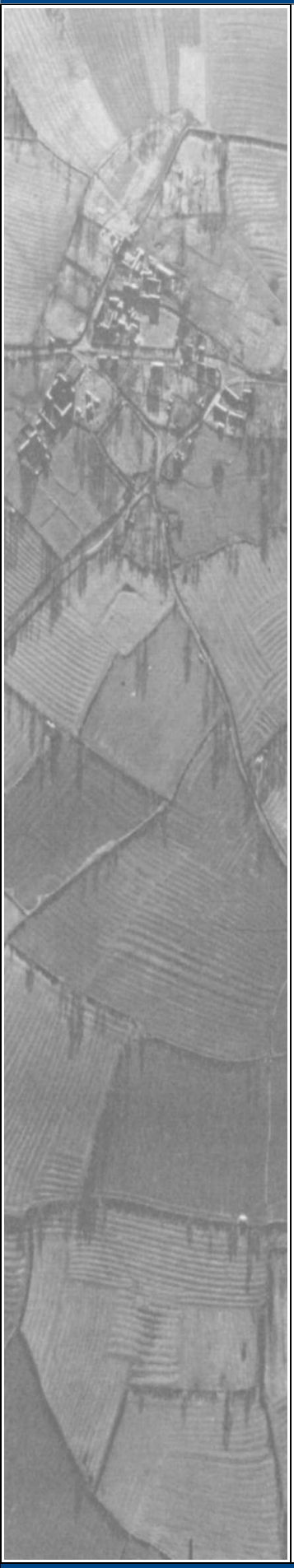

Land off Wentworth Drive
Nuneaton
Warwickshire

MAGNETOMETER SURVEY REPORT

for

Border Archaeology

Kerry Donaldson & David Sabin

September 2019

Ref. no. J788

ARCHAEOLOGICAL SURVEYS LTD

Land off Wentworth Drive
Nuneaton
Warwickshire

MAGNETOMETER SURVEY REPORT

for

Border Archaeology

Fieldwork by David Sabin BSc (Hons) MCIfA
Report by Kerry Donaldson BSc (Hons)
Report checked by David Sabin
Primary archive location - Archaeological Surveys Ltd, Yatesbury, Wiltshire

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Ordnance Survey Grid Reference – **SP 38780 90595**

Archaeological Surveys Ltd
1 West Nolands, Nolands Road, Yatesbury, Calne, Wiltshire, SN11 8YD
Tel: 01249 814231 Fax: 0871 661 8804
Email: info@archaeological-surveys.co.uk
Web: www.archaeological-surveys.co.uk

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SUMMARY

Detailed magnetometry was carried out by Archaeological Surveys Ltd, at the request of Border Archaeology, over land off Wentworth Drive on the south eastern edge of Nuneaton in Warwickshire. The results indicate the presence of a number of positive and some negative linear anomalies, and while a small number could relate to possible cut features, the majority are weak, short or fragmented and poorly defined. There is widespread evidence for agricultural activity, including ridge and furrow and land drains, with a number of formerly mapped field boundaries also located. Magnetic disturbance from modern ferrous material within and surrounding the site, as well as magnetic debris, has also been encountered.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Border Archaeology to undertake a magnetometer survey of an area of land to the north of Wentworth Drive, Nuneaton, Warwickshire. The site has been outlined for a proposed residential development and the survey forms part of an archaeological assessment.

1.1.2 The geophysical survey was carried out in accordance with a magnetometry method statement produced by Archaeological Surveys.

1.2 Survey objectives and techniques

1.2.1 The objective of the survey was to use magnetometry to locate geophysical anomalies that may be archaeological in origin so that they may be assessed prior to development of the site. The methodology is considered an efficient and effective approach to archaeological prospection.

1.2.2 Geophysical survey can provide useful information on the archaeological potential of a site; however, the outcome of any survey relies on a number of factors and as a consequence results can vary. The success in meeting the aims and objectives of a survey is, therefore, often impossible to predetermine.

1.3 Standards, guidance and recommendations for the use of this report

1.3.1 The survey and report generally follow the recommendations set out by: European Archaeological Council (2015) *Guidelines for the Use of Geophysics in Archaeology;* Institute for Archaeologists (2002) *The use of Geophysical Techniques in Archaeological Evaluations.* The work has been carried out to the Chartered Institute for Archaeologists (2014) *Standard and*

Guidance for Archaeological Geophysical Survey. Note: currently Historic England (2018) no longer support the guidelines set out in English Heritage (2008) *Geophysical survey in archaeological field evaluation* and there are currently no plans to update the document. As a consequence other sources of written guidance referring to this document may be out of date and/or contain unsupported information (e.g. Chartered Institute for Archaeologists, 2014).

1.3.2 Archaeological Surveys Ltd provide a detailed geophysical survey report and it is recommended that where possible the contents should be considered in full. The Summary provides a brief overview of the results with more detail available in the Discussion and/or Conclusion. The *List of anomalies* within the Results provides a detailed assessment of the anomalies within separate categories which can be useful in inferring a level of confidence to the interpretation. Quality and factors influencing the interpretation of anomalies is also set out within the results.

1.3.3 It is recommended that the full report should always be considered when using data and interpretation plots; where this is not possible, in the field for example, the abstraction and interpretation plots should retain their colour coding and be used with a corresponding legend.

1.3.4 Where targeting of anomalies by excavation is to be carried out, care should be taken to place trenches over solid lines or features visible on the abstraction and interpretation plots. Archaeological Surveys abstraction and interpretation avoids the use of dashed or dotted line formats, and broken or fragmented lines used in interpretive plots may well correspond closely with truncation of archaeological features.

