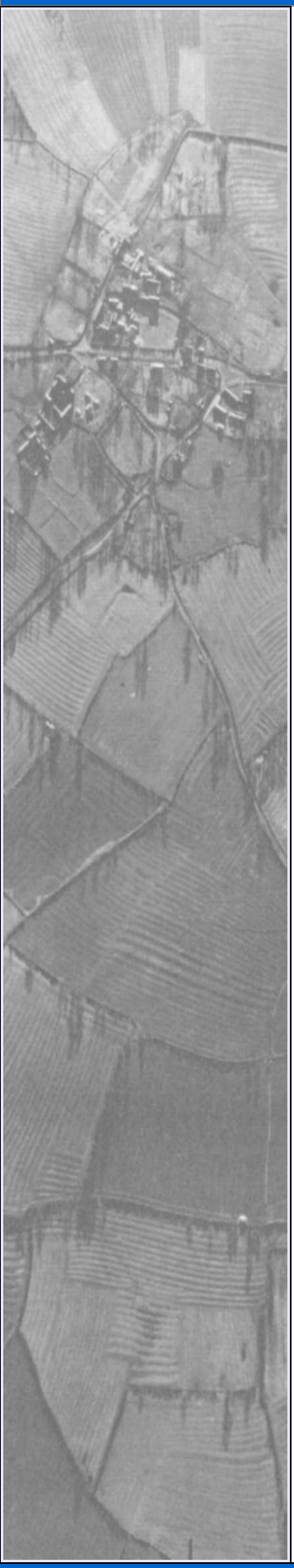

Sarsen Kennels
West Kennett
Avebury
Wiltshire

MAGNETOMETER AND
EARTH RESISTANCE SURVEY REPORT

for

AC Archaeology Ltd

David Sabin and Kerry Donaldson

December 2016

Ref. no. J688

ARCHAEOLOGICAL SURVEYS LTD

Sarsen Kennels
West Kennett
Avebury
Wiltshire

Magnetometer and Earth Resistance Survey

for

AC Archaeology Ltd

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

Survey dates – 16th, 19th, 22nd, 23rd & 29th November 2016
Ordnance Survey Grid Reference – **SU 11592 68094**

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SUMMARY

A geophysical survey was carried out by Archaeological Surveys Ltd on land within and to the east and west of Sarsen Kennels, West Kennett near Avebury in Wiltshire. The site lies within the scheduled monument of the West Kennet Avenue, which is believed to extend from Avebury to the north west to the Sanctuary immediately east of the site on Overton Hill. Much of the extent of the West Kennet Avenue comes from antiquarian sketch plans by Aubrey in the 17th century and Stukeley in the 18th century with further investigations by OGS Crawford in 1922 and Isobel Smith in 1965. Four stones have been mapped within the field margin on the southern edge of the A4 to the west of Sarsen Kennels from 1885 onwards. Although the line is purported to extend within the Sarsen Kennels property and beyond to the east, based on Stukeley's sketches and OGS Crawford's observations, no intrusive investigation has been carried out to determine this.

An earth resistance survey, supplemented by magnetometry, was carried out within two areas of the Sarsen Kennels garden (Areas 1 & 2) and to the east (Area 3) and to the west (Area 4). The results show a small number of high resistance anomalies within the Sarsen Kennels lawns; however, the site is highly disturbed with dumped material, trees, hedges and modern infrastructure including a septic tank and so while such high resistance responses can relate to buried stones, their archaeological potential cannot be determined due to the widespread modern contamination within the site.

Within Area 4 to the west, a high resistance response adjacent to the hedge appears to relate to stone 86b outlined in Crawford's and Smith's observations. To the south west of this are other high resistance anomalies, forming a line of two and a line of three, parallel with the A4, and also the Avenue. While they may relate to buried stones, it is not possible to determine if they are associated with the Avenue.

Within Area 3 a number of discrete low resistance responses correspond to discrete positive magnetic anomalies which indicate the presence of pit-like features. While such features can be naturally formed, the elongated shape of several could indicate intercut pits, similar to those identified through excavation within the Sanctuary immediately to the east and an archaeological origin should be considered. The line of at least three pipelines can be seen to extend through the northern part of Area 3, and it is possible that these have clipped the northern edge of the Sanctuary.

The results of the survey have not provided conclusive evidence or clarification of the line of the West Kennett Avenue within or immediately adjacent to the Sarsen Kennels.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by AC Archaeology Ltd, on behalf of Mr N Baldock, to undertake a magnetometer and earth resistance survey (resistivity) of an area of land at Sarsen Kennels, West Kennett, Avebury, Wiltshire. The site has been outlined for a proposed development and the survey forms part of an archaeological assessment of the site.

1.1.2 The site lies within the World Heritage Site of *Stonehenge, Avebury and Associated Sites* and has been designated as a part of the scheduled monument (No. 1015547) *West Kennet Avenue and an earthwork bank east of West Kennett Farm*. In order to carry out the geophysical survey within the scheduled area, a licence, under Section 42 of the 1979 Ancient Monuments and Archaeological Areas Act (as amended by the National Heritage Act 1983), was granted by Phil McMahon, Inspector of Ancient Monuments for Historic England, prior to commencing the fieldwork.

1.1.3 The owner of Sarsen Kennels is considering a future planning application with proposals that include renovation, conversion and extension of two of the existing buildings that may well be located in the vicinity of where the West Kennet Avenue stones may have been positioned. It is also proposed that other structures are to be removed which may have the potential to enhance the setting of the line of the West Kennet Avenue.

1.1.4 The actual position of the stones within the West Kennet Avenue has been subject to much speculation. It is considered likely that many stones have been destroyed and used within local buildings. As there is the potential for the site to contain stones or stone sockets related to the Avenue, it was proposed that the geophysical survey was undertaken within accessible and suitable parts of the Sarsen Kennels property and also within land immediately to the east and west of the site in order to try to establish the line of the avenue. As the land either side belongs to the National Trust, an Archaeological Research Agreement was granted by the National Trust Archaeologist, Dr Nicola Snashall.

1.1.5 The geophysical survey was carried out in accordance with a Written Scheme of Investigation (WSI) produced by Archaeological Surveys (2016). This was issued to Historic England as part of the Section 42 licence application and to the National Trust as part of the application for the Archaeological Research Agreement.

1.2 Survey objectives and techniques

1.2.1 The objectives of the survey are to use non-intrusive geophysical techniques to establish the presence/absence, extent, condition, character, quality and date of specifically any stones or stone settings and in general any archaeological deposits within the surveyable area.

1.2.2 Both magnetometry and resistivity were considered potentially useful techniques. Previous resistivity surveys carried out within the World Heritage Site and targeted on buried sarsen stones, or the location of former stones, have demonstrated useful results, with both high and low resistance anomalies located.

1.2.3 Prior to the survey, magnetic susceptibility tests were conducted using a Bartington MS2 meter on both burnt and unburnt sarsen fragments (approximately 300mm across) collected from land to the east of Swindon. It is known that large sarsens in the vicinity of the site were broken up by the use of fire. The unburnt fragments demonstrate a diamagnetic response with a very slightly enhanced magnetic susceptibility for burnt pieces. The latter were subject to intense heat and were slightly reddened in colour suggesting the presence of a very small amount of ferrous mineral within the rock. However, it is considered very unlikely that burnt or unburnt sarsens could be located by magnetometry. It may be possible to locate soil subject to intense burning where sarsens have been destroyed as its magnetic susceptibility is likely to be considerably higher. Magnetic survey may also locate other former cut features such as ditches and pits. A geophysical survey within the line of the Beckhampton Avenue located weakly positive magnetic responses interpreted as possible burnt sarsens associated with a pit (David et al, 1999) with resistivity indicating buried stones. Subsequent excavation revealed several pits containing buried sarsens and pits with removed sarsens (Gillings et al, 2000).

1.2.4 Much of the land within the Sarsen Kennels property has been developed with buildings, fences, vegetation and terraced gardens. The actual development area was considered unsuitable for survey. However, work was carried out in accessible and suitable areas; the lawn to the east of the property and the two fields to the east and west of the property, based on the purported positions of the stone settings of the West Kennet Avenue. The outlined survey area therefore covered the two lawned areas within the Sarsen Kennels gardens (Areas 1 & 2) and a zone to the east (Area 3) and to the west (Area 4), based on the line of the Avenue as indicate by OGS Crawford from Stukeley's sketch plans and his own observations of discoloured soils in 1922. However, the survey was extended towards the Sanctuary at the eastern edge of the site in order to be able to determine if any stone settings extended away from the monument.

1.2.5 The survey and report generally follow the recommendations set out by: English Heritage (2008) *Geophysical survey in archaeological field evaluation;* 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.*

1.3 Site location, description and survey conditions

1.3.1 The site is located at Sarsen Kennels, West Kennett, Avebury, Wiltshire. It is centred on Ordnance Survey National Grid Reference (OS NGR) SU 11592 68094, see Figs 01 and 02.For the purposes of this report, the site includes four separate survey areas which are described below.

1.3.2 Survey Areas 1 and 2 cover two small lawns amounting to 0.1ha immediately east of the proposed development. Both magnetometry and resistivity were carried out across the areas. The ground cover was short grass, Area 1 slopes down gently towards the west and Area 2 is generally flat. The former is bounded by buildings, sheds and fencing adjacent to the A4 along the northern side. To the west is a drive and parking area with fencing separating it from Area 3 to the south. Area 2 contains several inspection chambers possibly associated with a buried septic tank in the south western part of the lawn. There are trees and shrubs to the west and east with the house to the north and a drive to the south. The northern part of the lawn contains a large tree. The eastern side of the lawn is edged by sarsen stones.

Plate 1: Area 1 looking west

1.3.3 Area 3 is located within the field to the south and east of the Sarsen Kennels property on land owned by the National Trust. It is a zone that runs from the southern boundary of the Sarsen Kennels to the western boundary of the Sanctuary. Ground cover was long grass that was uneven and thick, a mown footpath crosses the area from east to west. Land slopes down from an elevated flat area at the Sanctuary to the lane to East Kennett. Approximately 1.35ha was covered using magnetometry and 0.8ha with resistivity. The survey area was extended from that proposed in the WSI due to widespread magnetic disturbance relating to buried pipelines obscuring much of the originally proposed survey zone. Although the resistivity survey was generally unaffected by the pipelines, the extension of this technique also was useful in clarifying the nature and extent of some anomalies.

Plate 2: Area 3 looking west towards Sarsen Kennels

1.3.4 Area 4 is a 30m wide strip within the field to the west of the lane to East Kennett located to the west of Sarsens Kennels. It lies immediately south of the hedgerow bounding the A4. Both magnetometry and resistivity were carried out over 0.4ha. The ground cover consisted of long grass and the hedgerow had spread into the field in places. A mown strip running from south east to north west crosses the western part of the area and defines the course of a footpath. An area of thick nettles appeared slightly raised possibly indicating recent deposition of soil or manure. Three large sarsen stones were visible within the boundary with the A4; one placed on top of another near the western end of the survey area and one to the north west of the central part of the survey. A distinct mound extending from the hedge into the field, close to the central part of the survey area, was considered a likely candidate for a buried sarsen.

Plate 3: Area 4 looking west

1.3.5 The ground conditions across the site were variable with challenging conditions within Areas 3 and 4 due to the presence of thick and tall ground cover impeding both magnetometry and resistivity.

1.3.6 Weather conditions during the survey were variable with survey abandoned on 2 days due to heavy rainfall. However, ground moisture at deeper levels was considered likely to be low for the time of year due to extended periods of dry weather through the Summer and Autumn.

