much weaker response from an archaeological feature.

3.2 A series of parallel linear anomalies have been identified parallel with the northern site boundary (not visible on the processed greyscale plots). These anomalies are interpreted as being caused by land drains.

3.3 At the northern end of the site areas have been identified where the magnetic background is significantly above the general background level prevailing across the rest of the site. Whilst there does not appear to be a large ferrous component in this data some of the individual responses are quite high as can be seen from the XY trace plot. It is not clear whether these anomalies are caused by localised tipping or to variations or localised pockets of more magnetic material within the alluvial material that is known to cover the site.

3.4 In the southern half of the site many small, discrete areas of magnetic enhancement have been identified. Although these anomalies could have an underlying archaeological cause, such as pits, it is considered more likely that these small anomalies are also due to variations or localised pockets of more magnetic material within the alluvial material.

4. Discussion and Conclusions

4.1 No anomalies have been identified that have been interpreted as archaeological in nature although there are numerous discrete areas of magnetic enhancement and bigger areas of magnetic variability that potentially could potentially have an archaeological cause. However, given the absence of any other supporting information, it is considered much more probable that these anomalies have a non-archaeological origin.

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.

Bibliography

David, A., 1995. *Geophysical Survey in Archaeological Field Evaluation: Research and Professional Services Guidelines* No. 1. English Heritage

Gaffney, C., Gater, J. and Ovenden, S. 2002. *The Use of Geophysical Techniques in Archaeological Evaluations.* IFA Technical Paper No. 6

JacobsBabtie., 2005. Specification for Geophysical Survey. Unpublished Document

Acknowledgements

Project Management

A. Webb BA MIFA

Fieldwork

T. S. Harrison BSc MSc PIFA

E. Heapy BSc

Report

A. Webb

Graphics

T. S. Harrison

Figures

Figure 1	Site location (1:50000)
Figure 2	Site location showing processed greyscale magnetometer data (1:4000)
Figure 4	Plot showing processed greyscale magnetometer data (1:1250)
Figure 5	Plot showing XY trace plot of raw magnetometer data (1:1250)
Figure 6	Plot showing interpretation of magnetometer data (1:1250)

Appendices

Appendix 1	Magnetic Survey: Technical Information
Appendix 2	Condition Survey
Appendix 3	Survey Location Information
Appendix 4	Geophysical Archive

