

**Broadway Farm  
Down Ampney  
Gloucestershire**

**MAGNETOMETER SURVEY REPORT**

for

**Cotswold Archaeology**

David Sabin and Kerry Donaldson

February 2015

Ref. no. 591

ARCHAEOLOGICAL SURVEYS LTD

**Broadway Farm  
Down Ampney  
Gloucestershire**

Magnetometer Survey Report

for

**Cotswold Archaeology**

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

Survey date – 12<sup>th</sup> February 2015  
Ordnance Survey Grid Reference – **SU 10215 97470**



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## SUMMARY

A detailed magnetometer survey was carried out by Archaeological Surveys Ltd, at the request of Cotswold Archaeology, on land at Broadway Farm, Down Ampney, Gloucestershire. The survey covered 1ha within an area of rough vegetation immediately to the north, and within the same plot of land, as a previous geophysical survey and evaluation which located a number of linear ditches containing 11<sup>th</sup> -13<sup>th</sup> pottery. The present survey located a positive linear anomaly that may be a continuation of a linear ditch revealed by the evaluation. Other linear anomalies were either weak, short or indistinct, but is it possible that some may relate to cut, ditch-like features. A small number of pit-like responses has also been located, but their origin is uncertain. A number of positive and negative linear anomalies along the north eastern corner may relate to former garden boundaries that were mapped until the late 20<sup>th</sup> century. A zone of magnetic debris is also likely to be associated with them and also possibly material from a smithy, formerly located immediately to the north east. Anomalies associated with ridge and furrow also exist within the site.

## 1 INTRODUCTION

### 1.1 Survey background

- 1.1.1 Archaeological Surveys Ltd was commissioned by Cotswold Archaeology to undertake a magnetometer survey of an area of land at Broadway Farm, Down Ampney, 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.
- 1.1.3 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.
- 1.1.4 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*.

## 1.2 *Site location, description and survey conditions*

- 1.2.1 The site is located at Broadway Farm, Down Ampney in Gloucestershire. It is centred on Ordnance Survey National Grid Reference (OS NGR) SU 10215 97470, see Figures 01 and 02.
- 1.2.2 The geophysical survey covers approximately 1ha at the northern part of an ungrazed pasture field. The site contained very tall vegetation and brambles, these zones were inaccessible for survey. Land immediately to the south, within the same field, has been previously subject to geophysical survey (Pre-Construct Geophysics, 2013) and evaluation (Cotswold Archaeology 2004 & 2013).
- 1.2.3 The ground conditions across the site were generally considered to be acceptable for the collection of magnetometry data though traversing was difficult. Weather conditions during the survey were overcast and dry.



Plate 1: Survey area looking south west

## 1.3 *Site history and archaeological potential*

- 1.3.1 Previous archaeological evaluation on land immediately to the south identified a number of shallow linear features containing 12<sup>th</sup> to 13<sup>th</sup> century pottery (Cotswold Archaeology, 2004), a pit containing a sherd of 11<sup>th</sup> to 13<sup>th</sup> century pottery and a number of undated shallow linear ditches (Cotswold Archaeology, 2013). A previous geophysical survey of these areas was affected by modern ferrous material; however, a number of weaker possible linear and discrete anomalies were located in the eastern part of the site (Pre-Construct Geophysics, 2013).

- 1.3.2 Within the wider vicinity there are a number of cropmark sites indicating prehistoric and Romano-British enclosures and settlements.
- 1.3.3 There is some potential for the geophysical survey to locate anomalies that may relate to archaeological features should they be present within the site.

