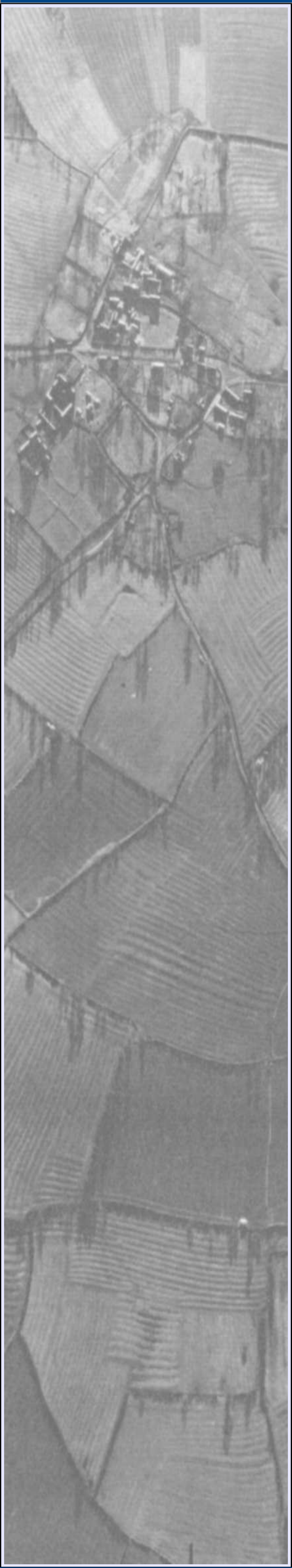
Archaeological Surveys Ltd
Specialist Geophysical Surveyors



Lower Ham Farm
Broad Town
Wiltshire

EARTH RESISTANCE & MAGNETOMETER SURVEY REPORT

for

Christina Wiederkehr

Kerry Donaldson & David Sabin

September 2020

Ref. no. J830

ARCHAEOLOGICAL SURVEYS LTD

Lower Ham Farm
Broad Town
Wiltshire

Earth Resistance & Magnetometer Survey Report

for

Christina Wiederkehr

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

Survey date – 11th September 2020
Ordnance Survey Grid Reference – **SU 07645 79853**

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

Archaeological Surveys Ltd is a company registered in England and Wales under registration number 6090102, Vat Reg no. 850 4641 37.
Registered office address, Unit 1 Gate Farm, Sutton Benger, Chippenham, SN15 4RE.
It is a Registered Organisation with the Chartered Institute for Archaeologists.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

SUMMARY

A geophysical survey, comprising both resistivity and magnetometry, was carried out by Archaeological Surveys Ltd at Lower Ham Farm, near Broad Town in Wiltshire, ahead of an indoor horse arena development. The results of the resistivity show a small number of relatively high resistance anomalies, some of which could relate to ground compaction, but they generally lack a coherent morphology. Detailed magnetometry was also carried out and a small number of weakly positive linear and negative linear anomalies were located. They do not generally correspond to any resistance anomalies and lack a coherent morphology preventing confident interpretation as cut features. Both data sets had anomalies associated with the extant ridge and furrow.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Agrarian Ltd, on behalf of Christina Wiederkehr, to undertake an earth resistance (resistivity) and magnetometer survey of an area of land at Lower Ham Farm, Broad Town, near Royal Wootton Bassett in Wiltshire. The site has been outlined for the proposed development of an indoor horse arena (Wiltshire Council planning application number 20/05772/FUL) and the survey forms part of an archaeological assessment.

1.1.2 The geophysical survey was carried out in accordance with a Written Scheme of Investigation (WSI) produced by Archaeological Surveys (2020) and approved by Michal Cepak, Assistant County Archaeologist for Wiltshire Council, prior to commencing the survey.

1.2 Survey objectives and techniques

1.2.1 The objective of the survey was to use earth resistance survey (resistivity) and magnetometry (gradiometry) 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 with the two techniques used to provide a complimentary dataset over the c0.26ha site.

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

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

1.3.1 The survey and report follow the recommendations set out by: European Archaeological Council (2015) *Guidelines for the Use of Geophysics in Archaeology;* Institute for Archaeologists (2002) *The use of Geophysical Techniques in Archaeological Evaluations.* The work has been carried out to the Chartered Institute for Archaeologists (2014) *Standard and Guidance for Archaeological Geophysical Survey.* Note: currently Historic England (2018) no longer support the guidelines set out in English Heritage (2008) Geophysical survey in archaeological field evaluation and there are currently no plans to update the document. As a consequence other sources of written guidance referring to this document may be out of date and/or contain unsupported information (e.g. Chartered Institute for Archaeologists, 2014).

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

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

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

1.4 Site location, description and survey conditions

1.4.1 The site is located at Lower Ham Farm, within the parish of Broad Town to the south of Royal Wootton Bassett in Wiltshire. It is centred on Ordnance Survey National Grid Reference (OS NGR) SU 07645 79853, see Figs 01 and 02. The geophysical survey covers approximately 0.26ha mainly within a single horse paddock.

1.4.2 The ground conditions across the site were generally considered to be favourable for the collection of geophysical data. Variable grass cover and small patches of open soil may affect the resistivity data. Weather conditions during the survey were fine.

