APPENDIX 6

Geophysical Survey

A19 Burn Bypass

near Selby

North Yorkshire

Geophysical Survey

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Summary

A magnetometer survey covering approximately 5.5 hectares was carried out at eight locations along the route of the proposed A19 Burn bypass. Magnetic anomalies caused by buried services and by ferrous debris are prominent in the results. Linear trend anomalies of an unknown origin have also been identified although underlying non-archaeological causes are considered probable. The magnetic survey has not identified any anomalies that are interpreted as probably archaeological in nature. However, it should be noted that the magnetic response on the prevailing soils can be variable such that the archaeological potential may be greater than initially suggested by the results of the magnetic survey. Nevertheless the archaeological potential of this site, based on the results of this survey and of a previous desk-based appraisal, is considered to be fairly low.

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1. Introduction and Archaeological Background

1.1 Archaeological Services WYAS was commissioned by Mr Ed Dennison, of Ed Dennison Archaeological Services Ltd on behalf of Golder Associates (UK) Ltd to carry out a geophysical (magnetometer) evaluation at several locations south and north-east of Burn, North Yorkshire (see Fig. 1) along the route of the proposed A19 Burn bypass. The site is centred at SE 595 286.

1.2 The proposed new road is about 1km in length and arcs east around the village of Burn rejoining the existing A19 via a roundabout on Brick Kiln Lane. The route crosses a former World War II airfield that covered an area of approximately 240 hectares between the A19, Selby Canal and the East Coast main railway line.

1.3 Eight discrete areas were surveyed north and south of the remaining airfield (see Fig. 2) covering an area of approximately 5.5 hectares in total. The ground cover comprised knee high wheat in Blocks 1, 2, 7 and 8, pasture in Blocks 3 and 4 and Blocks 5 and 6 were fallow.

1.4 Topographically the site is relatively flat lying less than 10m Above Ordnance Datum. The local geology comprises Glaciofluvial drift over cretaceous sand. The overlying soils are classified in the Newport 2 soil association. These soils are deep well drained sandy and often ferruginous. The survey was carried out between May 3rd and May 9th 2005. No problems were encountered during the fieldwork.

1.5 A Stage 1 Cultural Heritage Appraisal (Dennison 2004) revealed that little systematic archaeological research had been done within the general area. Of particular note was the absence of prehistoric activity although it was mentioned that this might have been a reflection of the lack of research rather than a real absence of material. There are some cropmarks suggestive of Iron Age and Romano-British settlement in the immediate vicinity but none within the proposed road corridor.

1.6 The settlement of Burn is recorded from the 11th century onwards although much of the evidence for the early settlement has since been destroyed. Archaeologically significant places near to the geophysical survey areas have been identified through place names. Burn Grange, north of Block 1, possibly represents the site of a monastic holding, although the '*grange*' name does have a common 19th century usage. Brick Kiln Lane, which bisects the southern blocks, may indicate the presence of former brick kilns or brick works in the vicinity.

1.7 The main archaeological site within the survey area is the Second World War airfield. This temporary airfield opened as a bomber station in November 1942 and by January 1944 it had grown into one of the largest in the area, containing 230 buildings on 12 separate sites around the airfield. Some of the airfield and its buildings were retained at the end of the war and are now used by Burn Glider Club. Other buildings were demolished and the remainder of the site returned to agricultural use in the late 1940s.

2. *Methodology and Presentation*

2.1 The primary objective of the geophysical survey was to establish the presence, absence, extent and nature of any archaeological anomalies within the identified survey areas.

2.2 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.

2.3 A general site location plan, incorporating the 1:50000 Ordnance Survey mapping, is shown in Figure 1. A more detailed location plan showing the magnetometer data is presented in Figure 2 at a scale of 1:4000. The processed magnetometer data are displayed in greyscale format, at a scale of 1:1000, in Figures 3, 6, 9 and 12 with an interpretation of the anomalies at the same scale in Figures 4, 7, 10 and 13. Figures 5, 8,11 and 14 show the unprocessed ('raw') data as an XY trace plot.

2.4 Technical information on the equipment used, data processing and magnetic survey methodology is given in Appendix 1. Appendix 2 details the survey location information and Appendix 3 describes the composition and location of the 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 Isolated dipolar anomalies ('iron spikes' - see Appendix 1) have been identified across all parts of the site. These 'iron spike' anomalies are indicative of ferrous objects or other magnetic material in the topsoil/subsoil and, although archaeological artefacts may cause them, they are more often the result of modern cultural debris that has been introduced into the topsoil. Many of these ferrous responses, particularly the clusters in Blocks 2 and 3 could be due to the spreading of construction debris following the demolition of some of the buildings on the airfield. The remainder are probably the result of centuries of manuring.

3.2 Block 1 (see Figs 3, 4 and 5)

3.2.1 The most obvious anomaly is the strong linear dipolar anomaly aligned from north to south that is caused by a buried mains water pipe. The anomaly can be seen curving slightly towards the west at the southern end of the block and consequently the pipe has not been detected in Block 2.

3.2.2 Parallel with the A19 is a long linear area of magnetic disturbance culminating in a larger area of disturbance at the northern end of the block. This disturbance is caused by a combination of modern services and passing traffic along the road edge and by modern tipping at the northern end of the block.

3.2.3 Three very weak (<1nT) linear trends can also be seen in the data. Without any supporting information it is impossible to give a probable cause for these anomalies although an archaeological origin cannot be discounted. However, a modern cause is considered probable.

3.2.4 The northern end of Block 1 shows a discontinuous curvilinear anomaly arcing towards the magnetic disturbance in the northern tip of the block. Again an archaeological origin cannot be dismissed but a modern cause is considered probable.

3.3 Block 2 (see Figs 6, 7 and 8)

3.3.1 A large area of magnetic disturbance is located across the southern half of this block. As suggested above (see Section 3.1) this is probably caused by modern material possibly resulting from the demolition of airfield buildings.

3.3.2 Several very weak linear trends can also be seen in the data. These appear to be on two basic alignments, from south-west to north-east (parallel with the field boundary to the east) or from north-west to south-east. The alignment of these anomalies is considered to be probably indicative of a modern or agricultural origin rather than an archaeological cause.

