ARCHAEOLOGICAL SERVICES WYAS

London-Edinburgh-Thurso Trunk Road
A1 Adderstone to Belford Dualling
Northumberland

Geophysical Survey

December 2005

Report No. 1476

Golder Associates (UK) Ltd.

London-Edinburgh-Thurso Trunk Road

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Northumberland

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Contents

Summary

Detailed magnetometer survey, covering 10.5 hectares, was undertaken at selected locations along the preferred route of the dualling of the A1 betweeen Adderstone and Belford. A plethora of anomalies indicative of geological and pedological variation have been identified in most of the survey areas. Other anomalies are due to agricultural activity. No anomalies of a probable archaeological origin have been identified although some anomalies that could have an archaeological cause have been noted in areas adjacent to cropmarks. It is considered possible that the strength and variability of the magnetic responses caused by the geological variation could be masking more subtle anomalies of possible archaeological origin.

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1. Introduction and Archaeological Background

1.1 Archaeological Services WYAS was commissioned to carry out a geophysical (magnetometer) survey at selected locations along the preferred (blue) route of the A1 Dualling between Adderstone and Belford by Mr Paul Wheelhouse of Golder Associates (UK) Ltd, acting as archaeological consultants to Mouchel Parkman.

1.2 The proposed route of the A1 Adderstone to Belford Dualling (see Fig. 1) runs from the A1/B6349 junction 1km south-east of Belford (NU 1175 3345) and extends southwards for approximately 4.7km to Adderstone Grange (NU 1320 3010). Ten areas (see Figs 2a, 2b and 3; Areas A – J) covering approximately 10.5 hectares were selected for survey either side of the existing carriageway. One of the areas covered the possible location of a balancing pond (Area I).

1.3 The underlying solid geology consists of Lower Carboniferous Bernician limestone overlain by glacial drift deposits of boulder clay. Geotechnical data collated during preparatory works for an earlier scheme proposal (see Section 1.5 below) indicated that the boulder clay is up to 2.5m in depth and contained cobbles and bands of clayey sand. The soils are typically deep, fine loams classified in the Nercwys soil association, the geotechnical work identifying igneous pebbles in the topsoil. Survey conditions were ideal as the ground cover comprised a young cereal crop and no problems were encountered during the fieldwork that was carried out between December 5th and 9th 2005.

1.4 The proposals for this survey were included in a Stage 2 Cultural Heritage Assessment (Golder Associates 2005a) that included an aerial photographic assessment and interpretation of the three possible road alignments. As a result of this report sixty-one sites were identified within the survey area. The cropmarks are shown on Figures 2a and 2b.

1.5 Geophysical surveys covering an area of just under 4 hectares were undertaken as part of the evaluation for an alternative, slightly shorter, scheme proposal (Geoquest Associates 2000a and 2000b) between New Mousen and Adderstone Mains. No anomalies indicative of significant archaeological activity were identified as a result of these surveys although numerous anomalies interpreted as being due to geological variation were noted throughout the three fields surveyed.

2. Objectives and Methodology

2.1 General objectives of the fieldwork were:

- to identify areas of possible archaeological interest;
- to establish the extent and character of any such archaeological interest within the limits of the defined areas.

2.2 These objectives were to be achieved by undertaking detailed magnetometer survey of the ten areas of potential identified in the Stage 2 Cultural Heritage Assessment and in accordance with an archaeological specification (Golder Associates 2005b). 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. Detailed survey allows the visualisation of weaker anomalies that may not be identifiable by magnetic scanning.

2.3 During this evaluation a team of three geophysicists used a Bartington Grad601 magnetic gradiometer, 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.

2.4 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.

2.5 A general site location plan, incorporating the 1:50000 Ordnance Survey mapping, is shown in Figure 1. Figures 2a and 2b show the processed magnetometer data superimposed onto a digital map base supplied by the client at a scale of 1:5000. The processed (greyscale) and unprocessed (XY trace plot) data, together with accompanying interpretation diagrams, are presented in Figures 3 to 29 inclusive at a scale of 1:1000.

2.6 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 site archive.

3. Results

3.1 Magnetometer Survey

3.1.1 Although detailed survey covering an area of 10.5 hectares was undertaken, anomalies indicative of archaeological activity have been identified in only one of the survey areas. Numerous anomalies are present in all the areas surveyed and they can be divided into five categories.

Areas of Magnetic Enhancement/Magnetic Variability

3.1.2 Areas where the magnetic background is elevated above the normal prevailing background has resulted in a random pattern of discrete, positive anomalies causing the grey tone plot to have a mottled appearance. This effect is particularly noticeable in Areas G and H but is noted to a lesser extent in all the other survey areas. The erratic, essentially random, nature of these anomalies points to a geological rather than an archaeological origin. These anomalies are thought to be due to concentrations of igneous and metamorphic rocks present in the boulder clay. The more broad areas of variation are probably also natural in origin being due to larger scale variation in the composition of the boulder clay and/or to changes in the depth and composition of the bedrock. These areas of variability are most prominent in Areas F and J.

3.1.3 One area of enhancement has been interpreted as potentially archaeological in nature at the northern end of Area A. This interpretation has been made solely on the proximity of a possible curvilinear cropmark (see Fig. 3) immediately to the west of the survey block.

Dipolar Anomalies (Iron Spikes)

3.2 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 caused by modern cultural debris that has been introduced into the topsoil often as a consequence of manuring.

Linear trends

3.2.1 Linear trends have been identified within the data in several areas. In Areas E and I the anomalies are most probably caused by field drains and in Area I the trends align with the direction of the ridge and furrow ploughing also identified as cropmarks (see Fig. 24). Stronger anomalies can also be seen in Area C where field drains are thought to be the likely cause.

3.2.2 In Area D, to the east of the A1, opposite Area C, several other trends on varying alignments have been identified. The most northerly anomaly is on the same alignment as one of the linear cropmarks approximately 100m to the north-east (see Fig. 2b) and has therefore been tentatively interpreted as archaeological in origin. The other linear trend anomalies in this area are also on alignments oblique to extant boundaries and roads and have likewise been tentatively interpreted as possibly archaeological in nature.

Dipolar Linear Trends

3.2.3 Within Area A there is a dipolar linear trend identified as a ferrous service pipe aligned roughly from north to south. A similar anomaly is located running from north-east to south-west in Area F.

Positive Linear Anomalies

3.2.4 A single positive linear anomaly has been identified in Area I. This anomaly is perpendicular with the A1 and also aligns with field boundaries and Mousen Burn to the east (see Fig. 2b). It is considered likely that this anomaly is caused by an infilled, modern field boundary, although none is shown on the O. S 1st edition map of 1865 or on later editions.

4. Discussion and Conclusions

4.1 The overwhelming majority of the identified anomalies are interpreted as having an underlying geological origin as, in general, the anomalies were strong and variable in nature with no coherent pattern that might imply an anthropogenic cause. These anomalies are probably due to the presence of erratics (igneous cobbles) in the topsoil and other changes in the composition of the soils caused by the undifferentiated nature of the boulder clay and to the relative depth and composition of the bedrock. However, it should be noted that there are numerous cropmarks indicative of archaeological activity in the vicinity of the survey areas. Although no linear anomalies have been identified to suggest enclosed settlement, some of the anomalies interpreted as having a natural (geological) cause might be due to discrete archaeological features associated with unenclosed settlement, particularly in Area A. Linear anomalies in Area D may be ditches associated with the archaeological activity (as evidenced by the cropmarks) immediately to the east but this interpretation is tentative at best.

4.2 In addition the relative strength of the geological anomalies may have prevented the identification of weaker anomalies of archaeological interest. Certainly in Areas A, B and J, where cropmarks would appear to impinge into the survey areas no anomalies of probable archaeological origin have been identified although there are plenty of anomalous responses that are interpreted as natural in origin. Therefore it cannot be said with any degree of confidence that the apparent absence of archaeological anomalies is due to an absence of such features or whether the prevailing pedological and geological factors combine to 'mask' the geomagnetic response from archaeological features.

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.

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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Figures

Appendices

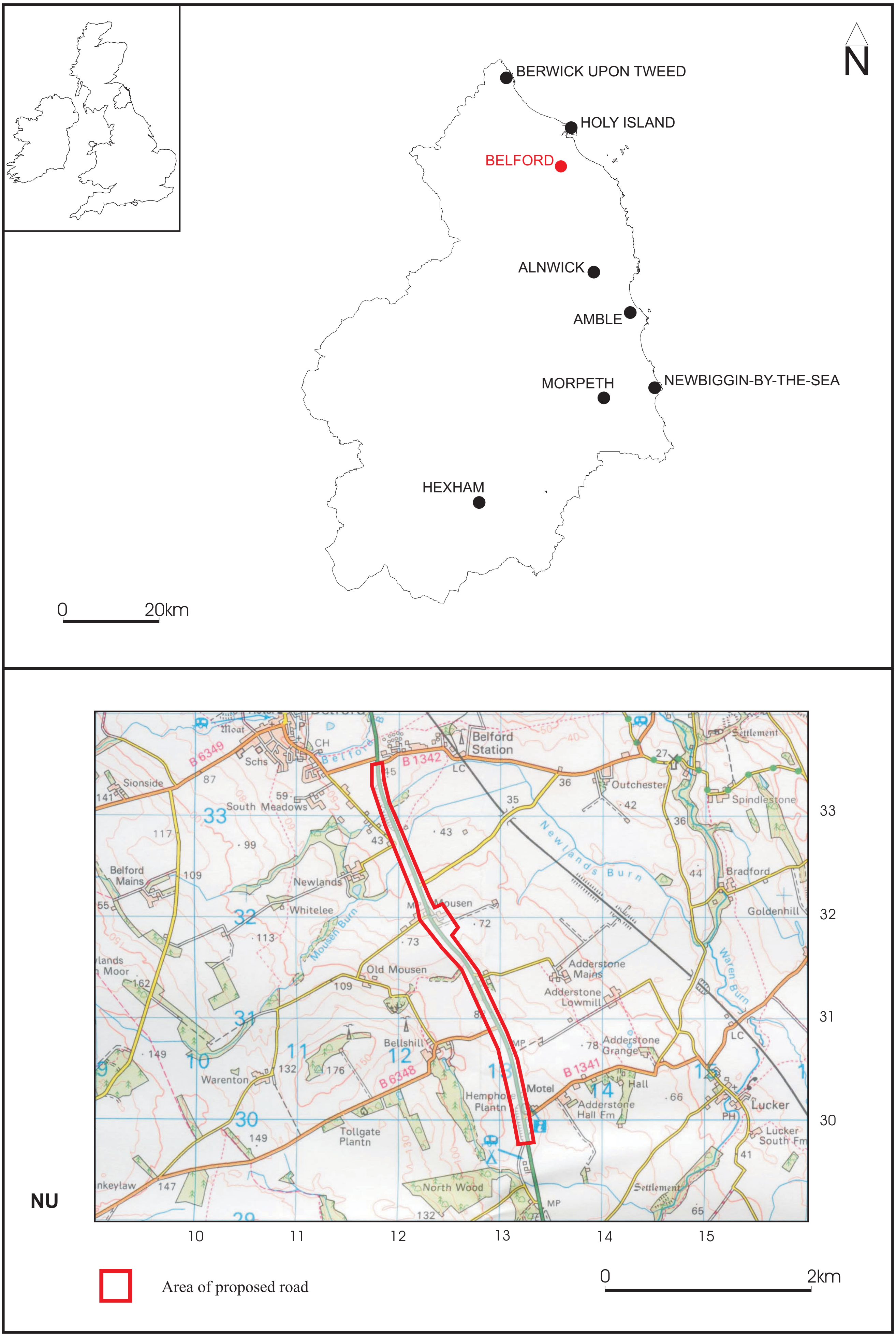

Fig. 1. Site location

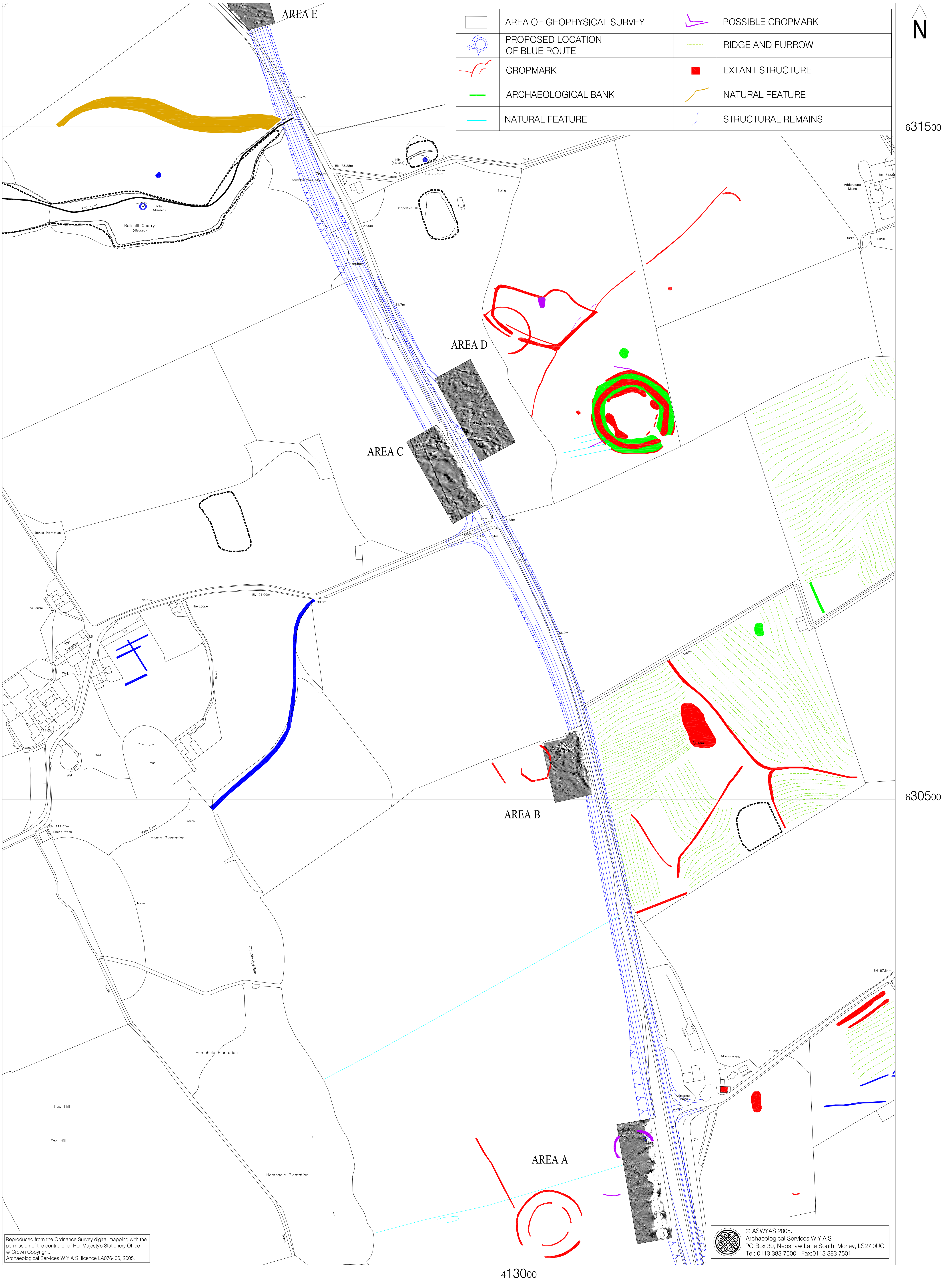

Fig. 2a. Proposed road corridor showing geophysical survey blocks and cropmark detail (After Deegan 2005)

