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ARCHAEOLOGICAL
SERVICES
WYAS

A16 - A158 Partney Bypass
Partney
Lincolnshire

Geophysical Survey

May 2002

Report No. 1013.

CLIENT

Babtie

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A16 - A158 Partney Bypass
Partney
Lincolnshire

Geophysical Survey

Contents

Summary

A geophysical (fluxgate gradiometer) survey was carried out along the route of the proposed A16 - A158 Partney Bypass over an area of approximately 12 hectares. A probable archaeological enclosure and three other areas of possible archaeological activity have been identified. A number of other linear anomalies and areas of magnetic enhancement could also locate archaeological features although a modern or geological cause for these anomalies is considered more probable. Anomalies caused by a palaeochannel, modern ferrous material, ridge and furrow ploughing and other agricultural features are also present.

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1. Introduction and Archaeological Background

1.1 Archaeological Services WYAS was commissioned by Mr A. Scruby, of Babtie Group, on behalf of Lincolnshire County Council, to carry out a geophysical (fluxgate gradiometer) survey along the proposed route of the A16 - A158 Partney Bypass (see Figs 1 and 2). The total survey area covered approximately 12 hectares.

1.2 The proposed A16 bypass is located to the west of Partney and runs for approximately 1.2km on a north to south alignment. The proposed A158 bypass is located to the south of Partney and runs for approximately 1.5km on an east to west alignment.

1.3 Both bypass routes are on generally flat ground, at about 20 metres AOD, with the occasional gentle undulations or break of slope. The geology varies across the bypass routes and includes the Claxby Ironstone Formation, at the north of the A16 bypass, Spilsby Sandstone, possibly outcropping at the northern and central parts of the A16 bypass, and Kimmeridge clays, located at the western and southern ends of both schemes. Drift deposits, comprising recent age River Alluvium, Glacial Sands and Gravels and Glacial Till, are also present within the proposed bypass routes.

1.4 At the time of survey, between the April 25th 2002 and May 14th 2002, the land use was a mixture of arable and pasture farmland. Further details on the agricultural regimes within each survey block are given in Section 3.

1.5 The village of Partney lies within the Lincolnshire Wolds, an area generally rich in archaeological remains, with evidence for settlement and farming dating from the Neolithic. Partney itself is believed to have a 6th century Anglian origin and a monastery, location now unknown, was founded there in the 7th century. A large round barrow, dated to circa AD600, that contained burials and grave goods is located at the eastern end of the proposed A158 bypass. There is also direct evidence for Romano-British and possibly earlier activity in the immediate vicinity of Partney. Within, and adjacent to, the proposed A16 bypass there are two cropmarked circular features, interpreted as Bronze Age funereal monuments, a cropmarked enclosure, interpreted as medieval in date, and Romano-British pottery findspots. A number of post medieval former field boundaries lie within the proposed bypass route. Further details on the archaeological and historical background of Partney can be found in the Specification for Geophysical Survey (Babtie Group 2002), details from which have been incorporated into Figure 2.

2. Methodology and Presentation

2.1 The objectives of the survey were:

- to use detailed magnetic survey to establish the presence, extent and character of any magnetic anomalies within the survey area.

2.2 The survey was carried out in accordance with the Specification for Geophysical Survey (Babtie Group 2002). The specification originally required a 20m wide corridor to be surveyed, centred on the proposed route of the bypass. However, prior to the commencement of the survey, Mr D.

Johnston, Principal Archaeologist of Babtie Group, amended the survey area to a 40m wide corridor, still centred on the proposed bypass route. The proposed route of the bypass was provided as a 1:10000 hardcopy with the Specification and although a number of field boundaries had been removed or altered compared to the Ordnance Survey map base the survey corridor could still be laid out with reasonable accuracy (see Appendix 2).

2.3 The survey methodology and report presentation also use the recommendations outlined in the English Heritage Guidelines (David 1995) as a minimum standard. All figures reproduced from Ordnance Survey mapping are done so with the permission of the controller of Her Majesty's Stationery Office, © Crown copyright.

2.4 A general site location plan incorporating the 1:50000 Ordnance Survey mapping is shown in Figure 1. Figure 2 shows the survey location information and the processed gradiometer data, in a greyscale format, superimposed onto an Ordnance Survey digital base map at a scale of 1:5000. This figure also includes digital information of the proposed road scheme and historical and archaeological detail, provided by Babtie Group (dated March 2002). The processed greyscale data is also shown, at a scale of 1:1000, in Figures 3, 5, 7, 9, 11, 13, 15, 17 and 19. The accompanying interpretations are shown at the same scale in Figures 4, 6, 8, 10, 12, 14, 16, 18 and 20. The unprocessed data is shown at a scale of 1:500 as both greyscale and X-Y trace plots in Appendix 4.

2.5 For ease of presentation and discussion the survey has been split into three areas; Area A, the A16 bypass and the A158 bypass. The two bypass routes have been further subdivided into survey blocks.

2.6 The raw data dot density displays and the processed X-Y trace plots of all of the survey areas were examined but it was felt that they did not provide any additional archaeological information and so, after consultation with Mr. D Johnston, Principal Archaeologist of Babtie Group, it was decided not to include these two display formats in the report. In all other aspects the report adheres to the Specification for Geophysical Survey (Babtie Group 2002).

2.7 Comprehensive technical details on the underlying principles of magnetic survey, the equipment used and general geophysical survey methodology are given in Appendix 1 along with details on data processing and display. The survey location information is presented in Appendix 2 and the composition of the archive is given in Appendix 3.

3. Results and Discussion

The interpretative figures should not be looked at in isolation but in conjunction with the relevant discussion section and with the information contained in the Appendices.

3.1 Anomalies of Modern Origin

3.1.1 There are 'iron spike' responses (see Appendix 1) across all parts of the site that are indicative of ferrous material in the topsoil or subsoil. These responses can be caused by archaeological artefacts but are more often caused by modern material. Unless there is strong supporting evidence to the contrary they are assumed not to be of archaeological importance. Only the stronger iron spike responses have been shown on the interpretation figures.

3.1.2 There are also areas of magnetic disturbance in many of the survey blocks adjacent to field boundaries. These anomalies are strongly suggestive of modern ferrous material and have not, therefore, been highlighted on the interpretation figures.

3.2 Area A (Figs 3 and 4)

3.2.1 This field was under a young cereal crop and the field boundaries consisted of a combination of ferrous fencing and hedgerows. Two separate survey grids were established for this area to cover the proposed roundabout and road to the north.

3.2.2 Several areas of magnetic enhancement, weak linear trends and positive linear anomalies are present.

3.2.3 The positive linear anomalies are suggestive of infilled cut features and they appear to describe part of a recti-linear enclosure. Infilled cut features or areas of burning could cause the areas of magnetic enhancement although it should be noted that this type of response can also be caused by geological variations (see Appendix 1). The weakness and intermittent nature of the responses makes a definite interpretation impossible and, whilst archaeological features could cause the anomalies, a non-archaeological origin should not be discounted. All of the areas of magnetic enhancement lie within the 'enclosure' formed by the positive linear anomalies and so it is probable that if the linear anomalies are archaeological in origin then so are the areas of magnetic enhancement.

3.3 Block A16_A (Figs 3 and 4)

3.3.1 A weak, linear trend and several areas of magnetic enhancement are present in the northern part of this survey block.

3.3.2 Whilst these types of anomaly can be caused by infilled cut features (see above and Appendix 1) it is probable that the majority of these anomalies are associated with the adjacent stream and are caused by either geological variations or modern activity such as infilling waterlogged areas or depositing material from the dredging or canalisation of the stream.

3.4 Block A16_B (Figures 3, 4, 5 and 6)

3.4.1 There are a number of areas of magnetic enhancement adjacent to the ditched stream at the southern field boundary. As can be seen in the X-Y trace plots (Appendix 4) many of these areas of magnetic enhancement are broad and uniformly strong; characteristics that are more suggestive of geological rather than archaeological features. It is again probable that these anomalies are associated with the stream.

3.4.2 In the central and northern parts of this survey block there is a series of broadly parallel, positive, linear anomalies and linear trends aligned north-west to south-east. There is also a discontinuous positive, linear anomaly (or several anomalies that have the same alignment) aligned perpendicular to these anomalies.

3.4.3 The alignment of these anomalies matches closely that of some former field boundaries and some of the anomalies appear to correspond directly with the former field boundaries (see Fig. 2). It seems probable that these anomalies are agricultural in origin and relate to former field divisions. However, it should be noted that there are more linear anomalies than there are known former field boundaries and that some of the anomalies may have a different origin. The anomalies that do not correspond directly with former field boundaries have therefore been ascribed an unknown origin.

3.4.4 There is a concentration of areas of magnetic enhancement in the central part of the survey block. These responses are not as strong or broad as those areas of magnetic enhancement in the south of the survey block and an archaeological origin is therefore possible. However, given a lack of other supporting information a geological origin is still the most probable cause for the anomalies.

3.5 Block A16_C (Figs 5 and 6)

3.5.1 This field appeared to have been recently planted with a root crop as there was a series of parallel ridges and troughs of about 0.2m to 0.3m in height. Consequently the survey was made difficult in this field because the orientation of this deep cultivation was oblique to the direction of traverse and the soil was sandy and soft underfoot. The difficult survey conditions, combined with ground disturbance caused by the deep cultivation, resulted in a strongly variable background magnetic susceptibility within this survey block.

3.5.2 Several possible linear trends within this survey block have been identified but, because of the variable magnetic background, a reliable interpretation cannot be made. It should be noted that some of the linear anomalies could be caused by artificial trends within the data and may not be caused by real features.

3.5.3 A single positive, linear anomaly at the northern end of this survey block is also noted. This anomaly corresponds with, and is probably caused by, a former field boundary.

3.6 Blocks A16_D and A16_E (Figs 7 and 8)

3.6.1 These survey blocks were aligned on the same survey grid but were located 5m apart, either side of a hedgerow. The western field (Block A16_D) was under a young arable crop and the eastern field (Block A16_E) was under rough pasture. The southern field boundary was a hedgerow and the northern field boundary was a wire mesh fence adjacent to a stream. The northern part of the pasture field adjacent to the stream was not suitable for detailed gradiometer survey because of the presence of dense vegetation and uneven ground conditions. The two cropmarked ring ditches and the cropmarked enclosure described in Section 1.5 lie within these survey blocks.

3.6.2 There are several parallel, linear trends aligned with the field boundary that separates the two fields. This alignment suggests that the anomalies may be caused by modern agricultural features although the anomalies are broader than would be expected from field drains or modern ploughing features. For this reason these anomalies have been ascribed an unknown origin.

3.6.3 At the southern end of the survey blocks there are three areas of magnetic enhancement and a positive, linear anomaly, aligned east to west. In the northern part of the block a strong, positive, linear anomaly forms three sides of a recti-linear enclosure and there are numerous areas of magnetic enhancement within, and to the north of this anomaly.

3.6.4 The recti-linear anomaly can be reliably interpreted as an archaeological enclosure with the stronger areas of magnetic enhancement probably caused by internal archaeological features. The weaker areas of magnetic enhancement and the anomalies located to the north of the enclosure have strong archaeological potential but it should be noted that some of these anomalies could be caused by geological variations. Given the presence of these definite archaeological features an archaeological origin for the linear anomaly and the areas of magnetic enhancement in the southern part of the block should be considered.

3.6.5 It is interesting that the two cropmarked ring ditches are not detected by the gradiometer survey and it is possible that these features have been truncated and no longer survive as sub-surface features. It is also possible that the features are present but that the material infilling the ditches does not have a magnetic contrast with the surrounding soil, although given that the enclosure is detected as such a strong anomaly this does not seem likely. The form of the recti-linear anomaly is suggestive of a Romano-British enclosure and the number of possible internal features may indicate settlement activity.

3.7 Blocks A16_F, A16_G and A_16H (Figs 9 and 10)

3.7.1 These survey blocks lay within two fields that were under a young arable crop. The eastern boundary of these fields consists of a hedgerow adjacent to the A16, a ditch and hedgerow separates the two fields and the field boundaries to the south-west comprise wire fencing adjacent to woodland.

3.7.2 Block A16_F contains numerous areas of magnetic enhancement. As discussed previously this type of anomaly can be difficult to interpret as they can have a number of different origins. However, the X-Y trace plot (Appendix 4) shows these anomalies to have responses that are suggestive of infilled cut features.

3.7.3 There are several broad, linear trends, aligned north-east to south-west in Block A16_G. The breadth of these responses and lack of a clear pattern makes interpretation of these anomalies difficult.

3.7.4 North-west of these linear trends there is a small area of strong magnetic disturbance. The X-Y trace plot shows this anomaly to have a strong 'spiky' response (see Appendix 1), which suggests that it is probably modern in origin.

3.7.5 The remaining anomalies in Blocks A16_G and A16_H consist of positive, linear anomalies and a linear series of small areas of magnetic enhancement. All of these anomalies are suggestive of infilled cut features.

3.7.6 These anomalies are not as strong or as clearly defined as those in Blocks A16_D and A16_E and so they have only been interpreted as possible archaeological anomalies. It is possible that modern features, such as field drains, cause the anomalies but, as they appear to have returns and to form two or more enclosures, an archaeological origin is considered the most probable cause. Given the presence of these possible archaeological enclosures an archaeological origin for the areas of magnetic enhancement in Block A16_F should also be considered.

3.8 Block A158_A (Figs 11 and 12)

3.8.1 This field was under a young cereal crop with a deeply cut stream immediately to the north of the road corridor.

3.8.2 One continuous broad linear area of magnetic enhancement, with numerous adjacent smaller areas, can be seen in the eastern part of the survey corridor. The breadth and shape of this anomaly is strongly suggestive of an infilled palaeochannel with the smaller areas also likely to be associated with episodes of erosion and deposition as the stream changed course through time.

3.8.3 In the western part of the survey block there are a number of other areas of magnetic enhancement and two areas of magnetic disturbance.

3.8.4 The areas of magnetic enhancement have a slightly different response to the probable palaeochannel anomalies and it is possible that these anomalies are caused by cut features. The magnetic disturbance has a 'spiky' response (see X-Y trace plot) and is probably modern in origin.

3.8.5 A definite interpretation of the areas of magnetic enhancement in the west of the survey block is difficult as they could be geological, possibly related to the palaeochannel, or modern in origin. The presence of the nearby areas of magnetic disturbance indicates that there has been some degree of modern ground disturbance. An archaeological origin should also not be ruled out given the presence of other possible archaeological anomalies in Area A.

3.9 Blocks A158_B and A158_C (Figs 13 and 14)

3.9.1 A knee-high barley crop in these two fields made surveying difficult along this stretch of the road corridor.

3.9.2 There are several areas of magnetic enhancement within these two survey blocks. An archaeological origin cannot be completely ruled out for these anomalies but, given the weakness of the responses and lack of a discernible pattern, a geological origin is considered the most probable cause.

3.10 Block A158_D and A158_E (Figs 15 and 16)

3.10.1 Two series of positive, linear anomalies within both survey blocks have been identified. The majority of these anomalies are aligned north-west to south-east with several anomalies perpendicular to these.

3.10.2 The linearity and regularity of these anomalies is strongly suggestive of a modern origin and it is probable that former agricultural regimes, possibly including ridge and furrow ploughing and drainage features, causes the anomalies.

3.10.3 At the western end of Block A158_E and in the eastern half of Block A158_D there are several stronger linear anomalies and areas of magnetic enhancement. These linear anomalies are on a slightly different alignment to the series of probable agricultural anomalies and some of them appear to have returns, rather than there being two separate interconnecting anomalies.

3.10.4 These factors coupled with the presence of the areas of magnetic enhancement, some of which are quite strong and linear, suggests archaeological activity, with possibly at least two archaeological enclosures. The complicating presence of the agricultural anomalies makes an exact interpretation difficult and it could be that some of the anomalies are agricultural rather than archaeological in origin. For this reason the anomalies have only been interpreted as possible archaeological features rather than probable. It is equally possible that some of the anomalies interpreted as agricultural may in fact be archaeological in origin and that the archaeology is more extensive than first appears.

3.11 Block A158_F and A158_G (Figs 17 and 18)

3.11.1 These two fields were under pasture and were bounded at the western and eastern ends by wire mesh fencing and separated by a hedgerow and mesh fencing. Extant ridge and furrow, aligned north to south, was visible in the eastern field (Block A158_G).

3.11.2 A series of positive, linear anomalies, aligned north to south were detected. These anomalies correspond with the extant ridge and furrow ploughing earthworks.

3.12 Block A158_H and A158_I (Figs 19 and 20)

3.12.1 This field was under a young cereal crop and was bounded at its western and eastern ends by wire mesh fencing and to the north by a hedgerow adjacent to the A158. The proposed road corridor curved in this field and so two survey grids were established to ensure full coverage of the proposed route. A large round barrow is known to have been located immediately to the east of Block A158_I (see Section 1.5).

3.12.2 A series of weak, positive, linear anomalies were detected in the western end of Block A158_H. These anomalies have the same alignment and distribution as the ridge and furrow anomalies to the west and probably reflect a continuation of this ploughing regime.

3.12.3 There are two series of weak linear trends in Block A158_I. One set of parallel anomalies is aligned north-east to south west and the other is aligned north-west to south-east. There is not enough information to reliably interpret these anomalies; they may be caused by continuations of the agricultural regimes identified to the west, field drains or other cut features.

3.12.4 A negative, linear anomaly, aligned broadly east to west, is also present in Block A158_I and adjacent to this there are several areas of magnetic disturbance. These types of anomaly are usually caused by modern features (see Appendix 1).

3.12.5 The remaining anomalies are all areas of magnetic enhancement none of which seem to form an obvious pattern.

3.12.6 Given the types of response identified and the lack of a coherent pattern a non-archaeological origin for all of the anomalies in Block A158_I would seem probable. However, given the presence of the nearby round barrow, that was known to have had ferrous archaeological artefacts within it, an archaeological origin for any of the anomalies should not totally be discounted. The size of the areas of magnetic disturbance would seem to preclude an archaeological origin but it is possible that some of the areas of magnetic enhancement, or even the linear trends, in the east of the survey block are caused by archaeological features.

4. Conclusions

4.1 A probable archaeological enclosure with internal features has been identified in Blocks A16_D and A16_E. Two cropmarked ring ditches that were believed to be in this area were not detected but it is not known whether this is because the features have been truncated or if there is an insufficient magnetic contrast between the infill of the ditches and the surrounding geological matrix for them to be detected by a gradiometer survey. Three possible archaeological enclosures have also been identified in Area A, in Blocks A16_G and A16_H and in Block A158_D.

4.2 A number of other linear anomalies and areas of magnetic enhancement could also locate archaeological features although a modern or geological cause for these anomalies is considered more probable. Anomalies caused by a palaeochannel, modern ferrous material, ridge and furrow ploughing and other agricultural features are also present.

