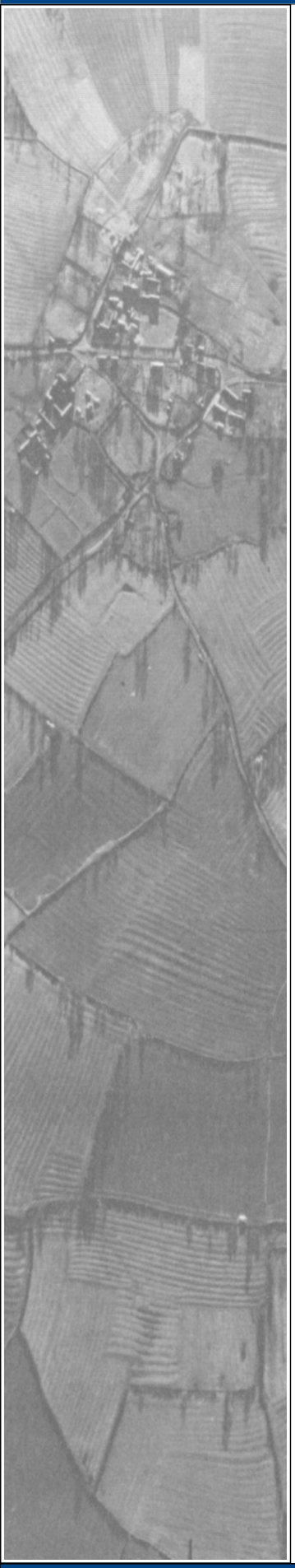


# Parcels H7 & H8
# Land at Millfields
# Cam
# Gloucestershire

## MAGNETOMETER SURVEY REPORT

for

## Cotswold Archaeology

on behalf of

## Bathurst Ltd

Kerry Donaldson & David Sabin

March 2023

Ref. no. J940

ARCHAEOLOGICAL SURVEYS LTD

# Parcels H7 & H8
# Land at Millfields
# Cam
# Gloucestershire

## MAGNETOMETER SURVEY REPORT

for

# Cotswold Archaeology

on behalf of

# Bathurst Ltd

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

Survey dates – 2nd - 7th March 2023
Ordnance Survey Grid Reference – **SO 75190 00545**

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

# CONTENTS

LIST OF FIGURES



LIST OF PLATES



LIST OF TABLES

# SUMMARY

A geophysical survey, comprising detailed magnetometry, was carried out by Archaeological Surveys Ltd within several fields outlined as parcels H7 and H8 within the Millfields development on the eastern edge of Cam in Gloucestershire. The results indicate the presence of a number of positive linear and possible rectilinear anomalies in the north western corner of the site which could relate to cut features; however, they are parallel with ridge and furrow and possibly later cultivation and they therefore may be associated with agricultural activity. A series of parallel linear anomalies appear to extend towards a linear ditch-like feature that extends through three fields, and it is possible that they are associated with land drainage. Other positive linear and discrete responses have been located, but they lack a coherent morphology and cannot be confidently interpreted.


# 1 INTRODUCTION

## *1.1 Survey background*

1.1.1 Archaeological Surveys Ltd was commissioned by Cotswold Archaeology, on behalf of Bathurst Ltd, to undertake a magnetometer survey of an area of land at Cam in Gloucestershire. The site has been outlined for a proposed residential development, identified as land parcels H7 and H8 within the larger Millfields development.

1.1.2 The geophysical survey was carried out in accordance with a Written Scheme of Investigation (WSI) produced by Archaeological Surveys (2023) and approved by Rachel Foster, Gloucestershire County Council Archaeologist and archaeological adviser for Stroud District Council, prior to commencing the fieldwork.

## *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 Archaeological Surveys Ltd is a Registered Organisation with the Chartered Institute for Archaeologists (CIfA) and both company directors are Members of the Chartered Institute for Archaeologists (MCIfA) and have therefore been assessed for their technical competence and ethical suitability and abide by the CIfA Codes of Conduct. The survey and report 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, updated 2020) Standard and Guidance for Archaeological Geophysical Survey.

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 the eastern edge of Cam in Gloucestershire. It is centred on Ordnance Survey National Grid Reference (OS NGR) SO 75190 00545, see Figs 01 and 02.

1.4.2 The geophysical survey covers approximately 12ha within five fields labelled H7a, H7b, H8a, H8b and H8c for the purposes of the report. At the time of survey the H7 land packages contained grass cover with the H8 land packages containing a short arable crop.

1.4.3 The site slopes down towards the River Cam that runs just to the west with the remains of a dismantled railway running along the western boundary and just into the western side of H7b. The eastern side of the site is approximately

55m AODN and the western side 35m AODN.

1.4.4 The ground conditions across the site were generally considered to be favourable for the collection of magnetometry data. Weather conditions during the survey were mainly fine and cold.

*Plate 1: Area H7b looking south towards H8a & H8b*

## *1.5 Site history and archaeological potential*

1.5.1 The survey area lies approximately 1km south of the site of an Iron Age and Romano-British settlement situated to the west of the River Cam (HER No: 48697). Further south of this, previous archaeological investigations have found formerly mapped field boundaries, but little of archaeological significance. Field H8a contains now levelled ridge and furrow identified during the Severn Vale NMP project from historic aerial photographs. Within the wider landscape, features include widespread ridge and furrow, boundaries and holloways (HER No: 51633). The western edge of the site is bounded by the dismantled Dursley branch of the Midland Railway and 19th and 20th century mapping shows the layout of the fields much the same as today.

1.5.2 Although the site does not contain any designated or undesignated heritage assets, it has not been subject to previous archaeological investigation. There is always potential for the survey to locate previously unrecorded archaeological features, should they be present within the site.

## *1.6 Geology and soils*

1.6.1 The underlying solid geology across the site is from the Blue Lias Formation

and Charmouth Mudstone Formation; superficial deposits are present in the form of a narrow band of alluvium running along the western sides of H7b and H8b (BGS, 2022).

1.6.2 The overlying soil across the majority of the survey area is from the Martock association and is a typical stagnogley soil. It consists of a slowly permeable, seasonally waterlogged, stoneless, silty over clayey soil. The eastern edge of the site is underlain by the Curtisden association which is a stagnogleyic argillic brown earth and consists of a silty soil over siltstone with slowly permeable subsoils and slight seasonal waterlogging (Soil Survey of England and Wales, 1983).