0 150m

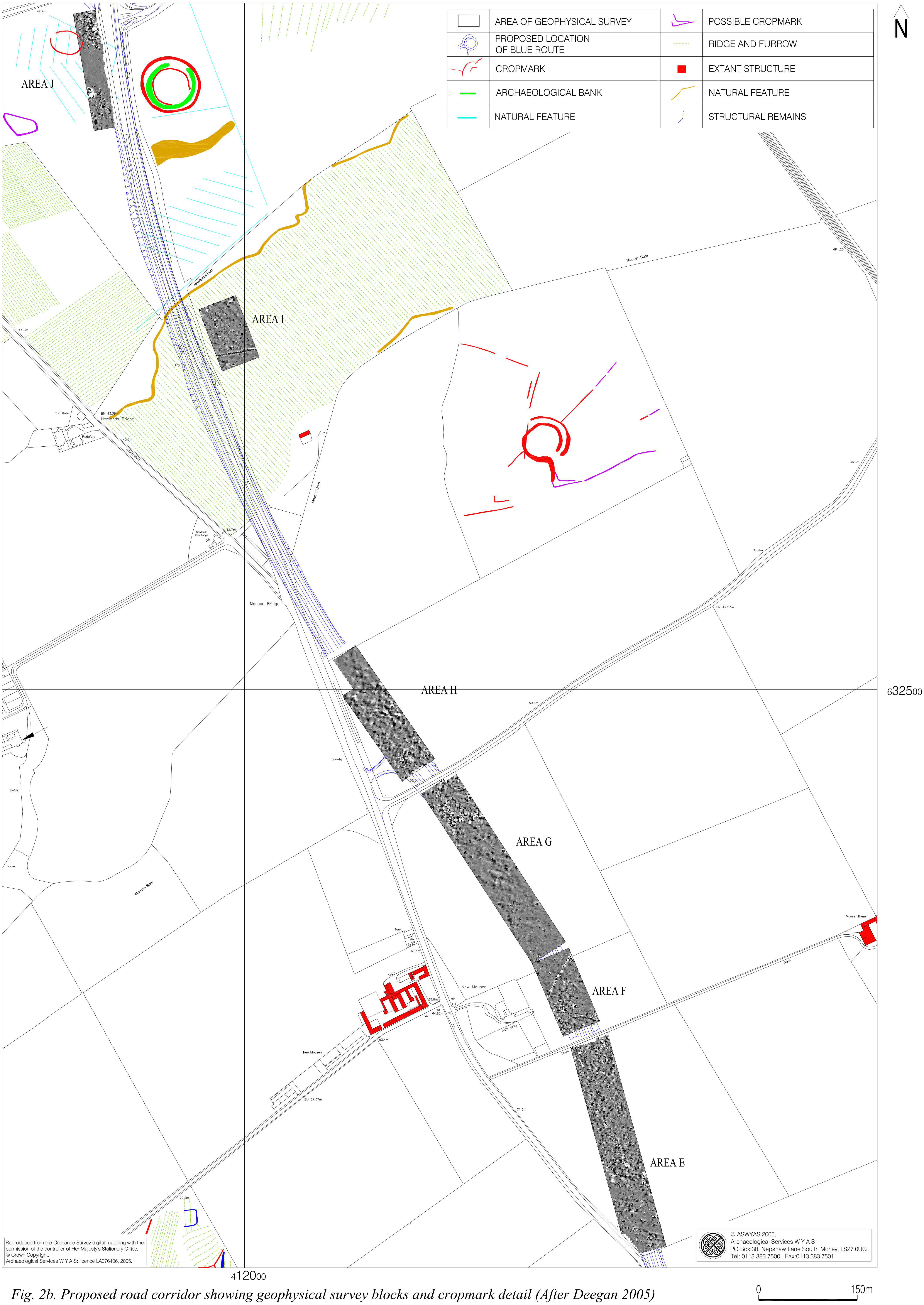

Fig. 2b. Proposed road corridor showing geophysical survey blocks and cropmark detail (After Deegan 2005)

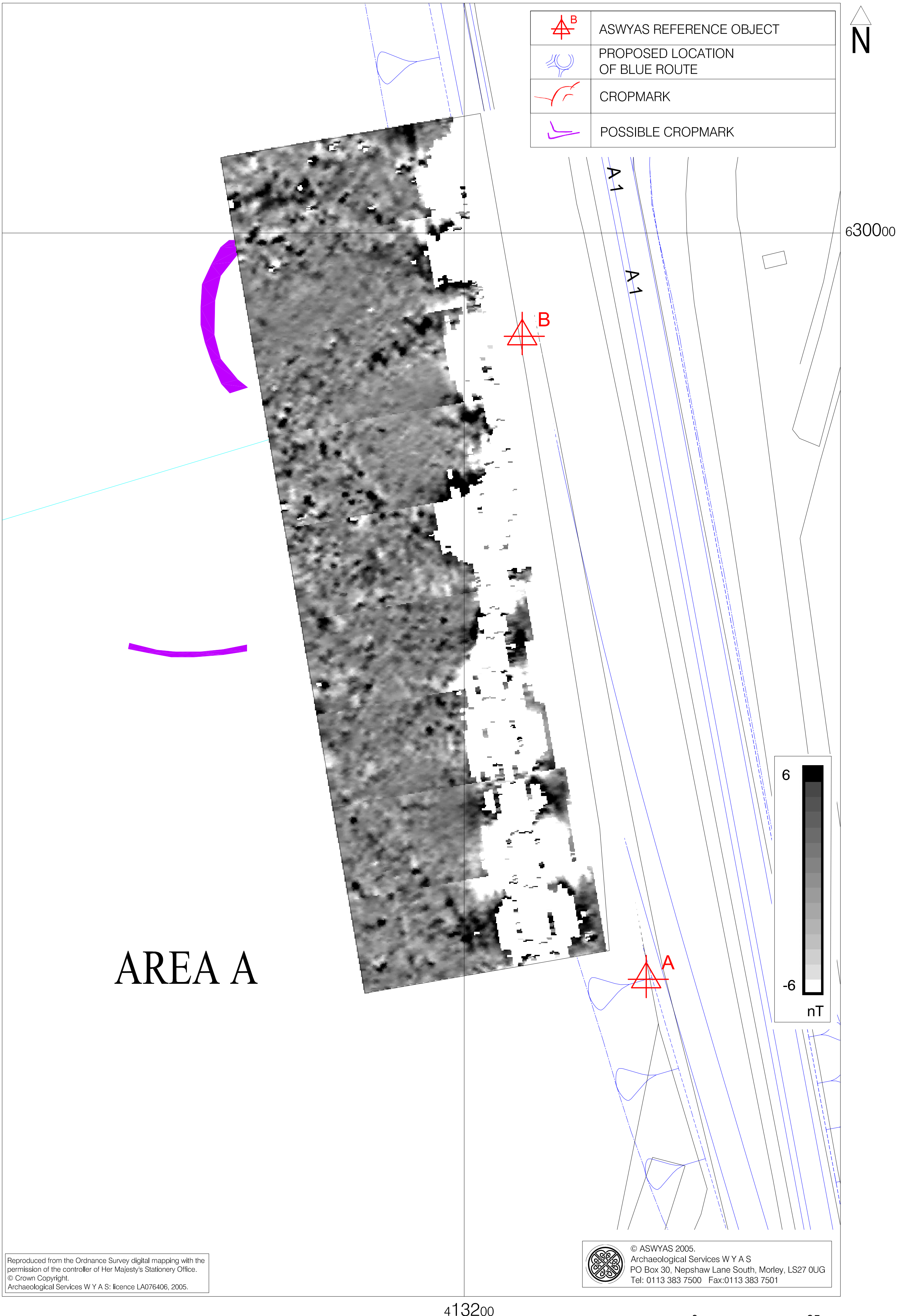

Fig. 3. Plot of greyscale magnetometer data; Area A

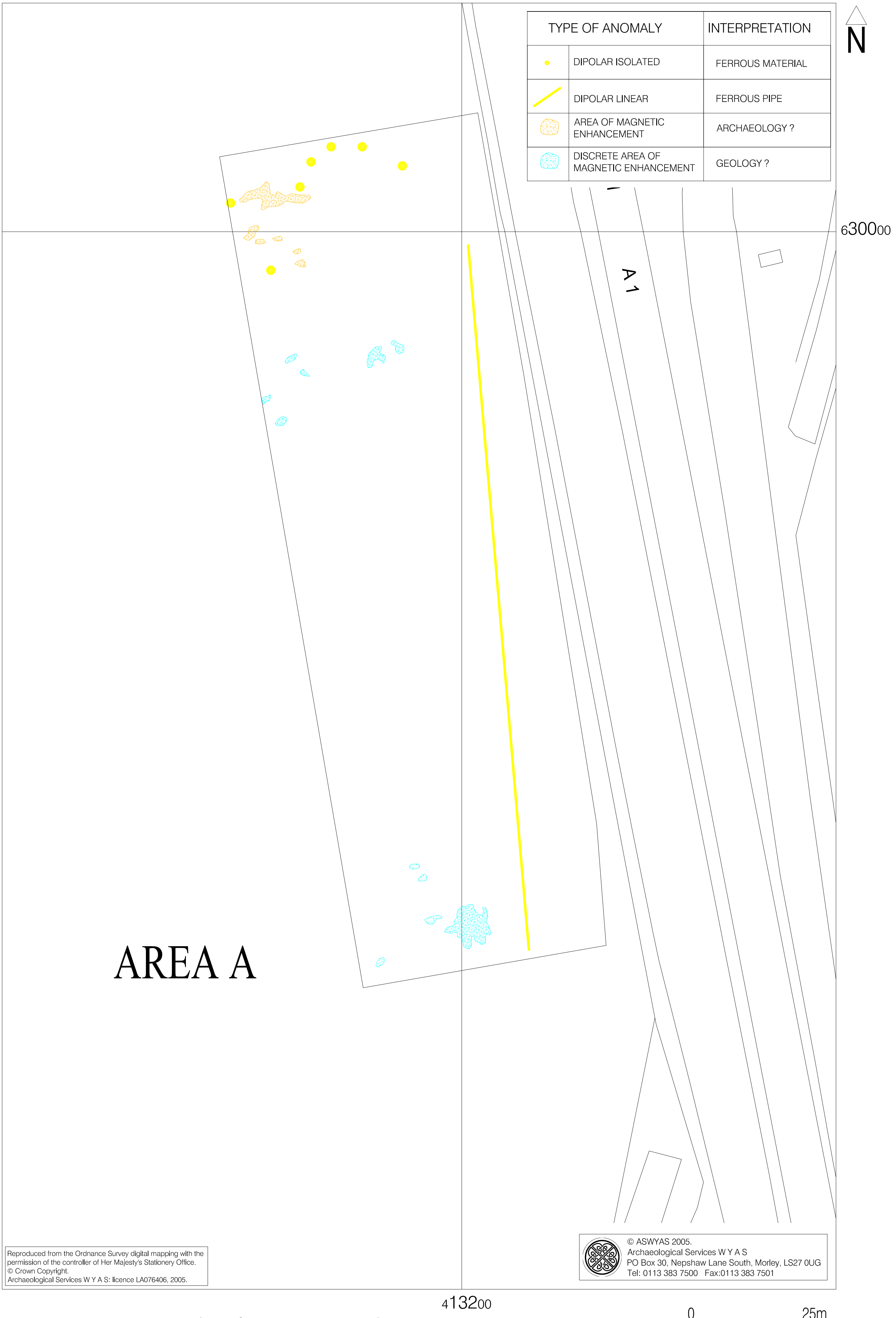

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Fig. 4. Interpretation plot of magnetometer data; Area A

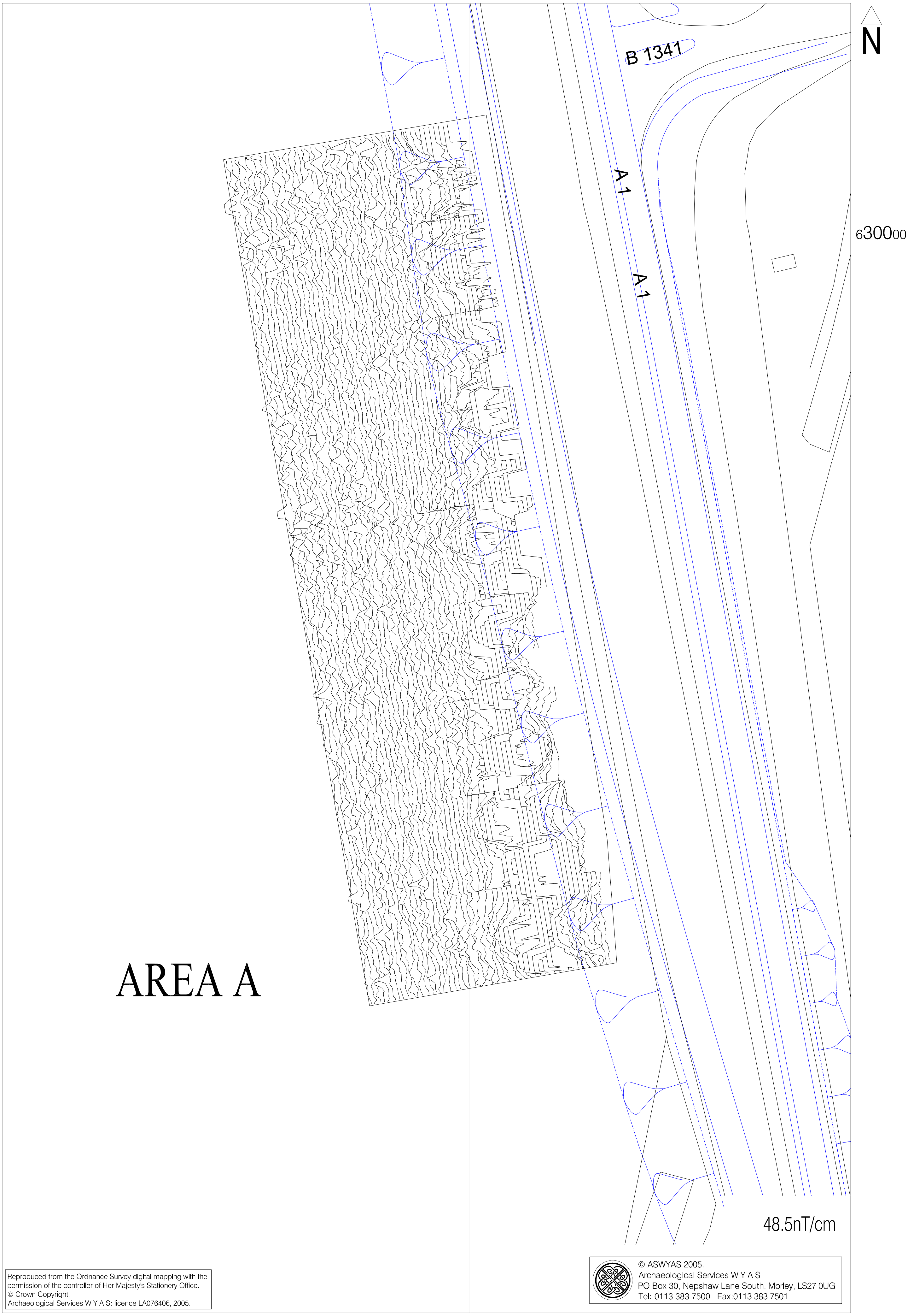

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Fig. 5. XY trace plot of magnetometer data; Area A

