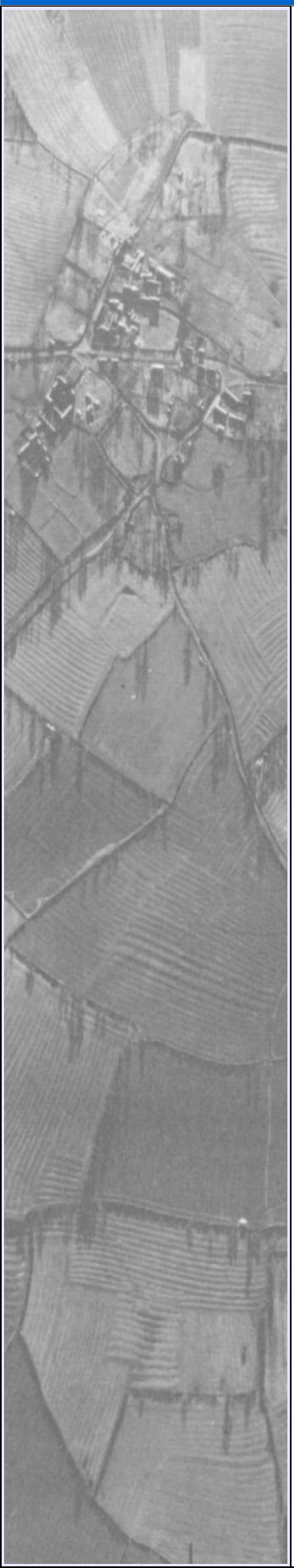

Block 11 Marlborough Park
Pipers Way
Swindon

MAGNETOMETER SURVEY REPORT

for

Oxford Archaeology

on behalf of

Places for People

Kerry Donaldson & David Sabin

April 2018

Ref. no. J746

ARCHAEOLOGICAL SURVEYS LTD

Block 11 Marlborough Park
Pipers Way
Swindon

Magnetometer Survey Report

for

Oxford Archaeology

on behalf of

Places for People

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 – 6th April 2018
Ordnance Survey Grid Reference – **SU 16062 82433**

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SUMMARY

Detailed magnetometry was carried out by Archaeological Surveys Ltd over a small area of land to the east of Pipers Way in Swindon. The survey located widespread magnetic contamination relating to steel/iron objects and possibly also magnetically thermoremnant material such as brick. The material is likely to be associated with landscaping and ground make up during earlier construction activity to the north of the site. The high magnitude of the magnetic contamination may obscure anomalies relating to archaeologically significant features should they exist below the made ground.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Oxford Archaeology, on behalf of Places for People, to undertake a magnetometer survey of an area of land at Marlborough Park, off Pipers Way in Swindon. The site has been outlined for a proposed residential development and the survey forms part of an archaeological assessment. The survey has been carried out within a small area, known as Block 11, at the western edge of the Marlborough Park development.

1.1.2 The geophysical survey was carried out in accordance with a Written Scheme of Investigation (WSI) produced by Archaeological Surveys (2018) and approved by Melanie Pomeroy-Kellinger, County Archaeologist for Wiltshire Council Archaeology Service, prior to commencing the survey.

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.

1.2.2 The methodology is considered an efficient and effective approach to archaeological prospection.

1.2.3 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 generally follow the recommendations set out by:

English Heritage (2008) *Geophysical survey in archaeological field evaluation;* 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 lines; broken or fragmented anomalies may well correspond closely with subsurface truncation.

1.4 Site location, description and survey conditions

1.4.1 The site is located on land to the east of Pipers Way, south of Wakefield House, Aspect Park and to the north of Broome Manor Golf Course. It is centred on Ordnance Survey National Grid Reference (OS NGR) SU 16062 82433, see Figs 01 and 02.

1.4.2 The geophysical survey covers approximately 0.7ha of mown grass, which slopes down to the south. The eastern boundary is a metalled service road and further to the east construction associated with the Marlborough Park development was underway. The service road contains numerous inspection chambers with a large steel lid covering a chamber located on high ground within the northern part of the survey area. At least two borehole monitoring points were noted along the eastern side of the survey area. A mature hedge forms the western boundary with a new hedge to the south and steel mesh fencing to the north.

Plate 1: Survey area looking towards the south

1.4.3 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 although very wet conditions had prevailed prior to the survey and the land was saturated.

