

GEOPHYSICAL SURVEY REPORT

sumo

Survey

**GEOPHYSICS FOR
ARCHAEOLOGY &
ENGINEERING**

Orgreave, Staffordshire

Client
Worcestershire County Council

For
Cemex UK

Survey Report
11126

Date
September 2017

Incorporating
GSB PROSPECTION LTD
and
STRATASCAN LTD

SUMO Services Ltd
Cowburn Farm
Market Street
Thornton
Bradford
BD13 3HW
T: 01274 835016

SUMO Services Ltd
Vineyard House
Upper Hook Road
Upton upon Severn
Worcestershire
WR8 0SA
T: 01684 592266

geophysics@sumoservices.com
www.sumoservices.com

GEOPHYSICAL SURVEY REPORT

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Orgreave, Staffordshire

SUMO Job reference:
11126

Client:
Worcestershire County Council
For:
Cemex UK

Survey date:
**18-20 April, 24-25 July & 21-25
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26 September 2017

Field co-ordinator:
Joe Perry BA
Rebecca Vickers BSc
Tom Cockcroft MSc

Field Team:
Andrew Edwards BSc MSc
David Stockwell BA
Rebecca Bowran BA
Rob Usher BA

Report written by:
Rebecca Davies BSc

CAD illustrations by:
Rebecca Davies BSc

Project Manager:
Simon Haddrell BEng AMBCS PCIfA

Report approved by:
David Elks MSc ACIfA

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DIGITAL CONTENT (Archive Data CD/DVD)

- Minimally Processed Greyscale Images and XY Trace Plots in DWG format
- Digital Copies of Report Text and Figures (both PDF and native formats)

1 SUMMARY OF RESULTS

A detailed magnetometer survey was conducted over approximately 55ha of arable farmland. No definite archaeological responses have been detected, however several anomalies of uncertain origin are visible. It is possible that these are related to former settlement activity, though their origin cannot be determined with confidence.

2 INTRODUCTION

2.1 Background synopsis

SUMO Services Ltd were commissioned to undertake a geophysical survey of an area outlined for the extraction of sand and gravel. This survey forms part of an archaeological investigation being undertaken by **Worcestershire County Council** on behalf of **Cemex UK**.

2.2 Site details

| | |
|-------------------------|--|
| NGR / Postcode | SK 148 152 / DE13 7DE |
| Location | The site is located to the west of Alrewas, south of the village of Orgreave, Staffordshire. The A513 forms the northern boundary of the site, with Pyford Brook at the southern edge. |
| HER/SMR | Staffordshire |
| District | Lichfield |
| Parish | Alrewas CP |
| Topography | Largely flat |
| Current Land Use | Arable |
| Weather | Sunny, occasional showers |
| Geology | Solid: Gunthorpe Member - mudstone. Superficial: Holme Pierrepoint Sand and Gravel Member - sand and gravel (BGS 2017). |
| Soils | Wigton Moor Association (831c) - fine and coarse loamy soils on generally flat land (SSEW 1983). |
| Archaeology | Alrewas Causewayed Enclosure, a scheduled ancient monument, is located approximately 800m to the south-east of the site. Several cropmark complexes have been identified both on and in the vicinity of the site, probably dating from the prehistoric period but also potentially including Roman and later elements. The complexes include pit alignments, enclosures, barrows and trackways. Heritage assets recorded within the site include a probable trackway and probable enclosure identified as cropmarks on an aerial photograph. These are of unknown date. The 1810 Enclosure map of the parish depicts a roughly circular area of small land parcels which partially lies within the site. This is referred to as the ancient enclosure of Micklebroom and is of potential archaeological interest (WCC 2016). |
| Survey Methods | Magnetometer survey (fluxgate gradiometer) |
| Study Area | c. 55ha |

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 Appendix A.

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 for each site involves a grey-scale plot of processed data. Magnetic anomalies are identified, interpreted and plotted onto the 'Interpretation' drawings. The minimally processed data are provided as a greyscale image in the Archive Data Folder with an XY trace plot in CAD format. A free viewer is available: <https://viewer.autodesk.com>

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 six survey areas (Areas 1-6) and specific anomalies have been given numerical labels [1] [2] which appear in the text below, as well as on the Interpretation Figure(s).

4.1 **Probable / Possible Archaeology**

4.1.1 No magnetic responses have been recorded that could be interpreted as being of archaeological interest.

4.2 **Uncertain**

4.2.1 A complex series of strong discrete and linear anomalies [1] is visible in the east of Area 6. These lie to the south of the possible trackway and enclosure cropmarks identified within the site (WCC 2016). The strength and rectilinear shape of the responses suggests that they could be of archaeological origin, i.e. an enclosure and associated internal features and boundaries; however, similar anomalies present across the site are thought to be of natural origin, hence the 'uncertain' classification.

4.2.2 In the west of Area 3, positive curvilinear responses [2] have been detected. These lie within the same area as the trackway and enclosure, visible as cropmarks on aerial photographs (WCC 2016). The responses themselves lack distinct shape or form, and their extent is not visible due to their proximity to a modern field boundary; as such, an uncertain origin has been determined. It is possible that they are of archaeological origin, though their sinuous nature means a natural origin cannot be ruled out.

4.2.3 To the north-east of [2], a small cluster of weak linear trends and discrete responses [3] can be seen. These may relate to a small former enclosure, however the responses are weak making further interpretation difficult. It is equally possible that these are of agricultural or natural origin.

