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Huddersfield
HD1 2JR

Our Ref: JM MW 020318

Date: 2nd March 2018

Balderstone Hall, Mirfield – Archaeology 2017/62/93935E

Dear Mr Woodward

Please find enclosed the geophysical survey report which details the results of the survey undertaken by Phase Site Investigations in February 2018.

The equipment used comprised a multi-sensor array cart system which consisted of 8 Foerster 4.032 Ferex CON 650 gradiometers with a control unit and data logger. This consistently produces high quality results than the standard single gradiometers. Subsequently the survey has produced very clear results and has provided a sound understanding of the archaeological resource within the site.

Within the survey area there are a number of possible enclosures and an associated trackway. There are also some sub-circular features which appear to be associated with the enclosures. Based on the form of the features they are likely to be Iron Age/ Romano British in origin.

Section 12 of the National Planning Policy Framework (paragraph 128) states that in determining applications the level of detail obtained '*….should be proportionate to the asset's importance and no more than is sufficient to understand the potential impact of the proposal on their significance'*. On this basis it is our professional opinion that the results of the survey provide sufficient information to determine the application with the trial trenching undertaken as a condition.

Yours sincerely

Jim MacQueen
Associate Director

enc Geophysical Survey Report

cc Mark Lane
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Balderstone Hall, Mirfield
West Yorkshire

Archaeological geophysical survey

Project No. ARC/2303/829

February 2018

Balderstone Hall, Mirfield
West Yorkshire

Archaeological geophysical survey

Project No. ARC/2303/829

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Signature	M. Whitt	Signature	NEMFairs
Date	23/02/18	Date	24/02/18

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DIGITAL COPY OF REPORT CAN BE FOUND ON CD ATTACHED TO BACK COVER

1. SUMMARY

Phase Site Investigations Ltd was commissioned to carry out a magnetic gradient survey at a site at Balderstone Hall, Mirfield. 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 4 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 survey has provided evidence for archaeological activity, in the form of parts of several enclosures, possible enclosures and a probable trackway. A sub-circular anomaly is present that is either a sub-enclosure related to the larger enclosure system or an earlier sub-circular feature that has been cut by a later enclosure. Anomalies indicative of ridge and furrow are also present.

A possible second sub-circular anomaly and a number of other curving responses are present but is not certain which of these, if any, are related to archaeological features as some of them could be a product of different agricultural regimes.

It is clear that the agricultural regimes, both ridge and furrow and later relatively modern ploughing, have truncated underlying archaeological features. This can be seen in Field 1 and also in parts of Field 2 where the responses are fragmented. It is also possible that archaeological features could be present that have the same alignment as the agricultural features and which could potentially be masked. There could therefore be additional features present underlying the agricultural features that could not be identified by the survey.

The majority of the remaining anomalies identified by this survey relate to modern material / objects, relatively agricultural activity and geological / pedological variations. There are a number of linear / curvi-linear anomalies and isolated positive responses of uncertain origin. Some of these could be caused by archaeological features / activity but many of them could be associated with agricultural activity, natural features / variations or modern material.

2. INTRODUCTION

2.1 Overview

Phase Site Investigations Ltd was commissioned by BWB Consulting Ltd to carry out an archaeological geophysical survey at a site at Balderstone Hall, Mirfield 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_2303_829_01.

2.2 Site description

The site is situated on the north-eastern edge of Mirfield, West Yorkshire (centred at NGR SE 210 211) and covered an area of approximately 4.8 ha.

The site encompassed two pasture fields. Each field has been given a number as shown in drawing ARC_2303_829_02. The smaller northernmost field was subdivided by metallic fencing.

The fields were relatively level and sloped gradually upwards from south to north. They were bounded by a mix of fencing, walls, hedges and dense vegetation.

The geology of the site consists of Falhouse Rock sandstone with no recorded superficial deposits (British Geological Survey, 2018). The soils of the site are described as slowly permeable seasonally wet acid loamy and clayey soils (Soilscapes, 2018).