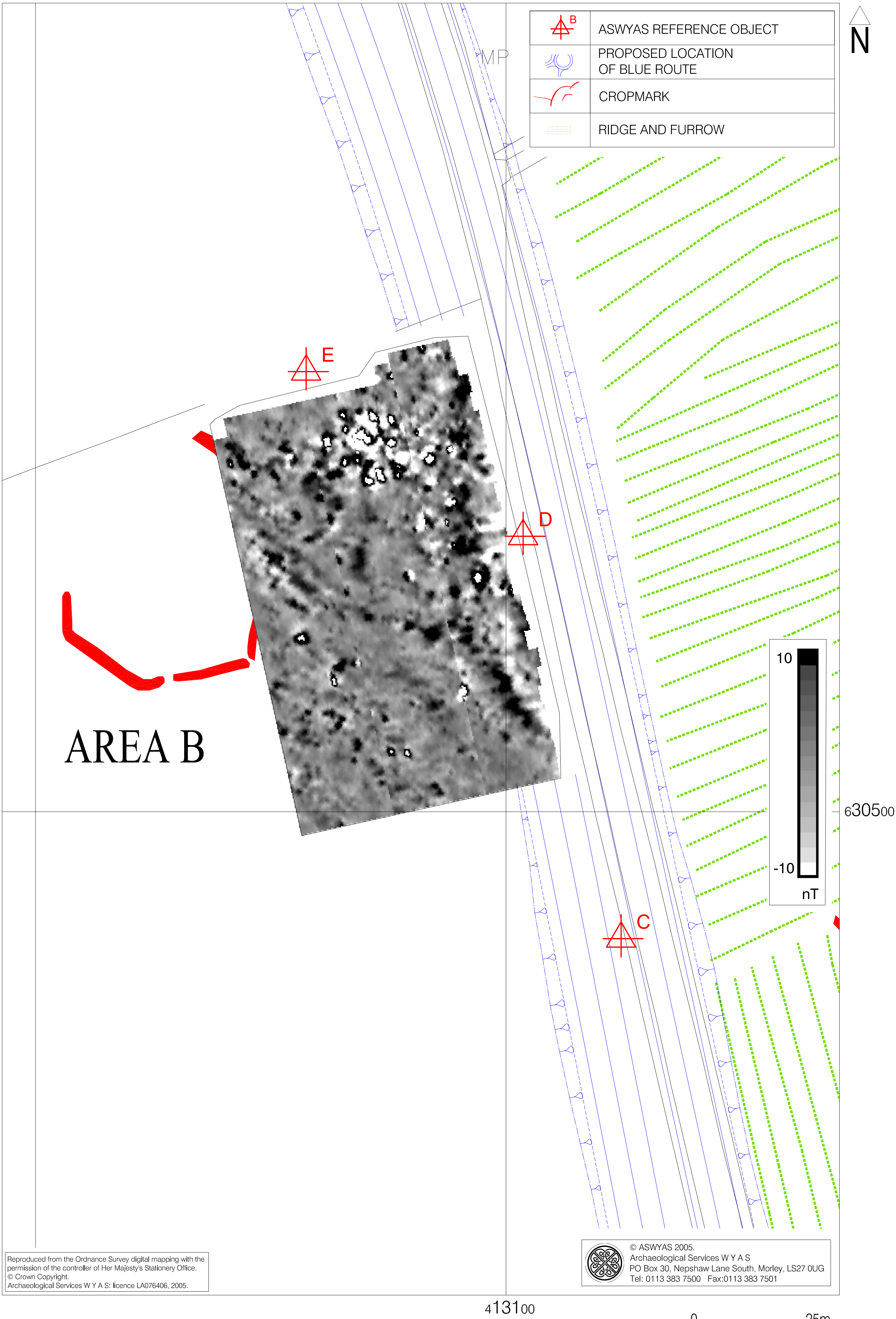

Fig. 6. Plot of greyscale magnetometer data; Area B

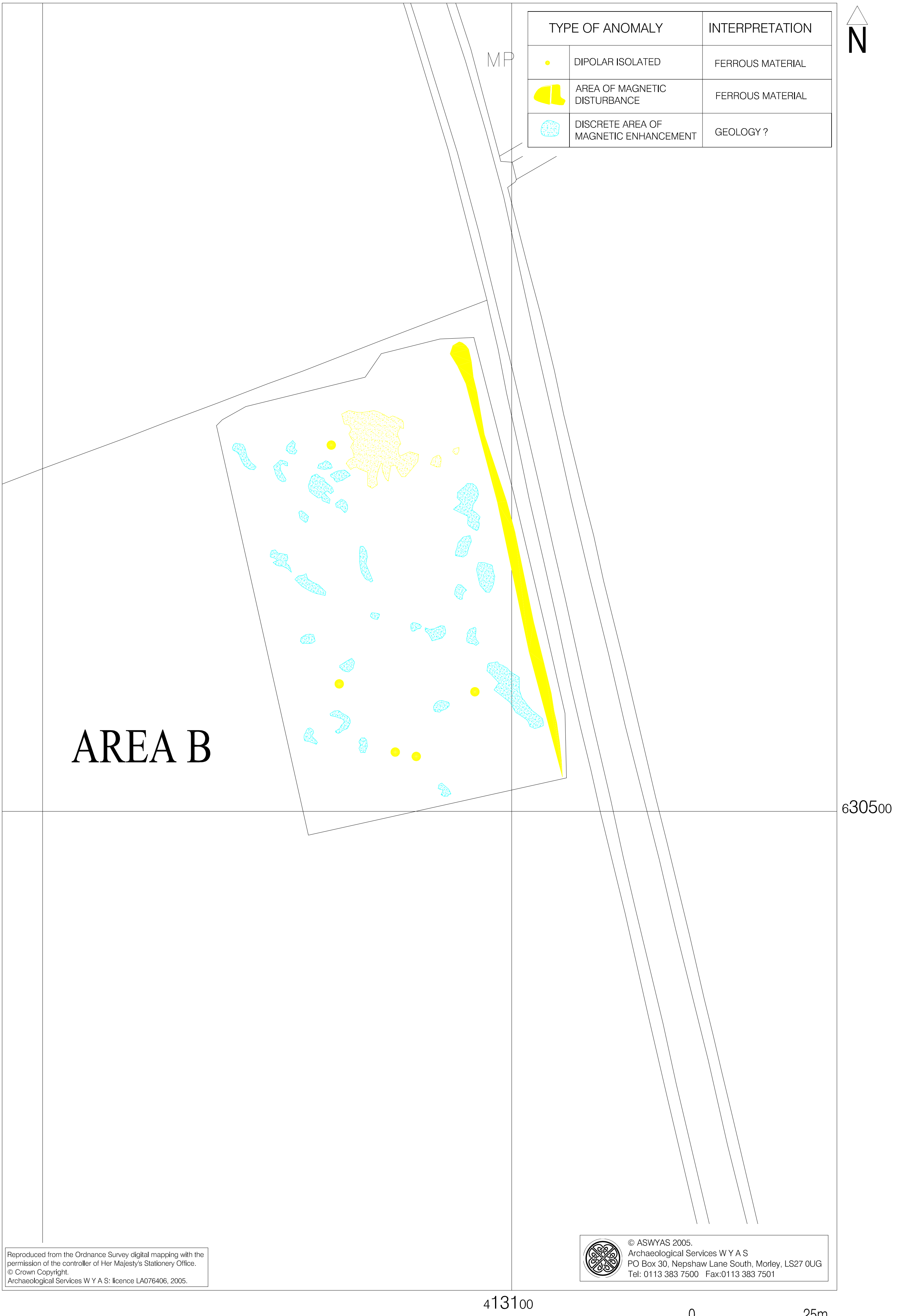

Fig. 7. Interpretation plot of magnetometer data; Area B

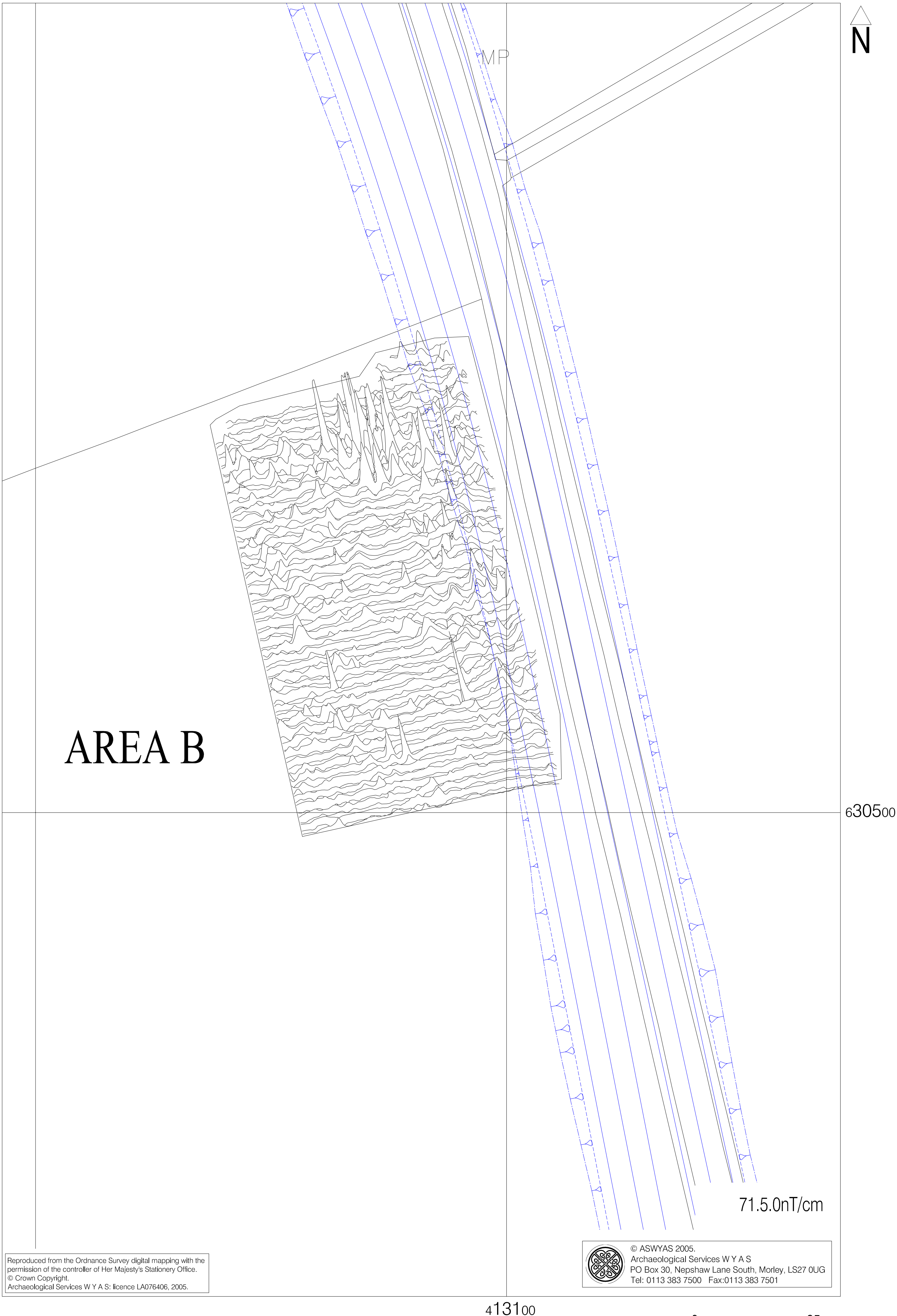

Fig. 8. XY trace plot of magnetometer data; Area B

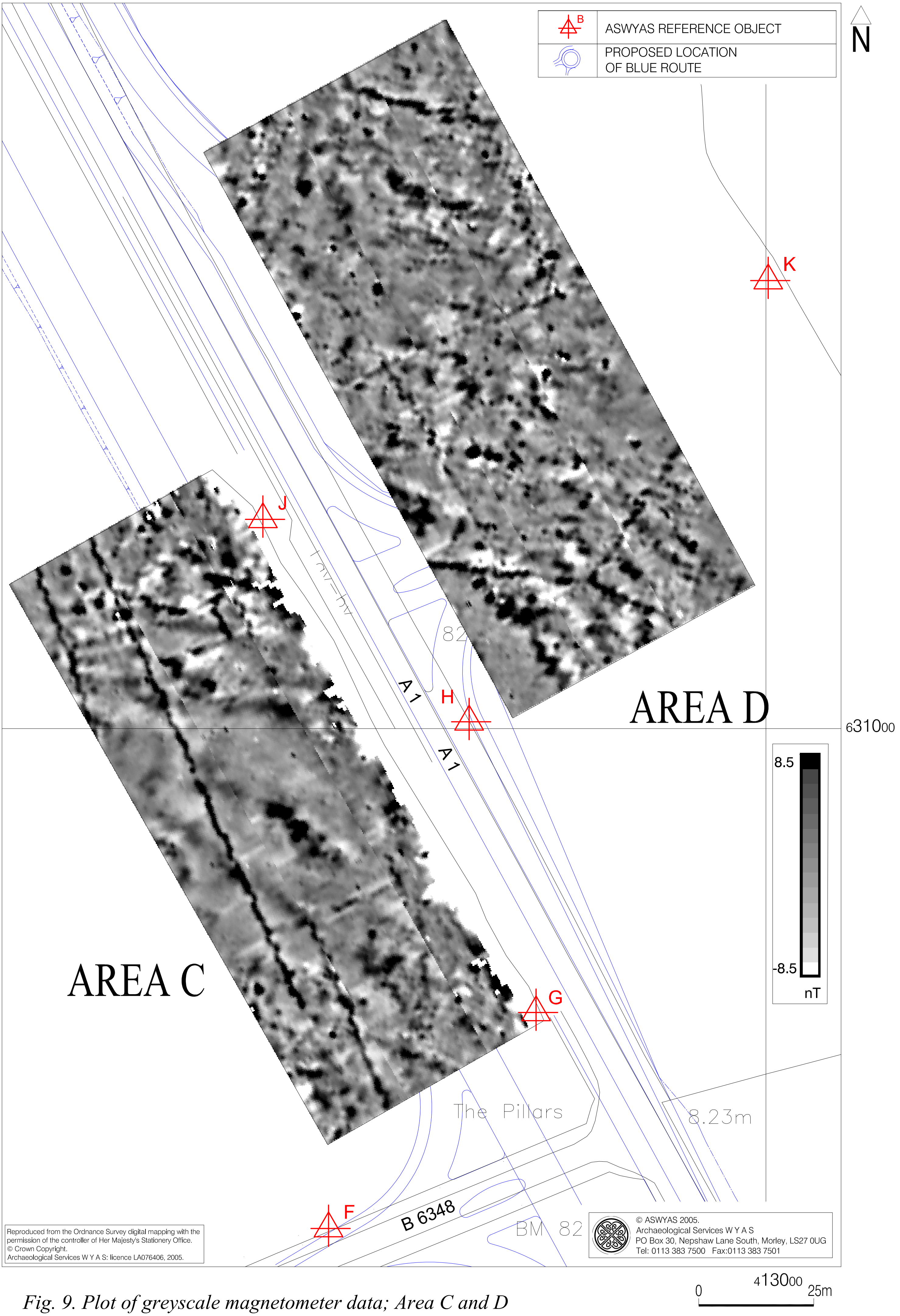

Fig. 9. Plot of greyscale magnetometer data; Area C and D

