Little Crow
Solar Park

Little Crow Solar Park, Scunthorpe

ENVIRONMENTAL STATEMENT: TECHNICAL APPENDICES

APPENDIX 8.2

GEOPHYSICAL SURVEY REPORT

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GEOPHYSICAL SURVEY REPORT

GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Little Crow Solar Park, Scunthorpe, North Lincolnshire

Client
Cotswold Archaeology
For
INRG Solar (Little Crow) Ltd

Survey Report
13201

Date
September 2018

Revision Number 3 dated November 2018

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GEOPHYSICAL SURVEY REPORT

Project name:
Little Crow Solar Park,
Scunthorpe,
North Lincolnshire

SUMO Job reference:
13201

Client:
Cotswold Archaeology
For:
INRG Solar (Little Crow) Ltd

Survey date:
23 July - 9 August &
13 August - 4 September 2018

Report date:
27 September 2018

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1 SUMMARY OF RESULTS

A detailed magnetometer survey was conducted over approximately 214 ha of arable land near Scunthorpe, Lincolnshire. A ring ditch has been identified in the data, along with a few other ditch-like anomalies of possible archaeological origin. Several linear responses are of uncertain origin and could be archaeological, agricultural or natural. Evidence of fracturing within the limestone geology is visible, along with further areas of natural magnetic variation. Former field boundaries and ploughing effects have been mapped, as well as underground services and areas of magnetic disturbance.

2 INTRODUCTION

2.1 Background synopsis

SUMO Geophysics Ltd were commissioned to undertake a geophysical survey of an area outlined for solar farm development. This survey forms part of an archaeological investigation being undertaken by Cotswold Archaeology on behalf of INRG Solar (Little Crow) Ltd.

2.2 Site details

NGR / Postcode	SE 941 150 / DN20 0BQ
Location	The site is located *c.*5km to the east of Scunthorpe, Lincolnshire, to the north-west of the village of Broughton. Areas of woodland surround the site on all sides.
HER/SMR	Lincolnshire
District	North Lincolnshire
Parish	The site straddles two parish boundaries; Broughton CP and Appleby CP
Topography	Gently sloping down from east to west
Current Land Use	Arable
Geology	Solid: Charmouth Mudstone Formation - mudstone is predominantly recorded across the west of the site, with bands of Pecten Ironstone - ironstone, Marlstone Rock Formation - ferruginous limestone and ferruginous sandstone flanking either side. Bands of Whitby Mudstone Formation - mudstone, Northampton Sand Formation - sandstone, Grantham Formation - sandstone, siltstone and

	mudstone and Lower Lincolnshire Limestone Member - limestone run down the centre of the site on a north-south alignment. The geology across the east of the site comprises Kirton Cementstone Beds - mudstone and limestone (interbedded) and Scawby Limestone - limestone and argillaceous rocks Superficial: Sutton Sand Formation - sand is recorded across the west of the site and in small pockets across the western half (BGS 2018).
Soils	Newport 1 Association (551d) - deep well drained sandy and coarse loamy soils (SSEW 1983).
Archaeology	Three potential prehistoric records from the NLHER have been identified within the site. These include the site of a possible round barrow (MLS22718) located on aerial photographs. The data, function and archaeological provenance of this cropmark have not been proven through fieldwork. The NLHER also records the findspot of a number of flints (MLS6695) and the posited route of a prehistoric track (MLS20003), called the Jurassic Way, which runs from Winteringham to Lincoln. The line of the former Ermine Street Roman road (MLS100) follows the line of the B1027, a small portion of which is included in the site boundary at its eastern-most extent. It is possible that the site comprised part of an agricultural landscape during the Roman period. Within the northern part of the site is the location of the former Gokewell Priory, a small Cistercian nunnery founded in the 12th century (MLS1805, ELS800, ELS2566, ELS4211). The priory was a minor establishment with a small community of nuns. Potential below-ground remains relating to a former WWII Heavy Anti-Aircraft Battery (MLS21408) could survive within the eastern portion of the site (Pegasus 2018).
Survey Methods	Magnetometer survey (fluxgate gradiometer)
Study Area	*c.* 214 ha

2.3 Aims and Objectives

To locate and characterise any anomalies of possible archaeological interest within the study area.

3 METHODS, PROCESSING & PRESENTATION

3.1 Standards & Guidance

This report and all fieldwork have been conducted in accordance with the latest guidance documents issued by Historic England (EH 2008) (then English Heritage), the Chartered Institute for Archaeologists (CIfA 2014) and the European Archaeological Council (EAC 2016).

3.2 Survey methods

Detailed magnetic survey was chosen as an efficient and effective method of locating archaeological anomalies.

Technique	Instrument	Traverse Interval	Sample Interval
Magnetometer	Bartington Grad 601-2	1.0m	0.25m

More information regarding this technique is included in

Appendices A, B and C.

3.3 Data Processing

The following basic processing steps have been carried out on the data used in this report:
De-stripe; de-stagger; interpolate

3.4 Presentation of results and interpretation

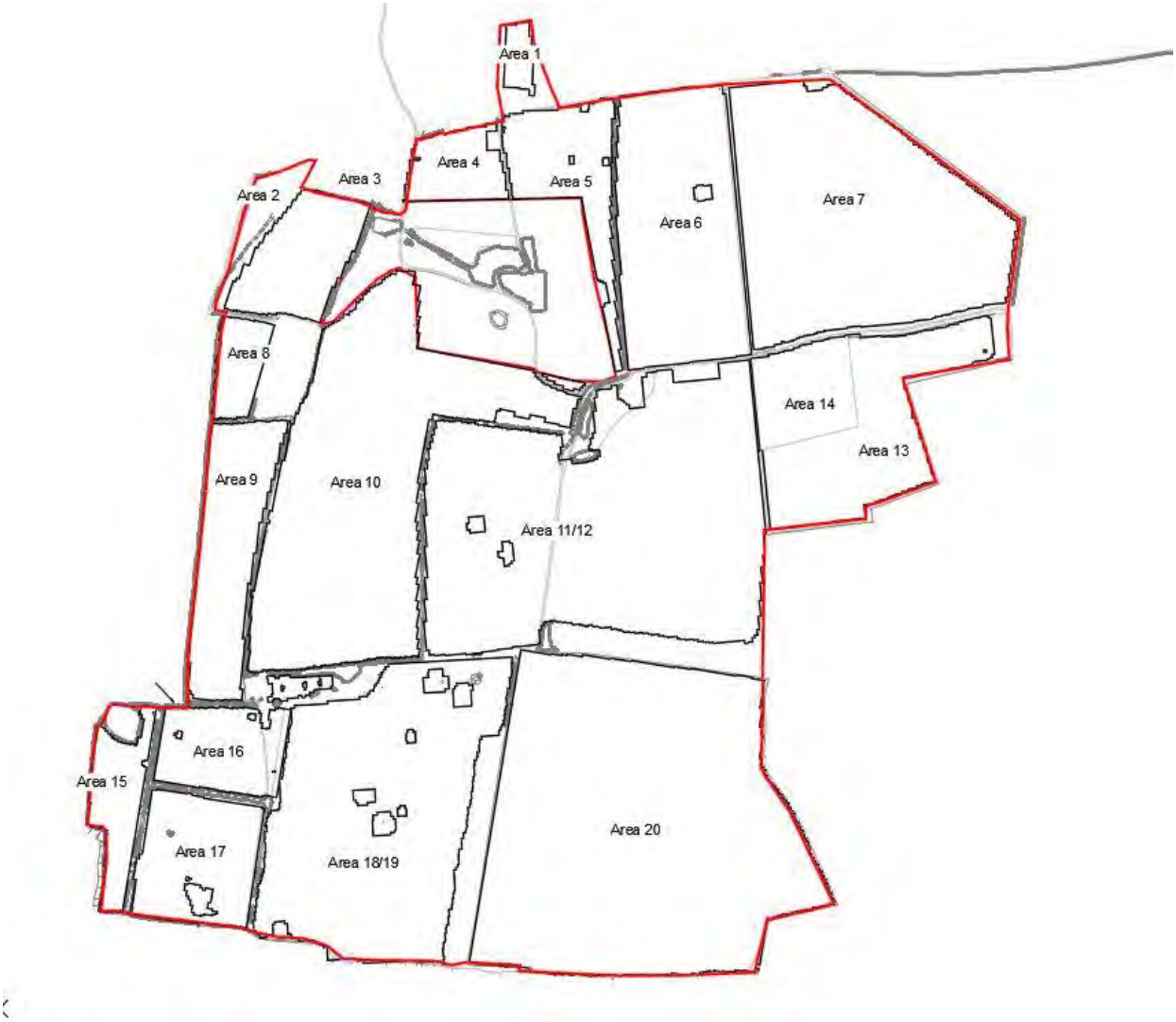
The presentation of the results includes a 'minimally processed data' and a 'processed data' greyscale plot. Magnetic anomalies are identified, interpreted and plotted onto the 'Interpretation' drawings.

