GEOPHYSICAL SURVEY REPORT

GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Burley on the Hill, Leicestershire

Client
Worcestershire County Council

Survey Report
11052

Date
May 2017

Incorporating

GSB PROSPECTION LTD

and

STRATASCAN LTD

SUMO Services Ltd
Cowburn Farm
Market Street
Thornton
Bradford
BD13 3HW
T: 01274 835016

SUMO Services Ltd
Vineyard House
Upper Hook Road
Upton upon Severn
Worcestershire
WR8 0SA
T: 01684 592266

geophysics@sumoservices.com
www.sumoservices.com

GEOPHYSICAL SURVEY REPORT

Project name:
Burley on the Hill, Leicestershire

SUMO Job reference:
11052

Client:
Worcestershire County Council

Survey date:
3-7 April 2017

Report date:
9 May 2017

Field co-ordinator:
Robert Knight BA

Field Team:
Stephanie Rhodes BSc FGS
Olivier Vansassenbrouck MSc

Report written by:
Rebecca Davies BSc

CAD illustrations by:
Rebecca Davies BSc

Project Manager:
Simon Haddrell BEng AMBCS PCIfA

Report approved by:
Dr John Gater BSc DSc(Hon) MCIfA FSA

TABLE OF CONTENTS

LIST OF FIGURES

DIGITAL CONTENT (Archive Data)

- Minimally Processed Greyscale Images and XY Trace Plots in DWG format
- DWG Viewer
- Digital Copies of Report Text and Figures (both PDF and native formats)

1 SUMMARY OF RESULTS

The survey at Burley on the Hill has identified a probable barrow cemetery and a multi-phase field system. Ridge and furrow is present across the site, along with natural pitting and fracturing of the underlying limestone.

2 INTRODUCTION

2.1 Background synopsis

SUMO Services Ltd were commissioned to undertake a geophysical survey of an area to assist the preparation of a Higher Tier Countryside Stewardship (HT CS) agreement. This survey forms part of an archaeological investigation being undertaken by **Worcestershire County Council (WCC).**

2.2 Site details

NGR / Postcode	SK 887 104 / LE15 7FL
Location	The site is located to the east of the Grade I listed, early 18th century Burley on the Hill country house (NHLE ref. 1073792; HER ref. MLE18273), and forms part of the Burley Estate Farm and Registered Park (NHLE ref. 1000380; HER ref. MLE5090).
HER/SMR	Leicestershire and Rutland
Unitary Authority	Rutland
Parish	Burley CP
Topography	Mostly flat
Current Land Use	Arable
Weather	Dry, clear
Geology	Solid: Northampton Sand Formation – ooidal ironstone. Superficial: None recorded (BGS 2017).
Soils	Banbury Association (544), well drained, brashy fine and coarse loamy ferruginous soils over ironstone (SSEW 1983).
Archaeology	Known archaeological features on the site comprise an undated field system identified based on cropmark data, including a linear north-west to south-east aligned ditch with a possible enclosure to the east, and a perpendicular ditch running north-east from the main ditch towards Cottesmore Road in the north (HER ref. MLE5098). Further aerial photographic data suggests this is part of a more extensive system with additional north-east to south-west aligned ditches to the east of the site. A Leicester and Melton metal detecting club event undertaken within the field has produced evidence of a potential early to middle Anglian cemetery site, including significant metalwork finds suggesting the presence of one or more high status burials (WCC 2016).
Survey Methods	Magnetometer survey (fluxgate gradiometer)
Study Area	12.7ha

2.3 Aims and Objectives

To locate and characterise any anomalies of possible archaeological interest within the study area.

3 METHODS, PROCESSING & PRESENTATION

3.1 Standards & Guidance

This report and all fieldwork have been conducted in accordance with the latest guidance documents issued by Historic England (EH 2008) (then English Heritage) and the Chartered Institute for Archaeologists (IfA 2002 & CIfA 2014).

3.2 Survey methods

Detailed magnetic survey was chosen as an efficient and effective method of locating archaeological anomalies.

Technique	Instrument	Traverse Interval	Sample Interval
Magnetometer	Bartington Cart	0.5m	0.125m

More information regarding this technique is included in Appendix A.

