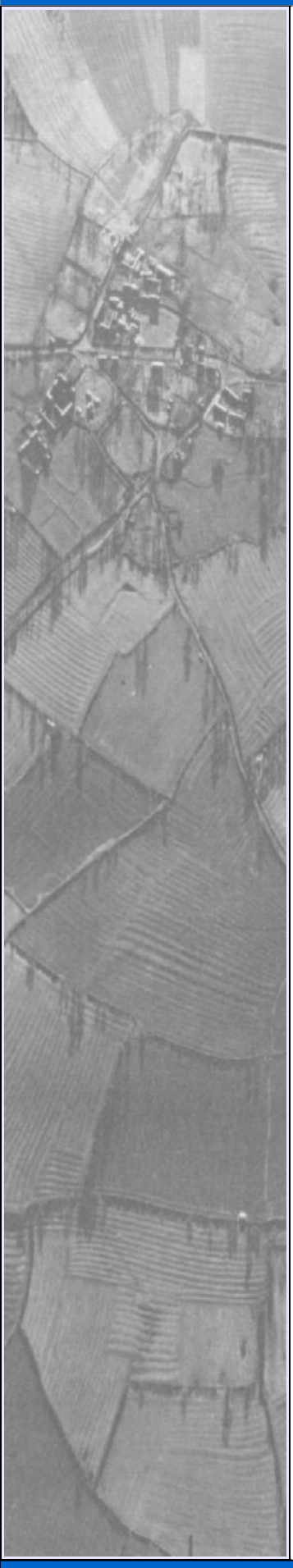

Land west of Cirencester Road
Tetbury
Gloucestershire

MAGNETOMETER SURVEY REPORT

for

Archaeological Landscape Investigation

on behalf of

Beechcroft Land Ltd

Kerry Donaldson & David Sabin

June 2015

Ref. no. 616

ARCHAEOLOGICAL SURVEYS LTD

Land west of Cirencester Road
Tetbury
Gloucestershire

Magnetometer Survey Report

for

Archaeological Landscape Investigation

on behalf of

Beechcroft Land Ltd

Fieldwork by David Sabin (Hons) MCIfA
Report by Kerry Donaldson BSc (Hons)
Report checked by David Sabin
Primary archive location - Archaeological Surveys Ltd, Yatesbury, Wiltshire

Survey date – 24th June 2015
Ordnance Survey Grid Reference – **ST 90000 94090**

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SUMMARY

A detailed magnetometer survey was carried out by Archaeological Surveys Ltd over land to the west of Cirencester Road on the north eastern edge of Tetbury in Gloucestershire. The results indicate the presence of a broad positive linear response that appears to relate to a 2.5m wide ditch, with a second conjoined ditch leading towards the east. A moderately enhanced discrete anomaly close to the ditches may relate to a pit containing burnt material. Several other weakly positive discrete and linear responses have been located, and although some of the linear responses may relate to agricultural activity, it is not clear if others relate to cut pit-like and ditch-like features. Large amounts of magnetic debris were also located, particularly around the periphery of the site. It is likely that this material is modern in origin and associated with dumped soil or ground consolidation.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Archaeological Landscape Investigation, on behalf of Beechcroft Land Ltd, to undertake a magnetometer survey of an area of land to the west of Cirencester Road, to the north east of Tetbury in Gloucestershire. The site has been outlined for a proposed residential development and the survey forms part of an archaeological assessment of the site.

1.1.2 The geophysical survey was carried out in accordance with a Written Scheme of Investigation (WSI) produced by Archaeological Surveys (2015) and approved by Charles Parry, Archaeologist for Gloucestershire County Council, prior to commencing the fieldwork.

1.2 Survey objectives and techniques

1.2.1 The objective of the survey was to use magnetometry to locate geophysical anomalies that may be archaeological in origin so that they may be assessed prior to development of the site. The methodology is considered an efficient and effective approach to archaeological prospection.

1.2.2 The survey and report generally follow the recommendations set out by: English Heritage (2008) *Geophysical survey in archaeological field evaluation;* and Institute for Archaeologists (2002) *The use of Geophysical Techniques in Archaeological Evaluations*. The work has been carried out to the Chartered Institute for Archaeologists (2014) *Standard and Guidance for Archaeological Geophysical Survey.*

1.3 Site location, description and survey conditions

1.3.1 The site is located on the north eastern edge of Tetbury in Gloucestershire. It is centred on Ordnance Survey National Grid Reference (OS NGR) ST 90000 94090, see Figures 01 and 02.

