A Report for

CAMBRIA ARCHAEOLOGY

on a

Geophysical Survey

carried out at

Brownslade Barrow, Castlemartin, Pembrokeshire, Wales

NGR SR 9052 9722

April-May2002

Job Ref. No. 1645

Author E J F Mercer BA MSc AIFA

CONTENTS

1 SUMMARY OF RESULTS

The magnetometer data did not locate any anomalies associated with the known archaeological features including the barrow. As a result the subsequent resistivity and GPR surveys were located on visible features. The resistivity data located evidence of the remains of a structure as well as defining the extent of the barrow. The GPR survey identified the badger burrows including three seen to be heading into the barrow.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned to undertake a geophysical survey of Brownslade barrow as part of on-going management and monitoring of the archaeological resource at the Castlemartin range. This survey forms part of an archaeological investigation being undertaken by Cambria Archaeology into the condition and defined extent of the barrow. In particular the threat from nearby badger sets.

2.2 Site location

The site is located within the Castlemartin Training Area (ATE) at OS NGR ref. SR 9052 9722 to the south west of Pembroke.

2.3 Description of site

The site of Brownslade Barrow is a scheduled ancient monument and lies within land occupied by the Ministry of Defence. It occupies a natural rise in the topography and is approximately 2m high and 22m in diameter. The remainder of the site is gently undulating and laid down to pasture. A known badger set is located immediately to the southeast of the barrow.

View of the barrow and badger set spoil

The underlying geology is Tournaisian and Viséan Carboniferous Limestone (British Geological Survey South Sheet, Third Edition Solid, 1979). The overlying soils are known as East Keswick soils which are typical brown earths. These consist of well drained fine loamy soils (Soil Survey of England and Wales, Sheet 3 Midland and Western England).

2.4 Site history and archaeological potential

Brownslade barrow is one of a number of archaeological features of probable Bronze Age date to be found on the Castlemartin ATE. In 1880 the antiquarians Laws and Lambton excavated the barrow and found it was partially made of sand. A number of burials, some of which were within stone lined cists, were located in and around the barrow. The discovery and style of other further burials and features suggest an early Christian phase of use in addition to its prehistoric origins.

Evidence of human bones brought to the surface probably by badgers

Approximately 30m to the north is an area containing stone foundations. Local tradition ascribes this to a chapel site which may have been associated with an enclosure bank now only detectable as an earthwork.

In February 2001 an active badger set outside of the currently designated scheduled area was bringing human bones to the surface. Therefore, it is possible that the barrow is situated within a wider area of archaeological significance relating to an early Christian use of the site.

2.5 Survey objectives

The objective of the survey was to locate any anomalies that may be of archaeological significance together with defining the extent of the barrow and its present condition. A survey would also help to determine the extent of any damage resulting from the badger sets.

Evidence of badger sets

2.6 Survey methods

Initially a magnetometer survey was carried out over 1.5ha to determine areas of potential which were subsequently targeted with resistivity and GPR. More information regarding these techniques is included in the Methodology section below.

3 METHODOLOGY

3.1 Date of fieldwork

The fieldwork was carried out over five days in total. The magnetometer survey was carried out on Monday 29th April and Tuesday 30th April 2002. The GPR and resistivity surveys were carried out on Thursday 2nd and Friday 3rd May 2002. A problem with the equipment used during the resistivity survey required a further day on site on Sunday 12th May 2002.

3.2 Grid locations

The location of the survey grids used for all three surveys has been plotted in Figure 3.

3.3 Description of techniques and equipment configurations

3.3.1 *Magnetometer*

Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.2 nanoTesla (nT) in an overall field strength of 48,000nT, can be accurately detected using an appropriate instrument.

The mapping of the anomaly in a systematic manner will allow an estimate of the type of material present beneath the surface. Strong magnetic anomalies will be generated by buried iron-based objects or by kilns or hearths. More subtle anomalies such as pits and ditches can be seen if they contain more humic material which is normally rich in magnetic iron oxides when compared with the subsoil.

To illustrate this point, the cutting and subsequent silting or backfilling of a ditch may result in a larger volume of weakly magnetic material being accumulated in the trench compared to the undisturbed subsoil. A weak magnetic anomaly should therefore appear in plan along the line of the ditch.

The magnetic survey was carried out using an FM36 Fluxgate Gradiometer, manufactured by Geoscan Research. The instrument consists of two fluxgates mounted 0.5m vertically apart, and very accurately aligned to nullify the effects of the earth's magnetic field. Readings relate to the difference in localised magnetic anomalies compared with the general magnetic background.

3.3.2 *Resistance Meter*

This method relies on the relative inability of soils (and objects within the soil) to conduct an electrical current which is passed through them. As resistivity is linked to moisture content, and therefore porosity, hard dense features such as rock will give a relatively high resistivity response, while features such as a ditch which retains moisture give a relatively low response.

The resistance meter used was an RM15 manufactured by Geoscan Research incorporating a mobile Twin Probe Array. The Twin Probes are separated by 0.5m and the associated remote probes were positioned approximately 15m outside the grid. The instrument uses an automatic data logger which permits the data to be recorded as the survey progresses for later downloading to a computer for processing and presentation.

Though the values being logged are actually resistances in ohms they are directly proportional to resistivity (ohm-metres) as the same probe configuration was used through-out.

3.3.3 *Ground probing radar*

Two of the main advantages of radar are its ability to give information of depth as well as work through a variety of surfaces, even in cluttered environments and which normally prevent other geophysical techniques being used.

A short pulse of energy is emitted into the ground and echoes are returned from the interfaces between different materials in the ground. The amplitude of these returns depends on the change in velocity of the radar wave as it crosses these interfaces. A measure of these velocities is given by the dielectric constant of that material. The travel times are recorded for each return on the radargram and an approximate conversion made to depth by calculating or assuming an average dielectric constant (see below).

Drier materials such as sand, gravel and rocks, i.e. materials which are less conductive (or more resistant), will permit the survey of deeper sections than wetter materials such as clays which are more conductive (or less resistant). Penetration can be increased by using longer wavelengths (lower frequencies) but at the expense of resolution (see 3.4.2 below).

As the antennae emit a "cone" shaped pulse of energy an offset target showing a perpendicular face to the radar wave will be "seen" before the antenna passes over it. A resultant characteristic *diffraction* pattern is thus built up in the shape of a hyperbola. A classic target generating such a diffraction is a pipeline when the antenna is travelling across the line of the pipe. However it should be pointed out that if the interface between the target and its surrounds does not result in a marked change in velocity then only a weak hyperbola will be seen, if at all.

The Ground Probing Impulse Radar used was a SIR2000 system manufactured by Geophysical Survey Systems Inc. (GSSI).

The radar surveys were carried out with a 400MHz antenna. This mid-range frequency offers a good combination of depth of penetration and resolution.

3.4 Sampling interval, depth of scan, resolution and data capture

3.4.1 *Sampling interval*

Magnetometer
Readings were taken at 0.5m centres along traverses 1m apart. This equates to 800 sampling points in a full 20m x 20m grid. All traverses are surveyed in a "parallel" rather than "zigzag" mode to avoid heading error.

Resistivity
Readings were taken at 1.0m centres along traverses 1.0m apart. This equates to 400 sampling points in a full 20m x 20 grid. All traverses were surveyed in a "zigzag" mode.

Ground probing radar
Radar scans were carried out along traverses 1m apart on an orthogonal grid positioned between the badger set and the barrow as shown in Figure 3. Data was collected at 40 scans/metre. A measuring wheel was used to put markers into the recorded radargram at 1m centres.

3.4.2 *Depth of scan and resolution*

Magnetometer
The FM36 has a typical depth of penetration of 0.5m to 1.0m. This would be increased if strongly magnetic objects have been buried in the site. The collection of data at 0.5m centres provides an optimum resolution for the technique.

Resistivity
The 0.5m probe spacing of a twin probe array has a typical depth of penetration of 0.5m to 1.0m The collection of data at 1m centres with a 0.5m probe spacing provides an optimum resolution for the technique.

Ground probing radar
The average velocity of the radar pulse is calculated to be 0.1/nsec which is typical for the type of sub-soils on the site. With a range setting of 50nsec this equates to a maximum depth of scan of 2.5m respectively but it must be remembered that this figure could vary by ± 10% or more. A further point worth making is that very shallow features are lost in the strong surface response experienced with this technique.

