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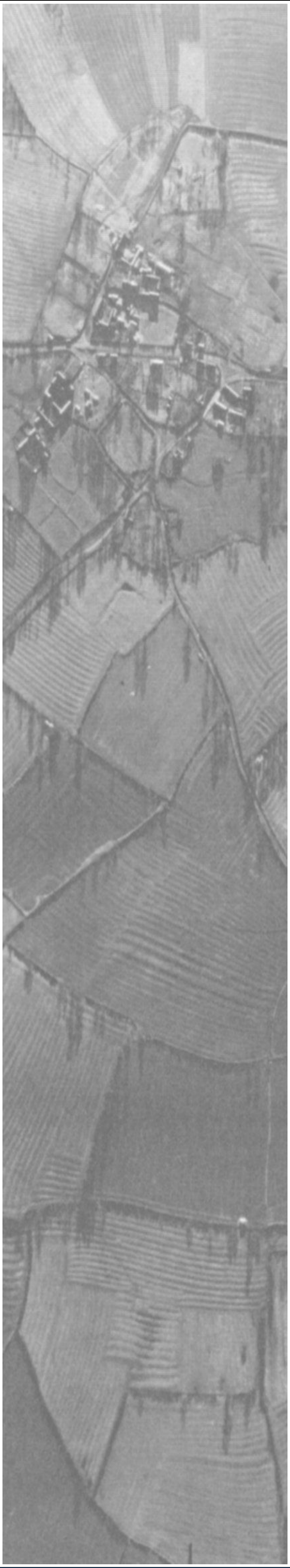

Minchinhampton Medical Centre
Minchinhampton
Gloucestershire

MAGNETOMETER & EARTH RESISTANCE SURVEY REPORT

for

Minch Health Limited

Kerry Donaldson & David Sabin

February 2023

Ref. no. J949

ARCHAEOLOGICAL SURVEYS LTD

Minchinhampton Medical Centre
Minchinhampton
Gloucestershire

Magnetometer & Earth Resistance Survey Report

for

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Report checked by David Sabin
Primary archive location - Archaeological Surveys Ltd, Yatesbury, Wiltshire

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It is a Registered Organisation with the Chartered Institute for Archaeologists.

CONTENTS

LIST OF FIGURES

LIST OF PLATES

LIST OF TABLES

SUMMARY

A geophysical survey was carried out by Archaeological Surveys Ltd within a small area of pasture on the north eastern edge of Minchinhampton, Gloucestershire, ahead of a new medical centre development. Both magnetometry and earth resistance surveys were carried out, with the magnetometry revealing a linear, ditch-like feature parallel with the northern and southern field boundaries, a number of natural pit-like responses, a pipe and anomalies associated with animal feeding. The earth resistance responses also generally related to animal feeding, although a group of high resistance anomalies are of uncertain origin.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Carl Dean Associates, on behalf of Minch Health Ltd, to undertake a magnetometer and earth resistance (resistivity) survey of an area of land on the north eastern edge of Minchinhampton in Gloucestershire. The site has been outlined for the proposed development of a new medical centre. The survey was carried out as part of a condition for an archaeological assessment of the site (Stroud District Council planning application no: S.21/0484/FUL).

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 and earth resistance survey (resistivity) to locate geophysical anomalies that may be archaeological in origin so that they may be assessed prior to development of the site. Resistivity was carried out over the main footprint of the development within the eastern part of the field, together with an area outlined for a new sewer pipe in the north west, while magnetometry was carried out within the entire field for context. 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 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 generally follow the recommendations set out by: European Archaeological Council (2015) *Guidelines for the Use of Geophysics in Archaeology;* Institute for Archaeologists (2002) *The use of Geophysical Techniques in Archaeological Evaluations.* The work has been carried out to the Chartered Institute for Archaeologists (2014) (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 to the north of Cirencester Road, on the north eastern edge of Minchinhampton, Gloucestershire. It is centred on Ordnance Survey National Grid Reference (OS NGR) SO 88035 01205, see Figs 01 and 02.

1.4.2 The geophysical survey comprised both magnetometry and resistivity covering approximately 0.56ha and 0.46ha respectively within a small pasture field. The resistivity covered the main area of the medical centre in the eastern part of the site, together with the location of a new sewer in the north west. Magnetometry covered all accessible parts of the field avoiding modern ferrous objects.

1.4.3 The field is located on level ground on an elevated limestone plateau just under 200m AODN. Field boundaries are drystone walls with a shelter belt of mature trees along the northern boundary. Residential dwellings are located immediately to the west of the field, Cirencester Road is located to the south with further agricultural land to the north and east. The area contained a small barn near the north eastern corner and a number of agricultural vehicles, implements and animal pens along much of the northern and north eastern sides of the site. Other steel objects and agricultural vehicles were located towards the south eastern corner of the site with waterlogged vehicle ruts towards the gateway in the south eastern corner.

1.4.4 The ground conditions across the site were generally considered to be favourable for the collection of geophysical data. Magnetic survey was avoided in close proximity to steel objects due to very high magnitude magnetic disturbance. Resistivity was carried out in accessible areas but not in the south western part of the field outside of the development zone. Weather conditions during the survey were mainly fine and cold, reasonably dry conditions prior to the survey were likely to be favourable to resistivity survey.

Plate 1: Eastern part of site looking north

Plate 2: Site looking west

1.5 Site history and archaeological potential

1.5.1 The Gloucestershire Historic Environment Record (HER) does not list any designated or undesignated heritage assets directly within the site, but an Iron Age/Roman coaxial field system is visible as earthwork banks on aerial photographs 230m to the east (HER no: 4170). Further linear earthworks have also been recorded 390m to the south west (HER no: 3493). The nearest scheduled monuments are the earthworks of banks and a ditch at Glebe Farm (Historic England List Entry no: 1015422) which is the most eastern stretch of the Bulwarks, the main site lying 570m to the west of the survey area, which is a large, multi-period site with Iron Age origins situated on Minchinhampton Common (List Entry no: 1014033). A previous geophysical survey (Archaeological Surveys, 2015) and archaeological evaluation (Cotswold Archaeology, 2015) on land 285m to the north west did not locate any features of archaeological origin. Further evaluations to the north and south of Cirencester Road, 385m to the west, also failed to locate any features or deposits of archaeological interest (Cotswold Archaeology, 2013).

1.6 Geology and soils

1.6.1 The underlying solid geology across the site is limestone from the Athelstan Oolite Formation (BGS, 2022).

1.6.2 The overlying soil across the survey area is from the Elmton 1 association (343a) and is a brown rendzina. It consists of a shallow, well drained, brashy, calcareous, fine, loamy soil over limestone (Soil Survey of England and Wales, 1983).