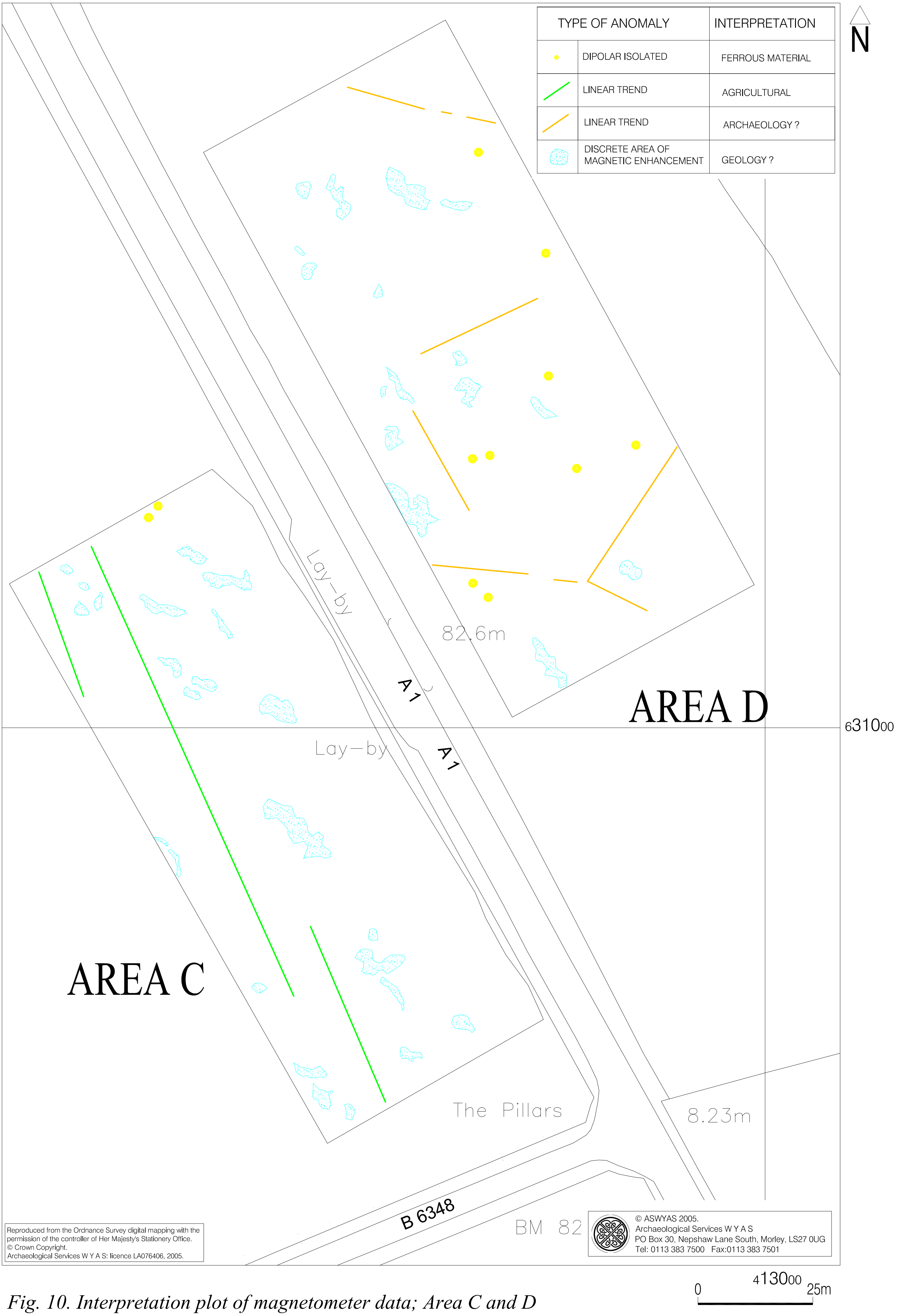

Fig. 10. Interpretation plot of magnetometer data; Area C and D

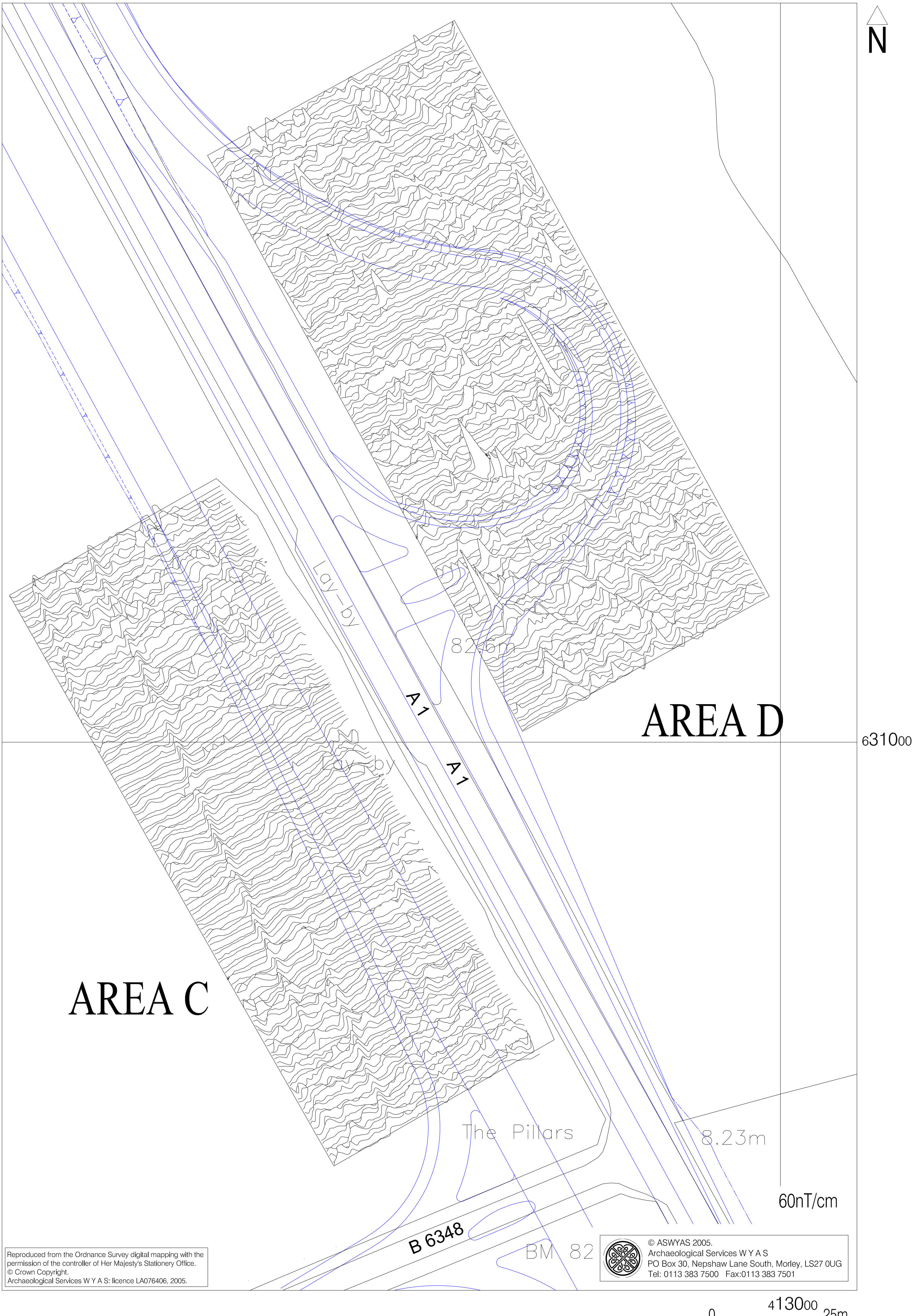

Fig. 11. XY trace plot of magnetometer data; Area C and D

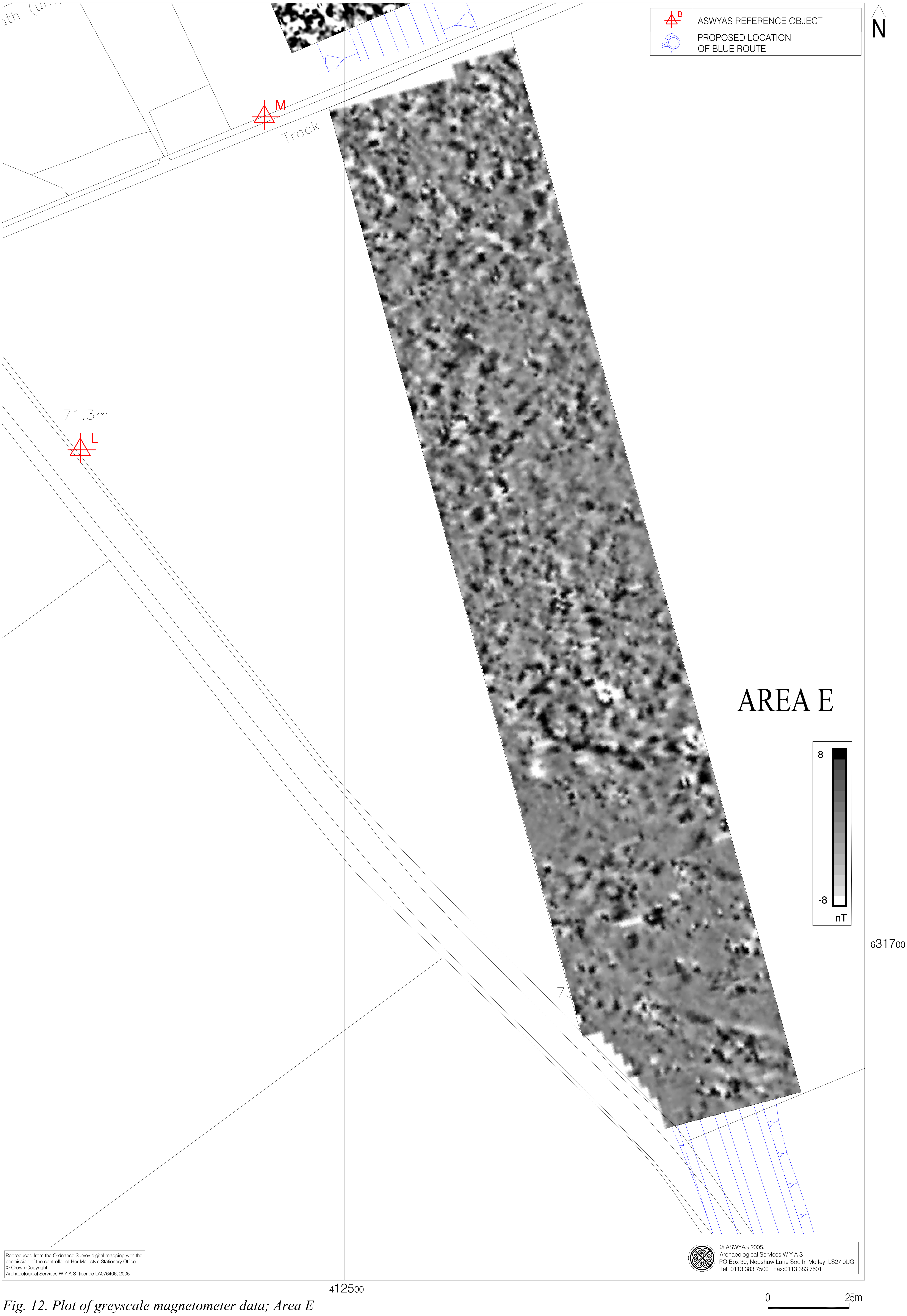

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Fig. 12. Plot of greyscale magnetometer data; Area E

