ARCHAEOLOGICAL
SERVICES
WYAS

Ryedale Gas Project
North Yorkshire

Geophysical Survey

September 2010

Report No. 2127

CLIENT
Moorland Energy Ltd

Ryedale Gas Project
North Yorkshire

Geophysical Survey

Summary

A geophysical (magnetometer) survey covering approximately 30 hectares was carried out at five locations along the route of a proposed pipeline that will carry gas from Ebberston Wellsite to Hurrell Lane Gas Processing Facility in Ryedale. The corridor crosses a landscape of known archaeological potential including a series of earthworks which are protected as scheduled monuments. At the northern end of the corridor previously unknown ditch features have been identified adjacent to Givendale Dike in Area C whilst an anomaly corresponding with a cropmark has been identified south of Oxmoor Dike in Area B. No anomalies of archaeological potential have been noted in Area A but this may be due to the presence of organic waste in the topsoil masking the response from archaeological features, if present. In Area D two hitherto unknown pit alignments have been identified either side of Diggerfoot Dyke which is also identified as a magnetic anomaly although it is no longer visible as an earthwork. Evidence of ridge and furrow ploughing is also identified here. Only geological anomalies and a probable former field boundary are identified in Area E.

Overall the surveys have confirmed the presence of archaeological features previously identified as cropmarks or from historic mapping and clarified the detail in several other instances. Previously unknown features, most notably the two pit alignments, have also been identified thereby successfully increasing our understanding of the archaeological potential of the landscape along the selected sections of the pipe corridor.

ARCHAEOLOGICAL
SERVICES
WYAS

Report Information

Client:	Moorland Energy Ltd
Address:	1, Farnham Road, Guildford, Surrey,GU2 4RG
Report Type:	Geophysical survey
Location:	Ryedale
County:	North Yorkshire
Grid Reference:	SE 902 871 (Area A) – SE 862 839 (Area E)
Period(s) of activity represented:	prehistoric, Iron Age/Romano-British?
Report Number:	2127
Project Number:	3624
Site Code:	RGP10
Planning Application No.:	NY/2020/0159/ENV (North Yorkshire County Council) NYM/2010/0262/EIA (North York Moors National Park)
Museum Accession No.:	n/a
Date of fieldwork:	August – September 2010
Date of report:	September 2010
Project Management:	Alistair Webb BA MIfA
Fieldwork:	Alex Harrison BSc Sam Harrison BSc MSc AIfA David Williams BSc
Report:	Alistair Webb
Illustrations:	Sam Harrison
Photography:	Site staff
Research:	n/a
Produced by:	Archaeological Services WYAS, PO Box 30, Nepshaw Lane South, Morley, Leeds LS27 0UG Telephone: 0113 383 7500 Email: admin@aswyas.com

Authorisation for distribution: --

ISOQAR ISO 9001:2008
Certificate No. 125QM8003

Contents

List of Figures

List of Plates

1 Introduction

Archaeological Services WYAS was instructed by Peter Cardwell, Archaeological and Heritage Consultant, on behalf of Moorland Energy Ltd, to carry out a programme of non-intrusive geophysical (magnetometer) survey at five locations (Area A – Area E inclusive) along the route of a proposed gas pipeline from Ebberston Wellsite to Hurrell Lane Gas Processing Facility (see Fig. 1). The survey was undertaken between mid-August and early September 2010. The results of the survey will be submitted as supporting information prior to the determination of a planning application for the Ryedale Gas Project.

Site location, topography and land use (see Figs 1 and 2)

The proposed pipe corridor extends from the Ebberston wellsite at SE 903 871 in the north-east to the Hurrell Lane Processing Plant at SE 849 819, just east of Thornton-le-Dale, a distance of approximately 8km. The proposed route follows a slightly meandering path (see Fig. 2) across a significantly undulating landscape. Overall the land falls from approximately 220m above Ordnance Datum (aOD) at the wellsite to about 25m aOD at the proposed processing facility.

More detailed descriptions of each area are given below.

Area A

Area A covers a strip 650m long and 50m wide (3.2ha) immediately west of the wellsite, centred at SE 900 872. The ground had been disc harrowed (see Plate 1 and Plate 2) and an organic mulch spread following harvest. The land was relatively flat at 220m aOD.

Area B

Area B, centred at SE 8950 8715, covered an irregular shaped block of 1.2ha west of the minor road to Givendale Head Farm with Oxmoor Dikes to the north and west. The ground had been disc harrowed and an organic mulch spread following harvest. The land was relatively flat at 220m aOD.

Area C

Area C, centred at SE 8925 8690, was also irregular in shape covering 2.9ha in a reverse L-shape around the northern end of the Givendale Dike system. The majority of this area was under permanent pasture (see Plate 4) with a strip of harrowed and fertilised stubble to the east. The ground sloped down towards the centre of the area from both the eastern and western sides across Givendale (see Plate 4 and Plate 5).

Area D

Area D covered by far the largest area, some 18 hectares, extending from SE 8810 8590 at the north-eastern end to SE 8751 8450 at the southern end. This area had just been harvested prior to survey and was under stubble (see Plates 6, 7 and 8). This area generally hugged the western edge of Givendale sloping from north to south from approximately 200m aOD at its northern end to about 160m aOD at its southern end.

Area E

Area A covered 4.3ha and extended from SE 8620 8385 at its western end to SE 8690 8400 at its north-easterly end. It too was under stubble (see Plate 9). The topography is undulating but generally sloping down towards the south and west dropping from approximately 145m aOD at the north-eastern end to 130m aOD at the eastern end.

Geology and soils

The solid geology comprises primarily Middle Calcareous Grit (calcareous sandstones with beds of sandy and oolitic limestones) in Areas A, B, C and D with some Lower Limestone on the sides of Givendale in Area C. Area E is located on passage beds (calcareous sandstones and shell detritus limestones).

The soils to the north are shallow well-drained brashy calcareous fine loams of the Elmton 2 association or well-drained stoneless sands and loams of the Fyfield 3 association.

2 Archaeological background

The pipe corridor passes across a landscape of known, high, multi-period, archaeological potential. A detailed archaeological background was included within the Environmental Statement (Barton Willmore 2010), with the appropriate sections abstracted and included within the Brief for Geophysical Survey (Cardwell 2010). It is not intended to repeat this information here but a brief summary of the known archaeological resource in the immediate vicinity of each of the five survey areas is included as the initial paragraph in the Results section which are described by area.

3 Aims, Methodology and Presentation

The principal objectives of the survey were:

- to determine the location and extent of any archaeological features within the defined survey areas;
- to characterise as far as possible the nature of any anomalies identified and
- to prepare a report summarising the results of the survey.

Additionally area specific objectives were:

- to establish the location, extent and survival of those lengths of the Oxmoor and Givendale Dikes within the survey areas together with any associated features in the vicinity (Areas B and C);
- to establish the location, extent and survival of that length of the Diggerfoot Dikes within the survey area together with any associated features in the vicinity (Area D) and;
- to establish the potential for subsurface archaeological features in areas where surface artefacts have been collected during the site walkover survey (Areas D and E) or in areas adjacent to where archaeological features or concentrations of surface artefacts have been recorded by either previous geophysical survey or archaeological investigations (Area A).

Magnetometer survey

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 mapping is shown in Figure 1. Figures 2 shows the location of the survey areas along the proposed pipe corridor. Plots of the processed data from each area are shown together with the first edition mapping detail on Figures 3, 11, 16, 21 and 39. The data are presented in processed (greyscale) and 'raw' (unprocessed) X-Y trace plot formats with accompanying interpretation graphics in Figures 5 to 45 inclusive at a scale of 1:1000.

Further 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 site archive. Appendix 4 is a copy of the Section 42 Licence extending permission to undertake the survey across a scheduled ancient monument.

The survey methodology, report and any recommendations comply with the Brief (Cardwell 2010), with guidelines outlined by English Heritage (David *et al* 2008) and by the IfA (Gaffney, Gater and Ovenden 2002). 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

Area A (Figs 2 – 10 inclusive; Plate 1 and Plate 2)

Archaeological background

Two Bronze Age round barrows, both of which are Scheduled Ancient Monuments (No's 35346 and 35437) are situated immediately north of Area A. The closest monument is only 65m north of the corridor (see Fig. 3 and Fig. 4 - 35436) on the edge of a forestry plantation whilst the second, better preserved, feature is within the plantation itself approximately 150m north of the corridor. This latter burial mound survives as a well preserved earthwork 17m in diameter and 0.8m in height.

Prior to the establishment of the wellsite a preliminary geophysical and surface collection survey (LRC 2007) was undertaken. This was followed by trial trenching and finally by a full topsoil strip and excavation (LRC 2009) covering both the wellsite and a new access road. Although the geophysical survey identified numerous anomalies most proved on excavation to be due to natural features. The few archaeological features identified were severely truncated by modern ploughing. However, the surface collection recovered a large lithic assemblage that had increased in number by the end of the excavations to in excess of 2400 pieces.

Magnetometer survey

The data from this area has a very speckled appearance (Area B and part of Area C have a similar appearance – see below) which results from the highly variable background magnetic susceptibility (see Fig. 5). This is in stark contrast to the appearance of the data collected along the route of the access road in 2007, which is immediately south of, and parallel with, the current survey area, and across the wellsite (Lyall and Powlesland 2007). The magnetic background from this earlier survey is extremely homogenous (possibly partly a product of the data processing) with the data having a monotonal appearance and the identified anomalies being of relatively low magnitude. The difference in data between the two surveys is attributed to the presence of an organic mulch that had been spread on the arable fields at this northern end of the corridor. This mulch had been spread across the whole of Area A and Area B and up to the field boundary in Area C (see Plate 2). It is conjectured that fermentation processes in the organic matter may have caused an increase in magnetic susceptibility of the topsoil. Whatever the explanation for the variable background susceptibility the consequence is that it is impossible to identify any archaeological features that have a weak magnetic susceptibility against this strong magnetic background. This would include truncated and/or shallow features and discrete features such as pits. Larger linear features or features with a very strong susceptibility enhancement would probably be identified (see Area B below). No archaeological anomalies have been identified in Area A.

Area B (Figs 2 and 11 to 15 inclusive; Plate 3)

Archaeological background

Area B butts up against the southern edge of a section of Oxmoor Dike (see Figs 11 and 12), one of several linear boundary features in the immediate vicinity. These features are usually dated to the late Bronze Age or early Iron Age, later than the round barrows, such as those immediately north of Area A (see above). Oxmoor Dikes, together with Givendale Dike (see below), are protected as a scheduled ancient monument (SM35443) and comprise three ditches between four banks aligned north-east/south-west which together extend for 2.3km. In the best preserved sections the monument is 38m wide and the ditches up to 2m in depth, relative to the height of the banks. A possible bank (MNY5469) extending south from the dike has been recorded from air photographs but there are no visible remains. This possible feature is of unknown date but is postulated as a land division broadly contemporary with the main dike system. Interestingly the location and alignment of this feature correlates closely with a field boundary shown on the first edition Ordnance Survey mapping.

Magnetometer survey

The data from Area B has the same characteristic speckled appearance as that in Area A and the eastern part of Area C, presumably for the same reasons (see above). However, in this area two linear anomalies can be quite clearly discerned. Towards the eastern side of the survey area a strong, discontinuous, linear anomaly (**A**), aligned north/south, is clearly visible extending from the northern edge of the survey area, adjacent to the dike, across the full width of the survey area. The location of this anomaly correlates with the plotted location of the cropmark feature but there is a discrepancy between the position of the anomaly and the field boundary as shown on the first edition mapping (see Fig. 12), this displacement being particularly pronounced at the southern end of the survey area. It is not clear whether the anomaly is caused by the remains of the bank or the associated infilled ditch but the anomaly is clearly of greater magnitude and extent than might be expected from an infilled, post-Enclosure Act, field boundary. Interestingly the 1854 mapping shows another north/south aligned field boundary approximately 275m to the east (see Fig. 11) crossing Area A. This former boundary does not manifest as a magnetic anomaly.

A second linear, dipolar anomaly (**B**), aligned north-north-west/south-south-east towards the western side of Area B is caused by a ferrous pipe.

Area C (Figs 2 and 16 to 20 inclusive; Plate 4 and Plate 5)

Archaeological background

Area C encompasses land adjacent to and west of Upper Givendale Dike and across and west of Lower Givendale Dike. Both features extend south from Oxmoor Dike but the relationship between the three features is far from clear, partly due to truncation by ploughing. Upper Givendale Dike is aligned broadly north/south with a central bank 8m wide and an overall depth of 1.2m – this area was not covered by the survey. It has been suggested that this feature may represent a later addition to, and strengthening of, Oxmoor Dikes whilst Lower Givendale Dike, located 150m to the west, may represent an earlier extension to Oxmoor Dikes. Lower Givendale Dike is badly truncated by ploughing.

Magnetometer survey

The data from Area C can be split into three distinct parts differentiated by the variability of the magnetic background which in turn has been affected by the current ground conditions and by current and past agricultural regimes.

The strip along the eastern edge of Area C, immediately to the west of Upper Givendale Dike, is separated from the rest of Area C by a barbed wire fence and here the field is under arable cultivation and had been dressed with organic mulch. Consequently the magnetic background is highly variable due to the presence of the mulch in the topsoil. Against this background only a single anomaly, **C**, at the northern edge of the strip has been identified. This anomaly is perpendicular to the Givendale Dike system and may be due to a former bank/ditch at, or close to, the intersection of Oxmoor Dike to the north and the Givendale Dikes to the south.

The remainder of Area C, was under permanent pasture (see Plate 4) and here the magnetic background was extremely homogenous as indicated by the uniform grey tone to the data, except at the western end to the west of a former field boundary. Against this low magnetic background several linear anomalies, many clearly not corresponding with the extant earthworks, and numerous discrete anomalies, have been identified. A broad, discontinuous anomaly, **D**, clearly does correlate with Lower Givendale Dike as currently shown on the Ordnance Survey mapping (see Fig. 20). Anomaly **E** is parallel and immediately east of the Lower Dike and is probably also part of the extant monument. Between the two dikes is a discontinuous linear, ditch type, anomaly, **F**, and perpendicular to it, and possibly linking it with Lower Givendale Dike is Anomaly **G**. Other weaker ephemeral linear anomalies, **H** and **I**, suggest the area between the two dikes may have been partitioned by ditches into small enclosures. Numerous discrete anomalies are identified in this inter-dike zone, many of which may have an archaeological origin, although a geological cause cannot be discounted.

Sixty metres west of Lower Givendale Dike and parallel with it is another ditch type anomaly, **J**, which is at, or very close to, the base of the valley; the areas of magnetic enhancement to the immediate east of **J** may be due to the accumulation of soil at or near the base of the slope.

Sixty metres west again is the strong linear anomaly, **K**, which is thought to locate a former boundary shown on the first edition mapping. However, there is a reasonable displacement (approximately 15m) between the anomaly and the mapped boundary which could suggest that the mapped feature and the anomaly are two separate features; a length of former boundary is visible as a break of slope at this location which appears to accord with the historic mapping. A cluster of discrete anomalies to the east of this former boundary have been identified. It is not clear whether these anomalies are archaeological or perhaps geological in origin.

To the west of the former boundary, **K**, the magnetic background is more perturbed. It is speculated that the field to the west of the boundary may have been in arable cultivation more recently and/or for longer than the field to the east possibly accounting for the observed difference in magnetic background. Certainly there are a greater number of 'iron spike' anomalies to the west of the former boundary than to the east. This could be purely co-incidental but ferrous debris in the topsoil is often introduced by manuring or during cultivation so a greater incidence of 'spikes' could indicate a longer period under cultivation.

Area D (Figs 2 and Figs 21 to 37 inclusive; Plates 6, 7 and 8)

Archaeological background

Area D, approximately 2km south-west of Area C, contains another linear boundary feature, Diggerfoot Dike (MN5464), which crosses the survey area aligned north-west/south-east (see Plate 8). There are no longer any upstanding remains of this feature within the survey area, although it is clearly shown on the first edition Ordnance Survey mapping, but it does survive as a single ditch between two banks in a plantation to the west of Givendale.

Magnetometer survey

The line of Diggerfoot Dike clearly manifests as a linear, ditch type, anomaly, (Fig. 28 – **L**) crossing the survey area aligned north-west/south-east. Interestingly the survey has identified two other anomalies north-east and south-west of the dike. Closer examination of the data suggests that, rather than being single continuous linear anomalies indicative of flanking ditches, the anomalies are separate and discrete indicative of two parallel pit alignments, (see Fig. 28 - **M** and **N)**, either side of the dike.

Parallel trends in the data aligned north-west/south-east can be discerned, particularly at the northern end of Area D. It is considered likely that these slightly curvilinear anomalies are caused by ridge and furrow ploughing. In some places very broad anomalies of a much greater magnitude, but on the same alignment as the ploughing trends, are identified. It is assumed that these anomalies are due to patches of soil with naturally elevated magnetic susceptibility having been moved in the direction of the ploughing. The ploughing anomalies terminate along an arcing line that would seem to broadly correspond with a trackway shown on the first edition mapping (see Fig. 22).

Three other linear anomalies (**O** and **P** - see Fig. 28, and **Q** – see Fig. 37) that are not obviously related to ploughing have also been identified. None manifests as a cropmark or corresponds with a mapped feature. All three have been ascribed a potential archaeological origin although these interpretations are tentative.

Area E (Figs 2 and 38 to 45 inclusive; Plate 9)

Archaeological background

There are no known archaeological remains in Area E although a possible earthwork was identified during the walkover survey on the northern edge of the survey corridor (see Plate 9). This feature has been tentatively interpreted as a round barrow although it may merely be due to natural topographic variation. A noticeable cluster of surface artefacts (flints) were also noted during the walkover in the vicinity of this possible feature.

Magnetometer survey

The geology in Area E is different from that in the other four survey areas with passage beds replacing the calcareous grits which prevail at the northern end of the corridor. This change in geology appears to be reflected in the data with numerous irregular, broadly linear, anomalies being identified. These anomalies generally trend east/west and are particularly prominent at the eastern end of Area E (see Fig. 45). At the western end of the area there are far fewer anomalies and the general trend of the anomalies is south-west/north-east. All these anomalies are interpreted as geological in origin with the exception of a single linear anomaly, **R**, which is more regular and less broad than the aforesaid geological anomalies. It is also parallel with a field boundary to the south (see Fig. 39) and so has been interpreted as a former field boundary.

There are no anomalies in the vicinity of the mound to suggest it is anything other than a natural feature.

5 Discussion and Conclusions

The data from the five survey areas has revealed that the land use and ground conditions have had a significant impact on the data quality and hence the ability of the magnetometer to identify potential archaeological features particularly where truncation by modern ploughing is also a factor. The effects of these variables are highlighted in Area C where the difference between data recorded on land under permanent pasture and on arable land which had been harrowed and fertilised (organic mulch) is clearly visible. Of greatest concern is the variability of the magnetic background in the areas where the organic mulch had been spread.

This mulch appeared to have affected the data over the whole of Area A and Area B and in the eastern strip of Area C. The effect of the mulch can be demonstrated by contrasting the current data with that collected during the preliminary geophysical survey along the route of the access road to the wellsite. It is considered likely that only the largest, best preserved, linear features could be identified against this variable magnetic background, such as the bank/ditch identified in Area B. Plough damaged or shallow and/or discrete features are unlikely to be identifiable against this background. Consequently it is considered highly likely that there may be archaeological features in Area A and B and, most particularly, in the eastern strip of Area C that remain undetected.

The contrast between the data from the eastern strip of Area C and that from the rest of the same area which is under grass could not be greater. On the permanent pasture the background is very homogenous enabling even the weakest anomalies to stand out. As a result several linear ditch type features between the two dikes have been identified. Although the anomalies are often discontinuous it is considered possible that they may have formed a series of small enclosures. Similarly numerous discrete anomalies have also been highlighted which might also be archaeological in nature. It is considered unlikely that any of these anomalies could have been identified had this part of the site been under arable cultivation and/or been top dressed with organic mulch; the number of discrete anomalies of archaeological potential identified in the zone between the two Givendale Dikes gives an idea of the number of discrete features which may be present in the areas to the east of the dikes that have been affected by the mulch.

In Area D the survey has been particularly successful identifying both the sub-surface, ploughed out, remains of Diggerfoot Dike and identifying two hitherto unknown parallel pit alignments either side of the dike. No other anomalies of archaeological potential have been identified.

No anomalies of archaeological potential have been identified in Area E. On the basis of the geophysical survey it is considered likely that the mound identified during the walkover survey is a natural feature.

Overall the specific objectives of the project have been for the most part achieved. The location of a cropmark feature in Area B adjacent to Oxmoor Dike has been confirmed and previously unknown features, presumably associated with Givendale Dike, have also been located in Area C. Two possible pit alignments have also been located to either side of Diggerfoot Dyke whose location and extent (within the pipe corridor and soil storage area) has also been confirmed despite all upstanding remains having been ploughed out over the last century. Even where significant plough damage has occurred it has still been possible to identify linear features. Consequently it is considered probable that all but the most truncated or ephemeral linear features are likely to have been detected by the magnetometer surveys. However, it is quite possible that there are other smaller, discrete, features that have not been identified.

The only problems were encountered in Area A and Area B where the variable background is such that the absence of any identifiable potential archaeological anomalies cannot be taken as a likely probability.

In conclusion the survey has confirmed and defined the extent of features previously identified as cropmarks or earthworks (some no longer extant) and in some instance identified previously unknown associated features. No anomalies have been located in apparently blank areas or where clusters of surface artefacts have previously been collected or noted.

The archaeological potential of selected zones within Area C and Area D is deemed to be high. In Area A and Area B the archaeological potential is considered to be moderate but this interpretation is based on the proximity of known features rather than by the results of the survey which have been partially compromised. The archaeological potential of Area E is considered to be low, other than the likely concentration of lithics in the topsoil.

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.

