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Date: 26th January 2026

LEE LANE, ROYSTON – GEOPHYSICAL SURVEY

Dear Mr Danforth

In 2018 Phase Site Investigations carried out a geophysical survey within the site to determine the presence of archaeological features and anomalies. The survey determined that most of the anomalies identified are likely to be associated with modern material / objects, agricultural activity and geological / pedological variations.

Recorded within the northern extent of the Site are two parallel features which has been suggested to be a trackway. In addition to this a number of other anomalies with a weaker response have been recorded which were suggested to be associated with drainage and agricultural activity including the ridge and furrow which runs across the survey area in a northwest southeast direction.

Given the quality of the survey, that shown provides a good impression of the likely archaeological activity within Site. The anomalies identified are likely to be associated with the areas previous agricultural use. In line with the requirement of Paragraph 207 of the NPPF, it will enable the planning authority's decision making with regard to the planning application.

Based on the clarity offered by the results, we would recommend that trial trenching is undertaken as a condition of the application to provide further detail on the recorded anomalies and to aid in the decision making process in regards to suitable mitigation, if required.

Yours sincerely

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enc. Geophysical Survey Report (Appendix 1)

APPENDIX 1
Geophysical Survey Report

Land off Lee Lane, Royston
South Yorkshire

Archaeological geophysical survey

Project No. ARC/2453/925

December 2018

Land off Lee Lane, Royston
South Yorkshire

Archaeological geophysical survey

Project No. ARC/2453/925

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Date	03/12/18	Date	05/12/18

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1. SUMMARY

Phase Site Investigations Ltd was commissioned to carry out a magnetic gradient survey at a site off Lee Lane, Royston, South Yorkshire. 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 ridge and furrow) and geological / pedological variations. There are two broadly parallel linear anomalies present that are suggestive of infilled features and which could be related to a trackway. These anomalies ‘fade out’ in the north-east of the site, as do responses related to agricultural activity. This suggests that the soils in this area, and also in the east of the site, may have a lower magnetic susceptibility than other parts of the site.

There a number of weak trends present that are of uncertain origin. It is likely that the majority of these are related to agricultural or drainage activity but it is possible that some of them could be caused by the infilled features. Generally the trends are too weak or fragmented to reliably interpret.

INTRODUCTION

1.1 Overview

Phase Site Investigations Ltd was commissioned by BWB Consulting Ltd to carry out an archaeological geophysical survey at a site off Lee Lane, Royston, South Yorkshire 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_2453_925_01.

1.2 Site description

The site is situated at land off Lee Lane on the south-western edge of Royston, South Yorkshire (centred at NGR SE 348 110), approximately 4.5 km to the north of Barnsley and covered an area of approximately 8.7 ha.

The site consisted of an arable field, which had been tilled prior the survey. The ground sloped gently upwards to the south-east. The survey area was bounded by bushes and trees on all sides with additional wooden and metal wire fencing along the east. A number of trees were present within the centre and the south-east of the site and a wooden overhead cable pole was present in the east of the field.

The geology of the majority of the site consists of sandstone of the Oaks Rock formation. A small area on the eastern edge of the site consists of mudstone, siltstone and sandstone of the Pennine Middle Coal Measures. The entire survey area is overlain by glacial till (British Geological Survey, 2018). The soils of the majority of the site are described as slowly permeable seasonally wet acid loamy and clayey soils, whereas a small area in the north-west described as freely draining slightly acid loamy soils (Soilscapes, 2018).

1.3 Archaeological background

An archaeological desk-based assessment (Wardell Armstrong, 2013) for a site to the north of Lee Lane, which is in close proximity to the current site, indicates that the site is located in an area with no scheduled monuments or HER assets. However, within 1 km radius there is a late prehistoric settlement at Notton Park (to the north-west of the current site) and several undated crop marks.

Historic maps (old-maps.co.uk, 2018) indicate that the site had been previously sub-divided into four smaller fields.

