Appendix 13.2 Archaeological Geophysical Survey

GEOPHYSICAL SURVEY REPORT

STRATASCAN™

SUMO Survey Services SUMO Group Member

Project name:

Haverhill, Suffolk

Client:

CgMs Consulting Ltd

December 2014

Job ref:

J7397

Report author:

Rebecca Davies BSc (Hons)

GEOPHYSICAL SURVEY REPORT

Project name:
Haverhill, Suffolk
Client:
CgMs Consulting Ltd

Job ref:
J7397

Field team:
Steven Chetwynd BA (Hons), **Richard Kemp** MA, **Robert Knight** BA (Hons), **Christian Adams** BA (Hons)

Techniques:
Detailed magnetic survey – Gradiometry

Project manager:
Simon Haddrell BEng(Hons) AMBCS PCIfA

Survey date:
20th - 24th November 2014

Report written By:
Rebecca Davies BSc (Hons)

Site centred at:
TL 685 463

CAD illustrations by:
Rebecca Davies BSc (Hons)

Post code:
CB9 7TB

Checked by:
David Elks MSc ACIfA

TABLE OF CONTENTS

LIST OF FIGURES

1 SUMMARY OF RESULTS

A detailed gradiometry survey was conducted over approximately 125 hectares of mixed use agricultural land. There is evidence for former settlement activity across the site, supporting the moderate potential for Iron Age remains outlined by the desk-based assessment. A number of former field boundaries and track ways indicate an agricultural past for the area. Several anomalies indicative of cut features may be of archaeological or natural origin. The remaining features are modern or natural in origin and include services, land drains, evidence of ploughing and disturbance from nearby ferrous 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 CgMs Consulting Ltd.

2.2 Site location

The site is located north east of the town of Haverhill, Suffolk at OS ref. TL 685 463. The site is bound by agricultural land to the north and east, and by residential areas to the south and west.

2.3 Description of site

The survey area is 125 hectares of mostly flat, mixed use agricultural land. Two areas of planted woodland and overgrown vegetation, totalling approximately 7 hectares, were unsurveyable.

2.4 Geology and soils

The underlying geology is undifferentiated chalk of Lewes Chalk formation and Seaford Chalk Formation of the Cretaceous (British Geological Survey website). There are superficial deposits of Head – clay, silt, sand and gravel between fields 17, 16, 20, 22 and 21 (British Geological Survey website).

The overlying soils are known as Hanslope which are typical calcareous pelosols. These consist of slowly permeable calcareous clayey soils and some slowly permeable non-calcareous clayey soils (Soil Survey of England and Wales, Sheet 4 Eastern England).

2.5 *Site history and archaeological potential*

Extract from "Great Wilsey Park, Haverhill, Suffolk – Heritage Desk-Based Assessment" (CgMs Consulting Ltd, 2014):

"The assessment has established that the site is considered to have moderate potential for Iron Age remains and localised areas (i.e. adjacent to the moated sites) of high potential for medieval remains. The site is considered to have low potential for remains of all other periods but the presence of Bronze Age and Roman remains cannot be ruled out."

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.*

Due to the high potential for medieval remains, the moderate potential for archaeological remains from the Iron Age and the good response of Cretaceous chalks for gradiometer 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 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. 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 Haverhill 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***

1-4 A number of positive linear and curvilinear anomalies in the south east, south and north east of the site. These are indicative of former settlement activity.

5 A circular anomaly and associated backfilled pit in the south of the site. This is likely to be related to a former ring ditch.

6-8 A number of discrete positive anomalies that are indicative of former cut features such as backfilled pits. These are associated with the former settlement activity of Anomalies 1 – 4.

9-13 Positive linear anomalies across the site that are related to former field boundaries visible on available historic mapping. Anomaly 9 is present 1876-1926. Anomaly 10 is present 1886-1926. Anomaly 11 is present 1876-1959. Anomaly 12 is present 1886-1967. Anomaly 13 is present 1876-1967.

14 A positive linear anomaly in the south of the site that is related to a former footpath visible on available historic mapping from 1876 to 1981.

15 A positive linear anomaly in the south of the site that is visible as a defiled boundary on available historic mapping from 1976 to 1981.

16 Positive linear anomalies in the east of the site that are related to former track ways visible on pre-1900 mapping.

17 Two small areas of scattered magnetic debris in the southeast of the site. These are related to former farm buildings visible on historic mapping from 1876 to 1892.

18 Positive linear anomalies in the northeast and south of the site. These are probable former track ways not visible on available historic mapping

19 Positive linear anomalies across the site. These are probable former field boundaries not visible on available historic mapping.

3.2 ***Possible Archaeology***

20 Positive linear anomalies across the site. These are indicative of former cut features and may be of archaeological origin.

21 A number of discrete positive anomalies across the site are indicative of former cut features such as backfilled pits. These may be of archaeological or natural origin.

22 A small number of positive anomalies across the site that may be of archaeological or natural origin.

23 A sub-circular negative anomaly in the centre of the site indicative of a possible former bank or earthwork. This may be of archaeological origin, however its exact origin is unknown.

3.3 ***Other Anomalies***

24 A number of closely spaced parallel linear anomalies across the site that are related to modern agricultural activity such as ploughing.

25 Bipolar linear anomalies in the north of the site that are related to pipes, cables or other modern services.

26 A small area of strong magnetic debris in the south of the site that is related to a former pond visible on historic mapping from 1876 to 1981.