1.6.3 Magnetometry survey carried out across similar soils has produced good results. 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 magnetic 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 positive magnetic anomalies that can be mapped by magnetic prospection. In addition, where soil is displaced by material of comparatively low magnetic susceptibility, such as many types of sedimentary rock, anomalies of negative value may occur which could be indicative of structural remains.

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 pushed at walking speed and not towed. 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 recorded range of ±3000nT, and resolution is approximately 0.1nT. They are linked to a Leica GS10 RTK GNSS with data recorded by SENSYS MonMX software on a rugged notebook 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 ±3000nT and clipped for display at ±3nT. 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. 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 2021, creating DWG (2018) 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.

### *2.4 Supplementary measurement of magnetic susceptibility*

2.4.1 Magnetic susceptibility is an important factor in the formation of magnetic anomalies located by a magnetometry survey, see 2.1. Accurate measurement of the magnetic susceptibility of soil, subsoil and underlying geology may enhance the results of the magnetometry survey by providing an assessment of magnetic contrast within a site. Where sampling of topsoil only is possible, measurement may assist in understanding whether the soil is likely to be associated with strong, moderate or weak anomalies, which may be a result of low levels of iron minerals, waterlogging, etc. Accurate measurement may also assist in determining industrial activity and the presence of layers or features not visually or texturally apparent on excavation.

2.4.2 Supplementary measurement of soil magnetic susceptibility is not considered part of the main objective of the survey and is discussed in section 3.2 below as a factor influencing the formation of anomalies.

2.4.3 Measurements are achieved using a Bartington MS2 Magnetic Susceptibility Meter with MS2B sensor. Small soil samples are measured in 10 cubic centimetre plastic pots after accurately weighing, generally each sample is subdivided and at least 3 separate measurements are made in order to provide a mean value, or assess variability due to ferrous contamination and other factors. Measurement can be made at low or high frequency, generally low frequency measurements are made but occasionally high frequency measurements are also recorded as the frequency dependence of a soil may be informative.

2.4.4 The measurements are converted to mass specific readings using SI units for bulk density. Archaeological Surveys express the measurements as $X_{lf}$ or $X_{hf}$ for low frequency or high frequency magnetic susceptibility respectively with units of $10^{-8}m^3kg^{-1.}$

# 3 RESULTS

## *3.1 General assessment of survey results*

3.1.1 The detailed magnetic survey was carried out over a total of five survey areas covering approximately 12.5ha.

3.1.2 Magnetic anomalies located can be generally classified as positive anomalies of an uncertain origin, linear anomalies of an agricultural origin, anomalies with a natural 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.

3.1.3 Anomalies located within each survey area have been numbered and are described in 3.4 and 3.5 below.

## *3.2 Data quality and factors affecting the interpretation or formation 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.

3.2.2 The site does not appear to contain widespread magnetic debris or disturbance, although a linear zone of strong magnetic debris along the western side of H7b, and near the north western corner of H8b, relates to the removed Dursley branch of the Midland Railway. The high magnitude magnetic response caused by the debris has the potential to obscure weak features should they occur within this part of the site.

3.2.3 In order to provide further understanding of the magnetic characteristics of the soil, a single topsoil sample was taken from the lower part of H7b but to the east of the course of the removed railway, and its mass specific magnetic susceptibility was measured (see 2.4). The sample produced an average low frequency mass specific magnetic susceptibility ($X_{lf}$) of 12 $10^{-8}m^3kg^{-1}$ and is consistent with low values generally obtained from clayey soil and/or alluvial deposits uncontaminated by ferrous material. However, it should be considered that a single sample may not be representative. Positive linear anomalies present within the magnetometry data are generally weak, possibly as a consequence of generally low magnetic susceptibility; however, linear anomalies relating to former ridge and furrow and naturally formed features were located and attest to the potential for useful magnetic contrast across the site.

## *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 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*** | 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. 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. |

Table 1: List and description of interpretation categories

## *3.4 List of anomalies - H7*

H7a centred on OS NGR 375220 200697, H7b centred on OS NGR 375060 200677 see Figs 06 – 08.

*Anomalies with an uncertain origin*

(1-3) – Several positive linear and possible rectilinear anomalies can be seen in H7b. While some are oriented east to west (1), several are parallel with the ridge and furrow (2) and it is not clear if it is material that has been disturbed or preserved by the former cultivation. Others are parallel with the eastern and western field boundaries (3), although they appear to have been truncated by the ridge and furrow. The anomalies are generally weak and poorly defined, but it is possible that they relate to cut, ditch-like features.

(4) – Two weakly positive linear anomalies have been located at the western edge of H7a. It is possible that they have some association with anomalies (1-3).

(5) – A small number of discrete, pit-like anomalies have been located within H7a. It is not possible to determine if they relate to natural or anthropogenic features.

*Anomalies associated with land management*

(6) – An L-shaped feature towards the north western corner of H7a appears to be a response to land drains.

*Anomalies with an agricultural origin*

(7) – Evidence for former ridge and furrow can be seen in H7b.

(8) – A series of parallel linear anomalies, oriented north east to south west relate to agricultural activity, possibly ridge and furrow in H7a

*Anomalies associated with magnetic debris*

(9) – A patch of magnetic debris in the central, western part of H7a relates to material within an infilled pond.

(10) – Strongly magnetic debris along the western edge of H7b relates to material associated with the dismantled Dursley branch line.

(11) – The site contains numerous and widespread strong, discrete, dipolar anomalies which relate to ferrous and other magnetically thermoremnant objects, such as brick and tile, within the topsoil.

*Anomalies with a modern origin*

(12) – A strong, multiple dipolar, linear anomaly extends around the north western corner of H7a and along the northern edge of H7b and is a response to a buried service/pipe.

## *3.5 List of anomalies - H8*

H8a centred on OS NGR 375260 200516, H8b centred on OS NGR 375115 200538, H8c centred on OS NGR 375195 200383, see Figs 06 – 11.

*Anomalies with an uncertain origin*

(13) – A U-shaped curvilinear anomaly can be seen in the northern part of H8b. The origin of the anomaly is uncertain, but it could be associated with anomalies (1-3) to the north.

(14) – A number of short, positive linear anomalies have been located within H8a & H8b, with a concentration at the northern end. They do not have a coherent

morphology and cannot be confidently interpreted.

