

**Swillbrook Farm
Minety
Wiltshire**

MAGNETOMETER SURVEY REPORT

for

Mr & Mrs P Walker

Kerry Donaldson & David Sabin

February 2021

Ref. no. J845

ARCHAEOLOGICAL SURVEYS LTD

**Swillbrook Farm
Minety
Wiltshire**

MAGNETOMETER SURVEY REPORT

for

Mr & Mrs P Walker

Fieldwork by David Sabin BSc (Hons) MCIfA

Report by Kerry Donaldson BSc (Hons)

Report checked by David Sabin

Primary archive location - Archaeological Surveys Ltd, Yatesbury, Wiltshire

Survey date – 8th February 2021

Ordnance Survey Grid Reference – **ST 02300 93175**



Archaeological Surveys Ltd
1 West Nolands, Nolands Road, Yatesbury, Calne, Wiltshire, SN11 8YD
Tel: 01249 814231 Fax: 0871 661 8804
Email: info@archaeological-surveys.co.uk
Web: www.archaeological-surveys.co.uk

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SUMMARY

Detailed magnetometry was carried out by Archaeological Surveys Ltd over 0.6ha at Swillbrook Farm, Minety. The results indicate the presence of widespread magnetic debris associated with modern dumping and burning. Weaker anomalies cannot be clearly defined as relating to cut features and are likely to also be associated with the ground disturbance/make-up. The survey area contained an orchard in the 19th and early 20th centuries and tree removal is also likely to have caused disturbance.

1 INTRODUCTION

1.1 *Survey background*

- 1.1.1 Archaeological Surveys Ltd was commissioned by Bourne Valley Associates Ltd, on behalf of Mr & Mrs P Walker, to undertake a magnetometer survey of an area of land at Swillbrook Farm in Minety. The site has been outlined for a proposed development of new stables, outdoor riding arena, horse walker, agricultural buildings, farm office and new access (Wiltshire Council planning application number 20/09054/FUL). The survey forms part of an archaeological assessment.
- 1.1.2 The geophysical survey was carried out in accordance with a Written Scheme of Investigation (WSI) produced by Archaeological Surveys (2020) and approved by Michal Cepak, 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 Geophysical survey can provide useful information on the archaeological potential of a site; however, the outcome of any survey relies on a number of factors and as a consequence results can vary. The success in meeting the aims and objectives of a survey is, therefore, often impossible to predetermine.

1.3 *Standards, guidance and recommendations for the use of this report*

- 1.3.1 The survey and report follow the recommendations set out by: European Archaeological Council (2015) *Guidelines for the Use of Geophysics in*

Archaeology; 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*.

- 1.3.2 Archaeological Surveys Ltd provide a detailed geophysical survey report and it is recommended that where possible the contents should be considered in full. The Summary provides a brief overview of the results with more detail available in the Discussion and/or Conclusion. The *List of anomalies* within the Results provides a detailed assessment of the anomalies within separate categories which can be useful in inferring a level of confidence to the interpretation. Quality and factors influencing the interpretation of anomalies is also set out within the results.
- 1.3.3 It is recommended that the full report should always be considered when using data and interpretation plots; where this is not possible, in the field for example, the abstraction and interpretation plots should retain their colour coding and be used with a corresponding legend.
- 1.3.4 Where targeting of anomalies by excavation is to be carried out, care should be taken to place trenches over solid lines or features visible on the abstraction and interpretation plots. Archaeological Surveys abstraction and interpretation avoids the use of dashed or dotted line formats, and broken or fragmented lines used in interpretive plots may well correspond closely with truncation of archaeological features.

1.4 Site location, description and survey conditions

- 1.4.1 The site is located at Swillbrook Farm on the northern edge of the parish of Minety, close to the county border with Gloucestershire which is defined by the Swill Brook. It is centred on Ordnance Survey National Grid Reference (OS NGR) SU 02300 93175, see Figs 01 and 02.
- 1.4.2 The geophysical survey covers approximately 0.6ha within the farmyard to the north of the farm complex at Swillbrook Farm. The site contained patches of dumped material, areas of burning, ground make-up and tracks. The northern and western boundaries to the site were hedgerows with several steel-framed barns located to the south.
- 1.4.3 The ground conditions across the site were variable but generally considered to be favourable for the collection of magnetometry data with the exception of a large mound of soil in the north eastern part of the site, some smaller zones of dumped soil in the south western part and an area of burning in the centre. Weather conditions during the survey were fine.