3.4 Block 3 and Block 7 (see Figs 9, 10 and 11)

3.4.1 Several parallel dipolar linear anomalies, aligned from south-south-west to north-north-east, have been located in the western corner of Block 3. These anomalies are interpreted as having a modern origin and may be part of a service system associated with the old airfield. Two adjacent areas of magnetic disturbance are also thought to have a recent origin being caused by ferrous material dumped when the airfield was closed.

3.4.2 In Block 7 several linear trend anomalies aligned from north to south, parallel with Brick Kiln Lane, are interpreted as having a modern agricultural cause.

3.5 Block 4, Block 5, Block 6 and Block 8 (see Figs 12, 13 and 14)

3.5.1 Three areas of magnetic disturbance have been identified along the northern edge of Block 4. The central area of disturbance correlates with a large visible concrete platform. Although the other two disturbed areas do not correlate with visible features they too are interpreted as modern in origin.

3.5.2 Along the southern edge of Block 4 two other areas of magnetic disturbance are identified. Here the responses are much weaker than the anomalies described above and are thought to be due to spreads of building debris. This spread does not extend into Block 5 to the south and therefore appears to be localised.

3.5.3 Parallel and perpendicular linear trends, mostly aligned from north to south, present in all four blocks are almost certainly a reflection of recent agricultural practice such as ploughing or land drainage. The stronger linear trend anomalies (shown in blue on Figure 13) are considered more likely to be caused by modern drains, rather than by ploughing.

3.5.4 Strong linear dipolar anomalies caused by service pipes cross both Blocks 4 and 8; that in Block 4 represents a continuation of the water main seen in Block 1, while that in Block 8 is an abandoned water main.

4. Discussion and Conclusions

4.1 Overall from an archaeological standpoint the survey has been disappointing; the results are dominated by anomalies caused by modern services and by the spreading of magnetic debris that probably derives from the demolition of buildings associated with the former airfield.

4.2 Indeed the survey has not identified any anomalies that are interpreted as probably archaeological in nature. Nevertheless, several anomalies of uncertain origin have been identified and any or all of these could be potentially archaeological in nature. However, on the basis of the linearity and orientation of these anomalies it is considered probable that they are likely to be agricultural (due to ploughing or land drainage) or modern in origin.

4.3 The reason that it has been difficult to be confident of the underlying cause of many of these anomalies is partly due to the very weak, discontinuous responses. The nature of these responses is probably due to the magnetic properties of the prevailing soils. Sands can be particularly complex especially if there is a high water table and this can lead to variable geophysical results. Deep undifferentiated soils can result in a very small change in magnetic susceptibility between the feature fill and the surrounding soil. In such circumstances the resulting anomalies will be weak. In this scenario the archaeological potential may be greater than initially suggested by the results of the geophysical survey. However, the archaeological potential of this site, based on the results of the desk-based appraisal and the magnetic survey, is considered to fairly 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.

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Acknowledgements

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Appendices

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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 selectively filtered.

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 at 10nT. 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

Survey Location Information

The site grid was laid out using a Geodimeter 600s total station theodolite and tied in to field boundaries and fence lines and three semi-permanent survey reference points (wooden stakes - see Fig. 2 – A, B, C) that were left on site; the co-ordinates of these points are tabulated below. The survey grids were then superimposed onto an Ordnance Survey digital map base using common boundary walls and other fixed points. 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 ±1.0m. 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. Local grid co-ordinates can be supplied if required.

Station	Easting	Northing
A	459906.3987	428910.7829
B	459588.3924	428741.7412
C	459746.1989	428600.4557
D	459305.3658	428361.2626
E	459423.6157	428346.9096
F	459436.5429	428320.3356
G	459269.7121	428247.7366
H	459584.9702	428232.4374
I	459389.9996	428148.3732
J	459372.6237	428027.0207
K	459490.1219	428001.2109

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

Appendix 3

Geophysical Archive

The geophysical archive comprises:-

- an archive disk containing compressed (WinZip 8) files of the raw data, report text (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 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 relevant Sites and Monument Record Office).

