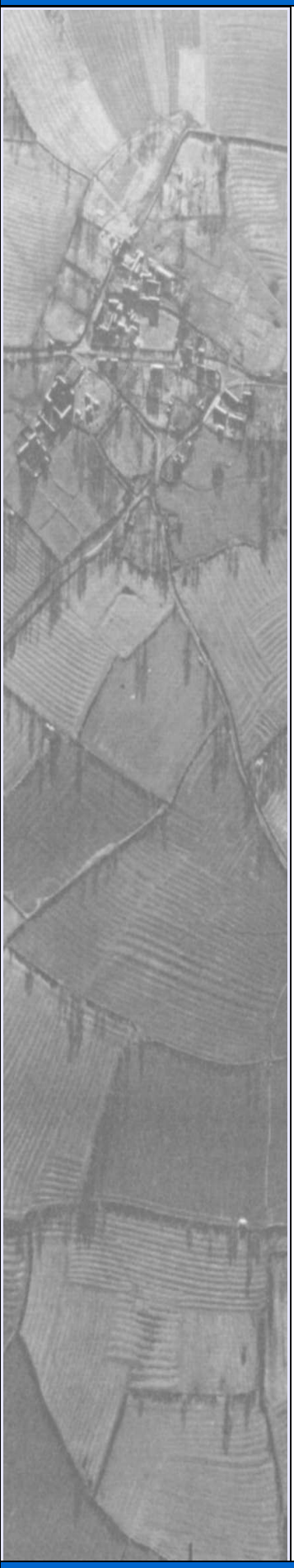

Townsend
Faulkland
Somerset

MAGNETOMETER SURVEY REPORT

for

AC Archaeology Ltd

David Sabin and Kerry Donaldson

March 2014

Ref. no. 531

ARCHAEOLOGICAL SURVEYS LTD

Townsend, Faulkland, Somerset

Magnetometer Survey Report

for

AC Archaeology Ltd

Fieldwork by David Sabin and Kerry Donaldson
Report by David Sabin BSc (Hons) MIFA and Kerry Donaldson BSc (Hons)

Survey date – 7th March 2014
Ordnance Survey Grid Reference – **ST 74118 54655**

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

SUMMARY

A detailed magnetometer survey was carried out over land on the north eastern edge of Faulkland in Somerset. A cart-based system, using 5 fluxgate gradiometers spaced 0.5m apart, was used and the results have revealed a number of positive linear and discrete anomalies within the site. Several of the anomalies are linear, rectilinear and possibly curvilinear in form and many appear to have been truncated or disturbed by agricultural activity, possibly ridge and furrow. Discrete and amorphous responses appear to relate to pit-like features, and although an anthropogenic origin is possible, a natural or agricultural origin should also be considered.

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 Townsend, Faulkland in Somerset. The site has been outlined for the proposed development of three residential dwellings and the survey forms part of an archaeological assessment of the site.

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 Institute for Archaeologists (2011) *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 the village of Faulkland, within the parish of Hemington in Somerset. It is centred on Ordnance Survey National Grid Reference (OS NGR) ST 74118 54655, see Figures 01 and 02.

1.3.2 The geophysical survey covers approximately 0.5haat the north western end of a 2ha pasture field bordered to the north west by the A366.

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 fine and sunny.

1.4 Site history and archaeological potential

1.4.1 The Somerset Historic Environment Record indicates that geophysical surveys carried out approximately 300m to the south east of the site identified a number of anomalies interpreted as relating to a medieval farmstead, possible Romano-British field systems and a possible Romano-British temple. A magnetometer survey previously undertaken by Archaeological Surveys (2013) approximately 300m to the west located a number of anomalies relating to possible enclosures, ditches and pits within a site containing earthworks and platforms.

1.4.2 The site lies on the edge of the existing village and is likely to have been used for agricultural purposes since at least the medieval period. However, there is some potential for the magnetometer survey to locate geophysical anomalies that may relate to cut features, should they exist within the field.

1.5 Geology and soils

1.5.1 The underlying geology is mudstone from the Forest Marble Formation (BGS, 2014).

1.5.2 The overlying soils across the site are from the Elmton 2 association which are brown rendzinas. These consist of shallow, well drained, brashy calcareous fine loamy soils (Soil Survey of England and Wales, 1983).