1.6.3 Geophysical surveys carried out over similar geology and soil has produced good results. The site is, therefore, considered suitable for both magnetic and earth resistance survey.

2 METHODOLOGY

2.1 Technical synopsis - magnetometry

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

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

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

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

2.2 Technical synopsis - resistivity

2.2.1 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.

2.2.2 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 B.

2.3 Equipment configuration, data collection and survey detail - magnetometry

2.3.1 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 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.

2.3.2 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.

2.3.3 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).

2.3.4 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 <60s.

2.4 Equipment configuration, data collection and survey detail - resistivity

2.4.1 The earth resistance survey was carried out using a Geoscan Research Ltd RM85 resistance meter with multiplexer and a mobile parallel twin probe array with a 0.5m electrode separation. Four probes on the 1.5m long array allow the collection of two readings at 1m intervals along a traverse, equating to two parallel traverses separated by 1m. The instrument was set to filter stray earth currents which can cause errors within the resistance measurements. The survey was carried out in a zig-zag fashion over grids 30m x 30m in size with each reading representing 1m x 1m. The twin probe array requires the use of two fixed remote probes located at least 15m beyond the limit of each survey grid and linked to the mobile array by cable. Occasionally the fixed remote probes are repositioned due to limited cable length or to ensure the minimum distance between them and the mobile probes. To ensure no offset values occur between grids when the probes are repositioned, the mobile probes remain in a fixed location and the separation between the fixed probes at their new location is adjusted until the RM85 displays the same resistance value as the original location.

2.4.2 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.

2.5 Data processing and presentation

2.5.1 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.

2.5.2 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.

2.5.3 The minimally processed magnetic data are collected between limits of ±3000nT and clipped for display at ±50nT and ±10nT. Data are interpolated to a resolution of effectively 0.5m between tracks and 0.15m along each survey track.

2.5.4 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.

2.5.5 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 are considered by the manufacturer to be data that are 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.

2.5.6 Data logged by the RM85 resistance meter are downloaded in Geoplot 4 and processed within TerraSurveyor 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.

2.5.7 TIF files are prepared in TerraSurveyor for the resistivity data. The main form of resistivity data display used in the report is the minimally processed greyscale raster graphic image which has been de-spiked in order to remove high contact resistance anomalies and clipped at 2 SD to improve contrast.

2.5.8 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 GPS, resection method, etc.

2.5.9 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.

2.5.10 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. Where further interpretation is possible, or where a number of possible origins should be considered, more subjective discussion is set out in Section 4.

2.5.11 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.
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	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.
Anomalies with a natural origin	Naturally formed features can produce variable anomalies that relate to the properties of the soil, subsoil and other drift or solid geologies. Anomalies may be amorphous, linear or curvilinear and may appear 'fluvial'or discrete; the latter are almost impossible to distinguish from pit-like anomalies with an anthropogenic origin. Fluvial, glacial and periglacial processes may be responsible for their formation within drift material and subsoil. Igneous and metamorphic activity can lead to magnetic anomalies within more solid geology. Trees and shrubs may produce high resistance anomalies that can obscure anomalies of archaeological significance.

Table 1: List and description of interpretation categories

3.2 General assessment of survey results - magnetometry

3.2.1 The detailed magnetic survey was carried out over approximately 0.56ha.

3.2.2 Magnetic anomalies located can be generally classified as positive and negative anomalies of an uncertain origin, anomalies of an agricultural origin, anomalies with a natural origin, areas of magnetic disturbance, strong discrete dipolar anomalies relating to ferrous objects. Anomalies located within the survey area have been numbered and are described in 3.4 below.

3.3 Magnetic data quality and factors affecting the interpretation/formation of anomalies

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

3.3.2 The data contain localised zones of magnetic disturbance relating to above surface steel objects and a service in the eastern part of the site. The disturbance has the potential to obscure weak anomalies should they be present within those zones.

3.3.3 Soil magnetic susceptibility is typically high on elevated parts of the Cotswolds and the solid geology beneath is typically very low; as a consequence anomalies are often strong and have good contrast. However, features of agricultural and natural origin have the potential to produce clear anomalies within the soils, and these may be difficult to separate from anomalies of archaeological potential.

3.4 List of anomalies – magnetometry

Area centred on OS NGR 388035 201205, see Figs 03 – 05 & 09.

Anomalies with an uncertain origin

(1) – A positive linear anomaly extends across the centre of the site from east to west and has an associated negative response at the western end. This could relate to a cut, ditch-like feature, although it is parallel with the northern and southern field boundaries, which could suggest a former field boundary or agricultural activity.

(2) – A number of negative linear and curvilinear anomalies are located in the south western corner of the site. It is not clear if they relate to natural features within the underlying limestone or have an anthropogenic origin. Agricultural activity, such as vehicle ruts can cause similar anomalies

(3) – Two discrete positive anomalies in the north western part of the site have a stronger response (20-40nT) than the majority of discrete responses (3-10nT) across the site. It appears, therefore, that these are more magnetically enhanced, but there is a high probability that they are associated with modern animal feeding.

Anomalies with an agricultural origin

(4 & 5) – Magnetically enhanced areas (4) and negative ring-shaped anomalies

within the site are associated with animal feeding.

Anomalies with a natural origin

(6) – The site contains a large number of discrete, positive responses, with a concentration towards the south western corner. These appear to relate to naturally formed, pit-like features, such as tree-throw pits and other soil-filled features within the underlying limestone geology.

Anomalies associated with magnetic debris

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

Anomalies with a modern origin

(8) – A strong, multiple dipolar, linear anomaly is a response to a buried pipe located parallel with and close to the eastern edge of the site.

3.5 General assessment of survey results – resistivity

3.5.1 The earth resistance survey was carried out over approximately 0.46ha.

3.5.2 Resistance anomalies located can be generally classified as high resistance anomalies of uncertain origin, anomalies associated with agricultural activity and anomalies associated with modern land use. Anomalies located within each survey area have been numbered and will be outlined in 3.5 below.

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

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

3.6.2 A small number of high resistance 'spikes' are present within the data and these may represent poor ground contact probably associated with localised areas of stone or large individual stones. They have been removed by data processing and are not considered significant.

3.6.3 The data demonstrate useful contrast between zones of high and low resistance and reflect good conditions for undertaking resistance survey.

3.7 List of anomalies – resistivity

Area centred on OS NGR 388040 201217, see Figs 06 – 09.

Anomalies of uncertain origin

(9) - A group of high resistance areas are located in the central part of the site. It is possible that they have some association with animal feeding, or possibly a natural origin but they do not have a coherent morphology and cannot be interpreted further.

Anomalies with an agricultural origin

(10) - Patches of low resistance are associated with areas currently and formerly used for animal feeding.

