GEOPHYSICAL SURVEY REPORT

STRATASCAN™

SUMO Survey Services
SUMO Group Member

Project name:
Land at Tuffley Farm, Gloucester

Client:
Orion Heritage

Job ref:
J9721

April 2016

GEOPHYSICAL SURVEY REPORT

Project name: **Land at Tuffley Farm, Gloucester** Client: **Orion Heritage**	Job ref: **J9721**
Survey date: **10th - 11th March 2016**	Report date: **April 2016**
Field team: **Lukasz Krawec** BSc **Richard Collins** BA (Hons) **Rosie Everett** BA (Hons) **Jay Griffiths** BSc (Hons) **Sonia Kostrzewska** MA	Project Manager: **Simon Haddrell** BEng(Hons) AMBCS PCIfA
Report written By: **Thomas Richardson** MSc ACIfA	Report approved by: **David Elks** MSc ACIfA
CAD illustrations by: **Thomas Richardson** MSc ACIfA	Site Director: **Peter Barker** CEng MICE MCIWEM MCIFA FCInistCES
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STRATASCAN LTD
Vineyard House Upper Hook Road Upton upon Severn
Worcestershire WR8 0SA United Kingdom

T: 01684 592266 F: 01684 594142
info@stratascansumo.com www.stratascan.co.uk

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1 SUMMARY OF RESULTS

A detailed gradiometry survey was carried out over approximately 10.5 hectares of pasture. An area of likely prehistoric or Romano-British settlement activity has been identified, comprising a series of linear and curvilinear features, along with a sub-rectangular enclosure and numerous pits. Further linear anomalies and possible pits may be associated with this settlement activity, though their exact origin is uncertain. Former field boundaries combined with evidence of ridge and furrow and a former pond indicate that the site has a largely agricultural past. The remaining features are natural or modern and include areas of natural magnetic variation, land drains, services, scattered magnetic debris, and disturbance from nearby ferrous metal objects.

2 INTRODUCTION

2.1 Background synopsis

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

2.2 Site Details

NGR / Postcode	SO 826 140 / GL4 0QQ
Location	The site is located at the south of Gloucester. Grange Road forms the northern boundary of the site while a railway line forms the western boundary.
HER/SMR	Gloucestershire
District	Gloucester
Parish	Non-parished – Tuffley is one of the 15 wards of the City of Gloucester.
Topography	Largely flat, sloping slightly down to the north.
Current Land Use	Pasture
Weather Conditions	Dry, clear
Soils	The overlying soils are known as Martock, which are typical stagnogley soils. These consist of slowly permeable, seasonally waterlogged, stoneless silty over clayey, and clayey soils over siltstone or shale (Soil Survey of England and Wales, Sheet 5 South West England).
Geology	The underlying geology comprises undifferentiated mudstone of Lias Formation and Charmouth Mudstone Formation. No drift geology is recorded (British Geological Survey website).

Archaeology	Extract from 'Tuffley Farm, Gloucester – Heritage Desk Based Assessment' (Orion Heritage, 2016): *The assessment has established that the study site is considered to have moderate potential for later prehistoric and Roman remains and low potential for all other archaeological periods. However, on the present evidence, it is considered unlikely that such remains, if present, would be of more than local significance and therefore, archaeology is not a design constraint on development.*
Survey Methods	Detailed magnetic survey (gradiometry)
Study Area	c.10.5ha

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

Given the moderate potential for prehistoric and Roman remains, 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 Tuffley Farm, Gloucester has identified a number of anomalies that have been characterised as being either of a *probable* or *possible* archaeological origin. The following list of numbered anomalies refers to numerical labels on the interpretation plots.

4.1 *Probable Archaeology*

1-2 A number of positive linear and curvilinear anomalies across the south of the area. These are indicative of former cut features, such as ditches, and are representative of an area of former settlement activity. The anomalies in the south-east of the area (Anomaly 1) form a sub-rectangular enclosure with additional linear features, while the anomalies in the west (Anomaly 2) are weaker in appearance and may represent a larger field system or enclosure ditch. The anomalies are characteristic of prehistoric or Romano-British settlement activity.

3-4 A number of small discrete positive anomalies situated amongst Anomalies 1 & 2. These are indicative of small former cut features, such as backfilled pits, and provide further evidence of prehistoric or Romano-British occupation on the site.

