GEOPHYSICAL SURVEY REPORT

STRATASCAN™

SUMO Survey Services
SUMO Group Member

Project name:

Lodge Farm, Dereham Road, Costessey

Client:

Archaeological Solutions Ltd

August 2013

Job ref:
J5545

Report author:
Thomas Richardson MSc

GEOPHYSICAL SURVEY REPORT

Project name:
Lodge Farm, Dereham Road, Costessey
Client:
Archaeological Solutions Ltd

Job ref:
J5545

Techniques:
Detailed magnetic survey – Gradiometry

Survey date:
1st-11th July

Site centred at:
TG 161 105

Post code:
NR5 0TS

Field team:
Aidan Rossiter BA, **Steve Hamflett** MSci, **Adam Green, Dominic Slevin**

Project manager:
Simon Haddrell BEng(Hons) AMBCS PIFA

Report written By:
Thomas Richardson MSc

CAD illustrations by:
Simon Haddrell BEng(Hons) AMBCS PIFA

Checked by:
David Elks MSc AIFA

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1 SUMMARY OF RESULTS

A detailed gradiometry survey was conducted over approximately 28 hectares of agricultural land. The survey identified an Iron Age boundary ditch, located in an adjoining field by earlier excavation. A number of anomalies of possible archaeological origin have also been identified, many of which are present on aerial photography of the area; however it is not possible to determine their origin with any degree of confidence. The remaining anomalies are of modern origin relating to a backfilled pond, a modern track and ferrous objects.

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 Ltd.

2.2 *Site location*

The site is located near Costessey, to the west of Norwich at OS ref. TG 161 105.

2.3 *Description of site*

The survey area is approximately 28 hectares of agricultural land covered by corn. There were areas of overgrown vegetation around field boundaries, and an unsurveyable area in the north-east. The remaining area was generally flat with no obstructions to the survey area.

2.4 *Geology and soils*

The underlying geology is Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation, Culver Chalk Formation (British Geological Survey website). The drift geology is Happisburgh Glacigenic Formation and Lowestoft Formation (undifferentiated) – Sand and Gravel (British Geological Survey website).

The overlying soils are known as Burlingham 1 which are typical Stagnogleyic argillic brown earth soils. These consist of deep coarse and fine loamy soils, some coarse loamy and sandy soils (Soil Survey of England and Wales, Sheet 4 Eastern England).

2.5 *Site history and archaeological potential*

Extract from 'Land West of Lodge Farm, Costessey, Norfolk An Archaeological Desk-based Assessment' (Archaeological Solutions Ltd 2011) conclusion:

6.1 The assessment site, located on a ridge of high ground between the rivers Wensum and Yare, lies within a prehistoric landscape that includes funerary monuments and field systems. The cropmark transcript indicates the presence of numerous fragmentary archaeological

features representing at least two phases, suggested as Bronze Age and Iron Age, with the highest concentration to the south-west of Lodge Farm (NHER 54472, 31518, Fig 5). A similar group of excavated cropmarks in the area abutting the east side of the site revealed concentrations of late Neolithic to early Bronze Age worked and burnt flint (NHER 37646, 39351), a late Bronze Age metal hoard (NHER 16398), and an early Iron Age boundary ditch which extended onto the assessment site (NHER 37646). Most of the finds came from the ploughsoil, but some archaeological features were encountered including the Iron Age ditch, and further prehistoric and undated features have been identified on the western edge of the site (NHER 20 33423, 12988, 29048). It is therefore almost certain that archaeological features of prehistoric or later date are present on the assessment site, although not all of the cropmarks are necessarily archaeological in nature.

6.2 A postulated Roman road crosses the southern part of the site roughly parallel with Long Lane, indicated by cropmarks and an excavated area containing a gravel spread between two ditches, although excavations on the A47(T) failed to locate it continuing to there (NHER 15768). Cropmarks of possible ditches have also been noted close to this roadway (NHER 54453, Fig 5). It is possible that some of the inferred prehistoric cropmarks are in fact medieval as they conform to the medieval landscape. A brick kiln existed just to the south of Costessey Lodge (NHER 7916, Fig. 6), and early historic maps show the presence of other buildings or structures on the site (Figs. 7-12). A large tunnel or drain and a huge pit were reported adjacent to the southernmost building (NHER 13634). The 1797 Faden map and the 1882 OS map show tracks running south and west respectively across the site which have since disappeared, and some of the field boundaries shown on early maps have since gone although some show up as cropmarks.