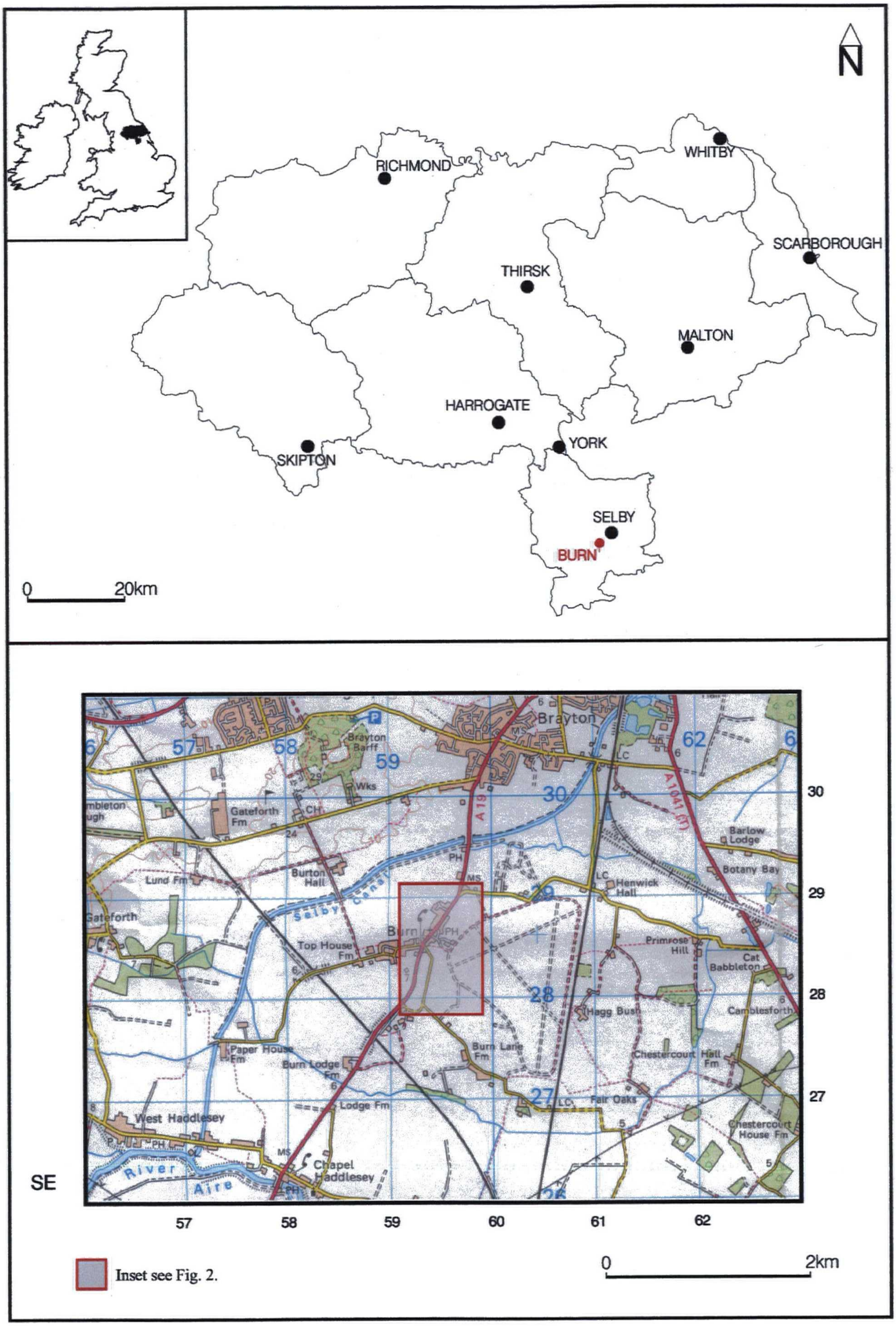

Fig. 1. Site location

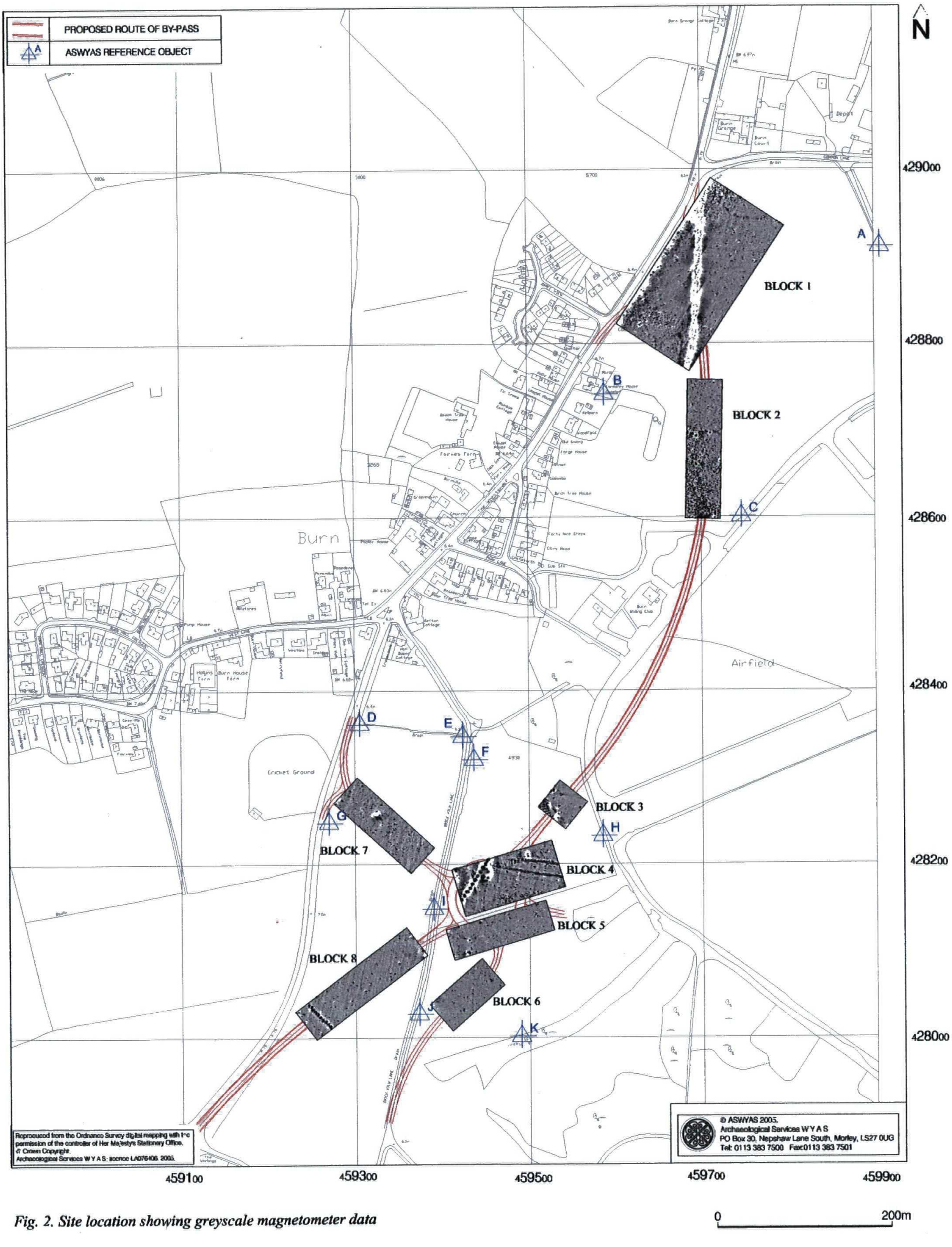

Fig. 2. Site location showing greyscale magnetometer data