1.5 Site history and archaeological potential

1.5.1 The site lies within 100m of the partially extant 17th century farmstead of Lower Ham Farm which is a Grade II listed building (Historic England List Entry no. 1022644). A number of other farms and outfarms, mainly dating to the 19th century, are indicated on the Wiltshire and Swindon Historic Environment Record (HER) with a number of Romano-British pottery sherds recorded to the north east of Thornhill, 630m to the south west. Aerial imagery shows that the site and the immediate environs contain extant, low ridge and furrow.

1.6 Geology and soils

1.6.1 The underlying solid geology across the site is mudstone from the Ampthill Clay Formation (BGS, 2017).

1.6.2 The overlying soil across the survey area is from the Denchworth association and is a pelo-stagnogley. This consists of a slowly permeable, seasonally waterlogged, clayey soil (Soil Survey of England and Wales, 1983).

1.6.3 Damp clayey soils tend to produce very poor conditions for the location of former cut features using earth resistance survey; however, former structural remains may produce strongly contrasting features, particularly after the current prolonged dry spell.

1.6.4 The underlying geology and soils are frequently associated with low magnetic contrast and low levels of magnetic susceptibility. However, cut features of archaeological potential may be located where human activity has altered the magnetic characteristics of the soil sufficiently. The underlying geology and soils are, therefore, considered acceptable, although less than optimum, for magnetic survey.

2 METHODOLOGY

2.1 Technical synopsis

2.1.1 The electrical resistance or resistivity of the soil depends upon moisture content and distribution. Buried features such as walls can affect the moisture distribution and are usually more moisture resistant than other features such as the infill of a ditch. A stone wall will generally give a high resistance response, and the moisture retentive content of a ditch can give a low resistance response although in certain conditions it may also produce a high resistance anomaly.

2.1.2 Localised variations in resistance are measured in ohms (Ω) which is the SI unit for electrical impedance or resistance. Additional details are set out in 2.2 below and within Appendix A.

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

2.1.4 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.

2.1.5 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.

2.1.6 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 B.

2.2 Equipment configuration, data collection and survey detail

2.2.1 The earth resistance survey was carried out with a Geoscan Research RM85 mounted on a MSP25 Mobile Sensor Platform. The platform comprises a wheeled resistance array with four spiked wheels that act as the four probes of a square array which are set 0.75m apart on an aluminium frame. It is configured as a multiplexed 0.75m square array recording alpha and beta measurements every 0.25m along traverses separated by 1m. Readings are triggered by distance encoder pulses from an MSP25 wheel after an initial calibration. The survey was carried out in a zig-zag fashion over grids 40m x 40m in size, although due to the small size of the survey area, partial grids were unavoidable.

2.2.2 The survey grids were set out to the Ordnance Survey OSGB36 datum using a Leica GS10 RTK GNSS. The GNSS is used in conjunction with Leica's SmartNet service, where positional corrections are sent via a mobile telephone link. Positional accuracy of around 10 – 20mm is possible using the system.

2.2.3 An additional 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 range of recording data between ±0.1nT and ±3000nT. They are linked to a Leica GS10 RTK GNSS with data recorded by SENSYS MAGNETO®MXPDA software on a rugged PDA computer system.

2.2.4 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.

2.2.5 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).

2.2.6 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 <60s.

2.3 Data processing and presentation

2.3.1 Data logged by the RM85 resistance meter are downloaded and processed within TerraSurveyor Geoplot 4 software. Appendix D metadata sets out the data range and the processing sequence, with further details regarding the processing functions set out within Appendix C.

2.3.2 TIF files are prepared in TerraSurveyor and Geoplot 4 for the earth resistance data. The main form of resistivity data display used in the report is the minimally processed greyscale raster graphic image. A filtered image is also displayed where a low pass filter is used to smooth the data and enhance anomalies.

2.3.3 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.

2.3.4 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.

2.3.5 The minimally processed magnetic data are collected between limits of ±3000nT and clipped for display at ±2nT. Data are interpolated to a resolution of effectively 0.5m between tracks and 0.15m along each survey track.

2.3.6 Additional data processing has been carried out in the form of both low pass and high pass filtering. Low pass filtering effectively removes high frequency variation along a traverse that has been caused by uneven ground and associated vibration. High pass filtering 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.

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

2.3.8 For magnetometry data a TIF file is produced by TerraSurveyor software along with an associated world file (.TFW) that allows automatic georeferencing (OSGB36 datum) when using GIS or CAD software. The main form of data display used in the report is the minimally processed greyscale plot. With regard to the Sensys MXPDA, minimally processed data is considered by the manufacturer to be data that is compensated by SENSYS MAGNETO DLMGPS software, see 2.3.3 and 2.3.4. Note: traceplots are not considered to be appropriate as they do not provide an accurate or useful assessment of the magnetic anomalies due to very high density of data collection.

2.3.9 The raster images are combined with base mapping using ProgeCAD

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

2.3.10 An abstraction and interpretation is also 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.

2.3.11 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.

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

3 RESULTS

3.1 Data interpretation

3.1.1 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 basic explanation of the characteristics of the geophysical 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. High resistance anomalies are indicative of comparatively low moisture and may indicate stone, compacted soil, changes in drainage, etc. Low resistance anomalies are indicative of comparatively high moisture and may relate to the fill of cut features, organic material within the soil, damp areas etc.
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. Resistivity anomalies may be high or low and are clearly associated with extant modern features.