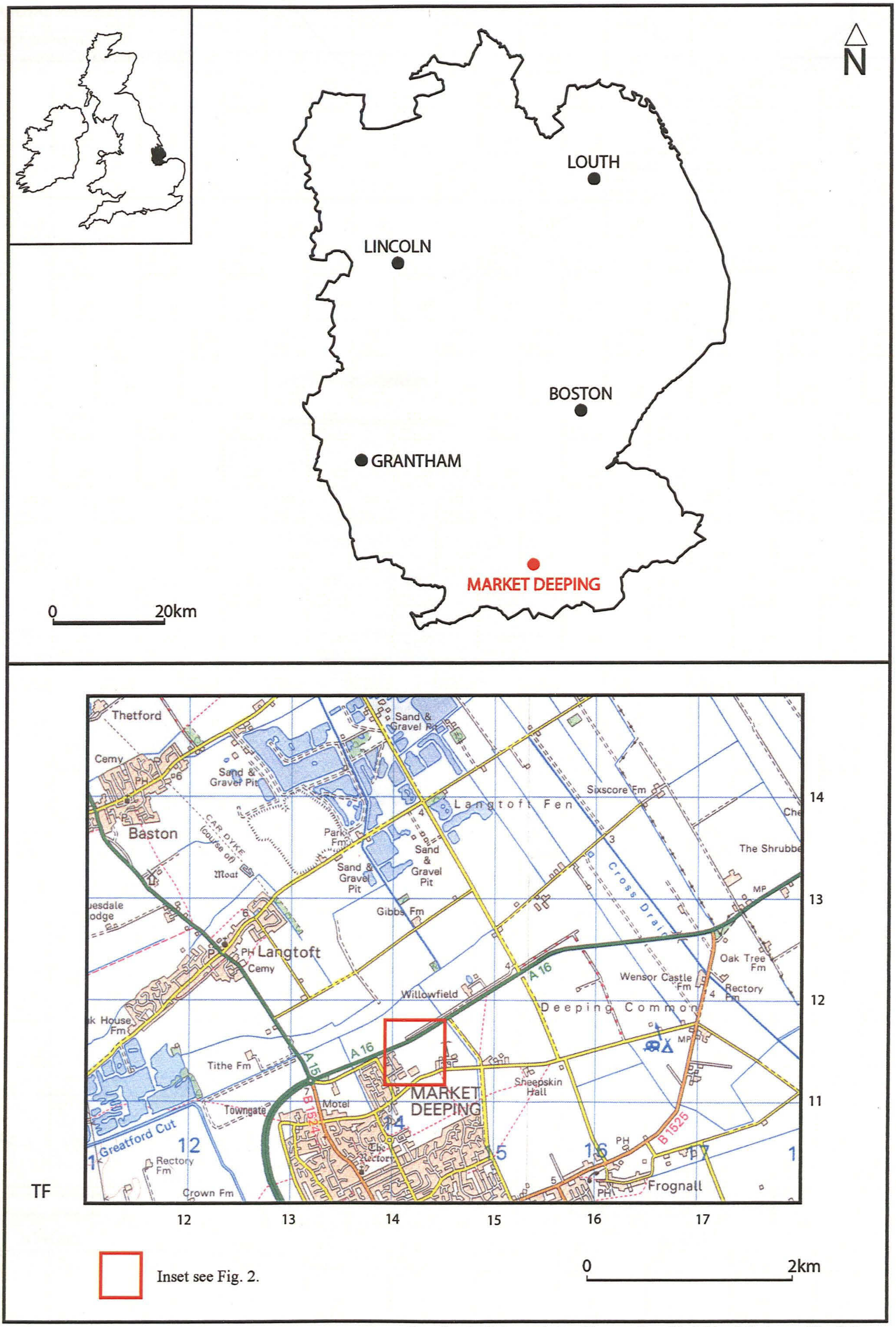


Fig. 1. Site location

