Boroughbridge Road
Knaresborough, North Yorkshire

Detailed Gradiometer Survey Report

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Summary

A detailed gradiometer survey was conducted over land north of Knaresborough, northeast of Harrogate, North Yorkshire (centred on NGR 435275, 458550). The project was commissioned by CgMs Consulting with the aim of establishing the presence and significance, or otherwise, of detectable archaeological features within the site ahead of a proposed development.

The site comprises three arable fields, approximately 6.15km northeast of the centre of Harrogate. The site occupies the lower eastern slope of a nearby hill named Coney Garth. The detailed gradiometer survey covered 6.5ha. This survey has demonstrated the presence of anomalies of definite, probable and possible archaeological interest within the survey area.

The geophysical data has revealed a field system with field boundaries, a possible enclosure, a drove/track and numerous isolated features observed that are possibly related. There are wide spreads of geological responses noted nearby too.

The survey was undertaken between 16th and the 18th September 2013.

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Acknowledgements

The detailed gradiometer survey was commissioned CgMs Consulting, and the assistance of Rachel Morse is gratefully acknowledged in this regard.

The fieldwork was undertaken by Phil Roberts and was assisted by Chris Hirst. Ben Urmston and Ross Lefort processed the geophysical data and this was interpreted by Ross Lefort who also wrote this report. The geophysical work was quality controlled by Ben Urmston. Illustrations were prepared by Karen Nichols. The project was managed on behalf of Wessex Archaeology by Chris Swales.

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1 INTRODUCTION

1.1 Project background

1.1.1 Wessex Archaeology was commissioned by CgMs Consulting to carry out a geophysical survey of land near Knaresborough, North Yorkshire (**Figure 1**), hereafter "the Site" (centred on NGR 435275, 458550). The survey forms part of a programme of archaeological works being undertaken to inform decisions regarding potential future development at the Site.

1.1.2 The aim of the geophysical survey is to establish the presence/absence, extent and character of detectable archaeological remains within the survey area.

1.1.3 This report presents a brief description of the methodology followed, the detailed survey results and the archaeological interpretation of the geophysical data.

1.2 The Site

1.2.1 The survey area comprises three arable fields measuring 6.75ha in area, located to the immediate north of Knaresborough approximately 6.15km northeast of Harrogate (**Figure 1**). A detailed gradiometer survey was undertaken covering the total available area of the Site (6.5ha).

1.2.2 The Site is located on the eastern lower slope of a hill named Coney Garth on Ordnance Survey (OS) maps. The site lies at a height a little over 55m above Ordnance Datum (aOD) at the northwest corner and slopes downwards to around 50m aOD to the east, the highest local point is Coney Garth (70m aOD) to the west. No mapped watercourses flow close to the site.

1.2.3 The underlying solid geology is made up of millstone grit and culm measures (Carboniferous) to the west and a mix of upper magnesian limestone and upper Permian marl (Permian) to the east (Ordnance Survey 1957). The superficial deposits are composed of boulder clay and morainic drift (Quaternary) (Ordnance Survey 1977).

1.2.4 The soils underlying the Site are most likely to be stagnogleyic argillic brown earths of the 572s (Bishampton 1) association (SSEW 1983). Soils derived from such geological parent material have been shown to produce magnetic contrasts suitable for the detection of archaeological remains through magnetometer survey.

2 METHODOLOGY

2.1 Introduction

2.1.1 The detailed magnetometer survey was conducted using a Bartington Grad601-2 dual fluxgate gradiometer system. The survey was conducted in accordance with English Heritage guidelines (2008).

2.1.2 The geophysical survey was undertaken by Wessex Archaeology's in-house geophysics team between 16th and 18th September 2013. Field conditions at the time of the survey were good.

2.2 Method

2.2.1 Individual survey grid nodes were established at 30m x 30m intervals using a Leica Viva RTK GNSS system, which is precise to approximately 0.02m and therefore exceeds English Heritage recommendations (2008).