Table 1: List and description of interpretation categories

3.2 General assessment of survey results – resistivity

3.2.1 The earth resistance survey was carried out over approximately 0.26ha.

3.2.2 Resistance anomalies located can be generally classified as high resistance anomalies of uncertain origin and anomalies associated with agricultural activity . Anomalies located within each survey area have been numbered and will be outlined in 3.4 below with subsequent discussion in Section 4.

3.3 Statement of data quality and other factors influencing the results - resistivity

3.3.1 Data are considered representative of the resistive anomalies present within the site. Although both alpha and beta data were collected at each recording station, alpha data proved noisy and only beta data were used for the purposes of this report.

3.3.2 Generally the data demonstrate low resistive contrast but a number of high resistance anomalies are present. It is possible that some weak anomalies relate to variations in the thickness of ground cover and associated variations in soil moisture content.

3.4 List of anomalies – resistivity

Area centred on OS NGR 407645 179853, see Figs 03 – 05.

Anomalies with an uncertain origin

(1) – A zone of relatively high resistance is located in the north eastern part of the survey area. This is located close to the field entrance and partly associated with bare soil. It is likely that it relates to soil compaction and ground consolidation near the entrance and it is associated with a patch of magnetic debris (9) seen in the magnetometry data.

(2) – High resistance data in the centre of the survey area is of uncertain origin, but taller grass cover and higher resistance on the ridges of the ridge and furrow could account for the anomaly.

(3) – A narrow, fragmented, high resistance anomaly appears to extend across the eastern part of the survey area. It is poorly defined and lacks a coherent morphology preventing interpretation.

Anomalies with an agricultural origin

(4) – Relatively high resistance linear anomalies are a response to the ridges associated with the extant ridge and furrow.

3.5 General assessment of survey results - magnetometry

3.5.1 The detailed magnetic survey was carried out over approximately 0.26ha.

3.5.2 Magnetic anomalies located can be generally classified as positive and negative linear anomalies of an uncertain origin, linear anomalies of an agricultural origin, strong discrete dipolar anomalies relating to ferrous objects and areas of magnetic disturbance. Anomalies located within the survey area have been numbered and are described in 3.7.

3.6 Statement of data quality and other factors influencing the results - magnetometry

3.6.1 Data are considered representative of the magnetic anomalies present within the site. There are no significant defects within the dataset.

3.6.2 With the exception of magnetic debris and disturbance, anomalies are very weak and of low contrast. However, due to the limited area covered by the survey, it is not possible to determine whether this relates to the underlying geology and soil or the nature of the features.

3.6.3 The survey area contains ridge and furrow earthworks that belong to a much larger system of former cultivation which may well be of medieval date. Some very weak linear anomalies relating to the earthworks were recorded, and it is considered unlikely that earlier features would have been obscured.

3.7 List of anomalies – magnetometry

Area centred on OS NGR 407649 179854, see Figs 06 – 08.

Anomalies with an uncertain origin

(5) – A small number of weakly positive linear anomalies can be seen within the data. Although this type of response could indicate cut features, they are very weak and lack a clear response and coherent morphology.

(6) – A negative linear anomaly is located in the western part of the survey area. This type of anomaly suggests a response to material with lower magnetic susceptibility than the surrounding soil, such as subsoil, but it does not have a clear morphology.

Anomalies with an agricultural origin

(7) – Linear anomalies oriented north north east to south south west are associated with the extant ridge and furrow, generally relating to the ridges.

(8) – A series of weak linear anomalies oriented north west to south east can be seen in the data. Although the site contains extant ridge and furrow on a different orientation and does not appear to have been ploughed recently, the regular linear

appearance does indicate agricultural activity post-dating the ridge and furrow.

Anomalies associated with magnetic debris

(9) – A patch of magnetic debris can be seen within the north eastern part of the survey area. This is likely to relate to dumped material or possible modern burning. It corresponds to a zone of high resistance (1). Similar patches can be seen within the land along the northern edge of the site.

(10) – Strong, discrete, dipolar anomalies are a response to ferrous and other magnetically thermoremnant objects within the topsoil.

Anomalies with a modern origin

(11) – Magnetic disturbance along the eastern edge is a response to adjacent ferrous material used in fencing etc.

4 CONCLUSION

4.1.1 The geophysical survey comprised resistivity and magnetometry within the site. The results of the resistivity demonstrate the presence of a number of high resistance anomalies which are likely to relate to ground consolidation. A high resistance linear lacks a coherent morphology and cannot characterised. Magnetometry was also carried out and although a number of weakly positive and a negative linear anomaly were located, they are indistinct and again lack a coherent morphology. The site contains extant ridge and furrow which has also caused weak anomalies in the data.

5 REFERENCES

Archaeological Surveys, 2020. *Lower Ham Farm, Broad Town, Wiltshire,, Geophysical Survey Written Scheme of Investigation.* Unpublished typescript document.

British Geological Survey, 2017. *Geology of Britain 3D (Beta version), 1:50 000 scale [online]* available from http://mapapps.bgs.ac.uk/geologyofbritain3d/index.html? [accessed 7/9/2020].

