STRATASCAN

Geophysical Survey Report

Water/Sewage Treatment Infrastructure
Near Exeter Airport
East Devon

for

Exeter Archaeology

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J2155

Hannah Heard BSc (Hons)

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Field Team: Karl Munster BSc (Hons), Sam Russell BSc (Hons), Luke Brown

Project Manager: Simon Stowe BSc (Hons)

Report written by: Hannah Heard BSc (Hons)

CAD illustration by: Hannah Heard BSc (Hons) and Niall Granger BSc (Hons)

Checked by: Peter Barker C.Eng MICE MCIWEM MIFA

Stratascan Ltd.

Vineyard House
Upper Hook Road
Upton upon Severn
WR8 0SA

Tel: 01684 592266
Fax: 01684 594142
Email: ppb@stratascan.co.uk

www.stratascan.co.uk

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1 SUMMARY OF RESULTS

A gradiometer survey was carried out over a 2.1km length, 30m wide corridor (6.5ha) and a 3ha area as part of an archaeological investigation prior to the development of a water/sewage treatment works. The 30m pipeline corridor and the 3ha area have both revealed features that may be of archaeological origin. Substantial cut features of possible archaeological origin have been identified within the corridor Areas 2a, 3b and Area 4. A possible concentration of archaeological activity can be seen within the north and southwest corner of survey Area 4. Agricultural marks can be seen within the majority of the survey areas. Possible pits or discrete cut features have been identified within Areas 1, 3c-f and Area 4.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned by Exeter Archaeology to undertake a geophysical survey of an area outlined for development as a water/sewage treatment works and pipeline. This survey forms part of an archaeological investigation undertaken by Exeter Archaeology.

2.2 Site location

The site is located northeast of Exeter, west of Exeter Airport at a central OS ref. SS 970 947.

2.3 Description of site

The pipeline survey area is approximately 6.3ha of agricultural land currently left to pasture (Areas 1-3). The site of the sewage treatment works covers an area of 3ha also under pasture (Area 4).

2.4 Geology and soils

The underlying geology is Permian basal breccias, sandstones and mudstones (British Geological Survey South Sheet, Fourth Edition Solid, 2001). The overlying soils are mainly Bridgenorth soils which are typical brown sands. These consist of Permo-Triassic and Carboniferous sandstone. The overlying soils of Areas 4 are likely to be Compton soils which are Pelo-alluvial gley soils. These consist of reddish river alluvium (Soil Survey of England and Wales, Sheet 5 South West England).

2.5 Site history and archaeological potential

No specific details were available to Stratascan.

2.6 Survey objectives

The objective of the survey was to locate any features of possible archaeological significance 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 7 days from the 30th May to the 1st June, 5th to 6th June and 22nd to 23rd June 2006. Weather conditions during the survey were fair and dry.

3.2 Grid locations

The location of the survey grids have been plotted in Figures 2 together with the referencing information. Grids were positioned and referenced with a Leica System 500 DGPS and were set out using a Leica 705auto Total Station.

3.3 Survey equipment

The magnetic survey was carried out using a dual sensor Grad601-2 Magnetic Gradiometer manufactured by Bartington Instruments Ltd. The Grad601-2 consists of two high stability fluxgate gradiometers suspended on a single frame. Each sensor has a 1m separation between the sensing elements increasing the sensitivity to small changes in the Earths magnetic field.

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 Grad601-2 has a typical depth of penetration of 0.5m to 1.0m. This would be increased if strongly magnetic objects have been buried in the site. The collection of data at 0.25m centres provides an appropriate methodology 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 down-loaded into a portable computer whilst on site. At the end of each job, 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 known as *Geoplot 3.* 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. 'Despiking' is also performed to remove the anomalies resulting from small iron objects often found on agricultural land. 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. *Despike* (useful for display and allows further processing functions to be carried out more effectively by removing extreme data values)

   Geoplot parameters:
   X radius = 1, y radius = 1, threshold = 3 std. dev.
   Spike replacement = mean

2. *Zero mean grid* (sets the background mean of each grid to zero and is useful for removing grid edge discontinuities)

Geoplot parameters:
Threshold = 0.25 std. dev.

3. *Zero mean traverse* (sets the background mean of each traverse within a grid to zero and is useful for removing striping effects)

Geoplot parameters:
Least mean square fit = off

3.5.2 Presentation of results and interpretation

The presentation of the data for each site involves a print-out of the raw data both as greyscale (Figures 3, 8, 13, 18, 23, 28) and trace plots (Figures 4, 5, 9, 10, 14, 15, 19, 20, 24, 25, 29, 30), together with a greyscale plot of the processed data (Figures 6, 11, 16, 21, 26, 31). Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing for the site (Figure 7, 12, 17, 22, 27, 32).

4 RESULTS

The following results have been divided into the four survey areas and will discuss the findings within each area. Substantial cut features have been found within two areas of the corridor survey that may relate to features of archaeological origin. A series of possible cut features and pits identified within Area 4 may relate to areas of archaeological activity.