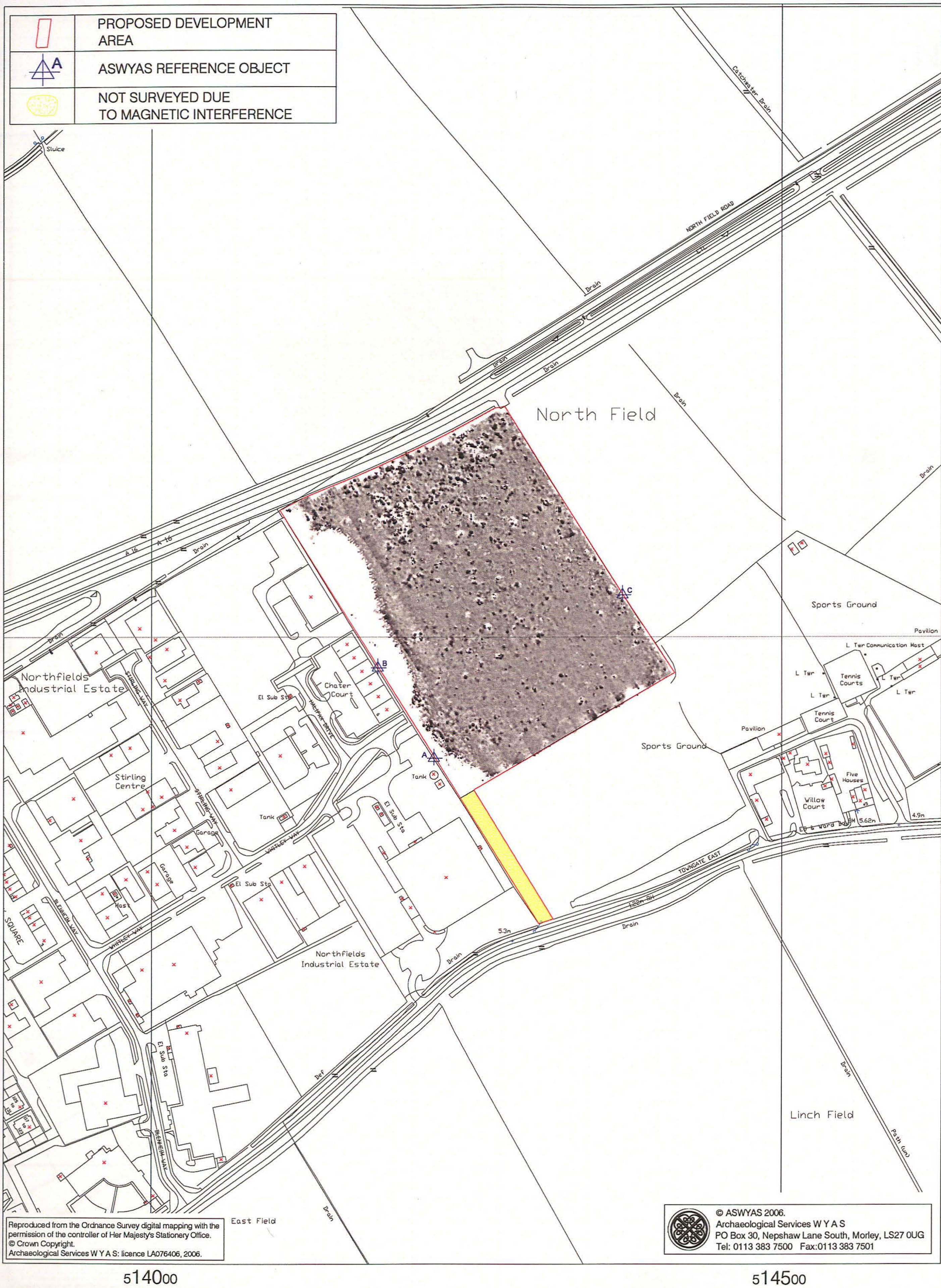


Fig. 2. Site