(15) – A number of discrete, pit-like anomalies have been identified, with several in the northern part of H8a. It is not possible to determine if they are natural or anthropogenic features.

(16) – A positive linear anomaly is located in the southern part of H8a. It appears to have been truncated by anomaly (18) and although it may relate to a linear, ditch-like feature, its date and function are uncertain.

(17) – A number of positive linear anomalies can be seen in the southern part of H8a, but their origin is uncertain.

(18 & 19) – A positive linear anomaly (18) extends from H8a, into the north eastern corner of H8c and into H8b where it then appears to split to form a Y-shaped feature. A number of parallel linear anomalies appears to extend towards it from the north east within H8a (19). The arrangement is indicative of land drains; however, the layout has no bearing on the current field boundaries, which have been mapped since the 1840s.

*Anomalies with an agricultural origin*

(20) – Linear anomalies, oriented north east to south west relate to former ridge and furrow.

(21) – Anomalies oriented north west to south east relate to more modern cultivation.

*Anomalies with a natural origin*

(23) – A number of sinuous responses extend from the south eastern corner of H8a, westwards into H8c. They relate to naturally formed features within a shallow natural depression.

# 4 CONCLUSION

4.1.1 The geophysical survey located a number of positive linear and possible rectilinear anomalies within the north western part of the site. Although they may relate to cut features, several are parallel with ridge and furrow and possible more modern agricultural activity and their origin is uncertain. Further south are a number of linear anomalies that could relate to land drainage, but which extend across three fields without regard to the existing land boundaries. A number of other linear and discrete anomalies have also been located, but it is not possible to determine if they relate to cut features with archaeological potential.

# 5 REFERENCES

Archaeological Surveys, 2023. *Parcels H7 & H8, Land at Millfields, Cam, Gloucestershire,Geophysical Survey Written Scheme of Investigation.* Unpublished typescript document.

Aspinall, A., Gaffney, C. and Schmidt, A. 2009. *Magnetometry for Archaeologists*. Lanham (US), AltaMira Press.

British Geological Survey, 2022. *Geology Viewer, [online]* available from https://geologyviewer.bgs.ac.uk [accessed 17/2/2023].

Chartered Institute for Archaeologists, 2014 (updated 2020). *Standard and Guidance for archaeological geophysical survey*. CIfA, University of Reading.

European Archaeological Council, 2015. *EAC Guidelines for the Use of Geophysics in Archaeology: Questions to Ask and Points to Consider.* Europae Archaeologia Consilium and Association Internationale sans But Lucratif, Belgium.

Historic England, 2018. Geophysical Survey Advice [online] available from https://historicengland.org.uk/advice/technical-advice/archaeological-science/geophysics/ [accessed July 2018].

Institute for Archaeologists, 2002. *The use of Geophysical Techniques in Archaeological Evaluations*. IfA Paper No. 6. IfA, University of Reading.

Schmidt, A., 2013. *Geophysical Data in Archaeology: A Guide to Good Practice.* Oxbow Books.

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 5 South West England.*

Paul, S. (ed), 2018. *Gloucestershire Archaeological Archive Standards. A Countywide Standard for the Creation, Compilation and Transfer of Archaeological Archives in Gloucestershire.* Version 1b. South West Museum Development Programme.

# 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.

*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.

*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

H7a minimally processed data
Filename: J940-mag-AreaH7a-proc.xcp
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):OSGB36
Northwest corner: 375094.35, 200808.35 m
Southeast corner: 375347.40, 200603.90 m
Collection Method: Randomised
Sensors: 5
Dummy Value: 32702
Dimensions
Survey Size (meters): 253 m x 204 m
X&Y Interval: 0.15 m
Source GPS Points: Active: 914775, Recorded: 914780
Stats
Max: 3.32
Min: -3.30
Std Dev: 0.80
Mean: 0.00
Median: 0.01
Composite Area: 5.1736 ha
Surveyed Area: 3.5429 ha
PROGRAM
Name: TerraSurveyor
Version: 3.0.37.0
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (UTM to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

H7a filtered data
Filename: J940-mag-AreaH7a-proc-hpf.xcp
Stats
Max: 3.32
Min: -3.30
Std Dev: 1.33
Mean: -0.08
Median: 0.02
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (UTM to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

H7b minimally processed data
Filename: J940-mag-AreaH7b-proc.xcp
Northwest corner: 375011.43, 200739.28 m
Southeast corner: 375117.03, 200605.78 m
Dimensions
Survey Size (meters): 106 m x 134 m
X&Y Interval: 0.15 m
Source GPS Points: Active: 243983, Recorded: 243988
Stats
Max: 3.32
Min: -3.30
Std Dev: 1.22
Mean: -0.08
Median: -0.02
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (UTM to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

H7b filtered data
Filename: J940-mag-AreaH7b-proc-hpf.xcp
Stats
Max: 3.32
Min: -3.30
Std Dev: 0.77
Mean: 0.00
Median: 0.00
GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (UTM to OSGB36).
3 DeStripe Median Traverse:
4 High pass Uniform (median) filter: Window dia: 203
5 Clip from -3.00 to 3.00 nT

H8a minimally processed data
Filename: J940-mag-AreaH8a-proc.xcp
Northwest corner: 375135.23, 200628.23 m
Southeast corner: 375398.78, 200336.48 m
Dimensions
Survey Size (meters): 264 m x 292 m
X&Y Interval: 0.15 m
Source GPS Points: Active: 1313336, Recorded: 1313341
Stats
Max: 3.32
Min: -3.30
Std Dev: 0.92
Mean: 0.01
Median: -0.01
Composite Area: 7.6891 ha
Surveyed Area: 4.0221 ha
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (UTM to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

H8a filtered data
Stats
Max: 3.32
Min: -3.30
Std Dev: 0.86
Mean: 0.01
Median: 0.00
GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (UTM to OSGB36).
3 DeStripe Median Traverse:
4 High pass Uniform (median) filter: Window dia: 300
5 Clip from -3.00 to 3.00 nT

H8b minimally processed data

Filename: J940-mag-AreaH8b-proc.xcp
Northwest corner: 375044.81, 200642.31 m
Southeast corner: 375190.61, 200430.51 m
Dimensions
Survey Size (meters): 146 m x 212 m
X&Y Interval: 0.15 m
Source GPS Points: Active: 528169, Recorded: 528174
Stats
Max: 3.32
Min: -3.30
Std Dev: 0.96
Mean: 0.01
Median: 0.00
Composite Area: 3.088 ha
Surveyed Area: 1.6685 ha
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (UTM to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

