Land off Allithwaite Road
Grange-over-Sands
Cumbria

Archaeological geophysical survey

Project No. ARC/2531/934

January 2019

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Date	09/01/19	Date	10/01/19

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1. SUMMARY

Phase Site Investigations Ltd was commissioned to carry out a magnetic gradient survey at land off Allithwaite Road, Grange-over-Sands. The aim of the survey was to help establish the presence / absence, extent, character, relationships and date (as far as circumstances and the inherent limitations of the technique permits) of archaeological features within the survey area.

The survey was undertaken using a Phase Site Investigations Ltd multi-sensor array cart system (MACS). The MACS comprised 8 Foerster 4.032 Ferex CON 650 gradiometers with a control unit and data logger. The MACS data was collected on profiles spaced 0.5 m apart with readings taken at between 0.1 and 0.15 m intervals.

The majority of the anomalies identified by this survey relate to modern material / objects, agricultural activity (including possible ridge and furrow) and geological / pedological variations.

Two broadly parallel curvi-linear anomalies, are present in the west of the site that that are suggestive of a trackway / road. There are no corresponding features shown on historic maps and there are no bipolar or dipolar responses that might be expected if the trackway was made from relatively modern material. However, it is not possible to date the underlying feature from the magnetic data.

Numerous linear trends are present that are weak, diffuse and / or irregular. The cause of these anomalies is not known. There is no obvious pattern to these responses and whilst it is likely that the majority of them will be associated with agricultural activity or natural features / variations an archaeological origin for some of them cannot be completely ruled out.

There are a number of relatively strong, large positive isolated responses, predominantly in the west of the site. The majority of these are suggestive of infilled features, and are more likely to be natural than anthropogenic, although some could be caused by areas of burning or deeper buried relatively modern material. It is understood that cremations were identified in natural hollows to the west of the site. These isolated positive responses could be caused by similar natural features, although the geophysical survey would be unable to determine if cremations were present.

2. INTRODUCTION

2.1 Overview

Phase Site Investigations Ltd was commissioned by Greenlane Archaeology Ltd to carry out an archaeological geophysical survey at land off Allithwaite Road, Grange-over-Sands utilising magnetic gradiometers.

The aim of the survey was to help establish the presence / absence, extent, character, relationships and date (as far as circumstances and the inherent limitations of the technique permits) of archaeological features within the survey area.

The location of the site is shown in drawing ARC_2531_934_01.

2.2 Site description

The site is situated near Grange-over-Sands, Cumbria (centred at NGR SD 393 760), and covered an area of approximately 14 ha.

The site encompassed 9 pasture fields and two areas of woodland / dense vegetation. Each field has been given a number as shown in drawing ARC_2531_934_02. The fields were bounded by a mixture of hedges and stone walls.

The topography varied across the site with a number of steep slopes and undulating ground. Limestone outcrops were visible in parts of the site.

The geology of the site consists of limestone of the Park and Urswick Limestone Formations overlain with superficial deposits of Devensian Till (British Geological Survey, 2018). The soils of the site are described as freely draining slightly acid but base-rich soils (Soilscapes, 2018).

2.3 Archaeological background

A heritage assessment undertaken by Greenlane Archaeology Ltd (2016) highlighted that due to the site being relatively undisturbed and undeveloped, in addition to being located near to other sites of archaeological interest:

'there is potential for archaeological remains to be present within the site, especially those of Bronze Age date. Cremation burials relating to this period have recently been unearthed at Jack Hill across the road from the proposed development site to the west, and the presence of field names containing the element 'barrow' to the east.' and '*it is worth noting that in the case of the 13 cremations found in 2001 these were positioned in natural hollows in buried limestone pavement*'.

It further goes on to suggest that: '*features of other periods are also possible, possibly including early mining. The site has seen little previous disturbance although is likely to have been subject to ploughing.'*

Historic maps within the heritage assessment (and old-maps.co.uk, 2018) indicate that the site has been in use for agriculture since before 1851. Several former field boundaries shown on historic maps are no longer present.

2.4 Scope of work

The entire site was covered by the magnetic survey. It is understood that two phases of development are proposed for the site. This report covers the entire site and a separate report

for each phase will also be produced, concentrating just on the anomalies identified within the fields covered by each phase.

No problems were encountered during the survey which was carried out between 11th and 13th December 2018.

3. SURVEY METHODOLOGY

3.1 Magnetic survey

The survey was undertaken using a Phase Site Investigations Ltd multi-sensor array cart system (MACS).

The MACS comprised 8 Foerster 4.032 Ferex CON 650 gradiometers with a control unit and data logger. The Foerster gradiometers do not require balancing as each sensor is automatically 'zeroed' using the control unit software.

The MACS utilises an RTK GNSS system which means that survey grids do not have to be established. Instead an area is surveyed over a series of continuous profiles and the position of each data point is recorded using an RTK GNSS system. The sensors have a separation of 0.5 m which means that data was collected on profiles spaced at 0.5 m apart. Readings were taken at between 0.1 m and 0.15 m intervals.

Data is collected on zig-zag profiles along the full length or width of a field, although fields can be sub-divided if they are particularly large. Marker canes are set-out along field boundaries at set intervals and these are used to align the profiles. The survey profiles are usually offset from field boundaries, buildings and other metallic features by several metres to reduce the detrimental effect that these surface magnetic features have on the data. The location of the MACS data is converted direct to Ordnance Survey co-ordinates using the UK OSTN 02 projection. As the survey is referenced direct to Ordnance Survey National Grid co-ordinates temporary survey stations are not established.

3.2 Data processing and presentation

The MACS data was stored direct to a laptop using in-house software which automatically corrects for instrument drift and calculates a mean value for each profile. A positional value is assigned to each data point based on the sensor number and recorded GNSS co-ordinates. The data is gridded using in-house software and parameters are set based on the sensor spacing and mean values. No additional processing is required. The gridded data is then displayed in Surfer 9 (Golden Software) and image files of the data are created.

The data was exported as raster images (PNG files) and are presented in greyscale format with accompanying interpretations at a scale of 1:1250. All greyscale plots were clipped at -2 nT to 3 nT. Greyscale plots have been 'smoothed' using a visual interpolation but the data itself has not been interpolated.

The data has been displayed relative to a digital Ordnance Survey base plan provided by the client as drawing *'Allithwaite Lane.dwg'*. The base plan was in the Ordnance Survey National Grid co-ordinate system and as the survey grids / data were referenced directly to National Grid co-ordinates the data could be simply superimposed onto the base plan in the correct position.

X-Y trace plots were examined for all of the data and overlain onto the greyscale plot to assist in the interpretation, primarily to help identify dipolar and bipolar responses that will probably be associated with surface / near-surface iron objects. However, X-Y trace plots have not been presented here as they do not show any additional anomalies that are not visible in the greyscale data. A digital drawing showing the X-Y trace plot overlain on the greyscale plot is provided in the digital archive.

All isolated responses have been assessed using a combination of greyscale and X-Y trace plots. There are a large number of 'iron spike', isolated dipolar anomalies present in the data.

There is no evidence to suggest that they are associated with archaeological features and so have not been shown in the interpretation.

Anomalies associated with agricultural regimes are present in the data but each individual anomaly has not been shown on the interpretation. Instead the general orientation of the regime is indicated.

The data was examined over several different ranges during the interpretation to ensure that the maximum information possible was obtained from the data.

The anomalies have been categorised based on the type of response that they exhibit and an interpretation as to the cause(s) or possible cause(s) of each anomaly type is also provided.

A general discussion of the anomalies is provided for the entire site and then the results are discussed on a field by field basis. A discussion of the general categories of anomaly which have been identified by the survey is provided in Appendix 1.5.

The geophysical interpretation drawing must be used in conjunction with the relevant results section and appendices of this report.

4. RESULTS

4.1 General

The data quality across the majority of the survey area is very good allowing the data to be viewed at a narrow range of readings to better identify weak anomalies. There are several areas that have a more disturbed magnetic background but this is due to the presence of magnetic material in the topsoil or sub-surface, rather than low data quality.

Numerous series of, broadly parallel positive linear anomalies are present in most of the data, associated with relatively modern ploughing activity and possible ridge and furrow. The presence of relatively strong responses related to agricultural activity usually indicates that the soil has a magnetic susceptibility that is sufficiently high to produce measureable magnetic responses when enhanced. When this occurs it is reasonable to assume that if significant (in terms of size / depth) infilled archaeological features are present that they would also produce measureable magnetic responses. Exceptions to this would be relatively small discrete features, cut features that were infilled rapidly or features that have been severely truncated. However, it is worth noting that two former field boundaries, shown on historic maps, have not been identified in the magnetic data and there are a number of weak responses within the data of uncertain origin. It is possible therefore that, despite the relatively strong and clear agricultural responses, the remnants of archaeological features / activity could be present that only produce weak or intermittent responses.

4.2 Field 1

Basic topography: Gentle slope upwards to the west.

Field description: Pasture. Relatively firm underfoot. Bounded by stone walls and hedges.

Interpretation drawing(s): ARC_2531_934_04 and ARC_2531_934_06.

