

Geophysical Survey Report

Land South of Burwell Road, Exning

for

Archaeological Solutions

November 2012

Job ref.J3205

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Document Title: **Geophysical Survey Report
Land South of Burwell Road, Exning**

Client: **Archaeological Solutions**

Stratascan Job No: **J3205**

Techniques: **Detailed magnetic survey (gradiometry)**

National Grid Ref: **TL 613 656**

Post Code: **CB8 7DU County Historic Environment Record Number: EXG 100**



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1 SUMMARY OF RESULTS

The geophysical survey undertaken over approximately 6ha of agricultural land near Exning, Suffolk has not identified any anomalies that can be confidently attributed as being of an archaeological origin. However, a number of anomalies of a possible archaeological origin, including three large circular features, are evident within the survey data.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned to undertake a geophysical survey of an area outlined for development. This survey forms part of an archaeological investigation being undertaken by Archaeological Solutions.

2.2 Site location

The site is located on the western limits of Exning, near Newmarket, Suffolk at OS ref. TL 613 656.

2.3 Description of site

The survey area comprises approximately 6ha of flat, ploughed arable land south of Burwell Road, Exning.

2.4 Geology and soils

The underlying geology is chalk (British Geological Survey South Sheet, Fifth Edition Solid, 2007). No drift geology is recorded for the site (British Geological Survey South Sheet, First Edition Quaternary, 1977).

The overlying soils are known as Swaffham Prior which are typical brown calcareous earths. These consist of well drained calcareous coarse and fine loamy soils over chalk rubble (Soil Survey of England and Wales, Sheet 4 Eastern England).

2.5 Site history and archaeological potential

The following is an extract from a Brief for a Geophysical Survey issued by Suffolk County Council (Tipper, 2012):

“Although there are currently no known heritage assets within the proposed site, this area has not been the subject of any systematic archaeological study. A large scatter of both prehistoric, Roman and medieval metalwork, indicative of further occupation deposits, is recorded in the Suffolk Historic Environment Record (HER no. EXG 051) to the south in a similar topographic setting.

The potential for below-ground archaeological remains, combined with the large size of the site and the topographic location, indicates that there is potential for archaeological remains to be defined within the application site, which has not been the subject of any previous systematic investigation.”

2.6 Survey objectives

The objective of the survey was to locate any features of a possible archaeological origin in order that they may be assessed prior to development.

2.7 Survey methods

Detailed magnetic survey (gradiometry) was used as an efficient and effective method of locating archaeological anomalies. More information regarding this technique is included in the Methodology section below.

3 **METHODOLOGY**

3.1 Date of fieldwork

The fieldwork was carried out over two days from the 11th October 2012. Weather conditions during the survey were overcast.

3.2 Grid locations

The location of the survey grids has been plotted in Figure 2 together with the referencing information. Grids were set out using a Leica Smart Rover RTK GPS.

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. A SmartNet RTK GPS uses Ordnance Survey's network of over 100 fixed base stations to give an accuracy of around 0.01m.

3.3 Survey equipment and gradiometer configuration

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 using an appropriate instrument.

The mapping of the anomaly in a systematic manner will allow an estimate of the type of material present beneath the surface. Strong magnetic anomalies will be generated by buried iron-based objects or by kilns or hearths. More subtle anomalies such as pits and ditches can be seen if they contain more humic material which is normally rich in magnetic iron oxides when compared with the subsoil.

To illustrate this point, the cutting and subsequent silting or backfilling of a ditch may result in a larger volume of weakly magnetic material being accumulated in the trench compared to the undisturbed subsoil. A weak magnetic anomaly should therefore appear in plan along the line of the ditch.

The magnetic survey was carried out using a dual sensor Grad601-2 Magnetic Gradiometer manufactured by Bartington Instruments Ltd. The instrument consists of two fluxgates very accurately aligned to nullify the effects of the Earth's magnetic field. Readings relate to the difference in localised magnetic anomalies compared with the general magnetic background. The Grad601-2 consists of two high stability fluxgate gradiometers suspended on a single frame. Each gradiometer has a 1m separation between the sensing elements so enhancing the response to weak anomalies.

3.4 Sampling interval, depth of scan, resolution and data capture

3.4.1 Sampling interval

Readings were taken at 0.25m centres along traverses 1m apart. This equates to 3600 sampling points in a full 30m x 30m grid.

3.4.2 Depth of scan and resolution

The Grad 601-2 has a typical depth of penetration of 0.5m to 1.0m, though strongly magnetic objects may be visible at greater depths. The collection of data at 0.25m centres provides an optimum methodology for the task balancing cost and time with resolution.

