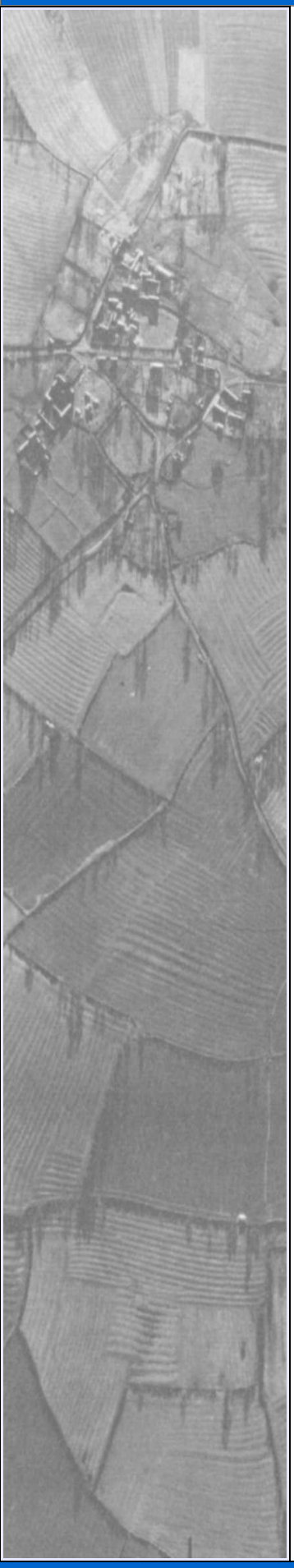

Bath College
Somer Valley Campus
Radstock
Bath & North East Somerset

MAGNETOMETER SURVEY REPORT

for

Cotswold Archaeology

Kerry Donaldson & David Sabin

June 2016

Ref. no. J670

ARCHAEOLOGICAL SURVEYS LTD

Bath College
Somer Valley Campus
Radstock
Bath & North East Somerset

Magnetometer Survey Report

for

Cotswold Archaeology

Fieldwork by David Sabin (Hons) MCIfA
Report by Kerry Donaldson BSc (Hons)
Report checked by David Sabin
Primary archive location - Archaeological Surveys Ltd, Yatesbury, Wiltshire

Survey date – 27th June 2016
Ordnance Survey Grid Reference – **ST 68440 54615**

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SUMMARY

A detailed magnetometer survey was carried out by Archaeological Surveys Ltd, at the request of Cotswold Archaeology, within the Bath College Somer Valley Campus in Radstock, Bath & North East Somerset. The results demonstrate the presence of widespread magnetic debris, indicative of ground make up, and this may have obscured weaker anomalies. A number of positive linear responses have been located within a car park but these cannot be confidently characterised as cut features. A former field boundary is associated with widespread magnetic debris and to the west of this are a number of linear, curvilinear and discrete positive responses. Again, due to the presence of strongly magnetic debris the origin of the anomalies is uncertain. In the western part of the site are a number of positive and negative linear and rectilinear anomalies, and it is possible that these are associated with the use of this part of the site for allotments during the early 20th century.

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 the Bath College Somer Valley Campus in Radstock, Bath & North East Somerset (B&NES). The site has been outlined for a proposed development of a construction skills centre. The geophysical survey has been requested by Richard Sermon, B&NES Senior Archaeological Officer, and 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 Chartered Institute for Archaeologists (2014) *Standard and Guidance for Archaeological Geophysical Survey.*

1.3 Site location, description and survey conditions

1.3.1 The site is located at the Bath College Somer Valley Campus, Wells Road, Radstock. It is centred on Ordnance Survey National Grid Reference (OS

NGR) ST 68440 54615, see Figures 01 and 02.