2.2.2 The magnetometer survey was conducted using a Bartington Grad601-2 fluxgate gradiometer instrument, which has a vertical separation of 1m between sensors. The detailed survey data were acquired at 0.25m intervals along transects spaced 1m apart. The system used has an effective sensitivity of 0.03nT, in accordance with EH guidelines (2008). Detailed data were collected in the zigzag method.

2.2.3 Data from the detailed survey was subject to minimal data correction processes. These comprise a zero mean traverse (ZMT) function (typically ±5nT thresholds) applied to correct for any variation between the two Bartington sensors used, a deslope function to remove errors created by the ZMT function in areas of broad and strong anomalies, and a de-step function to account for variations in traverse position due to varying ground cover and topography. These three processing step were used only with no interpolation applied to the data.

2.2.4 Further details of the geophysical and survey equipment, methods and processing are described in **Appendix 1**.

3 GEOPHYSICAL SURVEY RESULTS AND INTERPRETATION

3.1 Introduction

3.1.1 The gradiometer survey has been successful in identifying anomalies of definite, probable and possible archaeological interest across the Site. Results are presented as a series of greyscale and XY plots, and archaeological interpretations, at a scale of 1:1250 (**Figures 1** to **3**). The data are displayed at -2nT (white) to +3nT (black) for the greyscale images and ±25nT at 25nT per cm for the XY trace plots.

3.1.2 The interpretation of the datasets highlights the presence of potential archaeological anomalies, ferrous/burnt or fired objects, and magnetic trends. Full definitions of the interpretation terms used in this report are provided in **Appendix 2**.

3.1.3 Numerous ferrous anomalies are visible throughout the detailed survey dataset. These are presumed to be modern in provenance and are not referred to, unless considered relevant to the archaeological interpretation.

3.2 Detailed Gradiometer Survey Results and Interpretation

3.2.1 The most significant anomalies visible in the data lie at the western extent of the survey and comprise the edge of a possible enclosure and an associated drove or track at **4000** and **4001**. The area of the enclosure, around **4000** and **4002**, has strong positive values (over +3nT) defining a wide ditch enclosing the area with a concentration of ferrous and ceramic responses observed within. The 1890 OS map shows a pond in this area of the field (CgMs 2013) which may account for the increased magnetic response. The drove or track, around **4001**, is defined by curvilinear positive responses on either side that are considered to represent ditches and extends generally NW-SE across the western portion of the Site. The ditches vary in strength along their length with magnetic values ranging from less than 0.5nT to over +3nT. This variation suggests that the composition of the ditch fill varies along its length and the weaker areas may indicate regions where preservation is poor. It is unclear whether the area around **4000** represents an enclosure interior but these features are considered to be archaeological; some weaker ditch sections have been classified probable archaeology.

3.2.2 There are more anomalies possibly related to the enclosure at **4002**, including a ditch-like anomaly roughly aligned southeast to northwest and a ditch further south that is aligned roughly southwest to northeast. These ditches may complete the possible enclosure discussed above and have been classed as archaeology. A similar curved positive anomaly is observed to the southeast at **4005**.

3.2.3 A couple of linear and curvilinear positive anomalies are visible outside the enclosure around **4003**; both are considered to represent ditches. It is unclear what function these ditches had so they have been classed as probable archaeology. A peculiar looking positive anomaly is visible at **4004**. It has fairly weak positive values around +1.5nT with a sub-square area to the north with a ditch-like anomaly extending towards the southeast. It is considered to be a cut archaeological feature and has been classed as probable archaeology.

3.2.4 There are a number of positive pit-like anomalies around **4006**; they have positive magnetic values (over +3nT) and are sub-oval in shape. There is a linear positive anomaly to the southeast at **4007** that appears to line up with these pit-like responses and may be related. These anomalies have been interpreted as probable archaeology only as their slight irregular form suggests a geological explanation may also be possible.