2.6 *Survey objectives*

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

2.7 *Survey methods*

This report and all fieldwork have been conducted in accordance with both the English Heritage guidelines outlined in the document: *Geophysical Survey in Archaeological Field Evaluation, 2008* and with the Institute for Archaeologists document *Standard and Guidance for Archaeological Geophysical Survey.*

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 and in Appendix A.

2.8 *Processing, presentation and interpretation of results*

2.8.1 *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 minimally 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)

2.8.2 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, together with a greyscale plot of the processed data. Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing for the site.

3 RESULTS

The detailed magnetic gradiometer survey conducted at Costessey has identified a number of anomalies that have been characterised as being either of a *probable* or *possible* archaeological origin.

The difference between *probable* and *possible* archaeological origin is a confidence rating. Features identified within the dataset 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.

*3.1 **Probable Archaeology***

1 A positive linear anomaly in the eastern field. This is related to an Iron Age boundary ditch, which has been previously excavated in the adjoining field to the east.

3.2 *Possible Archaeology*

2 A number of positive linear anomalies across the site. These are indicative of former cut features. Anomalies 2a are related to anomalies identified by aerial photography in the desk-based assessment. It is likely that most of these anomalies are related to former field boundaries.

3 A number of small discrete positive anomalies across the site. These are indicative of small former cut features, such as back filled pits.

3.3 *Other Anomalies*

4 Two moderately strong dipolar anomalies. These anomalies are of an unknown origin, but their strength suggests that they are likely to be modern.

5 An area of strong dipolar responses in the eastern field. This is related to a backfilled pond present on mapping in the desk-based assessment.

6 An area of scattered magnetic debris related to a modern track.

7 Areas of scattered magnetic debris. These are likely to be modern in origin.

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.

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

4 CONCLUSION

The survey at Costessey has identified an Iron Age boundary ditch, which had been located previously by excavation in the adjoining field to the east. There are a number of other anomalies that have been identified as possible archaeology, some of which relate to those present on aerial photography of the area; however it is not possible to determine their origin with any degree of confidence.

The remaining anomalies are likely to be of modern origin. A backfilled pond and modern track have been identified. The remaining anomalies relate to modern ferrous objects and fencing.

REFERENCES

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APPENDIX A – METHODOLOGY & SURVEY EQUIPMENT

Grid locations

The location of the survey grids has been plotted together with the referencing information. Grids were set out using a Leica 705auto Total Station and referenced to suitable topographic features around the perimeter of the site or 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.

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.

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.

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.

Data capture

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.

APPENDIX B – 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.

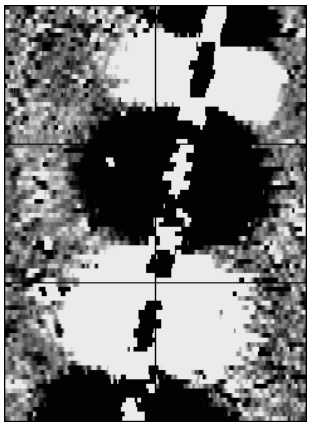
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement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

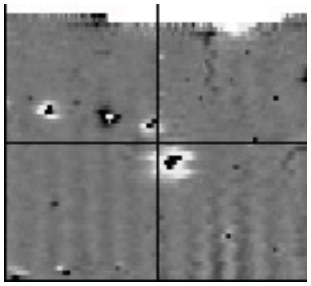
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES

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

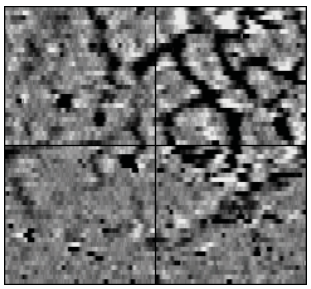


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

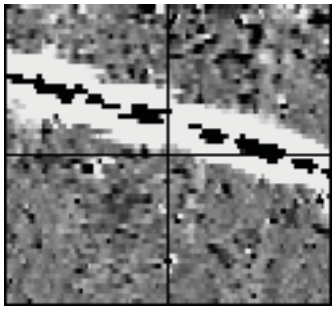
See bipolar and dipolar.