1.4 Site history and archaeological potential

1.4.1 A desk-based assessment of evidence for the West Kennet Avenue in the vicinity of Sarsen Kennels has been carried out by AC Archaeology (2016). The site lies within the World Heritage Site of *Stonehenge, Avebury and Associated Sites* and is part of the scheduled area (No. 1015547) *West Kennet Avenue and an earthwork bank east of West Kennett Farm*. The West Kennet Avenue is a double line of standing stones that is believed to link Avebury henge (2km to the north west) with the Sanctuary (150m to the east); however, there are few surviving stones. Much of the inferred position of the stones is based on antiquarian drawings by Aubrey and Stukeley in the 17th and 18th centuries, but also on the work of OGS Crawford in the 1920s in which he derived the positions from measurement of Stukeley's drawings and based on his own observations of the soil. This has been transposed onto Google Earth by Steve Marshall (2016a & 2016b) and the positions are indicated in Fig 2. Isobel Smith also recorded the line of the stones to the west of Sarsen Kennels in the 1960s and the position of four stones has been recorded in the western field since the first edition Ordnance Survey map in 1885.

1.4.2 The Sanctuary lies to the east of the survey area, on Overton Hill, first described as Millfield circle on Seven Barrow Hill by Aubury in the 17th century, named the Sanctuary by Stukeley in the 18th century. It was excavated in 1930 by Maud Cunnington where it was discovered to consist of two stone circles and six concentric circles of post-holes, with one containing an adolescent burial (Cunnington, 1931). Part of the site was re-excavated in 1999, which revealed that several of the pits were "doubles" or had several re-cuts and therefore appear more oval in shape, rather than circular. It appears that there were large timber posts erected, removed and replaced in what could be a short timescale (Pitts, 2001).

1.4.3 The eastern part of the site also contains an oil pipeline that was part of the Government Pipelines and Storage System, known as the CLH Pipeline System from 30th April 2015 when it was sold to a Spanish company. The pipeline extends from Avonmouth, eastwards to Aldermaston and eventually links up to the Isle of Grain in Kent. The network of pipelines were constructed at night during the Second World War, under statutory powers

relating to the Defence Regulations Act 1939, to supply aviation fuel to airfields across the country (MOD, 2011). They are now part of the commercial aviation fuel supply. A previous geophysical survey within the field established that there was more than one highly magnetic pipeline (Archaeological Surveys, 2008). The presence of the buried pipelines and the resulting widespread and strongly magnetic disturbance indicate that further magnetometer survey would be disturbed, with weaker anomalies obscured. The survey has been carried out using earth resistance measurements, supplemented by magnetometry, to establish the location of the pipelines and also mainly within less disturbed areas, weaker anomalies are likely to be visible.

1.5 Geology and soils

1.5.1 The underlying solid geology across the site from the Holywell Nodular Chalk Formation and New Pit Chalk Formation with overlying deposits of river terrace sands and gravels to the west (BGS, 2016).

1.5.2 The overlying soil across the survey area is on the cusp of the Andover 1 association, which is a brown rendzina and consists of a shallow, well drained, calcareous, silty soil over chalk with soil patterns locally, and the Frome association which is a calcareous alluvial gley soil consisting of shallow, calcareous and non-calcareous loams over flint gravel associated with a river terrace (Soil Survey of England and Wales, 1983).

1.5.3 Magnetometry survey carried out across similar soils has produced good results. However, magnetic susceptibility may be very low and as a consequence soil filled features may lack magnetic contrast and not produce anomalies.

2 METHODOLOGY

2.1 Technical synopsis

2.1.1 Magnetometry survey records localised magnetic fields that can be associated with features formed by human activity. Magnetic susceptibility and magnetic thermoremnance are factors associated with the formation of localised fields. Additional details are set out below and within Appendix A.

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

2.1.3 Magnetic thermoremnance can occur when ferrous minerals have been heated to

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

2.1.4 The localised variations in magnetism are measured as sub-units of the Tesla, which is a SI unit of magnetic flux density. These sub-units are nano Teslas (nT), which are equivalent to 10^{-9} Tesla (T).

2.1.5 The electrical resistance or resistivity of the soil depends upon the moisture content and distribution within the soil. 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. Localised variations in resistance are measured in ohms (Ω) which is the SI unit for electrical impedance or resistance.

2.1.6 The Twin Probe configuration used in this survey is favoured for archaeological prospection and can give a response to features up to 1m in depth with a mobile probe separation of 0.5m.

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 20 Hz. 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 ±10,000nT. They are linked to a Leica GS10 RTK GPS with data recorded by SENSYS MAGNETO®MXPDA software on a rugged PDA computer system.

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

2.2.3 Data are collected along a series of parallel survey transects to achieve 100% coverage of the surveyable land. The length of each transect is variable and relates to the size of the survey area and other factors including ground conditions. A visual display allows accurate placing of transects and helps maintain the correct

separation between adjacent traverses. Data are not collected within fixed grids and data points are considered to be random even though the data are collected in a systematic manner covering all accessible areas (Aspinall, Gaffney and Schmidt, 2009).

2.2.4 Fluxgate sensors are highly sensitive to temperature change and this is manifest 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.

2.2.5 The earth resistance survey was carried out using Geoscan Research Ltd RM85 resistance meter using a mobile parallel twin probe array with a 0.5m electrode separation. Data were recorded at 0.5m intervals along traverses separated by 0.5m. 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 in size.

2.2.6 The earth resistance survey grids were set out to the Ordnance Survey OSGB36 datum using a Leica GS10 RTK GPS. The GPS 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. The instrument is regularly checked against the ETRS89 reference framework using Ordnance Survey ground marker C1ST7784 (Horton).

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 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 ±10000nT and clipped for display at ±5nT. Data are interpolated to a resolution of effectively 0.5m between tracks and 0.15m along each survey track. Additional data processing has been carried out for Areas 1 and 3 in the form of high pass filtering (Fig 11). This effectively removes low frequency variation along a traverse that has been caused by large magnetic bodies, cultivation, rapid temperature change. Data treated to additional processing has been compared to unprocessed data to ensure that no significant anomalies have been removed.

2.3.4 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.

2.3.5 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 2.3.1 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 very high density of data collection.

2.3.6 Data logged by the resistance meter are downloaded and processed within TerraSurveyor Geoplot 4 software. Raw data are analysed and displayed within the report as well as processed data. Appendix C outlines the processing sequence with further information on processing set out within Appendix B. TIF files are prepared in TerraSurveyor Geoplot 4 for the earth resistance data. The main form of resistivity data display used in the report is the minimally processed greyscale plot.

2.3.7 The raster images are combined with base mapping using ProgeCAD Professional 2014 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.

2.3.8 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.

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

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

3 RESULTS

3.1 General assessment of survey results - magnetometry

3.1.1 The detailed magnetic survey was carried out over a total of four survey areas covering approximately 1.85ha.

3.1.2 Magnetic anomalies located can be generally classified as positive and negative anomalies of an uncertain origin, areas of magnetic 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 below with subsequent discussion in Section 4.

3.2 Statement of data quality - magnetometry

3.2.1 Data are considered representative of the magnetic anomalies present within the site. However, widespread magnetic disturbance within Areas 1 - 3 has the potential to obscure anomalies of archaeological potential. In addition, the magnetic contrast of a possible ditch-like feature in Area 4 is very poor, and the soil in this area may not be conducive to the formation of enhanced magnetic susceptibility limiting confidence in the location of features of archaeological potential.

3.3 Data interpretation - magnetometry

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

Report sub-heading CAD layer names and plot colour	Description and origin of anomalies
Anomalies with an uncertain origin AS-ABST MAG POS LINEAR UNCERTAIN AS-ABST MAG NEG LINEAR UNCERTAIN AS-ABST MAG POS DISCRETE UNCERTAIN 	The category applies to a range of anomalies where there is not enough evidence to confidently suggest an origin. Anomalies in this category may well be related to archaeologically significant features, but equally relatively modern features, geological/pedological features and agricultural features should be considered. Positive anomalies are indicative of magnetically enhanced soils that may form the fill of 'cut' features or may be produced by accumulation within layers or 'earthwork' features; soils subject to burning may also produce positive anomalies. Negative anomalies are produced by material of comparatively low magnetic susceptibility such as stone and subsoil.
Anomalies associated with magnetic debris AS-ABST MAG STRONG DIPOLAR 	Strong discrete dipolar anomalies are responses to ferrous objects within the topsoil.
Anomalies with a modern origin AS-ABST MAG DISTURBANCE AS-ABST MAG SERVICE 	The magnetic response is often strong and dipolar indicative of ferrous material and may be associated with extant above surface features such as wire fencing, cables, pylons etc.. Often a significant area around such features has a strong magnetic flux which may create magnetic disturbance; such disturbance can effectively obscure low magnitude anomalies if they are present. Fluxgate sensors may respond erratically and with hysteresis adjacent to strong magnetic sources. Buried services may produce characteristic multiple dipolar anomalies dependant upon their construction.

Table 1: List and description of magnetometry interpretation categories

3.4 General assessment of survey results - resistivity

3.4.1 The earth resistance survey was carried out over a total of four survey areas covering approximately 1.35ha.

3.4.2 Resistive anomalies located can be generally classified as high resistance anomalies associated with possible buried stones, high and low resistance anomalies of uncertain origin, high resistance anomalies associated with land management, high and low resistance anomalies associated with ground disturbance/dumping and anomalies with a modern origin. Anomalies located within each survey area have been numbered and will be outlined below with subsequent discussion in Section 4.

3.5 Statement of data quality - resistivity

3.5.1 Data are considered representative of the resistive anomalies present within the site. Resistive contrast appears useful with the location of both high and low resistance anomalies of anthropogenic origin. However, the underlying geology and soil has created a variable response that may complicate the abstraction and interpretation of features.

3.6 Data interpretation - resistivity

3.6.1 The listing of sub-headings below attempts to define a number of separate categories that reflect the range and type of features located during the earth resistance survey. A basic explanation of the characteristics of the anomalies is set out for each category in order to justify interpretation, a basic key is indicated to allow cross reference to the abstraction and interpretation plot. Sub-headings are then used to group anomalies with similar characteristics for each survey area.

Report sub-heading CAD layer names and plot colour	Description and origin of anomalies
Anomalies with archaeological potential AS-ABST RES HIGH DISCRETE ARCHAEOLOGY	High resistance may indicate structural material (e.g. stone); low resistance may relate to the moisture retentive fill of cut features.
Anomalies with an uncertain origin AS-ABST RES HIGH LINEAR UNCERTAIN AS-ABST RES LOW LINEAR UNCERTAIN AS-ABST RES HIGH DISCRETE UNCERTAIN AS-ABST RES LOW DISCRETE UNCERTAIN AS-ABST RES HIGH AREA UNCERTAIN AS-ABST RES LOW AREA UNCERTAIN	The category applies to a range of anomalies where there is not enough evidence to confidently suggest an origin. Anomalies in this category may well be related to archaeologically significant features, but equally relatively modern features, geological/pedological features and agricultural features should be considered. 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 relating to land management AS-ABST HIGH RES BANK/BOUNDARY	Anomalies are mainly linear and may relate to low resistance cut features (i.e. ditches) or high resistance features such as banks. The anomalies may be long and/or form rectilinear elements and they may relate to topographic features or be visible on early mapping. Associated agricultural anomalies (e.g. headlands, plough marks and former ridge and furrow) may support the interpretation.
Anomalies associated with ground disturbance AS-ABST HIGH RES DISURBANCE/TREE ROOTS AS-ABST LOW RES DISTURBANC/DUMPING	Anomalies associated with quarrying and infilled depressions may be a low resistance response. It may also have associated high resistance anomalies, possibly indicating bands of rock near the surface. High resistance responses can be associated with dumped material and also tree roots. Low resistance responses may also indicate dumped material with a high moisture content.
Anomalies with a natural origin AS-ABST RES SERVICE AS-ABST RES PATH	The anomalies may be high, low or variable. Low resistance linear anomalies may relate to the infilled cut of a service trench, or to the highly conductive properties of the service. Anomalies relating to existing paths and tracks can be high or low resistance anomalies and relate to visible or mapped paths.