1.3.2 The geophysical survey covers approximately 1ha within an irregularly shaped land parcel. Prior to survey the site had to be mown as it contained very tall and dense grass and weed growth, see Plate 1. The site sloped down gently towards the east and the surface was uneven in places due to dumped soil. A small zone at the southern end of the site consisted of bare soil and this was partly separated from the grassed area by a dilapidated fence. Steel fencing and containers were associated with construction works immediately to the south of the site.

Plate 1: Survey area looking north prior to mowing

1.3.3 The ground conditions were generally considered to be favourable for the collection of magnetometry data. Weather conditions during the survey were fine.

1.4 Site history and archaeological potential

1.4.1 The south western corner of the site lies 110m east of an area previously investigated through geophysical survey an subsequent archaeological evaluation. The results of the geophysical survey demonstrated the presence of a number of positive linear, rectilinear and discrete anomalies that appeared to form ditches, enclosures and pits; however, widespread highly magnetic debris had obscured much of the site making it difficult to identify the nature of

the anomalies (Archaeological Surveys, 2012). The evaluation revealed further features including ditches, gullies, pits, post-holes and a quarry with pottery finds dating these features to the later prehistoric and Roman periods (Foundations Archaeology, 2012.)

1.4.2 Also within the vicinity are a scheduled Bronze Age round barrow (Monument No: 212874) located 300m to the north and a possible prehistoric sub-rectangular enclosure identified from cropmarks 370m to the north west.

1.4.3 The location of prehistoric and Roman archaeology within the surrounding vicinity may indicate that there is potential for the geophysical survey to locate further, previously unrecorded archaeological features should they be present within the site.

1.5 Geology and soils

1.5.1 The underlying solid geology across the site is Jurassic limestone from the Forest Marble Formation (BGS, 2015).

1.5.2 The overlying soil across the survey area is from the Elmton 2 association and is a brown rendzina. It consists of a shallow, well drained, brashy, calcareous, fine, loamy soil over limestone (Soil Survey of England and Wales, 1983).

1.5.3 Magnetometry carried out over similar geology and soil has produced good results. The site is, therefore, considered suitable for magnetic survey.

2 METHODOLOGY

2.1 Technical synopsis

2.1.1 Magnetometry survey records localised magnetic fields that can be associated with features formed by human activity. Magnetic susceptibility and magnetic thermoremnance are factors associated with the formation of localised fields. Additional details are set out below and within Appendix A.

2.1.2 Iron minerals within the soil may become altered by burning and the break down of biological material; effectively the magnetic susceptibility of the soil is increased, and the iron minerals become magnetic in the presence of the Earth's magnetic field. Accumulations of magnetically enhanced soils within features, such as pits and ditches, may produce magnetic anomalies that can be mapped by magnetic prospection.

2.1.3 Magnetic thermoremnance can occur when ferrous minerals have been heated to high temperatures such as in a kiln, hearth, oven etc. On cooling, a permanent magnetisation may be acquired due to the presence of the Earth's magnetic field. Certain natural processes associated with the formation of some igneous and

metamorphic rock may also result in magnetic thermoremnance.

2.1.4 The localised variations in magnetism are measured as sub-units of the Tesla, which is a SI unit of magnetic flux density. These sub-units are nano Teslas (nT), which are equivalent to 10^{-9} Tesla (T).

2.2 Equipment configuration, data collection and survey detail

2.2.1 The detailed magnetic survey was carried out using a SENSYS MAGNETO®MXPDA 5 channel cart-based system. The instrument has 5 fluxgate gradiometers spaced 0.5m apart with readings recorded at 20Hz. The gradiometers have a range of recording data between 0.1nT and 10,000nT. The system is linked to a Leica GS10 RTK GPS with data recorded by SENSYS MAGNETO®MXPDA software on a rugged computer.

2.2.2 Data are collected along a series of parallel survey tracks wherever possible. The length of each track is variable and relates to the size of the survey area and other factors including ground conditions. A visual display aids accurate placing of tracks and their separation.

2.2.3 Data are not collected within fixed grids and data points are considered to be random even though the data are collected in a systematic manner covering all accessible areas (Aspinall, Gaffney and Schmidt, 2009).

2.3 Data processing and presentation

2.3.1 Magnetic data collected by the MAGNETO®MXPDA cart-based system are initially prepared using SENSYS MAGNETO®DLMGPS software. Survey tracks are analysed and georeferenced raw data (UTM Z30N) are then exported in ASCII format for further analysis and display using TerraSurveyor.

