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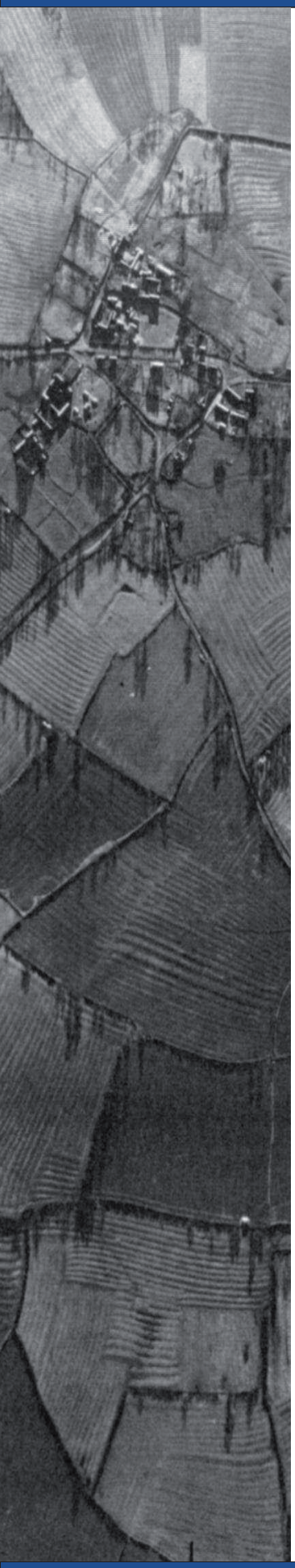

Ashton Vale, Bristol

MAGNETOMETER SURVEY REPORT

for

WSP Environment and Energy

David Sabin and Kerry Donaldson

April 2010

Ref. no. 274

ARCHAEOLOGICAL SURVEYS LTD

Ashton Vale, Bristol

Magnetometer Survey

for

WSP Environment and Energy

Fieldwork by David Sabin and Jack Cousins
Report by David Sabin BSc (Hons) MIFA and Kerry Donaldson BSc (Hons)

Survey date - **9th July 2009 and March 29th to April 1st 2010**
Ordnance Survey Grid Reference – **ST 56150 70620**

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CONTENTS

LIST OF FIGURES

LIST OF PLATES

LIST OF TABLES

SUMMARY

A magnetometer survey was commissioned by WSP Environment and Energy Ltd, to be carried out over a 7.1ha area of land at Ashton Vale, Bristol, ahead of a potential development of the new Bristol City Football Club stadium, residential dwellings and retail units.

An initial trial of detailed magnetometry proved that the technique was effective and that the soils were conducive to forming magnetic enhancement. A subsequent survey of all accessible areas located a number of geophysical anomalies that may relate to ditch-like or pit-like features. However, it has not been possible to ascertain the origin of many of these anomalies and although they may have been caused by anthropogenic activity, it is possible that some may be a response to naturally magnetically enhanced soils.

Several linear anomalies have been located that appear to be associated with former field boundaries visible on mapping between 1821 and 1938. Several other linear anomalies also relate to agricultural features, possibly associated with improving land drainage.

A zone of magnetic disturbance was located in areas adjacent to landfill, forming the northern part of the site, suggesting a high proportion of buried ferrous material. Zones of magnetic debris were frequently encountered and probably relate to ferrous material derived from nearby industrial sites.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by WSP Environment and Energy Ltd, to undertake a geophysical survey of an area of land at Ashton Vale, Bristol. The site has been outlined for the proposed new Bristol City Football Club stadium, together with residential and retail development. The survey forms part of an archaeological assessment of the site.

1.1.2 The geophysical survey was carried out in accordance with a Written Scheme of Investigation (WSI) produced by Archaeological Surveys (2009). The WSI considers the requirements of a Brief for geophysical survey issued by the Client.

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. A trial survey was undertaken in July 2009 to test the efficacy of the technique. The survey located several geophysical

anomalies, which indicated that magnetometry would prove effective in locating buried features.

1.2.2 The methodology is considered an efficient and effective approach to archaeological prospection. The survey and report generally follow the recommendations set out by: English Heritage, 2008, *Geophysical survey in archaeological field evaluation;* Institute for Archaeologists, 2002, *The use of Geophysical Techniques in Archaeological Evaluations*.

1.3 Site location, description and survey conditions

1.3.1 The site is located at Ashton Vale, Bristol. Ordnance Survey National Grid Reference (OS NGR) ST 56150 70620, see Figures 01 and 02. The majority of the survey area lies within the parish of St John the Baptist, Bedminster within the city of Bristol, with a small section of land on the western part of the site within the parish of Long Ashton, North Somerset.