Table 2: List and description of resistivity interpretation categories

3.7 List of anomalies – magnetometry Area 1

Area centred on OS NGR 411623 168092, see Figs 03, 04, 08 & 09.

3.7.1 Area 1 contains magnetic disturbance and strong discrete dipolar responses which relate to ferrous and other magnetically thermoremnant objects. No weaker anomalies are visible.

3.8 List of anomalies – magnetometry Area 2

Area centred on OS NGR 411580168103, see Figs 03, 04, 08 & 09.

3.8.1 Area 2 is a very small patch of lawn which is surrounded to the north and west by trees and contains a septic tank. Although a number of discrete positive responses can be seen, they are generally over 30nT and lie within a zone of magnetic disturbance and strong discrete dipolar anomalies; a modern origin is likely.

3.9 List of anomalies – magnetometry Area 3

Area centred on OS NGR 411670 168045, see Figs 03, 04, 08 & 09.

Anomalies with an uncertain origin

(1) - A number of discrete positive responses are located at the eastern end of the survey area. They are situated on the higher ground, but close to the Sanctuary. Some are circular, but most are elongated or more amorphous. Several correspond to low resistance discrete responses. It is possible that they relate to naturally formed pit-like features within the underlying chalk; however, they may relate to single, conjoined or recut pits with an archaeological origin.

(2 & 3) - Towards the western end of the survey area are two groups with positive and negative linear anomalies and several discrete responses. They are very weak and poorly defined and they lack a coherent morphology preventing interpretation.

Anomalies with a modern origin

(4) - The northern part of the survey area contains three buried pipelines with a short section of a fourth appearing to link between two of them. Unless they diverge abruptly at the eastern edge of the site, it appears that they enter the scheduled area of the Sanctuary. The strength of the responses is so strong, that there is widespread magnetic disturbance along the northern part of the survey area which may have obscured weaker anomalies. At least one oil pipeline was constructed during 1942, but it appears that at least two others have also been constructed.

(5) - Magnetic disturbance and strong dipolar responses are associated with the metal ties of a former electricity pole.

3.10 List of anomalies – magnetometry Area 4

Area centred on OS NGR 411447 168186, see Figs 03, 04, 08 & 10.

Anomalies with an uncertain origin

(6) - A small number of, discrete, positive responses are located in the survey area. There are also widespread strong discrete dipolar responses, and it is difficult to determine if these relate to cut, pit-like features, or if they also relate to magnetically thermoremnant material.

(7) - Very weakly positive linear anomalies can be seen, but they are so indistinct that their origin cannot be determined.

3.11 List of anomalies – resistivity Area 1

Area centred on OS NGR 411623 168092, see Figs 05 - 08 & 11.

Anomalies with an uncertain origin

(8) - A low resistance linear anomaly extends through the survey area. It is not clear if it continues into Area 3 to the south east, but it may have an association with anomaly (20) and possibly (21). There is no corresponding magnetometer anomaly, and it is not clear if it relates to a ditch-like feature or possibly a service.

(9 & 10) - Low resistance linear responses of uncertain origin that may indicate ditch-like features.

(11) - Discrete high resistance response is located close to the edge of the survey area. Its origin is uncertain.

(12) - Along the margins of the survey area are zones of high resistance. These relate to ground make up and tree roots or drier areas at the edge of the garden.

3.12 List of anomalies – resistivity Area 2

Area centred on OS NGR 411580 168103, see Figs 05 - 08 & 11.

Anomalies with an uncertain origin

(13) - A discrete high resistance response can be seen in the survey area. While this type of response could relate to a buried stone, it lies adjacent to a garden border bounded by sarsen stones and may be or relatively recent origin.

(14) - A high resistance anomaly in the north western corner of the lawn has been caused by dry ground adjacent to a tree.

3.13 List of anomalies – resistivity Area 3

Area centred on OS NGR 411670 168045 see Figs 05 - 08 & 11.

Anomalies with an uncertain origin

(15) - The far eastern part of the survey area contains a number of discrete low resistance responses. Many of them correspond to discrete positive responses seen in the magnetometer data and they appear to relate to pit-like features.

(16) - Several discrete high resistance responses can also be seen in the eastern part of the survey area. It is not possible to determine their origin.

(17) - A low resistance curvilinear response is located in the south eastern corner of the survey area. The response could suggest a curvilinear ditch-like feature, but this not certain.

(18) - A high resistance response, with an adjacent low resistance response, appears to be truncated by at least one pipeline (23).

(19) - High resistance linear and curvilinear responses are situated to the west of anomaly (18). It is possible that there has been some truncation by pipeline (24), but the origin of the anomaly or anomalies is uncertain.

(20) - Low resistance responses that appear to have some association with pipeline (24) but also possibly anomalies (8) and (10) in Area 1.

(21) - A low resistance linear anomaly does not extend along the line of a pipeline response as seen in the magnetometer results; however, it could still relate to a service that is not visible magnetically. The west north west to east south east orientation of the first part of (21) could be a continuation of anomalies (8) or (10), although it then appears to extend abruptly towards the north east.

(22) - Low resistance linear response is located just to the south of the highly magnetic response to a buried pipeline. The response is likely to be associated, with (24).

Anomalies with a modern origin

(23 & 24) - Low resistance linear anomalies relate to buried pipelines with corresponding responses in the magnetometer data.

(25) - A low resistance linear anomaly is a response to the footpath that extends through the survey area. The response is very similar to those associated with the pipelines, but no corresponding response can be seen in the magnetometry.

3.14 List of anomalies – resistivity Area 4

Area centred on OS NGR 411447 168186 see Figs 05 - 08 & 12.

Anomalies with an archaeological origin

(26) - A discrete high resistance anomaly at the northern edge of the field appears to relate to a buried stone. It is in the approximate position of stone 86b, outlined by OGS Crawford and as a 'fallen stone not visible' by Isobel Smith.

Anomalies with an uncertain origin

(27) - To the south of anomaly (26) are five discrete high resistance responses, formed by two responses parallel with the A4 and a line of three responses further to the south west. The responses may relate to buried stones.

(28) - A zone of low resistance corresponds to a nettle covered low mound within the field. It probably relates to dumped material, possibly manure or soil, and there is no corresponding magnetic response to indicate that ferrous or magnetically thermoremnant material is incorporated. Immediately to the east is the position of a fallen sarsen stone, indicated on Ordnance Survey mapping.

Anomalies associated with land management

(29) - Two high resistance linear anomalies correspond to low banks within the field and so are likely to relate to former land boundary features.

Anomalies with a modern origin

(30) - A low resistance linear anomaly relates to a mown footpath that extends within the western part of the survey area.

4 DISCUSSION

4.1.1 The survey areas within the garden of Sarsen Kennels (Areas 1 & 2) did not reveal anything that can be confidently interpreted as archaeological within the magnetometer data. This is mainly due to magnetic debris and disturbance. The earth resistance survey did reveal a number of low resistance linear anomalies within Area 1, one of which appears to relate to a linear mark seen on Google Earth aerial photographs. The origin of the responses is uncertain as although they may extend eastwards, the morphology of the response is not clear in Area 3. A ditch-like feature is possible, and it is parallel with the A4 18m to the north; however, a pipe or service is also possible. Discrete high resistance responses have been located, that would be typically expected for buried stones, but these are within areas that have been subject to modern

disturbance, and it is not possible to offer a confident interpretation. There is no clear corresponding response in the geophysical survey results to the positions of the stones indicated by OGS Crawford either within the gardens or within Area 3, see below for further discussion.

4.1.2 Any comparison of the stone positions indicated by Crawford and transposed by Steve Marshall (see 1.4.1) is likely to be very misleading for a number of reasons. Archaeological Surveys Ltd has no indication of map accuracy or potential errors in position related to scaling and ground measurement. In addition, Crawford's marked up OS map presumably relates to a pre OSGB36 datum that has been manipulated onto the WGS84 datum used by Google Earth. Archaeological Surveys has then reprojected this back to OSGB36 using MapInfo Professional GIS. The potential errors involved could be very significant. Additionally, Crawford's notes indicate that the former position of stones in the vicinity of Sarsen Kennels and the Sanctuary was recognised by discoloured soil which may also be very misleading. The position of stones has, therefore, not been combined with the geophysical data due to the very low level of confidence in both their recognition in the field and the subsequent mapping.

4.1.3 Area 3 lies on land to the east and south of Sarsen Kennels and extends towards the Sanctuary. Both techniques revealed a number of corresponding pit-like responses towards the eastern end, on the higher ground of Overton Hill. Although some appear circular, others are elongated or oval in shape, possibly suggesting conjoined pits, with dimensions of 2.5m by 1.8m and up to 4.5m by 3m. A number of similar pit-like responses have also been recorded during a previous geophysical survey on land immediately to the north of the A4 (Archaeological Surveys, 2008). It is possible that the responses relate to naturally formed pits or pits that formerly contained naturally occurring sarsens. Cunnington (1931) did locate sarsen fragments with evidence of burning in the post holes, and suggested that the hill was covered with sarsens that had been broken up with fire and cleared. A small number of discrete high resistance responses have also been located.

4.1.4 It is of note that a geophysical survey carried out by Archaeological Surveys (2014) on similar geology a short distance to the south, on a chalk spur immediately east of East Kennett long barrow, did not locate similar discrete anomalies in either the magnetometry or resistivity data. Small sarsen fragments were also noted on this site. It seems unlikely that the underlying geological conditions adjacent to the Sanctuary would vary significantly, the inference being, therefore, that the discrete responses located are potentially of archaeological significance.

4.1.5 Although OGS Crawford indicates that the line of the West Kennet Avenue extends well into Area 3, Cunnington's plan indicates lines of stone attributed to the Avenue extending from the north west quadrant of the outer stone circle, in a north westerly direction, rather than further south into the field. A sketch map by Aubury, does show pairs of stones extending to the north west, but then extending in a more westerly direction (Cunnington, 1931, Plate IV).

4.1.6 Both techniques have located anomalies associated with at least three pipelines in the northern part of Area 3, with the magnetometry indicating that they are constructed of steel, and that they may extend into the northern part of the Sanctuary. The resistivity results are less clear, with the responses less straight, which may indicate that there are other non-magnetic services or pipes also within the survey area. An electricity cable was buried in 2008, but there is no definite response to this.

4.1.7 Area 4 contains a high resistance response (26), within the vicinity of a buried stone, indicated on Isobel Smith's map as 'stone fallen, not visible' and Crawford's map as 86b, stone inferred from soil. The response does indicate a buried stone and an association with the Avenue is likely. Located to the south west of this are five discrete high resistance responses, formed by two responses 11.5m apart, with the westernmost anomaly 5m south west of anomaly (26) and also a line of three responses 11.8m further south and spaced 2m apart. The responses range from 2m by 1.5m to 2.5m by 2m, and they may relate to buried stones, although it is not possible to determine if they have any association with anomaly (26) or the line of the West Kennet Avenue as they are much more closely spaced than any stones recorded in the Avenue. High resistance linear anomalies relate to extant banks within the field, and although no field boundary is indicated on any Ordnance Survey mapping, a field boundary is indicated in Stukeley's sketch map of 1724. There are no magnetic anomalies that correspond to any of the resistivity responses within Area 4.