2.3.2 The data are collected between limits of ±10000nT and clipped for display at ±5nT . Data are interpolated to a resolution of effectively 0.5m between tracks and 0.15m along each survey track. A zero median traverse function is required in order to remove fixed offset values present within the sensors which do not undergo a zeroing procedure in the field. The approach ensures that the gradiometer sensors are very accurately aligned and fixed to the vertical magnetic field and are not influenced by localised magnetic fields or disturbed by vibration. Although a zero median traverse algorithm can remove anomalies aligned with the survey tracks, in practice this rarely occurs due to the use of long traverses, high resolution measurement and variability within the magnetic susceptibility of long linear features.

2.3.3 Appendix C contains metadata concerning the survey and data attributes and is derived directly from TerraSurveyor. Reference should be made to Appendix B for further information on any processes, such as clipping, carried out on the data.

2.3.4 A TIF file is produced by TerraSurveyor software along with an associated world file (.TFW) that allows automatic georeferencing (OSGB36 datum) when using GIS or CAD software. The main form of data display used in the report is the minimally processed greyscale plot.

2.3.5 The raster images are combined with base mapping using ProgeCAD Professional 2014, creating DWG (2010) file formats. All images are externally referenced to the CAD drawing in order to maintain good graphical quality. The CAD plots are effectively georeferenced facilitating relocation of features using GPS, resection method, etc.

2.3.6 An abstraction and interpretation is also drawn and plotted for all geophysical anomalies located by the survey. Anomalies are abstracted using colour coded points, lines and polygons. All plots are scaled to landscape A3 for paper printing.

2.3.7 A brief summary of each anomaly, with an appropriate reference number, is set out in list form within the results (Section 3) to allow a rapid and objective assessment of features within the survey area.

2.3.8 A digital archive is produced with this report, see Appendix D below. The main archive is held at the offices of Archaeological Surveys Ltd.

3 RESULTS

3.1 General assessment of survey results

3.1.1 The detailed magnetic survey was carried out over approximately 1ha within a single land parcel.

3.1.2 Magnetic anomalies located can be generally classified as positive linear and discrete positive responses of archaeological potential, positive and negative anomalies of an uncertain origin, areas of magnetic debris and strong discrete dipolar anomalies relating to ferrous objects. Anomalies located within each survey area have been numbered and are described in 3.4 below.

3.2 Statement of data quality

3.2.1 Data are considered representative of the magnetic anomalies present within the site. There are no significant defects within the dataset. Widespread magnetic debris is likely to relate to material of relatively modern origin, and in places it is strong enough to obscure anomalies of archaeological potential, should they exist within the site.

3.3 Data interpretation

3.3.1 The list of sub-headings below attempts to define a number of separate categories that reflect the range and type of features located during the survey. A basic explanation of the characteristics of the magnetic anomalies is set out for each category in order to justify interpretation, a basic key is indicated to allow cross referencing to the abstraction and interpretation plot. CAD layer names are included to aid reference to associated digital files (.dwg/.dxf). Sub-headings are then used to group anomalies with similar characteristics within the survey area.

Report sub-heading CAD layer names and plot colour	**Description and origin of anomalies**
Anomalies with archaeological potential AS-ABST MAG POS LINEAR ARCHAEOLOGY AS-ABST MAG POS DISCRETE ARCHAEOLOGY	Anomalies have the characteristics (mainly morphological) of a range of archaeological features such as pits, ring ditches, enclosures, etc..
Anomalies with an uncertain origin AS-ABST MAG POS LINEAR UNCERTAIN AS-ABST MAG NEG LINEAR UNCERTAIN AS-ABST MAG POS DISCRETE UNCERTAIN	The category applies to a range of anomalies where there is not enough evidence to confidently suggest an origin. Anomalies in this category may well be related to archaeologically significant features, but equally relatively modern features, geological/pedological features and agricultural features should be considered. Positive anomalies are indicative of magnetically enhanced soils that may form the fill of 'cut' features or may be produced by accumulation within layers or 'earthwork' features; soils subject to burning may also produce positive anomalies. Negative anomalies are produced by material of comparatively low magnetic susceptibility such as stone and subsoil.
Anomalies associated with magnetic debris AS-ABST MAG DEBRIS AS-ABST MAG STRONG DIPOLAR	Magnetic debris often appears as areas containing many small dipolar anomalies that may range from weak to very strong in magnitude. It often occurs where there has been dumping or ground make-up and is related to magnetically thermoremnant materials such as brick or tile or other small fragments of ferrous material. This type of response is occasionally associated with kilns, furnace structures, or hearths and may therefore be archaeologically significant. It is also possible that the response may be caused by natural material such as certain gravels and fragments of igneous or metamorphic rock. Strong discrete dipolar anomalies are responses to ferrous objects within the topsoil.