1.5 Site history and archaeological potential

- 1.5.1 The survey area lies to the north of the 19th century farmstead of Swillbrook

Farm (Wiltshire HER no. MWI66845) and 120m east of the site of a former outfarm (MWI66884). Earthwork platforms relating to a former medieval settlement are recorded 280m to the west (MWI9664) and extant ridge and furrow can be seen on aerial photos within the field immediately to the south west of the site. Ordnance Survey mapping shows the site containing trees, probably an orchard, between 1888 and 1924, but they had been removed by 1960.

- 1.5.2 The Swill Brook forms the county border between Wiltshire and Gloucestershire and is situated just over 200m to the north. Just to the north of this, the Gloucestershire HER records the site of a Romano-British settlement (HER no. 2404) and a field system (HER no. 3102), all subsequently removed by gravel extraction.

1.6 Geology and soils

- 1.6.1 The underlying solid geology across the site is mudstone from the Kellaways Clay Member with overlying deposits of Northmoor Sand and Gravel Member (BGS, 2017).
- 1.6.2 The overlying soil across the survey area is from the Kelmscot association which is a calcareo-cambic gley soil and consists of a calcareous, fine, loamy soil over gravel (Soil Survey of England and Wales, 1983).
- 1.6.3 Magnetometry survey carried out across similar soils has produced good results. The underlying geology and soils are, therefore, considered acceptable 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 (also known as thermoremanence) are factors associated with the formation of localised fields.
- 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). Additional details are set out in 2.2 below and within Appendix A.

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 (FGM650) spaced 0.5m apart with readings recorded at 20Hz. The cart is pushed at walking speed and not towed. Each sensor is not zeroed in the field as the vertical axis alignment is precisely fixed leaving sensor offsets that are removed during data processing. The fixing of the vertical alignment ensures the sensors are not unduly influenced by localised magnetic fields and that the vertical component of a magnetic anomaly is measured. The gradiometers have a measurement range of ± 8000 nT, although the recorded range is ± 3000 nT, and resolution is around 0.1nT. They are linked to a Leica GS10 RTK GNSS with data recorded by SENSYS MAGNETO®MXPDA software on a rugged PDA computer system.
- 2.2.2 Due to the fixed offsets within the fluxgate sensors, as a result of the manufacturing and tensioning process, the survey data do not provide a visually useful dataset until a zero median traverse algorithm is applied. It is recognised that this has the potential to affect some anomalies detrimentally by removing linear features orientated parallel to survey transects. However, this has not been noted as a particular problem with the system due to the high resolution data collection, generally long length of traverses and variability within the magnetic characteristics of a linear anomaly.
- 2.2.3 Data are collected along a series of parallel survey transects to achieve 100% coverage of the surveyable land. 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. 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).
- 2.2.4 Fluxgate sensors are highly sensitive to temperature change and this manifests as drift during the course of a survey. This can be particularly noticeable during the morning as temperatures rise and the equipment warms or cools. Sensor drift within the course of a traverse will appear as a line trending from negative to positive after

processing with a zero median traverse algorithm. To remove the potential for temperature drift, data were collected after a 20 minute stabilisation period and traverses were limited to a time of generally <60s.