3.3 Data Processing

The following basic processing steps have been carried out on the data used in this report:

De-stripe
De-stagger
Interpolate

3.4 Presentation of results and interpretation

The presentation of the results for each site involves a grey-scale plot of processed data. Magnetic anomalies are identified, interpreted and plotted onto the 'Interpretation' drawings. The minimally processed data are provided as a greyscale image in the Archive Data Folder with an XY trace plot in CAD format. A CAD viewer is also provided.

When interpreting the results, several factors are taken into consideration, including the nature of archaeological features being investigated and the local conditions at the site (geology, pedology, topography etc.). Anomalies are categorised by their potential origin. Where responses can be related to other existing evidence, the anomalies will be given specific categories, such as: *Abbey Wall* or *Roman Road*. Where the interpretation is based largely on the geophysical data, levels of confidence are implied, for example: *Probable*, or *Possible Archaeology*. The former is used for a confident interpretation, based on anomaly definition and/or other corroborative data such as cropmarks. Poor anomaly definition, a lack of clear patterns to the responses and an absence of other supporting data reduces confidence, hence the classification *Possible*.

4 RESULTS

4.1 *Probable Archaeology*

4.1.1 A series of positive annular anomalies [1-2] has been detected in the centre of the site and they all enclose discrete positive responses, indicative of backfilled pits. The form of the responses, without a clear entrance or visible break in the ditch, suggests that they are the remains of barrows, likely to contain burials and/or cremated remains in the pits.

The cluster of barrows likely represents a barrow cemetery set within a funerary landscape. If the metal artefacts are associated with the features, then an Anglo-Saxon date seems probable (WCC 2016).

4.1.2 A strong, positive linear anomaly [3], some 4m in width, is indicative of a substantial boundary ditch, perhaps 2-3 metres wide, depending upon the magnetic fill. This is likely to be the north-west to south-east aligned ditch visible as a cropmark on aerial photography (WCC 2016). A similar response oriented approximately north-south [4], and crossing the aforementioned ditch [3] has been detected, and corresponds with the cropmark described as running towards Cottesmore Road (WCC 2016).

These ditches are likely related to a former field system, and their proximity and apparent alignment with the annular anomalies [1-2] suggests that they may be of similar date.

4.1.3 A large, rectilinear enclosure [5] which is approximately 140m in width, has a similar magnetic response to the ditches in the west [3-4]. It is likely that the enclosure is another element of the funerary landscape.

4.1.4 Several positive linear anomalies [6] are visible across the site, most which are oriented roughly east-west, north-west to south-east or north-south. These are likely to be associated a field system, though their relationship to the large ditches and enclosures [3-5] is unclear. It is possible that these linears [6] represent a separate phase of activity and some may be related to ridge and furrow cultivation (see 4.3).

4.1.5 An area of increased magnetic response [7] to the west of ditch [4] is likely to be associated with an area of small-scale industrial activity, perhaps kilns/ovens/metalworking, or to a shallow, infilled pit.

4.2 *Possible Archaeology*

4.2.1 Two weak, sub-circular positive anomalies [8-9] may be related to further barrows, similar to those of [1-2] as each ring appears to contain a small discrete feature. However, it is feasible that the possible ditches are instead a chance alignment of plough lines, with the natural pitting of the limestone (see 4.4.2 below) creating what appears to be a backfilled pit at their centre.

4.2.2 An irregular shaped feature [10] in the south-west of the area could be part of a ring, and the same applies to the partial response [11], though again it is possible that they are both a result of chance alignments of plough lines, natural fracturing or pitting (see section 4.4).

4.2.2 Immediately east of [10] is an area of increased magnetic response, similar to that at [7] but less well defined, hence a ‘possible’ archaeological origin has been assigned.

4.3 *Agricultural – Ploughing, Land drains*

4.3.1 Widely spaced, slightly curved, parallel linear anomalies are visible across the site. These are a result of medieval ridge and furrow cultivation.

4.3.2 Magnetically weak, closely spaced, parallel linear responses can be seen along the north, west and south-eastern boundaries of the survey area. These are a result of modern agricultural activity, such as ploughing.

4.4 *Natural / Geological / Pedological / Topographic*

4.4.1 A series of intersecting linear anomalies, oriented north-east to south-west and north-west to south-east are visible across the site. The regularity and scale of the responses is typical of natural fracturing in limestone geology, with the anomalies likely representing major fractures within the rock. Evidence of the fracturing can be seen extending into the field to the north on Google Earth© imagery (GE 2011).

