GEOPHYSICAL SURVEY REPORT

STRATASCAN™

SUMO Survey Services
SUMO Group Member

Project name:

Outwoods, Burton on Trent, Staffordshire

Client:

Orion Heritage

December 2015

Job ref:

J9265

Report author:

Rebecca Davies BSc (Hons)

GEOPHYSICAL SURVEY REPORT

Project name:
Outwoods, Burton on Trent, Staffordshire
Client:
Orion Heritage

Job ref:
J9265

Techniques:
Detailed magnetic survey – Gradiometry

Survey date:
26th November 2015

Site centred at:
SK 225 256

Post code:
DE13 9QW

Field team:
Robert Knight BA (Hons)
Sam Wood

Project manager:
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1 SUMMARY OF RESULTS

A detailed gradiometry survey was conducted over approximately 1.3 hectares of agricultural land. No features of probable archaeological origin have been identified. Two possible backfilled pits have been detected, though these may also be natural in origin. A trackway and evidence of modern ploughing indicate that the site has a more recent agricultural past. A former marl pit has also been identified, and dominates the central area of the site supporting information from the HER search of the site having potential for evidence of industrial acivity.The remaining features are magnetic disturbance related to ferrous metal objects and magnetic spikes which are likely to be modern rubbish.

2 INTRODUCTION

2.1 *Background synopsis*

Stratascan were commissioned to undertake a geophysical survey of an area outlined for residential development. This survey forms part of an archaeological investigation being undertaken by Orion Heritage.

2.2 *Site location*

The site is located near Outwoods Lane between Anslow and Stretton at OS ref. SK 225 257.

2.3 *Description of site*

The survey area is approximately 1.3 hectares of agricultural land. A track-way running roughly north-south through the site and an area of woodland in the south of the site are the only obstructions, but have not significantly affected the survey area.

2.4 *Geology and soils*

The underlying geology is Mercia Mudstone Group - mudstone (British Geological Survey website). No drift geology is recorded across the site (British Geological Survey website).

The overlying soils are known as Worcester which are typical argillic pelosols. These consist of slowly permeable non-calcareous and calcareous reddish soils over mudstone (Soil Survey of England and Wales, Sheet 3 Midland and Western England).

2.5 *Site history and archaeological potential*

A search of Staffordshire HER (Staffordshire County Council, 2015) within a 1km radius of the site identifies a number of former field boundaries, visible as earthworks on aerial photographs along with several areas of ridge and furrow cultivation. The site of a post-medieval brickworks (05218) with associated clay pit and building platform is recorded to the north-west of the survey area, indicating the area has an industrial past. Earthwork banks

visible on aerial photography to the north of the site (05255, 05256 & 05263) are thought to be related to former field boundaries, while a series of cropmarks (05261) to the north of the survey area is possibly related to a post-medieval field system.

Several areas of ridge and furrow cultivation to the north, south-west and north-east of the site are recorded (20714, 20284, 53500, & 20283) suggesting that the area has been largely used for agricultural purposes since the medieval period.

2.6 Survey objectives

The objective of the survey was to locate any features of possible archaeological origin in order that they may be assessed prior to development.

2.7 Survey methods

This report and all fieldwork have been conducted in accordance with both the English Heritage guidelines outlined in the document: *Geophysical Survey in Archaeological Field Evaluation, 2008* and with the Chartered Institute for Archaeologists document *Standard and Guidance for Archaeological Geophysical Survey.*

Due to the potential for agricultural and industrial remains, detailed magnetic survey (gradiometry) was used as an efficient and effective method of locating archaeological anomalies. More information regarding this technique is included in Appendix A.

2.8 Processing, presentation and interpretation of results

2.8.1 Processing

Processing is performed using specialist software. This can emphasise various aspects contained within the data but which are often not easily seen in the raw data. Basic processing of the magnetic data involves 'flattening' the background levels with respect to adjacent traverses and adjacent grids. Once the basic processing has flattened the background it is then possible to carry out further processing which may include low pass filtering to reduce 'noise' in the data and hence emphasise the archaeological or man-made anomalies.

The following schedule shows the basic processing carried out on all minimally processed gradiometer data used in this report:

1. *Destripe* (Removes striping effects caused by zero-point discrepancies between different sensors and walking directions)
2. *Destagger* (Removes zigzag effects caused by inconsistent walking speeds on sloping, uneven or overgrown terrain)

2.8.2 Presentation of results and interpretation

The presentation of the data for each site involves a print-out of the minimally processed data both as a greyscale plot and a colour plot showing extreme magnetic values. Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of

Anomalies' drawing for the site.

