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February 2023

London Luton Airport Expansion

Planning Inspectorate Scheme Ref: TR020001

Volume 5 Environmental Statement and Related Documents

5.02 Appendix 10.3 Geophysical Survey Report (SUMO 2018)

Application Document Ref: TR020001/APP/5.02

APFP Regulation: 5(2)(a)

The Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

London Luton Airport Expansion Development Consent Order 202x

5.02 ENVIRONMENTAL STATEMENT APPENDIX 10.3 GEOPHYSICAL SURVEY REPORT (SUMO 2018)

Regulation number:	Regulation 5(2)(a)
Planning Inspectorate Scheme Reference:	TR020001
Document Reference:	TR020001/APP/5.02
Author:	Luton Rising

Version	Date	Status of Version
Issue 01	February 2023	Application issue

GEOPHYSICAL SURVEY REPORT

GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

New Century Park

Client
London Luton Airport Ltd

Survey Report
11318

Date
January 2018

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GEOPHYSICAL SURVEY REPORT

Project name:
New Century Park

SUMO Job reference:
11318

Client:
London Luton Airport Ltd

Survey date:
18 - 24 May, 4 – 8 September and 18 December 2017

Report date:
15 January 2018

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LIST OF FIGURES

DIGITAL CONTENT (Archive Data)

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

1 SUMMARY OF RESULTS

A detailed magnetometer survey was carried out over approximately 41ha to the north-east of Luton Airport. The survey has identified a small complex of magnetic responses which are probably a component of a small Romano-British site, which has been partially excavated. The anomalies are not very well defined and as such the features may well be plough damaged. A possible pit alignment has also been identified but it is unclear if this relates to entries in the HER. Elsewhere natural magnetic responses reflect localised changes in the chalk bedrock and soils.

2 INTRODUCTION

2.1 Background synopsis

SUMO Services Ltd were commissioned to undertake a geophysical survey of an area outlined for development. This survey forms part of an archaeological investigation being undertaken for **London Luton Airport Ltd**.

2.2 Site details

NGR / Postcode	TL 130 217 / LU2 8PA
Location	The survey area lies immediately north-east of Luton Airport and approximately 3km to the east of Luton. The site is situated adjacent to Wigmore Park and Eaton Green Road.
HER/SMR	Luton and Bedfordshire HER (LBHER) and Hertfordshire HER
District	North Hertfordshire
Parish	Kings Walden CP
Topography	Hilly with some steep slopes, two valleys cross through the site.
Current Land Use	Agricultural
Weather	Rain/sun
Geology	Solid: Lewes Nodular and Seaford chalk foundations. Superficial: none recorded (BGS 2017).
Soils	Hornbeam (582 a/c/d) Associations: plateau drift / chalky till - deep loamy over clayey soils with slowly permeable subsoils and seasonal waterlogging; some soils are very flinty. (SSEW 1983)
Archaeology	Romano-British activity is considered to have a high potential of being found at the site, whereas the possibility of prehistoric material being found is only considered to be medium. Early medieval, medieval and post medieval are thought to have a low potential. HER records within the site include: 10808 – Romano-British enclosure / occupation site; 12422 – pit alignments (ARUP 2017).
Survey Methods	Magnetometer survey (fluxgate gradiometer)
Study Area	41 ha

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), the Chartered Institute for Archaeologists (CIfA 2014) and the European Archaeological Council (EAC 2016).

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 Grad 601-2	1.0m	0.25m

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 free viewer is available: [redacted]

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

The survey has been divided into four survey areas (Areas 1-4, with 3 and 4 being further sub-divided into 3a, 3b, 3c, 4a and 4b). Specific anomalies have been given numerical labels [1] [2] *which appear in the text below, as well as on the Interpretation Figure(s).*

4.1 *Probable Archaeology*

4.1.1 A group of linear anomalies and trends [1] in the data from Area 1 indicate a number of ditches, which, although appearing disjointed, are probably associated with an enclosure recorded in the LBHER (10808). The presence of pit-like responses adds weight to the (existing) interpretation of the responses being associated with Romano-British settlement activity. The poor definition and weak strength of the anomalies suggests that the tops of features have been removed by ploughing or it is a reflection of the fact that some of the features have already been excavated.