Chartered Institute for Archaeologists, 2014. *Standard and Guidance for archaeological geophysical survey*. IfA, 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.*

Appendix A – basic principles of earth resistance survey (resistivity)

Earth resistance survey, commonly known as resistivity, relies on the variability of conduction of current through soil and the subsurface matrix. The variability relates to the distribution of moisture within different materials so that non-porous features, such as foundations, produce a relatively high resistance response and more moisture retentive soil, such as found within the fill of a former ditch, produces a low resistance measurement. The technique is, therefore, influenced by climatic factors although the success of a survey can be difficult to predict based on these alone. Soil type, ground use, vegetative cover and the nature of buried features and subsoil are all factors that will influence the outcome of a survey.

The technique involves inputting a small electrical current into the ground and measuring subtle variations to the current at regular intervals across an area. The current input and measurement requires a series of probes to be inserted into the ground and the configuration of these can influence the resolution of resistive anomalies and the depth of response. Research has demonstrated that the twin electrode configuration is one of the most useful for archaeological prospection. It requires a mobile frame with two electrodes separated usually by 0.5m and a pair of remote probes linked to the logging instrument using a long cable.

Cart-based systems are also regularly used in archaeological prospection, and generally these require four spiked wheels to inject current into the ground and take measurements. The four wheels act as a square array which can be electronically switched to change the orientation of measurement and current input. Two or three readings are rapidly logged at each recording station and these are referred to as alpha, beta and gamma. The gamma is often not recorded as this represents the difference between the alpha and beta configurations and can be derived during data processing. The alpha and beta datasets often demonstrate subtle differences that relate to the orientation of subsurface features and both are analysed as part of the abstraction and interpretation process. Advantages of cart systems are speed and resolution and they do not require a trailing cable; however, ground conditions are more critical and problems can be encountered with ground cover and in areas that are excessively damp or dry.

When using the twin probe configuration a useful reading interval for archaeological prospection across an area is 1m. Data are logged at 1m centres along traverses separated by 1m. Where areas contain known archaeological features 0.5m x 0.5m or 1m x 0.5 readings are considered more informative. Data collected by cart-based systems are typically at 0.25m centres along traverses separated by 1m.

Appendix B – 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 C – data processing notes

Clipping

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

Despike

Removal of data points that exceed the mean/median/threshold by selecting a window size of data points and replace by mean/median/threshold. Magnetic spikes can be caused iron objects on the surface or within the topsoil. Spikes in resistivity data are often related to poor electrical contact often associated with ground conditions. Despike can improve the appearance of data and remove extreme readings that may affect further processing.

Edge Match

Calculates the mean of the 2 lines (rows or columns) of data either side of the edge to match. It then subtracts the difference between the means from all datapoints in the selected area. The process is used to suppress or remove discontinuities between survey grids that are often a consequence of changes in soil moisture content during the course of a survey.

High Pass Filter

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

Low Pass Filter

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

Zero Median/Mean Traverse

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

Appendix D – survey and data information

Filename: J830-res-raw.xcp
Description: Imported as Composite from GeoPlot : J830 res beta
Instrument Type: Resist. (RM85)
Units: ohm
Collection Method: Zig-zag
Dummy Value: 2047.5
Dimensions
Composite Size (readings): 320 x 40
Survey Size (meters): 80 m x 40 m
Grid Size: 40 m x 40 m
X Interval: 0.25 m
Y Interval: 1 m
Stats
Max: 8.85
Min: -6.73
Std Dev: 1.39
Mean: 1.01
Median: 1.00
Composite Area: 0.32 ha
Surveyed Area: 0.2673 ha
Processes: 2
1 Base Layer
2 Clip at 2.00 SD

Filename: J830-res-proc.xcp
Stats
Max: 3.44
Min: -1.43
Std Dev: 0.81
Mean: 1.005
Median: 0.97
rocesses: 4
1 Base Layer
2 Clip at 3.00 SD
3 Despike Threshold: 3 Window size: 1x1
4 Low pass Uniform (mean) filter: Window1 x 1

Filename: J830-mag-proc.xcp
Description: Imported as Composite from: J830-mag.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):
Northwest corner: 407604.022, 179895.34 m
Southeast corner: 407694.62, 179776.99 m
Collection Method: Randomised
Sensors: 5
Dummy Value: 32702
Source GPS Points: 114900
Dimensions
Composite Size (readings): 604 x 789
Survey Size (meters): 90.6 m x 118 m
Grid Size: 90.6 m x 118 m
X Interval: 0.15 m
Y Interval: 0.15 m
Stats
Max: 3.32
Min: -3.30
Std Dev: 1.02
Mean: -0.02
Median: 0.02
Composite Area: 1.0723 ha
Surveyed Area: 0.36312 ha
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

Filename: J830-mag-proc-hpf-lpf.xcp
Stats
Max: 2.21
Min: -2.20
Std Dev: 0.70
Mean: -0.01
Median: 0.01

GPS based Proce6
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 High pass Uniform (median) filter: Window dia: 253
5 Lo pass Uniform (median) filter: Window dia: 13
6 Clip from -2.00 to 2.00 nT