Anomalies with a modern origin

(11) – A low resistance linear anomaly corresponds to the pipe (8) identified in the magnetometry survey.

4 CONCLUSION

4.1.1 The geophysical survey comprised magnetometry and resistivity within the site. The results of the magnetometry indicate the presence of a possible linear ditch-like feature; however, the majority of the anomalies are either associated with animal feeding or natural pit-like features. The results of the resistivity demonstrate the presence of a number of high resistance zones but they lack a coherent morphology and cannot be confidently interpreted. Low resistance anomalies are also associated with animal feeding.

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Appendix A – basic principles of magnetic survey

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

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

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

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

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

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

Appendix B – 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 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 - resistivity

Removal of data points that exceed the mean/median/threshold by selecting a window size of data points and replace by mean/median/threshold. 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.

Zero Median/Mean Traverse - magnetometry

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

Minimally processed magnetometer data

Filename: J949-mag-proc.xcp
Instrument Type: Sensys DLMGPS
Units:
UTM Zone: 30U
Survey corner coordinates (X/Y):OSGB36
Northwest corner: 387989.509, 201251.71 m
Southeast corner: 388087.45, 201169.21 m
Collection Method: Randomised
Sensors: 5
Dummy Value: 32702
Dimensions
Survey Size (meters): 98 m x 82.5 m
X&Y Interval: 0.15 m
Source GPS Points: Active: 162794, Recorded: 162794
Stats
Max: 11.05
Min: -11.00
Std Dev: 4.75
Mean: 0.10
Median: 0.10
Composite Area: 0.80809 ha
Surveyed Area: 0.56239 ha
PROGRAM
Name: TerraSurveyor
Version: 3.0.37.0
GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (UTM to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -20.00 to 20.00
5 Clip from -10.00 to 10.00

Raw resistivity data

Filename: J949-res-raw.xcp
Description: Imported as Composite from GeoPlot : J949-res
Instrument Type: Resist. (RM85)
Units: ohm
Direction of 1st Traverse: East
Collection Method: Zig-zag
Sensors: 4
Dummy Value: 2047.5
Dimensions
Composite Size (readings): 180 x 120
Survey Size (meters): 180 m x 120 m
Grid Size: 30 m x 30 m
X Interval: 1 m
Y Interval: 1 m
Stats
Max: 81.97
Min: 39.97
Std Dev: 5.93
Mean: 60.88
Median: 61.35
Composite Area: 2.16 ha
Surveyed Area: 0.4614 ha
Processes: 2
1 Base Layer
2 Clip at 2.00 SD

Processed resistivity data

Filename: J949-res-proc.xcp
Geoplot process: 1 Despike X=1 Y=1Thr=3 Repl=Mean
Stats
Max: 75.55
Min: 45.55
Std Dev: 5.39
Mean: 60.88
Median: 61.30
Processes: 2
1 Base Layer
2 Clip at 2.00 SD

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 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).

File type	Naming scheme	Description
Data	J949-mag-**[area number/name]**.asc J949-mag-**[area number/name]**.xcp J949-mag-**[area number/name]**-proc.xcp	Raw data as ASCII CSV TerraSurveyor raw data TerraSurveyor minimally processed data
Graphics	J949-mag-**[area number/name]**-proc.tif	Image in TIF format
Drawing	J949-**[version number]**.dwg	CAD file in 2018 dwg format
Report	J949 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 MAG POS DISCRETE UNCERTAIN		255,127,0	Solid donut, point 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
Anomalies associated with magnetic debris			
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 G – copyright and intellectual property

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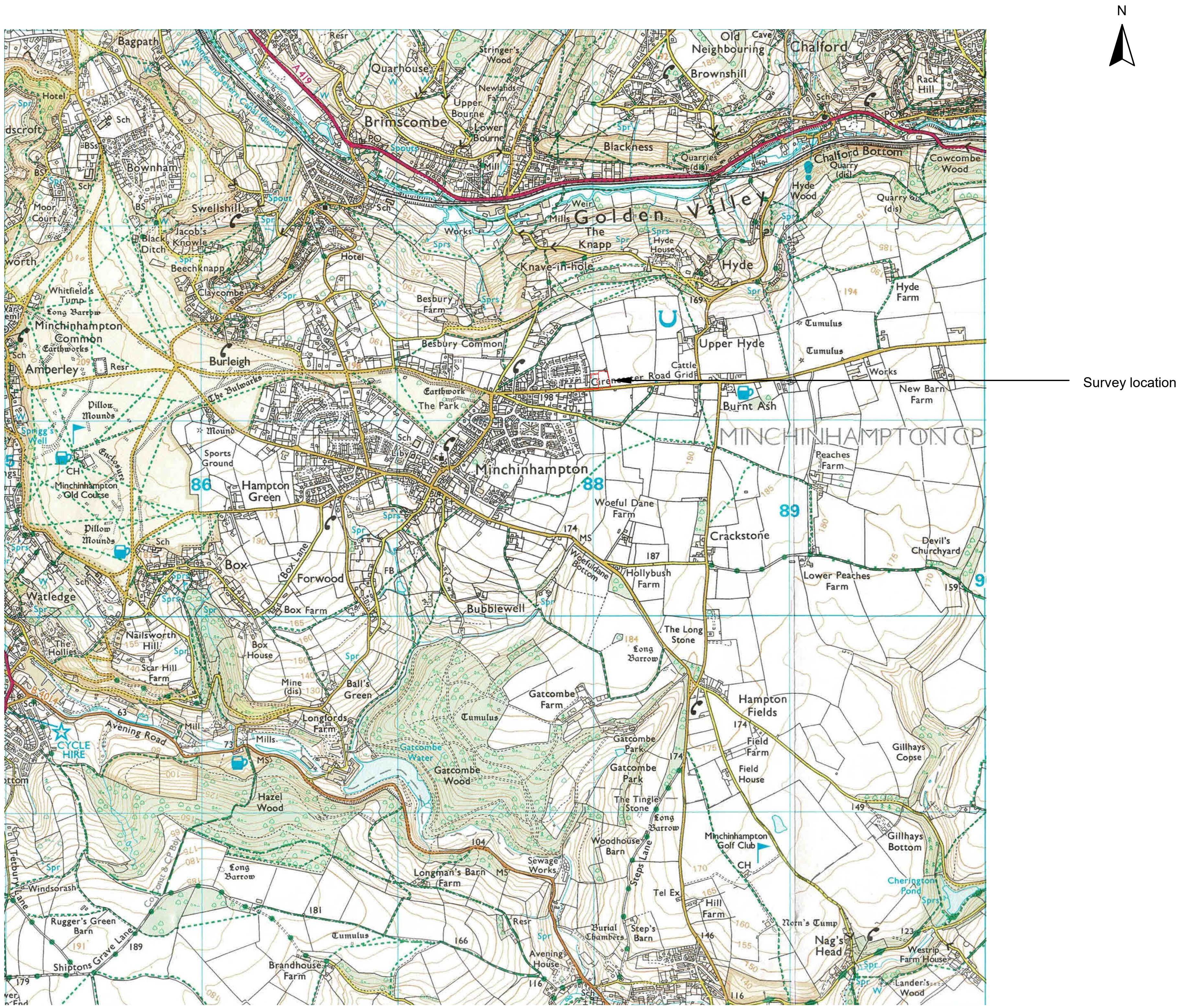
Minchinhampton
Gloucestershire