Fig. 3. Greyscale plot of magnetometer data; Block 1

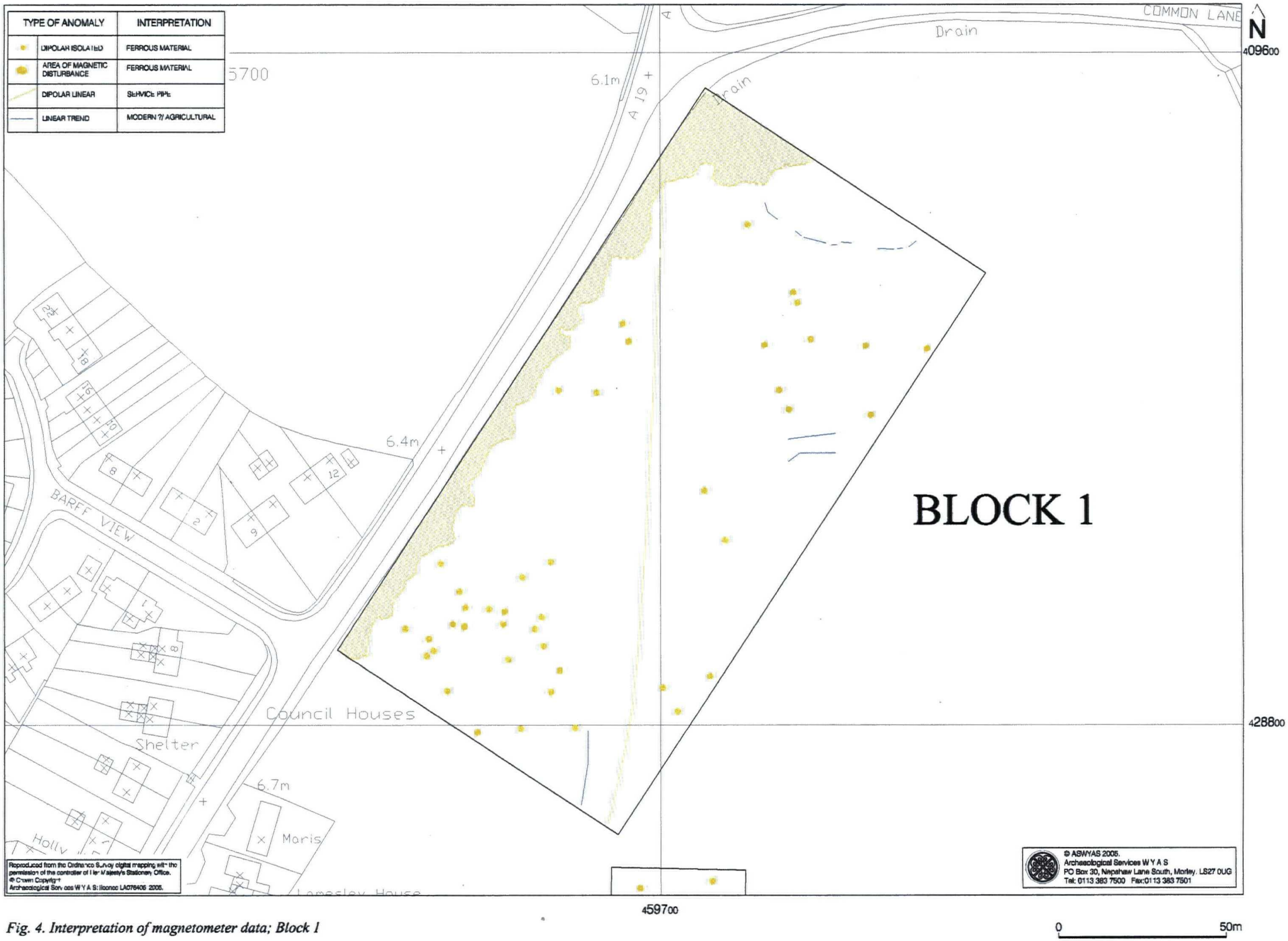

Fig. 4. Interpretation of magnetometer data; Block 1

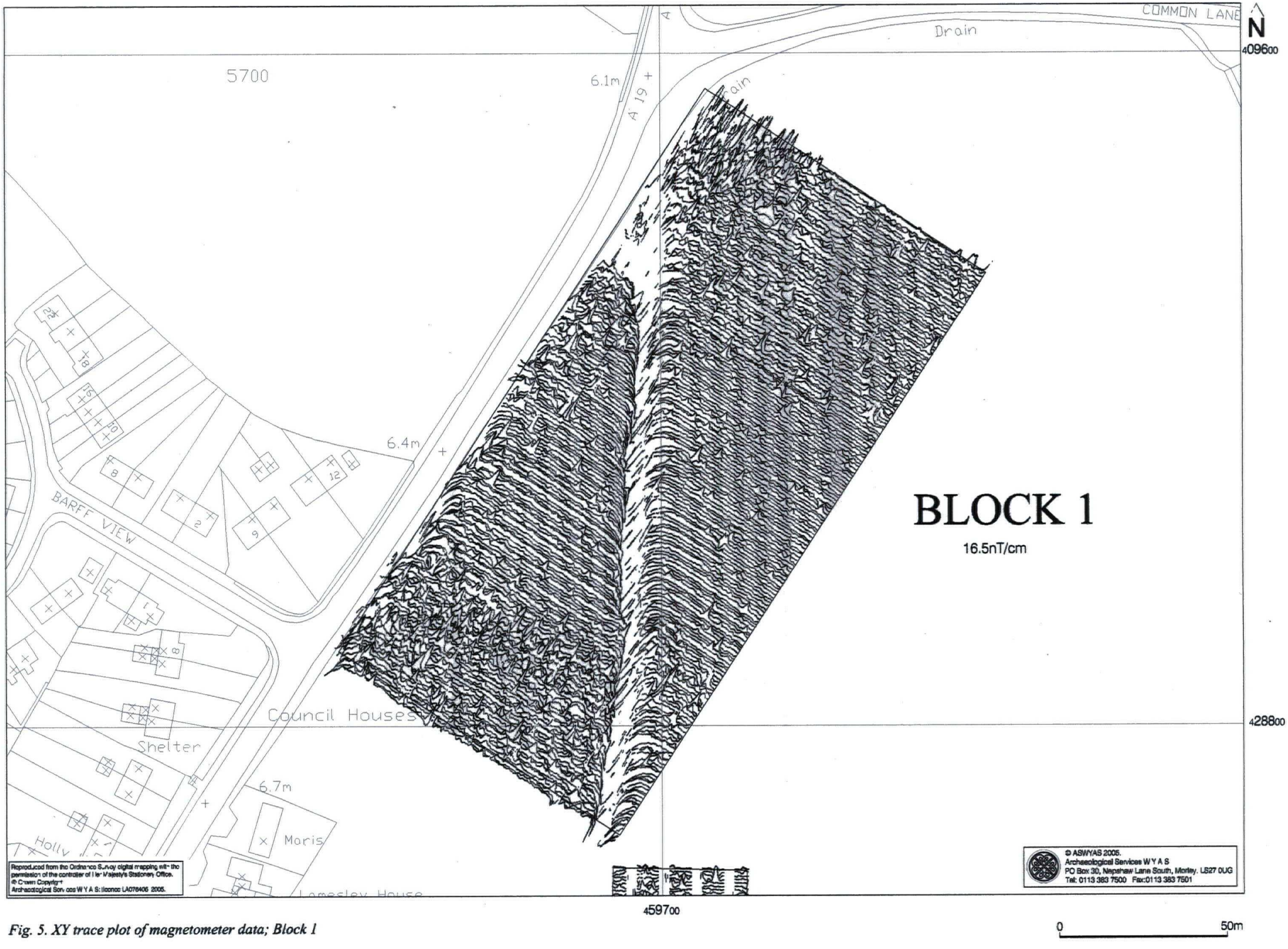