location showing greyscale magnetometer data

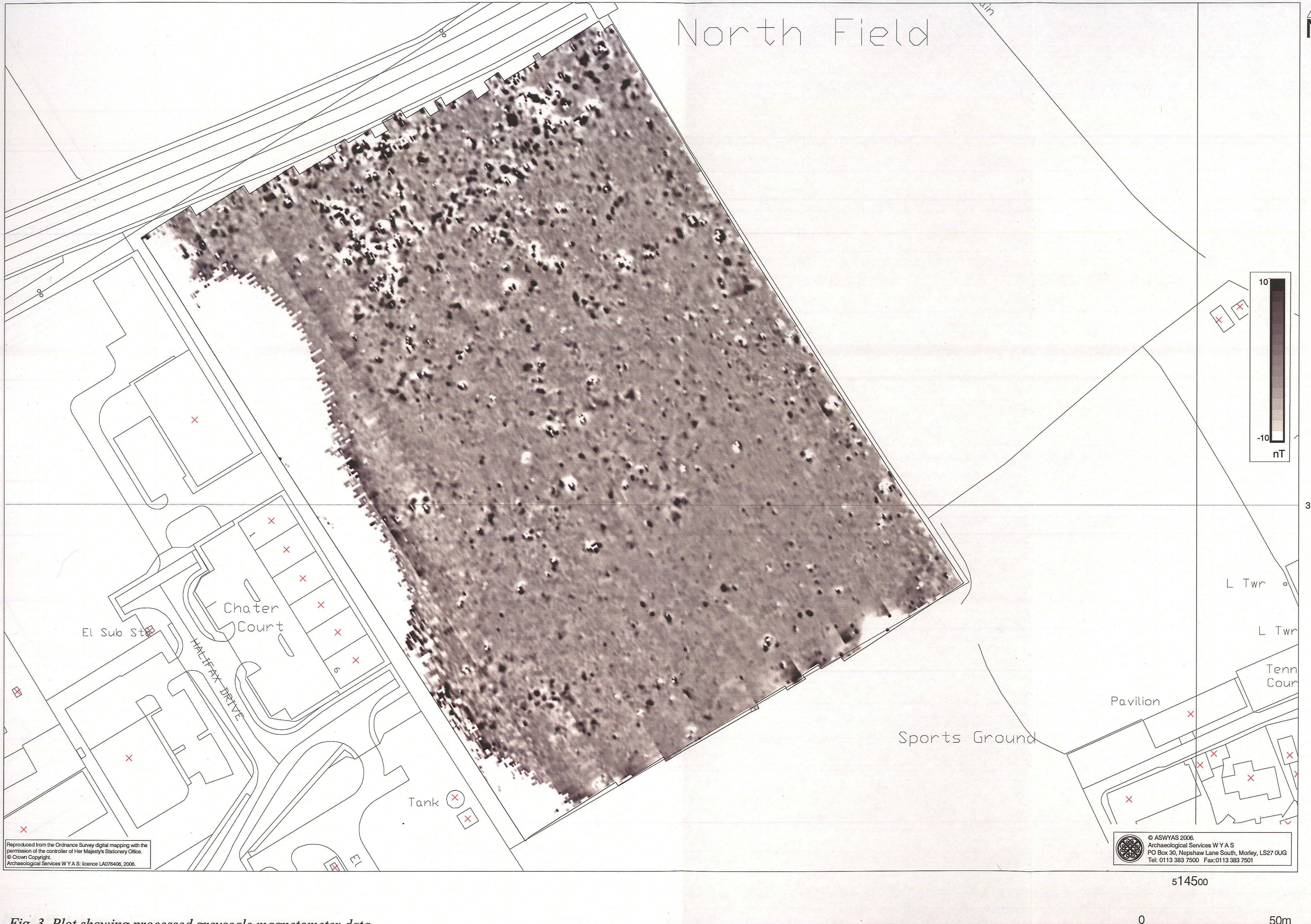