4.3 There is a variable geology across the proposed road corridor and so there may be areas where there will be little or no magnetic contrast between any cut features and the surrounding geological matrix. It is possible therefore that there are archaeological features present that cannot be detected by a gradiometer survey. However, given the strong magnetic responses that are observed in the majority of the survey blocks this is considered unlikely and it is thought that the anomalies detected reflect the true level of possible archaeology.

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Babtie Group, 2002. *A16 – A158 Partney Bypass, Archaeological Evaluation Works: Specification for Geophysical Survey*. Babtie Group.

Acknowledgements

Fieldwork

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Figures

Appendices

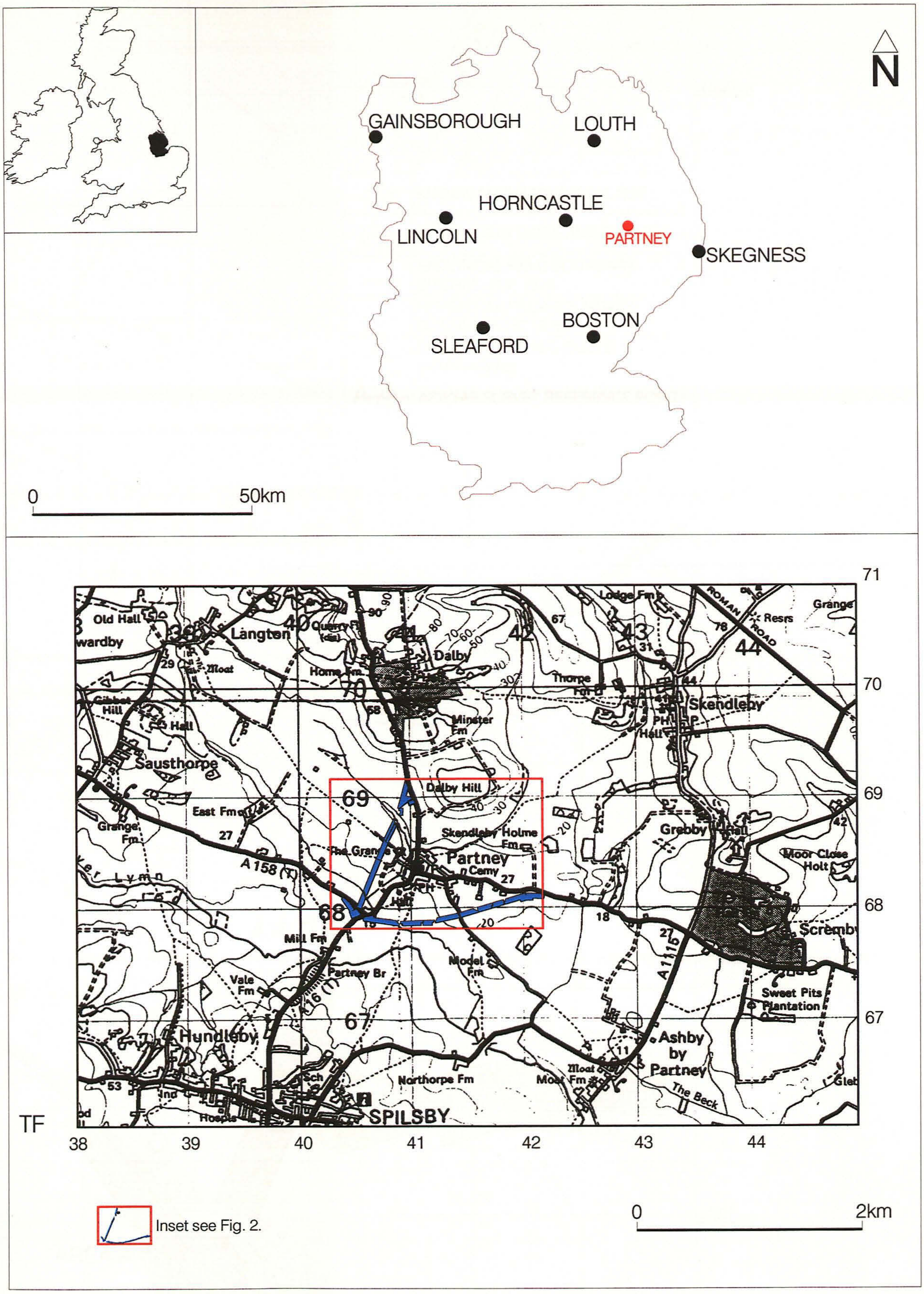

Fig. 1. Site location

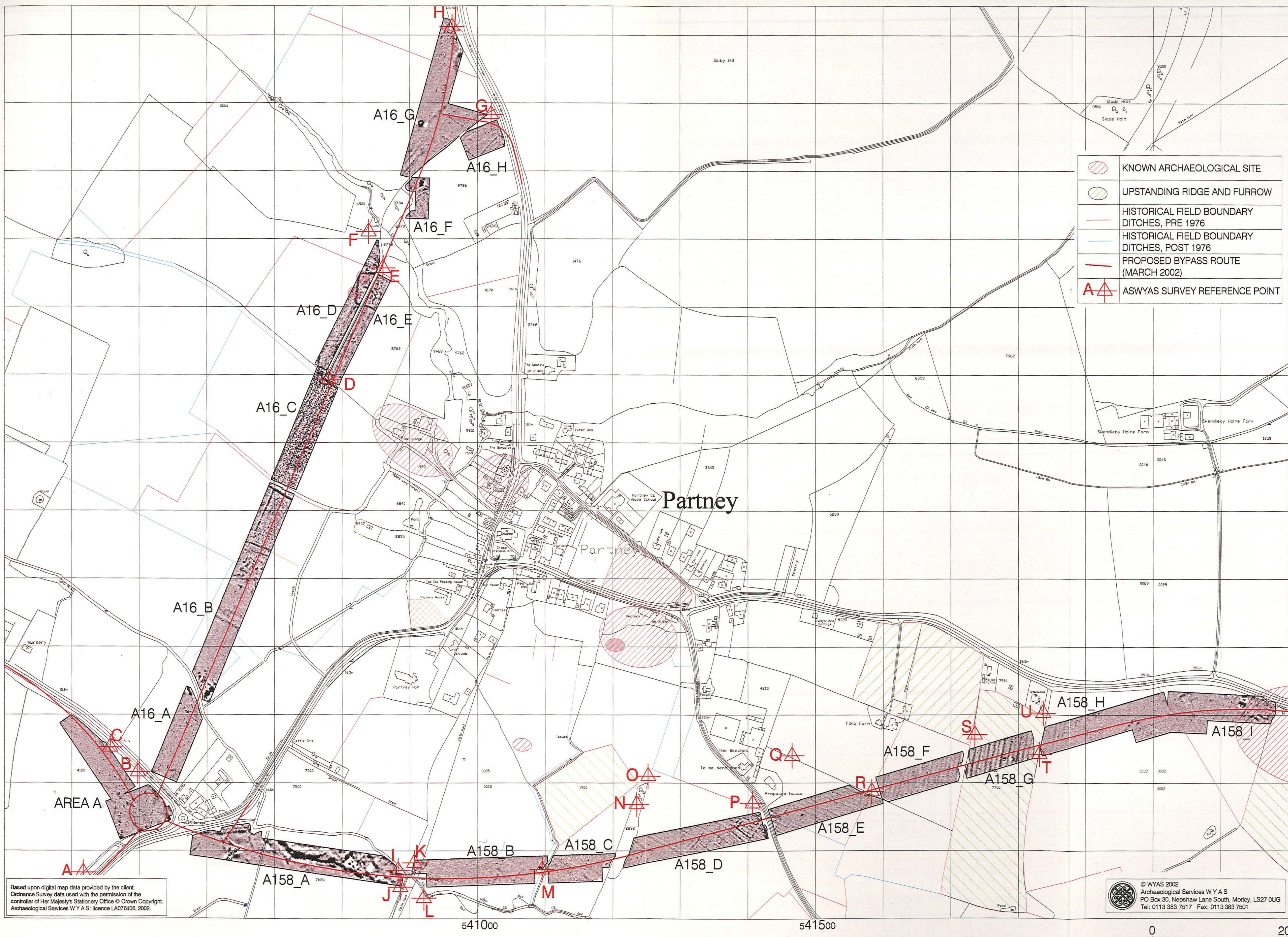

Fig. 2. Survey location information showing processed greyscale gradiometer data and detail from the Specification for Geophysical Survey (after Babtie Group 2002)

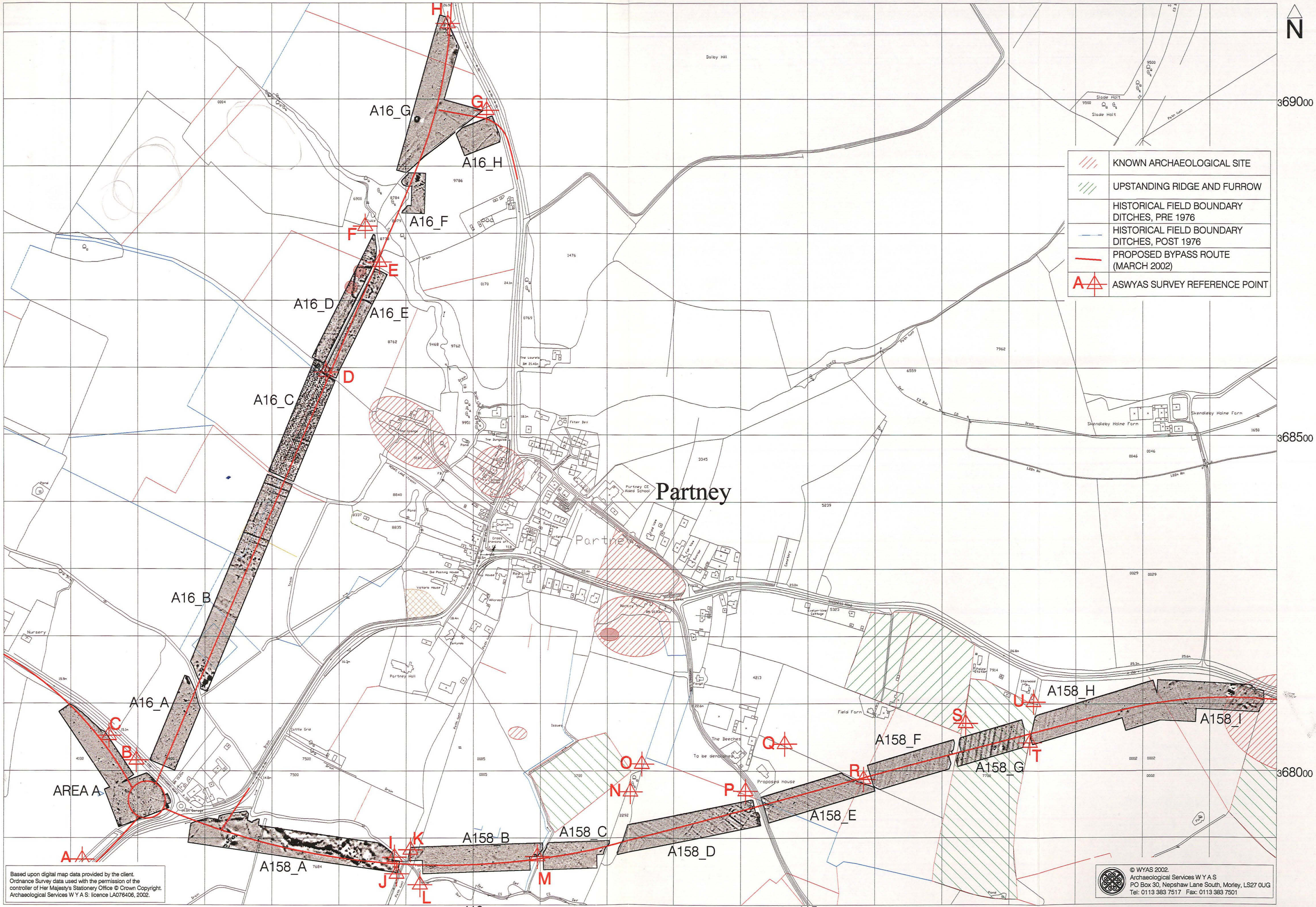

Fig. 2. Survey location information showing processed greyscale gradiometer data and detail from the Specification for Geophysical Survey (after Babtie Group 2002)

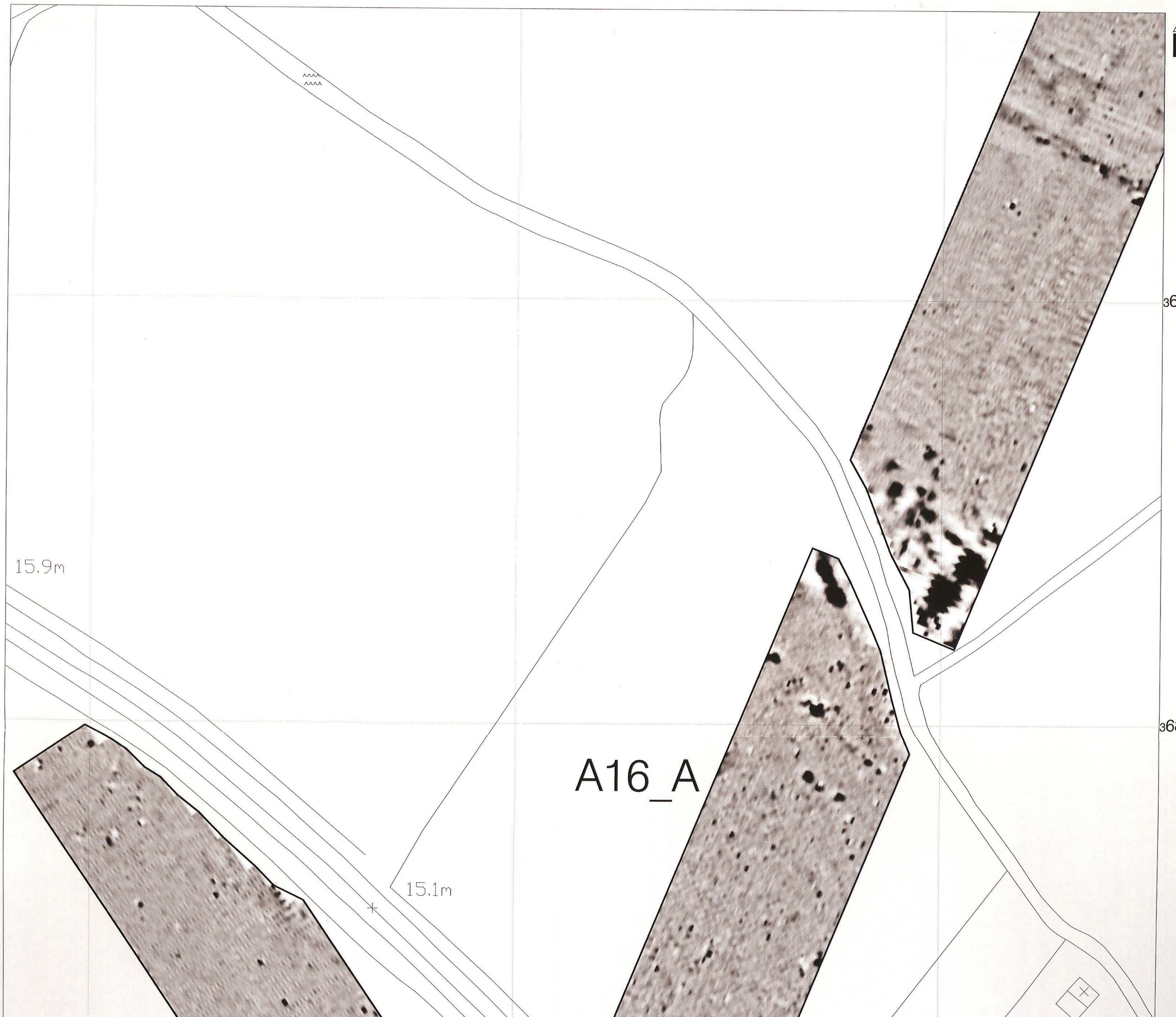

Fig. 3. Greyscale plot of the processed gradiometer data; Area A, Block A16_A and Block A16_B (southern part)

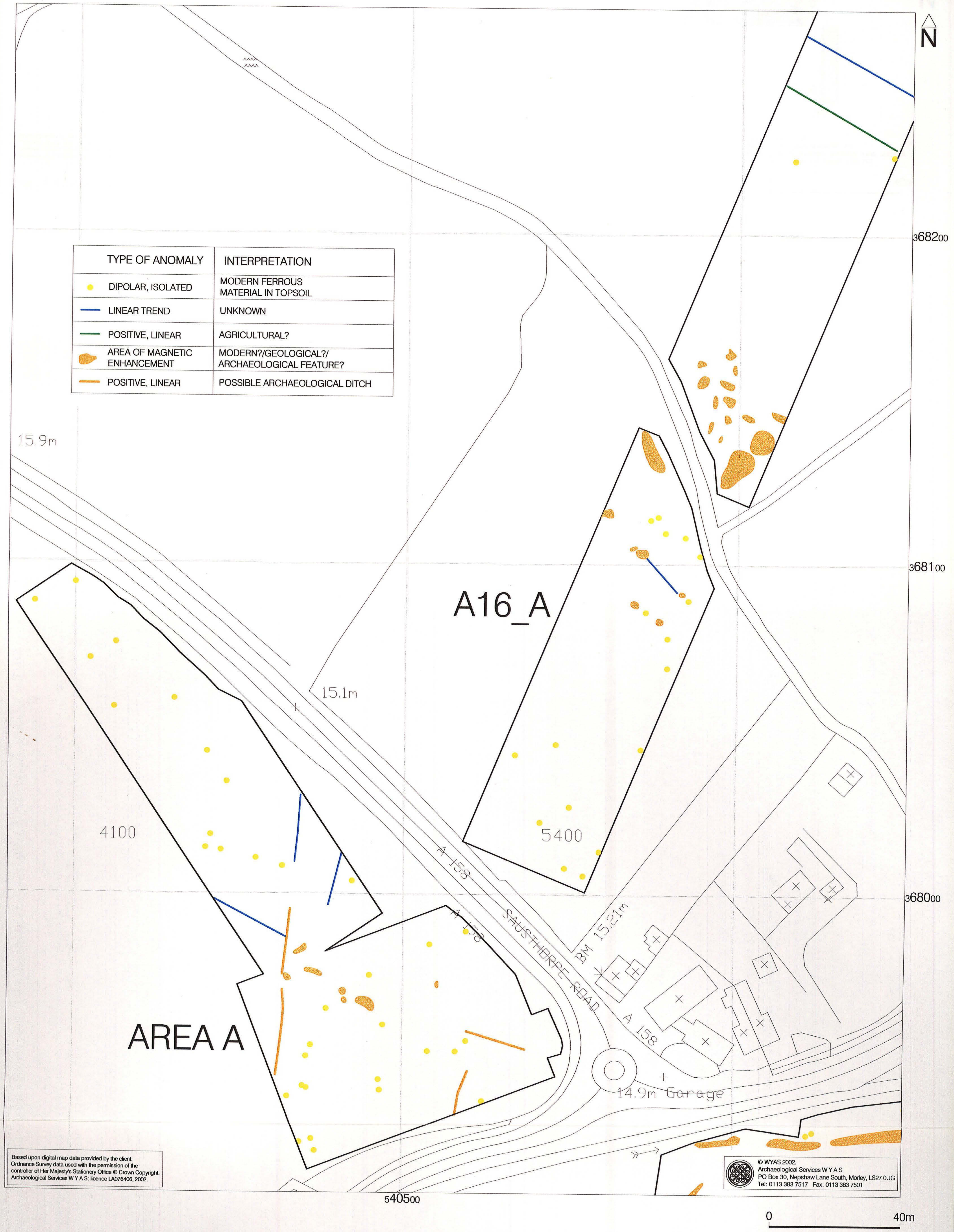

Fig. 4. Interpretation of gradiometer data; Area A, Block A16_A and Block A16_B (southern part)