Fig. 5. XY trace plot of magnetometer data; Block 1

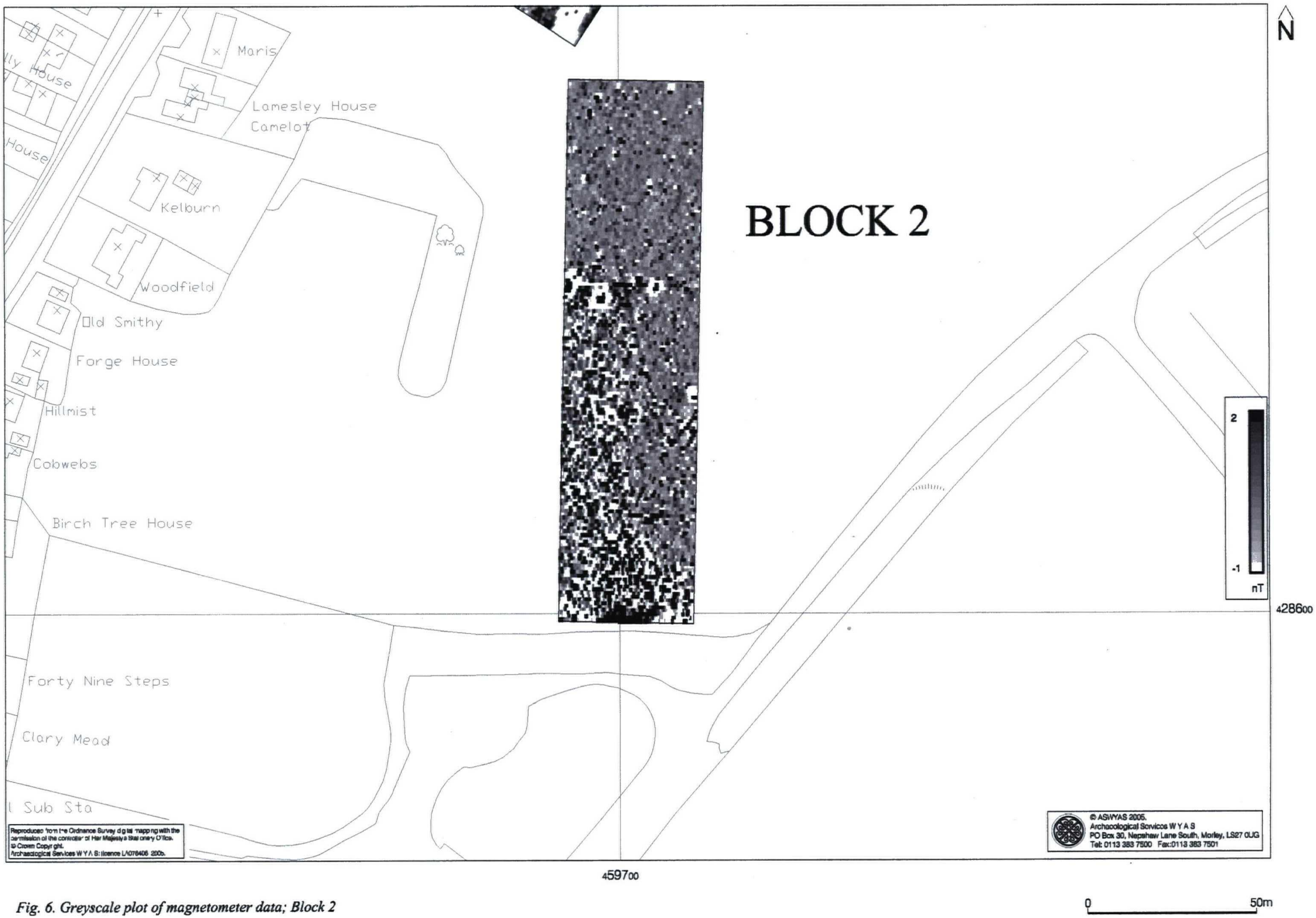

Fig. 6. Greyscale plot of magnetometer data; Block 2

