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**A61 Birdwell Junction
Barnsley
South Yorkshire**

Geophysical Survey

Report no. 2648

July 2014

Client: Barnsley Metropolitan Borough Council



A61 Birdwell Junction Barnsley South Yorkshire

Geophysical Survey

Summary

A geophysical (magnetometer) survey covering 1 hectare was carried out on land east of the A61 Birdwell Junction, to provide further information on the archaeological resource prior to proposed road improvement works. Anomalies have been identified which are consistent with near-surface geological variation and the industrial use of the land for mineral extraction. No anomalies have been identified to either confirm or negate the presence of features associated with the 17th-century battle of Tankersley Moor which is thought to have taken place in the locality. On the basis of the geophysical survey, the archaeological potential of the site is considered to be low.



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Report Information

Client:	Barnsley Metropolitan Borough Council
Address:	Highway Design and Infrastructure, Westgate Plaza 1, PO Box 601, Barnsley S70 9FA
Report Type:	Geophysical Survey
Location:	Birdwell
County:	South Yorkshire
Grid Reference:	SE 350 002
Period(s) of activity:	Modern
Report Number:	2648
Project Number:	4254
Site Code:	BRB14
OASIS ID:	archaeol11-191022
Planning Application No.:	Pre-application
Museum Accession No.:	n/a
Date of fieldwork:	June 2014
Date of report:	July 2014
Project Management:	David Harrison BA MSc MIfA
Fieldwork:	Daniel Waterfall BA Alexander Schmidt BA
Report:	David Harrison
Illustrations:	David Harrison
Photography:	Daniel Waterfall
Research:	n/a

Authorisation for
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1 Introduction

Archaeological Services WYAS (ASWYAS) was commissioned by Andy Jones of Barnsley Metropolitan Borough Council (the Client), to undertake a geophysical (magnetometer) survey in advance of proposed highway improvement works at the A61 Birdwell Roundabout, south of Barnsley, South Yorkshire. The work was undertaken in accordance with a Project Design (Harrison 2014) supplied to and approved by the client, with guidance contained within the National Planning Policy Framework (2012) and in line with current best practice (Institute for Archaeologists 2013; David *et al.* 2008). The survey was carried out on June 10th 2014 to provide additional information on the archaeological resource of the site.

Site location, topography and land-use

The A61 Birdwell Roundabout is approximately 5.5 miles to the south of Barnsley and a mile south of the village of Birdwell, centred at SE 3485 0050 (see Fig. 1). The A61 Sheffield Road passes north-south through the length of Birdwell and at its southern end joins Birdwell Roundabout which is the junction between the M1 motorway at Junction 36 and the A61. The proposed development area (PDA) is on the eastern side of the roundabout within a single pasture field (see Fig. 2; Plate 1).

The topography of the site is level at approximately 146m above Ordnance Datum.

Soils and geology

The underlying bedrock comprises Pennine Middle Coal Measures Formation - mudstone, siltstone and sandstone (British Geological Survey 2014). A near-surface coal seam is recorded within the PDA on a north-south alignment (SYMAS 2013), and is shown on Figure 2. The soils in this area are classified in the Dale association, characterised as slowly permeable, seasonally waterlogged clays, fine loams over clays and fine silts (Soil Survey of England and Wales 1983).

2 Archaeological Background

A desk-based assessment (ASWYAS 2014) carried out as part of the proposed improvement works identified no designated heritage assets within the PDA or the immediate surrounding area. However, this may reflect the absence of archaeological investigations rather than an absence of archaeology. Increased historical settlement of the area is linked to post-medieval mineral extraction and industrialisation which dominates the landscape with several opencast coal mines being recorded locally. The southern extent of the PDA passes through the former site of Tankersley Common opencast mine (see Fig. 2) which originated in the 1940s.

The desk-based assessment identified some potential within the PDA for the presence of unrecorded features associated with the 17th-century battle of Tankersley Moor, although the

exact site of the battle is unknown. Cannon balls and a musket ball were found in a field near Tankersley Lane which runs 160m to the south of the PDA.

3 Aims, Methodology and Presentation

The general objective of the geophysical survey was to provide information about the presence/absence, character, and extent of any archaeological remains identified within the defined areas and to help inform further strategies should they be required.

Specifically, the 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 1.0m 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. A large scale (1:1500) survey location plan is provided as Figure 2. The processed and minimally processed data, together with interpretation graphics of the survey results are presented in Figures 3, 4 and 5, at a scale of 1:1000.

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 archive.