When interpreting the results, several factors are taken into consideration, including the nature of archaeological features being investigated and the local conditions at the site (geology, pedology, topography etc.). Anomalies are categorised by their potential origin. Where responses can be related to other existing evidence,

the anomalies will be given specific categories, such as: *Abbey Wall* or *Roman Road*. Where the interpretation is based largely on the geophysical data, levels of confidence are implied, for example: *Probable*, or *Possible Archaeology*. The former is used for a confident interpretation, based on anomaly definition and/or other corroborative data such as cropmarks. Poor anomaly definition, a lack of clear patterns to the responses and an absence of other supporting data reduces confidence, hence the classification *Possible*.

4 RESULTS

The survey has been divided into twenty survey areas (Areas 1-20) and specific anomalies have been given numerical labels [1] [2] *which appear in the text below, as well as on the Interpretation Figure(s).*



Plan showing boundaries of individual survey areas 1-20.

4.1 *Probable Archaeology*

4.1.1 A small, circular anomaly [1] in Area 14 is the only response of 'probable' archaeological origin that has been identified in the data. The anomaly is indicative of a ring ditch which could be associated with a former barrow, though does not correspond with the location of the possible barrow (MLS22718) identified on aerial photographs.

4.2 *Possible Archaeology*

4.2.1 A long curvilinear anomaly [2] can be seen in Area 7 and has been assigned a 'possible' archaeological origin. The response is ditch-like in its characteristics, hence its classification as being possibly archaeological; however, there is no further evidence of archaeological activity within the area. It is possible that the response could relate to a former field boundary, but none are visible on historic mapping, hence the possible archaeological interpretation.

4.2.2 Similar ditch-type anomalies [3-4] have been identified in Areas 17 and 20. These are both of uncertain antiquity; the responses are very straight which suggests they may have a more recent origin and could relate to former field boundaries. However, no boundaries are visible in these locations on available historic maps.

4.3 *Uncertain*

4.3.1 A series of linear and rectilinear anomalies [5] can be seen throughout Area 20. Although they have the appearance of archaeological enclosures, the pattern is very similar to that typically produced by limestone fracturing and therefore their exact origin cannot be determined with confidence. The anomalies have therefore been assigned to the category *Uncertain Origin*.

4.3.2 A small rectilinear feature with closely spaced linear anomalies within [6] has been identified in the south-west of Areas 18 and 19. The anomaly is of uncertain origin, and an archaeological explanation is thought unlikely. The feature could instead be a result of more recent agricultural activity.

4.3.3 Several linear trends [7] and other ditch-like anomalies are present in the data and their interpretation is subjective. They could be the result of former ditches though their exact origin remains unclear; they may have archaeological, natural or agricultural origins.

4.4 *Former Field Boundary*

4.4.1 A number of linear anomalies [8-16] have been identified across the site and are associated with former field boundaries, visible on available historic OS mapping dating from 1889. Other linear anomalies in Areas 11-12 and 16 may be a result of former boundaries, though no such features are visible in these locations on historic mapping; hence the conjectural interpretation.

4.5 *Agricultural – Ploughing*

4.5.1 Closely spaced, parallel linear anomalies have been identified throughout the site. These are a result of agricultural activity.

4.6 *Natural / Geological / Pedological / Topographic*

4.6.1 A large number of amorphous, sinuous and curving responses have been identified in several areas. These are of natural origin and are a result of localised variations in the underlying geology.

4.7 *Ferrous / Magnetic Disturbance*

4.7.1 Magnetic disturbance is visible across Areas 3, 4, 5, 6 10, 11, 12 and 15, but have not been marked on the interpretation figures so as not to detract from other visible anomalies. This disturbance is a result of the spreading of modern 'green waste' fertilisers which contain large numbers of small ferrous items and metal contaminants and has the potential to mask weaker, more ephemeral responses. The ironstone geology underling the site is also likely to be contributing to the enhanced magnetic responses in these areas.

4.7.2 Strong bipolar linear anomalies running across Areas 6, 7, 13-14 and 20 are related to underground services, such as pipes or cables.

4.7.3 Ferrous responses close to boundaries are due to adjacent fences and gates. Smaller scale ferrous anomalies ("iron spikes") are present throughout the data and are characteristic of small pieces of ferrous debris (or brick / tile) in the topsoil; they are commonly assigned a modern origin. Only the most prominent of these are highlighted on the interpretation diagram.

5 DATA APPRAISAL & CONFIDENCE ASSESSMENT

5.1 Historic England guidelines (EH 2008) Table 4 states that the average magnetic response on limestone, mudstone and sandstone can be variable. The results from this survey indicate the presence of a ring ditch, along with possible archaeological ditches and several linear trends of uncertain origin. However, the 'green waste' fertiliser and effects of ferruginous geology has the potential to mask weaker features, with only the strongest of features being visible. In areas where there is geological cracking, a medium level of confidence has been assigned.