3.2.5 There are a number of other positive ditch-like anomalies across the survey area at **4008**, **4009**, **4010**, **4011**, **4012** and **4013**; these features have positive values and are considered to represent former field boundaries. These ditches vary in strength from 0.5nT to over +3nT and their form suggests they define a rectilinear field system that may be contemporary with the possible enclosure and track at **4000** and **4001**. These features are clearly not modern as the field system detected in the data runs at an angle to the modern layout and orientation of field boundaries. These features have been classed as either archaeology or probable archaeology depending on their magnetic values.

3.2.6 There are four concentrations of positive anomalies of possible archaeological interest at **4014**, **4015**, **4016** and **4017**; they range in form from pit-like to ditch-like anomalies. They have been classed as possible archaeology as they are located within or close to a wide area of geological responses and may prove to be natural in origin. The remaining anomalies are small positive anomalies that are mainly sub-oval or sub-rounded in shape. These features could prove to be either small archaeological features such as postholes or geological features. As they do not have any significant patterning in their spatial

distribution they have been classed as possible archaeology, although similar anomalies nearby are more likely to be geological in origin.

3.2.7 There are numerous trends visible throughout the survey data; most of these are associated with modern or recent agricultural activity. There are other trends that are not clearly related to ploughing such as at **4018**, **4019** and **4020** and include linear and curvilinear trends; some of these anomalies may prove to be archaeological.

3.2.8 There are also a number of fairly strong positive anomalies running parallel to one another on a roughly east-west alignment such as the example at **4021**. They have magnetic values around +2nT and have been interpreted as agricultural, possibly representing drainage features.

3.2.9 There are several concentrated regions of bipolar and dipolar responses such as those at **4022** and **4023**; these are considered to either represent geological variations or concentrations of modern ceramic and metallic debris.

3.2.10 A wide area of geological responses has been observed in the data at **4024**; this area is characterised by a concentration of very weak and diffuse-edged positive and negative responses. This spread of geology is not considered strong enough to mask strongly magnetised archaeological features.

3.3 Gradiometer Survey Results and Interpretation: Modern Services

3.3.1 There are no modern services visible in the data. There is however some repeating black and white ferrous shadows running up the eastern side of the survey area which may suggest that a service lies close by outside of the survey area. Similar responses can be seen in close proximity to the southern boundary.

3.3.2 Gradiometer data will not be able to locate and identify all services present on site. This report and accompanying illustrations should not be used as the sole source for service locations and appropriate equipment (e.g. CAT and Genny) should be used to confirm the location of buried services before any trenches are opened on site.

4 DISCUSSION

4.1 Summary

4.1.1 The detailed gradiometer survey has been successful in detecting anomalies of definite, probable and possible archaeological interest within the Site. In particular a former field system, a possible enclosure and a drove/track have been detected within the survey area. It is difficult to assess how significant these remains may be, as it is not possible to determine from what period they date based upon the geophysical survey alone.

4.1.2 There are some other peculiar isolated anomalies such as at **4004**; this feature has a peculiar but clearly anthropogenic form in plan and is aligned with the field system identified. This feature may relate to past agricultural activity.

4.1.3 There are geological spreads visible in place in the data; it is possible that some of the anomalies with more irregular shapes in plan may prove to be geological. The remaining features detected relate to more recent use of this area with ploughing trends and metallic debris detected.

4.1.4 It should be noted that small, weakly magnetised features may produce responses that are below the detection threshold of magnetometers. It may therefore be the case that

more archaeological features may be encountered than have been identified through geophysical survey.

5 REFERENCES

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APPENDIX 1: SURVEY EQUIPMENT AND DATA PROCESSING

Survey Methods and Equipment

The magnetic data for this project was acquired using a Bartington 601-2 dual magnetic gradiometer system. This instrument has two sensor assemblies fixed horizontally 1m apart allowing two traverses to be recorded simultaneously. Each sensor contains two fluxgate magnetometers arranged vertically with a 1m separation, and measures the difference between the vertical components of the total magnetic field within each sensor array. This arrangement of magnetometers suppresses any diurnal or low frequency effects.