1.4 Site location, description and survey conditions

1.4.1 The site is located on arable land surrounding Hill Farm to the north of Wentworth Drive on the south eastern edge of Nuneaton in Warwickshire. It is centred on Ordnance Survey National Grid Reference (OS NGR) SP 38780 90595 see Figs 01 and 02.

1.4.2 The geophysical survey covers approximately 32ha of agricultural land split between 7 arable fields and 3 small areas of pasture close to the buildings at Hill Farm. The land tends to be gently undulating with the western part of the site sloping down towards the north west and the eastern side sloping down slightly towards the south east. The site contains several large steel pylons that are sources of high magnitude magnetic disturbance.

1.4.3 The ground conditions across the site were generally considered to be favourable for the collection of magnetometry data. Arable land contained level soil and stubble with pasture areas having long grass that was occasionally difficult to traverse. Weather conditions during the survey were fine.

Plate 1: Area 3 looking south west towards pylons in Area 4

1.5 Site history and archaeological potential

1.5.1 A previous geophysical survey was carried out on land to the north west which located a number of positive anomalies that could relate to ditches and pits 300m to the north west of the present survey area (Archaeological Surveys, 2015). Subsequent trial trench evaluation identified a number of Iron Age pits and gullies that corresponded with some of these anomalies, with a number of Roman gullies further to the north east that did not appear to have a clearly corresponding geophysical anomaly (Archaeology Warwickshire, 2015). Also lying between 175m and 450m north to north west of the survey area are the findspots of a number of Palaeolithic hand axes from near to the River Anker.

1.5.2 The location of cut features from the Iron Age and Roman periods nearby indicates that there is potential for the site to contain similar features. Palaeolithic finds are not associated with cut features and are unlikely to result in geophysical anomalies.

1.6 Geology and soils

1.6.1 The underlying geology is Mercia Mudstone, with two bands of dolomitic siltstone from the Gunthorpe Member running north east to south west through the central part of the site (Areas 2, 3 and 5). In the north western part of the site there is overlying alluvium from the River Anker (Areas 4 and 7) and a small amount of glacial till from the Thrusington Member along the far north eastern edge (Area 9) (BGS, 2017).

1.6.2 The overlying soil across the western part of the site is from the Whimple 3 association and is a stagnogleyic argillic brown earth. It consists of a reddish, fine, loamy or fine silty over clayey soil with a slowly permeable subsoil and slight seasonal waterlogging. In the eastern part of the site the soil is from the Beccles 3 association and is a typical stagnogley soil. It consists of a slowly permeable, seasonally waterlogged, fine loamy over clayey soil (Soil Survey of England and Wales, 1983).

1.6.3 The underlying geology and soils can be associated with low magnetic contrast and low levels of magnetic susceptibility. However, cut features of archaeological potential may be located where human activity has altered the magnetic characteristics of the soil sufficiently (see 3.2.2). The underlying geology and soils are, therefore, considered acceptable for magnetic survey.

2 METHODOLOGY

2.1 Technical synopsis

2.1.1 Magnetometry survey records localised magnetic fields that can be associated with features formed by human activity. Magnetic susceptibility and magnetic thermoremnance (also known as thermoremanence) are factors associated with the formation of localised fields.

2.1.2 Iron minerals within the soil may become altered by burning and the break down of biological material; effectively the magnetic susceptibility of the soil is increased, and the iron minerals become magnetic in the presence of the Earth's magnetic field. Accumulations of magnetically enhanced soils within features, such as pits and ditches, may produce magnetic anomalies that can be mapped by magnetic prospection.

2.1.3 Magnetic thermoremnance can occur when ferrous minerals have been heated to high temperatures such as in a kiln, hearth, oven etc. On cooling, a permanent magnetisation may be acquired due to the presence of the Earth's magnetic field. Certain natural processes associated with the formation of some igneous and metamorphic rock may also result in magnetic thermoremnance.

2.1.4 The localised variations in magnetism are measured as sub-units of the Tesla, which is a SI unit of magnetic flux density. These sub-units are nano Teslas (nT), which are equivalent to 10^{-9} Tesla (T). Additional details are set out in 2.2 below and within Appendix A.

2.2 Equipment configuration, data collection and survey detail

2.2.1 The detailed magnetic survey was carried out using a SENSYS MAGNETO®MXPDA 5 channel cart-based system. The instrument has 5 fluxgate gradiometers (FGM650) spaced 0.5m apart with readings recorded at 20Hz. The

cart is primarily towed using an ATV where possible with small areas of infill surveyed by manually pushing the cart. Each sensor is not zeroed in the field as the vertical axis alignment is precisely fixed leaving sensor offsets that are removed during data processing. The fixing of the vertical alignment ensures the sensors are not unduly influenced by localised magnetic fields and that the vertical component of a magnetic anomaly is measured. The gradiometers have a range of recording data between ±0.1nT and ±8000nT. They are linked to a Leica GS10 RTK GNSS with data recorded by SENSYS MAGNETO®MXPDA software on a rugged PDA computer system.

2.2.2 Due to the fixed offsets within the fluxgate sensors, as a result of the manufacturing and tensioning process, the survey data do not provide a visually useful dataset until a zero median traverse algorithm is applied. It is recognised that this has the potential to affect some anomalies detrimentally by removing linear features orientated parallel to survey transects. However, this has not been noted as a particular problem with the system due to the high resolution data collection, generally long length of traverses and variability within the magnetic characteristics of a linear anomaly.

