



**PHASE**  
SITE INVESTIGATIONS

**Meadowlands**  
**Barrow-in-Furness, Cumbria**

**Archaeological geophysical survey**

**Project No. ARC/1834/665**

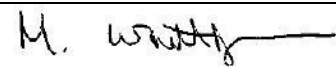
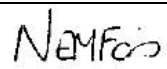
**May 2016**



# Meadowlands Barrow-in-Furness, Cumbria

## Archaeological geophysical survey

Project No. ARC/1834/665

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| Date               | 20/05/16  | Date              | 20/05/16  |

## Table of Contents

|  |   |
|--|---|
| <b>1. SUMMARY</b>                        | <b>1</b>                                      |
| <b>2. INTRODUCTION</b>                   | <b>2</b>                                      |
| 2.1 OVERVIEW                             | 2   |
| 2.2 SITE DESCRIPTION                     | 2   |
| 2.3 ARCHAEOLOGICAL BACKGROUND            | 2   |
| 2.4 SCOPE OF WORK                        | 2   |
| <b>3. SURVEY METHODOLOGY</b>             | <b>3</b>                                      |
| 3.1 MAGNETIC SURVEY                      | 3   |
| 3.2 DATA PROCESSING AND PRESENTATION     | 3   |
| <b>4. RESULTS</b>                        | <b>5</b>                                      |
| 4.1 GENERAL                              | 5   |
| 4.2 ANOMALY TYPES AND FURTHER DISCUSSION | 5   |
| <b>5. DISCUSSION AND CONCLUSIONS</b>     | <b>7</b>                                      |
| <b>DRAWINGS</b>                          |   |
| ARC_1834_665_01                          | Site location map                             |
| ARC_1834_665_02                          | Greyscale plots of magnetic gradient data     |
| ARC_1834_665_03                          | Interpretation of magnetic gradient data      |
| <b>BIBLIOGRAPHY AND REFERENCES</b>       | <b>8</b>                                      |
| <b>APPENDIX 1</b>                        | <b>Magnetic survey; technical information</b> |
|  | <b>9</b>                                      |

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## 1. SUMMARY

Phase Site Investigations Ltd was commissioned to carry out a magnetic gradient survey at a site Meadowlands, Barrow-in-Furness, Cumbria. 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 Bartington component was collected at 1 m by 0.25 m intervals over a series of 30 m grids.

The majority of the anomalies identified by this survey relate to modern material / objects, possible former agricultural activity and geological / pedological variations. There are several weak, diffuse linear / curvi-linear trends of unknown origin. These do not form a clear pattern that would suggest an archaeological origin but the exact cause of the responses cannot be determined.

There are several areas where very strong responses or magnetic disturbance from modern features dominate the surrounding data. It should be recognised that the strength of the strong responses could mask anomalies from other sub-surface features in the area.

## **2. INTRODUCTION**

### **2.1 Overview**

Phase Site Investigations Ltd was commissioned by Greenlane Archaeology Ltd to carry out an archaeological geophysical survey at a site at Meadowlands, Barrow-in-Furness, Cumbria 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\_1834\_665\_02.

### **2.2 Site description**

The site is situated on the eastern edge of Barrow-in-Furness, Cumbria (centred at NGR SD 218 708) and covered an area of approximately 2 ha located within part of a single pasture field.

The field was relatively flat and firm underfoot, with the exception of an area of standing water and boggy ground in the east of the site.

The survey area was bounded to the north, south and east by metal fences and there were no fixed boundaries delimiting the survey area in the east.

The geology of the site consists of the Sherwood Sandstone Group overlain by glacial till (British Geological Survey, 2016). The soils of the site are described as slowly permeable loamy and clayey (Soilscapes, Cranfield University, 2016).

### **2.3 Archaeological background**

Archaeological background information was not available at the time of writing this report.

### **2.4 Scope of work**

The survey area was specified by the client based on a proposed development boundary.

