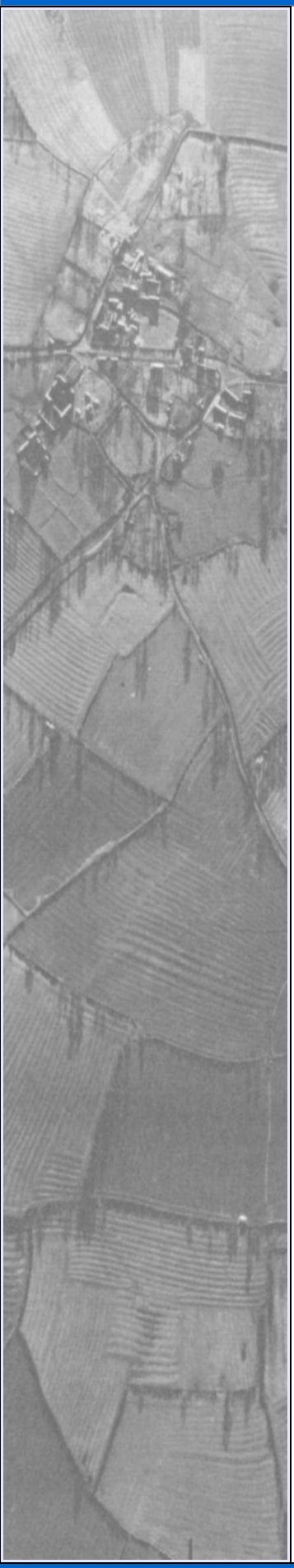

Land at Sandleaze Farm
Worton
Wiltshire

MAGNETOMETER SURVEY REPORT

for

AC Archaeology Ltd

Kerry Donaldson & David Sabin

August 2016

Ref. no. J679

ARCHAEOLOGICAL SURVEYS LTD

Land at Sandleaze Farm
Worton
Wiltshire

Magnetometer Survey Report

for

AC Archaeology 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 – 19th August 2016
Ordnance Survey Grid Reference – **ST 98140 57440**

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SUMMARY

A detailed magnetometer survey was undertaken by Archaeological Surveys Ltd, at the request of AC Archaeology Ltd, within an area of land at Sandleaze Farm, Worton, Wiltshire ahead of a potential residential development. The results demonstrate the presence of a number of positive linear anomalies within the western part of the site which may be associated with ridge and furrow, although they have a more sinuous or curvilinear form in places and, therefore, may relate to other ditch-like features. To the north of these are a number of very weakly positive linear anomalies of uncertain origin. The site also contains widespread magnetic debris associated with recent redevelopment of a farmyard, areas of recent burning, ground make-up and other agricultural activities.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by AC Archaeology Ltd to undertake a magnetometer survey of an area of land at Sandleaze Farm, Worton, Wiltshire. The site has been outlined for a proposed residential developement 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 (2016) and approved by Rachel Foster, Assistant County Archaeologist for Wiltshire 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 at Sandleaze Farm, Worton, Wiltshire. It is centred on

Ordnance Survey National Grid Reference (OS NGR) ST 98140 57440, see Figs 01 and 02.

1.3.2 The geophysical survey covers approximately 2ha within the northern half of two pasture fields. It lies to the south and east of residential dwellings several of which have been recently constructed at Sandleaze Farm (Sandleaze Court). The north eastern part of the site is located adjacent to a small barn and storage area.

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

Plate 1: Area 1 looking south east

1.4 Site history and archaeological potential

1.4.1 The online Wiltshire HER indicates that a single Roman coin was located within the garden of Sandleaze Cottage, 150m west of the site in 1978/79 (MWI4098) and another single Roman coin found over 600m to the south west (MWI4096). The site lies within an area with numerous farms and outfarms including MWI69148 site of an outfarm in Cuckold's Green, immediately north, which dates to the 19th century but has been demolished. Others are partially extant and date to the medieval and post medieval periods, including MWI69152 Manor Farm 300m to the west and MWI69144 Park Farm 200m to the west (Wiltshire Council, 2016).

1.4.2 One field boundary has been recently removed and modern dwellings have been constructed to the north and west of the site at Sandleaze Court, but the majority of the site appears to have been used for agricultural purposes since at least the 19th century. It is possible that the survey could locate geophysical anomalies that relate to 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 from the Wardour Formation of interbedded sandstone and argillaceous rocks from the Jurassic period (Portland Group) (BGS, 2016).