4.2 *Possible Archaeology*

5 A number of positive linear anomalies in the centre, north-east and far north of the site. These are indicative of former cut features such as ditches, and may be of archaeological origin. These anomalies may be related to the settlement activity evidenced by Anomalies 1-4, however they appear to be isolated from the main focus of activity and may be modern or agricultural features

6 A number of small discrete anomalies dispersed among the linear features of Anomaly 5. These may be related to former backfilled pits, however their exact origin cannot be determined with confidence.

4.3 Medieval/Post-Medieval Agriculture

7-8 Weak linear anomalies in the north and east of the site. These are related to former field boundaries that are visible on available OS mapping. Anomaly 7 is visible on mapping from 1884 to 1891 while Anomaly 8 is visible from 1884 to 1955.

9 A number of widely spaced, slightly curved, parallel linear anomalies across the site. These are associated with medieval ridge and furrow cultivation.

10 A large discrete area of strong magnetic debris near the centre of the site and a further area of magnetic debris in the north These are related to a former pond that is visible on available OS mapping from 1884 to 1955.

4.4 Other Anomalies

11 Two areas of enhanced magnetic variation in the south of the area. These are likely to be natural, i.e. geological, in origin.

12 Two weak bipolar linear anomalies, one in the north and one in the south-east of the site. These are likely to be related to land drains.

13 Strong bipolar linear anomalies in the north and centre of the area. These are related to underground services, such as pipes or cables.

14 A small area of weak scattered magnetic debris near the centre of the area. This is likely to be modern in origin.

15 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.

16 A number of magnetic ‘spikes’ (strong focussed values with associated antipolar response) indicate ferrous metal objects. These are likely to be modern rubbish.

5 DATA APPRAISAL & CONFIDENCE ASSESSMENT

Lias Formation and Charmouth Mudstone formation geologies often provide a good response for magnetic survey. In this instance, a wide range of archaeological and agricultural anomalies have been detected with most anomalies having a relatively high contrast in comparison to the background magnetic response. This high contrast, coupled with the number of archaeological features detected, indicates that the survey has been effective.

6 CONCLUSION

The survey at Tuffley Farm, Gloucester has identified a number of features of archaeological origin, corresponding with the desk-based assessment of the site having a moderate potential for prehistoric and Romano-British remains. Further linear anomalies and possible pits may be of archaeological origin, though their exact origin cannot be determined with confidence. Evidence of ridge and furrow, former field boundaries and a former pond indicate that the site has been used for agricultural purposes since the medieval period. The remaining features are natural or modern in origin and include underground services, land drains, a small area of scattered magnetic debris, disturbance from nearby ferrous objects, and magnetic spikes.

7 REFERENCES

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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.

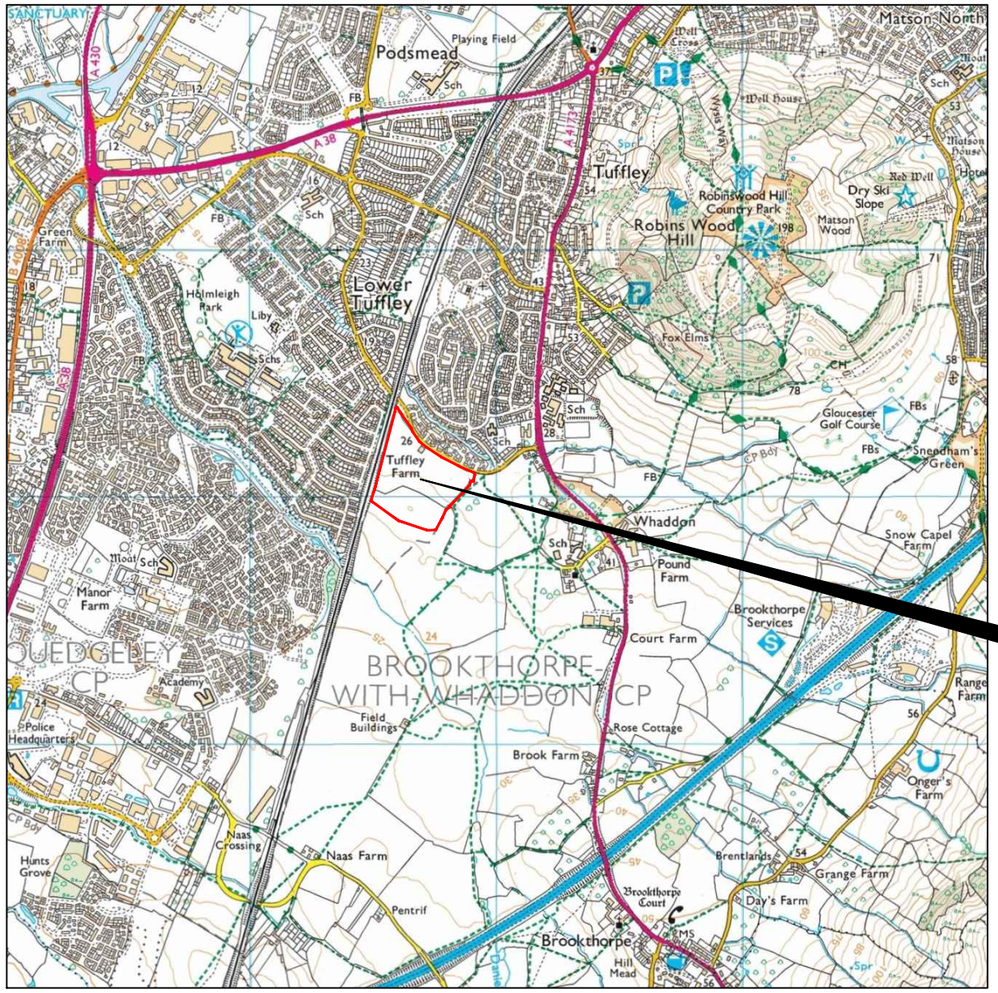
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement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