2.2.3 Data are collected along a series of parallel survey transects to achieve 100% coverage of the surveyable land. The length of each transect is variable and relates to the size of the survey area and other factors including ground conditions. A visual display allows accurate placing of transects and helps maintain the correct separation between adjacent traverses. Data are not collected within fixed grids and data points are considered to be random even though the data are collected in a systematic manner covering all accessible areas (Aspinall, Gaffney and Schmidt, 2009).

2.2.4 Fluxgate sensors are highly sensitive to temperature change and this manifests as drift during the course of a survey. This can be particularly noticeable during the morning as temperatures rise and the equipment warms or cools. Sensor drift within the course of a traverse will appear as a line trending from negative to positive after processing with a zero median traverse algorithm. To remove the potential for temperature drift, data were collected after a 20 minute stabilisation period and traverses were limited to a time of generally <100s.

2.3 Data processing and presentation

2.3.1 Magnetic data collected by the MAGNETO®MXPDA cart-based system are initially prepared using SENSYS MAGNETO®DLMGPS software. The software effectively allocates a geographic position for each data point and can compensate for fixed offsets present within the FGM650 sensors. The offsets are positive or negative values present on all fluxgate gradiometer sensors. Some systems use manual or electronic balancing to effectively zero the sensors; however, this is a short term measure that is prone to drift through temperature changes and vibration and can easily be incorrectly set due to localised magnetic fields. The FGM650 sensors are very accurately aligned to the vertical magnetic gradient and are highly stable showing

negligible drift on long traverses. The offset values are removed using TerraSurveyor software.

2.3.2 Survey tracks are analysed and georeferenced raw data (UTM Z30N) are then exported in ASCII format for further analysis and display within TerraSurveyor. The removal of the offset values (compensation) of the sensors is also carried out in TerraSurveyor using a zero median traverse function. Data are then considered to be minimally processed. Note: without the zero median traverse function it is not possible to create a meaningful data plot as all sensors have a different offset value. Although a zero median traverse algorithm can remove anomalies aligned with the survey tracks, in practice this rarely occurs due to the use of long traverses, high resolution measurement and variability within the magnetic susceptibility of long linear features.

2.3.3 The minimally processed data are collected between limits of ±8000nT and clipped for display at ±6nT. Data are interpolated to a resolution of effectively 0.5m between tracks and 0.15m along each survey track.

2.3.4 Additional data processing has been carried out in the form of high pass filtering. This effectively removes low frequency variation along a traverse that has been caused by large magnetic bodies, cultivation or rapid temperature change. Data treated to additional processing have been compared to unprocessed data to ensure that no significant anomalies have been removed.

2.3.5 Appendix C contains metadata concerning the survey and data attributes and is derived directly from TerraSurveyor. Reference should be made to Appendix B for further information on processing.

2.3.6 A TIF file is produced by TerraSurveyor software along with an associated world file (.TFW) that allows automatic georeferencing (OSGB36 datum) when using GIS or CAD software. The main form of data display used in the report is the minimally processed greyscale plot. With regard to the Sensys MXPDA, minimally processed data are considered by the manufacturer to be data that are compensated by SENSYS MAGNETO DLMGPS software, see 2.3.1 and 2.3.2. Note: traceplots are not considered to be appropriate as they do not provide an accurate or useful assessment of the magnetic anomalies due to the very high density of data collection. In addition, traceplots cannot be meaningfully plotted against base mapping and in areas of complexity traces may be lost or highly confused. Traceplots may be used to demonstrate characteristic magnetic profiles across discrete features where it is considered beneficial.

2.3.7 The raster images are combined with base mapping using ProgeCAD Professional 2016, creating DWG (2010) file formats. All images are externally referenced to the CAD drawing in order to maintain good graphical quality. The CAD plots are effectively georeferenced facilitating relocation of features using GNSS, resection method, etc.

2.3.8 An abstraction and interpretation is drawn and plotted for all geophysical

anomalies located by the survey. Anomalies are abstracted using colour coded points, lines and polygons. All plots are scaled to landscape A3 for paper printing. Appendix E sets out CAD layer names with colour and graphic content for each interpretation category, see 3.3.

2.3.9 A brief summary of each anomaly, with an appropriate reference number, is set out in list form within the results (Section 3) to allow a rapid and objective assessment of features within each survey area.

2.3.10 A digital archive is produced with this report, see Appendix D below. The main archive is held at the offices of Archaeological Surveys Ltd.

3 RESULTS

3.1 General assessment of survey results

3.1.1 The detailed magnetic survey was carried out over a total of 10 survey areas covering approximately 32ha.

3.1.2 Magnetic anomalies located can be generally classified as positive and negative anomalies of an uncertain origin, anomalies associated with land management, linear anomalies of an agricultural origin, areas of magnetic debris and disturbance, strong discrete dipolar anomalies relating to ferrous objects and strong multiple dipolar linear anomalies relating to buried services or pipelines. Anomalies located within each survey area have been numbered and are described in 3.4 below.

3.2 Statement of data quality and factors influencing the interpretation of anomalies

3.2.1 Data are considered representative of the magnetic anomalies present within the site. There are no significant defects within the dataset. Magnetic disturbance caused by steel pylons and a steel-framed barn have caused some banding within the datasets after compensation of the sensors. Additional high pass filtering was carried out in order to suppress the effect of the disturbance. Both filtered and unfiltered data are analysed in order to ensure no anomalies are removed or altered by the additional processing.