1.5.3 Detailed magnetometer surveys carried out on similar soils and geology have demonstrated a strong magnetic contrast between the fill of cut features and the material into which they are cut. However, any ground disturbance such as ploughing and tree throw pits can also form strongly contrasting geophysical anomalies.

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 20 Hz. The gradiometers record 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 PDA computer system.

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. Georeferenced data are then exported in ASCII format for compensation (destriping), interpolation and clipping using TerraSurveyor. Greyscale images are also produced using TerraSurveyor.

2.3.2 Appendix C contains specific information concerning the survey and data attributes and is derived directly from TerraSurveyor; this should be used in conjunction with information provided by Figure 02.

2.3.3 Only minimal processing is carried out in order to enhance the results of the survey for display. Raw data are always analysed as processing can modify anomalies. The following schedule sets out the data and image processing used in this survey for the SENSYS MAGNETO data:

- clipping of processed data at ±20 nT to enhance low magnitude anomalies,
- zero median traverse at 1.5SD is applied in order to balance readings along each traverse.

2.3.4 An abstraction and interpretation is offered for all geophysical anomalies located by the survey. 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.

2.3.5 Reference should be made to Appendix B for further information on the specific processes carried out on the data. Appendix C metadata includes details on the processing sequence used for each survey area.

2.3.6 The main form of data display prepared for this report is the 'processed' greyscale plot followed by an abstraction and interpretation plot. Anomalies are abstracted using colour coded points, lines and polygons. All plots are scaled to landscape A3 for paper printing.

2.3.7 Data captured with the SENSYS MAGNETO cart-based system are resampled to a resolution of effectively 0.5m between tracks and 0.2m along each survey track. A GeoTIFF file is produced by TerraSurveyor software and projected to Ordnance Survey coordinates (OSGB36).

2.3.8 The raster images are combined with base mapping using ProgeCAD Professional 2014 and AutoCAD LT 2007, creating DWG file formats. All images are externally referenced to the CAD drawing in order to maintain good graphical quality. Quality can be compromised by rotation of graphics in order to allow the data to be orientated with respect to grid north; this is considered acceptable as the survey results are effectively georeferenced allowing relocation of features using GPS, resection method etc.

2.3.9 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 0.5ha within the north western part of a single 2ha pasture field.

3.1.2 Magnetic anomalies located can be generally classified as positive anomalies of an uncertain origin, anomalies relating to land management, linear anomalies of an agricultural origin, areas of magnetic 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. Zones of magnetic disturbance were encountered close to the western and north western periphery of the site and these have the potential to obscure low magnitude anomalies.

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.

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 AS-ABST MAG POS 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 relating to land management AS-ABST MAG BOUNDARY	Anomalies are mainly linear and may be indicative of the magnetically enhanced fill of cut features (i.e. ditches). The anomalies may be long and/or form rectilinear elements and they may relate to topographic features or be visible on early mapping. Associated agricultural anomalies (e.g. headlands, plough marks and former ridge and furrow) may support the interpretation. Land drains can appear in a classic herringbone pattern of interconnected multiple dipolar linear anomalies, or as parallel linear anomalies. The multiple dipolar response indicates a ceramic land drain.
Anomalies with an agricultural origin AS-ABST MAG AGRICULTURAL	The anomalies are often linear and form a series of parallel responses or are parallel to extant land boundaries. Where the response is broad, former ridge and furrow is likely; narrow response is often related to modern ploughing.
Anomalies associated with magnetic 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. Buried services may produce characteristic multiple dipolar anomalies dependant upon their construction.

Table 1: List and description of interpretation categories

3.4 List of anomalies

Area centred on OS NGR 374118 154655, see Figures 03 & 04.

Anomalies with an uncertain origin

(1) – Positive linear anomalies that appear to relate to cut features. They are crossed by a recently removed field boundary (8) and disturbed by agricultural activity. The anomalies may have some association with (2) and (3).

(2) – A broad positive response appears to be associated with anomalies (1); however, it is oriented parallel with anomalies (9) and an agricultural origin is possible.

(3) – Narrow, positive linear anomalies may be a continuation of (1). Although a natural origin is possible, the linear anomalies could relate to cut features with an anthropogenic origin.

(4) – A group of discrete and amorphous anomalies are located to the north of (2). It is possible that these relate to pit-like features; however, a natural or agricultural origin should also be considered.

(5) – A number of weakly positive linear and curvilinear anomalies are located in the northern part of the survey area. It is possible that these relate to cut features but this is not certain.