Fig. 7. Interpretation of magnetometer data; Block 2

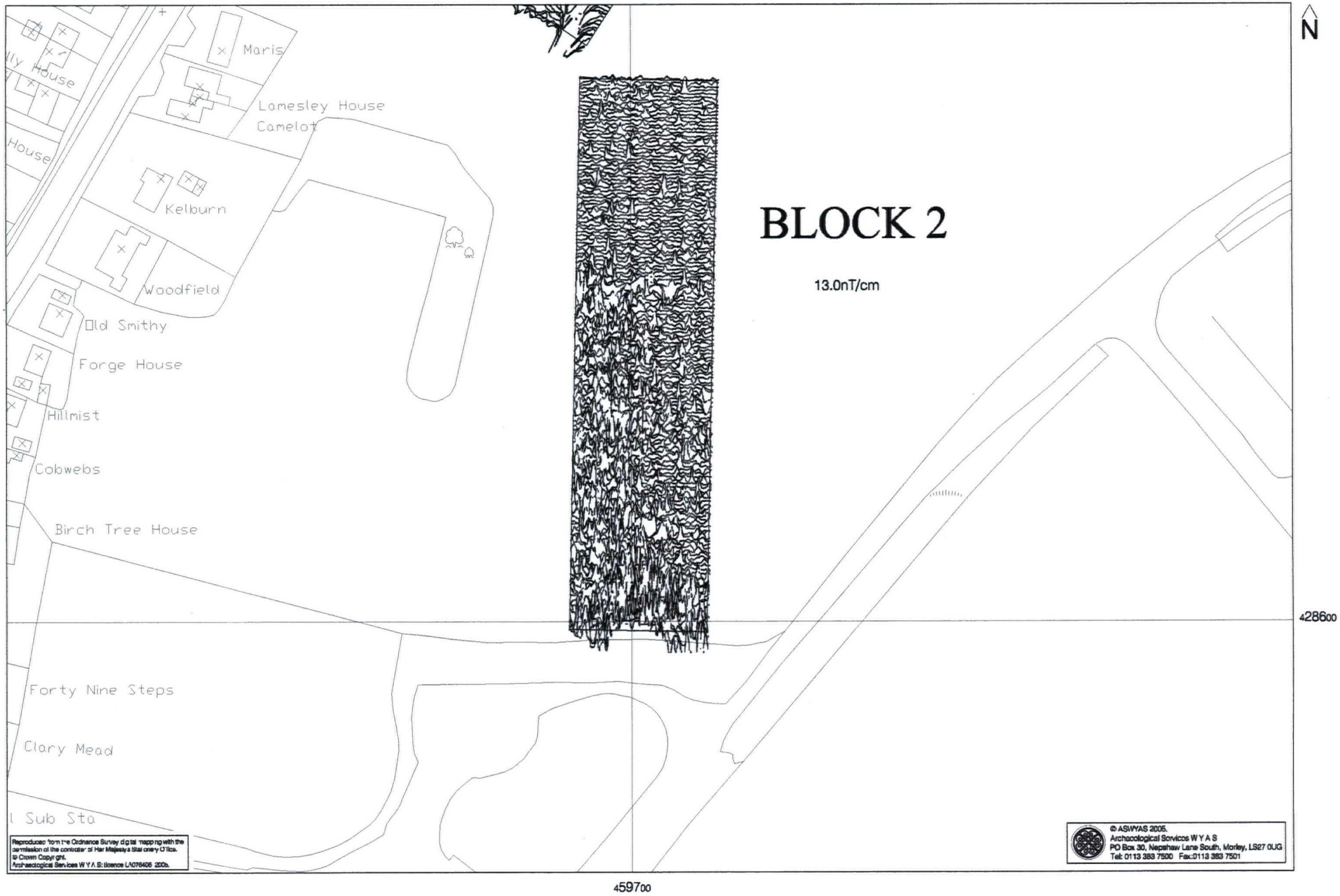

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Fig. 8. XY trace plot of magnetometer data; Block 2