3.4.3 Data capture

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

3.5 Processing, presentation of results and interpretation

3.5.1 Processing

Processing is performed using specialist software. This can emphasise various aspects contained within the data but which are often not easily seen in the raw data. Basic processing of the magnetic data involves 'flattening' the background levels with respect to adjacent traverses and adjacent grids. Once the basic processing has flattened the background it is then possible to carry out further processing which may include low pass filtering to reduce 'noise' in the data and hence emphasise the archaeological or man-made anomalies.

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

1. *Destripe* (Removes striping effects caused by zero-point discrepancies between different sensors and walking directions)
2. *Destagger* (Removes zigzag effects caused by inconsistent walking speeds on sloping, uneven or overgrown terrain)

3.5.2 Presentation of results and interpretation

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

4 RESULTS

The detailed magnetic gradiometer survey undertaken over 6ha of agricultural land west of Exning has identified a number of anomalies that have been characterised as being of a *possible* archaeological origin.

The difference between *probable* and *possible* archaeological origin is a confidence rating. Features identified within the data set that form recognisable archaeological patterns or seem to be related to a deliberate historical act have been interpreted as being of a probable archaeological origin. Features of possible archaeological origin tend to be more amorphous anomalies which may have similar magnetic attributes in terms of strength or polarity but are difficult to classify as being archaeological or natural.

The following list of numbered anomalies refers to numerical labels on the interpretation plots.

Probable Archaeology

No anomalies have been identified that can be confidently attributed as being of an archaeological origin.

Possible Archaeology

1. A number of positive linear and area anomalies can be noted throughout the survey area. These anomalies may be related to cut features, such as pits and ditches, of an archaeological origin. However their amorphous nature means that a natural origin cannot be ruled out at this stage.

Two large circular anomalies (**1a**) are evident in the central and eastern region of the site. These features measure approximately 35m in diameter and may be related to circular enclosures of an archaeological origin. However their very weak magnetic value makes it difficult to interpret them confidently. As a result they have been attributed as being of a *possible* as opposed to *probable* archaeological origin.

2. A large circular negative anomaly can be noted in the western region of the survey area. This anomaly is similar to those annotated as 1a above. However this feature seems to have been comprised of an earthwork as opposed to a ditch.

3. Magnetic 'spikes' (strong focussed values with associated antipolar response) indicate ferrous metal objects. Although most of these are likely to be modern debris, some may be of archaeological interest. Particular attention may be paid to those found in association with other potentially archaeological anomalies.

Other Anomalies

4. Two swathes of magnetic variation are evident within the survey data. These anomalies have been interpreted as being of a pedological or geological origin.
5. These close centred linear anomalies have been interpreted as being related to modern plough activity.
6. Linear anomalies have been identified along the northern and eastern perimeter of the survey area. These features are related to deep vehicle tracks present in these areas at the time of survey.
7. These small areas of magnetic disturbance are likely to be related to spreads of ferrous debris.
8. Areas of magnetic disturbance are the result of substantial nearby ferrous metal objects such as fences and underground services. These effects can mask weaker archaeological anomalies, but on this site have not affected a significant proportion of the area.

5 CONCLUSION

The detailed magnetic gradiometer survey undertaken over 6ha of land south of Burwell Road has identified three large circular features which may be related to archaeological enclosures or monuments. These anomalies are very weak in magnetic value however, which makes it difficult to interpret them with confidence.

6 REFERENCES

British Geological Survey South Sheet, 1977. *Geological Survey Ten Mile Map, South Sheet First Edition (Quaternary)*. Institute of Geological Sciences.

British Geological Survey, 2007. *Geological Survey Ten Mile Map, South Sheet, Fifth Edition (Solid)*. British Geological Society.

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 3 Eastern England*.

Tipper, J. (2012) *Brief for a Geophysical Survey at Land South of Burwell Road, Exning*. Suffolk County Council.

APPENDIX A – Basic principles of magnetic survey

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.

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.

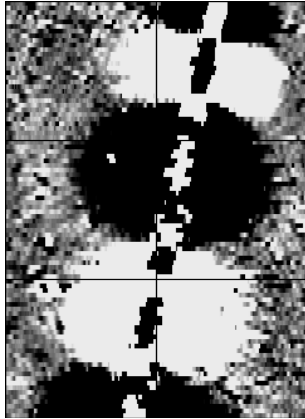
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement 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 either 0.5 or 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.

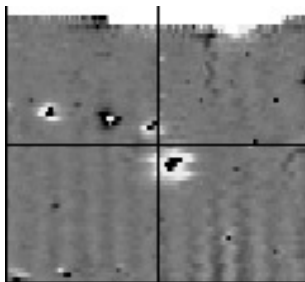
APPENDIX B – Glossary of magnetic anomalies

Bipolar



A bipolar anomaly is one that is composed of both a positive response and a negative response. It can be made up of any number of positive responses and negative responses. For example a pipeline consisting of alternating positive and negative anomalies is said to be bipolar. See also dipolar which has only one area of each polarity. The interpretation of the anomaly will depend on the magnitude of the magnetic field strength. A weak response may be caused by a clay field drain while a strong response will probably be caused by a metallic service.