1.4 Scope of work

The survey area was specified by the client.

Areas adjacent to field boundaries, where there is likely to be disturbance from modern material, were left unsurveyed. An area of approximately 7.2 ha was covered by the magnetic survey, the location of which is shown in drawing ARC_2453_925_02.

No other problems were encountered during the survey which was carried out on the 12th and 13th November 2018.

2. SURVEY METHODOLOGY

2.1 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.

2.2 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 1:1500. 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 base plan provided by the client as drawing *'S9051 – Lee Lane, Royston.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 these 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. 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.

3. RESULTS

3.1 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.

The interpretation of the data is complicated slightly by the presence of former agricultural regimes and drainage regimes with different and intersecting alignments. This has meant that in some cases it is not certain if an anomaly is related to one of these regimes, or if it is caused by an underlying feature. It is also possible that the intersecting regimes have created anomalies that look regular or curving and hence could suggest the presence of archaeological features but which are actually not associated with sub-surface features. Many of the trends that have been shown may actually be a product of the agricultural activity and not caused by underlying features.

It is noticeable that the eastern part of the site and the north-eastern area have a much more uniform magnetic background and responses from agricultural activity are much weaker or not visible. This suggests that the soils in these areas may have a lower magnetic susceptibility than other parts of the site. Features could be present in these areas that contain fill material which is not sufficiently magnetically enhanced to allow their reliable detection.

The categories of anomaly, and their possible causes, which have been identified by the survey are discussed in detail below.

3.2 Anomaly types and further discussion

There are numerous **isolated dipolar** responses (iron spikes) across the survey area. These contain a strong positive and negative component and are indicative of ferrous or fired material on or near to the surface. **Isolated bipolar** responses are also present. These have strong positive and negative components but are not technically magnetic dipoles. They tend to be caused by ferrous or fired material on or near to the surface and are usually produced from larger, or more strongly magnetic, objects (compared to dipolar anomalies) or a concentration of strongly magnetic smaller objects. In the large majority of cases these two types of isolated responses will be caused by modern material. The potential for some of the responses of this type to be associated with archaeological activity may be increased slightly if they are located in proximity to other archaeological features / activity. The isolated dipolar and smaller bipolar responses at this site are all assumed not to be of archaeological significance and have not been shown on the interpretation.

Several larger bipolar responses have been shown on the interpretation because they are considered to be more likely to be associated with more significant sub-surface features or material (although in this instance they are not thought to be of archaeological interest). For these responses the main positive component(s) of the response is shown (as this will better represent where an underlying feature / material may be located) and the overall extent of the response is also shown. The latter will usually extend well beyond the underlying feature but may indicate an area where the strong bipolar anomaly could mask responses from any other underlying features.

A group of strong bipolar responses (**Anomalies A**) in the north-east of the site stand out as they indicate the presence of significant, strongly magnetic material / features. The exact cause of these is not certain but they are likely to be relatively modern in origin.

Areas of **magnetic disturbance** are present. These are areas of strong bipolar and dipolar responses and are usually associated with concentrations of relatively modern magnetic material. In this case they are not considered to be archaeologically significant.

A very strong response at the perimeter of the survey area is associated with adjacent strongly magnetic modern features. The extent of this area is shown 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.

There are several series of **broadly parallel positive linear anomalies**, some of which are relatively weak, that are associated with recent agricultural ploughing regimes.

There is also evidence for a number of drainage and possible drainage regimes. Where there are a number of **broadly parallel linears** related to drainage the general orientation of these has been shown. Some of these responses are negative anomalies, suggesting that plastic drains may be present.

There are other series of **broadly parallel positive linears / trends** that will be associated with agricultural features. They are of uncertain origin as they have irregular patterns or are weak, fragmented responses. They are possibly related to former ploughing regimes or field drains but they could also be related to the remnants of ridge and furrow.

There are several series of **broadly parallel positive linear anomalies** that are associated with the remnants of ridge and furrow and possible ridge and furrow.