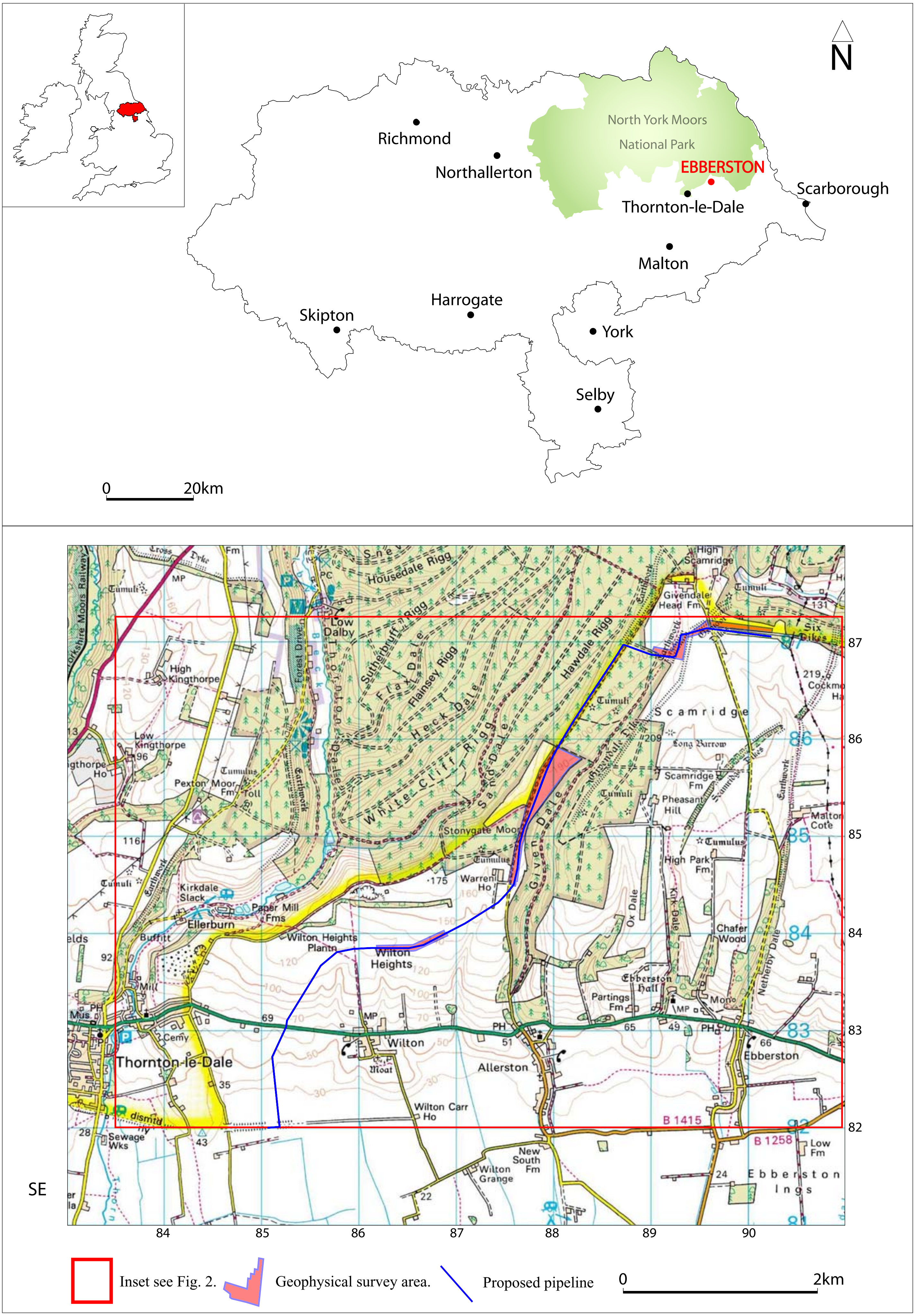


Fig. 1. Site location

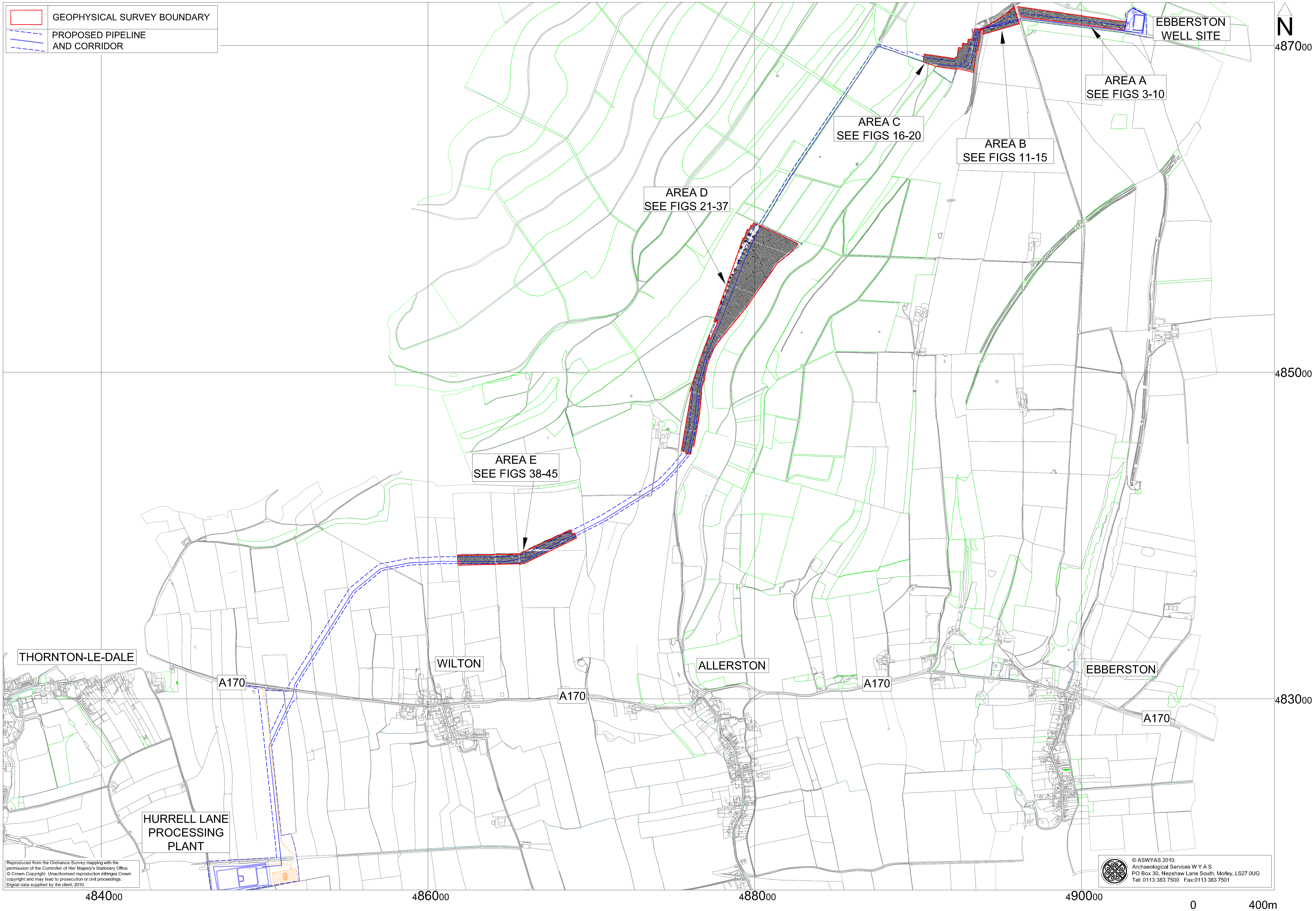


Fig. 2. Site location showing magnetometer data and proposed pipeline route (1:20000 @ A3)

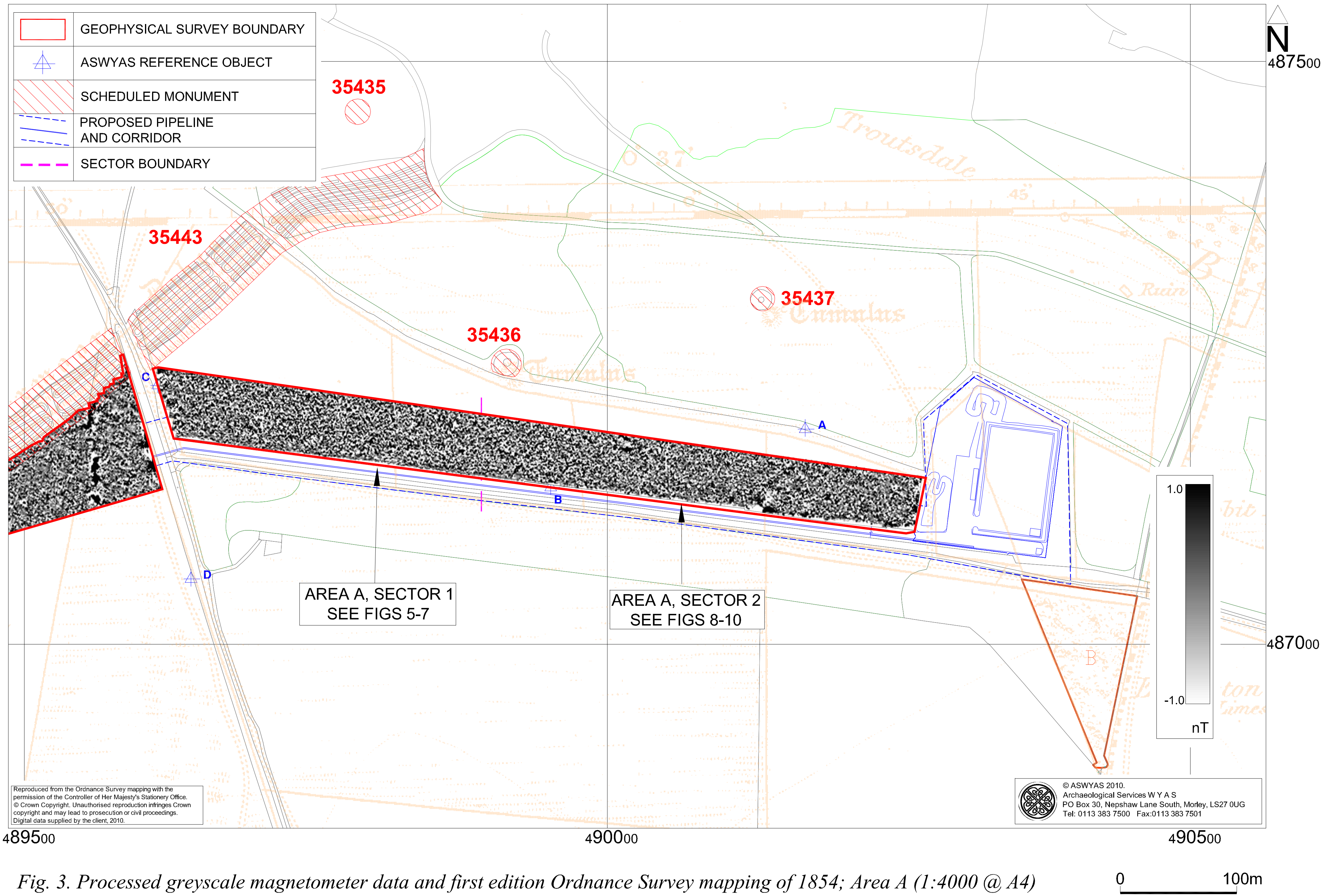


Fig. 3. Processed greyscale magnetometer data and first edition Ordnance Survey mapping of 1854; Area A (1:4000 @ A4)

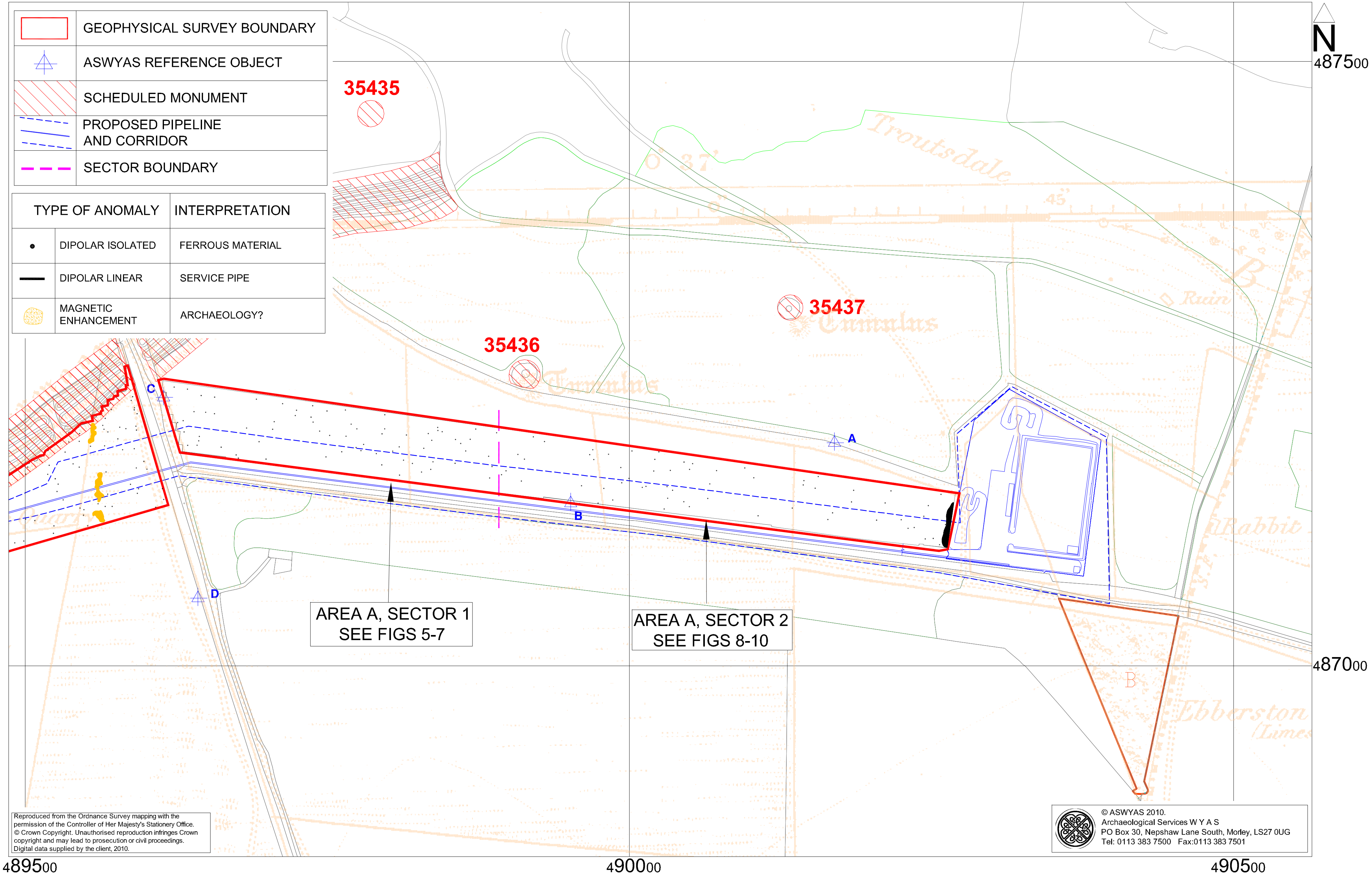


Fig. 4. Interpretation of magnetometer data and first edition Ordnance Survey mapping of 1854; Area A (1:4000 @ A4)

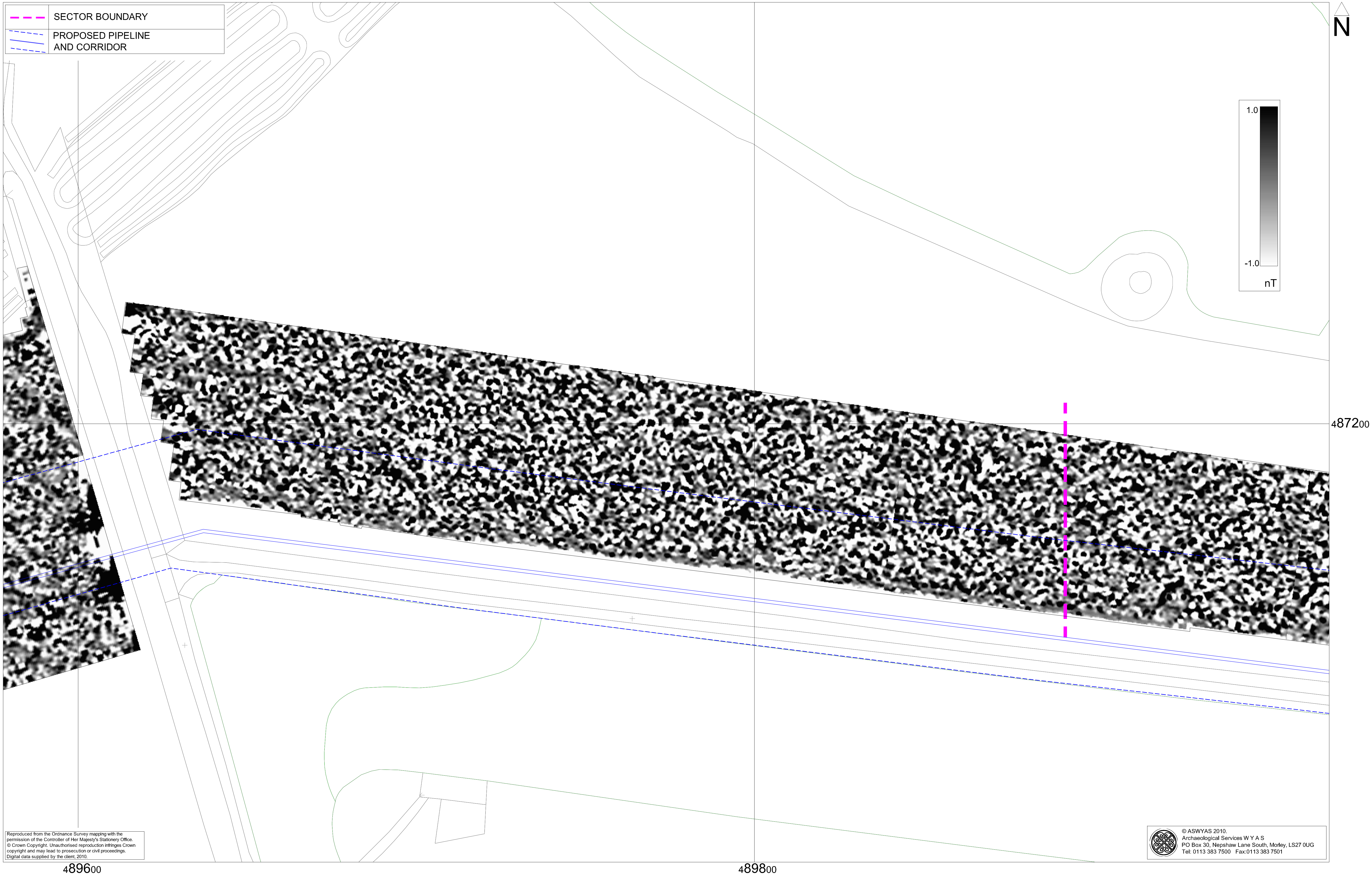


Fig. 5. Processed greyscale magnetometer data; Area A, Sector 1 (1:1000 @ A3)

0 20m

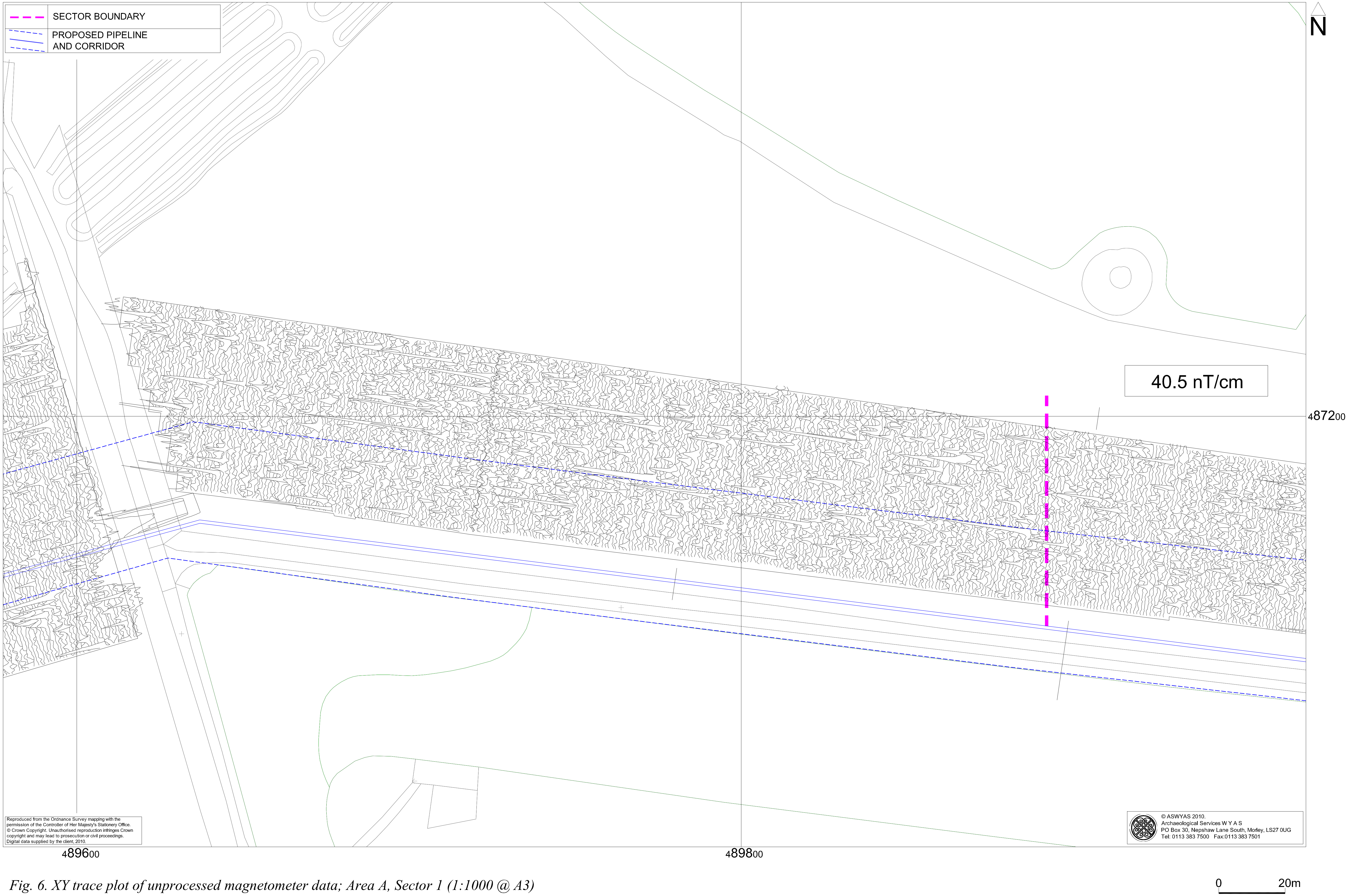


Fig. 6. XY trace plot of unprocessed magnetometer data; Area A, Sector 1 (1:1000 @ A3)