5 CONCLUSION

5.1.1 The geophysical survey comprised earth resistance and magnetometry within four survey areas, Areas 1 and 2 in the garden of Sarsen Kennels, Area 3 in the field to the south and east and Area 4 in the field to the west. The results of the earth resistance survey indicate the presence of a buried stone in Area 4 which is likely to be related to a stone previously mapped as number 86b within the West Kennet Avenue. Also within this field, parallel to the line of the A4 and the Avenue are a further five high resistance responses in a line of two and a line of three. It is not possible to determine if they are associated with the Avenue; however, an archaeological origin is possible.

5.1.2 Within Area 3 in the eastern part of the site a number of discrete low resistance responses correspond to discrete positive responses and indicate the presence of pit-like features. They are often oval or elongated, possibly indicating conjoined pits. Although a natural origin is possible, the archaeological potential of these pits, immediately west of the Sanctuary should be considered. In the northern part of the survey area, widespread magnetic disturbance from at least three buried pipelines may have obscured weaker magnetic anomalies, and the earth resistance results may indicate

that there is some complexity to the trench cuts of the pipelines. The results also indicate that unless the pipelines veer abruptly northwards to the east of the survey area, it is highly likely that they pass through the northern edge of the Sanctuary.

5.1.3 Within the garden of Sarsen Kennels, modern disturbance in the form of buildings, ground make up and vegetation have all produced responses in both the magnetic and resistivity data. A discrete high resistance response in a small area of lawn could be inferred to be close to the position of one of OGS Crawford's stones/pits; however, a modern origin cannot be discounted. Within a larger area of lawn, low resistance responses could indicate ditch-like features, although garden features or possible services could also produce such responses and it is not possible to determine the origin of any of the anomalies within the garden.

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Appendix A – basic principles of magnetic survey

Iron minerals are always present to some degree within the topsoil and enhancement associated with human activity is related to increases in the level of magnetic susceptibility and thermoremnant material.

Magnetic susceptibility is an induced magnetism within a material when it is in the presence of a magnetic field. This can be thought of as effectively permanent due to the presence of the Earth's magnetic field.

Thermoremnant magnetism occurs when ferrous material is heated beyond a specific temperature known as the Curie Point. Demagnetisation occurs at this temperature with re-magnetisation by the Earth's magnetic field upon cooling.

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

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

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

Magnetic survey or magnetometry can be carried out using a fluxgate gradiometer and may be referred to as gradiometry. The gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 1m apart. The instrument is carried about 30cm above the ground surface and the upper sensor measures the Earth's magnetic field as does the lower sensor but this is influenced to a greater degree by any localised buried field. The difference between the two sensors will relate to the strength the magnetic field created by the buried feature. If no enhanced feature is present the field measured by both sensors will be similar and the difference close to zero.

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

Appendix B – data processing notes

Clipping

Minimum and maximum values are set and replace data outside of the range with those values. Extreme values are removed improving colour or greyscale contrast associated with data values that may be archaeologically significant. It has been found that clipping data to ranges between ±15nT and ±10nT often improves the appearance of features associated with archaeology. Different ranges are applied to data in order to determine the most suitable for anomaly abstraction and display.

Zero Median/Mean Traverse

The median (or mean) of each traverse is calculated ignoring data outside a threshold value, the median (or mean) is then subtracted from the traverse. The process is used to equalise slight differences between the set-up and stability of gradiometer sensors and can remove striping. The process can remove archaeological features that run along a traverse so data analysis is also carried out prior its application.

High Pass Filtering

A mathematical process used to remove low frequency anomalies relating to survey tracks and modern agricultural features.

Appendix C – survey and data information

Area 1 raw resistance
Filename: J688-res-Area1.xcp
Description: Imported as Composite from GeoPlot : J688-res-Area1
Instrument Type: Resist. (RM85P)
Units: ohm
Comments: Source Timestamp: 16/11/2016 19:15:22
Collection Method: Zig-zag
Sensors: 4
Dummy Value: 2047.5
Dimensions
Composite Size (readings): 120 x 120
Survey Size (meters): 60 m x 60 m
Grid Size: 30 m x 30 m
X Interval: 0.5 m
Y Interval: 0.5 m
Stats
Max: 73.10
Min: 9.10
Std Dev: 6.34
Mean: 27.40
Median: 26.00
Composite Area: 0.36 ha
Surveyed Area: 0.1024 ha
Processes: 1
1 Base Layer

Area 1 processed resistance

Filename: J688-res-Area1-proc.xcp
Description: Imported as Composite from GeoPlot : J688-res-Area1
Instrument Type: Resist. (RM85P)
Units: ohm
Comments: Source Timestamp: 16/11/2016 19:15:22
Collection Method: Zig-zag
Sensors: 4
Dummy Value: 2047.5
Dimensions
Composite Size (readings): 120 x 120
Survey Size (meters): 60 m x 60 m
Grid Size: 30 m x 30 m
X Interval: 0.5 m
Y Interval: 0.5 m
Stats
Max: 33.00
Min: 19.00
Std Dev: 3.91
Mean: 26.47
Median: 26.00
Composite Area: 0.36 ha
Surveyed Area: 0.1024 ha
Processes: 2
1 Base Layer
2 Clip from 19.00 to 33.00 ohm

Area 2 raw resistance

Filename: J688-res-Area2.xcp
Description: Imported as Composite from GeoPlot : J688-res-Area2
Instrument Type: Resist. (RM85P)
Units: ohm
Comments: Source Timestamp: 16/11/2016 19:17:38
Collection Method: Zig-zag
Sensors: 4
Dummy Value: 2047.5
Dimensions
Composite Size (readings): 60 x 60
Survey Size (meters): 30 m x 30 m
Grid Size: 30 m x 30 m
X Interval: 0.5 m
Y Interval: 0.5 m
Stats
Max: 51.00
Min: 18.20
Std Dev: 4.83
Mean: 27.92
Median: 27.23
Composite Area: 0.09 ha
Surveyed Area: 0.02315 ha
Processes: 1
1 Base Layer

Area 2 processed resistance

Filename: J688-res-Area2-proc.xcp
Description: Imported as Composite from GeoPlot : J688-res-Area2
Instrument Type: Resist. (RM85P)
Units: ohm
Comments: Source Timestamp: 16/11/2016 19:17:38
Collection Method: Zig-zag
Sensors: 4
Dummy Value: 2047.5

Dimensions
Composite Size (readings): 60 x 60
Survey Size (meters): 30 m x 30 m
Grid Size: 30 m x 30 m
X Interval: 0.5 m
Y Interval: 0.5 m
Stats
Max: 51.00
Min: 18.20
Std Dev: 4.83
Mean: 27.92
Median: 27.23
Composite Area: 0.09 ha
Surveyed Area: 0.02315 ha
Processes: 1
1 Base Layer

Area 3 raw resistance

Filename: J688-res-Area3.xcp
Description: Imported as Composite from GeoPlot : J688-res-Area3
Instrument Type: Resist. (RM85P)
Units: ohm
Comments: Source Timestamp: 29/11/2016 17:11:40
Collection Method: Zig-zag
Sensors: 4
Dummy Value: 2047.5
Dimensions
Composite Size (readings): 480 x 240
Survey Size (meters): 240 m x 120 m
Grid Size: 30 m x 30 m
X Interval: 0.5 m
Y Interval: 0.5 m
Stats
Max: 204.70
Min: -32.65
Std Dev: 11.23
Mean: 34.28
Median: 29.45
Composite Area: 2.88 ha
Surveyed Area: 0.79523 ha
Processes: 1
1 Base Layer

Area 3 processed resistance

Filename: J688-res-Area3-proc.xcp
Description: Imported as Composite from GeoPlot : J688-res-Area3
Instrument Type: Resist. (RM85P)
Units: ohm
Comments: Source Timestamp: 29/11/2016 17:11:40
Collection Method: Zig-zag
Sensors: 4
Dummy Value: 2047.5
Dimensions
Composite Size (readings): 480 x 240
Survey Size (meters): 240 m x 120 m
Grid Size: 30 m x 30 m
X Interval: 0.5 m
Y Interval: 0.5 m
Stats
Max: 64.00
Min: 20.00
Std Dev: 10.04
Mean: 33.92
Median: 29.25
Composite Area: 2.88 ha
Surveyed Area: 0.79523 ha
Processes: 3
1 Base Layer
2 Clip from 20.00 to 64.00 ohm
3 Despike Threshold: 1 Window size: 5x5

Area 3 filtered resistance

Filename: J688-res-Area3-proc-despike-hpf.xcp
Description: Imported as Composite from GeoPlot : J688-res-Area3
Instrument Type: Resist. (RM85P)
Units: ohm
Comments: Source Timestamp: 29/11/2016 17:11:40
Collection Method: Zig-zag
Sensors: 4
Dummy Value: 2047.5
Dimensions
Composite Size (readings): 480 x 240

Survey Size (meters): 240 m x 120 m
Grid Size: 30 m x 30 m
X Interval: 0.5 m
Y Interval: 0.5 m
Stats
Max: 8.00
Min: -6.00
Std Dev: 2.02
Mean: 0.04
Median: 0.09
Composite Area: 2.88 ha
Surveyed Area: 0.79523 ha
Processes: 4
1 Base Layer
2 Despike Threshold: 1 Window size: 5x5
3 High pass Uniform (mean) filter: Window: 31 x 31
4 Clip from -6.00 to 8.00 ohm

Area 4 raw resistance

Filename: J688-res-Area4.xcp
Description: Imported as Composite from GeoPlot : J688-res-Area4
Instrument Type: Resist. (RM85P)
Units: ohm
Comments: Source Timestamp: 23/11/2016 13:22:38
Collection Method: Zig-zag
Sensors: 4
Dummy Value: 2047.5
Dimensions
Composite Size (readings): 300 x 60
Survey Size (meters): 150 m x 30 m
Grid Size: 30 m x 30 m
X Interval: 0.5 m
Y Interval: 0.5 m
Stats
Max: 35.05
Min: 8.79
Std Dev: 2.95
Mean: 21.82
Median: 21.85
Composite Area: 0.45 ha
Surveyed Area: 0.3489 ha
Processes: 2
1 Base Layer
2 Clip at 3.00 SD

Area 4 processed resistance

Filename: J688-res-Area4-proc.xcp
Description: Imported as Composite from GeoPlot : J688-res-Area4
Instrument Type: Resist. (RM85P)
Units: ohm
Comments: Source Timestamp: 23/11/2016 13:22:38
Collection Method: Zig-Zag
Sensors: 4
Dummy Value: 2047.5
Dimensions
Composite Size (readings): 300 x 60
Survey Size (meters): 150 m x 30 m
Grid Size: 30 m x 30 m
X Interval: 0.5 m
Y Interval: 0.5 m
Stats
Max: 29.00
Min: 15.00
Std Dev: 2.71
Mean: 21.75
Median: 21.83
Composite Area: 0.45 ha
Surveyed Area: 0.3489 ha
Processes: 3
1 Base Layer
2 Clip from 15.00 to 29.00 ohm
3 Despike Threshold: 1 Window size: 3x3