OS 100km square = SO

16
15
14
13
12



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Job No. 9721

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GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPTON UPON SEVERN
WR8 0SA
T: 01684 592266
E: info@stratascan.co.uk
www.stratascan.co.uk

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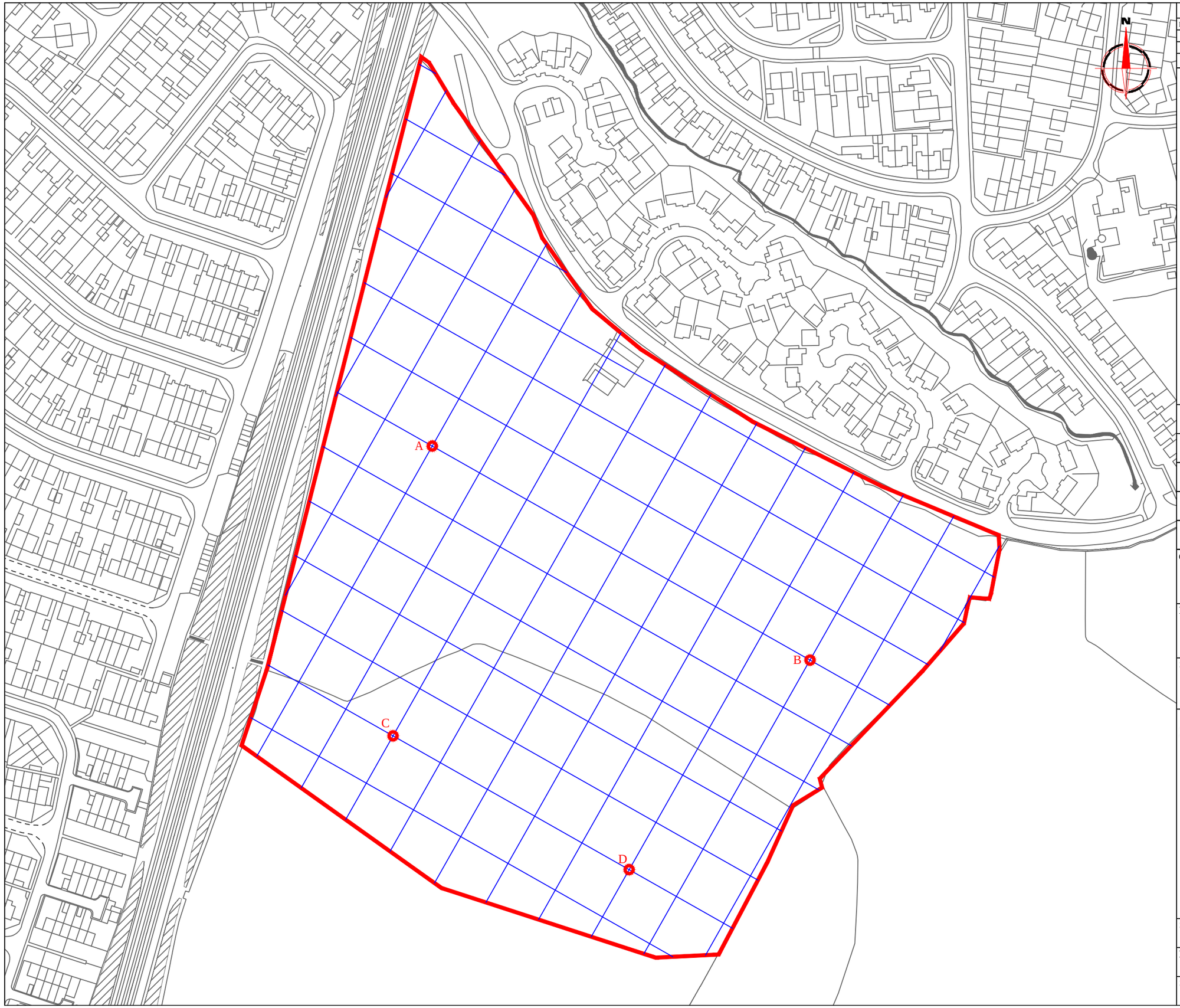