Positive linear



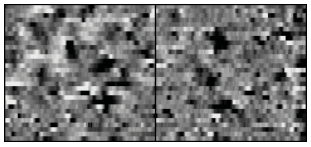
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

Positive linear anomaly with associated negative response



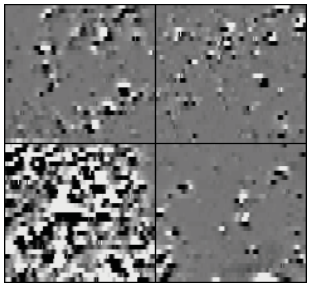
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field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

Positive point/area



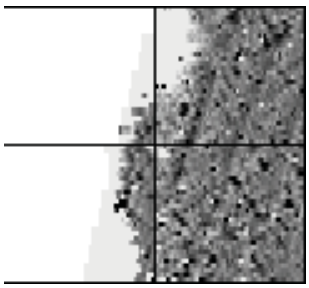
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



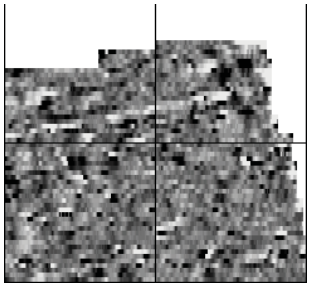
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low (+/-3nT) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly (+/-250nT) 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

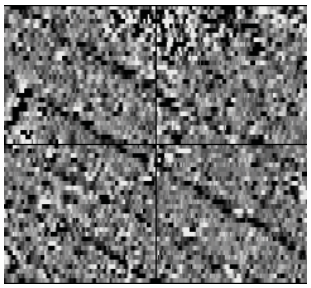


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative the background top soil is built up. See also ploughing activity.

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).

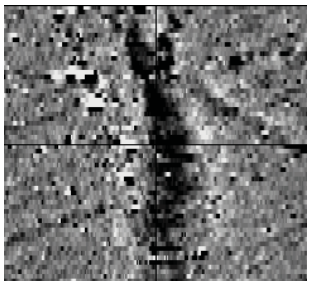
Strength of response

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 10m^2 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.

STRATASCAN™

SUMO Group Member

STRATASCAN LTD
Vineyard House Upper Hook Road Upton upon Severn
Worcestershire WR8 0SA United Kingdom

T:0 1684 592266 F: 01684 594142
info@stratascan.co.uk www.stratascan.co.uk

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OS 100km square = TG

Amendments

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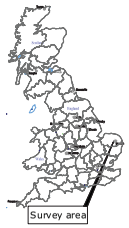

Site centred on NGR TG 161 105

OS REFERENCING INFORMATION

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C	616012.74, 310545.09
D	616012.74, 310455.09
E	615982.74, 310335.09
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G	616252.74, 310335.09
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Job No.	Survey Date
J5545	JULY 2013

Client

ARCHAEOLOGICAL SOLUTIONS LTD

Project Title

GEOPHYSICAL SURVEY - LODGE FARM, DEREHAM ROAD, COSTESSEY

Subject

SITE LOCATION, SURVEY AREA & REFERENCING

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 50 60 70 80m)