6 CONCLUSION

6.1 The survey at Little Crow has revealed evidence of a ring ditch along with linear anomalies which may be related to former ditches. Several linear trends are of uncertain origin, though an archaeological explanation cannot be ruled out entirely. Former field boundaries and evidence of ploughing can be seen in the data, along with natural fracturing in the limestone geology and other areas of localised magnetic variations. Green waste fertiliser appears to have been spread across several fields though uncertain linear features can still be seen. The remaining responses are modern and include underground services and disturbance from nearby ferrous objects such as fences and pylons.

7 REFERENCES

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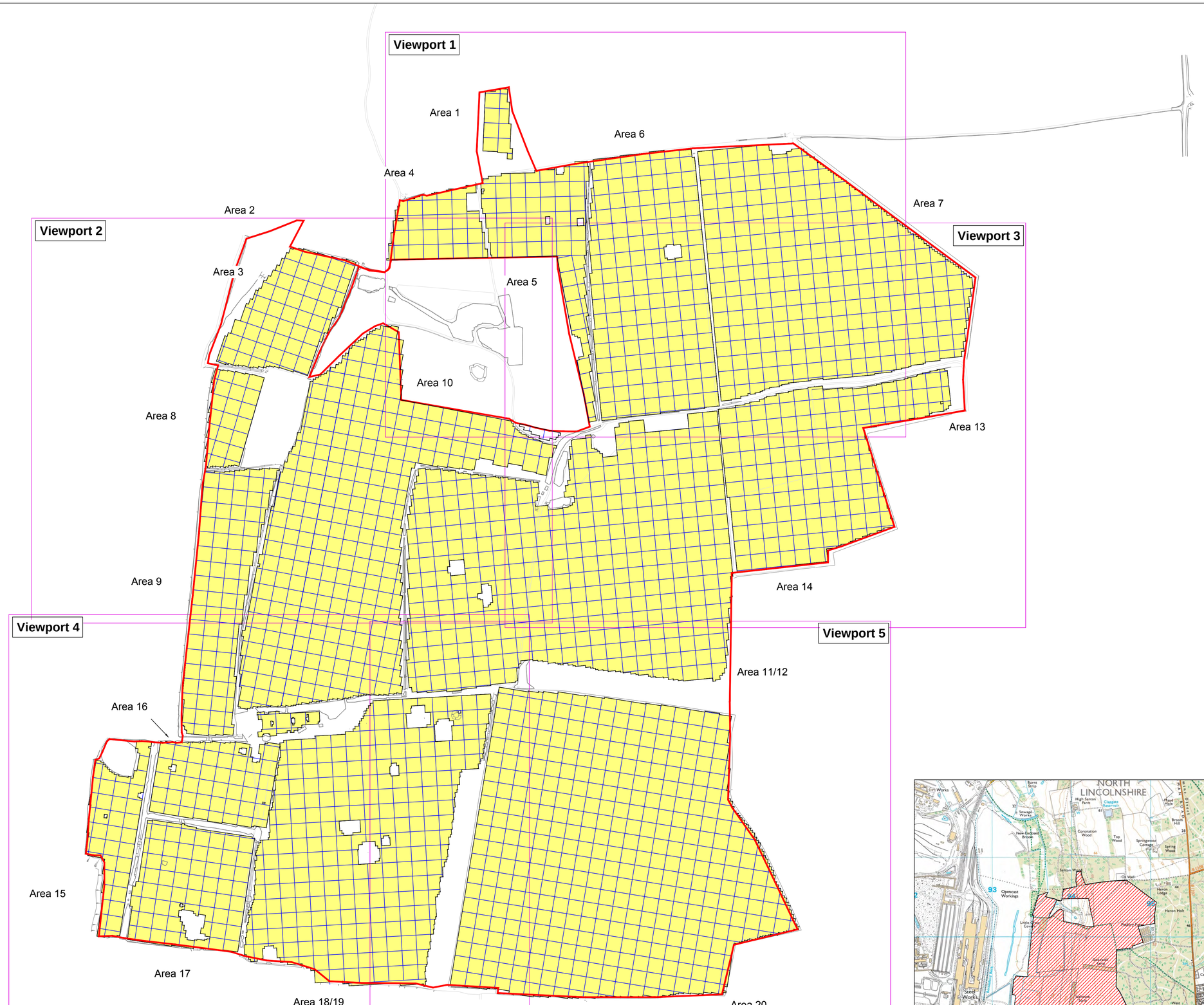

N

Site Location

Survey Area - showing 30m grid

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Site Location Diagram and Location of Survey Areas

Client: Cotswold Archaeology

Project: 13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire

Scale: 0 metres 200
1:4000 @ A1

Fig No: 01

N

+5nT

-5nT

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:
Magnetometer Survey - Greyscale Plots - Overview

Client:
Cotswold Archaeology

Project:
13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire

Scale:
0 metres 200
1:4000 @ A1

Fig No:
02

KEY

	Probable archaeology
	Possible archaeology (discrete anomaly / trend)
	Uncertain Origin (discrete anomaly / trend)
	Former field boundary (corroborated)
	Former field boundary (conjectural)
	Agriculture (plough)
	Natural (e.g. geological / pedological)
	Magnetic disturbance
	Service
	Ferrous

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey - Interpretation - Overview

Client: Cotswold Archaeology

Project: 13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire

Scale: 0 metres 200
1:4000 @ A1

Fig No: 03

Area 1

Area 6

Area 4

Area 5

Area 10

N

+5nT

-5nT

sumo Survey

GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey - Greyscale Plots - Viewport 1