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LOCATION OF SURVEY GRIDS AND REFERENCING

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VINEYARD HOUSE
UPTON UPON SEVERN
WR8 0SA
T: 01684 592266
E: info@stratascan.co.uk
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GEOPHYSICAL SURVEY - LAND AT TUFFLEY FARM, GLOUCESTER

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COLOUR PLOT OF GRADIOMETER DATA SHOWING EXTREME VALUES - OVERVIEW

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VINEYARD HOUSE
UPTON UPON SEVERN
WR8 0SA
T: 01684 592266
E: info@stratascan.co.uk
www.stratascan.co.uk

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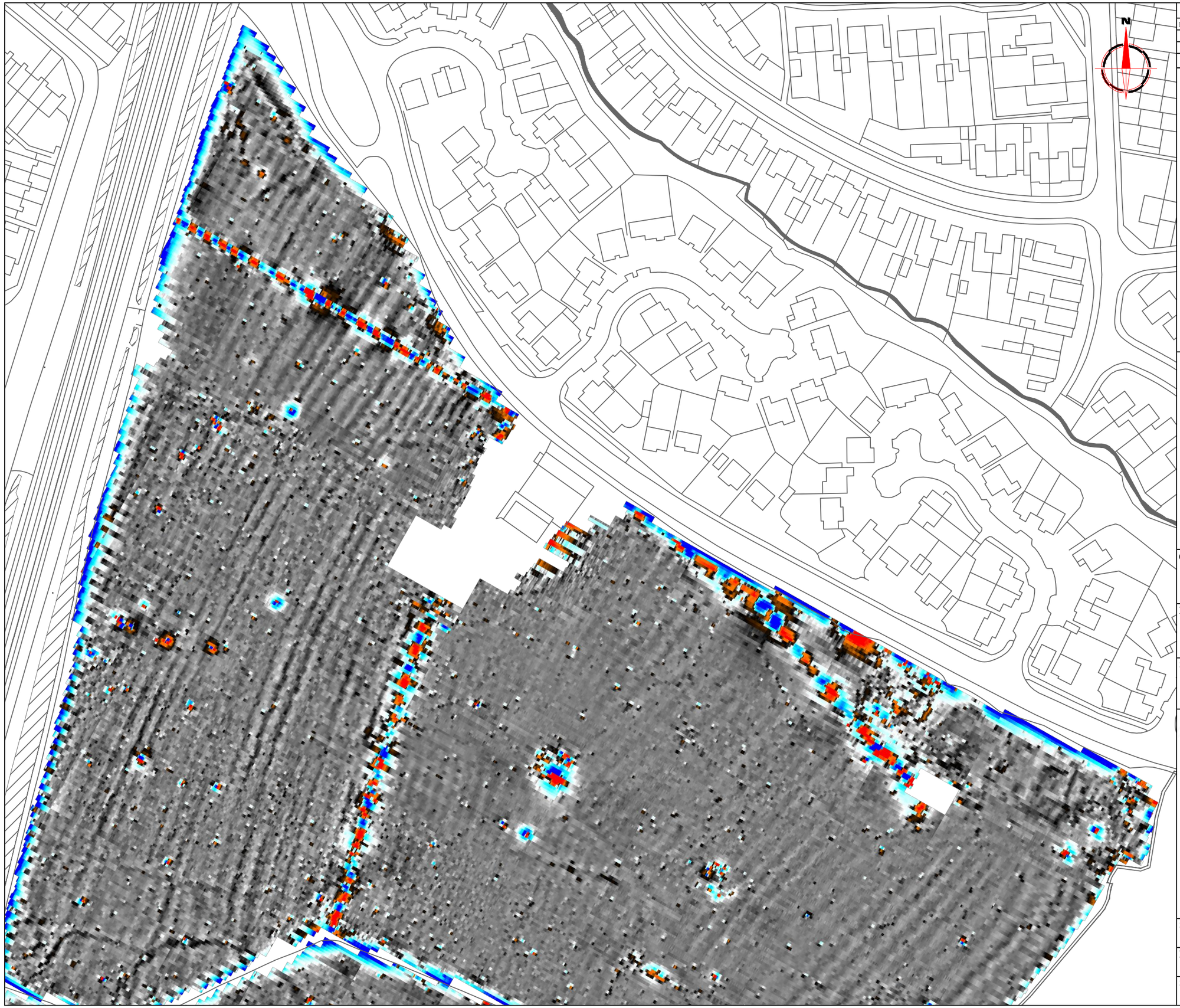