Under ideal circumstances the minimum size of a vertical feature seen by a 200MHz (relatively low frequency) antenna in a damp soil would be 0.1m (i.e. this antenna has a wavelength in damp soil of about 0.4m and the vertical resolution is one quarter of this wavelength). It is interesting to compare this with the 400MHz antenna, which has a wavelength in the same material of 0.2m giving a theoretical resolution of 0.05m. A 900MHz antenna would give 0.09m and 0.02m respectively.

3.4.3 *Data capture*

Magnetometer
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 job, data is transferred to the office for processing and presentation.

Resistivity
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 job, data is transferred to the office for processing and presentation.

Ground probing radar
Data is displayed on a monitor as well as being recorded onto an internal hard disk. The data is later downloaded into a computer for processing.

3.5 Processing, presentation of results and interpretation

3.5.1 *Processing*

Magnetometer
Processing is performed using specialist software known as *Geoplot 3*. This can emphasise various aspects contained within the data but which are often not easily seen in the raw data. Basic processing of the magnetic data involves 'flattening' the background levels with respect to adjacent traverses and adjacent grids. 'Despiking' is also performed to remove the anomalies resulting from small iron objects often found on agricultural land. Once the basic processing has flattened the background it is then possible to carry out further processing which may include low pass filtering to reduce 'noise' in the data and hence emphasise the archaeological or man-made anomalies.

The following schedule shows the basic processing carried out on all processed magnetometer data used in this report:

Zero mean grid	*Threshold = 0.25 std. dev.*
Zero mean traverse	*Last mean square fit = off*
Despike	*X radius = 1 Y radius = 1*
	Threshold = 3 std. dev.
	Spike replacement = mean

Resistivity

The processing was carried out using specialist software known as *Geoplot 3* and involved the 'despiking' of high contact resistance readings and the passing of the data though a high pass filter. This has the effect of removing the larger variations in the data often associated with geological features. The nett effect is aimed at enhancing the archaeological or man-made anomalies contained in the data.

The following schedule shows the processing carried out on the processed resistance plots.

Despike	*X radius = 1*
	Y radius = 1
	Spike replacement
High pass filter	*X radius = 10*
	Y radius = 10
	Weighting = Gaussian

Ground probing radar

Each radargram has been studied and those anomalies thought to be significant were noted and classified as detailed below. Inevitably some simplification has been made to classify the diversity of responses found in radargrams.

i. Strong and weak discrete reflector.
These may be a mix of different types of reflectors but their limits can be clearly defined. Their inclusion as a separate category has been considered justified in order to emphasise anomalous returns which may be from archaeological targets and would not otherwise be highlighted in the analysis.

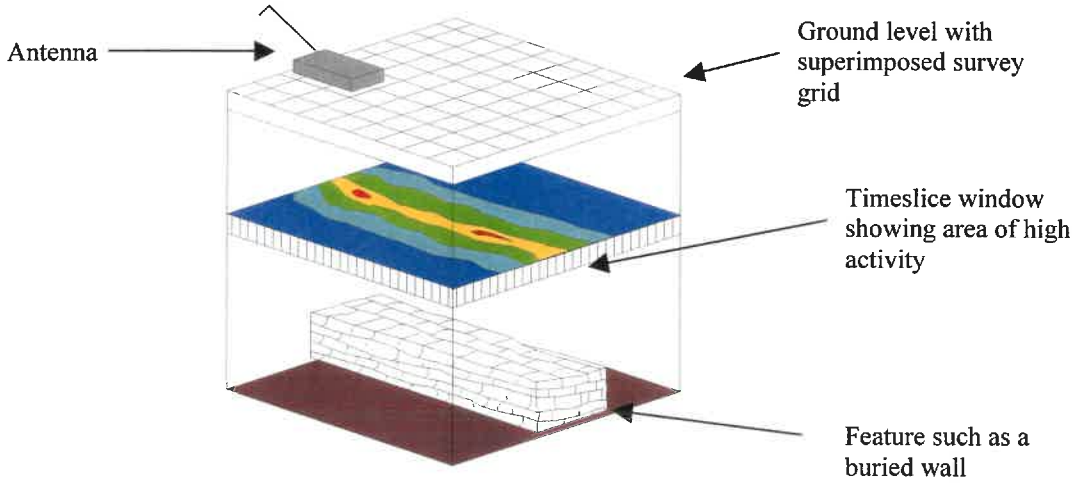
ii. Complex reflectors.
These would generally indicate a confused or complex structure to the subsurface. An occurrence of such returns, particularly where the natural soils or rocks are homogeneous, would suggest artificial disturbances. These are subdivided into both strong and weak giving an indication of the extent of change of velocity across the interface, which in turn may be associated with a marked change in material or moisture content.

iii. Point diffractions.
These may be formed by a discrete object such as a stone or a linear feature such as a small diameter pipeline being crossed by the radar traverse (see also the second sentence in 4. below).

iv. Convex reflectors and broad crested diffractions.
A convex reflector can be formed by a convex shaped buried interface such as a vault or very large diameter pipeline or culvert. A broad crested diffraction as opposed to a point diffraction can be formed by (for example) a large diameter pipe or a narrow wall generating a hybrid of a point diffraction and convex reflector where the central section is a reflection off the top of the target and the edges/sides forming diffractions.

v. Planar returns.
These may be formed by a floor or some other interface parallel with the surface. These are subdivided into both strong and weak giving an indication of the extent of change of velocity across the interface which in turn may be associated with a marked change in material or moisture content.

Timeslice plots
A computer analysis has also been carried out. The radar data was interrogated for areas of high activity and the results presented in a plan format known as timeslice plots (Figure 12). In this way it is easy to see if the high activity areas form recognisable patterns.



In order for a computer to produce coherent area plans of the radar survey it was first necessary to carry out pre-processing. This involved linearising each traverse so that the horizontal scale was accurate, processing to remove column and row biasing caused by instrument effects and normalising the data to obtain maximum contrast. The data was then sampled and modelled to produce activity plots at various depths. As the radar is actually measuring the time for each of the reflections found, these are called "time slice windows". Plots for various time slices have been included in the report after linearising, despiking and, where appropriate, thresholding the data to emphasise the low activity areas. Based on an average velocity calculations have been made to show the equivalent depth into the ground. The data was sampled between different time intervals effectively producing plans at different depths into the ground.

The weaker reflections in the time slice windows are shown as dark colours namely blues and greens. The stronger reflections are represented by brighter colours such as light green, yellow, orange, red and white (see key provided in Figure 12).

Reflections within the radar image are generated by a change in velocity of the radar from one medium to another. It is not unreasonable to assume that the higher activity anomalies are related to marked changes in materials within the ground such as foundations or surfaces within the soil matrix.

3.5.2 *Presentation of results and interpretation*

Magnetometer
The presentation of the data for the trial survey involves a print-out of the raw data both as grey scale (Figure 4) and trace plots (Figure 5 and 6), together with a grey scale plot of the processed data (Figure 7). Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing for the site (Figure 8).

Resistivity
The presentation of the data for the site involves a print-out of the raw data as a grey scale plot (Figure 9), together with a grey scale plot of the processed data (Figure 10). Anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing (Figure 11).

Ground probing radar
An abstraction and interpretation of anomalies has been plotted in Figure 13. An example timeslice plot has also been plotted in Figure 12.

4 RESULTS

4.1 *Magnetometry*

The results from the magnetometer data do not show any obvious anomalies relating to the barrow or any associated archaeological features. This is probably due to the low magnetic properties of the soil. The trace plots (Figures 5 and 6) demonstrate the large amount of magnetic debris which exists on site and has been abstracted in Figure 8.

As a result of the lack of potential targets the decision was taken to target the resistivity survey on the barrow and extend it northwards to cover the known structural remains thought to be a chapel. The GPR survey was targeted on the area between the barrow and the badger set to investigate the extent of any damage.

4.2 *Resistivity*

The resistivity data clearly shows a doughnut-shaped area of high resistance relating to the barrow. From the southern side of the barrow the high resistance appears to spread out. Due to its position in the corner of the survey area it is very difficult to make an assessment as to its origin. However, the high resistance does appear to be broken by the position of the badger set which may indicate some disturbance.

In the immediate area surrounding the barrow the data appears to be noisy when compared to that further north. The reason for this is unclear but may be associated with the degradation of the barrow. These two differing areas of resistance is divided by a broad high resistance anomaly which corroborates with an embankment.

