GEOPHYSICAL SURVEY REPORT

STRATASCAN™

SUMO Survey Services
SUMO Group Member

Project name:
Lilley Brook Golf course, Cheltenham

Client:
Worcestershire County Council

Job ref:
J9920

June 2016

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Project name: **Lilley Brook Golf course, Cheltenham** Client: **Worcestershire County Council**	Job ref: **J9920**
Survey date: **18th May 2016**	Report date: **June 2016**
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1 SUMMARY OF RESULTS

A detailed gradiometry survey was carried out over approximately 3.8 hectares of managed grassland, forming part of Lilley Brook Golf Course. No features of probable archaeology have been detected, despite the potential for Roman remains. A small number of possible backfilled pits may equally be related to the golf practice area or be of natural origin. Ridge and furrow along with evidence of modern agricultural activity suggests the site has been used for agricultural purposes since the medieval period. The remaining features are natural or modern. The modern features include several features related to the golf course practice area, underground services, scattered magnetic debris, magnetic disturbance from nearby ferrous objects and magnetic spikes.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned to undertake a geophysical survey of an area subject to archaeological investigation as a Roman burial has previously been discovered in close proximity to the site. This survey forms part of an archaeological investigation being undertaken by Worcestershire County Council.

2.2 Site Details

NGR / Postcode	SO 959 192 / GL53 9DH
Location	The site is located at the south of Cheltenham, Gloucestershire, and forms part of Lilley Brook Golf Course. Sandy Lane forms the western boundary of the site, while all other sides are bound by dense vegetation associated with the golf course.
HER/SMR	Gloucestershire
District	Cheltenham
District Ward	Charlton Park
Topography	Undulating
Current Land Use	Golf practice area
Weather Conditions	Dry, clear
Soils	The overlying soil for Lilly Brook Golf course is Martock, which are typical stagnogley soils. These consist of stoneless silty over clayey and clayey soils over siltstone or shale (Soils of England and Wales, Sheet 5).

Geology	The underlying geology of the majority of the site comprises Dyrham Formation - siltstone and mudstone, with Charmouth Mudstone - mudstone recorded in the north-west corner of the site. No superficial deposits are recorded across the site (British Geological Society, 2016).
Archaeology	A search of Historic England's PastScape (2016) identifies a number of medieval remains within a 1km radius of the site, along with a small number of Iron Age and Roman remains, including a Roman burial recorded adjacent to the site. An Iron Age domestic site (Monument No. 117396), partially destroyed by a now disused sandpit, is recorded c.700m north-west of the study area. The site was excavated in the 1950s and ash, charcoal, worked flints and animal bones were recovered. A Romano-British burial (Monument No. 117372) was discovered during gravel digging on Sandy Lane, immediately west of the site. Part of a skeleton and five iron nails were recovered. A findspot of a Roman coin (Monument No. 117697) is recorded in the Charlton Kings area, c 1km to the north-east of the site. The presumed site of a medieval building known as New Court (Monument No. 518283) is recorded c. 1km north of the site, along with a late 16th or 17th century timber framed building (Monument No. 908805). Areas of ridge and furrow (Monument No. 1509832, 1509834) are recorded c. 250m and 900m north-west of the site respectively. The ridge and furrow c.250m from the site remains partially visible as earthworks on modern aerial photographs, however the remains c.900m from the site had been levelled by aerial photographs taken in 1962 due to urban expansion. Second World War air raid shelters (Monument No. 1409411) are visible on aerial photographs at Charlton Kings Infant School, consisting of interconnecting earth covered shelters, forming a zig-zag pattern. Given the range of archaeological remains recorded within 1km of the site, it can be determined that there is a moderate potential for remains of all periods. The close proximity of a Romano-British burial suggests the site has a moderate-high potential for Roman remains.
Survey Methods	Detailed magnetic survey (gradiometry)
Study Area	c. 6.3 hectares - areas of dense vegetation reduced the total area surveyed to 3.8 hectares.

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 (2008) and the Chartered Institute for Archaeologists (2002 & 2014).

Stratascan Ltd are a Registered Organisation with the CIfA and are committed to upholding its policies and standards.

3.2 Survey methods

Due to the close proximity of a Roman burial (Monument No. 117372), detailed magnetic survey was used as an efficient and effective method of locating archaeological anomalies.

More information regarding this technique is included in Appendix A.

3.3 Processing

The following schedule shows the basic processing carried out on the data used in this report:

1. *Destripe*
2. *Destagger*

3.4 Presentation of results and interpretation

The presentation of the data for each site involves a plot of the minimally processed data as a greyscale plot and a colour plot showing extreme magnetic values. Magnetic anomalies have been identified and plotted onto the 'Interpretation of Anomalies' drawing.