The survey methodology, report and any recommendations comply with 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)

An increased level of background magnetic variation has been recorded within the west of the PDA with a low level of variation observed in the east. The interface between these two magnetic backgrounds corresponds to the former extent of Tankersley Common opencast mine (see Fig. 2) with the low level of variation to the east thought to be due to the more homogenous material used to backfill the mine. In contrast, numerous anomalies (discrete areas of magnetic enhancement) have been identified within the western limits of the PDA. Whilst any of these anomalies could, in theory, be archaeological in origin, the sheer number of anomalies combined with the evidence for near-surface geological variation (SYMAS 2013) suggests that a geological origin is likely. A fragmented and sinuous north/south aligned linear anomaly, **A**, corresponds closely to the Swallow Wood coal seam (see Fig. 2) and is caused by the enhanced magnetic properties within the coal.

Within the western limits of the dataset a more clearly defined linear anomaly, **B**, corresponds to a former field boundary which is depicted on the first edition Ordnance Survey map (1855). The anomaly is caused by the contrast between the soil-fill of the former boundary ditch and the surrounding soils. The identification of this anomaly demonstrates that the west of the PDA is undisturbed by the 20th-century coal mining.

Ferrous responses, either as individual 'spike' anomalies or more extensive areas of magnetic disturbance, are identified throughout the PDA and are typically caused by modern ferrous (magnetic) debris, either on the ground surface or in the plough-soil. It is possible that cannon balls and musket balls, if present, would also manifest in the data as ferrous 'spikes' although, whilst this cannot be discounted, there is no reason to assume that this is the case based on the survey results. Broader areas of magnetic disturbance at the northern and western site perimeters are caused by magnetic material within the adjacent field boundaries.

5 Conclusions

No anomalies of obvious archaeological potential have been identified by the geophysical survey. The survey has identified anomalies which are consistent with geological outcropping and the industrial use of the land for mineral extraction.

Therefore, based upon the results of the geophysical survey, the archaeological potential of the PDA is assessed as being low.