Map of survey area



● Survey location

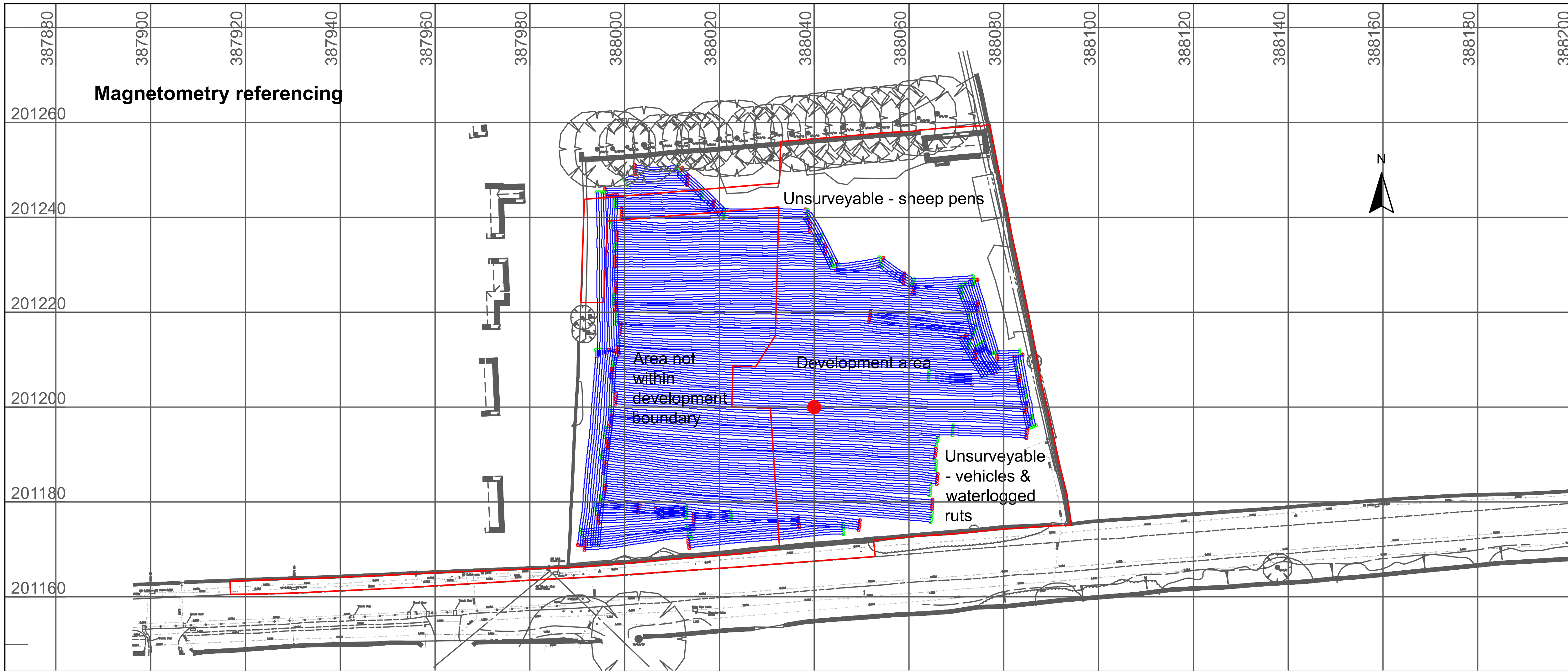
Site centred on OS NGR
SO 88040 01205

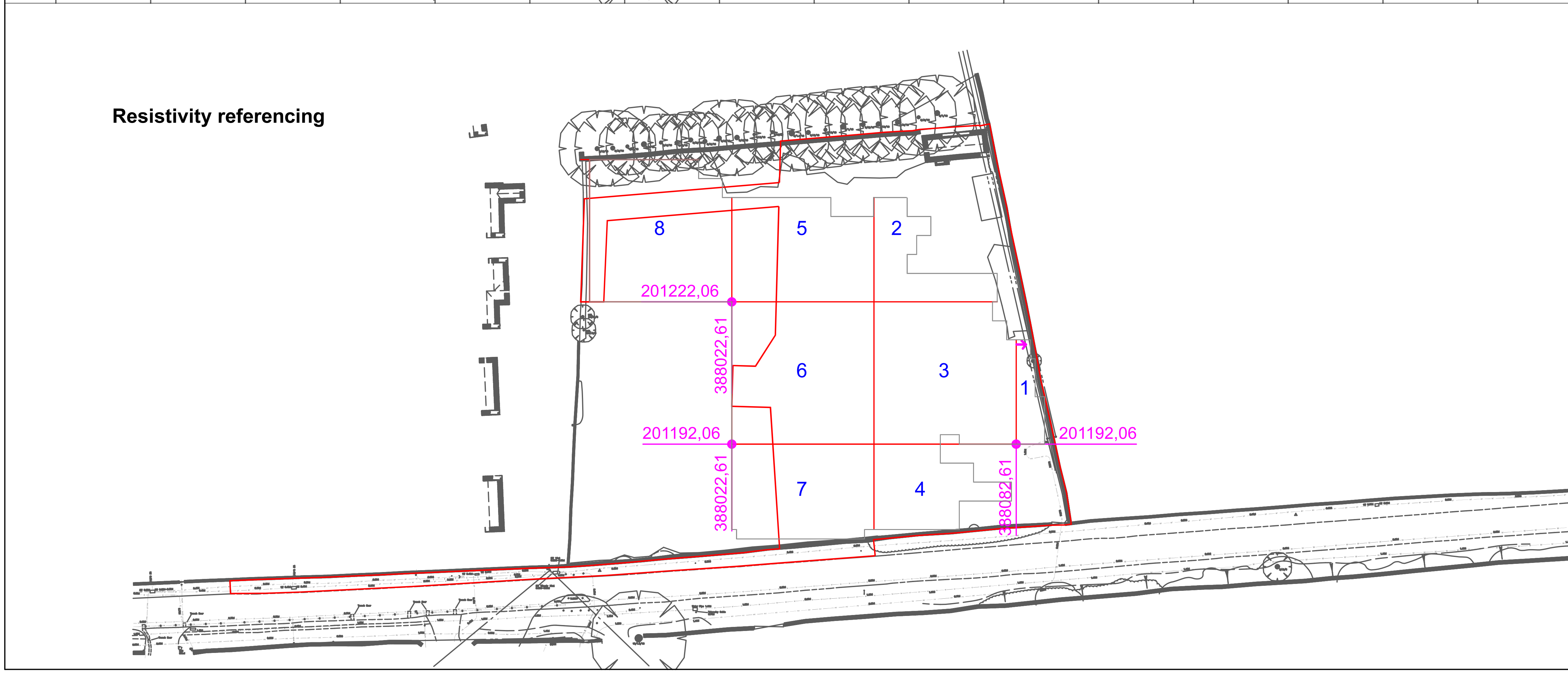
SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 01