4.4.2 Larger areas of enhanced magnetic response are visible in the north, north-east and south-west of the site. These are likely to be of natural origin, relating to slight variations in the underlying geology or soil.

4.5 *Uncertain*

A straight, positive linear anomaly [12] runs north-east to south-west across the entire site, and its exact origin is uncertain. The length and straight nature of the response suggests that it may be of modern agricultural origin, however its location within an area of a substantial prehistoric field system means an archaeological origin cannot be entirely ruled out.

4.5.2 Two weak positive, parallel linear anomalies [13] run approximately east-west in the west of the site. Similar to anomaly [12], these are of uncertain origin. The straightness of the responses again suggests that they are of modern origin, and may relate to some form of agricultural activity.

4.6 *Ferrous / Magnetic Disturbance*

4.6.1 A strong bipolar linear anomaly has been detected at the south of the area, and is characteristic of an underground service, such as a pipe. To the east of this, two straight, negative anomalies have been identified. These are likely to be of modern origin, and are indicative of non-ferrous pipes or drains.

4.6.2 Ferrous responses close to boundaries are due to adjacent fences and gates. Smaller scale ferrous anomalies ("iron spikes") are present throughout the data and their form is best illustrated in the XY trace plots. These responses are characteristic of small pieces of ferrous debris (or brick / tile) in the topsoil and are commonly assigned a modern origin. Only the most prominent of these are highlighted on the interpretation diagram.

5 DATA APPRAISAL & CONFIDENCE ASSESSMENT

5.1 English Heritage Guidelines (EH 2008) Table 4 states that the typical magnetic response on limestone is good. The detection of several ring ditches, a field system and ridge and furrow suggests that the survey has been effective.

5.2 Large areas of natural pitting are visible across the site, which is typical across limestone geologies. The large number of pits means it is difficult to determine between possible archaeological pits and those which are natural. It may be possible that some of the pits are in fact archaeological, though no specific responses can be picked out individually.

6 CONCLUSION

6.1 The survey at Burley on the Hill has revealed an extensive barrow cemetery and possible associated field system, while further linear responses appear to relate to a separate phase of activity. There appear to be a minimum of eight barrows, all with internal features.

6.2 Evidence of ridge and furrow cultivation is present across the site, providing evidence that the site has a more recent agricultural past.

6.3 The site also shows extensive evidence of natural fracturing due to the underlying limestone geology, along with substantial areas of natural pitting. This pitting makes it difficult to abstract individual, discrete responses which are of probable or possible archaeological origin, as opposed to being natural.

7 REFERENCES

BGS 2017 British Geological Survey *website*: (http://www.bgs.ac.uk/opengeoscience/home.html?Accordion1=1#maps) Geology of Britain viewer [Accessed 09/05/2017].

CIfA 2014 *Standard and Guidance for Archaeological Geophysical Survey.* Amended 2016. CIfA Guidance note. Chartered Institute for Archaeologists, Reading http://www.archaeologists.net/sites/default/files/CIfAS%26GGeophysics_2.pdf

EH 2008 *Geophysical Survey in Archaeological Field Evaluation.* English Heritage, Swindon https://content.historicengland.org.uk/images-books/publications/geophysical-survey-in-archaeological-field-evaluation/geophysics-guidelines.pdf/

GE 2011 *Google Earth.* Imagery Date: 27/9/2011. Centred at 52º41’03.35”N, 0º41’17.87W

IfA 2002 *The Use of Geophysical Techniques in Archaeological Evaluations*, IFA Paper No 6, C. Gaffney, J. Gater and S. Ovenden. Institute for Archaeology, Reading

SSEW 1983 *Soils of England and Wales. Sheet 3, Midland and Western England*. Soil Survey of England and Wales, Harpenden.

WCC 2016 *Project Design: COSMIC+. Archaeological Risk Assessment to inform a Higher Tier Countryside Stewardship Scheme Application. Burley Estate Farm Partnership, Burley, Oakham, Rutland. Project ref. P4999*

Appendix A - Technical Information: Magnetometer Survey Method

Grid Positioning
For hand held gradiometers the location of the survey grids has been plotted together with the referencing information. Grids were set out using a Trimble R8 Real Time Kinematic (RTK) VRS Now GNSS GPS system.