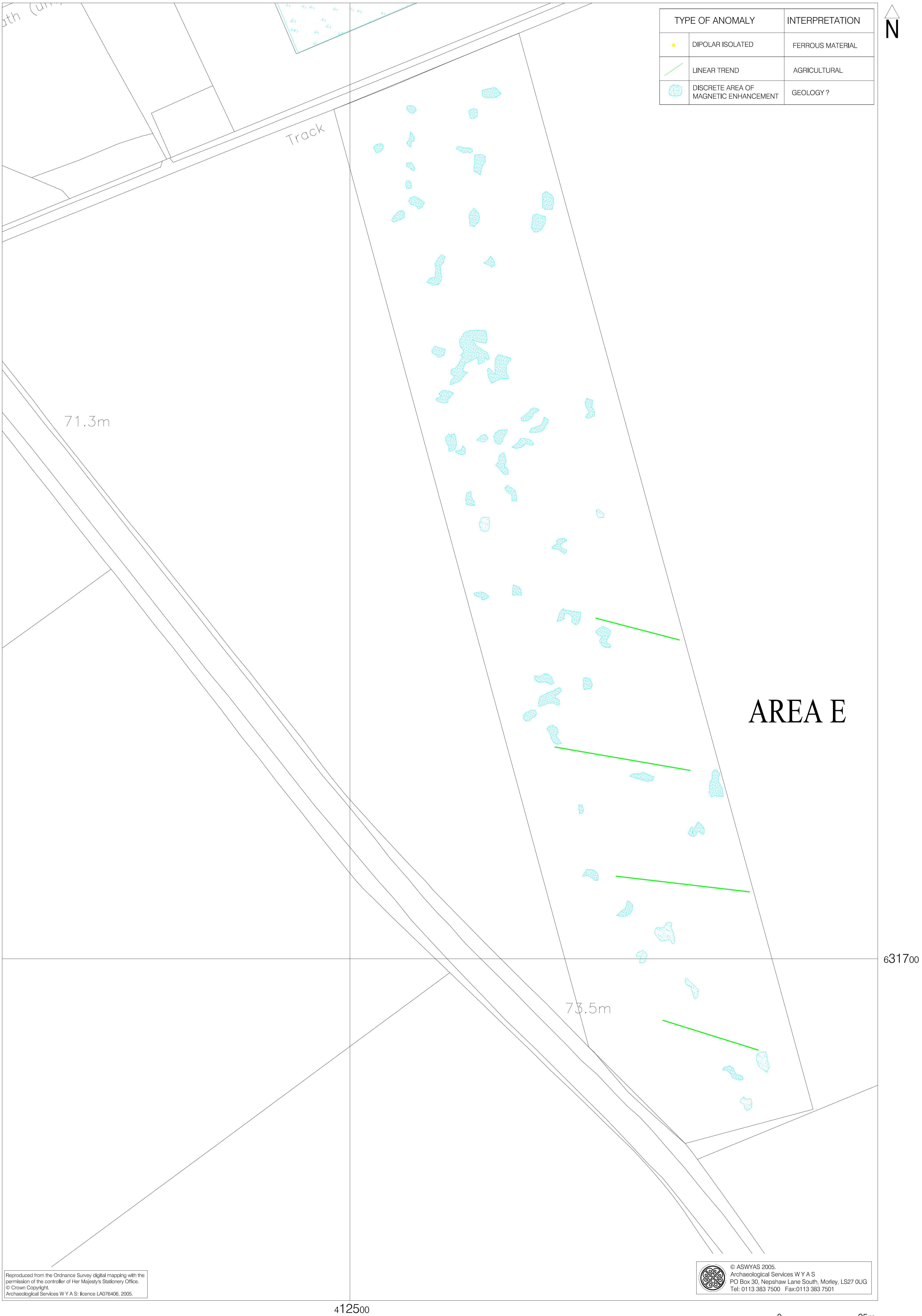


Fig. 13. Interpretation plot of magnetometer data; Area E

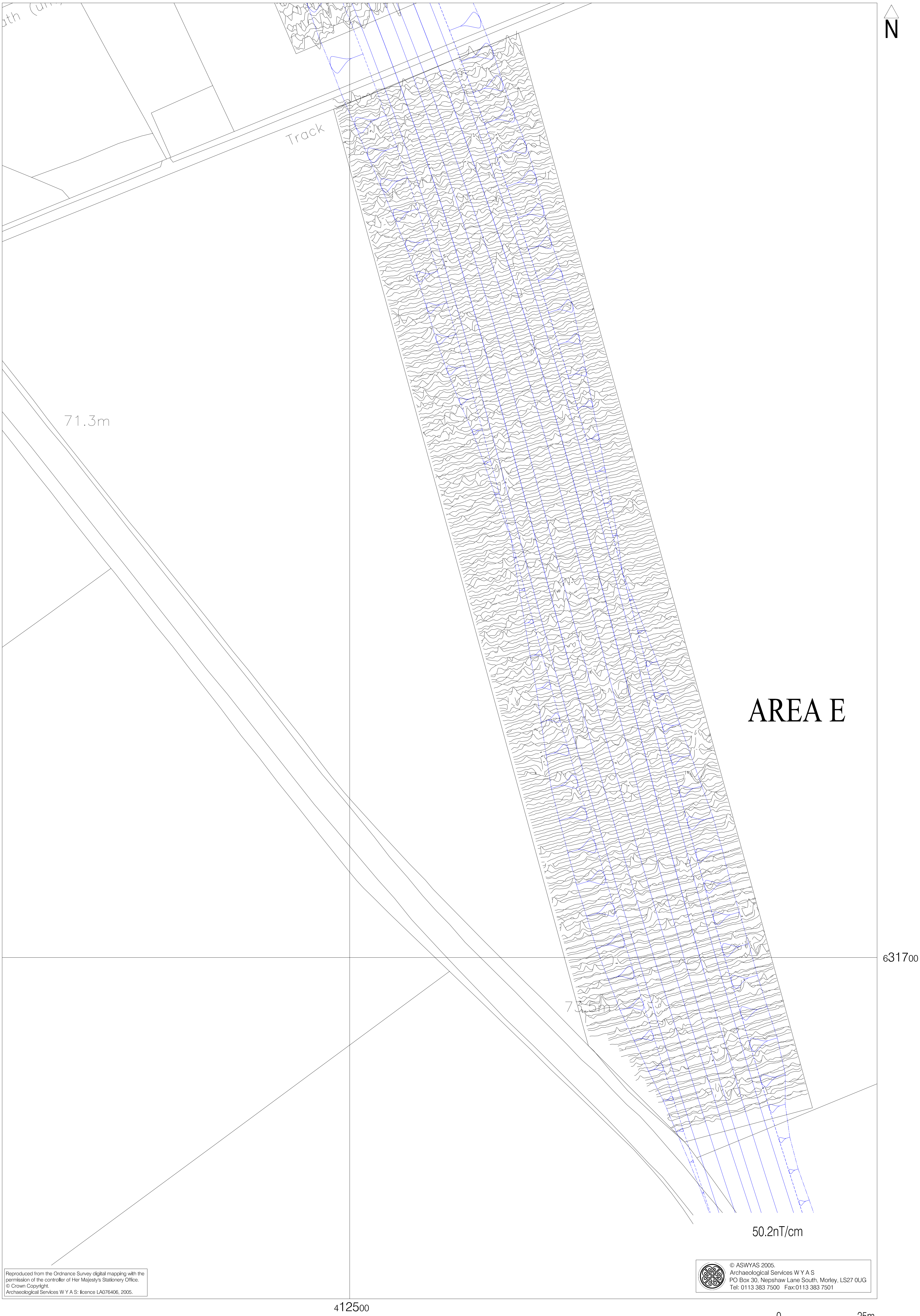


Fig. 14. XY trace plot of magnetometer data; Area E

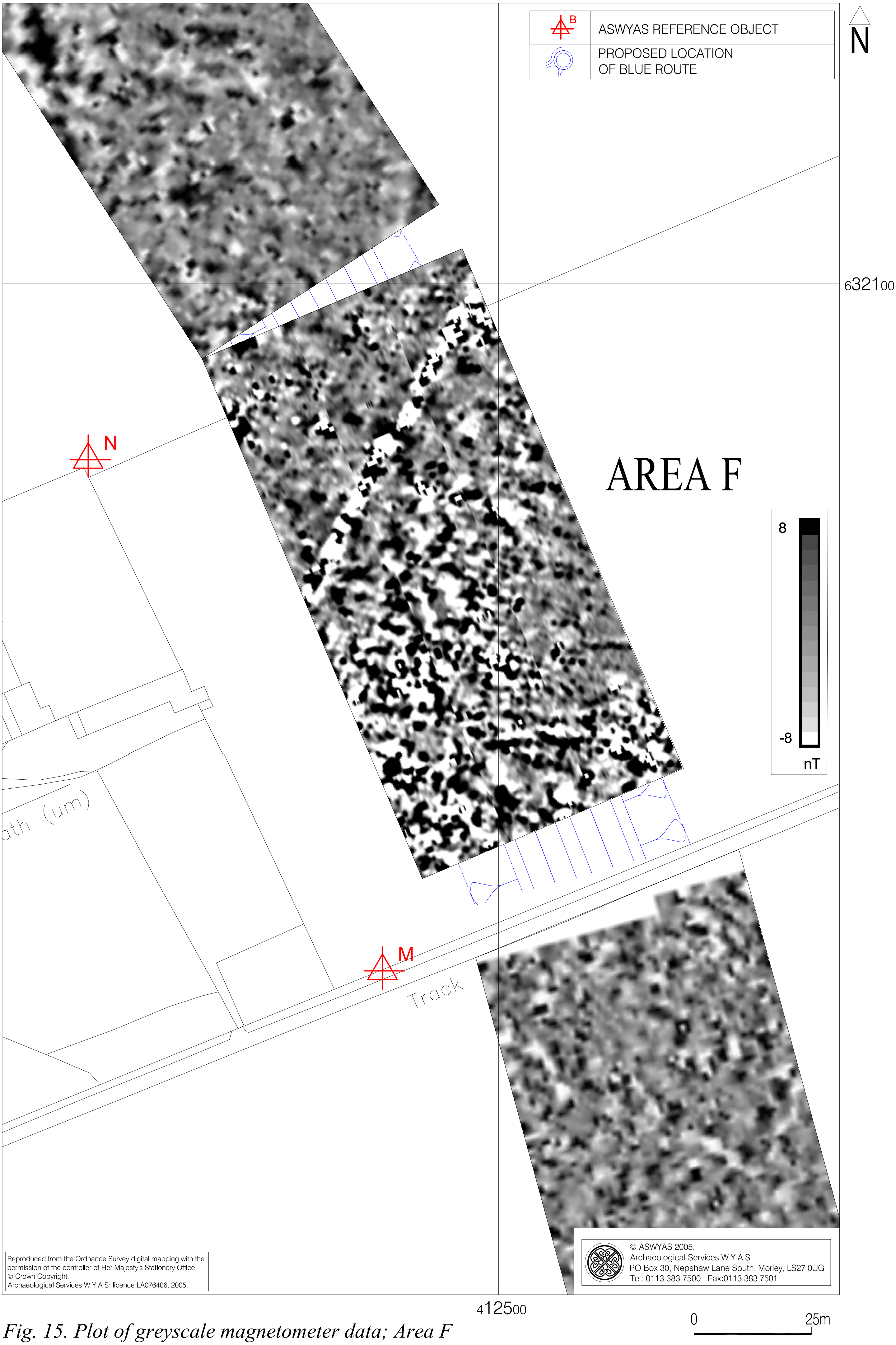


Fig. 15. Plot of greyscale magnetometer data; Area F

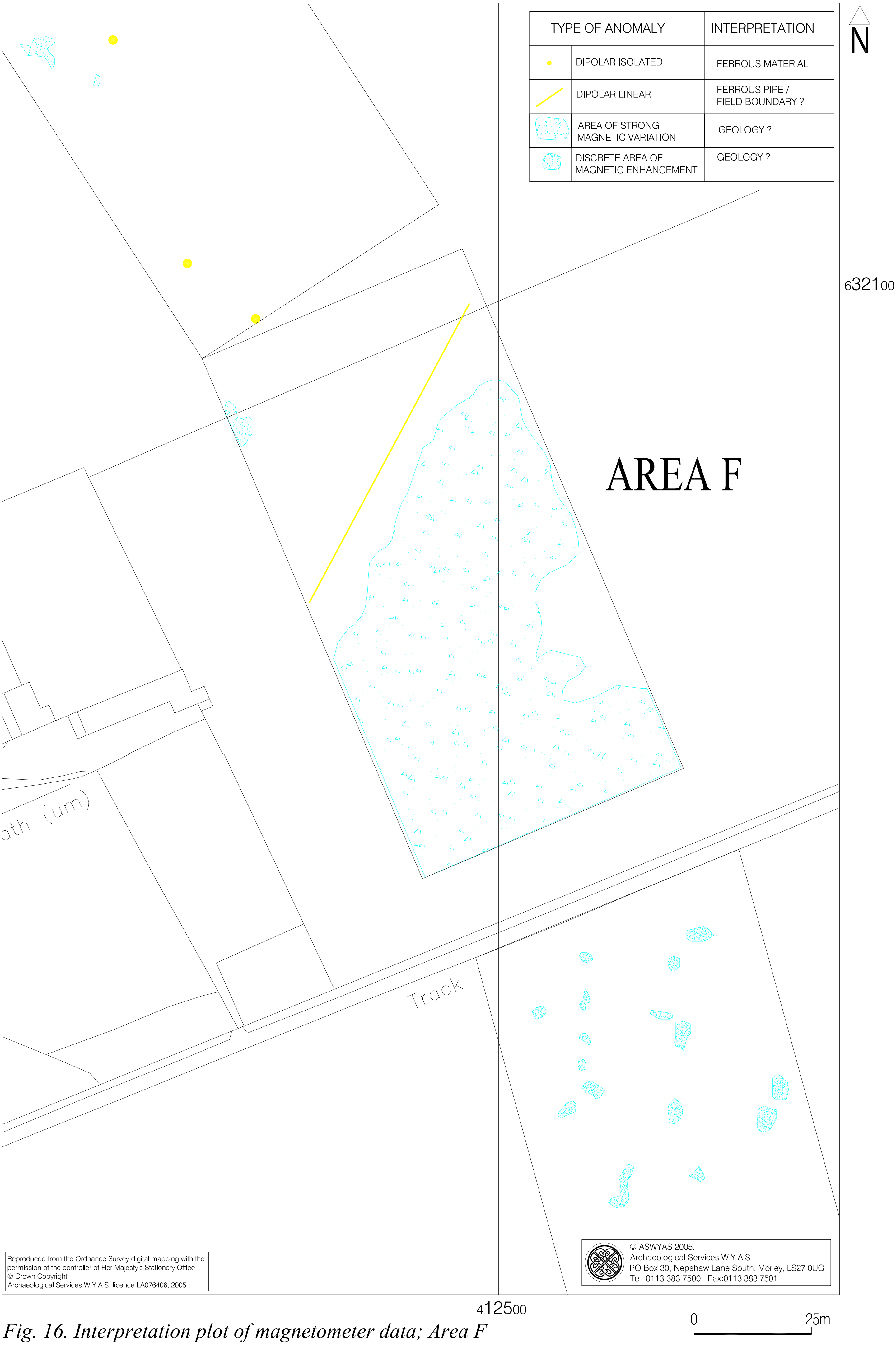


Fig. 16. Interpretation plot of magnetometer data; Area F

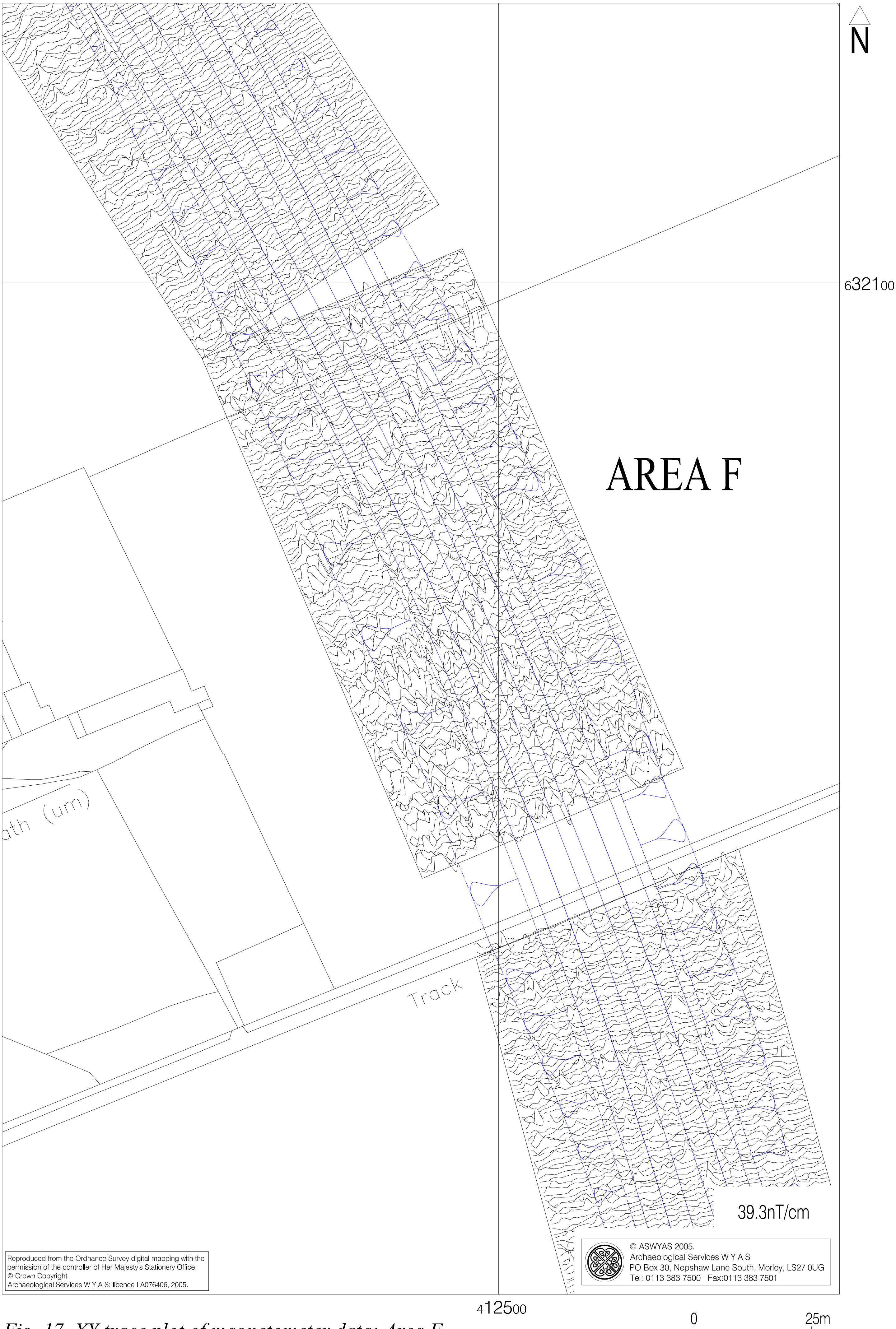