Dipolar

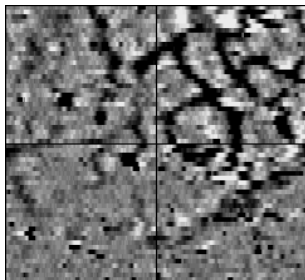


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very strong anomaly is likely to be caused by a ferrous object.

Positive anomaly with associated negative response

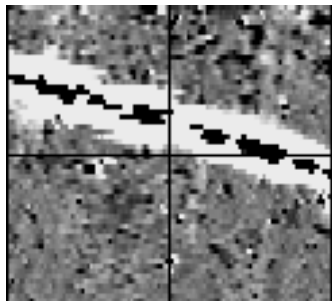
See bipolar and dipolar.

Positive linear



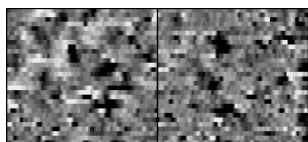
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity and some may even have a natural origin.

Positive linear anomaly with associated negative response



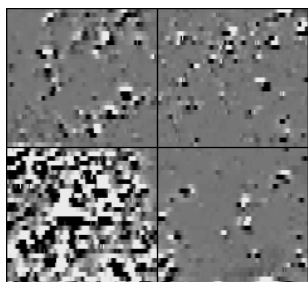
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field boundaries.

Positive point/area



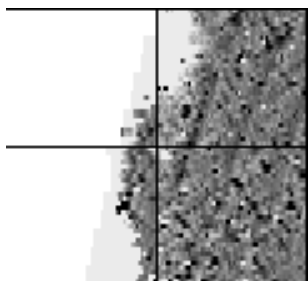
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally occurring depressions in the ground.

Magnetic debris



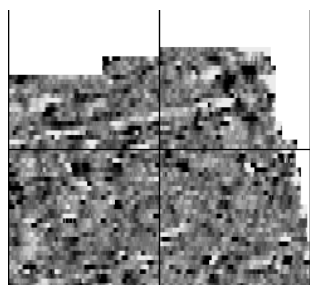
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low ($\pm 3\text{nT}$) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly ($\pm 250\text{nT}$) is more indicative of a spread of ferrous debris. Moderately strong anomalies may be the result of a spread of thermoremanent material such as bricks or ash.

Magnetic disturbance



Magnetic disturbance is high amplitude and can be composed of either a bipolar anomaly, or a single polarity response. It is essentially associated with magnetic interference from modern ferrous structures such as fencing, vehicles or buildings, and as a result is commonly found around the perimeter of a site near to boundary fences.

Negative linear

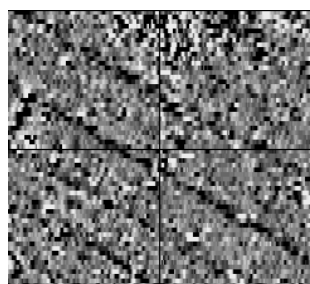


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative the background top soil is built up. See also ploughing activity.

Negative point/area

Opposite to positive point anomalies these responses may be caused by raised areas or earthen banks. These could be of an archaeological origin or may have a natural origin.

Ploughing activity



Ploughing activity can often be visualised by a series of parallel linear anomalies. These can be of either positive polarity or negative polarity depending on site specifics. It can be difficult to distinguish between ancient ploughing and more modern ploughing, clues such as the separation of each linear, straightness, strength of response and cross cutting relationships can be used to aid this, although none of these can be guaranteed to differentiate between different phases of activity.

Polarity

Term used to describe the measurement of the magnetic response. An anomaly can have a positive polarity (values above 0nT) and/or a negative polarity (values below 0nT).

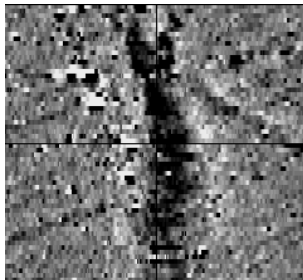
Strength of response

The amplitude of a magnetic response is an important factor in assigning an interpretation to a particular anomaly. For example a positive anomaly covering a 10m² area may have values up to around 3000nT, in which case it is likely to be caused by modern magnetic interference. However, the same size and shaped anomaly but with values up to only 4nT may have a natural origin. Colour plots are used to show the amplitude of response.

Thermoremanent response

A feature which has been subject to heat may result in it acquiring a magnetic field. This can be anything up to approximately ± 100 nT in value. These features include clay fired drains, brick, bonfires, kilns, hearths and even pottery. If the heat application has occurred in situ (e.g. a kiln) then the response is likely to be bipolar compared to if the heated objects have been disturbed and moved relative to each other, in which case they are more likely to take an irregular form and may display a debris style response (e.g. ash).