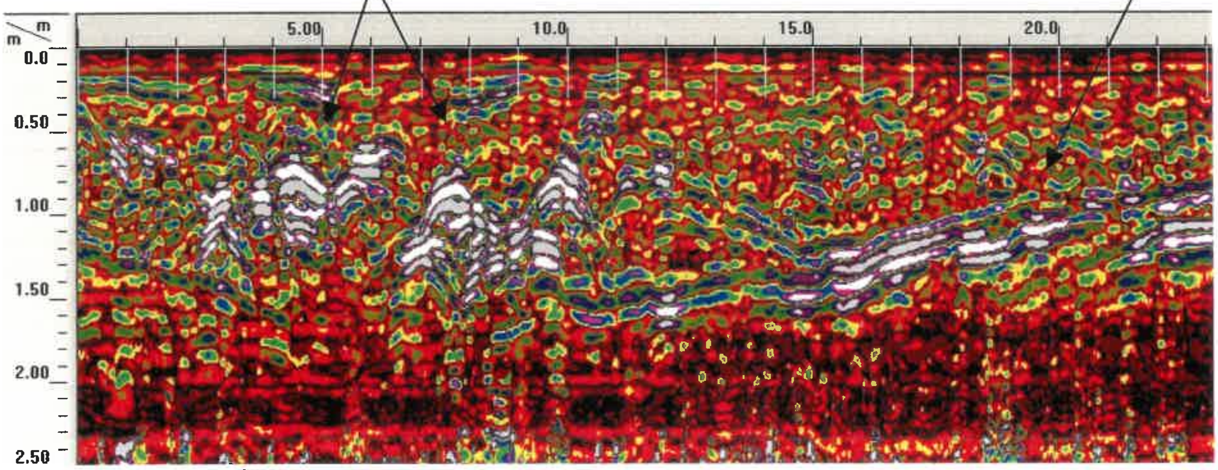
The area north of the barrow was surveyed in order to locate any anomalies associated with the remains of a wall visible on site. The data shows a complex arrangement of very regular high resistance linear anomalies reminiscent of structural remains. These may belong to the chapel.

4.3 *Ground probing radar*

The radar survey area was sited in order to examine the extent of the badger set towards the barrow. The burrows are clearly evident in the example timeslice plot for 1.25m (Figure 12).

The radargrams were individually inspected and anomalies were noted and interpreted in Figure 13. The interpretation shows numerous burrows around the known badger set. In places these were quite complex and are thought to be interlinked. In terms of making sense of the data some simplification of the burrows had to be made. Nevertheless, heading towards the barrow are three distinct burrows suggesting that the barrow is undergoing some damage .

Interestingly, areas of inclining horizons have also been noted in the radar data. However, it is not certain whether these are of an archaeological origin or are natural or even resulting from MOD activity.



Example radargram of 24E

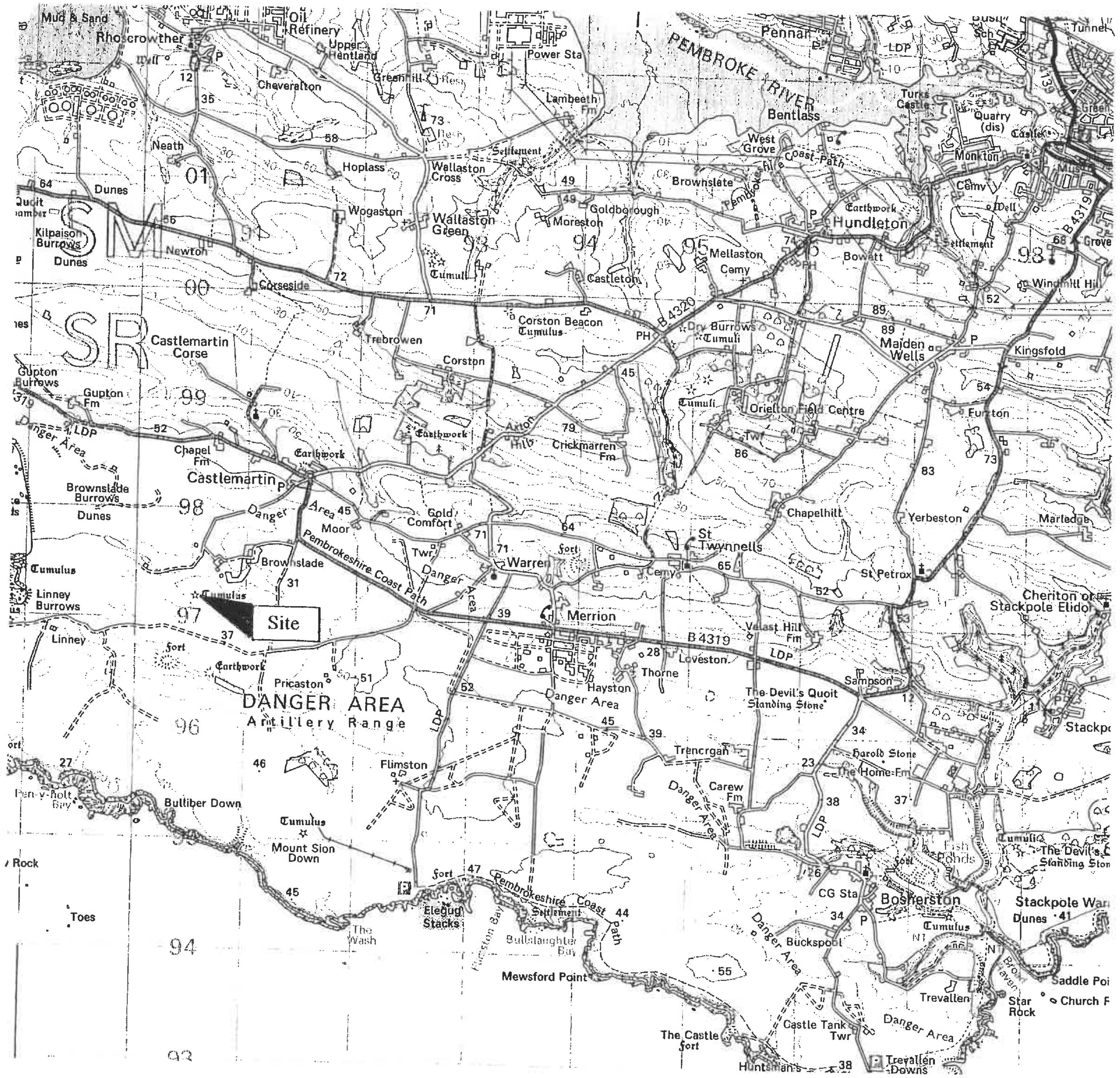
5 CONCLUSIONS AND RECOMMENDATIONS

The magnetometer data did not locate any anomalies of archaeological significance which would help target further survey. Therefore, the resistivity data was sited on the known barrow and remains of a wall and the GPR was positioned between the badger set and the barrow.

The resistivity results were more successful as the extent of the barrow was identified together with an interesting area of high resistance towards the south. The cause of this was unknown and could not be identified in the GPR data. Therefore it is recommended for further investigation. To the north of the barrow an embankment was located and beyond this the probable remains of a structure which is also recommended for investigation.

The GPR effectively identified the badger burrows of which three were seen to run towards the barrow. As a result it appears that the barrow is under threat from the badgers.