1.3.2 The geophysical survey covers an area of approximately 7.1ha of rough pasture within six separate parcels labelled Areas 1 – 6, see Plates 1 - 3. The land within the northern part of the potential development area had been discounted for survey as it had been previously used for landfill. A separate section of land to the north east of this was also unsurveyable due to the presence of brambles and other shrubs associated with the abandoned and overgrown allotments.

Plate 1: Northern part of the site looking towards the north west

Plate 2: Eastern part of the site looking south

Plate 3: Waterlogging within the northern part of the site

1.3.3 The ground conditions across the site were generally acceptable for the collection of magnetometry data although heavily waterlogged and boggy areas were avoided, see Plate 3. Survey was also impeded along the western side of the site by piles of decaying vegetation. Weather conditions during the survey were very poor with periods of heavy rain and high winds.

1.4 Site history and archaeological potential

1.4.1 An Archaeological Desk-Based Assessment was carried out by Bristol and Region Archaeological Services (BaRAS, 2008). They identified a lack of archaeological sites and findspots within the site; however, there is evidence for prehistoric and Romano-British activity within the wider surrounding area. The site was in arable cultivation during the medieval period with evidence for ridge and furrow within aerial photographs taken during the 1940s and 1950s.

1.4.2 The immediate area was subject to coal mining during the 19th century, with the Starveall pit located within the north eastern part of the site and a further mine shaft situated some 200m to the southwest, just outside the site. There is therefore potential to locate geophysical anomalies that relate to industrial activity.

1.5 Geology and soils

1.5.1 The underlying solid geology across the site is Triassic Keuper Marl with overlying deposits of river alluvium in the northern part of the site and 1st river terrace alluvium in the southern part of the site (BGS, 1962).

1.5.2 The overlying soil across the survey area is from the Brockhurst 2 association, which are typical stagnogley soils. These consist of slowly permeable, seasonally waterlogged, reddish fine loamy over clayey soils (Soil Survey of England and Wales, 1983).

1.5.3 Although the response to buried features under alluvial deposits can be average to poor (English Heritage 2008), it appears from the site that the deposits relate to Pleistocene events rather than from more recent inundations. There is evidence for ridge and furrow which also suggests that alluvial deposits are not recent. The trial survey located a number of geophysical anomalies that may relate to cut features, or naturally magnetically enhanced features, which indicates that magnetometry is effective across the soils.

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 are factors associated with the formation of localised fields. Additional details are set out below and within Appendix A.

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).

2.2 Equipment configuration, data collection and survey detail

2.2.1 The detailed magnetic survey was carried out using a Bartington Grad601-2 gradiometer. This instrument effectively measures a magnetic gradient between two fluxgate sensors mounted vertically 1m apart. Two sets of sensors are mounted on a single frame 1m apart horizontally.

2.2.2 The instrument is extremely sensitive and is able to measure magnetic variation to 0.01nanoTesla (nT), with an effective resolution of 0.03nT. The data are limited to ±100nT when surveying with the highest sensitivity. All readings are saved to an integral data logger for analysis and presentation.

2.2.3 The instrument is operated according to the manufacturer's instructions with consideration given to the local conditions. An adjustment procedure is required, prior to collection of data, in order to balance the sensors and remove the effects of the Earth's magnetic field; further adjustment is required during the survey due to instrument drift often associated with temperature change.

2.2.4 It can be very difficult to obtain optimum balance for the sensors due to localised magnetic vectors that may be associated with large ferrous objects, geological/pedological features, 'magnetic debris' within the topsoil and natural temperature fluctuations. Imperfect balance results in a heading error often visible as striping within the data; this can be effectively removed by software processing and generally has little effect on the data unless extreme.

2.2.5 The Bartington gradiometer undergoes regular servicing and calibration by the manufacturer. A current assessment of the instrument is shown in Table 1 below.

Date of calibration/service	16th May 2009
Sensor type	Bartington Grad - 01 – 1000 Nos. 084 and 085
Bandwidth	12Hz (100nT range) both sensors
Noise	<100pT peak to peak
Adjustable errors	<2nT

Table 1: Bartington fluxgate gradiometer sensor calibration results

The instrument was considered to be in good working order prior to the survey with no known faults or defects.

2.2.6 Data were collected at 0.25m centres along traverses 1m apart. The survey area was separated into 30m by 30m grids (900m²) giving 3600 recorded measurements per grid. This sampling interval is very effective at locating archaeological features and is the recommended methodology for archaeological prospection (English Heritage, 2008).

2.2.7 The survey grids were set out to the Ordnance Survey OSGB36 datum using a Penmap RTK GPS. The GPS is used in conjunction with Topcon's TopNet service where positional corrections are sent via a mobile telephone link. Positional accuracy of around 10 – 20mm is possible using the system. The instrument is regularly checked against the ETRS89 reference framework using Ordnance Survey ground marker C1ST7784 (Horton).