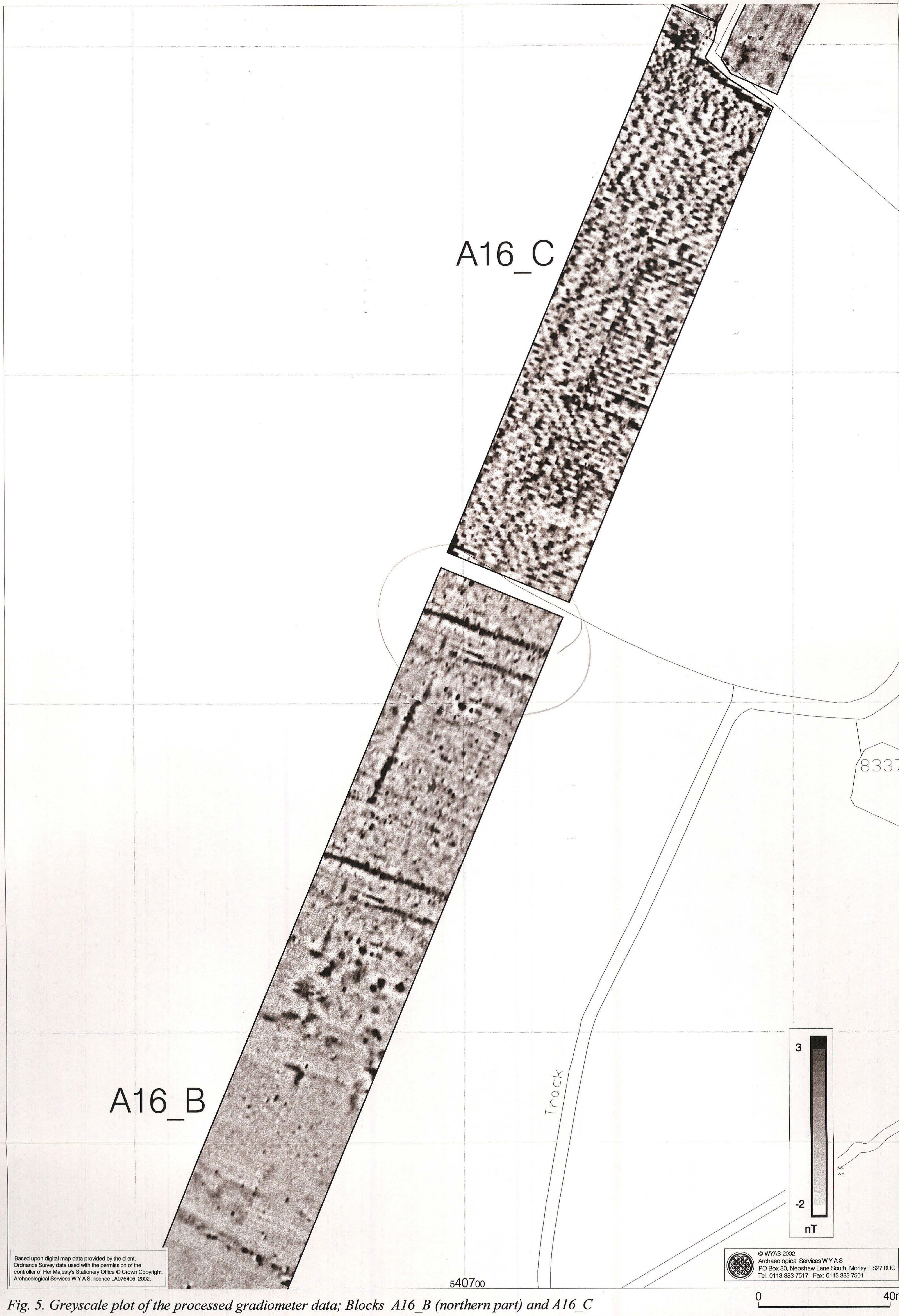

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Fig. 5. Greyscale plot of the processed gradiometer data; Blocks A16_B (northern part) and A16_C

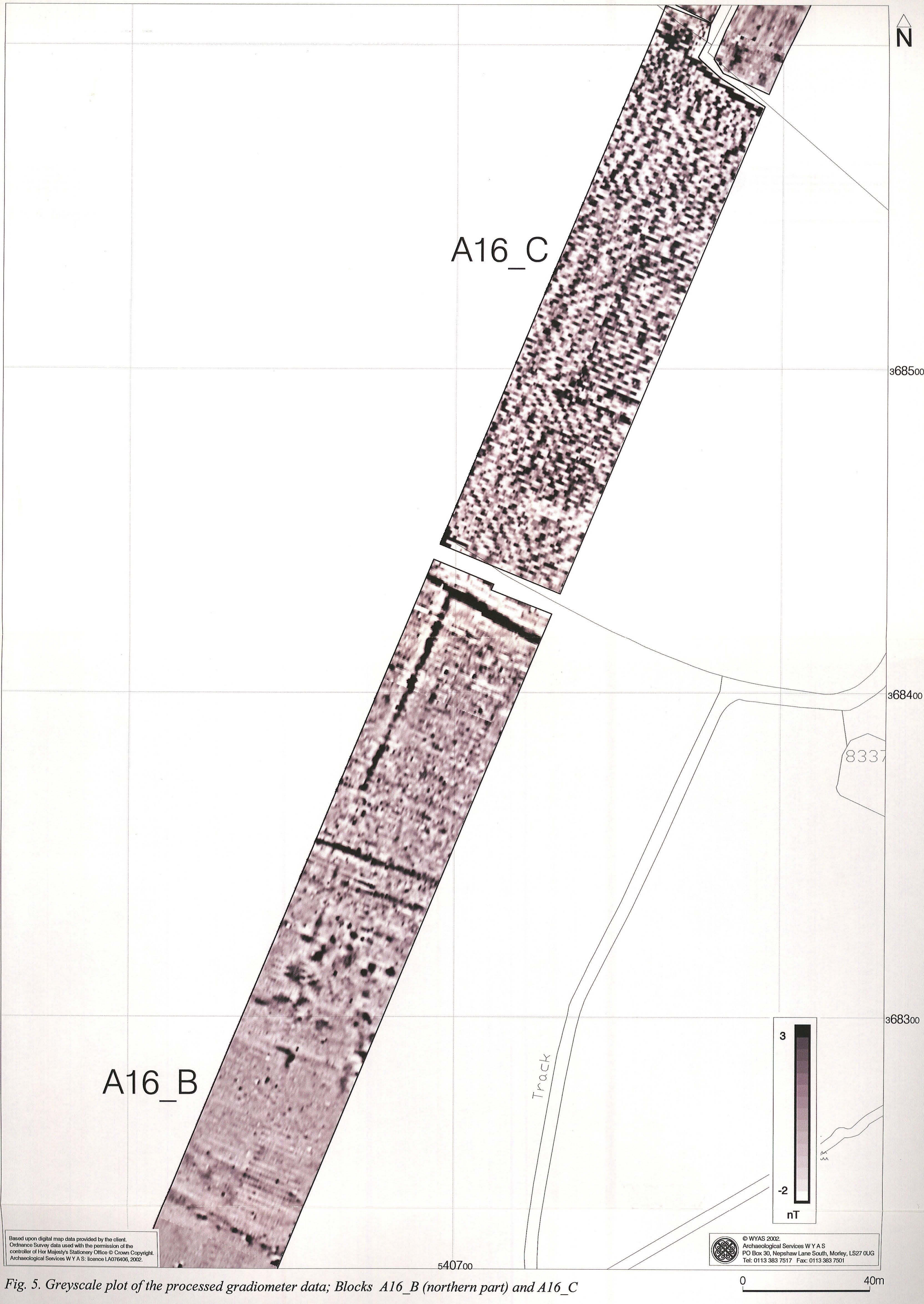

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Fig. 5. Greyscale plot of the processed gradiometer data; Blocks A16_B (northern part) and A16_C

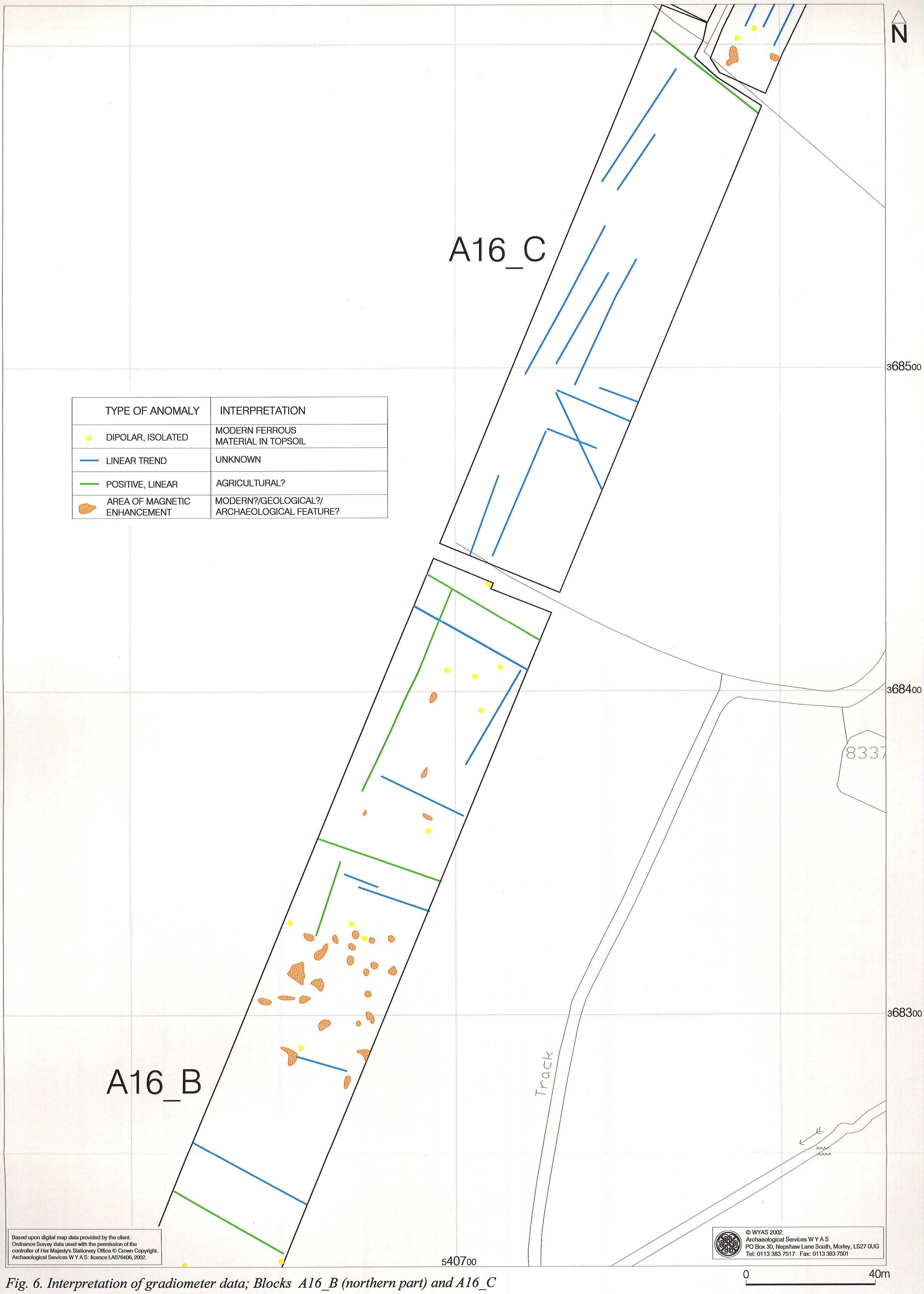

Fig. 6. Interpretation of gradiometer data; Blocks A16_B (northern part) and A16_C

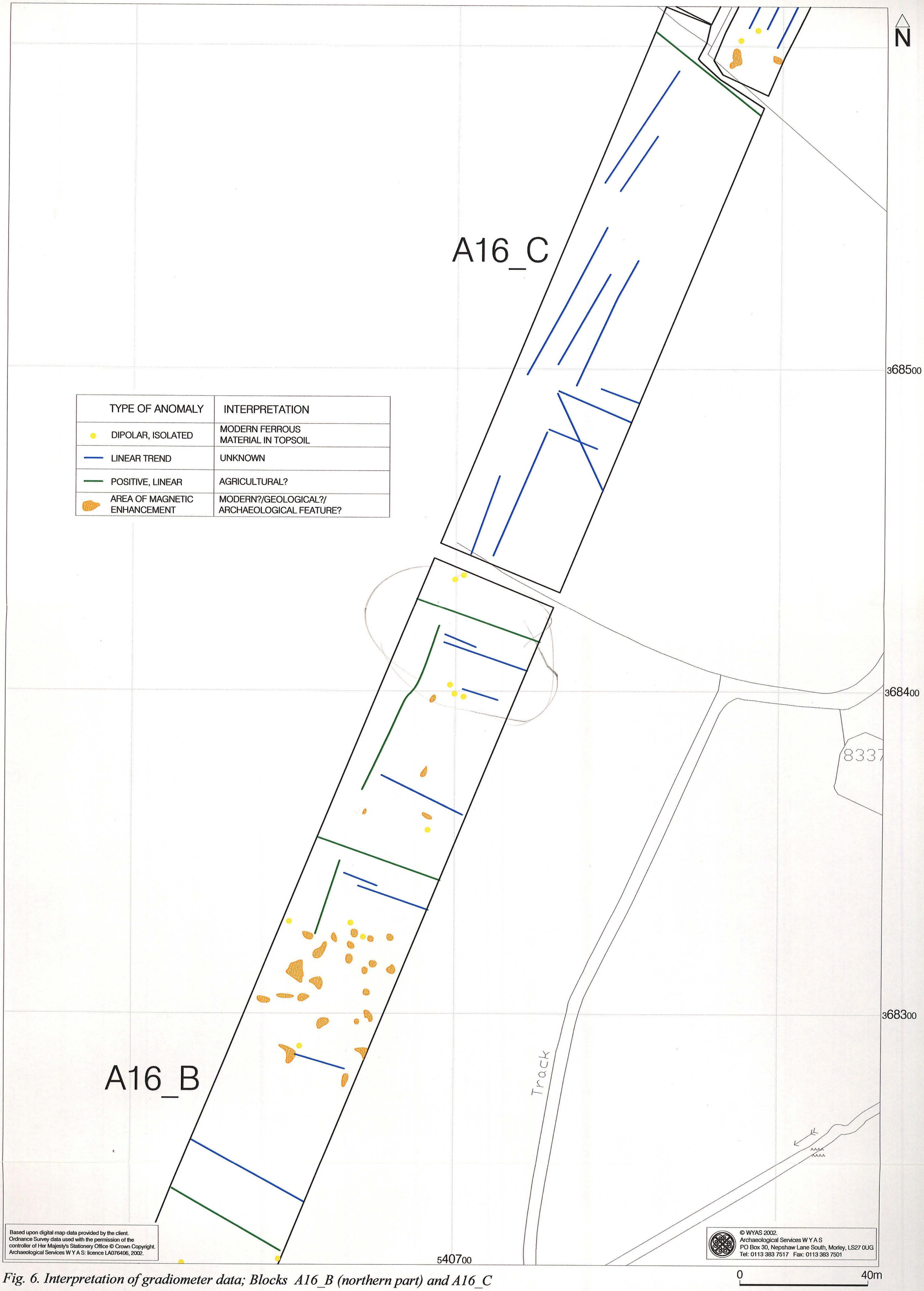

Fig. 6. Interpretation of gradiometer data; Blocks A16_B (northern part) and A16_C

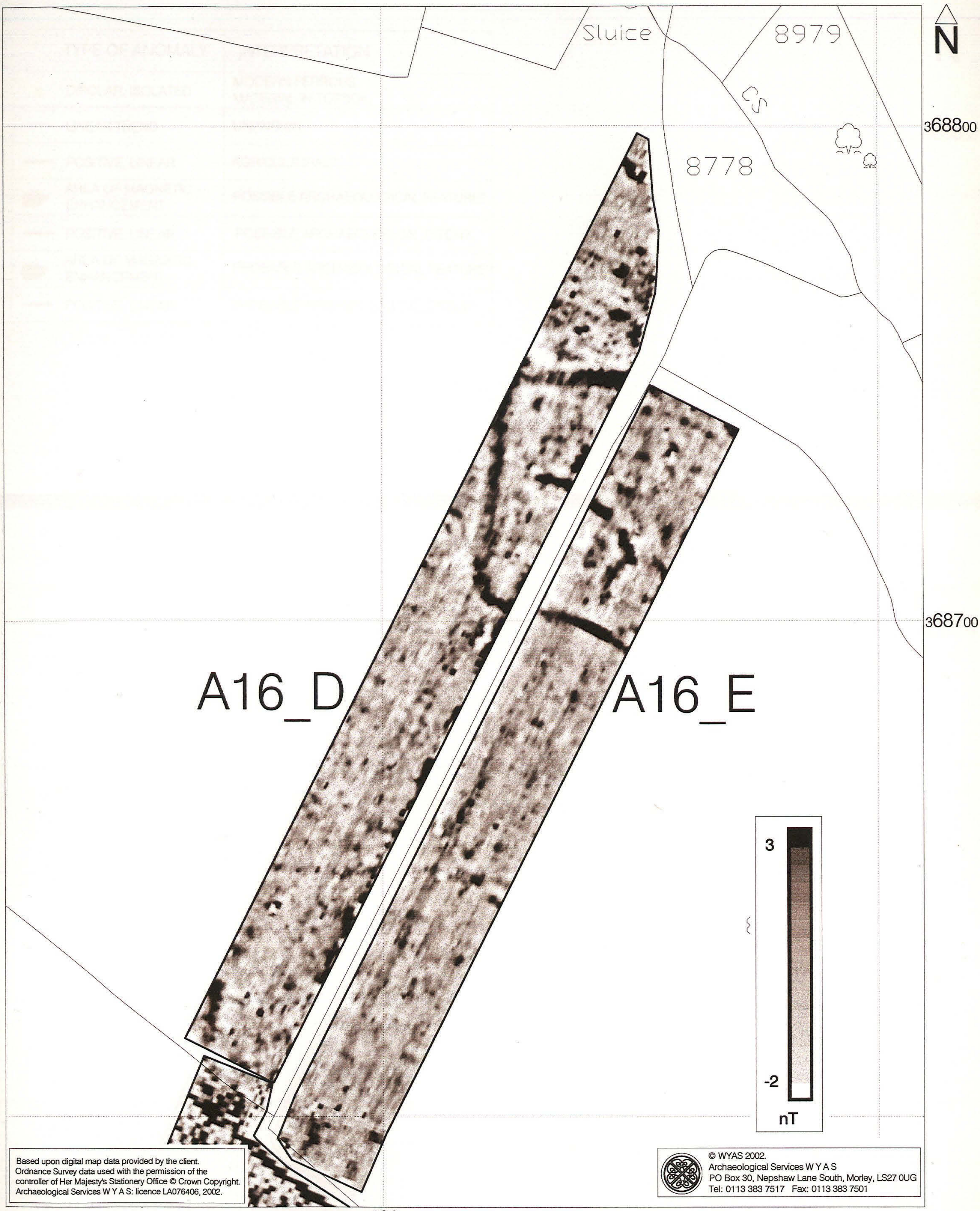

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Fig. 7. Greyscale plot of the processed gradiometer data; Blocks A16_D and A16_E