3 RESULTS

The detailed magnetic gradiometer survey conducted at Outwoods, Burton on Trent has identified a small number of anomalies that have been characterised as being of a *possible* archaeological origin.

The following list of numbered anomalies refers to numerical labels on the interpretation plots.

3.1 Probable Archaeology

No probable archaeology has been identified within the survey area.

3.2 Possible Archaeology

1 Two small discrete positive anomalies in the north and east of the site. These are indicative of possible former cut features, such as backfilled pits, though these may equally be of natural origin.

3.3 Medieval/Post-Medieval Agriculture

2 A small area of closely spaced parallel linear anomalies in the north-west of the site. These are likely to be related to modern agricultural activity, such as ploughing.

3.4 Other Anomalies

3 A large area of strong magnetic debris in the centre of the site. This is related to a former marl pit, present on the 1888 OS map and recorded as 'Old Marl Pit' on the 1955 OS map of the site.

4 An area of magnetic disturbance forming a linear feature in the west of the site. This is related to a modern track-way, visible on aerial photographs of the site.

5 Areas of magnetic disturbance are the result of substantial nearby ferrous metal objects such as fences and underground services. These effects can

mask weaker archaeological anomalies, but on this site have not affected a significant proportion of the area.

6 A number of magnetic 'spikes' (strong focussed values with associated antipolar response) indicate ferrous metal objects. These are likely to be modern rubbish.

4 DATA APPRAISAL & CONFIDENCE ASSESSMENT

Mercia Mudstone geologies, such as those across the site, can give variable results for gradiometer survey. The data across much of the site is fairly uniform in appearance, and is dominated by the former marl pit in the centre of the survey area. Despite this, possible backfilled pits have been identified along with an area of modern ploughing indicating that the survey has been effective.

5 CONCLUSION

The survey at Outwoods, Burton on Trent has not identified any features of archaeological origin. Two possible backfilled pits have been identified, though the exact origin of these is unknown and they may well be of natural origin. Evidence of modern ploughing and a track-way indicate that the site has been used for agricultural purposes, and supports the information of the HER search of the site having a predominantly agricultural past. A former marl pit, recorded on the 1888 OS map of the site has also been identified, again supporting the HER search whereby an industrial past is recorded. The remaining features are modern in origin and include areas of magnetic disturbance from nearby ferrous objects and magnetic spikes which are likely to be modern rubbish.

6 REFERENCES

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APPENDIX A – METHODOLOGY & SURVEY EQUIPMENT

Grid locations

The location of the survey grids has been plotted together with the referencing information. Grids were set out using a Leica 705auto Total Station and referenced to suitable topographic features around the perimeter of the site or a Leica Smart Rover RTK GPS.

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. A SmartNet RTK GPS uses Ordnance Survey's network of over 100 fixed base stations to give an accuracy of around 0.01m.

Survey equipment and gradiometer configuration

Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.2 nanoTeslas (nT) in an overall field strength of 48,000nT, can be accurately detected using an appropriate instrument.

The mapping of the anomaly in a systematic manner will allow an estimate of the type of material present beneath the surface. Strong magnetic anomalies will be generated by buried iron-based objects or by kilns or hearths. More subtle anomalies such as pits and ditches can be seen if they contain more humic material which is normally rich in magnetic iron oxides when compared with the subsoil.

To illustrate this point, the cutting and subsequent silting or backfilling of a ditch may result in a larger volume of weakly magnetic material being accumulated in the trench compared to the undisturbed subsoil. A weak magnetic anomaly should therefore appear in plan along the line of the ditch.

The magnetic survey was carried out using a dual sensor Grad601-2 Magnetic Gradiometer manufactured by Bartington Instruments Ltd. The instrument consists of two fluxgates very accurately aligned to nullify the effects of the Earth's magnetic field. Readings relate to the difference in localised magnetic anomalies compared with the general magnetic background. The Grad601-2 consists of two high stability fluxgate gradiometers suspended on a single frame. Each gradiometer has a 1m separation between the sensing elements so enhancing the response to weak anomalies.

Sampling interval

Readings were taken at 0.25m centres along traverses 1m apart. This equates to 3600 sampling points in a full 30m x 30m grid.

Depth of scan and resolution

The Grad 601-2 has a typical depth of penetration of 0.5m to 1.0m, though strongly magnetic objects may be visible at greater depths. The collection of data at 0.25m centres provides an optimum methodology for the task balancing cost and time with resolution.

Data capture

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.

APPENDIX B – BASIC PRINCIPLES OF MAGNETIC SURVEY

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.

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 and material such as brick and tile may be magnetised through the same process.