There are three **linear positive responses / trends** that correspond with former field boundaries and will be related to the remnants of these features.

Numerous linear / curvi-linear **trends** have been identified that do not correspond with the obvious agricultural regimes. It is probable that the majority of these trends relate to agricultural or drainage features or natural features / variations. However, some of the trends may indicate the presence of sub-surface features or variations.

There are several **isolated positive responses** across the survey area, some of which are relatively large or strong. This type of anomaly can have a variety of causes including natural variations, deeper buried ferrous or fired material or accumulations of topsoil related to agricultural activity. It is possible that some of the isolated positive responses are caused by infilled discrete features but there is no obvious pattern or relationship to their distribution that would indicate an archaeological origin and it is considered more likely that they are caused by natural variations or deeper buried relatively modern, ferrous or fired material.

There are two **linear positive responses** that run parallel in the east of the site (**Anomalies B**). They are indicative of infilled features, and are suggestive of infilled ditches relating to an archaeological trackway. The anomalies become weaker and fade out to the east. It is possible that the underlying features terminate or have been truncated / removed to a greater extent in the east but it is more likely that a change in soil conditions in this part of the site means that the fill material is much less magnetic in the east. This means that the underlying features probably continue but the responses are much weaker in the east. Where the response is stronger it has been shown as a positive anomaly, where it is weaker or more fragmented it has been shown on as a trend. The latter may indicate where there is greater truncation or they could reflect where the fill material is less magnetic.

In the north of the site there are a number of weak trends (**Anomalies C**). Anomalies relating to ridge and furrow may terminate adjacent to Anomalies C, although as this is located on the edge of the survey area this cannot be confirmed with certainty. It is possible that some of the trends are associated with the ridge and furrow, and may be related to a headland or change in agricultural regime, but some of the trends could also be caused by underlying infilled features, although whether these could be related to archaeological features, drainage or other agricultural activity is not certain.

Anomaly D is a trend that is located in proximity but has a different alignment to Anomalies C. It is not certain if this is related to Anomalies C or has a different cause.

Two other trends (**Anomalies E**) are present that run oblique to the main agricultural regimes. Again it is not certain if these are related to drainage or agricultural activity or whether they caused by other infilled features.