OS 100km square = SR



Amendments		
Issue No.	Date	Description
-	-	-

Site centred on NGR SR 9052 9722

Client
CAMBRIA ARCHAEOLOGY

Project Title — Job No. 1645
BROWNSLADE BARROW, CASTLEMARTIN, PEMBROKESHIRE

Subject
GENERAL LOCATION PLAN

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GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPPER HOOK ROAD
UPTON UPON SEVERN
UK
WR8 0SA
T: +44 (0)1684 592266
F: +44 (0)1684 594142
E: info@stratascan.co.uk
www.stratascan.co.uk

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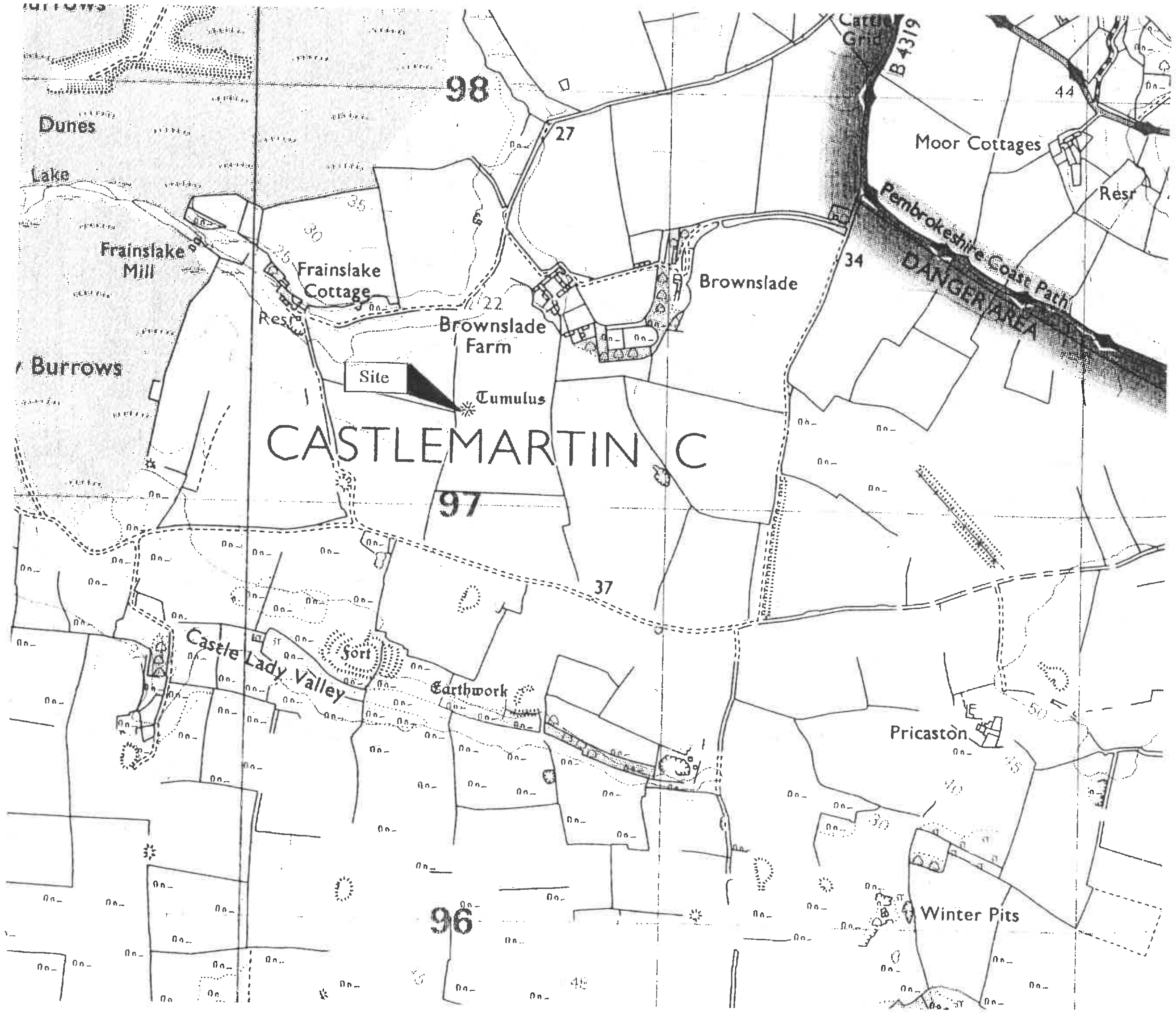
Scale 1:50 000 — 0km 1km 2km

Plot	Checked by	Issue No.
A3	PPB	01
Date	Drawn by	Figure No.
APRIL-MAY 02	EJFM	01

Digital plan supplied by Cambria Archaeology

OS 100km square = SR



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Project Title — Job No. 1645
BROWNSLADE BARROW, CASTLEMARTIN, PEMBROKESHIRE

Subject
DETAILED LOCATION PLAN

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GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPPER HOOK ROAD
UPTON UPON SEVERN
UK
WR8 0SA
T: +44 (0)1684 592266
F: +44 (0)1684 594142
E: info@stratascan.co.uk
www.stratascan.co.uk
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Scale 1:12 500 — 0m 100 200 300 400 500m

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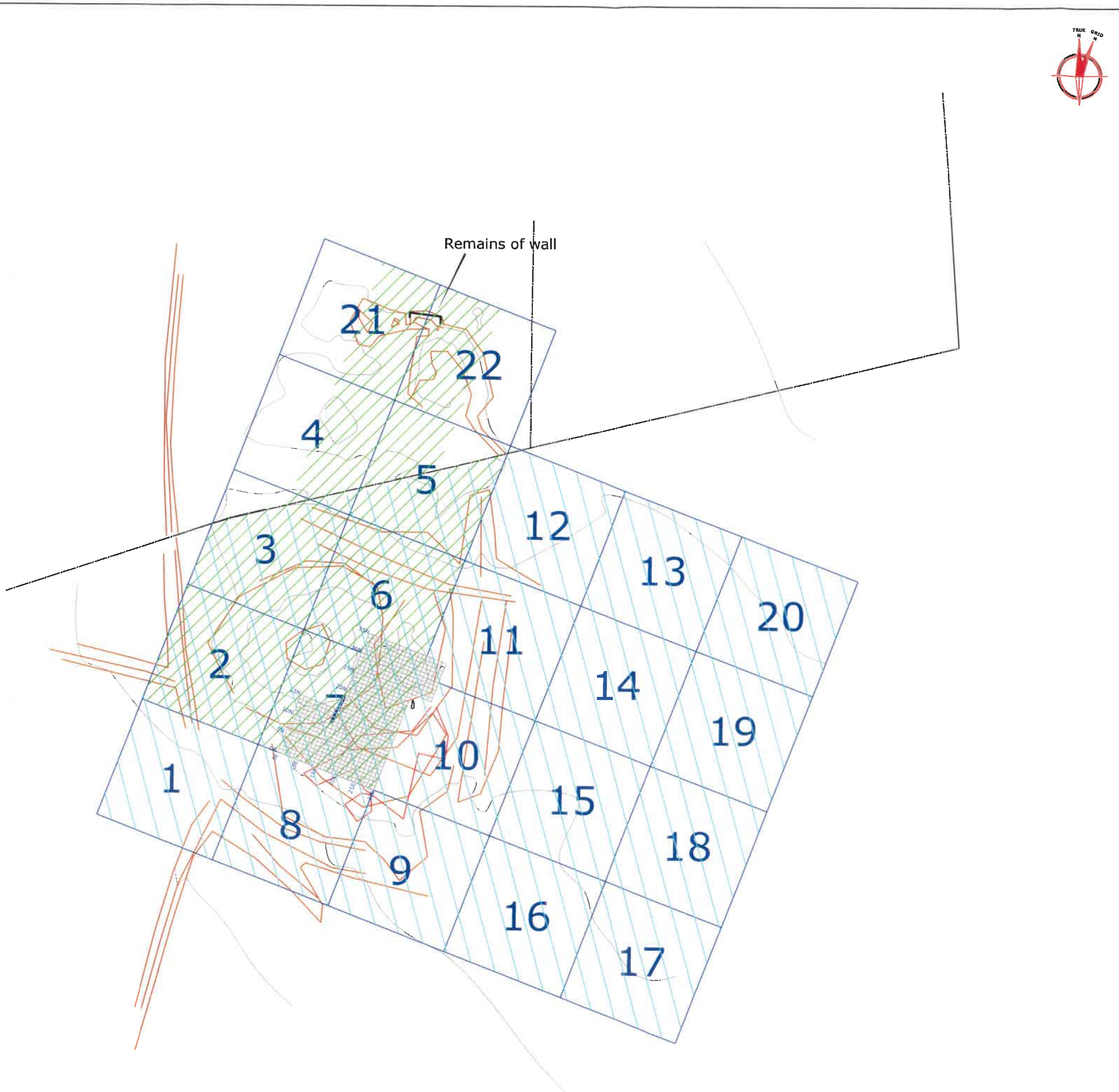
APRIL-MAY 02	EJFM	01

Digital plan supplied by Cambria Archaeology



Amendments

Issue No.	Date	Description
-	-	-

REFERENCING INFORMATION

●	Grid node points surveyed in and information supplied by client
/	Approximate outline of badger set
2	Geophysical survey grids
▦	Ground probing radar grid
▧	Area surveyed within grid using magnetometry
▨	Area surveyed within grid using resistivity