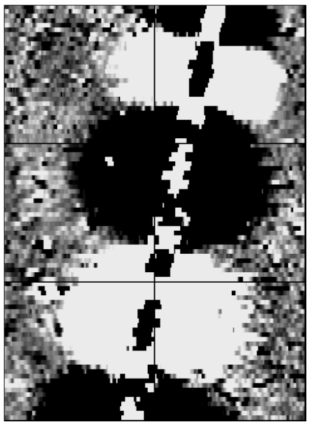
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement 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 field. The difference between the two sensors will relate to the strength of a magnetic field created by a buried 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, disturbance from modern services etc.

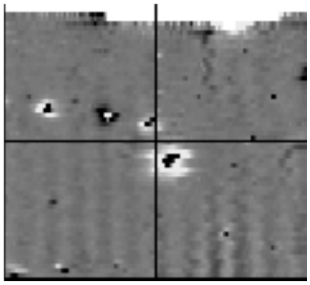
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES

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

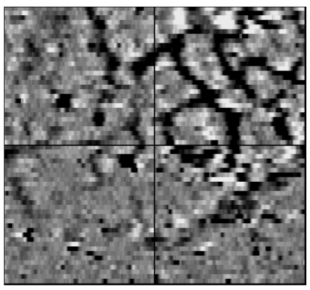


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

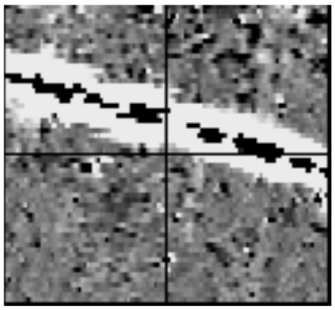
See bipolar and dipolar.

Positive linear



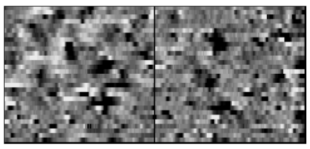
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

Positive linear anomaly with associated negative response



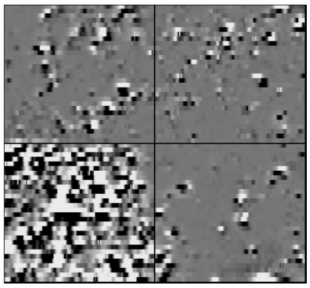
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field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

Positive point/area



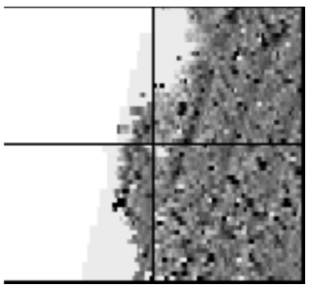
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



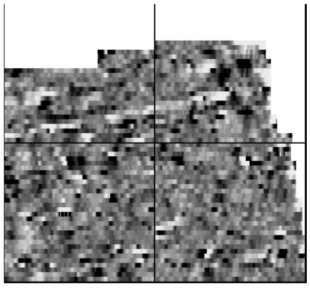
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low (+/-3nT) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly (+/-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

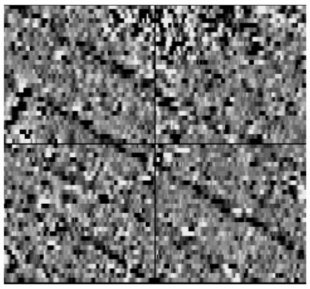


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative to the background top soil is built up. See also ploughing activity.

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).

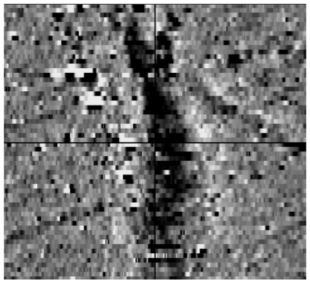
Strength of response

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 10m^2 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.