2.3 Archaeological background

A heritage assessment undertaken by BWB Consulting Ltd (2017) highlights that, '*No archaeological sites or historic features have been identified within the proposed development site'*.

The heritage assessment states that there is only sporadic evidence for prehistoric activity and no clear evidence for Roman period activity in the Mirfield area. It is probable that there was a rural settlement at Mirfield during the Anglo Saxon period which continued through the medieval period. During the post-medieval period Mirfield become more industrialised.

Balderstone Hall, to the east of the site was proabbly built in the early to mid-18th century.

Historic maps shown in the heritage assessment indicate that the larger southern field was sub-divided by at least two former field boundaries in the mid 1800s, the last of which was removed by the 1930s.

2.4 Scope of work

Due to the presence of dense vegetation and metallic fencing around the perimeter of the field, and sub-dividing the northern field, the area accessible / suitable for survey was reduced to approximately 3.9 ha, the extents of which are shown in drawing ARC_2303_829_02.

No other problems were encountered during the survey which was carried out on the 08 and 09 of February 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 4 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 '*Fig 2.dwg*'. The base plan was in the 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. Isolated dipolar responses have been shown in proximity to some anomalies that are suggestive of archaeological features and some responses of uncertain origin. These responses are highly likely to be caused by modern material but the potential for these to be associated with archaeological features is increased slightly by their proximity to other anomalies / features.

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 an 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.

Strong, broadly parallel positive linear anomalies are present in most of the data, associated with ridge and furrow or modern ploughing activity, and there are numerous strong anomalies associated with infilled archaeological feature. These responses indicate that the soil has a magnetic susceptibility that is sufficiently high to produce measureable magnetic responses when enhanced. This usually suggests 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. It is worth noting that former field boundaries shown on historic maps are not visible in the magnetic data which confirms that some types of infilled features (potentially those that were not extant for a long period and which may have been infilled relatively rapidly) are not detected by a magnetic survey.

4.2 Field 1

Basic topography:	Relatively level.
Field description:	Pasture. Firm underfoot. Bounded by fencing, hedges and dense vegetation and sub-divided by metal fencing.
Summary of anomalies:	Numerous isolated dipolar and bipolar responses, the majority of which are probably modern in origin.
	Very strong responses associated with strongly magnetic modern features / material. The feature / material causing the response may be located beyond the survey area.
	Weak positive linear responses are present associated with agricultural activity. The majority of these will be related to modern ploughing regimes but some responses could be caused by the remnants of ridge and furrow.
	Positive linear responses associated with ridge and furrow.
	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.
	Positive linear / curvi-linear responses possibly associated with parts of archaeological enclosures.

Further discussion / additional information:

Responses related to the ridge and furrow is clearly visible in the western part of this field but are less clear in the eastern part. There are anomalies suggestive of relatively recent agricultural regimes in the eastern part of the field and it seems likely that ridge and furrow has been removed or severely truncated by this more recent agricultural activity. Although it is possible that the remnants of ridge and furrow could be present but have been partially masked by responses related to the modern ploughing activity.

There are positive linear / curvi-linear in this field (**Anomalies A**) that are suggestive of infilled archaeological features. However the responses in this field are fragmented and located at the edges of the survey area and so it is not possible to say definitively that they are associated with archaeological features.

A linear trend is present in the western part of the field (**Anomaly B**). This anomaly is very straight which could suggest that it is caused by a modern feature, such as a pipe or drain, but its exact cause is not known.

There are numerous isolated positive responses in this field. There is no obvious pattern to the distribution of these anomalies that would indicate an archaeological origin and it is thought that the majority of these will be caused by pedological variations, although some could be caused by deeper buried ferrous or fired material.