Due to the presence of metallic fencing and an area of standing water and boggy ground the area suitable for survey was reduced and an area of approximately 1.8 ha was surveyed, the extent of which is shown in drawing ARC\_1834\_665\_02.

The survey was undertaken on 18 May 2016.

### 3. SURVEY METHODOLOGY

#### 3.1 Magnetic survey

The survey was undertaken using a Phase Site Investigations Ltd multi-sensor array cart system (MACS). The MACS comprised 8 Foerster 4.032 Ferex CON 650 gradiometers with a control unit and data logger. The Foerster gradiometers do not require balancing as each sensor is automatically 'zeroed' using the control unit software.

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

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

#### 3.2 Data processing and presentation

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

The data was exported as raster images (PNG files) and are presented in greyscale format with accompanying interpretations at a scale of 1:1000. 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 '65287315\_os-detail-12-month-licence.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 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 a possible agricultural regime 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.***

## 4. RESULTS

### 4.1 General

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

There is a series of strong fragmented responses present in the data, which are visible as positive anomalies in parts of the site and as negative responses in others. These anomalies are very regular, straight and are aligned very closely with the direction that the survey was undertaken. Linear responses along the traverse direction of a survey can sometimes be an artificial product but in this instance analysis of the data suggests that they are 'real' anomalies as the spacing between them varies between 6 m and 7.5 m. The survey width was 4 m, with sensors at a 0.5 m spacing, and as the anomalies are not a consistent distance apart or a product of 4 m it is unlikely that they are artificial. The fragmented nature of the anomalies may be due to the fact that coincidentally the survey has closely followed the alignment of an underlying agricultural regime. The process of working out an average background value for the sensors when using a multi-sensor array can have an effect on linear anomalies along the same alignment if they are at a consistent spacing and this may have occurred in this instance. This does not affect linear anomalies that are archaeological in origin as they would not appear on the same orientation on multiple adjacent traverses but in some rare instances could affect responses from agricultural regimes. It is also possible that the underlying regime that is causing the anomalies have been differentially truncated and only produce fragmented responses.

### 4.2 Anomaly types and further discussion

There are numerous isolated dipolar responses (iron spikes) across the survey area that are indicative of ferrous or fired material on or near to the surface. This type of anomaly have not been shown on the interpretation as there is no evidence to suggest that they may be archaeological in origin.

The very strong responses around the perimeter of the survey area are associated with adjacent strongly magnetic modern features. The extent of these areas is usually 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. It should be recognised that other sub-surface features located within these areas may not be detected.

Areas of **magnetic disturbance** will be associated with concentrations of modern magnetic material.

As discussed above the series of **broadly parallel linear anomalies** are thought to be associated with a former agricultural regime.

Several linear / curvi-linear **trends** have been identified that do not correspond with the possible former agricultural regime. The trends may indicate the presence of sub-surface features or variations but they are too weak or diffuse to reliably interpret. In the north-east of the survey area the trends appear to form a curving pattern but it cannot be determined if these are related to a natural or anthropogenic feature / variation.



Several **isolated positive / enhanced responses** have been identified. This type of response can be caused by isolated infilled features but at this site they do not form a pattern that would indicate an anthropogenic origin and it is probable that these responses are caused by natural variations or deeper buried, relatively modern, ferrous or fired material.

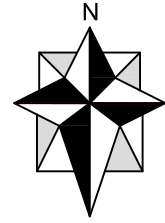
## 5. DISCUSSION AND CONCLUSIONS

The majority of the anomalies identified by this survey relate to modern material / objects, possible former agricultural activity and geological / pedological variations. There are several weak, diffuse linear / curvi-linear trends of unknown origin. These do not form a clear pattern that would suggest an archaeological origin but the exact cause of the responses cannot be determined.