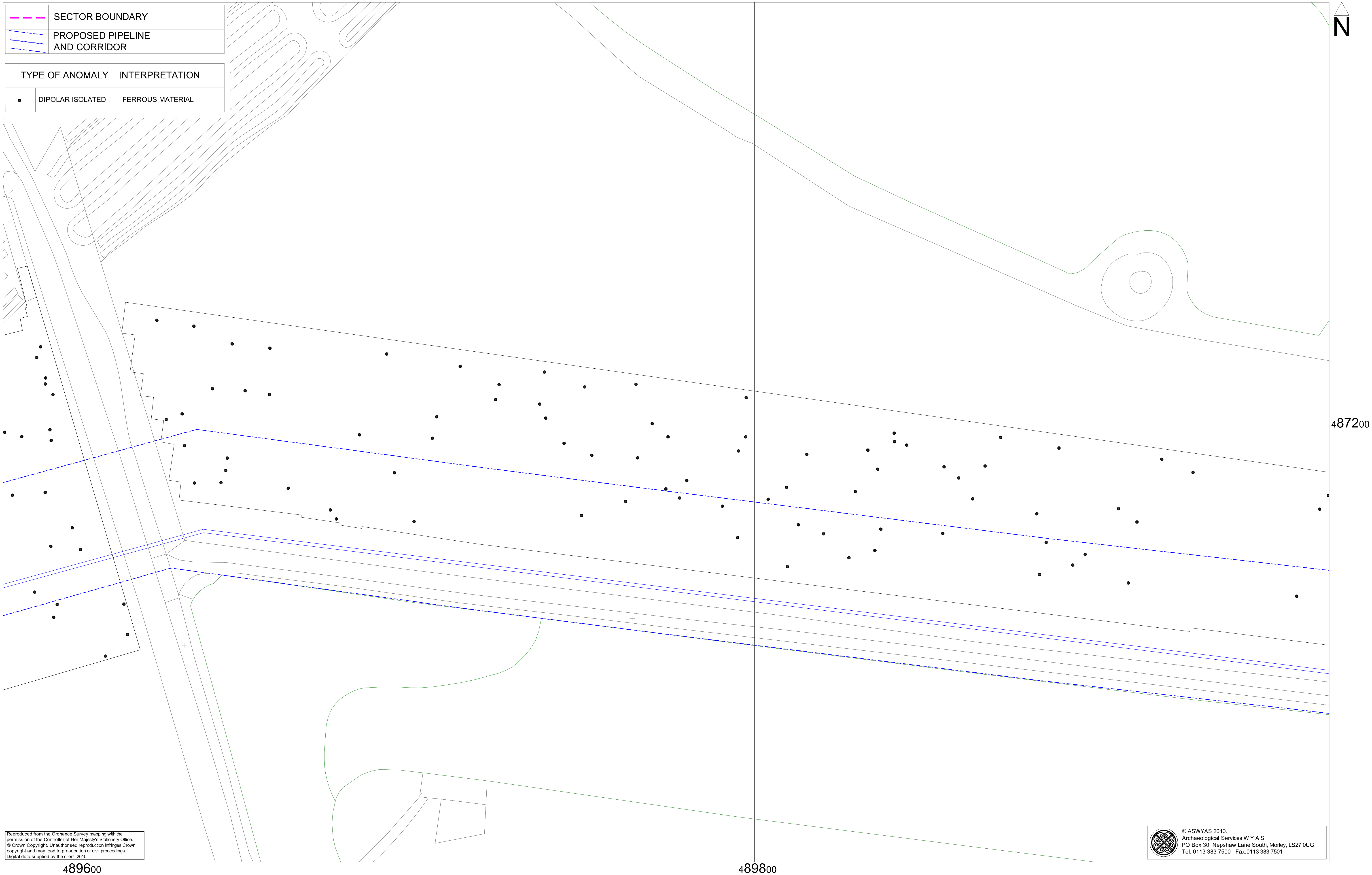


Fig. 7. Interpretation of magnetometer data; Area A, Sector 1 (1:1000 @ A3)

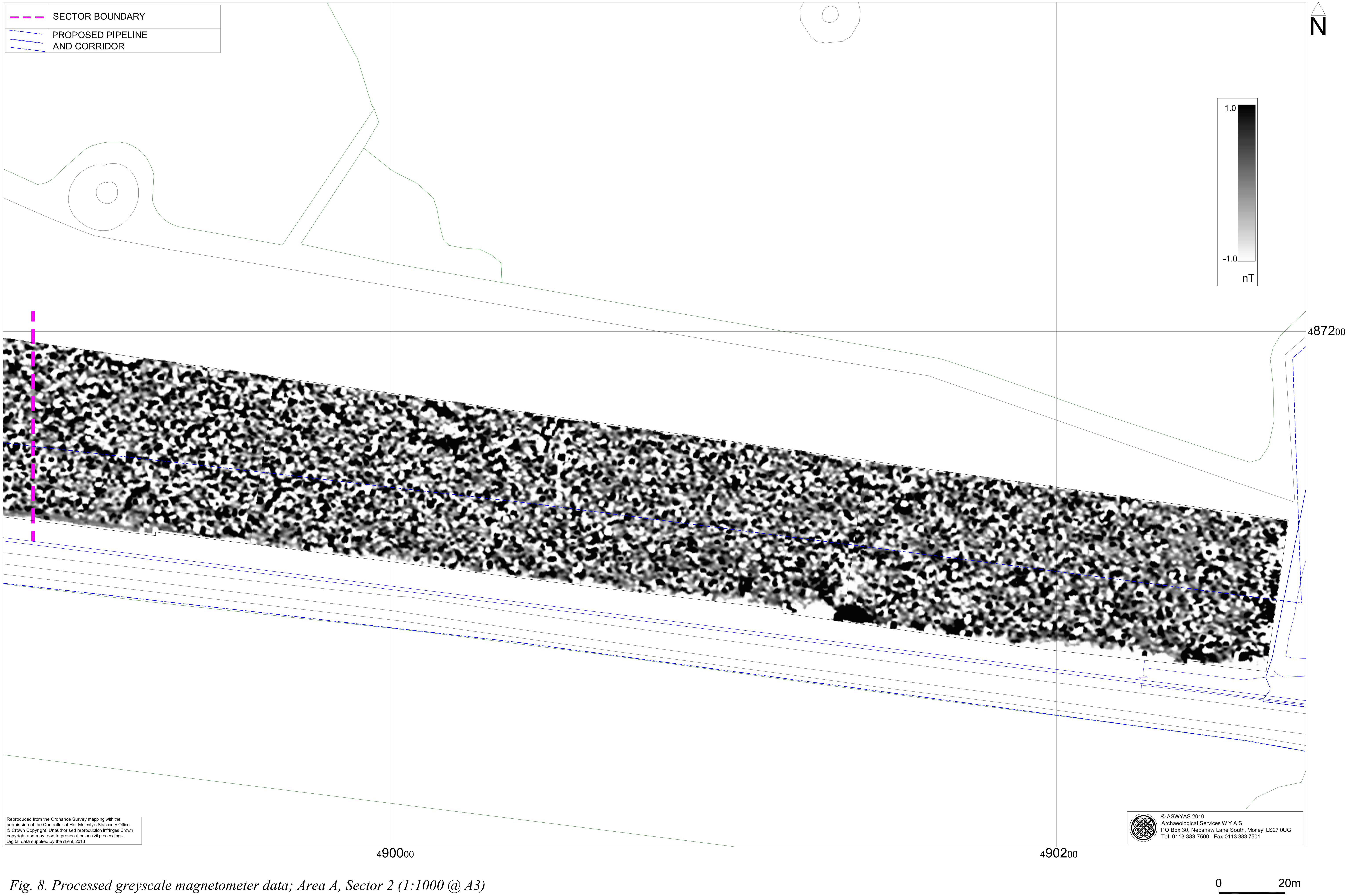


Fig. 8. Processed greyscale magnetometer data; Area A, Sector 2 (1:1000 @ A3)

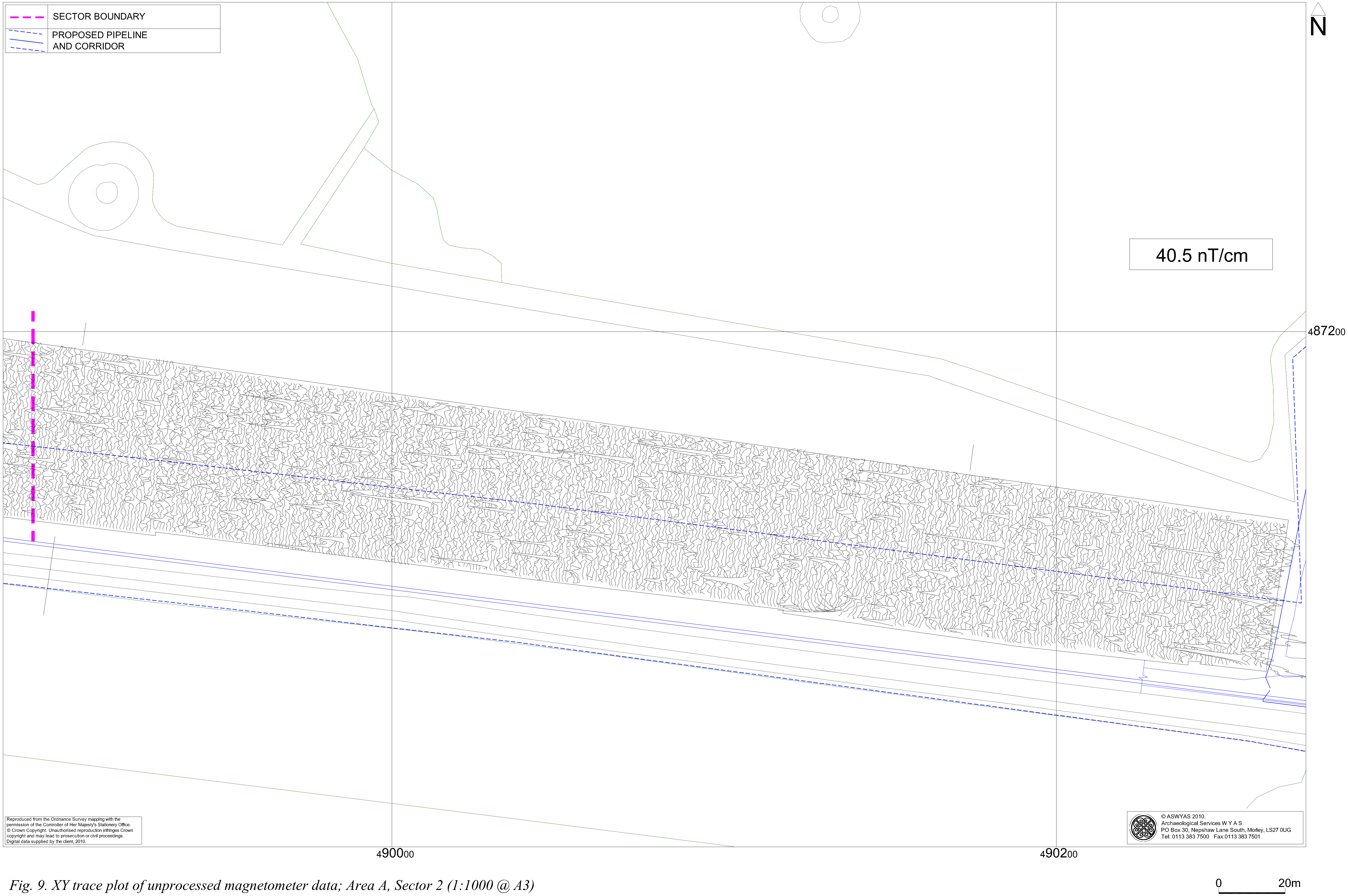


Fig. 9. XY trace plot of unprocessed magnetometer data; Area A, Sector 2 (1:1000 @ A3)

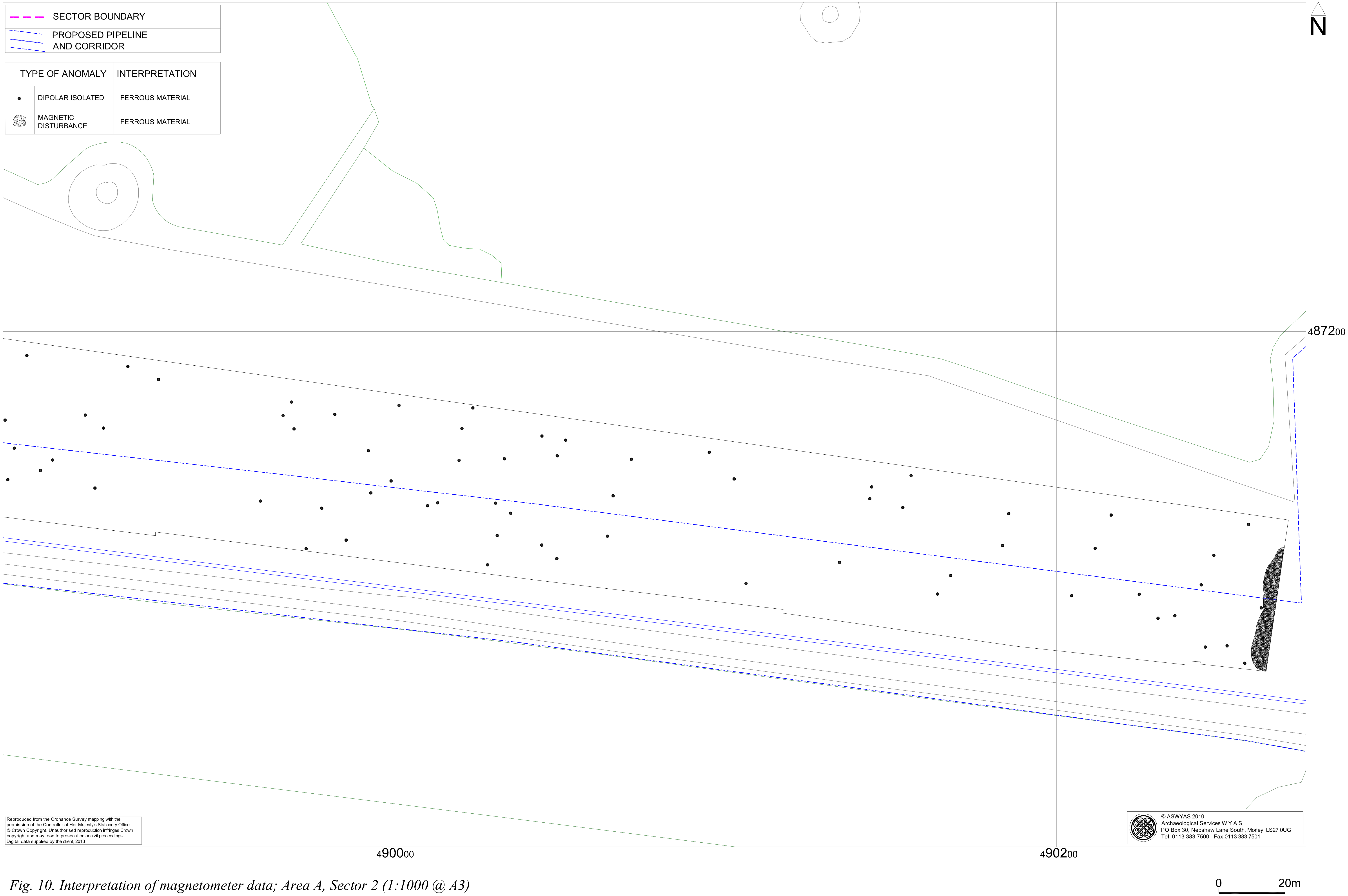


Fig. 10. Interpretation of magnetometer data; Area A, Sector 2 (1:1000 @ A3)

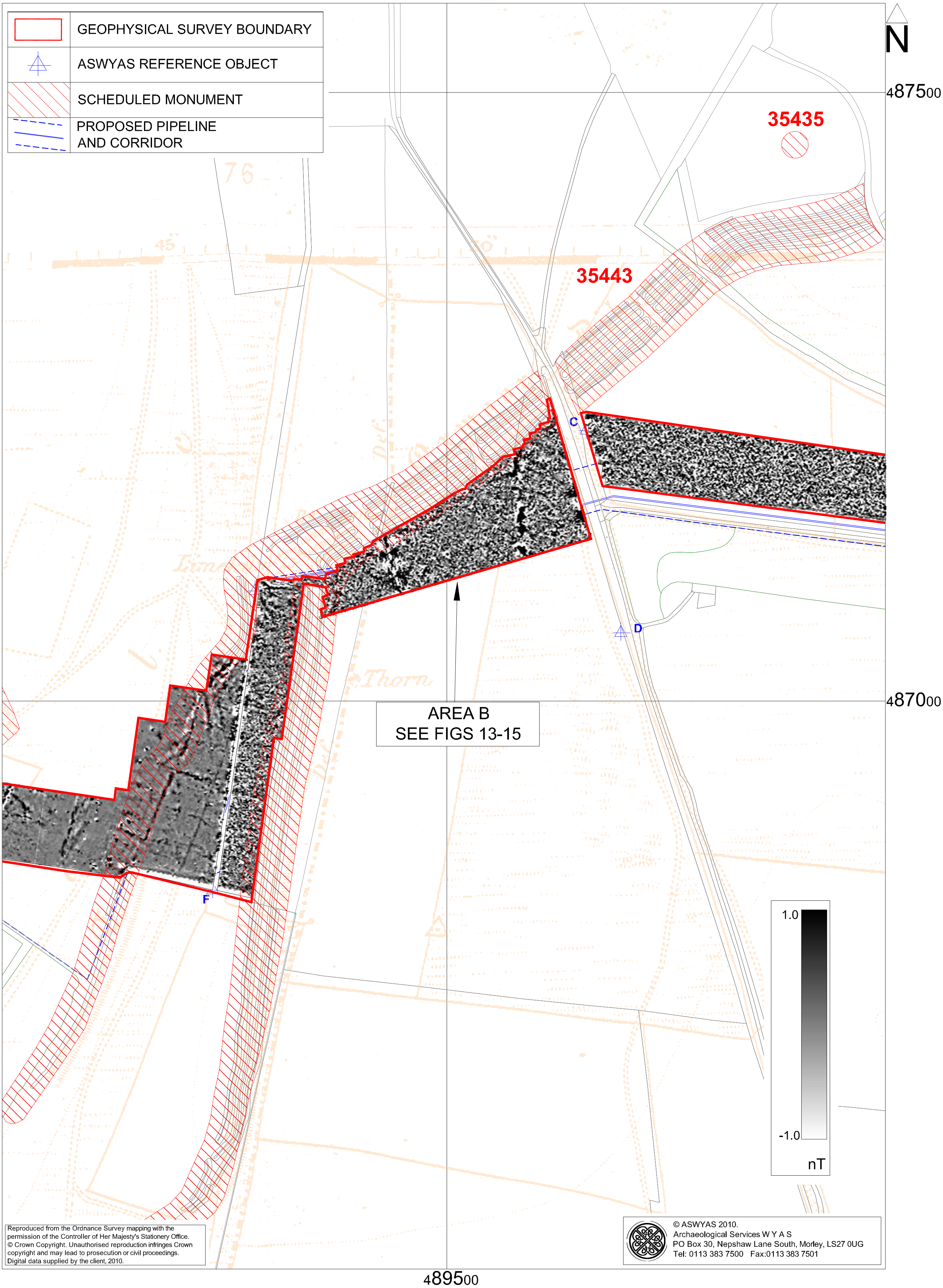


Fig. 11. Processed greyscale magnetometer data and first edition Ordnance Survey mapping of 1854; Area B (1:4000 @ A4)

0 100m

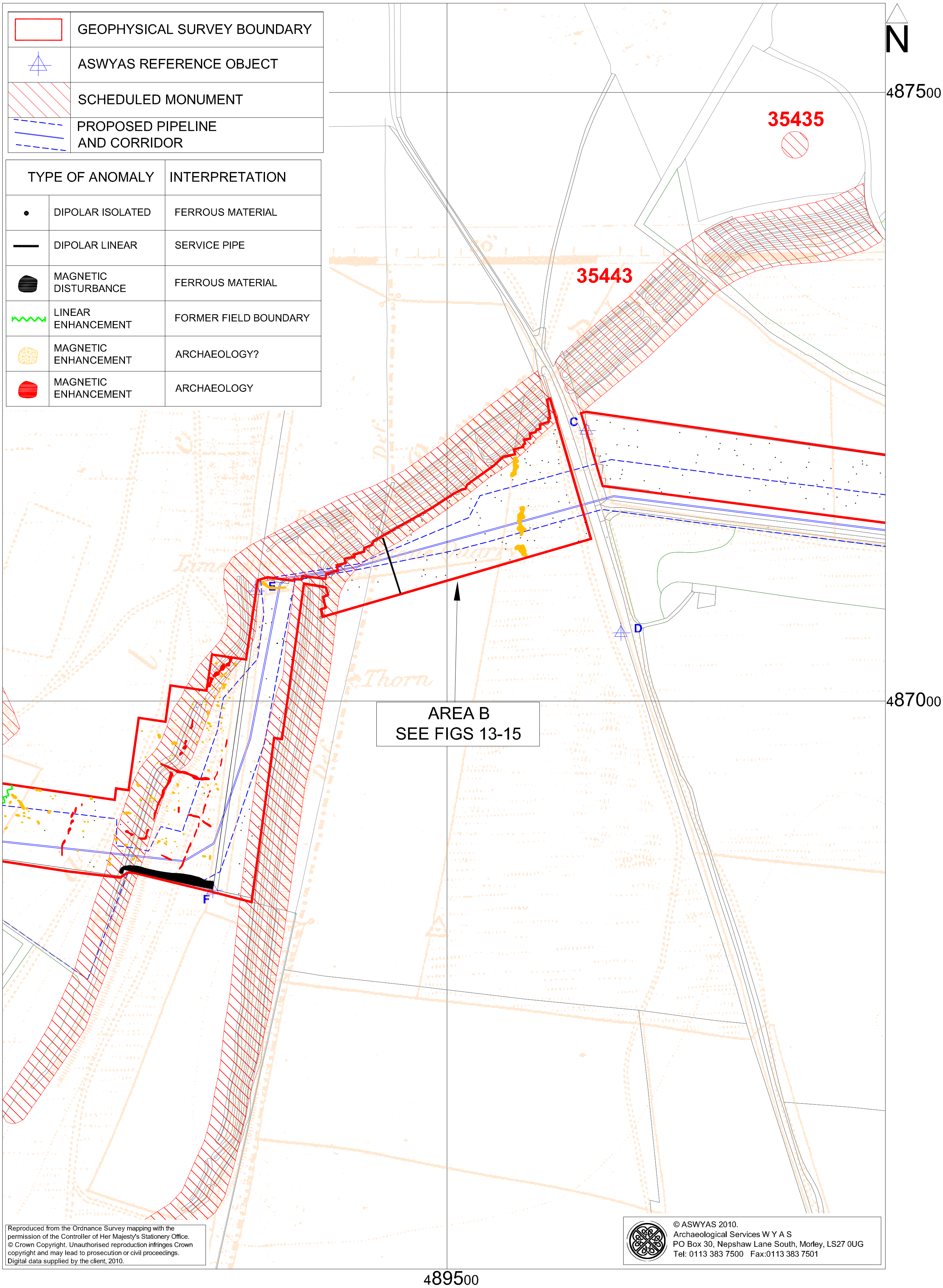


Fig. 12. Interpretation of magnetometer data and first edition Ordnance Survey mapping of 1854; Area B (1:4000 @ A4)