#### 1.4 *Geology and soils*

- 1.4.1 The underlying solid geology across the site is mudstone from the Oxford Clay Formation with overlying deposits of Summertown-Radley Sand and Gravel Member (BGS, 2013).
- 1.4.2 The overlying soil across the survey area is from the Badsey 1 association and is a typical brown calcareous earth. It consists of a well drained, calcareous and non-calcareous, fine, loamy soil over limestone gravel (Soil Survey of England and Wales, 1983).
- 1.4.3 Magnetometry carried out over similar geology and soil has produced good results. The site is 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 20 Hz. The gradiometers have a range of recording data between 0.1nT and 10,000nT. They are linked to a Leica GS10 RTK GPS with data recorded by SENSYS MAGNETO®MXPDA software on a rugged PDA computer system.
- 2.2.2 Data are collected along a series of parallel survey transects wherever possible. The length of each transect is variable and relates to the size of the survey area and other factors including ground conditions. A visual display allows accurate placing of transects and helps maintain the correct separation between adjacent traverses.

## **2.3 *Data processing and presentation***

- 2.3.1 Magnetic data collected by the MAGNETO®MXPDA cart-based system are initially prepared and automatically compensated using SENSYS MAGNETO®DLMGPS software. Georeferenced raw data are then exported in ASCII format for further analysis and display using TerraSurveyor.
- 2.3.2 The data are collected at  $\pm 10000\text{nT}$  and clipped for display at  $\pm 20\text{nT}$ . Data are resampled to a resolution of effectively 0.5m between tracks and 0.15m along each survey track. Appendix C contains specific information 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.
- 2.3.3 A TIFF 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.
- 2.3.4 The raster images are combined with base mapping using ProgeCAD Professional 2014, creating DWG 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.
- 2.3.5 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. Anomalies are abstracted using colour coded points, lines and polygons. All plots are scaled to landscape A3 for paper printing.



2.3.6 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 1ha within a single plot of land.


3.1.2 Magnetic anomalies located can be generally classified as positive and negative anomalies of an uncertain origin, linear anomalies of an agricultural origin, areas of magnetic debris and disturbance, strong discrete dipolar anomalies relating to ferrous objects and strong multiple dipolar linear anomalies relating to buried services or pipelines.

### 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 have the potential to obscure weak 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 within the survey area.

Report sub-heading CAD layer names and plot colour	Description and origin of anomalies
<p><b>Anomalies with an uncertain origin</b></p> <p>AS-ABST MAG POS LINEAR UNCERTAIN AS-ABST MAG NEG LINEAR UNCERTAIN AS-ABST MAG POS DISCRETE UNCERTAIN</p> 	<p>The category applies to a range of anomalies where <u>there is not enough evidence to confidently suggest an origin</u>. Anomalies in this category <u>may well be related to archaeologically significant features, but equally relatively modern features, geological/pedological features and agricultural features should be considered</u>. 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.</p>
<p><b>Anomalies with an agricultural origin</b></p>	<p>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</p>






AS-ABST MAG RIDGE AND FURROW		response is often related to modern ploughing.
<p><b>Anomalies associated with magnetic debris</b></p> <p>AS-ABST MAG DEBRIS</p> <p>AS-ABST MAG STRONG DIPOLAR</p>	 	<p>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 thermoremanent 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 <u>may therefore be archaeologically significant</u>. 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.</p>
<p><b>Anomalies with a modern origin</b></p> <p>AS-ABST MAG DISTURBANCE</p> <p>AS-ABST MAG SERVICE</p>	 	<p>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.</p>

Table 1: List and description of interpretation categories

### 3.4 List of anomalies

Area centred on OS NGR 410215 197470, see Figures 03 & 04.

#### *Anomalies with an uncertain origin*

(1) – A weakly positive linear anomaly is located at the south western side of the survey area. The response is weak (1-1.5nT) and over 2m wide. It is possible that it is a continuation of the linear ditch 103 recorded during evaluation by Cotswold Archaeology in 2013.

(2) – A weakly positive linear anomaly extends across the southern part of the survey area and may have been truncated by the ridge and furrow (6). It is also possible that it may be associated with another positive linear anomaly that extends north westwards from its western end.

(3) – The survey area contains a number of short, weakly positive, linear responses. Due to their short lengths and lack of coherent morphology it is not possible to determine their origin.