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Referencing information

Magnetometry referencing grid to OSGB36 datum at 20m intervals. Data collected at 20Hz and georeferenced to ETRS89 zone 30 with conversion to OSGB36 using OSTN02

388040 201200

Survey tracks

Survey track start

Survey track stop

Development boundary

Resistivity grid coordinates based on Ordnance Survey OSGB36 datum

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

Survey grid size = 30m

Survey start and traverse direction

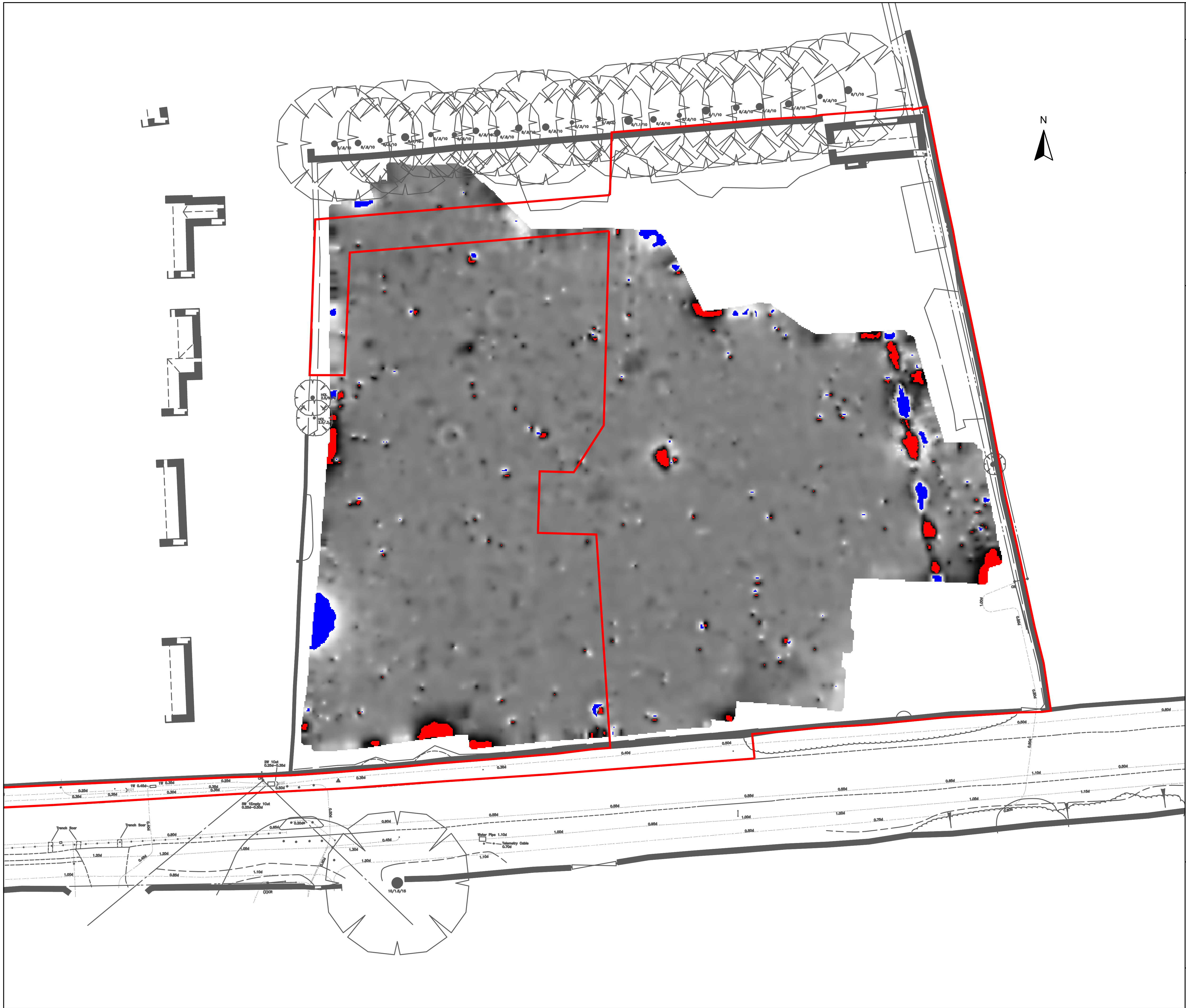
1 Grid reference number and filename

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 02



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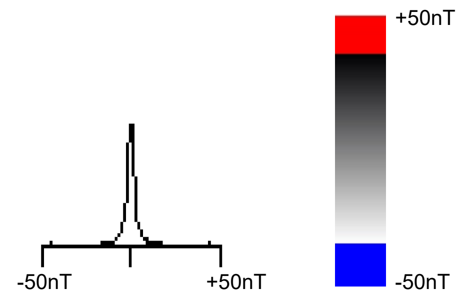
Greyscale plot of minimally processed magnetometer data clipped at ±50nT