2.2.8 The fixed orientation of survey grids based on the OSGB36 datum was considered appropriate given that the orientation of land boundaries was variable and consequently partial survey grids were unavoidable. In addition, there is an optimum north – south traverse direction for magnetic survey (English Heritage, 2008). Survey in this direction can produce anomalies with a higher contrast when compared to other orientations; this is a function of their presence within the Earth's magnetic field. A fixed grid across the site also simplifies its relocation should that be required.

2.3 Data processing and presentation

2.3.1 Magnetometry data downloaded from the Grad 601-2 data logger are analysed and processed in specialist software known as ArcheoSurveyor. The software allows greyscale and trace plots to be produced for presentation and display. Survey grids are assembled to form an overall composite of data (composite file) creating a dataset of the complete survey area. Appendix C contains specific information concerning the survey and data attributes and is derived directly from ArcheoSurveyor; this should be used in conjunction with information provided by Figure 02.

2.3.2 Only minimal processing is carried out in order to enhance the results of the

survey for display. Raw data are always analysed as processing can modify anomalies. The following schedule sets out the data and image processing used in this survey:

- clipping of the raw data at ±30nT to improve greyscale resolution,
- clipping of processed data at ±3nT to enhance low magnitude anomalies,
- de-stagger is used to enhance linear anomalies,
- zero median/mean traverse is applied in order to balance readings along each traverse.

Reference should be made to Appendix B for further information on the specific processes carried out on the data. Appendix C metadata includes details on the processing sequence used for each survey area.

2.3.3 An abstraction and interpretation is offered for all geophysical anomalies located by the survey. 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. Where further interpretation is possible, or where a number of possible origins should be considered, more subjective discussion is set out in Section 4.

2.3.4 The main form of data display used in this report is the greyscale plot. Both 'raw' and 'processed' data have been shown followed by an abstraction and interpretation plot. Anomalies are abstracted using colour coded points, lines and polygons. All plots are scaled to landscape A3 for paper printing.

2.3.5 Graphic raster images in bitmap format (.BMP) are initially prepared in ArcheoSurveyor. Regardless of survey orientation, data captured along each traverse are displayed and processed by ArcheoSurveyor from left to right; this corresponds to a direction of south to north in the field. Prior to displaying against base mapping, raster graphics require a rotation of 90° anticlockwise to restore north to the top of the image. Greyscale images are rotated by AutoCAD.

2.3.6 The raster images are combined with base mapping using ProgeCAD Professional 2009 and AutoCAD LT 2007, creating DWG file formats. All images are externally referenced to the CAD drawing in order to maintain good graphical quality. Quality can be compromised by rotation of graphics in order to allow the data to be orientated with respect to grid north; this is considered acceptable as the survey results are effectively georeferenced allowing relocation of features using GPS, resection method etc.. A digital archive, including raster images, is produced with this report allowing separate analysis if necessary, see Appendix D below.

3 RESULTS

3.1 General overview

3.1.1 The detailed magnetic survey was carried out over a total of 6 survey areas covering approximately 7.1ha. Geophysical anomalies located can be generally classified as positive and negative anomalies of an uncertain origin, linear anomalies associated with former field boundaries, linear anomalies of an agricultural origin, areas of magnetic debris and disturbance and strong discrete dipolar anomalies relating to ferrous objects. Anomalies located within each survey area have been numbered and are described below with subsequent discussion in Section 4.

3.1.2 Data are influenced in parts of the site by zones of magnetic disturbance and debris although it is unlikely that significant anomalies have been obscured. Parts of the site were unsurveyable due to boggy and waterlogged ground and patches of scrubby and decaying vegetation.

3.1.3 The listing 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 basic explanation of the characteristics of the magnetic anomalies is set out for each category in order to justify interpretation, a basic key is indicated to allow cross reference to the abstraction and interpretation plot. CAD layer names are included to aid reference to associated digital files (.dwg/.dxf). Sub-headings are then used to group anomalies with similar characteristics for each survey area.

Report sub-heading **CAD layer names and plot colour**	**Description and origin of anomalies**
Anomalies with an uncertain origin AS-ABST POS LINEAR UNCERTAIN AS-ABST NEG LINEAR UNCERTAIN AS-ABST POS DISCRETE UNCERTAIN AS-ABST POS AREA UNCERTAIN	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. 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 former field boundaries AS-ABST BOUNDARY	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.
Anomalies with an agricultural origin AS-ABST AGRICULTURAL AS-ABST RIDGE AND FURROW	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.

Anomalies associated with magnetic debris AS-ABST MAGNETIC DEBRIS AS-ABST STRONG DIPOLAR	Magnetic debris often appears as areas containing many small dipolar anomalies that may range from weak to very strong in magnitude. It often occurs where there has been dumping or ground make-up and is 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, or hearths 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 AS-ABST MAGNETIC DISTURBANCE	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 such 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 and with hysteresis adjacent to strong magnetic sources. Buried services may produce characteristic multiple dipolar anomalies dependant upon their construction.