Client

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SITE PLAN SHOWING LOCATION OF SURVEY GRIDS AND REFERENCING

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VINEYARD HOUSE
UPPER HOOK ROAD
UPTON UPON SEVERN
UK
WR8 0SA
T: +44 (0)1684 592266
F: +44 (0)1684 594142
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Scale 1:1000 — 0m 10 20 30 40m

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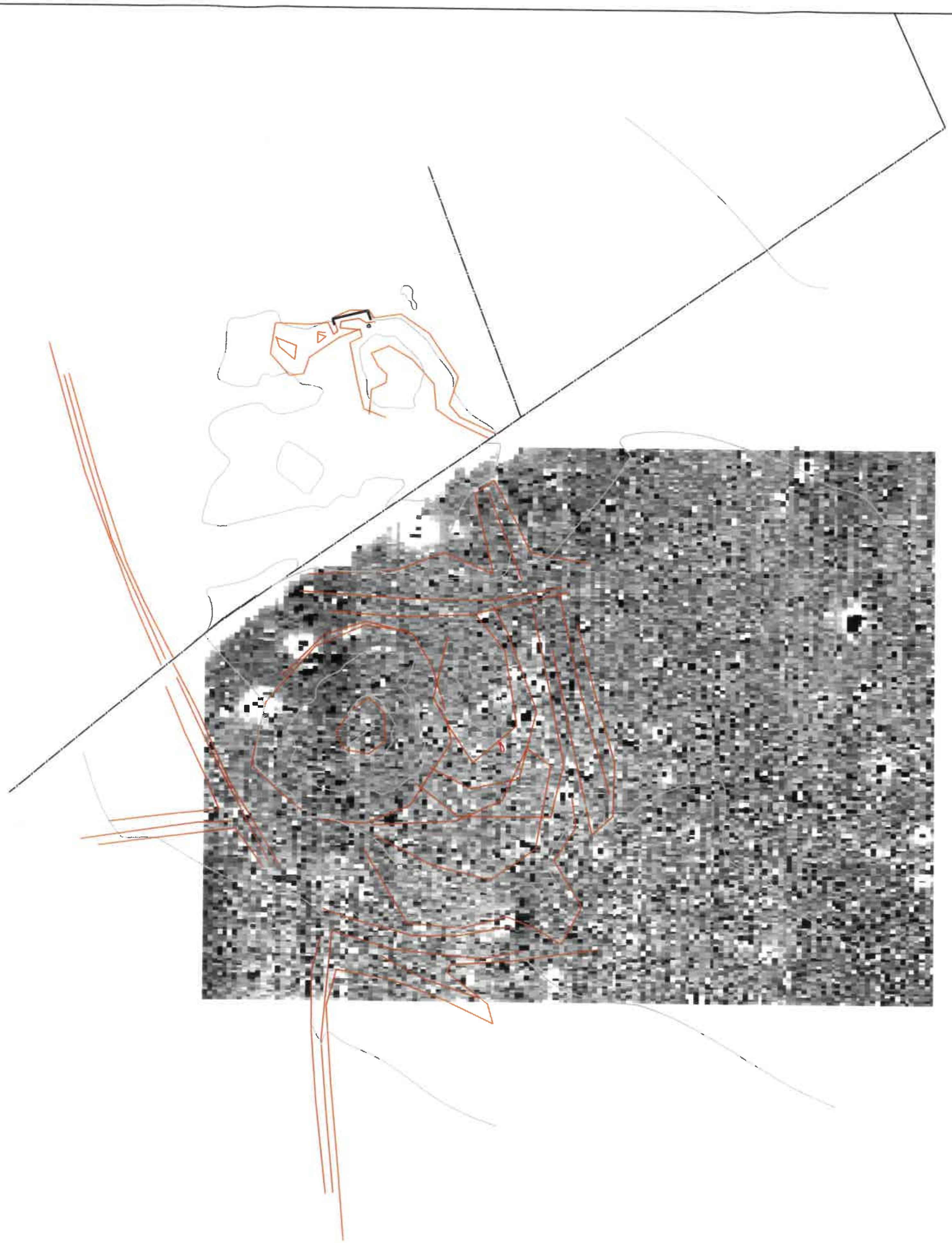

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Plotting parameters

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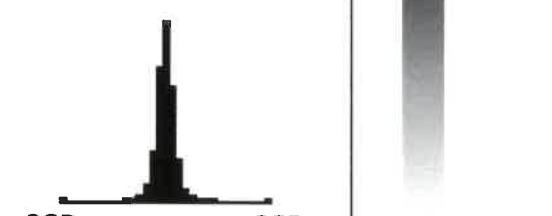
Minimum -7.5nT (white)



Client

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Project Title Job No. 1645

BROWNSLADE BARROW, CASTLEMARTIN, PEMBROKESHIRE

Subject

PLOT OF RAW MAGNETOMETER DATA

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GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPPER HOOK ROAD
UPTON UPON SEVERN
UK
WR8 0SA
T: +44 (0)1684 592266
F: +44 (0)1684 594142
E: info@stratascan.co.uk
www.stratascan.co.uk
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Scale 1:1000 — 0m 10 20 30 40m

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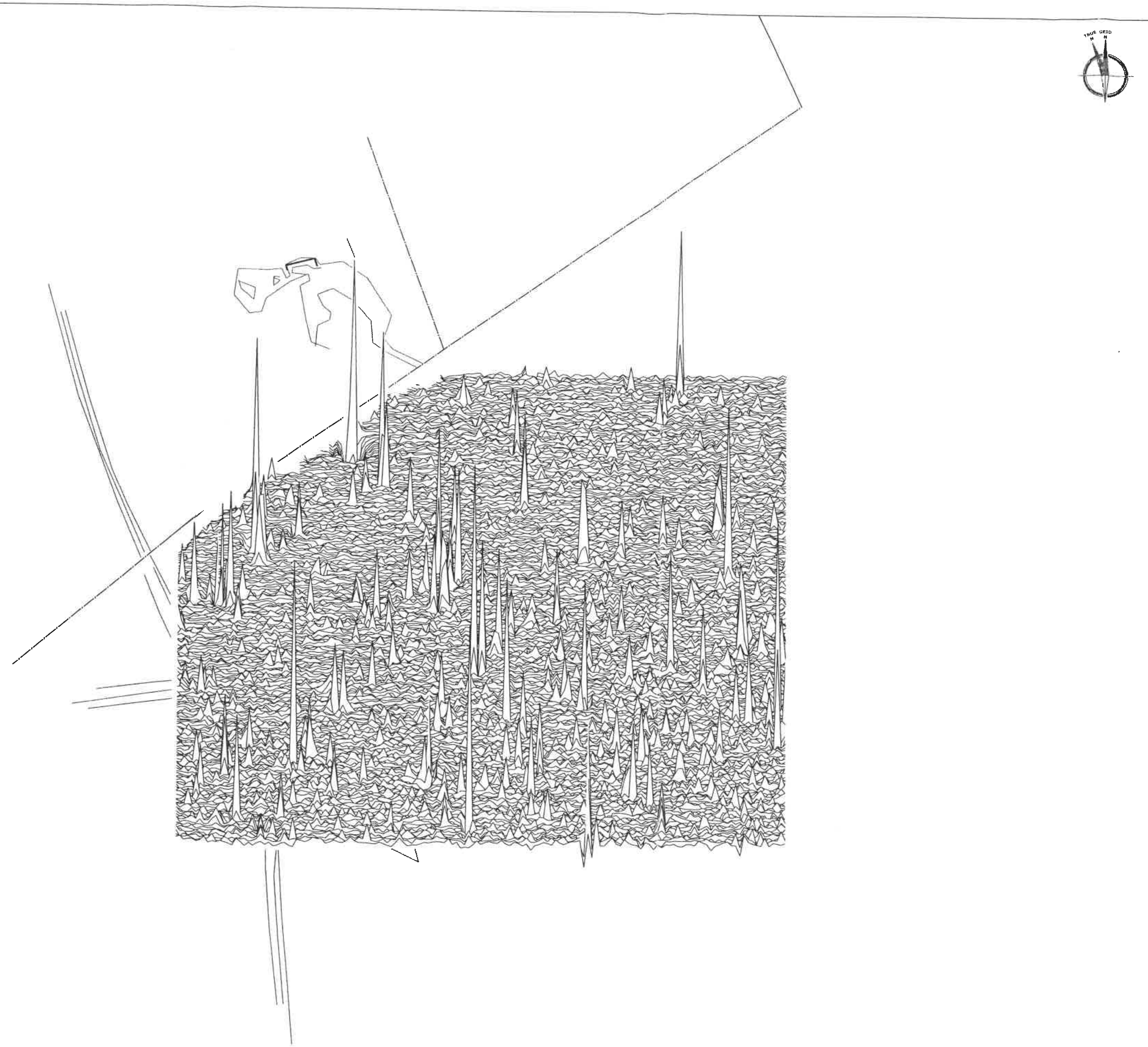
Date	Drawn by	Figure No.
APRIL-MAY 02	EJFM	04