1.5.2 The overlying soil across the survey area is from the Burlesdon association which is stagnogleyic argillic brown earth. It consists of a deep, fine, loamy soil with slowly permeable subsoil and slight seasonal waterlogging (Soil Survey of England and Wales, 1983).

1.5.3 Magnetometry carried out over similar geology and soil has produced variable results as the underlying geologies can result in low magnetic susceptibility and very poor contrast between the fill of cut features and the material into which they are cut. However, where there has been long term occupation and/or industrial activity there can be sufficient magnetic contrast within cut features.

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 sensors are not zeroed in the field, as the vertical axis alignment is fixed using a tension band system. In order to produce visible, useful greyscale images a zero median traverse process is undertaken in TerraSurveyor. 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 each 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 a total of two survey areas covering approximately 2ha. The results of the two areas will be outlined together in 3.4 below.

3.1.2 Magnetic anomalies located can be generally classified as positive anomalies of an uncertain origin, areas of magnetic debris and disturbance and strong discrete dipolar anomalies relating to ferrous objects.

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. Zones of magnetic debris and disturbance have the potential to obscure weak anomalies should they exist.

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 for each survey area.

Report sub-heading CAD layer names and plot colour	Description and origin of anomalies
Anomalies with an uncertain origin AS-ABST MAG POS 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.
Anomalies with a modern origin AS-ABST MAG DISTURBANCE 	The magnetic response is often strong and dipolar indicative of ferrous material and may be associated with extant above surface features such as wire fencing, cables, pylons etc.. Often a significant area around such features has a strong magnetic flux which may create magnetic disturbance; such disturbance can effectively obscure low magnitude anomalies if they are present. Fluxgate sensors may respond erratically and with hysteresis adjacent to strong magnetic sources.

Table 1: List and description of interpretation categories

3.4 List of anomalies

Area centred on OS NGR 398140 157440, see Figs 03 & 04.

Anomalies with an uncertain origin

(1) - The western part of the site contains three weakly positive, broad, linear anomalies. It is possible that they are associated with ridge and furrow; however, the westernmost anomalies do curve and other ditch-like features should be considered.

(2) - A small number of very weakly positive linear anomalies are located in the north western part of the site. It is not possible to determine if they relate to cut features.

Anomalies associated with magnetic debris

(3) - Much of the site contains strongly magnetic debris. This is a response to ferrous and other magnetically thermoremnant material. The majority is likely to relate to former agricultural activity and structures removed prior to recent development of a Sandleaze Farm yard. Ground make-up and recent burning are also likely sources.

(4) - The site contains a large number of strong, discrete, dipolar responses which are associated with the widespread magnetic debris.

Anomalies with a modern origin

(5) - Magnetic disturbance is evident adjacent to ferrous fences, sheds and above ground steel objects.

4 CONCLUSION

4.1.1 Within the western part of the site, the magnetometer survey revealed three broad, weakly positive, linear anomalies. It is possible that they are associated with former ridge and furrow; however, there is a more sinuous or curving form to them and they are of uncertain origin. Other very weakly positive linear responses are located within the north western part of the site; however, these lack a coherent morphology and are also of uncertain origin.

4.1.2 Widespread magnetic debris is evident over much of the site and this may have obscured weaker anomalies. The densest areas of debris are likely to relate to former agricultural structures and material derived from the recently developed yard at Sandleaze Farm.

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 ±5nT and ±3nT 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

Area 1 minimally processed data

COMPOSITE
Filename: J679-mag-Area1-proc.xcp
Description: Imported as Composite from: J679-mag-Area1.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):OSGB36
Northwest corner: 398050.229706897, 157518.806539221 m
Southeast corner: 398251.379706897, 157379.606539221 m
Collection Method: Randomised
Sensors: 5
Dummy Value: 32702

Source GPS Points: 482000

Dimensions
Composite Size (readings): 1341 x 928
Survey Size (meters): 201 m x 139 m
Grid Size: 201 m x 139 m
X Interval: 0.15 m
Y Interval: 0.15 m

Stats
Max: 5.53
Min: -5.50
Std Dev: 2.58
Mean: -0.09
Median: 0.04
Composite Area: 2.8 ha
Surveyed Area: 1.5616 ha