3.2.2 Anomalies that potentially relate to the fill of former cut features generally appear weak and of poor contrast possibly indicating less than optimum conditions for magnetometry. To further assess the magnetic characteristics of the topsoil and subsoil, low frequency mass specific magnetic susceptibility measurements were made using a Bartington MS2 meter with MS2B sensor. The average value obtained for the topsoil (X_{lf}) = **16.5** $10^{-8}m^3kg^{-1}$ with the subsoil (X_{lf}) = **9.5** $10^{-8}m^3kg^{-1}$. Although only single bulk samples were obtained from the soil units, and it is unclear whether they are representative of the whole site, it does demonstrate some useful contrast between topsoil and subsoil and implies that former cut features should be visible in areas where

former human activity has further increased magnetic susceptibility. The presence of weak anomalies associated with modern cultivation and former ridge and furrow also demonstrates and confirms the potential for magnetic contrast within the soil.

3.3 Data interpretation

3.3.1 The list of sub-headings below attempts to define a number of separate categories that reflect the range and type of features located during the survey. A general explanation of the characteristics of the magnetic anomalies is set out for each category in order to justify interpretation, see Table 1.

Interpretation category	Description and origin of anomalies
Anomalies with archaeological potential	Anomalies have the characteristics (mainly morphological) of a range of archaeological features such as pits, ring ditches, enclosures, etc. The category is used where there is a high level of confidence which may be due to additional supporting information where morphology is unclear or uncharacteristic.
Anomalies with an uncertain origin	The category applies to a range of anomalies where there is not enough evidence to confidently suggest an origin. Anomalies in this category may well be related to archaeologically significant features, but equally relatively modern features, geological/pedological features and agricultural features should be considered. Morphology may be unclear or uncharacteristic and there may be a lack of additional supporting information. Positive anomalies are indicative of magnetically enhanced soils that may form the fill of 'cut' features or may be produced by accumulation within layers or 'earthwork' features; soils subject to burning may also produce positive anomalies. Negative anomalies are produced by material of comparatively low magnetic susceptibility such as stone and subsoil.
Anomalies relating to land management	Anomalies are mainly linear and may be indicative of the magnetically enhanced fill of cut features (i.e. ditches). The anomalies may be long and/or form rectilinear elements and they may relate to topographic features or be visible on early mapping. Associated agricultural anomalies (e.g. headlands, plough marks and former ridge and furrow) may support the interpretation. Land drains can appear in a classic herringbone pattern of interconnected multiple dipolar linear anomalies, or as parallel linear anomalies. The multiple dipolar response indicates ceramic land drains.
Anomalies with an agricultural origin	The anomalies are often linear and form a series of parallel responses or are parallel to extant land boundaries. Where the response is broad, former ridge and furrow is likely; narrow response is often related to modern ploughing. This category does not include agricultural features of early date or considered to be of archaeological potential (e.g. animal stockades, enclosures, farmsteads, etc).
Anomalies associated with magnetic debris	Magnetic debris often appears as areas containing many small dipolar anomalies that may range from weak to very strong in magnitude. They often occur where there has been dumping or ground make-up and are related to magnetically thermoremnant materials such as brick or tile or other small fragments of ferrous material. This type of response is occasionally associated with kilns, furnace structures, hearths and nail spreads from former wooden structures or rooves and may, therefore, be archaeologically significant. It is also possible that the response may be caused by natural material such as certain gravels and fragments of igneous or metamorphic rock. Strong discrete dipolar anomalies are responses to ferrous objects within the topsoil.

Anomalies with a modern origin	The magnetic response is often strong and dipolar indicative of ferrous material and may be associated with extant above surface features such as wire fencing, cables, pylons etc. Often a significant area around these features has a strong magnetic flux which may create magnetic disturbance; such disturbance can effectively obscure low magnitude anomalies if they are present. Fluxgate sensors may respond erratically adjacent to strong magnetic sources. Buried services may produce characteristic multiple dipolar anomalies dependant upon their construction.
Anomalies with a natural origin	Naturally formed magnetic anomalies are caused by localised variability in the magnetic susceptibility of soils, subsoils and other drift or solid geologies. Anomalies may be amorphous, linear or curvilinear and may appear 'fluvial' or discrete; the latter are almost impossible to distinguish from pit-like anomalies with an anthropogenic origin. Fluvial, glacial and periglacial processes may be responsible for their formation within drift material and subsoil. Igneous and metamorphic activity can lead to anomalies within more solid geology.

Table 1: List and description of interpretation categories

3.4 List of anomalies - Area 1

Area centred on OS NGR 439155 290488, see Figs 06 – 08.

Anomalies with an uncertain origin

(1) - A small number of weakly positive linear anomalies have been located in the western part of the survey area. They are indistinct and lack a coherent morphology.

(2) - A small number of discrete positive anomalies have been located in the eastern part of the survey area. It is not clear if they relate to pit-like features or modern disturbance.

Anomalies associated with land management

(3) - A positive linear anomaly relates to the line of a relatively recently removed field boundary.

(4) - A number of land drains are located in the eastern part of the survey area.

Anomalies with an agricultural origin

(5) - A series of parallel linear anomalies appear to relate to ridge and furrow.

Anomalies with a modern origin

(6) - Very strong magnetic disturbance in the south eastern part of the survey area is a response to a former sewage works recorded on 1960s mapping.

(7) - Widespread magnetic disturbance from an electricity pylon is evident to the north of (6). The steel-framed barn further to the north west has also resulted in widespread magnetic disturbance, as has a service extending along the eastern edge of the field.

3.5 List of anomalies - Area 2

Area centred on OS NGR 439938 290430, see Figs 09 – 11.

Anomalies with an uncertain origin

(8) - The survey area contains a number of short or fragmented positive and also negative linear and curvilinear anomalies.

Anomalies with an agricultural origin

(9) - A series of parallel linear anomalies relate to agricultural activity.