Digital plan supplied by Cambria Archaeology



Amendments

Issue No.	Date	Description
-	-	-

Plotting parameters

+40nT

(*Positive values displace above the trace line. Hidden values have not been plotted*)

200nT
160nT
120nT
80nT
40nT
0nT

Client

CAMBRIA ARCHAEOLOGY

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BROWNSLADE BARROW, CASTLEMARTIN, PEMBROKESHIRE

Subject

TRACE PLOT OF RAW MAGNETOMETER DATA SHOWING POSITIVE VALUES

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GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPPER HOOK ROAD
UPTON UPON SEVERN
UK
WR8 0SA
T: +44 (0)1684 592266
F: +44 (0)1684 594142
E: info@stratascan.co.uk
www.stratascan.co.uk
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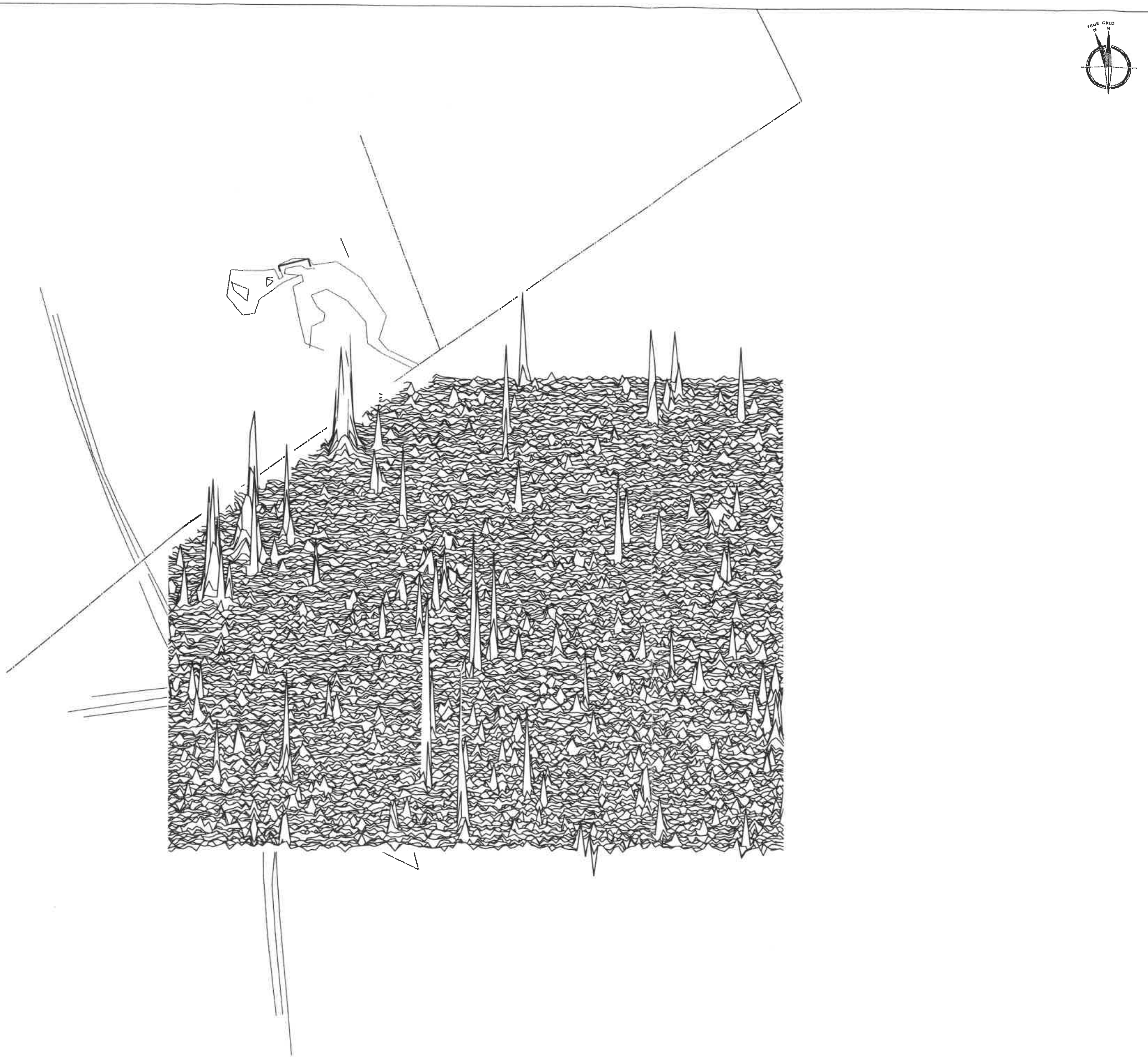
Date APRIL-MAY 02	Drawn by EJFM	Figure No. 05



Issue No.	Date	Description
-	-	-

Amendments

Plotting parameters

-40nT

(Negative values displace above the trace line. Hidden values have not been plotted)

-200nT
-160nT
-120nT
-80nT
-40nT
0nT

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BROWNSLADE BARROW, CASTLEMARTIN, PEMBROKESHIRE

Subject
TRACE PLOT OF RAW MAGNETOMETER DATA SHOWING NEGATIVE VALUES

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GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPPER HOOK ROAD
UPTON UPON SEVERN
UK
WR8 0SA
T: +44 (0)1684 592266
F: +44 (0)1684 594142
E: info@stratascan.co.uk
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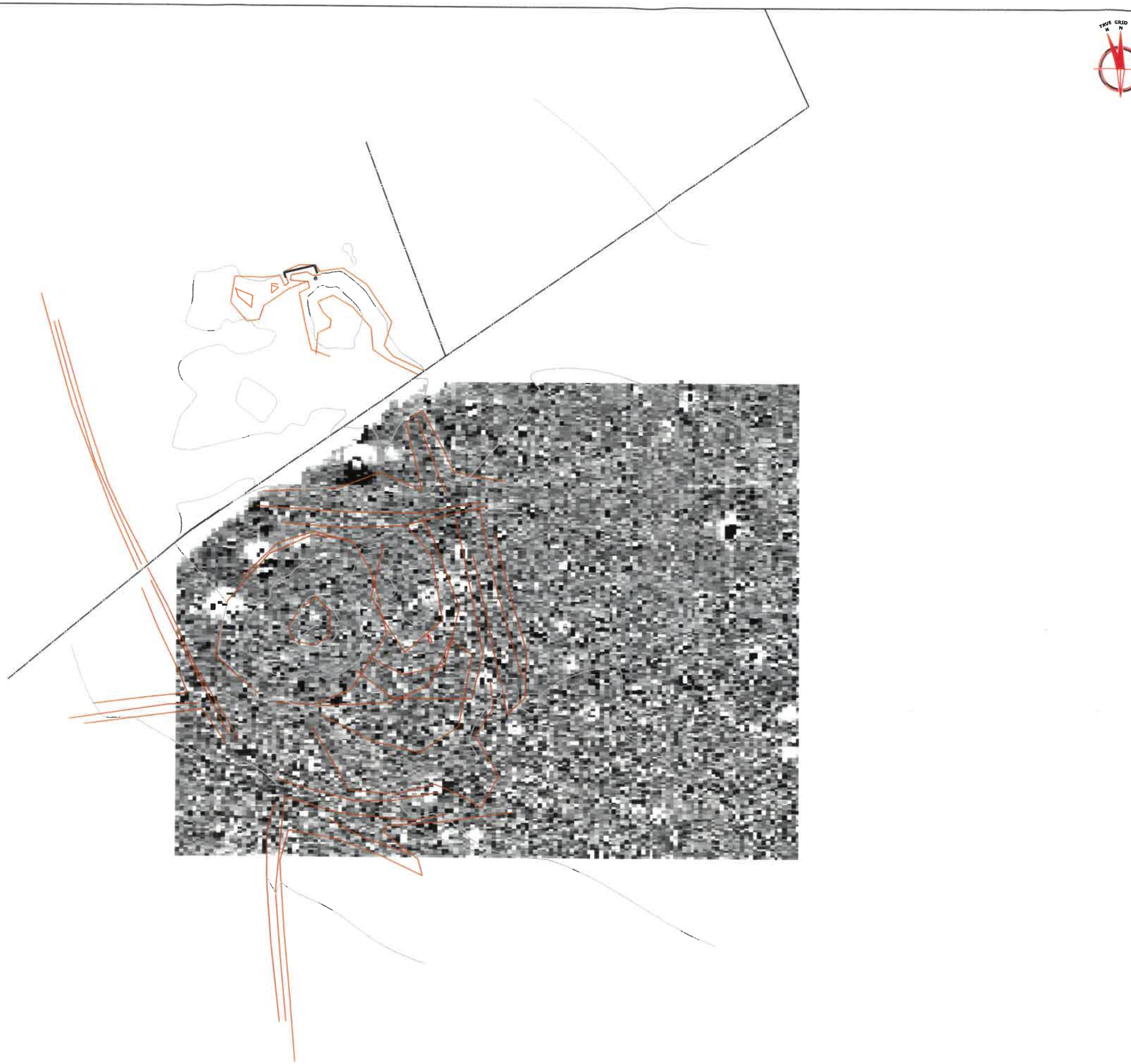