4.3 **Former Field Boundary**

4.3.1 Several weak linear responses [4-8] are visible in Areas 1, 4 and 6, all of which correspond with former field boundaries present on historic maps. Anomaly [4] is visible from 1840-1887, [5] from 1840-1925, [6-7] from 1840-1955 and [8] from 1887-1925.

4.4 **Agricultural – Ploughing, Land Drains**

4.4.1 Widely spaced, slightly curved parallel linear anomalies are present in Areas 1 and 3 and are a result of ridge and furrow cultivation.

4.4.2 Evidence of modern agricultural activity, i.e. ploughing, has been detected in the form of magnetically weak, parallel, linear anomalies in Areas 1, 5 and 6.

4.4.3 Weak, bipolar linear anomalies in Areas 1, 4 and 6 are indicative of land drains.

4.5 **Natural / Geological / Pedological / Topographic**

4.5.1 Large areas of amorphous magnetic variation are visible in the data across the site. These are typical of responses detected over deposits of sand and gravel.

4.6 **Ferrous / Magnetic Disturbance**

- 4.6.1 Large areas of magnetic debris are visible in the data, covering the whole of Area 2, a central band of Area 4 and the north of Area 5. This response is typical of that of 'green waste' fertiliser spread across fields, containing numerous small pieces of ferrous debris or rubbish.
- 4.6.2 Several underground services are visible across the site, in the form of strongly magnetic, bipolar linear anomalies.
- 4.6.3 Ferrous responses close to boundaries are due to adjacent fences and gates. Smaller scale ferrous anomalies ("iron spikes") are present throughout the data and their form is best illustrated in the XY trace plots. These responses are characteristic of small pieces of ferrous debris (or brick / tile) in the topsoil and 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 mudstone geologies, along with superficial deposits of sand and gravel can be variable. Due to the presence of several anomalies of uncertain origin and former field boundaries, it is likely that the technique has been effective. Large areas of magnetic disturbance have the potential to mask weaker archaeological responses.

6 CONCLUSION

- 6.1 The survey at Orgreave has not identified any anomalies of definite archaeological origin. Several responses of uncertain origin have been detected, including a possible enclosure and associated features; however these responses could also be of natural origin. Former field boundaries, evidence of ridge and furrow and modern ploughing indicate that the site has a largely agricultural past.

7 REFERENCES

- BGS 2017 British Geological Survey, Geology of Britain viewer [Accessed 25/09/2017] *website:* (<http://www.bgs.ac.uk/opengeoscience/home.html?Accordion1=1#maps>)
- ClfA 2014 *Standard and Guidance for Archaeological Geophysical Survey*. Amended 2016. ClfA Guidance note. Chartered Institute for Archaeologists, Reading
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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.

| | |
|--|--|
| <i>Archaeology / Probable Archaeology</i> | 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. |
| <i>Possible Archaeology</i> | 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. |
| <i>Industrial / Burnt-Fired</i> | 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. |
| <i>Former Field Boundary (probable & possible)</i> | 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. |
| <i>Ridge & Furrow</i> | 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. |
| <i>Agriculture (ploughing)</i> | Parallel linear anomalies or trends with a narrower spacing, sometimes aligned with existing boundaries, indicating more recent cultivation regimes. |
| <i>Land Drain</i> | 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. |
| <i>Natural</i> | These responses form clear patterns in geographical zones where natural variations are known to produce significant magnetic distortions. |
| <i>Magnetic Disturbance</i> | 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. |
| <i>Service</i> | 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. |
| <i>Ferrous</i> | 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. |
| <i>Uncertain Origin</i> | 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 <i>Possible Archaeology / Natural</i> or (in the case of linear responses) <i>Possible Archaeology / Agriculture</i> ; 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.

