GEOPHYSICAL SURVEY REPORT

Castell Nadolig, Ceredigion

Client

Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMW)

Survey Report

16161

Date

December 2019

Comisiwn Brenhinol
Henebion Cymru
Royal Commission on the Ancient
and Historical Monuments of Wales

Survey Report 16161: Castell Nadolig, Ceredigion

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2. SURVEY TECHNIQUE

Detailed magnetic survey (magnetometry) was chosen as the most efficient and effective method of locating the type of archaeological anomalies which might be expected at this site. A 0.5m traverse interval was chosen to provide extra detail over the enclosure itself.

Bartington Cart System	Traverse Interval 1.0m	Sample Interval 0.125m
Bartington Cart System	Traverse Interval 0.5m	Sample Interval 0.125m

3 SUMMARY OF RESULTS

3.1 A detailed magnetometry survey was conducted over approximately 7.8 ha of pasture at Castell Nadolig, Ceredigion, with the aim of clarifying the nature of the hillfort and any internal or external buried remains. The survey has identified the ditches associated with the fort and a possible entranceway is visible into the main enclosure on its eastern side. Two sub-circular responses within the main enclosure provide tentative evidence of domestic use. The eastern, crescent-shaped annex is clearly visible, and contains a tentative ring-ditch at its southern extent. A complex of ring-ditches have been identified to the east of the hillfort which are likely to represent funerary monuments. Additional linear, curvilinear and sub-circular anomalies in the west of the site may be a result of settlement activity, while further ditches and pit-like responses are visible across the site. Modern ploughing effects can be seen across the majority of the area, while natural magnetic variations and an underground service are visible in the west.

4 INTRODUCTION

4.1 **SUMO Geophysics Ltd** were commissioned by the **Royal Commission on the Ancient and Historical Monuments of Wales** to carry out a geophysical survey.

4.2 Scheduled Monument Consent, under Section 42, was granted by Cadw in order to undertake a geophysical survey Castell Nadolig (CD053).

4.3 Site details

NGR / Postcode	SN 298 504 / SA43 2JP
Location	The site is located to the south of Penbryn, Ceredigion, immediately north-west of the A487.
HER	Dyfed Archaeological Trust (DAT)
Unitary Authority	Dyfed
Parish	Penbryn
Topography	The site occupies a rounded summit at 212m aOD.
Current Land Use	Pasture
Geology (BGS 2019)	Bedrock: Allt Formation - mudstone. Superficial: none recorded.
Soils (CU 2019)	Soilscape 6; freely draining slightly acid loamy soils.
Archaeology (RCAHMW 2019)	Castell Nadolig (NPRN 304136; CD053) is an under-researched scheduled Iron Age hillfort above Penbryn in south Ceredigion; it is of high archaeological interest for Wales, and the UK. The hillfort is marked today by monumental concentric ramparts, fossilised in hedgebanks. A pair of bronze 'spoons' were unearthed from beneath a 'heap of stones' in around 1829; they are extremely rare in a British context and date to the 1st century BC. Only 15 other pairs of similar character are known from Britain and Ireland. A study of the artefacts suggests the site was likely to have been used for religious purposes; a later study of the site shows the existence of a prominent rock-cut spring against the inner enclosure which is of particular significance in terms of the ritual finds from the site. Three cremation urns (a rarity for a hillfort in Wales) were also unearthed at the site in the 19th century (Driver, T 2019).
Survey Methods	Magnetometer survey (fluxgate gradiometer)
Study Area	*c.* 7.8 ha

4.4 Aims and Objectives

To characterise the nature of the buried remains, to clarify the morphology of the enclosure, and to locate and characterise any anomalies of archaeological interest to assist in the long-term management of the site.

5 RESULTS

The survey has been divided into eight survey areas (Areas 1 - 8) and specific anomalies have been given numerical labels [1] [2] *which appear in the text below, as well as on the Interpretation Figure(s).*

5.1 *Hillfort / Defences*

5.1.1 Elements of the hillfort defences are visible in the magnetic data [1] with many ditch lengths and banks corresponding with extant earthworks on the site (Plates 1 and 2 below). The earthwork diagram indicates a gateway into the hillfort on the south-eastern side at (A); however, there is no break in the magnetic anomaly at this point. This may suggest that any gate is closer to (B); there are parallel linear trends in the data which could indicate a trackway leading to said gate. There is a break in the defensive ditches in the eastern side of the fort, which would provide access into the annex, even though there is no apparent gap in the earthworks at (C). Further ditch-type anomalies [2] have been identified to the west of the main hillfort defences and it is likely that these are related to additional ditches or earthworks, which appear to have been ploughed out immediately to the north.