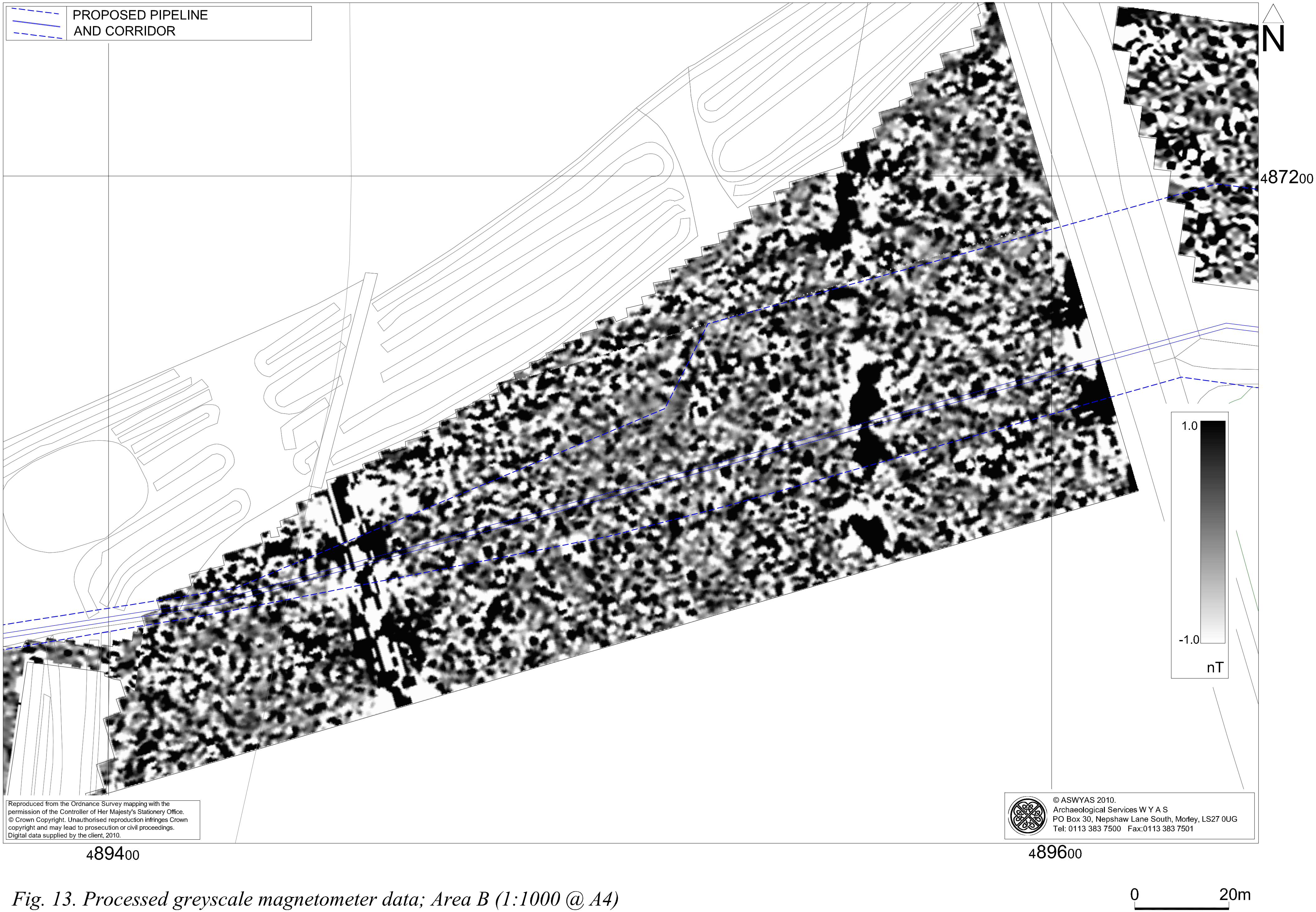


Fig. 13. Processed greyscale magnetometer data; Area B (1:1000 @ A4)

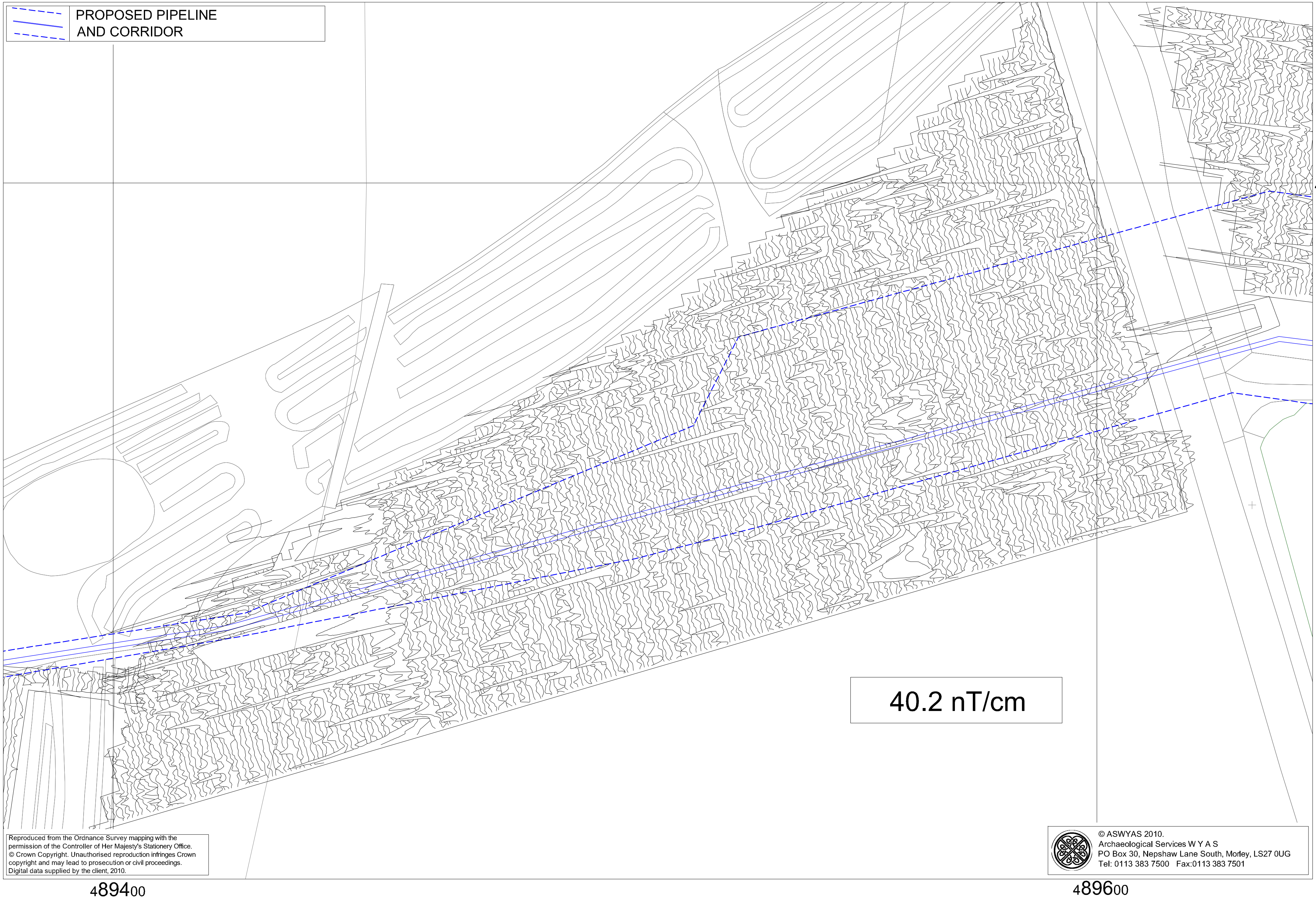


Fig. 14. XY trace plot of unprocessed magnetometer data; Area B (1:1000 @ A4)

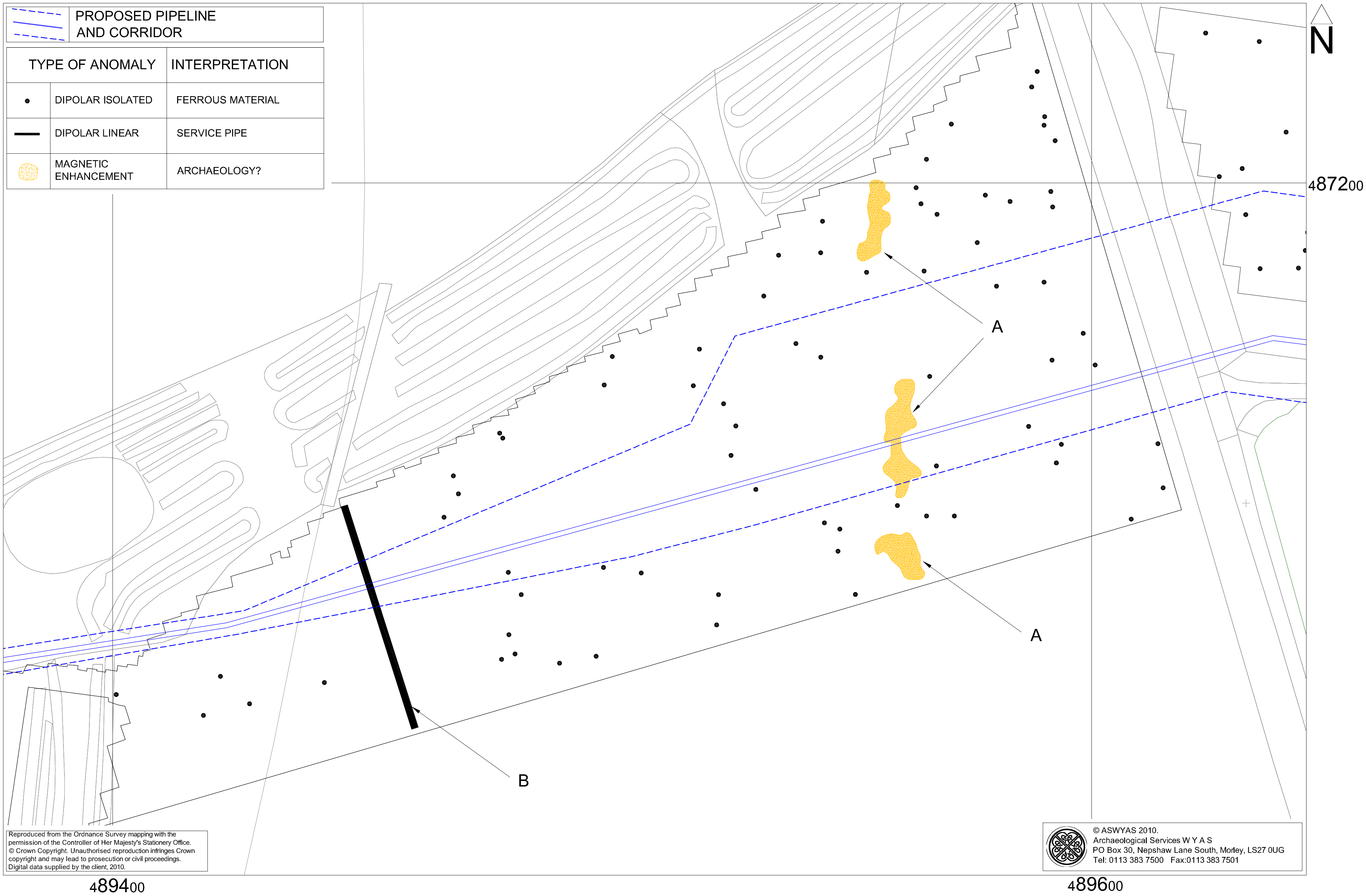


Fig. 15. Interpretation of magnetometer data; Area B (1:1000 @ A4)

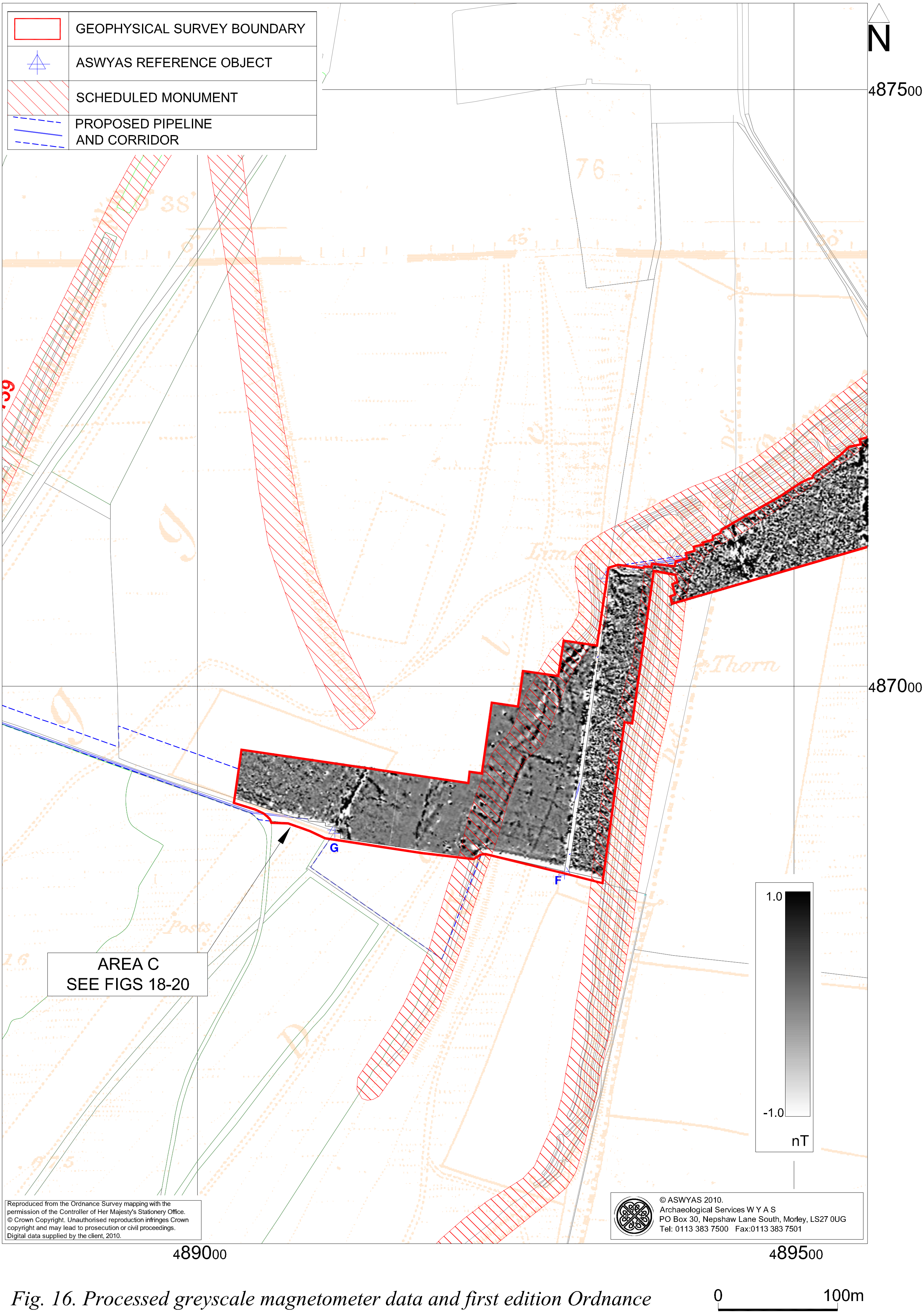


Fig. 16. Processed greyscale magnetometer data and first edition Ordnance Survey mapping of 1854; Area C (1:4000 @ A4)

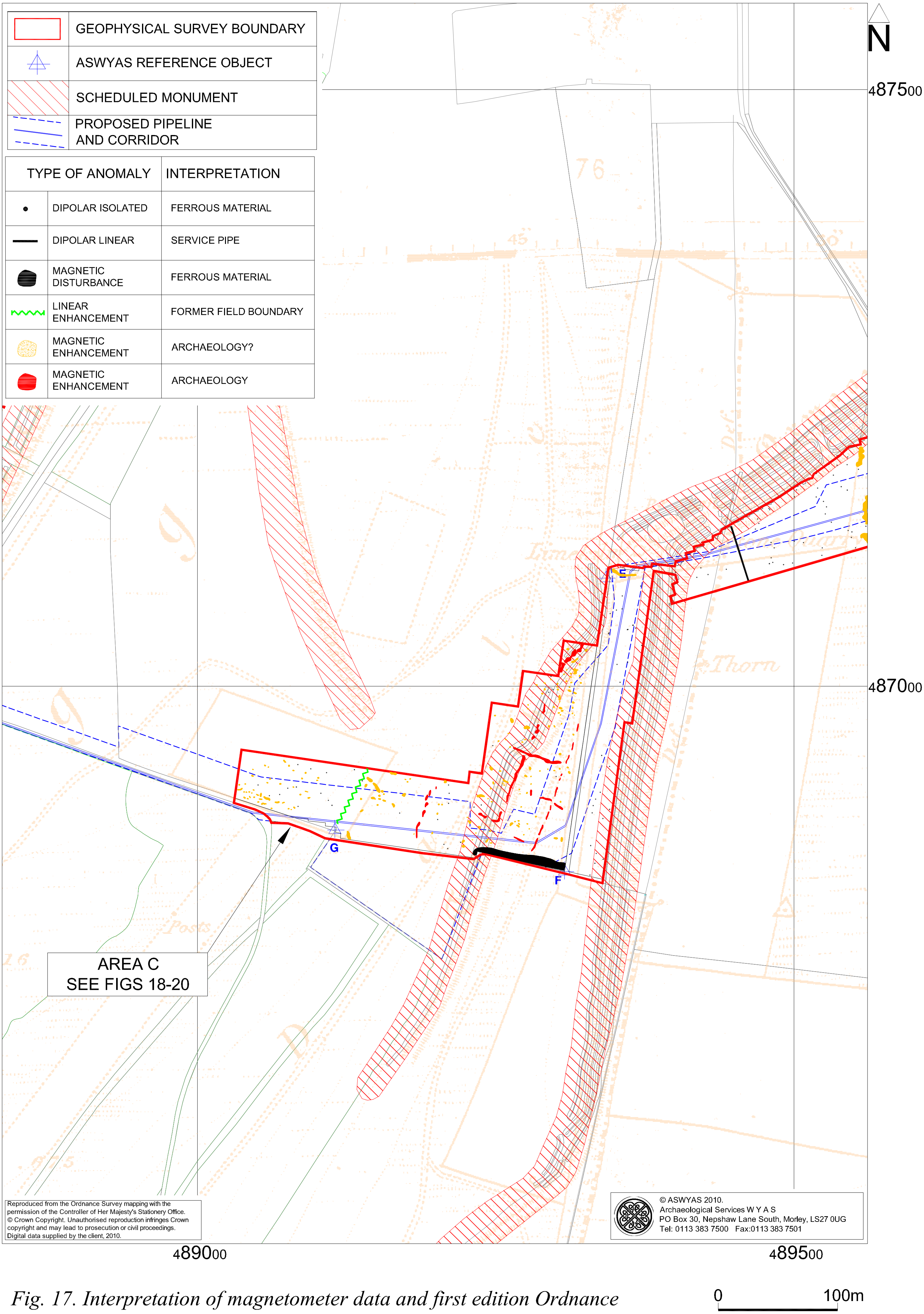


Fig. 17. Interpretation of magnetometer data and first edition Ordnance Survey mapping of 1854; Area C (1:4000 @ A4)

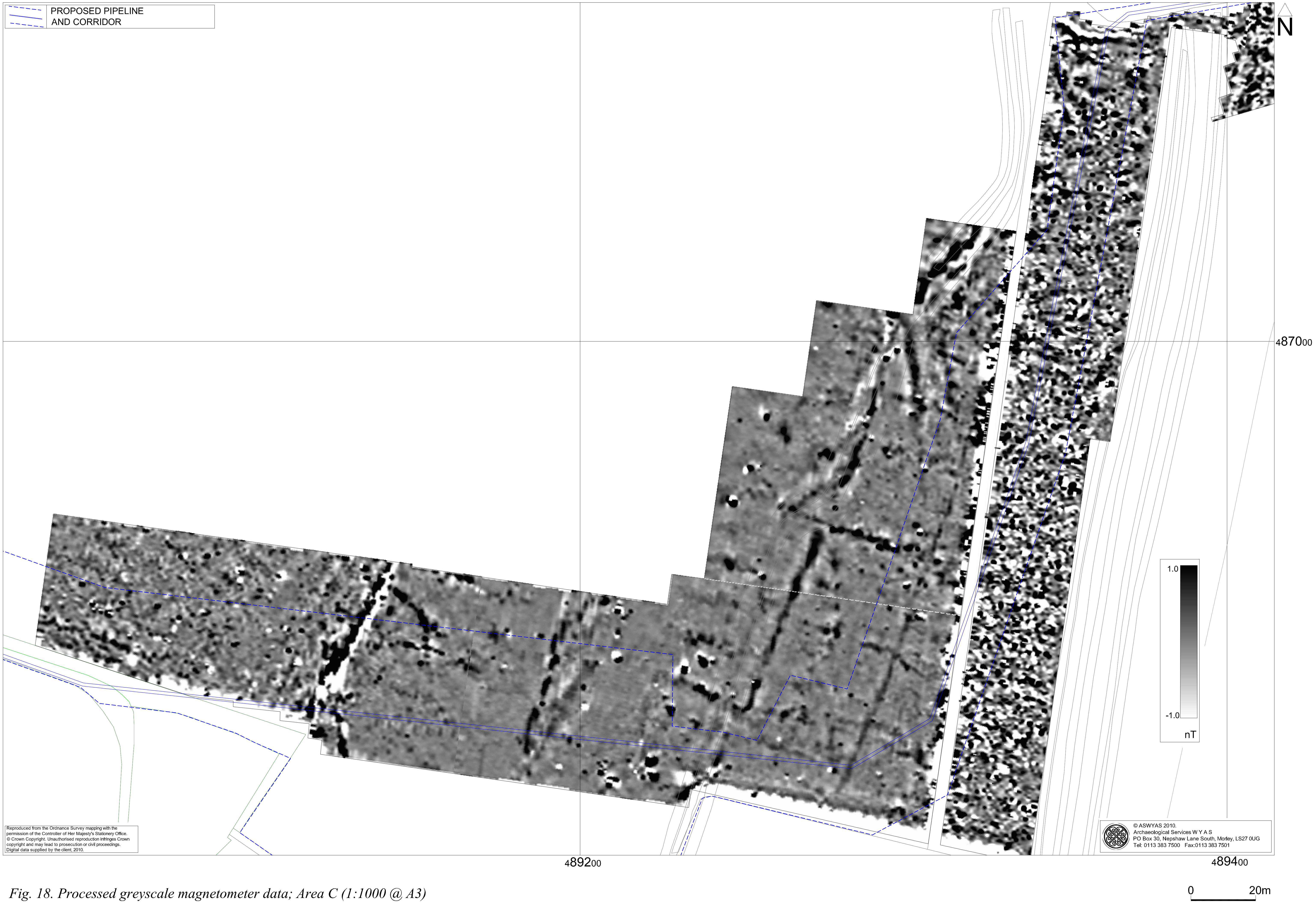


Fig. 18. Processed greyscale magnetometer data; Area C (1:1000 @ A3)