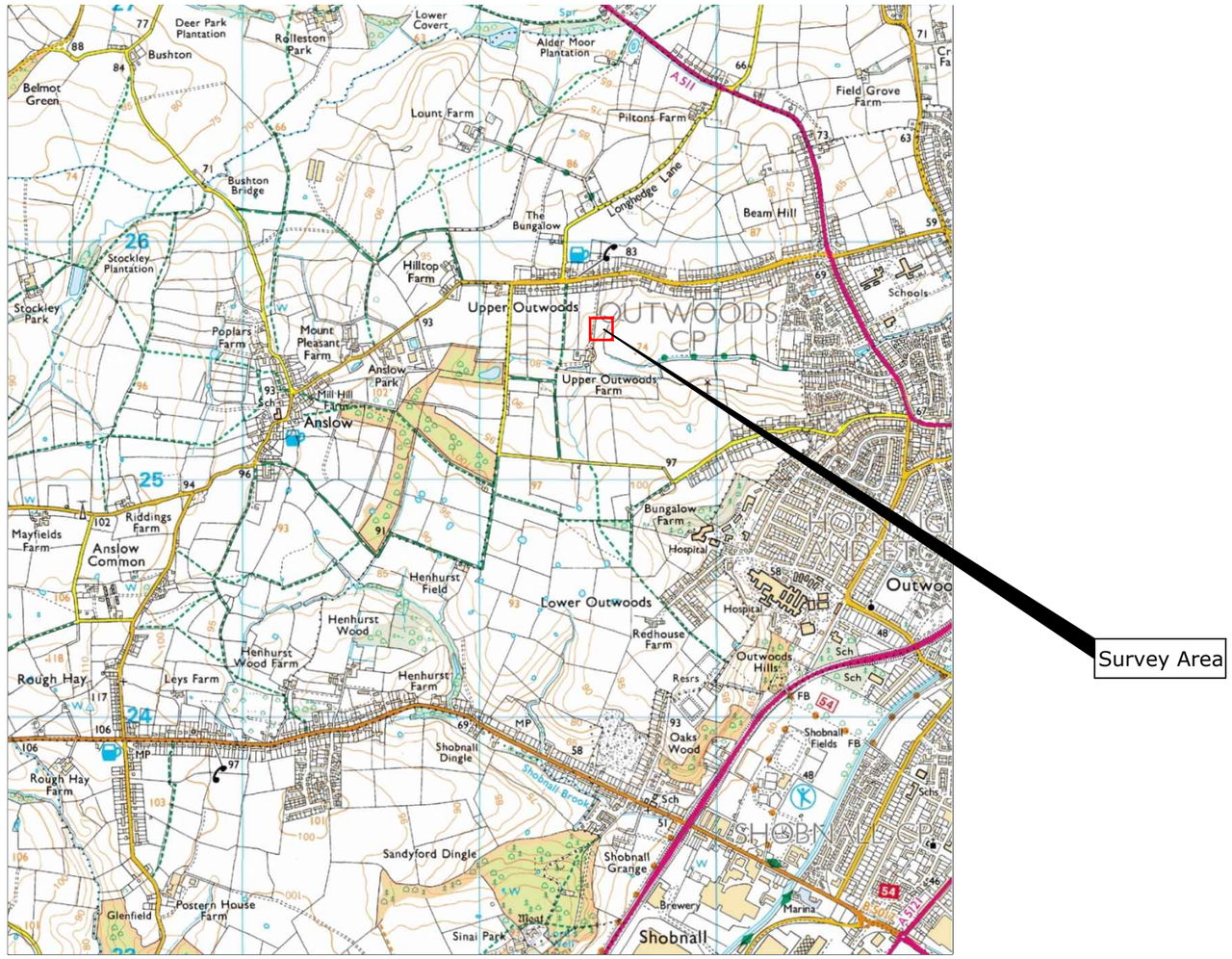
Thermoremanent response

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.



27
26
25
24
23
20 21 22 23 24

Amendments

Issue No.	Date	Description
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-	-	-

Site centred on NGR: SK 225 256

Client: ORION HERITAGE

Project Title: GEOPHYSICAL SURVEY - OUTWOODS, BURTON ON TRENT, STAFFORDSHIRE

Job No. 9265

Subject: LOCATION PLAN OF SURVEY AREA

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Scale: 1:25000 (0m 500 1000m)