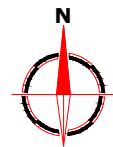
Weak background variations



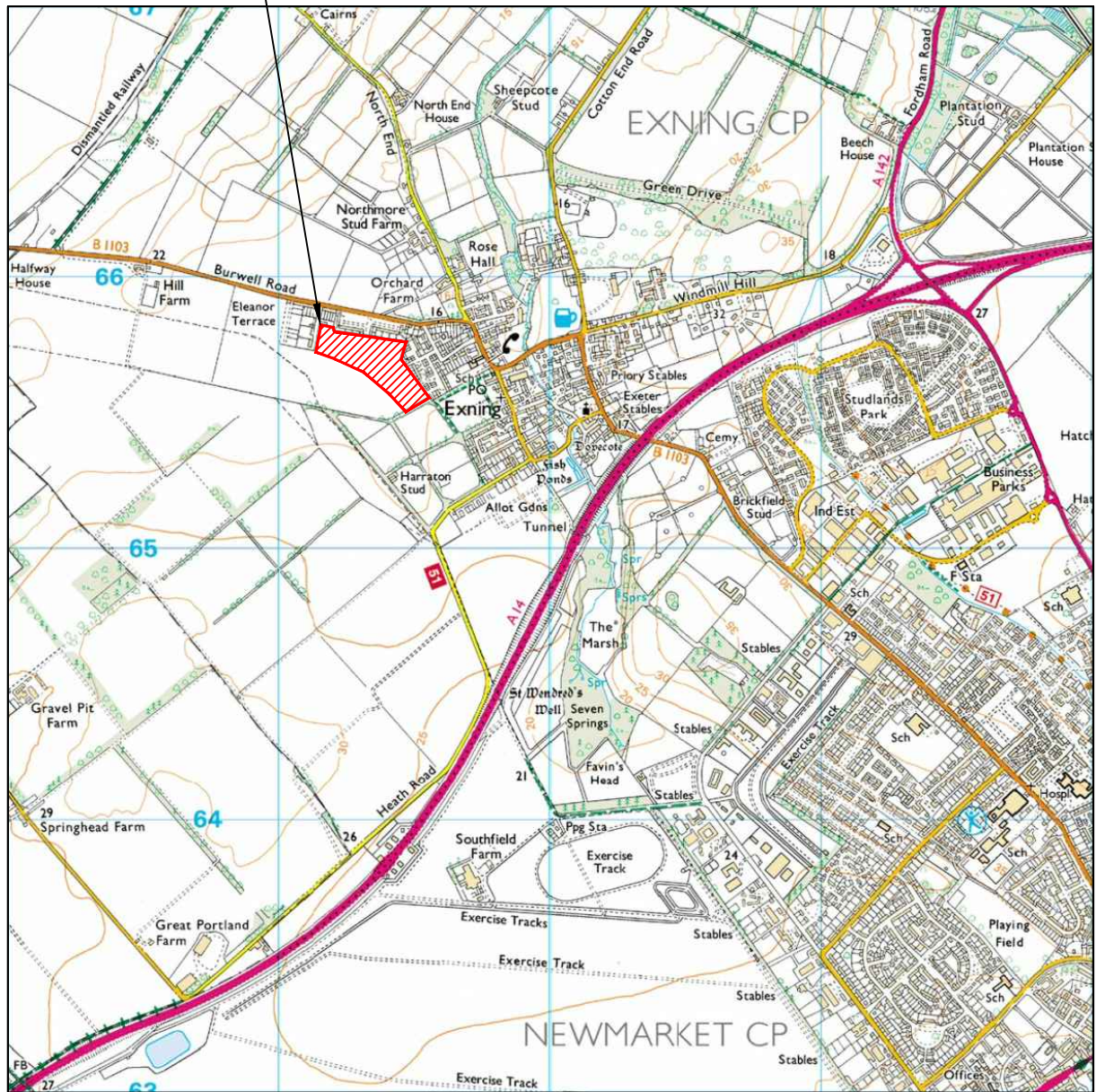
Weakly magnetic wide scale variations within the data can sometimes be seen within sites. These usually have no specific structure but can often appear curvy and sinuous in form. They are likely to be the result of natural features, such as soil creep, dried up (or seasonal) streams. They can also be caused by changes in the underlying geology or soil type which may contain unpredictable distributions of magnetic minerals, and are usually apparent in several locations across a site.