(4) – In the north eastern corner of the survey area are a number of positive and negative linear anomalies. Several of these are oriented north north west to south south east and west south west to east north east and they are likely to relate to

former garden boundaries, mapped in the area since the 19<sup>th</sup> century until the late 20<sup>th</sup> century. Other, more curving linear anomalies may relate to agricultural marks within the magnetic debris (7).

(5) – There are a number of discrete positive responses that appear as pit-like features. It is not possible to determine if they are anthropogenic or naturally formed features.

#### *Anomalies with an agricultural origin*

(6) – A series of linear anomalies can be seen within the survey, oriented north north west to south south east, and these relate to former ridge and furrow.

#### *Anomalies associated with magnetic debris*

(7) – A zone of magnetic debris is evident along the eastern edge of the survey area and is a response to ferrous and other magnetically thermoremanent material. The zone corresponds to the location of former back gardens that existed within the site until the late 20<sup>th</sup> century. A smithy is mapped just to the north east and it is likely that some of the material has been derived from it, as well as associated with former boundaries and their demolition material.

(8) – Strong, discrete, dipolar anomalies are a response to ferrous and other magnetically thermoremanent objects within the topsoil.

#### *Anomalies with a modern origin*

(9) – A strong, multiple dipolar, linear anomaly is a response to a buried service.

## 4 CONCLUSION

4.1.1 The detailed magnetometer survey located a number of positive linear and discrete responses within the survey area. One of these, extending northwards from close to the south western corner of the survey area, may be a continuation of a linear ditch recorded during evaluation immediately to the south. Two other very weakly positive linear anomalies may also relate to cut, ditch-like features, but they are weak and indistinct. There are a number of pit-like responses, but their origin is uncertain.

4.1.2 In the north eastern corner of the survey area are a number of positive and negative linear anomalies and a zone of magnetic debris. It is possible that the linear anomalies are relate to mapped former garden boundaries and the magnetic debris to material associated with them and their demolition. It is also possible that this material has been derived from the former adjacent smithy.

## 5 REFERENCES

- Archaeological Surveys, 2015. *Broadway Farm, Down Ampney, Gloucestershire, Geophysical Survey Written Scheme of Investigation*. Unpublished typescript document.
- British Geological Survey, 2013. *Geology of Britain viewer, 1:50 000 scale [online]* available from <http://mapapps.bgs.ac.uk/geologyofbritain/home.html> [accessed 3/2/2015].
- Cotswold Archaeology, 2004. *Broadway Farm, Down Ampney, Gloucestershire: Archaeological Evaluation*, CA Report No. 04128.
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- Institute for Archaeologists, 2002. *The use of Geophysical Techniques in Archaeological Evaluations*. IfA Paper No. 6. IfA, University of Reading.
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- Pre-Construct Geophysics, 2013. *Archaeological Geophysical Survey: Land at Broadway Farm, Down Ampney, Gloucestershire*.
- 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 thermoremanent 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.

Thermoremanent 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. Thermoremanent features include ovens, hearths, and kilns. In addition thermoremanent 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  $\pm 20\text{nT}$  and  $\pm 10\text{nT}$  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.

## Appendix C – survey and data information

### COMPOSITE

Path: C:\Business\Jobs\J591 Down Ampney\Data\Mag\comps\  
Filename: J591-mag-proc.xcp  
Description: Imported as Composite from: J591-mag.asc  
Instrument Type: Sensys DLMGPS  
Units: nT  
UTM Zone: 30U  
Survey corner coordinates (X/Y):  
Northwest corner: 410134.103985877, 197537.539790786 m  
Southeast corner: 410291.903985877, 197406.289790786 m  
Direction of 1st Traverse: 90 deg  
Collection Method: Parallel  
Sensors: 1  
Dummy Value: 32702

Source GPS Points: 426900

### Dimensions

Composite Size (readings): 1052 x 875  
Survey Size (meters): 158 m x 131 m  
Grid Size: 158 m x 131 m  
X Interval: 0.15 m  
Y Interval: 0.15 m