Table 2: List and description of interpretation categories

3.2 List of anomalies - Area 1

Area centred on OS NGR 356015 170725, see Figures 03, 04 and 06.

Anomalies with an uncertain origin

(1) – A positive linear anomaly may indicate a former cut feature such as boundary ditch with a moderately enhanced response (<7nT).

(2) – A weakly positive amorphous response that may relate to magnetically enhanced material soil. A natural origin is possible.

(3) – Weakly positive linear anomalies of uncertain origin located between anomalies (1) and (2).

(4) – A positive curvilinear anomaly that may indicate a ditch-like feature.

(5) – A positive linear and pit-like response may relate to a cut features.

(6) – Positive discrete, amorphous and linear anomalies in the northern part of the survey area, indicate the presence of magnetically enhanced material within possible “cut” features or natural depressions.

Anomalies with an agricultural origin

(7) – A series of parallel linear anomalies within the southern part of the site have been caused by agricultural activity.

Anomalies associated with magnetic debris

(8) – The survey area contains many strong discrete dipolar anomalies that indicate the presence of ferrous material within the topsoil.

3.3 List of anomalies - Area 2

Area centred on OS NGR 356120 170740, see Figures 03, 04 and 06.

Anomalies with an uncertain origin

(9) – A cluster of positive discrete anomalies may relate to pit-like features; however, it is possible that they have a natural origin. They have similar diameters up to approximately 5.5m and are moderately enhanced at up to 13nT.

(10) – Positive anomaly of uncertain origin.

(11) – Positive linear anomalies close to the south eastern corner of Area 2 may relate to ditch-like features.

Anomalies with an agricultural origin

(12) – A series of linear anomalies likely to relate to agricultural activity.

Anomalies associated with magnetic debris

(13) – Magnetic debris with a very strong response is located along the southern edge of Area 2 and is likely to relate to dumped magnetically thermoremnant material.

(14) – Strong discrete dipolar anomalies relate to fragments of ferrous/magnetically thermoremnant material within the topsoil.

Anomalies with a modern origin

(15) – Magnetic disturbance along the northern edge of Area 2 is a response to ferrous/magnetically thermoremnant material within the landfill site to the north.

3.4 List of anomalies - Area 3

Area centred on OS NGR 356225 170720, see Figures 03, 04 and 06.

Anomalies with an uncertain origin

(16) – A short positive linear anomaly close to the north eastern corner of Area 3 may indicate a ditch-like feature.

Anomalies with an agricultural origin

(17) – A series of negative linear anomalies are associated with agricultural activity and are likely to relate to land drainage.

Anomalies associated with magnetic debris

(18) – Magnetic debris along the south eastern edge of Area 3 has been caused by magnetically thermoremnant material that is likely to have been dumped on site.

(19) – Widespread strong discrete dipolar anomalies indicate ferrous/magnetically thermoremnant material within the topsoil.

Anomalies with a modern origin

(20) – Magnetic disturbance from ferrous/magnetically thermoremnant material within the landfill site to the north.

3.5 List of anomalies - Area 4

Area centred on OS NGR 356135 170530, see Figures 03, 05 and 07.

Anomalies with an uncertain origin

(21) – Negative linear anomalies that indicate material of low magnetic susceptibility such as subsoil.

(22) – Weak linear and curvilinear anomalies that may indicate ditch-like features.

(23) – Discrete positive pit-like anomalies that may relate to pit-like features of anthropogenic or natural origin.

(24) – A rectilinear anomaly formed from positive and negative linear responses may have been “cut” by a former field boundary.

(25) – Weak broad positive responses flank a former field boundary (27) and may be associated with agricultural activity.

Anomalies associated with former field boundaries

(26) – Negative and weakly positive linear anomalies indicate the location of a former field boundary.

(27) – Several negative linear anomalies appear to relate to former field boundaries.

(28) – A negative linear anomaly oriented north-north-east to south-south-west, appears to relate to a former field boundary.

Anomalies associated with magnetic debris

(29) – Widespread magnetic debris within the southern part of the site is likely to be associated with ferrous/magnetically thermoremnant material, such as industrial waste, that has been incorporated into the topsoil.

(30) – Fragments of ferrous/magnetically thermoremnant material.

3.6 List of anomalies - Area 5

Area centred on OS NGR 356255 170620, see Figures 03, 04 and 06.

Anomalies with an uncertain origin

(31) – A broad positive linear anomaly extending along the eastern edge of the survey area may relate to a former trackway.

(32) – Positive linear anomalies of uncertain origin.

Anomalies associated with magnetic debris

(33) – A zone of magnetic debris relates to magnetically thermoremnant material that has been dumped/used for ground make-up. A particularly black soil with fragments of coal was noted during the survey.