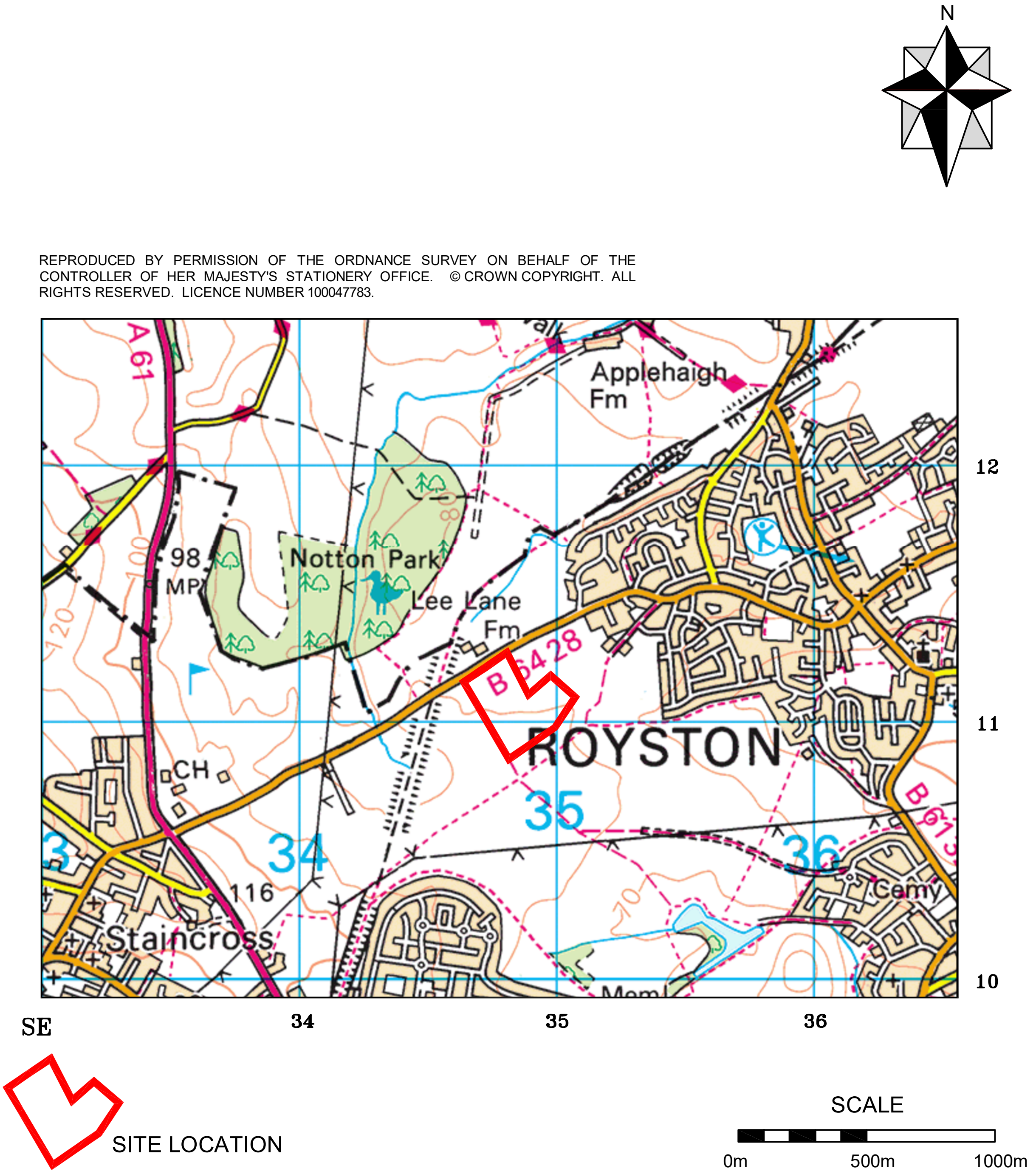
There are a number of weak, curvi-linear trends present (**Anomalies F**). Curving anomalies can be caused by the remnants of circular / sub-circular features but they can also be a product of intersecting agricultural regimes, which produce the illusion of a curving response, and may not be caused by sub-surface features. There is no clear evidence for Anomalies F be related to archaeological features / activity but the trends are too weak to reliably interpret.

4. DISCUSSION AND CONCLUSIONS

The majority of the anomalies identified by this survey relate to modern material / objects, agricultural activity (including ridge and furrow) and geological / pedological variations. There are two broadly parallel linear anomalies present that are suggestive of infilled features and which could be related to a trackway. These anomalies 'fade out' in the north-east of the site, as do responses related to agricultural activity, but the underlying features probably continue. This suggests that the soils in this area, and also in the east of the site, may have a lower magnetic susceptibility than other parts of the site. Features could be present in these areas that contain fill material which is not sufficiently magnetically enhanced to allow their reliable detection.

There a number of weak trends present that are of uncertain origin. The interpretation of the data is complicated slightly by the presence of former agricultural regimes and drainage regimes with different and intersecting alignments but it is likely that the majority of the trends are related to agricultural or drainage activity, however, it is possible that some of them could be caused by the infilled features. Generally the trends are too weak or fragmented to reliably interpret.

The interpretation of the data is complicated slightly by the presence of former agricultural regimes and drainage regimes with different and intersecting alignments. This has meant that in some cases it is not certain if an anomaly is related to one of these regimes, or if it is caused by an underlying feature. It is also possible that the intersecting regimes have created anomalies that look regular or curving and hence could suggest the presence of archaeological features but which are actually not associated with sub-surface features. Many of the trends that have been shown may actually be a product of the agricultural activity and not caused by underlying features.