Summary of anomalies: Numerous isolated dipolar and small bipolar responses, that are all thought to be associated with modern material. These have not been shown on the interpretation.

Very strong responses associated with strongly magnetic modern features / material. The feature / material causing the response may be located beyond the survey area.

Positive linear responses are present probably associated with relatively modern ploughing regimes.

A broad diffuse area of positive and negative responses probably associated with a natural feature or variations, although some responses could be related to relatively modern material.

Trends of uncertain origin.

Numerous isolated positive responses, the majority of which are probably geological / pedological in origin or related to relatively modern deeper buried ferrous / fired material

Further discussion / additional information:

The broad, diffuse area of positive and negative responses in the east of the field broadly corresponds with a steeper slope where the limestone bedrock was exposed in places. The responses are probably caused by natural variations in the soil or possibly by relatively modern material if the field has been levelled or partially infilled in this area. These responses are not archaeologically significant but they could possibly mask responses from any underlying features (although given the exposed bedrock it is unlikely that there would be significant sub-surface features present in this area).

There are numerous weak or diffuse trends in this field. These are too weak to allow a definite interpretation or even ascertain if they are caused by sub-surface features. There are at least two regimes of agricultural responses visible in the data and some of the trends could also be related to agricultural activity. It is also possible that some of the trends could be caused by natural infilled fissures within the limestone bedrock. However, as the exact cause of these responses cannot be determined with certainty the possibility that some of them are related to the remnants of other infilled features cannot be discounted. Several trends stand out (**Anomalies A**) as they are slightly stronger / more coherent and could have greater potential to be caused by infilled features but as discussed above they could also be related to agricultural activity.

4.3 Field 2

Basic topography: Level in the west, with a steep slope downwards to the east from the centre of the field.

Field description: Pasture. Relatively firm underfoot. Bounded by stone walls and hedges. A small overhead cable post was located in the north of the field.

Interpretation drawing(s): ARC_2531_934_04 and ARC_2531_934_06.

Summary of anomalies: Numerous isolated dipolar and small bipolar responses, that are all thought to be associated with modern material. These have not been shown on the interpretation.

Several larger isolated bipolar responses are present. These will be related to a concentration, or a larger object or feature, of relatively modern ferrous or fired material.

Very strong responses associated with strongly magnetic modern features / material. The feature / material causing the response may be located beyond the survey area.

Positive linear responses are present associated with relatively modern ploughing regime(s).

A broad diffuse area of positive and negative responses probably associated with a natural feature or variations, although some responses could be related to relatively modern material.

Trends of uncertain origin.

A fragmented positive linear anomaly is present. The anomaly is suggestive of an agricultural feature or former field boundary.

Numerous isolated positive responses, the majority of which are probably geological / pedological in origin or related to relatively modern deeper buried ferrous / fired material.

Further discussion / additional information:

The broad, diffuse area of positive and negative responses broadly corresponds with a steeper slope where the limestone bedrock was exposed in places. The responses are probably caused by natural variations in the soil or possibly by relatively modern material if the field has been levelled or partially infilled in this area. These responses are not archaeologically significant but they could possibly mask responses from any underlying features (although given the exposed bedrock it is unlikely that there would be significant sub-surface features present in this area).

There are numerous weak or diffuse trends in this field. These are too weak to allow a definite interpretation or even ascertain if they are caused by sub-surface features. There are at least two regimes of agricultural responses visible in the data and some of the trends could also be related to agricultural activity. It is also possible that some of the trends could be caused by natural infilled fissures within the limestone bedrock. However, as the exact cause of these responses cannot be determined with certainty the possibility that some of them are related to the remnants of other infilled features cannot be discounted. Several trends stand out (**Anomalies A**) as they are slightly stronger / more coherent and could have greater potential to be caused by infilled features but as discussed above they could also be related to agricultural activity.

A fragmented positive linear anomaly (**Anomaly B**) is present in the east of the field. The anomaly is on the same alignment as responses related to an agricultural regime and it is likely that Anomaly B is also related to agricultural activity. The anomaly is stronger than the other agricultural responses possibly indicating that it is caused by an infilled feature, such as a former field boundary (although no such boundaries are shown on historic maps). The anomaly does not continue into the adjacent fields, further suggesting that it respects and may be caused by related activity, the current / historic field boundaries / agricultural regimes.

4.4 Field 3

Basic topography: Gentle slope upwards to the north / west.

Field description: Pasture. Relatively firm underfoot. Bounded by stone walls and hedges.

Interpretation drawing(s): ARC_2531_934_06.

Summary of anomalies: Numerous isolated dipolar and small bipolar responses, that are all thought to be associated with modern material. These have not been shown on the interpretation.

A larger isolated bipolar response. This will be related to a concentration, or a larger object or feature, of relatively modern ferrous or fired material.

Very strong responses associated with strongly magnetic modern features / material. The feature / material causing the response may be located beyond the survey area.

Relatively weak positive linear responses are present associated with modern ploughing regime(s).

Trends of uncertain origin.

A number of isolated positive responses, the majority of which are probably geological / pedological in origin or related to relatively modern deeper buried ferrous / fired material.

Further discussion / additional information:

The isolated bipolar response in this field is very strong which suggest that it is caused by relatively modern material.

Several weak or diffuse trends are present in this field. These are too weak to allow a definite interpretation or even ascertain if they are caused by sub-surface features. There are responses related to agricultural activity visible in the data and some of the trends could also be caused by agricultural activity. It is also possible that some of the trends could be caused by natural infilled fissures within the limestone bedrock. However, as the exact cause of these responses cannot be determined with certainty the possibility that some of them are related to the remnants of other infilled features cannot be discounted.

One curving trend stands out (**Anomaly A**) as is it slightly stronger / more coherent. This could have greater potential to be caused by an infilled feature but as discussed above it could also be related to agricultural activity. There is a suggestion that Anomaly A in this field may form a broadly circular shape but this may in part be due to intersecting former agricultural regimes. There are no anomalies to the west of Anomaly A that are well-defined enough to interpret as being related to the same feature. Two other broad, diffuse trends are present (**Anomalies C**). The diffuse responses could mean that they are caused by a natural feature but it is not possible to determine the cause of these with any certainty.

A relatively large isolated positive response is present (**Anomaly D**). Responses of this type can have a variety of causes, including an infilled discrete feature, such a natural hollow or solution feature or anthropogenic pit, an area of burning or industrial activity or by relatively modern magnetic material buried at depth. The response in this field is more suggestive of an infilled feature than the other possibilities but the exact cause of the anomaly is not certain.

4.5 Field 4

Basic topography: Gradual slope upwards to the east.

Field description: Pasture. Relatively firm underfoot. Bounded by stone walls, hedges and wooden panel fencing.

Interpretation drawing(s): ARC_2531_934_04 and ARC_2531_934_06.

Summary of anomalies: Numerous isolated dipolar and small bipolar responses, that are all thought to be associated with modern material. These have not been shown on the interpretation.

Very strong responses associated with strongly magnetic modern features / material. The feature / material causing the response may be located beyond the survey area.

Positive linear responses are present associated with modern ploughing regimes.

Trends of uncertain origin.

Numerous isolated positive responses, the majority of which are probably geological / pedological in origin or related to relatively modern deeper buried ferrous / fired material.

Curvi-linear positive anomalies and trends probably associated with a former trackway / road.

Further discussion / additional information:

There are numerous weak or diffuse trends in this field. These are too weak to allow a definite interpretation or even ascertain if they are caused by sub-surface features. There are at least two regimes of agricultural responses visible in the data and some of the trends could also be related to agricultural activity. It is also possible that some of the trends could be caused by natural infilled fissures within the limestone bedrock. However, as the exact cause of these responses cannot be determined with certainty the possibility that some of them are related to the remnants of other infilled features cannot be discounted. Several trends stand out (**Anomalies A**) as they are slightly stronger / more coherent and could have greater potential to be caused by infilled features but as discussed above they could also be related to agricultural activity.

A number of relatively large isolated positive response are present (**Anomalies D**). Responses of this type can have a variety of causes, including an infilled discrete feature, such a natural hollow or solution feature or anthropogenic pit, an area of burning or industrial activity or by relatively modern magnetic material buried at depth. The responses in this field are more suggestive of infilled features than the other possibilities but the exact cause of the anomalies is not certain.

In the west of the area there are two broadly parallel curvi-linear anomalies, with relatively strong positive components and weaker trends (**Anomalies E**) that are suggestive of a trackway / road. There are no corresponding features shown on historic maps and there are no bipolar or dipolar responses that might be expected if the trackway was made from relatively modern material. However, it is not possible to date the underlying feature from the magnetic data.

4.6 Field 5

Basic topography: Relatively steep slope upwards to the east.

Field description: Pasture. Relatively firm underfoot. Bounded by stone walls and hedges.

Interpretation drawing(s): ARC_2531_934_04 and ARC_2531_934_06.

Summary of anomalies: Numerous isolated dipolar and small bipolar responses, that are all thought to be associated with modern material. These have not been shown on the interpretation.

A larger isolated bipolar response. This will be related to a concentration, or a larger object or feature, of relatively modern ferrous or fired material.