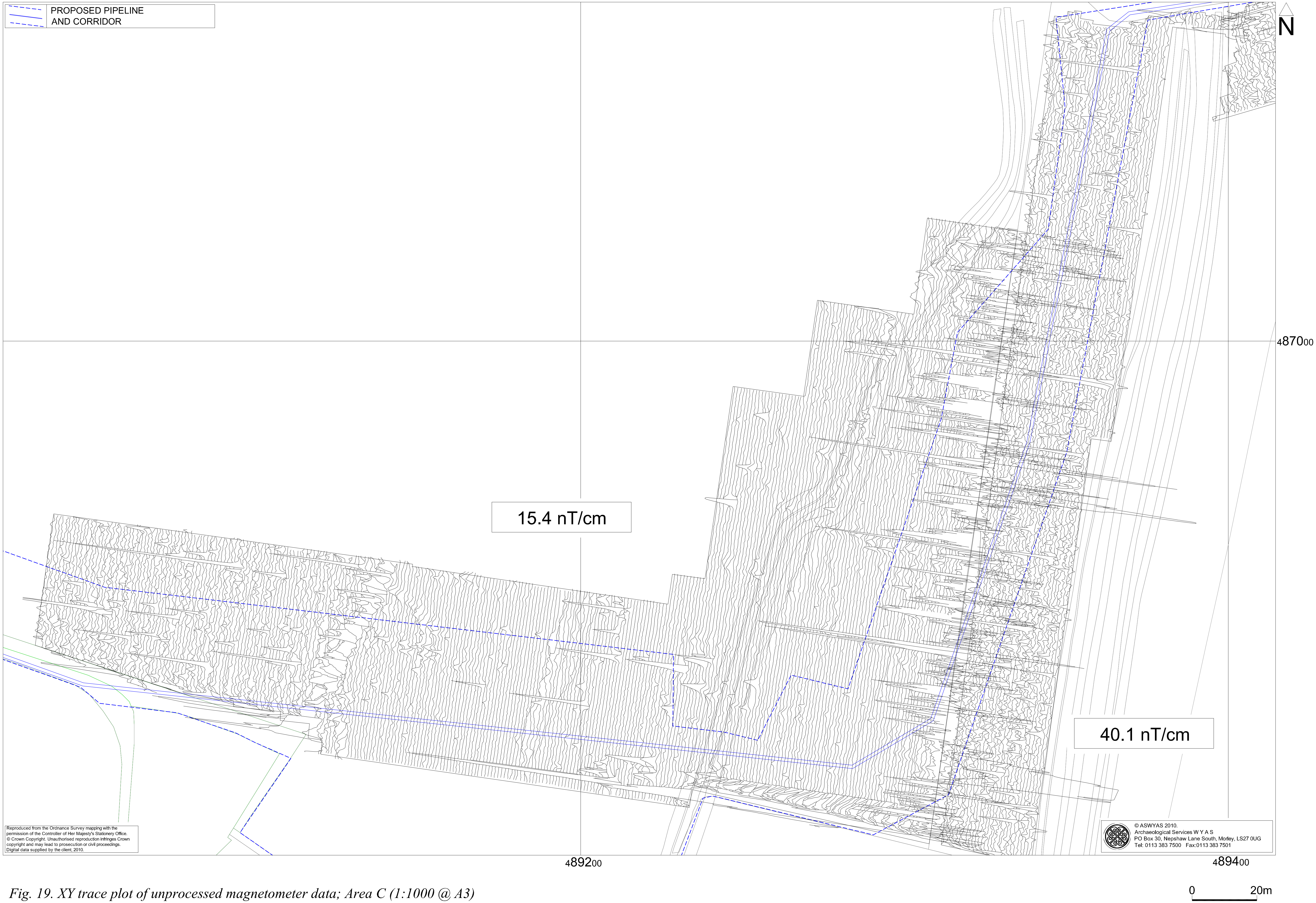


Fig. 19. XY trace plot of unprocessed magnetometer data; Area C (1:1000 @ A3)

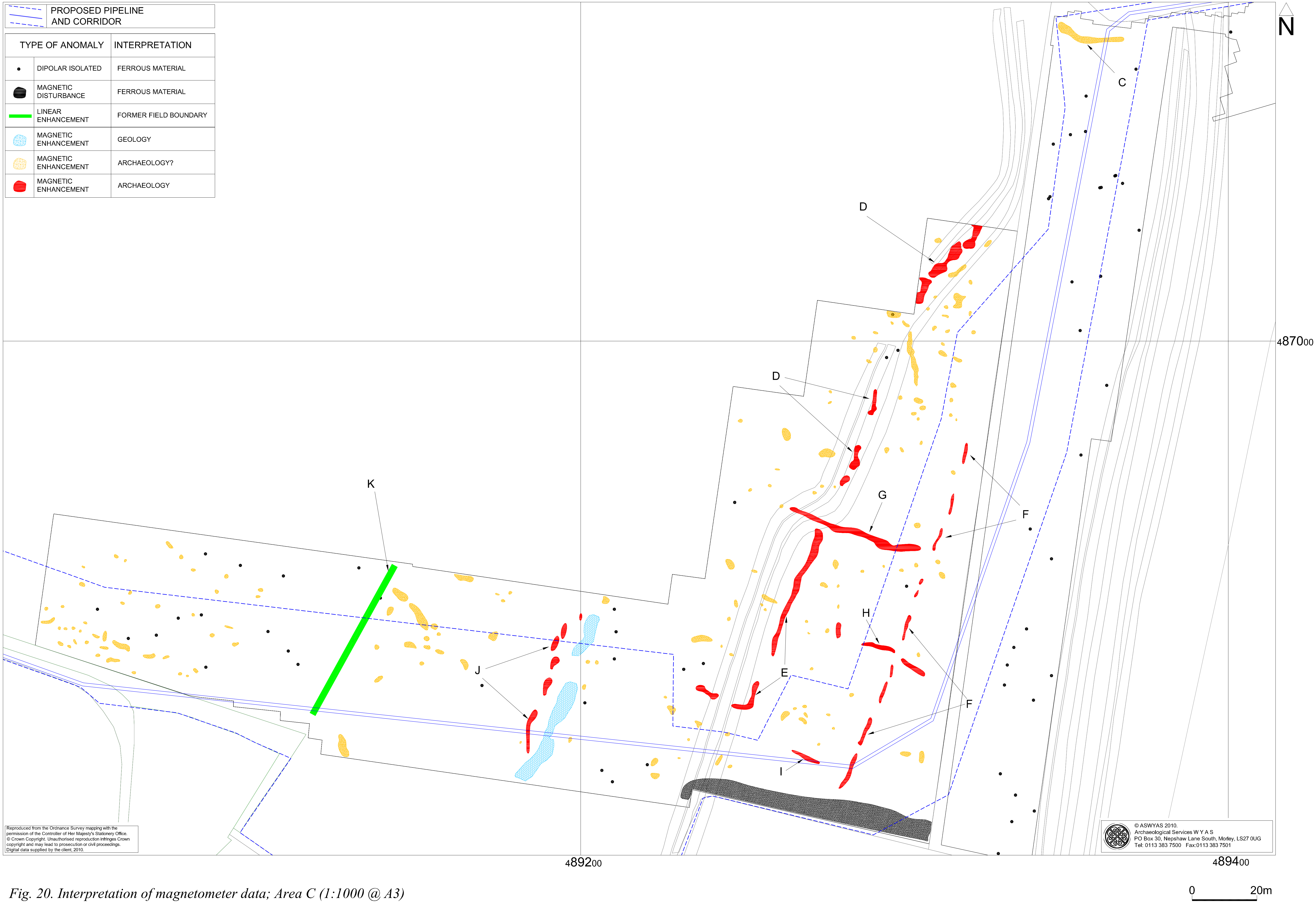


Fig. 20. Interpretation of magnetometer data; Area C (1:1000 @ A3)

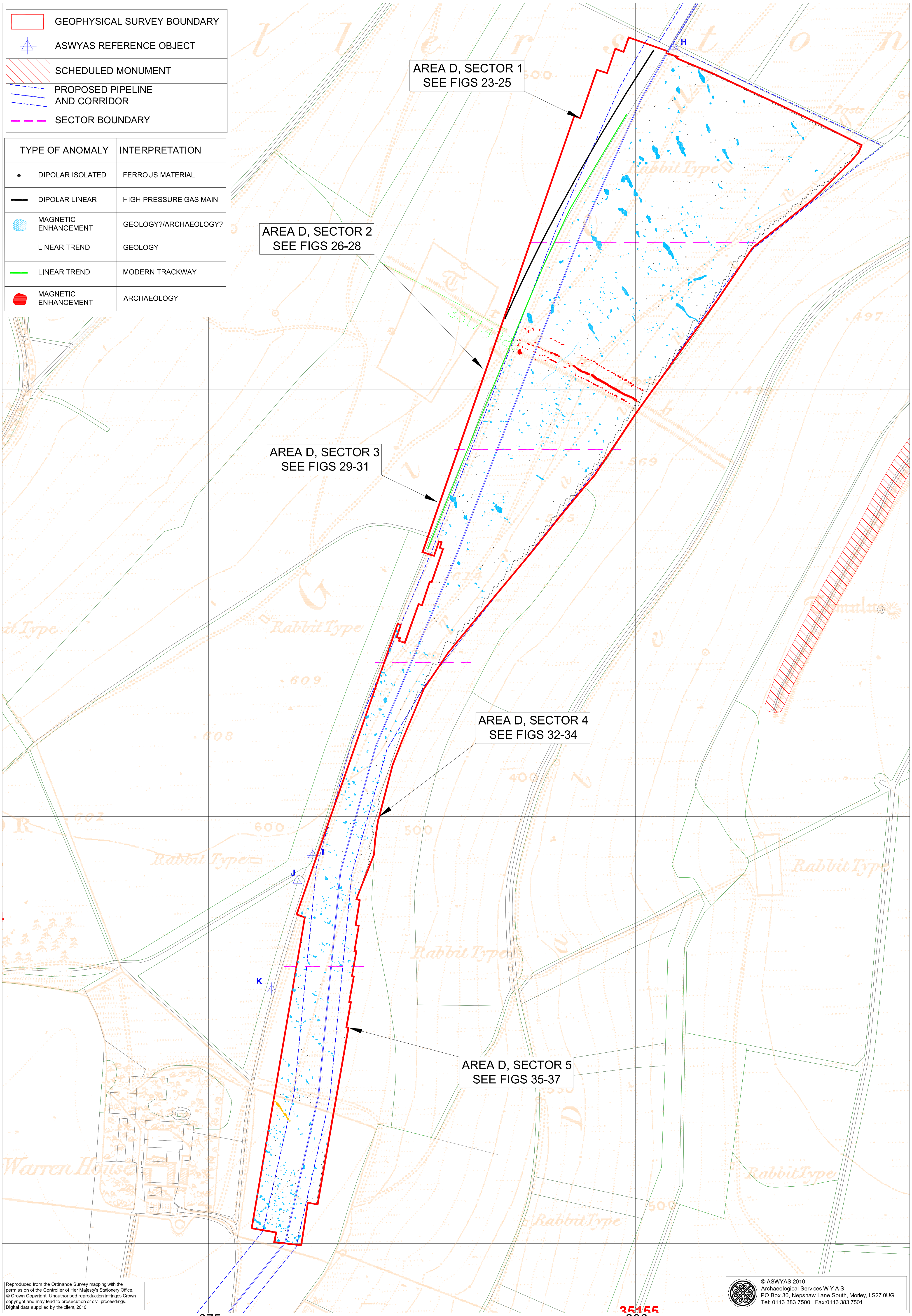


Fig. 22. Interpretation of magnetometer data and first edition Ordnance Survey mapping of 1854; Area D (1:4000 @ A3)

0 100m

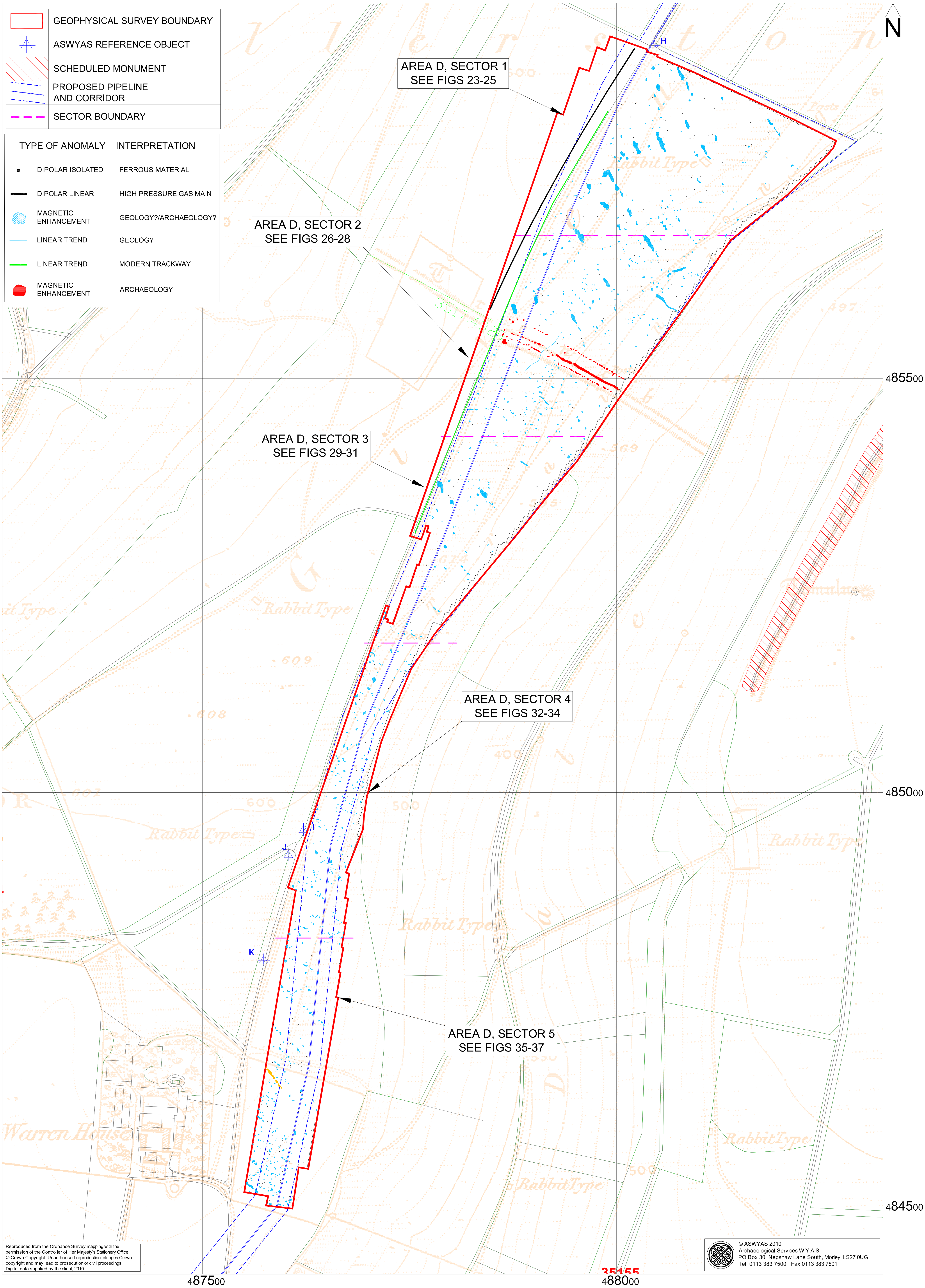


Fig. 22. Interpretation of magnetometer data and first edition Ordnance Survey mapping of 1854; Area D (1:4000 @ A3)

0 100m

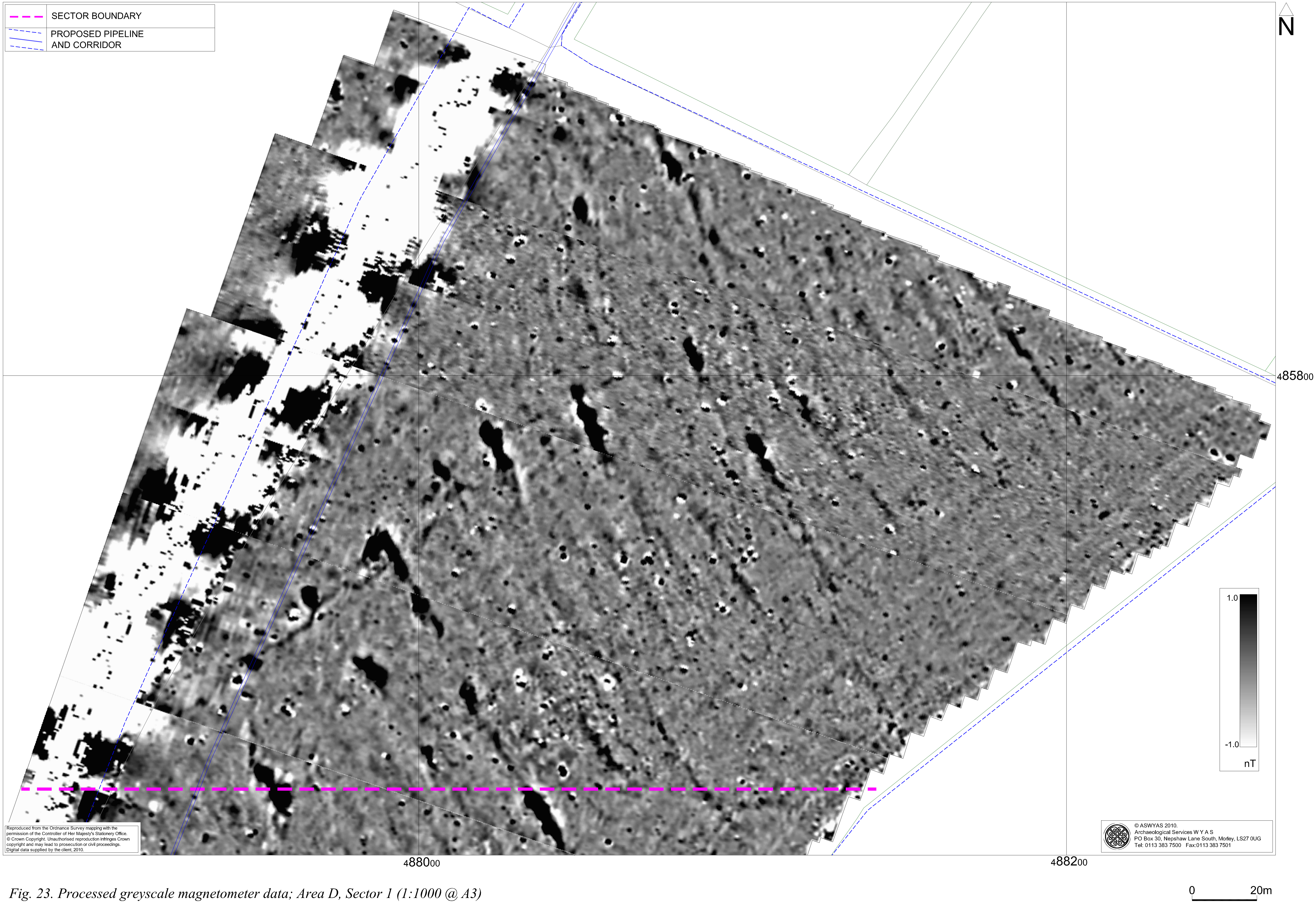
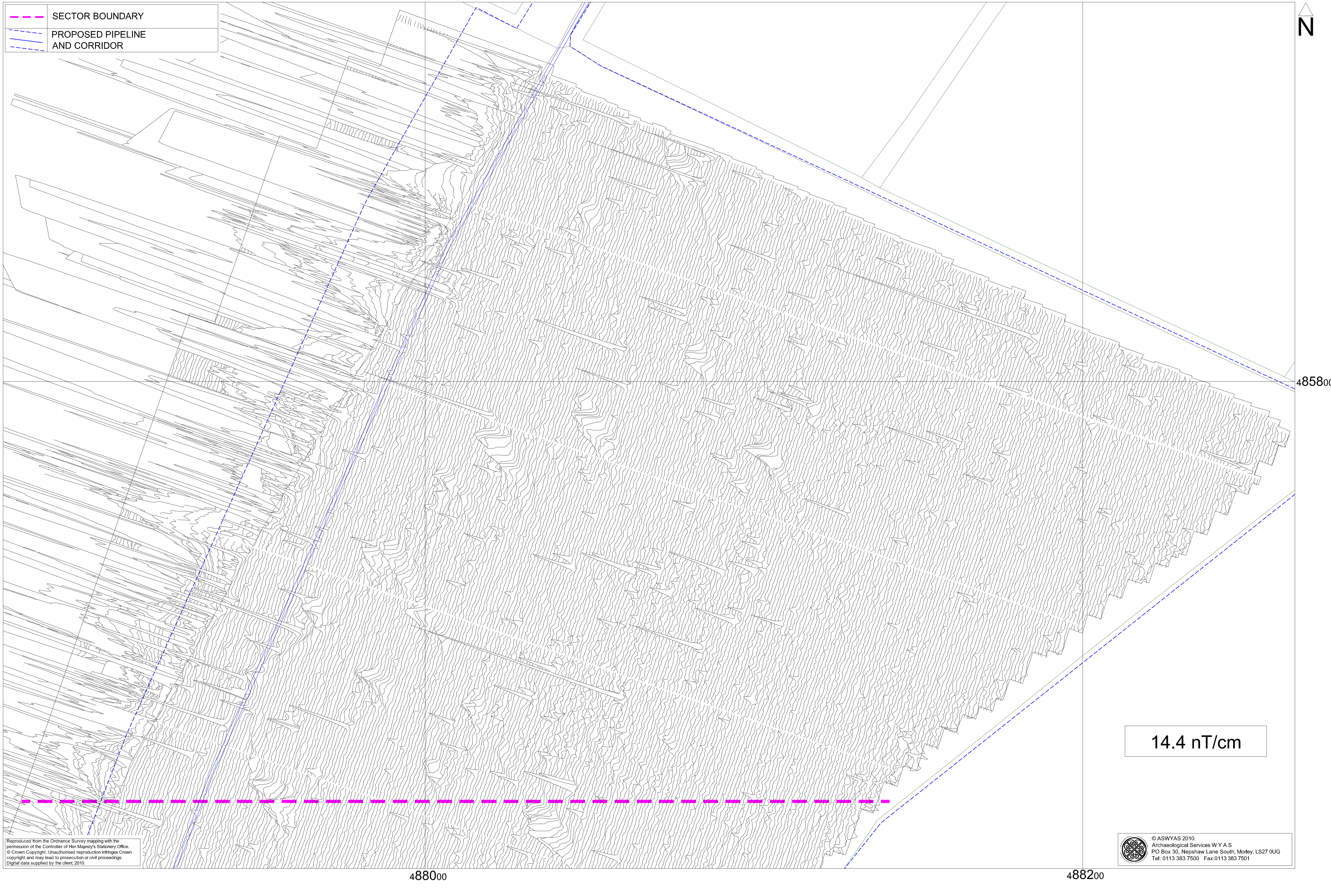


Fig. 23. Processed greyscale magnetometer data; Area D, Sector 1 (1:1000 @ A3)



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

Fig. 24. XY trace plot of unprocessed magnetometer data; Area D, Sector 1 (1:1000 @ A3)