Anomalies with a modern origin

(10) - A linear anomaly, appearing as a series of conjoined discrete positive anomalies, relates to a buried cable. It extends along the line of a removed field boundary. It extends northwards into the south east corner of Area 3 and then to the south east along the south western corner of Area 1.

3.6 List of anomalies - Area 3

Area centred on OS NGR 438900 290610, see Figs 12 – 14.

Anomalies with an uncertain origin

(11) - Two positive linear anomalies have a north east to south west orientation and are situated 100m apart. The westerly anomaly appears to be situated on the eastern edge of a low extant linear bank seen within the field. The easterly anomaly is on a similar orientation to a former field boundary to the south, now indicated by a buried cable (10), and it is possible that these anomalies relate to former unmapped land boundaries.

(12) - The survey area contains a number of very weakly positive linear anomalies with no coherent morphology or pattern.

Anomalies associated with land management

(13) - The survey area contains a series of land drains.

Anomalies with an agricultural origin

(14) - A series of parallel linear anomalies appear to relate to ridge and furrow.

3.7 List of anomalies - Area 4

Area centred on OS NGR 438674 690612, see Figs 15 – 17.

Anomalies with an uncertain origin

(15) - Positive linear anomalies in the north eastern part of Area 4 are on a similar orientation and projection of former land boundary (17), although there is no such feature mapped on any Ordnance Survey mapping.

(16) - The survey area contains a number of short positive linear and curvilinear anomalies. It is not clear if they relate to cut features.

Anomalies associated with land management

(17) - Three positive linear anomalies cross the centre of the survey area and relate to formerly mapped field boundaries.

(18) - A number of land drains are evident within the survey area.

Anomalies associated with magnetic debris

(19) - A patch of strongly magnetic debris appears to relate to dumped material within a former quarry.

(20) - Zones of magnetic debris are evident around the field margins and relate to dumped magnetically thermoremnant material.

3.8 List of anomalies - Area 5

Area centred on OS NGR 438613 290460, see Figs 15 – 17.

Anomalies with an uncertain origin

(21) - A small number of weakly positive linear anomalies have been located in the north eastern corner of Area 5 and appear to partially extend northwards into Area 4. It is not clear if they relate to cut features.

(22) - A negative linear anomaly crosses the central part of Area 5. It is possible that this relates to a buried sewer pipe.

Anomalies associated with land management

(23) - A positive linear anomaly relates to a formerly mapped field boundary.

3.9 List of anomalies - Area 6

Area centred on OS NGR 438387 290610, see Figs 18 – 20.

Anomalies with an uncertain origin

(24) - A number of positive linear and a negative linear anomaly are located in the northern part of the survey area. This area is slightly raised; however, it is not clear if the anomalies relate to anthropogenic or natural features.

Anomalies associated with land management

(25) - The lower lying land within the field contains a large number of land drains.

Anomalies with an agricultural origin

(26) - Parallel linear anomalies relate to former ridge and furrow.

Anomalies associated with magnetic debris

(27) - Strong, discrete, dipolar anomalies are evident within all of the survey areas. The responses are widespread and too numerous to abstract individually across the site. This type of anomaly is a response to ferrous and other magnetically thermoremnant objects within the topsoil and would be spread during the process of manuring.

Anomalies associated with a modern origin

(28) - Strong, discrete, dipolar anomalies that are evident as a central negative response with a positive halo or a strongly positive response with a negative halo relate to steel markers placed by the geotechnical team to mark the proposed site of their investigations.

3.10 List of anomalies - Area 7

Area centred on OS NGR 438408 290756, see Figs 21 – 23.

Anomalies with an uncertain origin

(29) - A number of weakly positive linear anomalies can be seen in the south eastern corner of the survey area. It is possible that they continue into Area 4 to the east (16), but it is not clear if they relate to cut features.

Anomalies associated with land management

(30) - A number of land drains have been located in the survey area.

Anomalies with a natural origin

(31) - Magnetically variable anomalies in the south western part of the survey area appears to relate to natural features.

3.11 List of anomalies - Areas 8, 9 & 10

Area 8 centred on OS NGR 439155 290613, see Figs 6 – 8.
Area 8 centred on OS NGR 439273 290573, see Figs 6 – 8.
Area 8 centred on OS NGR 438890 290697, see Figs 12 – 14.

Anomalies associated with land management

(32) - Two positive linear anomalies at the far eastern end of Area 9 relate to former field boundaries.

(33) - Areas 9 and 10 contain evidence for ceramic land drains within extant ridge and furrow.

Anomalies associated with magnetic debris

(34) - Magnetic debris is associated with the low lying land at the far eastern end of Area 9 and the former land boundaries. It can also be seen within Area 8 adjacent to farm buildings. This is likely to relate to dumped ferrous and magnetically thermoremnant material used for ground consolidation.

4 CONCLUSION

4.1.1 The geophysical survey located a number of positive and negative linear anomalies within the majority of the survey areas. However, the anomalies are generally very weak, short, fragmented and lack a coherent morphology and layout for them to be confidently interpreted as cut features. Several of the survey areas contain evidence for ridge and furrow and more recent agricultural activity as well as a number of formerly mapped field boundaries which indicates that the fill of any cut features should be magnetically enhanced. Numerous land drains have also been located within the majority of survey areas as well as widespread magnetic debris likely to have been spread during the process of ground consolidation and manuring.

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Appendix A – basic principles of magnetic survey

Iron minerals are always present to some degree within the topsoil and enhancement associated with human activity is related to increases in the level of magnetic susceptibility and thermoremnant material. Magnetic susceptibility is an induced magnetism within a material when it is in the presence of a magnetic field. This can be thought of as effectively permanent due to the presence of the Earth's magnetic field. Thermoremnant magnetism occurs when ferrous material is heated beyond a specific temperature known as the Curie Point. Demagnetisation occurs at this temperature with re-magnetisation by the Earth's magnetic field upon cooling.