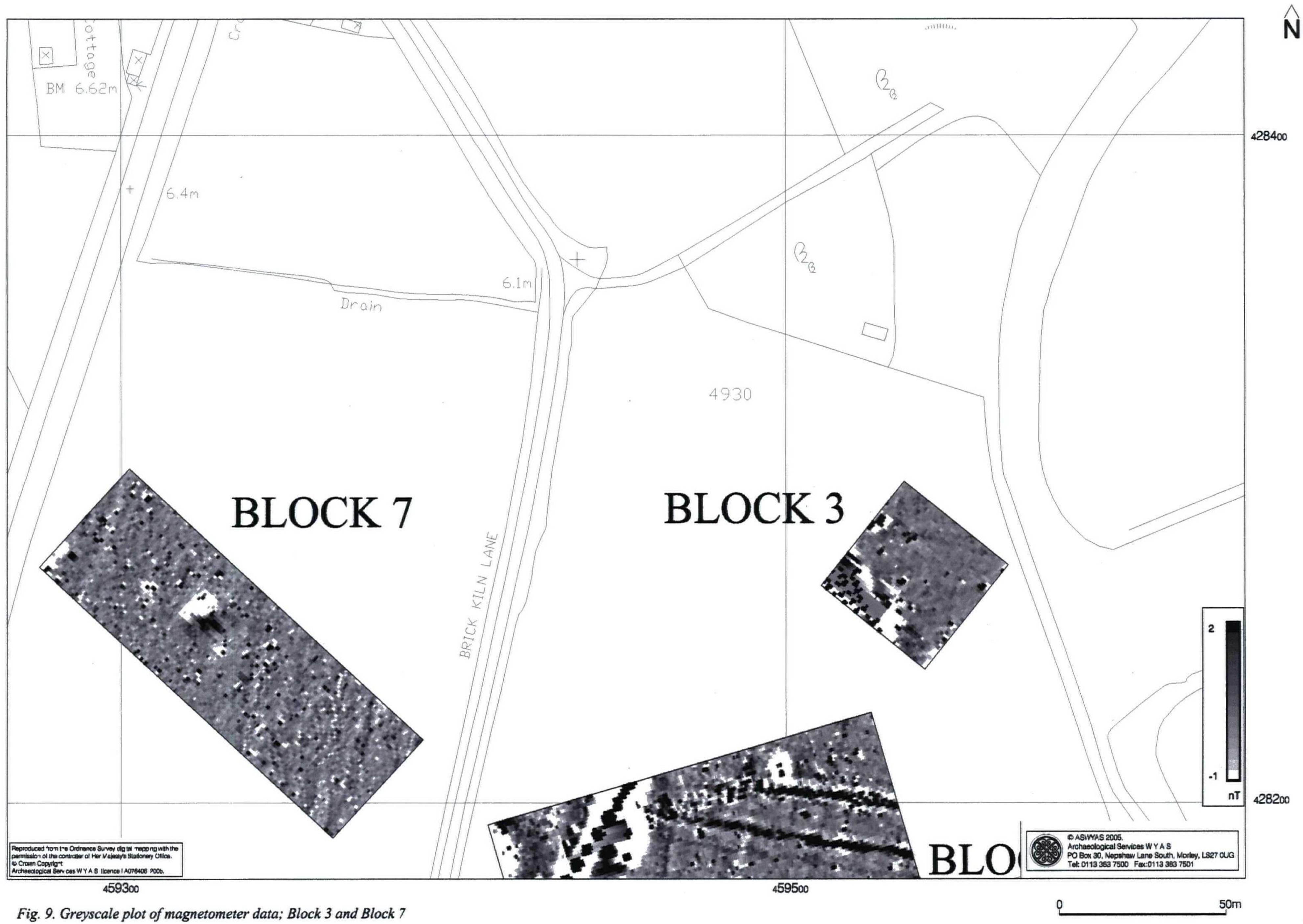

Fig. 9. Greyscale plot of magnetometer data; Block 3 and Block 7

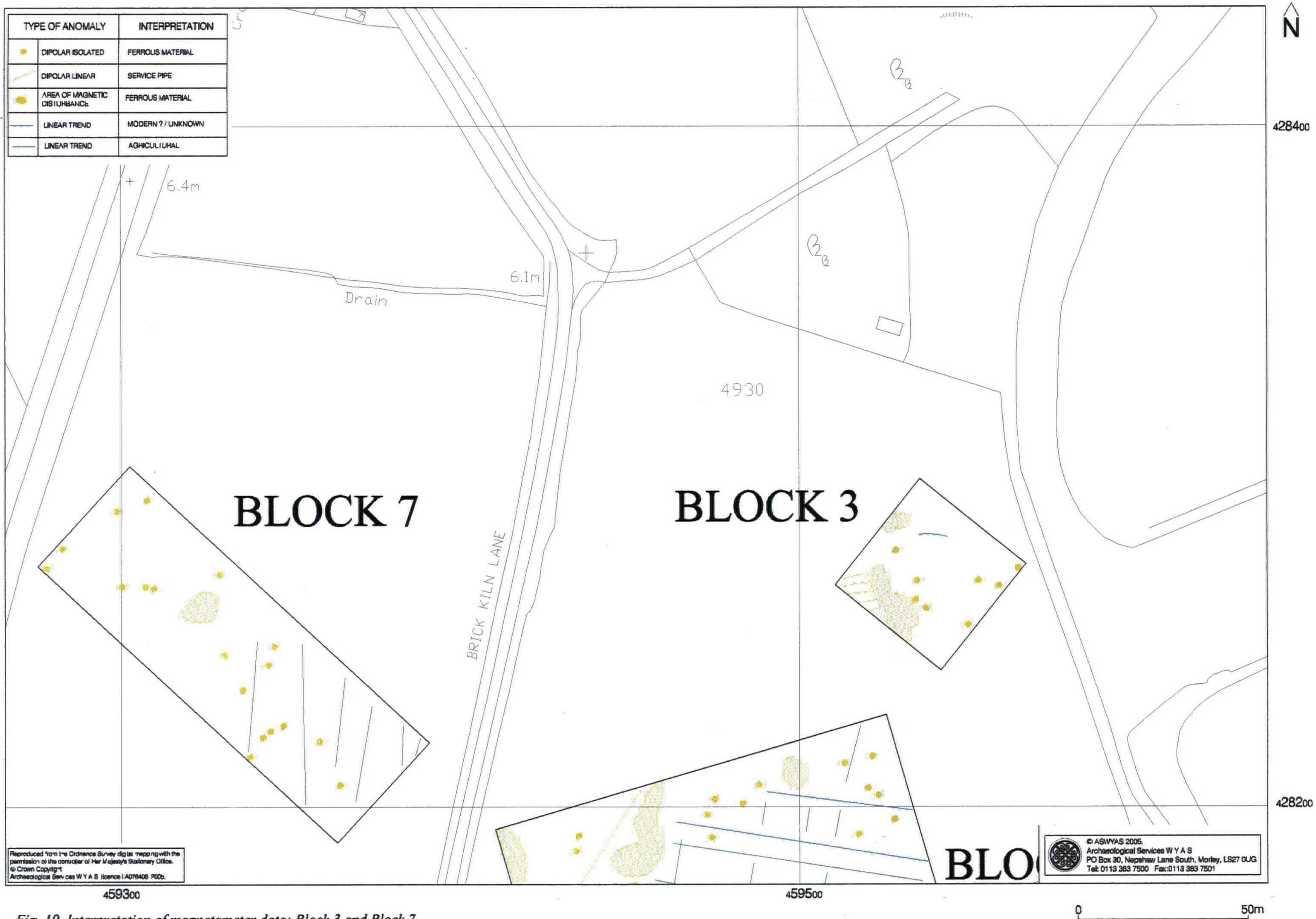

Fig. 10. Interpretation of magnetometer data; Block 3 and Block 7

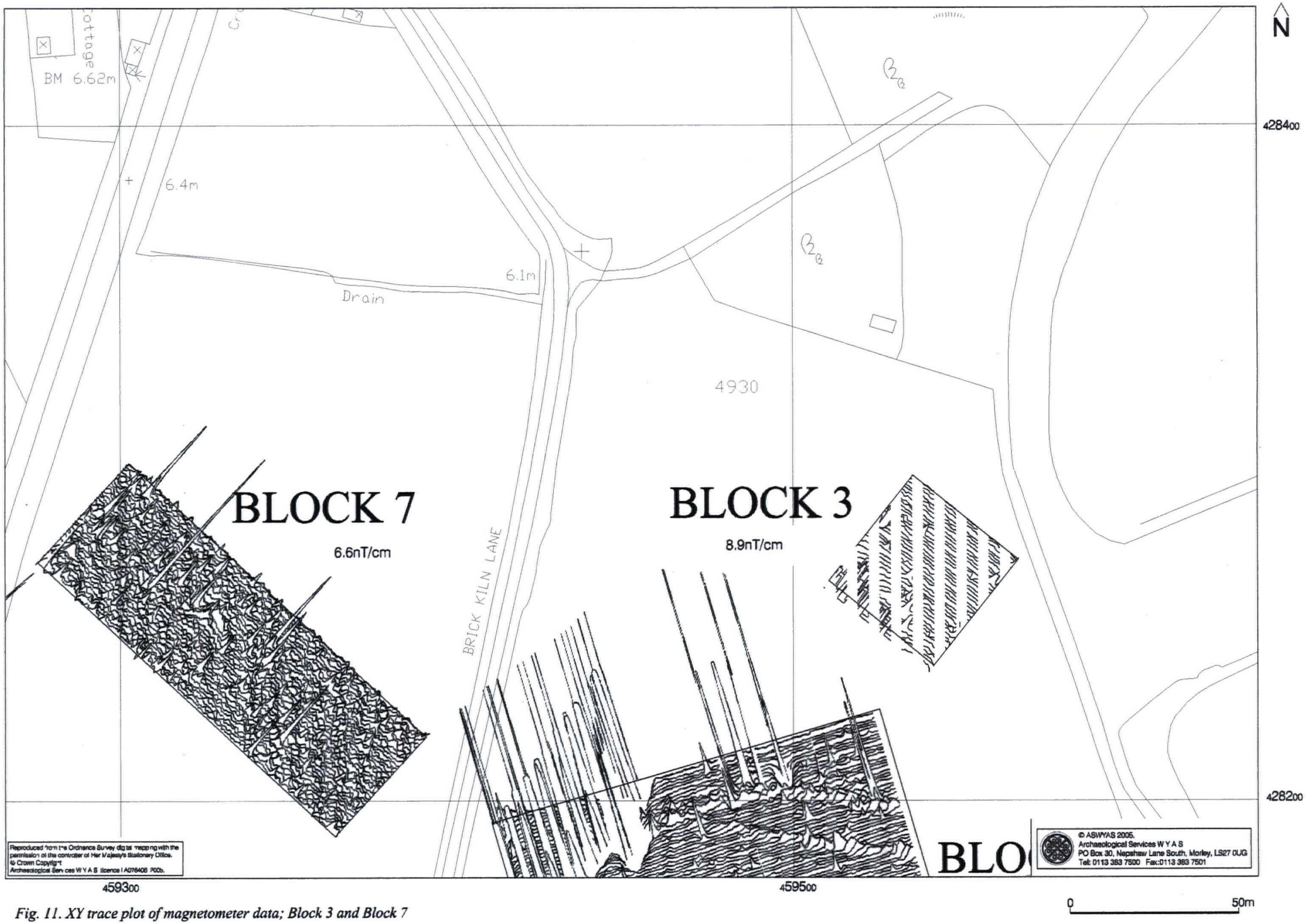