Area 1
Situated in the western end of the survey area is a large manhole and is the cause of the large bipolar response and magnetic disturbance in the area. A number of strong positive linear anomalies have been identified in the west of the area and may represent cut features of archaeological origin. However the linear anomaly identified running either side of the magnetic debris may relate to a service trench associated with the manhole.

Three discrete positive anomalies have been identified in the centre of Area 1. These anomalies may represent cut features or possible pits of archaeological origin.

Area 2
Area 2 has identified an interesting number of features that may relate to areas of archaeological activity. A number of linear and curvilinear positive anomalies have been identified with Area 2a. These anomalies may represent cut features of archaeological origin. A pair of positive and negative linear anomalies situated in the northern corner of Area 2a may represent a bank with an associated ditch. A negative linear anomalies situated in the south of 2b may represent an earthen bank or area of

compacted ground. A small area of magnetic disturbance can be seen with 2a and may indicate an area of disturbed ground.

A series of parallel linear anomalies running in an approximate north to south orientation have been identified across the survey area. These anomalies are likely to represent agricultural marks. Areas of magnetic disturbance situated in the south of 2c are associated with nearby field boundaries and roadways. Positive discrete anomalies with associated negative returns have been identified across the survey area. These anomalies are likely to represent near surface ferrous objects. A possible service or drain may be seen running across area 2b and is identified by a bipolar linear response.

Area 3

Area 3b has revealed a large positive curvilinear anomaly that may represent a cut feature of archaeological origin. Further cut linear anomalies of possible archaeological origin can be seen 3b, the centre of 3c, the eastern ends of 3d and 3f and the western end of 3e. Agricultural marks have been identified running in a north to south orientation within areas 3e and f.

Discrete positive responses have been identified across survey areas 3c-f, with substantial positive anomalies within areas e and f. These anomalies may represent cut features or pits of possible archaeological origin.

A series of negative linear anomalies can be seen within area 3c and may represent the remnants of an earthwork or is possibly associated with agricultural activity. Area 3a is dominated by magnetic area responses possibly associated with areas of ground disturbance.

Positive discrete anomalies with associated negative returns have been identified across the survey area. These anomalies are likely to represent near surface ferrous objects. Areas of magnetic debris situated across area 3e and f are associated with a series of electric fences, nearby boundaries and roads. A possible service (identified by the areas of magnetic debris) may run along the northern edges of survey areas 3b and e.

Area 4

A set of strong positive parallel linear anomalies have been identified to the north of Mill Lane. A negative linear anomaly flanked by two positive linear anomalies can be seen running approximately east to west across the survey area and then turning at right angles to the north. These anomalies may represent a bank, flanked by ditches and may be of archaeological origin (**a**). A further positive linear can be seen to the south of the possible bank and ditch and may represent an additional ditch of archaeological origin. However, these anomalies may also be associated with agricultural activity or indicate a previous field boundary (although no additional field boundaries can be seen on the 1890 Ordnance Survey). Anomaly **a** appears to cut a positive linear anomaly running in a northeast to southwest orientation (**b**). Anomaly **b** may represent a cut feature of archaeological origin that predates anomaly **a**.

A series of linear and curvilinear positive anomalies have been identified in the southwest of the survey area (**c**, **d**, **e**, **f, g**). These anomalies may indicate cut features of archaeological origin.

A positive linear anomaly can be seen across the south of the survey area in an east to west orientation (**i**). This anomaly may represent a cut feature of archaeological or agricultural origin.

A large number of discrete positive anomalies can be seen in the south and southwest corner of the survey area (**h**). These anomalies may represent pits or cut features of archaeological origin.

A large number of agricultural marks can be seen across the survey area in an approximate northeast to southwest and north to south orientation. A negative linear anomaly situated in the east of the survey may represent a possible service or drain associated with agricultural activity (**j**).

Positive discrete anomalies with associated negative returns have been identified across the survey area. These anomalies are likely to represent near surface ferrous objects. Large areas of magnetic disturbance can be seen mainly situated around the perimeter of the survey area. These area anomalies are caused by the nearby pylon, animal feeders and field boundaries. The magnetic linear anomalies situated in the northwest of the survey area represent a metal fence.

An area of magnetic debris situated in the northeast of the survey may indicate an area of ground disturbance.

5 CONCLUSION

The gradiometer survey carried out along the 30m pipeline corridor and the 3ha area has both revealed features that may be of archaeological origin. Substantial cut features of possible archaeological origin have been identified within Areas 2a, 3b and 4. A possible concentration of archaeological activity can be seen within the southwest corner of survey Area 4. Agricultural marks have been identified within the majority of the survey areas. Possible pits or discrete cut features of possible archaeological origin have been identified within Areas 1, 3c-f and Area 4.

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 *thermoremnant* 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.

Thermoremnance 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. Thermoremnant 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.