Fig. 17. XY trace plot of magnetometer data; Area F

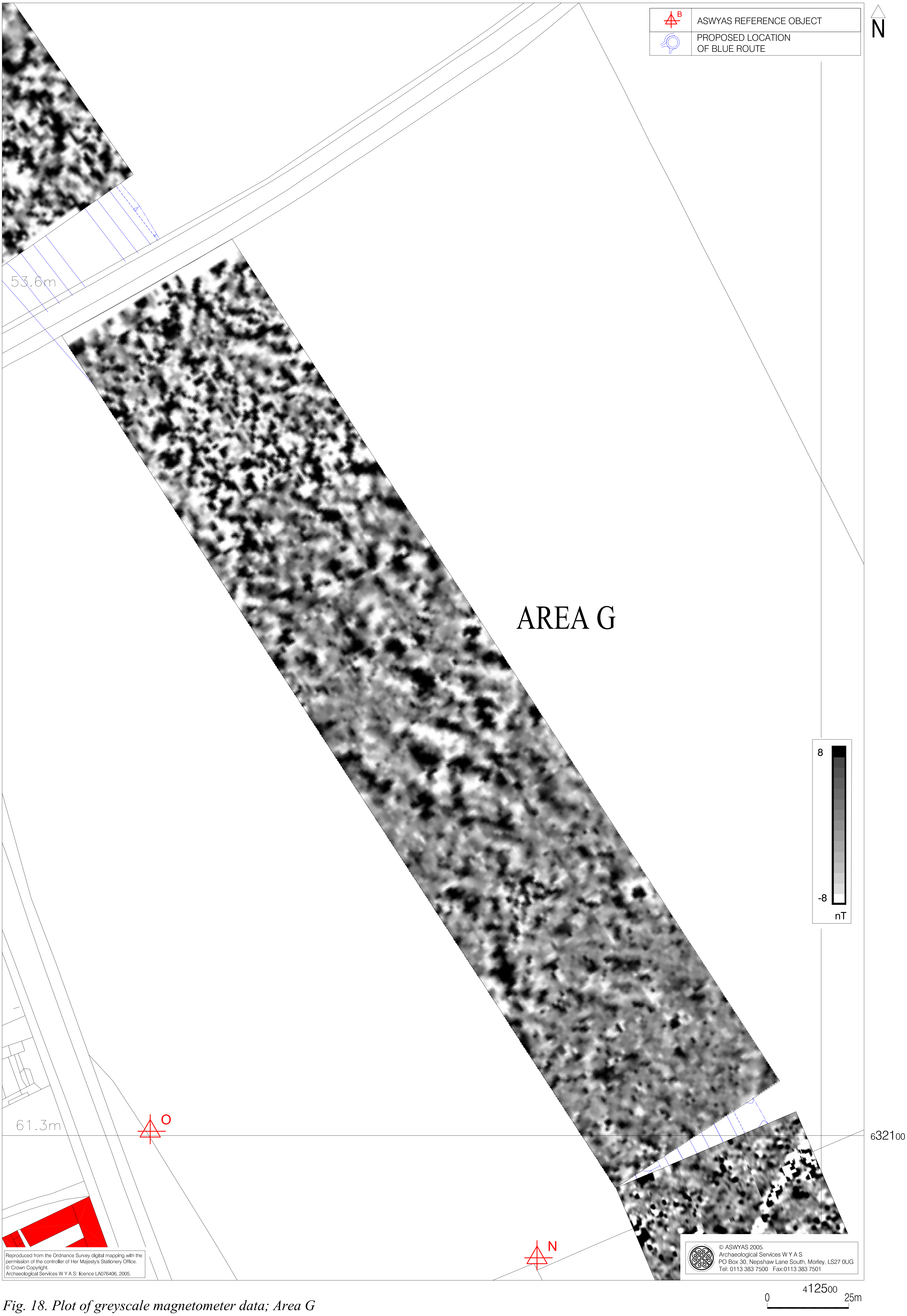


Fig. 18. Plot of greyscale magnetometer data; Area G

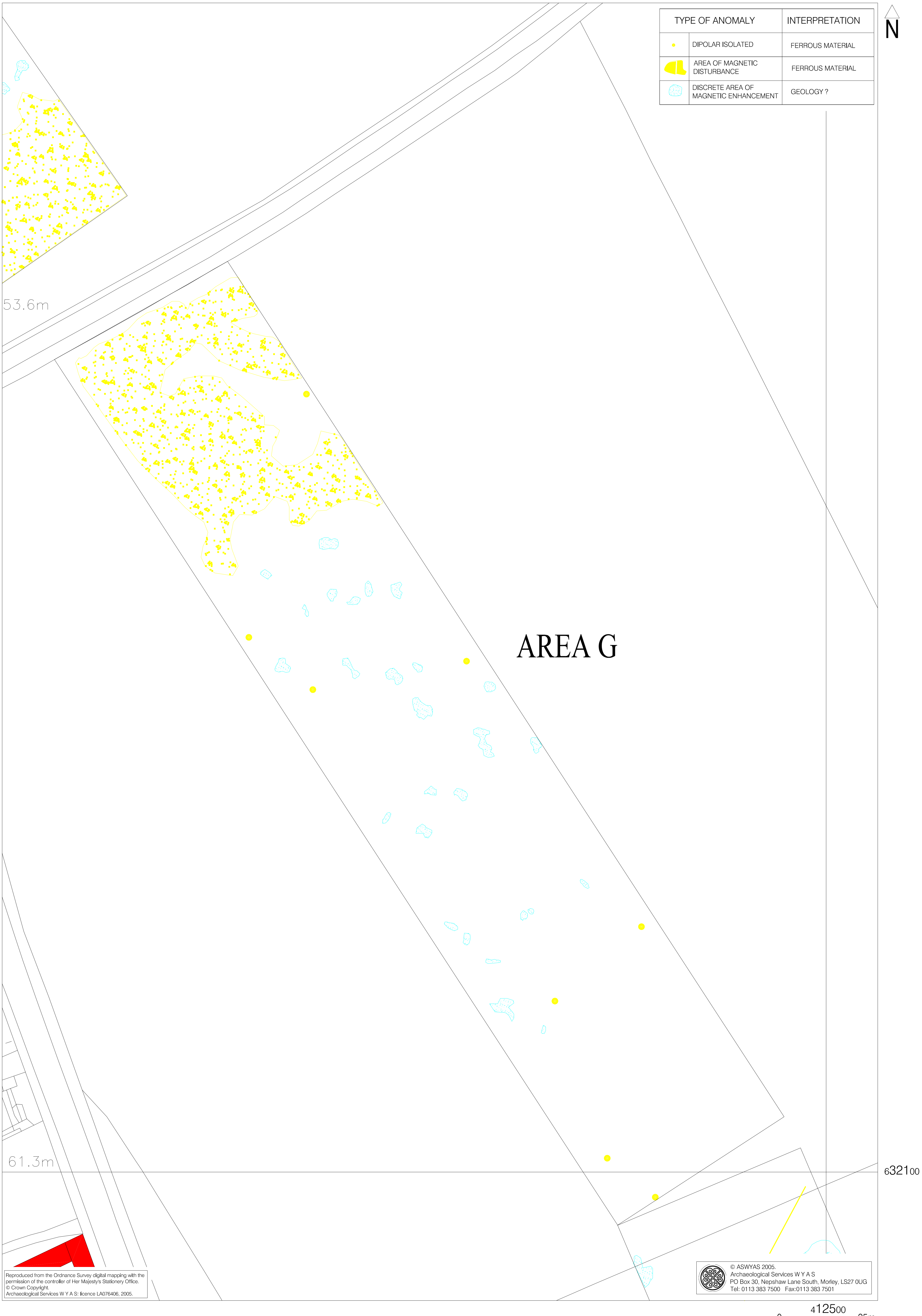


Fig. 19. Interpretation plot of magnetometer data; Area G

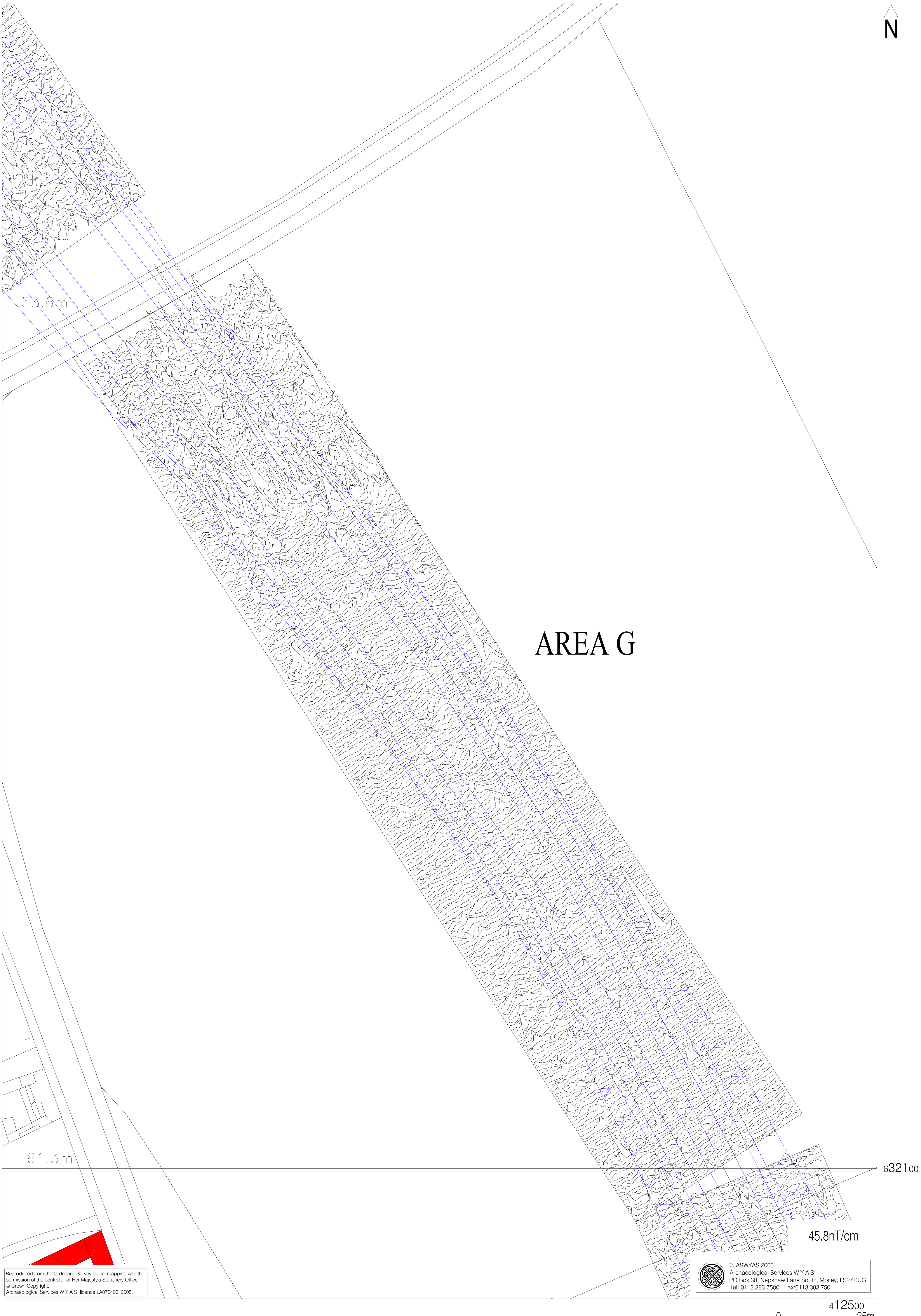


Fig. 20. XY trace plot magnetometer data; Area G

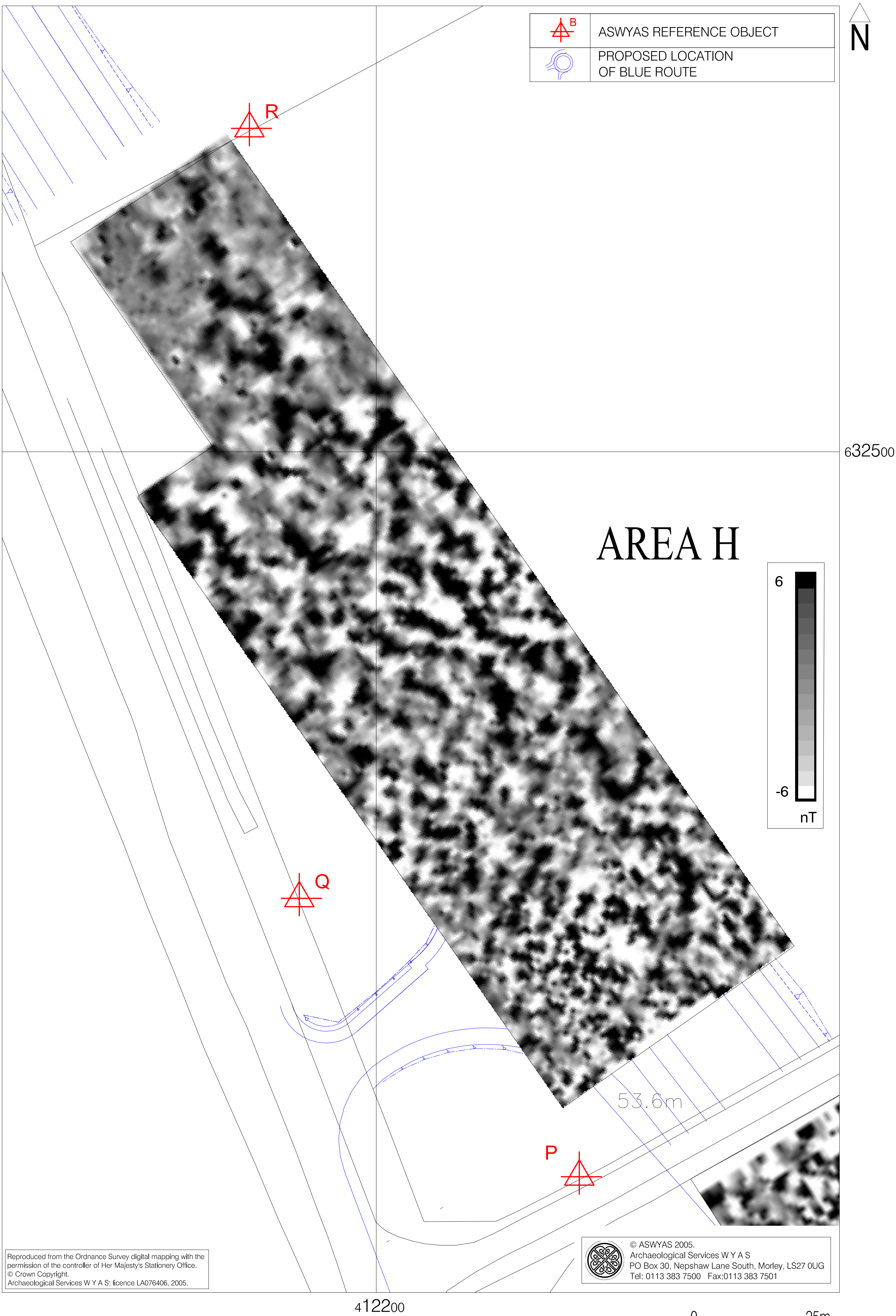
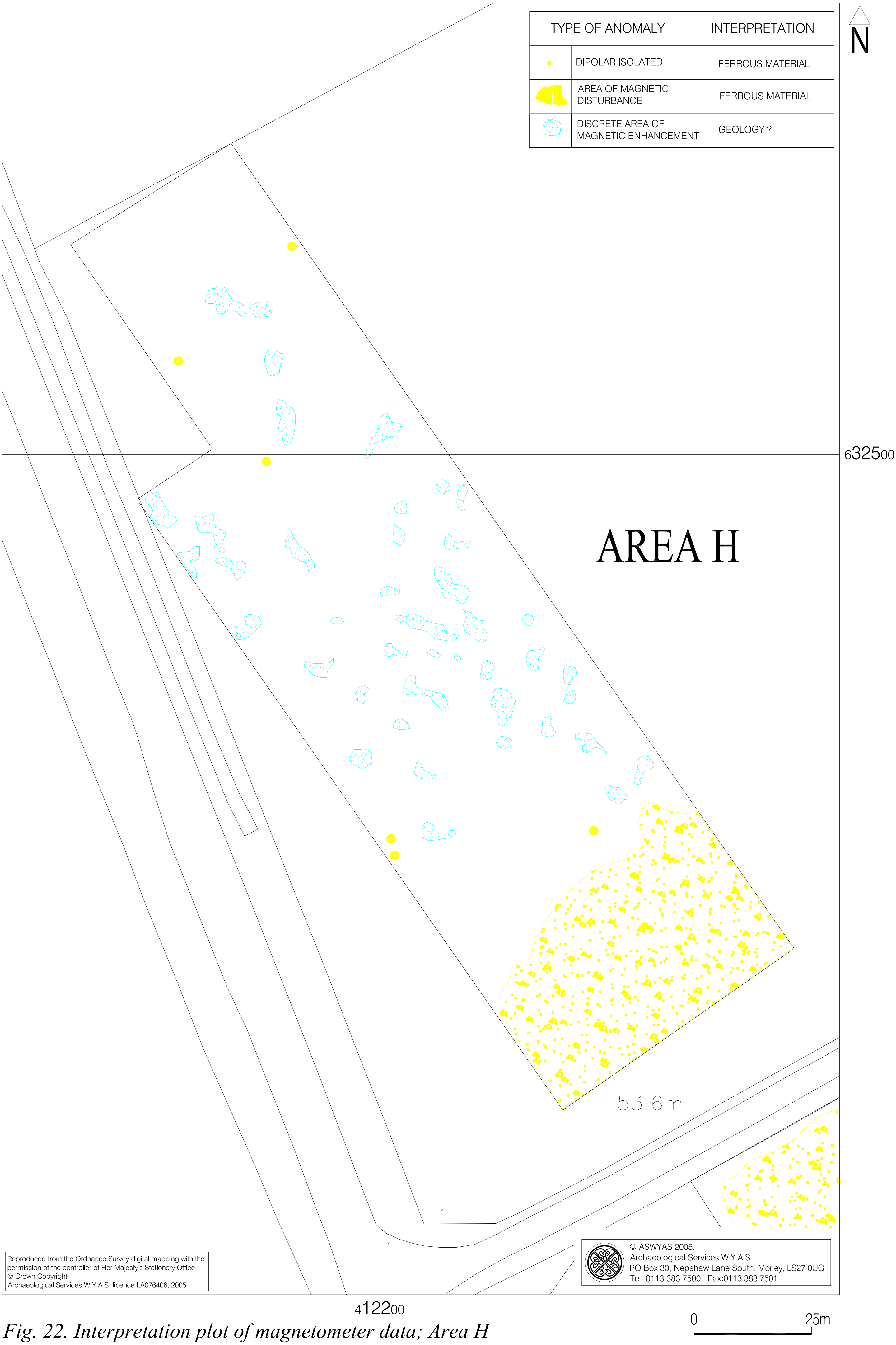