Area 1 magnetometry

Filename: J688-mag-Area1-proc.xcp
Description: Imported as Composite from: J688-mag-Area1.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):OSGB36
Northwest corner: 411589.768928711, 168102.673733769 m
Southeast corner: 411657.418928711, 168080.773733769 m
Collection Method: Randomised
Sensors: 1
Dummy Value: 32702
Source GPS Points: 29600
Dimensions
Composite Size (readings): 451 x 146
Survey Size (meters): 67.7 m x 21.9 m
Grid Size: 67.7 m x 21.9 m
X Interval: 0.15 m
Y Interval: 0.15 m
Stats
Max: 5.53
Min: -5.50
Std Dev: 3.02
Mean: -0.05
Median: -0.05
Composite Area: 0.14815 ha
Surveyed Area: 0.097803 ha
Processes: 1
1 Base Layer
GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 High pass Uniform (median) filter: Window dia: 200
5 Clip from -5.00 to 5.00 nT

Area 2 magnetometry

Filename: J688-mag-Area2-proc.xcp
Description: Imported as Composite from: J688-mag-Area2.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):OSGB36
Northwest corner: 411573.091952407, 168113.662152442 m
Southeast corner: 411590.791952407, 168092.362152442 m
Collection Method: Randomised
Sensors: 1
Dummy Value: 32702
Source GPS Points: 7100
Dimensions
Composite Size (readings): 118 x 142
Survey Size (meters): 17.7 m x 21.3 m
Grid Size: 17.7 m x 21.3 m
X Interval: 0.15 m
Y Interval: 0.15 m
Stats
Max: 11.05
Min: -11.00
Std Dev: 7.13
Mean: 0.67
Median: 0.40
Composite Area: 0.037701 ha
Surveyed Area: 0.020916 ha
Processes: 1
1 Base Layer
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -10.00 to 10.00 nT

Area 3 magnetometry

Filename: J688-mag-Area3-proc-hpf.xcp
Description: Imported as Composite from: J688-mag-Area3.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):OSGB36
Northwest corner: 411520.72853882, 168078.963444038 m
Southeast corner: 411815.32853882, 168000.213444038 m
Collection Method: Randomised
Sensors: 1
Dummy Value: 32702
Source GPS Points: 526700
Dimensions
Composite Size (readings): 1964 x 525
Survey Size (meters): 295 m x 78.8 m
Grid Size: 295 m x 78.8 m
X Interval: 0.15 m
Y Interval: 0.15 m
Stats
Max: 5.53
Min: -5.50
Std Dev: 3.10
Mean: 0.08
Median: 0.01
Composite Area: 2.32 ha
Surveyed Area: 1.3506 ha
Processes: 1
1 Base Layer
GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 High pass Uniform (median) filter: Window dia: 300
5 Clip from -5.00 to 5.00 nT

Area 4 magnetometry

Filename: J688-mag-Area4-proc.xcp
Description: Imported as Composite from: J688-mag-Area4.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y): OSGB36
Northwest corner: 411386.717458497, 168254.563584898 m
Southeast corner: 411510.167458497, 168123.013584898 m
Collection Method: Randomised
Sensors: 1
Dummy Value: 32702
Source GPS Points: 118700
Dimensions
Composite Size (readings): 823 x 877
Survey Size (meters): 123 m x 132 m
Grid Size: 123 m x 132 m
X Interval: 0.15 m
Y Interval: 0.15 m
Stats
Max: 5.53
Min: -5.50
Std Dev: 1.91
Mean: 0.01
Median: 0.01
Composite Area: 1.624 ha
Surveyed Area: 0.39683 ha
Processes: 1
1 Base Layer
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -5.00 to 5.00 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 printed copy of the report and a PDF copy will be supplied to the Wiltshire Historic Environment Record. Copies of the report with the data will also be sent to Dr Nicola Snashall, National Trust archaeologist and reports issued to Historic England southwest team in Bristol and Paul Linford at Fort Cumberland. The report will also be uploaded to the Online AccesS to the Index of archaeological investigationS (OASIS).

Geophysical data magnetometry - path: J688\Sarsen Kennels\Data				
Path and Filename	**Software**	**Description**	**Date**	**Creator**
Mag\sarsen1\MX\.prm,.dgb,.disp Mag\sarsen2\MX\.prm,.dgb,.disp Mag\sarsen2\MX\.prm,.dgb,.disp Mag\sarsen2\MX\.prm,.dgb,.disp	Sensys MXPDA	Proprietary data formats representing magnetometer survey traverses logged to a PDA.		D.J.Sabin
Mag\sarsen1\MX\J688-mag-Area3.asc Mag\sarsen2\MX\J688-mag-Area4.asc Mag\sarsen3\MX\J688-mag-Area2.asc Mag\sarsen4\MX\J688-mag-Area1.asc	Sensys DLMGPS	ASCII CSV (tab) file representing survey area in eastings, northings (UTM Z30N), magnetic measurement, traverse file and sensor number.	28/11/16 24/11/16 24/11/16 28/11/16	D.J.Sabin
Mag\Area1\comps\J688-mag-Area1.xcp Mag\Area2\comps\J688-mag-Area2.xcp Mag\Area3\comps\J688-mag-Area3.xcp Mag\Area4\comps\J688-mag-Area4.xcp	TerraSurveyor 3.0.23.0	Composite data file derived from ASCII CSV.	28/11/16 24/11/16 24/11/16 28/11/16	D.J.Sabin
Mag\Area1\comps\J688-mag-Area1-proc.xcp Mag\Area2\comps\J688-mag-Area2-proc.xcp Mag\Area3\comps\J688-mag-Area3-proc.xcp Mag\Area3\comps\J688-mag-Area3-proc-hpf.xcp Mag\Area4\comps\J688-mag-Area4-proc.xcp	TerraSurveyor 3.0.23.0	Processed composite data file (zmt and clipping to ±5nT for Areas 1, 3 & 4 and ±10nT for Area 2).	28/11/16 24/11/16 24/11/16 28/11/16	D.J.Sabin
Geophysical data resistivity - path: J688\Sarsen Kennels\Data				
Res\Area1\comps\J688-res-Area1.xcp Res\Area2\comps\J688-res-Area2.xcp Res\Area3\comps\J688-res-Area3.xcp Res\Area4\comps\J688-res-Area4.xcp	TerraSurveyor 3.0.23.0	Composite data file	16/11/16 16/11/16 29/11/16	D.J.Sabin
Res\Area1\comps\J688-res-Area1-proc.xcp Res\Area2\comps\J688-res-Area2-proc.xcp Res\Area3\comps\J688-res-Area3-proc.xcp Res\Area3\comps\J688-res-Area3-proc-despike-hpf.xcp Res\Area4\comps\J688-res-Area4-proc.xcp	TerraSurveyor 3.0.23.0	Processed composite data file	20/11/16 20/11/16 29/11/16 29/11/16 24/11/16	D.J.Sabin
Graphic data - path: J688\Sarsen Kennels\Data				
Mag\Area1\graphics\J688-mag-Area1-proc.tif Mag\Area1\graphics\J688-mag-Area1-proc-hpf.tif Mag\Area2\graphics\J688-mag-Area2-proc.tif Mag\Area3\graphics\J688-mag-Area3-proc-5nT.tif Mag\Area3\graphics\J688-mag-Area3-proc-hpf-5nT.tif Mag\Area4\graphics\J688-mag-Area4-proc.tif	TerraSurveyor 3.0.23.0	TIF file showing a minimally processed greyscale plot clipped to ±5nT.	28/11/16 28/11/16 24/11/16 28/11/16 28/11/16 24/11/16	K.T.Donaldson
Mag\Area1\graphics\J688-mag-Area1-proc.tfw Mag\Area1\graphics\J688-mag-Area1-proc-hpf.tfw Mag\Area2\graphics\J688-mag-Area2-proc.tfw Mag\Area3\graphics\J688-mag-Area3-proc-5nT.tfw Mag\Area3\graphics\J688-mag-Area3-proc-hpf-5nT.tfw Mag\Area4\graphics\J688-mag-Area4-proc.tfw	TerraSurveyor 3.0.23.0	World file for georeferencing TIF to OSGB36.	28/11/16 28/11/16 24/11/16 28/11/16 28/11/16 24/11/16	K.T.Donaldson
Res\Area1\graphics\J688-res-Area1-raw.tif Res\Area2\graphics\J688-res-Area2-raw.tif Res\Area3\graphics\J688-res-Area3-raw.tif Res\Area4\graphics\J688-res-Area4-raw.tif	TerraSurveyor 3.0.23.0	TIF file showing a raw greyscale plot of survey area	20/11/16 13/12/16 13/12/16 13/12/16	K.T.Donaldson
Res\Area1\graphics\J688-res-Area1-proc.tif Res\Area2\graphics\J688-res-Area2-proc.tif Res\Area3\graphics\J688-res-Area3-proc.tif Res\Area3\graphics\J688-res-Area3-proc-hpf.tif Res\Area4\graphics\J688-res-Area4-proc.tif	TerraSurveyor 3.0.23.0	TIF file showing a processed greyscale plot of survey area.	20/11/16 20/11/16 20/11/16 29/11/16 24/11/16	K.T.Donaldson
CAD data - path: J688\Sarsen Kennels CAD				
J688 version 1.dwg	ProgeCAD 2014	CAD file for creating plots of greyscales, abstraction, interpretation and mapping. Grid coordinates as OSGB. AutoCAD 2010 format.	29/09/16	K.T.Donaldson
Text data - path: J688\Sarsen Kennels\Documentation				
J688 report.odt	OpenOffice.org 3.0.1 Writer	Report text as an Open Office document.	04/12/16	K.T.Donaldson

Appendix E – copyright and intellectual property

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Historic England Geophysical Survey Database Questionnaire

Survey Details

Name of Site: Sarsen Kennels, West Kennett, Avebury

County: Wiltshire

NGR Grid Reference (Centre of survey to nearest 100m):SU 11592 68094

Start Date: 16th November 2016 **End Date:** 29th November 2016

Geology at site (Drift and Solid): Chalk (Holywell Nodular Chalk Formation & New Pit Chalk Formation)

Known archaeological Sites/Monuments covered by the survey
(Scheduled Monument No. or National Archaeological Record No. if known)
West Kennet Avenue and an earthwork bank east of West Kennett Farm. List entry number 1015547.

Archaeological Sites/Monument types detected by survey
(Type and Period if known. "?" where any doubt).
Stone - Neolithic
Pits - uncertain

Surveyor (Organisation, if applicable, otherwise individual responsible for the survey):David Sabin & Kerry Donaldson, Archaeological Surveys Ltd
Name of Client, if any: AC Archaeology on behalf of Mr N Baldock

Purpose of Survey: To establish the presence, layout and extent of any buried sarsens or stone settings associated with the West Kennet Avenue with the gardens of Sarsen Kennels and within National Trust land to the east and west.