Client: Cotswold Archaeology

Project: 13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire

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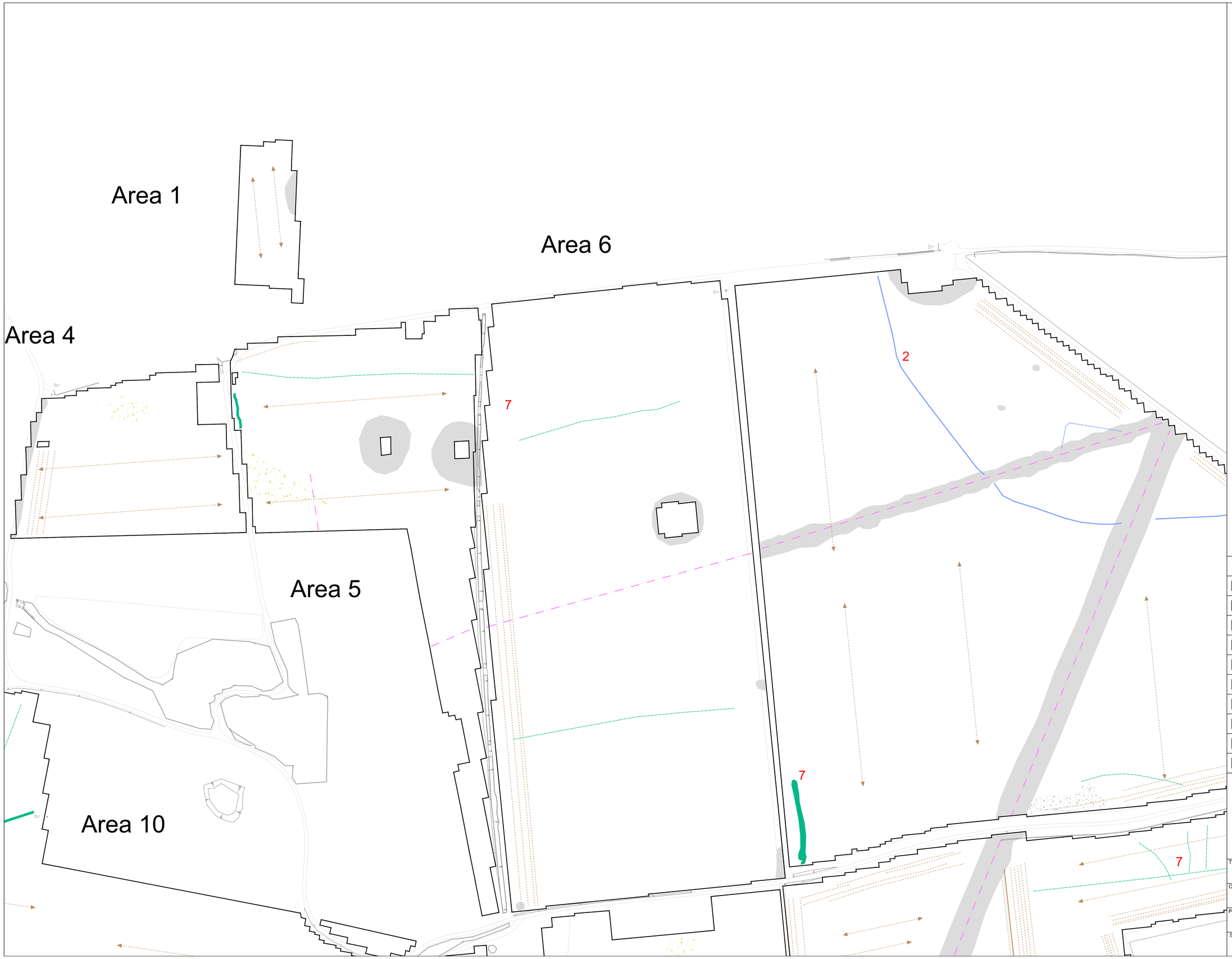
Fig No: 04



KEY

	Probable archaeology
	Possible archaeology (discrete anomaly / trend)
	Uncertain Origin (discrete anomaly / trend)
	Former field boundary (corroborated)
	Former field boundary (conjectural)
	Agriculture (plough)
	Natural (e.g. geological / pedological)
	Magnetic disturbance
	Service
	Ferrous

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey - Interpretation - Viewport 2

Client: Cotswold Archaeology

Project: 13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire

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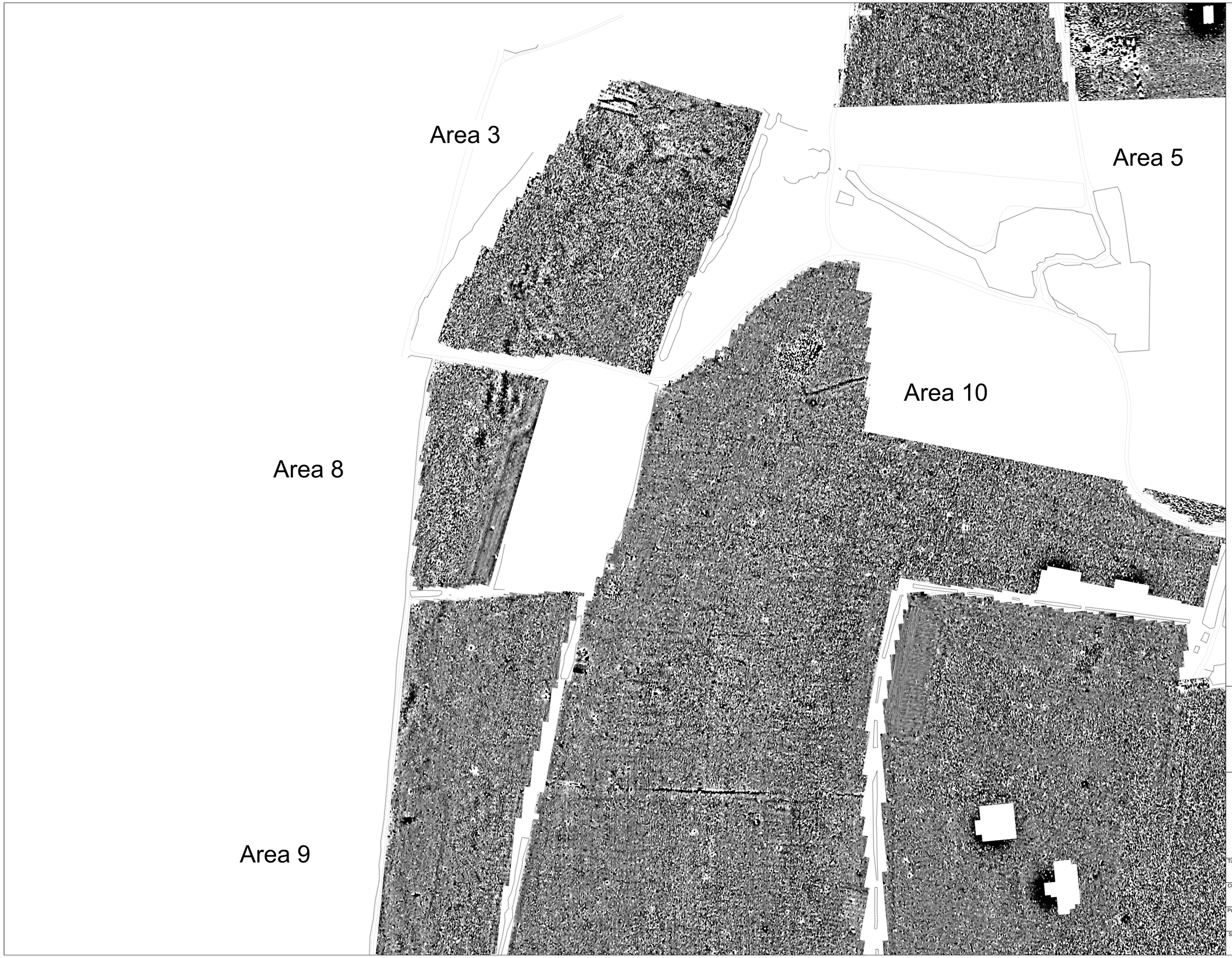
Fig No: 05



sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey - Greyscale Plots - Viewport 2