Fig. 21. Plot of greyscale magnetometer data; Area H



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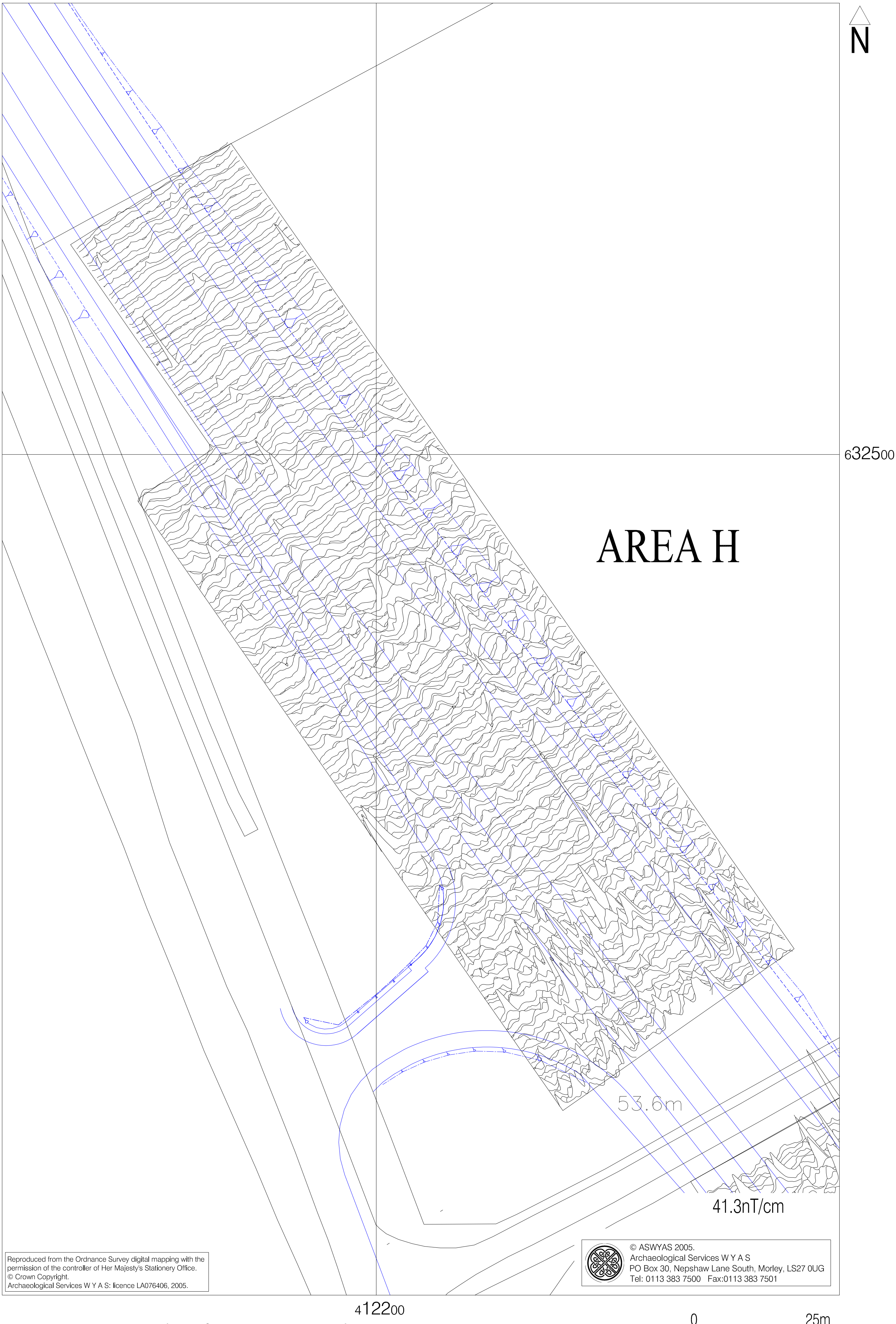

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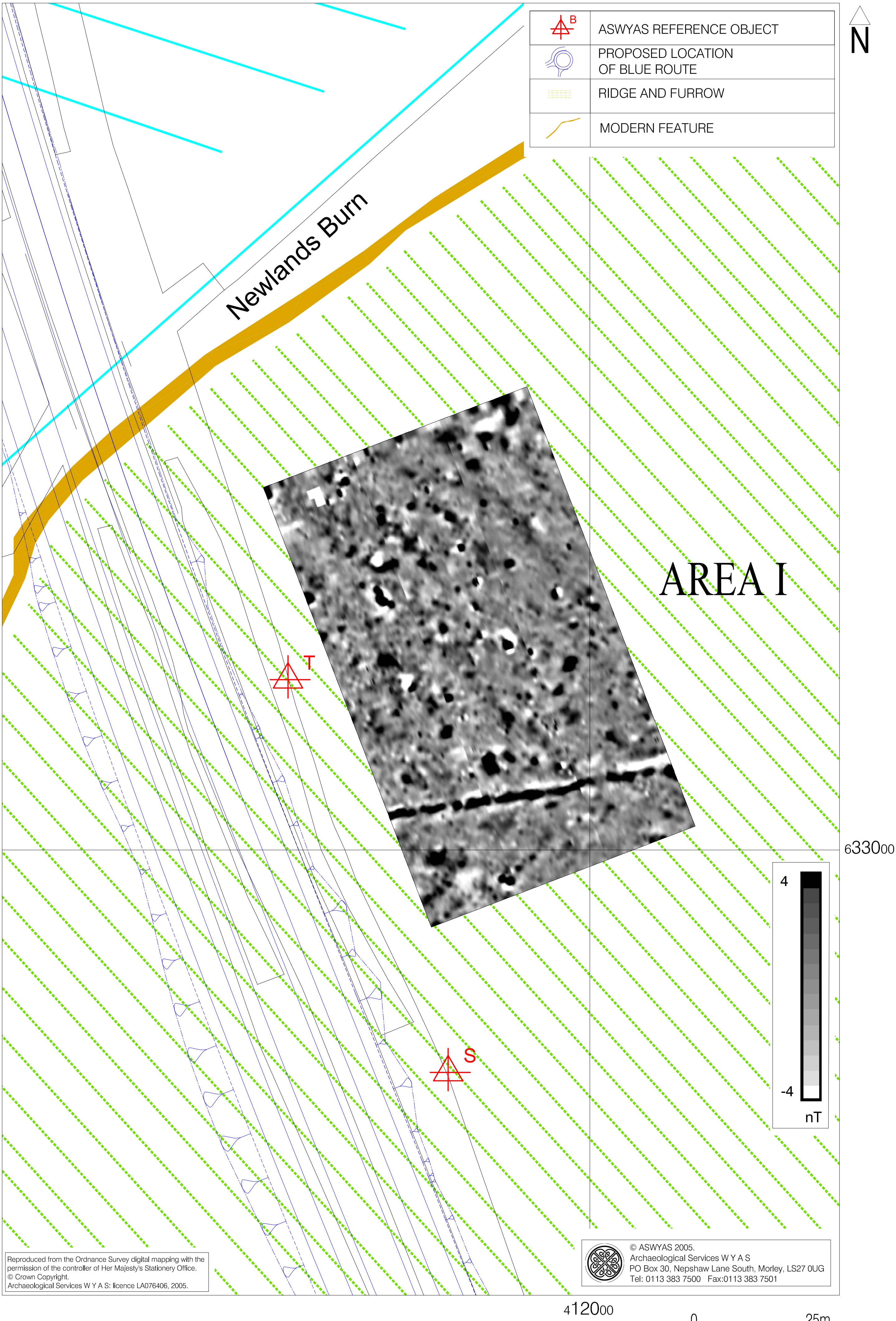

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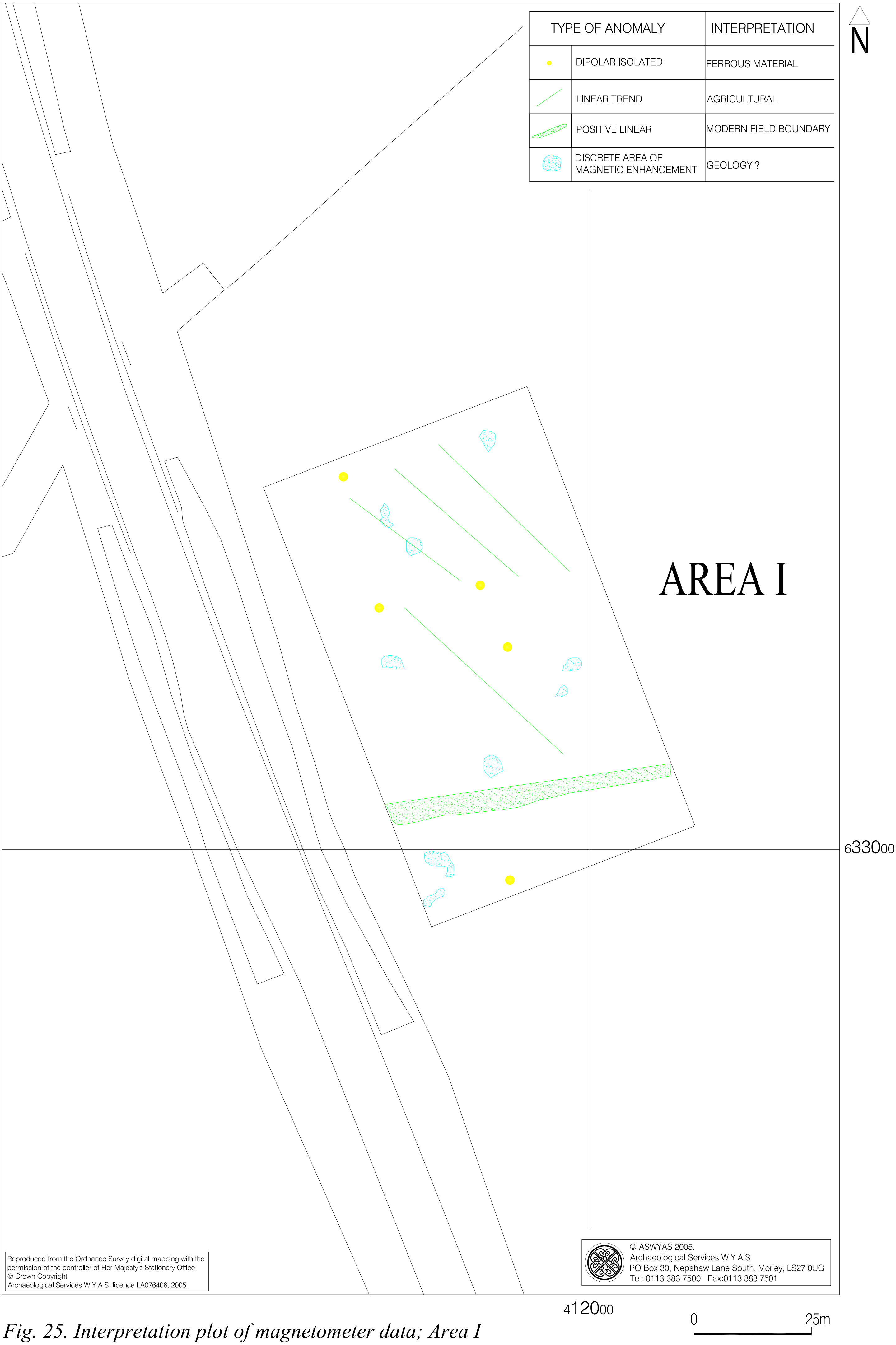
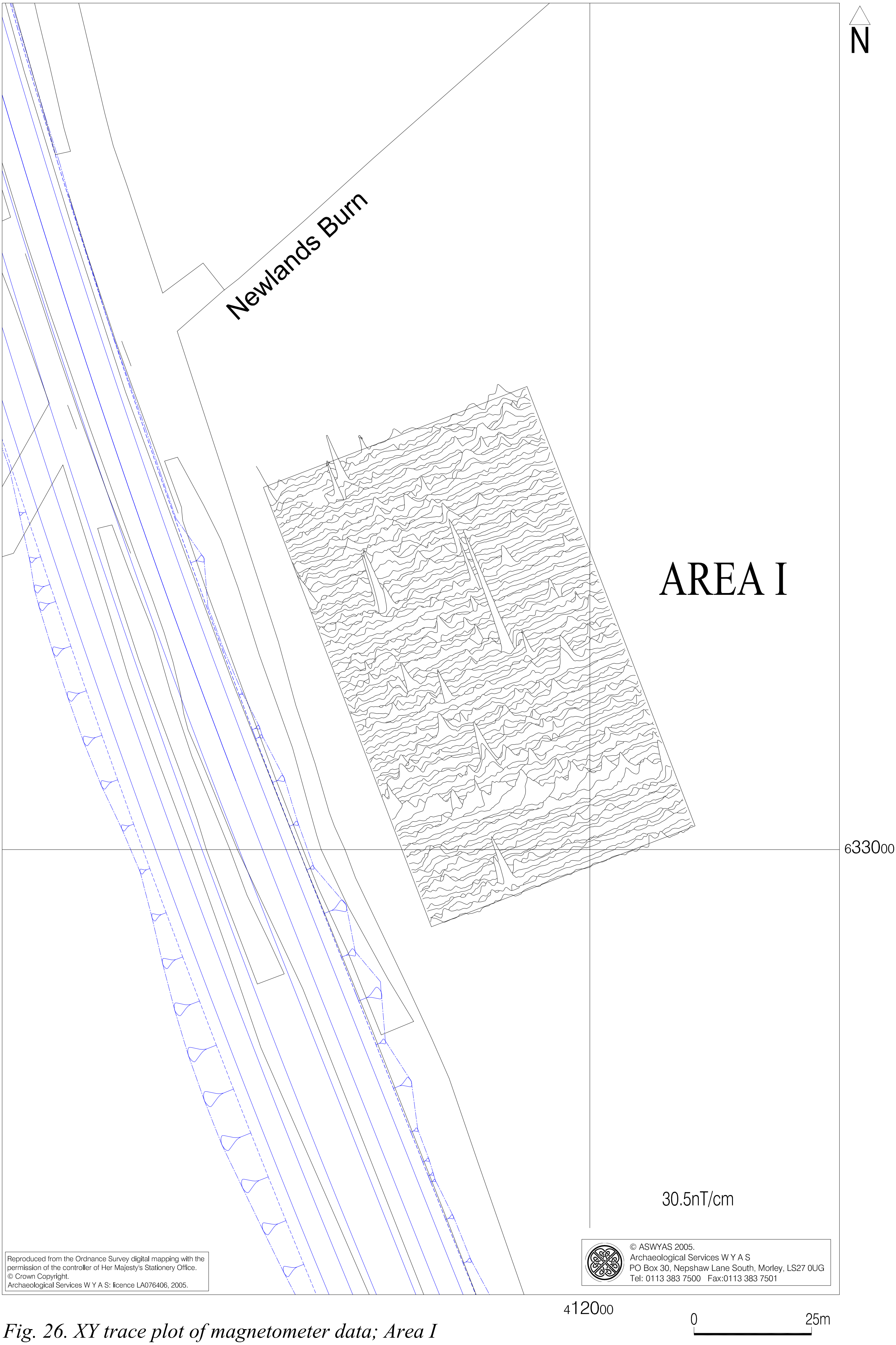