Plate 1: Castell Nadolig, magnetometer data of hillfort (SUMO 2019)

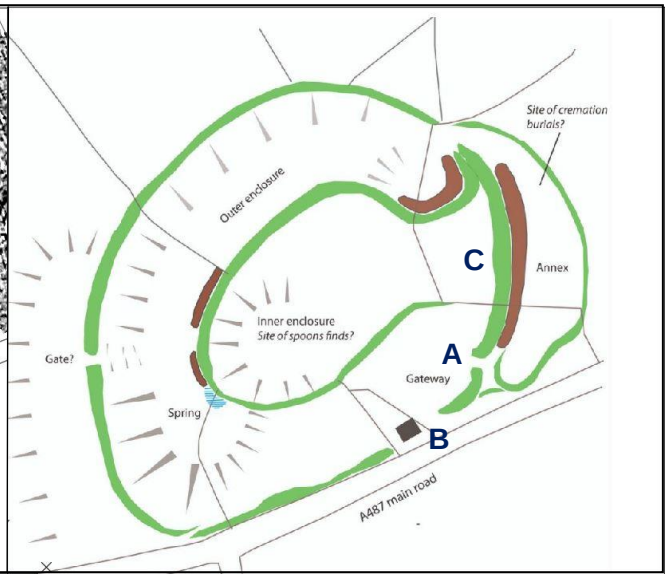

Plate 2: Castell Nadolig, plan of hillfort showing earthworks and topographic features (Driver, T 2019).

5.2 *Inner Enclosure*

5.2.1 Two tentative partial sub-circular responses [4, 5] and pit-like anomalies have been identified within the central enclosure of the fort, with the southernmost feature [4] some 17m in diameter. It is possible that these are indicative of domestic structures, i.e. roundhouses, though the responses lack clarity making further interpretation difficult. A ditch-type response [6] cuts through the southern tentative ring-shaped feature [4]; it could be of archaeological origin; however, it is may also represent a more recent field boundary.

5.3 *Outer Enclosure*

5.3.1 Ditch-type responses, linear trends and discrete anomalies [7] are visible at the west of the fort; these could be archaeological or a result of agricultural activity. A sub-circular response [8] is also visible in the outer enclosure; it could potentially relate to another ring-ditch, though its exact origin remains unclear.

5.4 *Annex*

5.4.1 The eastern, crescent-shaped annex [9] is also clearly visible in the results, though there are no indications for internal features that are suggestive of burials in the location indicated by the earthwork diagram above (Plate 2). There is tentative evidence for a ring-ditch [10] at the southern extent of the annex, though it is equally possible that this is of natural origin.

5.5 *Eastern Exterior*

5.5.1 A complex of circular [11a, b, c], rectilinear [12, 13] and curvilinear [14] anomalies have been identified to the east of the crescent-shaped annex [9]. The annular response [11a] at the eastern boundary of the site comprises a ditch measuring some 2.6m wide and the ring has a diameter of 11m. It is not clear as to whether this response contains any internal features, as it is cut by the present-day field boundary. Immediately to its west lies a smaller circular anomaly [11b] which is approximately 7.5m in diameter and may have a potential entrance on its northern edge. Two small discrete features are noted within the ring-ditch that are indicative of backfilled pits. Two adjoining rectilinear responses [12] to the north-west of the ring-ditches [11a, b] may represent small enclosures or subdivisions of land, with the tentative ditch-type response [14] potentially forming part of an additional annex. Several curvilinear and discrete features adjacent to the ditch at [14] could be a result of further ring-ditches and pits. A further small rectilinear response [13], approximately 7.5m in width and containing a small pit-like feature at its centre, can be seen to the north of the complex of activity. This could represent an additional funerary monument, similar to the ring-ditches / circular anomalies [11a, b, c] identified to its south, though its rectilinear form indicates that it could be associated with later settlement activity.

5.6 *Western Exterior*

5.6.1 A complex series of curvilinear, sub-circular, sub-rectangular, and discrete anomalies plus an area of increased magnetic response [15] have been identified to the west of the main enclosure [1]. The incomplete sub-circular anomalies may be a result of a series of adjoining ring-ditches, with the small discrete responses indicative of pits. The responses lack clarity and appear to have been truncated as a result of modern ploughing activity; hence their interpretation as ‘possible’ archaeology.

5.7 ***Uncertain***

5.7.1 Numerous discrete anomalies are present in the data across the site (they have not been abstracted onto the interpretation plan to avoid over-complicating the drawing), while additional linear trends have been detected in the western exterior. They could all have an archaeological, natural or modern explanation.