Appendix E – digital archive

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

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

File type	Naming scheme	Description
Data	J830-mag.asc J830-mag.xcp J830-mag-proc.xcp J830-mag-proc-hpf-lpf.xcp J830-res-raw.xcp J830-res-proc.xcp	Raw data as ASCII CSV TerraSurveyor raw data TerraSurveyor minimally processed data TerraSurveyor filtered data TerraSurveyor raw data TerraSurveyor processed data
Graphics	J830-mag-proc.tif J830-mag-proc-hpf-lpftif J830-res-raw.tif J830-res-proc.tif	Image in TIF format
Drawing	J830-[version 3].dwg	CAD file in 2010 dwg format
Report	J830 report.odt	Report text in Open Office odt format

Table 2: Archive metadata

Appendix F – CAD layers for abstraction and interpretation plots

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

Report sub-heading and associated CAD layer names	Colour with RGB index		Layer content
Anomalies with an uncertain origin			
AS-ABST MAG POS LINEAR UNCERTAIN		255,127,0	Line, polyline or polygon (solid)
AS-ABST MAG NEG LINEAR UNCERTAIN		Blue 0,0,255	Line, polyline or polygon (solid)
AS-ABST RES HIGH LINEAR UNCERTAIN		153,133,76	Line, polyline or polygon (solid)
AS-ABST RES HIGH AREA UNCERTAIN		153,133,76	Polygon (net)
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)
AS-ABST RES RIDGE AND FURROW		63,127,11	Line, polyline or polygon (cross hatched net)
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)

Table 3: CAD abstraction layering

Appendix G – copyright and intellectual property

Archaeological Surveys
Specialist Geophysical Surveyors

Geophysical Survey
Lower Ham Farm
Broad Town
Wiltshire

Map of survey area

Survey location

● Survey location

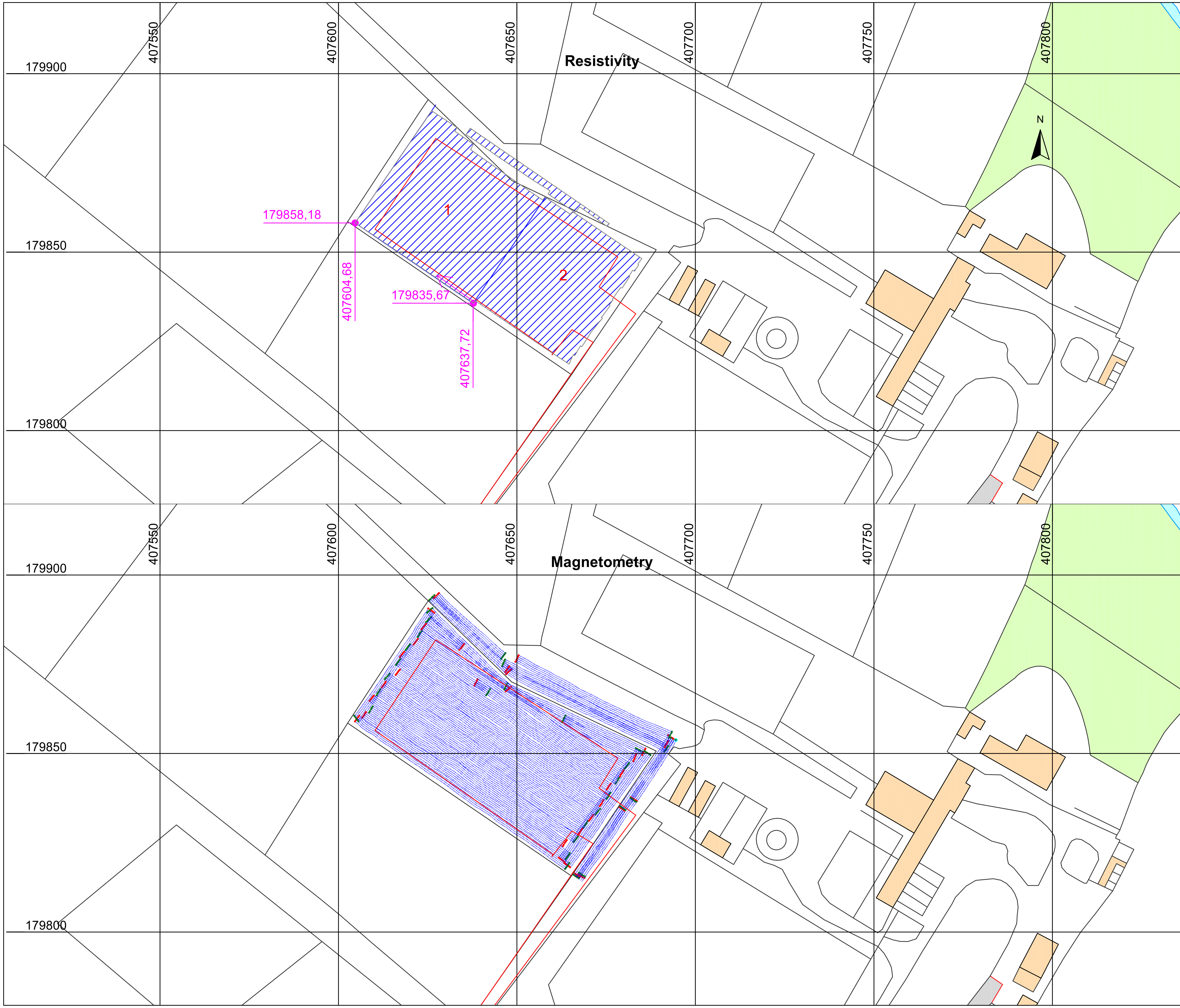
Site centred on OS NGR
SU 07645 79853

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
Lower Ham Farm
Broad Town
Wiltshire