Fig. 11. XY trace plot of magnetometer data; Block 3 and Block 7

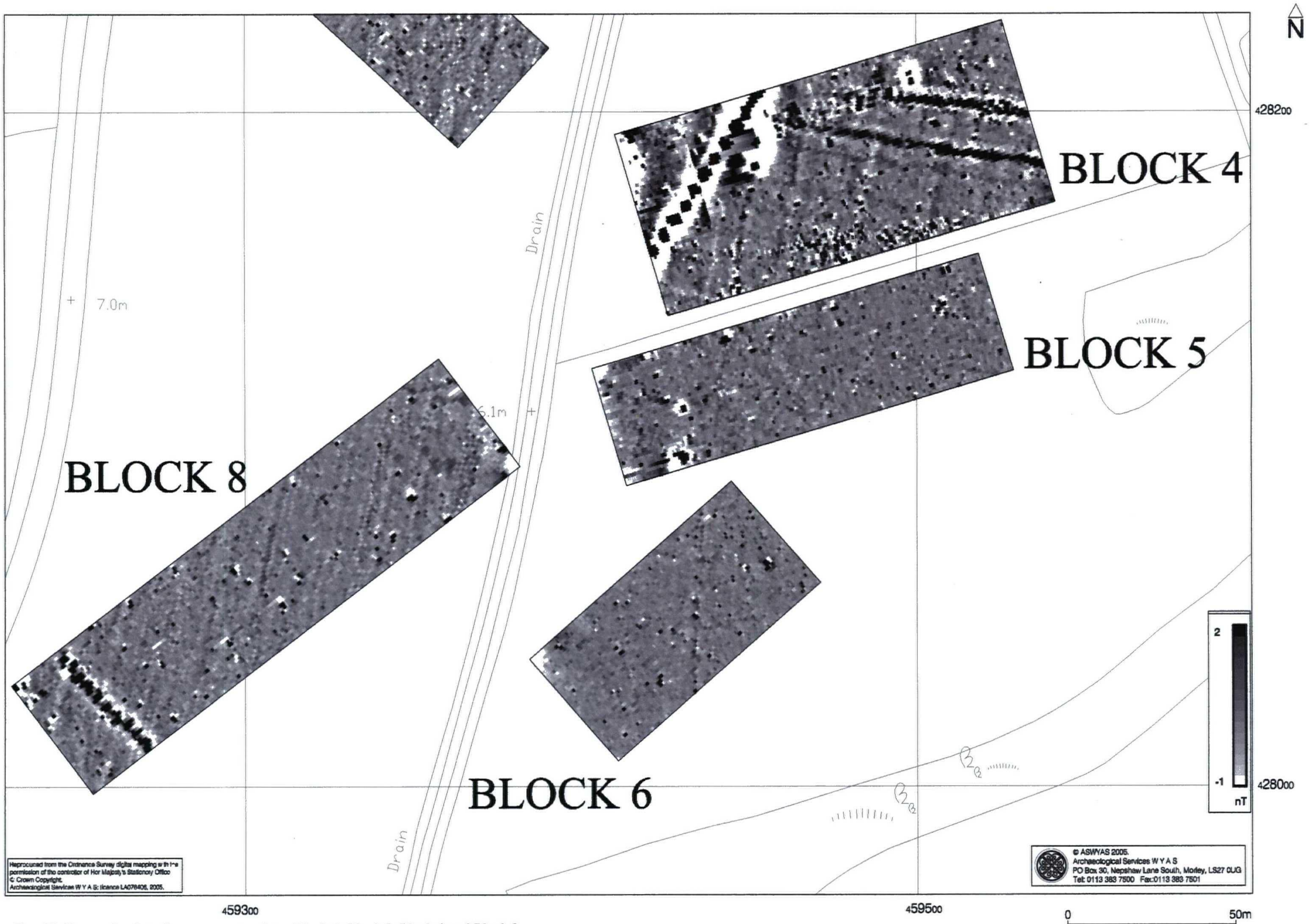

Fig. 12. Greyscale plot of magnetometer data; Block 4, Block 5, Block 6 and Block 8

Fig. 13. Interpretation of magnetometer data; Block 4, Block 5, Block 6 and Block 8