Very strong responses associated with strongly magnetic modern features / material. The feature / material causing the response may be located beyond the survey area.

Positive linear responses are present associated with modern ploughing regimes.

Trends of uncertain origin.

Numerous isolated positive responses, the majority of which are probably geological / pedological in origin or related to relatively modern deeper buried ferrous / fired material.

Curvi-linear trends probably associated with a former trackway / road

Further discussion / additional information:

There are numerous weak or diffuse trends in this field. These are too weak to allow a definite interpretation or even ascertain if they are caused by sub-surface features. There are at least two regimes of agricultural responses visible in the data and some of the trends could also be related to agricultural activity. It is also possible that some of the trends could be caused by natural infilled fissures within the limestone bedrock. However, as the exact cause of these responses cannot be determined with certainty the possibility that some of them are related to the remnants of other infilled features cannot be discounted. Several trends stand out (**Anomalies A**) as they are slightly stronger / more coherent and could have greater potential to be caused by infilled features but as discussed above they could also be related to agricultural activity.

A number of relatively large isolated positive response are present (**Anomalies D**). Responses of this type can have a variety of causes, including an infilled discrete feature, such a natural hollow or solution feature or anthropogenic pit, an area of burning or industrial activity or by relatively modern magnetic material buried at depth. The responses in this field are more suggestive of infilled features than the other possibilities but the exact cause of the anomalies is not certain.

In the west of the area there are two broadly parallel curvi-linear trends (**Anomalies E**) that are suggestive of a trackway / road. These are a continuation of anomalies identified in Field 4 but the responses are slightly weaker and more diffuse, There are no corresponding features shown on historic maps and there are no bipolar or dipolar responses that might be expected if the trackway was made from relatively modern material. However, it is not possible to date the underlying feature from the magnetic data.

4.7 Field 6

Basic topography: Steep slope upwards to the west.

Field description: Rough pasture. Bounded by stone walls and hedges.

Interpretation drawing(s): ARC_2531_934_06 and ARC_2531_934_08

Summary of anomalies: Numerous isolated dipolar and small bipolar responses, that are all thought to be associated with modern material. These have not been shown on the interpretation.

Very strong responses associated with strongly magnetic modern features / material. The feature / material causing the response may be located beyond the survey area.

Relatively weak positive linear responses are present associated with modern ploughing regime(s).

Trends of uncertain origin.

Numerous isolated positive responses, the majority of which are probably geological / pedological in origin or related to relatively modern deeper buried ferrous / fired material

Further discussion / additional information:

There are several weak or diffuse trends in this field. These are too weak to allow a definite interpretation or even ascertain if they are caused by sub-surface features. There is no pattern to the distribution of the trends that would suggest they are caused by archaeological features / activity and it is more likely that the trends in this field are related to natural features / variations or agricultural activity.

4.8 Field 7

Basic topography: Level in the north, with a slope falling steeply downwards to the south in the middle of the field before levelling out near the southern boundary.

Field description: Rough pasture. Bounded by hedges and stone walls in the north, east and south. Wooden and metal wire fencing in the west.

Interpretation drawing(s): ARC_2531_934_06 and ARC_2531_934_08

Summary of anomalies: Numerous isolated dipolar and small bipolar responses, that are all thought to be associated with modern material. These have not been shown on the interpretation.

Very strong responses associated with strongly magnetic modern features / material. The feature / material causing the response may be located beyond the survey area.

Relatively weak positive linear responses are present associated with modern ploughing regime(s).

A broad diffuse area of positive and negative responses probably associated with a natural feature or variations, although some responses could be related to relatively modern material.

Trends of uncertain origin.

Numerous isolated positive responses, the majority of which are probably geological / pedological in origin or related to relatively modern deeper buried ferrous / fired material

Further discussion / additional information:

The broad, diffuse area of positive and negative responses broadly corresponds with a steeper slope where the soil cover may be reduced. The responses are probably caused by natural variations in the soil or possibly by relatively modern material if the field has been levelled or partially infilled in this area. These responses are not archaeologically significant, other than potentially indicating where the bedrock is close to the surface.

There are several weak or diffuse trends in this field. These are too weak to allow a definite interpretation or even ascertain if they are caused by sub-surface features. There is no pattern to the distribution of the trends that would suggest they are caused by archaeological features

/ activity and it is more likely that the trends in this field are related to natural features / variations or agricultural activity.

4.9 Field 8

Basic topography: Steep slope down from the north-west to the east and south.

Field description: Rough pasture. Bounded by hedges and stone walls in the north and south, wooden and metal wire fencing in the east, and wooden panel fencing in the west. A number of metal feeding troughs were located in the west.

Interpretation drawing(s): ARC_2531_934_08

Summary of anomalies: Numerous isolated dipolar and small bipolar responses, that are all thought to be associated with modern material. These have not been shown on the interpretation.

Very strong responses associated with strongly magnetic modern features / material. The feature / material causing the response may be located beyond the survey area.

Relatively weak positive linear responses are present associated with modern ploughing regime(s).

Relatively weak positive linear responses are present possibly associated with the remnants of ridge and furrow, although they could be related to later ploughing activity.

A broad diffuse area of positive and negative responses probably associated with a natural feature or variations, although some responses could be related to relatively modern material.

Trends of uncertain origin.

Numerous isolated positive responses, the majority of which are probably geological / pedological in origin or related to relatively modern deeper buried ferrous / fired material

Further discussion / additional information:

There are several weak or diffuse trends in this field. These are too weak to allow a definite interpretation or even ascertain if they are caused by sub-surface features. There is no pattern to the distribution of the trends that would suggest they are caused by archaeological features / activity and it is more likely that the trends in this field are related to natural features / variations or agricultural activity. Several trends stand out (**Anomalies A**) as they are slightly stronger / more coherent and could have greater potential to be caused by infilled features but as discussed above they could also be related to agricultural activity.

A relatively large isolated positive response is present (**Anomaly D**). Responses of this type can have a variety of causes, including an infilled discrete feature, such a natural hollow or solution feature or anthropogenic pit, an area of burning or industrial activity or by relatively modern magnetic material buried at depth. The response in this field is suggestive of an infilled feature or deeper buried ferrous material but the exact cause of the anomaly is not certain.

4.10 Field 9

Basic topography:	Undulating generally sloping downwards to the east and north.
Field description:	Rough pasture. Bounded by hedges in the north, metal wire fencing in the south and wooden panel fences in the west. A wooden overhead cable post was located in the north of the field.
Interpretation drawing(s):	ARC_2531_934_08
Summary of anomalies:	Numerous isolated dipolar and small bipolar responses, that are all thought to be associated with modern material. These have not been shown on the interpretation. Larger isolated bipolar responses. These will be related to a concentration, or a larger object or feature, of relatively modern ferrous or fired material. Very strong responses associated with strongly magnetic modern features / material. The feature / material causing the response may be located beyond the survey area. Relatively weak positive linear responses are present possibly associated with the remnants of ridge and furrow, although they could be related to later ploughing activity. A broad diffuse area of positive and negative responses probably associated with a natural feature or variations, although some responses could be related to relatively modern material. Trends of uncertain origin. Numerous isolated positive responses, the majority of which are probably geological / pedological in origin or related to relatively modern deeper buried ferrous / fired material

Further discussion / additional information:

There are a number of weak or diffuse trends in this field. These are too weak to allow a definite interpretation or even ascertain if they are caused by sub-surface features. There is no pattern to the distribution of the trends that would suggest they are caused by archaeological features / activity and it is more likely that the trends in this field are related to natural features / variations or agricultural activity.