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OS 100km square = TL



Survey Area



Amendments

Issue No.	Date	Description
-	-	-
-	-	-

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Site centred on NGR TL 613 656

Client
ARCHAEOLOGICAL SOLUTIONS

Project Title
GEOPHYSICAL SURVEY - LAND SOUTH OF BURWELL ROAD, EXNING

Subject
LOCATION PLAN OF SURVEY AREA

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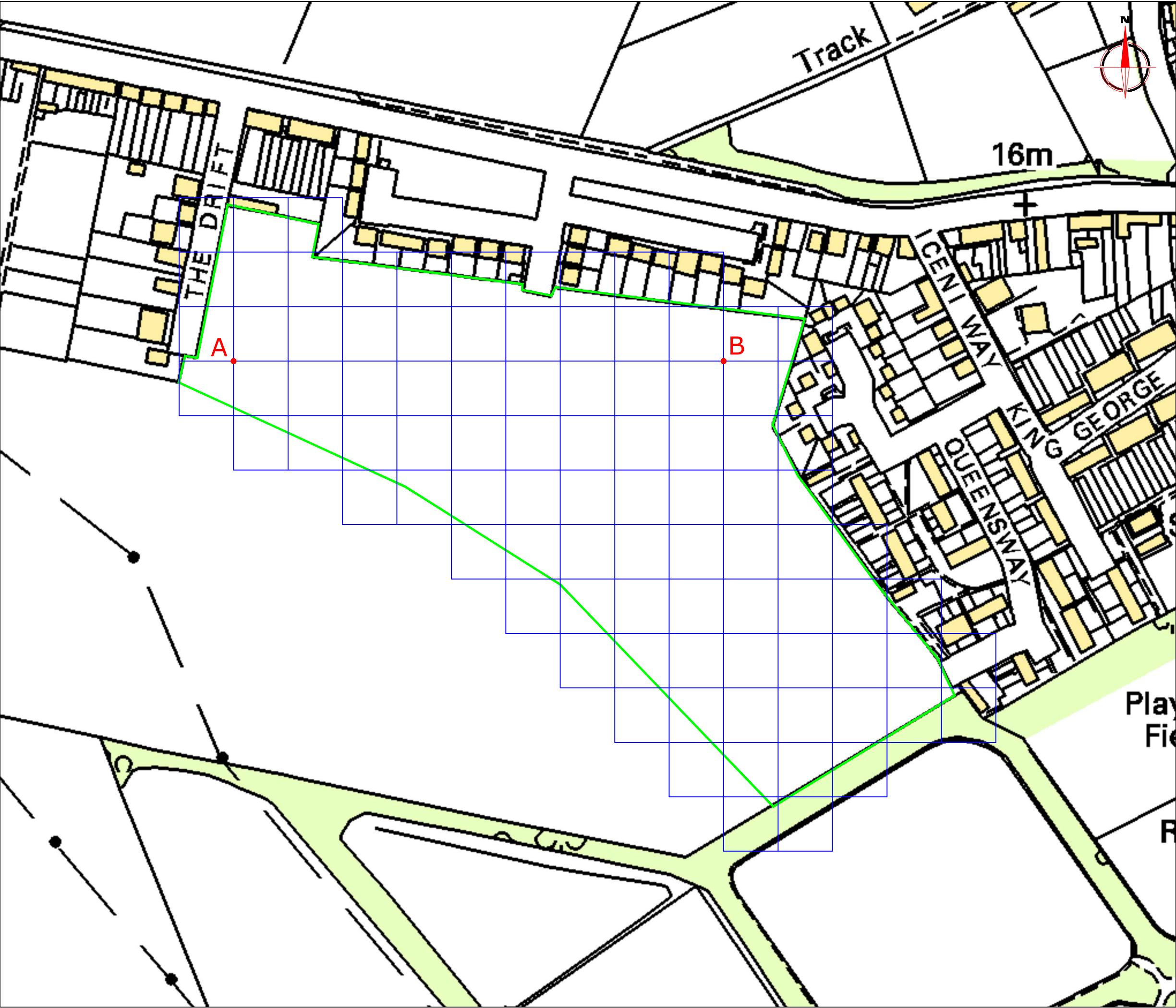


SUMO GROUP MEMBER



Scale 1:25000
0m 500 1000m

Plot A3	Checked by PPB	Issue No. 01
Survey date OCT 2012	Drawn by RAJS	Figure No. 01



Amendments

Issue No.	Date	Description
-	-	-
-	-	-

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KEY

Survey area

Survey grid

A

GPS referencing point

OS GRID REFERENCES

A

561159.84 , 265747.56

B

561429.84 , 265747.56

Client

ARCHAEOLOGICAL SOLUTIONS

Project Title

Job No.

GEOPHYSICAL SURVEY - LAND SOUTH OF BURWELL ROAD, EXNING

3205

Subject

LOCATION OF SURVEY GRIDS AND REFERENCING

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Scale

1:2000

0m 20 40 60 80 100

Plot

A3

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Issue No.

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Survey date

OCT 2012

Drawn by

RAJS

Figure No.