4.2 *Possible Archaeology*

4.2.1 A line of pit-like responses [2] is visible in the data in the southern half of Area 2. These are interpreted as being of possible archaeological interest, based largely on an entry in the LBHER (12422) which refers to a pit alignment of unknown date. The magnetic responses actually lie to the south of an area highlighted in the DBA (Arup 2017: Figure 2) but it seems reasonable to link the two pieces of evidence. However, the HER refers to further pit alignments to the north-west and to the east, but outside of the survey area; these are not immediately evident in the magnetic data. As such the HER entry may actually relate to the natural chalk geology (see 4.5 below). The responses [2] are only classified as being of possible archaeological interest.

4.3 *Uncertain*

4.3.1 There are a few linear trends in the data which could be archaeological or agricultural, perhaps even natural. A trend traversing Area 4a aligns with the former field boundary in Area 1, but the latter is not shown on historic mapping as extending into Area 4. The trends therefore fall into the category of having an uncertain origin.

4.3.2 There are several broad magnetic responses in the data which could indicate infilled depressions. While they could be natural hollows an alternative interpretation is that they coincide with test boreholes, which are known to have been dug across the fields (they are visible on Google© imagery).

4.4 *Former Field Boundary*

4.4.1 A linear anomaly, comprising a narrow strip of ferrous like responses is visible crossing through Areas 1 and 2 on an east-west alignment. This equates with an old field boundary which first appears on the 1938 OS map and still marked as a footpath in 1960.

4.5 *Natural / Geological / Pedological / Topographic*

4.5.1 There are four bands of amorphous anomalies, the first [3] in Areas 1 and 3; a second [4] in Area 1; and a third [5] which clips Area 1 but is mainly within Area 2; and finally, a fourth [6] in the south of Area 2. The results are typical of natural responses associated with variations in the underlying chalk geology and coincide with natural bedrock changes visible both on Google© imagery and on the local geological mapping (BGS 2017).

4.6 ***Ferrous / Magnetic Disturbance***

4.6.1 Ferrous responses close to boundaries are due to adjacent fences and gates; in Area 4a they are associated with sports and play equipment. 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 Historic England guidelines (EH 2008) Table 4 states that the average magnetic response on chalk is good. The results from this survey suggest that the technique has been successful in mapping archaeological features.

6 CONCLUSION

6.1 Several ditch and small pit-like responses have been detected and although the anomalies are quite poorly defined, they coincide with an enclosure recorded in the HER. These features proved, upon partial excavation, to be Romano-British in date. However, there is no evidence in the geophysical data for any ring ditches, which were also referenced in the records. Elsewhere, a possible pit alignment has been highlighted in the magnetic data; this may equate with another HER entry but the locations may not totally agree.

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6.1.2 A former field boundary / footpath has also been identified and there are three distinctive bands of anomalies in the data which are associated with the natural chalk geology. Some of the ferrous-like responses in the results may indicate test boreholes.

7 REFERENCES

ARUP 2017 *Luton Airport Expansion, Historic Environment Desk-Based Assessment,* ARUP Report, Job Number 245580, report, unpublished.