5.8 ***Agricultural – Ploughing***

5.8.1 Closely spaced, magnetically weak parallel linear anomalies are visible across the site on varying orientations, with the anomalies in Areas 2 and 3 curving to respect the field boundaries and earthworks. They are likely to be a result of modern agricultural practice, i.e. ploughing. The effect of the ploughing on the buried archaeological remains is evident in some locations, whereby the agriculture appears to cut through or truncate likely archaeological ditches.

5.9 ***Natural / Geological / Pedological***

5.9.1 Amorphous magnetic anomalies are visible in the west of the site and are likely to have natural origins, i.e. reflecting localised variations in the underlying geology.

5.10 ***Ferrous / Magnetic Disturbance***

5.10.1 A weak bipolar linear anomaly runs northwest-southeast across the west of Area 8 and is indicative of an underground service, such as a pipe or drain.

5.10.2 Ferrous responses close to boundaries are due to adjacent fences and gates. Smaller scale ferrous anomalies ("iron spikes") are present throughout the data and are characteristic of small pieces of ferrous debris (or brick / tile) in the topsoil; they are commonly assigned a modern origin. Only the most prominent of these are highlighted on the interpretation diagram.

6 DATA APPRAISAL & CONFIDENCE ASSESSMENT

6.1 Historic England guidelines (EH 2008) Table 4 states that the typical magnetic response on the local soils / geology is generally good but it can be variable. The results from this survey indicate the presence of numerous archaeological features; it can therefore be determined that the technique has been effective.

7 CONCLUSION

7.1 The survey at Castell Nadolig, Ceredigion, has confirmed the location of ditches and banks associated with the scheduled hillfort site (CD053). The results suggest that an entranceway depicted on the earthworks plan may lie further south; a 'new' gateway into the annex has been identified. There is tentative evidence for domestic activity within the fort, in the form of two large sub-circular responses and possible pits. A complex of previously unknown circular responses have been identified outside the fort to the east; they could be representative of ring-ditches or barrows, the largest of which is bisected by a current field boundary. A complex series of curvilinear and sub-annular anomalies to the west of the main enclosure could represent a number of adjoining ring-ditches and peripheral settlement evidence, though the anomalies are truncated by modern ploughing activity making further interpretation difficult.

7.2 The remaining linear anomalies identified in the survey could have archaeological, natural or agricultural origins. Evidence for modern ploughing is visible across the site, along with a couple of areas of natural magnetic variation and an underground service.