Client: Cotswold Archaeology

Project: 13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire

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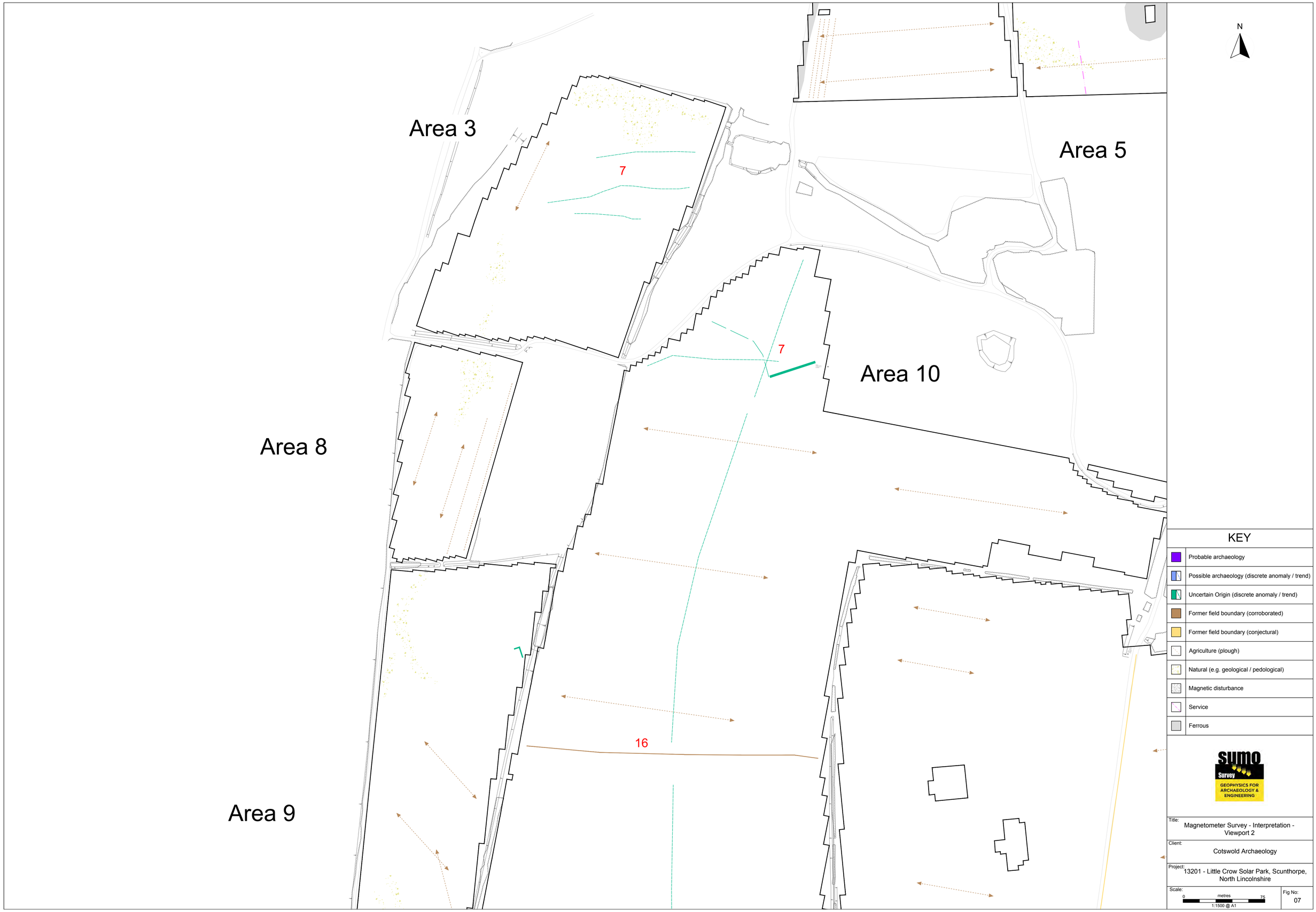
Fig No: 06



KEY

- Probable archaeology
- Possible archaeology (discrete anomaly / trend)
- Uncertain Origin (discrete anomaly / trend)
- Former field boundary (corroborated)
- Former field boundary (conjectural)
- Agriculture (plough)
- Natural (e.g. geological / pedological)
- Magnetic disturbance
- Service
- Ferrous

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey - Interpretation - Viewport 2

Client: Cotswold Archaeology

Project: 13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire

Scale: 0 metres 75
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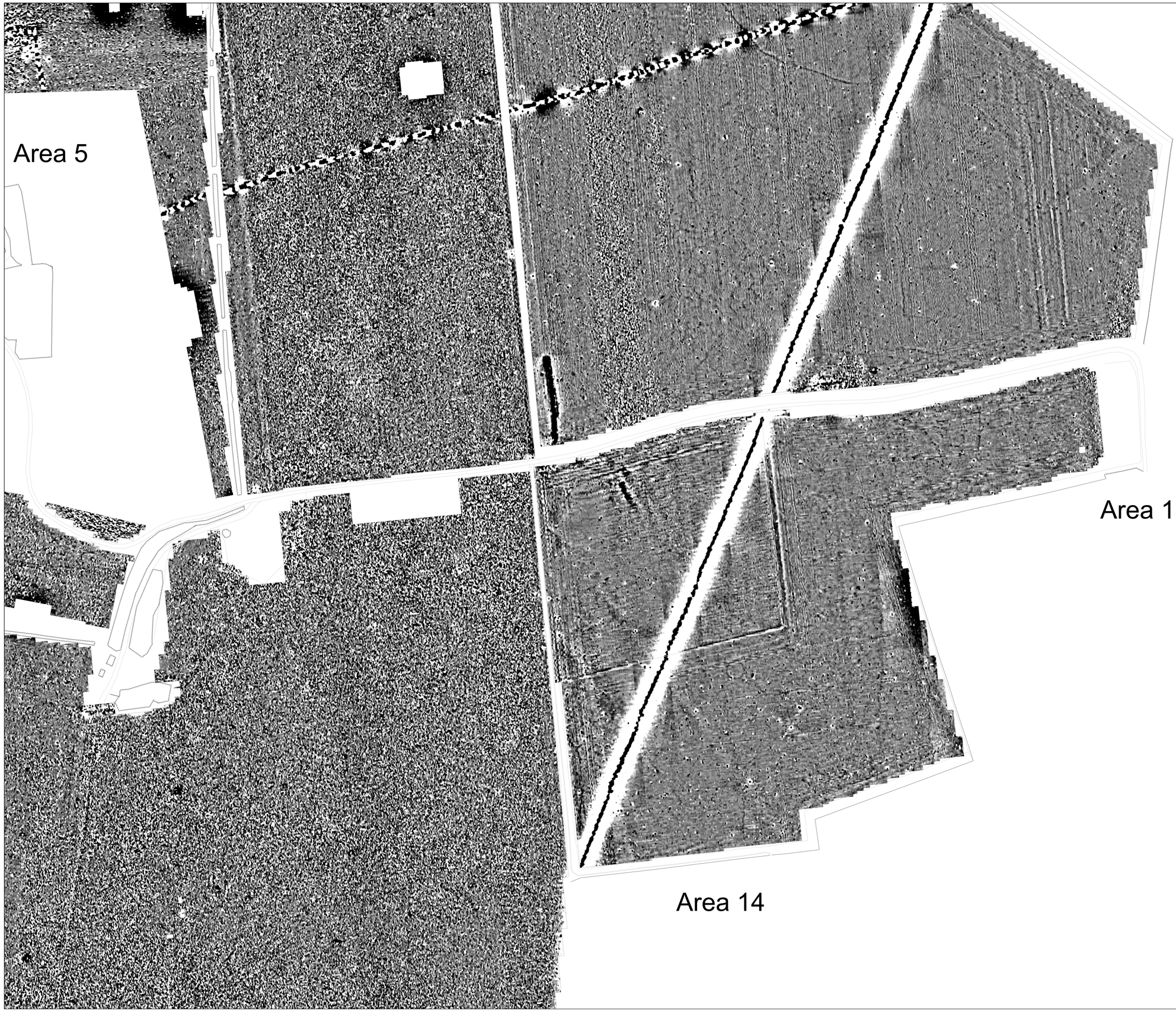
Fig No: 07