Location of:

a) Primary archive, i.e. raw data, electronic archive etc:
Archaeological Surveys Ltd, 1 West Nolands, Nolands Road, Yatesbury, Calne, SN11 8YD

b) Full Report: As above with copy to OASIS and HER

Historic England

Technical Details

(Please fill out a separate sheet for each survey technique used)

Type of Survey (Use term from attached list or specify other):
Magnetometry

Area Surveyed, if applicable (In hectares to one decimal place): 1.85ha

Traverse Separation, if regular: 0.5m **Reading/Sample Interval:**20Hz

Type, Make and model of Instrumentation:

Sensys Magneto MXPDA (multiple fluxgate gradiometers)

Land use at the time of the survey (Use term/terms from the attached list or specify other):
Garden - Area 1 & 2
Grassland - Areas 3 & 4

Historic England

Technical Details

(Please fill out a separate sheet for each survey technique used)

Type of Survey (Use term from attached list or specify other):
Earth resistance

Area Surveyed, if applicable (In hectares to one decimal place): 1.35ha

Traverse Separation, if regular: 0.5m **Reading/Sample Interval:**0.5

Type, Make and model of Instrumentation:

Geoscan RM85 resistance meter with mobile twin probe array configuration

Land use at the time of the survey (Use term/terms from the attached list or specify other):

Grassland - Areas 1-3
Arable - Area 4

N

Archaeological Surveys Ltd

Geophysical Survey
Sarsen Kennels
West Kennett
Wiltshire

Map of survey area

● Survey location

Site centred on OS NGR
SU 11592 68094

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

FIG 01

Archaeological Surveys Ltd

Geophysical Survey
Sarsen Kennels
West Kennett
Wiltshire

Referencing information

Resistivity survey grid size = 30m

Survey start and traverse direction

1 Grid reference number and filename

Position of buried sarsen / pit derived from OGS Crawford by Steve Marshall

Survey carried out at 0.5m centres along 0.5m traverses. Survey start at 0.5m in from baseline

Grid coordinates based on Ordnance Survey OSGB36 datum. Grids set out using RTK GPS with Leica SmartNet correction data RTCMv2 format OSTN02 transformation

Magnetometry referencing grid to OSGB36 datum at 50m intervals

Data collected at 20Hz and georeferenced to ETRS89 zone 30 with conversion to OSGB36 using OSTN02

SCALE 1:2000

0m 20 40 60 80 100m

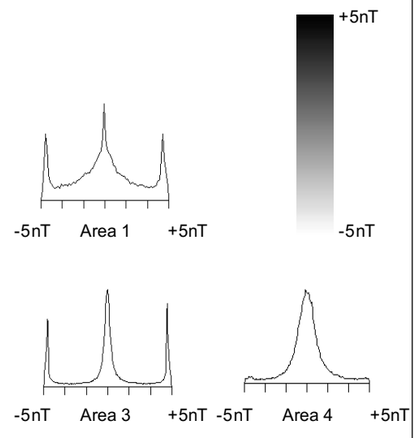
SCALE TRUE AT A3

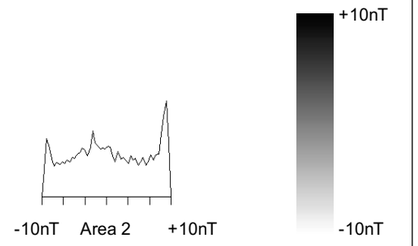
FIG 02

Archaeological Surveys Ltd

Geophysical Survey
Sarsen Kennels
West Kennett
Wiltshire

Greyscale plot of minimally processed magnetometer data





Area 4

2008 survey area

Sarsen Kennels

Area 1

Area 2

Scheduled monument boundary

Area 3

The Sanctuary

Tumuli

Barrow

N

SCALE 1:1500

0m 10 20 30 40 50m

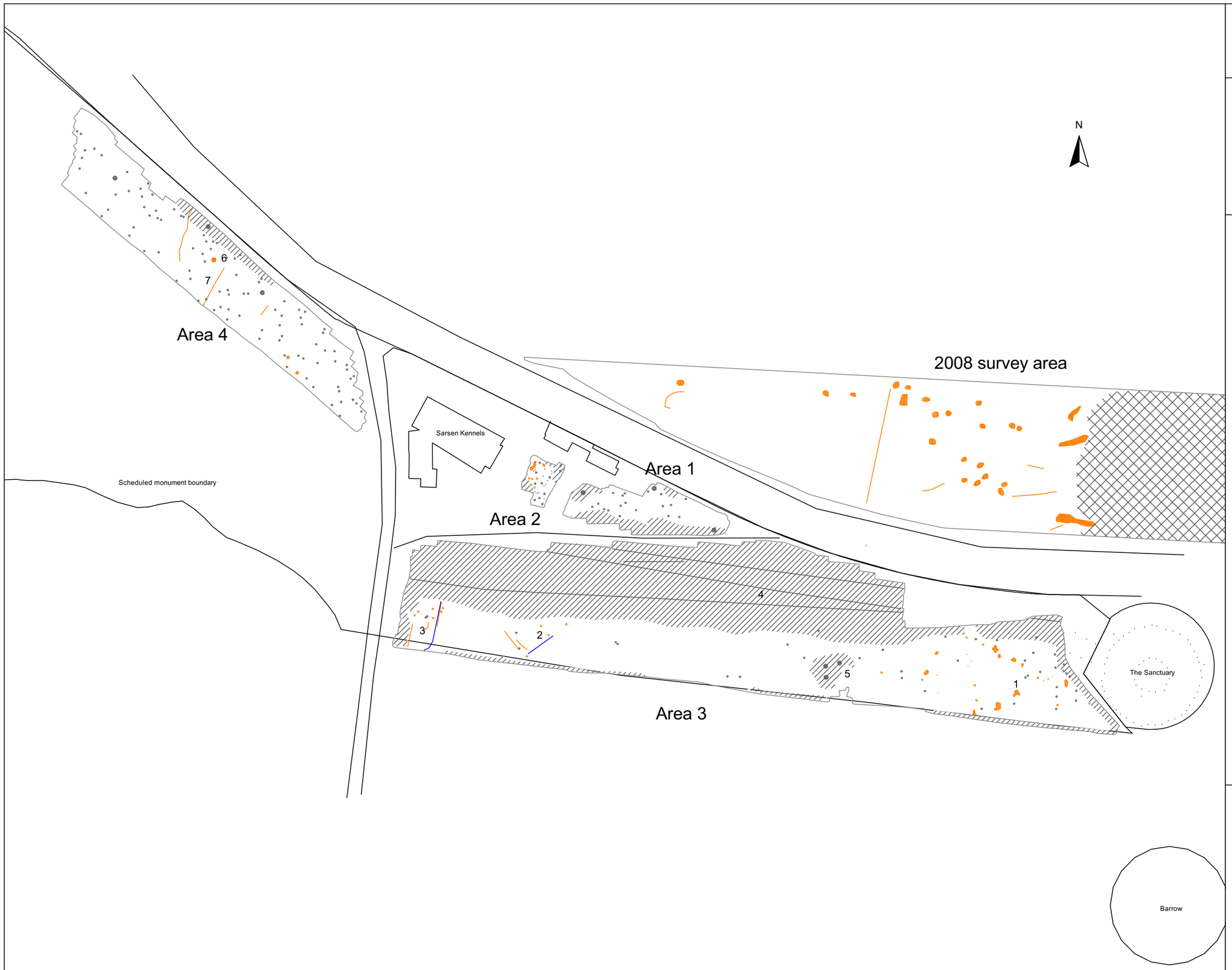
SCALE TRUE AT A3

FIG 03

Archaeological Surveys Ltd

Geophysical Survey
Sarsen Kennels
West Kennett
Wiltshire

Abstraction and interpretation of magnetometer anomalies



- Positive linear anomaly - possible ditch-like feature
- Negative linear anomaly - material of low magnetic susceptibility
- Discrete positive response - possible pit-like feature
- Magnetic disturbance from ferrous material
- Strong multiple dipolar linear anomaly - pipeline / cable / service
- Strong dipolar anomaly - ferrous object