Every point that is recorded using the cart system is referenced using a Trimble R* RTK GNSS system. An RTK GPS (Real-time Kinematic Global Positioning System) can locate a point on the ground to a far greater accuracy than a standard GPS unit. A standard GPS suffers from errors created by satellite orbit errors, clock errors and atmospheric interference, resulting in an accuracy of 5m-10m. An RTK system uses a single base station receiver and a number of mobile units. The base station re-broadcasts the phase of the carrier it measured, and the mobile units compare their own phase measurements with those they received from the base station. This results in an accuracy of around 0.01m.

Technique	Instrument	Traverse Interval	Sample Interval
Magnetometer	Bartington Cart	0.5m	0.125m

Instrumentation: Bartington Cart
Bartington instruments operate in a gradiometer configuration which comprises fluxgate sensors mounted vertically, set 0.5m apart. The fluxgate gradiometer suppresses any diurnal or regional effects. The instruments are carried, or cart mounted, with the bottom sensor approximately 0.1-0.3m from the ground surface. At each survey station, the difference in the magnetic field between the two fluxgates is measured in nanoTesla (nT). The sensitivity of the instrument can be adjusted; for most archaeological surveys the most sensitive range (0.1nT) is used. Generally, features up to 1m deep may be detected by this method, though strongly magnetic objects may be visible at greater depths. The Bartington Cart can collect four lines of data per traverse with gradiometer units mounted laterally with a separation of 0.5m. The readings are logged consecutively into the data logger which in turn is daily down-loaded into a portable computer whilst on site. At the end of each site survey, data is transferred to the office for processing and presentation.

The Bartington magnetometer cart system collects data at 10Hz which approximates 0.125m.

The readings are logged consecutively into the data logger which in turn is daily down- loaded into a portable computer whilst on site. At the end of each site survey, data is transferred to the office for processing and presentation.

Data Processing

Zero Mean Traverse	This process sets the background mean of each traverse within each grid to zero. The operation removes striping effects and edge discontinuities over the whole of the data set.
Step Correction (De-stagger)	When gradiometer data are collected in 'zig-zag' fashion, stepping errors can sometimes arise. These occur because of a slight difference in the speed of walking on the forward and reverse traverses. The result is a staggered effect in the data, which is particularly noticeable on linear anomalies. This process corrects these errors.

Display

Greyscale/ Colourscale Plot	This format divides a given range of readings into a set number of classes. Each class is represented by a specific shade of grey, the intensity increasing with value. All values above the given range are allocated the same shade (maximum intensity); similarly, all values below the given range are represented by the minimum intensity shade. Similar plots can be produced in colour, either using a wide range of colours or by selecting two or three colours to represent positive and negative values. The assigned range (plotting levels) can be adjusted to emphasise different anomalies in the data-set.

Interpretation Categories

In certain circumstances (usually when there is corroborative evidence from desk-based or excavation data) very specific interpretations can be assigned to magnetic anomalies (for example, *Roman Road, Wall,* etc.) and where appropriate, such interpretations will be applied. The list below outlines the generic categories commonly used in the interpretation of the results.

Archaeology / Probable Archaeology	This term is used when the form, nature and pattern of the responses are clearly or very probably archaeological and /or if corroborative evidence is available. These anomalies, whilst considered anthropogenic, could be of any age.
Possible Archaeology	These anomalies exhibit either weak signal strength and / or poor definition, or form incomplete archaeological patterns, thereby reducing the level of confidence in the interpretation. Although the archaeological interpretation is favoured, they may be the result of variable soil depth, plough damage or even aliasing as a result of data collection orientation.
Industrial / Burnt-Fired	Strong magnetic anomalies that, due to their shape and form or the context in which they are found, suggest the presence of kilns, ovens, corn dryers, metal-working areas or hearths. It should be noted that in many instances modern ferrous material can produce similar magnetic anomalies.
Former Field Boundary (probable & possible)	Anomalies that correspond to former boundaries indicated on historic mapping, or which are clearly a continuation of existing land divisions. Possible denotes less confidence where the anomaly may not be shown on historic mapping but nevertheless the anomaly displays all the characteristics of a field boundary.
Ridge & Furrow	Parallel linear anomalies whose broad spacing suggests ridge and furrow cultivation. In some cases, the response may be the result of more recent agricultural activity.
Agriculture (ploughing)	Parallel linear anomalies or trends with a narrower spacing, sometimes aligned with existing boundaries, indicating more recent cultivation regimes.
Land Drain	Weakly magnetic linear anomalies, quite often appearing in series forming parallel and herringbone patterns. Smaller drains may lead and empty into larger diameter pipes, which in turn usually lead to local streams and ponds. These are indicative of clay fired land drains.
Natural	These responses form clear patterns in geographical zones where natural variations are known to produce significant magnetic distortions.
Magnetic Disturbance	Broad zones of strong dipolar anomalies, commonly found in places where modern ferrous or fired materials (e.g. brick rubble) are present. They are presumed to be modern.
Service	Magnetically strong anomalies, usually forming linear features are indicative of ferrous pipes/cables. Sometimes other materials (e.g. pvc) or the fill of the trench can cause weaker magnetic responses which can be identified from their uniform linearity.
Ferrous	This type of response is associated with ferrous material and may result from small items in the topsoil, larger buried objects such as pipes, or above ground features such as fence lines or pylons. Ferrous responses are usually regarded as modern. Individual burnt stones, fired bricks or igneous rocks can produce responses similar to ferrous material.
Uncertain Origin	Anomalies which stand out from the background magnetic variation, yet whose form and lack of patterning gives little clue as to their origin. Often the characteristics and distribution of the responses straddle the categories of *Possible Archaeology* / *Natural* or (in the case of linear responses) *Possible Archaeology* / *Agriculture*; occasionally they are simply of an unusual form.