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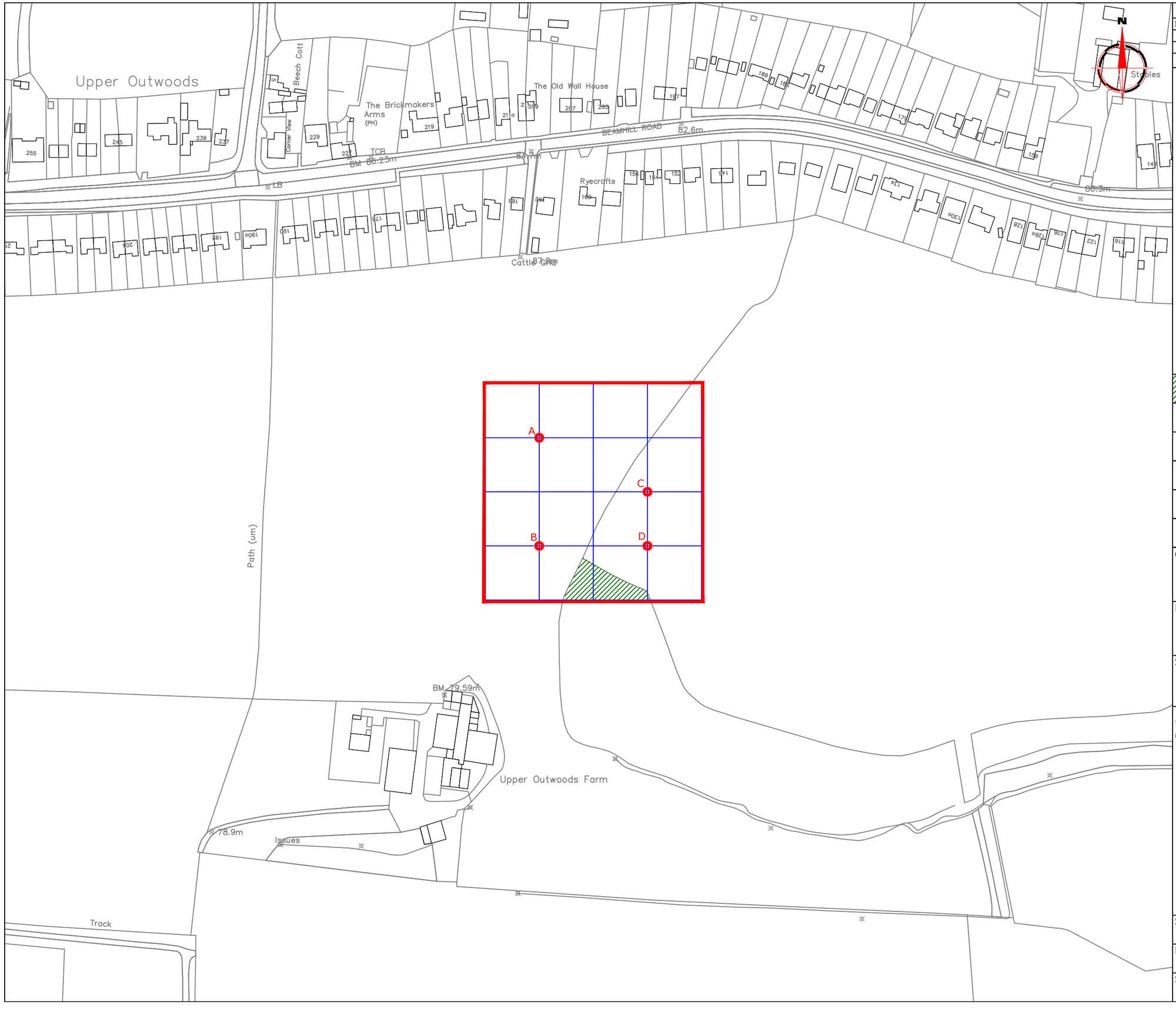
Survey date	Drawn by	Figure No.
NOV 15	RD	01



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Area unsurveyable - woodland

OS GRID REFERENCES

A	422508.96, 25693.07
B	422508.96, 325633.07
C	422568.96, 325663.07
D	422568.96, 325633.07

Client

ORION HERITAGE

Project Title — Job No. 9265

GEOPHYSICAL SURVEY - OUTWOODS, BURTON ON TRENT, STAFFORDSHIRE

Subject

LOCATION OF SURVEY GRIDS AND REFERENCING WITHIN WIDER AREA

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Scale 1:2000 (0m 20 40 60 80 100m)

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Amendments

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Plotting parameters

Maximum +100nT (red)
Minimum -100nT (blue)

