GEOPHYSICAL SURVEY REPORT

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SUMO Survey Services
SUMO Group Member

Project name:
North Baldock, Hertfordshire

Client:
Albion Archaeology

Job ref:
J9595

June 2016

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Survey date: **2nd-8th, 14th-24th & 29th-31st March, 6th-8th April & 23rd-27th May 2016**	Report date: **June 2016**
Field team: **Christian Adams** BA (Hons) **Lukasz Krawec** BSc **Samuel Woods** **Rosie Everett** BA (Hons) **Jay Griffiths** BSc (Hons) **Jack Larner** **Robert Knight** BA (Hons) **Richard Collins** BA (Hons)	Project Manager: **Simon Haddrell** BEng(Hons) AMBCS PCIfA
Report written By: **Rebecca Davies** BSc (Hons)	Report approved by: **David Elks** MSc ACIfA
CAD illustrations by: **Rebecca Davies** BSc (Hons)	Site Director: **Peter Barker** CEng MICE MCIWEM MCIfA FCInstCES
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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 conducted over approximately 137 hectares of mixed arable farmland and pasture. An area of late prehistoric or Roman settlement activity has been identified in the south-east along with further areas of Iron Age or Roman occupation across the site, with complex series of anomalies comprising linear and curvilinear features, sub-rectangular enclosures, ring ditches and backfilled pits. A Bronze Age barrow cemetery has been identified in the centre of the site and comprises five ring ditches. A field system has also been identified, which may be contemporary with the settlements on the site. Further linear anomalies and small discrete anomalies may be of archaeological origin, however their exact origin cannot be determined with confidence. Evidence of ridge and furrow, modern ploughing, former field boundaries, and a trackway indicate that the site has been used for agricultural purposes since the medieval period. The remaining features are natural or modern in origin with the modern features including a possible former pond, underground services, scattered magnetic debris, areas of made ground, an electric fence line, and magnetic 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 Albion Archaeology.

2.2 Site Details

NGR / Postcode	TL 252 348 / SG7 5DS
Location	The site is located to the north of Baldock, Hertfordshire. The site is bound to the west by the A507, North Road, and the south by a railway line. The survey area is dissected by Bygrave Road, which runs in an east-west direction from Baldock to Bygrave.
HER/SMR	Hertfordshire
Planning Authority / Ref	North Hertfordshire County Council
District	North Hertfordshire
Parish	Bygrave
Topography	The site lies on relatively level land, at the foot of several undulating ridges to the north, east, and south of Baldock.

Current Land Use	Arable in the north and east, grassland and paddocks in the south-west.
Weather Conditions	Mostly dry, occasional showers, overcast.
Soils	The overlying soils are known as Swaffham Prior, which are typical brown calcareous earths. These consist of calcareous coarse and fine loamy soils over chalk rubble (Soil Survey of England and Wales, Sheet 4 Eastern England).
Geology	The underlying geology across the majority of the site comprises Holywell Nodular Chalk Formation and New Pit Chalk Formation (undifferentiated). Areas of Melbourn Rock Member – chalk are recorded in the west and north of the site, along with Zag Chalk Formation along the northern boundary. Superficial deposits of Lowestoft Formation – diamicton are recorded running across the centre of the north of the site, with Head – clay, silt, sand and gravel recorded along the northern edge and south of the area. Glaciofluvial deposits of sand and gravel are recorded in the south-west (Field 19) (British Geological Survey website).
Archaeology	The following is taken from "Land North of Baldock, Site BA1, Hertfordshire – Heritage Assessment" (Albion Archaeology, 2016): The Roman town of Baldock has seen a relatively large number of [archaeological] investigations. The status and extent of the Roman settlement was first recognised during excavations in the 1920s and '30s and further large-scale interventions were carried out in the 1960s and '70s. The investigations demonstrated that there was occupation at Baldock from the late Iron Age period into the early Saxon period. Land south of Blackhorse Farm (HER 6826), immediately to the west of the proposed development area (PDA), revealed occupation dating to the late Iron Age, Roman, Saxon and medieval periods (EHT4508). A cluster of seven Bronze Age barrows and a small Bronze Age roundhouse were excavated at the northern end of the A505 bypass, close to the PDA, along with Roman boundary ditches and enclosures, possibly indicating a re-organisation of an earlier Iron Age field system. There are a large number of cropmark sites on the PDA, identified from aerial photographs. On morphological grounds, many of them can be dated to the early prehistoric period, in particular ring ditches and barrows. Other cropmark sites, including sub-rectangular enclosures and linear features, are more difficult to date and could range in date from the Iron Age/Roman to the medieval to post-medieval period. A large cropmark complex in the south-eastern part of the PDA could represent such a settlement and field system, most likely of Iron Age/Roman date.