5. DISCUSSION AND CONCLUSIONS

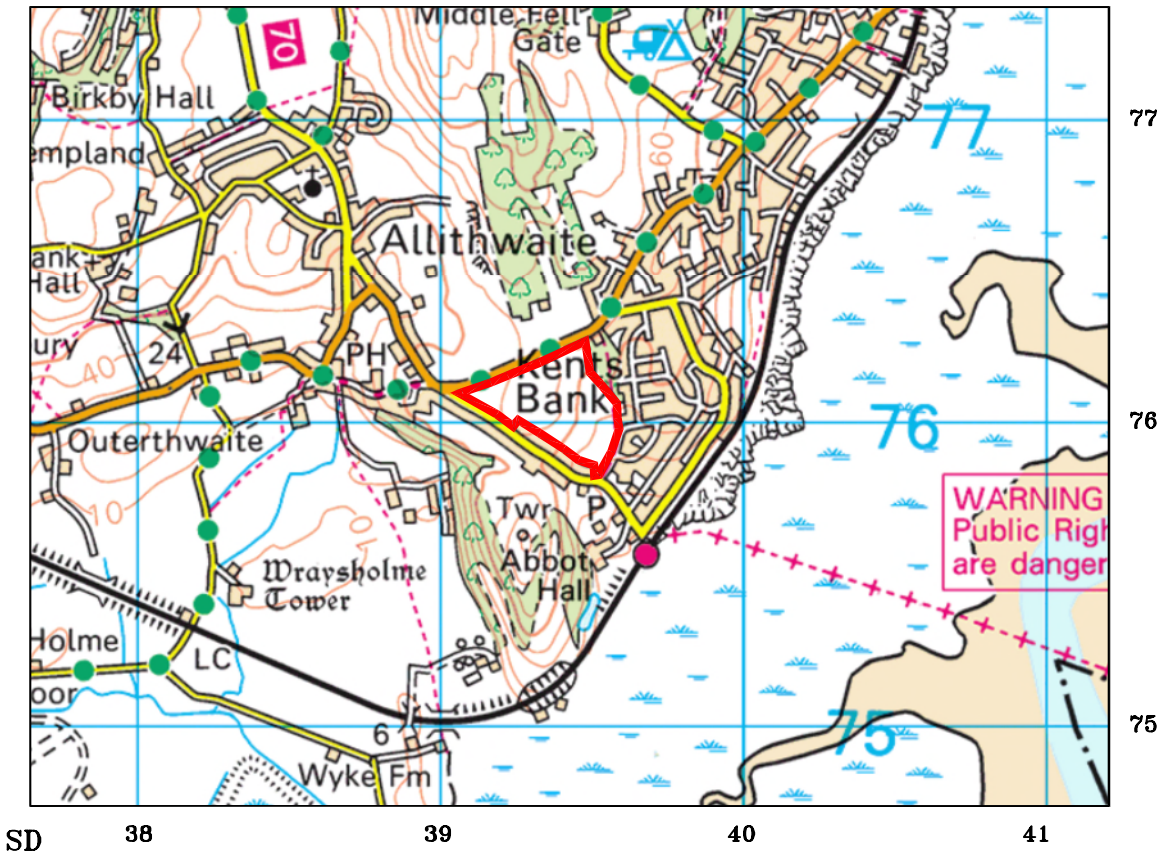
The majority of the anomalies identified by this survey relate to modern material / objects, agricultural activity (including possible ridge and furrow) and geological / pedological variations.

Two broadly parallel curvi-linear anomalies, are present in the west of the site that that are suggestive of a trackway / road. There are no corresponding features shown on historic maps and there are no bipolar or dipolar responses that might be expected if the trackway was made from relatively modern material. However, it is not possible to date the underlying feature from the magnetic data.

Numerous linear trends are present that are weak, diffuse and / or irregular. The cause of these anomalies is not known. There is no obvious pattern to these responses and whilst it is likely that the majority of them will be associated with agricultural activity or natural features / variations an archaeological origin for some of them cannot be completely ruled out.

There are a number of relatively strong, large positive isolated responses, predominantly in the west of the site. The majority of these are suggestive of infilled features, and are more likely to be natural than anthropogenic, although some could be caused by areas of burning or deeper buried relatively modern material. It is understood that cremations were identified in natural hollows to the west of the site. These isolated positive responses could be caused by similar natural features, although the geophysical survey would be unable to determine if cremations were present.

It should be noted that a geophysical survey does not directly locate sub-surface features - it identifies variations or anomalies in the background response caused by features. The interpretation of geophysical anomalies is often subjective and it is rarely possible to identify the cause of all such anomalies. Not all features will produce a measurable anomaly and the effectiveness of a geophysical survey is also dependant on the site-specific conditions. The main factors that may limit whether a feature can be detected are the composition of a feature, its depth and size and the surrounding material. It is not possible to guarantee that a geophysical survey will identify all sub-surface features. Confirmation on the identification of anomalies and the presence or absence of sub-surface features can only be achieved by intrusive investigation.



SITE LOCATION

SCALE

0m 500m 1000m

NOTE

PHASE SITE INVESTIGATIONS

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Scale [A4 Sheet]	Drawing	Status
AS SHOWN	ARC_2531_934_01	FINAL

Client: GREENLANE ARCHAEOLOGY LTD ULVERSTON

Site: LAND OFF ALLITHWAITE LANE GRANGE OVER SANDS CUMBRIA

Title: SITE LOCATION MAP

Job No: ARC_2531_934

		Drawn	CA
Chk.	MW	Date	14/12/2018

NOTES

1. THIS DRAWING MUST BE USED IN CONJUNCTION WITH THE ACCOMPANYING REPORT (ARC_2531_934_RPT.DOC) WHICH PROVIDES DETAILS OF THE TECHNIQUES EMPLOYED, THEIR INHERENT LIMITATIONS AND ANY SITE SPECIFIC ISSUES.
2. THIS DRAWING IS BASED UPON DRAWING 'Allithwaite Lane.dwg' PROVIDED BY THE CLIENT. THE ORDNANCE SURVEY CO-ORDINATES OBTAINED FOR THIS SURVEY WERE MEASURED USING THE UKOSTN02 PROJECTION. THIS PROJECTION SHOULD BE TAKEN INTO ACCOUNT IF THE SURVEY GRID IS RELOCATED.
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Scale [A3 Sheet]	Drawing	Status
1:2500	ARC_2531_934_02	FINAL

Client
GREENLANE ARCHAEOLOGY LTD
ULVERSTON

Site
LAND OFF ALLITHWAITE ROAD
GRANGE-OVER-SANDS, CUMBRIA

Title
LOCATION OF SITE SHOWING MAGNETIC GRADIENT DATA

Job No
ARC_2531_934

Surveyed	JW, CA	Drawn	CA
Chk.	NF	Date	13/12/2018

NOTES

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Scale [A3 Sheet]	Drawing	Status
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Client
GREENLANE ARCHAEOLOGY LTD
ULVERSTON

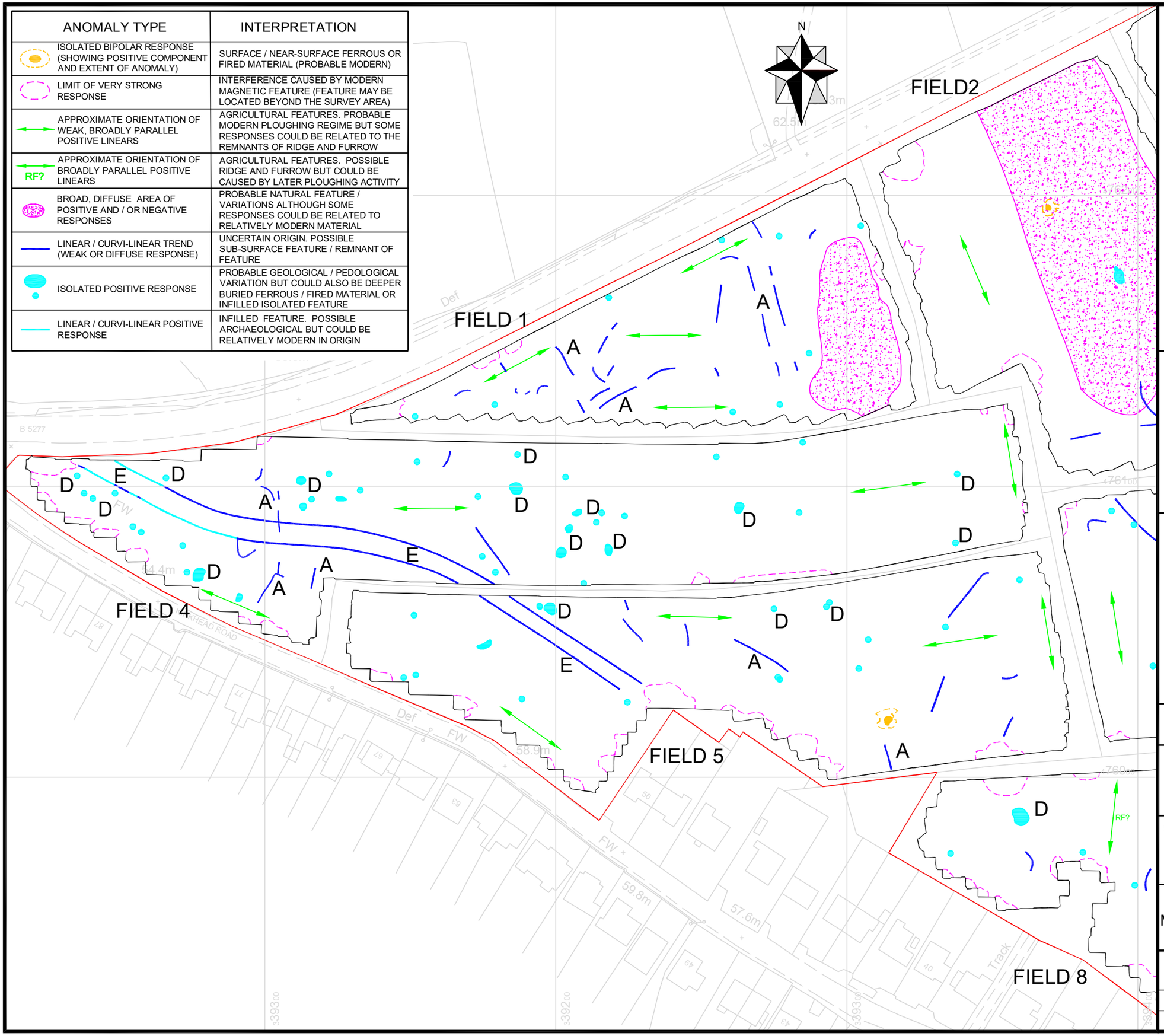
Site
LAND OFF ALLITHWAITE ROAD
GRANGE-OVER-SANDS, CUMBRIA