Plate 1: Survey area looking north

1.3.2 The geophysical survey covers approximately 0.85ha mainly covering lawn, with a small area of car park available for survey (see Plate 1 above). The latter is surrounded by a bank and has a surface formed by Carboniferous limestone chippings. Wire mesh fencing is present along part of the southern edge of the survey area, and several steel lamp posts are located around the perimeter of the car park.

1.3.3 The ground conditions across the site were generally considered to be favourable for the collection of magnetometry data. Some small patches of very long grass were encountered in the northern part of the survey area but these did not impede the survey. Weather conditions were mainly fine.

1.4 Site history and archaeological potential

1.4.1 A Historic Environment Desk-Based Assessment has been carried out by Cotswold Archaeology (2016a). The site of a Bronze Age round barrow is listed on the HER as lying on the south eastern edge of the proposed development area. However, this was excavated by local antiquarian Rev. John Skinner in 1780 and although skeletons were found within, there is little recorded detail of the excavations, contents or accurate location of the barrow.

1.4.2 The nearest Scheduled Monument is at Camerton, 1.4km to the north which is the site of a Roman town, but includes evidence for activity and occupation from the Neolithic to the early medieval period. It also contains a number of Bronze Age round barrows and a 5th/6th century Saxon cemetery. A second Iron Age/Romano-British settlement is located at Tyning Colliery, 1.2km north east of the site. There is further evidence for Roman activity 360m to the east with a tombstone in the St Nicholas churchyard and Roman finds 500m south

of the site.

1.4.3 The site is depicted on the 1759 Map of Radstock as being within agricultural fields with a field boundary dividing the survey area. Allotments are recorded to the west of this field boundary in 1931, but both had been removed by 1967 when the site is depicted as playing fields, with the Norton Radstock Technical College buildings further east. More recently, a road, car parks and a new college building have been built on the site. An Archaeological Watching Brief carried out by Cotswold Archaeology (2016b) during geotechnical investigations records evidence for ground make up in several of the trial pits and boreholes.

1.4.4 The possible location of the round barrow investigated by Skinner in 1780 indicates that there is potential for the site to contain buried archaeological remains. However, the eastern part of the site contains a car park and much of the site has been subject to ground make up and levelling and this may have truncated/obscured any potential buried features. The presence of modern material, coupled with the former use of the western part of the site as allotments, may indicate that there will be widespread magnetic anomalies associated with the modern use of the site.

1.5 Geology and soils

1.5.1 The underlying geology is undifferentiated mudstone and limestone from the Langport Member and Blue Lias Formation (BGS, 2016).

1.5.2 The overlying soil across the site is not mapped due to its urban location; however, as the underlying geology is Jurassic clay and limestone, it may be from the Sherborne association which is a brown rendzina consisting of a shallow, well drained, brashy, calcareous, clayey soil over limestone (Soil Survey of England and Wales, 1983). A watching brief carried out during geotechnical investigations indicates that the natural substrate is mid orange brown clay with frequent angular limestone inclusions, overlain in places by a layer of modern make up containing coal, clinker and glass in several of the trial pits and boreholes (Cotswold Archaeology, 2016b).

1.5.3 Magnetometry carried out over similar geology and soil has produced good results. The site is, therefore, considered suitable for magnetic survey although modern magnetic material may obscure weaker features.

2 METHODOLOGY

2.1 Technical synopsis

2.1.1 Magnetometry survey records localised magnetic fields that can be associated with features formed by human activity. Magnetic susceptibility and magnetic thermoremnance are factors associated with the formation of localised fields.

Additional details are set out below and within Appendix A.

2.1.2 Iron minerals within the soil may become altered by burning and the break down of biological material; effectively the magnetic susceptibility of the soil is increased, and the iron minerals become magnetic in the presence of the Earth's magnetic field. Accumulations of magnetically enhanced soils within features, such as pits and ditches, may produce magnetic anomalies that can be mapped by magnetic prospection.