1.5 Site history and archaeological potential

1.5.1 Previous archaeological investigations by Oxford Archaeology between 2004 and 2009 on land immediately to the south east revealed two phases of activity. Late Iron Age and early Roman enclosures were located with a second phase of occupation and activity during the medieval period. This included features from the 11th-13th centuries with two rectangular enclosures, a series of stakeholes and a crop drying oven represented by a pit filled with large quantities of burnt material (Oxford Archaeology, 2010). The 1923 Ordnance Survey map indicates "ancient foundations" under a modern mound just to the south of the current survey area. It also shows that Broome Sewage Farm and allotment gardens were situated on land to the west. During construction of Wakefield House (formerly Burmah House) to the north in the 1970s, associated landscaping was responsible for modern disturbance and truncation in the wider area (Oxford Archaeology, 2010).

1.6 Geology and soils

1.6.1 The underlying solid geology across the site is sandstone from the Kimmeridge Clay Formation (BGS, 2017).

1.6.2 The overlying soil across the survey area is mapped as from the Wickham 3 association and is a typical stagnogley soil. It consists of a slowly permeable, seasonally waterlogged, fine, loamy over clayey soil (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. However, modern landscaping and ground make-up may contain material that could obscure weaker underlying 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 (FGM650) spaced 0.5m apart with readings recorded at 20 Hz. 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 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 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 is manifest 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 <100s.

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 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 ±10000nT and clipped for display at ±250nT and ±20nT. 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.

2.3.6 The raster images are combined with base mapping using ProgeCAD Professional 2016, 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.

2.3.7 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 approximately 0.7ha within a single survey area.

3.1.2 Magnetic anomalies located can be generally classified as areas of magnetic debris.

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 survey area contains widespread magnetic debris that is consistent with ground make-up using soil mixed with other magnetic materials of modern origin (ferrous objects and magnetically thermoremnant material such as brick/tile). The slightly convex east - west profile of the survey area and lack of modern debris visible on the surface may indicate a covering of cleaner soil. The magnitude and density of the magnetic material is likely to mask anomalies relating to archaeological features should they exist within the site

3.3 Summary of results

3.3.1 The entire site contains widespread strongly magnetic debris. Many of the anomalies are several metres in diameter and have a response of over 1000nT, which indicates ferrous objects (steel or iron). The wider area was subject to landscaping and ground make-up during construction works to the north during the 1970s and the results of the survey indicate that the entire area has been subject to ground disturbance and make-up. Due to the widespread and very highly magnetic responses it is not possible to determine the presence of weaker anomalies.

4 CONCLUSION

4.1.1 The detailed magnetometry results indicate widespread strongly magnetic debris across the entire site due to former landscaping and ground make-up, and it is not possible to determine if any weaker anomalies, relating to archaeologically significant features, are present.

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 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. 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, modern agricultural features and other large magnetic bodies within or adjacent to survey areas.

Low Pass Filtering

A mathematical process used to remove high frequency anomalies relating to uneven ground, vibration, etc.

Appendix C – survey and data information

Minimally processed data clipped at ±20nT

Filename: J746-mag-proc.xcp
Description: Imported as Composite from: J746-mag.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):OSGB36
Northwest corner: 416016.706299469, 182528.415885868 m
Southeast corner: 416091.106299469, 182338.065885868 m
Collection Method: Randomised
Sensors: 5
Dummy Value: 32702
Source GPS Points: 186600
Dimensions
Composite Size (readings): 496 x 1269
Survey Size (meters): 74.4 m x 190 m
Grid Size: 74.4 m x 190 m
X Interval: 0.15 m
Y Interval: 0.15 m
Stats
Max: 22.10
Min: -22.00
Std Dev: 14.41
Mean: -0.04
Median: 0.28
Composite Area: 1.4162 ha
Surveyed Area: 0.68528 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 -20.00 to 20.00 nT

Minimally processed data clipped at ±250nT

Filename: J746-mag-proc-2.xcp
Stats
Max: 276.25
Min: -275.00
Std Dev: 75.47
Mean: 1.09
Median: 0.48
Composite Area: 1.4162 ha
Surveyed Area: 0.68528 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 -250.00 to 250.00 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:

File type	Naming scheme	Description
Data	J746-mag-**[area number/name]**.asc J746-mag-**[area number/name]**.xcp J746-mag-**[area number/name]**-proc.xcp	Raw data as ASCII CSV TerraSurveyor raw data TerraSurveyor minimally processed data
Graphics	J746-mag-**[area number/name]**-proc.tif	Image in TIF format
Drawing	J746-**[version number]**.dwg	CAD file in 2010 dwg format
Report	J746 report.odt	Report text in Open Office odt format

Table 1: Digital archive data

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 associated with magnetic debris			
AS-ABST MAG DEBRIS		132, 132, 132	Polygon (cross hatched ANSI37)