Referencing information

Resistivity grid coordinates based on Ordnance Survey OSGB36 datum

Grids set out using RTK GNSS with Leica SmartNet correction data RTCMv2 format OSTN02 transformation

Survey grid size = 40m

Survey start and traverse direction

1 Grid reference number and filename

Resistivity coverage

Development boundary

Magnetometry referencing grid to OSGB36 datum at 50m intervals. Survey carried out using 5 channel cart system linked to RTK GNSS

Survey tracks

Survey track start

Survey track stop

SCALE 1:1000

0m 10 20 30 40 50m

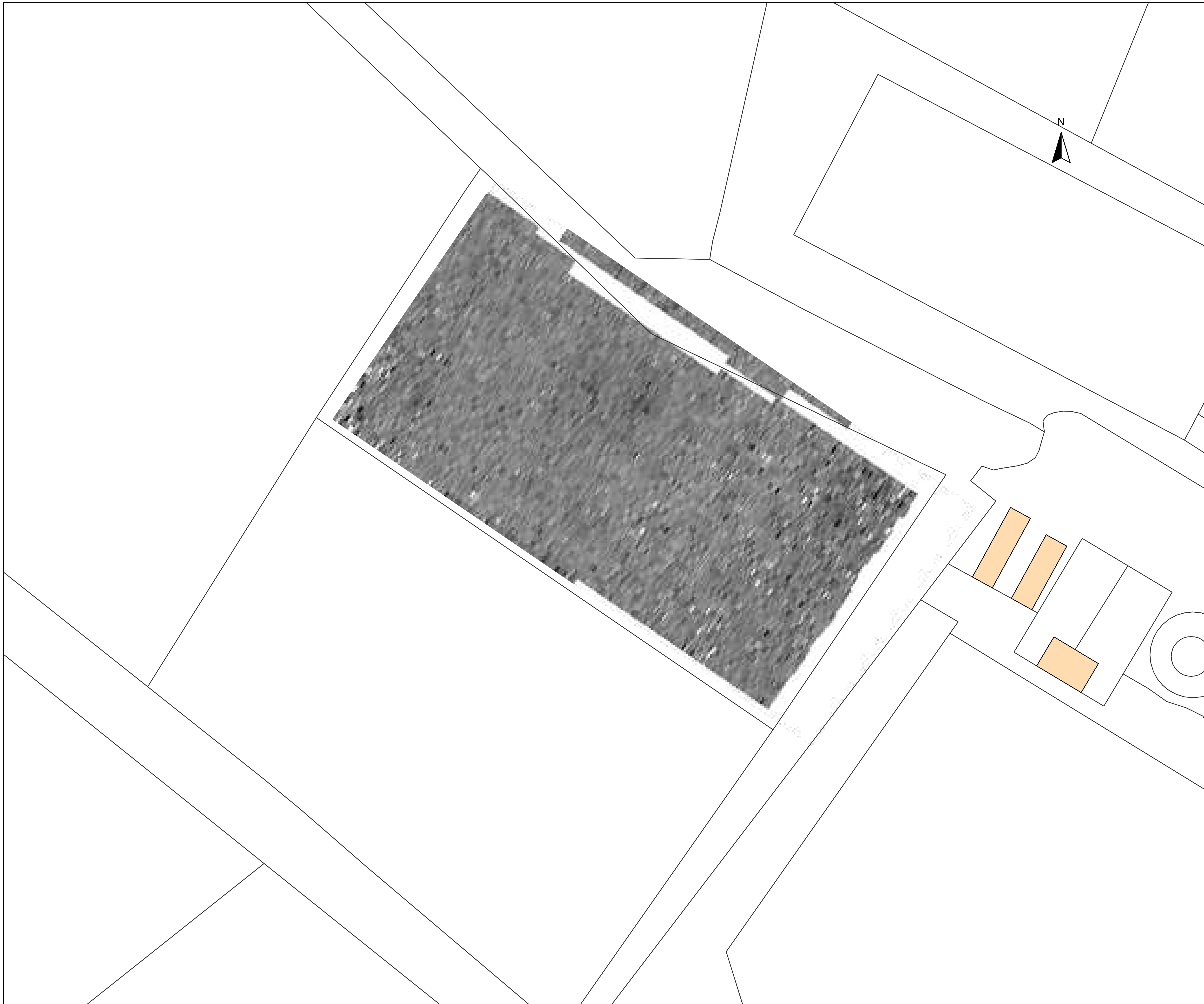
SCALE TRUE AT A3

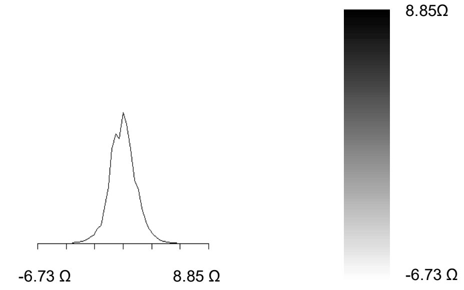
DRAWN BY	CHECKED BY	
KTD	DJS	FIG 02

Archaeological Surveys
Specialist Geophysical Surveyors