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. The software effectively allocates a geographic position for each data point and can compensate for fixed offsets present within the FGM650 sensors. The offsets are positive or negative values present on all fluxgate gradiometer sensors. Some systems use manual or electronic balancing to effectively zero the sensors; however, this is a short term measure that is prone to drift through temperature changes and vibration and can easily be incorrectly set due to localised magnetic fields. The FGM650 sensors are very accurately aligned to the vertical magnetic gradient and are highly stable showing negligible drift on long traverses. The offset values are removed using TerraSurveyor software.
- 2.3.2 Survey tracks are analysed and georeferenced raw data (UTM Z30N) are then exported in ASCII format for further analysis and display within TerraSurveyor. The removal of the offset values (compensation) of the sensors is also carried out in TerraSurveyor using a zero median traverse function. Data are then considered to be minimally processed. Note: without the zero median traverse function it is not possible to create a meaningful data plot as all sensors have a different offset value. 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 The minimally processed data are collected between limits of $\pm 3000\text{nT}$ and clipped for display at $\pm 100\text{nT}$, $\pm 10\text{nT}$ and $\pm 3\text{nT}$ (Fig 03). Data are interpolated to a resolution of effectively 0.5m between tracks and 0.15m along each survey track.
- 2.3.4 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 processing.
- 2.3.5 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. With regard to the Sensys MXPDA, minimally processed data are considered by the manufacturer to be data that are compensated by SENSYS MAGNETO DLMGPS software, see 2.3.1 and 2.3.2. Note: traceplots are not considered to be appropriate as they do not provide an accurate or useful assessment of the magnetic anomalies due to the very high density of data collection. In addition, traceplots cannot be

meaningfully plotted against base mapping and in areas of complexity traces may be lost or highly confused. Traceplots may be used to demonstrate characteristic magnetic profiles across discrete features where it is considered beneficial.

- 2.3.6 The raster images are combined with base mapping using ProgeCAD Professional 2020, creating DWG (2018) 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 GNSS, resection method, etc.
- 2.3.7 An abstraction and interpretation is 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. Appendix E sets out CAD layer names with colour and graphic content for each interpretation category, see 3.3.
- 2.3.8 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.
- 2.3.9 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 a total of 0.6ha within a single survey area.
- 3.1.2 Magnetic anomalies located can be generally classified as positive anomalies of an uncertain 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. Anomalies located within the survey area are described in 3.4 below.

3.2 *Statement of data quality and factors influencing the interpretation of anomalies*

- 3.2.1 Data are considered representative of the magnetic anomalies present within the site. There are no significant defects within the dataset.
- 3.2.2 The site is likely to have been subject to periodic soil dumping and disposal of waste by burning due to its close proximity to the farmyard. Numerous ferrous objects were visible in the soil during the course of the survey and, as a consequence, high magnitude responses were recorded. Zones of high

magnitude magnetic debris have the potential to obscure weaker anomalies of archaeological potential should they exist within those areas but quieter parts of the area were encountered, particularly on the western side and near the north western corner.

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 general explanation of the characteristics of the magnetic anomalies is set out for each category in order to justify interpretation, see Table 1.

Interpretation category	Description and origin of anomalies
Anomalies with an uncertain origin	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> . Morphology may be unclear or uncharacteristic and there may be a lack of additional supporting information. 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	Magnetic debris often appears as areas containing many small dipolar anomalies that may range from weak to very strong in magnitude. They often occur where there has been dumping or ground make-up and are 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, hearths and nail spreads from former wooden structures or rooves 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.
Anomalies with a modern origin	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 these 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 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 Anomalies located by the survey

Area centred on OS NGR 402300 193175, see Fig 03.

3.4.1 The survey area contains widespread strongly magnetic debris derived from dumped material and burning. Where there is less material the results indicate several weakly positive responses; however, these may well also relate to dumped soil and ground disturbance/make-up and cannot be clearly interpreted as cut features.

4 CONCLUSION

- 4.1.1 The results of the geophysical survey indicate widespread magnetic debris associated with dumping and burning. Several weaker anomalies were located in magnetically quieter zones, but these could also be the result of dumping or ground disturbance. The area has been used as a farmyard with widespread dumped material and bonfires and was previously an orchard until the mid 20th century. The area has also been subject to much ground disturbance in the recent past.

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 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 magnetic field. The difference between the two sensors will relate to the strength of 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. 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 data from 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 offset values of the gradiometer sensors. The process can remove archaeological features that run along a traverse but with the high resolution datasets created by the Sensys FGM650 sensors and the method of data collection this has not been a notable problem. In fact, the removal of offsets using software avoids carrying out a balancing procedure on site, which inevitably can never be done in magnetically clean conditions and results in improperly aligned fluxgate sensors and/or electronic adjustment values.