(6) – Positive linear anomalies and a number of discrete anomalies may indicate a group of cut features that have some association with anomalies (1).

(7) – The survey area contains a number of positive discrete and amorphous anomalies that may appear to relate to pit-like features. However, it is not possible to determine their origin, and they could relate to natural or agricultural features.

Anomalies relating to land management

(8) – A number of closely spaced positive and negative linear anomalies extend across the southern half of the survey area. These anomalies are in the position of a recently removed field boundary and are likely to be associated.

Anomalies with an agricultural origin

(9) – The survey area contains a number of parallel linear anomalies. These are most apparent in the northern half of the field but they do extend throughout. These anomalies are related to agricultural activity, possibly former ridge and furrow, and there appears to be some truncation or disturbance to other anomalies, such as (1) and (2).

Anomalies associated with magnetic debris

(10) – Strong, discrete dipolar anomalies are a response to ferrous and other magnetically thermoremnant objects in the topsoil.

Anomalies with a modern origin

(11) – Magnetic disturbance is evident along the edges of the survey area where it is close to modern ferrous objects and material.

4 CONCLUSION

4.1.1 The detailed magnetometer survey located a number of anomalies that may relate to cut features, such as ditches and pits, although they are fragmented and indistinct. The anomalies appear to have been truncated or disturbed by agricultural activity, possibly relating to ridge and furrow. A natural origin should also be considered possible for several of the anomalies.

5 REFERENCES

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Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 5 South West England.*

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 gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 1m apart. The instrument is carried about 30cm 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. If no enhanced feature is present the field measured by both sensors will be similar and the difference close to zero.

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 ±1nT 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 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 slight differences between the set-up and stability of gradiometer sensors and can remove striping. The process can remove archaeological features that run along a traverse so data analysis is also carried out prior its application.

De-stagger

Compensates for small positional errors within data collection by shifting the position of the readings along each traverse by a specified amount. Data lost at the end of each traverse are extrapolated from adjacent value in the same row.

Deslope

Corrects for striping and distortion caused by metal objects/services etc.. The process calculates a curve based on a polynomial best fit mathematical function for each traverse. This curve is then subtracted from the actual data.

Edge Match

Calculates the mean of the 2 lines (rows or columns) of data either side of the edge to match. It then subtracts the difference between the means from all datapoints in the selected area.

FFT (Fast Fourier Transform) spectral filtering

A mathematical process used to determine the frequency components of a traverse. Repetitive features, such as plough marks, produce characteristic spectral zones that can be suppressed allowing greyscale images to appear clearer.

Appendix C – survey and data information

COMPOSITE

Filename: J531-mag-proc.xcp
Description: Imported as Composite from: J531-mag.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):
Northwest corner: 374079.572170098, 154695.290318523 m
Southeast corner: 374167.772170098, 154600.190318523 m
Direction of 1st Traverse: 90 deg
Collection Method: Parallel
Sensors: 1
Dummy Value: 32702

Source GPS Points: 124100

Dimensions
Composite Size (readings): 588 x 634
Survey Size (meters): 88.2 m x 95.1 m
Grid Size: 88.2 m x 95.1 m
X Interval: 0.15 m
Y Interval: 0.15 m

Stats
Max: 20.00
Min: -20.00
Std Dev: 10.43
Mean: 0.58
Median: -0.01
Composite Area: 0.83878 ha
Surveyed Area: 0.45791 ha

PROGRAM
Name: TerraSurveyor
Version: 3.0.23.0

Processes: 2
1 Base Layer
2 Clip from -20.00 to 20.00 nT

GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse: Threshold: 1.5 SDs
4 Clip from -20.00 to 20.00 nT

Appendix D – digital archive

Archaeological Surveys Ltd hold the primary digital archive at their offices in Wiltshire (see inside cover for address). 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.