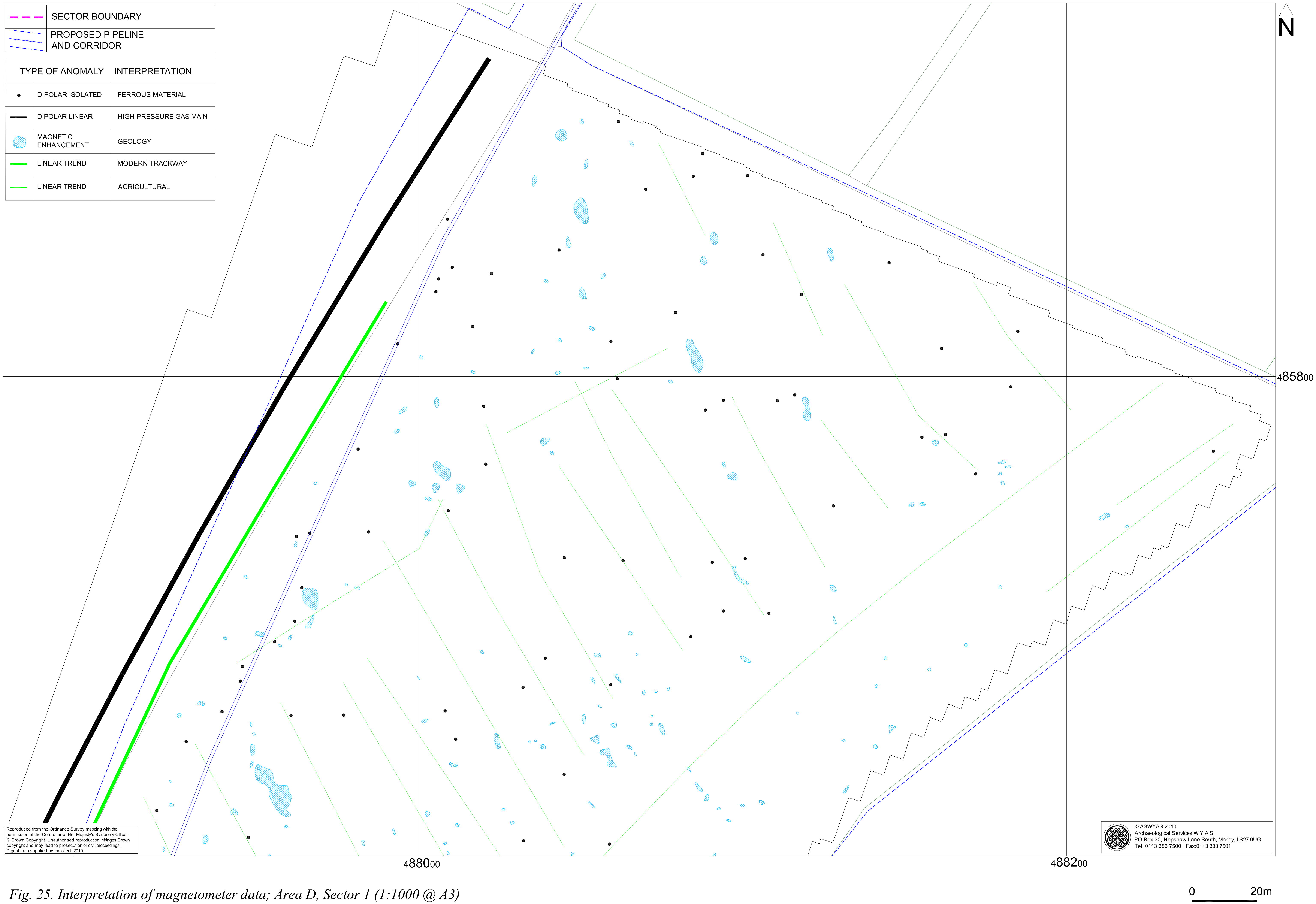


Fig. 25. Interpretation of magnetometer data; Area D, Sector 1 (1:1000 @ A3)

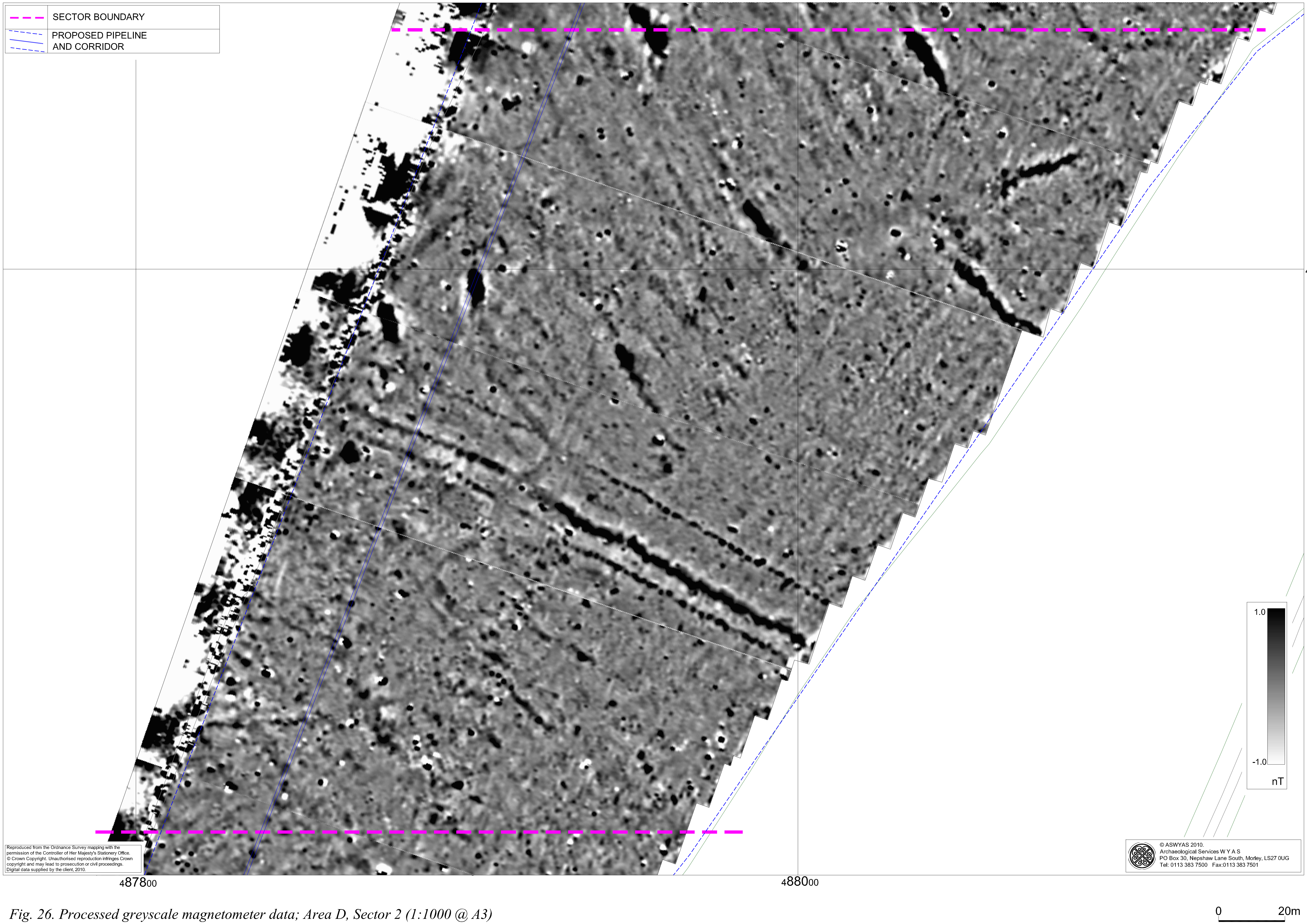


Fig. 26. Processed greyscale magnetometer data; Area D, Sector 2 (1:1000 @ A3)

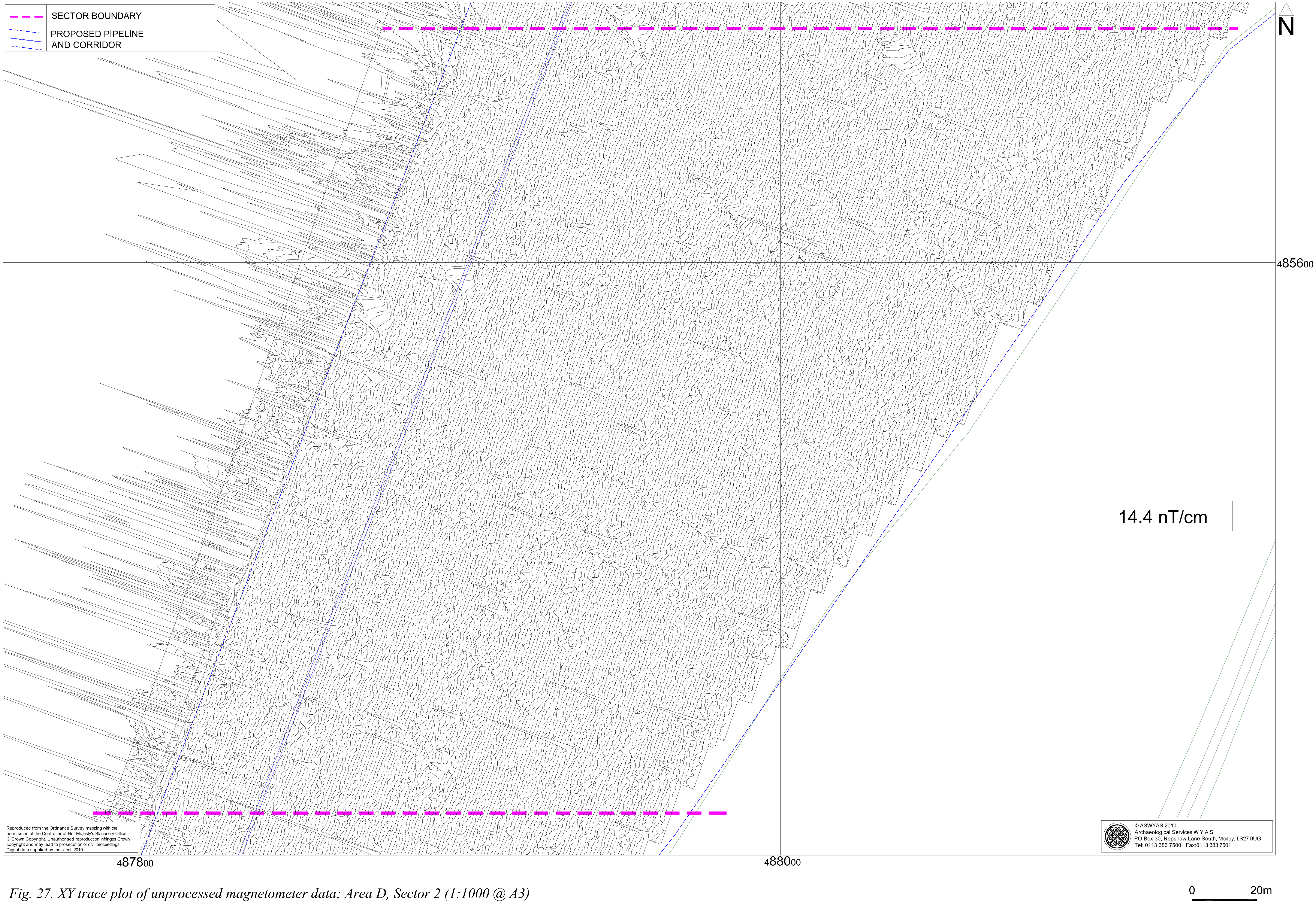


Fig. 27. XY trace plot of unprocessed magnetometer data; Area D, Sector 2 (1:1000 @ A3)

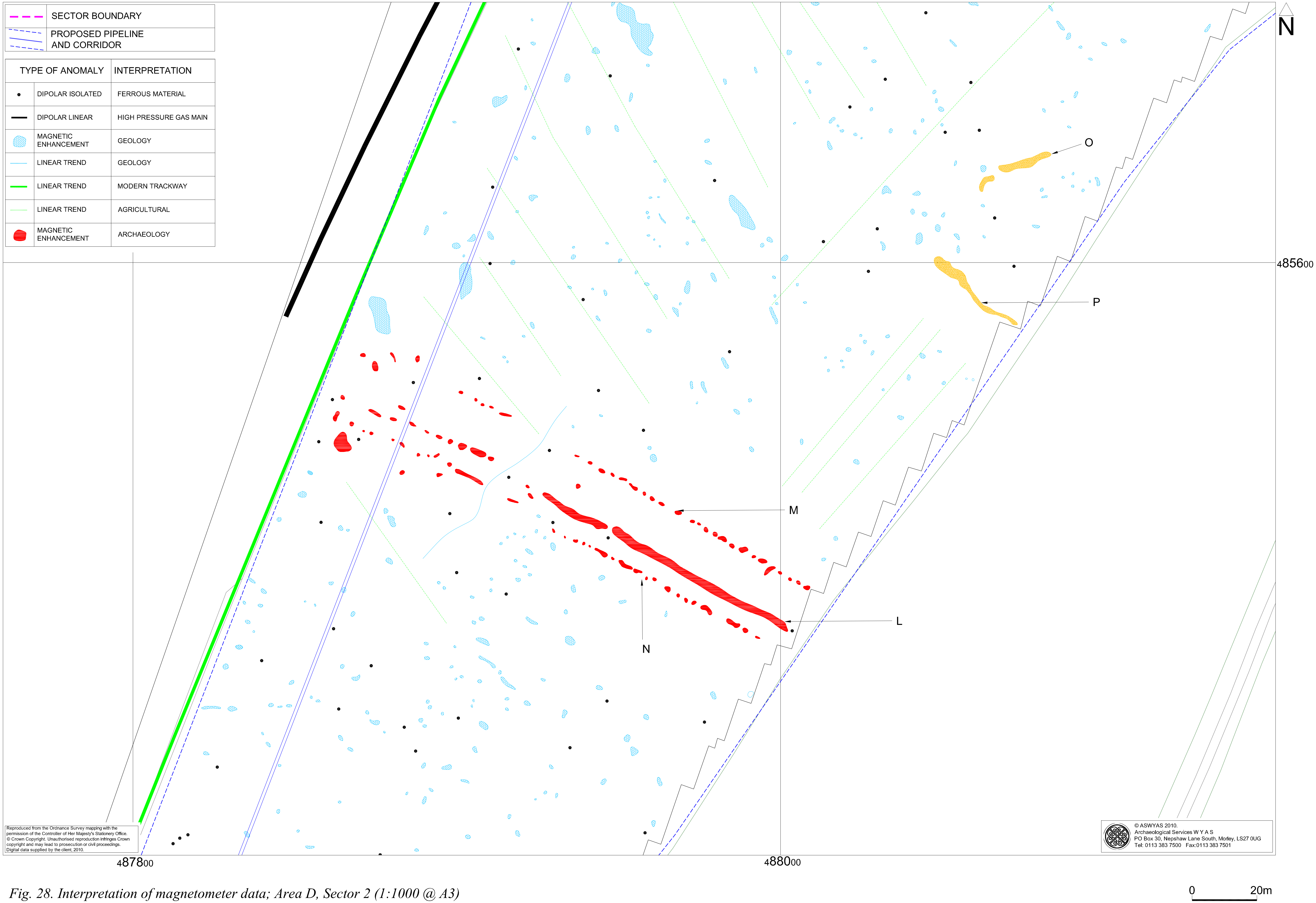


Fig. 28. Interpretation of magnetometer data; Area D, Sector 2 (1:1000 @ A3)

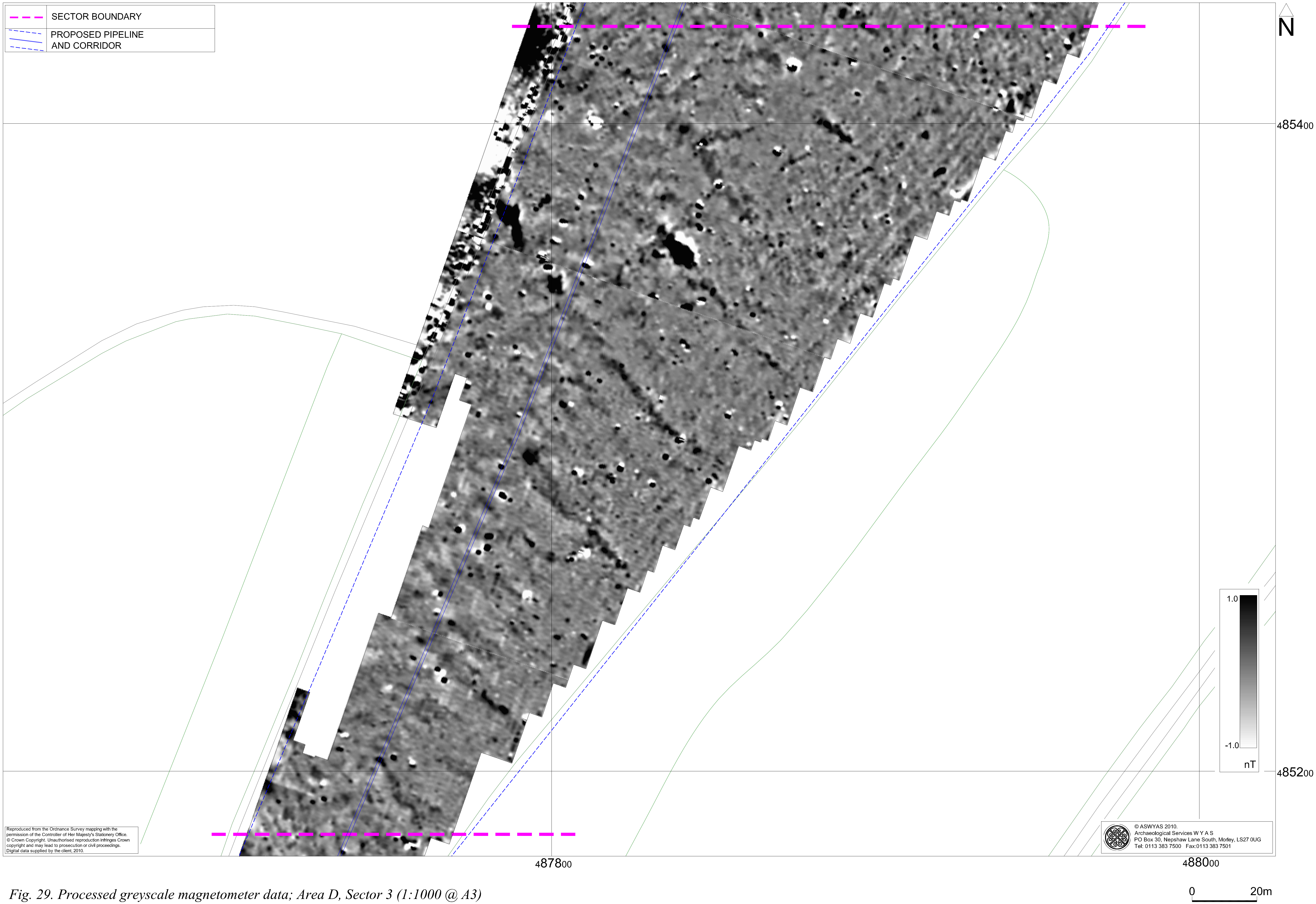


Fig. 29. Processed greyscale magnetometer data; Area D, Sector 3 (1:1000 @ A3)

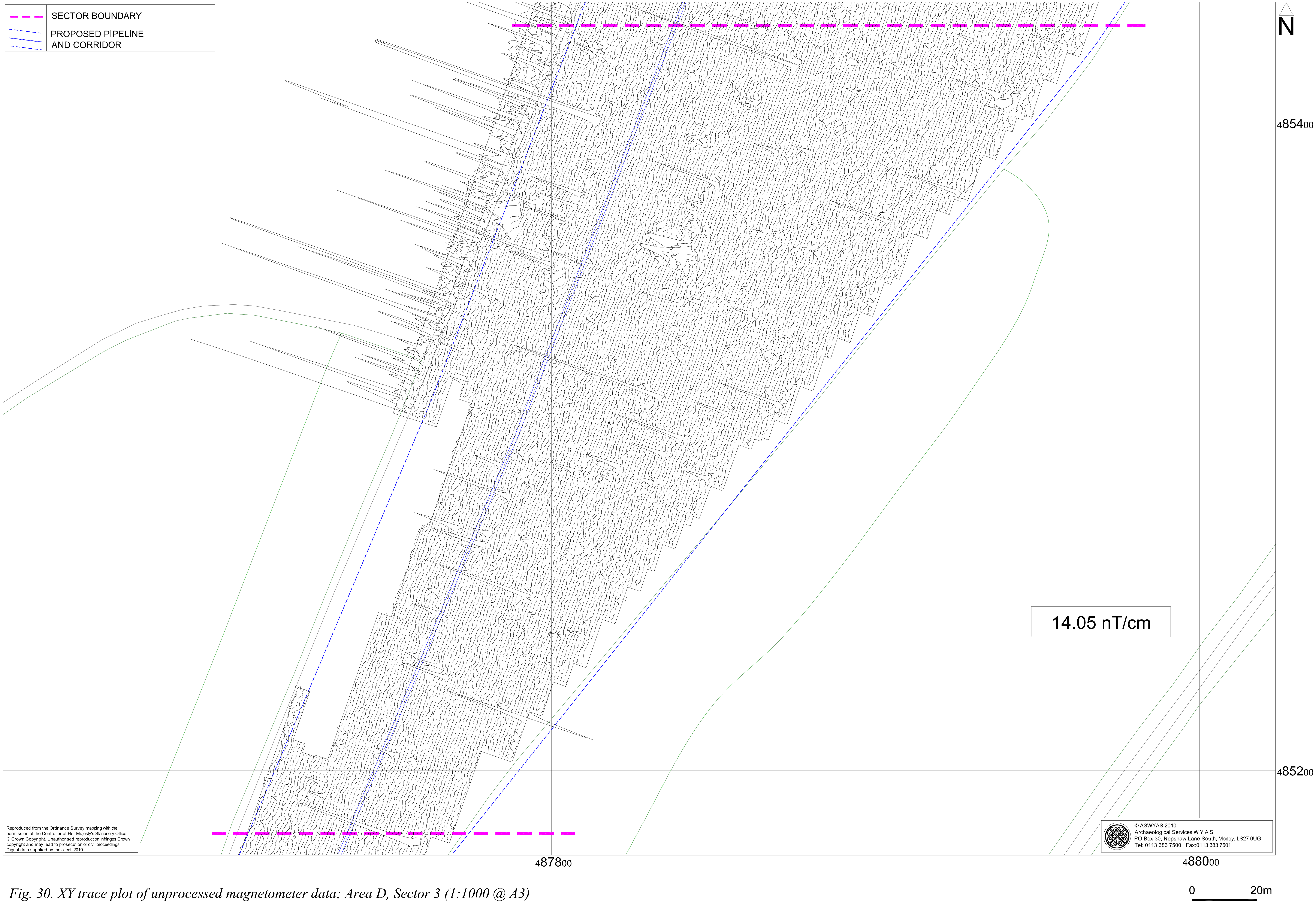


Fig. 30. XY trace plot of unprocessed magnetometer data; Area D, Sector 3 (1:1000 @ A3)