2.1.3 Magnetic thermoremnance can occur when ferrous minerals have been heated to high temperatures such as in a kiln, hearth, oven etc. On cooling, a permanent magnetisation may be acquired due to the presence of the Earth's magnetic field. Certain natural processes associated with the formation of some igneous and metamorphic rock may also result in magnetic thermoremnance.

2.1.4 The localised variations in magnetism are measured as sub-units of the Tesla, which is a SI unit of magnetic flux density. These sub-units are nano Teslas (nT), which are equivalent to 10^{-9} Tesla (T).

2.2 Equipment configuration, data collection and survey detail

2.2.1 The detailed magnetic survey was carried out using a SENSYS MAGNETO®MXPDA 5 channel cart-based system. The instrument has 5 fluxgate gradiometers spaced 0.5m apart with readings recorded at 20Hz. The gradiometers have a range of recording data between 0.1nT and 10,000nT. The sensors are not zeroed in the field, as the vertical axis alignment is fixed using a tension band system. In order to produce visible, useful greyscale images a zero median traverse process is undertaken in TerraSurveyor. The system is linked to a Leica GS10 RTK GPS with data recorded by SENSYS MAGNETO®MXPDA software on a rugged computer.

2.2.2 Data are collected along a series of parallel survey tracks wherever possible. The length of each track is variable and relates to the size of the survey area and other factors including ground conditions. A visual display aids accurate placing of tracks and their separation.

2.2.3 Data are not collected within fixed grids and data points are considered to be random even though the data are collected in a systematic manner covering all accessible areas (Aspinall, Gaffney and Schmidt, 2009).

2.3 Data processing and presentation

2.3.1 Magnetic data collected by the MAGNETO®MXPDA cart-based system are initially prepared using SENSYS MAGNETO®DLMGPS software. Survey tracks are analysed and georeferenced raw data (UTM Z30N) are then exported in ASCII format for further analysis and display using TerraSurveyor.

2.3.2 The data are collected between limits of ±10000nT and clipped for display at

±10nT. Data are interpolated to a resolution of effectively 0.5m between tracks and 0.15m along each survey track. A zero median traverse function is required in order to remove fixed offset values present within the sensors which do not undergo a zeroing procedure in the field. The approach ensures that the gradiometer sensors are very accurately aligned and fixed to the vertical magnetic field and are not influenced by localised magnetic fields or disturbed by vibration. Although a zero median traverse algorithm can remove anomalies aligned with the survey tracks, in practice this rarely occurs due to the use of long traverses, high resolution measurement and variability within the magnetic susceptibility of long linear features.

2.3.3 Appendix C contains metadata concerning the survey and data attributes and is derived directly from TerraSurveyor. Reference should be made to Appendix B for further information on any processes, such as clipping, carried out on the data.

2.3.4 A TIF file is produced by TerraSurveyor software along with an associated world file (.TFW) that allows automatic georeferencing (OSGB36 datum) when using GIS or CAD software. The main form of data display used in the report is the minimally processed greyscale plot.

2.3.5 The raster images are combined with base mapping using ProgeCAD Professional 2014, creating DWG (2010) file formats. All images are externally referenced to the CAD drawing in order to maintain good graphical quality. The CAD plots are effectively georeferenced facilitating relocation of features using GPS, resection method, etc.

2.3.6 An abstraction and interpretation is also drawn and plotted for all geophysical anomalies located by the survey. Anomalies are abstracted using colour coded points, lines and polygons. All plots are scaled to landscape A3 for paper printing.

2.3.7 A brief summary of each anomaly, with an appropriate reference number, is set out in list form within the results (Section 3) to allow a rapid and objective assessment of features within the survey area.

2.3.8 A digital archive is produced with this report, see Appendix D below. The main archive is held at the offices of Archaeological Surveys Ltd.

3 RESULTS

3.1 General assessment of survey results

3.1.1 The detailed magnetic survey was carried out over approximately 0.85ha within an irregularly shaped area of lawn and a small section of car park.