Appendix C – survey and data information

Filename:	J845-mag-proc-100nT.xcp	GPS based Proce4
Description:	Imported as Composite from: J845-mag.asc	1 Base Layer.
Instrument Type:	Sensys DLMGPS	2 Unit Conversion Layer (Lat/Long to OSGB36).
Units:	nT	3 DeStripe Median Traverse:
UTM Zone:	30U	4 Clip from -100.00 to 100.00 nT
Survey corner coordinates (X/Y):	OSGB36	Filename:
Northwest corner:	402250.47, 193231.44 m	J845-mag-proc-10nT.xcp
Southeast corner:	402372.12, 193117.89 m	GPS based Proce5
Collection Method:	Randomised	1 Base Layer.
Sensors:	5	2 Unit Conversion Layer (Lat/Long to OSGB36).
Dummy Value:	32702	3 DeStripe Median Traverse:
Source GPS Points:	213400	4 High pass Uniform (median) filter: Window dia: 300
Dimensions		5 Clip from -10.00 to 10.00 nT
Composite Size (readings):	811 x 757	Filename:
Survey Size (meters):	122 m x 114 m	J845-mag-proc-3nT.xcp
Grid Size:	122 m x 114 m	Stats
X Interval:	0.15 m	Max:
Y Interval:	0.15 m	Min:
Stats		Std Dev:
Max:	110.50	Mean:
Min:	-110.00	Median:
Std Dev:	37.25	GPS based Proce6
Mean:	-1.09	1 Base Layer.
Median:	0.07	2 Unit Conversion Layer (Lat/Long to OSGB36).
Composite Area:	1.3813 ha	3 DeStripe Median Traverse:
Surveyed Area:	0.59771 ha	4 High pass Uniform (median) filter: Window dia: 300
PROGRAM		5 Clip from -10.00 to 10.00 nT
Name:	TerraSurveyor	6 Clip from -3.00 to 3.00 nT
Version:	3.0.23.0	

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 PDF copy will be supplied to the Wiltshire Historic Environment Record with greyscale images and abstraction layers made available on request. The report will also be uploaded to the Online Access to the Index of archaeological investigations (OASIS).

Archive contents:

File type	Naming scheme	Description
Data	J845-mag-[area number/name].asc J845-mag-[area number/name].xcp J845-mag-[area number/name]-proc.xcp	Raw data as ASCII CSV TerraSurveyor raw data TerraSurveyor minimally processed data
Graphics	J845-mag-[area number/name]-proc.tif	Image in TIF format
Drawing	J845-[version number].dwg	CAD file in 2010 dwg format
Report	J845 report.odt	Report text in Open Office odt format

Table 2: Archive metadata

Appendix E – CAD layers for abstraction and interpretation plots

The table below sets out Archaeological Surveys Ltd CAD layer names with associated colours and graphical content. Where CAD files are available layers may be extracted for further CAD/GIS use. Note: hatched polygon boundaries are contained within layers with the RGB colour code 254, 255, 255 (near white) in order to prevent their visibility.






Report sub-heading and associated CAD layer names	Colour with RGB index	Layer content
Anomalies with an uncertain origin		
AS-ABST MAG POS LINEAR UNCERTAIN	 255,127,0	Line, polyline or polygon (solid)
Anomalies associated with magnetic debris		
AS-ABST MAG DEBRIS	 132, 132, 132	Polygon (cross hatched ANSI37)
AS-ABST MAG STRONG DIPOLAR	 132, 132, 132	Solid donut, point or polygon (solid)
Anomalies with a modern origin		
AS-ABST MAG DISTURBANCE	 132, 132, 132	Polygon (hatched ANSI31)
AS-ABST MAG SERVICE	 132, 132, 132	Line or polyline

Table 3: CAD layering

Appendix F – copyright and intellectual property

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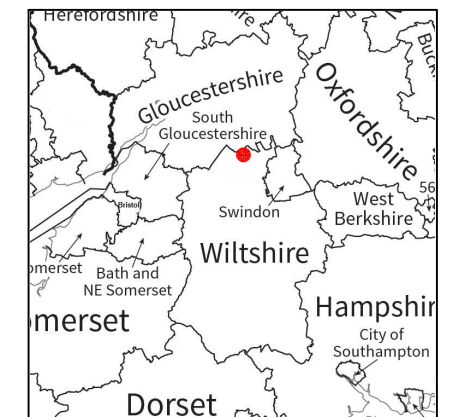