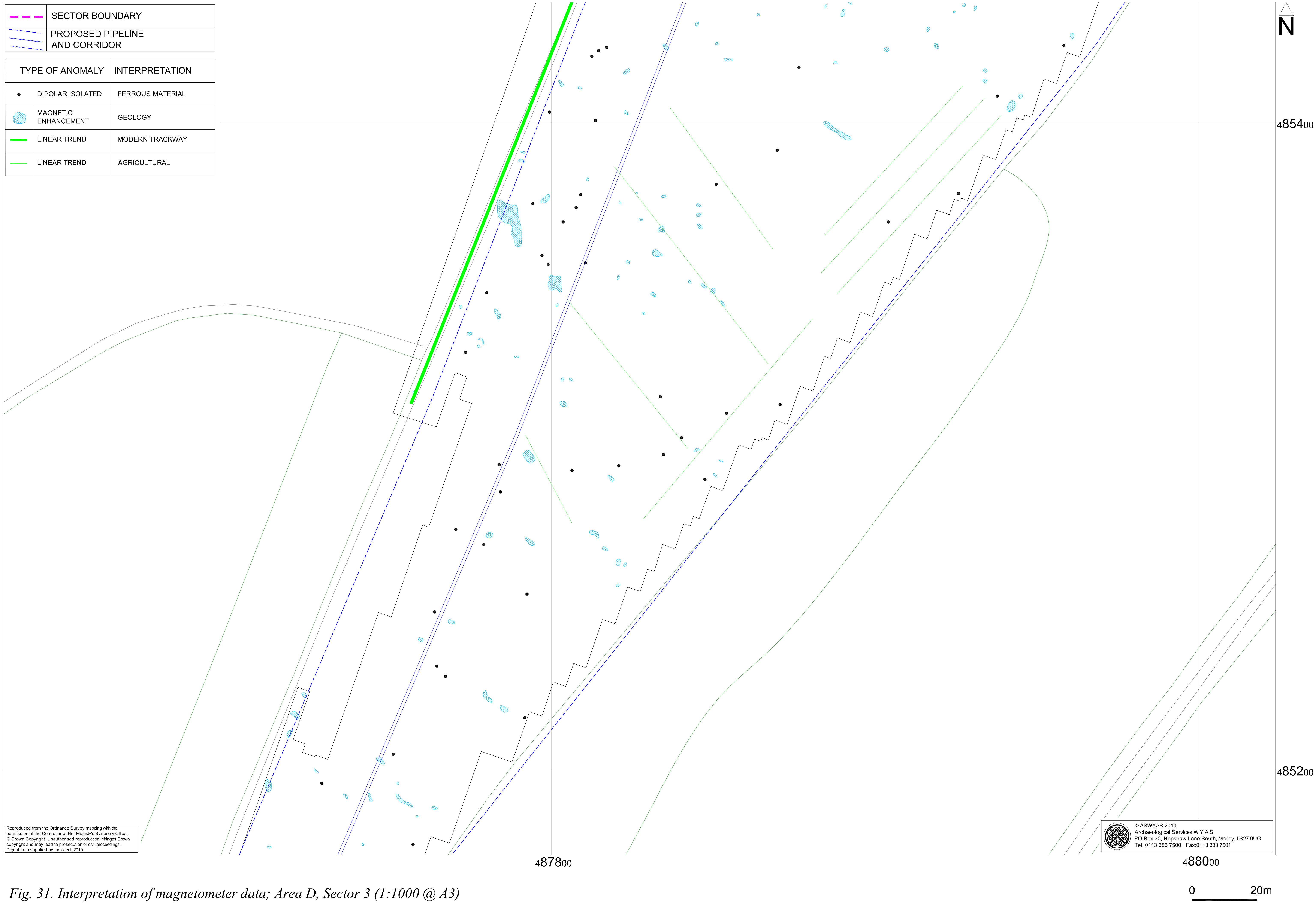


Fig. 31. Interpretation of magnetometer data; Area D, Sector 3 (1:1000 @ A3)

Fig. 32. Processed greyscale magnetometer data; Area D, Sector 4 (1:1000 @ A3)

0 20m

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

Fig. 33. XY trace plot of unprocessed magnetometer data; Area D, Sector 4 (1:1000 @ A3)

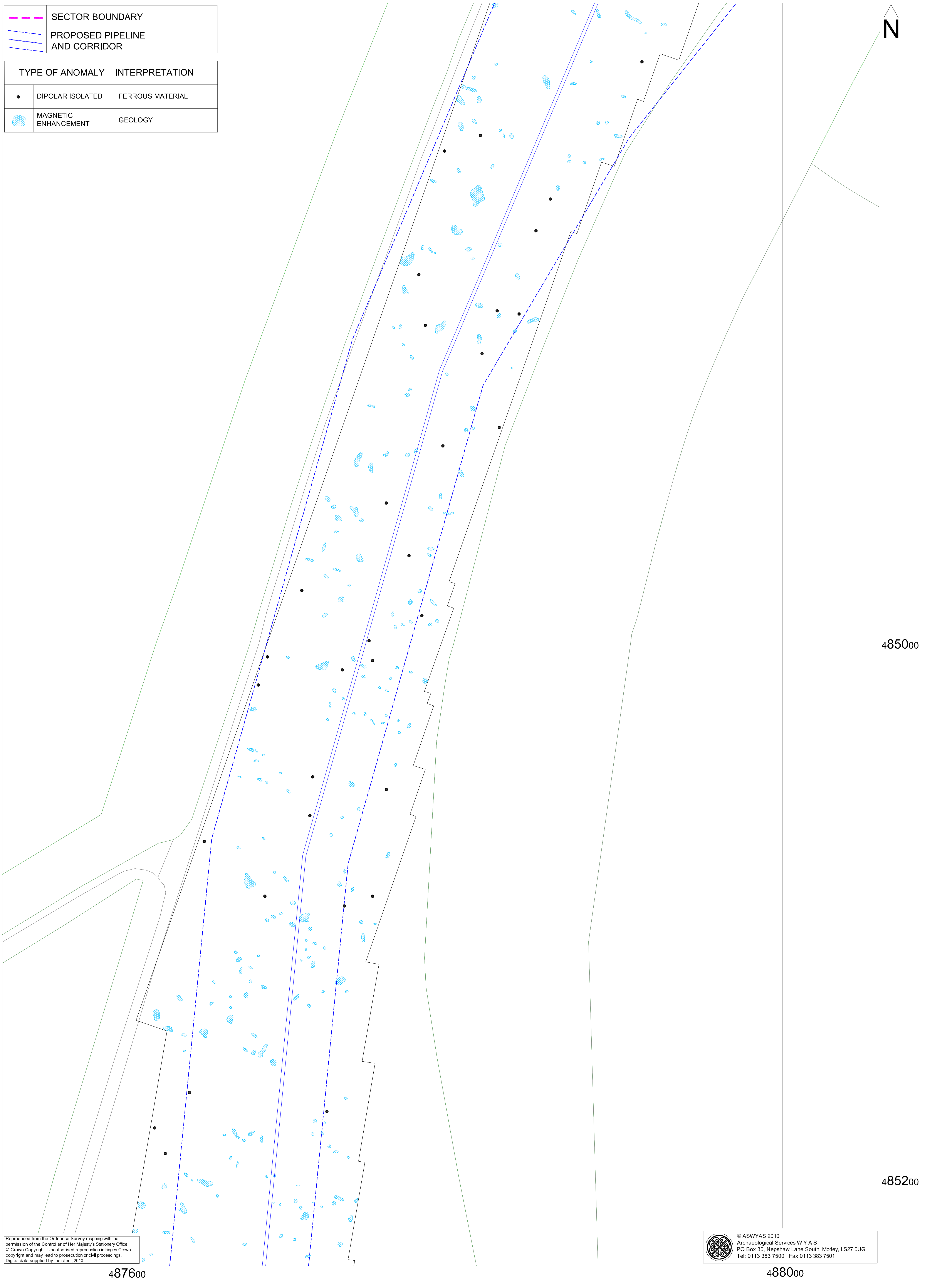


Fig. 34. Interpretation of magnetometer data; Area D, Sector 4 (1:1000 @ A3)

Fig. 35. Processed greyscale magnetometer data; Area D, Sector 5 (1:1000 @ A3)

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

Fig. 36. XY trace plot of unprocessed magnetometer data; Area D, Sector 5 (1:1000 @ A3)

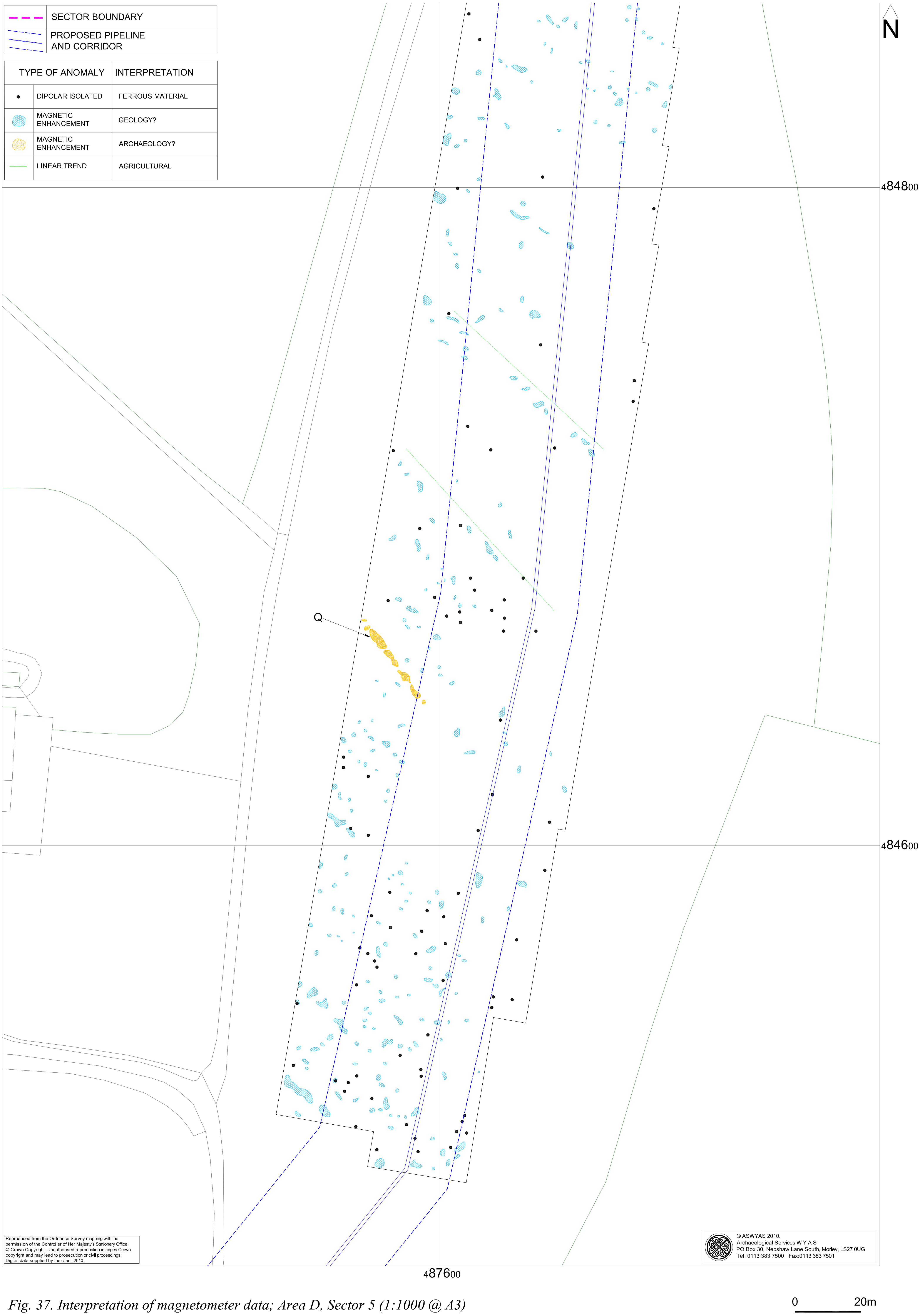


Fig. 37. Interpretation of magnetometer data; Area D, Sector 5 (1:1000 @ A3)

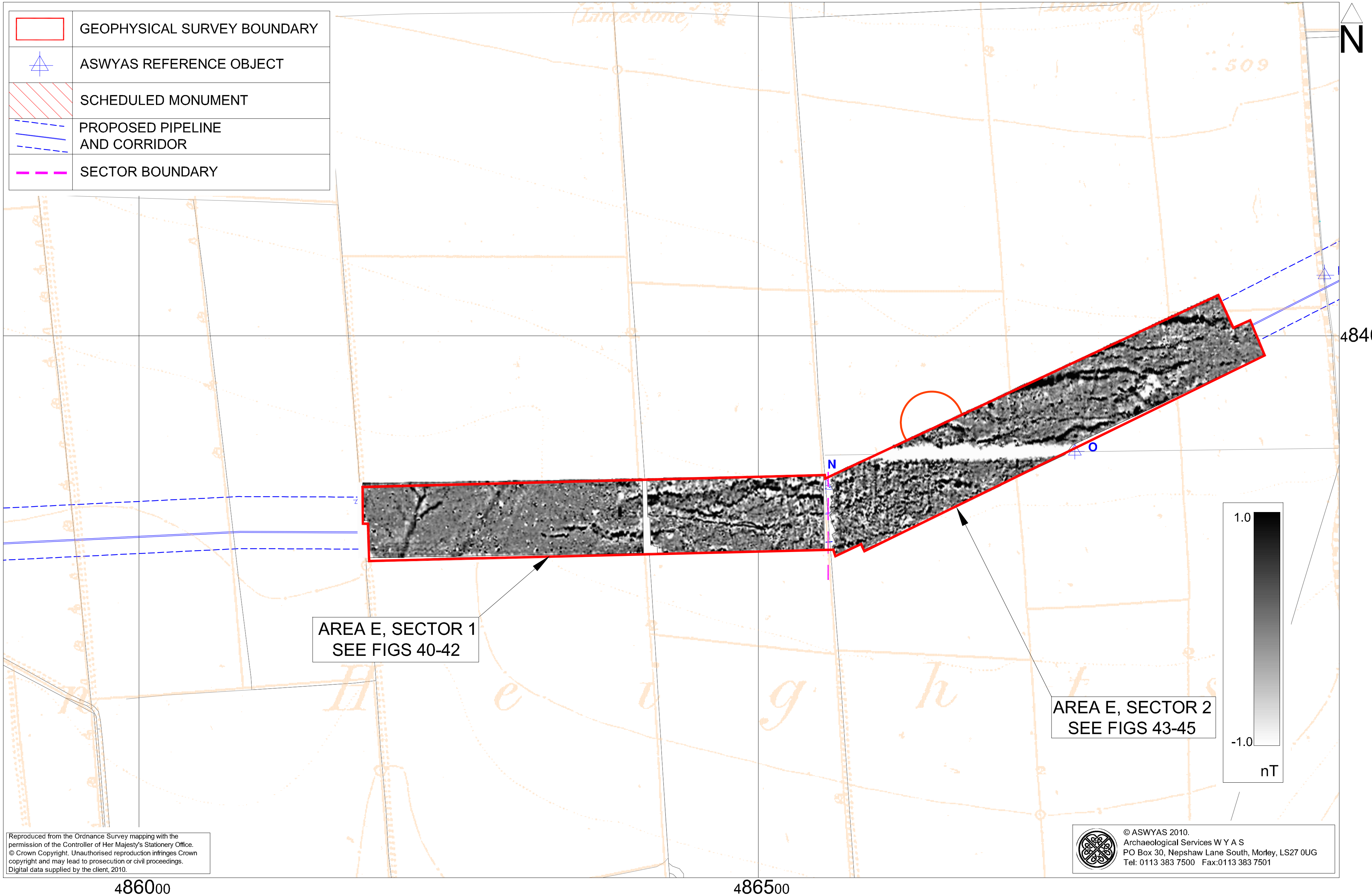


Fig. 38. Processed greyscale magnetometer data and first edition Ordnance Survey mapping of 1854; Area E (1:4000 @ A4)

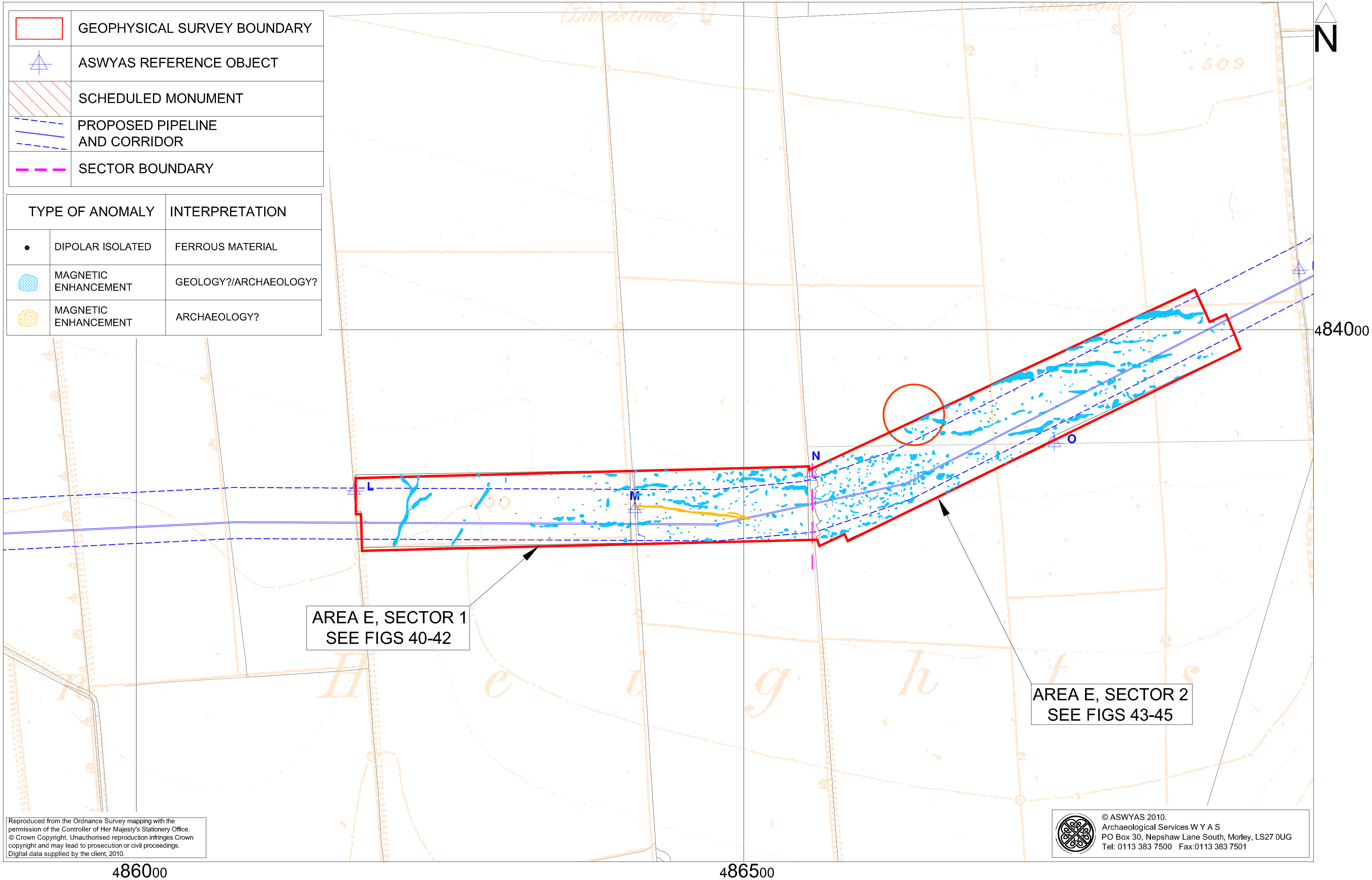


Fig. 39. Interpretation of magnetometer data and first edition Ordnance Survey mapping of 1854; Area E (1:4000 @ A4)

0 100m

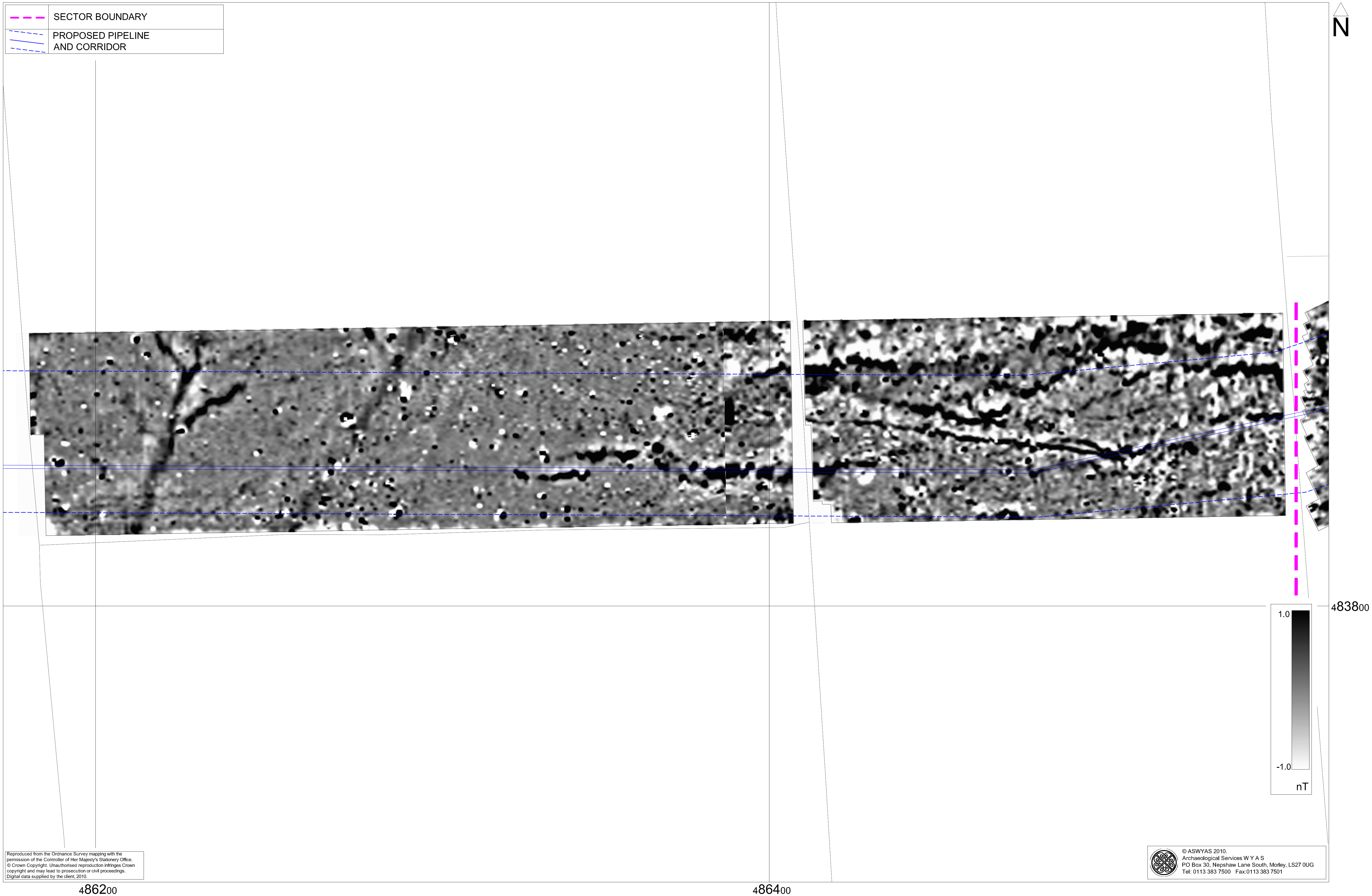


Fig. 40. Processed greyscale magnetometer data; Area E, Sector 1 (1:1000 @ A3)