N

+5nT

-5nT

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey - Greyscale Plots - Viewport 3

Client: Cotswold Archaeology

Project: 13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire

Scale: 0 metres 75
1:1500 @ A1

Fig No: 08

Area 5

Area 13

Area 14

7

7

10

9

1

N

KEY

	Probable archaeology
	Possible archaeology (discrete anomaly / trend)
	Uncertain Origin (discrete anomaly / trend)
	Former field boundary (corroborated)
	Former field boundary (conjectural)
	Agriculture (plough)
	Natural (e.g. geological / pedological)
	Magnetic disturbance
	Service
	Ferrous

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey - Interpretation - Viewport 3

Client: Cotswold Archaeology

Project: 13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire

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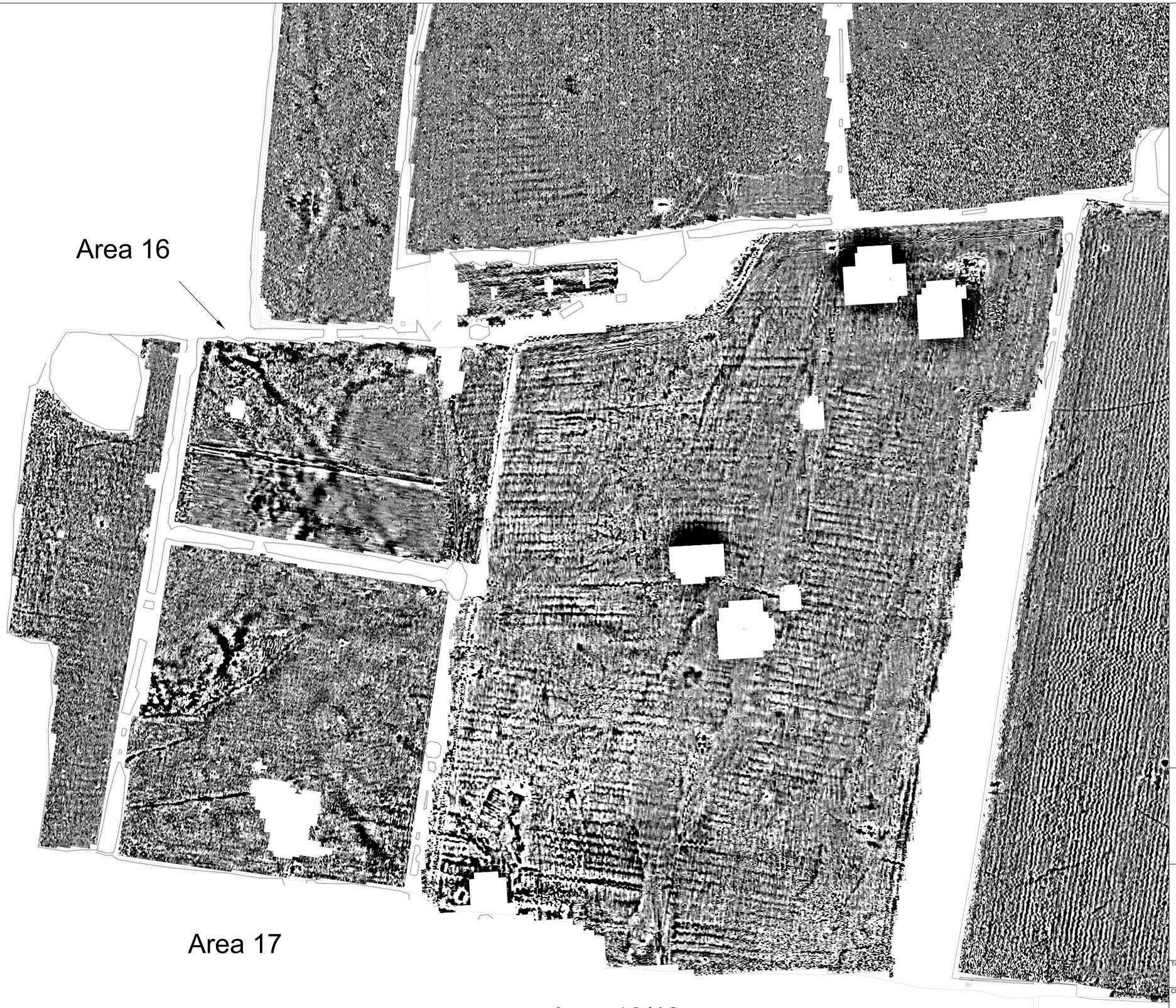


N

+5nT

-5nT

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey - Greyscale Plots - Viewport 4

Client: Cotswold Archaeology

Project: 13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire

Scale: 0 metres 75
1:1500 @ A1

Fig No: 10

KEY

	Probable archaeology
	Possible archaeology (discrete anomaly / trend)
	Uncertain Origin (discrete anomaly / trend)
	Former field boundary (corroborated)
	Former field boundary (conjectural)
	Agriculture (plough)
	Natural (e.g. geological / pedological)
	Magnetic disturbance
	Service
	Ferrous

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey - Interpretation - Viewport 4

Client: Cotswold Archaeology

Project: 13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire

Scale: 0 metres 75 1:1500 @ A1

Fig No: 11

N

+5nT
-5nT

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey - Greyscale Plots - Viewport 5

Client: Cotswold Archaeology

Project: 13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire

Scale: 0 metres 75
1:1500 @ A1

Fig No: 12

Area 11/12

Area 20

3

5

11

7

N

KEY

- Probable archaeology
- Possible archaeology (discrete anomaly / trend)
- Uncertain Origin (discrete anomaly / trend)
- Former field boundary (corroborated)
- Former field boundary (conjectural)
- Agriculture (plough)
- Natural (e.g. geological / pedological)
- Magnetic disturbance
- Service
- Ferrous

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey - Interpretation - Viewport 5

Client: Cotswold Archaeology

Project: 13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire

Scale: 0 metres 75
1:1500 @ A1

Fig No: 13

Appendix A - Technical Information: Magnetometer Survey Method

Grid Positioning
For hand held gradiometers the location of the survey grids has been plotted together with the referencing information. Grids were set out using a Trimble R8 Real Time Kinematic (RTK) VRS Now GNSS GPS system.