H8b filtered data
Filename: J940-mag-AreaH8b-proc-hpf.xcp
Stats
Max: 3.32
Min: -3.30
Std Dev: 0.87
Mean: 0.01
Median: 0.00
GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (UTM to OSGB36).
3 DeStripe Median Traverse:
4 High pass Uniform (median) filter: Window dia: 300
5 Clip from -3.00 to 3.00 nT

H8c minimally processed data
Filename: J940-mag-AreaH8c-proc.xcp
Northwest corner: 375116.45, 200489.55 m
Southeast corner: 375270.95, 200276.70 m
Dimensions
Survey Size (meters): 155 m x 213 m
X&Y Interval: 0.15 m
Source GPS Points: Active: 650304, Recorded: 650309
Stats
Max: 3.32
Min: -3.30
Std Dev: 0.92
Mean: 0.02
Median: -0.01
Composite Area: 3.2885 ha
Surveyed Area: 1.6376 ha
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (UTM to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

H8c filtered data
Filename: J940-mag-AreaH8c-proc-hpf.xcp
Stats
Max: 3.32
Min: -3.30
Std Dev: 0.78
Mean: 0.01
Median: 0.00
GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (UTM 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 copy of the report in PDF/A format will be supplied to the Gloucestershire Historic Environment Record, together with a DXF of the survey boundary. In order to comply with the Gloucestershire Archaeological Archive Standards (Paul, 2018) the data will be archived with the Archaeology Data Service (ADS) and the

report uploaded to Online AccesS to the Index of archaeological investigationS (OASIS) in the formats stated below for archiving:

Archive contents:

| File type | Naming scheme | Description |
|---|---|---|
| Data | J940-mag-**[area number/name]**.asc<br>J940-mag-**[area number/name]**.xcp<br>J940-mag-**[area number/name]**-proc.xcp | Raw data as ASCII CSV<br>TerraSurveyor raw data<br>TerraSurveyor minimally processed data |
| Graphics | J940-mag-**[area number/name]**-proc.tif | Image in TIF format |
| Drawing | J940-**[version number]**.dwg | CAD file in 2018 dwg format |
| Report | J940 report.odt | Report text in LibreOffice 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 POS DISCRETE UNCERTAIN | | 255,127,0 | Solid donut, point or polygon (solid) |
| AS-ABST MAG POS UNCERTAIN | | 255,127,0 | Polygon (cross hatched ANSI37) |
| ***Anomalies relating to land management*** | | | |
| 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 | | 204,178,102 | Polygon (cross hatched ANSI37) |

Table 3: CAD layering

# Appendix F – copyright and intellectual property

This report may contain material that is non-Archaeological Surveys Ltd copyright (eg Ordnance Survey, Crown Copyright) or the intellectual property of third parties, which we are able to provide for limited reproduction under the terms of our own copyright licences, but for which copyright itself is non-transferable by Archaeological Surveys Ltd. Users remain bound by the conditions of the Copyright, Design and Patents Act 1988 with regard to multiple copying and electronic dissemination of this report.

Archaeological Surveys Ltd shall retain intellectual property rights for the materials and records created as part of this project. A non-exclusive and royalty-free licence shall be granted to the client on full payment of works in order for them to use, reproduce and enhance the reports, documentation, graphics and illustrations produced as part of this project for the purpose for which they were commissioned.

A non-exclusive licence will also be granted to the local authority for planning use and within the Historic Environment Record for public dissemination upon payment by the client.

Please note that a non-exclusive licence does not transfer full copyright which remains with Archaeological Surveys Ltd. A non-exclusive licence also does not allow the licensee to pass on usage rights to third parties.

Any document produced to meet planning requirements may be freely copied for planning, development control, research and outreach purposes without recourse to the originator, subject to all due and appropriate acknowledgements being provided and to the terms of the original contract with the client. Archaeological Surveys Ltd shall retain the right to be identified as the author and originator of the material.

The report, data and any associated material produced by Archaeological Surveys Ltd cannot be freely used for any commercial activity other than those set out above. Any unauthorised use will be considered to be in breach of copyright including the use of graphic items by third parties unless an additional non-exclusive licence has been granted by Archaeological Surveys Ltd.