8 REFERENCES

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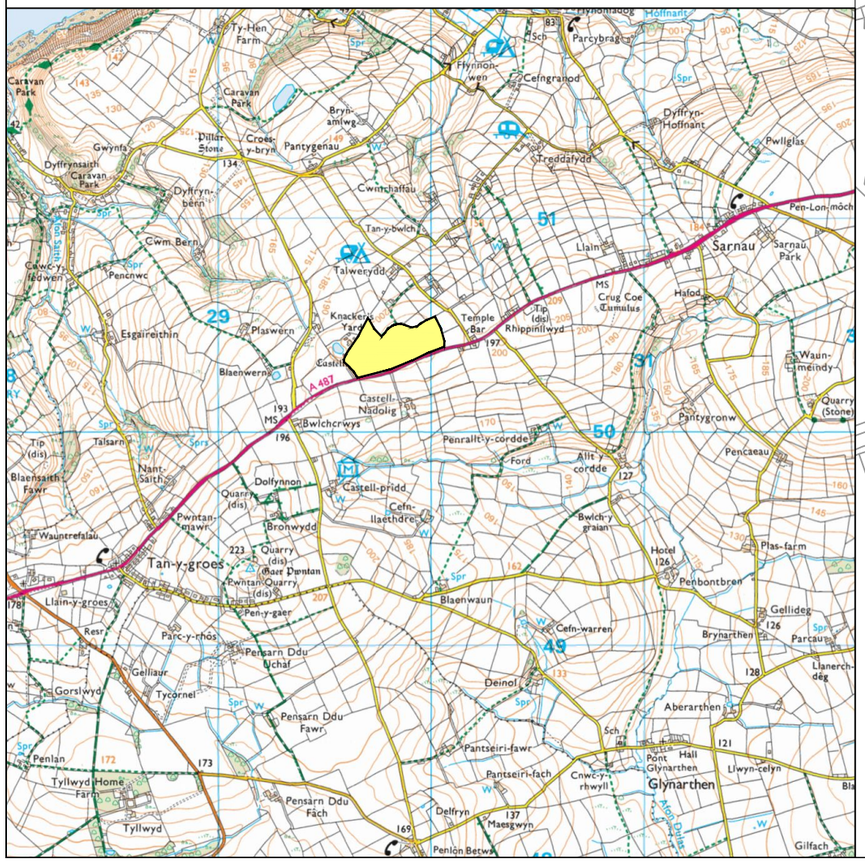
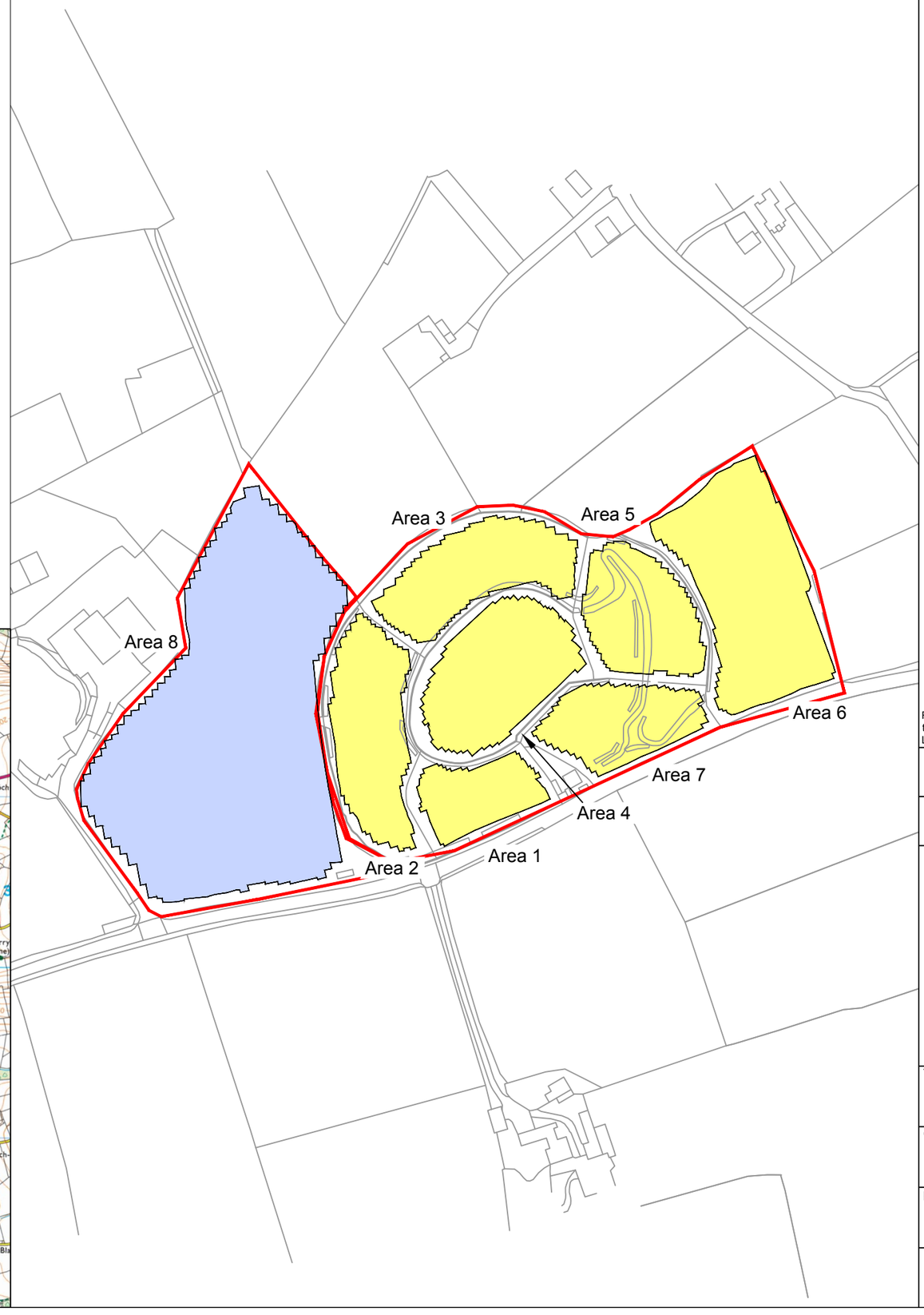




Survey Areas (0.5m x 0.125m)	
Survey Areas (1.0m x 0.125m)	

N

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:
Site Location

Client:
Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMW)

Project:
16161 - Castell Nadolig, Ceredigion

Scale:
NOT TO SCALE

Fig No:
01

N

+4nT

-2nT

sumo Survey

GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:

Magnetometer Survey - Greyscale Plots [1]

Client:

Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMW)

Project:

16161 - Castell Nadolig, Ceredigion

Scale:

0 metres 75

1:1500 @ A3

Fig No:

02

N

+10nT

-4nT

sumo Survey

GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

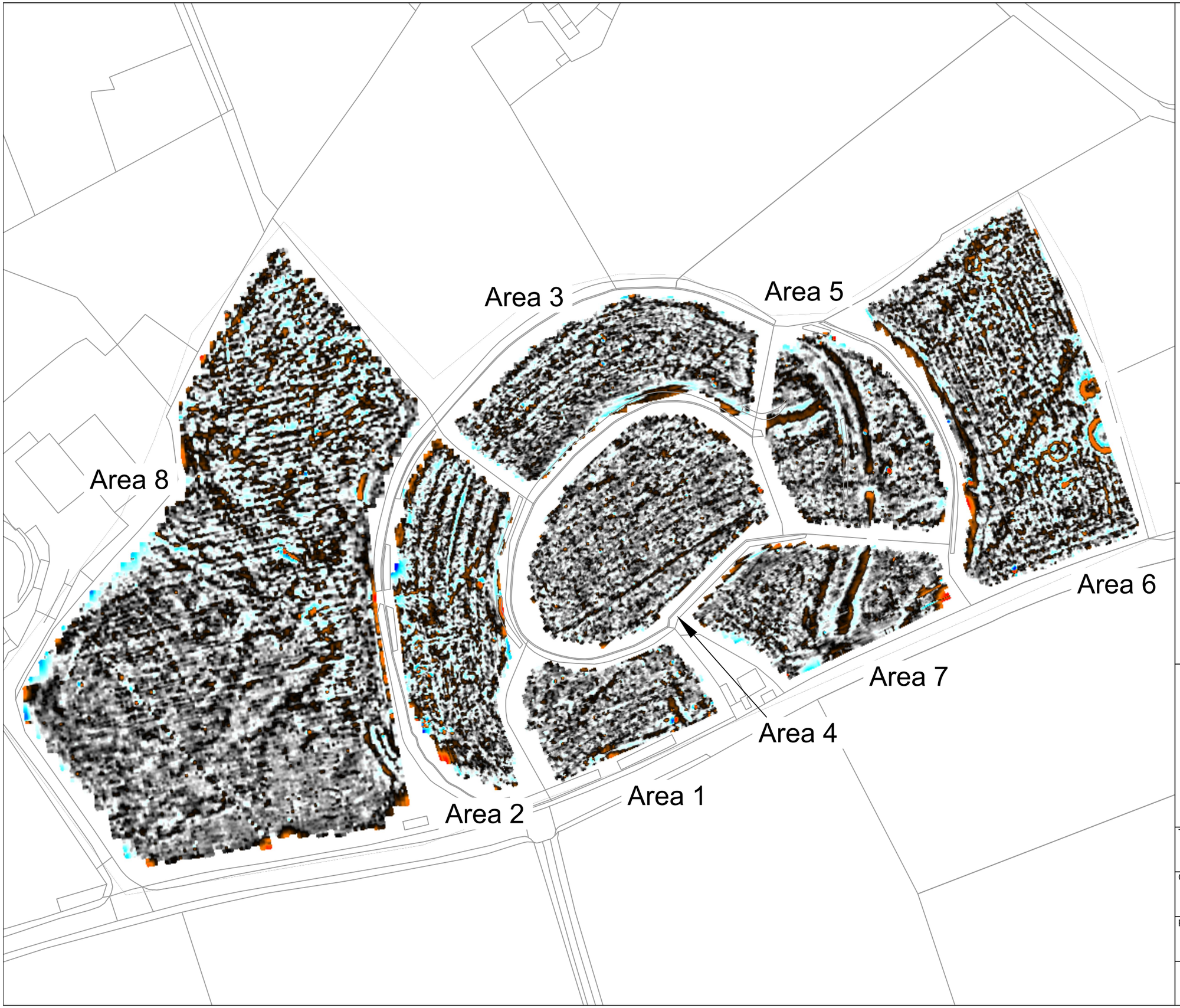
Title:
Magnetometer Survey - Greyscale Plots [2]

Client:
Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMW)