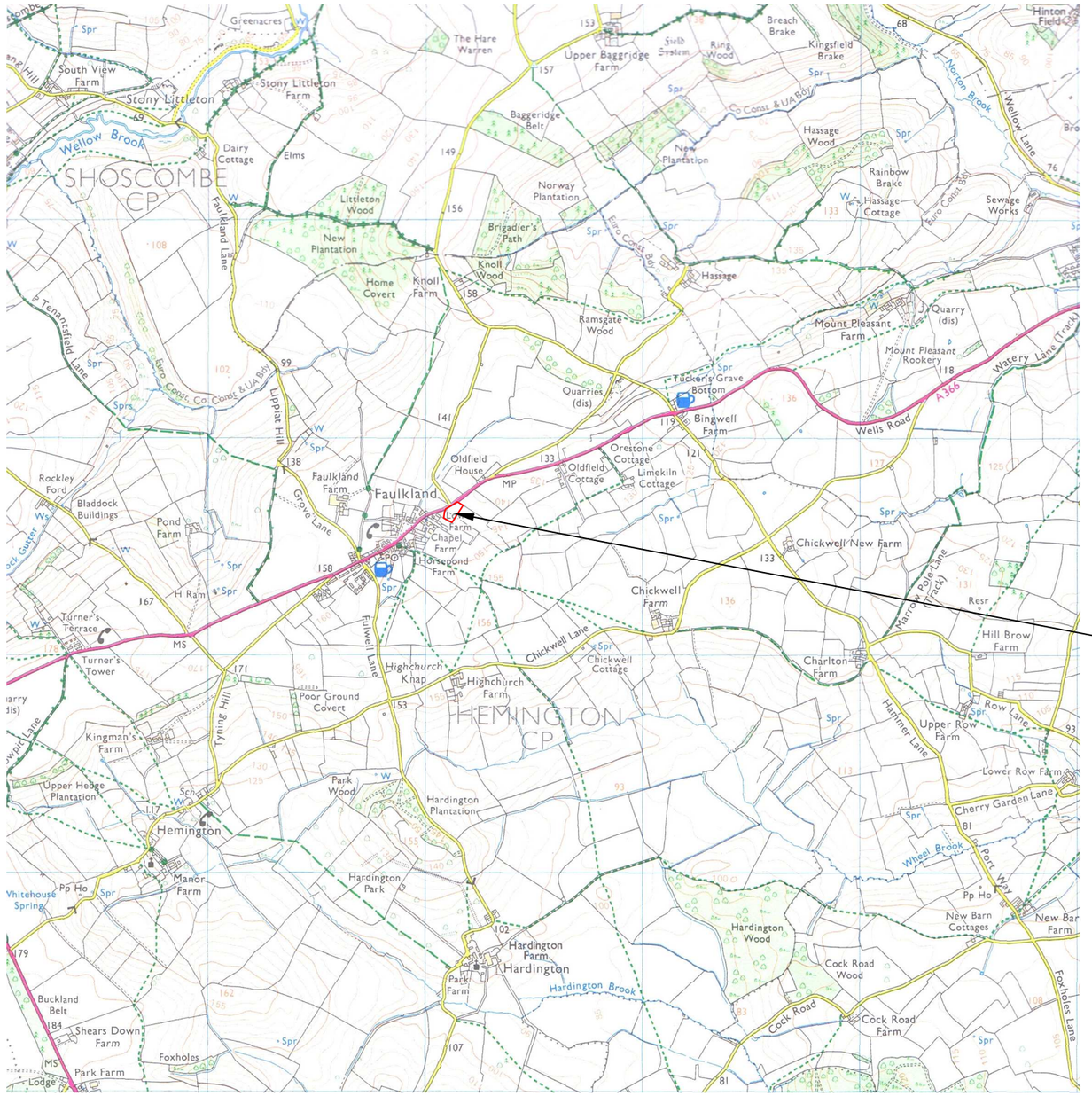
Surveys are reported on in hardcopy (recycled paper) using A4 for text and A3 for plots (all plots are scaled for A3).

This report has been prepared using the following software on a Windows XP platform:

- TerraSurveyor version 3.0.23.0 (geophysical data analysis),
- SENSYS MAGNETO®ARCH version 1.00-03 (geophysical data analysis),
- ProgeCAD Professional 2014 (report graphics),
- AutoCAD LT 2007 (report figures),
- OpenOffice.org 3.0.1 Writer (document text),
- PDF Creator version 0.9 (PDF archive).

Digital data produced by the survey and report include the following files:

- TerraSurveyor grid and composite files for all geophysical data,
- CSV files for raw and processed composites,
- geophysical composite file graphics as Bitmap images,
- AutoCAD DWG files in 2000 and 2007 versions,
- report text as OpenOffice.org ODT file,
- report text as Word 2000 doc file,
- report text as rich text format (RTF),
- report text as PDF,
- PDFs of all figures.