4.3 Field 2

Basic topography:	Relatively level, sloping downwards gradually to the north.
Field description:	Pasture. Firm underfoot. Bounded by fencing, hedges and dense vegetation.
Summary of anomalies:	Numerous isolated dipolar and bipolar responses, the majority of which are probably modern in origin.
	Very strong responses associated with strongly magnetic modern features / material. The feature / material causing the response may be located beyond the survey area.
	Weak positive linear responses are present associated with relatively modern ploughing activity.
	Positive linear responses associated with ridge and furrow.
	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.
	Positive linear / curvi-linear responses possibly associated with parts of archaeological enclosures.

Further discussion / additional information:

There are a number of anomlaies in this field that are clearly related to infilled archaeological features. **Anomalies C** are caused by boundary ditches associated with parts of enclosures. The enclosure responses in the south of the field are more fragmented and there is no clear relationship between this and the responses in the central and northern parts of the field, suggesting that there may have been different degrees of truncation across the field and that some archaeological features may have been removed or only have faint remnants left.

In the west of the field there are parallel responses (**Anomalies D**) suggestive of a trackway but this is less clear in the north-west of the field where the responses are more fragmented (**Anomalies D1**). There is also a possible parallel response in the central part of the field (**Anomalies D2**) but these responses are very weak and fragmented and are only visible as faint trend. The alignment of D2 is also very similar to responses associated with the modern ploughing regime. It is not certain if D2 is caused by modern ploughing activity or is associated with the remnants of an archaeological feature.

There is a sub-circular anomaly (**Anomaly E1**) adjacent to one of the enclosure responses, which is approximately 16 m across. This response is either related to a circular feature (such as a large round house or barrow) that has been cut across at its edge by a later linear archaeological feature, or it is a broadly circular sub-enclosure that is attached to the linear archaeological feature.

There is a suggestion of a second sub-circular feature which is similar in size to E1 but these responses are weaker and more fragmented (**Anomaly E2**). The anomaly could be related to a circular feature, which has been severely truncated in parts, but it is also possible that the responses are a product of a combination of agricultural activity and possible curvi-linear features / variations.

There are suggestions of a number of other curving trends, in proximity to Anomalies E1 and E2 and also in other parts of the field. Again it is not certain if these are related to sub-surface features or if they are a product of the different agricultural regimes.

A number of additional linear trends and positive linear responses are present. Some of these could be related to archaeological features, particularly where they are in proximity to Anomalies C, but others could be associated with agricultural activity.

There are numerous positive isolated responses across this field. There is no obvious pattern to the distribution of these anomalies that would indicate an archaeological origin and it is thought that the majority of these will be caused by pedological variations, although some could be caused by deeper buried ferrous or fired material. Two of these responses stand out due to their relatively large size (**Anomalies F**) and while they could possibly be caused by archaeological features or activity they could also be a product of natural features / variations, localised pedological variations or modern material.