02



Amendments

Issue No.	Date	Description
-	-	-
-	-	-

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Plotting parameters

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

Zero
Mean

-2nT+2nT

+2nT

-2nT

Client

ARCHAEOLOGICAL SOLUTIONS

Project Title

Job No. 3205

GEOPHYSICAL SURVEY - LAND SOUTH OF BURWELL ROAD, EXNING

Subject

PLOT OF MINIMALLY PROCESSED GRADIOMETER DATA- WEST

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Scale

1:1000

0m 10 20 30 40 50

Plot A3	Checked by PPB	Issue No. 01
Survey date OCT 2012	Drawn by RAJS	Figure No. 03



Amendments

Issue No.	Date	Description
-	-	-
-	-	-

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KEY

PROBABLE ARCHAEOLOGY

	Positive anomaly / weak positive anomaly - probable cut feature of archaeological origin
	Negative anomaly / weak negative anomaly - probable bank or earthwork of archaeological origin
	Moderate strength discrete anomaly - probable thermoremanent feature
	Widely spaced curving parallel linear anomalies - probably related to ridge-and-furrow

POSSIBLE ARCHAEOLOGY

	Positive anomaly / weak positive anomaly - possible cut feature of archaeological origin
	Negative anomaly / weak negative anomaly - possible bank or earthwork of archaeological origin
	Moderate strength discrete anomaly - possible thermoremanent feature
	Magnetic spike - probable ferrous object

OTHER ANOMALIES

	Closely spaced parallel linear anomalies - probably related to agricultural activity such as ploughing
	Linear anomaly - probably related to pipe, cable or other modern service
	Linear anomaly - possibly related to vehicle track
	Magnetic disturbance associated with nearby metal object such as service or field boundary
	Strong magnetic debris - possible disturbed or made ground
	Scattered magnetic debris
	Area of amorphous magnetic variation - probable natural (e.g. geological or pedological) origin

Client

ARCHAEOLOGICAL SOLUTIONS

Project Title

Job No. 3205

GEOPHYSICAL SURVEY - LAND SOUTH OF BURWELL ROAD, EXNING

Subject

ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES- WEST

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Scale

1:1000

Plot	A3	Checked by	PPB	Issue No.	01
Survey date	OCT 2012	Drawn by	RAJS	Figure No.	04



Amendments

Issue No.	Date	Description
-	-	-
-	-	-

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Plotting parameters

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

Zero
Mean

-2nT+2nT

+2nT

-2nT

Client

ARCHAEOLOGICAL SOLUTIONS

Project Title

Job No. 3205

GEOPHYSICAL SURVEY - LAND SOUTH OF BURWELL ROAD, EXNING

Subject

PLOT OF MINIMALLY PROCESSED GRADIOMETER DATA- EAST

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MANAGEMENT
SYSTEMS

Scale

1:1000

0m 10 20 30 40 50

Plot

A3

Checked by

PPB

Issue No.