3.1.2 Magnetic anomalies located can be generally classified as positive and

negative anomalies of an uncertain origin, anomalies associated with land management, areas of magnetic debris and disturbance and strong discrete dipolar anomalies relating to ferrous objects. Anomalies located within each survey area have been numbered and are described in 3.4 below.

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. Magnetic debris is widespread and has 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**
Anomalies with an uncertain origin AS-ABST MAG POS LINEAR UNCERTAIN AS-ABST MAG NEG LINEAR UNCERTAIN AS-ABST MAG POS DISCRETE UNCERTAIN 	The category applies to a range of anomalies where there is not enough evidence to confidently suggest an origin. Anomalies in this category may well be related to archaeologically significant features, but equally relatively modern features, geological/pedological features and agricultural features should be considered. Positive anomalies are indicative of magnetically enhanced soils that may form the fill of 'cut' features or may be produced by accumulation within layers or 'earthwork' features; soils subject to burning may also produce positive anomalies. Negative anomalies are produced by material of comparatively low magnetic susceptibility such as stone and subsoil.
Anomalies 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.
Anomalies associated with magnetic debris AS-ABST MAG DEBRIS AS-ABST MAG STRONG DIPOLAR 	Magnetic debris often appears as areas containing many small dipolar anomalies that may range from weak to very strong in magnitude. It often occurs where there has been dumping or ground make-up and is related to magnetically thermoremnant materials such as brick or tile or other small fragments of ferrous material. This type of response is occasionally associated with kilns, furnace structures, or hearths and may therefore be archaeologically significant. It is also possible that the response may be caused by natural material such as certain gravels and fragments of igneous or metamorphic rock. Strong discrete dipolar anomalies are responses to ferrous objects within the topsoil.

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

Table 1: List and description of interpretation categories

3.4 List of anomalies

Area centred on OS NGR 368440 154615, see Figs 03 & 04.

Anomalies with an uncertain origin

(1) - Within the car park area are a small number of very weakly positive linear and discrete anomalies. Due to the presence of modern ground make-up and magnetic debris the anomalies are indistinct and it is not possible to determine their origin.

(2) - A group of positive linear, curvilinear and discrete anomalies are located immediately west of former field boundary (5) within a zone containing widespread magnetic debris (6). Due to the presence of numerous strong dipolar responses it is not clear if this relates to a cut feature, magnetically enhanced material or modern material associated with the magnetic debris.

(3) - In the western part of the survey area are a number of positive and negative linear and rectilinear anomalies. They are generally parallel with the existing and former field boundaries and this part of the site is recorded as containing allotments in the 1930s and it is possible that these anomalies are associated.

(4) - A positive and negative linear anomaly extend across the survey area and appear to end or join former field boundary (5). This type of response may indicate former unmapped land division, possibly again associated with the allotments, but on a slightly different orientation.

Anomalies associated with land management

(5) - A positive linear anomaly, associated with a wider zone of magnetic debris (6), relates to a former land boundary that is mapped within the site and has been removed by 1967.

Anomalies associated with magnetic debris

(6 & 7) - The majority of the site contains widespread and strongly magnetic debris. Only the most concentrated areas have been abstracted but all of the site has been affected to a greater or lesser degree. There is a concentration in the southern part

of the site clustered along and close to former field boundary (5) but with spreads into the car park to the east and associated with anomalies (4) to the west. In the north eastern part of the site, very large, strongly magnetic responses have been located (7). The material is likely to be related to ground make-up.

(8) - The entire site contains widespread and numerous strong, discrete, dipolar responses and these relate to buried ferrous and other magnetically thermoremnant objects.