**Geophysical Survey
Swillbrook Farm
Minety
Wiltshire**

Map of survey area



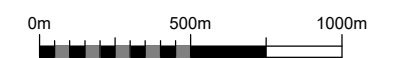
Survey location



● Survey location

Site centred on OS NGR
SU 02300 93175

SCALE 1:25 000



SCALE TRUE AT AS

Geophysical Survey
Swillbrook Farm
Minety
Wiltshire

Referencing information

Referencing grid to OSGB36 datum at 100m intervals

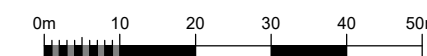
● 402300 193200

— Survey tracks

⋯ Survey track start

⋯ Survey track stop

SCALE 1:1000

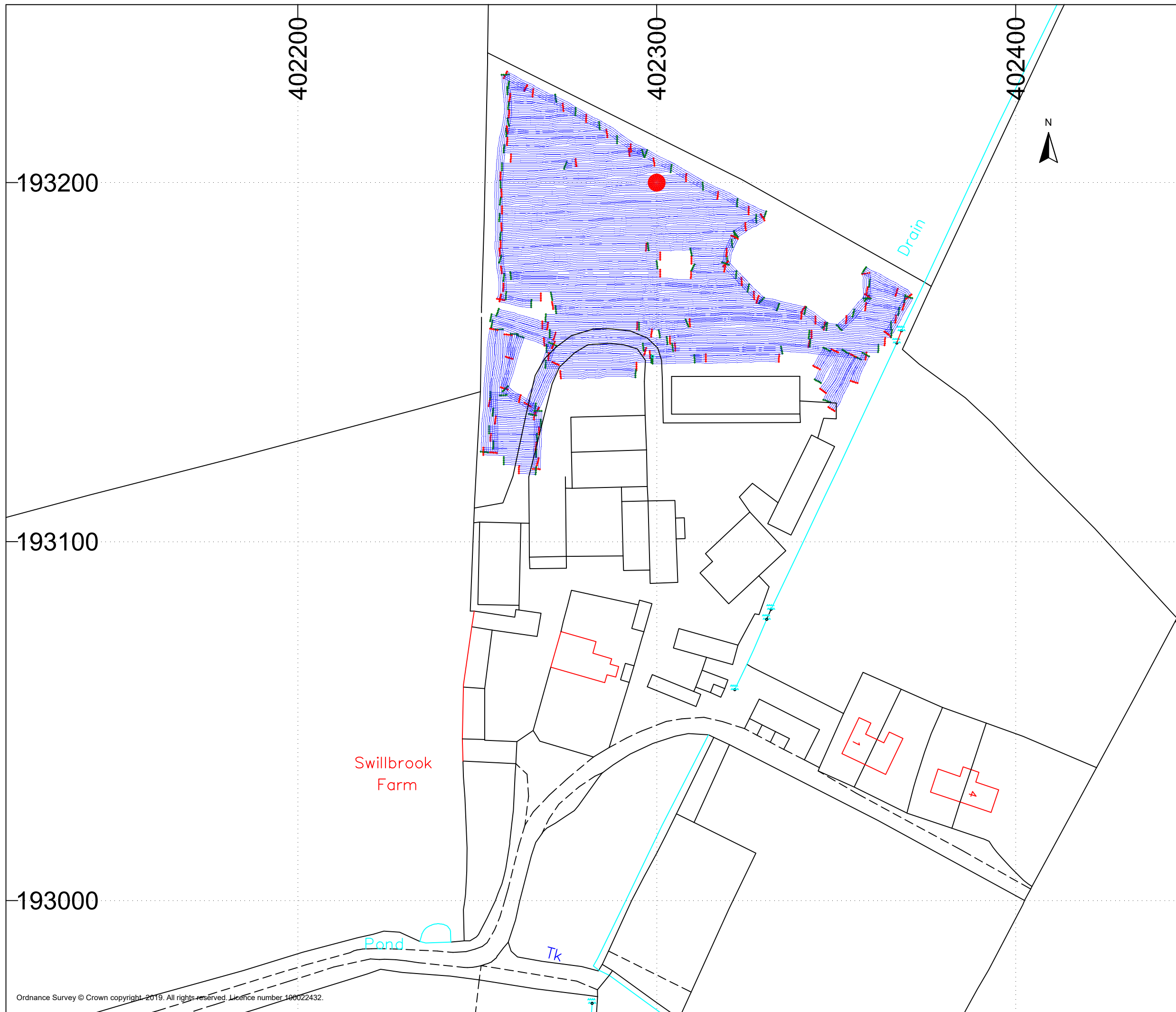


SCALE TRUE AT AS

DRAWN BY
KTD







CHECKED BY
DJS

FIG 02

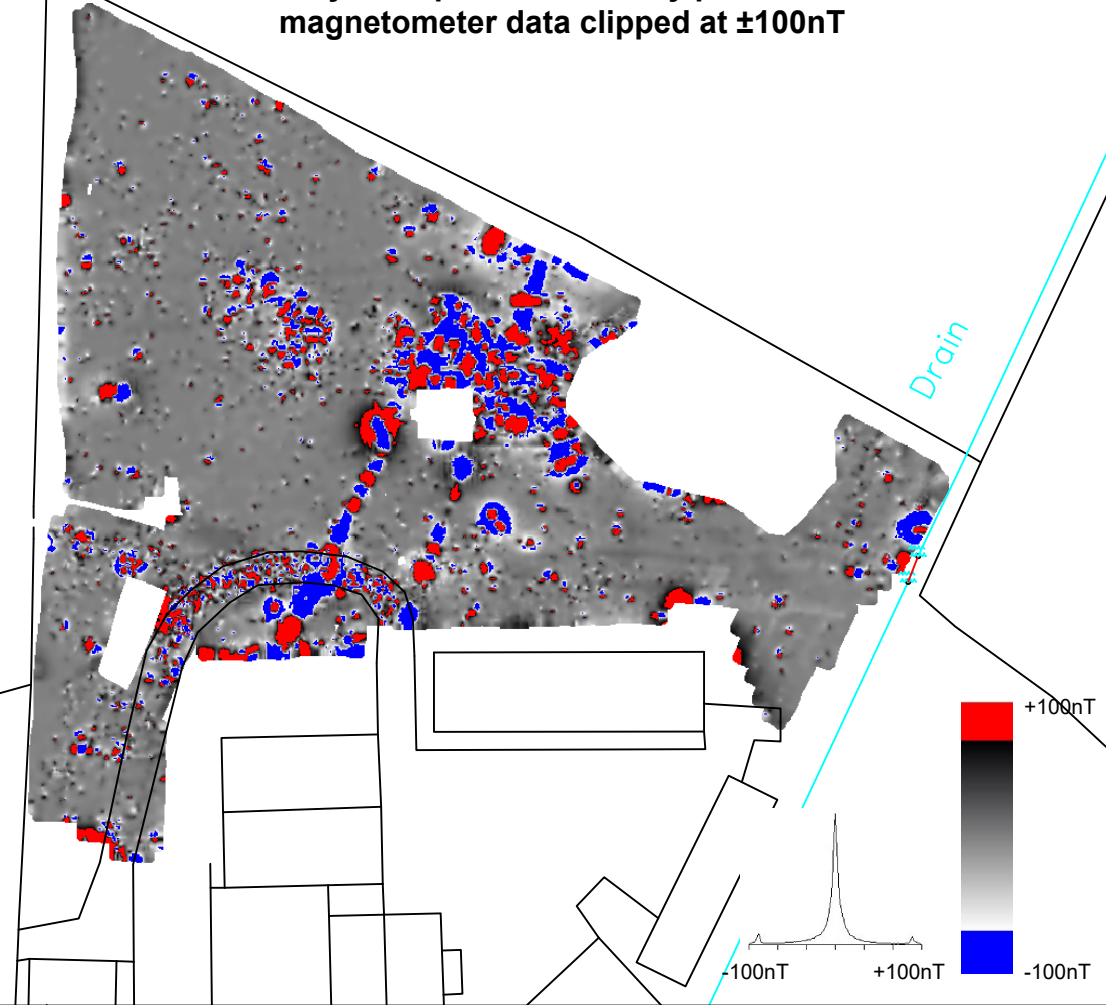


**Geophysical Survey
Swillbrook Farm
Minety
Wiltshire**

Greyscale plots of magnetometer data & abstraction & interpretation of magnetic anomalies