Where appropriate some anomalies will be further classified according to their form (positive or negative) and relative strength and coherence (trend: weak and poorly defined).

Appendix B - Technical Information: Magnetic Theory

Detailed magnetic survey can be used to effectively define areas of past human activity by mapping spatial variation and contrast in the magnetic properties of soil, subsoil and bedrock. Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.1 nanoTeslas (nT) in an overall field strength of 48,000 (nT), can be accurately detected.

Weakly magnetic iron minerals are always present within the soil and areas of enhancement relate to increases in *magnetic susceptibility* and permanently magnetised *thermoremanent* material.

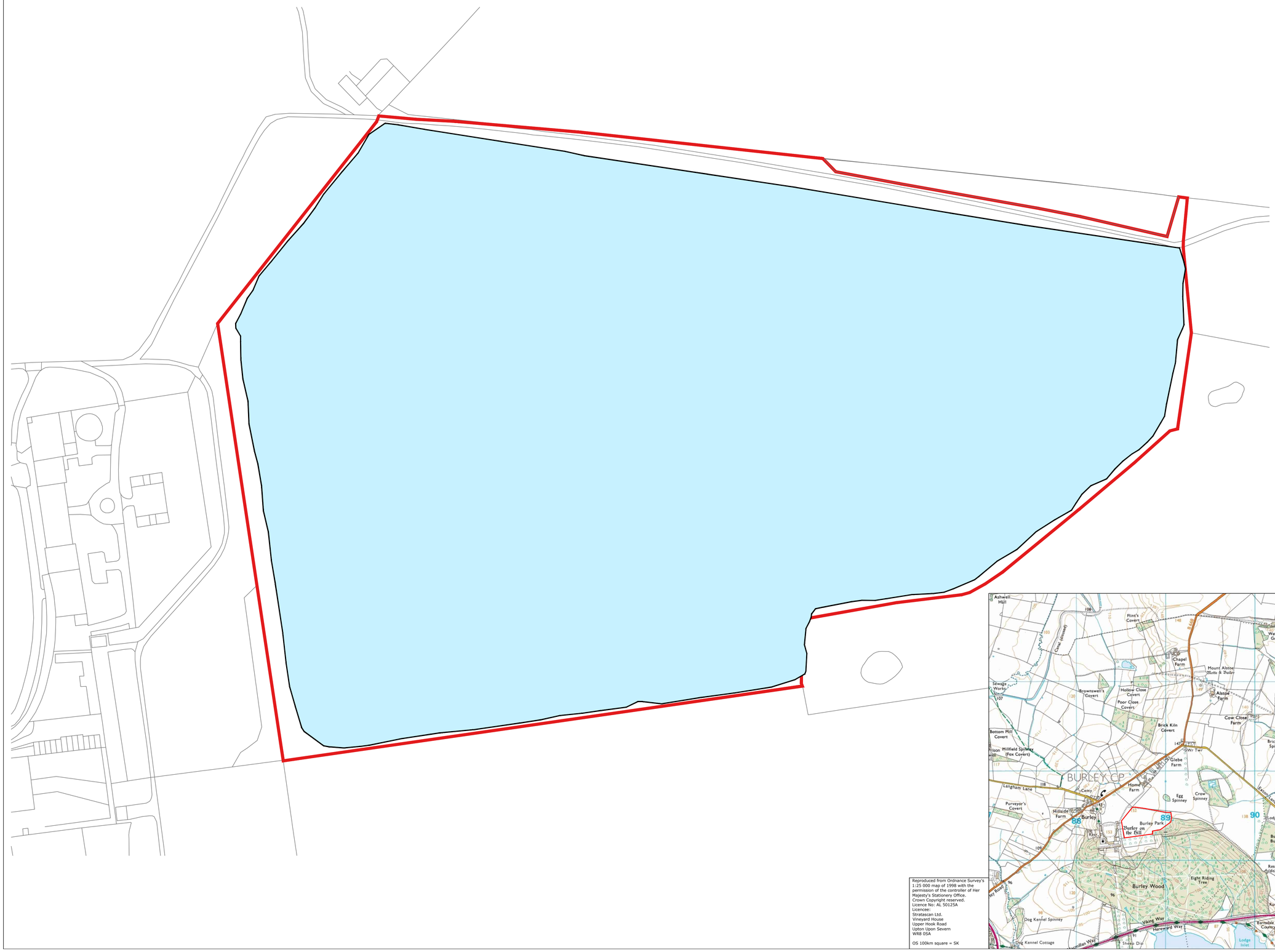
Magnetic susceptibility relates to the induced magnetism of a material when in the presence of a magnetic field. This magnetism can be considered as effectively permanent as it exists within the Earth's magnetic field. Magnetic susceptibility can become enhanced due to burning and complex biological or fermentation processes.