Table 1: List and description of interpretation categories

3.4 List of anomalies

Area centred on OS NGR 390000 194090, see Figures 03 & 04.

Anomalies of archaeological potential

(1) - A positive linear anomaly extends across the eastern part of the survey area. It has a response of 3-5nT and is 2.5m wide. It appears to relate to a linear ditch that is not parallel with the existing field boundaries. A second linear anomaly appears

to extend eastwards from it, but the response is not clear due to the presence of magnetic debris.

(2) - A discrete positive response is located just to the south west of anomaly (1). It has a moderately strong response (29nT) which may indicate that there is burnt material incorporated within the fill of a pit, or it is associated with burning.

Anomalies with an uncertain origin

(3) - The survey area contains a small number of discrete positive anomalies with a response of 3-4nT, with some peaking at 8nT. It is not clear if they relate to pit-like features with a natural or anthropogenic origin.

(4) - A number of short, positive, linear responses can be seen within the survey area. Several are oriented almost north to south and may be associated with agricultural activity. Others have different orientations, but all are generally short and indistinct.

(5) - Negative linear anomalies are located within the site. It is not clear if they relate to linear bank-like features with archaeological potential or if they relate to a modern feature such as a buried pipe or agricultural vehicle rut.

Anomalies associated with magnetic debris

(6) - The perimeter of the site contains zones of strongly magnetic debris. This relates to ferrous and magnetically thermoremnant material.

(7) - The entire site contains widespread and numerous strong, discrete, dipolar anomalies which are a spread of ferrous material associated with the zones of magnetic debris (6).

4 CONCLUSION

4.1.1 The detailed magnetometer survey located a positive linear anomaly that appears to relate to a ditch within the eastern part of the site and is oriented north north west to south south east. A second short positive linear anomaly appears to extend eastwards from it, possibly forming a rectilinear feature. A moderately enhanced discrete response close by may relate to a pit or area of burning.

4.1.2 The site contains a number of discrete positive responses, and although these may relate to cut, pit-like features, it is not clear from their morphology and response if they have archaeological potential. Several short, positive linear responses are also evident, and while some may relate to former agricultural activity, they are not all parallel and their origin is unclear. Negative linear anomalies are also located within the site, and the origin of these is also

uncertain.

4.1.3 The entire area contains widespread magnetic debris, with concentrations around the edges. This is likely to relate to ferrous and other magnetically thermoremnant material such as brick and tile that has been dumped on the site.

5 REFERENCES

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Appendix A – basic principles of magnetic survey

Iron minerals are always present to some degree within the topsoil and enhancement associated with human activity is related to increases in the level of magnetic susceptibility and thermoremnant material.

Magnetic susceptibility is an induced magnetism within a material when it is in the presence of a magnetic field. This can be thought of as effectively permanent due to the presence of the Earth's magnetic field.

Thermoremnant magnetism occurs when ferrous material is heated beyond a specific temperature known as the Curie Point. Demagnetisation occurs at this temperature with re-magnetisation by the Earth's magnetic field upon cooling.

Enhancement of magnetic susceptibility can occur in areas subject to burning and complex fermentation processes on biological material; these are frequently associated with human settlement. Thermoremnant features include ovens, hearths, and kilns. In addition thermoremnant material such as tile and brick may also be associated with human activity and settlement.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil can create an area of enhancement compared with surrounding soils and subsoils into which the feature is cut. Mapping enhanced areas will produce linear and discrete anomalies allowing an assessment and characterisation of hidden subsurface features.

It should be noted that areas of negative enhancement can be produced from material having lower magnetic properties compared to the topsoil. This is common for many sedimentary bedrocks and subsoils which were often used in the construction of banks and walls etc. Mapping these 'negative' anomalies may also reveal archaeological features.

Magnetic survey or magnetometry can be carried out using a fluxgate gradiometer and may be referred to as gradiometry. The SENSYS gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 65cm apart. The instrument is carried about 10-20cm above the ground surface and the upper sensor measures the Earth's magnetic field as does the lower sensor but this is influenced to a greater degree by any localised buried field. The difference between the two sensors will relate to the strength the magnetic field created by the buried feature.

