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**Willington Road  
Etwall  
Derbyshire**

**Geophysical Survey**

Report no. 2577

March 2014

Client: Bloor Homes



# Willington Road Etwall Derbyshire

## Geophysical Survey

### *Summary*

*A geophysical (magnetometer) survey covering approximately 7 hectares was carried out on agricultural land on the south-eastern fringe of Etwall, in order to provide an evaluation of the archaeological potential of the site prior to the proposed development of the site for housing. The data set is dominated throughout by anomalies indicative of ridge and furrow cultivation, the anomalies being most pronounced in the eastern half of the site where low earthworks are still visible. No anomalies of archaeological origin have been identified confirming the conclusions of an earlier desk-based assessment that the site had low/nil archaeological potential based on the current evidence.*



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**Report Information**

Client: Bloor Homes  
 Address: Ashby Road, Measham, Swadlincote, Derbyshire, DE12 7JP  
 Report Type: Geophysical Survey  
 Location: Willington Road, Etwall  
 County: Derbyshire  
 Grid Reference: SK 272 313  
 Period(s) of activity: medieval?/post-medieval  
 Report Number: 2577  
 Project Number: 4212  
 Site Code: WRE14  
 OASIS ID: archaeol11-173353  
 Planning Application No.:  
 Museum Accession No.: n/a  
 Date of fieldwork: February 2014  
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## 1 Introduction

Archaeological Services WYAS (ASWYAS) were commissioned by Myk Flitcroft of CgMs Consulting (The Consultant), on behalf of Bloor Homes (The Client) to undertake a geophysical (magnetometer) survey on land at Willington Road, Etwall, approximately 10km west of Derby (see Fig. 1), in order to provide an evaluation of the archaeological potential of the site prior to a proposed housing development. The work was undertaken in accordance with a Project Design (Sykes 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 on February 25th and February 26th 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 situated on the south-eastern edge of Etwall, centred at SK 272 313, immediately south-west of Willington Road (see Fig. 2), which forms the north-eastern site boundary. The PDA comprises two fields under permanent pasture (see plates) and covers 6.9 hectares. Residential properties border the PDA to the west and north with agricultural land to the south. The site slopes down from the northern end at approximately 75m above Ordnance Datum (aOD) to 65m aOD in the south.

### Soils and geology

The underlying bedrock comprises Gunthorpe Member mudstone overlain by superficial deposits of sands and gravel to the south-western extremity of the site (British Geological Survey 2014). Elsewhere no superficial deposits are recorded.

The soils in this area are classified in the Oak 1 association, being characterised as slowly permeable, seasonally waterlogged clays (Soil Survey of England and Wales 1983).

## 2 Archaeological Background

An Archaeological Desk-Based Assessment (CgMs 2014) confirmed that there are no archaeological assets within the PDA nor any designated archaeological assets within 0.5km of the PDA. Visible earthworks, indicative of medieval/post-medieval ridge and furrow cultivation (a non-designated asset), were recorded in the easternmost field during a site walkover.

### 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 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 the whole of the PDA, approximately 6.9 hectares, 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 (1:2000) location plan displaying the processed magnetic data. Detailed data plots ('raw' and processed) and an interpretative figure are presented at a scale of 1:1500 in Figures 3, 4 and 5.

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 (Sykes 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 3, 4 and 5)

Generally, a low level of background variation has been recorded across the PDA with only very subtle changes in background magnetic response being noted. Nevertheless, numerous anomalies have been identified by the survey. These fall into three different categories according to their origin and these are discussed below and cross-referenced to specific examples and locations within the site, 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, as is the case here. 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 common but there is no obvious pattern or clustering to their distribution to suggest anything other than a random background scatter of ferrous debris in the soil. A single high magnitude ‘spike’, **A**, is caused by an electricity pole.

##### **Agricultural Anomalies**

Early Ordnance Survey mapping and the 1849 tithe map shows that the division and layout of fields within the PDA has remained unchanged over the last 165 years. Low earthworks indicative of ridge and furrow cultivation, aligned north/south, are still visible in the eastern field (see Plate 2) and these manifest in the data set as the characteristic, sinuous, linear trends in the data that are present across the whole of the field. Towards the western side of the field a particularly prominent anomaly, **B**, probably locates a former headland/boundary although none is recorded on the historic mapping. In the western field the ploughing anomalies are much straighter and may be indicative of a later phase of ploughing.