Title
GREYSCALE PLOTS OF MAGNETIC GRADIENT DATA: FIELDS 1, 4, 5 AND PARTS OF FIELDS 2 AND 8

Job No
ARC_2531_934

Surveyed	JW, CA	Drawn	CA
Chk.	NF	Date	13/12/2018

ANOMALY TYPE	INTERPRETATION
ISOLATED BIPOLAR RESPONSE (SHOWING POSITIVE COMPONENT AND EXTENT OF ANOMALY)	SURFACE / NEAR-SURFACE FERROUS OR FIRED MATERIAL (PROBABLE MODERN)
LIMIT OF VERY STRONG RESPONSE	INTERFERENCE CAUSED BY MODERN MAGNETIC FEATURE (FEATURE MAY BE LOCATED BEYOND THE SURVEY AREA)
APPROXIMATE ORIENTATION OF WEAK, BROADLY PARALLEL POSITIVE LINEARS	AGRICULTURAL FEATURES. PROBABLE MODERN PLOUGHING REGIME BUT SOME RESPONSES COULD BE RELATED TO THE REMNANTS OF RIDGE AND FURROW
RF? APPROXIMATE ORIENTATION OF BROADLY PARALLEL POSITIVE LINEARS	AGRICULTURAL FEATURES. POSSIBLE RIDGE AND FURROW BUT COULD BE CAUSED BY LATER PLOUGHING ACTIVITY
BROAD, DIFFUSE AREA OF POSITIVE AND / OR NEGATIVE RESPONSES	PROBABLE NATURAL FEATURE / VARIATIONS ALTHOUGH SOME RESPONSES COULD BE RELATED TO RELATIVELY MODERN MATERIAL
LINEAR / CURVI-LINEAR TREND (WEAK OR DIFFUSE RESPONSE)	UNCERTAIN ORIGIN. POSSIBLE SUB-SURFACE FEATURE / REMNANT OF FEATURE
ISOLATED POSITIVE RESPONSE	PROBABLE GEOLOGICAL / PEDOLOGICAL VARIATION BUT COULD ALSO BE DEEPER BURIED FERROUS / FIRED MATERIAL OR INFILLED ISOLATED FEATURE
LINEAR / CURVI-LINEAR POSITIVE RESPONSE	INFILLED FEATURE. POSSIBLE ARCHAEOLOGICAL BUT COULD BE RELATIVELY MODERN IN ORIGIN



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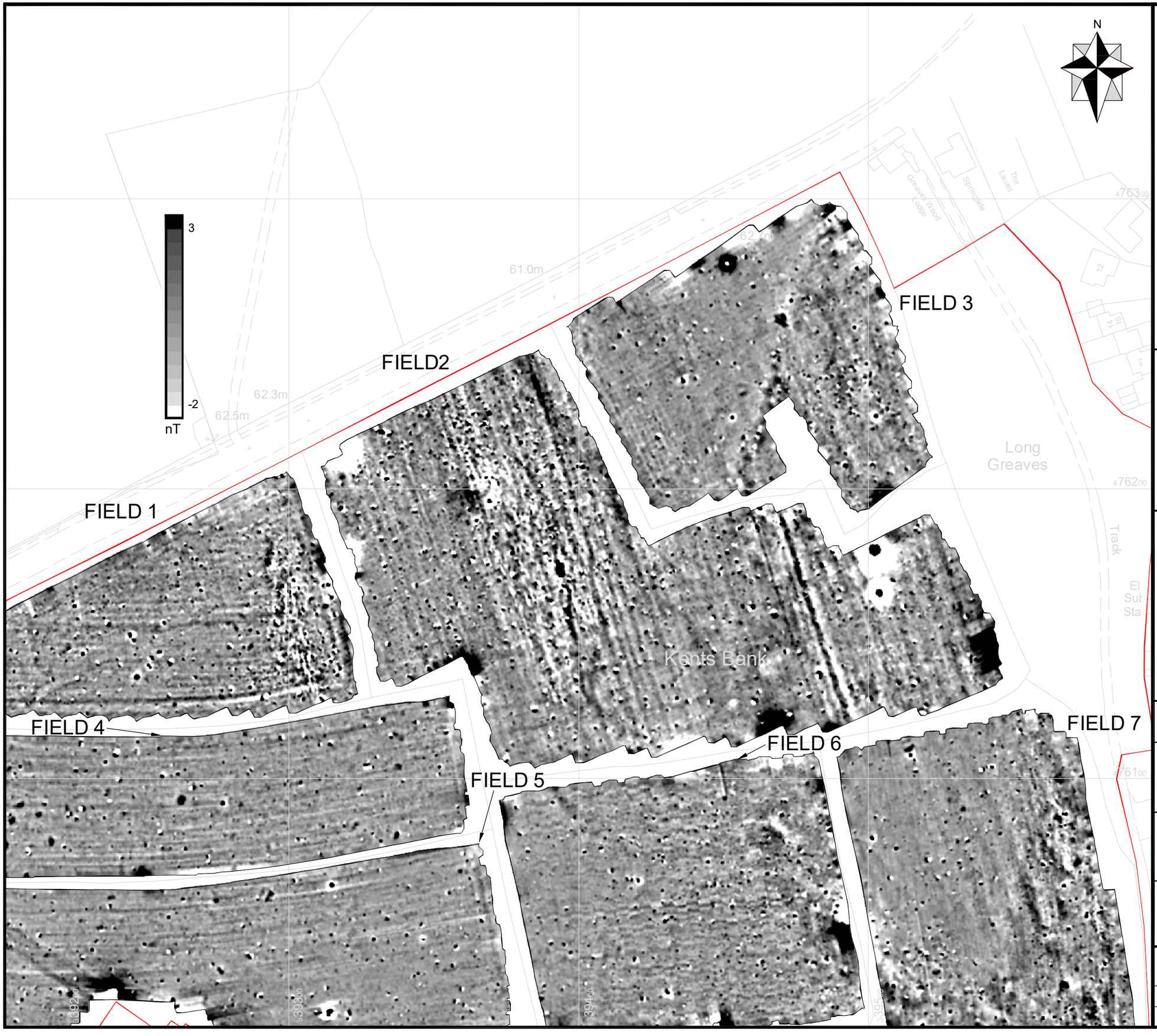
Client
GREENLANE ARCHAEOLOGY LTD
ULVERSTON

Site
LAND OFF ALLITHWAITE ROAD
GRANGE-OVER-SANDS, CUMBRIA

Title
INTERPRETATION OF MAGNETIC GRADIENT DATA: FIELDS 1, 4, 5 AND PARTS OF FIELDS 2 AND 8

Job No
ARC_2531_934

Surveyed	JW, CA	Drawn	CA, MW
Chk.	NF	Date	13/12/2018



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Client
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ULVERSTON

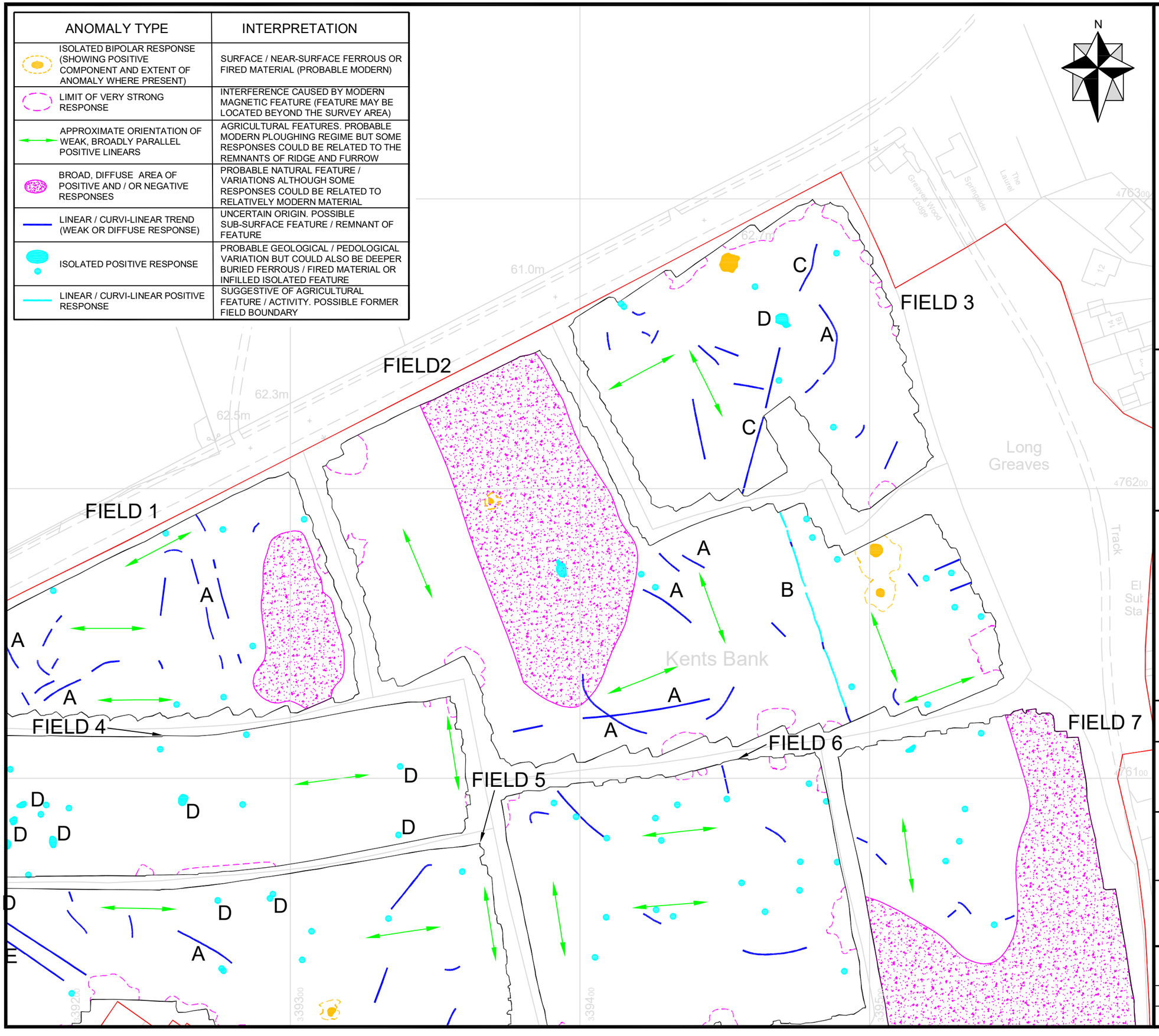
Site
LAND OFF ALLITHWAITE ROAD
GRANGE-OVER-SANDS, CUMBRIA