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Issue No.	Date	Description
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Plotting parameters

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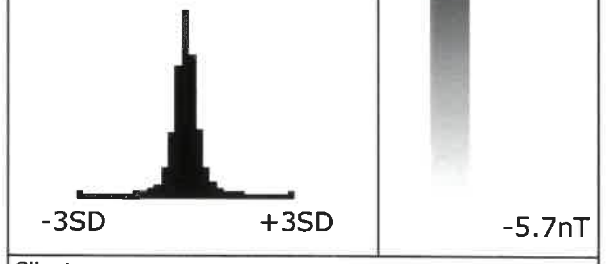
Minimum -5.7nT (white)



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BROWNSLADE BARROW, CASTLEMARTIN, PEMBROKESHIRE

Subject
PLOT OF PROCESSED MAGNETOMETER DATA

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UPPER HOOK ROAD
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WR8 0SA
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Scale 1:1000 — 0m 10 20 30 40m

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A3	PPB	01
Date	Drawn by	Figure No.
APRIL-MAY 02	EJFM	07

Digital plan supplied by Cambria Archaeology

Amendments		
Issue No.	Date	Description
-	-	-

Feint positive linear anomaly - cut feature of ?archaeological significance

General scatter of magnetic debris

Strong discrete positive anomaly with negative return - ferrous object

Client

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BROWNSLADE BARROW, CASTLEMARTIN, PEMBROKESHIRE

Subject

ABSTRACTION AND INTERPRETATION OF MAGNETOMETER ANOMALIES

STRATASCAN™
GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPPER HOOK ROAD
UPTON UPON SEVERN
UK
WR8 0SA
T: +44 (0)1684 592266
F: +44 (0)1684 594142
E: info@stratascan.co.uk
www.stratascan.co.uk

REGISTERED ORGANISATION IFA

Scale 1:1000	0m 10 20 30 40m	
Plot A3	Checked by PPB	Issue No. 01
Date APRIL-MAY 02	Drawn by EJFM	Figure No. 08

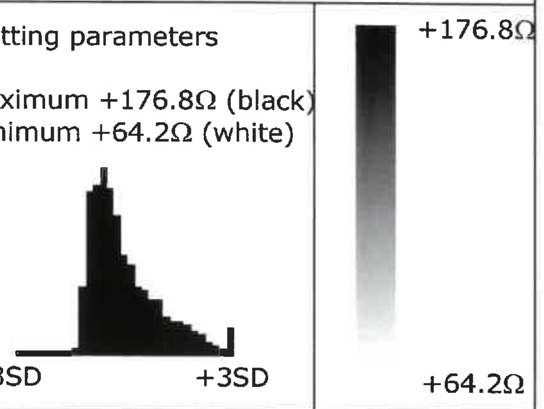
Digital plan supplied by Cambria Archaeology

Digital plan supplied by
Cambria Archaeology

Amendments		
Issue No.	Date	Description
-	-	-

Plotting parameters

Maximum +176.8Ω (black)
Minimum +64.2Ω (white)



Client

CAMBRIA ARCHAEOLOGY

Project Title — Job No. 1645

BROWNSLADE BARROW, CASTLEMARTIN, PEMBROKESHIRE

Subject

PLOT OF RAW RESISTIVITY DATA

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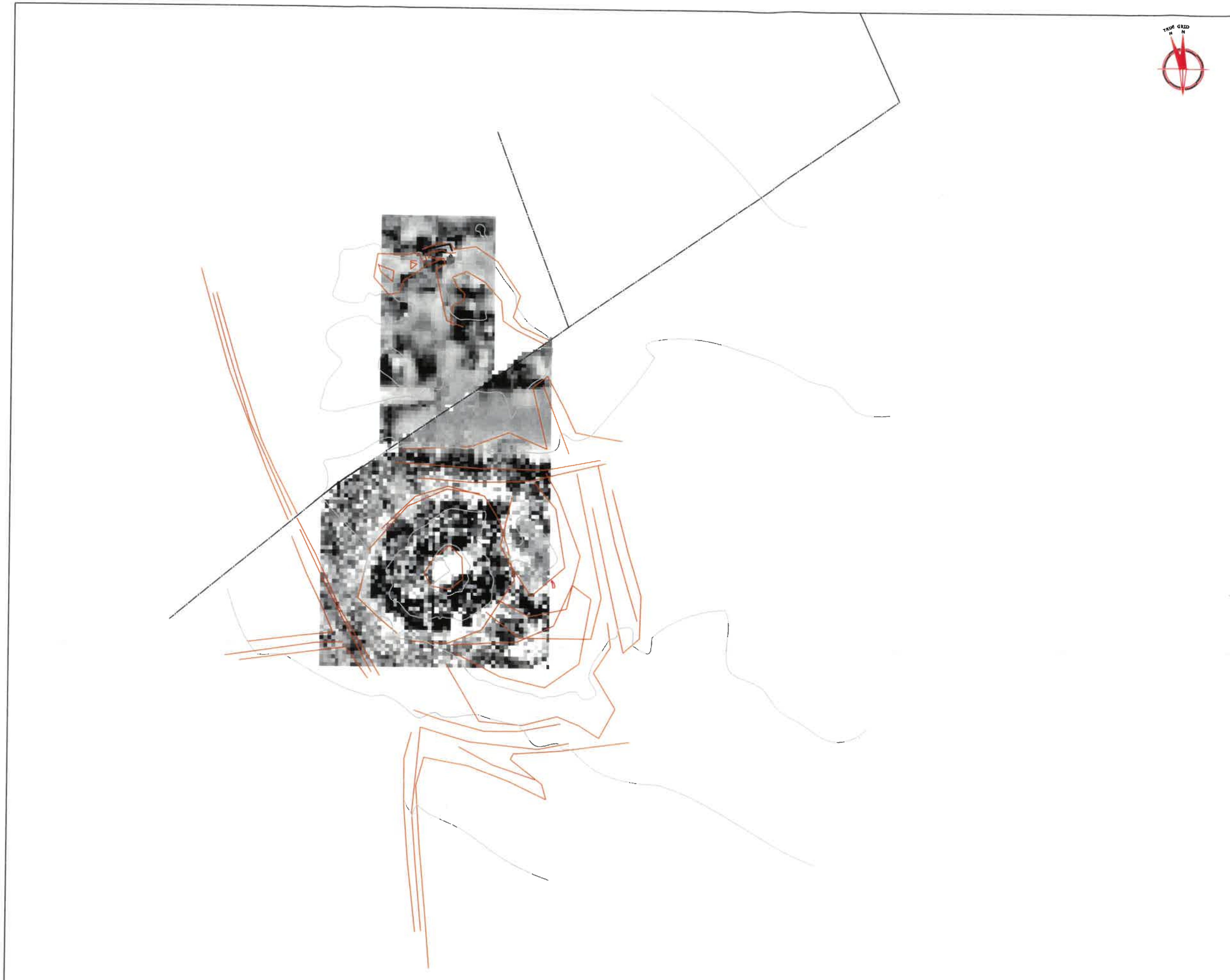
GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPPER HOOK ROAD
UPTON UPON SEVERN
UK
WR8 0SA
T: +44 (0)1684 592266
F: +44 (0)1684 594142
E: info@stratascan.co.uk
www.stratascan.co.uk