Plot	Checked by	Issue No.
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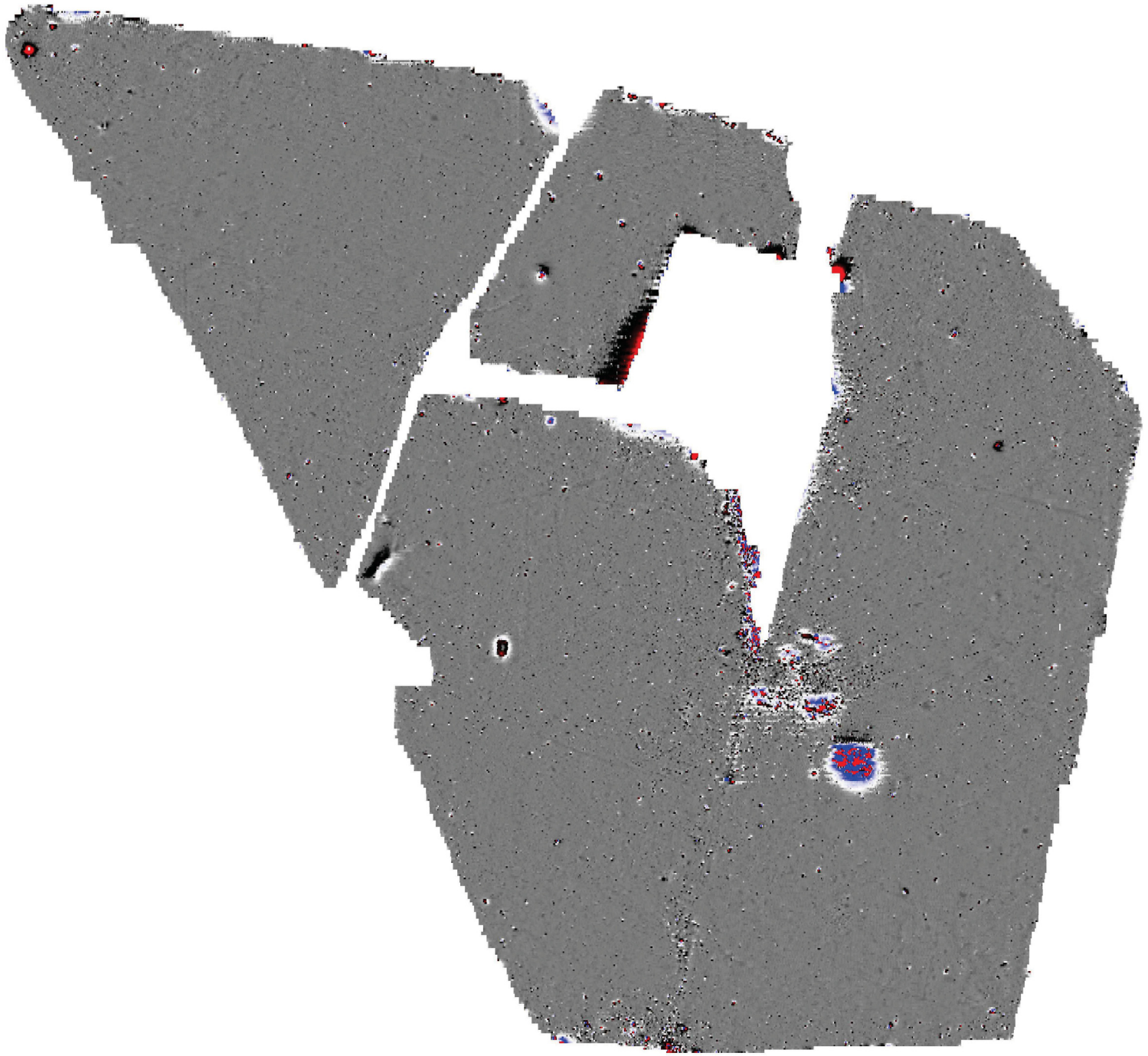
Date	Drawn by	Figure No.
AUG 2013	SDH	01



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Plotting parameters

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

+100nT
+10nT
-10nT
-100nT

Job No.	Survey Date
J5545	JULY 2013

Client

ARCHAEOLOGICAL SOLUTIONS LTD

Project Title

GEOPHYSICAL SURVEY - LODGE FARM, DEREHAM ROAD, COSTESSEY

Subject

COLOUR PLOT OF MINIMALLY PROCESSED GRADIOMETER DATA SHOWING EXTREME VALUES

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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Scale 1:1250 (0m 10 20 30 40 50 60 70 80m)