##### **Geological anomalies**

Against a very low background variation a few low magnitude discrete anomalies are identified and characterised as localised areas of enhanced magnetic response. These anomalies are interpreted as geological in origin being caused by variation in the composition of the soils and superficial deposits, if present.



## 5 Conclusions

As indicated by the desk-based assessment there is evidence of post-medieval agricultural activity in the form of ridge and furrow cultivation across all parts of the site, possibly indicative of two different phases, as indicated by the degree of linearity of the anomalies in each field. However, these features are considered to be of only minor significance. The survey has not identified any anomalies of probable or possible archaeological potential. Therefore, on the basis of the geophysical survey, the archaeological potential of the site is considered to be very low, confirming the conclusions of the desk-based assessment.

*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.*

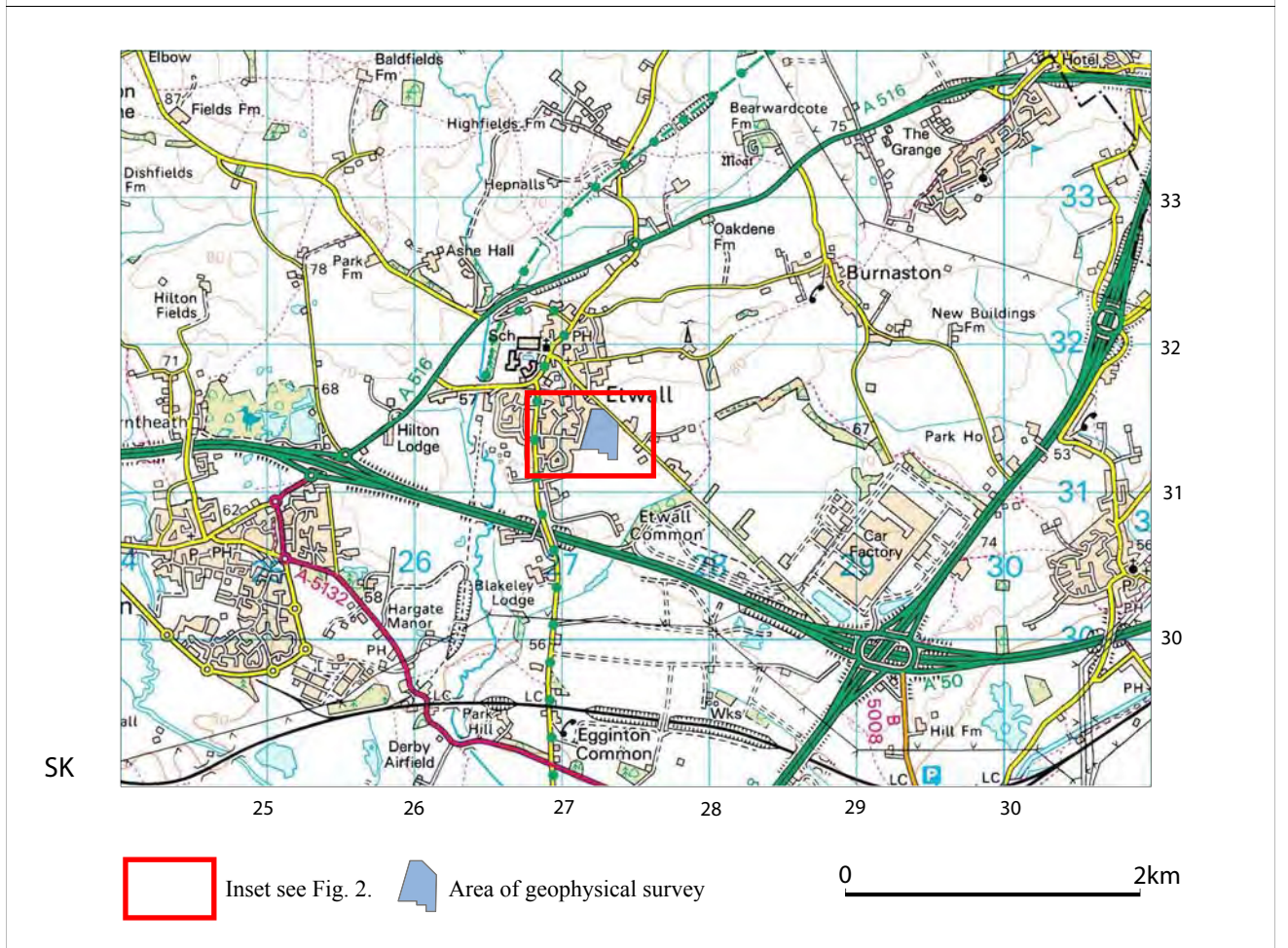
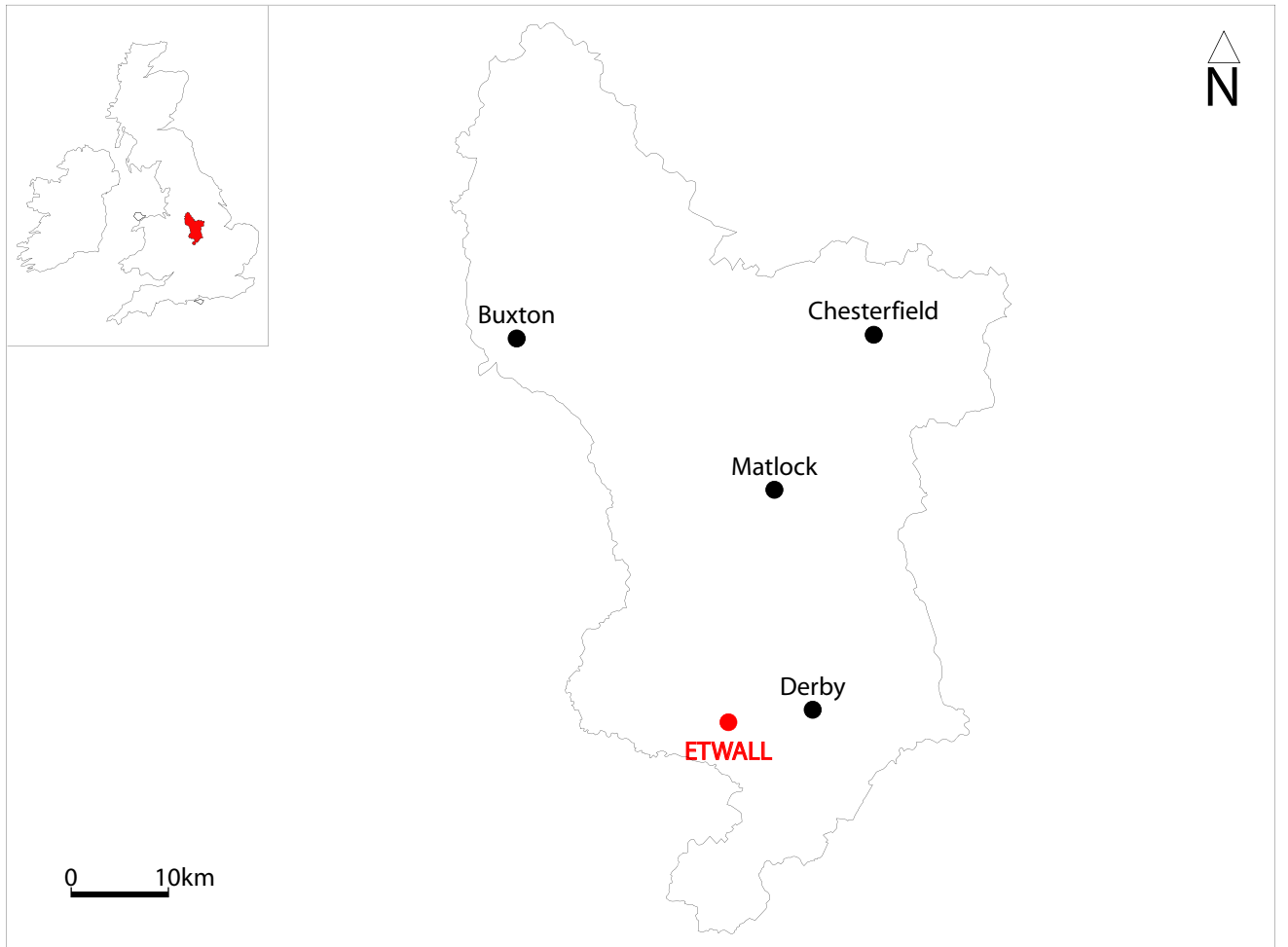