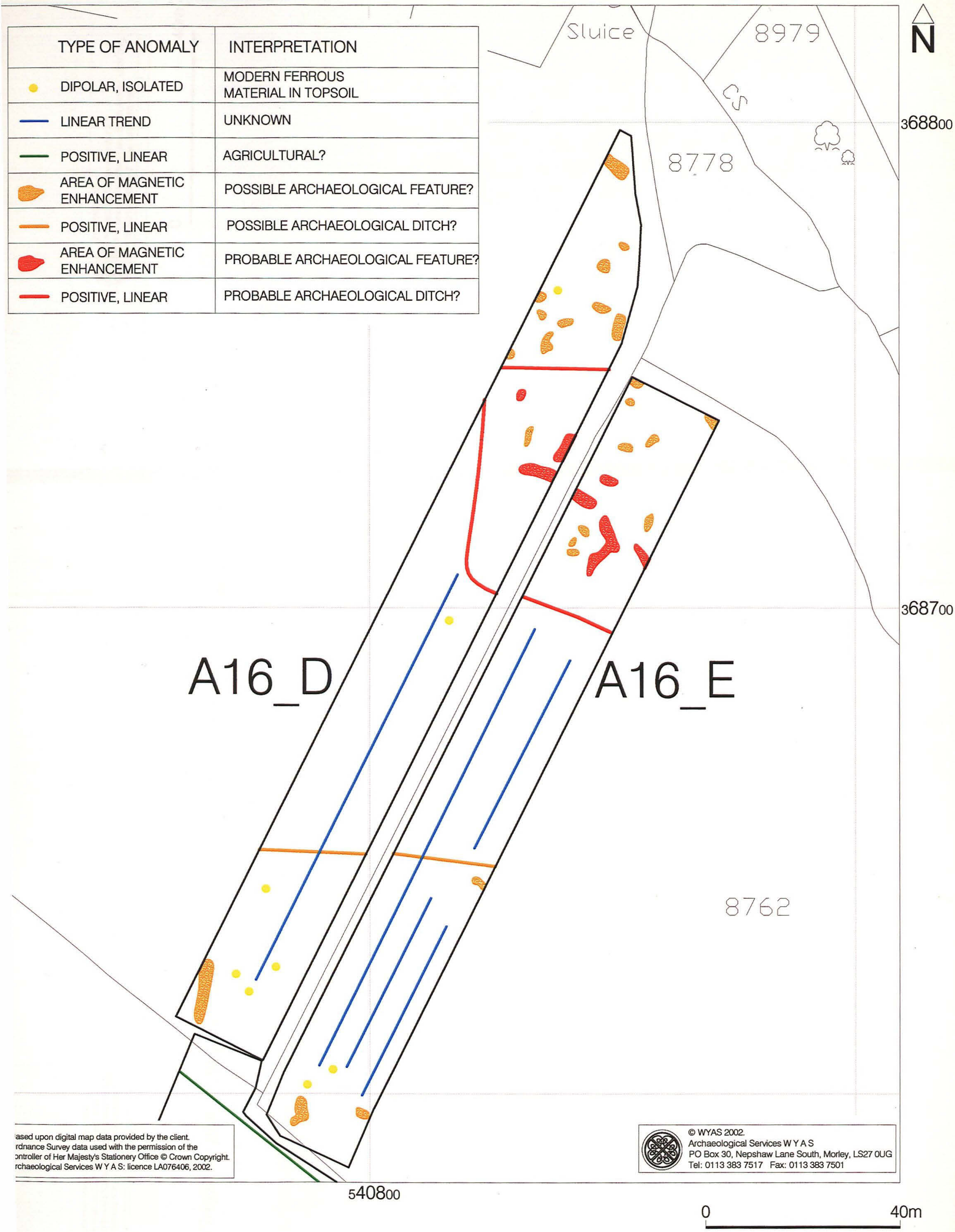


Fig. 8. Interpretation of gradiometer data; Blocks A16_D and A16_E

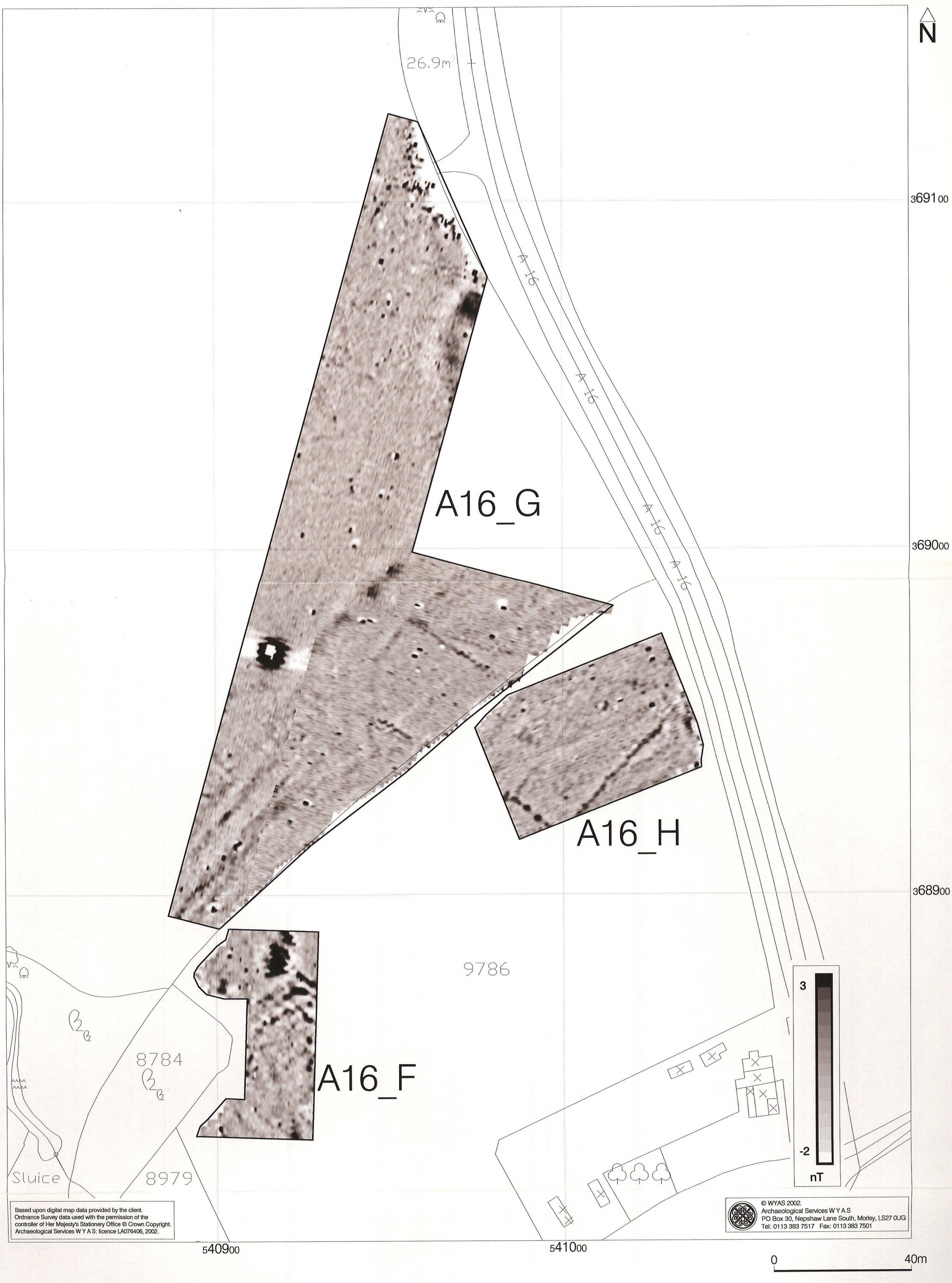


Fig. 9. Greyscale plot of the processed gradiometer data; Blocks A16_F, A16_G and A16_H

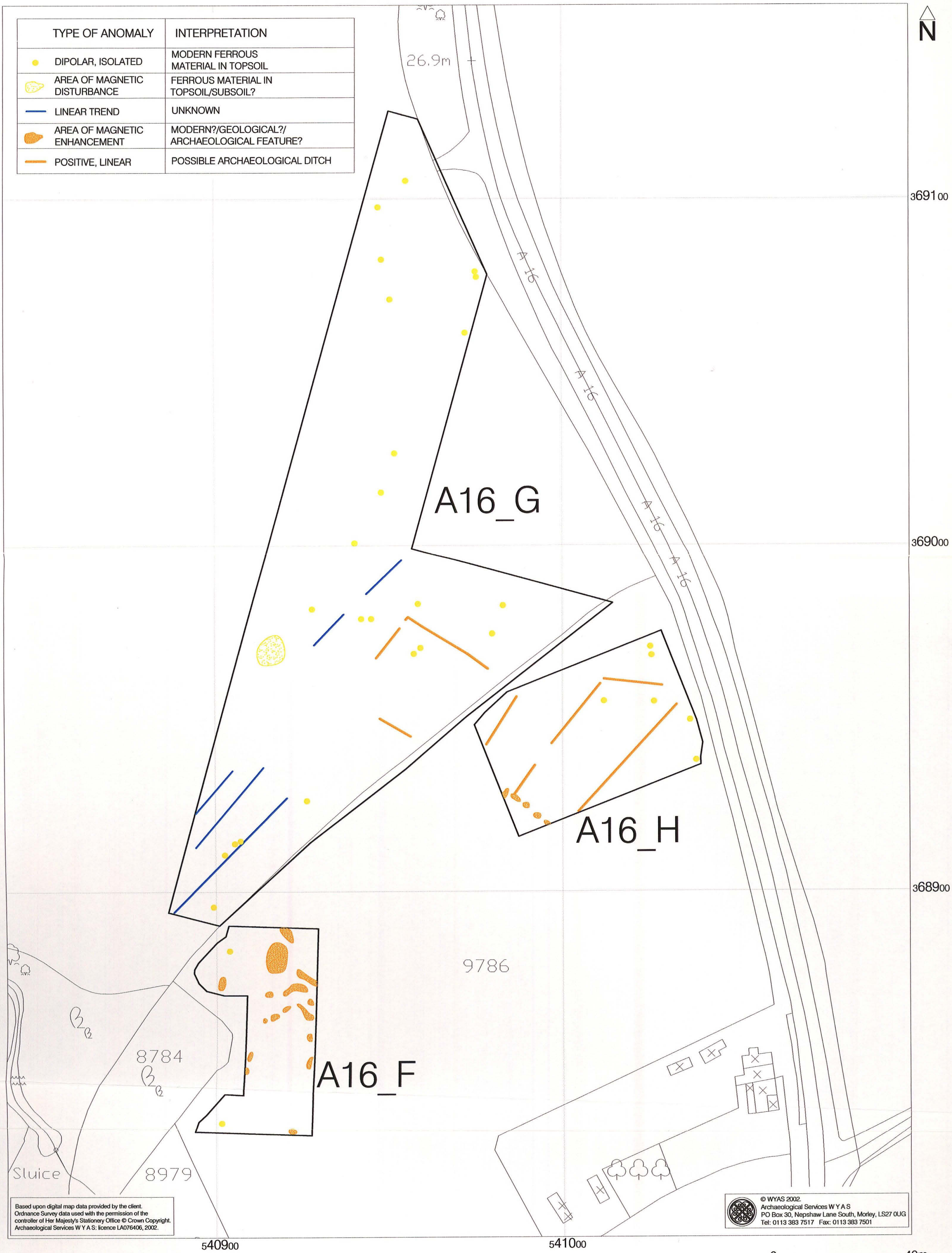


Fig. 10. Interpretation of gradiometer data; Blocks A16_F, A16_G and A16_H

Fig. 11. Greyscale plot of the processed gradiometer data; Block A158_A

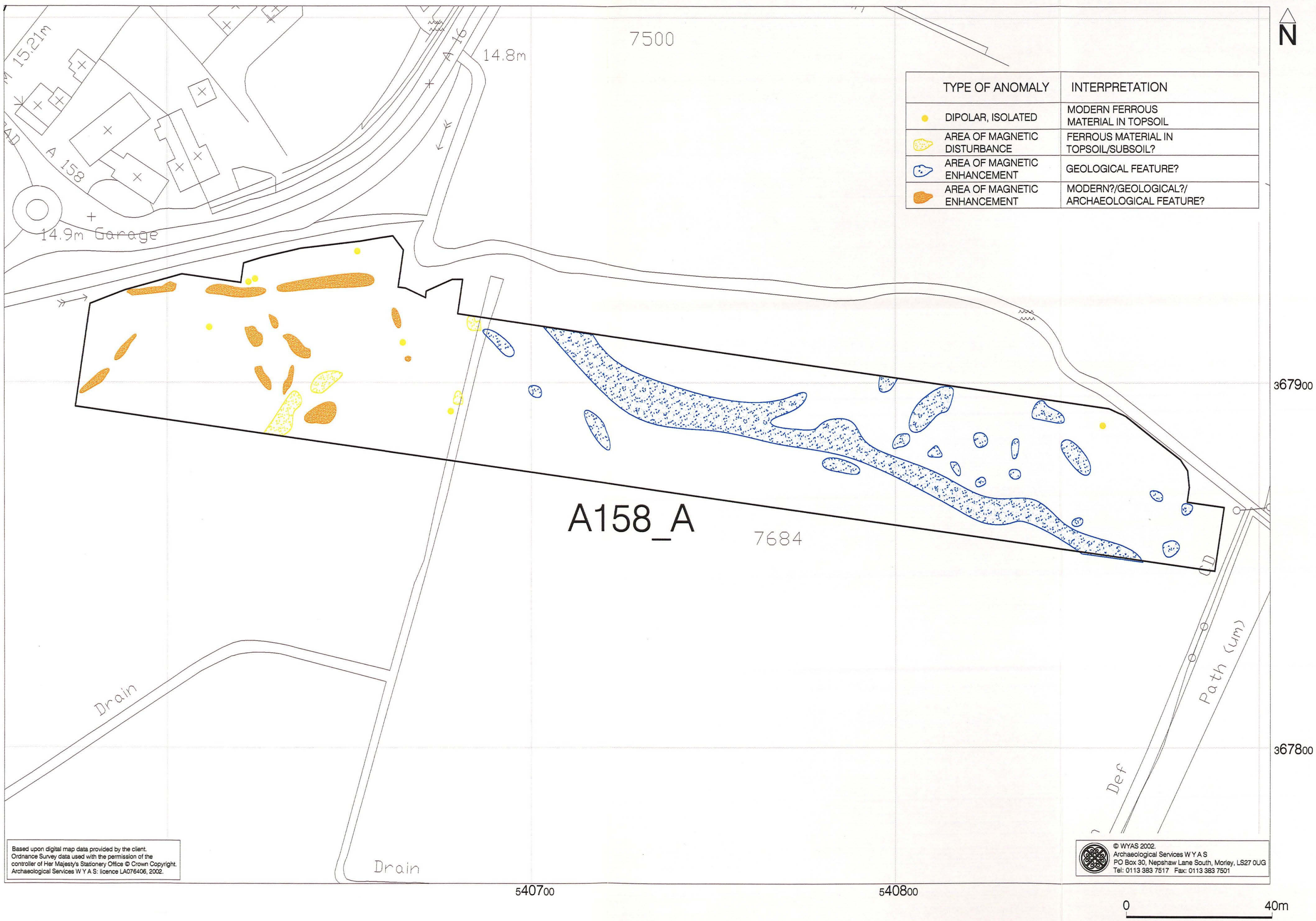
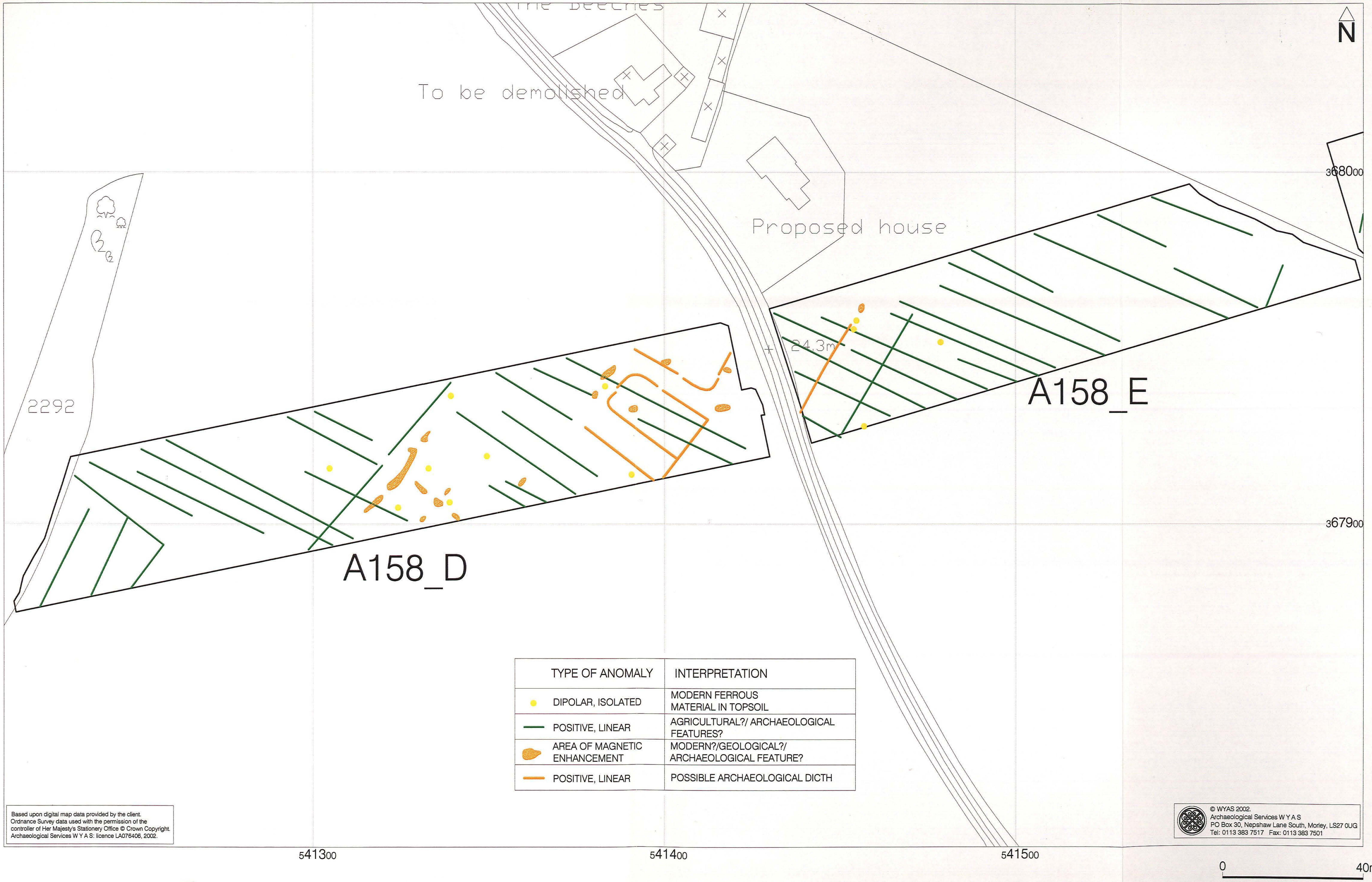