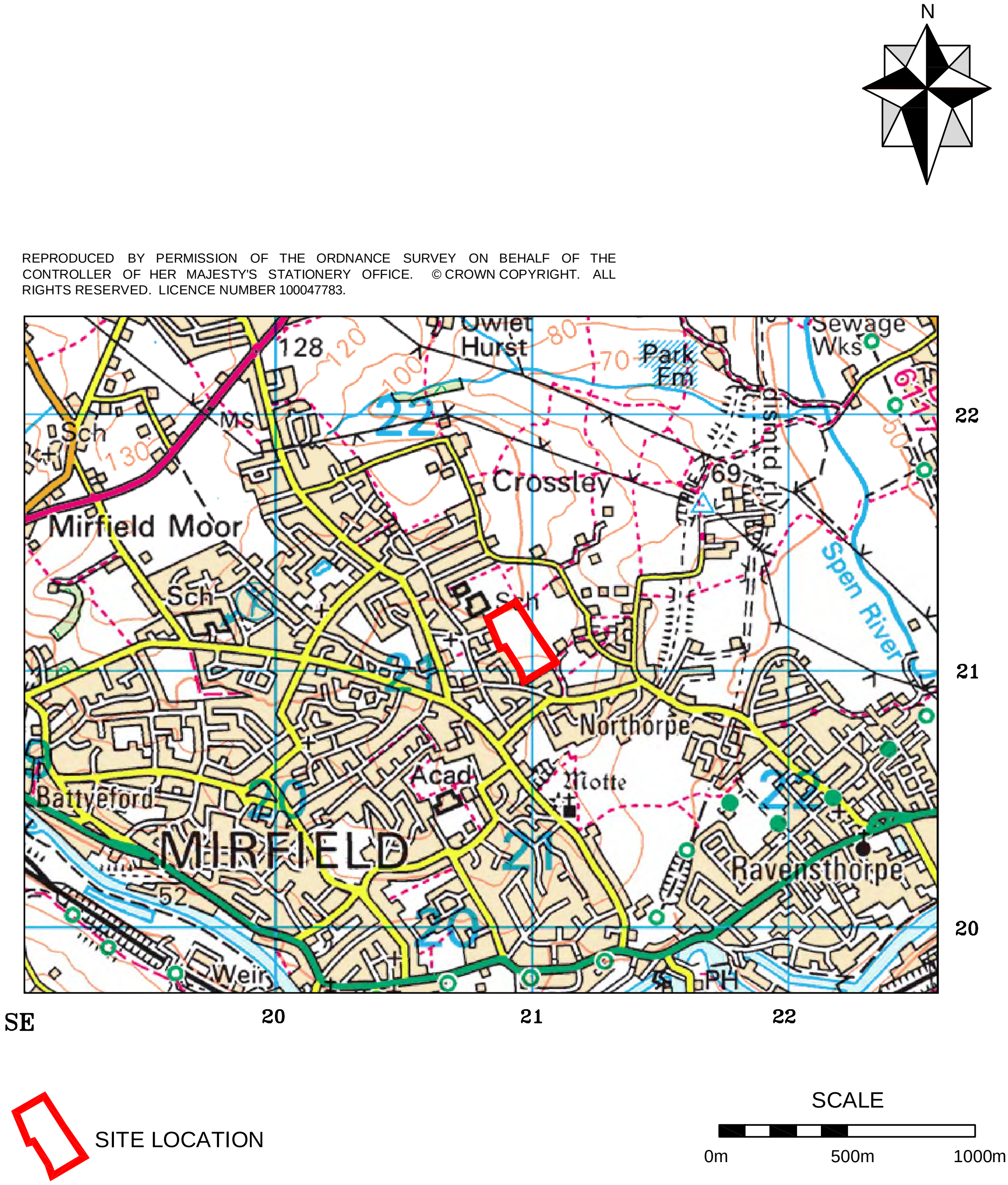
5. DISCUSSION AND CONCLUSIONS

The survey has provided evidence for archaeological activity, in the form of parts of several enclosures, possible enclosures and a probable trackway. A sub-circular anomaly is present that is either a sub-enclosure related to the larger enclosure system or an earlier sub-circular feature that has been cut by a later enclosure. Anomalies indicative of ridge and furrow are also present.

A possible second sub-circular anomaly and a number of other curving responses are present but is not certain which of these, if any, are related to archaeological features as some of them could be a product of different agricultural regimes.

It is clear that the agricultural regimes, both ridge and furrow and later relatively modern ploughing, have truncated underlying archaeological features. This can be seen in Field 1 and also in parts of Field 2 where the responses are fragmented. It is also possible that archaeological features could be present that have the same alignment as the agricultural features and which could potentially be masked. There could therefore be additional features present underlying the agricultural features that could not be identified by the survey.

The majority of the remaining anomalies identified by this survey relate to modern material / objects, relatively agricultural activity and geological / pedological variations. There are a number of linear / curvi-linear anomalies and isolated positive responses of uncertain origin. Some of these could be caused by archaeological features / activity but many of them could be be associated with agricultural activity, natural features / variations or modern material.