Enhancement of magnetic susceptibility can occur in areas subject to burning and complex fermentation processes on biological material; these are frequently associated with human settlement. Thermoremnant features include ovens, hearths, and kilns. In addition thermoremnant material such as tile and brick may also be associated with human activity and settlement.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil can create an area of enhancement compared with surrounding soils and subsoils into which the feature is cut. Mapping enhanced areas will produce linear and discrete anomalies allowing an assessment and characterisation of hidden subsurface features.

It should be noted that areas of negative enhancement can be produced from material having lower magnetic properties compared to the topsoil. This is common for many sedimentary bedrocks and subsoils which were often used in the construction of banks and walls etc. Mapping these 'negative' anomalies may also reveal archaeological features.

Magnetic survey or magnetometry can be carried out using a fluxgate gradiometer and may be referred to as gradiometry. The SENSYS gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 65cm apart. The instrument is carried about 10-20cm above the ground surface and the upper sensor measures the Earth's magnetic field as does the lower sensor but this is influenced to a greater degree by any localised buried magnetic field. The difference between the two sensors will relate to the strength of the magnetic field created by the buried feature.

There are a number of factors that may affect the magnetic survey and these include soil type, local geology and previous human activity. Situations arise where magnetic disturbance associated with modern services, metal fencing, dumped waste material etc., obscures low magnitude fields associated with archaeological features.

Appendix B – data processing notes

Clipping

Minimum and maximum values are set and replace data outside of the range with those values. Extreme values are removed improving colour or greyscale contrast associated with data values that may be archaeologically significant. Different ranges are applied to data in order to determine the most suitable for anomaly abstraction and display.

Despike

Removal of data points that exceed the mean/median/threshold by selecting a window size of data points and replace by mean/median/threshold. Magnetic spikes can be caused iron objects on the surface or within the topsoil. Despike can improve the appearance of data and remove extreme readings that may affect further processing.

High Pass Filter

Removes low frequency anomalies within the data that are not considered to be archaeologically significant and may be natural in origin. A window passes over the data, the mean of all the data within the window is subtracted from the centre value. The size of the window is adjusted as is the weighting which may be uniform or Gaussian. The process is used to improve the visibility of anomalies of interest.

Low Pass Filter

Removes high frequency anomalies or 'noise' within datasets and provides a smoother output. A window passes over the data, the mean of all the data within the window is used to replace the centre value. The size of the window is adjusted as is the weighting. The process is used to improve the visibility of anomalies of interest.

Zero Median/Mean Traverse

The median (or mean) of data from each traverse is calculated ignoring data outside a threshold value, the median (or mean) is then subtracted from the traverse. The process is used to equalise differences between the offset values of the gradiometer sensors. The process can remove archaeological features that run along a traverse but with the high resolution datasets created by the Sensys FGM650 sensors and the method of data collection this has not been a notable problem. In fact, the removal of offsets using software avoids carrying out a balancing procedure on site, which inevitably can never be done in magnetically clean conditions and results in improperly aligned fluxgate sensors and/or electronic adjustment values.

Appendix C – survey and data information

Area 1 minimally processed data

Filename: J788-mag-Area1-proc.xcp
Description: Imported as Composite from: J788-mag-Area1.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):OSGB36
Northwest corner: 438977.12, 290589.07 m
Southeast corner: 439340.87, 290376.97 m
Collection Method: Randomised
Sensors: 5
Dummy Value: 32702
Source GPS Points: 1089000
Dimensions
Composite Size (readings): 2425 x 1414
Survey Size (meters): 364 m x 212 m
Grid Size: 364 m x 212 m
X Interval: 0.15 m
Y Interval: 0.15 m
Stats
Max: 3.32
Min: -3.30
Std Dev: 1.37
Mean: 0.02
Median: 0.01
Composite Area: 7.7151 ha
Surveyed Area: 4.2 ha
PROGRAM
Name: TerraSurveyor
Version: 3.0.23.0
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

Area 1 filtered data

Filename: J788-mag-Area1-proc-hpf.xcp
Stats
Max: 3.32
Min: -3.30
Std Dev: 1.23
Mean: 0.00
Median: 0.00
GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 High pass Uniform (median) filter: Window dia: 300
5 Clip from -3.00 to 3.00 nT

Area 2 minimally processed data

Filename: J788-mag-Area2-proc.xcp
Description: Imported as Composite from: J788-mag-Area2.asc
Northwest corner: 438762.95, 290512.86 m
Southeast corner: 439111.40, 290323.41m
Source GPS Points: 718200
Dimensions
Composite Size (readings): 2323 x 1263
Survey Size (meters): 348 m x 189 m
Grid Size: 348 m x 189 m
X Interval: 0.15 m
Y Interval: 0.15 m
Stats
Max: 3.32
Min: -3.30
Std Dev: 1.08
Mean: 0.05
Median: 0.02
Composite Area: 6.6014 ha
Surveyed Area: 3.3843 ha
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

Area 2 filtered data

Filename: J788-mag-Area2-proc-hpf.xcp
Stats
Max: 3.32
Min: -3.30
Std Dev: 0.99
Mean: 0.02
Median: 0.01
GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 High pass Uniform (median) filter: Window dia: 300
5 Clip from -3.00 to 3.00 nT