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

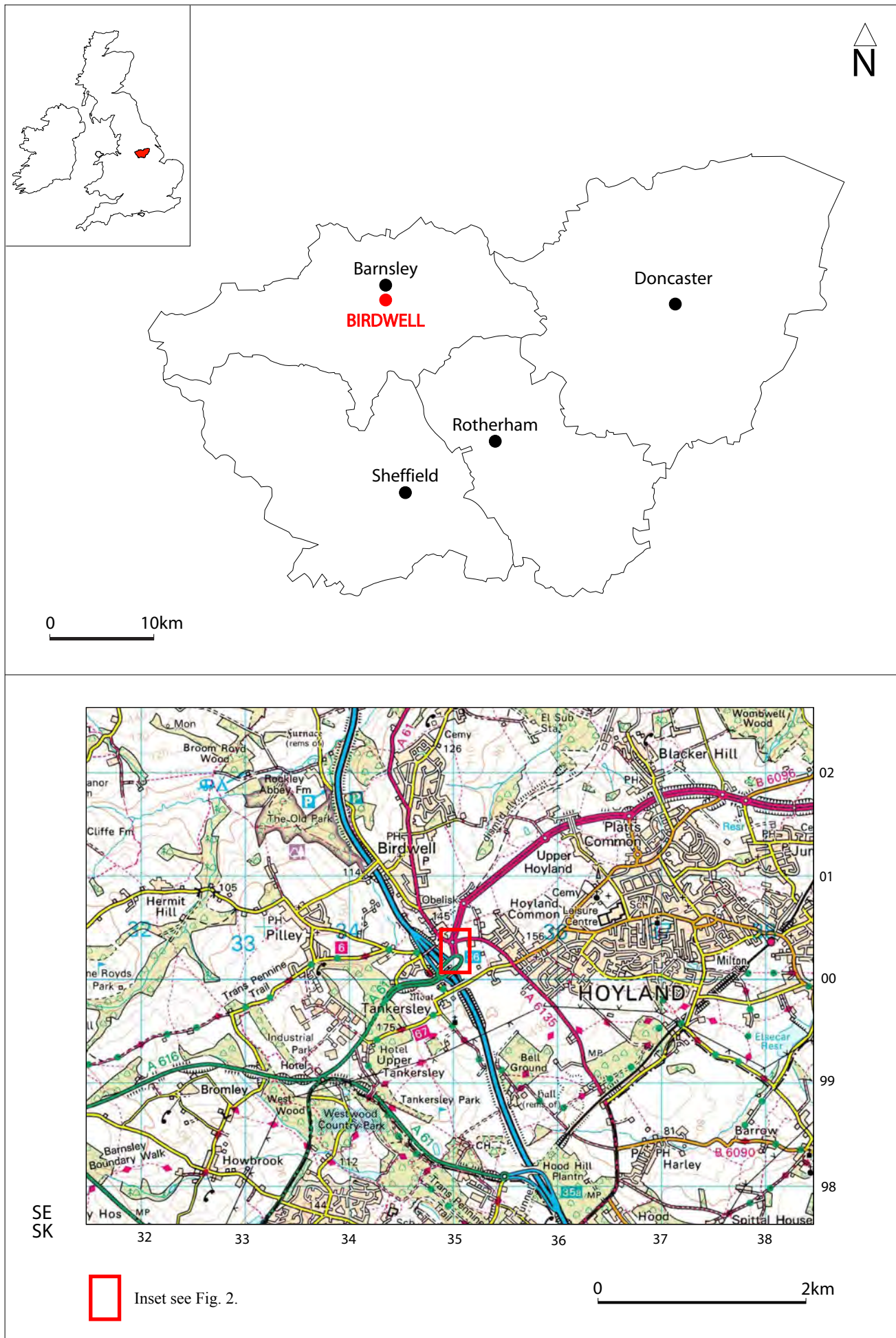


Fig. 1. Site location

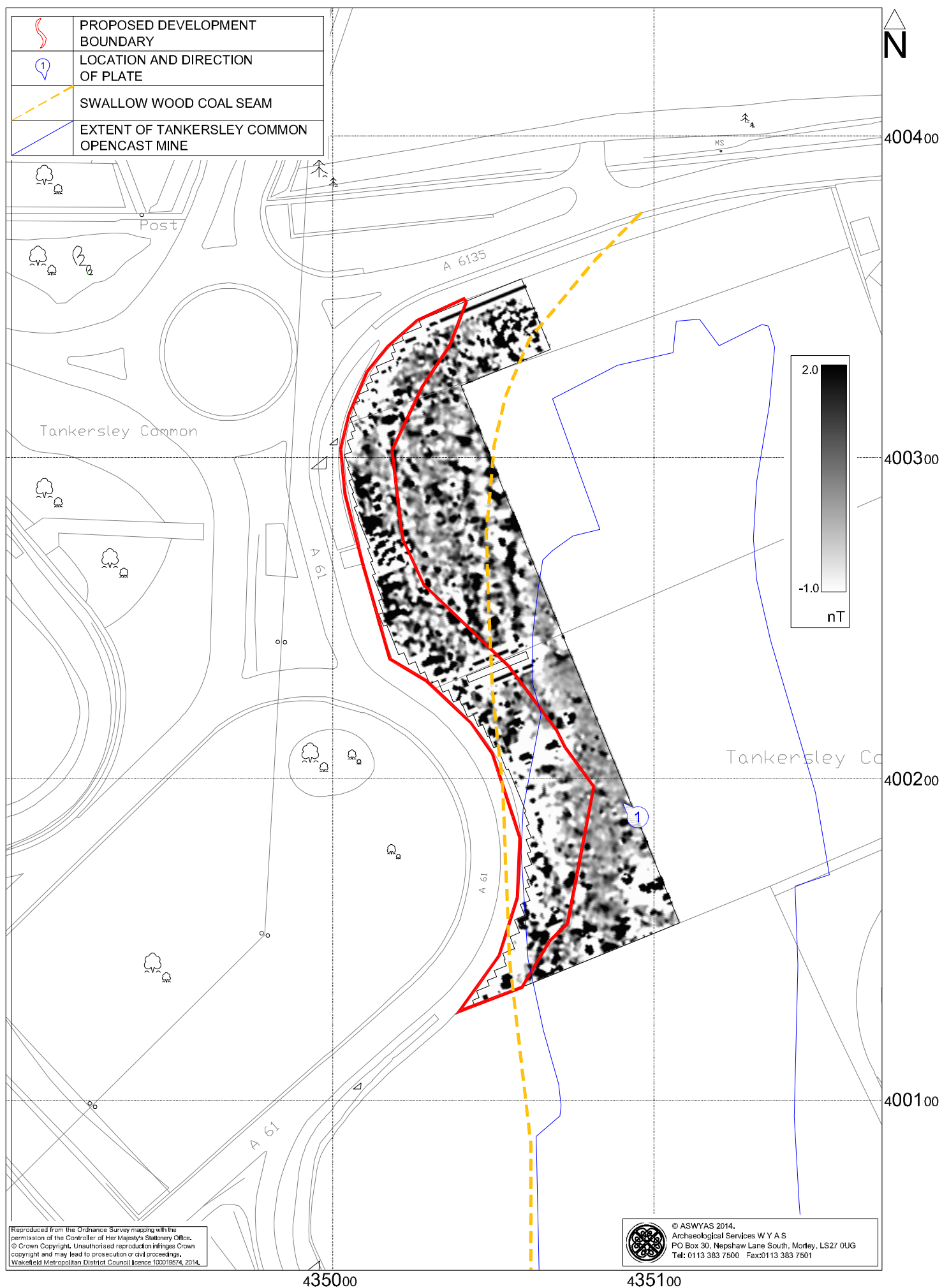