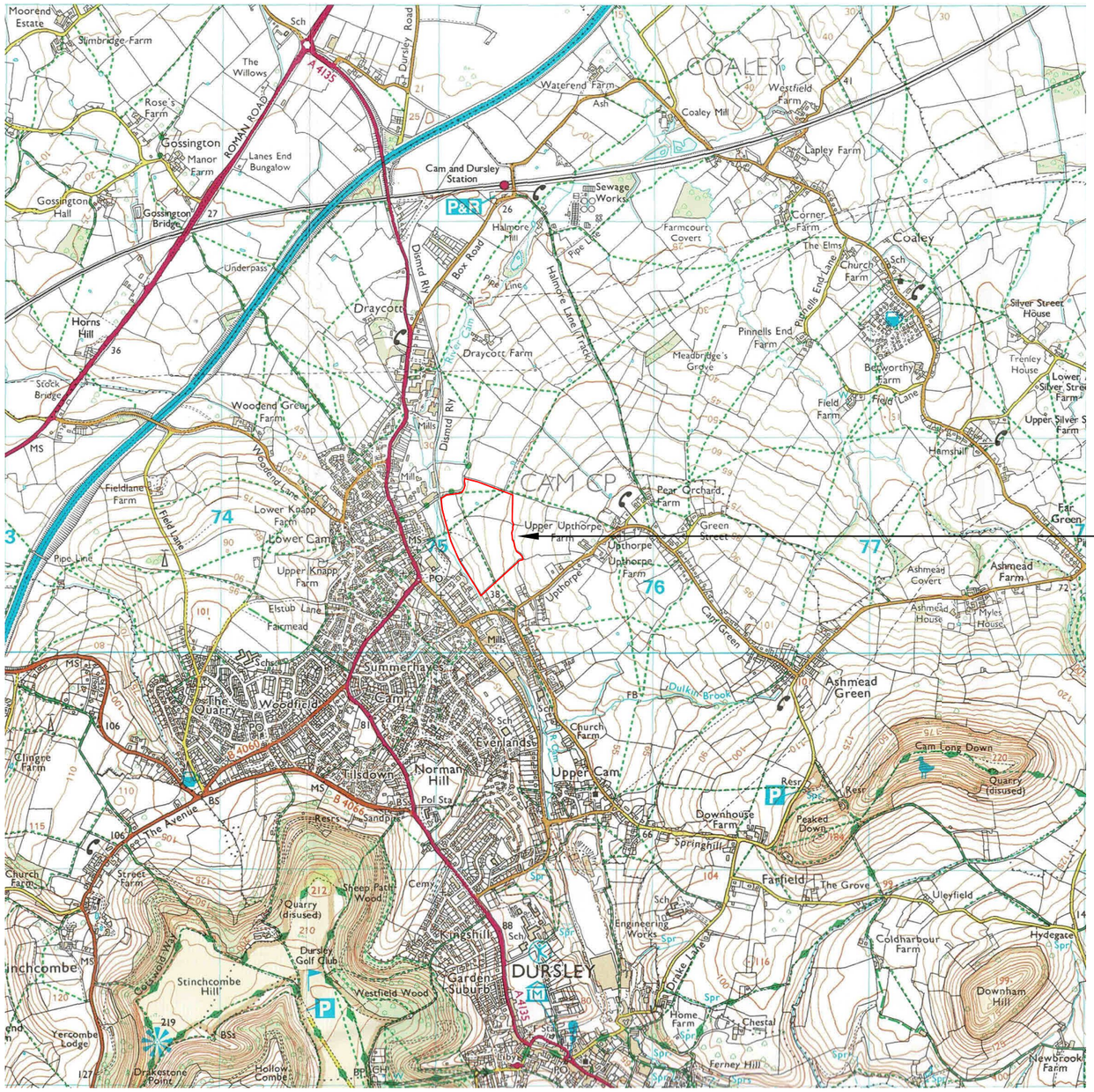
Title of Goods remains with Archaeological Surveys Ltd until payment has cleared. Late payment may jeopardise any planning decision as there will be no transfer of title, licensing or any other right of copy or use of this report. Archaeological Surveys Ltd do not give permission for use of the report and associated data in cases of late payment. Any such use will be considered to be in breach of copyright. Late payment may also incur interest at 8% over the Bank of England base rate. Non-payment will be pursued by legal action.

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

Archaeological Surveys
Specialist Geophysical Surveyors

# Geophysical Survey
# Parcels H7 & H8
# Land at Millfields
# Cam
# Gloucestershire

## Map of survey area





● Survey location

Site centred on OS NGR
SO 75210 00545

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

| DRAWN BY | CHECKED BY | |
|---|---|---|
| KTD | DJS | FIG 01 |

Archaeological Surveys
Specialist Geophysical Surveyors

# Geophysical Survey
# Parcels H7 & H8
# Land at Millfields
# Cam
# Gloucestershire

## Referencing information

Referencing grid to OSGB36 datum at 100m intervals

375200 200500

Survey tracks

Survey track start

Survey track stop

SCALE 1:2000

0m 20 40 60 80 100m

SCALE TRUE AT A3

| DRAWN BY | CHECKED BY | |
|---|---|---|
| KTD | DJS | FIG 02 |

Archaeological Surveys
Specialist Geophysical Surveyors

# Geophysical Survey
# Parcels H7 & H8
# Land at Millfields
# Cam
# Gloucestershire

**Greyscale plot of minimally processed magnetometer data**

+3nT

-3nT

H7a

H7b

H8a

H8b

H8c

Path

Lower Cam

Courthouse Farm

PW

Hall

River Cam

HIGH ST

CHAPEL STREET

N

SCALE 1:2000

0m 20 40 60 80 100m

SCALE TRUE AT A3

| DRAWN BY | CHECKED BY | |
|---|---|---|
| KTD | DJS | FIG 03 |

Archaeological Surveys
Specialist Geophysical Surveyors

# Geophysical Survey
# Parcels H7 & H8
# Land at Millfields
# Cam
# Gloucestershire

**Greyscale plot of filtered magnetometer data**

+3nT

-3nT

Lower Cam

Courthouse Farm

H7a

H7b

Path

N

H8a

H8b

H8c

River Cam

PW

Hall

CHAPEL STILE



SCALE 1:2000

0m 20 40 60 80 100m

SCALE TRUE AT A3

| DRAWN BY | CHECKED BY | |
|---|---|---|
| KTD | DJS | FIG 04 |

Archaeological Surveys
Specialist Geophysical Surveyors

# Geophysical Survey
# Parcels H7 & H8
# Land at Millfields
# Cam
# Gloucestershire

## Abstraction and interpretation of magnetic anomalies

H7a
H7b
H8a
H8b
H8c
Path
Lower Cam
Courthouse Farm
PW
Hall
River Cam
CHAPEL STILE
RICHS
N

- Positive linear anomaly - possible ditch-like feature
- Positive/weak multiple dipolar linear anomaly - possible land drain
- Linear anomaly - ridge and furrow
- Linear anomaly - of agricultural origin
- Discrete positive response - possible pit-like feature
- Positive anomaly - magnetically enhanced material
- Variable magnetic response - of natural origin
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong multiple dipolar linear anomaly - pipeline / cable / service
- Strong dipolar anomaly - ferrous object