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VINEYARD HOUSE
UPTON UPON SEVERN
WR8 0SA
T: 01684 592266
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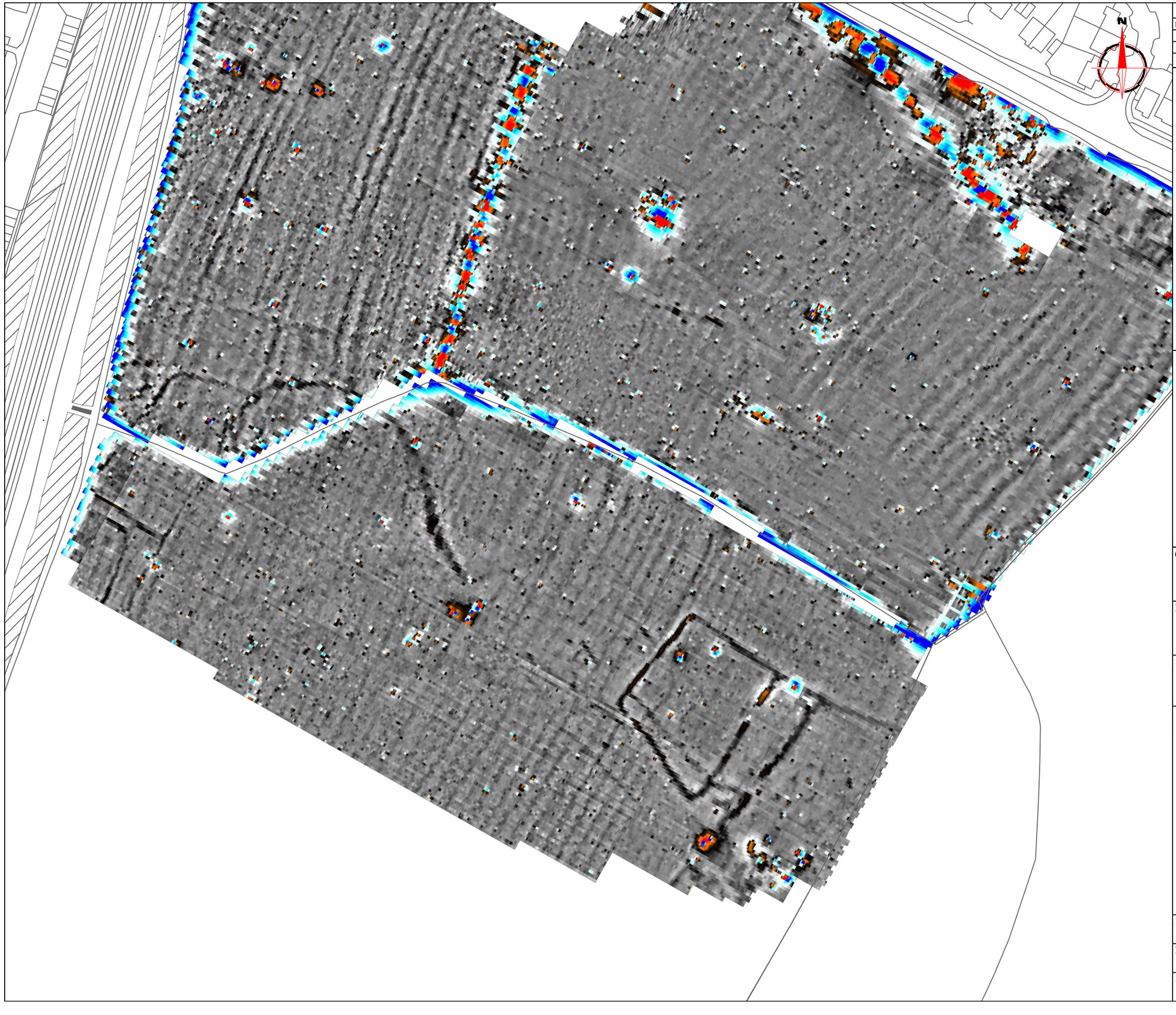