	The south facing slope of the PDA accommodates the sites of fifteen ring ditches (2430, 2431, 2500, 2502, 2503, 2504, 4473 7459, 7460, 9124), with a group of ring ditches (4773, 4774, 4775, 2385, 2386) in the central southern part of the PDA together forming a barrow cemetery (6444). Further ring ditches are located in fields adjacent to the PDA in the east and a Bronze Age barrow cemetery (6441), comprising eleven ring ditches, was excavated on the line of the Baldock bypass to the south of the PDA. Iron Age and Roman heritage assets on the PDA are in the form of late Iron Age and Roman field boundary and enclosure ditches, excavated during an evaluation in the south-western corner of the area (17445, EHT6923). These ditches have been interpreted as part of a field system adjacent to the Icknield Way, between the main Roman settlement to the south and agricultural land to the north. Saxon settlement evidence in the form of early Saxon sunken-feature building (SFB) and associated post-holes was excavated south of Blackhorse Farm (6828), and a large Roman pit, later converted into a Saxon SFB, was recorded in an excavation on Clothall Common (13177, EHT5536). No medieval heritage assets are recorded on the PDA, but it is possible that some of the undated cropmarks of linear features (7840, 2511, 4748, 7750) could represent medieval boundary ditches trackways.
Survey Methods	Detailed magnetic survey (gradiometry)
Study Area	c.140 hectares – approximately 3 hectares could not be surveyed due to overgrown vegetation and outbuildings, reducing the area surveyed to c.137 hectares.

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

Due to the high potential for prehistoric, Iron Age and Roman remains, combined with the good response of chalk geologies for gradiometer survey, 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 Baldock 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

A number of positive linear anomalies **[1]** and sub-rectangular enclosures **[2]** within a larger rectilinear enclosure covering approximately 3.5 hectares has been identified in the south-east of the survey area. These are discussed in the desk-based assessment as representing an Iron Age or Roman settlement and associated field system. In the north-east of the site, a further complex series of positive linear anomalies and enclosures **[3]** provide evidence of Iron Age or Roman settlement activity. Two sub-rectangular enclosures **[4-5]** in the central northern area and north-west of the site offer further evidence of prehistoric or Roman occupation. A series of positive linear anomalies in the north-western edge of the site **[6]** are indicative of former cut features, such as ditches. These features lie close to the site at Blackhorse Farm (6826) where occupation dating to the late Iron Age, Roman, Saxon and

medieval periods has been revealed. Positive curvilinear **[7]** and negative linear anomalies **[7a]** in the south-west of the site are indicative of former ditches and earthworks. These anomalies are related to Iron Age and Roman field boundary and enclosure ditches (17445) and have been linked to a field system adjacent to the Icknield Way.

In the north, centre and south-east of the site, sub-circular positive anomalies **[8-10]** relate to ring ditches or small ditched enclosures. The anomalies in the south-east and north **[8-9]** could represent roundhouses or barrows, while the anomalies in the centre of the area relate to a Bronze Age barrow cemetery (6444). The barrow cemetery comprises five ring ditches **[10]**, one of which is made up of a double-ditch and contains a cluster of backfilled pits **[10a]** at its centre.

Further positive linear anomalies **[11]** across a large portion of the site may relate to a field system contemporary with the settlement activity on the site, with a positive linear anomaly, approximately 1.4km in length, running along the southern boundary of the site. Further positive linear anomalies **[12]** and two parallel linear anomalies **[12a]** across the site are likely to be related to the prehistoric or Roman occupation, and are indicative of former ditches. A number of small discrete positive anomalies **[13],** mostly dispersed among areas of settlement activity, are indicative of former backfilled pits. Four pits in the south-east form an alignment **[13a]**. A number of discrete areas of enhanced magnetic response **[14]** are indicative of former cut features, and are likely associated with the extensive prehistoric or Roman occupation.

4.2 Possible Archaeology

A number of positive linear anomalies **[15]** across the site are indicative of former cut features, such as ditches, though their origin cannot be determined with confidence due to their weak magnetic response. A linear anomaly of enhanced magnetic response **[15a]** in the south of the site may be archaeological in origin, however a natural origin is possible. A number of small discrete positive anomalies **[16]** and larger discrete features **[17]** may be related to former backfilled pits, however they are dispersed across the site and appear not to be associated with areas of settlement activity. Negative linear anomalies in the west of the site **[18]** are indicative of former banks or earthworks, though these may equally relate to more recent agricultural activity.