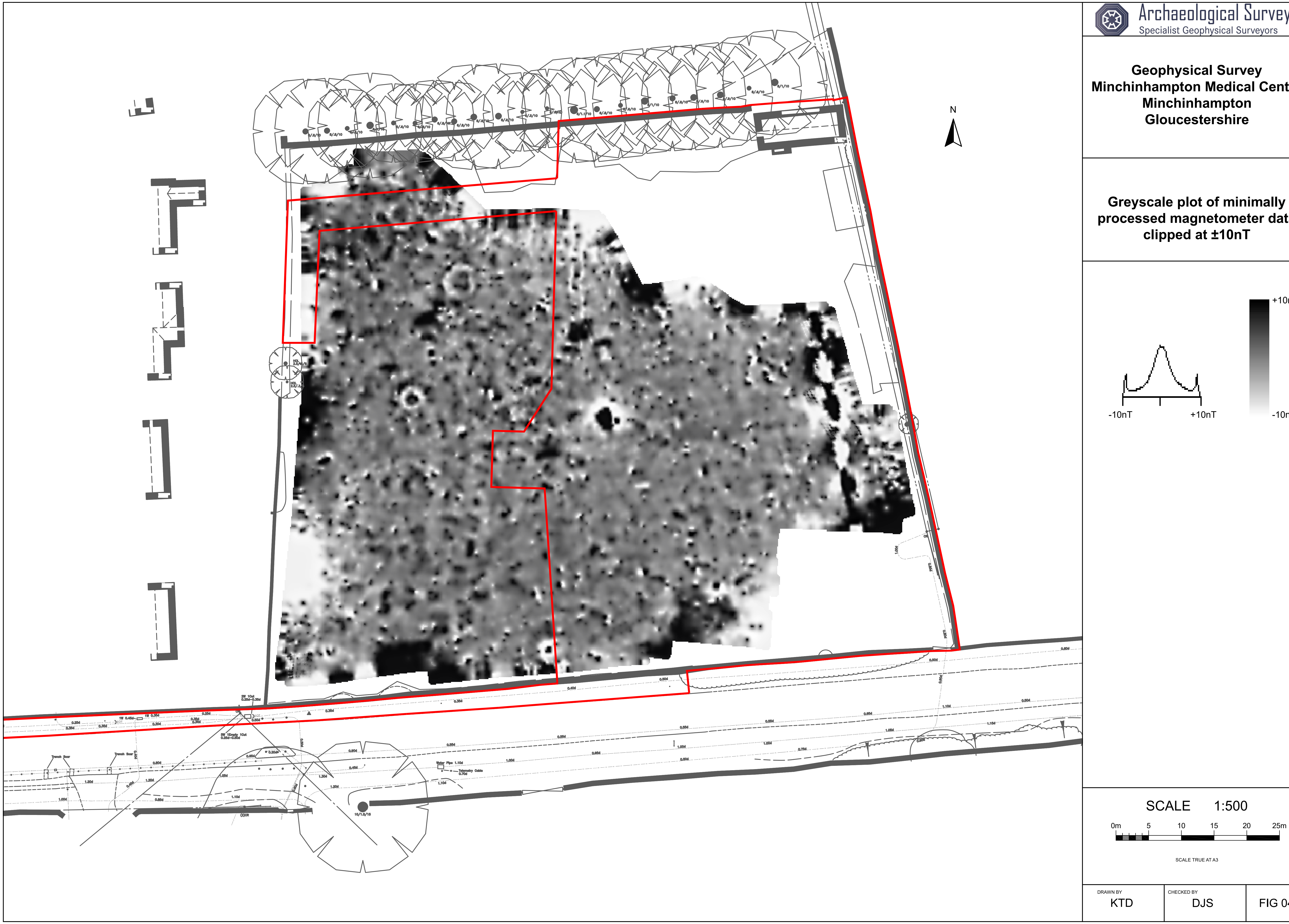


SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 03



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Greyscale plot of minimally processed magnetometer data clipped at ±10nT

SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 04

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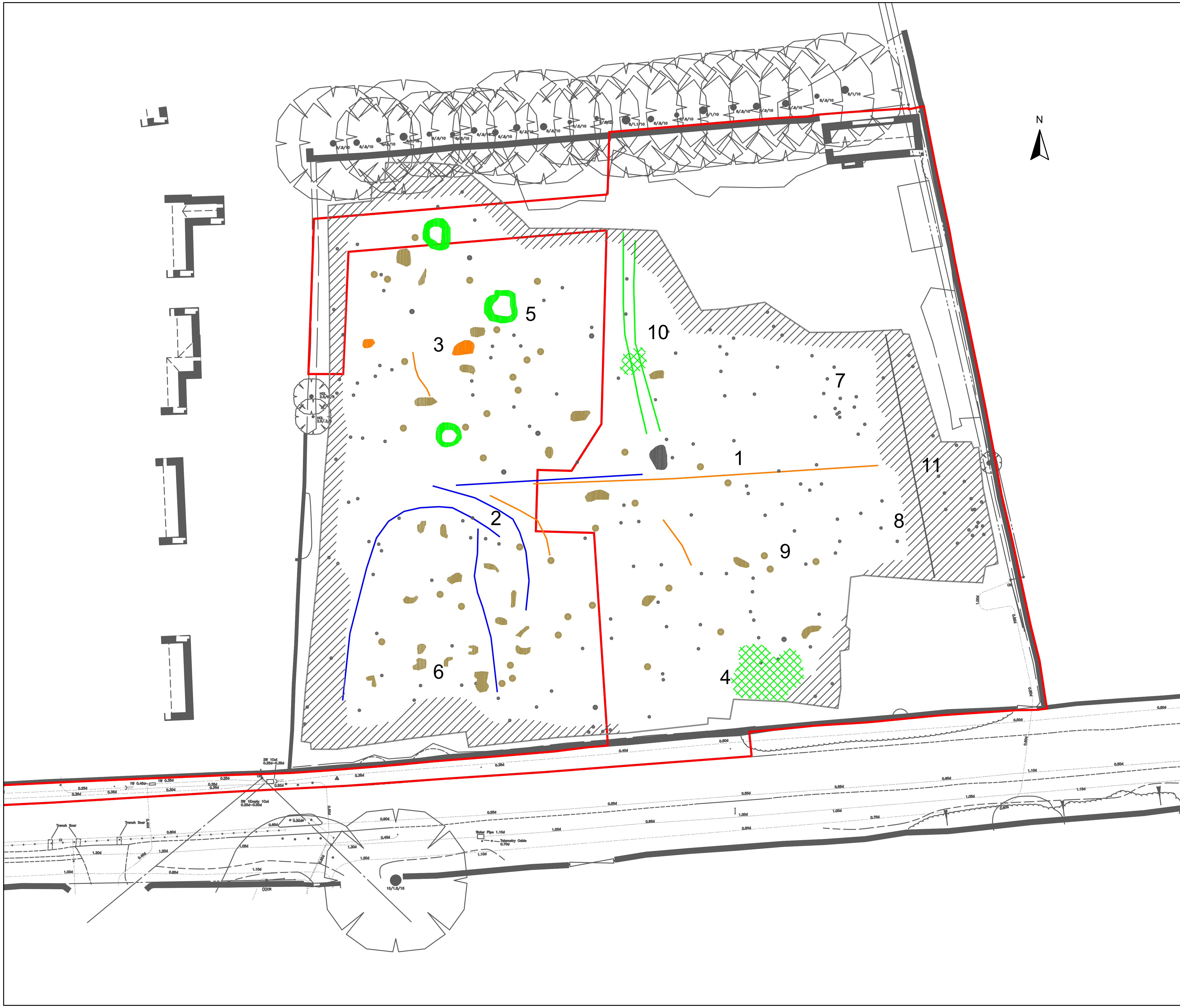
Abstraction and interpretation of magnetic anomalies