An RTK GPS (Real-time Kinematic Global Positioning System) can locate a point on the ground to a far greater accuracy than a standard GPS unit. A standard GPS suffers from errors created by satellite orbit errors, clock errors and atmospheric interference, resulting in an accuracy of 5m-10m. An RTK system uses a single base station receiver and a number of mobile units. The base station re-broadcasts the phase of the carrier it measured, and the mobile units compare their own phase measurements with those they received from the base station. This results in an accuracy of around 0.01m.

Technique	Instrument	Traverse Interval	Sample Interval
Magnetometer	Bartington Grad 601-2	1m	0.25m

Instrumentation: Bartington *Grad* 601-2
Bartington instruments operate in a gradiometer configuration which comprises fluxgate sensors mounted vertically, set 1.0m apart. The fluxgate gradiometer suppresses any diurnal or regional effects. The instruments are carried, or cart mounted, with the bottom sensor approximately 0.1-0.3m from the ground surface. At each survey station, the difference in the magnetic field between the two fluxgates is measured in nanoTesla (nT). The sensitivity of the instrument can be adjusted; for most archaeological surveys the most sensitive range (0.1nT) is used. Generally, features up to 1m deep may be detected by this method, though strongly magnetic objects may be visible at greater depths. The Bartington instrument can collect two lines of data per traverse with gradiometer units mounted laterally with a separation of 1.0m. The readings are logged consecutively into the data logger which in turn is daily down-loaded into a portable computer whilst on site. At the end of each site survey, data is transferred to the office for processing and presentation.

Data Processing

Zero Mean Traverse	This process sets the background mean of each traverse within each grid to zero. The operation removes striping effects and edge discontinuities over the whole of the data set.
Step Correction (De-stagger)	When gradiometer data are collected in 'zig-zag' fashion, stepping errors can sometimes arise. These occur because of a slight difference in the speed of walking on the forward and reverse traverses. The result is a staggered effect in the data, which is particularly noticeable on linear anomalies. This process corrects these errors.

Display

Greyscale/ Colourscale Plot	This format divides a given range of readings into a set number of classes. Each class is represented by a specific shade of grey, the intensity increasing with value. All values above the given range are allocated the same shade (maximum intensity); similarly, all values below the given range are represented by the minimum intensity shade. Similar plots can be produced in colour, either using a wide range of colours or by selecting two or three colours to represent positive and negative values. The assigned range (plotting levels) can be adjusted to emphasise different anomalies in the data-set.

Interpretation Categories

In certain circumstances (usually when there is corroborative evidence from desk-based or excavation data) very specific interpretations can be assigned to magnetic anomalies (for example, *Roman Road, Wall,* etc.) and where appropriate, such interpretations will be applied. The list below outlines the generic categories commonly used in the interpretation of the results.

Archaeology / Probable Archaeology	This term is used when the form, nature and pattern of the responses are clearly or very probably archaeological and /or if corroborative evidence is available. These anomalies, whilst considered anthropogenic, could be of any age.
Possible Archaeology	These anomalies exhibit either weak signal strength and / or poor definition, or form incomplete archaeological patterns, thereby reducing the level of confidence in the interpretation. Although the archaeological interpretation is favoured, they may be the result of variable soil depth, plough damage or even aliasing as a result of data collection orientation.
Industrial / Burnt-Fired	Strong magnetic anomalies that, due to their shape and form or the context in which they are found, suggest the presence of kilns, ovens, corn dryers, metal-working areas or hearths. It should be noted that in many instances modern ferrous material can produce similar magnetic anomalies.
Former Field Boundary (probable & possible)	Anomalies that correspond to former boundaries indicated on historic mapping, or which are clearly a continuation of existing land divisions. Possible denotes less confidence where the anomaly may not be shown on historic mapping but nevertheless the anomaly displays all the characteristics of a field boundary.
Ridge & Furrow	Parallel linear anomalies whose broad spacing suggests ridge and furrow cultivation. In some cases, the response may be the result of more recent agricultural activity.
Agriculture (ploughing)	Parallel linear anomalies or trends with a narrower spacing, sometimes aligned with existing boundaries, indicating more recent cultivation regimes.
Land Drain	Weakly magnetic linear anomalies, quite often appearing in series forming parallel and herringbone patterns. Smaller drains may lead and empty into larger diameter pipes, which in turn usually lead to local streams and ponds. These are indicative of clay fired land drains.
Natural	These responses form clear patterns in geographical zones where natural variations are known to produce significant magnetic distortions.
Magnetic Disturbance	Broad zones of strong dipolar anomalies, commonly found in places where modern ferrous or fired materials (e.g. brick rubble) are present. They are presumed to be modern.
Service	Magnetically strong anomalies, usually forming linear features are indicative of ferrous pipes/cables. Sometimes other materials (e.g. pvc) or the fill of the trench can cause weaker magnetic responses which can be identified from their uniform linearity.
Ferrous	This type of response is associated with ferrous material and may result from small items in the topsoil, larger buried objects such as pipes, or above ground features such as fence lines or pylons. Ferrous responses are usually regarded as modern. Individual burnt stones, fired bricks or igneous rocks can produce responses similar to ferrous material.
Uncertain Origin	Anomalies which stand out from the background magnetic variation, yet whose form and lack of patterning gives little clue as to their origin. Often the characteristics and distribution of the responses straddle the categories of *Possible Archaeology* / *Natural* or (in the case of linear responses) *Possible Archaeology* / *Agriculture*; occasionally they are simply of an unusual form.

Where appropriate some anomalies will be further classified according to their form (positive or negative) and relative strength and coherence (trend: weak and poorly defined).

Appendix B - Technical Information: Magnetic Theory

Detailed magnetic survey can be used to effectively define areas of past human activity by mapping spatial variation and contrast in the magnetic properties of soil, subsoil and bedrock. Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.1 nanoTeslas (nT) in an overall field strength of 48,000 (nT), can be accurately detected.

Weakly magnetic iron minerals are always present within the soil and areas of enhancement relate to increases in *magnetic susceptibility* and permanently magnetised *thermoremanent* material.

Magnetic susceptibility relates to the induced magnetism of a material when in the presence of a magnetic field. This magnetism can be considered as effectively permanent as it exists within the Earth's magnetic field. Magnetic susceptibility can become enhanced due to burning and complex biological or fermentation processes.

Thermoremanence is a permanent magnetism acquired by iron minerals that, after heating to a specific temperature known as the Curie Point, are effectively demagnetised followed by re-magnetisation by the Earth's magnetic field on cooling. Thermoremanent archaeological features can include hearths and kilns; material such as brick and tile may be magnetised through the same process.

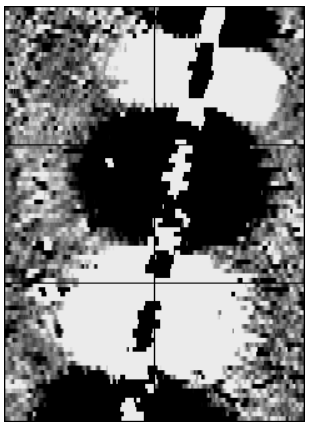
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement allowing assessment and characterisation of subsurface features. Material such as subsoil and non-magnetic bedrock used to create former earthworks and walls may be mapped as areas of lower enhancement compared to surrounding soils.