Title
GREYSCALE PLOTS OF MAGNETIC GRADIENT DATA: FIELDS 2, 3 AND PARTS OF FIELDS 1, 4, 5, 6 AND 7

Job No
ARC_2531_934

Surveyed	JW, CA	Drawn	CA
Chk.	NF	Date	13/12/2018

ANOMALY TYPE	INTERPRETATION
ISOLATED BIPOLAR RESPONSE (SHOWING POSITIVE COMPONENT AND EXTENT OF ANOMALY WHERE PRESENT)	SURFACE / NEAR-SURFACE FERROUS OR FIRED MATERIAL (PROBABLE MODERN)
LIMIT OF VERY STRONG RESPONSE	INTERFERENCE CAUSED BY MODERN MAGNETIC FEATURE (FEATURE MAY BE LOCATED BEYOND THE SURVEY AREA)
APPROXIMATE ORIENTATION OF WEAK, BROADLY PARALLEL POSITIVE LINEARS	AGRICULTURAL FEATURES. PROBABLE MODERN PLOUGHING REGIME BUT SOME RESPONSES COULD BE RELATED TO THE REMNANTS OF RIDGE AND FURROW
BROAD, DIFFUSE AREA OF POSITIVE AND / OR NEGATIVE RESPONSES	PROBABLE NATURAL FEATURE / VARIATIONS ALTHOUGH SOME RESPONSES COULD BE RELATED TO RELATIVELY MODERN MATERIAL
LINEAR / CURVI-LINEAR TREND (WEAK OR DIFFUSE RESPONSE)	UNCERTAIN ORIGIN. POSSIBLE SUB-SURFACE FEATURE / REMNANT OF FEATURE
ISOLATED POSITIVE RESPONSE	PROBABLE GEOLOGICAL / PEDOLOGICAL VARIATION BUT COULD ALSO BE DEEPER BURIED FERROUS / FIRED MATERIAL OR INFILLED ISOLATED FEATURE
LINEAR / CURVI-LINEAR POSITIVE RESPONSE	SUGGESTIVE OF AGRICULTURAL FEATURE / ACTIVITY. POSSIBLE FORMER FIELD BOUNDARY



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Scale [A3 Sheet]	Drawing	Status
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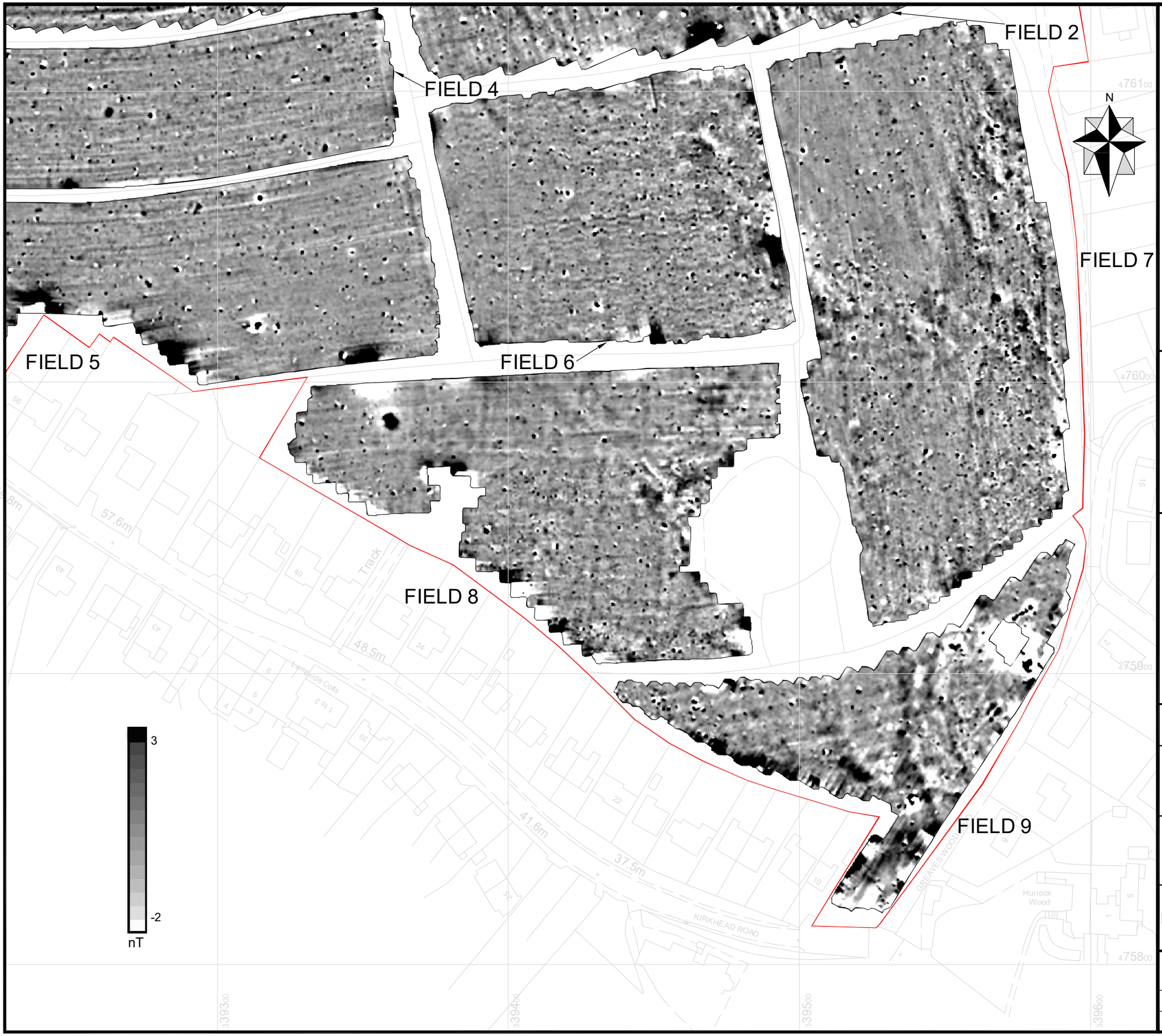
Client
GREENLANE ARCHAEOLOGY LTD
ULVERSTON

Site
LAND OFF ALLITHWAITE ROAD
GRANGE-OVER-SANDS, CUMBRIA

Title
INTERPRETATION OF MAGNETIC GRADIENT DATA: FIELDS 2, 3 AND PARTS OF FIELDS 1, 4, 5, 6 AND 7

Job No
ARC_2531_934

Surveyed	JW, CA	Drawn	CA, MW
Chk.	NF	Date	13/12/2018



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Scale [A3 Sheet]	Drawing	Status
1:1250	ARC_2531_934_07	FINAL