There are a number of factors that may affect the magnetic survey and these include soil type, local geology and previous human activity. Situations arise where magnetic disturbance associated with modern services, metal fencing, dumped waste material etc., obscures low magnitude fields associated with archaeological features.

Appendix B – data processing notes

Clipping

Minimum and maximum values are set and replace data outside of the range with those values. Extreme values are removed improving colour or greyscale contrast associated with data values that may be archaeologically significant. It has been found that clipping data to ranges between ±20nT and ±10nT often improves the appearance of features associated with archaeology. Different ranges are applied to data in order to determine the most suitable for anomaly abstraction and display.

Zero (destripe) Median/Mean Traverse

The median (or mean) of each traverse is calculated ignoring data outside a threshold value, the median (or mean) is then subtracted from the traverse. The process is used to equalise differences between the baseline value of gradiometer sensors.

High Pass Filtering

A mathematical process used to remove low frequency anomalies relating to survey tracks and modern agricultural features.

Appendix C – survey and data information

COMPOSITE
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Filename: J616-mag-proc.xcp
Description: Imported as Composite from: J616-mag.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):
Northwest corner: 389936.377584458, 194139.699000944 m
Southeast corner: 390073.927584458, 194015.949000944 m
Sensors: 5
Dummy Value: 32702

Source GPS Points: 350800

Dimensions
Composite Size (readings): 917 x 825
Survey Size (meters): 138 m x 124 m
Grid Size: 138 m x 124 m
X Interval: 0.15 m
Y Interval: 0.15 m

Stats
Max: 5.53
Min: -5.50
Std Dev: 2.52
Mean: -0.02
Median: 0.03
Composite Area: 1.7022 ha
Surveyed Area: 0.98711 ha

PROGRAM
Name: TerraSurveyor
Version: 3.0.23.0

Processes: 1
1 Base Layer

GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -10.00 to 10.00 nT
5 Clip from -5.00 to 5.00 nT

Appendix D – digital archive

Archaeological Surveys Ltd hold the primary digital archive at their offices in Wiltshire. Data are backed-up onto an on-site data storage drive and at the earliest opportunity data are copied to CD ROM for storage on-site and off-site.

A copy of the report in PDF/A format will be supplied to the Gloucestershire Historic Environment Record, together with a DXF of the survey boundary. The report will also be uploaded to the Online AccesS to the Index of archaeological investigationS (OASIS).

Archive contents:

Geophysical data Area 1 - path: J616 Tetbury\Data				
Path and Filename	**Software**	**Description**	**Date**	**Creator**
tetbury1\MX\ .prm .dgb .disp	Sensys MXPDA	Proprietary data formats representing magnetometer survey traverses logged to a PDA.	24/06/15	D.J.Sabin
tetbury1\MX\J616-mag.asc	Sensys DLMGPS	ASCII CSV (tab) file representing survey Area 1 in eastings, northings (UTM Z30N), magnetic measurement, traverse file and sensor number.	24/06/15	D.J.Sabin
Mag\comps\J616-mag.xcp	TerraSurveyor 3.0.23.0	Composite data file derived from ASCII CSV.	24/06/15	D.J.Sabin
Mag\comps\J616-mag-proc.xcp	TerraSurveyor 3.0.23.0	Processed composite data file (zmt and clipping to ±5nT).	24/06/15	D.J.Sabin
Graphic data - path: J616 Tetbury\Data				
Mag\graphics\ J616-mag-proc.tif	TerraSurveyor 3.0.23.0	TIF file showing a minimally processed greyscale plot clipped to ±5nT.	24/06/15	D.J.Sabin
Mag\graphics\ J616-mag-proc.tfw	TerraSurveyor 3.0.23.0	World file for georeferencing TIF to OSGB36.	24/06/15	D.J.Sabin
CAD data - path: J616 Tetbury\CAD				
J616 version 2.dwg	ProgeCAD 2014	CAD file for creating plots of greyscales, abstraction, interpretation and mapping. Grid coordinates as OSGB. AutoCAD 2010 format.	24/06/15	K.T.Donaldson
Text data - path: J616 Tetbury\Documentation				
J616 report.odt	OpenOffice.org 3.0.1 Writer	Report text as an Open Office document.	26/06/15	K.T.Donaldson