PROGRAM
Name: TerraSurveyor
Version: 3.0.23.0

Processes: 1
1 Base Layer

GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -5.00 to 5.00 nT

Area 2 minimally processed data

COMPOSITE
Filename: J679-mag-Area2-proc.xcp
Description: Imported as Composite from: J679-mag-Area2.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):OSGB36
Northwest corner: 398188.654431013, 157509.464790227 m
Southeast corner: 398225.104431013, 157416.764790227 m
Collection Method: Randomised
Sensors: 5
Dummy Value: 32702

Source GPS Points: 82300

Dimensions
Composite Size (readings): 243 x 618
Survey Size (meters): 36.5 m x 92.7 m
Grid Size: 36.5 m x 92.7 m
X Interval: 0.15 m
Y Interval: 0.15 m

Stats
Max: 5.53
Min: -5.50
Std Dev: 3.27
Mean: -0.02
Median: 0.02
Composite Area: 0.33789 ha
Surveyed Area: 0.22371 ha

Processes: 1
1 Base Layer

GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 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 printed copy of the report and a PDF copy will be supplied to the Wiltshire Historic Environment Record. The report will also be uploaded to the Online AccesS to the Index of archaeological investigationS (OASIS).

Archive contents:

Geophysical data - path: J679 Sandleaze Farm Worton\Data				
Path and Filename	**Software**	**Description**	**Date**	**Creator**
worton1\MX\ worton2\MX\ .prm .dgb .disp	Sensys MXPDA	Proprietary data formats representing magnetometer survey traverses logged to a PDA.	19/08/16	D.J.Sabin
worton1\MX\J679-mag-Area1.asc worton2\MX\J679-mag-Area2.asc	Sensys DLMGPS	ASCII CSV (tab) file representing survey Area 1 in eastings, northings (UTM Z30N), magnetic measurement, traverse file and sensor number.	23/08/16	K.T.Donaldson
Area1\comps\J679-mag-Area1.xcp Area2\comps\J679-mag-Area2.xcp	TerraSurveyor 3.0.23.0	Composite data file derived from ASCII CSV.	23/08/16	K.T.Donaldson
Area1\comps\J679-mag-Area1-proc.xcp Area2\comps\J679-mag-Area2-proc.xcp	TerraSurveyor 3.0.23.0	Processed composite data file (zmt and clipping to ±5nT).	23/08/16	K.T.Donaldson
Graphic data - path: J679 Sandleaze Farm Worton\Data				
Area1\graphics\ J679-mag-Area1-proc.tif	TerraSurveyor 3.0.23.0	TIF file showing a minimally processed greyscale plot clipped to ±3nT.	23/05/16	K.T.Donaldson
Area1\graphics\ J679-mag-Area1-proc.tfw	TerraSurveyor 3.0.23.0	World file for georeferencing TIF to OSGB36.	23/08/16	K.T.Donaldson
Area2\graphics\ J679-mag-Area2-proc.tif	TerraSurveyor 3.0.23.0	TIF file showing a minimally processed greyscale plot clipped to ±5nT.	23/08/16	K.T.Donaldson
Area2\graphics\ J679-mag-Area2-proc.tfw	TerraSurveyor 3.0.23.0	World file for georeferencing TIF to OSGB36.	23/08/16	K.T.Donaldson
CAD data - path: J679 Sandleaze Farm Worton\CAD				
J679 version 1.dwg	ProgeCAD 2016	CAD file for creating plots of greyscales, abstraction, interpretation and mapping. Grid coordinates as OSGB. AutoCAD 2010 format.	19/08/16	K.T.Donaldson
Text data - path: J679 Sandleaze Farm Worton\Documentation				
J679report.odt	OpenOffice.org 3.0.1 Writer	Report text as an Open Office document.	23/08/16	K.T.Donaldson

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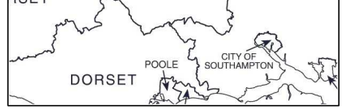
Archaeological Surveys Ltd