SCALE 1:2000

0m 20 40 60 80 100m

SCALE TRUE AT A3

| DRAWN BY | CHECKED BY | |
|---|---|---|
| KTD | DJS | FIG 05 |

Archaeological Surveys
Specialist Geophysical Surveyors

# Geophysical Survey
# Parcels H7 & H8
# Land at Millfields
# Cam
# Gloucestershire

## Greyscale plot of minimally processed magnetometer data - H7 & H8 north

H7a

H7b

Path

N

+3nT

-3nT

-3nT H7a +3nT

-3nT H7b +3nT

SCALE 1:1000

0m 10 20 30 40 50m

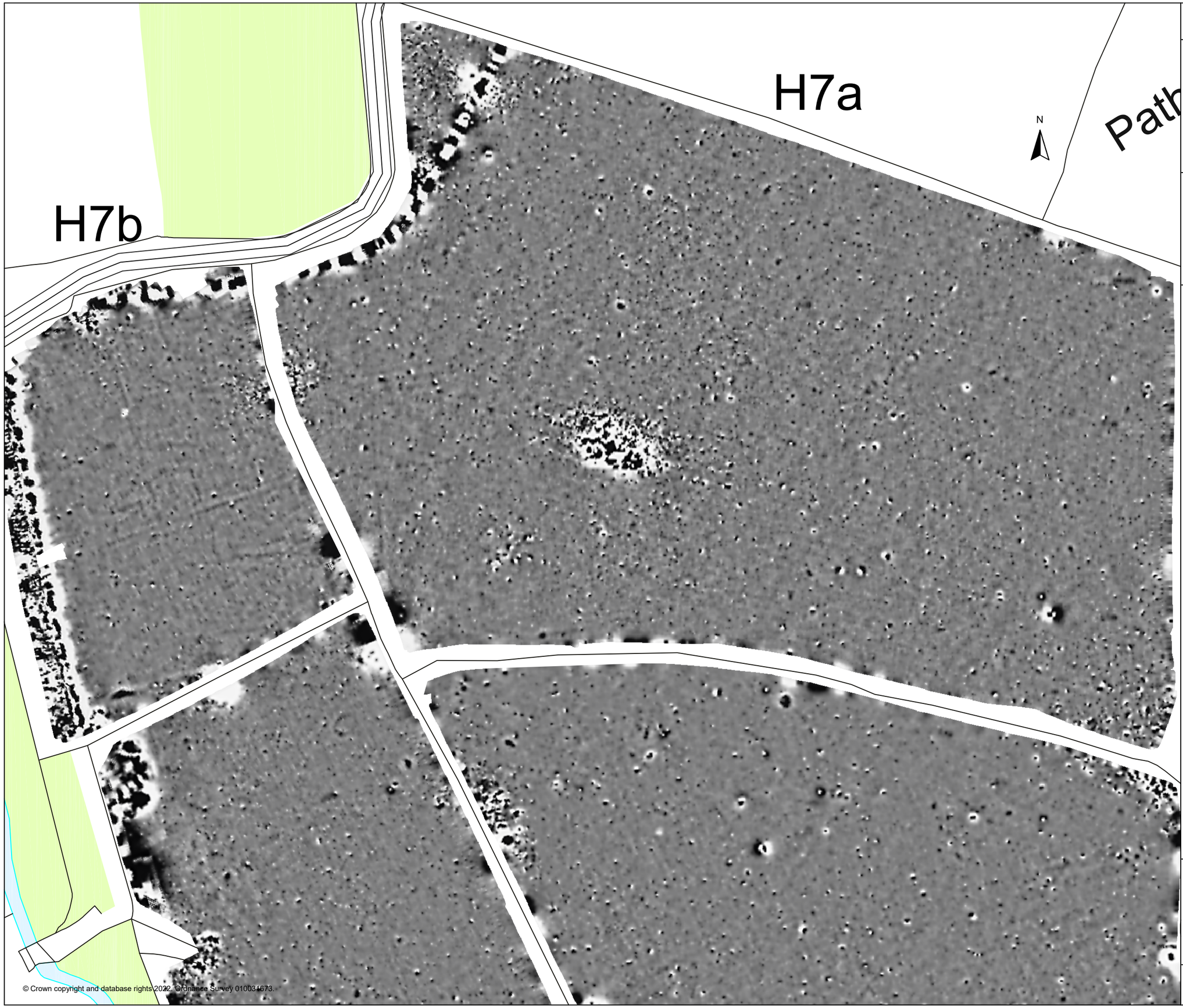
SCALE TRUE AT A3

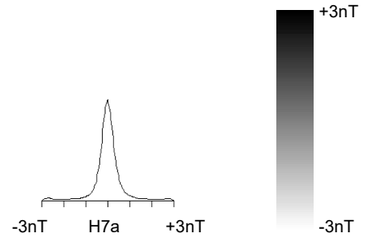
| DRAWN BY | CHECKED BY | |
|---|---|---|
| KTD | DJS | FIG 06 |

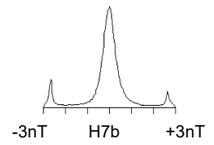
Archaeological Surveys
Specialist Geophysical Surveyors