### Stats

Max: 8.84  
Min: -8.80  
Std Dev: 4.33  
Mean: -0.08  
Median: -0.03  
Composite Area: 2.0711 ha  
Surveyed Area: 1.0113 ha

### PROGRAM

Name: TerraSurveyor  
Version: 3.0.23.0

Processes: 1

- 1 Base Layer

GPS based Proce3

- 1 Base Layer.
- 2 Unit Conversion Layer (Lat/Long to OSGB36).
- 3 Clip from -8.00 to 8.00 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). A digital copy of the report will be provided to the Gloucestershire County Archaeology Service together with a dxf of the survey location for the Gloucestershire Historic Environment Service.

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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 1.00-04(geophysical data analysis),
- ProgeCAD Professional 2014 (report graphics),
- OpenOffice.org 3.0.1 Writer (document text),
- PDF Creator version 0.9 (PDF)
- Solid PDF Creator version 8 (PDF archive).

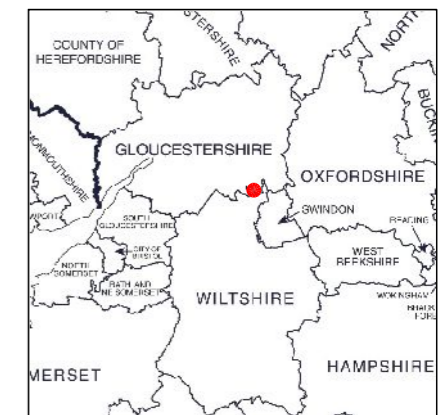
Digital data produced by the survey and report include the following files:

- TerraSurveyor grid and composite files for all geophysical data,
- CSV files for raw and processed composites,
- geophysical composite file graphics as TIF images,
- CAD DWG files in 2007 version,
- report text as OpenOffice.org ODT file,
- report text and figures as PDF/A.

### Geophysical Survey Broadway Farm Down Ampney Gloucestershire

#### Map of survey area

Reproduced from OS Explorer map no.169 1:25 000  
by permission of Ordnance Survey on behalf of The  
Controller of Her Majesty's Stationery Office.  
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Licence number 100043739.