Survey location

Archaeological Surveys Ltd

Geophysical Survey
Townsend
Faulkland
Somerset

Map of survey area

● Survey location

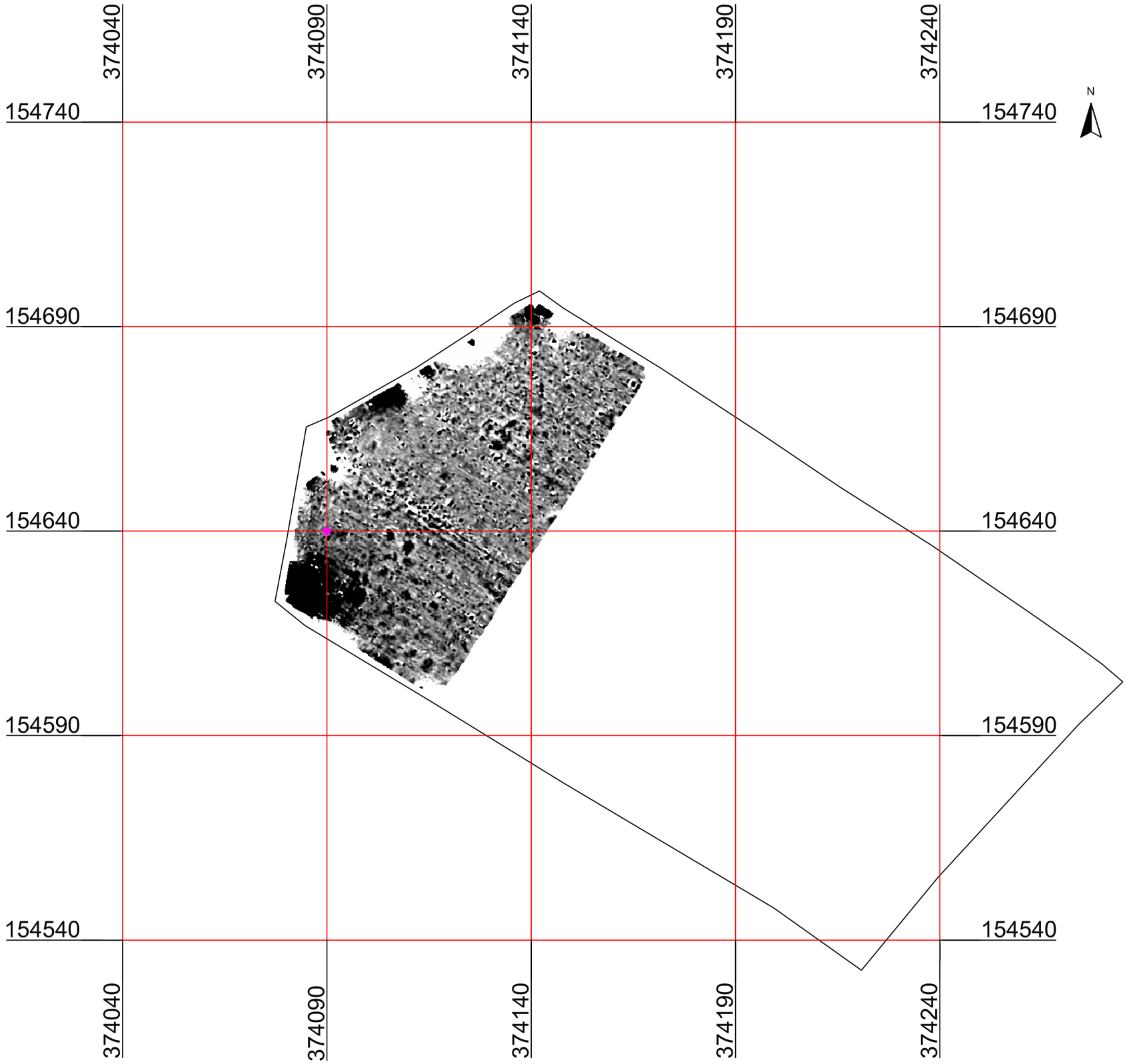
Site centred on OS NGR
ST 74118 54655

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

FIG 01



Archaeological Surveys Ltd

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Somerset