# Geophysical Survey
# Parcels H7 & H8
# Land at Millfields
# Cam
# Gloucestershire

## Greyscale plot of filtered magnetometer data - H7 & H8 north



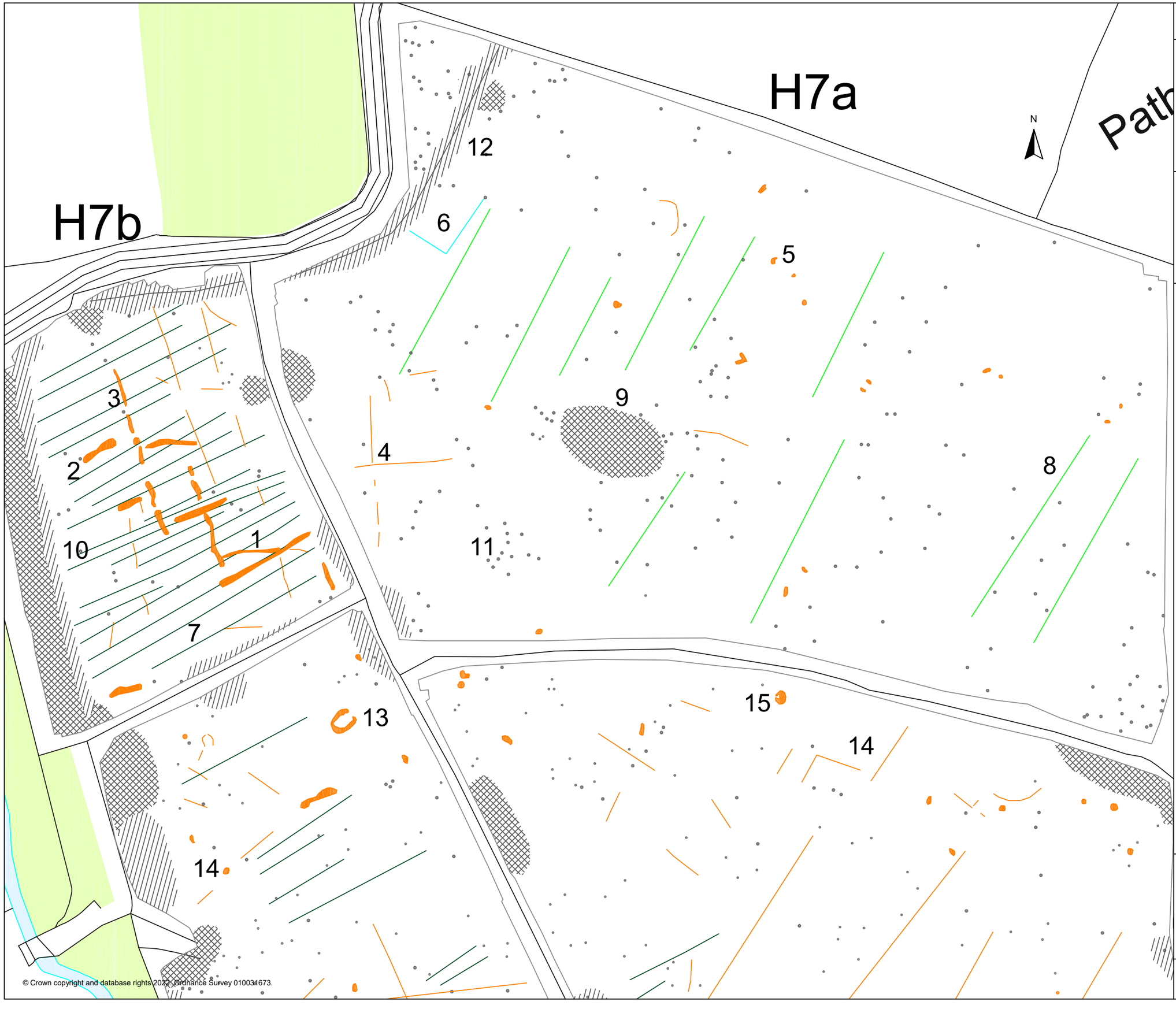




SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

| DRAWN BY | CHECKED BY | |
|---|---|---|
| KTD | DJS | FIG 07 |




Archaeological Surveys
Specialist Geophysical Surveyors

**Geophysical Survey**
**Parcels H7 & H8**
**Land at Millfields**
**Cam**
**Gloucestershire**

**Abstraction and interpretation of magnetic anomalies - H7 & H8 north**

- Positive linear anomaly - possible ditch-like feature
- Positive/weak multiple dipolar linear anomaly - possible land drain
- Linear anomaly - ridge and furrow
- Linear anomaly - of agricultural origin
- Discrete positive response - possible pit-like feature
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong multiple dipolar linear anomaly - pipeline / cable / service
- Strong dipolar anomaly - ferrous object

SCALE 1:1000

0m 10 20 30 40 50m

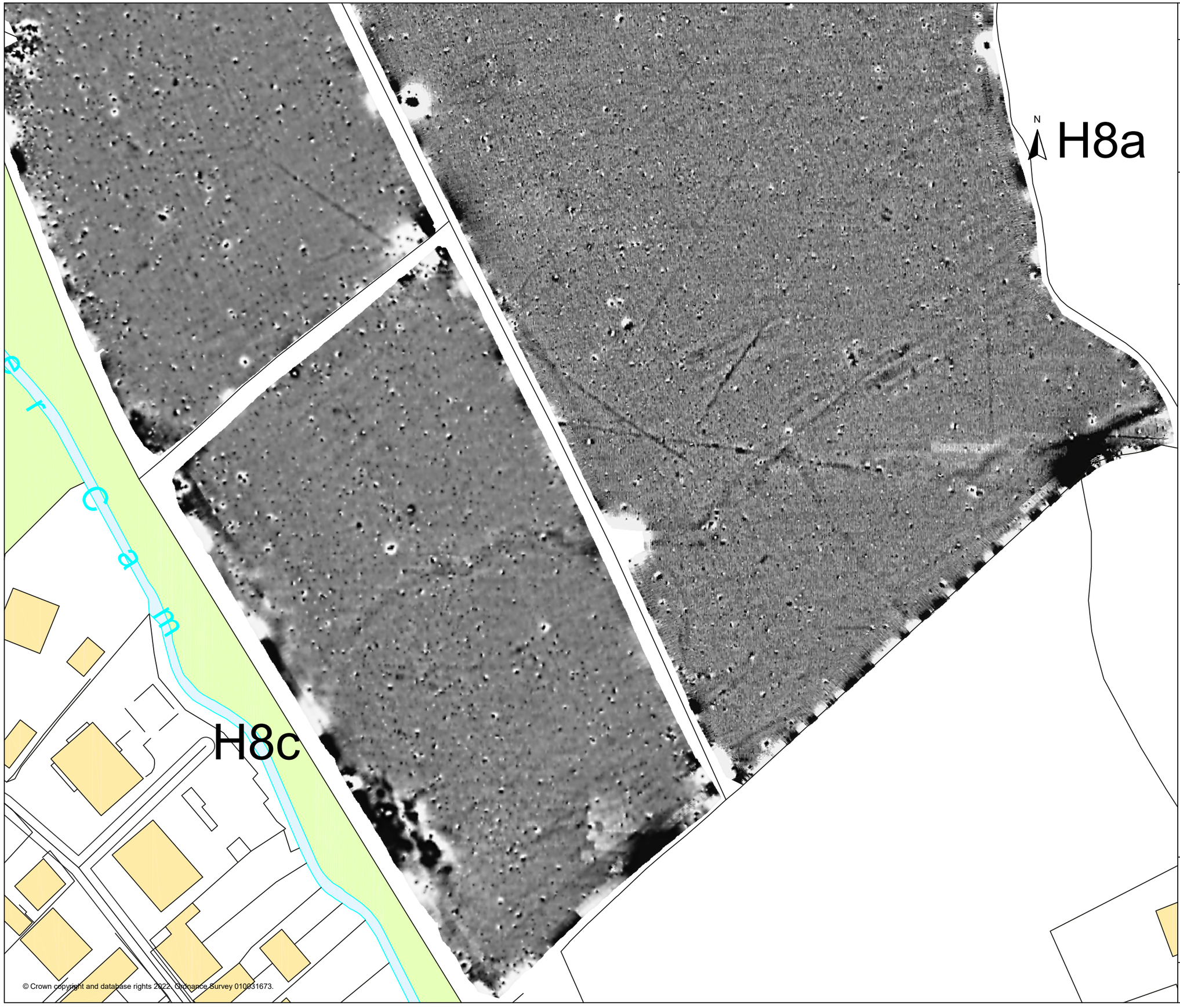
SCALE TRUE AT A3

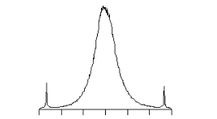
| DRAWN BY | CHECKED BY | |
|---|---|---|
| KTD | DJS | FIG 08 |