3.7 List of anomalies - Area 6

Area centred on OS NGR 356335 170720, see Figures 03, 04 and 06.

Anomalies with an uncertain origin

(34 & 35) – Broad positive response (34) and positive linear anomaly (35) are located approximately in the position of a mapped sewage pipe.

Anomalies associated with magnetic debris

(36) – Magnetic debris is associated with spreads of magnetically thermoremnant material.

Anomalies with a modern origin

(37) – Magnetic disturbance along the western edge of Area 6 is associated with ferrous/magnetically thermoremnant material within the adjacent landfill site.

4 DISCUSSION

4.1.1 Magnetometry has been effective in locating a number of positive and negative anomalies across the site. Many of these appear to be associated with former agricultural practices such as drainage and land division, while others cannot be confidently interpreted from their morphology alone.

4.1.2 Area 1 was surveyed as a strip, some 330m long, along the western edge of the site. The initial trial survey established the presence of a steel waterpipe adjacent to the eastern field boundary; the associated magnetic disturbance resulted in the exclusion of a zone approximately 30m wide between Area 1 and the boundary. Several positive linear and discrete responses were located within the area, it is possible that some relate to cut ditch-like or pit-like features.

4.1.3 Area 2, located to the east of Area 1 and immediately south of the landfill site, contained many moderately enhanced pit-like anomalies. It is not possible to confidently determine if they relate to “cut” pit-like features or have a natural origin; this type of feature occasionally be found in periodically waterlogged conditions. A number of parallel linear anomalies are associated with agricultural activity and these can be seen to extend into Area 3 to the east. Along the edge of Areas 2, 3 and 6 magnetic disturbance has been caused by magnetically thermoremnant material within the make up of the landfill.

4.1.4 The southern part of the site, Area 4, contained several linear anomalies that appear to relate to former field boundaries dividing the southern part of the field into several smaller plots. These are visible on the Bedminster tithe map between 1827 and 1841 but the majority have been removed by the 1882, with the remaining removed before 1938. Other anomalies may relate to former agricultural activity; however, it has not been possible to determine the origin of a positive/negative rectilinear anomaly (24), short positive anomalies (22) and discrete positive anomalies in this area (23).

4.1.5 The majority of the survey areas contain widespread magnetic debris indicating the presence of ferrous material within the topsoil. Given the proximity of the survey area to former coal workings and other industrial sites, it seems likely that the magnetic debris is waste material either dumped or used in ground make-up.

5 CONCLUSION

5.1.1 The detailed magnetometer survey, carried out over 7.1ha, located a number of geophysical anomalies that relate to the predominately agricultural use of the site. Several former field boundaries have been located within the southern part of the site (Area 4) and other linear anomalies may relate to features associated with improvement of land drainage.

5.1.2 A number of discrete positive responses may indicate pit-like features within Area 2 and 4; however, it is not possible to confidently interpret them as anthropogenic in origin. It may be that some or all relate to magnetically enhanced material caused by natural biological and pedogenic processes within waterlogged ground.

5.1.3 Magnetic disturbance has been caused by the landfill site to the north of Areas 2 and 3 and to the west of Area 6, indicating that it contains large quantities of ferrous material. Widespread zones of magnetic debris have been located across much of the site, suggesting that magnetically thermoremnant material has been dumped on the site or used as ground make-up. The material is likely to have originated from a nearby coal pit and other industrial sites.

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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 gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 1m apart. The instrument is carried about 30cm 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 field. The difference between the two sensors will relate to the strength the magnetic field created by the buried feature. If no enhanced feature is present the field measured by both sensors will be similar and the difference close to zero.

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. It has been found that clipping data to ranges between ±5nT and ±1nT often improves the appearance of features associated with archaeology. Different ranges are applied to data in order to determine the most suitable for anomaly abstraction and display.

Zero Median/Mean Traverse

The median (or mean) of 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 slight differences between the set-up and stability of gradiometer sensors and can remove striping. The process can remove archaeological features that run along a traverse so data analysis is also carried out prior its application.

De-stagger

Compensates for small positional errors within data collection by shifting the position of the readings along each traverse by a specified amount. Data lost at the end of each traverse are extrapolated from adjacent value in the same row.

Deslope

Corrects for striping and distortion caused by metal objects/services etc.. The process calculates a curve based on a polynomial best fit mathematical function for each traverse. This curve is then subtracted from the actual data.

FFT (Fast Fourier Transform) spectral filtering

A mathematical process used to determine the frequency components of a traverse. Repetitive features, such as plough marks, produce characteristic spectral zones that can be suppressed allowing greyscale images to appear clearer.