Project:
16161 - Castell Nadolig, Ceredigion

Scale:
0 metres 75
1:1500 @ A3

Fig No:
03



N

+100nT

-100nT

sumo Survey

GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

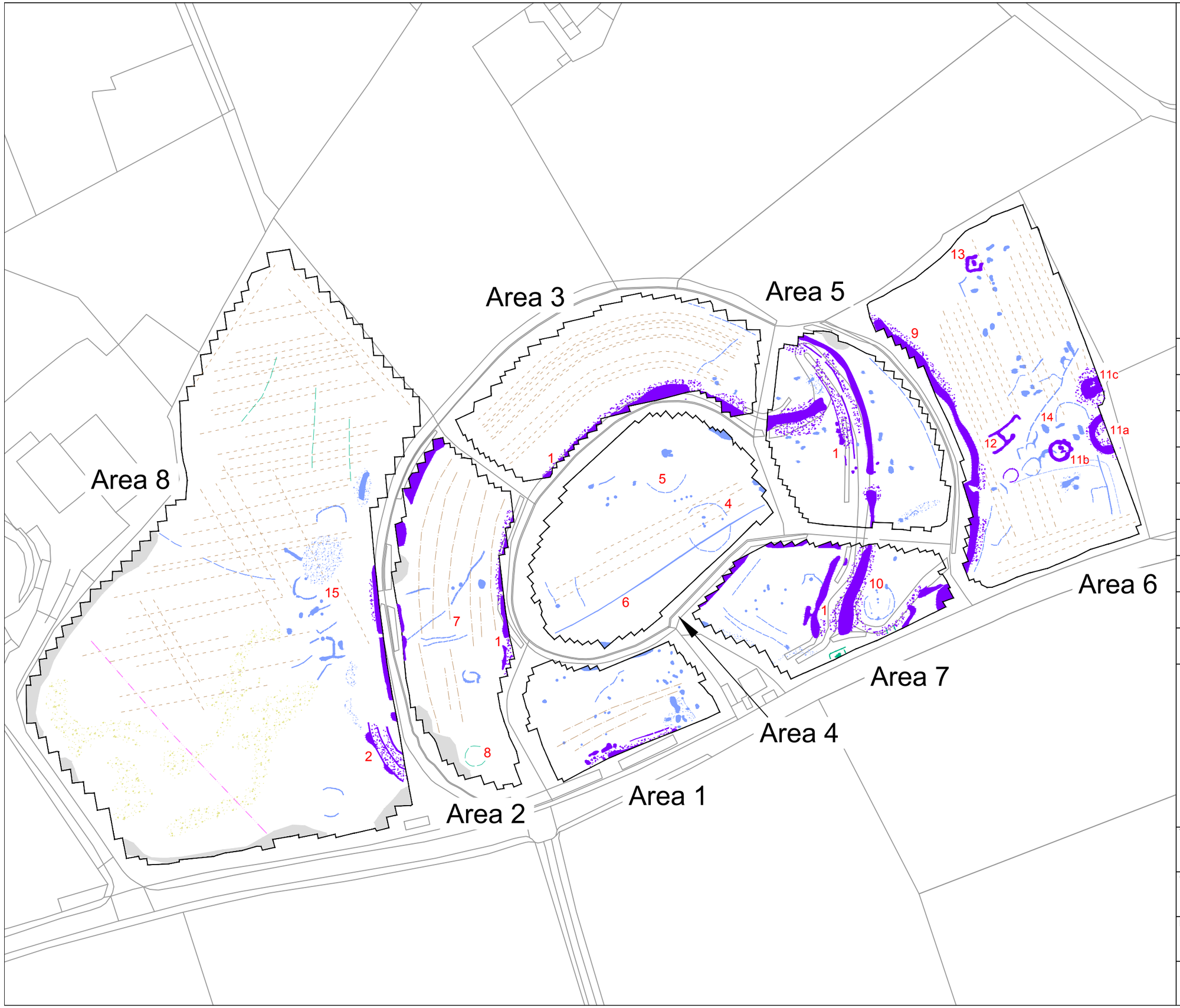
Title:
Magnetometer Survey - Colour Plots

Client:
Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMW)

Project:
16161 - Castell Nadolig, Ceredigion

Scale:
0 metres 75
1:1500 @ A3

Fig No:
04



N

KEY

	Probable archaeology (discrete anomaly / trend / area of increased magnetic response)
	Possible archaeology (discrete anomaly / trend / area of increased magnetic response)
	Uncertain Origin (trend)
	Agriculture (ridge and furrow)
	Agriculture (plough)
	Natural (e.g. geological / pedological)
	Possible service / drain
	Ferrous

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:
Magnetometer Survey - Interpretation

Client:
Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMW)

Project:
16161 - Castell Nadolig, Ceredigion

Scale:
0 metres 75
1:1500 @ A3

Fig No:
05

N

+10nT

-4nT

sumo Survey

GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:
Magnetometer Survey - Greyscale Plots overlain on 2009 Google Earth Image (©Google Earth 2019)

Client:
Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMW)

Project:
16161 - Castell Nadolig, Ceredigion

Scale:
0 metres 75
1:1500 @ A3

Fig No:
06

N

+10nT

-10nT

sumo Survey

GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:

Minimally Processed Data - Greyscale Plots

Client:

Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMW)

Project:

16161 - Castell Nadolig, Ceredigion

Scale:

0 metres 75

1:1500 @ A3

Fig No:

07

Appendix A - Technical Information: Magnetometer Survey Method, Processing and Presentation

Standards & Guidance

This report and all fieldwork have been conducted in accordance with the latest guidance documents issued by Historic England (EH 2008) (then English Heritage), the Chartered Institute for Archaeologists (CIfA 2014) and the European Archaeological Council (EAC 2016).