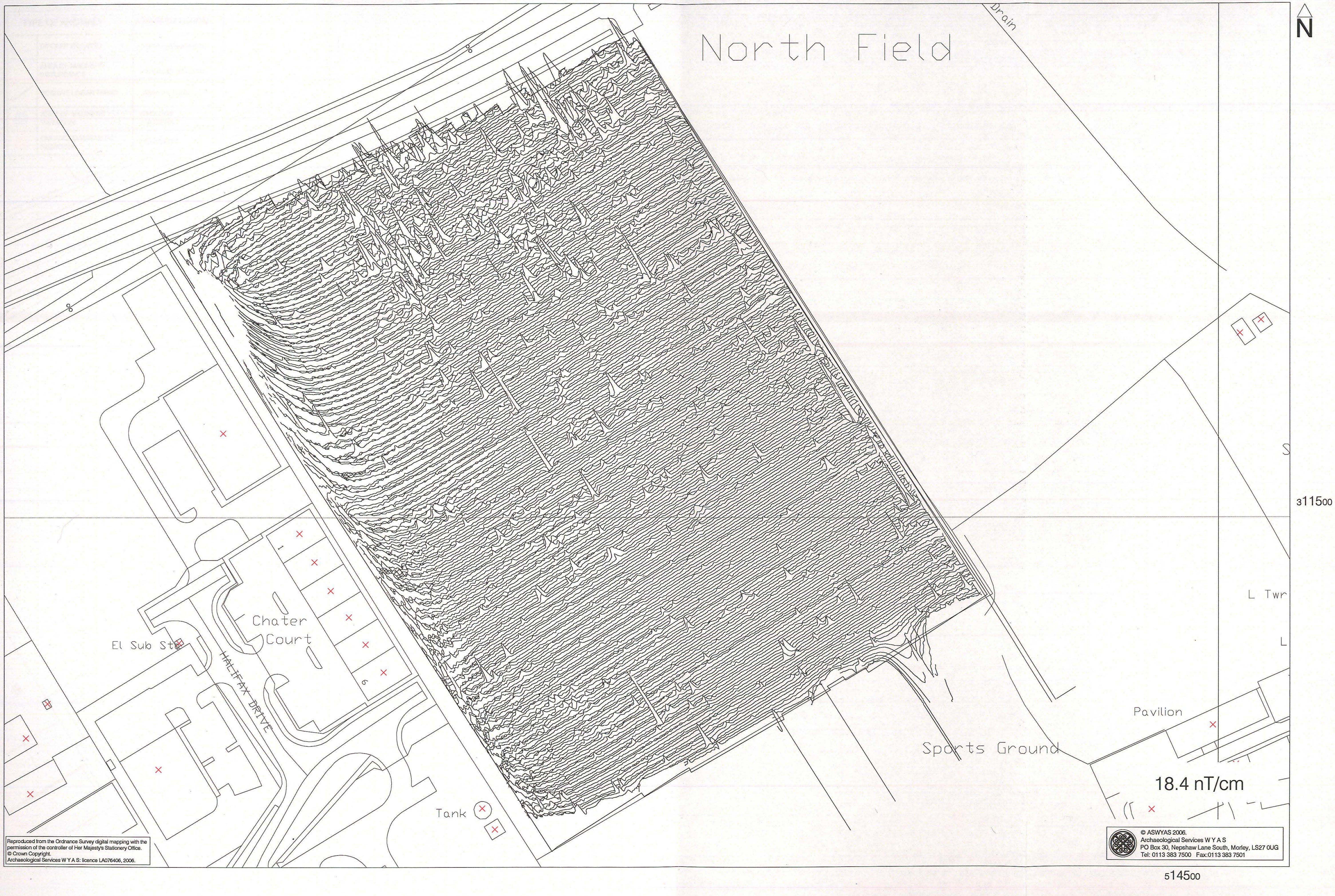