Referencing information

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

Referencing grid to OSGB36 datum at 50m intervals

- 374090 154640

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 02

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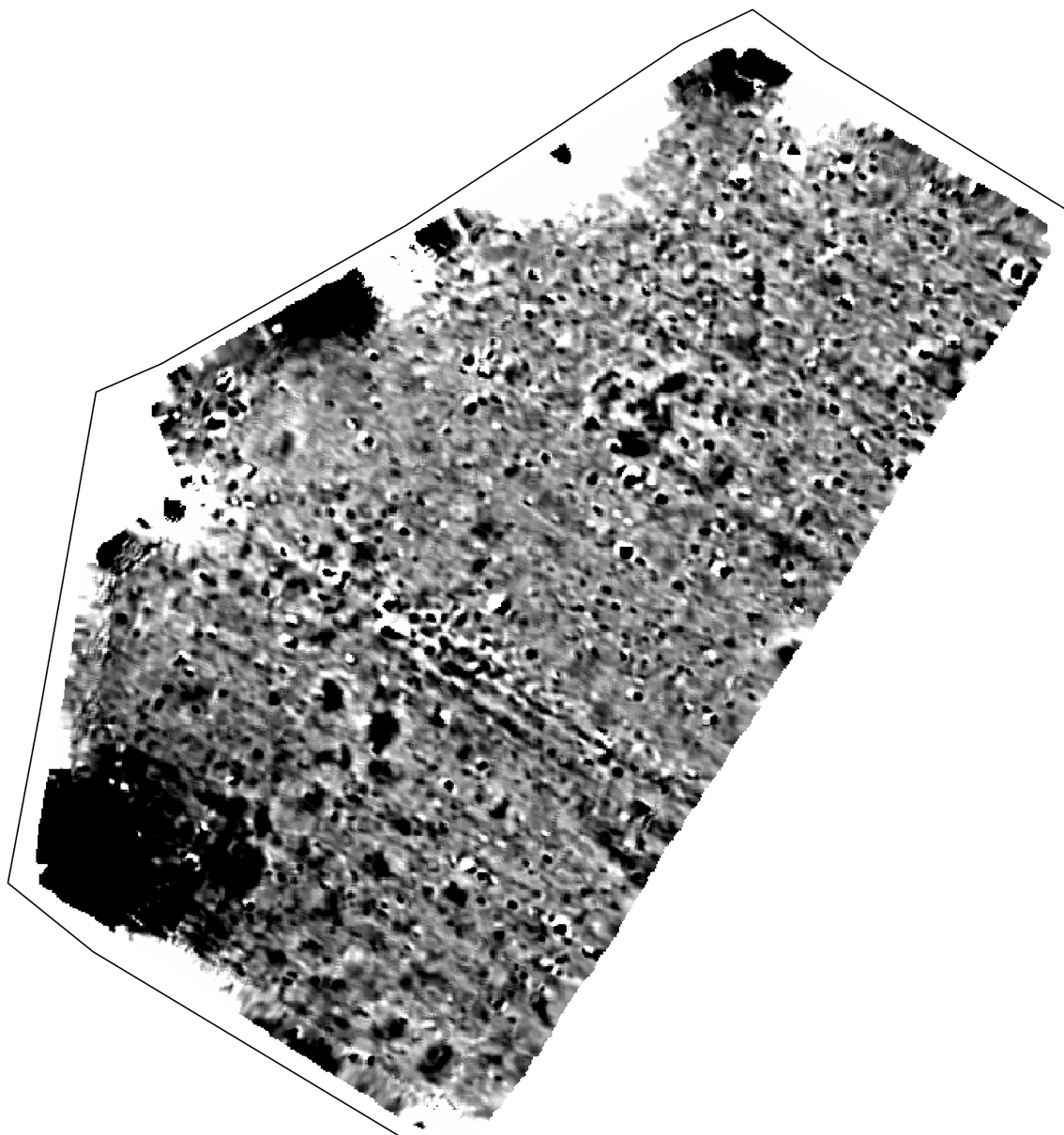
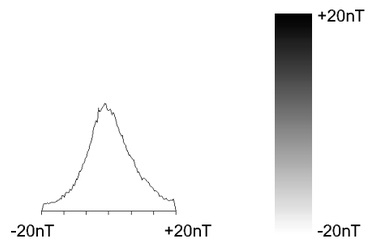
Somerset