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COLOUR PLOT OF GRADIOMETER DATA SHOWING EXTREME VALUES - SOUTH

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VINEYARD HOUSE
UPTON UPON SEVERN
WR8 0SA
T: 01684 592266
E: info@stratascan.co.uk
www.stratascan.co.uk

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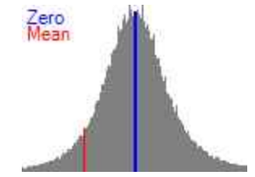

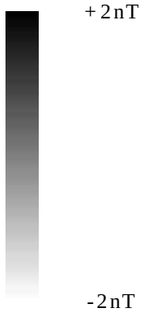

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PLOT OF MINIMALLY PROCESSED GRADIOMETER DATA - OVERVIEW

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VINEYARD HOUSE
UPTON UPON SEVERN
WR8 0SA
T: 01684 592266
E: info@stratascan.co.uk
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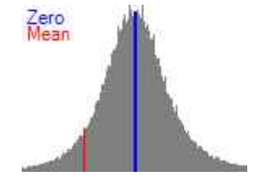

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PLOT OF MINIMALLY PROCESSED GRADIOMETER DATA - NORTH

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GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPTON UPON SEVERN
WR8 0SA
T: 01684 592266
E: info@stratascan.co.uk
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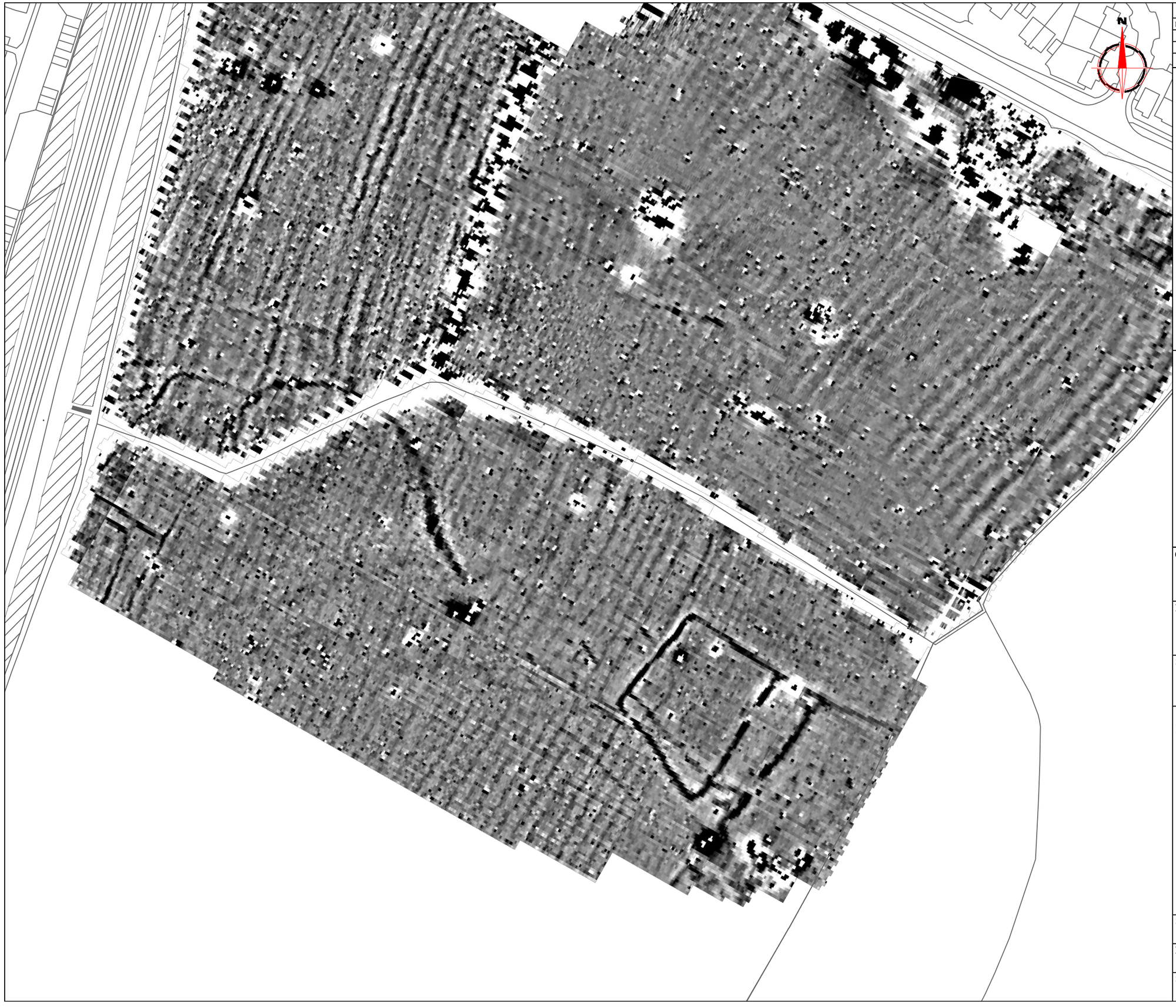