01

Survey date

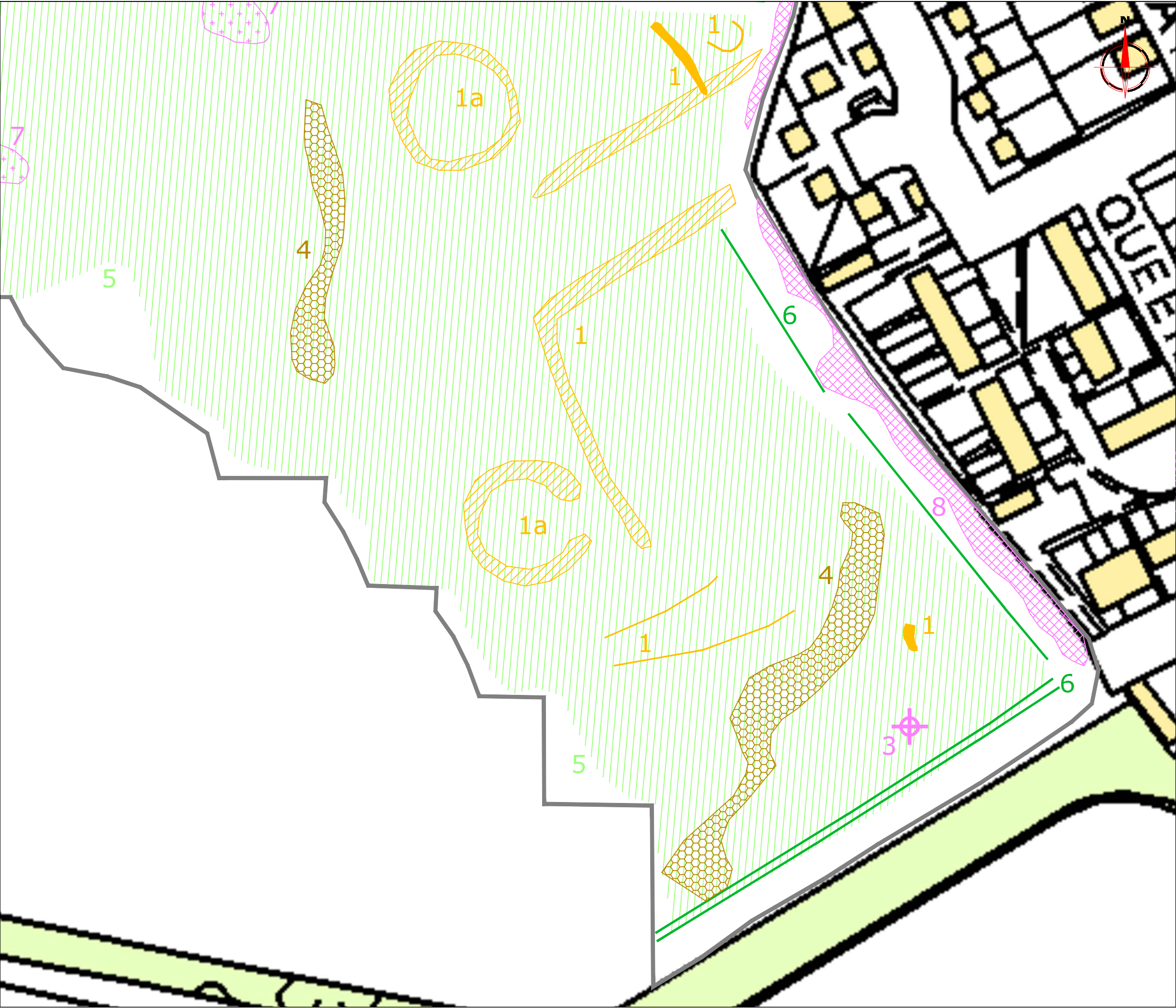
OCT 2012

Drawn by

RAJS

Figure No.

05



Amendments

Issue No.	Date	Description
-	-	-
-	-	-

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KEY

PROBABLE ARCHAEOLOGY

	Positive anomaly / weak positive anomaly - probable cut feature of archaeological origin
	Negative anomaly / weak negative anomaly - probable bank or earthwork of archaeological origin
	Moderate strength discrete anomaly - probable thermoremanent feature
	Widely spaced curving parallel linear anomalies - probably related to ridge-and-furrow

POSSIBLE ARCHAEOLOGY

	Positive anomaly / weak positive anomaly - possible cut feature of archaeological origin
	Negative anomaly / weak negative anomaly - possible bank or earthwork of archaeological origin
	Moderate strength discrete anomaly - possible thermoremanent feature
	Magnetic spike - probable ferrous object

OTHER ANOMALIES

	Closely spaced parallel linear anomalies - probably related to agricultural activity such as ploughing
	Linear anomaly - probably related to pipe, cable or other modern service
	Linear anomaly - possibly related to vehicle track
	Magnetic disturbance associated with nearby metal object such as service or field boundary
	Strong magnetic debris - possible disturbed or made ground
	Scattered magnetic debris
	Area of amorphous magnetic variation - probable natural (e.g. geological or pedological) origin

Client

ARCHAEOLOGICAL SOLUTIONS

Project Title

Job No. 3205

GEOPHYSICAL SURVEY - LAND SOUTH OF BURWELL ROAD, EXNING

Subject

ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES- EAST

GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING

VINEYARD HOUSE
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SUMO GROUP MEMBER

Scale

1:1000

Plot	Checked by	Issue No.
A3	PPB	01
Survey date	Drawn by	Figure No.
OCT 2012	RAJS	06



Amendments

Issue No.	Date	Description
-	-	-
-	-	-

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Plotting parameters

Maximum +100nT (red)
Minimum -100nT (blue)

+100nT

-100nT

Client

ARCHAEOLOGICAL SOLUTIONS

Project Title

Job No. 3205

GEOPHYSICAL SURVEY - LAND SOUTH OF BURWELL ROAD, EXNING

Subject

COLOUR PLOT OF GRADIOMETER DATA SHOWING EXTREME VALUES

STRATASCAN™

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EUROPEAN GPR ASSOCIATION

THE SURVEY ASSOCIATION

REGISTERED ORGANISATION

UVDB UTILITIES PREQUALIFICATION SCHEME

SUMO GROUP MEMBER

IMS ISO 9001 certified

UKAS ISO 9001

IMS ISO 14001 certified

UKAS ISO 14001

Scale

1:1500

0m 10 20 30 40 50m

Plot	Checked by	Issue No.
A3	PPB	01
Survey date	Drawn by	Figure No.
OCT 2012	RAJS	07