Grid Positioning

For hand held gradiometers the location of the survey grids has been plotted together with the referencing information. Grids were set out using a Trimble R8 Real Time Kinematic (RTK) VRS Now GNSS GPS system.

An RTK GPS (Real-time Kinematic Global Positioning System) can locate a point on the ground to a far greater accuracy than a standard GPS unit. A standard GPS suffers from errors created by satellite orbit errors, clock errors and atmospheric interference, resulting in an accuracy of 5m-10m. An RTK system uses a single base station receiver and a number of mobile units. The base station re-broadcasts the phase of the carrier it measured, and the mobile units compare their own phase measurements with those they received from the base station. This results in an accuracy of around 0.01m.

Technique	Instrument	Traverse Interval	Sample Interval
Magnetometer	Bartington Grad 601-2	1m	0.25m

Instrumentation: Bartington *Grad* 601-2

Bartington instruments operate in a gradiometer configuration which comprises fluxgate sensors mounted vertically, set 1.0m apart. The fluxgate gradiometer suppresses any diurnal or regional effects. The instruments are carried, or cart mounted, with the bottom sensor approximately 0.1-0.3m from the ground surface. At each survey station, the difference in the magnetic field between the two fluxgates is measured in nanoTesla (nT). The sensitivity of the instrument can be adjusted; for most archaeological surveys the most sensitive range (0.1nT) is used. Generally, features up to 1m deep may be detected by this method, though strongly magnetic objects may be visible at greater depths. The Bartington instrument can collect two lines of data per traverse with gradiometer units mounted laterally with a separation of 1.0m. The readings are logged consecutively into the data logger which in turn is daily down-loaded into a portable computer whilst on site. At the end of each site survey, data is transferred to the office for processing and presentation.

Data Processing

Zero Mean Traverse	This process sets the background mean of each traverse within each grid to zero. The operation removes striping effects and edge discontinuities over the whole of the data set.
Step Correction (De-stagger)	When gradiometer data are collected in 'zig-zag' fashion, stepping errors can sometimes arise. These occur because of a slight difference in the speed of walking on the forward and reverse traverses. The result is a staggered effect in the data, which is particularly noticeable on linear anomalies. This process corrects these errors.

Display

Greyscale/ Colourscale Plot	This format divides a given range of readings into a set number of classes. Each class is represented by a specific shade of grey, the intensity increasing with value. All values above the given range are allocated the same shade (maximum intensity); similarly, all values below the given range are represented by the minimum intensity shade. Similar plots can be produced in colour, either using a wide range of colours or by selecting two or three colours to represent positive and negative values. The assigned range (plotting levels) can be adjusted to emphasise different anomalies in the data-set.

Presentation of results and interpretation

The presentation of the results includes a ‘minimally processed data’ and a ‘processed data’ greyscale plot. Magnetic anomalies are identified, interpreted and plotted onto the ‘Interpretation’ drawings.

When interpreting the results, several factors are taken into consideration, including the nature of archaeological features being investigated and the local conditions at the site (geology, pedology, topography etc.). Anomalies are categorised by their potential origin. Where responses can be related to other existing evidence, the anomalies will be given specific categories, such as: Abbey Wall or Roman Road. Where the interpretation is based largely on the geophysical data, levels of confidence are implied, for example: Probable, or Possible Archaeology. The former is used for a confident interpretation, based on anomaly definition and/or other corroborative data such as cropmarks. Poor anomaly definition, a lack of clear patterns to the responses and an absence of other supporting data reduces confidence, hence the classification Possible.

Interpretation Categories

In certain circumstances (usually when there is corroborative evidence from desk-based or excavation data) very specific interpretations can be assigned to magnetic anomalies (for example, *Roman Road, Wall,* etc.) and where appropriate, such interpretations will be applied. The list below outlines the generic categories commonly used in the interpretation of the results.