Geophysical Survey
Lower Ham Farm
Broad Town
Wiltshire

Greyscale plot of raw earth resistance data



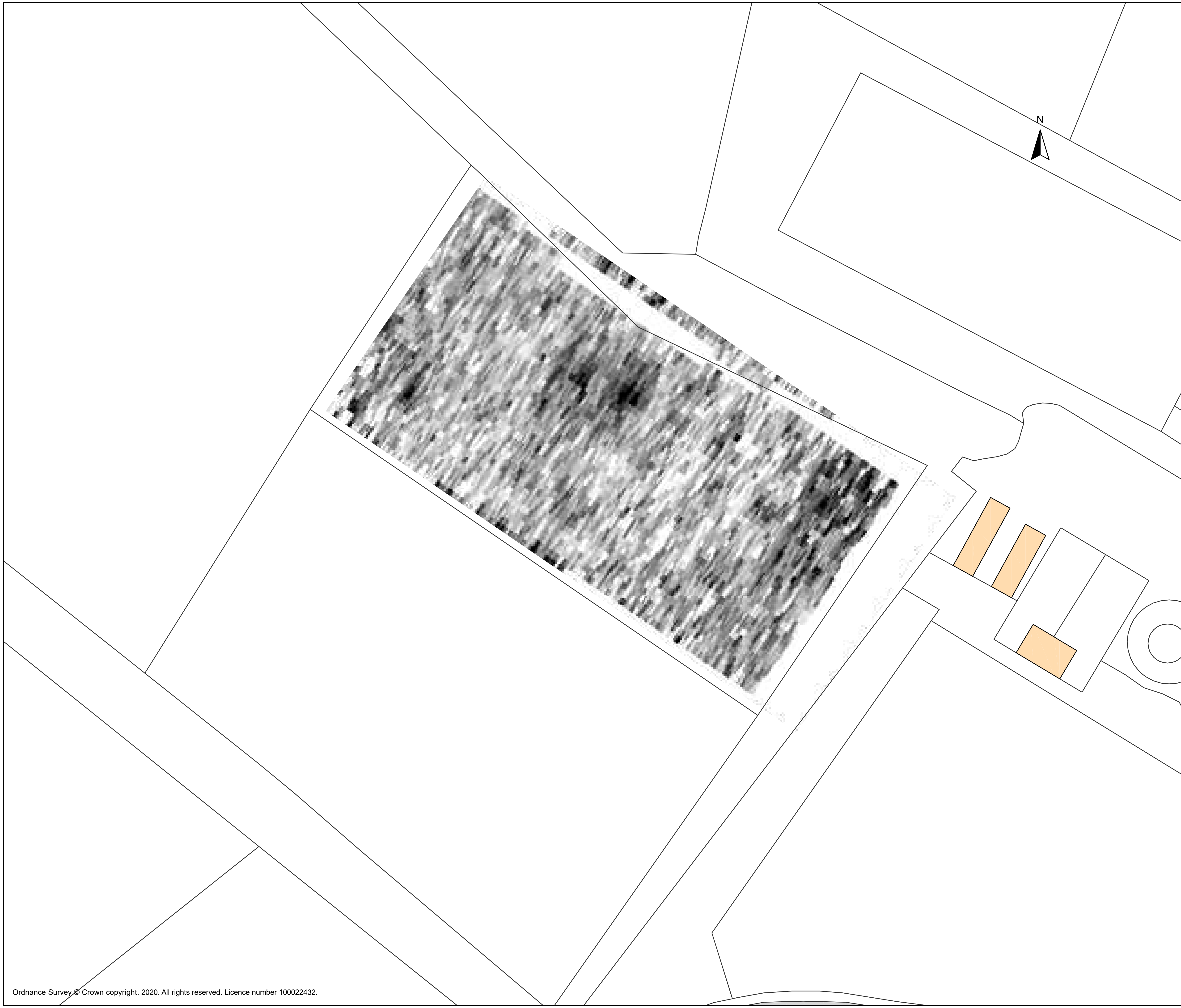


SCALE 1:500

0m 10 20 30 40 50m

SCALE TRUE AT A3

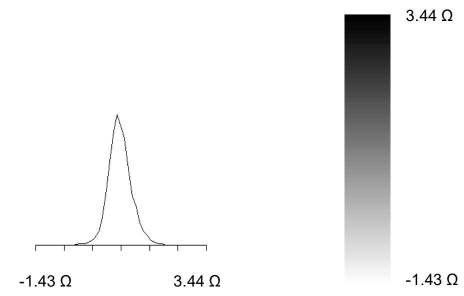
DRAWN BY	CHECKED BY	
KTD	DJS	FIG 03



Archaeological Surveys
Specialist Geophysical Surveyors

Geophysical Survey
Lower Ham Farm
Broad Town
Wiltshire

Greyscale plot of processed earth resistance data



SCALE 1:500

0m 10 20 30 40 50m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 04

Archaeological Surveys
Specialist Geophysical Surveyors

Geophysical Survey
Lower Ham Farm
Broad Town
Wiltshire

Abstraction and interpretation of earth resistance anomalies

High resistance linear anomaly - ridge & furrow (ridge)