- Positive linear anomaly - possible ditch-like feature
- Negative linear anomaly - material of low magnetic susceptibility
- Linear anomaly - vehicle ruts
- Negative curvilinear anomaly - associated with animal feeding
- Discrete positive response - possible pit-like feature
- Discrete positive response - pit-like feature of natural origin
- Magnetic enhancment - associated with animal feeding
- Magnetic disturbance from ferrous material
- Strong multiple dipolar linear anomaly - pipeline / cable / service
- Strong dipolar anomaly - ferrous object

SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 05

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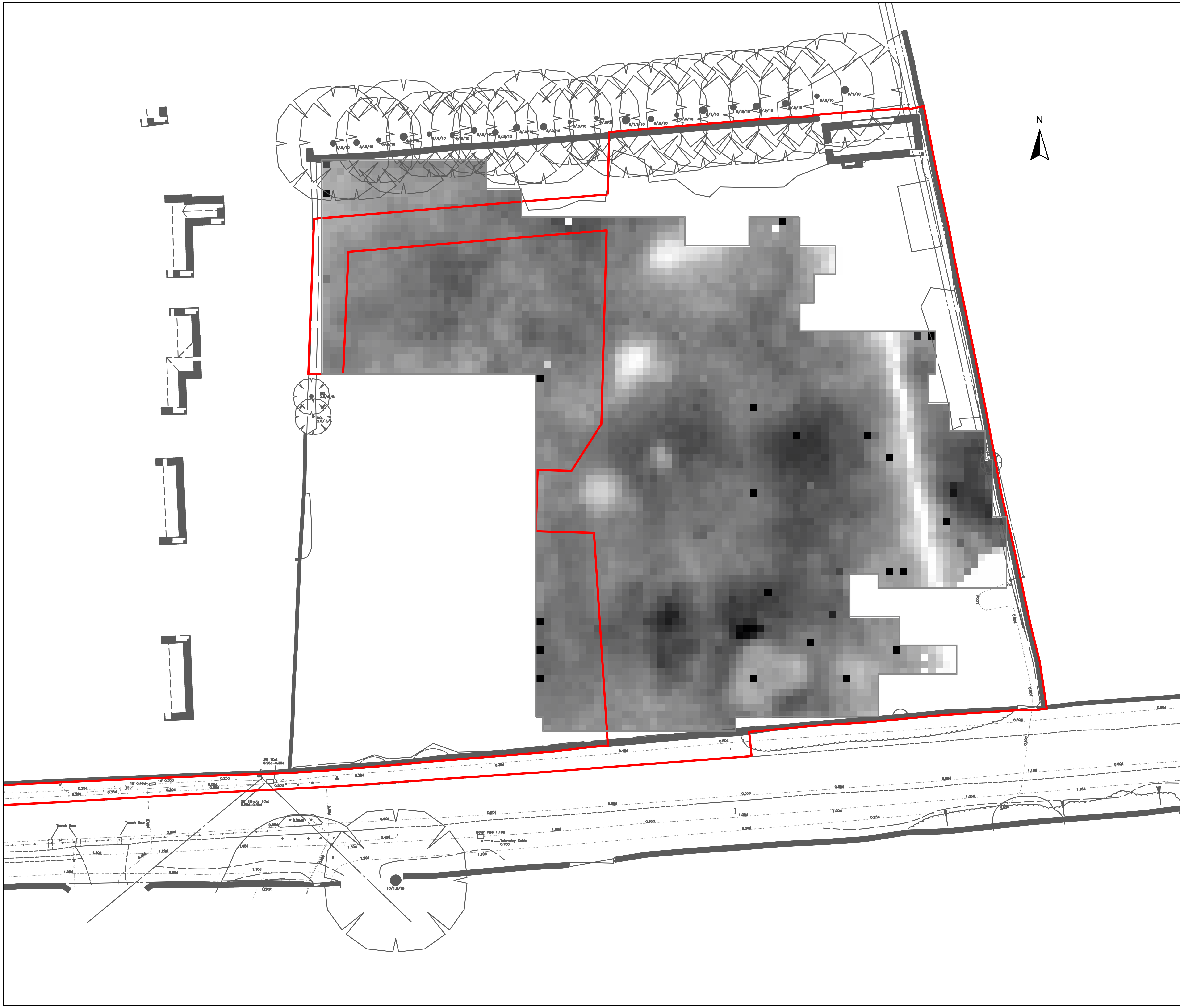
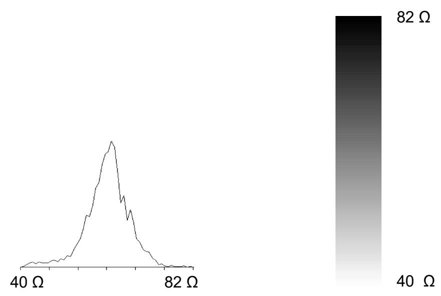