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Survey location

Archaeological Surveys Ltd

Geophysical Survey
Land west of Cirencester Road
Tetbury
Gloucestershire

Map of survey area

Survey location

Site centred on OS NGR
ST 90000 94090

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

FIG 01

Archaeological Surveys Ltd

Geophysical Survey
Land west of Cirencester Road
Tetbury
Gloucestershire

Referencing information

Referencing grid to OSGB36 datum at 50m intervals

Data collected at 20Hz and georeferenced to ETRS89 zone 30 with conversion to OSGB36 using OSTN02

● 389950 194050

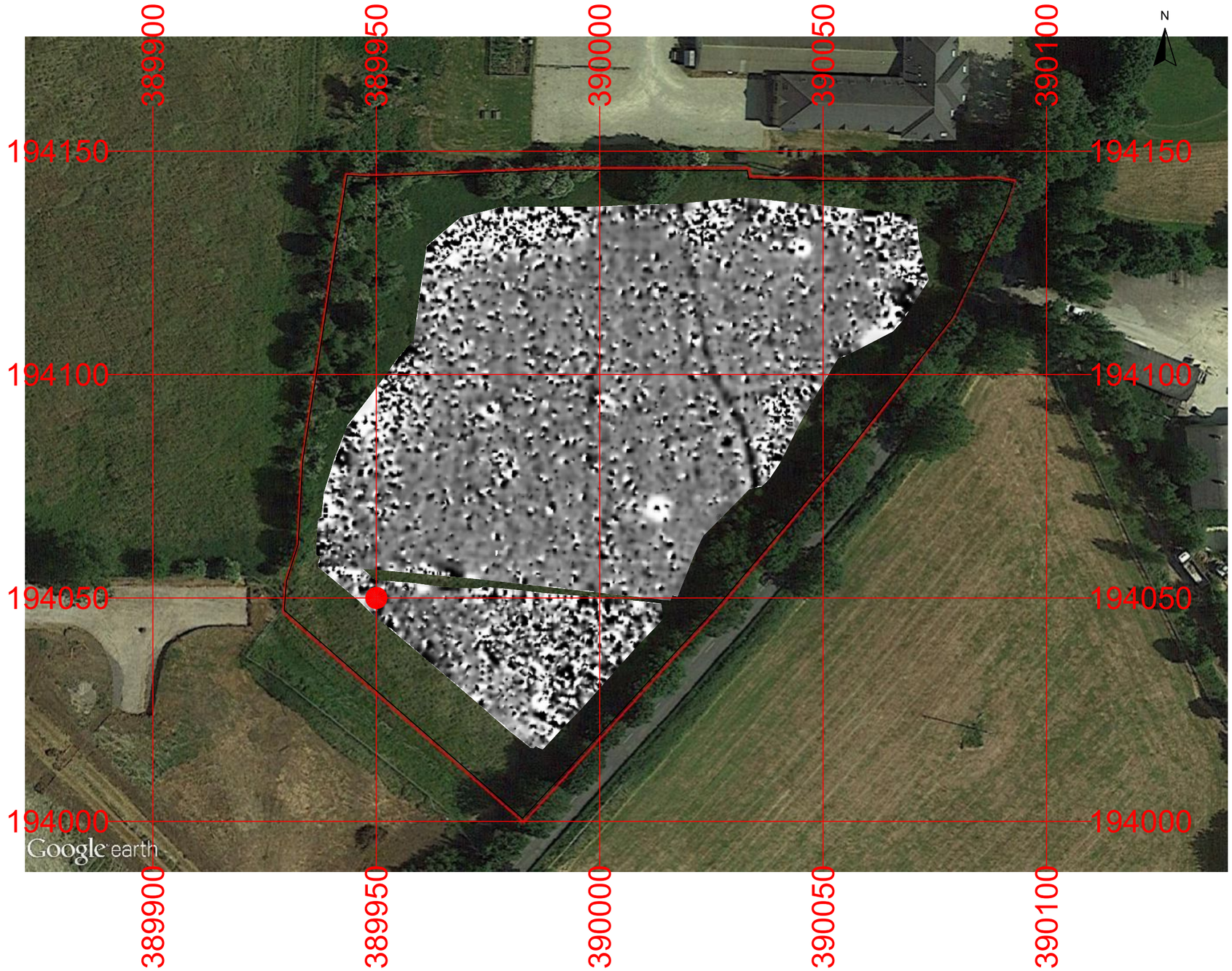

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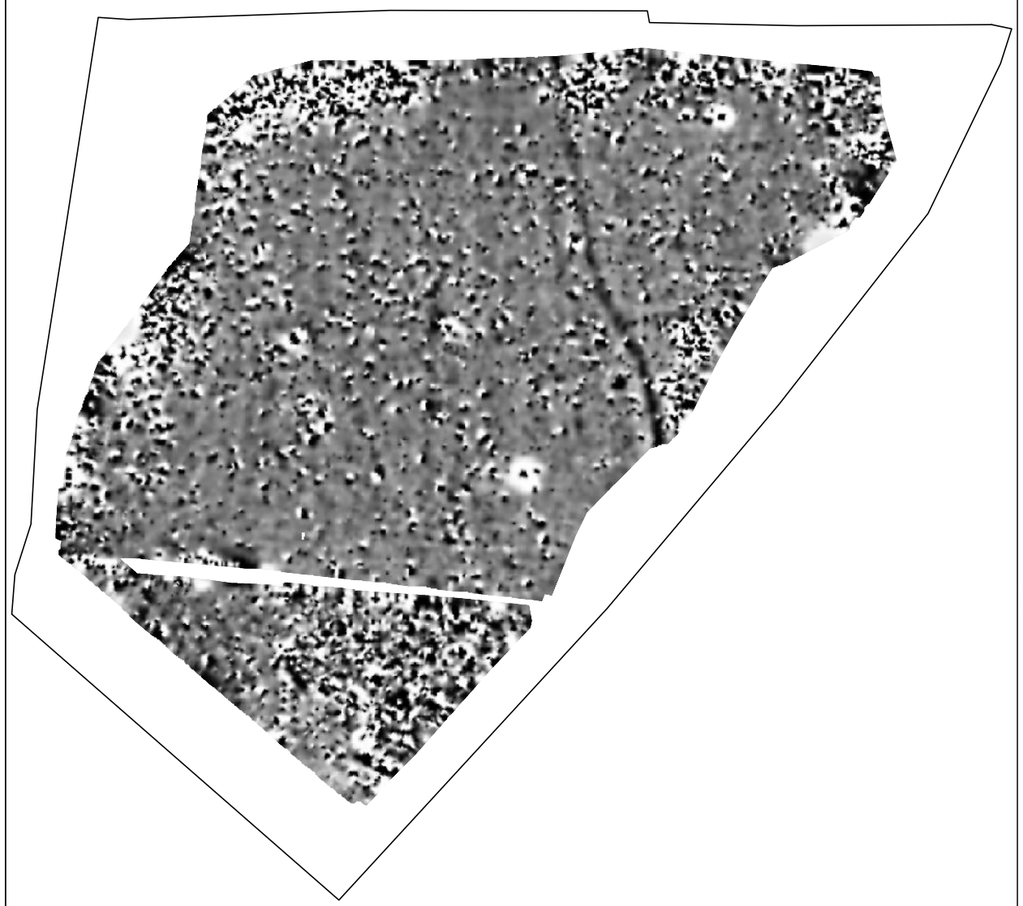
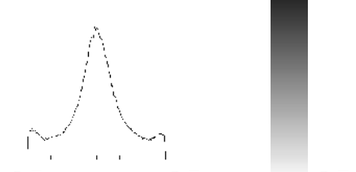
FIG 02