Thermoremanence is a permanent magnetism acquired by iron minerals that, after heating to a specific temperature known as the Curie Point, are effectively demagnetised followed by re-magnetisation by the Earth's magnetic field on cooling. Thermoremanent archaeological features can include hearths and kilns; material such as brick and tile may be magnetised through the same process.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement allowing assessment and characterisation of subsurface features. Material such as subsoil and non-magnetic bedrock used to create former earthworks and walls may be mapped as areas of lower enhancement compared to surrounding soils.

Magnetic survey is carried out using a fluxgate gradiometer which is a passive instrument consisting of two sensors mounted vertically 1m apart. The instrument is carried about 30cm above the ground surface and the top sensor measures the Earth's magnetic field whilst the lower sensor measures the same field but is also more affected by any localised buried feature. The difference between the two sensors will relate to the strength of a magnetic field created by this feature, if no field is present the difference will be close to zero as the magnetic field measured by both sensors will be the same.

Factors affecting the magnetic survey may include soil type, local geology, previous human activity and disturbance from modern services.



OS GRID REFERENCES

Area surveyed with cart

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

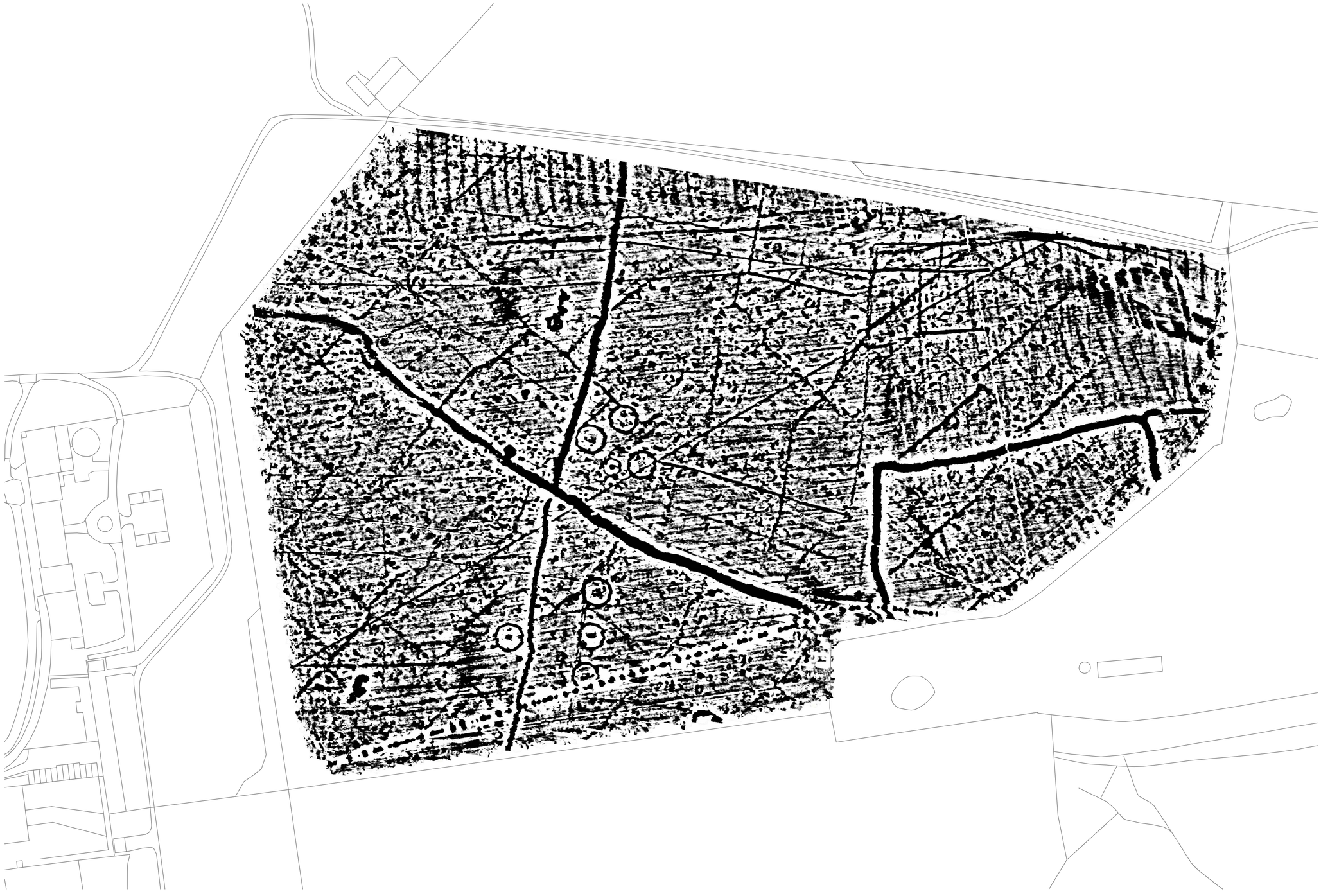
Title:
SITE LOCATION DIAGRAM AND LOCATION OF SURVEY AREA

Client:
WORCESTERSHIRE COUNTY COUNCIL

Project:
11052 - BURLEY ON THE HILL, LEICESTERSHIRE

Scale: 1:1000 @ A1
0m 10 20 30 40 50 60m

Fig No:
01



N

Plotting parameters

Maximum +2nT (black)
Minimum -1nT (white)

+2nT

-1nT

sumo Survey

GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:
MAGNETOMETER SURVEY - GREYSCALE PLOT