+100nT
+25nT
+3nT
-3nT
-25nT
-100nT

Client

ORION HERITAGE

Project Title — Job No. 9265

GEOPHYSICAL SURVEY - OUTWOODS, BURTON ON TRENT, STAFFORDSHIRE

Subject

COLOUR PLOT OF GRADIOMETER DATA SHOWING EXTREME VALUES WITHIN WIDER AREA

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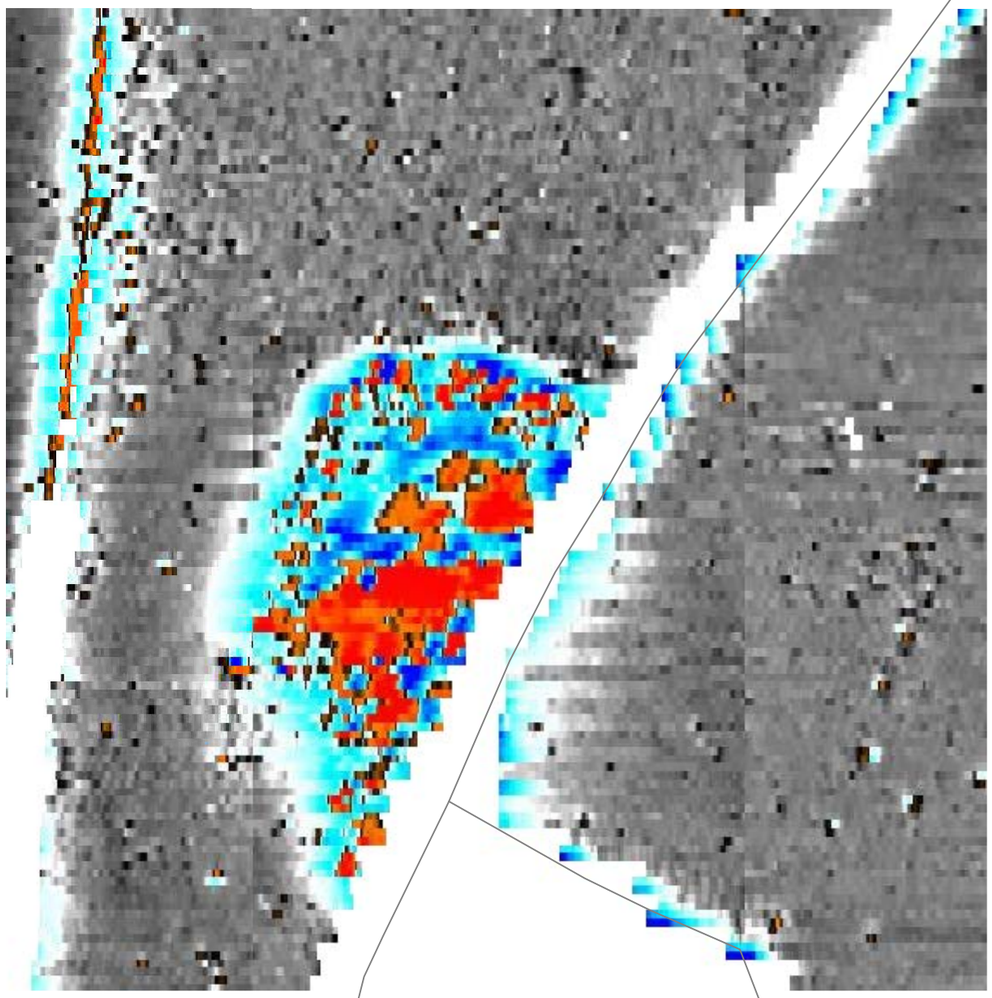

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Plotting parameters

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Minimum -100nT (blue)

+100nT
+25nT
+3nT
-3nT
-25nT
-100nT

Client

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Project Title — Job No. 9265

GEOPHYSICAL SURVEY - OUTWOODS, BURTON ON TRENT, STAFFORDSHIRE

Subject

COLOUR PLOT OF GRADIOMETER DATA SHOWING EXTREME VALUES

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ISO 9001 certified

ISO 14001 certified

Scale 1:750

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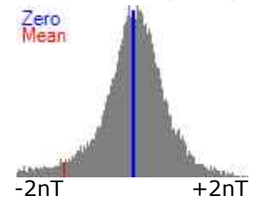

Client

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Project Title — Job No. 9265