4 CONCLUSION

4.1.1 The results of the geophysical survey indicate that there is widespread magnetic contamination within the site indicative of ground make-up. A small number of weakly positive responses have been located within the car park area; however, they are indistinct and lack a coherent morphology preventing confident interpretation. A former field boundary is associated with widespread and strongly magnetic debris in the centre of the site, and a group of positive linear, curvilinear and discrete responses are located immediately adjacent to this former boundary. It is not clear if they relate to cut features or a cluster of magnetic responses associated with the magnetic debris. In the western part of the site a number of positive and negative linear and rectilinear anomalies are parallel with the existing and former land boundaries, and may be associated with the use of this part of the site as allotments in the early 20th century.

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Appendix A – basic principles of magnetic survey

Iron minerals are always present to some degree within the topsoil and enhancement associated with human activity is related to increases in the level of magnetic susceptibility and thermoremnant material.

Magnetic susceptibility is an induced magnetism within a material when it is in the presence of a magnetic field. This can be thought of as effectively permanent due to the presence of the Earth's magnetic field.

Thermoremnant magnetism occurs when ferrous material is heated beyond a specific temperature known as the Curie Point. Demagnetisation occurs at this temperature with re-magnetisation by the Earth's magnetic field upon cooling.

Enhancement of magnetic susceptibility can occur in areas subject to burning and complex fermentation processes on biological material; these are frequently associated with human settlement. Thermoremnant features include ovens, hearths, and kilns. In addition thermoremnant material such as tile and brick may also be associated with human activity and settlement.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil can create an area of enhancement compared with surrounding soils and subsoils into which the feature is cut. Mapping enhanced areas will produce linear and discrete anomalies allowing an assessment and characterisation of hidden subsurface features.

It should be noted that areas of negative enhancement can be produced from material having lower magnetic properties compared to the topsoil. This is common for many sedimentary bedrocks and subsoils which were often used in the construction of banks and walls etc. Mapping these 'negative' anomalies may also reveal archaeological features.

Magnetic survey or magnetometry can be carried out using a fluxgate gradiometer and may be referred to as gradiometry. The SENSYS gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 65cm apart. The instrument is carried about 10-20cm above the ground surface and the upper sensor measures the Earth's magnetic field as does the lower sensor but this is influenced to a greater degree by any localised buried field. The difference between the two sensors will relate to the strength the magnetic field created by the buried feature.

There are a number of factors that may affect the magnetic survey and these include soil type, local geology and previous human activity. Situations arise where magnetic disturbance associated with modern services, metal fencing, dumped waste material etc., obscures low magnitude fields associated with archaeological features.

Appendix B – data processing notes

Clipping

Minimum and maximum values are set and replace data outside of the range with those values. Extreme values are removed improving colour or greyscale contrast associated with data values that may be archaeologically significant. It has been found that clipping data to ranges between ±5nT and ±3nT often improves the appearance of features associated with archaeology. Different ranges are applied to data in order to determine the most suitable for anomaly abstraction and display.

Zero (destripe) Median/Mean Traverse

The median (or mean) of each traverse is calculated ignoring data outside a threshold value, the median (or mean) is then subtracted from the traverse. The process is used to equalise differences between the baseline value of gradiometer sensors.

High Pass Filtering

A mathematical process used to remove low frequency anomalies relating to survey tracks and modern agricultural features.

Appendix C – survey and data information

Minimally processed data

COMPOSITE
Filename: J670-mag-proc.xcp
Description: Imported as Composite from: J670-mag.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):OSGB36
Northwest corner: 368370.627093281, 154695.496748401 m
Southeast corner: 368490.627093281, 154536.196748401 m
Collection Method: Randomised
Sensors: 5
Dummy Value: 32702

Source GPS Points: 256600

Dimensions
Composite Size (readings): 800 x 1062
Survey Size (meters): 120 m x 159 m
Grid Size: 120 m x 159 m
X Interval: 0.15 m
Y Interval: 0.15 m

Stats
Max: 11.05
Min: -11.00
Std Dev: 6.07
Mean: -0.29
Median: 0.00
Composite Area: 1.9116 ha
Surveyed Area: 0.85957 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 -10.00 to 10.00 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.