Greyscale plot of raw earth resistance data

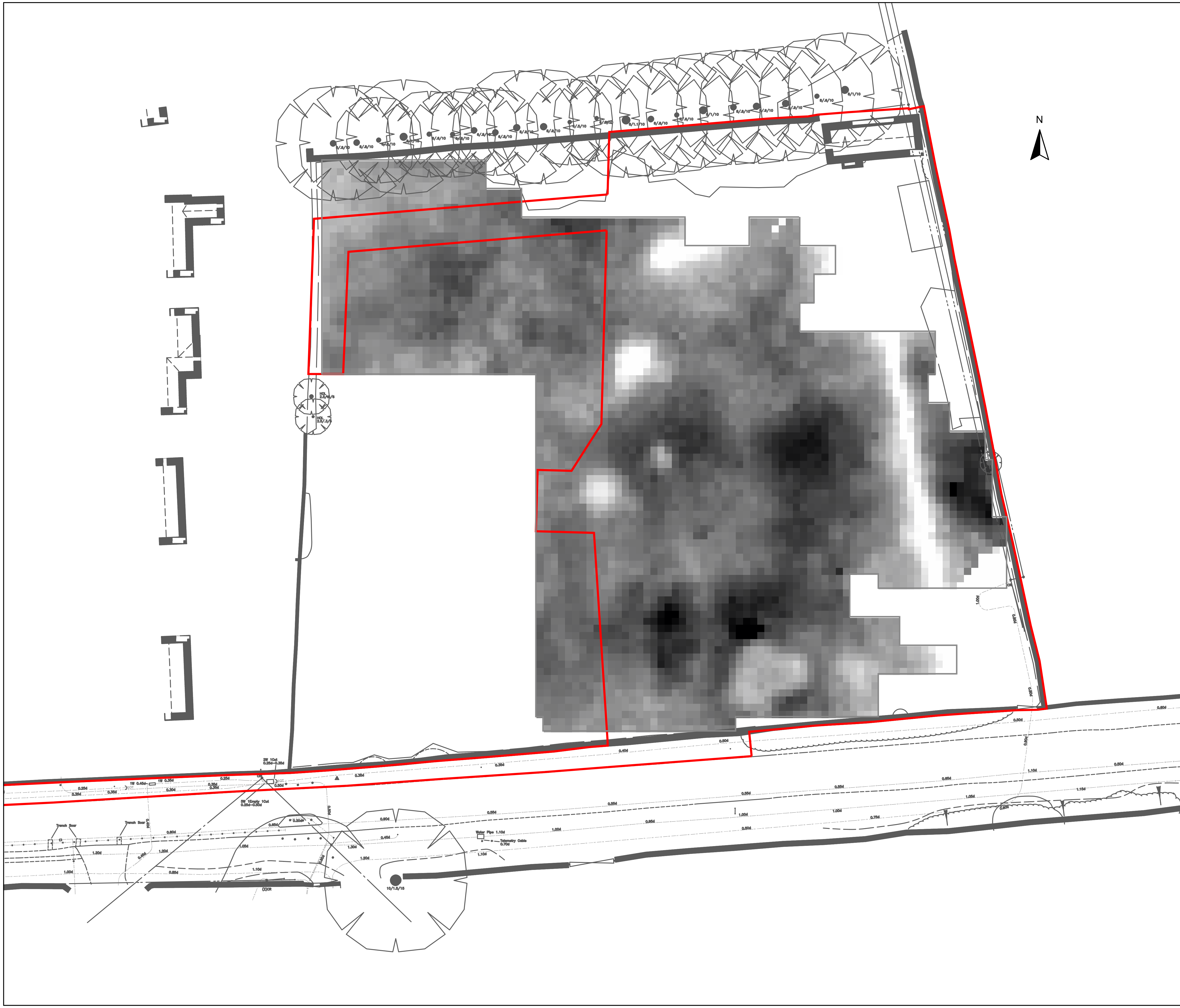


SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 06



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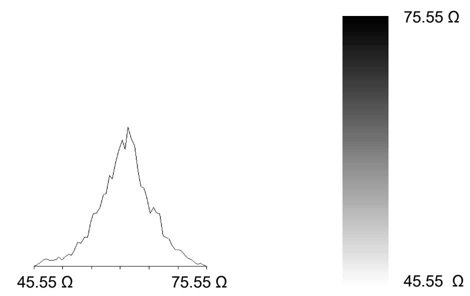
Greyscale plot of processed earth resistance data

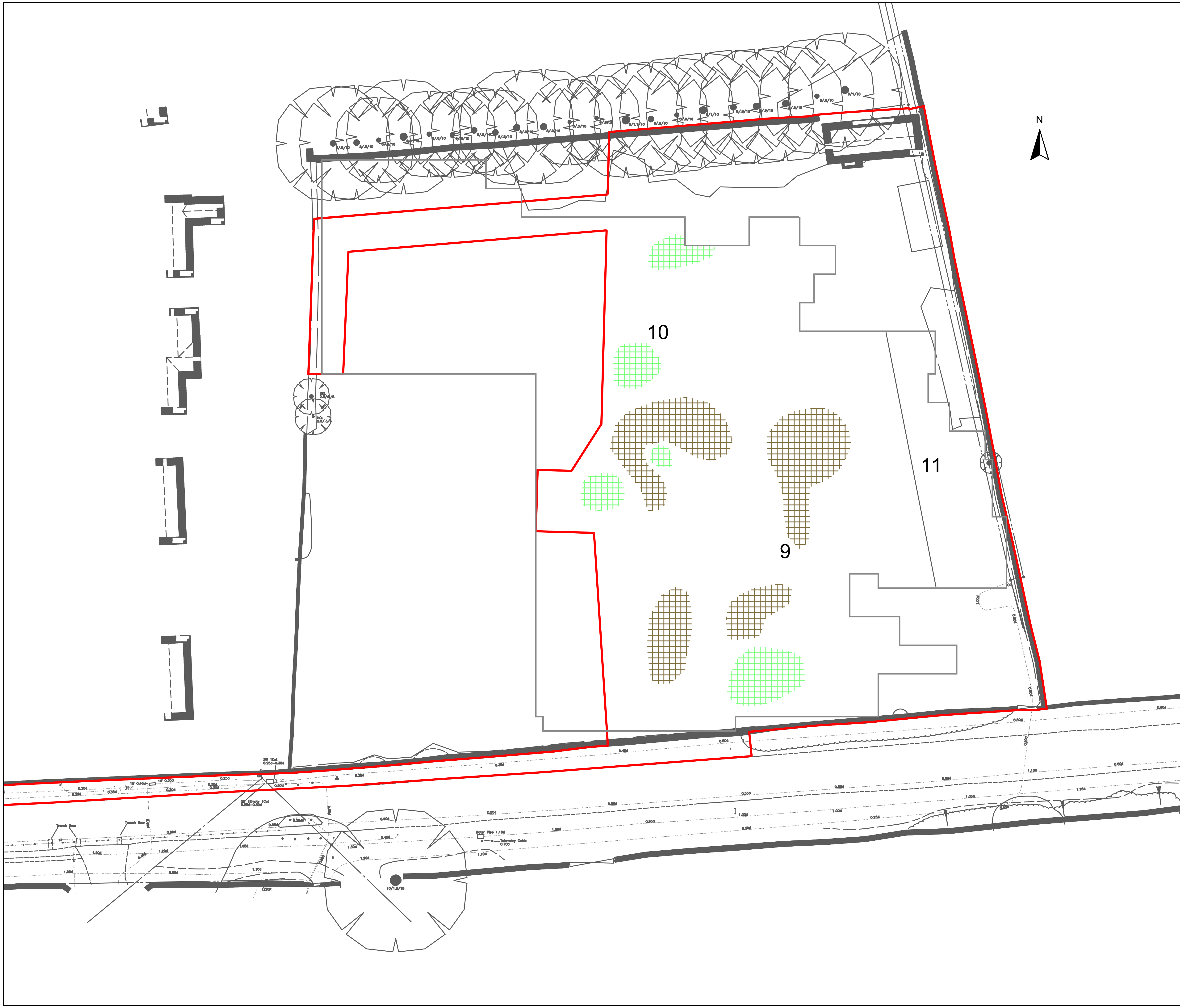


SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 07



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Abstraction and interpretation of earth resistance anomalies

Area of low resistance - associated with animal feeding

Area of high resistance - of uncertain origin

Low resistance linear anomaly - service/pipe

SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 08

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Abstraction and interpretation of magnetic anomalies

SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 09