27 A number of weak bipolar anomalies across the site that are likely to be related to modern land drains.

28 Large areas of amorphous magnetic variation across the site that are likely to be natural (geological or pedological) in origin.

29 A small area of strong magnetic debris in the southwest of the site. This is likely to be modern in origin and is related to areas of disturbed ground.

30 A number of areas of scattered magnetic debris across the site. These are modern in origin.

31 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.

32 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 Haverhill has identified a number of anomalies of probable and possible archaeological origin. Former backfilled pits, linear features indicative of cut features of archaeological origin and a former ring ditch provide evidence of former settlement activity on the site. The exact date of these anomalies is unknown, however it could support information from the desk-based assessment of the site having a moderate potential for Iron Age remains. A number of anomalies of possible archaeological or natural origin have been identified, although their exact origin is unknown. Several former field boundaries and track ways, along with evidence of modern agricultural activity such as ploughing, indicate an agricultural past for the area. The remaining features are natural or modern in origin and include land drains, underground services, a former pond, scattered magnetic debris, magnetic disturbance and spikes caused by nearby ferrous metal objects.

5 REFERENCES

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

British Geological Survey, 2001. *Geological Survey Ten Mile Map, South Sheet, Fourth Edition (Solid)*. British Geological Society.

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

CgMs Consulting Ltd, 2014. Great Wilsey Park, Haverhill, Suffolk – Heritage Desk-Based Assessment.

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

Institute For Archaeologists. *Standard and Guidance for Archaeological Geophysical Survey.* http://www.archaeologists.net/sites/default/files/nodefiles/Geophysics2010.pdf

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 4 Eastern England*.

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.

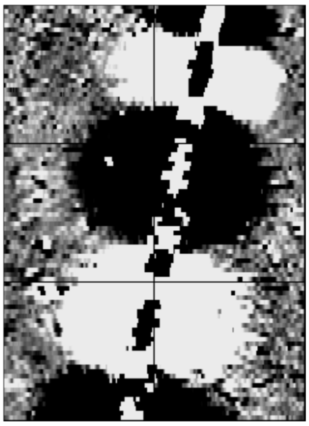
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement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

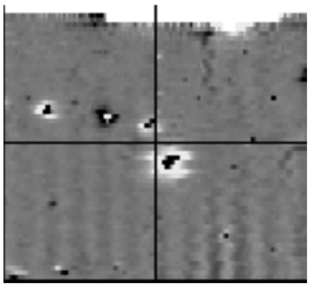
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES

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

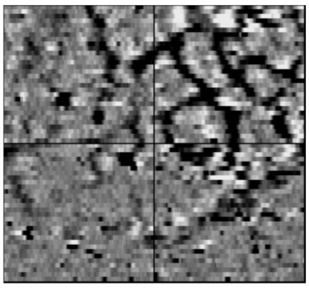


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

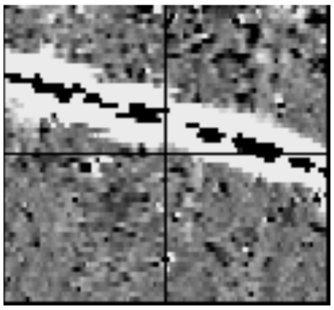
See bipolar and dipolar.

Positive linear



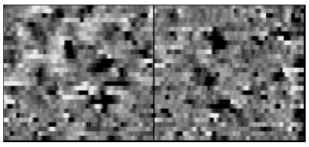
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

Positive linear anomaly with associated negative response



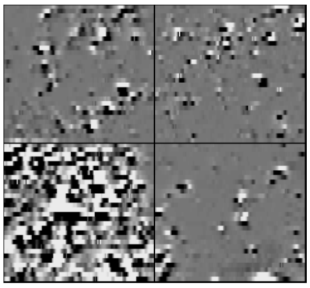
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field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

Positive point/area



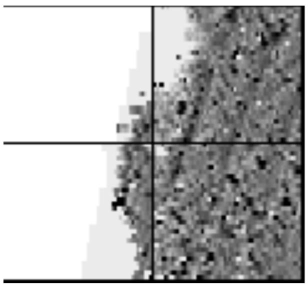
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



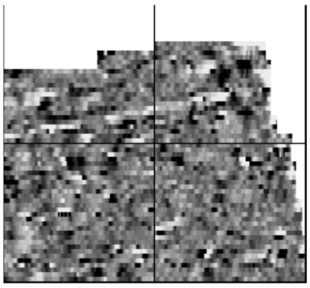
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low (+/-3nT) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly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

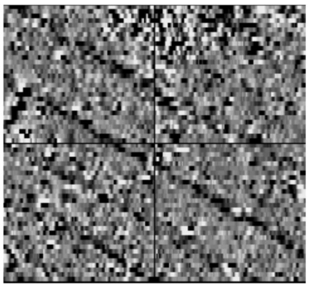


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative to the background top soil is built up. See also ploughing activity.

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).

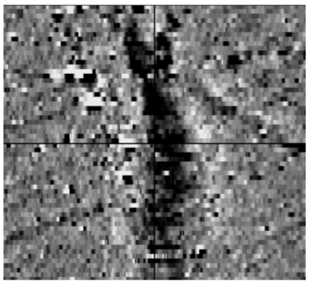
Strength of response

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