Fig. 2. Survey location showing processed greyscale magnetometer data (1:1500 @ A4)

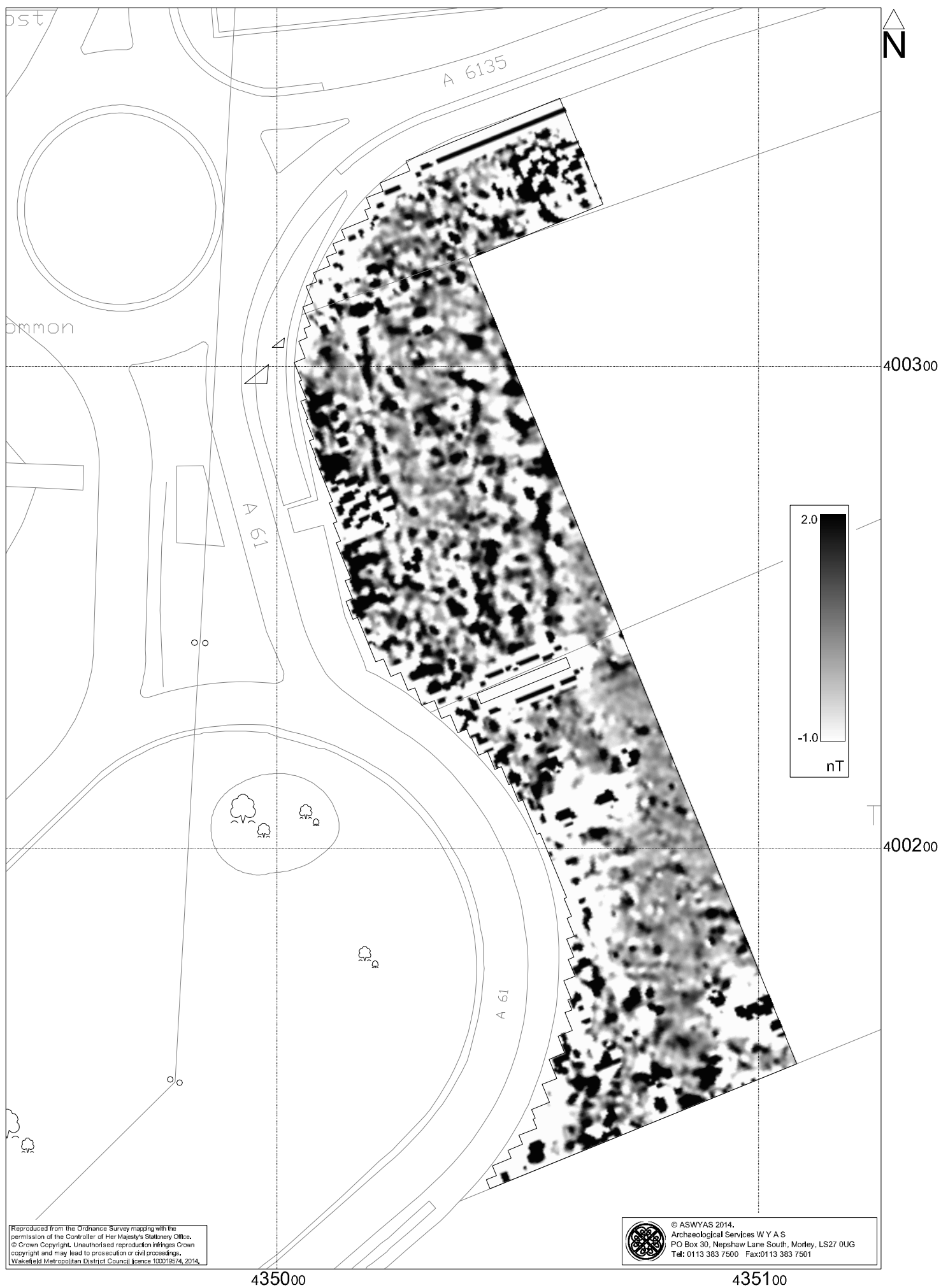


Fig. 3. Processed greyscale magnetometer data (1:1000 @ A4)