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Scale [A4 Sheet]	Drawing	Status
AS SHOWN	ARC_2453_925_01	FINAL

Client: BWB CONSULTING LTD LEEDS

Site: LAND OFF LEE LANE, ROYSTON SOUTH YORKSHIRE

Title: SITE LOCATION MAP

Job No: ARC_2453_925

		Drawn	AB
Chk.	MW	Date	15/11/2018

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Scale [A3 Sheet]	Drawing	Status
1:3000	ARC_2453_925_02	PRELIM

Client: BWB CONSULTING LTD LEEDS

Site: LAND OFF LEE LANE, ROYSTON SOUTH YORKSHIRE

Title: LOCATION OF SITE SHOWING MAGNETIC GRADIENT DATA

Job No: ARC_2453_925

Surveyed	AB, CA	Drawn	AB, JW
Chk.	MW	Date	13/11/2018

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Scale [A3 Sheet]	Drawing	Status
1:1500	ARC_2453_925_03	FINAL

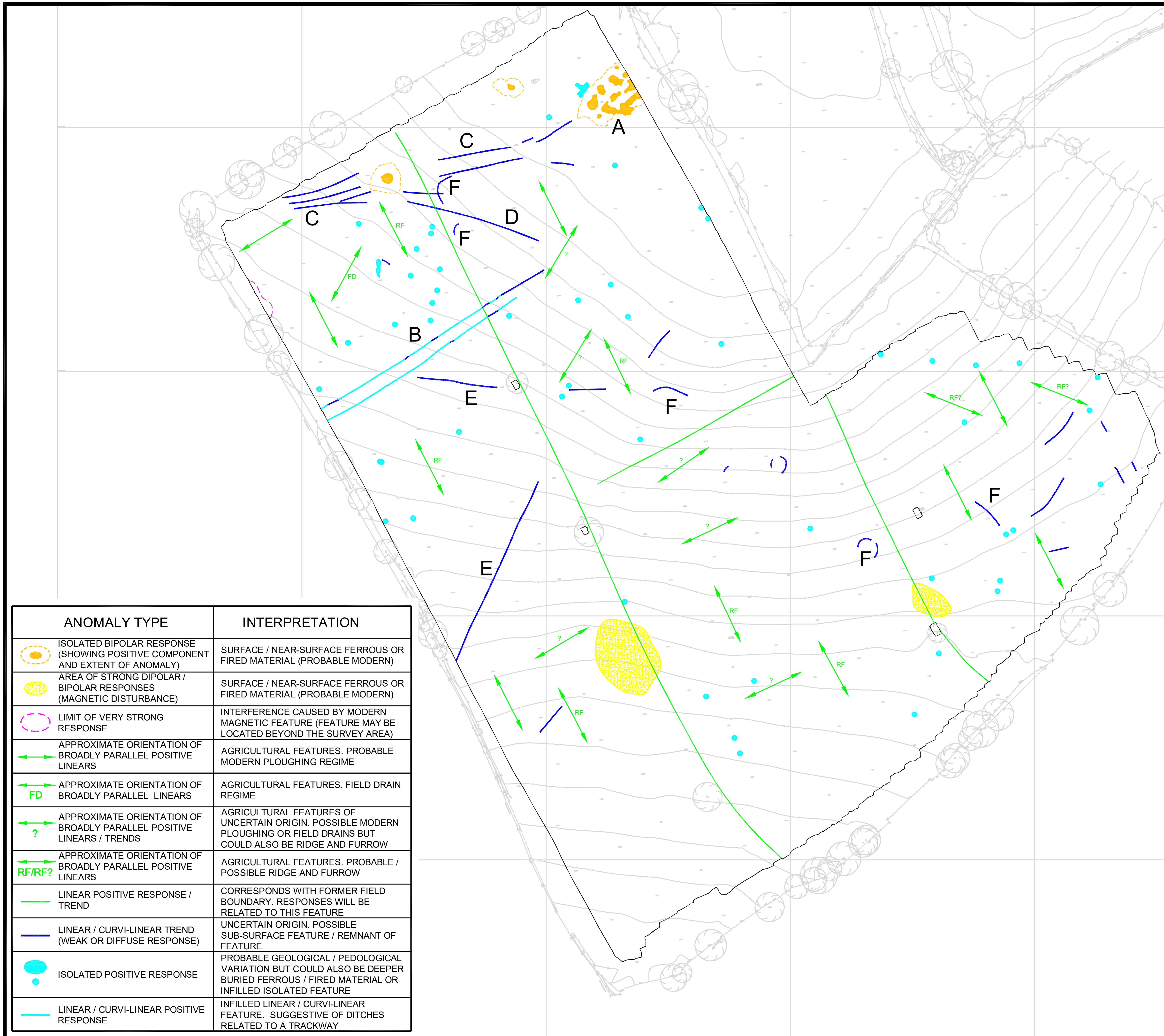
Client: BWB CONSULTING LTD LEEDS

Site: LAND OFF LEE LANE, ROYSTON SOUTH YORKSHIRE

Title: GREYSCALE PLOT OF MAGNETIC GRADIENT DATA

Job No: ARC_2453_925

Surveyed	AB, CA	Drawn	AB, JW
Chk.	MW	Date	13/11/2018



ANOMALY TYPE / INTERPRETATION

ANOMALY TYPE	INTERPRETATION
ISOLATED BIPOLAR RESPONSE (SHOWING POSITIVE COMPONENT AND EXTENT OF ANOMALY)	SURFACE / NEAR-SURFACE FERROUS OR FIRED MATERIAL (PROBABLE MODERN)
AREA OF STRONG DIPOLAR / BIPOLAR RESPONSES (MAGNETIC DISTURBANCE)	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 BROADLY PARALLEL POSITIVE LINEARS	AGRICULTURAL FEATURES. PROBABLE MODERN PLOUGHING REGIME
FD APPROXIMATE ORIENTATION OF BROADLY PARALLEL LINEARS	AGRICULTURAL FEATURES. FIELD DRAIN REGIME
? APPROXIMATE ORIENTATION OF BROADLY PARALLEL POSITIVE LINEARS / TRENDS	AGRICULTURAL FEATURES OF UNCERTAIN ORIGIN. POSSIBLE MODERN PLOUGHING OR FIELD DRAINS BUT COULD ALSO BE RIDGE AND FURROW