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	Client BWB CONSULTING LTD LEEDS		
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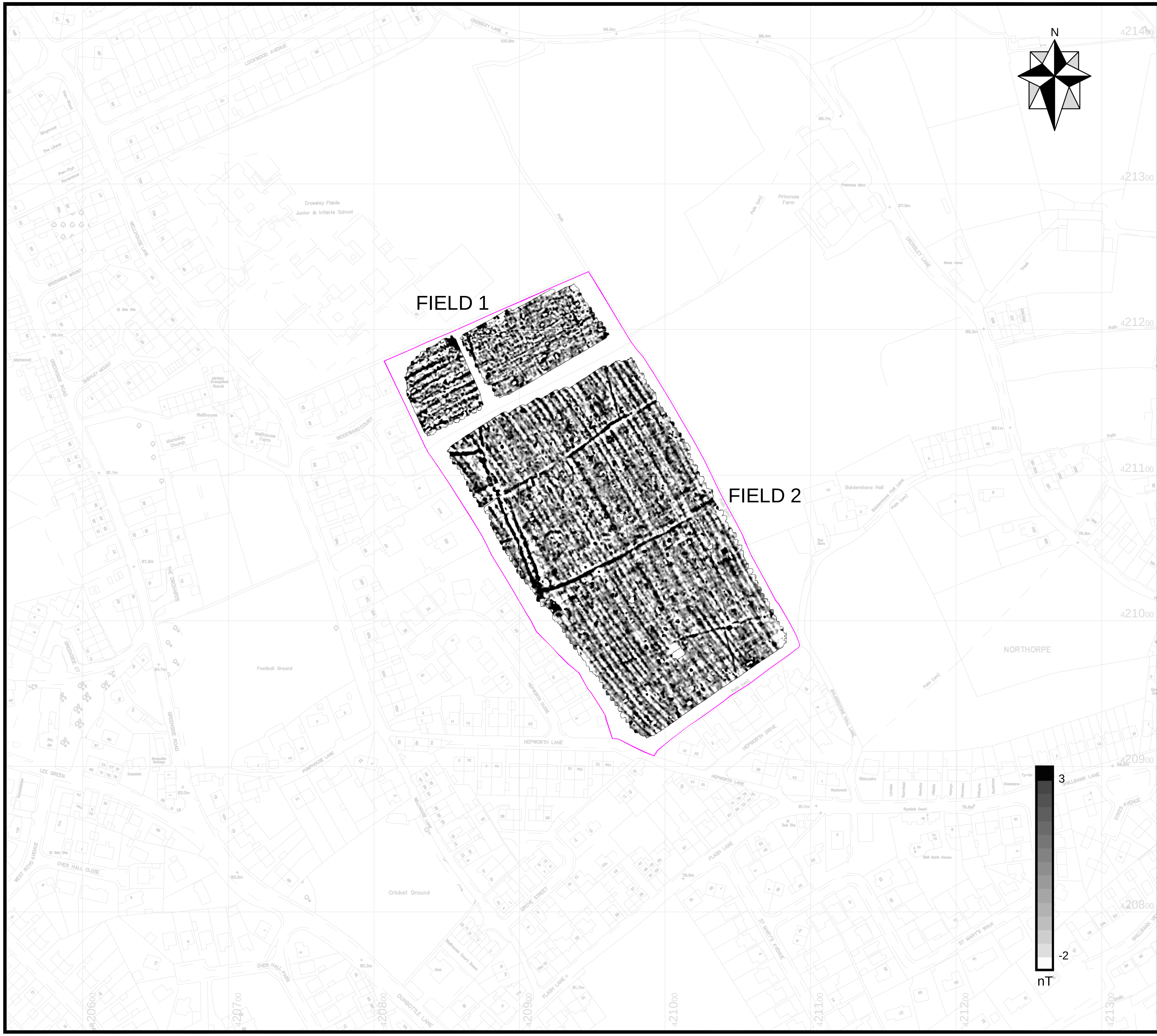
	Title SITE LOCATION MAP		
	Job No ARC_2303_829		
		Drawn	AB
	Chk. MW	Date	12/02/2018