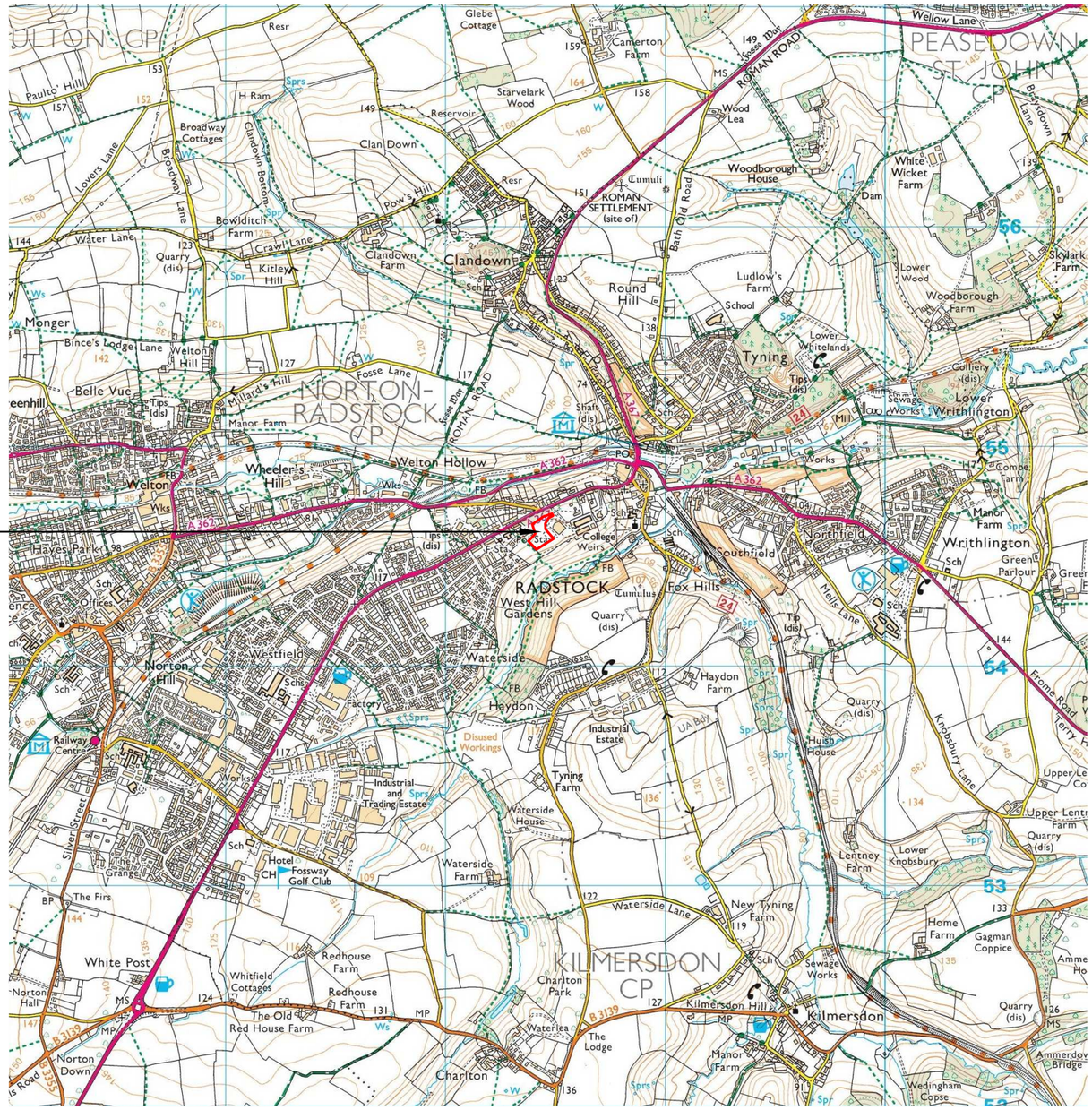
A PDF copy will be supplied to the B&NES Historic Environment Record with printed copies on request. The report will also be uploaded to the Online AccesS to the Index of archaeological investigationS (OASIS).