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 very specific known features documented in other sources, this is done (for example: Abbey Wall, Roman Road). For the generic categories levels of confidence are indicated, 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

The detailed magnetic gradiometer survey conducted at Lilly Brook Golf course has identified a small number of anomalies that have been characterised as being of a *possible* archaeological origin. The following numbered anomalies refers to numerical labels on the interpretation plots.

4.1 Probable Archaeology

No probable archaeology has been identified within the survey area.

4.2 *Possible Archaeology*

Four small, discrete positive anomalies **[1]** in the north-west of the site. These are indicative of small former cut features, and may be related to former backfilled pits, though they may equally be related to the golf course landscaping.

4.3 *Medieval/Post-Medieval Agriculture*

Two areas of ridge and furrow cultivation **[2]** are visible in the centre and south-east of the site in the form of widely spaced, parallel linear anomalies. Evidence of modern agricultural activity, such as ploughing, **[3]** is visible across a large area of the site in the form of magnetically weak, closely spaced, parallel linear anomalies.

4.4 *Other Anomalies*

Three discrete areas of enhanced magnetic variation **[4]** and linear anomalies **[5]** in the north-west, north-east, south-west and south-east of the site are related to practice greens, visible on aerial photographs of the site. Weak positive linear anomalies **[6]** in the south-east of the site are possibly associated with features of the golf course, or related to land drains. A strong bipolar linear anomaly and two negative linear anomalies **[7]** are related to underground services such as pipes or cables, with the two negative linear features representative of non-ferrous pipes. A small area of scattered magnetic debris **[8]** near the centre of the site is likely to be modern in origin and relate to the golf course. An area of strong magnetic debris **[10]** is indicative of an area of made ground, and is related to raised tee areas of the golf course. Areas of enhanced magnetic response **[9]** across the north of the area are likely to be of natural origin. Areas of magnetic disturbance **[11]** are the result of nearby ferrous metal objects, such as fences while smaller ferrous anomalies, or 'magnetic spikes' **[12]** indicate ferrous objects and are likely to be modern rubbish.

5 DATA APPRAISAL & CONFIDENCE ASSESSMENT

Both Dyrham Formation siltstone and mudstone, and Charmouth Mudstone Formation mudstone generally provide good results for magnetic survey. The data across the site shows a relatively high contrast between anomalies and the background magnetic response, with a small number of possible archaeological features and agricultural features having been detected. The site's use as a practice area of a golf course means that many of the features detected may be related to this, and the area of made ground in the north has the potential to mask weaker archaeological features.

6 CONCLUSION

The survey at Lilley Brook Golf Course has not identified any features of probable archaeological origin, despite the potential for Roman remains given the close proximity of a Romano-British burial (Monument No. 117372). A small number of possible backfilled pits have been identified, though these may equally relate to the golf practice area or be of natural origin. Areas of ridge and furrow and evidence of modern ploughing indicate that the site has been used for agricultural purposes since the medieval period. Areas of enhanced magnetic response and linear features are related to the practice greens visible on aerial photographs, while further linear anomalies may be related to land drains. An area of strong magnetic debris is related to raised tee areas, also visible on aerial photographs. The remaining features are natural or modern and include areas of natural magnetic variation, underground services and non-ferrous pipes, an area of scattered magnetic debris, magnetic disturbance from nearby ferrous objects, and magnetic spikes which are likely to be modern rubbish.

7 REFERENCES

British Geological Survey, n.d., *website*: (http://www.bgs.ac.uk/opengeoscience/home.html?Accordion1=1#maps) Geology of Britain viewer. [Accessed 07/06/2016]

Chartered Institute For Archaeologists. *Standard and Guidance for Archaeological Geophysical Survey. (*http://www.archaeologists.net/sites/default/files/CIfAS&GGeophysics_1.pdf)

Dorset County Council, 2016. *Historic Environment Record [online]* Available through: www.heritagegateway.org.uk [Accessed 06/05/2016]

English Heritage, 2008. *Geophysical Survey in Archaeological Field Evaluation.*

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

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 5 South West England*

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.

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 Grad 601-2	1m	0.25m

Instrumentation: Bartington *Grad*601-2

Bartington instruments operate in a gradiometer configuration which comprises fluxgate sensors mounted vertically, set 1.0m 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 instrument can collect two lines of data per traverse with gradiometer units mounted laterally with a separation of 1.0m.

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 (Destagger)	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 response 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 will often lead and empty into larger diameter pipes and 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 indicative of ferrous pipes/cables. Sometimes other materials (e.g. pvc) cause weaker magnetic responses and can be identified from their uniform linearity crossing large expanses.
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* and *Possible Natural* or (in the case of linear responses) *Possible Archaeology* and *Possible 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 0.2 nanoTeslas (nT) in an overall field strength of 48,000nT, 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 and 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 field. The difference between the two sensors will relate to the strength of a magnetic field created by a buried 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, disturbance from modern services etc.

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