Amendments

Issue No.	Date	Description
-	-	-
-	-	-

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Plotting parameters

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

-2nT +2nT

+2nT
-2nT

Client

ARCHAEOLOGICAL SOLUTIONS

Project Title

GEOPHYSICAL SURVEY - LAND SOUTH OF BURWELL ROAD, EXNING

Job No. 3205

Subject

PLOT OF MINIMALLY PROCESSED GRADIOMETER DATA

STRATASCAN™
GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING

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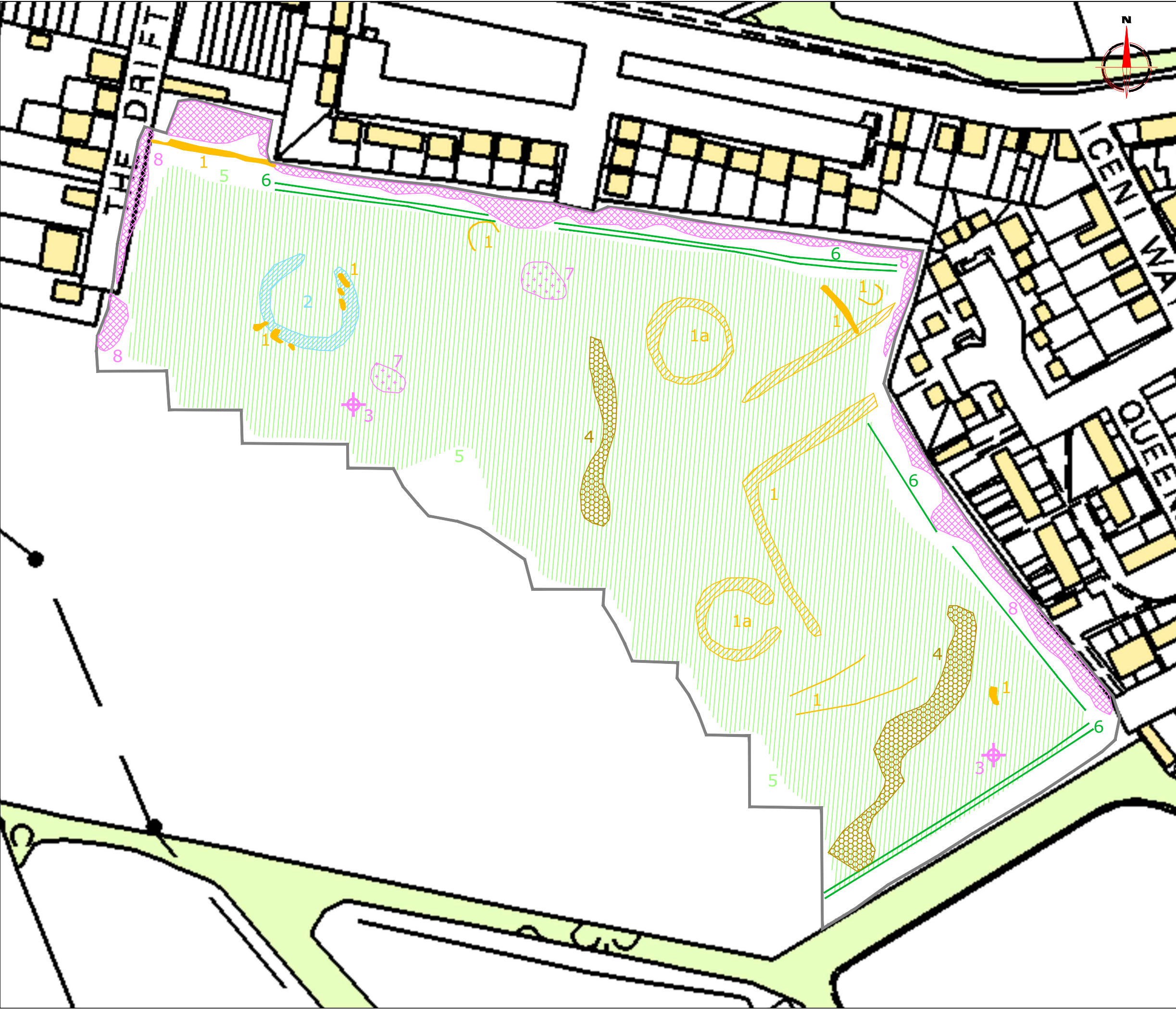
EUROPEAN GPR ASSOCIATION
THE SURVEY ASSOCIATION
UVDB UTILITIES PREQUALIFICATION SCHEME

SUMO GROUP MEMBER
ISO 9001 certified
ISO 14001 certified

Scale

1:1500

Plot	A3	Checked by	PPB	Issue No.	01
Survey date	OCT 2012	Drawn by	RAJS	Figure No.	08



Amendments		
Issue No.	Date	Description
-	-	-
-	-	-
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Client		
ARCHAEOLOGICAL SOLUTIONS		
Project Title		Job No. 3205
GEOPHYSICAL SURVEY - LAND SOUTH OF BURWELL ROAD, EXNING		
Subject		
ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES		
GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING		
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Scale 1:1500		
Plot	Checked by	Issue No.
A3	PPB	01
Survey date	Drawn by	Figure No.
OCT 2012	RAJS	09