Table 2: CAD layering

Appendix F – copyright and intellectual property

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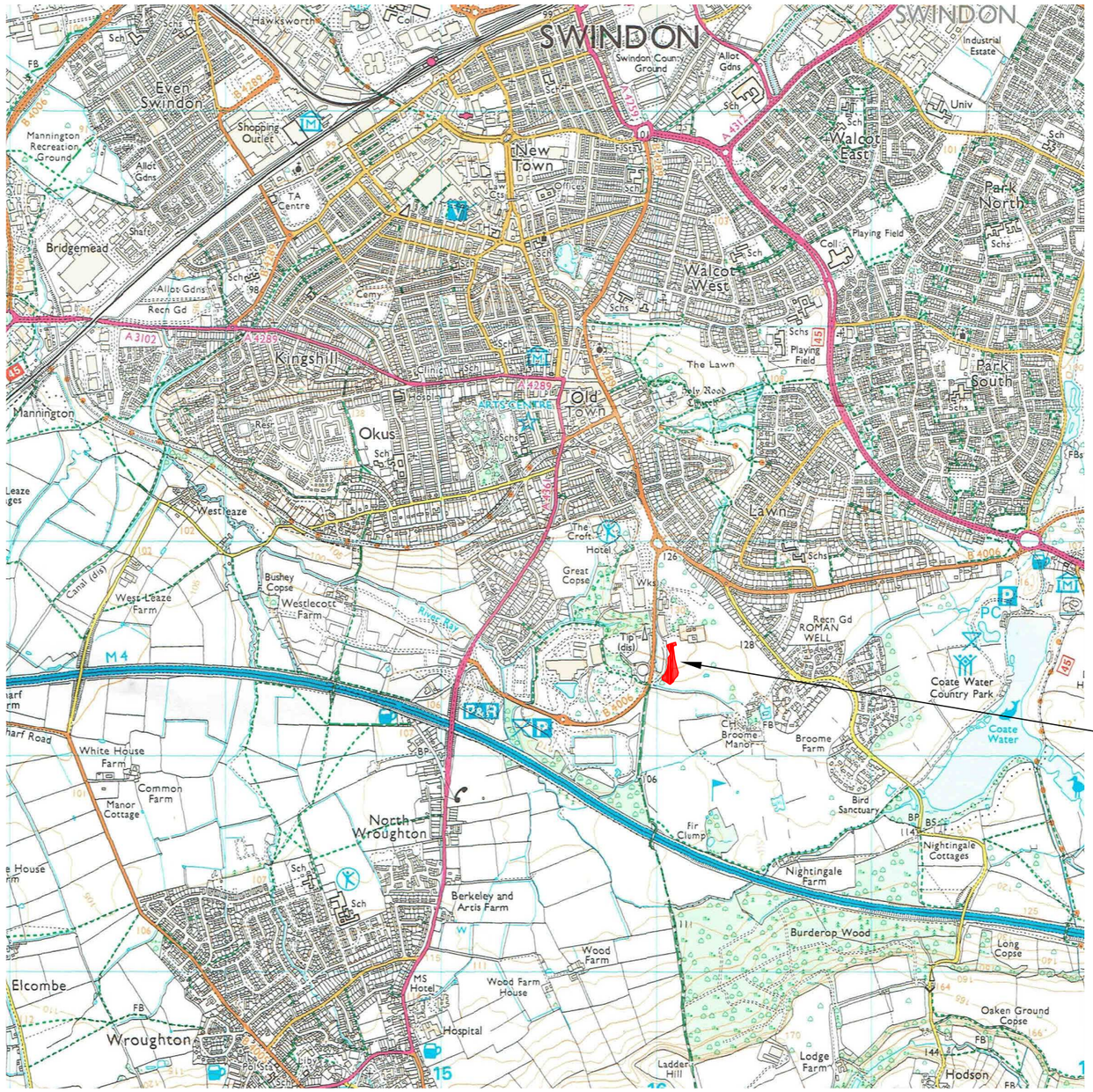

Survey location

Archaeological Surveys Ltd

Geophysical Survey
Block 11 Marlborough Park
Pipers Way
Swindon

Map of survey area

● Survey location

Site centred on OS NGR
SU 16062 82433

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

FIG 01

Archaeological Surveys Ltd

Geophysical Survey
Block 11 Marlborough Park
Pipers Way
Swindon

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

● 416050 182350

SCALE 1:1500

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 02

Archaeological Surveys Ltd

Geophysical Survey
Block 11 Marlborough Park
Pipers Way
Swindon

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

Marlborough Lane

Allotment Gardens

Drain

+250nT

-250nT

-250nT

+250nT

+20nT

-20nT

-20nT

+20nT

N

Magnetic debris - spread of magnetically thermoremnant/ferrous material

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 03