Fig. 12. Interpretation of gradiometer data; Block A158_A

Fig. 13. Greyscale plot of the processed gradiometer data; Blocks A158_B and C

Fig. 14. Interpretation of gradiometer data; Blocks A158_B and C

Fig. 15. Greyscale plot of the processed gradiometer data; Blocks A158_D and E



TYPE OF ANOMALY	INTERPRETATION
DIPOLAR, ISOLATED	MODERN FERROUS MATERIAL IN TOPSOIL
POSITIVE, LINEAR	AGRICULTURAL?/ ARCHAEOLOGICAL FEATURES?
AREA OF MAGNETIC ENHANCEMENT	MODERN?/GEOLOGICAL?/ ARCHAEOLOGICAL FEATURE?
POSITIVE, LINEAR	POSSIBLE ARCHAEOLOGICAL DICTH

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Fig. 16. Interpretation of gradiometer data; Blocks A158_D and E

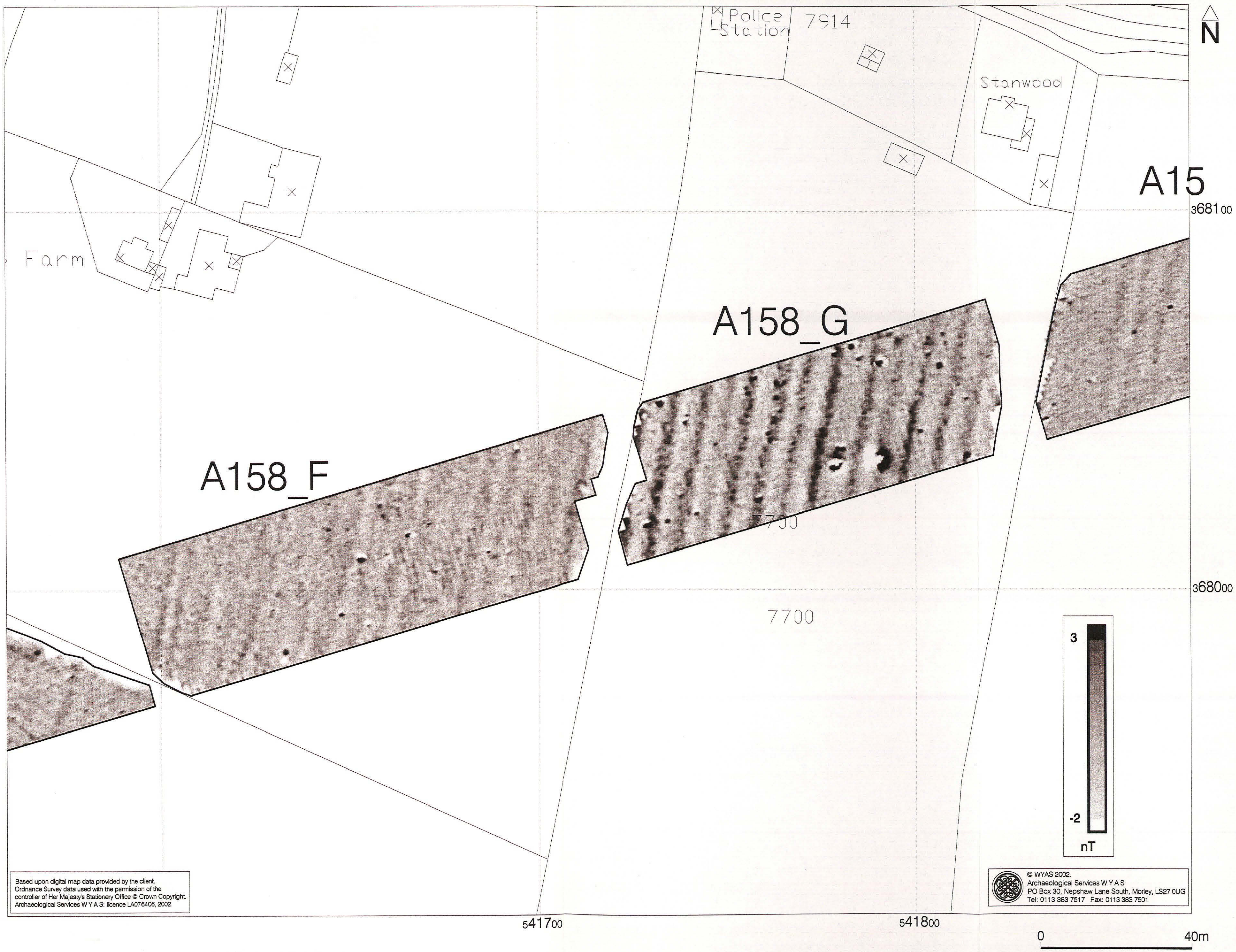


Fig. 17. Greyscale plot of the processed gradiometer data; Blocks A158_F and G

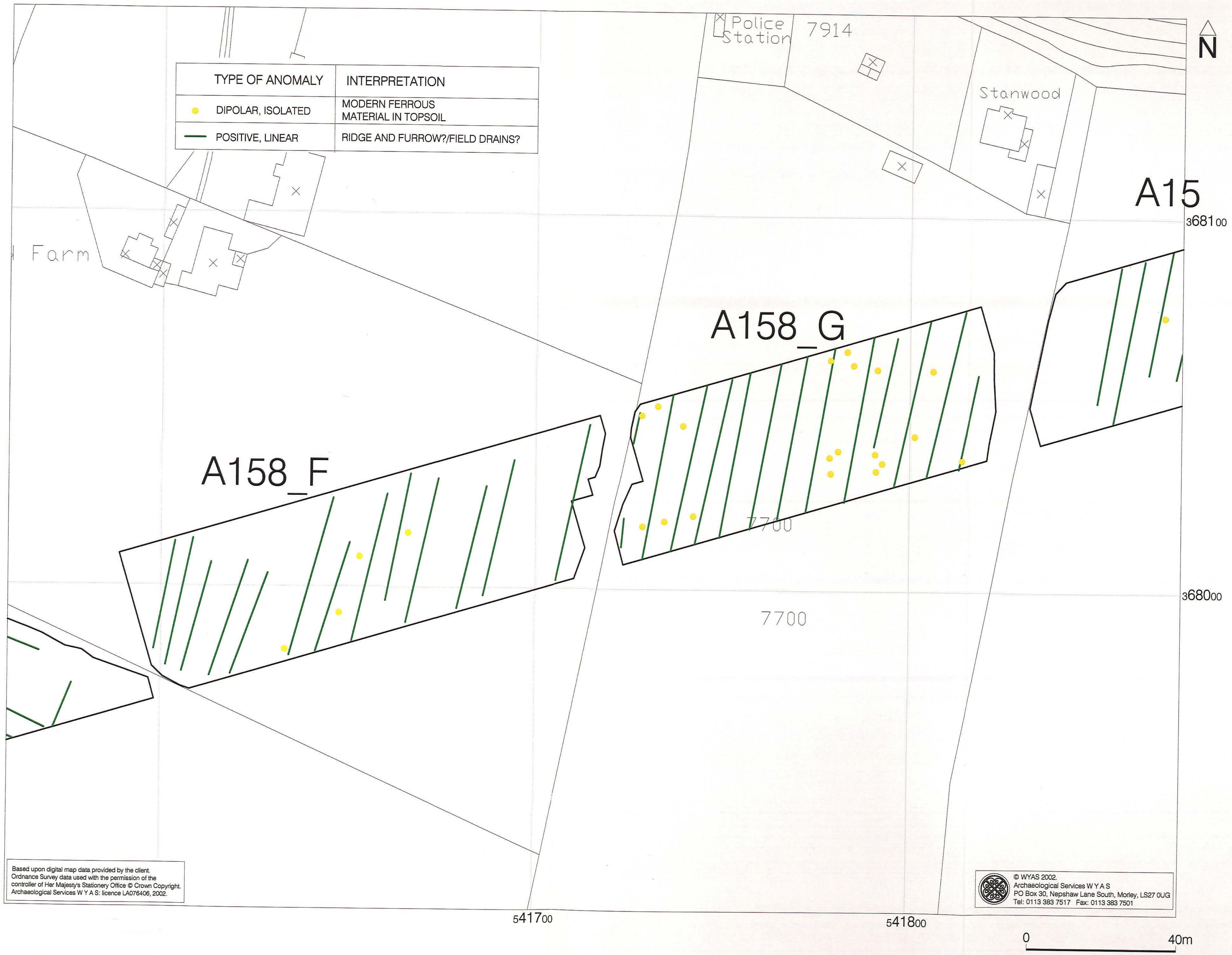


Fig. 18. Interpretation of gradiometer data; Blocks A158_F and G

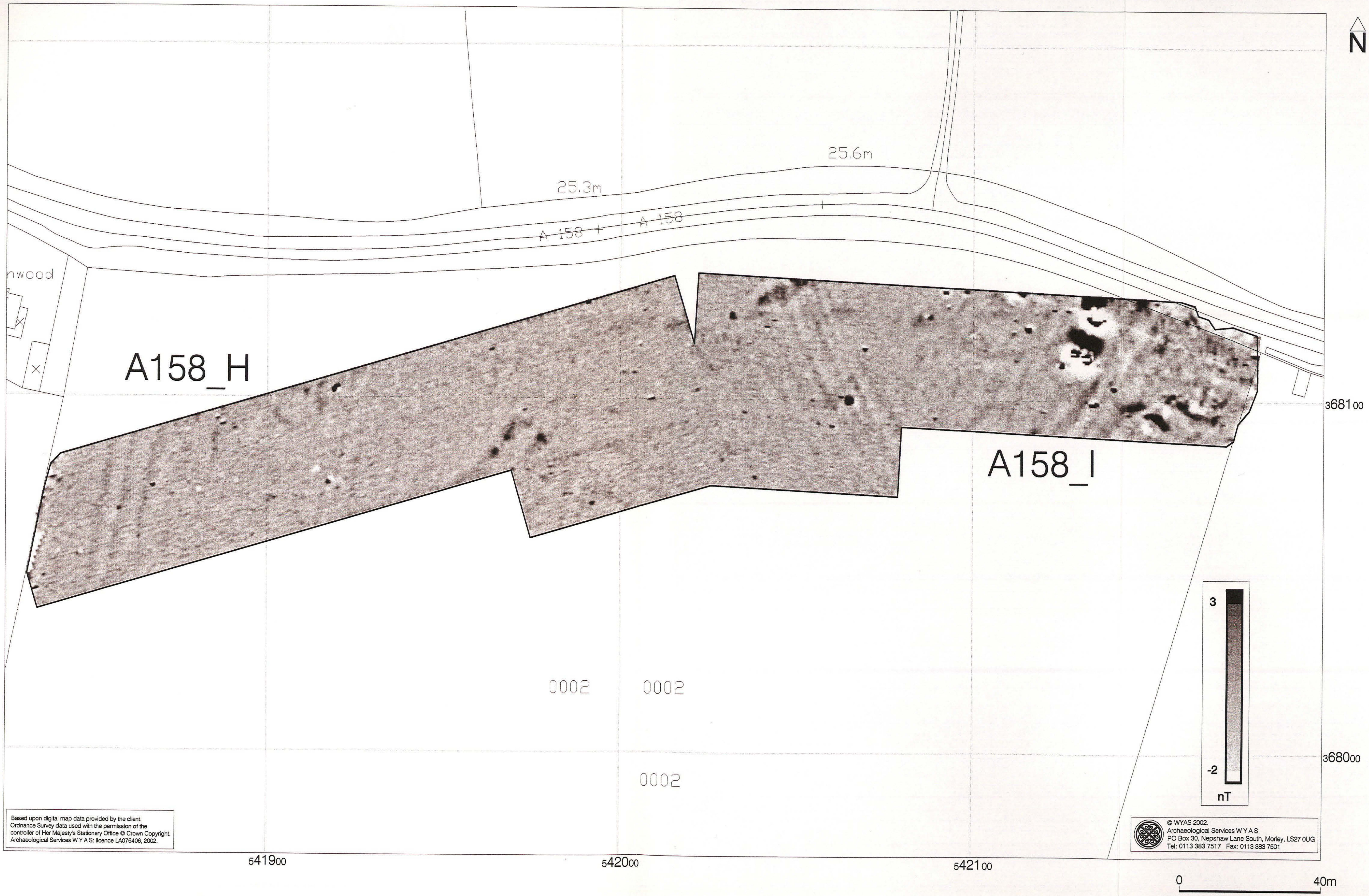


Fig. 19. Greyscale plot of the processed gradiometer data; Blocks A158_H and I

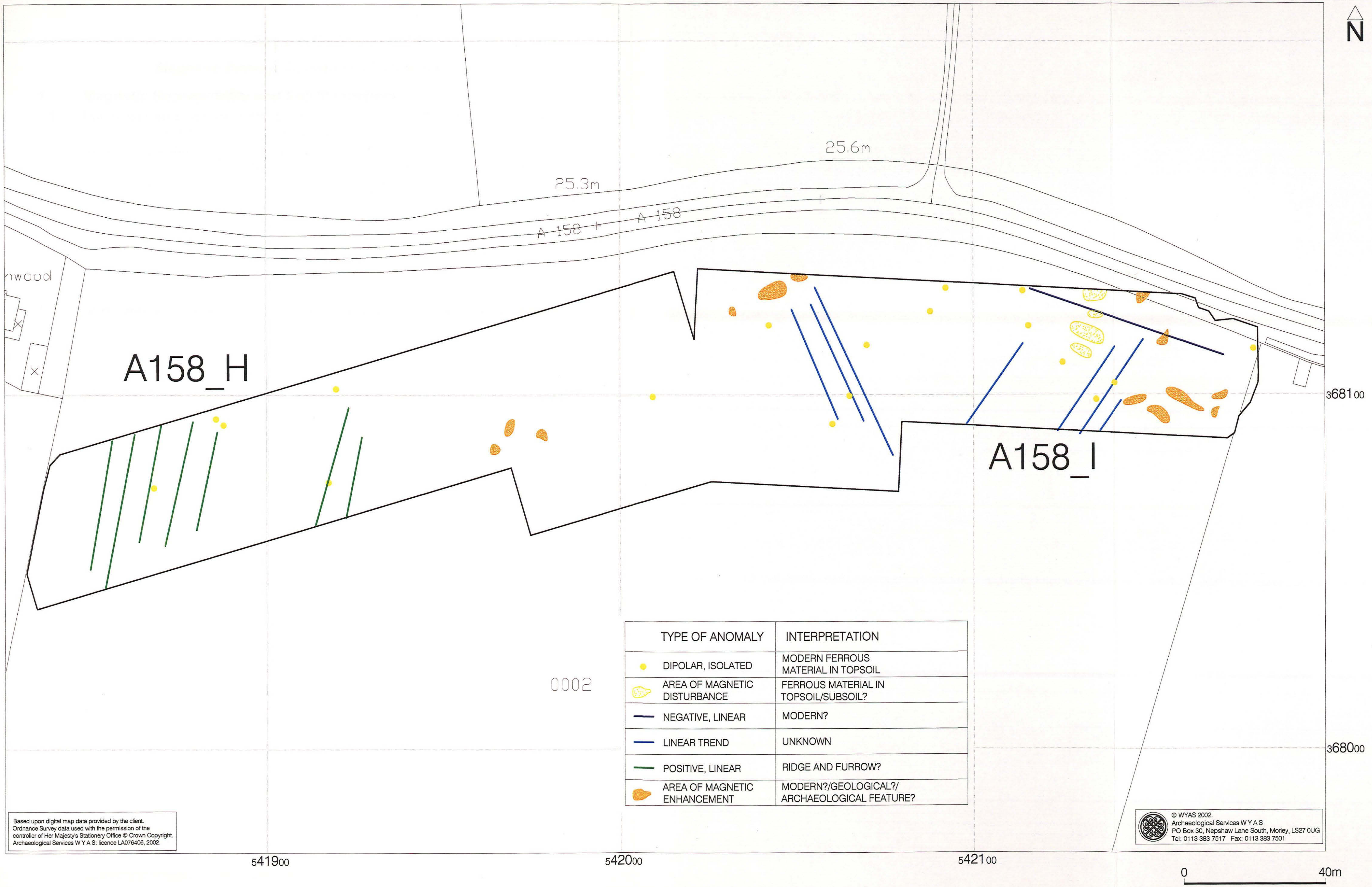


Fig. 20. Interpretation of gradiometer data; Blocks A158_H and I

Appendix 1

Magnetic Survey: Technical Information

1. Magnetic Susceptibility and Soil Magnetism

1.1 Iron makes up about 6% of the Earth's crust and is mostly present in soils and rocks as minerals such as maghaemite and haematite. 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).

1.2 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 which intrude into the topsoil may give a negative magnetic response relative to the background level.