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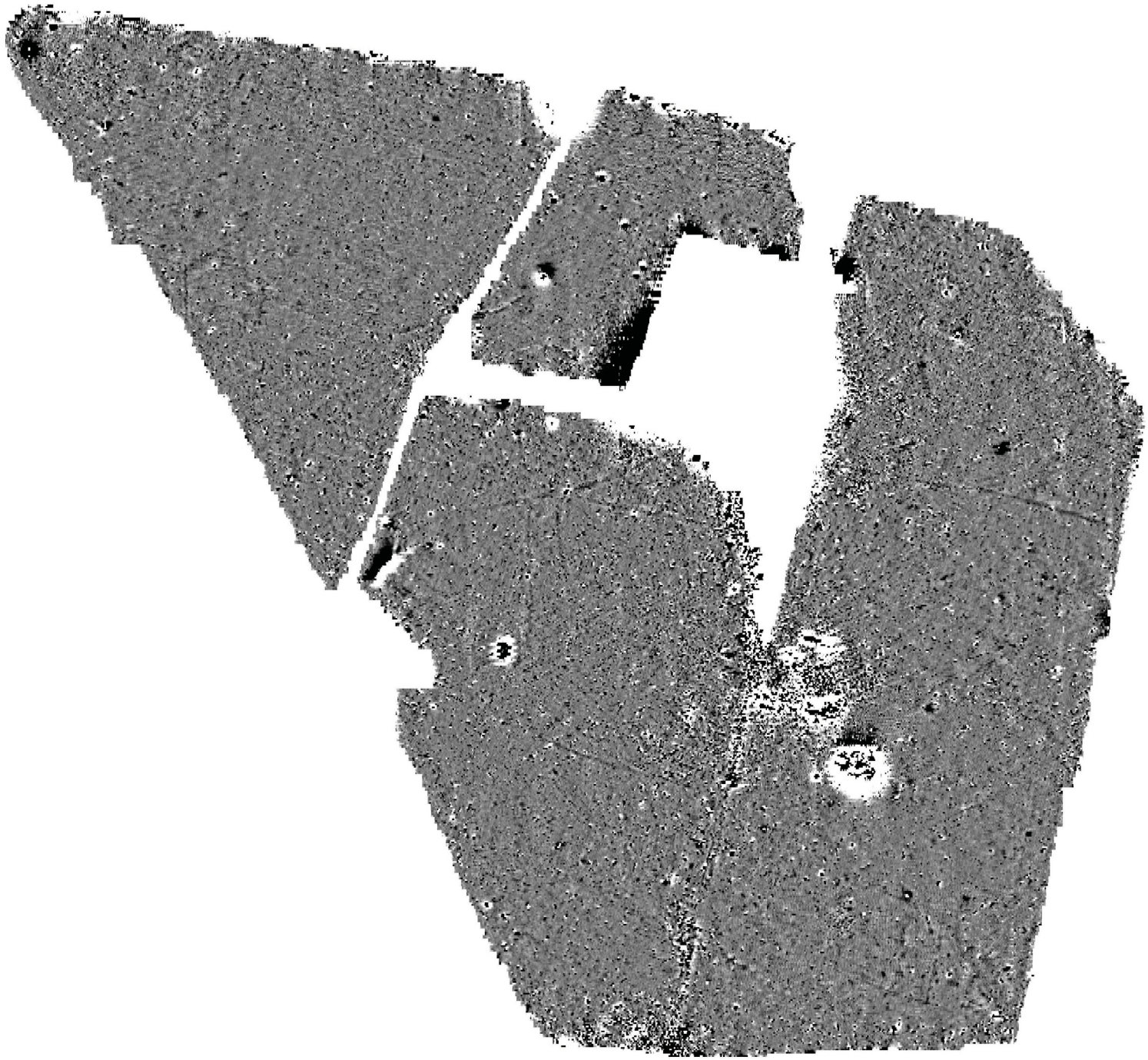

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Issue No.	Date	Description
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Plotting parameters

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

-2nT +2nT

+2nT

-2nT

Job No.	Survey Date
J5545	JULY 2013

Client

ARCHAEOLOGICAL SOLUTIONS LTD

Project Title

GEOPHYSICAL SURVEY - LODGE FARM, DEREHAM ROAD, COSTESSEY

Subject

PLOT OF MINIMALLY PROCESSED GRADIOMETER DATA

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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Scale 1:1250 (0m 10 20 30 40 50 60 70 80m)

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A1	DGE	01
Date	Drawn by	Figure No.
AUG 2013	SDH	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
- Linear anomaly - associated with Iron Age boundary ditch
- 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

OTHER ANOMALIES

- Dipolar anomalies - unknown origin
- 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 land drain
- Magnetic disturbance associated with nearby metal object such as service or field boundary
- Strong magnetic debris - related to back filled pond
- Scattered magnetic debris - related to modern track
- Scattered magnetic debris
- Area of amorphous magnetic variation - probable natural (e.g. geological or pedological) origin
- Magnetic spike - probable ferrous object

Job No.	Survey Date
J5545	JULY 2013

Client: ARCHAEOLOGICAL SOLUTIONS LTD

Project Title: GEOPHYSICAL SURVEY - LODGE FARM, DEREHAM ROAD, COSTESSEY

Subject: INTERPRETATION

STRATASCAN™
GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPTON UPON SEVERN
WR8 0SA
T: 01684 592266
E: info@stratascan.co.uk
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Scale 1:1250 (0m 10 20 30 40 50 60 70 80m)

Plot	Checked by	Issue No.
A1	DGE	01
Date	Drawn by	Figure No.
AUG 2013	SDH	04