Area 1 minimally processed data

Filename: J788-mag-Area3-proc.xcp
Description: Imported as Composite from: J788-mag-Area3.asc
Northwest corner: 438789.07, 290706.86 m
Southeast corner: 439038.37, 290479.16 m
Source GPS Points: 683400

Dimensions
Composite Size (readings): 1662 x 1518
Survey Size (meters): 249 m x 228 m
Grid Size: 249 m x 228 m
X Interval: 0.15 m
Y Interval: 0.15 m
Stats
Max: 3.32
Min: -3.30
Std Dev: 0.93
Mean: 0.05
Median: 0.01
Composite Area: 5.6766 ha
Surveyed Area: 3.4313 ha
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

Area 3 filtered data

Filename: J788-mag-Area-proc-hpf.xcp
Stats
Max: 3.32
Min: -3.30
Std Dev: 0.83
Mean: 0.02
Median: 0.00
GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 High pass Uniform (median) filter: Window dia: 300
5 Clip from -3.00 to 3.00 nT

Area 4 minimally processed data

Filename: J788-mag-Area4-proc.xcp
Description: Imported as Composite from: J788-mag-Area4.asc
Northwest corner: 438536.35 290755.61 m
Southeast corner: 438800.35, 290469.11 m
Source GPS Points: 897000
Dimensions
Composite Size (readings): 1760 x 1910
Survey Size (meters): 264 m x 287 m
Grid Size: 264 m x 287 m
X Interval: 0.15 m
Y Interval: 0.15 m
Stats
Max: 3.32
Min: -3.30
Std Dev: 1.14
Mean: 0.09
Median: 0.01
Composite Area: 7.5636 ha
Surveyed Area: 4.7751 ha
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

Area 4 filtered data

Filename: J788-mag-Area4-proc-hpf.xcp
Stats
Max: 3.32
Min: -3.30
Std Dev: 0.99
Mean: 0.03
Median: 0.01
GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 High pass Uniform (median) filter: Window dia: 300
5 Clip from -3.00 to 3.00 nT

Area 5 minimally processed data

Filename: J788-mag-Area5-proc.xcp
Description: Imported as Composite from: J788-mag-Area5.asc
Northwest corner: 438480.58, 290536.12 m
Southeast corner: 438748.93, 290397.22 m
Source GPS Points: 344900
Dimensions
Composite Size (readings): 1789 x 926
Survey Size (meters): 268 m x 139 m
Grid Size: 268 m x 139 m
X Interval: 0.15 m
Y Interval: 0.15 m
Stats

Max: 3.32
Min: -3.30
Std Dev: 1.15
Mean: 0.00
Median: 0.01
Composite Area: 3.7274 ha
Surveyed Area: 1.5828 ha
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

Area 5 filtered data

Filename: J788-mag-Area5-proc-hpf.xcp
Stats
Max: 3.32
Min: -3.30
Std Dev: 1.10
Mean: 0.01
Median: 0.01
GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 High pass Uniform (median) filter: Window dia: 300
5 Clip from -3.00 to 3.00 nT

Area 6 minimally processed data

Filename: J788-mag-Area6-proc.xcp
Description: Imported as Composite from: J788-mag-Area6.asc
Northwest corner: 438229.98, 290729.84 m
Southeast corner: 438555.33, 290468.99 m
Source GPS Points: 950900
Dimensions
Composite Size (readings): 2169 x 1739
Survey Size (meters): 325 m x 261 m
Grid Size: 325 m x 261 m
X Interval: 0.15 m
Y Interval: 0.15 m
Stats
Max: 3.32
Min: -3.30
Std Dev: 0.96
Mean: 0.02
Median: 0.01
Composite Area: 8.4868 ha
Surveyed Area: 5.4528 ha
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

Area 6 filtered data

Filename: J788-mag-Area6-proc-hpf.xcp
Stats
Max: 3.32
Min: -3.30
Std Dev: 0.94
Mean: 0.03
Median: 0.01
GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 High pass Uniform (median) filter: Window dia: 300
5 Clip from -3.00 to 3.00 nT

Area 7minimally processed data

Filename: J788-mag-Area7-proc.xcp
Description: Imported as Composite from: J788-mag-Area7.asc
Northwest corner: 438246.44, 290881.53 m
Southeast corner: 438578.39, 290626.08 m
Source GPS Points: 726000
Dimensions
Composite Size (readings): 2213 x 1703
Survey Size (meters): 332 m x 255 m
Grid Size: 332 m x 255 m
X Interval: 0.15 m
Y Interval: 0.15 m
Stats
Max: 3.32
Min: -3.30
Std Dev: 0.76
Mean: 0.02
Median: 0.00
Composite Area: 8.4797 ha
Surveyed Area: 4.0027 ha
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

Area 7 filtered data

Filename: J788-mag-Area7-proc-hpf.xcp
Stats
Max: 3.32
Min: -3.30
Std Dev: 0.74
Mean: 0.02
Median: 0.00
GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 High pass Uniform (median) filter: Window dia: 300
5 Clip from -3.00 to 3.00 nT

Area 8 minimally processed data

Filename: J788-mag-Area8-proc.xcp
Description: Imported as Composite from: J788-mag-Area8.asc
Northwest corner: 439128.58, 290635.52 m
Southeast corner: 439181.38, 290594.27 m
Source GPS Points: 35900
Dimensions
Composite Size (readings): 352 x 275
Survey Size (meters): 52.8 m x 41.3 m
Grid Size: 52.8 m x 41.3 m
X Interval: 0.15 m
Y Interval: 0.15 m
Stats
Max: 3.32
Min: -3.30
Std Dev: 1.82
Mean: 0.04
Median: -0.08
Composite Area: 0.2178 ha
Surveyed Area: 0.12266 ha
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