Greyscale plot of processed magnetometer data





SCALE 1:500

SCALE TRUE AT A3

FIG 03

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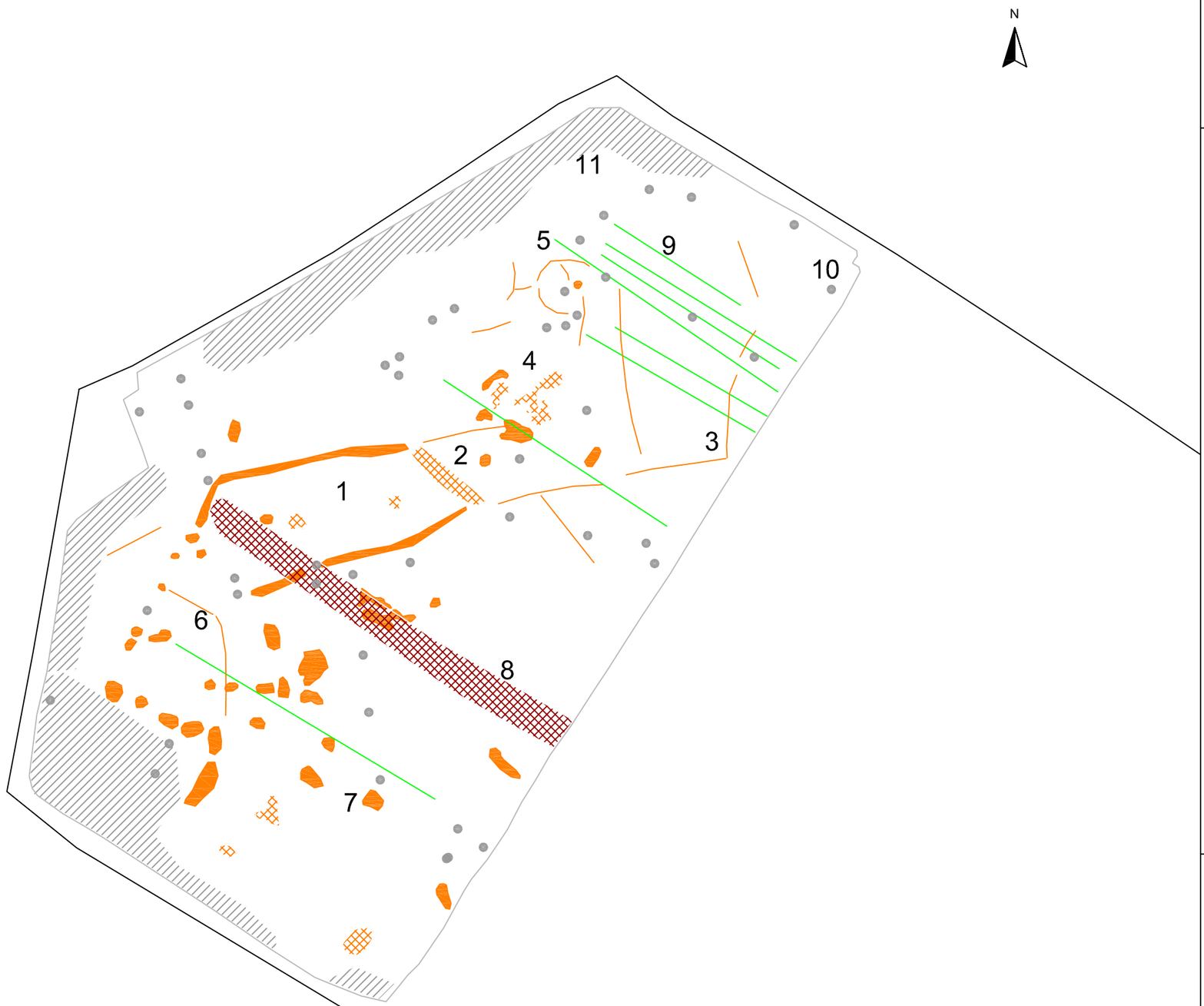

Abstraction and interpretation of magnetometer anomalies

- Positive linear anomaly - cut feature of archaeological potential
- Positive linear anomaly - possible ditch-like feature
- Linear anomaly - of agricultural origin
- Linear anomaly - ridge and furrow
- Positive linear anomaly - possible land drain
- Positive linear anomaly - possible former field boundary
- Negative linear anomaly - material of low magnetic susceptibility
- Discrete positive response - cut feature of archaeological potential
- Discrete positive response - possible pit-like feature
- Positive anomaly - magnetically enhanced material
- Variable magnetic response - of natural origin
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material

- Strong multiple dipolar linear anomaly - pipeline / cable / service
- Strong dipolar anomaly - ferrous object

SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

FIG 04