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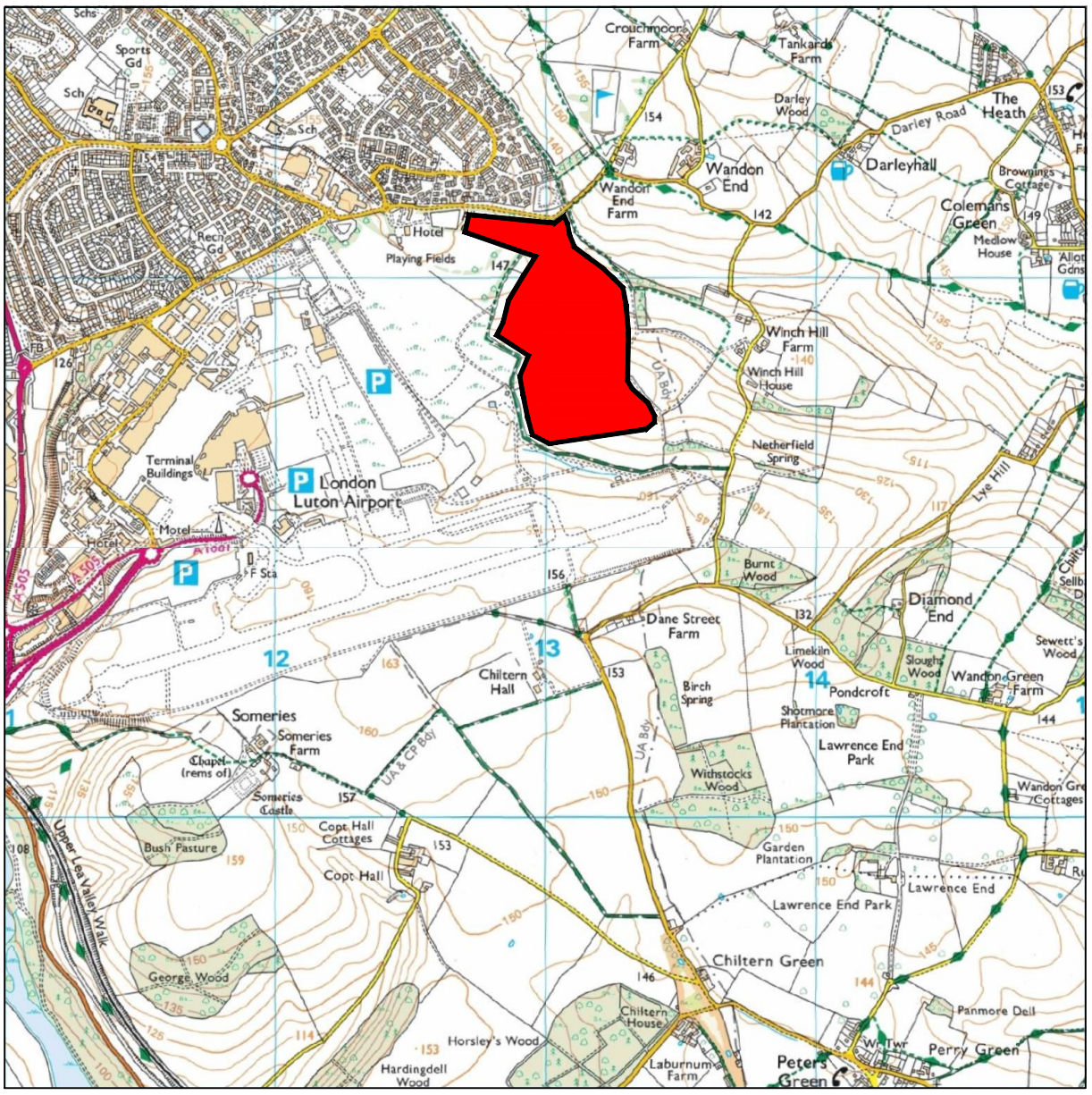
SSEW 1983 *Soils of England and Wales. Sheet 6, South East England*. Soil Survey of England and Wales, Harpenden.