SCALE 1:1500

0m 10 20 30 40 50m

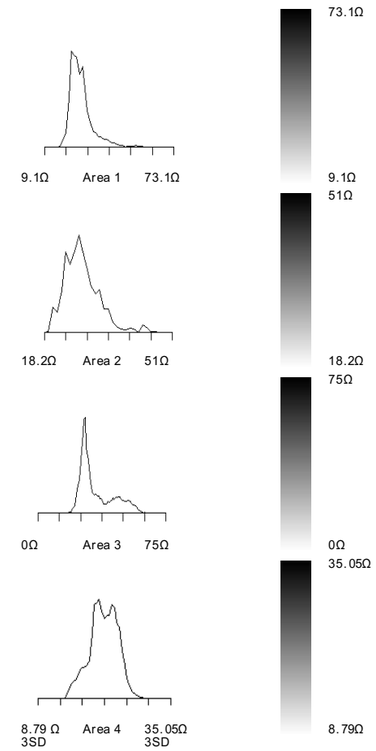
SCALE TRUE AT A3

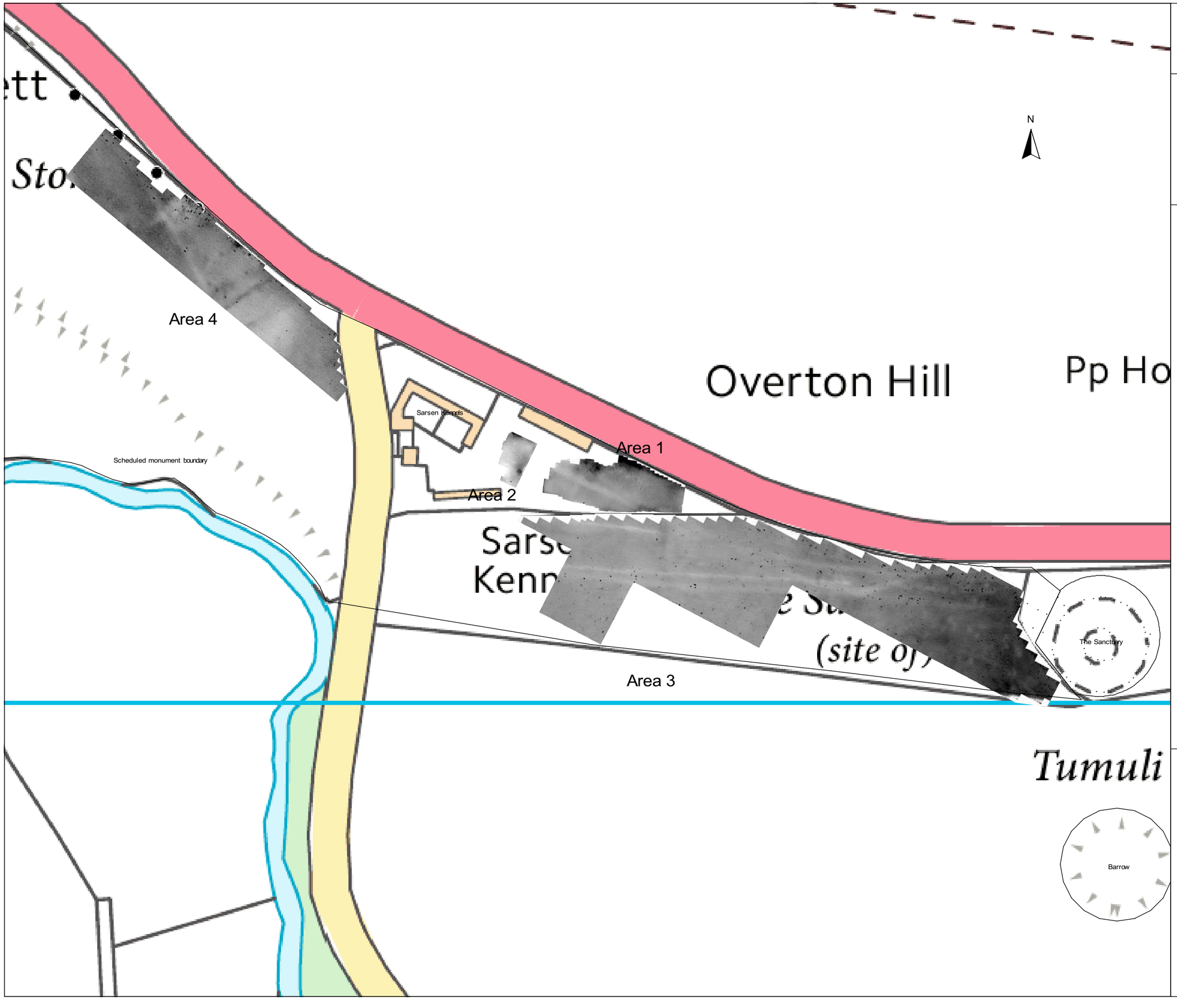
FIG 04

Archaeological Surveys Ltd

Geophysical Survey
Sarsen Kennels
West Kennett
Wiltshire

Greyscale plot of raw resistance data





SCALE 1:1500

0m 10 20 30 40 50m

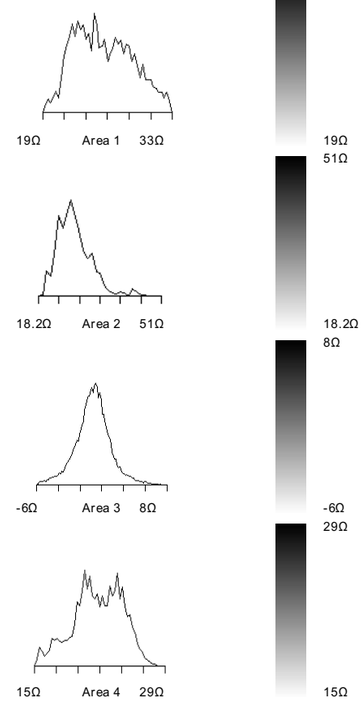
SCALE TRUE AT A3

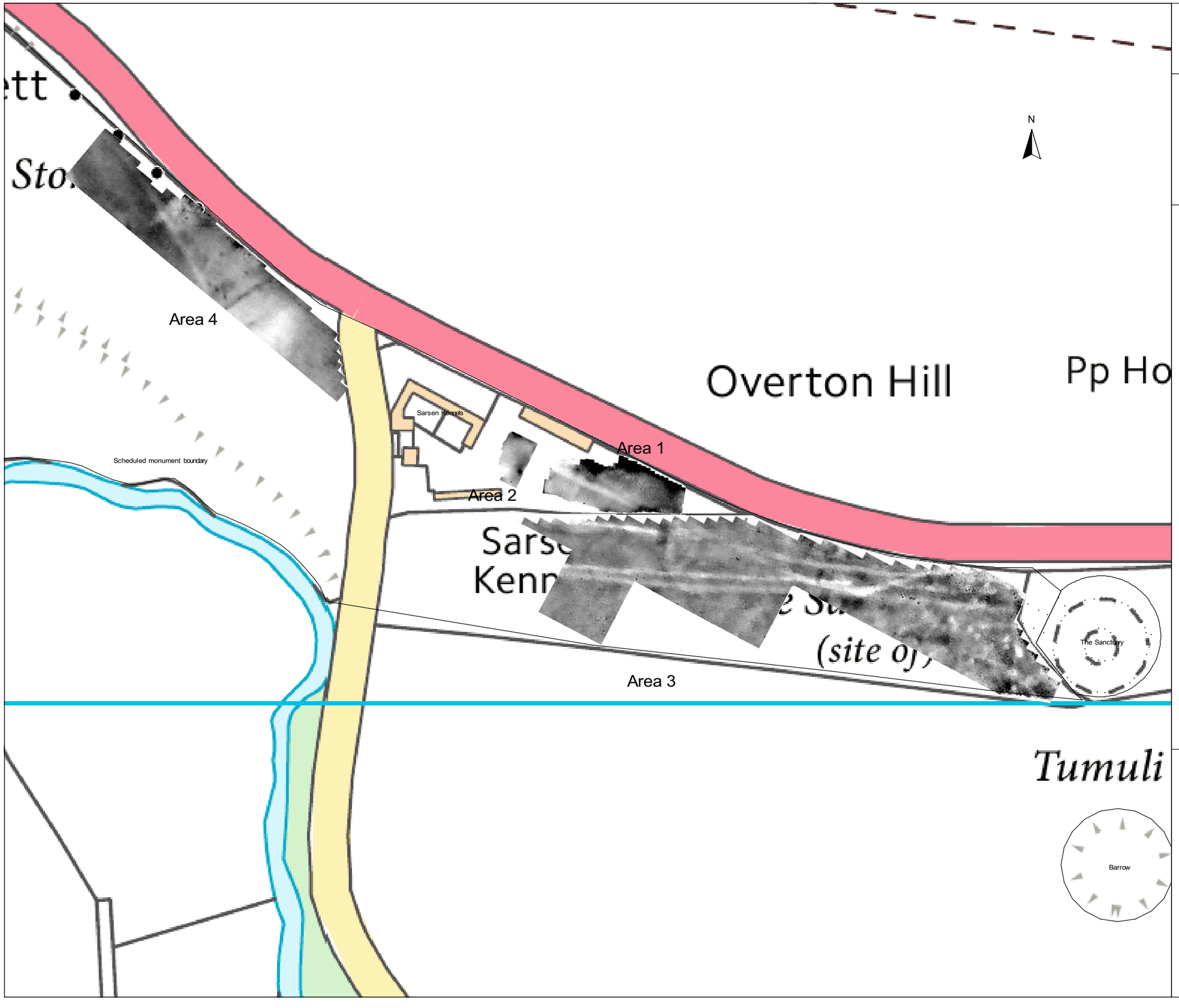
FIG 05

Archaeological Surveys Ltd

Geophysical Survey
Sarsen Kennels
West Kennett
Wiltshire

Greyscale plot of processed resistance data





SCALE 1:1500

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 06

Archaeological Surveys Ltd

Geophysical Survey
Sarsen Kennels
West Kennett
Wiltshire

Abstraction and interpretation of resistance anomalies

- High resistance linear anomaly - of uncertain origin
- Low resistance linear anomaly - of uncertain origin
- Low resistance anomaly - pipeline/service
- High resistance linear anomaly - extant bank/boundary feature
- Discrete high resistance response - possible buried sarsen
- Discrete high resistance response - of uncertain origin
- Discrete low resistance response - pit-like feature of uncertain origin
- Area of high resistance - of uncertain origin
- Area of low resistance - of uncertain origin
- Area of high resistance - possible made ground/tree roots
- Area of low resistance - area of dumped material
- Area of low resistance - footpath

N

Area 1

Area 2

Area 3

Area 4

Sarsen Kennels

The Sanctuary

Barrow

Scheduled monument boundary

SCALE 1:1500

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 07

Archaeological Surveys Ltd

Geophysical Survey
Sarsen Kennels
West Kennett
Wiltshire

Abstraction and interpretation of resistivity & magnetometer anomalies

- High resistance linear anomaly - of uncertain origin
- Low resistance linear anomaly - of uncertain origin
- Low resistance anomaly - pipeline/service
- Discrete high resistance response - possible buried sarsen
- Discrete high resistance response - of uncertain origin
- Discrete low resistance response - pit-like feature of uncertain origin
- Area of high resistance - of uncertain origin
- Area of low resistance - of uncertain origin
- Area of high resistance - possible made ground/tree roots
- Area of low resistance - area of dumped material
- Area of low resistance - footpath
- Positive linear anomaly - possible ditch-like feature
- Negative linear anomaly - material of low magnetic susceptibility
- Discrete positive response - possible pit-like feature
- Strong multiple dipolar linear anomaly - pipeline / cable / service
- Strong dipolar anomaly - ferrous object

SCALE 1:1500

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 08

Overton Hill

Sarsen Kennels

Area 1

Area 2

Area 3

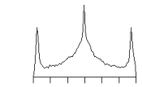
N

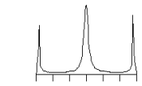
The Sanctuary

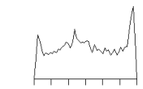
Archaeological Surveys Ltd

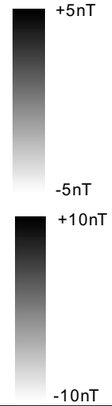
Geophysical Survey
Sarsen Kennels
West Kennett
Wiltshire

Greyscale plot of filtered magnetometer data - east









Sarsen Kennels

Area 1

Area 2

Area 3

4

3

2

5

1

The Sanctuary

Abstraction and interpretation of magnetometer anomalies - east

- Positive linear anomaly - possible ditch-like feature
- Negative linear anomaly - material of low magnetic susceptibility
- Discrete positive response - possible pit-like feature
- Magnetic disturbance from ferrous material
- Strong multiple dipolar linear anomaly - pipeline / cable / service
- Strong dipolar anomaly - ferrous object