Area 8 filtered data

Filename: J788-mag-Area8-proc-hpf.xcp
Stats
Max: 3.32
Min: -3.30
Std Dev: 1.64
Mean: 0.06
Median: 0.04
GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 High pass Uniform (median) filter: Window dia: 300
5 Clip from -3.00 to 3.00 nT

Area 9 minimally processed data

Filename: J788-mag-Area9-proc.xcp
Description: Imported as Composite from: J788-mag-Area9.asc
Northwest corner: 439177.57, 290618.08 m
Southeast corner: 439360.72, 290510.38 m
Source GPS Points: 244600
Dimensions
Composite Size (readings): 1221 x 718
Survey Size (meters): 183 m x 108 m
Grid Size: 183 m x 108 m
X Interval: 0.15 m
Y Interval: 0.15 m
Stats
Max: 3.32
Min: -3.30
Std Dev: 1.45
Mean: -0.01
Median: 0.01
Composite Area: 1.9725 ha
Surveyed Area: 0.6883 ha
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

Area 9 filtered data

Filename: J788-mag-Area9-proc-hpf.xcp
Stats
Max: 3.32
Min: -3.30
Std Dev: 1.38
Mean: 0.01
Median: 0.01
GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 High pass Uniform (median) filter: Window dia: 300
5 Clip from -3.00 to 3.00 nT

Area 10 minimally processed data

Filename: J788-mag-Area10-proc.xcp
Description: Imported as Composite from: J788-mag-Area10.asc
Northwest corner: 438814.94, 290729.23 m
Southeast corner: 438976.79, 290666.83 m
Source GPS Points: 100700
Dimensions
Composite Size (readings): 1079 x 416
Survey Size (meters): 162 m x 62.4 m
Grid Size: 162 m x 62.4 m
X Interval: 0.15 m
Y Interval: 0.15 m
Stats
Max: 3.32
Min: -3.30
Std Dev: 1.44
Mean: -0.02
Median: 0.00
Composite Area: 1.0099 ha
Surveyed Area: 0.31085 ha
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

Area 10 filtered data

Filename: J788-mag-Area10-proc-hpf.xcp
Stats
Max: 3.32
Min: -3.30
Std Dev: 1.37
Mean: -0.02
Median: 0.01
GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 High pass Uniform (median) filter: Window dia: 300
5 Clip from -3.00 to 3.00 nT

Appendix D – digital archive

Archaeological Surveys Ltd hold the primary digital archive at their offices in Wiltshire. Data are backed-up onto an on-site data storage drive and at the earliest opportunity data are copied to CD ROM for storage on-site and off-site.

A PDF copy will be supplied to the Warwickshire Historic Environment Record. The report will also be uploaded to the Online AccesS to the Index of archaeological investigationS (OASIS).

Archive contents:

File type	Naming scheme	Description
Data	J788-mag-**[area number/name]**.asc J788-mag-**[area number/name]**.xcp J788-mag-**[area number/name]**-proc.xcp J788-mag-**[area number/name]**-proc.xcp	Raw data as ASCII CSV TerraSurveyor raw data TerraSurveyor minimally processed data TerraSurveyor high pass filtered data
Graphics	J788-mag-**[area number/name]**-proc.tif J788-mag-**[area number/name]**-proc-hpf.tif	Image in TIF format Image in TIF format
Drawing	J788-**[version number]**.dwg	CAD file in 2010 dwg format
Report	J788 report.odt	Report text in Open Office odt format

Table 2: Archive metadata

Appendix E – CAD layers for abstraction and interpretation plots

The table below sets out Archaeological Surveys Ltd CAD layer names with associated colours and graphical content. Where CAD files are available layers may be extracted for further CAD/GIS use. Note: hatched polygon boundaries are contained within layers with the RGB colour code 254, 255, 255 (near white) in order to prevent their visibility.

Report sub-heading and associated CAD layer names	Colour with RGB index		Layer content
Anomalies with an uncertain origin			
AS-ABST MAG POS LINEAR UNCERTAIN		255,127,0	Line, polyline or polygon (solid)
AS-ABST MAG NEG LINEAR UNCERTAIN		Blue 0,0,255	Line, polyline or polygon (solid)
AS-ABST MAG POS DISCRETE UNCERTAIN		255,127,0	Solid donut, point or polygon (solid)
Anomalies relating to land management			
AS-ABST MAG BOUNDARY		127,0,0	Line, polyline or polygon (solid or cross hatched ANSI37)
AS-ABST MAG LAND DRAIN		Cyan 0,255,255	Line or polyline
Anomalies with an agricultural origin			
AS-ABST MAG AGRICULTURAL		Green 0,255,0	Line or polyline
AS-ABST MAG RIDGE AND FURROW		0,127,63	Line, polyline or polygon (cross hatched ANSI37)
Anomalies associated with magnetic debris			
AS-ABST MAG DEBRIS		132, 132, 132	Polygon (cross hatched ANSI37)
AS-ABST MAG STRONG DIPOLAR		132, 132, 132	Solid donut, point or polygon (solid)
Anomalies with a modern origin			
AS-ABST MAG DISTURBANCE		132, 132, 132	Polygon (hatched ANSI31)
AS-ABST MAG SERVICE		132, 132, 132	Line or polyline
Anomalies with a natural origin			
AS-ABST MAG NATURAL FEATURES		Yellow 255,255,0	Polygon (cross hatched ANSI37)

Table 3: CAD layering

Appendix F – copyright and intellectual property

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www.archaeological-surveys.co.uk
info@archaeological-surveys.co.uk
Tel: 01249 814 231