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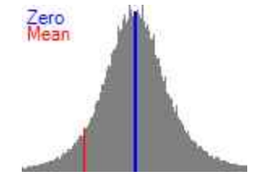

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VINEYARD HOUSE
UPTON UPON SEVERN
WR8 0SA
T: 01684 592266
E: info@stratascan.co.uk
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-	-	-

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

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

MEDIEVAL/POST-MEDIEVAL AGRICULTURE

- Widely spaced curving parallel linear anomalies - probably related to ridge-and-furrow
- Strong magnetic debris - related to pond visible on available mapping
- Linear anomaly - probably related to a former field boundary not present on available mapping
- Linear anomaly - related to a former field boundary present on available mapping

OTHER ANOMALIES

- Linear anomaly - probably related to pipe, cable or other modern service
- Linear anomaly - possibly related to land drain
- Magnetic disturbance associated with nearby metal object such as service or field boundary
- Scattered magnetic debris
- Area of amorphous magnetic variation - probable natural (e.g. geological or pedological) origin
- Magnetic spike - probable ferrous object

Client

ORION HERITAGE LTD

Project Title — Job No. 9721

GEOPHYSICAL SURVEY - LAND AT TUFFLEY FARM, GLOUCESTER

Subject

ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES - OVERVIEW

STRATASCAN™
GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPTON UPON SEVERN
WR8 0SA
T: 01684 592266
E: info@stratascan.co.uk
www.stratascan.co.uk

SUMO GROUP MEMBER

Scale 1:2000 (0m 20 40 60 80 100m)