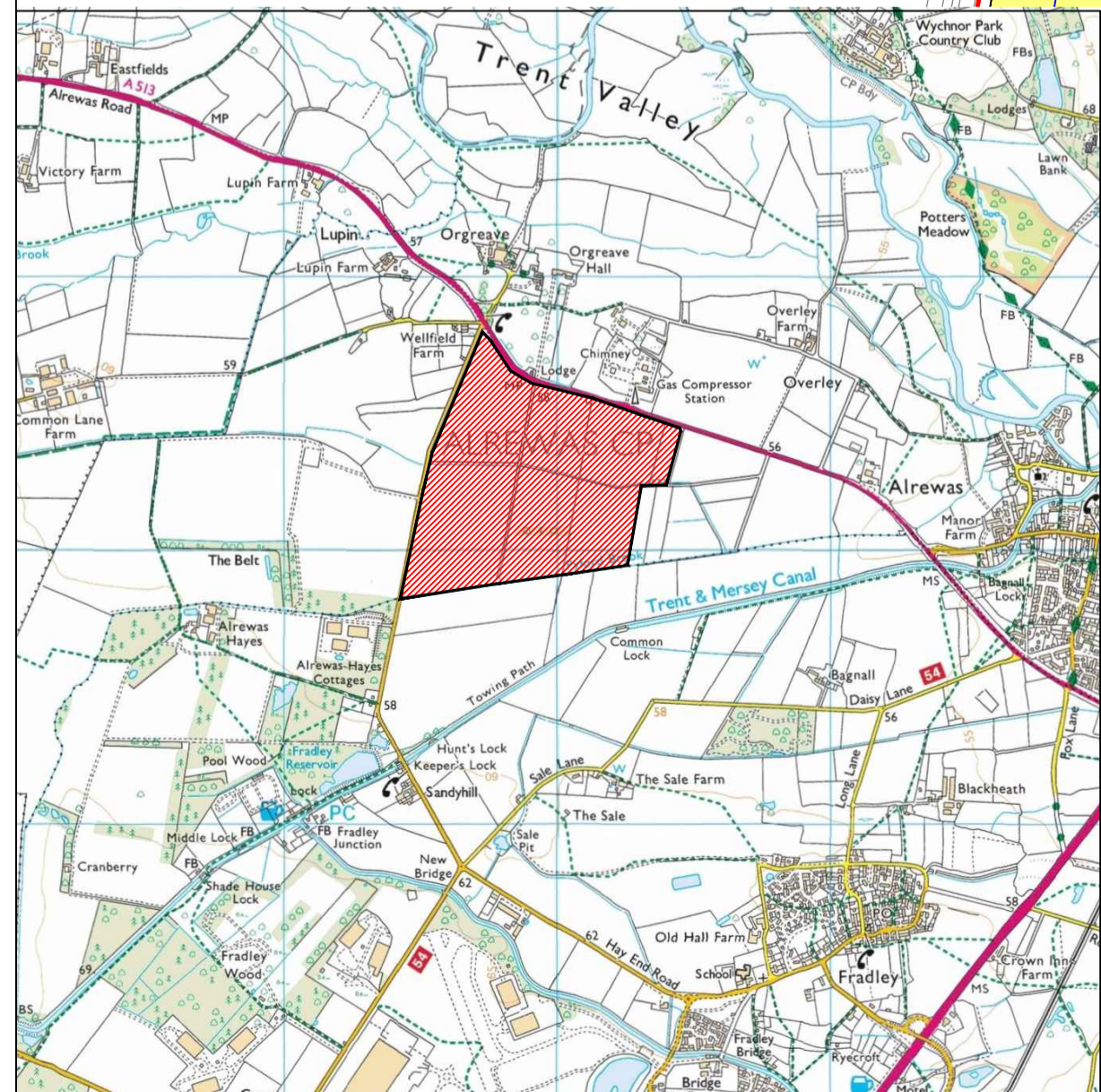
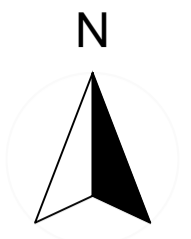
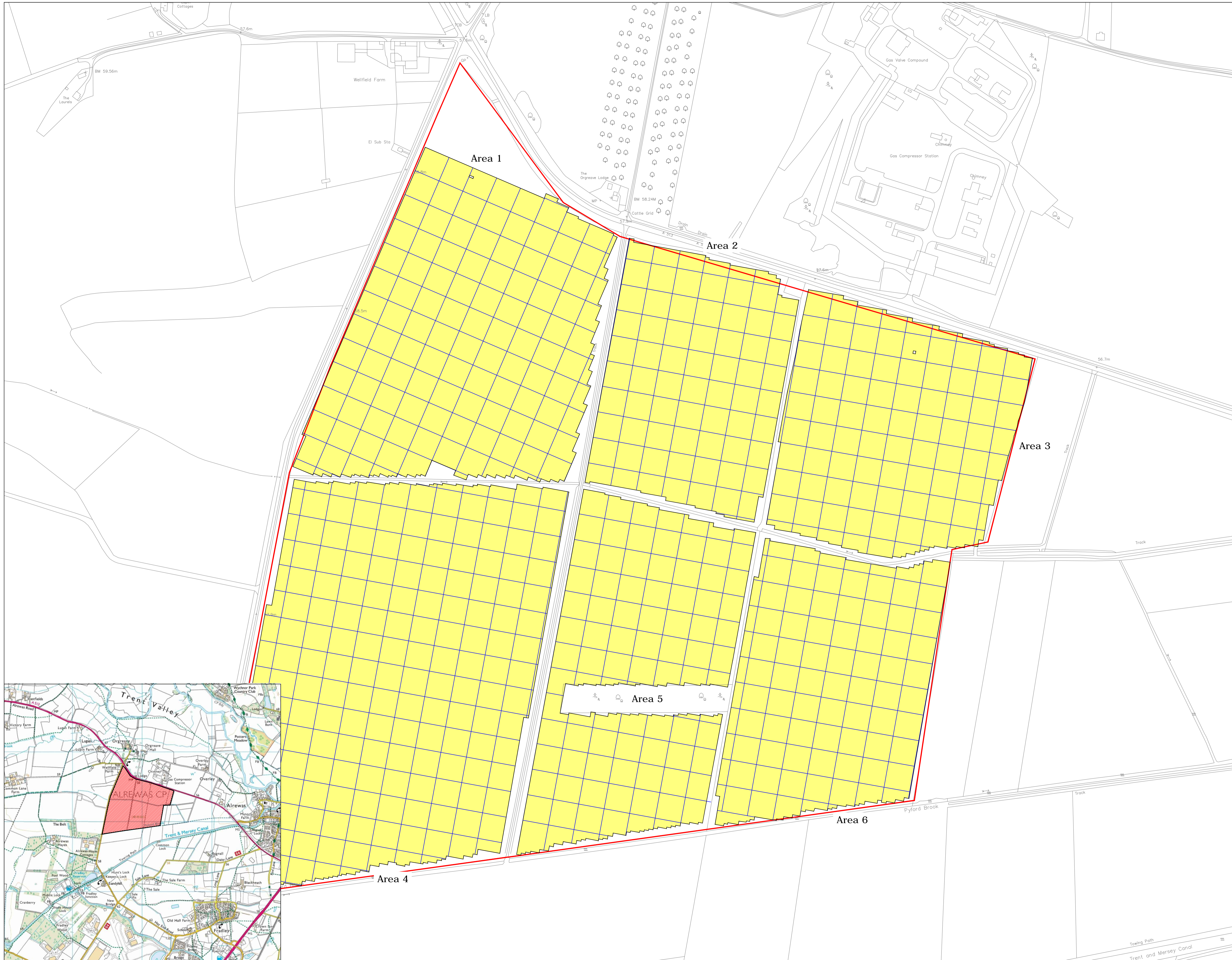
Magnetic susceptibility relates to the induced magnetism of a material when in the presence of a magnetic field. This magnetism can be considered as effectively permanent as it exists within the Earth's magnetic field. Magnetic susceptibility can become enhanced due to burning and complex biological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