Fig. 1. Site location



Fig. 2. Survey location showing greyscale magnetometer data (1:2000 @ A3)



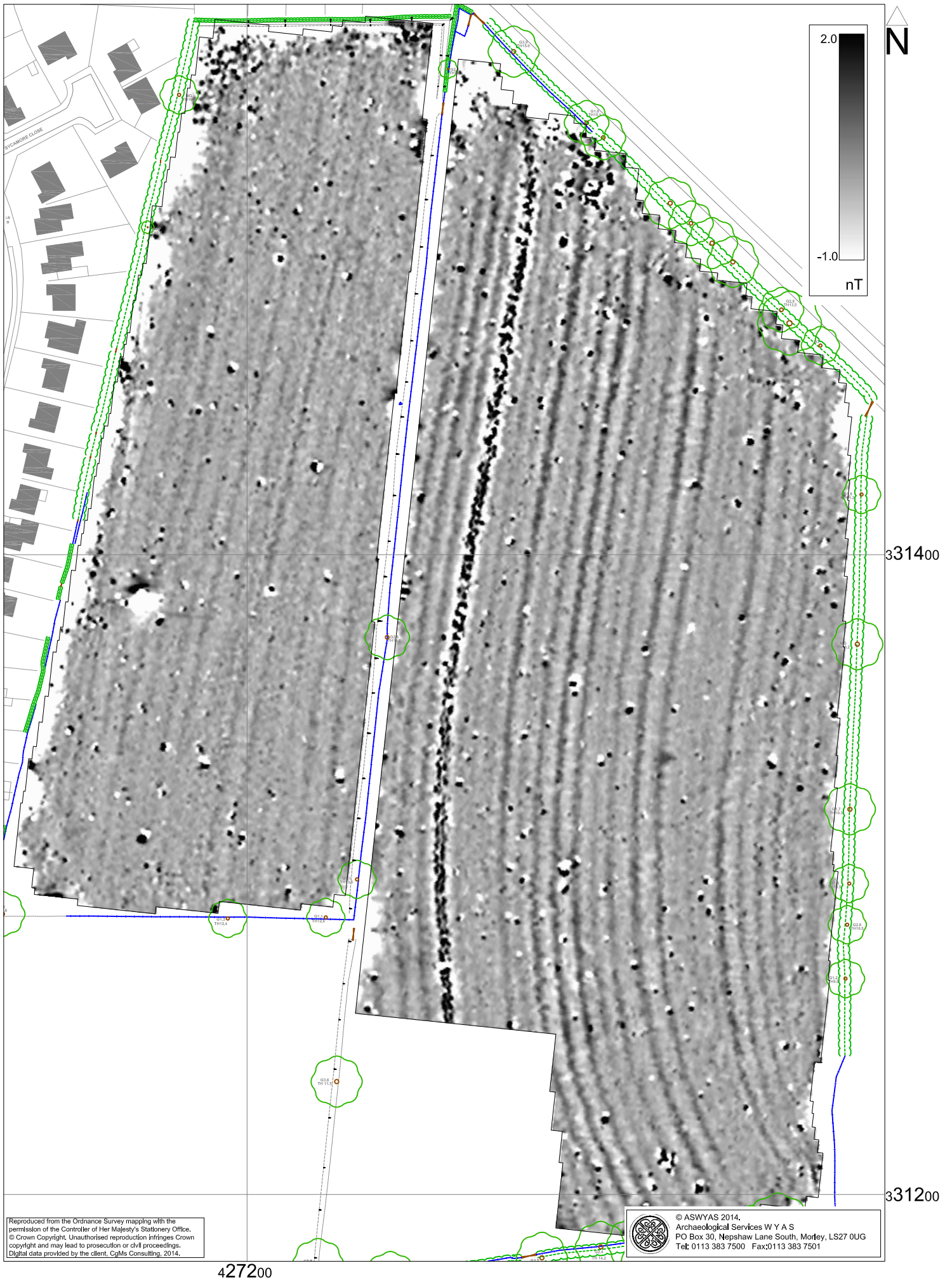


Fig. 3. Processed greyscale magnetometer data (1:1500 @ A4)