Archive contents:

Geophysical data - path: J670 Bath College, Radstock\Data				
Path and Filename	**Software**	**Description**	**Date**	**Creator**
radstock1\MX\.prm,.dgb,.disp	Sensys MXPDA	Proprietary data formats representing magnetometer survey traverses logged to a PDA.	27/06/16	D.J.Sabin
radstock1\MX\J670-mag.asc	Sensys DLMGPS	ASCII CSV (tab) file representing survey area in eastings, northings (UTM Z30N), magnetic measurement, traverse file and sensor number.	28/06/16	K.T.Donaldson
Mag\comps\J670-mag.xcp	TerraSurveyor 3.0.23.0	Composite data file derived from ASCII CSV.	28/06/16	K.T.Donaldson
Mag\comps\J670-mag-proc.xcp	TerraSurveyor 3.0.23.0	Processed composite data file (zmt and clipping to ±10nT).	28/06/16	K.T.Donaldson
Graphic data - path: J670 Bath College, Radstock\Data				
Mag\graphics\J670-mag-proc.tif	TerraSurveyor 3.0.23.0	TIF file showing a minimally processed greyscale plot clipped to ±10nT.	28/06/16	K.T.Donaldson
Mag\graphics\J670-mag-proc.tfw	TerraSurveyor 3.0.23.0	World file for georeferencing TIF to OSGB36.	28/06/16	K.T.Donaldson
CAD data - path: J670 Bath College, Radstock\CAD				
J670 version 1.dwg	ProgeCAD 2016	CAD file for creating plots of greyscales, abstraction, interpretation and mapping. Grid coordinates as OSGB. AutoCAD 2010 format.	23/06/16	K.T.Donaldson
Text data - path: J670 Bath College, Radstock\Documentation				
J670 report.odt	OpenOffice.org 3.0.1 Writer	Report text as an Open Office document.	30/06/16	K.T.Donaldson

Appendix E – copyright and intellectual property

Survey location



Archaeological Surveys Ltd

Geophysical Survey
Bath College
Somer Valley Campus
Radstock
Bath & North East Somerset

Map of survey area

● Survey location

Site centred on OS NGR
ST 68440 54615

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

FIG 01

Archaeological Surveys Ltd

Geophysical Survey
Bath College
Somer Valley Campus
Radstock
Bath & North East Somerset