Archaeology / Probable Archaeology	This term is used when the form, nature and pattern of the responses are clearly or very probably archaeological and /or if corroborative evidence is available. These anomalies, whilst considered anthropogenic, could be of any age.
Possible Archaeology	These anomalies exhibit either weak signal strength and / or poor definition, or form incomplete archaeological patterns, thereby reducing the level of confidence in the interpretation. Although the archaeological interpretation is favoured, they may be the result of variable soil depth, plough damage or even aliasing as a result of data collection orientation.
Industrial / Burnt-Fired	Strong magnetic anomalies that, due to their shape and form or the context in which they are found, suggest the presence of kilns, ovens, corn dryers, metal-working areas or hearths. It should be noted that in many instances modern ferrous material can produce similar magnetic anomalies.
Former Field Boundary (probable & possible)	Anomalies that correspond to former boundaries indicated on historic mapping, or which are clearly a continuation of existing land divisions. Possible denotes less confidence where the anomaly may not be shown on historic mapping but nevertheless the anomaly displays all the characteristics of a field boundary.
Ridge & Furrow	Parallel linear anomalies whose broad spacing suggests ridge and furrow cultivation. In some cases, the response may be the result of more recent agricultural activity.
Agriculture (ploughing)	Parallel linear anomalies or trends with a narrower spacing, sometimes aligned with existing boundaries, indicating more recent cultivation regimes.
Land Drain	Weakly magnetic linear anomalies, quite often appearing in series forming parallel and herringbone patterns. Smaller drains may lead and empty into larger diameter pipes, which in turn usually lead to local streams and ponds. These are indicative of clay fired land drains.
Natural	These responses form clear patterns in geographical zones where natural variations are known to produce significant magnetic distortions.
Magnetic Disturbance	Broad zones of strong dipolar anomalies, commonly found in places where modern ferrous or fired materials (e.g. brick rubble) are present.
Service	Magnetically strong anomalies, usually forming linear features are indicative of ferrous pipes/cables. Sometimes other materials (e.g. pvc) or the fill of the trench can cause weaker magnetic responses which can be identified from their uniform linearity.
Ferrous	This type of response is associated with ferrous material and may result from small items in the topsoil, larger buried objects such as pipes, or above ground features such as fence lines or pylons. Ferrous responses are usually regarded as modern. Individual burnt stones, fired bricks or igneous rocks can produce responses similar to ferrous material.
Uncertain Origin	Anomalies which stand out from the background magnetic variation, yet whose form and lack of patterning gives little clue as to their origin. Often the characteristics and distribution of the responses straddle the categories of *Possible Archaeology* / *Natural* or (in the case of linear responses) *Possible Archaeology* / *Agriculture*; occasionally they are simply of an unusual form.

Where appropriate some anomalies will be further classified according to their form (positive or negative) and relative strength and coherence (trend: weak and poorly defined).

Appendix B - Technical Information: Magnetic Theory

Detailed magnetic survey can be used to effectively define areas of past human activity by mapping spatial variation and contrast in the magnetic properties of soil, subsoil and bedrock. Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.1 nanoTeslas (nT) in an overall field strength of 48,000 (nT), can be accurately detected.

Weakly magnetic iron minerals are always present within the soil and areas of enhancement relate to increases in *magnetic susceptibility* and permanently magnetised *thermoremanent* material.

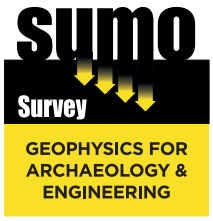
Magnetic susceptibility relates to the induced magnetism of a material when in the presence of a magnetic field. This magnetism can be considered as effectively permanent as it exists within the Earth's magnetic field. Magnetic susceptibility can become enhanced due to burning and complex biological or fermentation processes.

Thermoremanence is a permanent magnetism acquired by iron minerals that, after heating to a specific temperature known as the Curie Point, are effectively demagnetised followed by re-magnetisation by the Earth's magnetic field on cooling. Thermoremanent archaeological features can include hearths and kilns; material such as brick and tile may be magnetised through the same process.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement allowing assessment and characterisation of subsurface features. Material such as subsoil and non-magnetic bedrock used to create former earthworks and walls may be mapped as areas of lower enhancement compared to surrounding soils.

Magnetic survey is carried out using a fluxgate gradiometer which is a passive instrument consisting of two sensors mounted vertically 1m apart. The instrument is carried about 30cm above the ground surface and the top sensor measures the Earth's magnetic field whilst the lower sensor measures the same field but is also more affected by any localised buried feature. The difference between the two sensors will relate to the strength of a magnetic field created by this feature, if no field is present the difference will be close to zero as the magnetic field measured by both sensors will be the same.

Factors affecting the magnetic survey may include soil type, local geology, previous human activity and disturbance from modern services.



- Archaeological
- Geophysical
- Laser Scanning
- Measured Building
- Topographic
- Utility Mapping

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