4.3 Medieval/Post-Medieval Agriculture

Medieval or post-medieval ridge and furrow cultivation **[19]** is present in the south and south-west of the site in the form of widely spaced, slightly curved, parallel linear anomalies. Evidence of more modern agricultural activity, such as ploughing **[20]** can be seen across the site, and is visible as magnetically weak, closely spaced, parallel linear anomalies. A number of linear anomalies across the site are related to former field boundaries present on available mapping

[21-27]. Anomalies 21-23 are visible on maps from 1880-1901, Anomaly 24 is visible from 1880-1960, Anomalies 25-26 are visible from 1880-1994 and Anomaly 27 is visible only on the 1960 OS map. A further linear anomaly **[28]**, extending south from Anomaly 21, is likely to be a field boundary but is not visible on available historic mapping. A magnetically strong linear anomaly in the south-west of the site **[29]** is related to a former trackway visible on the 1960 OS map along with more recent aerial photographs. A small area of strong magnetic debris **[30]** in the centre of the site is consistent with the type of response detected from a former pond, though there is no evidence of a pond in this location on historic mapping.

4.4 Other Anomalies

Areas of strong magnetic disturbance **[31]** in the north-east and north-west of the site are of uncertain origin, however the strength of the responses suggests that they are of modern origin. An area of enhanced magnetic response **[31a]** may be associated with a former pit or be of natural origin, though its exact origin is uncertain. Negative linear anomalies **[31b]** in the south-west of the site may be related to underground services, such as plastic pipes, though their origin cannot be determined with confidence. Large areas of amorphous magnetic variation across the site **[32]** are likely to be of natural, i.e. geological, origin. A number of strong bipolar linear anomalies **[33]**, and a negative linear anomaly **[33a]** in the south and south-west of the site respectively, are likely to be related to modern underground services, such as pipes or cables. The negative anomaly is more likely to be related to a non-ferrous pipe. Small areas of weak scattered magnetic debris **[34]** in the centre and west of the area are likely to be modern in origin, as are areas of strong magnetic debris **[35]** which are indicative of made ground. A linear anomaly in the south of the site **[36]** is related to an electric fence line separating horse paddocks. Areas of magnetic disturbance **[37]** are the result of nearby ferrous metal objects, such as fences and underground services. The effects of this disturbance can mask weaker archaeological anomalies, but on this site have not affected a large proportion of the area. Smaller ferrous anomalies, or 'magnetic spikes', **[38]** indicate ferrous objects and are likely to be modern rubbish.

5 DATA APPRAISAL & CONFIDENCE ASSESSMENT

Chalk geologies, such as those present across the site, generally provide a good response for gradiometer survey, while superficial deposits of diamicton and Head can provide variable results. Potato furrows, present at the time of survey in fields 1a, 2 and 4a, often has a detrimental effect on data quality. In this instance, the data from these fields and those adjacent to them are similar in appearance, and the effects of the potato furrows do not appear to have significantly affected the quality of data.

In the areas where the diamicton and Head are present, archaeological anomalies provide weaker responses. This indicates that the superficial deposits have the potential to mask weaker archaeological anomalies. Ten ring ditches have been identified across the site, where fifteen are known to be present. It is unclear whether the circular anomalies identified are among the known ring ditches on the site, however it may be possible that the superficial deposits of diamicton and Head have limited the effectiveness of the survey in these areas.

6 CONCLUSION

The survey at North Baldock has identified extensive evidence of Bronze Age, Iron Age and Roman occupation. An area of settlement activity has been identified in the south-east, supporting information from the heritage assessment whereby a series of cropmarks were thought to be related to an Iron Age or Roman settlement. Further areas of occupation have been detected across the site, with complex series of anomalies comprising linear and curvilinear features, sub-rectangular enclosures, ring ditches and backfilled pits. An area of activity identified in the far west of the site lies near to the excavated site of Blackhorse Farm (6826), where evidence of Iron Age, Roman, Saxon and medieval occupation have been revealed. A barrow cemetery (6444), discussed in the heritage assessment, has been identified in the centre of the site and comprises five ring ditches (4773, 4774, 4775, 2385, 2386). A field system has also been identified, which may be contemporary with the settlements on the site. Further linear anomalies and small discrete anomalies may be of archaeological origin, however their exact origin cannot be determined with confidence.

Evidence of ridge and furrow, modern ploughing, former field boundaries, and a trackway indicate that the site has been used for agricultural purposes since the medieval period, supporting information from the heritage assessment that some undated linear cropmarks may be related to medieval boundary ditches.

The remaining features are natural or modern in origin. The modern features include areas of strong magnetic disturbance, underground services such as pipes or cables, scattered magnetic debris, areas of made ground, an electric fence line, and magnetic disturbance from nearby ferrous metal objects.

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Appendix A - Technical Information: Magnetometer Survey Method

Handheld Collection

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.

Cart collection

Every point that is recorded is referenced using a Trimble R8 RTK GNSS 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.

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 magnetic survey was carried out using a Bartington magnetometer cart system utilizing Bartington 1000L Gradiometer sensors. 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.

Sampling interval

For cart collected data readings were taken at intervals of 0.125m along traverses 0.75m apart.

Depth of scan and resolution

The CartEasyN magnetometer cart system collects data at 10Hz which approximates 0.125m.

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.

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.

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