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Scale [A3 Sheet]	Drawing	Status
1:2500	ARC_2303_829_02	FINAL

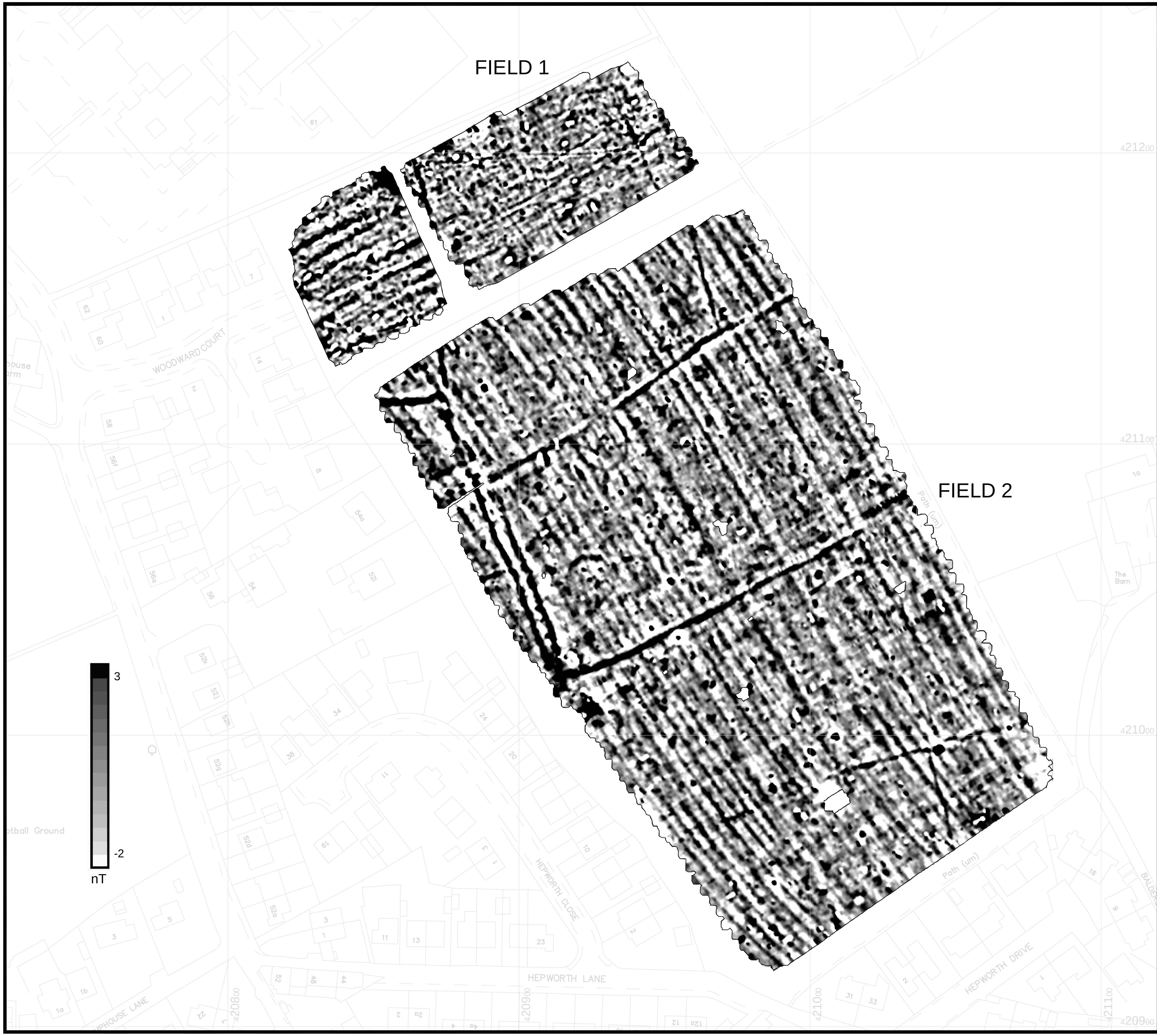
Client: BWB CONSULTING LTD LEEDS

Site: BALDERSTONE HALL, MIRFIELD WEST YORKSHIRE

Title: LOCATION OF SITE SHOWING MAGNETIC GRADIENT SURVEY DATA

Job No: ARC_2303_829

Surveyed	CT, JW	Drawn	MW
Chk.	NF	Date	09/02/2018



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Scale [A3 Sheet]	Drawing	Status
1:1250	ARC_2303_829_03	FINAL