GEOPHYSICAL SURVEY - OUTWOODS, BURTON ON TRENT, STAFFORDSHIRE

Subject

PLOT OF MINIMALLY PROCESSED GRADIOMETER DATA WITHIN WIDER AREA

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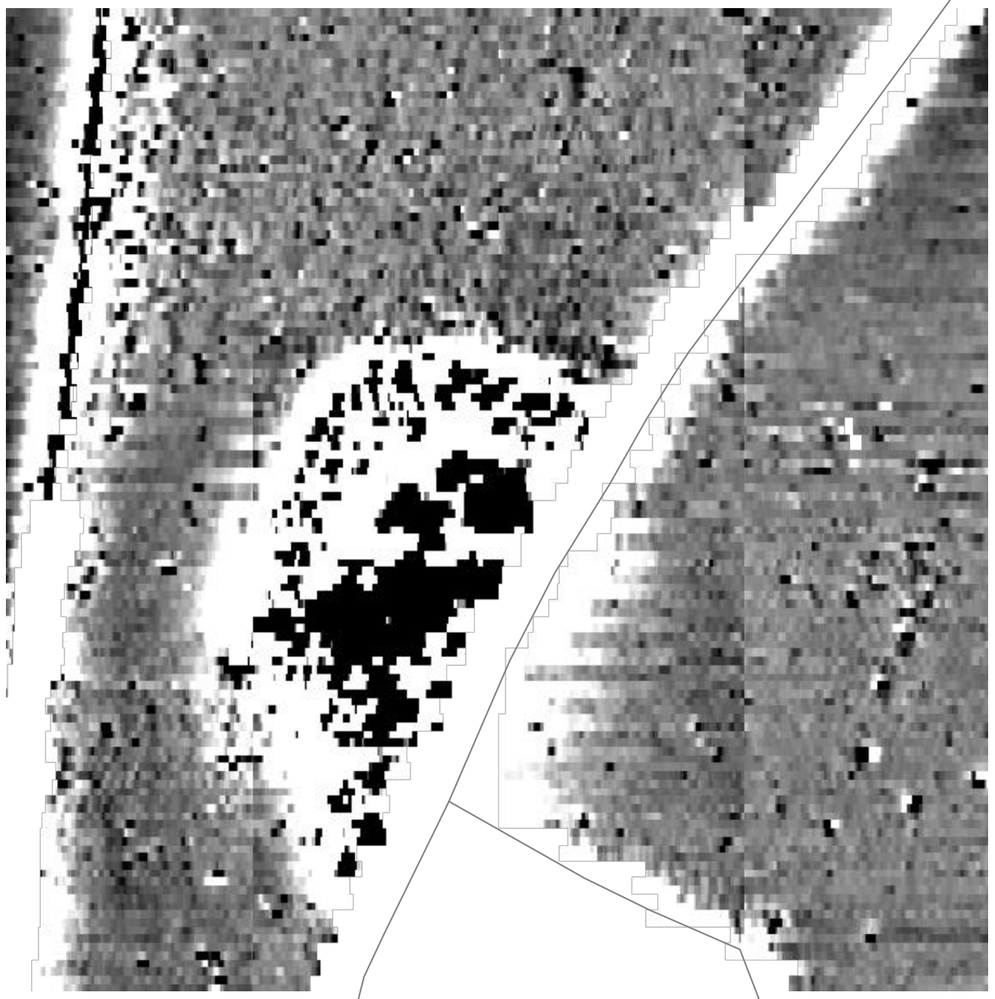

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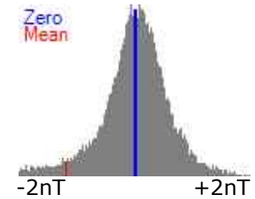
Maximum +2nT (black)
Minimum -2nT (white)



Client
ORION HERITAGE

Project Title
GEOPHYSICAL SURVEY - OUTWOODS, BURTON ON TRENT, STAFFORDSHIRE

Job No. 9265

Subject
PLOT OF MINIMALLY PROCESSED GRADIOMETER DATA

STRATASCAN™
GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
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WR8 0SA
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SUMO GROUP MEMBER

Scale 1:750

0m 5 15 30m

Plot	Checked by	Issue No.
A3	DGE	01
Survey date	Drawn by	Figure No.
NOV 15	RD	06

Amendments

Issue No.	Date	Description
-	-	-
-	-	-

PROBABLE ARCHAEOLOGY

- Positive anomaly / weak positive anomaly - probable cut feature of archaeological origin
- Negative anomaly / weak negative anomaly - probable bank or earthwork of archaeological origin

POSSIBLE ARCHAEOLOGY

- Positive anomaly / weak positive anomaly - possible cut feature of archaeological origin
- Negative anomaly / weak negative anomaly - possible bank or earthwork of archaeological origin

MEDIEVAL/POST-MEDIEVAL AGRICULTURE

- Widely spaced curving parallel linear anomalies - probably related to ridge-and-furrow
- Closely spaced parallel linear anomalies - probably related to agricultural activity such as ploughing
- Linear anomaly - probably related to a former field boundary not present on available mapping
- Linear anomaly - related to a former field boundary present on available mapping

OTHER ANOMALIES

- Magnetic disturbance - related to modern trackway visible on aerial photography
- Strong magnetic debris - related to backfilled marl pit
- Magnetic disturbance associated with nearby metal object such as service or field boundary
- Strong magnetic debris - possible disturbed or made ground
- Scattered magnetic debris
- Area of amorphous magnetic variation - probable natural (e.g. geological or pedological) origin
- Magnetic spike - probable ferrous object