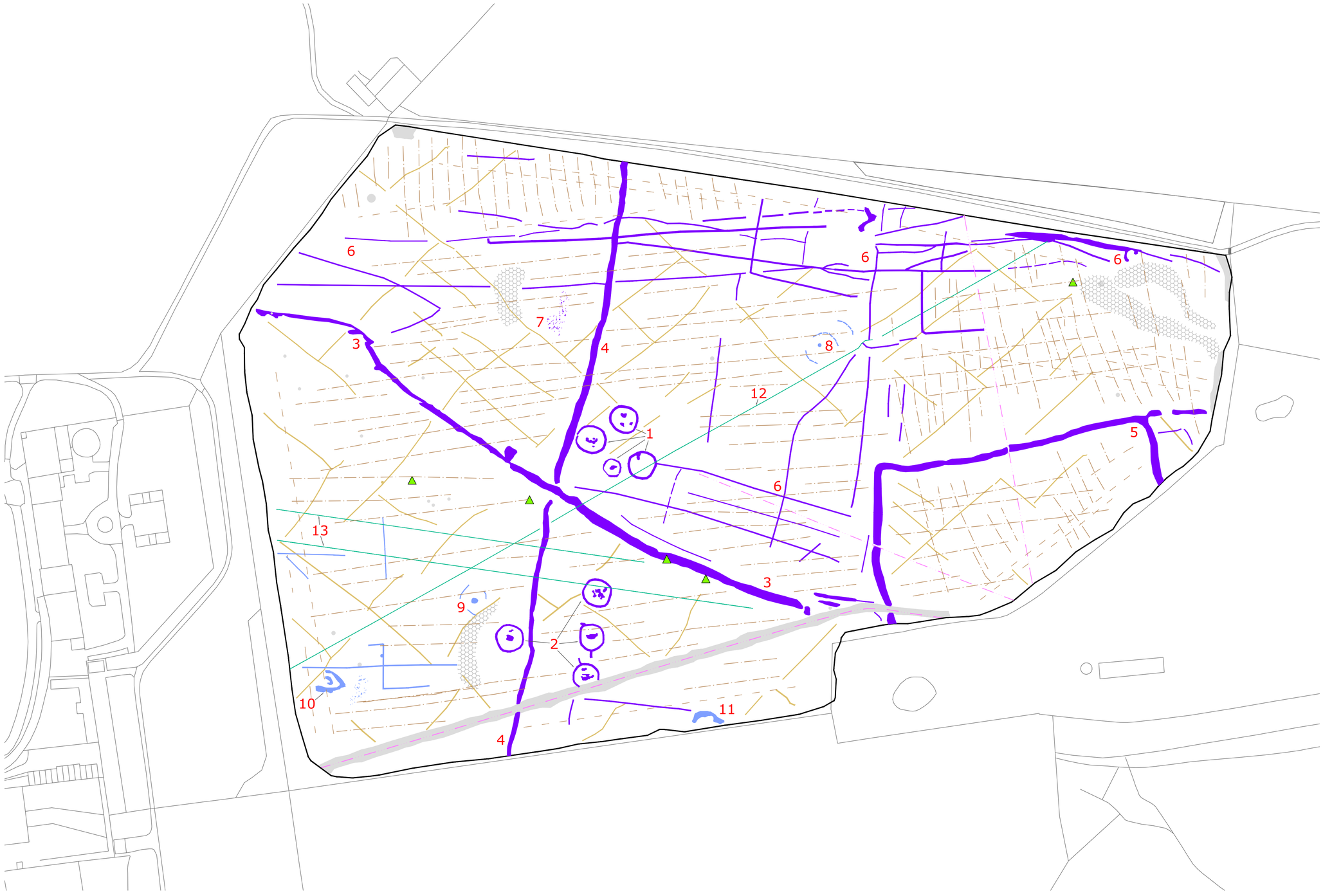
Client:
WORCESTERSHIRE COUNTY COUNCIL

Project:
11052 - BURLEY ON THE HILL, LEICESTERSHIRE

Scale: 1:1000 @ A1

0m 10 20 30 40 50 60m

Fig No:
02



KEY

	Metal detector find location
	Probable archaeology (positive/area of increased response/trend)
	Possible archaeology (positive/area of increased response)
	Ridge and furrow
	Agriculture (e.g. ploughing)
	Natural (e.g. geological or pedological)
	Natural (e.g. limestone fractures)
	Service
	Ferrous
	Uncertain (positive)

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: MAGNETOMETER SURVEY - INTERPRETATION

Client: WORCESTERSHIRE COUNTY COUNCIL

Project: 11052 - BURLEY ON THE HILL, LEICESTERSHIRE

Scale: 1:1000 @ A1

0m 10 20 30 40 50 60m

Fig No: 03

N

6
6
6
7
3
4
8
12
1
5
6
13
3
9
2
10
11
4

KEY

	Metal detector find location
	Probable archaeology (positive/area of increased response/trend)
	Possible archaeology (positive/area of increased response)
	Uncertain (positive)

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

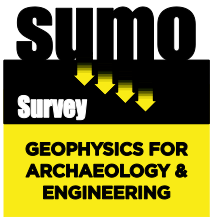
Title:
MAGNETOMETER SURVEY - INTERPRETATION (ARCHAEOLOGY)

Client:
WORCESTERSHIRE COUNTY COUNCIL

Project:
11052 - BURLEY ON THE HILL, LEICESTERSHIRE

Scale: 1:1000 @ A1
0m 10 20 30 40 50 60m

Fig No:
04



- Archaeological
- Geophysical
- Laser Scanning
- Measured Building
- Topographic
- Utility Mapping

SUMO Services Ltd, incorporated under the laws of England and Wales,
Company Registration No.4275993.
Registered Office Unit 8 Hayward Business Centre, New Lane, Havant, Hampshire, PO9 2NL