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

368400 154550

Approximate development boundary

SCALE 1:1000

0m 20 40 60 80 100m

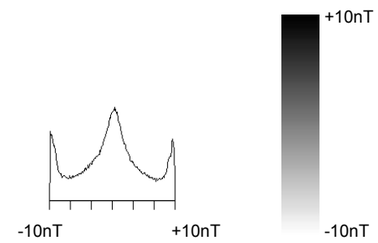
SCALE TRUE AT A3

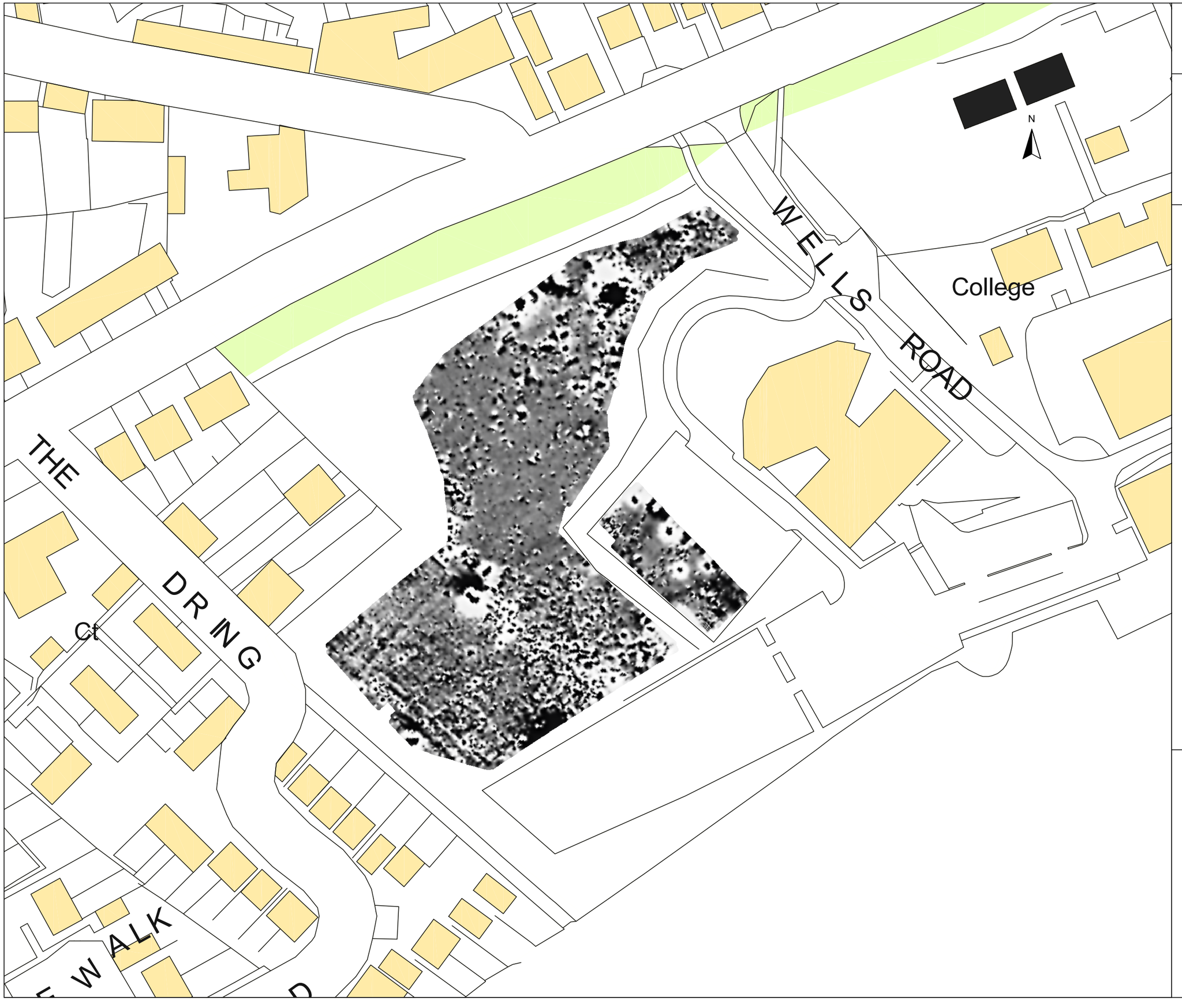
FIG 02

Archaeological Surveys Ltd

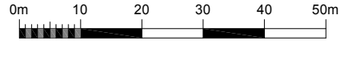
Geophysical Survey
Bath College
Somer Valley Campus
Radstock
Bath & North East Somerset

Greyscale plot of minimally processed magnetometer data





SCALE 1:1000



SCALE TRUE AT A3

FIG 03

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Geophysical Survey
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Bath & North East Somerset

Abstraction and interpretation of magnetometer anomalies

- Positive linear anomaly - possible ditch-like feature
- Positive linear anomaly - former field boundary
- Negative linear anomaly - material of low magnetic susceptibility
- Discrete positive response - possible pit-like feature
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong dipolar anomaly - ferrous object

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 04

N

WELLS ROAD

College

THE DRING

Ct

W ALK

1
2
3
4
5
6
7
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