There are several areas where very strong responses or magnetic disturbance from modern features dominate the surrounding data. It should be recognised that the strength of the strong responses could mask anomalies from other sub-surface features in the area.

There is a series of parallel linear responses that are closely aligned with the direction on which the survey was undertaken. There is a slight possibility that these are an artificial data construct related to the data collection but it is considered more likely that they are the remnants of an underlying former agricultural regime that coincidentally is on the same alignment as the survey traverses. Whatever the exact cause of these anomalies that are not thought to be strong enough to mask responses from underlying features, if any such features were present.

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

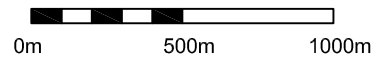


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SITE LOCATION

SCALE



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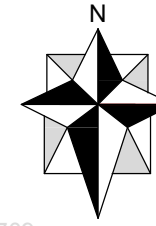
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| Site | MEADOWLANDS<br>BARROW-IN-FURNESS, CUMBRIA |
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| Title | SITE LOCATION MAP |
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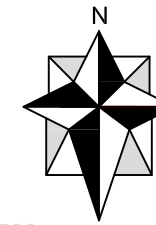
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| Surveyed | AJ, MJ | Drawn | MW         |
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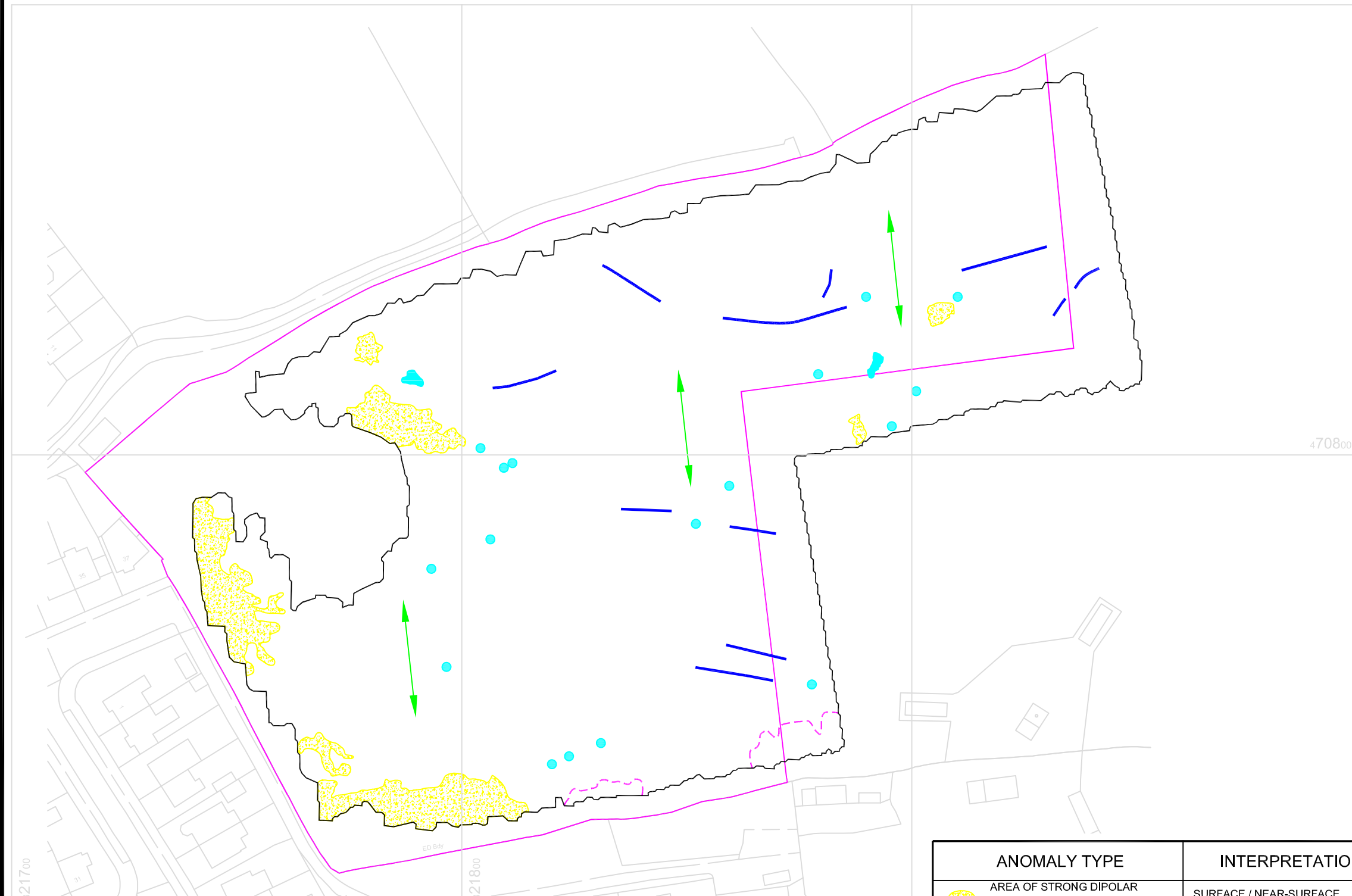
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ULVERSTON, CUMBRIA**