Fig. 3. Plot showing processed greyscale magnetometer data



Archaeological Services W Y A S
PO Box 30, Nepshaw Lane South, Morley, LS27 0UG
Tel: 0113 383 7500 Fax:0113 383 7501

Fig. 4. Plot showing XY trace plot of raw magnetometer data

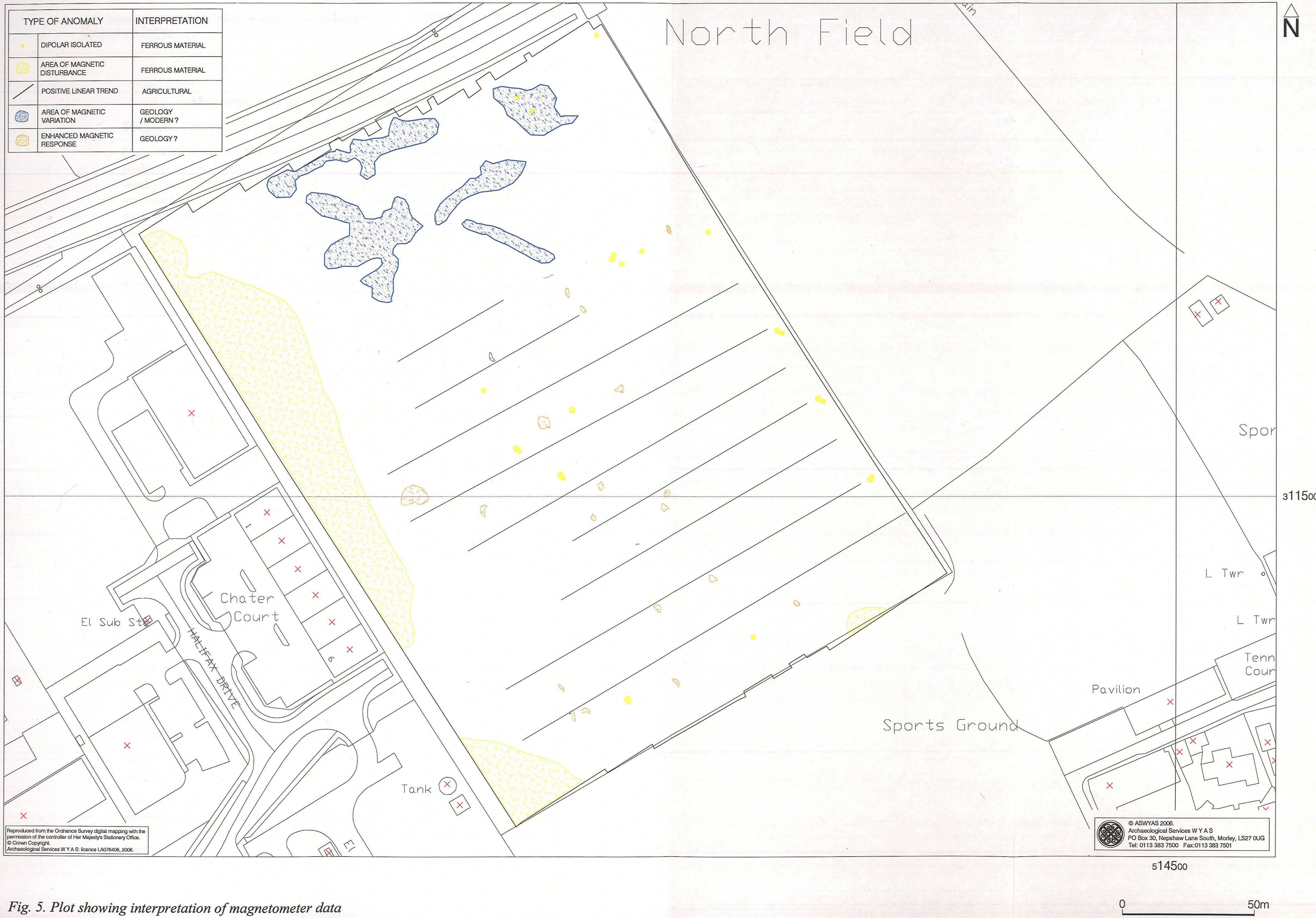


Fig. 5. Plot showing interpretation of magnetometer data

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. Less magnetic material such as masonry or plastic service pipes that intrude into the topsoil may give a negative magnetic response relative to the background level.

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

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. Such negative anomalies are often very faint and are commonly caused by modern, non-ferrous, features such as plastic water pipes. Infilled natural features may also appear as negative anomalies on some geological substrates.

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. An agricultural origin, either ploughing or land drains is 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. 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 negative results from magnetic scanning should **always** be checked with at least a 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 0.5m or 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 20m by 20m 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 1600 readings were obtained for each 20m by 20m grid. The same program was used to produce the greyscale images. All greyscale plots are displayed using a linear incremental scale.

Appendix 2

Condition Survey

ASWYAS

Archaeological Services WYAS

Geophysical Condition Survey

Job Number:...2854		Job Name...Northfields, Market Deeping	
Site Code......NMD			
Field Number..........		Date...22/01/06	Surveyor...TSH

Land Use......Land has a young crop growing. Rubbish in the south west edge of the field

....

....

Condition......Young crop. Lots of rubbish along west edge of field

....

....

....

Existing Crop Damage.........N/A

....

....

....

Damage Caused by ASWYAS......Total station survey point: Crop trampled.

....

....

....

Photos Taken and Direction.........General view of area facing E. Ferrous fencing facing north west

....

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Plate 1: General view of site facing East.

Plate 2: View of ferrous fencing and buildings facing North-West.

Plate 3: General view of site after the survey facing East.

Appendix 3

Survey Location Information

The site grid was laid out using a Geodimeter 600s total station theodolite and tied in to the corners of buildings and other permanent landscape features and to temporary reference points (survey marker stakes) 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 internal accuracy of the survey grid relative to these markers is better than 0.05m. The survey grids were then superimposed onto a map base provided by the client as a 'best fit' to produce the displayed block locations. Overall there was a good correlation between the local survey and the digital map base and it is estimated that the average 'best fit' error is better than ±1.5m. However, it should be noted that Ordnance Survey co-ordinates for 1:2500 map data have an error of ±1.9m at 95% confidence. This potential error must be considered if co-ordinates are measured off for relocation purposes.

Station	Easting	Northing
A	514223.8993	311403.5942
B	514179.3619	311475.2469
C	514373.6484	311533.1658

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 4

Geophysical Archive

The geophysical archive comprises:-

- an archive disk containing compressed (WinZip 8) files of the raw data, report text (Word 2000), and graphics files (CorelDraw6 and AutoCAD 2000) files.
- 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 will 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 relevant Sites and Monument Record Office) in compliance with the terms of the Section 42 Licence.