Plot	Checked by	Issue No.
A3	DGE	01
Survey date	Drawn by	Figure No.
MAR 16	RD	09

Amendments

Issue No.	Date	Description
-	-	-
-	-	-

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Client

ORION HERITAGE LTD

Project Title — Job No. 9721

GEOPHYSICAL SURVEY - LAND AT TUFFLEY FARM, GLOUCESTER

Subject

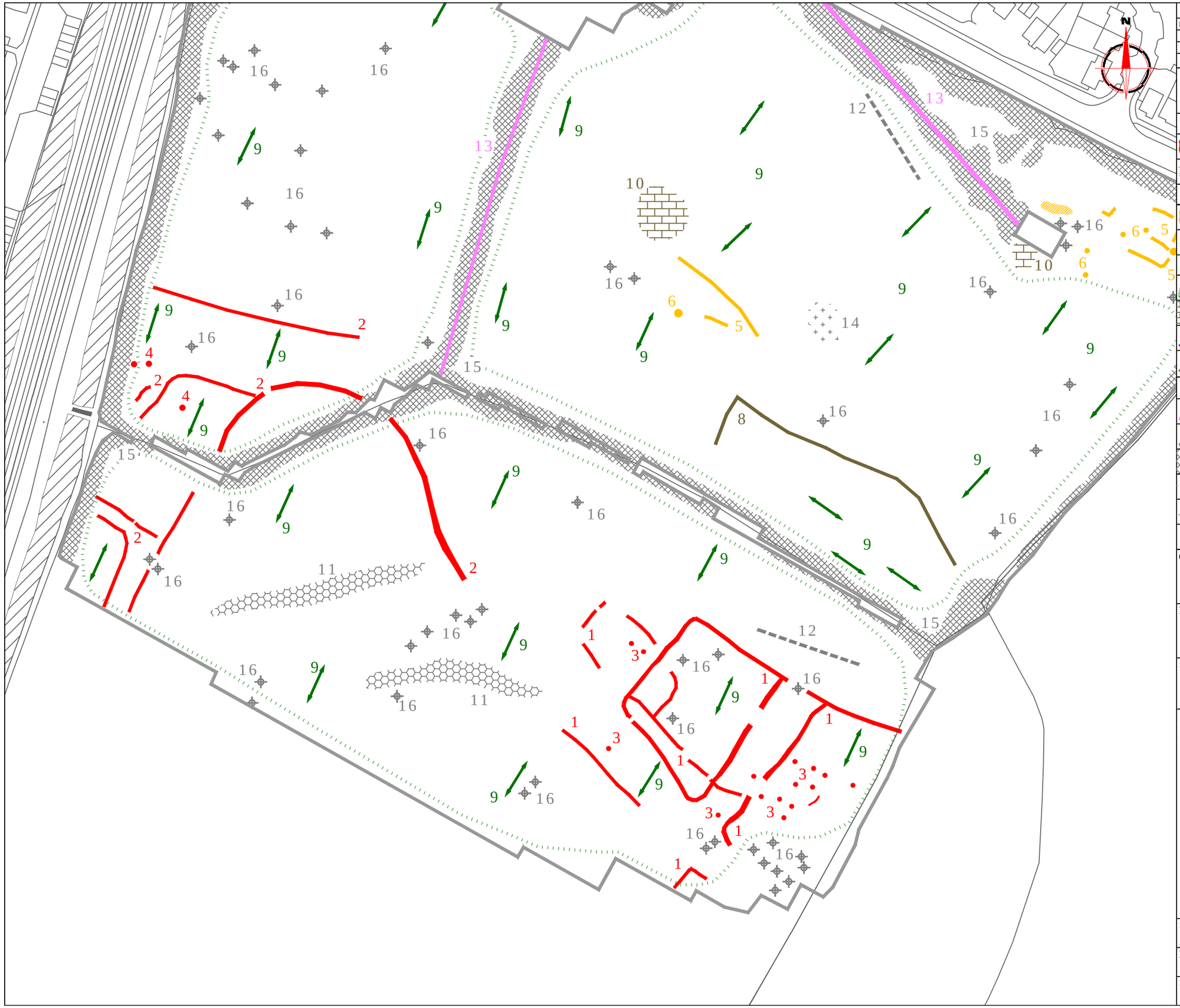
ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES - NORTH

STRATASCAN™
GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPTON UPON SEVERN
WR8 0SA
T: 01684 592266
E: info@stratascan.co.uk
www.stratascan.co.uk

SUMO GROUP MEMBER

Scale 1:1250 (0m 10 20 30 40 50m)

Plot	Checked by	Issue No.
A3	DGE	01
Survey date	Drawn by	Figure No.
MAR 16	RD	10



Amendments

Issue No.	Date	Description
-	-	-
-	-	-

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Client

ORION HERITAGE LTD

Project Title — Job No. 9721

GEOPHYSICAL SURVEY - LAND AT TUFFLEY FARM, GLOUCESTER

Subject

ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES - SOUTH

STRATASCAN™
GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPTON UPON SEVERN
WR8 0SA
T: 01684 592266
E: info@stratascan.co.uk
www.stratascan.co.uk

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MAR 16	RD	11

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