1.3 The magnetic susceptibility of the soil can also be enhanced significantly by heating. This can lead to the detection of features such as hearths, kilns or burnt areas.

2. Types of Magnetic Anomaly

2.1 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 which, 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 geologies.

2.2 Where it is not possible to give a probable cause of an observed anomaly a '?' is appended.

2.3 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.

2.4 The types of response mentioned above can be divided into five main categories which 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. This type of anomaly is characterised by very strong, 'spiky' variations in the magnetic background. 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 X–Y trace plot) on two or three successive traverses. In neither instance is there the intense dipolar response characteristic of an area of magnetic disturbance or of an 'iron spike' (see above). These anomalies can be caused by infilled discrete archaeological features such as pits or post holes or by kilns, with the latter often being characterised by a strong, positive double peak response. 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.

3. *Methodology*

3.1 Magnetic Susceptibility Survey

3.1.1. 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.

3.2 Gradiometer Survey

3.2.1. There are two main methods of using the fluxgate gradiometer for commercial evaluations. The first of these is referred to as scanning and requires the operator to visually identify anomalous responses on the instrument display panel whilst covering the site in widely spaced traverses, typically 10-15m 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. In favourable circumstances scanning may be used to map out the full extent of features located during a detailed survey.

3.2.2. 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 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.

3.2.3. The Geoscan FM36 fluxgate gradiometer and ST1 sample trigger were used for the detailed gradiometer 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.

3.3 Data Processing and Presentation

3.3.1. The detailed gradiometer data has been presented in this report in X-Y trace and greyscale formats. An X-Y 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'. The X-Y trace plots were produced using Geoplot 3.0 (Geoscan Research) and were printed out at a range of 0.3 (12nT/cm). These print-outs were scanned and imported into AutoCAD 2000 as Tiff files so that the data could be superimposed onto the digital map base. The greyscale plots were also produced using Geoplot 3.0 (Geoscan Research). All greyscale plots are displayed in the range –2nT to 3nT using a linear incremental scale.

3.3.2. The 'raw' data, presented in Appendix 4 has had a grid biasing algorithm applied to balance the girds so that they all have mean of zero but has otherwise not undergone any processing. The processed data, as shown in Figures 2 to 20, has been selectively filtered to remove spurious errors such as striping effects and edge discontinuities caused by instrument drift and inconsistencies in survey technique caused by poor field conditions. A low pass filter has been applied and the data has been interpolated by 0.5 in both the X and the Y axes.

Appendix 2

Survey Location Information

1. A total of thirteen different geophysical survey grids were established. The centreline for each survey grid was established by measuring to the points at which the proposed road corridor intersected with extant field boundaries, as shown on the hardcopy 1:10000 plan provided by Babtie Group in their Specification for Geophysical Survey. There was generally a good match between the field boundaries, as indicated on the plan, and the actual boundaries in the field although there were problems in the fields containing Blocks A158_A and A158_D where the field boundaries did not match well those shown on the map base. Despite this all of the survey blocks were able to be located so that, where ground conditions allowed, the entire proposed road corridor was covered by detailed gradiometer survey.

2. Each survey grid was laid out and tied in to 'permanent' landscape features, such as fence lines, drains and temporary reference points (Fig. 2 and below), using a Trimble Geodimeter 600s total station theodolite. The survey grids were then superimposed onto an Ordnance Survey digital map base, provided by the client, using common field boundaries. Ordnance survey grid co-ordinates were then obtained for the reference points (Fig. 2 and below). The accuracy of the geophysical survey grids relative to the reference points is approximately ±0.05m.

3. There was generally a good correlation between the geophysical survey data and the digital map base and it is estimated that the average 'best fit' error is better than ±0.5m. Despite this good correlation it is recommended that if any of the survey grids need to be re-established accurately then the reference points listed below should be used. If other points are used then the error quoted by the Ordnance Survey for their digital data (±1.08m at 1:2500) must be considered.

4. The following is a brief description of the different survey grids and their respective reference points:

   Area A. Two survey grids were used and tied in to points A, B and C.

   A16_A, A16_B and A16_C. These blocks were laid out on the same survey grid and tied in to points A and B.

   A16_D and A16_E. These blocks were established 5m apart on the same survey grid and were tied in to points D, E and F.

   A16_F, A16_G and A16_H. Three separate survey grids were used for these blocks and all of them were tied in together to points G and H. The eastern part Block A16_G was surveyed on a different orientation to the western part.

   A158_A. Tied in to points I, J, K, L, M, N and O.

   A158_B and A158_C. These blocks were on the same survey grid and were also tied in to points I, J, K, L, M, N and O.

   A158_D. Tied in to points O and N.

   A158_E and A158_F. These blocks were laid out on the same survey grid and tied in to points Q and R.

A158_G. This block was on the same grid as A158_E and A158_F and was tied in to points R, S, U and T.

A158_H and I. These blocks were on different survey grids and were tied in to points U and T.

Station	Easting	Northing
A (wooden stake)	540417.22	367867.99
B (wooden stake)	540497.72	368015.89
C (wooden stake)	540456.85	368052.32
D (wooden stake)	540780.44	368593.49
E (wooden stake)	540860.55	368757.23
F (wooden stake)	540839.33	368810.70
G (wooden stake)	541020.27	368983.25
H (wooden stake)	540962.33	369112.57
I (borehole cover)	540882.72	367871.59
J (wooden stake)	540885.95	367846.66
K (wooden stake)	540906.59	367882.40
L (wooden stake)	540920.74	367830.51
M (borehole cover)	541095.62	367872.55
N (wooden stake)	541235.26	367968.43
O (wooden stake)	541252.46	368009.94
P (borehole cover)	541407.03	367970.15
Q (wooden stake)	541465.45	368040.11
R (survey marker)	541583.12	367987.26
S (wooden stake)	541735.42	368070.95
T (wooden stake)	541831.12	368042.05
U (survey marker)	541836.66	368102.67

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

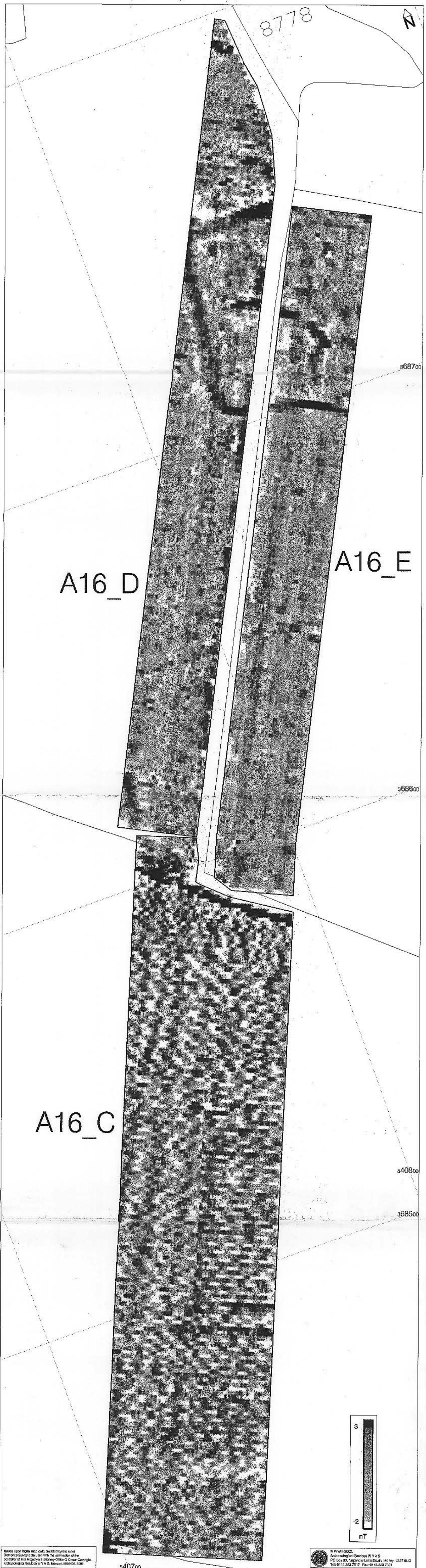
The geophysical archive comprises:-

- A digital archive containing compressed (WinZip 6) files of the raw data, report text (Word 97), and graphics files (CorelDraw6 and AutoCAD 2000).
- a full copy of the report

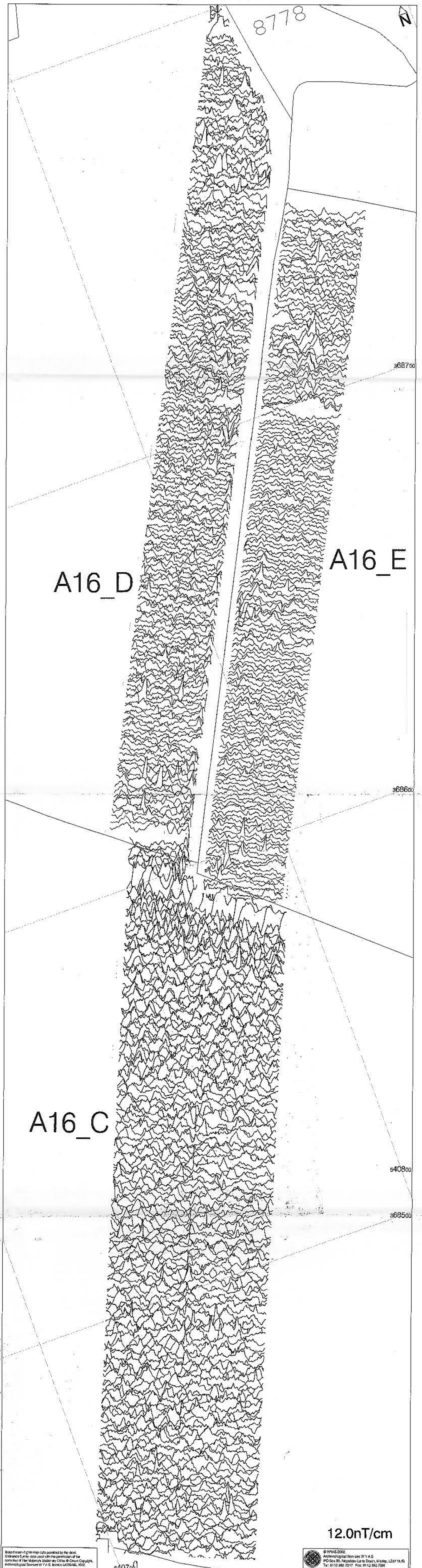
At present the archive is held by Archaeological Services WYAS although it is anticipated that it may eventually be lodged with the Archaeology Data Service (ADS). Brief details may also be forwarded for inclusion on the English Heritage Geophysical Survey Database after the contents of the report are deemed to be in the public domain (i.e. available for consultation in the relevant Sites and Monument Record Office).

Appendix 4

Gradiometer Data (1:500)



A16 - A158 Partney Bypass, Lincolnshire
Greyscale plot of the unprocessed gradiometer data; Blocks A16_C, A16_D and A16_E (1:500)



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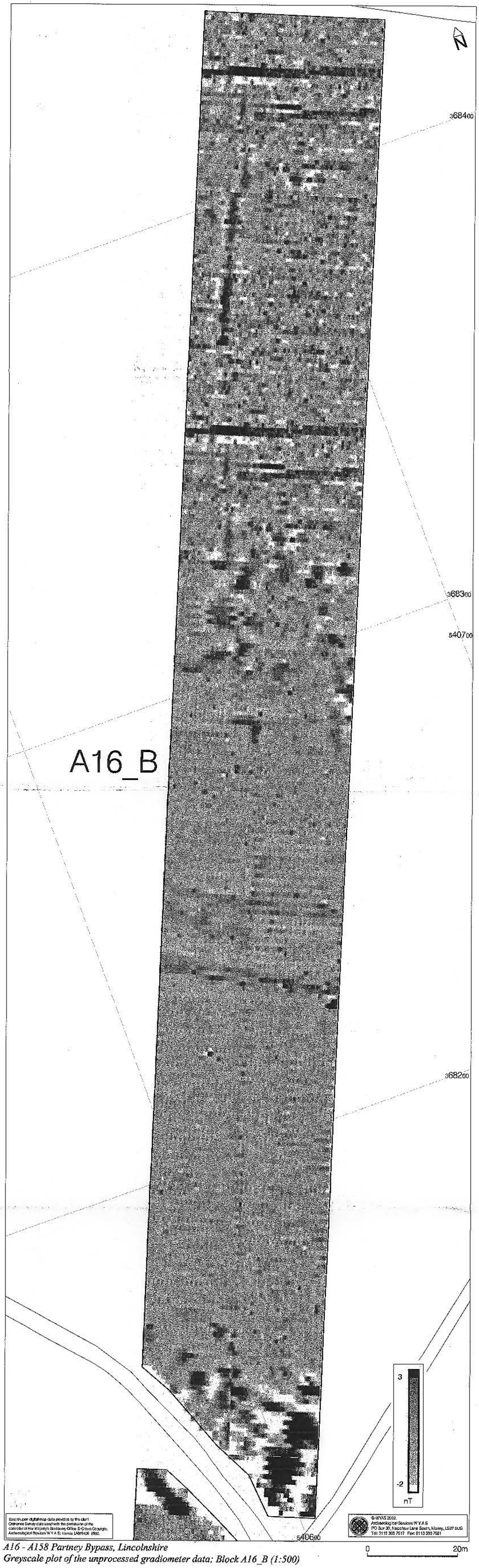
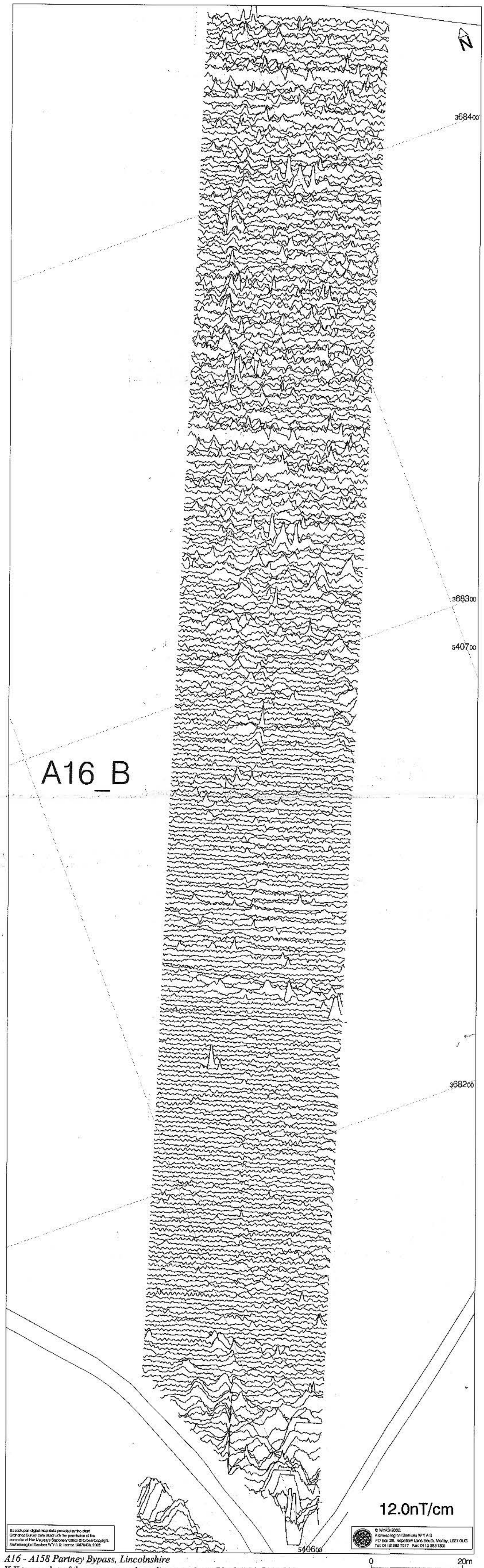
X-Y trace plot of the unprocessed gradiometer data; Blocks A16_C, A16_D and A16_E (1:500)



A16 - A158 Partney Bypass, Lincolnshire
Greyscale plot of the unprocessed gradiometer data; Block A16_B (1:500)