Client

ORION HERITAGE

Project Title — Job No. 9265

GEOPHYSICAL SURVEY - OUTWOODS, BURTON ON TRENT, STAFFORDSHIRE

Subject

ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES WITHIN WIDER AREA

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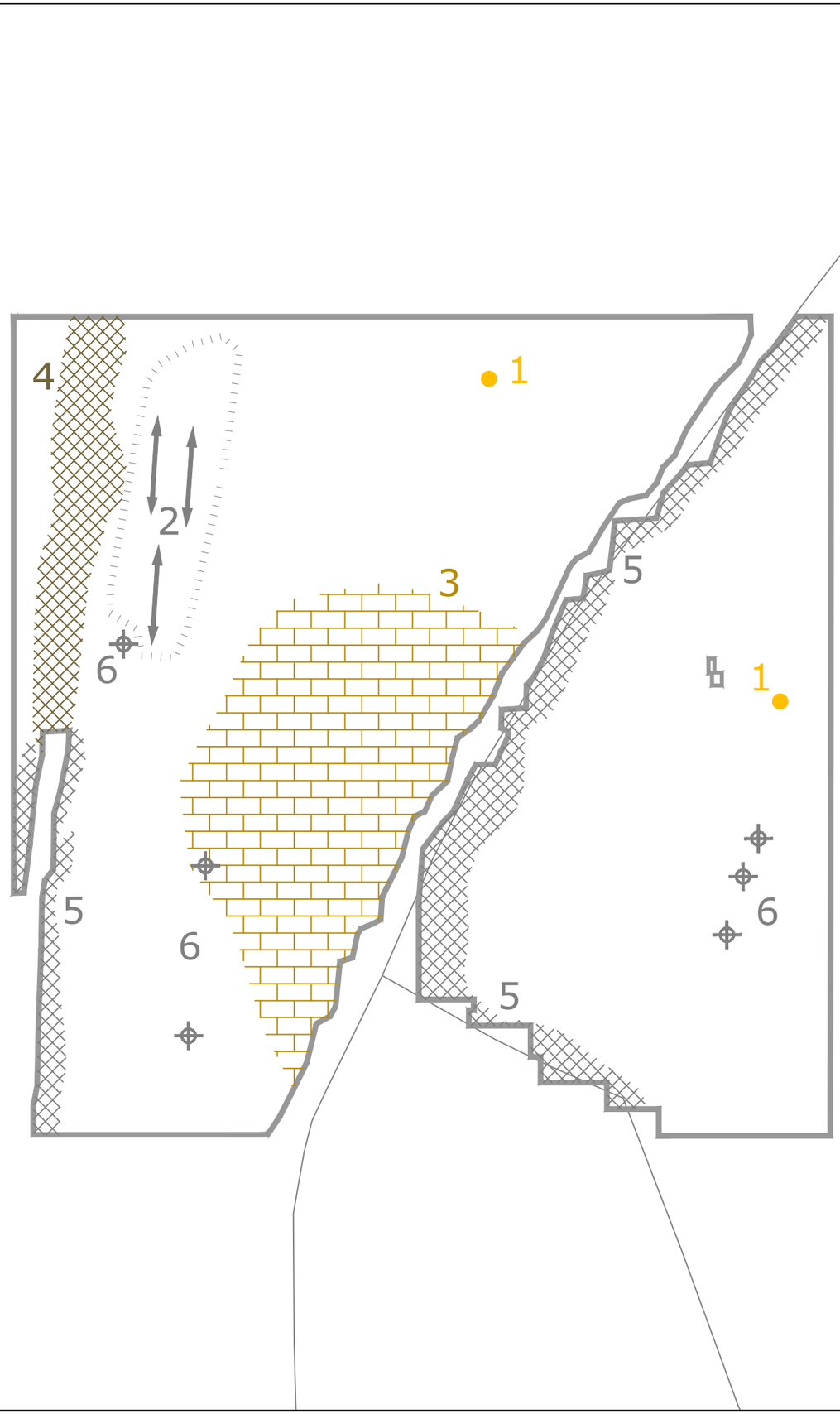
Scale 1:2000 (0m 20 40 60 80 100m)

Plot	Checked by	Issue No.
A3	DGE	01
Survey date	Drawn by	Figure No.
NOV 15	RD	07



Amendments

Issue No.	Date	Description
-	-	-
-	-	-

PROBABLE ARCHAEOLOGY

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- Strong magnetic debris - possible disturbed or made ground
- Scattered magnetic debris
- Area of amorphous magnetic variation - probable natural (e.g. geological or pedological) origin
- Magnetic spike - probable ferrous object

Client

ORION HERITAGE

Project Title — Job No. 9265

GEOPHYSICAL SURVEY - OUTWOODS, BURTON ON TRENT, STAFFORDSHIRE

Subject

ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES

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EUROPEAN GPR ASSOCIATION

SUMO GROUP MEMBER

ISO 9001 certified

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Scale 1:750 (0m 5 15 30m)

Plot	Checked by	Issue No.
A3	DGE	01
Survey date	Drawn by	Figure No.
NOV 15	RD	08

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