Appendix C – survey and data information

Area 1 raw magnetometry data

Filename: J274-Area1-raw.xcp
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 05/04/2010
Assembled by: on 05/04/2010
Direction of 1st Traverse: 0 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702
Origin: Zero

Dimensions
Composite Size (readings): 1320 x 60
Survey Size (meters): 330 m x 60 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 2.99
Mean: 0.30
Median: 0.18
Composite Area: 1.98 ha
Surveyed Area: 0.87815 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 12
1 Col:0 Row:1 grids\12.xgd
2 Col:1 Row:1 grids\11.xgd
3 Col:2 Row:1 grids\10.xgd
4 Col:3 Row:1 grids\09.xgd
5 Col:4 Row:1 grids\02.xgd
6 Col:5 Row:1 grids\01.xgd
7 Col:6 Row:1 grids\08.xgd
8 Col:7 Row:1 grids\07.xgd
9 Col:8 Row:1 grids\06.xgd
10 Col:9 Row:1 grids\05.xgd
11 Col:10 Row:0 grids\03.xgd
12 Col:10 Row:1 grids\04.xgd

Area 1 processing

Processes: 4
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Median Traverse: Grids: All
4 Clip from -3.00 to 3.00 nT

Area 2 raw magnetometry data

Filename: J274-Area2-raw.xcp
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 05/04/2010
Assembled by: on 05/04/2010
Direction of 1st Traverse: 0 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702
Origin: Zero

Dimensions
Composite Size (readings): 720 x 150
Survey Size (meters): 180 m x 150 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 4.48
Mean: -0.55
Median: 0.26
Composite Area: 2.7 ha
Surveyed Area: 1.038 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 19
1 Col:0 Row:0 grids\18.xgd
2 Col:0 Row:1 grids\19.xgd
3 Col:1 Row:0 grids\17.xgd
4 Col:1 Row:1 grids\03.xgd
5 Col:1 Row:2 grids\04.xgd
6 Col:2 Row:0 grids\15.xgd
7 Col:2 Row:1 grids\01.xgd
8 Col:2 Row:2 grids\02.xgd
9 Col:2 Row:3 grids\16.xgd
10 Col:3 Row:0 grids\11.xgd
11 Col:3 Row:1 grids\12.xgd
12 Col:3 Row:2 grids\13.xgd
13 Col:3 Row:3 grids\14.xgd
14 Col:4 Row:0 grids\07.xgd
15 Col:4 Row:1 grids\08.xgd
16 Col:4 Row:2 grids\09.xgd
17 Col:4 Row:3 grids\10.xgd
18 Col:5 Row:0 grids\05.xgd
19 Col:5 Row:1 grids\06.xgd

Area 2 processing

Processes: 9
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Median Traverse: Grids: 18.xgd 19.xgd 17.xgd 03.xgd 04.xgd 15.xgd 01.xgd 02.xgd 16.xgd
4 DeStripe Median Sensors: 12.xgd 13.xgd
5 Clip from -3.00 to 3.00 nT
6 DeStripe Median Sensors: 14.xgd
7 DeStripe Median Sensors: 07.xgd
8 DeStripe Mean Traverse: Grids: 11.xgd Threshold: 2 SDs
9 Clip from -3.00 to 3.00 nT

Area 3 raw magnetometry data

Filename: J274-Area3-raw.xcp
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 31/03/2010
Assembled by: on 31/03/2010
Direction of 1st Traverse: 0 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702
Origin: Zero

Dimensions
Composite Size (readings): 480 x 150
Survey Size (meters): 120 m x 150 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 4.39
Mean: -0.24
Median: 0.34
Composite Area: 1.8 ha
Surveyed Area: 0.93485 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 18
1 Col:0 Row:0 grids\15.xgd
2 Col:0 Row:1 grids\16.xgd
3 Col:0 Row:2 grids\17.xgd
4 Col:0 Row:3 grids\18.xgd
5 Col:1 Row:0 grids\12.xgd
6 Col:1 Row:1 grids\03.xgd
7 Col:1 Row:2 grids\04.xgd
8 Col:1 Row:3 grids\13.xgd
9 Col:1 Row:4 grids\14.xgd
10 Col:2 Row:0 grids\09.xgd
11 Col:2 Row:1 grids\01.xgd
12 Col:2 Row:2 grids\02.xgd
13 Col:2 Row:3 grids\10.xgd
14 Col:2 Row:4 grids\11.xgd
15 Col:3 Row:0 grids\05.xgd
16 Col:3 Row:1 grids\06.xgd
17 Col:3 Row:2 grids\07.xgd
18 Col:3 Row:3 grids\08.xgd