Site  
**MEADOWLANDS  
BARROW-IN-FURNESS, CUMBRIA**






Title  
**INTERPRETATION OF MAGNETIC  
GRADIENT DATA**

Job No  
**ARC\_1834\_665**

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| Surveyed | AJ, MJ | Drawn | MW         |
| Chk.     | NF     | Date  | 18/05/2016 |



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| ANOMALY TYPE  | INTERPRETATION  |
|---|---|
|  AREA OF STRONG DIPOLAR RESPONSES (MAGNETIC DISTURBANCE)       | SURFACE / NEAR-SURFACE FERROUS OR FIRED MATERIAL  |
|  LIMIT OF VERY STRONG RESPONSE                                 | INTERFERENCE CAUSED BY MODERN MAGNETIC FEATURE. OTHER FEATURES WITHIN THIS AREA MAY NOT BE DETECTED                               |
|  APPROXIMATE ORIENTATION OF, BROADLY PARALLEL LINEAR ANOMALIES | POSSIBLE REMNANTS OF AN AGRICULTURAL REGIME   |
|  LINEAR / CURVI-LINEAR TREND                                   | POSSIBLE SUB-SURFACE FEATURE  |
|  ISOLATED POSITIVE OR ENHANCED RESPONSE                        | POSSIBLE GEOLOGICAL / PEDOLOGICAL VARIATION BUT COULD ALSO BE DEEPER BURIED FERROUS / FIRED MATERIAL OR INFILLED ISOLATED FEATURE |

## **BIBLIOGRAPHY AND REFERENCES**

British Geological Survey, 2016, online resource - [www.bgs.ac.uk](http://www.bgs.ac.uk)

Soilscapes, Cranfield University, 2016, online resource - [www.landis.org.uk/soilscapes](http://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 thermoremanent 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 Thermoremanent magnetism indicates the amount of magnetism inherent in an object as a result of heating. Material that has been heated to a high temperature (fired), such as brick, can acquire strong magnetic properties and so although they may not appear to have a high iron content they can produce strong magnetic anomalies
- 1.1.5 The magnetic survey method is highly sensitive to interference from surface and near-surface magnetic 'contaminants'. Surface features such as metallic fencing, reinforced concrete, buildings or walls all have very strong magnetic signatures that can dominate readings collected adjacent to them. Identification of anomalies caused by sub-surface features is therefore more difficult, or even impossible, in the vicinity of surface magnetic features. The presence of made ground also has a detrimental effect on the magnetic data quality as this usually contains magnetic material in the form of metallic scrap and brick. Identification of features beneath made ground is still possible if the target feature is reasonably large and has a strong magnetic response but smaller features or magnetically weak features are unlikely to be identified.
- 1.1.6 The interpretation of magnetic anomalies is often subjective and it is rarely possible to identify the cause of all magnetic anomalies. Not all features will produce a measurable magnetic response and the effectiveness of a magnetic survey is also dependant on the site-specific conditions. The main factors that may limit whether a feature can be detected are the