Client
GREENLANE ARCHAEOLOGY LTD
ULVERSTON

Site
LAND OFF ALLITHWAITE ROAD
GRANGE-OVER-SANDS, CUMBRIA

Title
GREYSCALE PLOTS OF MAGNETIC GRADIENT DATA: FIELDS 6, 7, 8 9 AND PARTS OF FIELDS 2, 4 AND 5

Job No
ARC_2531_934

Surveyed	JW, CA	Drawn	CA
Chk.	NF	Date	13/12/2018

FIELD 2

FIELD 4

FIELD 5

FIELD 6

FIELD 7

FIELD 8

FIELD 9

N

NOTES

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APPROXIMATE SITE BOUNDARY

ANOMALY TYPE	INTERPRETATION
ISOLATED BIPOLAR RESPONSE (SHOWING POSITIVE COMPONENT AND EXTENT OF ANOMALY)	SURFACE / NEAR-SURFACE FERROUS OR FIRED MATERIAL (PROBABLE MODERN)
LIMIT OF VERY STRONG RESPONSE	INTERFERENCE CAUSED BY MODERN MAGNETIC FEATURE (FEATURE MAY BE LOCATED BEYOND THE SURVEY AREA)
APPROXIMATE ORIENTATION OF WEAK, BROADLY PARALLEL POSITIVE LINEARS	AGRICULTURAL FEATURES. PROBABLE MODERN PLOUGHING REGIME
RF? APPROXIMATE ORIENTATION OF BROADLY PARALLEL POSITIVE LINEARS	AGRICULTURAL FEATURES. POSSIBLE RIDGE AND FURROW BUT COULD BE CAUSED BY LATER PLOUGHING ACTIVITY
BROAD, DIFFUSE AREA OF POSITIVE AND / OR NEGATIVE RESPONSES	PROBABLE NATURAL FEATURE / VARIATIONS
LINEAR / CURVI-LINEAR TREND (WEAK OR DIFFUSE RESPONSE)	UNCERTAIN ORIGIN. POSSIBLE SUB-SURFACE FEATURE / REMNANT OF FEATURE
ISOLATED POSITIVE RESPONSE	PROBABLE GEOLOGICAL / PEDOLOGICAL VARIATION BUT COULD ALSO BE DEEPER BURIED FERROUS / FIRED MATERIAL OR INFILLED ISOLATED FEATURE
LINEAR / CURVI-LINEAR POSITIVE RESPONSE	SUGGESTIVE OF AGRICULTURAL FEATURE / ACTIVITY. POSSIBLE FORMER FIELD BOUNDARY

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Scale [A3 Sheet]	Drawing	Status
1:1250	ARC_2531_934_08	FINAL

Client
GREENLANE ARCHAEOLOGY LTD
ULVERSTON

Site
LAND OFF ALLITHWAITE ROAD
GRANGE-OVER-SANDS, CUMBRIA

Title
INTERPRETATION OF MAGNETIC GRADIENT DATA: FIELDS 6, 7, 8 9 AND PARTS OF FIELDS 2, 4 AND 5

Job No
ARC_2531_934

Surveyed	JW, CA	Drawn	CA, MW
Chk.	NF	Date	13/12/2018

BIBLIOGRAPHY AND REFERENCES

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APPENDIX 1

Magnetic survey: technical information

1.1 Theoretical background

1.1.1 Magnetic instruments measure the value of the Earth's magnetic field; the units of which are nanoTeslas (nT). The presence of surface and sub-surface features can cause variations or anomalies in this magnetic field. The strength of the anomaly is dependent on the magnetic properties of a feature and the material that surrounds it. The two magnetic properties that are of most interest are magnetic susceptibility and thermoremnant magnetism.

1.1.2 Magnetic susceptibility indicates the amount of ferrous (iron) minerals that are present. These can be redistributed or changed (enhanced) by human activity. If enhanced material subsequently fills in features such as pits or ditches then these can produce localised increases in magnetic responses (anomalies) which can be detected by a magnetic gradiometer even when the features are buried under additional soil cover.

1.1.3 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. The strength of magnetic responses that a feature will produce will depend on the background magnetic susceptibility, how rapidly the feature has been infilled, the level and type of human activity in the area and the size and depth of a feature. Not all infilled features can be detected and natural variations can also produce localised positive and negative anomalies.

1.1.4 Thermoremnant magnetism indicates the amount of magnetism inherent in an object as a result of heating. Material that has been heated to a high temperature (fired), such as brick, can acquire strong magnetic properties and so although they may not appear to have a high iron content they can produce strong magnetic anomalies

1.1.5 The magnetic survey method is highly sensitive to interference from surface and near-surface magnetic 'contaminants'. Surface features such as metallic fencing, reinforced concrete, buildings or walls all have very strong magnetic signatures that can dominate readings collected adjacent to them. Identification of anomalies caused by sub-surface features is therefore more difficult, or even impossible, in the vicinity of surface magnetic features. The presence of made ground also has a detrimental effect on the magnetic data quality as this usually contains magnetic material in the form of metallic scrap and brick. Identification of features beneath made ground is still possible if the target feature is reasonably large and has a strong magnetic response but smaller features or magnetically weak features are unlikely to be identified.

1.1.6 The interpretation of magnetic anomalies is often subjective and it is rarely possible to identify the cause of all magnetic anomalies. Not all features will produce a measurable magnetic response and the effectiveness of a magnetic survey is also dependant on the site-specific conditions. The main factors that may limit whether a feature can be detected are the

composition of a feature, its depth and size and the surrounding material. It is not possible to guarantee that a magnetic survey will identify all sub-surface features.

1.1.7 Most high resolution, near surface magnetic surveys utilise a magnetic gradiometer. A gradiometer is a hand-held instrument that consists of two magnetic sensors, one positioned directly above the other, which allows measurement of the magnetic gradient component of the magnetic field. A gradiometer configuration eliminates the need for applying corrections due to natural variations in the overall field strength that occur during the course of a day but it only measures relative variations in the local magnetic field and so comparison of absolute values between sites is not possible.

1.1.8 Features that are commonly located using magnetic surveys include archaeological ditches and pits, buried structures or foundations, mineshafts, unexploded ordnance, metallic pipes and cables, buried piles and pile caps. The technique can also be used for geological mapping; particularly the location of igneous intrusions.

1.2 Instrumentation

1.2.1 A multi-sensor array cart system (MACS) utilising 8 Foerster 4.032 Ferex CON 650 gradiometers, spaced at 0.5 m intervals, with a control unit and data logger was used for the magnetic survey.

1.3 Survey methodology

1.3.1 The MACS utilises an RTK GNSS system which means that survey grids do not have to be established. Instead an area is surveyed over a series of continuous profiles and the position of each data point is recorded using an RTK GNSS system. The sensors have a separation of 0.5 m which means that data was collected on profiles spaced at 0.5 m apart. Readings were taken at between 0.1 m and 0.15 m intervals.

1.3.2 Data is collected on zig-zag profiles along the full length or width of a field, although fields can be sub-divided if they are particularly large. Marker canes are set-out along field boundaries at set intervals and these are used to align the profiles. The survey profiles are usually offset from field boundaries, buildings and other metallic features by several metres to reduce the detrimental effect that these surface magnetic features have on the data. The location of the MACS data is converted direct to Ordnance Survey co-ordinates using the UK OSTN 02 projection. As the data is related direct to Ordnance Survey National Grid co-ordinates temporary survey stations are not established.

1.3.3 The Foerster gradiometers have a resolution of 0.2 nT but the stability of the cart system significantly reduces noise caused by instrument tilt and movement when compared with a traditional hand-held gradiometer system and the increased data intervals provide a higher resolution data set. The sensors have a range of ± 10,000nT and readings are taken at 0.1 nT resolution.

1.4 Data processing and presentation

1.4.1 The MACS data is stored direct to a laptop using in-house software which automatically corrects for instrument drift and calculates a mean value for each profile. A positional value is assigned to each data point based on the sensor number and recorded GNSS co-ordinates. The data is gridded using in-house software and parameters are set based on the sensor spacing and mean values. No additional processing is required. The gridded data is then displayed in Surfer 9 (Golden Software) and image files of the data are created.

1.4.2 The data was exported as raster images (PNG files), and are presented in greyscale format at 1:1250.

1.4.3 The data has been displayed relative to a digital Ordnance Survey base plan provided by the client as drawing *'Allithwaite Lane.dwg'*. The base plan was in the Ordnance Survey National Grid co-ordinate system and as the survey grids were set-out directly to National Grid co-ordinates the data could be simply superimposed onto the base plan in the correct position.

1.5 Interpretation

1.5.1 The anomalies have been categorised based on the type of response that they have and an interpretation as to the cause(s) or possible cause(s) of each anomaly type is also provided. The following anomaly types may be present within the data:

Dipolar and bipolar responses

Dipolar and bipolar responses are those that have a sharp variation between strongly positive and negative components.

In the majority of cases these responses are usually caused by modern ferrous features / objects, although fired material (such as brick), some ferrous or industrial archaeological features and strongly magnetic gravel could also produce dipolar and bipolar responses.

Isolated dipolar responses are those that have a single positive and negative element. They are usually caused by isolated, ferrous or fired material on or near to the surface. The objects that cause dipolar responses are usually relatively small, such as spent shotgun cartridges, iron nails and horseshoes (hence they are often referred to as 'iron spikes') or pieces of modern brick or pot. Some types of archaeological artefacts can also produce this type of response but unless there is strong supporting evidence to the contrary they are assumed not to be of archaeological significance.

Bipolar anomalies have strong positive and negative components but are not technically magnetic dipoles. The majority of **isolated bipolar responses** are caused by ferrous or fired material on or near to the surface. These responses tend to be produced from larger objects, compared to dipolar anomalies, or a concentration of smaller objects. Some archaeological features/ activity, including areas of burning or industrial activity can also produce this type of response but unless there is strong supporting evidence to the contrary they are assumed not to be of archaeological significance.