RF/RF? APPROXIMATE ORIENTATION OF BROADLY PARALLEL POSITIVE LINEARS	AGRICULTURAL FEATURES. PROBABLE / POSSIBLE RIDGE AND FURROW
LINEAR POSITIVE RESPONSE / TREND	CORRESPONDS WITH FORMER FIELD BOUNDARY. RESPONSES WILL BE RELATED TO THIS FEATURE
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 LINEAR / CURVI-LINEAR FEATURE. SUGGESTIVE OF DITCHES RELATED TO A TRACKWAY

NOTES

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Scale [A3 Sheet]	Drawing	Status
1:1500	ARC_2453_925_04	FINAL

Client: BWB CONSULTING LTD LEEDS

Site: LAND OFF LEE LANE, ROYSTON SOUTH YORKSHIRE

Title: INTERPRETATION OF MAGNETIC GRADIENT DATA

Job No: ARC_2453_925

Surveyed	AB, CA	Drawn	AB, JW
Chk.	MW	Date	13/11/2018

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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 to survey part of the site.

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 1:1500.

1.4.3 The data has been displayed relative to a digital base plan provided by the client as drawing *'S9051 – Lee Lane, Royston.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.

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.

There are no bipolar linear anomalies in this data set.

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.

At this site it is highly likely that all negative linear anomalies are associated with drainage or agricultural activity and they are not thought to be archaeological significant.

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.

There are no anomalies of this type in this data set.

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.

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.