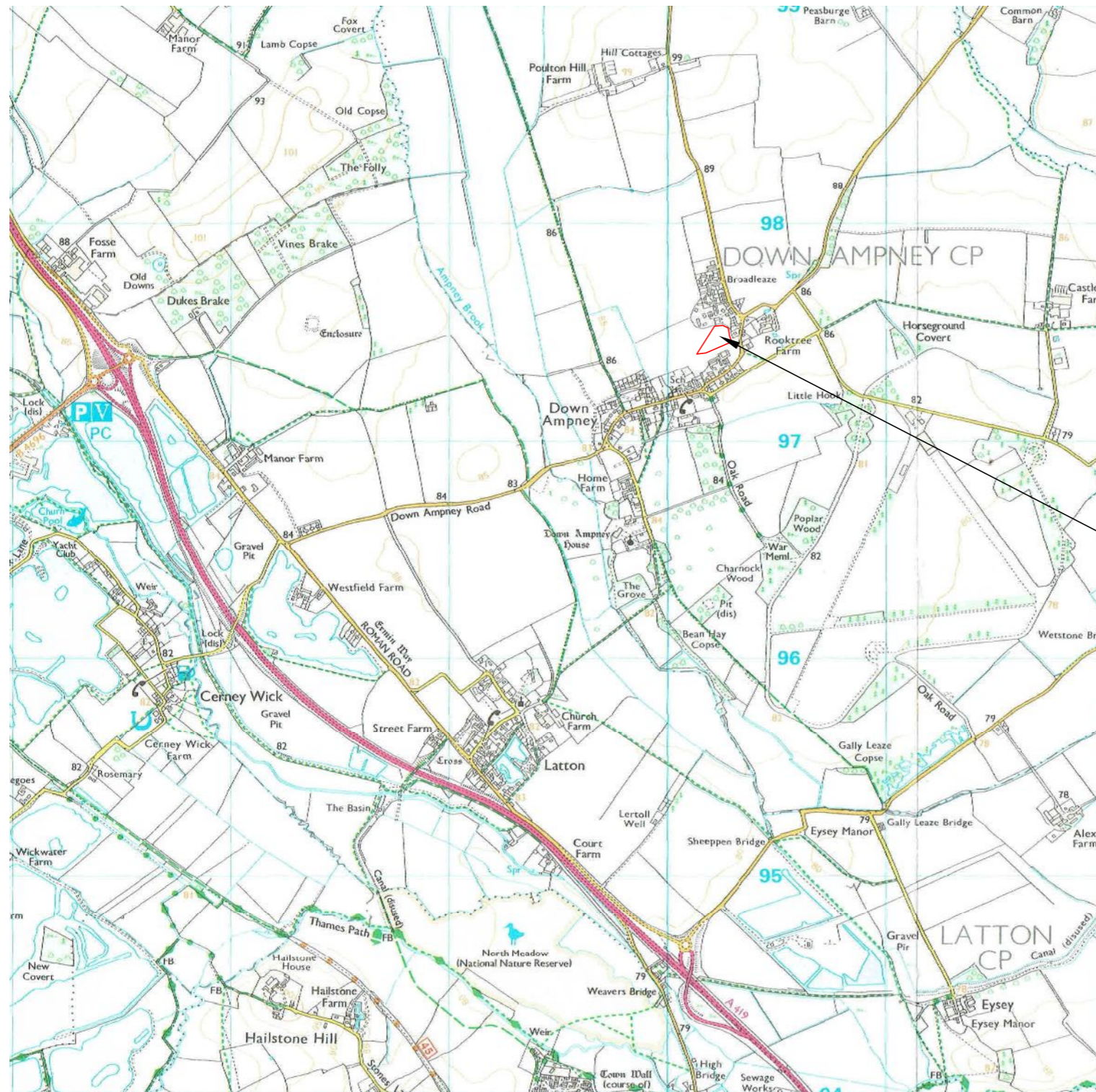
● Survey location

Site centred on OS NGR  
SU 10215 97470

SCALE 1:25 000



SCALE TRUE AT A3



Survey location



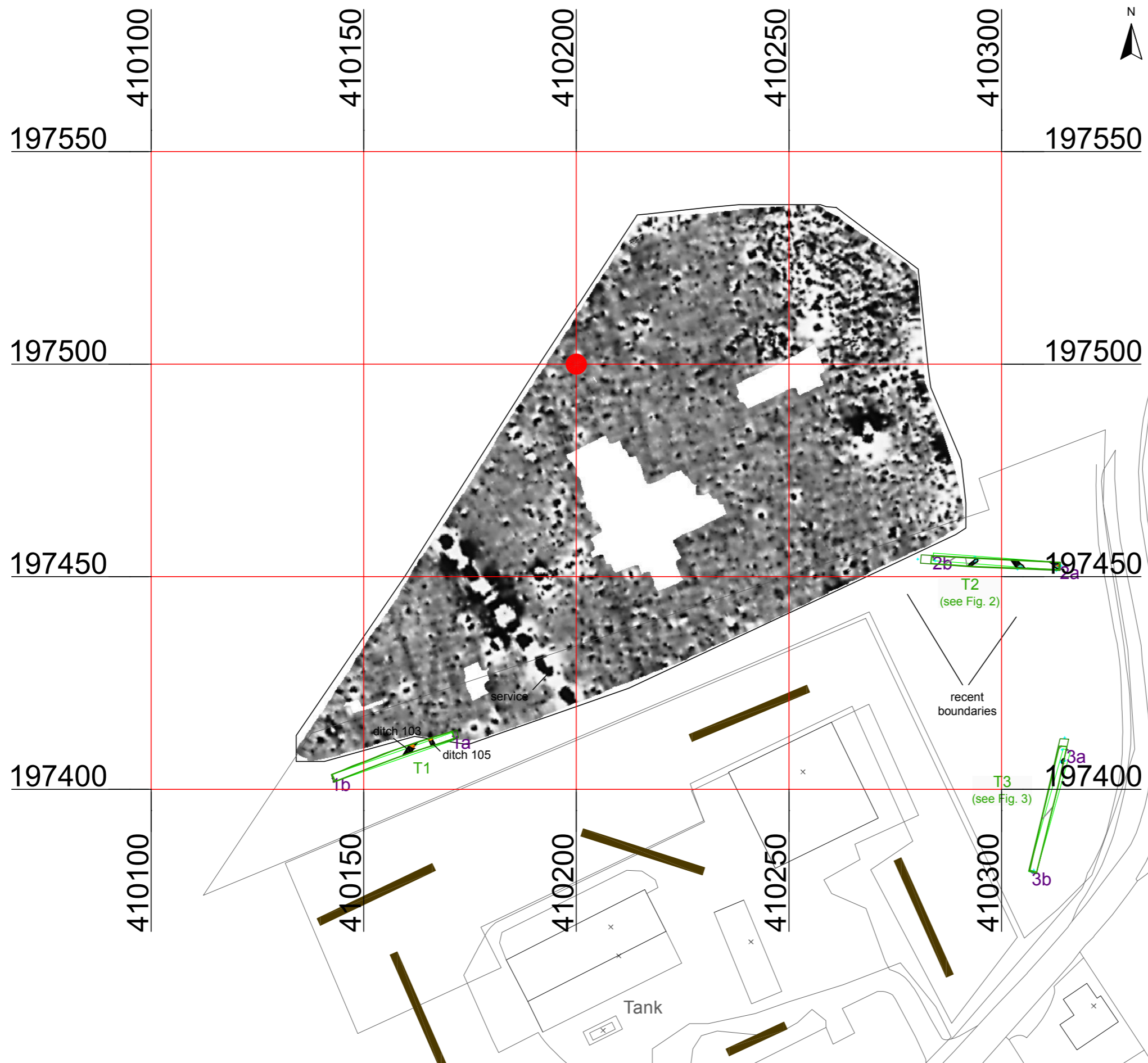
**Geophysical Survey  
Broadway Farm  
Down Ampney  
Gloucestershire**

**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

● 410200 197500



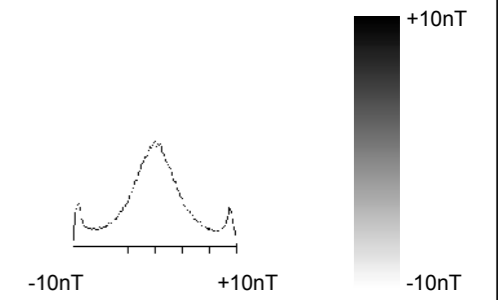
SCALE 1:2000



SCALE TRUE AT A3

**Geophysical Survey  
Broadway Farm  
Down Ampney  
Gloucestershire**

**Greyscale plot of minimally  
processed magnetometer data**











SCALE 1:1000



SCALE TRUE AT A3

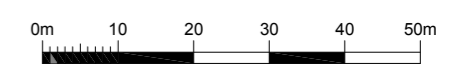
**Geophysical Survey  
Broadway Farm  
Down Ampney  
Gloucestershire**

**Abstraction and interpretation of  
magnetometer anomalies**

-  Positive linear anomaly - possible ditch-like feature
-  Linear anomaly - ridge and furrow
-  Negative linear anomaly - material of low magnetic susceptibility
-  Discrete positive response - possible pit-like feature
-  Magnetic debris - spread of magnetically thermoremanent/ferrous material
-  Magnetic disturbance from ferrous material
-  Strong multiple dipolar linear anomaly - pipeline / cable / service
-  Strong dipolar anomaly - ferrous object



SCALE 1:1000



SCALE TRUE AT A3

FIG 04