Fig. 25. Interpretation plot of magnetometer data; Area I



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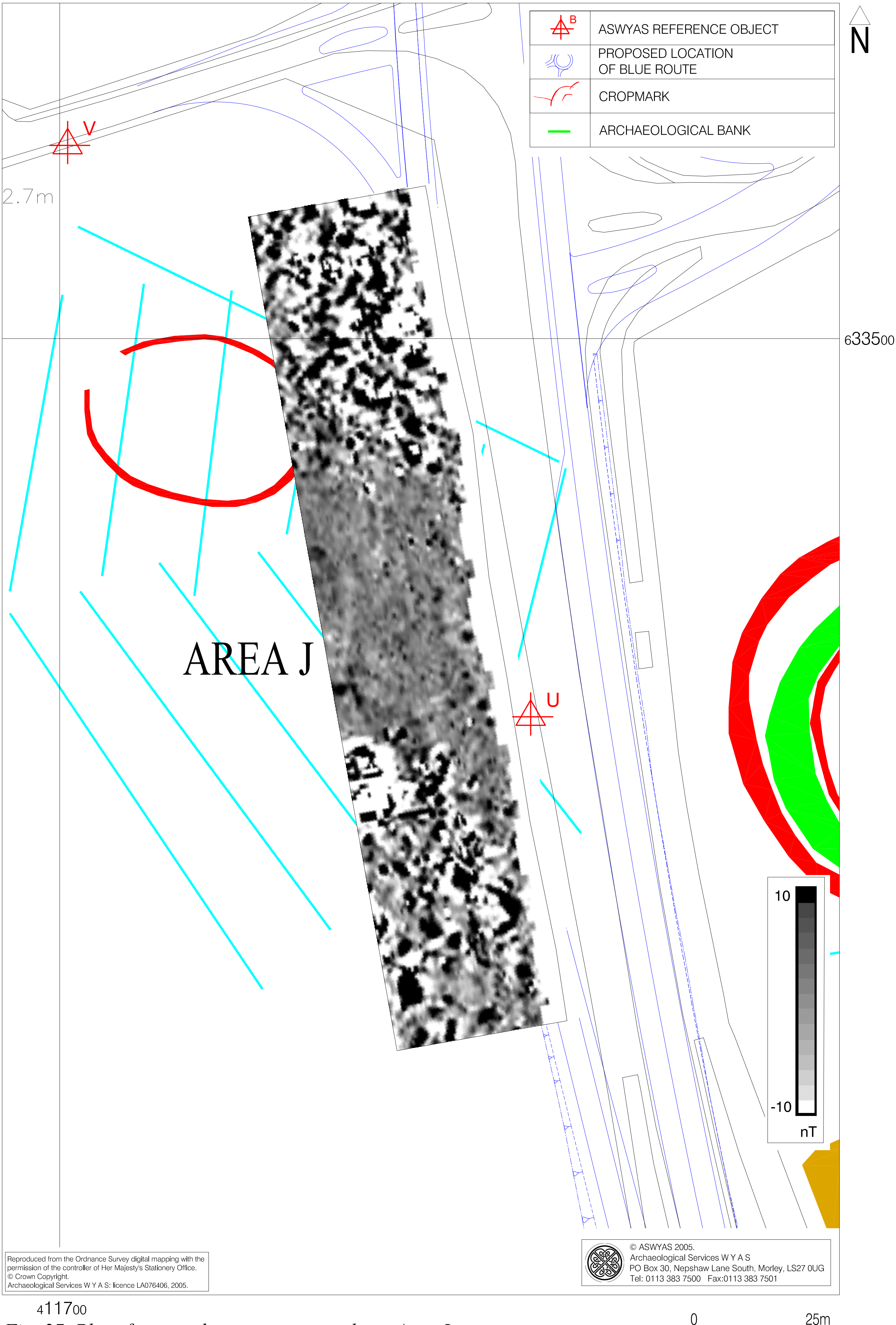

Fig. 27. Plot of greyscale magnetometer data; Area J

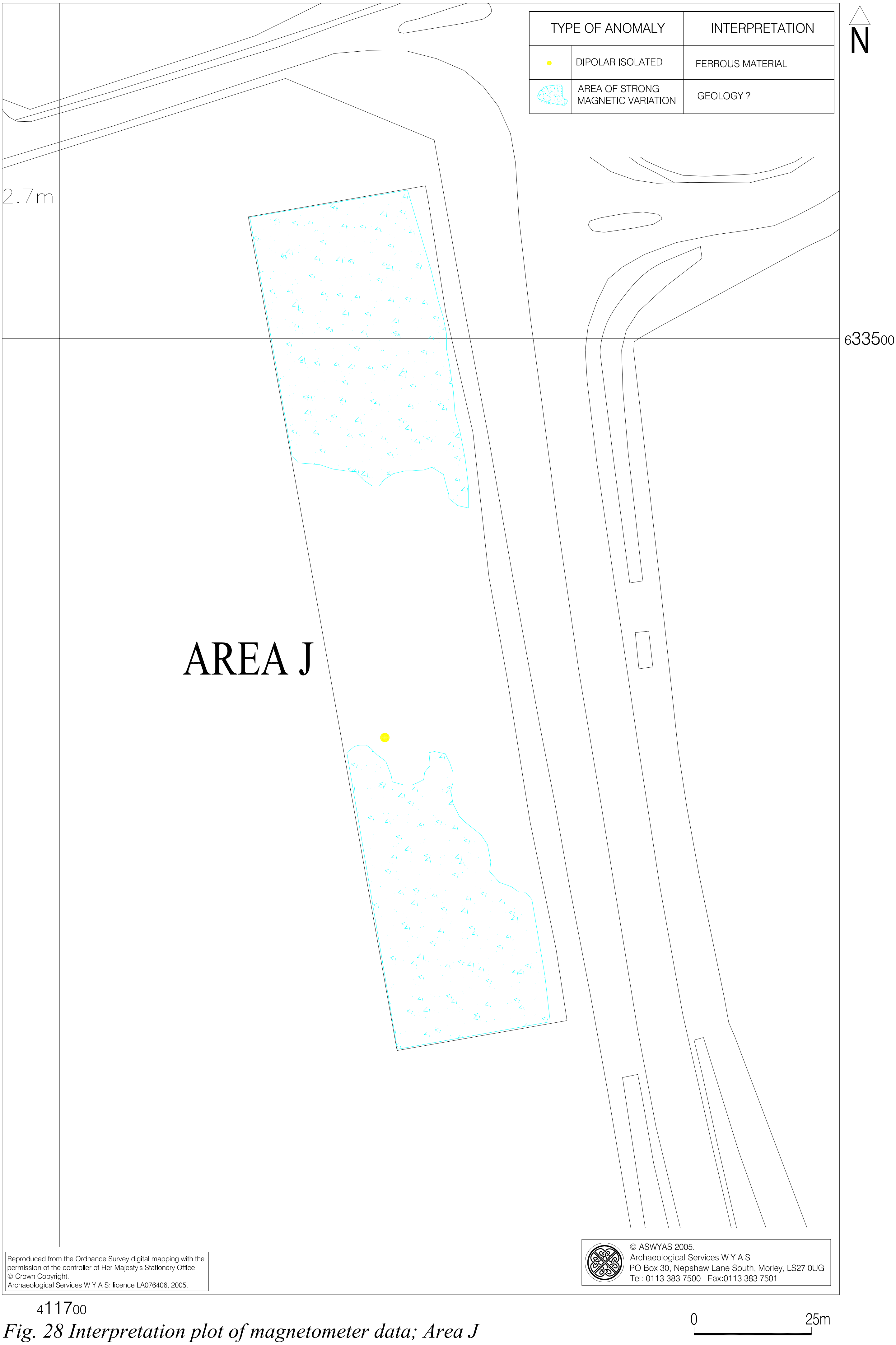

Fig. 28 Interpretation plot of magnetometer data; Area J

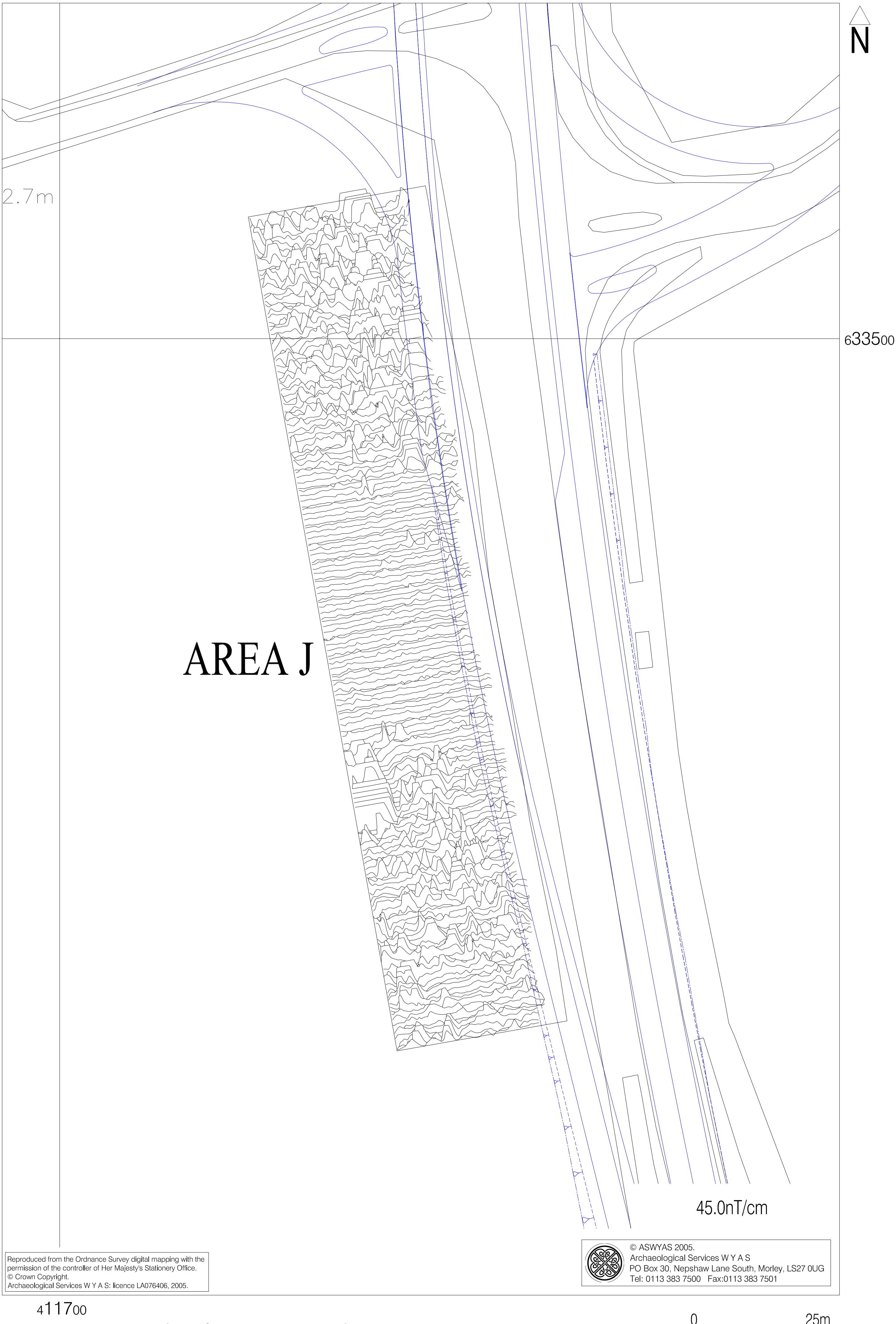

Fig. 29. XY trace plot of magnetometer data; Area J

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 that are interpreted as modern in origin may 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 0.25m 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.

A Bartington Grad601 magnetometer was used during this survey. Readings were taken, 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 processed gradiometer data has been presented in this report in greyscale format having been selectively processed and interpolated using Geoplot v.3 (Geoscan Research) software to form an array of regularly spaced values. The greyscale plots are displayed using a linear incremental scale as indicated on the individual display plots.

The unprocessed ('raw') data is displayed in XY trace plot format. This format allows the full range of data to be viewed, dependent on the clip, allowing the ‘shape’ of individual anomalies to be discerned and potentially archaeological anomalies differentiated from ferrous ‘iron spike’ responses.

Appendix 2

Survey Location Information

Temporary reference points (survey marker stakes) were established and left in place following completion of the fieldwork for accurate geo-referencing. The grids were tied-in relative to these markers and to field boundaries. 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.

The locations of the temporary reference points are shown on the interpretation figures and the local grid co-ordinates tabulated below.

Station	Easting	Northing
A	413238.6208	629841.5624
B	413212.3137	629978.1723
C	413124.5190	630473.0519
D	413103.6857	630558.5135
E	413057.4691	630593.4929
F	412904.9579	630891.4291
G	412950.0648	630938.3885
H	412935.5299	631001.5518
J	412890.7828	631045.3435
K	413000.4763	631097.3287
L	412418.8827	631851.6648
M	412475.3044	631953.8388
N	412412.7995	632062.4388
O	412294.0930	632101.4079
P	412243.1831	632346.0125
Q	412138.6658	632405.1276
R	412173.0573	632568.7803
S	411969.8930	632952.7774
T	411935.8534	633036.1831
U	411800.1529	633419.7358

V	411701.7150	633541.1705

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 digital archive is held by Archaeological Services WYAS. 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).