High resistance linear anomaly - of uncertain origin

Area of high resistance - of uncertain origin

SCALE 1:500

0m 10 20 30 40 50m

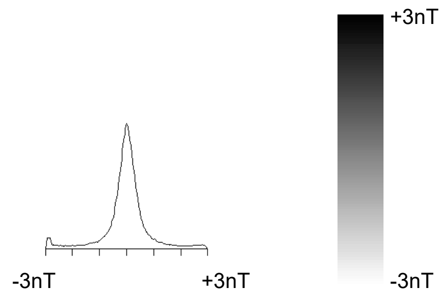
SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 05

Archaeological Surveys
Specialist Geophysical Surveyors

Geophysical Survey
Lower Ham Farm
Broad Town
Wiltshire

Greyscale plot of minimally processed magnetometer data

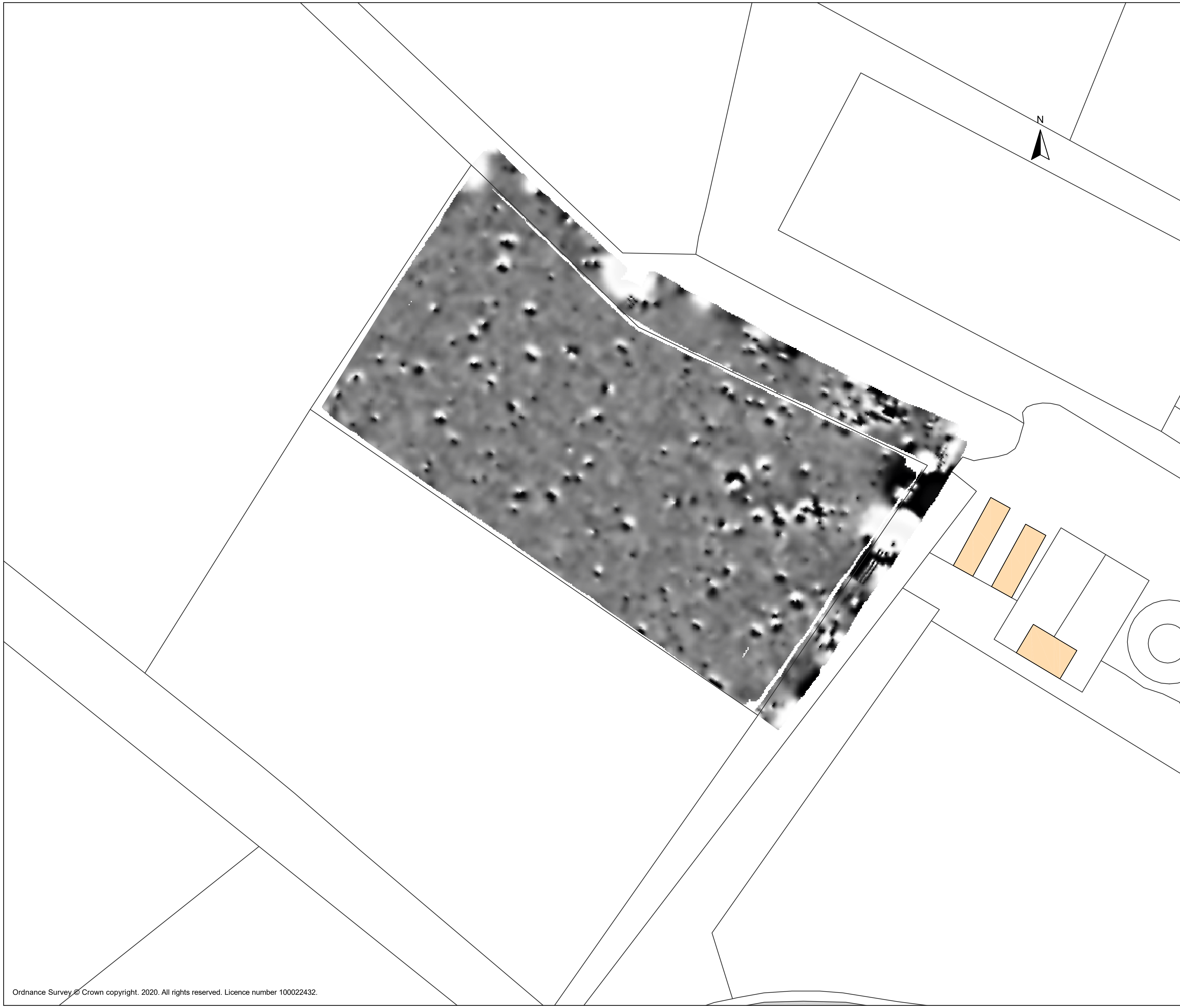


SCALE 1:500

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
Lower Ham Farm
Broad Town
Wiltshire

Greyscale plot of filtered magnetometer data

SCALE 1:500

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
Lower Ham Farm
Broad Town
Wiltshire

Abstraction and interpretation of magnetic anomalies

- Positive linear anomaly - of uncertain origin
- Linear anomaly - of agricultural origin
- Linear anomaly - ridge and furrow
- Negative linear anomaly - material of low magnetic susceptibility
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong dipolar anomaly - ferrous object

SCALE 1:500

0m 10 20 30 40 50m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 08