-  Positive linear anomaly - magnetic enhancement of uncertain origin
-  Positive anomaly - magnetically enhanced material
-  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

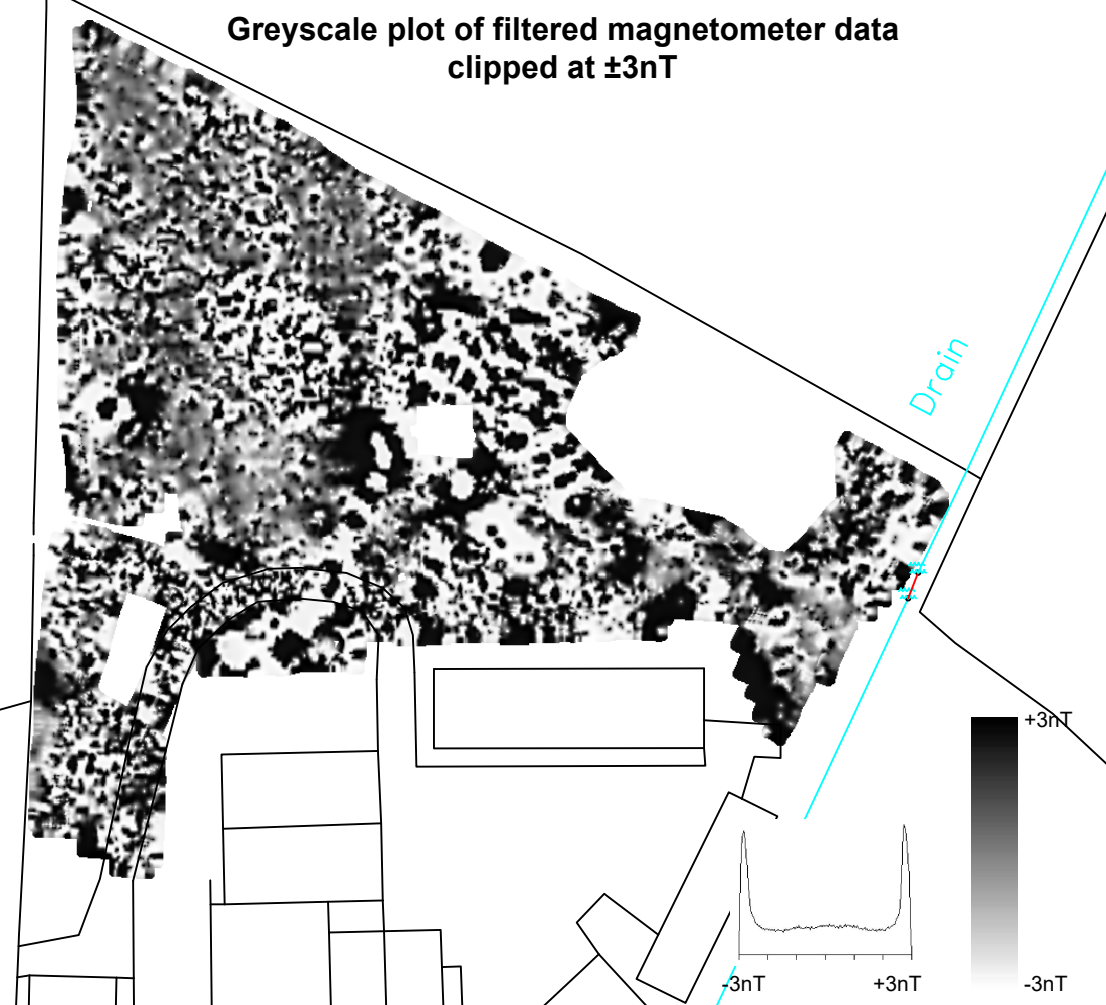
Greyscale plot of minimally processed magnetometer data clipped at $\pm 100\text{nT}$



Greyscale plot of filtered magnetometer data clipped at $\pm 10\text{nT}$



Greyscale plot of filtered magnetometer data clipped at $\pm 3\text{nT}$



SCALE 1:1000



SCALE TRUE AT A3

DRAWN BY
KTD

CHECKED BY
DJS

FIG 03