0 50m



Fig. 4. XY trace plot of minimally processed magnetometer data (1:1500 @ A4)

0 50m



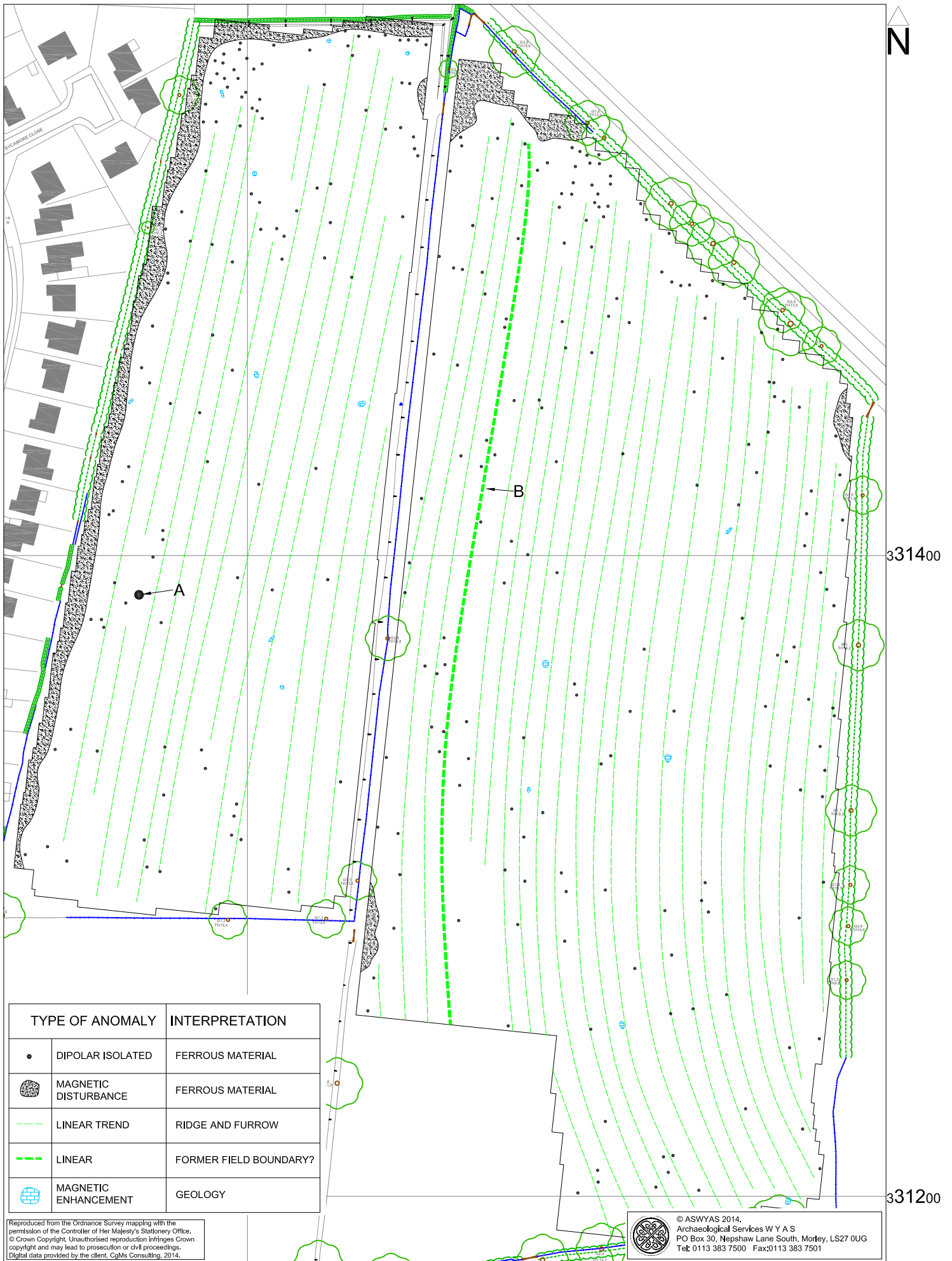


Fig. 5. Interpretation of magnetometer data (1:1500 @ A4)

0 50m



*Plate 1. General view of western field, looking north-west*



*Plate 2. General view of eastern field, looking north-west*

## **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 Derbyshire Historic Environment Record).

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