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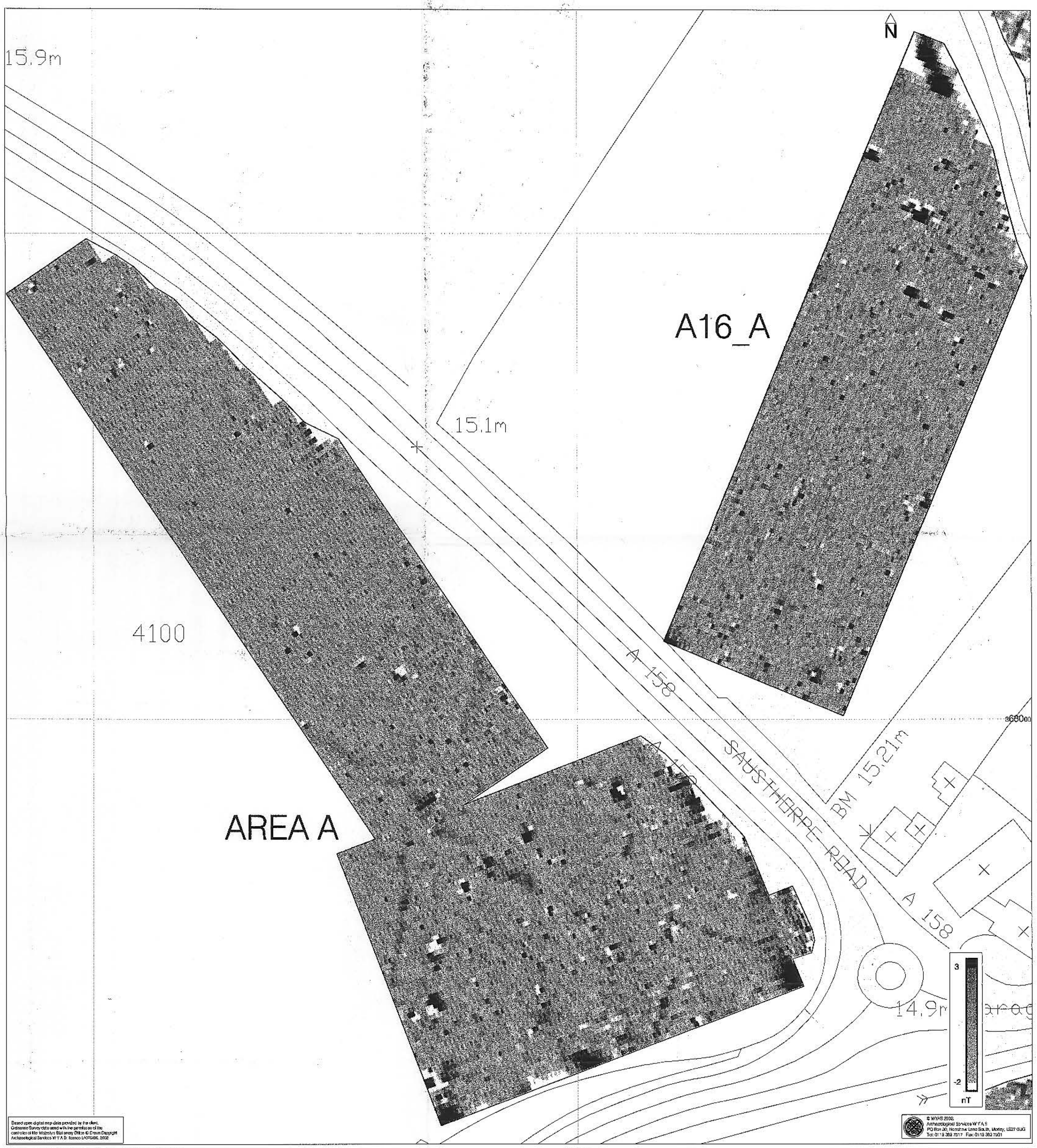
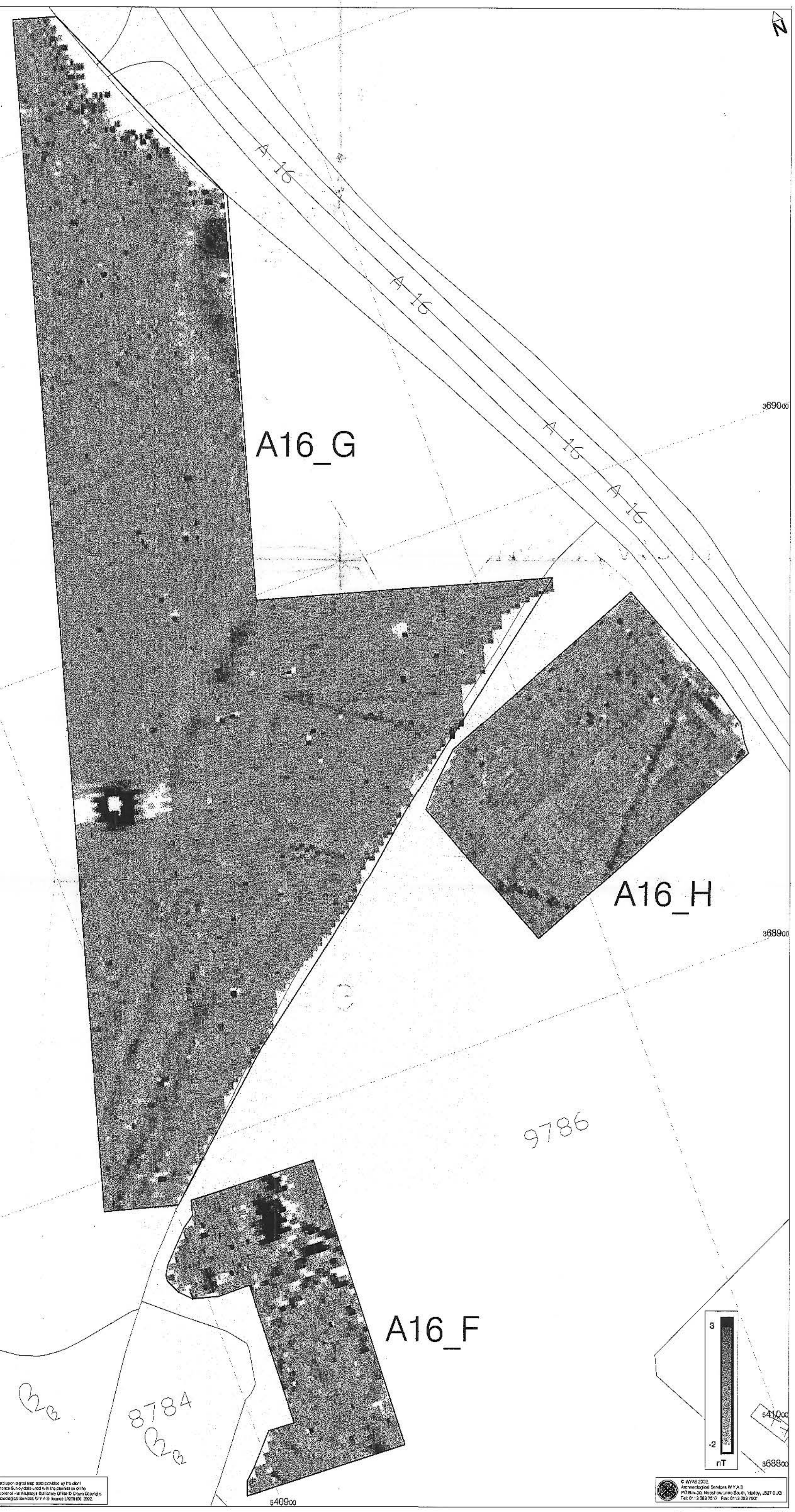
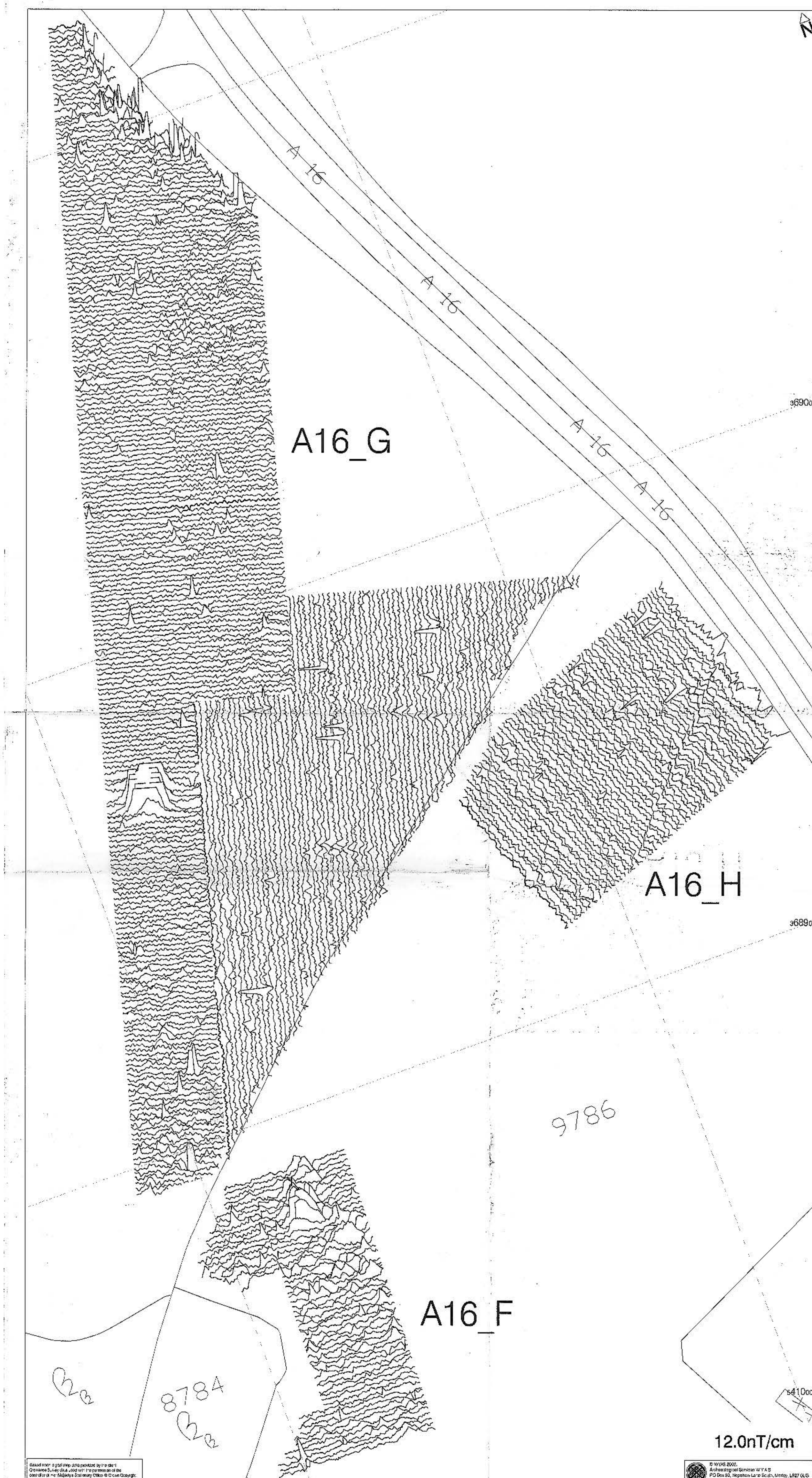


A16 - A158 Partney Bypass, Lincolnshire
Greyscale plot of the unprocessed gradiometer data; Area A and Block A16_A (1:500)

A16 - A158 Partney Bypass, Lincolnshire
X-Y trace plot of the unprocessed gradiometer data; Area A and Block A16_A (1:500)



16 - A158 Partney Bypass, Lincolnshire
reyscale plot of the unprocessed gradiometer data; Blocks A16_F, A16_G and A16_H (1:500)



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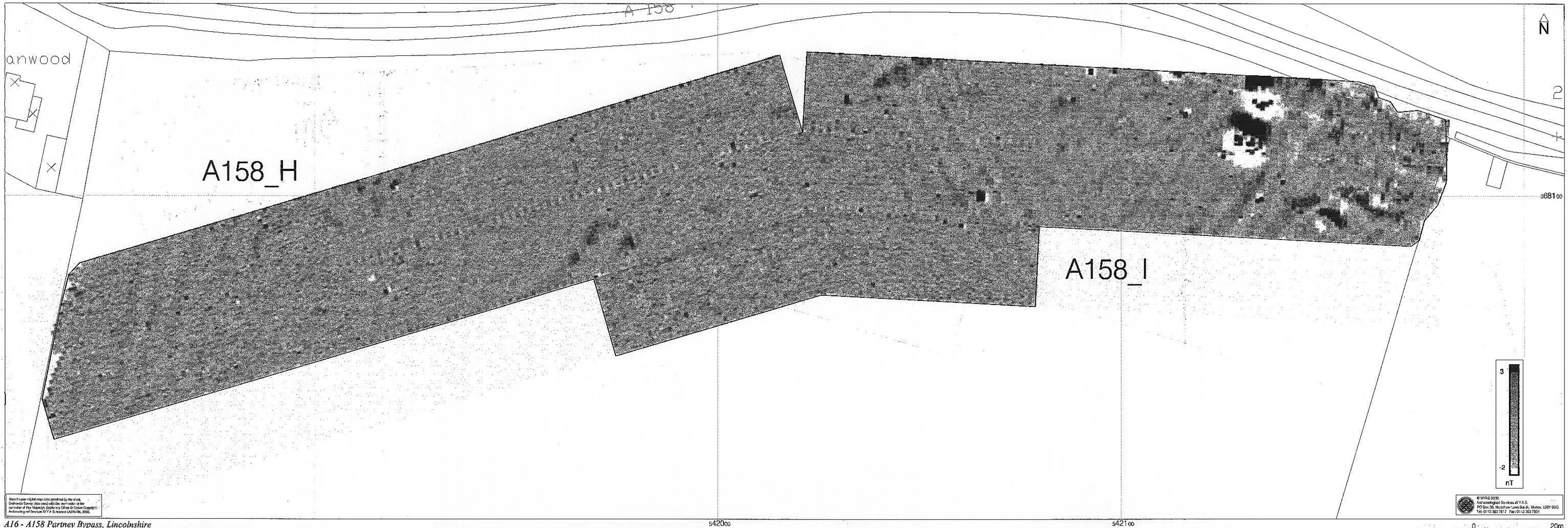
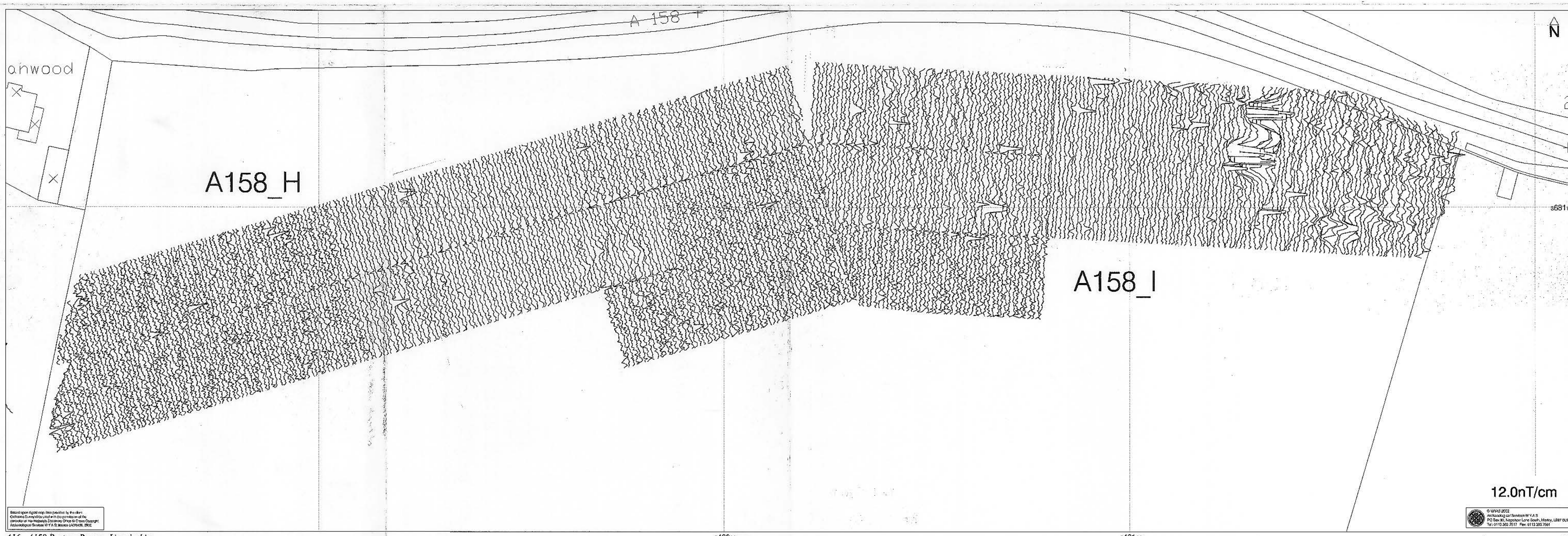
X-Y trace plot of the unprocessed gradiometer data; Blocks A16_F, A16_G and A16_H (1:500)



A16 - A158 Partney Bypass, Lincolnshire
Greyscale plot of the unprocessed gradiometer data; Blocks A158_H and A158_I (1:500)



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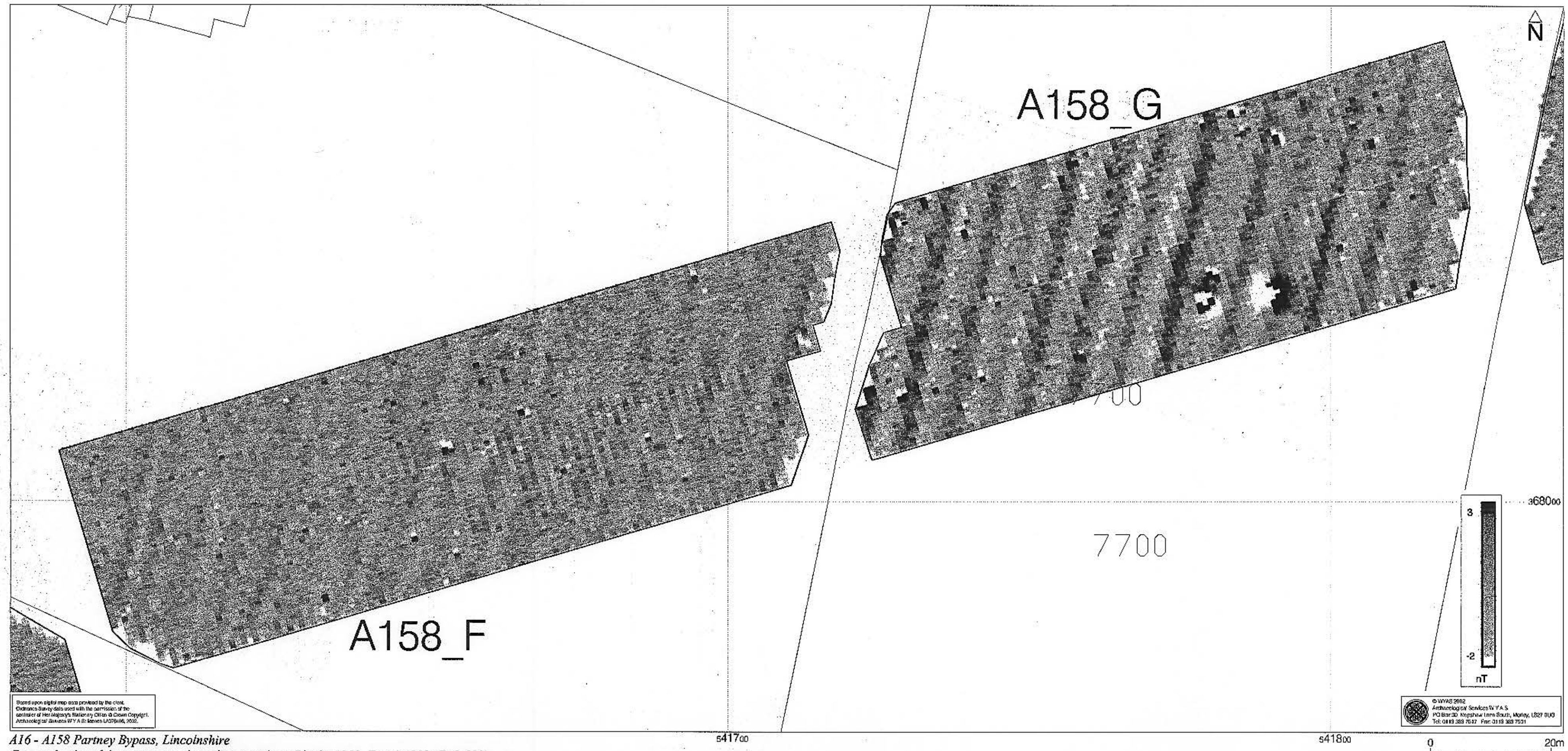
X-Y trace plot of the unprocessed gradiometer data; Blocks A158_H and A158_I (1:500)