Isolated dipolar and bipolar responses have not been shown on the interpretation as there is no evidence to suggest that they may be archaeological in origin

Smaller isolated dipolar and bipolar responses have not been shown on the interpretation as there is no evidence to suggest that they are related to archaeological activity. Several larger isolated bipolar responses have been shown as these could be associated with more significant sub-surface features or material (although in this instance they are not thought to be of archaeological interest).

Bipolar linear anomalies are usually produced by buried pipes / cables that are usually metallic, although in some instances ceramic pipes can also produce popular anomalies. In some instances the anomaly can extend for a sigfncaint distance beyond the feature that produces the anomaly. Bipolar anomalies are often very strong and can potentially mask responses from other sub-surface features in the vicinity of the pipe or cable.

Areas containing numerous **strong dipolar / bipolar responses (magnetic disturbance)** are usually caused by greater concentrations of ferrous or fired material and are often

found adjacent to field boundaries where such material tends to accumulate. Above ground metallic or strongly magnetic features, such as fences, gates, pylons and buildings can also produce very strong bipolar responses. If an area of magnetic disturbance is located away from existing field boundaries then it could indicate a former field boundary, several large isolated objects in close proximity, an area where modern material has been tipped or an infilled cut feature, such as a quarry pit. Areas of dipolar / bipolar response can occasionally be caused by features / material associated with archaeological industrial activity or natural deposits that have varying magnetic properties but they are usually caused by modern activity. Responses in areas of magnetic disturbance can sometimes be so strong that archaeological features located beneath them may not be detected.

Very strong responses, notably bipolar anomalies, from modern features can dominate the data for a significant distance beyond the feature. The extent of these areas is usually shown either as part of the bipolar anomaly or as a **limit of very strong response.** It should be noted that this effect extends beyond the feature and so the limit of the response does not correspond to the actual size or location of the feature within it. In many cases where these strong responses are present at the edge of survey area the feature causing the anomaly be actually be located beyond the survey area. It should be recognised that other sub-surface features located within these areas may not be detected.

Negative linear anomalies

Negative linear anomalies occur when a feature has lower magnetic readings than the surrounding material and can often be associated with ploughing regimes or plastic / concrete pipes or natural features.

They can also indicate the presence of a feature that cuts into magnetic soils or bedrock and which is infilled with less magnetic material and in certain geologies can be associated with archaeological features.

There are no significant negative linear anomalies in this data set.

Linear / curvi-linear anomalies (probable agricultural)

In many geological / pedological conditions agricultural features / regimes can produce magnetic anomalies due to the accumulation / alignment of magnetic topsoil. In most cases these are exhibited as a series of **broadly parallel positive linear** anomalies. The majority of these responses are associated with modern ploughing regimes but in some instances, where the responses are broader and more widely spaced, they can indicate the presence of the remnants of ridge and furrow.

Field drain systems can also produce linear anomalies, usually where the drains are made from fired ceramic or infilled with magnetic gravels.

Where a series of parallel anomalies are present then the approximate orientation of the anomalies are shown on the interpretation drawing to indicate the direction of the agricultural regime but for the sake of clarity individual anomalies have not been shown.

Individual anomalies may be shown if the response is not part of a regime.

Broad area of positive / negative responses

Broad areas of positive / negative responses can have a variety of causes. If the areas are generally quite large and irregular in shape then they are usually suggestive of natural features, such as lenses of sand and gravel deposits, palaeochannels or other natural features / variations where the natural material differs from the surrounding sub-surface.

In some instances anomalies of this type can be associated with anthropogenic (usually modern) activity.

Linear / curvi-linear trends

An anomaly is categorised as a **trend** if it is not certain that the response is associated with an extant sub-surface feature. Trends are usually weak, irregular, diffuse or discontinuous and it is usually not certain what their cause is, if they represent significant sub-surface features or even if they are associated with definite features.

It is possible that some of the trends are associated with geological / pedological variations. Others may be produced by artificial constructs within the data, either caused by processing or in some instances by intersecting anomalies (usually different agricultural regimes) that give the appearance of curving or regular shapes. Many trends are a product of weak, naturally occurring responses that happen to form a regular pattern but which are not associated with a sub-surface feature.

In some instances former features that have been severely truncated can still produce broad, diffuse or weak responses even if the underlying feature has been removed. This is due to the presence of magnetic soils associated with the former feature still being present along its route. In other instances the magnetic properties of the soils filling a feature may vary and so the magnetic signature of the feature can change, even if the sub-surface feature itself remains uniform. If a response from a feature becomes significantly weak or diffuse then part of the anomaly may be shown as a trend as it is uncertain if the feature is still present or has been severely truncated or removed.

Isolated positive responses

Isolated positive responses can occur if the magnetism of a feature, area or material has been enhanced or if a feature is naturally more magnetic than the surrounding material. It is often difficult to determine which of these factors causes any given responses and so the origin of this type of anomaly can be difficult to determine. They can have a variety of causes including geological variations, infilled archaeological features, areas of burning (including hearths), industrial archaeological features, such as kilns, or deeper buried ferrous material and modern fired material.

The large number of isolated responses and lack of an obvious pattern to their distribution suggests that these anomalies are probably associated with geological / pedological variations. Only the larger or stronger areas of positive response have been shown on the interpretation.

Positive linear / curvi-linear anomalies

Positive magnetic anomalies indicate an increase in magnetism and if the resulting anomaly is linear or curvi-linear then this can indicate the presence of a man-made feature. **Positive or enhanced linear / curvi-linear** anomalies can be associated with agricultural activity, drainage features but they can also be caused by ditches that are infilled with magnetically enhanced material and as such can indicate the presence of archaeological features. Some natural infilled features can also produce positive anomalies.

1.5.2 Several different ranges of data were used in the interpretation to ensure that the maximum information possible is obtained from the data.

1.5.3 X-Y trace plots were examined for all of the data and overlain onto the greyscale plot to assist in the interpretation, primarily to help identify dipolar / bipolar responses that will probably

be associated with surface / near-surface iron objects. X-Y trace plots have not been used in the report as they do not show any additional anomalies that are not visible in the greyscale data. A digital drawing showing the X-Y trace plot overlain on the greyscale plot has been provided in the digital archive.

1.5.4 All isolated responses have been assessed using a combination of greyscale and X-Y trace plots.

1.5.5 Anomalies associated with agricultural regimes are present in the data. The general orientation of these regimes has been shown on the interpretation but, for the sake of clarity, each individual anomaly has not been shown.

1.5.6 The greyscale plots and the accompanying interpretations of the anomalies identified in the magnetic data are presented as 2D AutoCAD drawings. The interpretation is made based on the type, size, strength and morphology of the anomalies, coupled with the available information on the site conditions. Each type of anomaly is displayed in separate, easily identifiable layers annotated as appropriate.

1.6 Limitations of magnetic surveys

1.6.1 The magnetic survey method requires the operator to walk over the site at a constant walking pace whilst holding the instrument. The presence of an uneven ground surface, dense, high or mature vegetation or surface obstructions may mean that some areas cannot be surveyed.

1.6.2 The depth at which features can be detected will vary depending on their composition, size, the surrounding material and the type of magnetometer used for the survey. In good conditions large, magnetic targets, such as buried drums or tanks can be located at depths of more than 4 m. Smaller targets, such as buried foundations or archaeological features can be located at depths of between 1 m and 2 m.

1.6.3 A magnetic survey is highly sensitive to interference from surface and near-surface magnetic 'contaminants'. Surface features such as metallic fencing, reinforced concrete, buildings or walls all have very strong magnetic signatures that can dominate readings collected adjacent to them. Identification of anomalies caused by sub-surface features is therefore more difficult or even not possible in the vicinity of surface and near-surface magnetic features.

1.6.4 The presence of made ground also has a detrimental effect on the magnetic data quality as this usually contains magnetic material in the form of metallic scrap and brick. Identification of features beneath made ground is still possible if the target feature is reasonably large and has a strong magnetic response but smaller features or magnetically weak features are unlikely to be identified.

1.6.5 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.

1.6.6 A magnetic survey does not directly locate sub-surface features - it identifies variations or anomalies in the local magnetic field caused by features. It can be possible to interpret the cause of anomalies based on the size, shape and strength of response but it should be recognised that a magnetic survey produces a plan of magnetic variations and not a plan of all sub-surface features. Interpretation of the anomalies is often subjective and it is rarely possible to identify the cause of all magnetic anomalies. Geological or pedological (soil) variations or features can produce responses similar to those caused by man-made (anthropogenic) features.

1.6.7 Anomalies identified by a magnetic survey are located in plan. It is not usually possible to obtain reliable depth information on the features that cause the anomalies.

1.6.8 Not all features will produce a measurable magnetic response and the effectiveness of a magnetic survey is also dependant on the site-specific conditions. It is not possible to guarantee that a magnetic survey will identify all sub-surface features. A magnetic survey is often most-effective at identifying sub-surface features when used in conjunction with other complementary geophysical techniques.