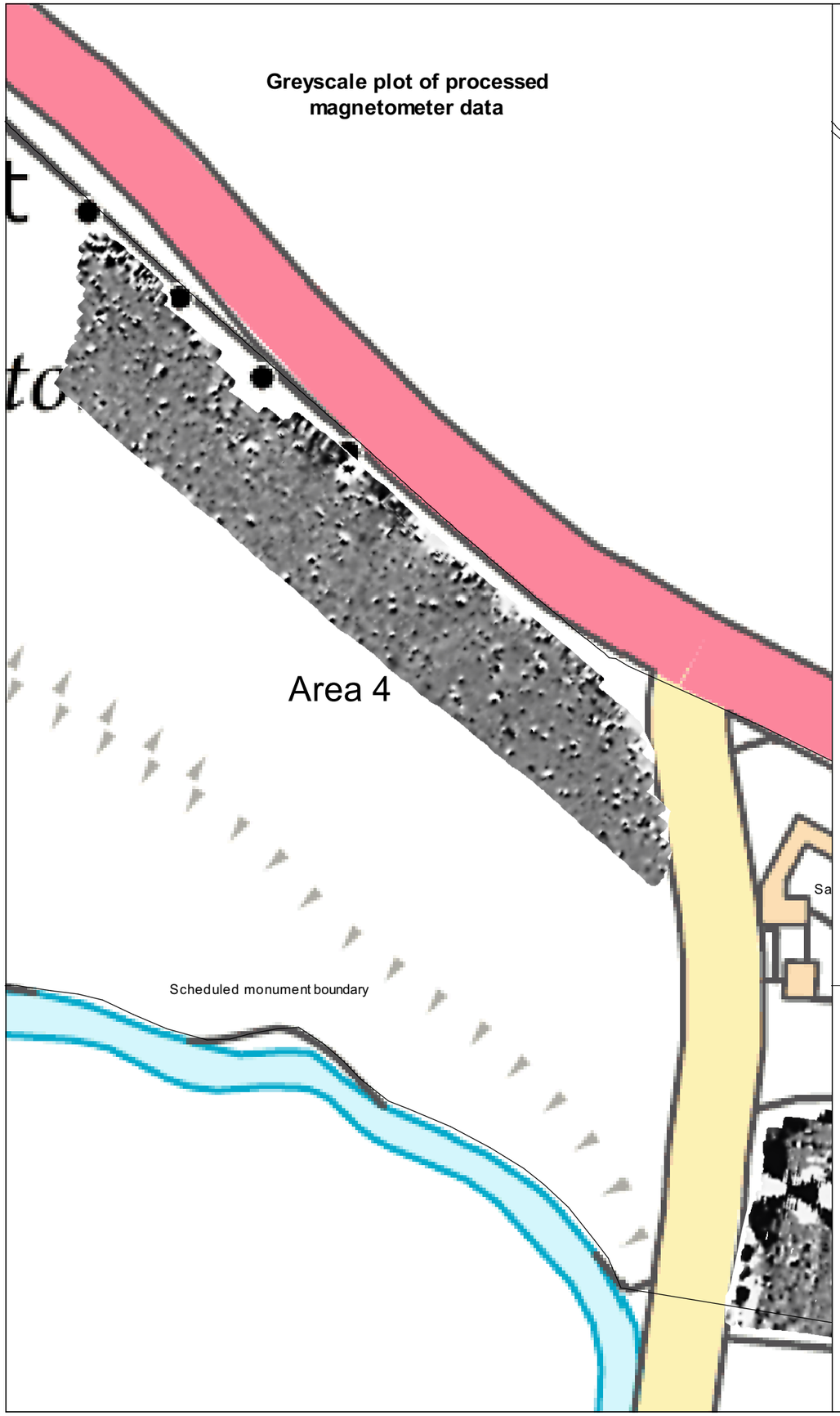
SCALE 1:1000

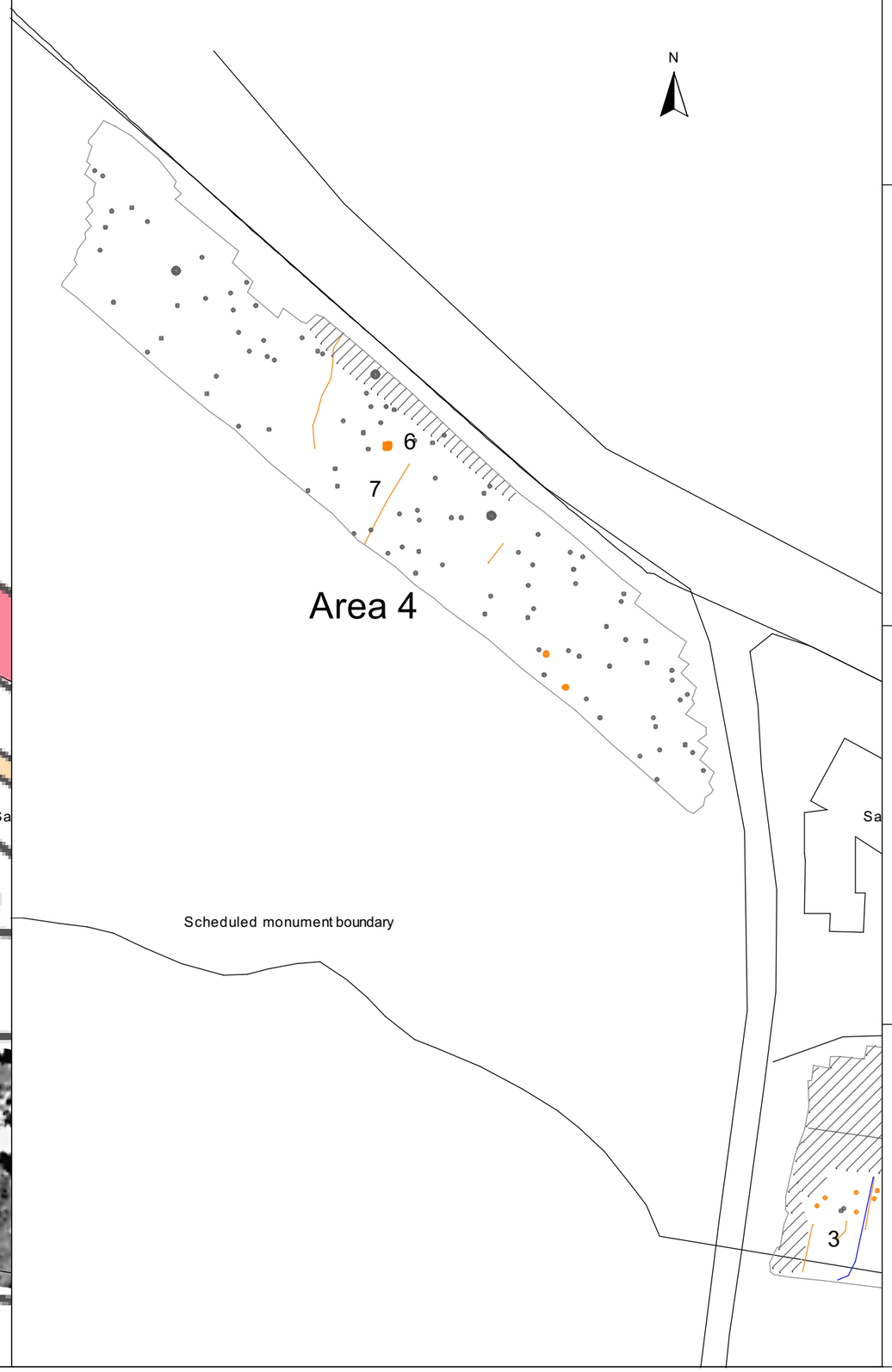
0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 09

Greyscale plot of processed magnetometer data

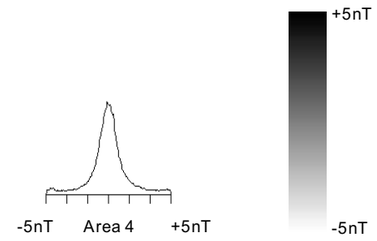




Archaeological Surveys Ltd

Geophysical Survey
Sarsen Kennels
West Kennett
Wiltshire

Greyscale plot of processed magnetometer data - east



Abstraction and interpretation of magnetometer anomalies - east

- Positive linear anomaly - possible ditch-like feature
- Discrete positive response - possible pit-like feature
- Strong dipolar anomaly - ferrous object

SCALE 1:1000

0m 10 20 30 40 50m

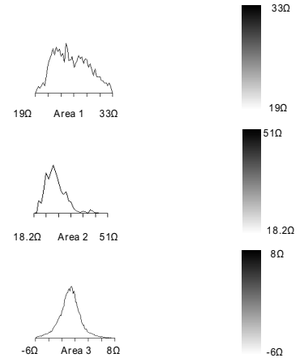
SCALE TRUE AT A3

FIG 10

Archaeological Surveys Ltd

Geophysical Survey
Sarsen Kennels
West Kennett
Wiltshire

Greyscale plot of processed resistivity data - east



Abstraction and interpretation of resistance anomalies - east

- High resistance linear anomaly - of uncertain origin
- Low resistance linear anomaly - of uncertain origin
- Low resistance anomaly - pipeline/service
- Discrete high resistance response - of uncertain origin
- Discrete low resistance response - pit-like feature of uncertain origin
- Area of high resistance - of uncertain origin
- Area of low resistance - of uncertain origin
- Area of high resistance - possible made ground/tree roots
- Area of low resistance - footpath

SCALE 1:1000

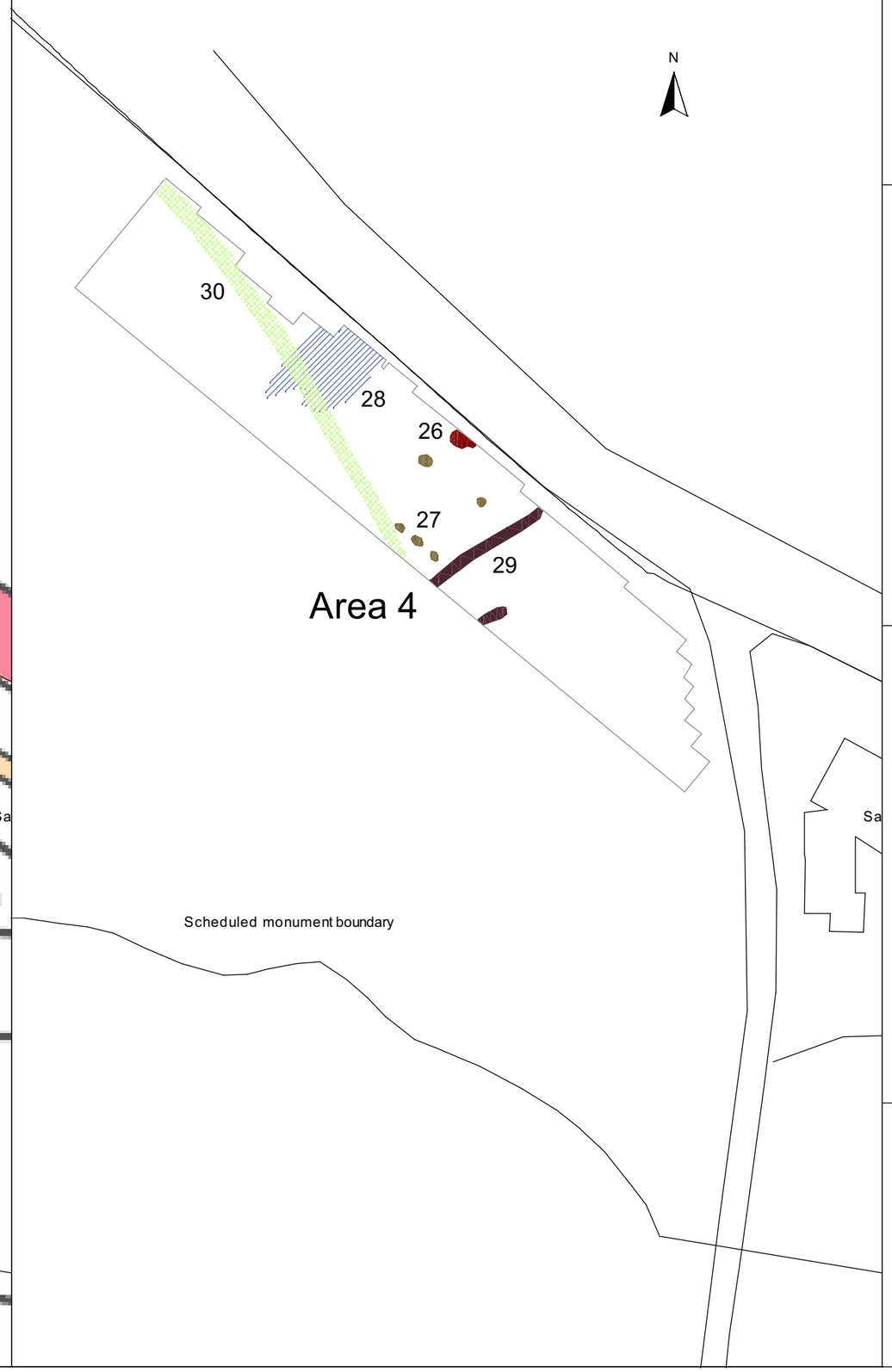
0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 11

Area 4

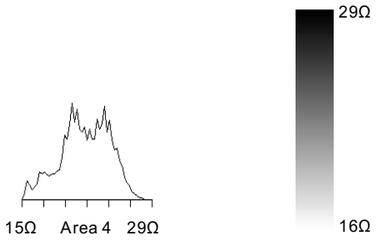
Scheduled monument boundary



Archaeological Surveys Ltd

Geophysical Survey
Sarsen Kennels
West Kennett
Wiltshire

Greyscale plot of processed resistivity data - west



Abstraction and interpretation of resistance anomalies - west

- High resistance linear anomaly - extant bank/boundary feature
- Discrete high resistance response - possible buried sarsen
- Discrete high resistance response - of uncertain origin
- Discrete low resistance response - pit-like feature of uncertain origin
- Area of low resistance - area of dumped material
- Area of low resistance - footpath

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 12