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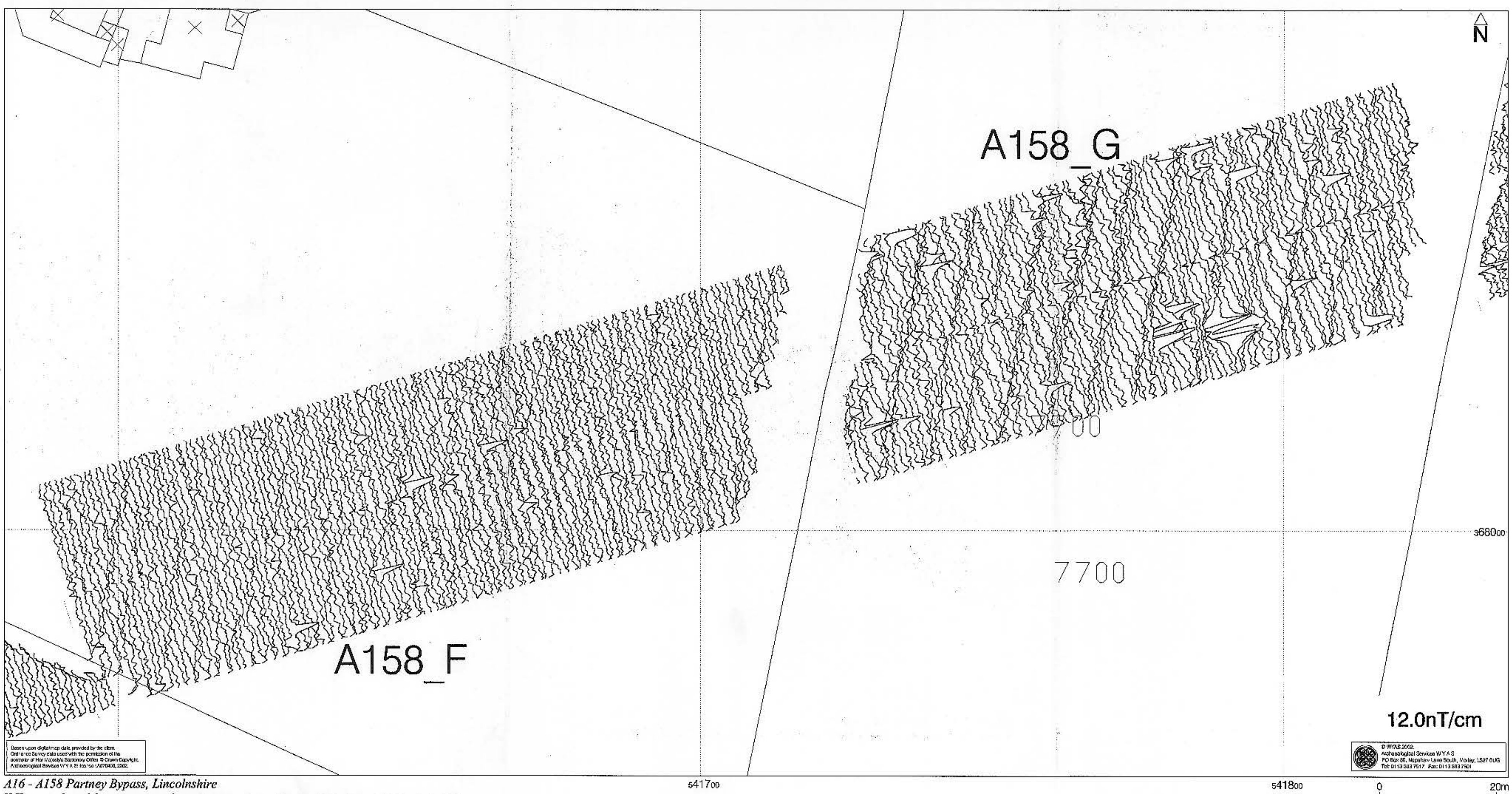
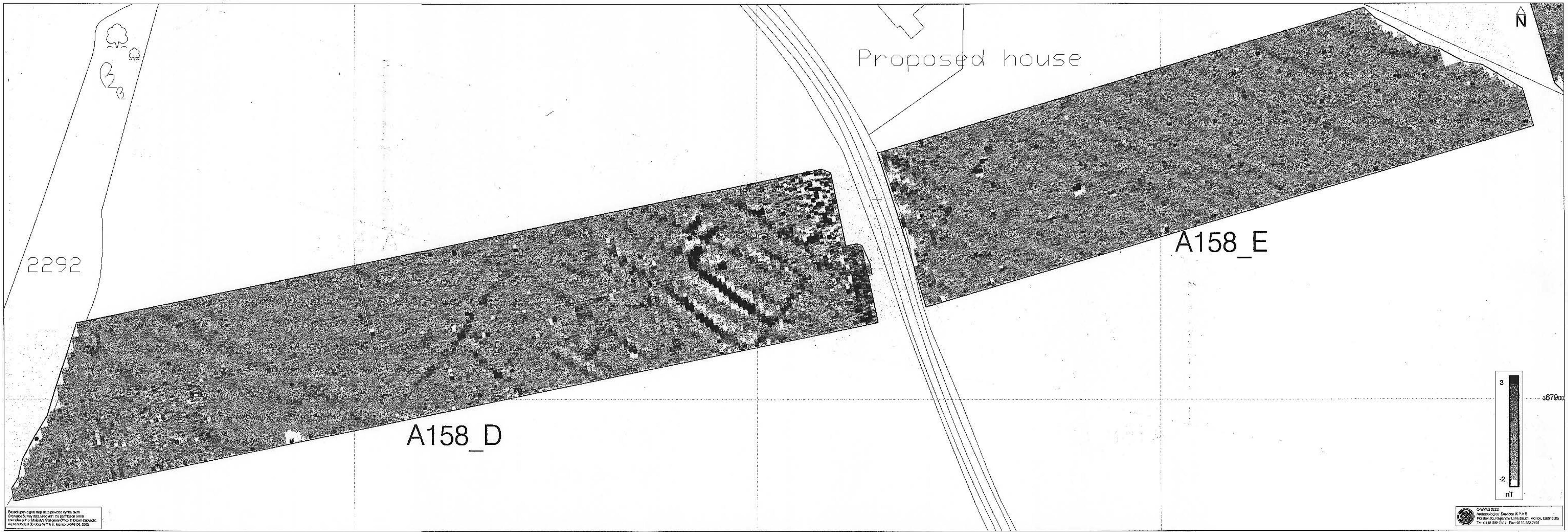
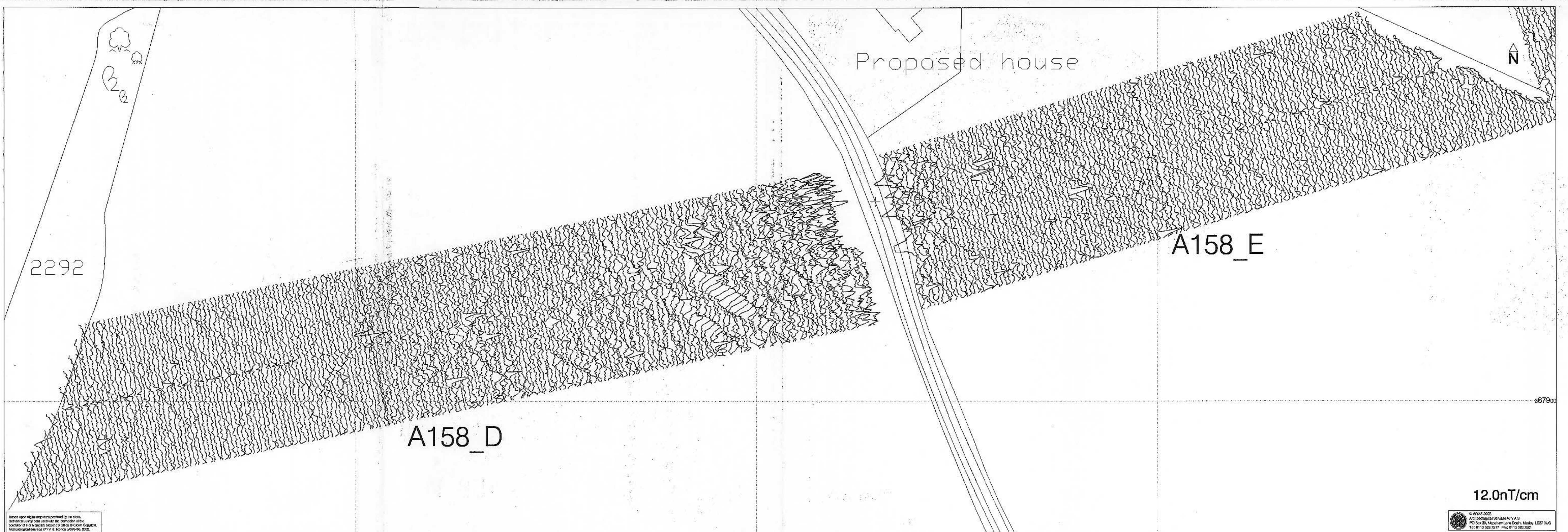
Greyscale plot of the unprocessed gradiometer data; Blocks A158_F and A158_G (1:500)



A16 - A158 Partney Bypass, Lincolnshire
X-Y trace plot of the unprocessed gradiometer data; Blocks A158_F and A158_G (1:500)

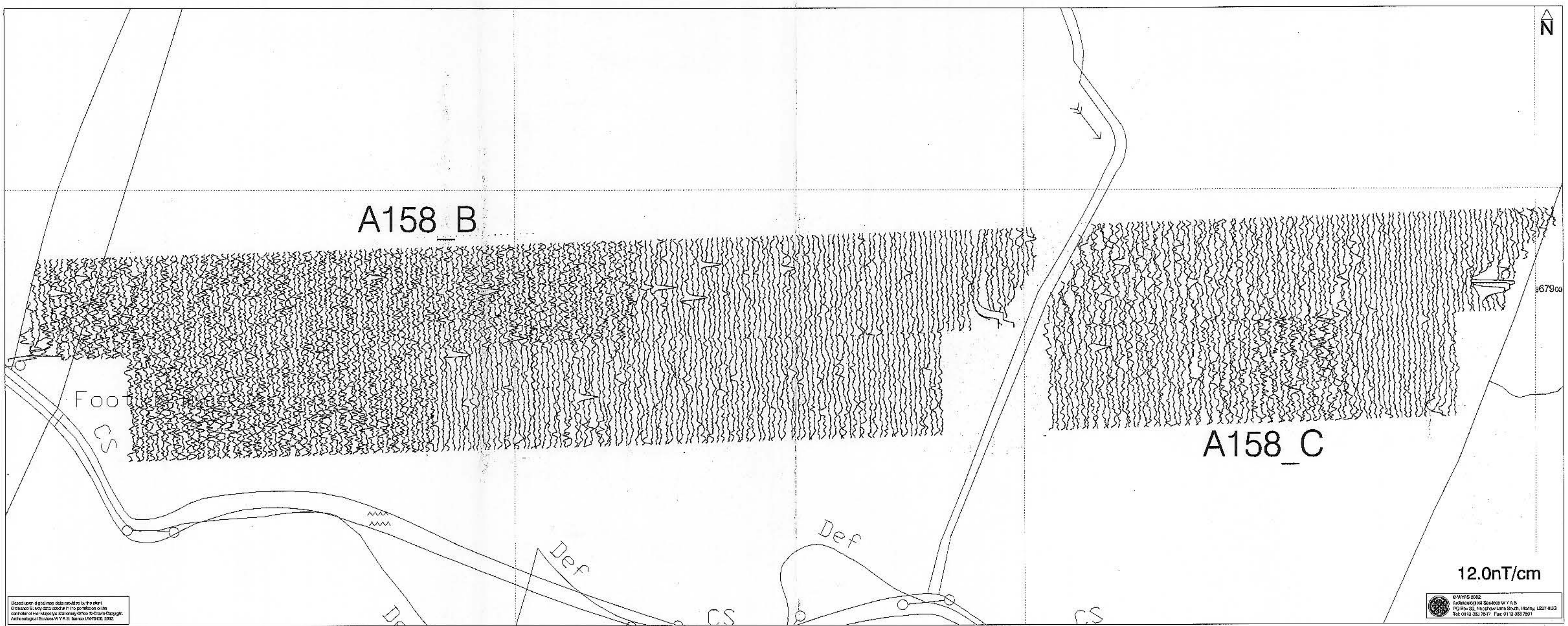


A16 - A158 Partney Bypass, Lincolnshire
Greyscale plot of the unprocessed gradiometer data; Blocks A158_D and A158_E (1:500)

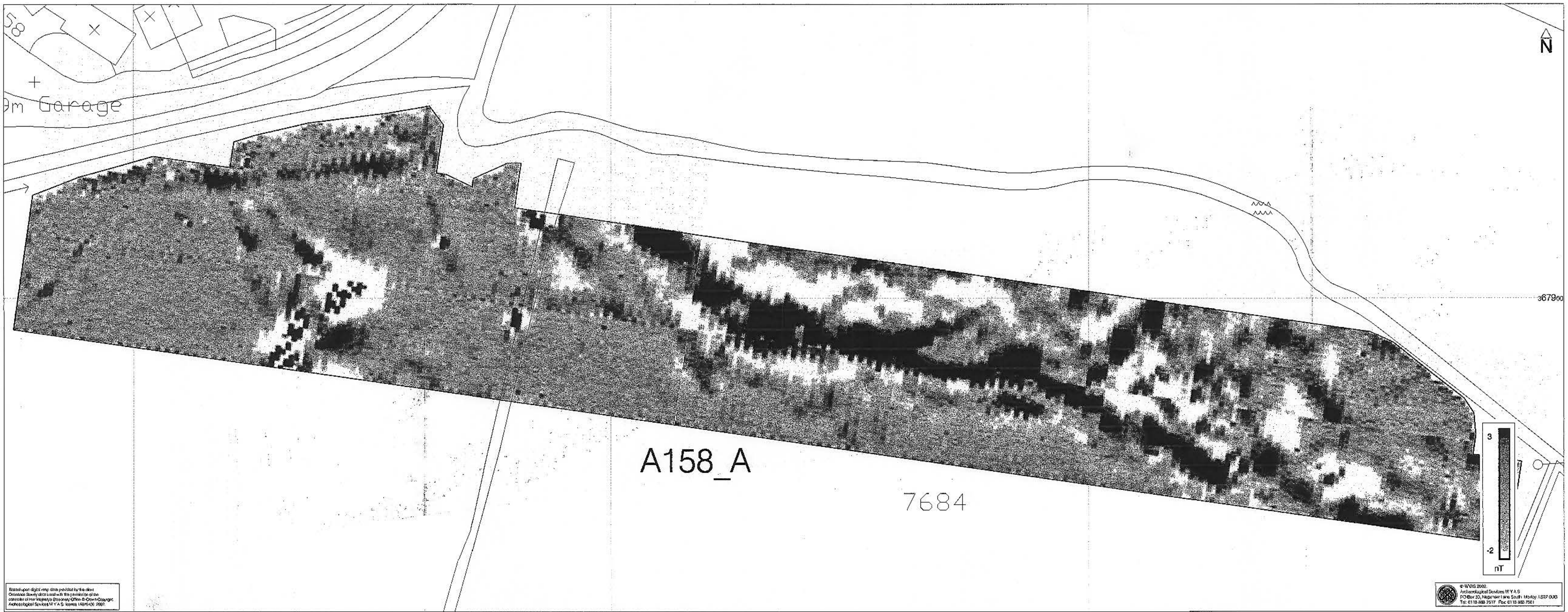


A16 - A158 Partney Bypass, Lincolnshire
X-Y trace plot of the unprocessed gradiometer data; Blocks A158_D and A158_E (1:500)

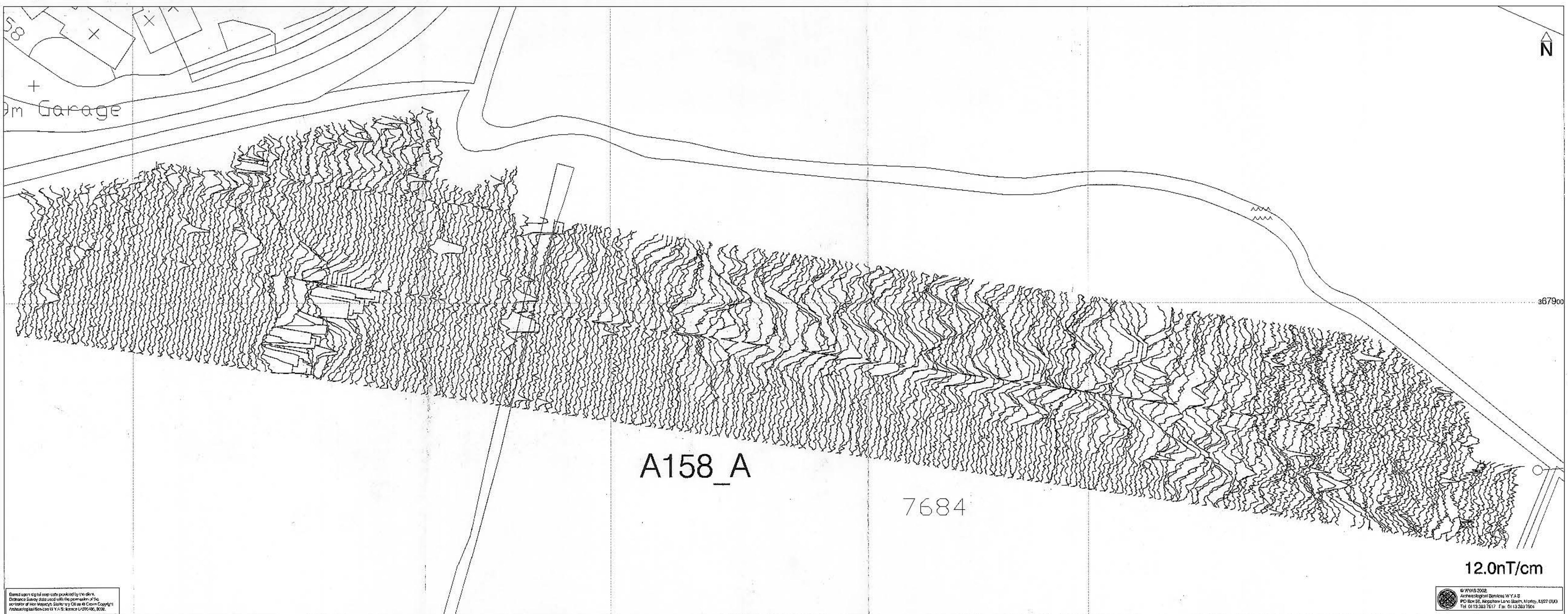
A16 - A158 Partney Bypass, Lincolnshire
Greyscale plot of the unprocessed gradiometer data; A158 bypass western survey blocks (1:500)



A16 - A158 Partney Bypass, Lincolnshire
X-Y trace plot of the unprocessed gradiometer data; Blocks A158_B and A158_C (1:500)



A16 - A158 Partney Bypass, Lincolnshire
Greyscale plot of the unprocessed gradiometer data; Block A158_A (1:500)



A16 - A158 Partney Bypass, Lincolnshire
X-Y trace plot of the unprocessed gradiometer data; Block A158_A (1:500)