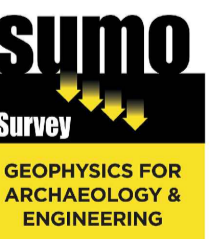
Factors affecting the magnetic survey may include soil type, local geology, previous human activity and disturbance from modern services.



 Survey Area - showing 30m grid

 Site Location

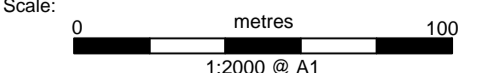
Reproduced from Ordnance Survey's 1:25 000 map of 1998 with the permission of the controller of Her Majesty's Stationery Office. Crown Copyright reserved. Licence No: AL 50125A

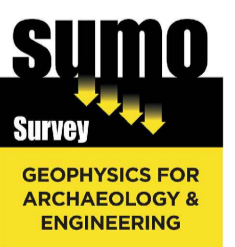
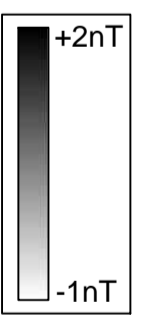
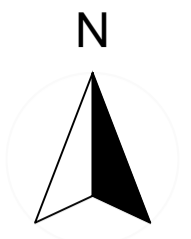


Title: Site Location Diagram & Location of Survey Area

Client: Worcestershire County Council

Project: 11126 - Orgreave, Staffordshire

Scale:  1:2000 @ A1 Fig No: 01



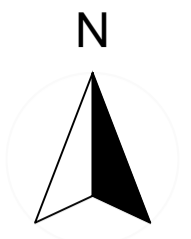
Magnetometer Survey - Greyscale Plot - Overview

Worcestershire County Council

Project: 11126 - Orgreave, Staffordshire

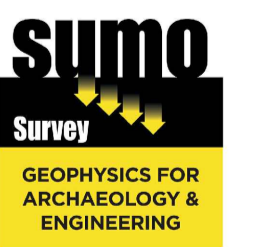
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Fig No: 02



KEY

| | |
|--|--|
| | Uncertain Origin (discrete anomaly / trend / area of increased response) |
| | Former field boundary (corroborated) |
| | Agriculture (ridge and furrow / plough) |
| | Land drain |
| | Natural (e.g. geological / pedological) |
| | Magnetic disturbance |
| | Service |
| | Ferrous |



Title: Magnetometer Survey - Interpretation - Overview
 Client: Worcestershire County Council
 Project: 11126 - Orgreave, Staffordshire