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

- 1.1.7 Most high resolution, near surface magnetic surveys utilise a magnetic gradiometer. A gradiometer is a hand-held instrument that consists of two magnetic sensors, one positioned directly above the other, which allows measurement of the magnetic gradient component of the magnetic field. A gradiometer configuration eliminates the need for applying corrections due to natural variations in the overall field strength that occur during the course of a day but it only measures relative variations in the local magnetic field and so comparison of absolute values between sites is not possible.
- 1.1.8 Features that are commonly located using magnetic surveys include archaeological ditches and pits, buried structures or foundations, mineshafts, unexploded ordnance, metallic pipes and cables, buried piles and pile caps. The technique can also be used for geological mapping; particularly the location of igneous intrusions.

## **1.2 Instrumentation**

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

## **1.3 Survey methodology**

- 1.3.1 The MACS utilises an RTK GNSS system which means that survey grids do not have to be established. Instead an area is surveyed over a series of continuous profiles and the position of each data point is recorded using an RTK GNSS system. The sensors have a separation of 0.5 m which means that data was collected on profiles spaced at 0.5 m apart. Readings were taken at between 0.1 m and 0.15 m intervals.
- 1.3.2 Data is collected on zig-zag profiles along the full length or width of a field, although fields can be sub-divided if they are particularly large. Marker canes are set-out along field boundaries at set intervals and these are used to align the profiles. The survey profiles are usually offset from field boundaries, buildings and other metallic features by several metres to reduce the detrimental effect that these surface magnetic features have on the data. The location of the MACS data is converted direct to Ordnance Survey co-ordinates using the UK OSTN 02 projection. As the data is related direct to Ordnance Survey National Grid co-ordinates temporary survey stations are not established.
- 1.3.3 The Foerster gradiometers have a resolution of 0.2 nT but the stability of the cart system significantly reduces noise caused by instrument tilt and movement when compared with a traditional hand-held gradiometer system and the increased data intervals provide a higher resolution data set. The sensors have a range of  $\pm 10,000$ nT 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 1:1000.
- 1.4.3 The data has been displayed relative to a digital Ordnance Survey base plan provided by the client as drawing '65287315\_os-detail-12-month-licence.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.

## 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 responses

Dipolar responses are those that have a sharp variation between strongly positive and negative components. In the majority of cases dipolar 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 responses.

There are numerous **isolated dipolar responses** (iron spikes) across the survey area that are indicative of ferrous or fired material on or near to the surface. The isolated responses are often caused by small objects, such as spent shotgun cartridges, iron nails and horseshoes or pieces of modern brick or pot. 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. This type of anomaly have not been shown on the interpretation as there is no evidence to suggest that they may be archaeological in origin.

Areas containing strong or numerous dipolar responses (**magnetic disturbance**) are usually caused by 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 dipolar 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 response can occasionally be caused by features / material associated with archaeological industrial activity 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.

Linear anomalies that contain dipolar responses (categorised as **dipolar linear**) are usually caused by modern pipes or cables. There are no dipolar linear anomalies in this data set.

Very strong responses from modern features can dominate the data for a significant distance beyond the feature. The extent of these areas is usually 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. 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.

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.

The main negative linear responses at this site are part of a series of anomalies that are believed to be related to a former agricultural regime.

### 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.

### 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 or enhanced responses

**Isolated positive or enhanced 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, or possibly deeper buried ferrous / fired material.

### Positive or enhanced 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.

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

- 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 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 a possible former 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.