Area 3 processing

Processes: 19
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Median Traverse: Grids: 15.xgd 16.xgd 17.xgd 18.xgd 12.xgd 03.xgd 04.xgd 13.xgd 14.xgd
4 DeStripe Median Traverse: Grids: 09.xgd 01.xgd
5 DeStripe Median Traverse: Grids: 05.xgd
6 DeStripe Mean Traverse: Grids: 02.xgd 10.xgd 11.xgd Threshold: 1 SDs
7 DeStripe Mean Traverse: Grids: 06.xgd 07.xgd 08.xgd Threshold: 0.5 SDs
8 Clip from -3.00 to 3.00 nT
9 Edge Match (Area: Top 90, Left 240, Bottom 119, Right 359) to Left edge
10 Edge Match (Area: Top 90, Left 360, Bottom 119, Right 479) to Left edge
11 Edge Match (Area: Top 60, Left 240, Bottom 89, Right 359) to Left edge
12 Edge Match (Area: Top 60, Left 360, Bottom 89, Right 479) to Left edge
13 Edge Match (Area: Top 120, Left 240, Bottom 149, Right 359) to Left edge
14 Edge Match (Area: Top 30, Left 240, Bottom 59, Right 359) to Left edge
15 Edge Match (Area: Top 30, Left 360, Bottom 59, Right 479) to Left edge
16 Edge Match (Area: Top 30, Left 240, Bottom 59, Right 359) to Left edge
17 Edge Match (Area: Top 30, Left 360, Bottom 59, Right 479) to Left edge
18 Edge Match (Area: Top 0, Left 360, Bottom 29, Right 479) to Bottom edge
19 Edge Match (Area: Top 0, Left 360, Bottom 29, Right 479) to Left edge

Area 4 raw magnetometry data

Filename: J274-Area4-raw.xcp
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 31/03/2010
Assembled by: on 31/03/2010
Direction of 1st Traverse: 0 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702
Origin: Zero

Dimensions
Composite Size (readings): 1200 x 180
Survey Size (meters): 300 m x 180 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 3.89
Mean: 0.48
Median: 0.28
Composite Area: 5.4 ha
Surveyed Area: 3.5059 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 53
1 Col:0 Row:0 grids\49.xgd
2 Col:0 Row:1 grids\50.xgd
3 Col:0 Row:2 grids\51.xgd
4 Col:0 Row:3 grids\52.xgd
5 Col:0 Row:4 grids\53.xgd
6 Col:1 Row:0 grids\44.xgd
7 Col:1 Row:1 grids\45.xgd
8 Col:1 Row:2 grids\46.xgd
9 Col:1 Row:3 grids\47.xgd
10 Col:1 Row:4 grids\48.xgd
11 Col:2 Row:0 grids\41.xgd
12 Col:2 Row:1 grids\42.xgd
13 Col:2 Row:2 grids\07.xgd
14 Col:2 Row:3 grids\08.xgd
15 Col:2 Row:4 grids\43.xgd
16 Col:3 Row:0 grids\38.xgd
17 Col:3 Row:1 grids\39.xgd
18 Col:3 Row:2 grids\05.xgd
19 Col:3 Row:3 grids\06.xgd
20 Col:3 Row:4 grids\40.xgd
21 Col:4 Row:0 grids\33.xgd
22 Col:4 Row:1 grids\34.xgd
23 Col:4 Row:2 grids\35.xgd
24 Col:4 Row:3 grids\36.xgd
25 Col:4 Row:4 grids\37.xgd
26 Col:5 Row:0 grids\28.xgd
27 Col:5 Row:1 grids\29.xgd
28 Col:5 Row:2 grids\30.xgd
29 Col:5 Row:3 grids\31.xgd
30 Col:5 Row:4 grids\32.xgd
31 Col:6 Row:0 grids\25.xgd
32 Col:6 Row:1 grids\26.xgd
33 Col:6 Row:2 grids\03.xgd
34 Col:6 Row:3 grids\04.xgd
35 Col:6 Row:4 grids\27.xgd
36 Col:7 Row:0 grids\21.xgd
37 Col:7 Row:1 grids\22.xgd
38 Col:7 Row:2 grids\01.xgd
39 Col:7 Row:3 grids\02.xgd
40 Col:7 Row:4 grids\23.xgd
41 Col:7 Row:5 grids\24.xgd
42 Col:8 Row:0 grids\15.xgd
43 Col:8 Row:1 grids\16.xgd
44 Col:8 Row:2 grids\17.xgd
45 Col:8 Row:3 grids\18.xgd
46 Col:8 Row:4 grids\19.xgd
47 Col:8 Row:5 grids\20.xgd
48 Col:9 Row:0 grids\09.xgd
49 Col:9 Row:1 grids\10.xgd
50 Col:9 Row:2 grids\11.xgd
51 Col:9 Row:3 grids\12.xgd
52 Col:9 Row:4 grids\13.xgd
53 Col:9 Row:5 grids\14.xgd