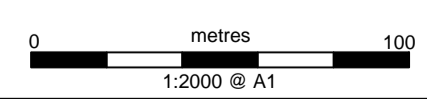
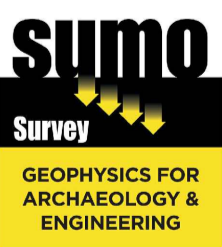
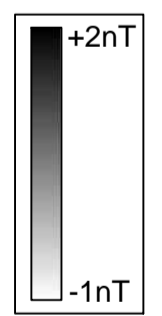
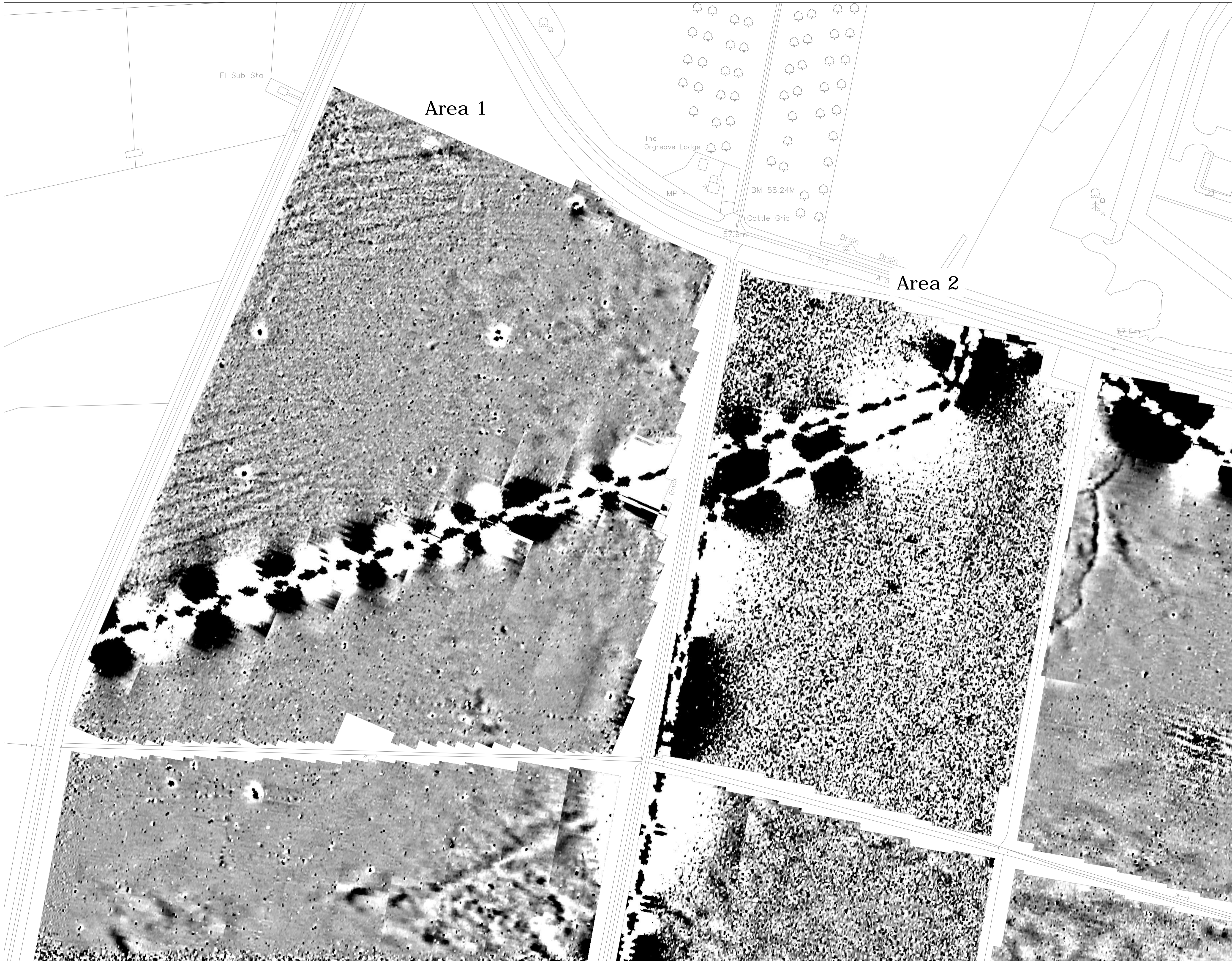


Fig No: 03



Magnetometer Survey - Greyscale Plot
- Areas 1-2

Worcestershire County Council

Project: 11126 - Orgreave, Staffordshire

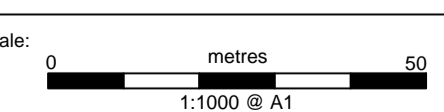
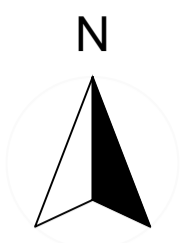
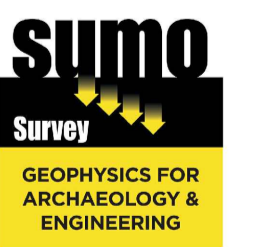


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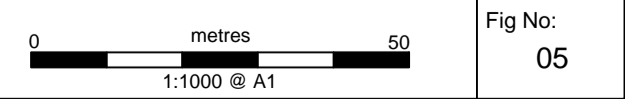