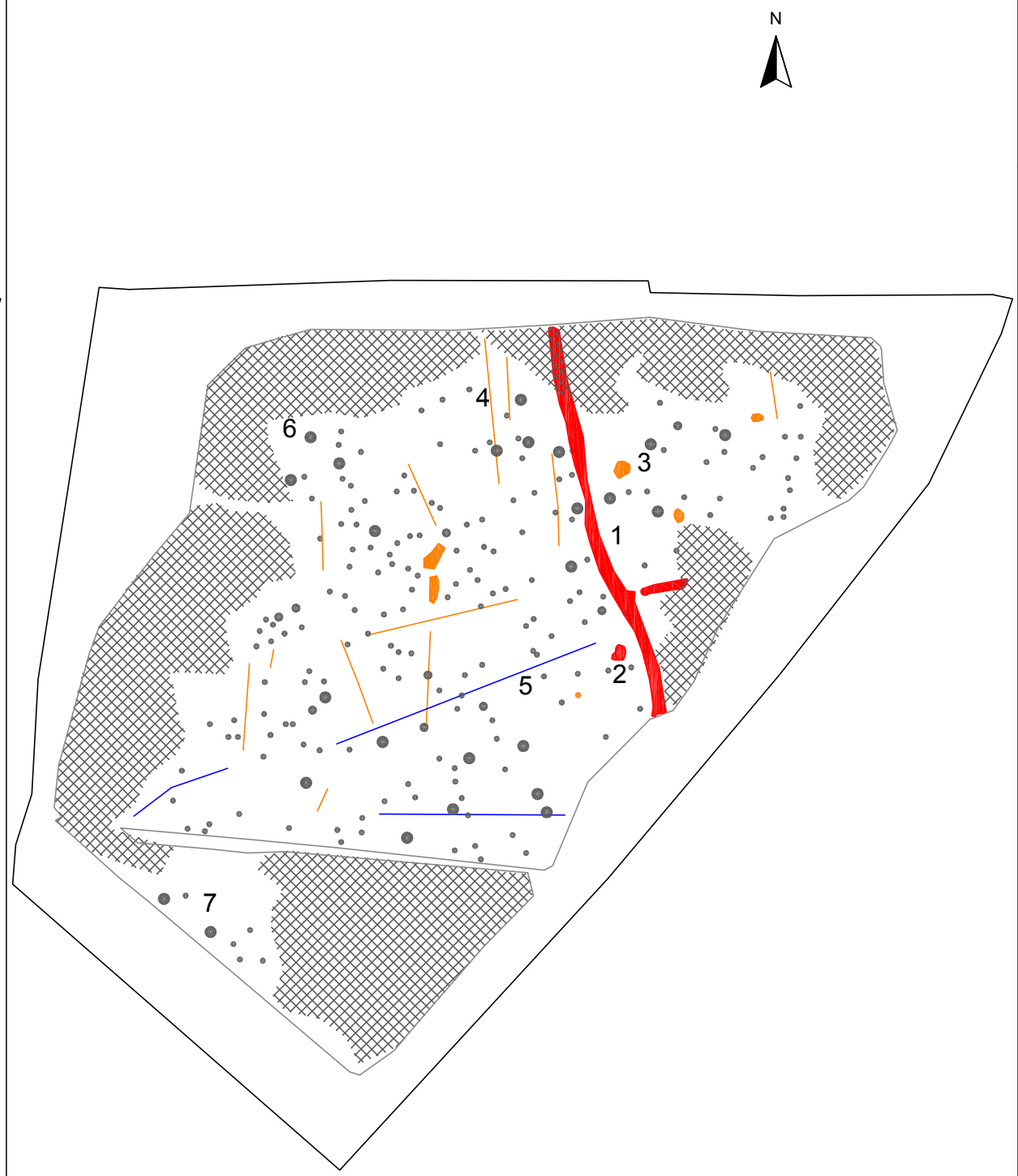
Aerial image © Google Earth

Greyscale plot of minimally processed magnetometer data





Abstraction and interpretation of magnetometer anomalies



Archaeological Surveys Ltd

Geophysical Survey
Land west of Cirencester Road
Tetbury
Gloucestershire

Greyscale plot of magnetomter data and abstraction and interpretation of magnetometer anomalies

- Positive linear anomaly - cut feature of archaeological potential
- Positive linear anomaly - possible ditch-like feature
- Negative linear anomaly - material of low magnetic susceptibility
- Discrete positive response - cut feature of archaeological potential
- Discrete positive response - possible pit-like feature
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Strong dipolar anomaly - ferrous object

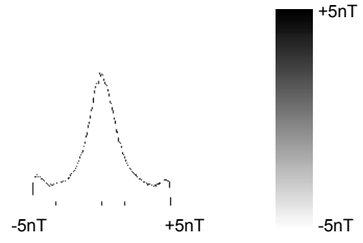
SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 03

Greyscale plot of minimally processed magnetometer data



Aerial image © Google Earth

Abstraction and interpretation of magnetometer anomalies

Archaeological Surveys Ltd

Geophysical Survey
Land west of Cirencester Road
Tetbury
Gloucestershire

Greyscale plot of magnetomter data and abstraction and interpretation of magnetometer anomalies with Google Earth image

- Positive linear anomaly - cut feature of archaeological potential
- Positive linear anomaly - possible ditch-like feature
- Negative linear anomaly - material of low magnetic susceptibility
- Discrete positive response - cut feature of archaeological potential
- Discrete positive response - possible pit-like feature
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Strong dipolar anomaly - ferrous object

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 04