Magnetic survey is carried out using a fluxgate gradiometer which is a passive instrument consisting of two sensors mounted vertically 1m apart. The instrument is carried about 30cm above the ground surface and the top sensor measures the Earth's magnetic field whilst the lower sensor measures the same field but is also more affected by any localised buried feature. The difference between the two sensors will relate to the strength of a magnetic field created by this feature, if no field is present the difference will be close to zero as the magnetic field measured by both sensors will be the same.

Factors affecting the magnetic survey may include soil type, local geology, previous human activity and disturbance from modern services.

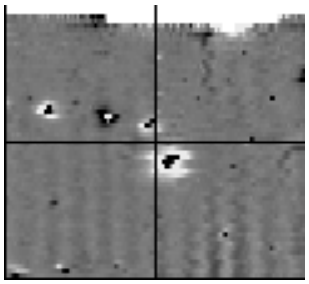
Appendix C - Glossary of Magnetic Anomalies

Bipolar



A bipolar anomaly is one that is composed of both a positive response and a negative response. It can be made up of any number of positive responses and negative responses. For example a pipeline consisting of alternating positive and negative anomalies is said to be bipolar. See also dipolar which has only one area of each polarity. The interpretation of the anomaly will depend on the magnitude of the magnetic field strength. A weak response may be caused by a clay field drain while a strong response will probably be caused by a metallic service.

Dipolar

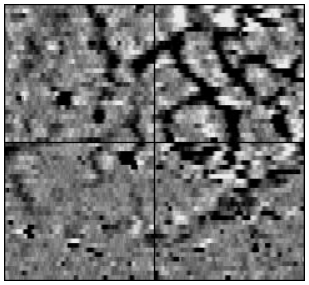


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very strong anomaly is likely to be caused by a ferrous object.

Positive anomaly with associated negative response

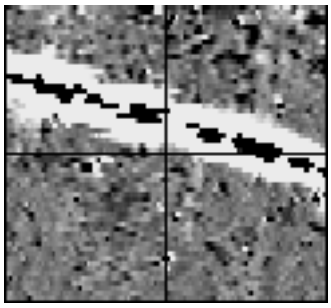
See bipolar and dipolar.

Positive linear



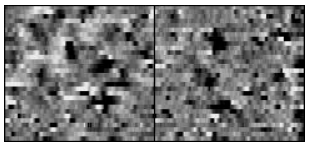
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity and some may even have a natural origin.

Positive linear anomaly with associated negative response



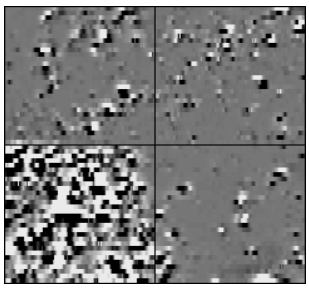
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field boundaries.

Positive point/area



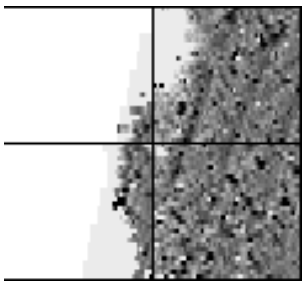
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally occurring depressions in the ground.

Magnetic debris



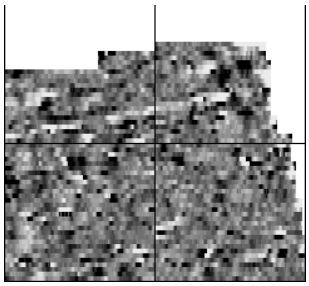
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low (+/-3nT) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly (+/-250nT) is more indicative of a spread of ferrous debris. Moderately strong anomalies may be the result of a spread of thermoremanent material such as bricks or ash.

Magnetic disturbance



Magnetic disturbance is high amplitude and can be composed of either a bipolar anomaly, or a single polarity response. It is essentially associated with magnetic interference from modern ferrous structures such as fencing, vehicles or buildings, and as a result is commonly found around the perimeter of a site near to boundary fences.

Negative linear

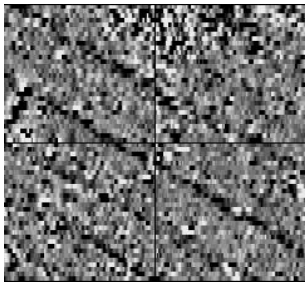


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative to the background top soil is built up. See also ploughing activity.

Negative point/area

Opposite to positive point anomalies these responses may be caused by raised areas or earthen banks. These could be of an archaeological origin or may have a natural origin.

Ploughing activity



Ploughing activity can often be visualised by a series of parallel linear anomalies. These can be of either positive polarity or negative polarity depending on site specifics. It can be difficult to distinguish between ancient ploughing and more modern ploughing. Clues such as the separation of each linear, straightness, strength of response and cross cutting relationships can be used to aid this, although none of these can be guaranteed to differentiate between different phases of activity.

Polarity

Term used to describe the measurement of the magnetic response. An anomaly can have a positive polarity (values above 0nT) and/or a negative polarity (values below 0nT).

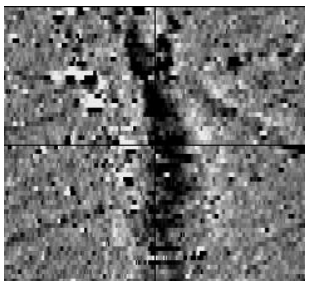
Strength of response

The amplitude of a magnetic response is an important factor in assigning an interpretation to a particular anomaly. For example a positive anomaly covering a 10m2 area may have values up to around 3000nT, in which case it is likely to be caused by modern magnetic interference. However, the same size and shaped anomaly but with values up to only 4nT may have a natural origin. Colour plots are used to show the amplitude of response.

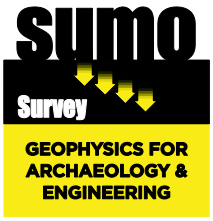
Thermoremanent response

A feature which has been subject to heat may result in it acquiring a magnetic field. This can be anything up to approximately +/-100 nT in value. These features include clay fired drains, brick, bonfires, kilns, hearths and even pottery. If the heat application has occurred in situ (e.g. a kiln) then the response is likely to be bipolar compared to if the heated objects have been disturbed and moved relative to each other, in which case they are more likely to take an irregular form and may display a debris style response (e.g. ash).

Weak background variations



Weakly magnetic wide scale variations within the data can sometimes be seen within sites. These usually have no specific structure but can often appear curvy and sinuous in form. They are likely to be the result of natural features, such as soil creep, dried up (or seasonal) streams. They can also be caused by changes in the underlying geology or soil type which may contain unpredictable distributions of magnetic minerals, and are usually apparent in several locations across a site.



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