Geophysical Survey
Land at Sandleaze Farm
Worton
Wiltshire

Map of survey area

N



● Survey location

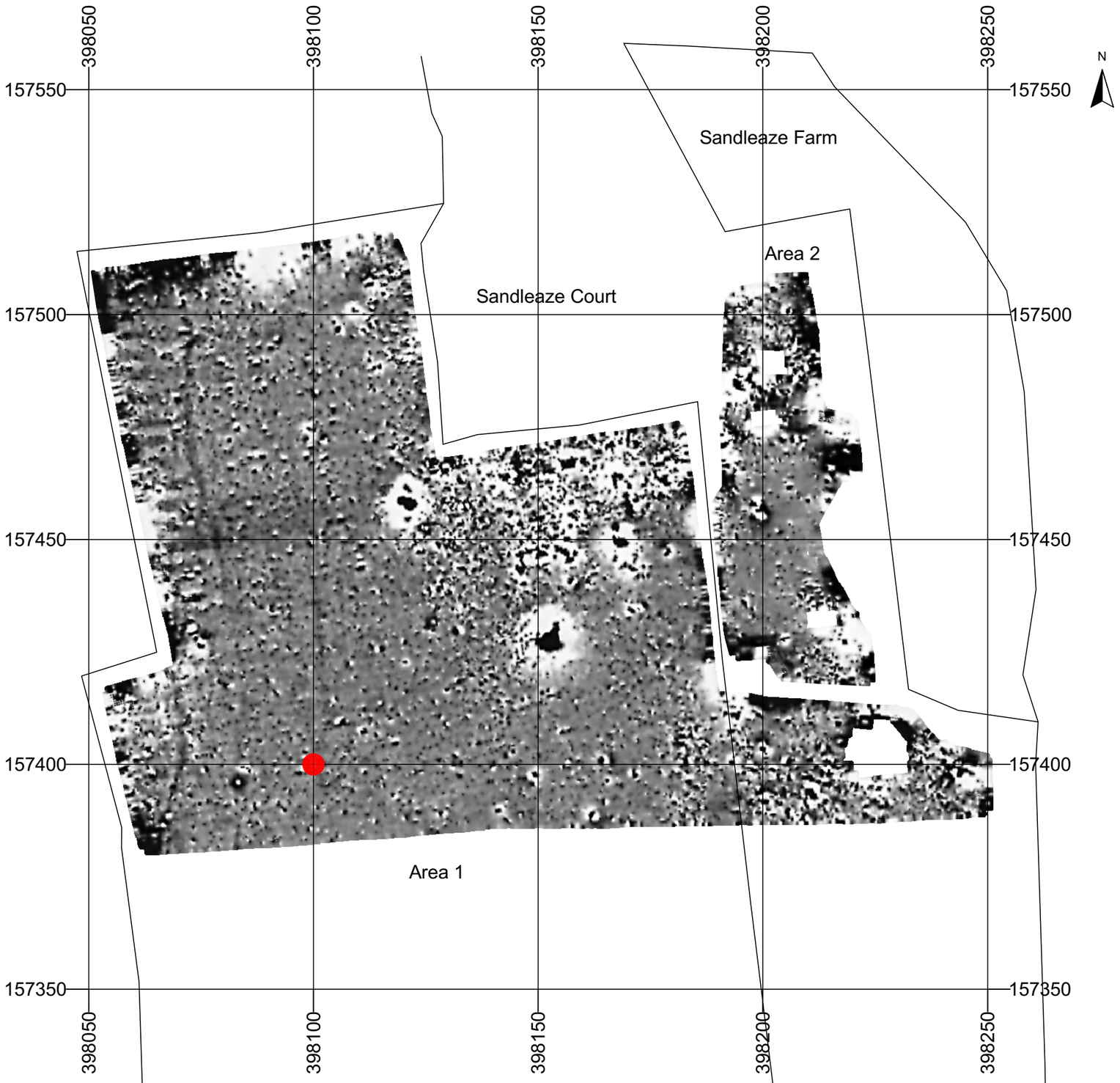
Site centred on OS NGR
ST 98140 57440

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

FIG 01



Archaeological Surveys Ltd

Geophysical Survey
Land at Sandleaze Farm
Worton
Wiltshire

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

398100 157400

SCALE 1:1000

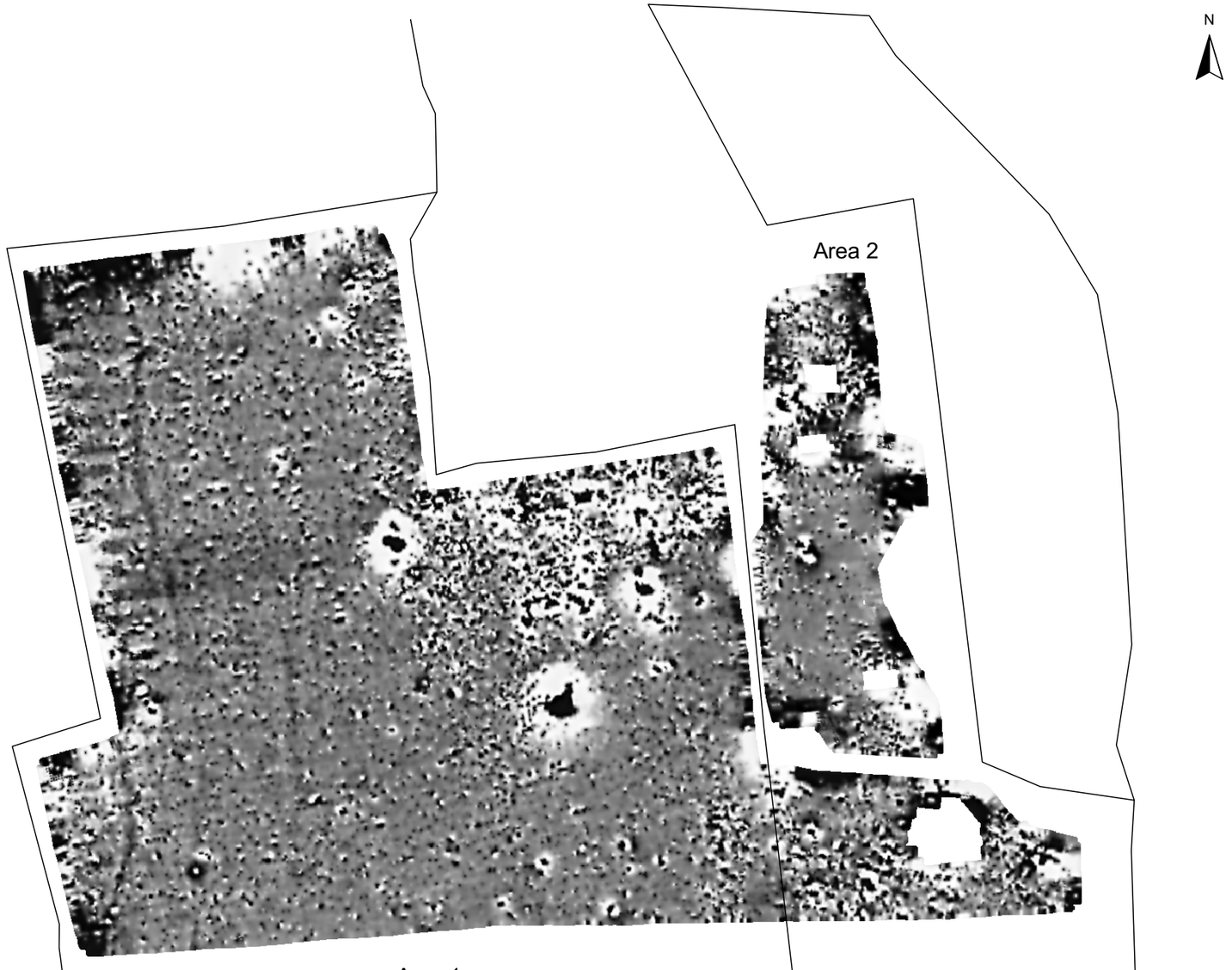
0m 10 20 30 40 500m

SCALE TRUE AT A3

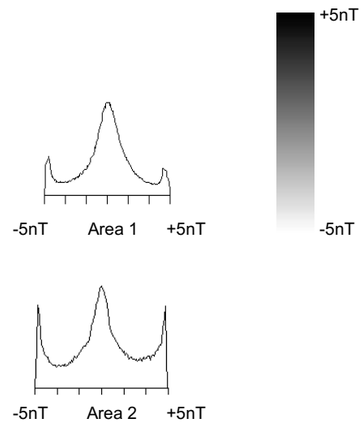
FIG 02

Archaeological Surveys Ltd

Geophysical Survey
Land at Sandleaze Farm
Worton
Wiltshire



Greyscale plot of minimally processed magnetometer data



SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 03

Archaeological Surveys Ltd

Geophysical Survey
Land at Sandleaze Farm
Worton
Wiltshire

Abstraction and interpretation of magnetometer anomalies

- Positive linear anomaly - possible ditch-like feature
- Discrete positive response - possible pit-like feature
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong dipolar anomaly - ferrous object

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 04