Archaeological Surveys
Specialist Geophysical Surveyors

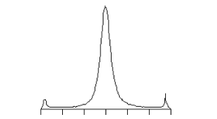
# Geophysical Survey
# Parcels H7 & H8
# Land at Millfields
# Cam
# Gloucestershire

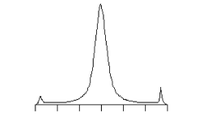
**Greyscale plot of minimally processed magnetometer data - H8 south**










SCALE 1:1000

0m 10 20 30 40 50m

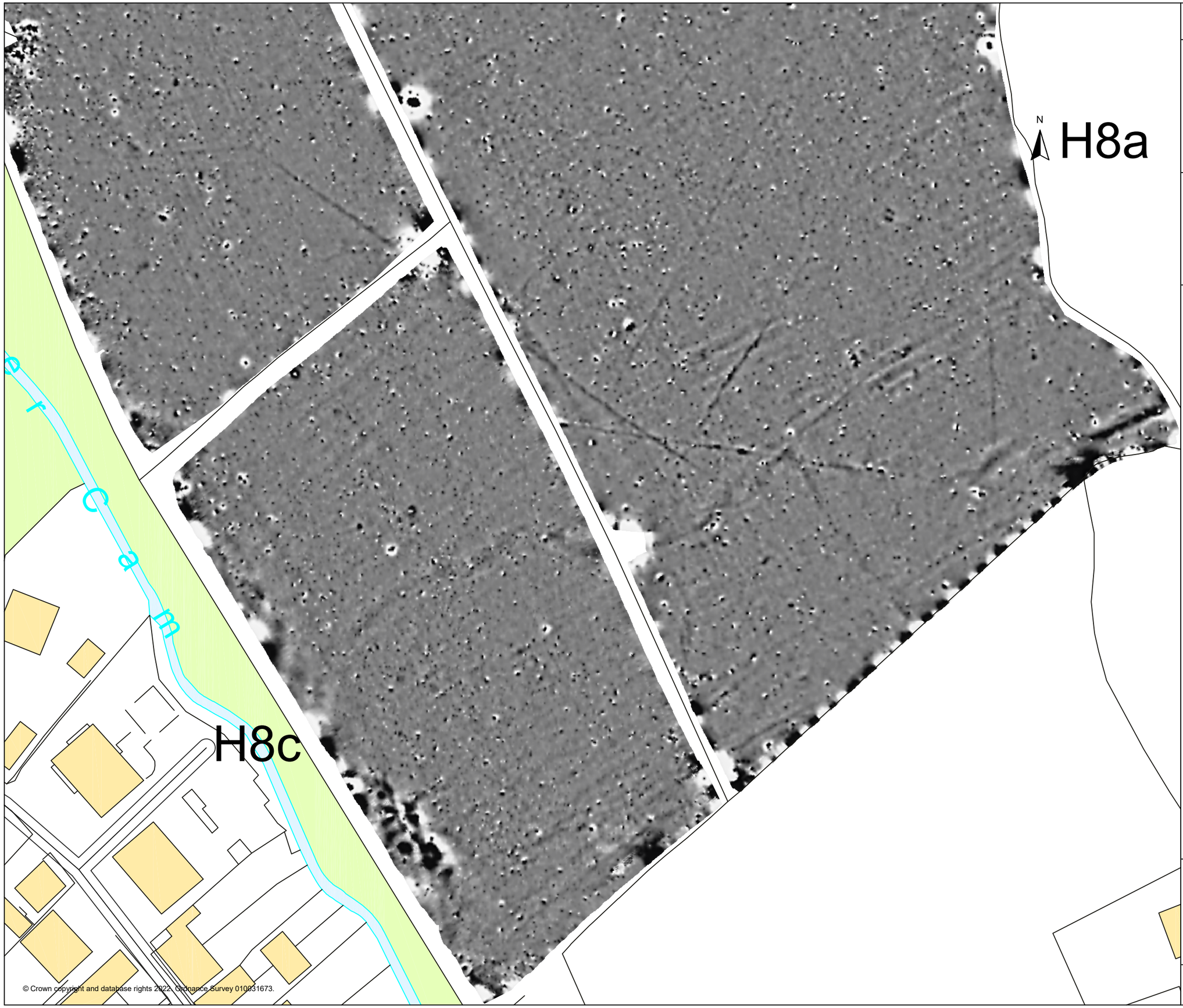
SCALE TRUE AT A3

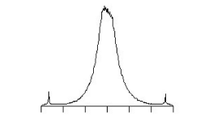
| DRAWN BY | CHECKED BY | |
|---|---|---|
| KTD | DJS | FIG 09 |

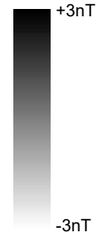
Archaeological Surveys
Specialist Geophysical Surveyors

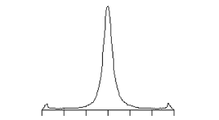
# Geophysical Survey
# Parcels H7 & H8
# Land at Millfields
# Cam
# Gloucestershire

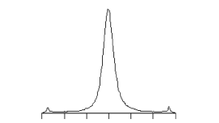
## Greyscale plot of filtered magnetometer data - H8 south




SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

| DRAWN BY | CHECKED BY | |
|---|---|---|
| KTD | DJS | FIG 10 |

Archaeological Surveys
Specialist Geophysical Surveyors

# Geophysical Survey
# Parcels H7 & H8
# Land at Millfields
# Cam
# Gloucestershire

## Abstraction and interpretation of magnetic anomalies - H8 south

N

H8a

H8c

18

19

18

16

20

21

23

17

- Positive linear anomaly - possible ditch-like feature
- Linear anomaly - ridge and furrow
- Linear anomaly - of agricultural origin
- Discrete positive response - possible pit-like feature
- Positive anomaly - magnetically enhanced material
- Variable magnetic response - of natural origin
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong multiple dipolar linear anomaly - pipeline / cable / service
- Strong dipolar anomaly - ferrous object

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

| DRAWN BY | CHECKED BY | |
|---|---|---|
| KTD | DJS | FIG 11 |