N

Site Location

sumo Survey
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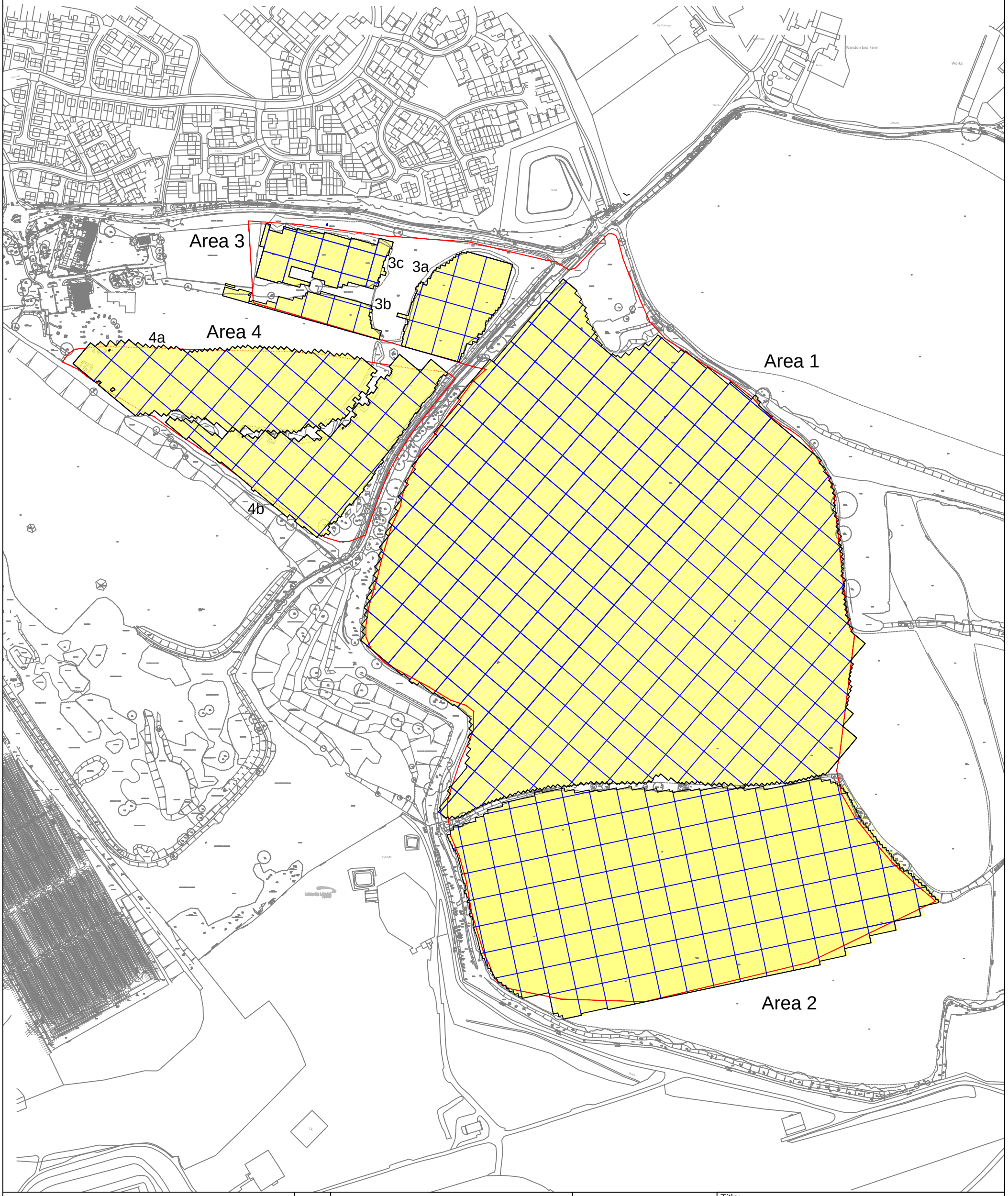
Title: Site Location Diagram

Client: London Luton Airport Ltd.

Project: 11318 New Century Park

Scale: 0 metres 1250
1:25000 @ A3

Fig No: 01



Magnetometer Survey Area showing 30m grids

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Location of Survey Areas

Client: London Luton Airport Ltd.

Project: 11318 New Century Park

Scale: 0 metres 200
1:4000 @ A3

Fig No: 02

N

2
nT
-1

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:
Magnetometer Survey
Greyscale Plots

Client:
London Luton Airport Ltd.

Project:
11318 New Century Park

Scale:
0 metres 200
1:4000 @ A3

Fig No:
03

Area 3

3c

3a

3b

Area 4

4a

4b

Area 1

Area 2

N

KEY

	Probable Archaeology (discrete anomaly / trend)		Natural (zone / trend)
	Possible Archaeology		Magnetic Disturbance
	Uncertain Origin (discrete anomaly / trend)		Ferrous
	Former Field Boundary (Corroborated)		

sumo Survey

GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey Interpretation

Client: London Luton Airport Ltd.

Project: 11318 New Century Park

Scale: 0 metres 200

1:4000 @ A3

Fig No: 04

3c
3a
3b
Area 1
Ponds
N
2
nT
-1
sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING
Title:
Magnetometer Survey [Area 1]
Greyscale Plot
Client:
London Luton Airport Ltd.
Project:
11318 New Century Park
Scale:
0 metres 100
1:2000 @ A3
Fig No:
05

3c
3a
3b
3
3
3
Area 1
1
4
4
5
5
5
N
Ponds

KEY

	Probable Archaeology (discrete anomaly / trend)		Natural (zone / trend)
	Possible Archaeology		Magnetic Disturbance
	Uncertain Origin (discrete anomaly / trend)		Ferrous
	Former Field Boundary (Corroborated)		

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey [Area 1] Interpretation

Client: London Luton Airport Ltd.

Project: 11318 New Century Park

Scale: 0 metres 100
1:2000 @ A3

Fig No: 06

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 (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.
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.

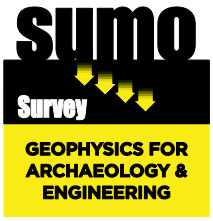
Magnetic susceptibility relates to the induced magnetism of a material when in the presence of a magnetic field. This magnetism can be considered as effectively permanent as it exists within the Earth's magnetic field. Magnetic susceptibility can become enhanced due to burning and complex biological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



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

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