Area 4 processing

Processes: 6
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Median Traverse: Grids: 41.xgd 42.xgd 07.xgd 08.xgd 43.xgd 38.xgd 39.xgd 05.xgd 06.xgd 40.xgd 33.xgd 34.xgd 35.xgd 36.xgd 37.xgd 28.xgd 29.xgd 30.xgd 31.xgd 32.xgd 25.xgd 26.xgd 03.xgd 04.xgd 27.xgd 21.xgd 22.xgd 01.xgd 02.xgd 23.xgd 24.xgd 15.xgd 16.xgd 17.xgd 18.xgd 19.xgd 20.xgd 09.xgd 10.xgd 11.xgd 12.xgd 13.xgd 14.xgd
4 DeStripe Median Traverse: Grids: 50.xgd 51.xgd 52.xgd 53.xgd 45.xgd 46.xgd 47.xgd 48.xgd
5 DeStripe Mean Traverse: Grids: 49.xgd 44.xgd Threshold: 1 SDs
6 Clip from -3.00 to 3.00 nT

Area 5 raw magnetometry data

Filename: J274-Area5-raw.xcp
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 31/03/2010
Assembled by: on 31/03/2010

Direction of 1st Traverse: 0 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702
Origin: Zero

Dimensions
Composite Size (readings): 480 x 90
Survey Size (meters): 120 m x 90 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 8.89
Mean: -0.40
Median: -0.42
Composite Area: 1.08 ha
Surveyed Area: 0.4003 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 11
1 Col:0 Row:0 grids\10.xgd
2 Col:0 Row:1 grids\11.xgd
3 Col:1 Row:0 grids\07.xgd
4 Col:1 Row:1 grids\08.xgd
5 Col:1 Row:2 grids\09.xgd
6 Col:2 Row:0 grids\04.xgd
7 Col:2 Row:1 grids\05.xgd
8 Col:2 Row:2 grids\06.xgd
9 Col:3 Row:0 grids\01.xgd
10 Col:3 Row:1 grids\02.xgd
11 Col:3 Row:2 grids\03.xgd

Area 5 processing

Processes: 3
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 Clip from -3.00 to 3.00 nT

Area 6 raw magnetometry data

Filename: J274-Area6-raw.xcp

Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 31/03/2010
Assembled by: on 31/03/2010
Direction of 1st Traverse: 0 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702
Origin: Zero

Dimensions
Composite Size (readings): 600 x 90
Survey Size (meters): 150 m x 90 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 7.04
Mean: -1.50
Median: -1.07
Composite Area: 1.35 ha
Surveyed Area: 0.36615 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 9
1 Col:0 Row:0 grids\08.xgd
2 Col:0 Row:1 grids\09.xgd
3 Col:1 Row:0 grids\06.xgd
4 Col:1 Row:1 grids\07.xgd
5 Col:2 Row:1 grids\05.xgd
6 Col:3 Row:1 grids\03.xgd
7 Col:3 Row:2 grids\04.xgd
8 Col:4 Row:1 grids\01.xgd
9 Col:4 Row:2 grids\02.xgd

Area 6 processing

Processes: 4
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Median Sensors: All
4 Clip from -3.00 to 3.00 nT

Appendix D – digital archive

Archaeological Surveys Ltd hold the primary digital archive at Castle Combe, Wiltshire (see inside cover for address). 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. Digital data are also supplied to the client on CD ROM, see below.

Surveys are reported on in hardcopy (recycled paper) using A4 for text and A3 for plots (all plots are scaled for A3). The distribution of both hardcopy report and digital data is considered the responsibility of the Client unless explicitly stated in the survey Brief, Written Scheme of Investigation or other contractual agreement.

This report has been prepared using the following software on a Windows XP platform:

- ArcheoSurveyor version 2.5.3.2 (geophysical data analysis),
- ProgeCAD Professional 2009 (report graphics),
- AutoCAD LT 2007 (report figures),
- OpenOffice.org 3.0.1 Writer (document text),
- PDF Creator version 0.9 (PDF archive).

Digital data are supplied on CD ROM which includes the following files:

- ArcheoSurveyor grid and composite files for all geophysical data,
- CSV files for raw and processed composites,
- geophysical composite file graphics as Bitmap images,
- AutoCAD DWG files in 2000 and 2007 versions,
- report text as OpenOffice.org ODT file,
- report text as Word 2000 doc file,
- report text as rich text format (RTF),
- report text as PDF,
- PDFs of all figures,
- photographic record in JPEG format.

The CD ROM structure is formed from a tree of directories under the title J274 Ashton Vale – CD. Directory titles include Data, Documentation, CAD, PDFs and Photos. Multiple directories exist under Data and hold Grid, Composite and Graphic files with CSV composite data held in Export.

The CAD file contains externally referenced graphics that are rotated with separate A3 size layouts for each figure. Layouts are fixed using frozen layers and named views allowing straightforward plotting or analysis on screen. (Note – CAD files are prepared using AutoCAD's e Transmit function to produce a directory containing the digital drawing along with any externally referenced graphics which may need reloading).