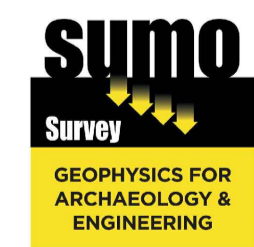
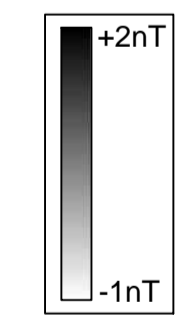
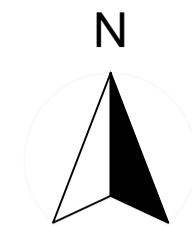
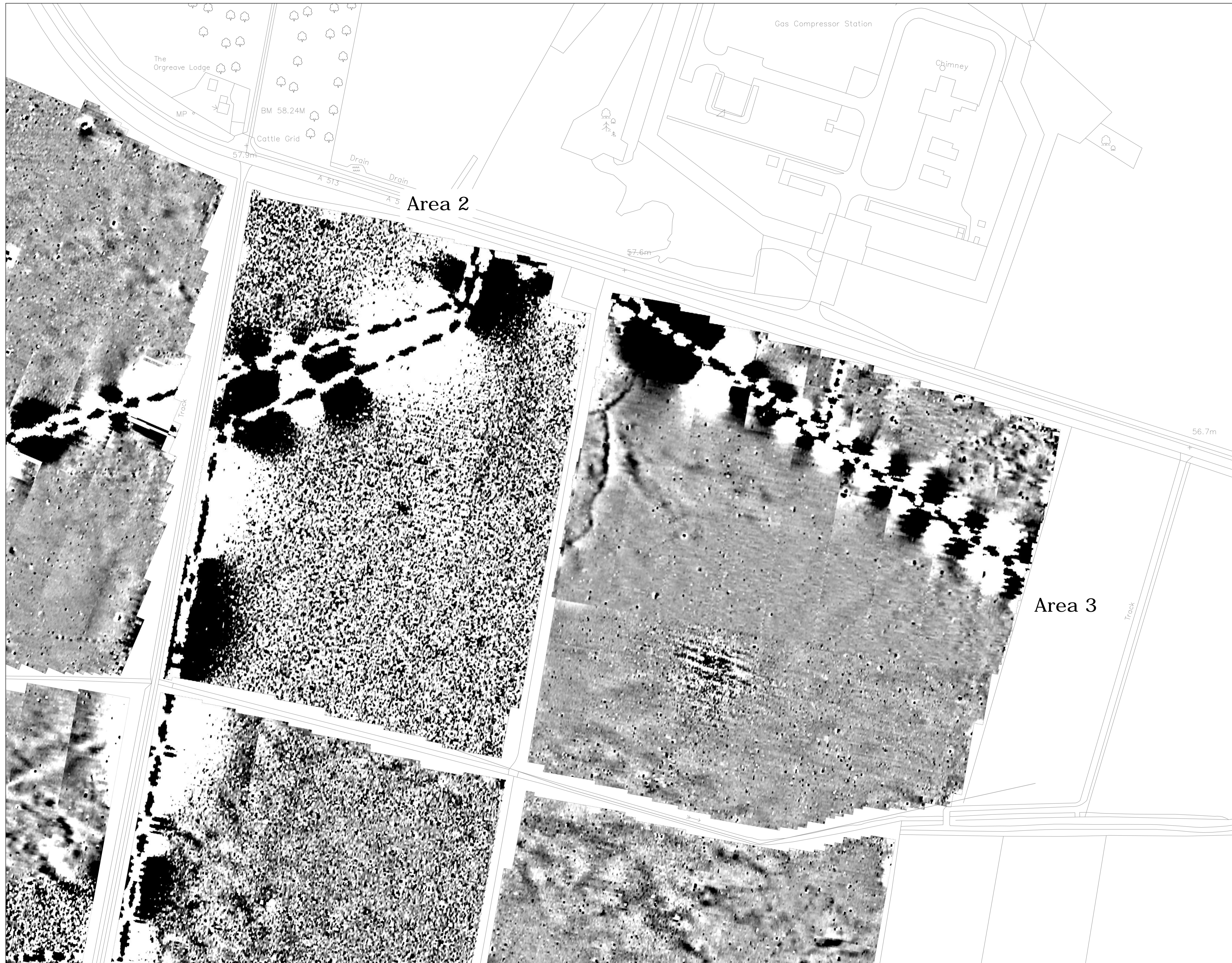
KEY

| | |
|--|--|
| | Uncertain Origin (discrete anomaly / trend / area of increased response) |
| | Former field boundary (corroborated) |
| | Agriculture (ridge and furrow / plough) |
| | Land drain |
| | Natural (e.g. geological / pedological) |
| | Magnetic disturbance |
| | Service |
| | Ferrous |



Title: Magnetometer Survey
- Interpretation - Areas 1-2
Client: Worcestershire County Council
Project: 11126 - Orgreave, Staffordshire





Magnetometer Survey - Greyscale Plot
- Areas 2-3

Worcestershire County Council

Project: 11126 - Orgreave, Staffordshire

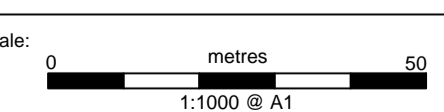
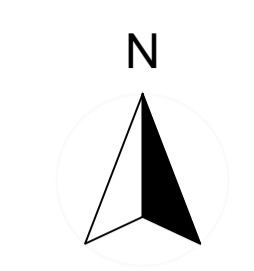
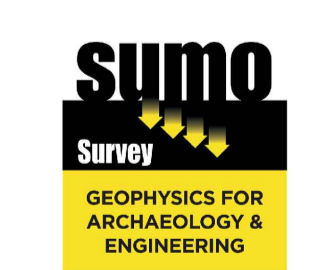


Fig No: 06



KEY

| | |
|--|--|
| | Uncertain Origin (discrete anomaly / trend / area of increased response) |
| | Former field boundary (corroborated) |
| | Agriculture (ridge and furrow / plough) |
| | Land drain |
| | Natural (e.g. geological / pedological) |
| | Magnetic disturbance |
| | Service |
| | Ferrous |