0 20m

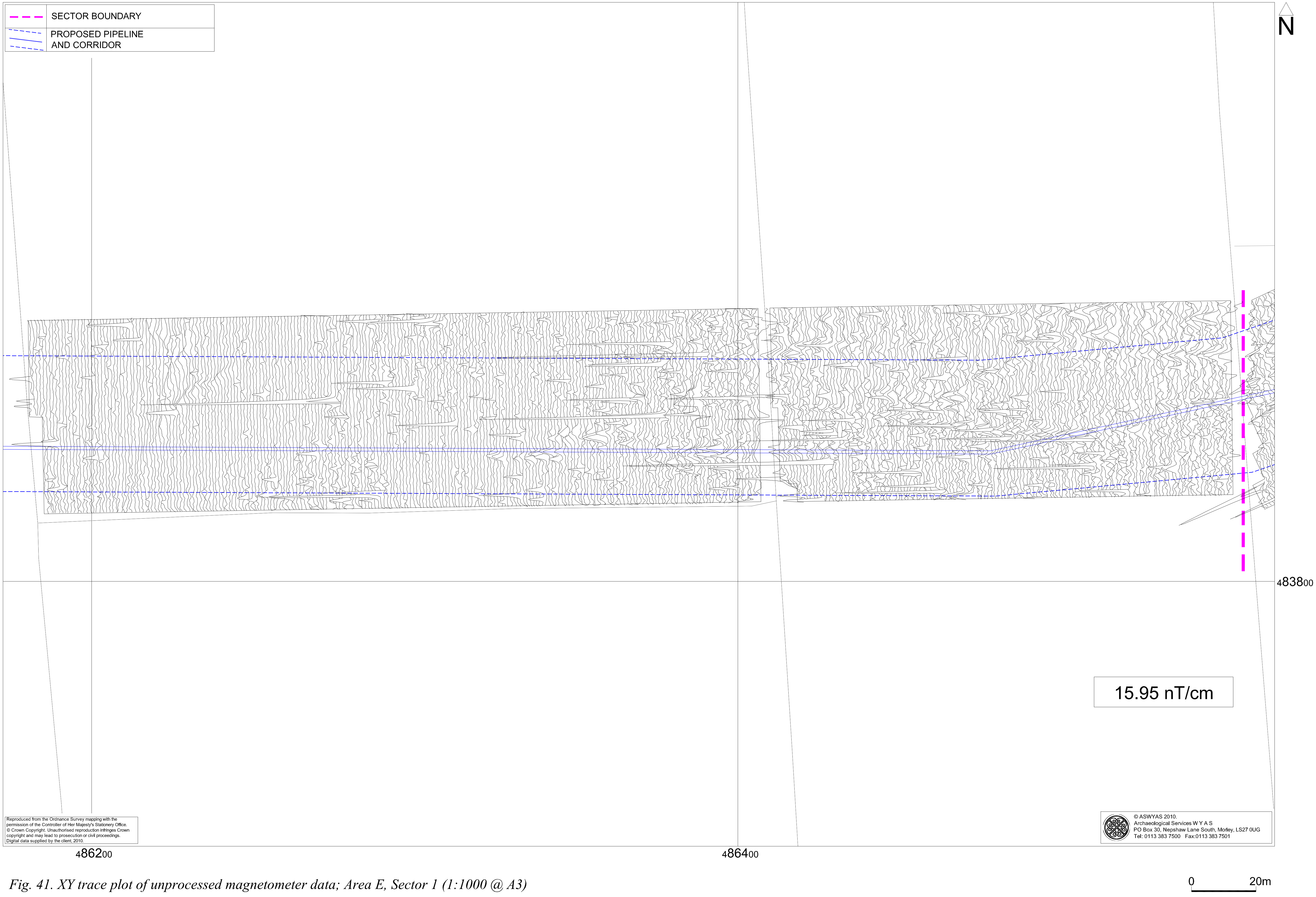


Fig. 41. XY trace plot of unprocessed magnetometer data; Area E, Sector 1 (1:1000 @ A3)

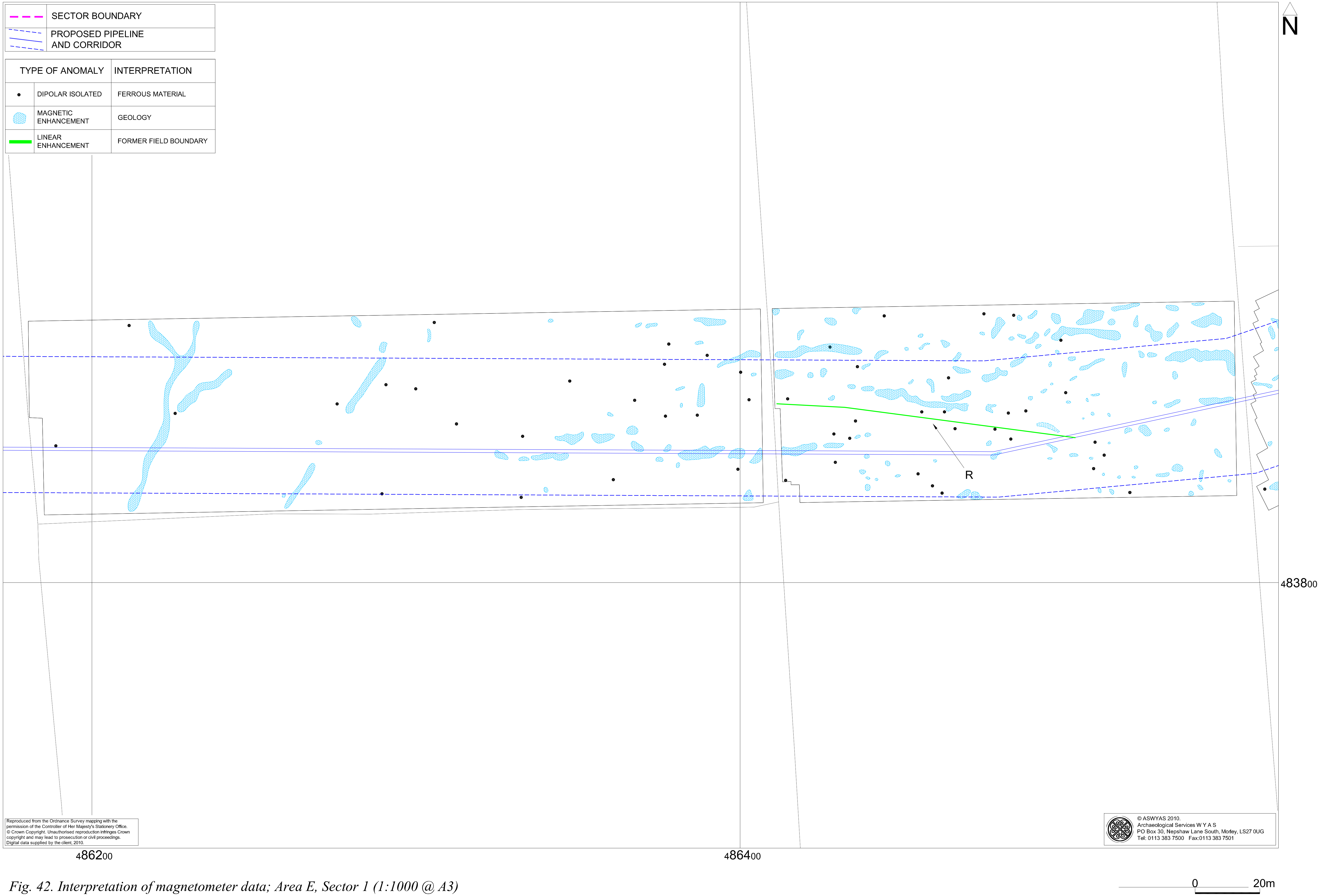


Fig. 42. Interpretation of magnetometer data; Area E, Sector 1 (1:1000 @ A3)

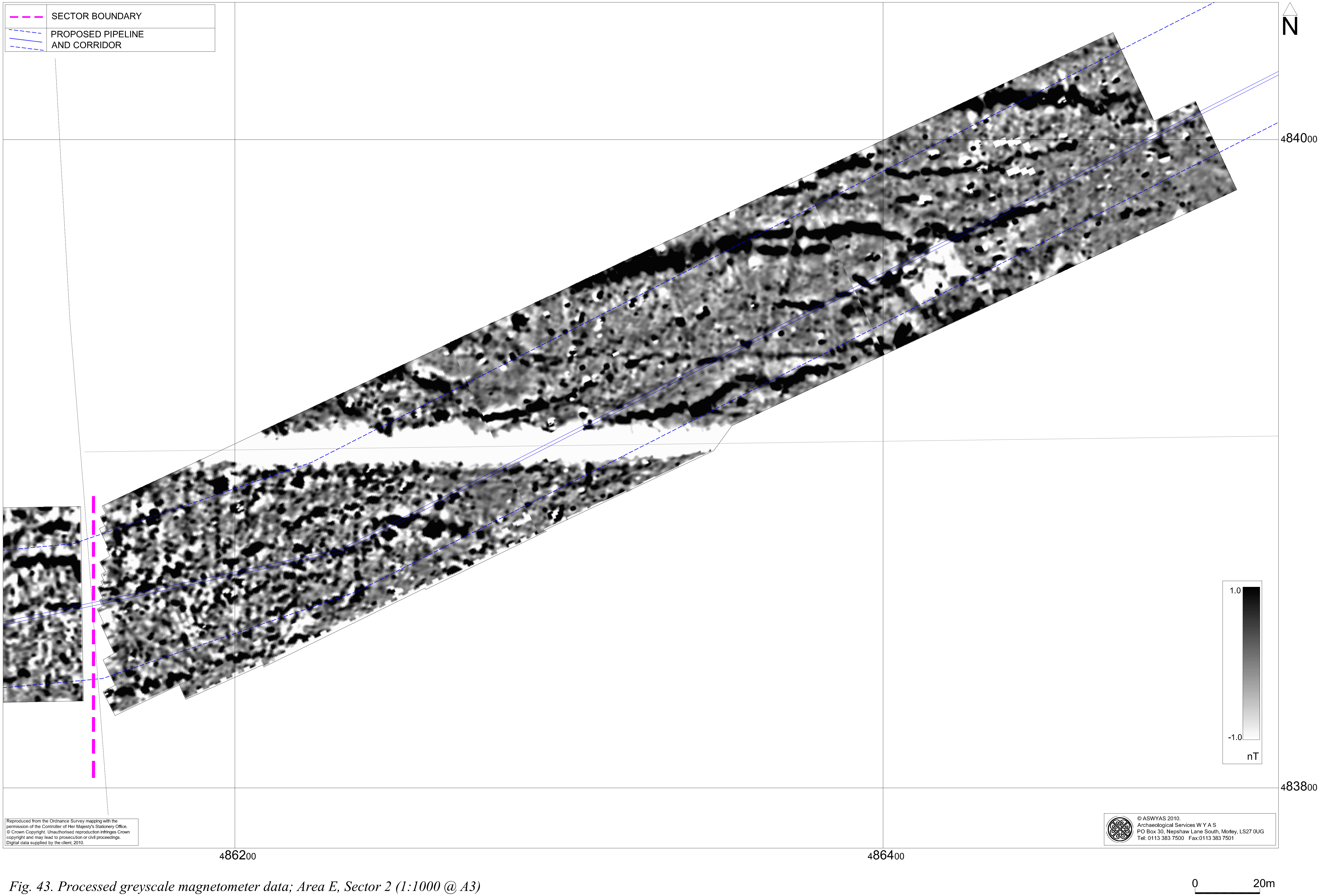


Fig. 43. Processed greyscale magnetometer data; Area E, Sector 2 (1:1000 @ A3)

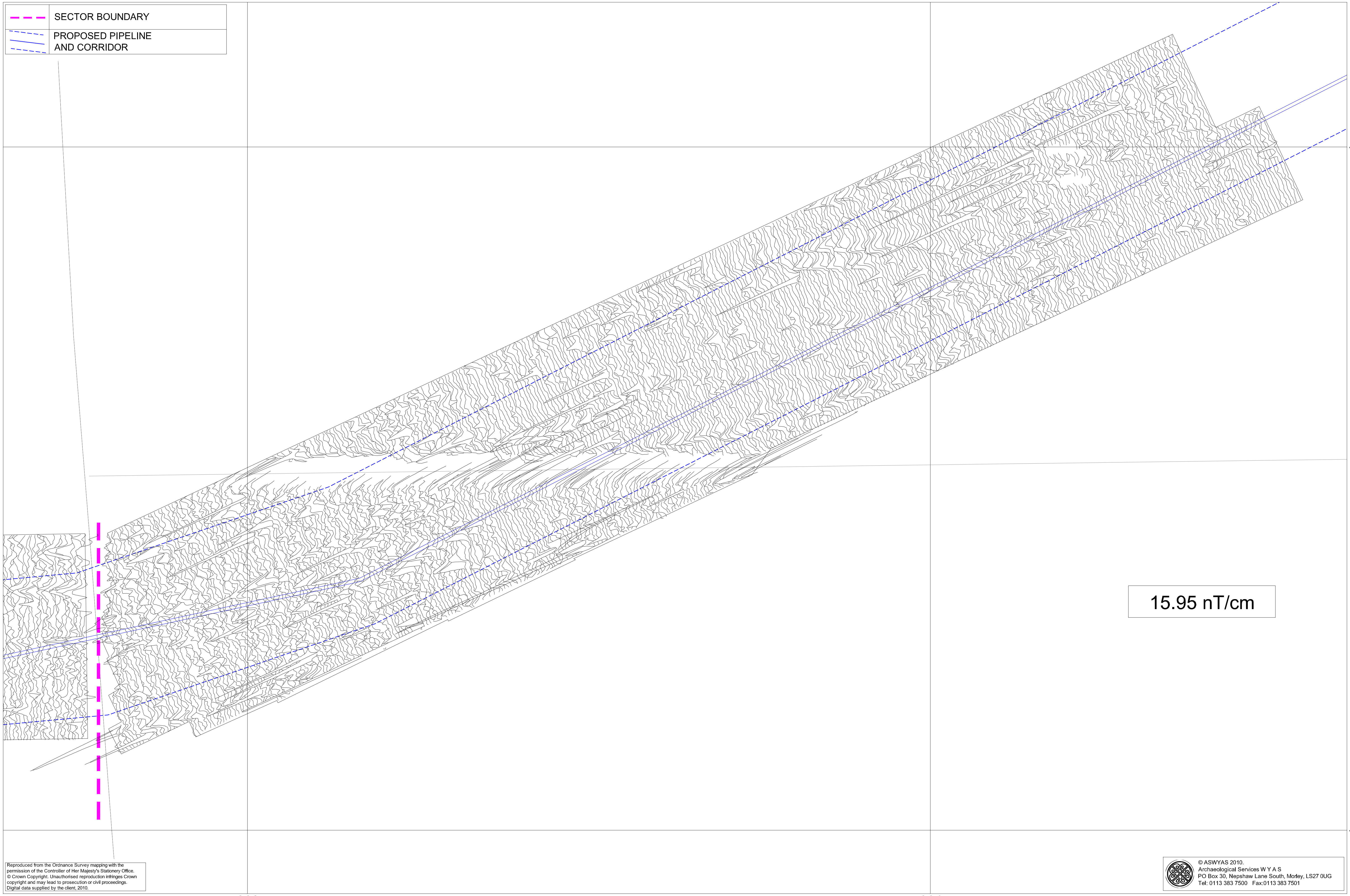


Fig. 44. XY trace plot of unprocessed magnetometer data; Area E, Sector 2 (1:1000 @ A3)

0 20m

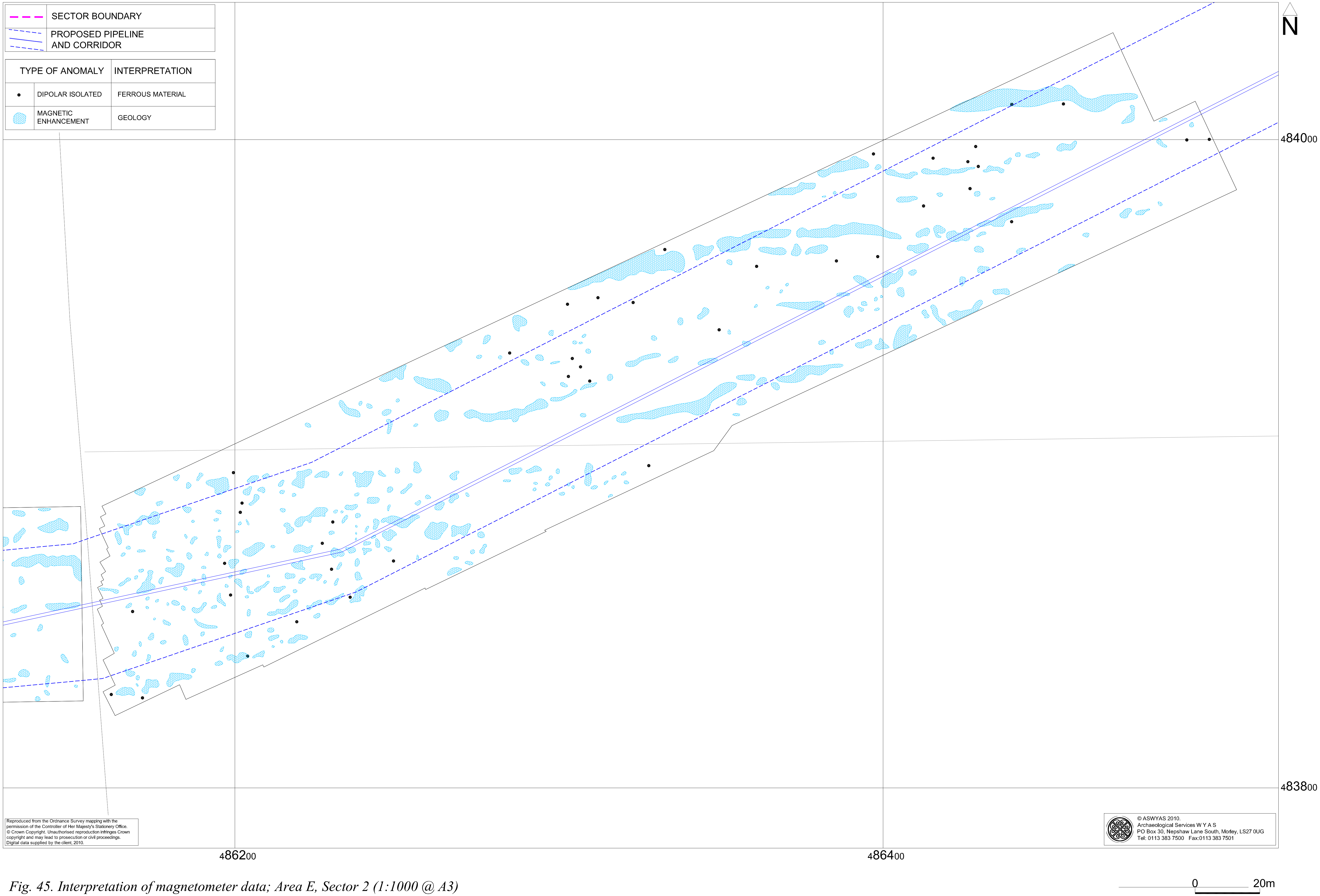


Fig. 45. Interpretation of magnetometer data; Area E, Sector 2 (1:1000 @ A3)

Plate 1. Area A, survey in progress, looking east towards the wellsite.

Plate 2. Area A, showing bands of organic mulch in the topsoil, looking north.

Plate 3. Area B, looking west.

Plate 4. Central part of Area C, looking south towards Givendale Dikes.

Plate 5. Area C, looking north towards Givendale Head Farm.

Plate 6. Southern section of Area D, looking south.

Plate 7. Southern section of Area D, looking north.

Plate 8. Area D, looking north - Diggerfoot Dike running along base of slope to centre of shot.

Plate 9. Postulated burial mound in Area E, looking east-north-east.

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 it 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 Geodimeter 600s total station theodolite and tied in to the corners of buildings, fields and other permanent landscape features and to temporary reference objects (survey marker stakes) that were established and left in place following completion of the fieldwork for accurate geo-referencing. The locations of the temporary reference points are shown on Figures 3, 11, 16, 21 and 39 and the Ordnance Survey grid co-ordinates tabulated below. The internal accuracy of the survey grid relative to these markers is better than 0.05m. The survey grids were then superimposed onto a map base provided by the client as a 'best fit' to produce the displayed block locations. Overall there was a good correlation between the local survey and the digital map base and it is estimated that the average 'best fit' error is better than ±1.5m. However, it should be noted that Ordnance Survey co-ordinates for 1:2500 map data have an error of ±1.9m at 95% confidence. This potential error must be considered if co-ordinates are measured off for relocation purposes.

Archaeological Services WYAS cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party.

A	490169.7138	487184.5283
B	489951.3519	487134.6224
C	489614.4955	487222.1307
D	489642.9315	487055.9992
E	489342.5503	487090.4683
F	489307.7467	486844.5338
G	489115.2098	486879.3605
H	488044.9144	485901.8317
I	484954.7014	487622.0476
J	487603.7807	484924.4876
K	487573.9732	484797.2729
L	486179.1959	483867.4470
M	486410.3074	483852.3700
N	486554.4306	483879.0772
O	486755.4611	483906.6290
P	486957.0054	484048.9476

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.
- 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 Historic Environment Record).

Section 4: Section 42 Licence

ENGLISH HERITAGE
YORKSHIRE & THE HUMBER REGION

Mr Sam Harrison
West Yorkshire Archaeology Service
PO Box 30
Morley
LEEDS
LS27 0UG

Direct Dial: 01904 601988
Direct Fax: 01904 601999

Our ref: AA/23034/5

16 August 2010

Dear Mr Harrison

Ancient Monuments and Archaeological Areas Act 1979 (as amended) section 42 - licence to carry out a geophysical survey

OXDALE AND GIVENENDALE DIKES, NORTH YORKSHIRE, ACKLAM, RYEDALE, NORTH YORKSHIRE
Case No:SL00000737
Monument no 35443

I refer to your application dated 13 August 2010, to carry out a geophysical survey at the above site.

English Heritage is empowered to grant licences for such activity and I can confirm that we are prepared to do so as set out below.

By virtue of powers contained in section 42 of the 1979 Ancient Monuments and Archaeological Areas Act (as amended by the National Heritage Act 1983) English Heritage hereby grants permission for geophysical survey of OXDALE AND GIVENENDALE DIKES, for the areas shown on the map that accompanied your application (copy attached). This permission is subject to the following conditions.

1. The permission shall only be exercised by Sam Harrison, Project Archaeologise (Geophysics), WYAS and by no other person. It is not transferable to another individual.

2. The permission shall commence on 23 August 2010 and shall cease to have effect on 29 October 2010.

3. A full report summarising the results of the survey and their interpretation shall be sent to Keith Emerick, Lucie Hawkins NYCC, Graham Lee, NYMNPA, NMR, Swindon and to Paul Linford of the English Heritage Geophysics Team at Fort Cumberland (Fort Cumberland Road, Eastney, Portsmouth, Hampshire, PO4

9LD), no later than 1 month after the completion of the survey.

You are also asked to complete and return the enclosed questionnaire about the survey to the Geophysics Team, Fort Cumberland (address as above), in order to assist with maintenance of our national database of geophysical surveys. Information from this questionnaire will be entered onto our database as a preliminary record which would be updated when you send to us a copy of the full report. If the work is to be done by a contractor could you please pass the form on to the surveyor.

Being part of our survey database, some details of your survey will be made publicly accessible on the Internet, although no images or data sets will be included. We will assume you have no objection to this unless you let us know to the contrary.

This letter does not carry any consent or approval required under any enactment, bye-law, order or regulation other than section 42 of the 1979 Act (as amended).

You are advised that the person nominated under this licence to carry out the activity should keep a copy of this licence in their possession in case they should be challenged whilst on site.

Yours sincerely

J Irvine

pp **Keith Emerick**
Ancient Monuments Inspector
E-mail: Keith.Emerick@english-heritage.org.uk

Bibliography

Barton Willmore, 2010. *Ryedale Gas Project: Environmental Statement*

Cardwell, P., 2010. *Ryedale Gas Project, North Yorkshire: Brief For Geophysical Survey*

David, A., N. Linford, P. Linford and L. Martin, 2008. *Geophysical Survey in Archaeological Field Evaluation: Research and Professional Services Guidelines (2nd edition)* English Heritage

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

Lyall, J and Powlesland, D., 2007. *Ebberston Moor EB2 Exploratory Well Site, North Yorkshire: Fluxgate Gradiometer and Surface Collection Survey*. Landscape Research Centre Unpublished Client Report