REGISTERED ORGANISATION IFA

Scale 1:1000 — 0m 10 20 30 40m

Plot	Checked by	Issue No.
A3	PPB	01
Date	Drawn by	Figure No.
APRIL-MAY 02	EJFM	09



Digital plan supplied by
Cambria Archaeology

Amendments		
Issue No.	Date	Description
-	-	-

Plotting parameters

Maximum +28.1Ω (black)
Minimum -28.6Ω (white)

-3SD +3SD

+28.1Ω

-28.6Ω

Client
CAMBRIA ARCHAEOLOGY

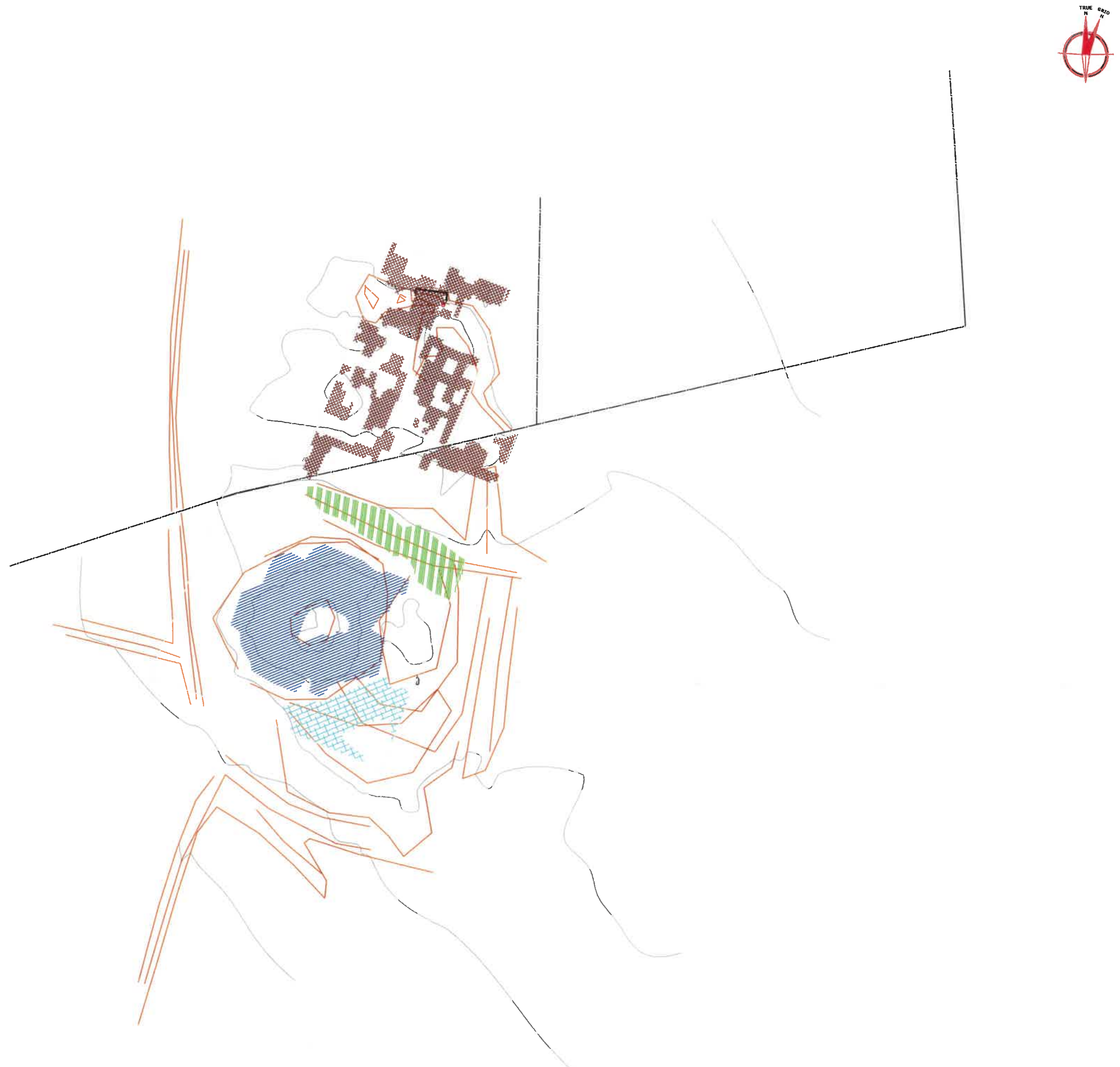
Project Title
Job No. 1645
BROWNSLADE BARROW,
CASTLEMARTIN, PEMBROKESHIRE

Subject
PLOT OF PROCESSED
RESISTIVITY DATA

STRATASCAN TM
GEOPHYSICS FOR ARCHAEOLOGY
AND ENGINEERING
VINEYARD HOUSE
UPPER HOOK ROAD
UPTON UPON SEVERN
UK
WR8 0SA
T: +44 (0)1684 592266
F: +44 (0)1684 594142
E: info@stratascan.co.uk
www.stratascan.co.uk
REGISTERED ORGANISATION IFA

Scale 1:1000 0m 10 20 30 40m

Plot	Checked by	Issue No.
A3	PPB	01
Date	Drawn by	Figure No.
APRIL-MAY 02	EJFM	10



Digital plan supplied by Cambria Archaeology

Amendments		
Issue No.	Date	Description
-	-	-

Key	
	Arrangement of high resistance linear anomalies - possible structural remains
	Circular area of high resistance - remains of barrow
	Area of high resistance probably relating to embankment
	Area of high resistance relating to either the badger set or ?archaeology

Client

CAMBRIA ARCHAEOLOGY

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BROWNSLADE BARROW, CASTLEMARTIN, PEMBROKESHIRE

Subject

ABSTRACTION AND INTERPRETATION OF RESISTIVITY ANOMALIES

STRATASCAN™
GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPPER HOOK ROAD
UPTON UPON SEVERN
UK
WR8 0SA
T: +44 (0)1684 592266
F: +44 (0)1684 594142
E: info@stratascan.co.uk
www.stratascan.co.uk

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Scale 1:1000 — 0m 10 20 30 40m

Plot	Checked by	Issue No.
A3	PPB	01
Date	**Drawn by**	**Figure No.**
APRIL-MAY 02	EJFM	11

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Amendments

Issue No.	Date	Description
-	-	
		-

Colour Scale for Timeslice 'Activity' Plots and Simplified Key

INCREASING
ENERGY LEVEL
DECREASING

High Energy Return - Probable Foundation

Medium Energy Return - Mixed Ground

Low Energy Return - Homogeneous Material

Client

CAMBRIA ARCHAEOLOGY

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BROWNSLADE BARROW, CASTLEMARTIN, PEMBROKESHIRE

Subject

TIMESLICE PLOT SHOWING APPROXIMATE DEPTH OF 1.25M

STRATASCAN™
GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPPER HOOK ROAD
UPTON UPON SEVERN
UK
WR8 0SA
T: +44 (0)1684 592266
F: +44 (0)1684 594142
E: info@stratascan.co.uk
www.stratascan.co.uk

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Scale	1:500	0m 5 10 15 20m
Plot: A3	Checked by: PPB	Issue No.: 01
Date: APRIL-MAY 02	Drawn by: EJFM	Figure No.: 12

Digital plan supplied by Cambria Archaeology

Amendments		
Issue No.	Date	Description
-	-	-

Key	
	Inclining horizon - ?archaeological feature
	Area of complexity possibly relating to badger set
	Area of complexity possibly relating to barrow
	Discrete anomalies thought to belong to badger set

Client

CAMBRIA ARCHAEOLOGY

Project Title — Job No. 1645

BROWNSLADE BARROW, CASTLEMARTIN, PEMBROKESHIRE

Subject

ABSTRACTION AND INTERPRETATION OF GPR ANOMALIES

STRATASCAN™
GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPPER HOOK ROAD
UPTON UPON SEVERN
UK
WR8 0SA
T: +44 (0)1684 592266
F: +44 (0)1684 594142
E: info@stratascan.co.uk
www.stratascan.co.uk
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Scale 1:500 — 0m 5 10 15 20m

Plot	Checked by	Issue No.
A3	PPB	01
Date	**Drawn by**	**Figure No.**
APRIL-MAY 02	EJFM	13