The gradiometers have an effective resolution of 0.03nT over a ±100nT range, and measurements from each sensor are logged at intervals of 0.25m. All of the data are stored on an integrated data logger for subsequent post-processing and analysis.

Wessex Archaeology undertakes two types of magnetic surveys: scanning and detail. Both types depend upon the establishment of an accurate 20m or 30m site grid, which is achieved using a Leica Viva RTK GNSS instrument and then extended using tapes. The Leica Viva system receives corrections from a network of reference stations operated by the Ordnance Survey and Leica Geosystems, allowing positions to be determined with a precision of 0.02m in real-time and therefore exceed the level of accuracy recommended by English Heritage (2008) for geophysical surveys.

Scanning surveys consist of recording data at 0.25m intervals along transects spaced 10m apart, acquiring a minimum of 80 data points per transect. Due to the relatively coarse transect interval, scanning surveys should only be expected to detect extended regions of archaeological anomalies, when there is a greater likelihood of distinguishing such responses from the background magnetic field.

The detailed surveys consist of 20m x 20m or 30m x 30m grids, and data are collected at 0.25m intervals along traverses spaced 1m apart. These strategies give 1600 or 3600 measurements per 20m or 30m grid respectively, and are the recommended methodologies for archaeological surveys of this type (EH, 2008).

Data may be collected with a higher sample density where complex archaeological anomalies are encountered, to aid the detection and characterisation of small and ephemeral features. Data may be collected at up to 0.125m intervals along traverses spaced up to 0.25m apart, resulting in a maximum of 28800 readings per 30m grid, exceeding that recommended by English Heritage (2008) for characterisation surveys.

Post-Processing

The magnetic data collected during the detail survey are downloaded from the Bartington system for processing and analysis using both commercial and in-house software. This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

As the scanning data are not as closely distributed as with detailed survey, they are georeferenced using the GPS information and interpolated to highlight similar anomalies in adjacent transects. Directional trends may be removed before interpolation to produce more easily understood images.

Typical data and image processing steps may include:

- Destripe – Applying a zero mean traverse in order to remove differences caused by directional effects inherent in the magnetometer;
- Destagger – Shifting each traverse longitudinally by a number of readings. This corrects for operator errors and is used to enhance linear features;
- Despike – Filtering isolated data points that exceed the mean by a specified amount to reduce the appearance of dominant anomalous readings (generally only used for earth resistance data)

Typical displays of the data used during processing and analysis:

- XY Plot – Presents the data as a trace or graph line for each traverse. Each traverse is displaced down the image to produce a stacked profile effect. This type of image is useful as it shows the full range of individual anomalies.
- Greyscale – Presents the data in plan view using a greyscale to indicate the relative strength of the signal at each measurement point. These plots can be produced in colour to highlight certain features but generally greyscale plots are used during analysis of the data.

APPENDIX 2: GEOPHYSICAL INTERPRETATION

The interpretation methodology used by Wessex Archaeology separates the anomalies into two main categories: archaeological and unidentified responses.

The archaeological category is used for features when the form, nature and pattern of the anomaly are indicative of archaeological material. Further sources of information such as aerial photographs may also have been incorporated in providing the final interpretation. This category is further sub-divided into three groups, implying a decreasing level of confidence:

- Archaeology – used when there is a clear geophysical response and anthropogenic pattern.
- Probable archaeology – used for features which give a clear response but which form incomplete patterns.
- Possible archaeology – used for features which give a response but which form no discernible pattern or trend.

The unidentified category is used for features when the form, nature and pattern of the anomaly are not sufficient to warrant a classification as an archaeological feature. This category is further sub-divided into:

- Increased magnetic response – used for areas dominated by indistinct anomalies which may have some archaeological potential.
- Trend – used for low amplitude or indistinct linear anomalies.
- Ferrous – used for responses caused by ferrous material. These anomalies are likely to be of modern origin.

Finally, services such as water pipes are marked where they have been identified.