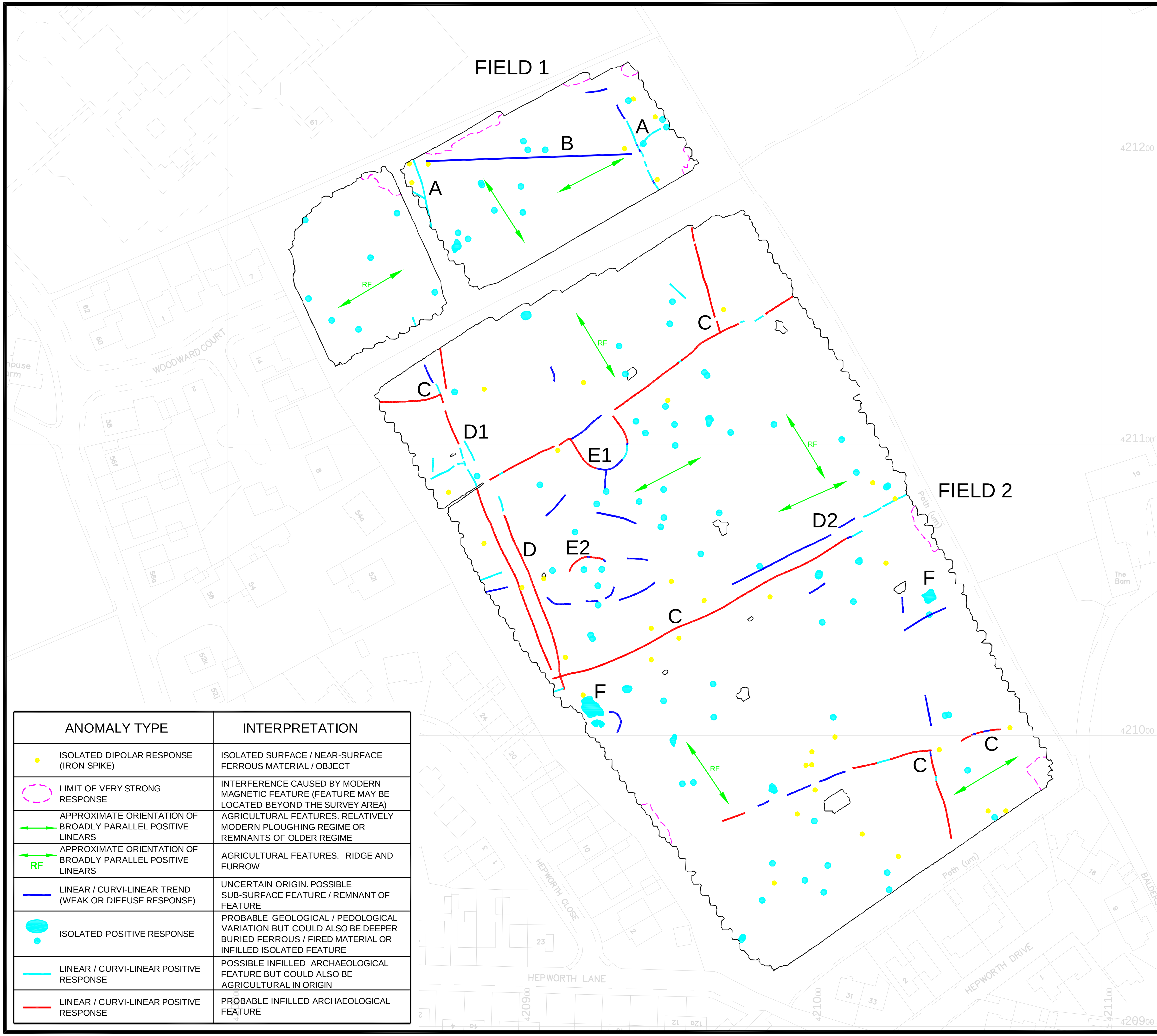
Client: BWB CONSULTING LTD LEEDS

Site: BALDERSTONE HALL, MIRFIELD WEST YORKSHIRE

Title: GREYSCALE PLOTS OF MAGNETIC GRADIENT DATA

Job No: ARC_2303_829

Surveyed	CT, JW	Drawn	MW
Chk.	NF	Date	09/02/2018



ANOMALY TYPE	INTERPRETATION
ISOLATED DIPOLAR RESPONSE (IRON SPIKE)	ISOLATED SURFACE / NEAR-SURFACE FERROUS MATERIAL / OBJECT
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. RELATIVELY MODERN PLOUGHING REGIME OR REMNANTS OF OLDER REGIME
RF APPROXIMATE ORIENTATION OF BROADLY PARALLEL POSITIVE LINEARS	AGRICULTURAL FEATURES. RIDGE AND FURROW
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	POSSIBLE INFILLED ARCHAEOLOGICAL FEATURE BUT COULD ALSO BE AGRICULTURAL IN ORIGIN
LINEAR / CURVI-LINEAR POSITIVE RESPONSE	PROBABLE INFILLED ARCHAEOLOGICAL FEATURE

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Scale [A3 Sheet]	Drawing	Status
1:1250	ARC_2303_829_04	FINAL

Client: BWB CONSULTING LTD LEEDS

Site: BALDERSTONE HALL, MIRFIELD WEST YORKSHIRE

Title: INTERPRETATION OF MAGNETIC GRADIENT DATA

Job No: ARC_2303_829

Surveyed	CT, JW	Drawn	MW
Chk.	NF	Date	09/02/2018

BIBLIOGRAPHY AND REFERENCES

BWB Consulting Ltd, 2017, Balderstone Hall, Mirfield, Heritage assessment

British Geological Survey, 2018, online resource - www.bgs.ac.uk

Soilscapes, 2018, online resource - www.landis.org.uk/soilscapes

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 4 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 Where required the data was destriped and destaggered to remove errors caused by instrument drift and heading errors. This data has been classed as minimally processed data as no other processing steps were used.

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

1.4.4 The data has been displayed relative to a digital Ordnance Survey base plan provided by the client as drawing '*Fig 2.dwg*'. The base plan was in the 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.

A large majority, if not all, of the dipolar and bipolar responses at this site will be non-archaeological in origin but there may be greater potential for them to be related to archaeological features / activity where they are located in proximity to probable or possible archaeological features. Selected isolated responses have therefore been shown on the interpretation.

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.

There are no significant areas of magnetic disturbance in this data set.

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.

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 the majority anomalies are probably associated with geological / pedological variations. Larger or stronger areas of positive response have been shown on the interpretation as have those isolated responses located in close proximity to possible or probable archaeological features. These anomalies could also be associated with geological / pedological variations but their size or proximity to other anomalies increases their archaeological potential.

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.