Title: Magnetometer Survey
- Interpretation - Areas 2-3

Client: Worcestershire County Council

Project: 11126 - Orgreave, Staffordshire

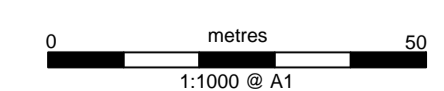
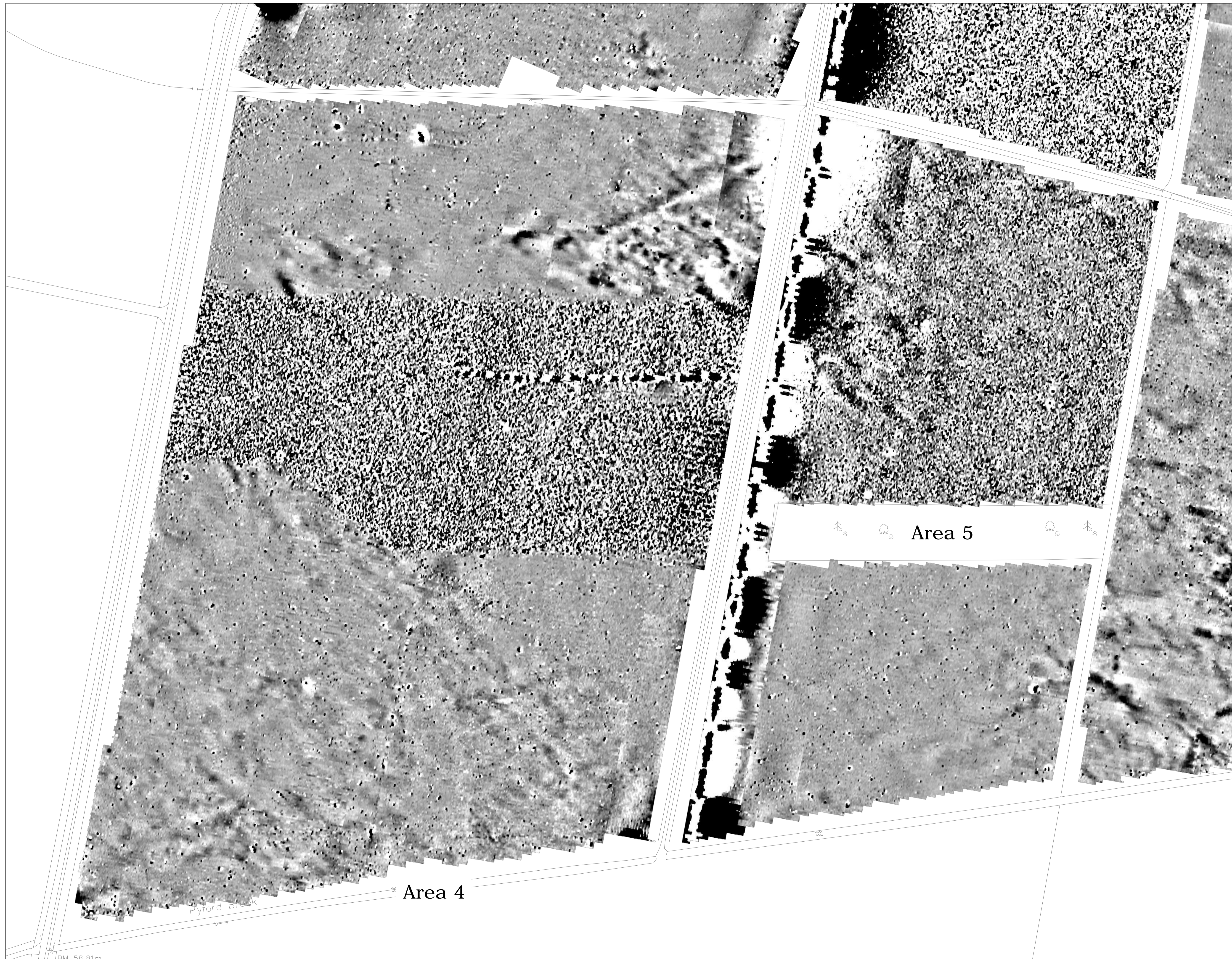


Fig No: 07

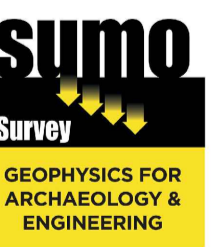
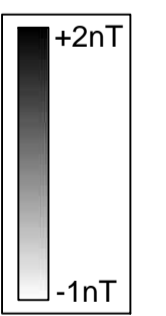


Area 5

Area 4

Pyford Brook

BM 58.81m



Magnetometer Survey - Greyscale Plot
- Areas 4-5

Worcestershire County Council

Project: 11126 - Orgreave, Staffordshire

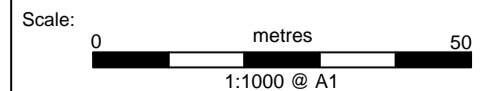
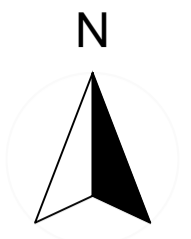
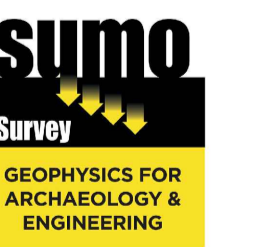


Fig No: 08



KEY

| | |
|--|--|
| | Uncertain Origin (discrete anomaly / trend / area of increased response) |
| | Former field boundary (corroborated) |
| | Agriculture (ridge and furrow / plough) |
| | Land drain |
| | Natural (e.g. geological / pedological) |
| | Magnetic disturbance |
| | Service |
| | Ferrous |