0 30m



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

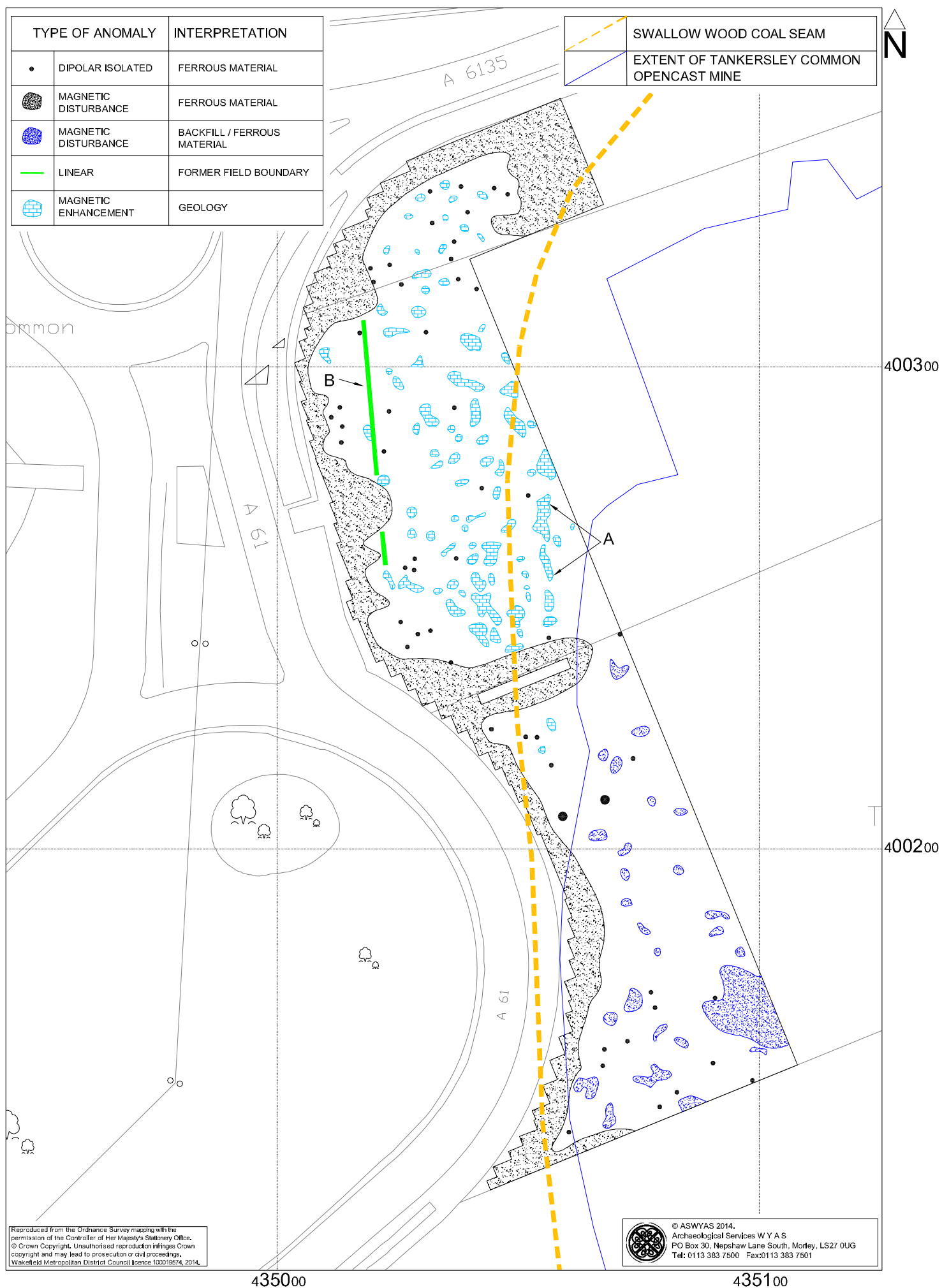


Fig. 5. Interpretation of magnetometer data (1:1000 @ A4)

0 30m



Plate 1. General view of survey area, 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 0.5m 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.

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

The site grid was laid out using a Trimble dual frequency Global Positioning System (GPS) with two Rovers (Trimble 5800 models) working in real-time kinetic mode. The accuracy of such equipment was better than 0.02m. 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 for relocation purposes.

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 South Yorkshire Historic Environment Record).

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