Title: Magnetometer Survey
- Interpretation - Areas 4-5

Client: Worcestershire County Council

Project: 11126 - Orgreave, Staffordshire

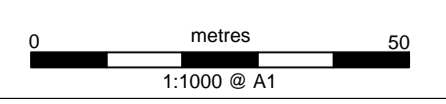
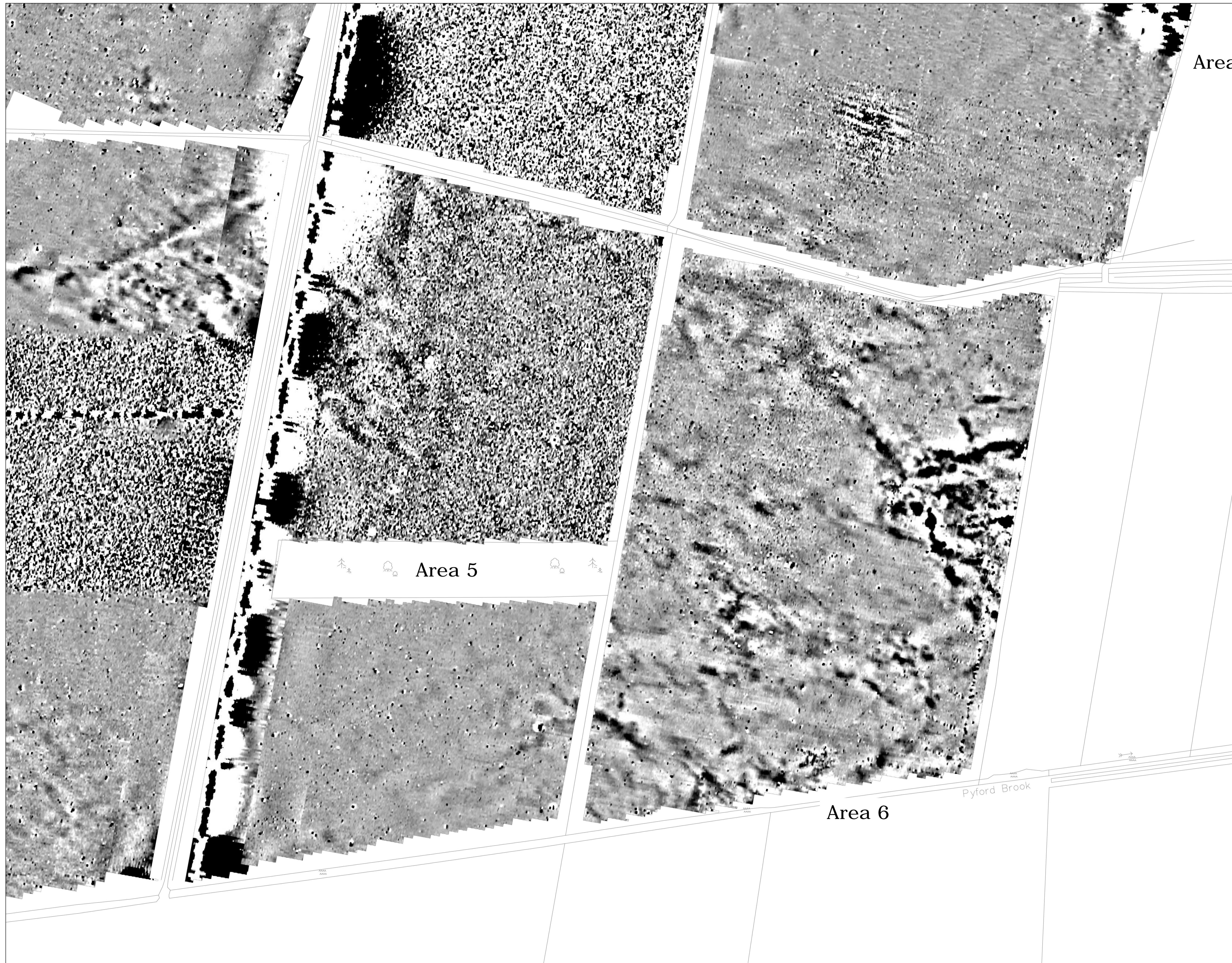


Fig No: 09



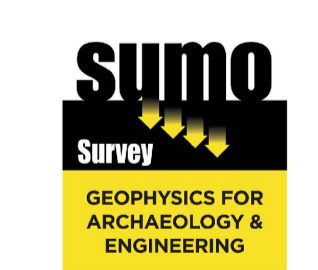
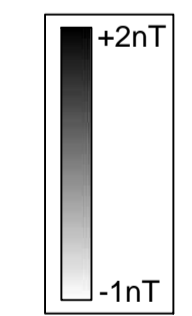
Area



Area 5

Area 6

Pyford Brook



Magnetometer Survey - Greyscale Plot
- Areas 5-6

Worcestershire County Council

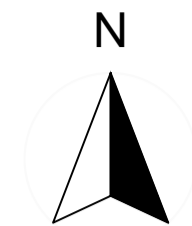
Project: 11126 - Orgreave, Staffordshire

Scale: 0 metres 50
1:1000 @ A1

Fig No: 10



Area



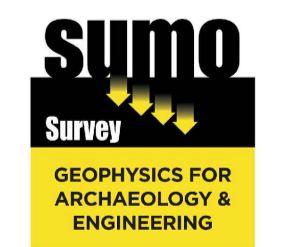
Area 5

Area 6

Pyford Brook

KEY

| | |
|--|--|
| | Uncertain Origin (discrete anomaly / trend / area of increased response) |
| | Former field boundary (corroborated) |
| | Agriculture (ridge and furrow / plough) |
| | Land drain |
| | Natural (e.g. geological / pedological) |
| | Magnetic disturbance |
| | Service |
| | Ferrous |



Title: Magnetometer Survey - Interpretation - Areas 5-6
 Client: Worcestershire County Council
 Project: 11126 - Orgreave, Staffordshire

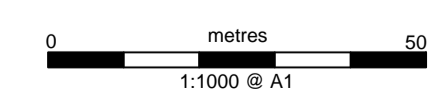
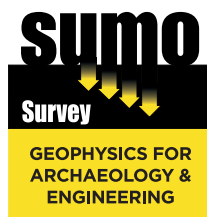


Fig No: 11



- Archaeological
- Geophysical
- Laser Scanning
- Measured Building
- Topographic
- Utility Mapping

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Company Registration No.4275993.
Registered Office Unit 8 Hayward Business Centre, New Lane, Havant, Hampshire, PO9 2NL