



An archaeological gradiometer survey

Land adjacent to Tulip Foods Bugle, Cornwall

Ordnance Survey (E/N): 203510,60230 (point)

Report: 140801

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1 August 2014

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Accompanying CD-ROM

Report.....	Adobe PDF format
Copies of report figures	Adobe PDF format
Raw and processed grid & composite files.....	DW Consulting TerraSurveyor 3 formats
Minimal processing data plots and metadata	Adobe PDF format
GIS project, shape files and classification schema	
GIS project.....	Manifold 8 '.map' file
GIS shape files	ESRI standard
GIS classification schema	Adobe PDF format
AutoCAD version of the survey interpretation	AutoCAD DXF

1 Survey description and summary

Type of survey: twin-sensor fluxgate gradiometer
Date of survey: 3 July 2014
Area surveyed: 3ha
Lead surveyor: Ross Dean BSc MSc MA MifA

Client

AC Archaeology Ltd, 4 Halthaies Workshops, Bradninch, Nr Exeter, Devon EX5 4QL

Location

Site: Land adjacent to Tulip Foods
Parish: Luxulyan
Town: Bugle (parish of Treverbyn)
County: Cornwall
Nearest Postcode: PL26 8RR
NGR: SX 035 602
Ordnance Survey E/N: 203510,60230 (point)
OASIS number: substrat1-186404
Archive: At the time of writing, the archive of this survey will be held by Substrata.

Summary

This report was commissioned by AC Archaeology Ltd on behalf of clients and has been prepared as part of a programme of work in support of a forthcoming planning application at the above site. The location of the proposed development area is shown in Figure 4.

The magnetic contrast across the area was relatively low but sufficient to be able to differentiate between anomalies representing possible archaeological features and background magnetic responses.

Fourteen magnetic anomaly groups were identified as pertaining to archaeological deposits or structures. The majority of these groups have patterns typical of anomalies representing former field and enclosure boundaries of unknown date and archaeological provenance although some may relate to subsoil disturbance by ploughing. Some anomalies were identified as possible pits although natural origins for these could not be ruled out.

While there is an Historical Environment Record entry suggesting the presence of prehistoric hut circles within the field although outwith the survey area, no evidence for any form of settlement was recorded in the survey dataset.

2 Survey aims and objectives

Survey aims

1. Define and characterise and detectable archaeological remains on the site.
2. Inform any future archaeological investigation of the area.

Survey Objectives

1. Complete a gradiometer survey across agreed parts of the survey area.
2. Identify any magnetic anomalies that may be related to archaeological deposits, structures or artefacts.
3. Within the limits of the techniques and dataset, archaeologically characterise any such anomalies or patterns of anomalies.
4. Accurately record the location of the identified anomalies.
5. Produce a report based on the survey that is sufficiently detailed to inform any subsequent development on the site about the location and possible archaeological character of the recorded anomalies.

3 Standards

The standards used to complete this survey are defined by the Institute for Archaeologists (2011). The codes of approved practice that were followed are those of the Institute for Archaeologists (2008 and 2009) and Archaeology Data Service/Digital Antiquity Guides (undated). The document text was written using the house style of the Institute for Archaeologists (Institute for Archaeologists, undated).

4 Site description

Landscape and land use

A location plan is provided in Figure 4, appendix 1. The field was under grass pasture at the time of the survey.

Geology

The site is located on a solid geology granite of the Permian and Carboniferous St Austell Intrusion. The superficial geology is not recorded in the source used (British Geological Survey, undated).

5 Archaeological background

The following is a short interpretation of information obtained from the Cornwall and Scilly Historic Environment Record (HER) relevant to the immediate survey area. Except where specifically cited, this information was obtained using the Heritage Gateway (English Heritage, undated 1). A summary of the entries consulted can be found in Appendix 4 and the location of the entries is provided in Figure 5.

The reader is advised that this summary should not be used outside the context of this report and is referred to the Cornwall and Scilly HER for informed provision of the record.

Heritage Assets within the survey field

A cropmark consisting of two circles with an inter-connecting, curving boundary, just south of a spring, is situated within the survey field to the north of the survey area (HER entry 27679, Figures 1 and 5). It appears to represent round houses or something similar. No such structures are immediately visible on the ground although there are two roughly circular platforms, more or less consistent with the cropmark.

No evidence for roundhouses or other form of past settlement was recorded in the survey dataset.

Heritage Assets in adjacent fields

Eluvial streamworks were identified in an adjacent field to the northwest of the survey field (HER 27683). The workings were described as a single, sinuous cutting, 2m deep and 10-25m wide. This, a second adjacent cutting, and a series of linear spoil dumps are visible on aerial photographs. The workings run for 365m in total. In the same field a series of rectangular fields, typically 52m x 24m, are visible as low earth banks on air photographs (HER 75368). The fields lie within Anciently Enclosed Land and are likely to be medieval in origin.

A series of field boundaries, up to 130m long, are visible as low earth banks on air photographs in an adjacent field to the northeast of the survey field (HER 75365). One of these is double-banked and likely to be a trackway.

There is evidence in the dataset of possible field boundaries of unknown archaeological provenance.

6 Results, discussion and conclusions

This survey was designed to record magnetic anomalies. The anomalies themselves cannot be regarded as actual archaeological features and the dimensions of the anomalies shown do not represent the dimensions of any associated archaeological features. The analysis presented below attempts to identify and characterise anomalies and anomaly groups that may pertain to archaeological deposits and structures.

The reader is referred to section 7.

6.1 Results

Figure 1 shows the interpretation of the survey. It includes the anomaly groups identified as pertaining to archaeological deposits along with their numbers. Table 1 is an extract from a detailed analysis of the survey data provided in the attribute tables of the GIS project on the accompanying CD-ROM.

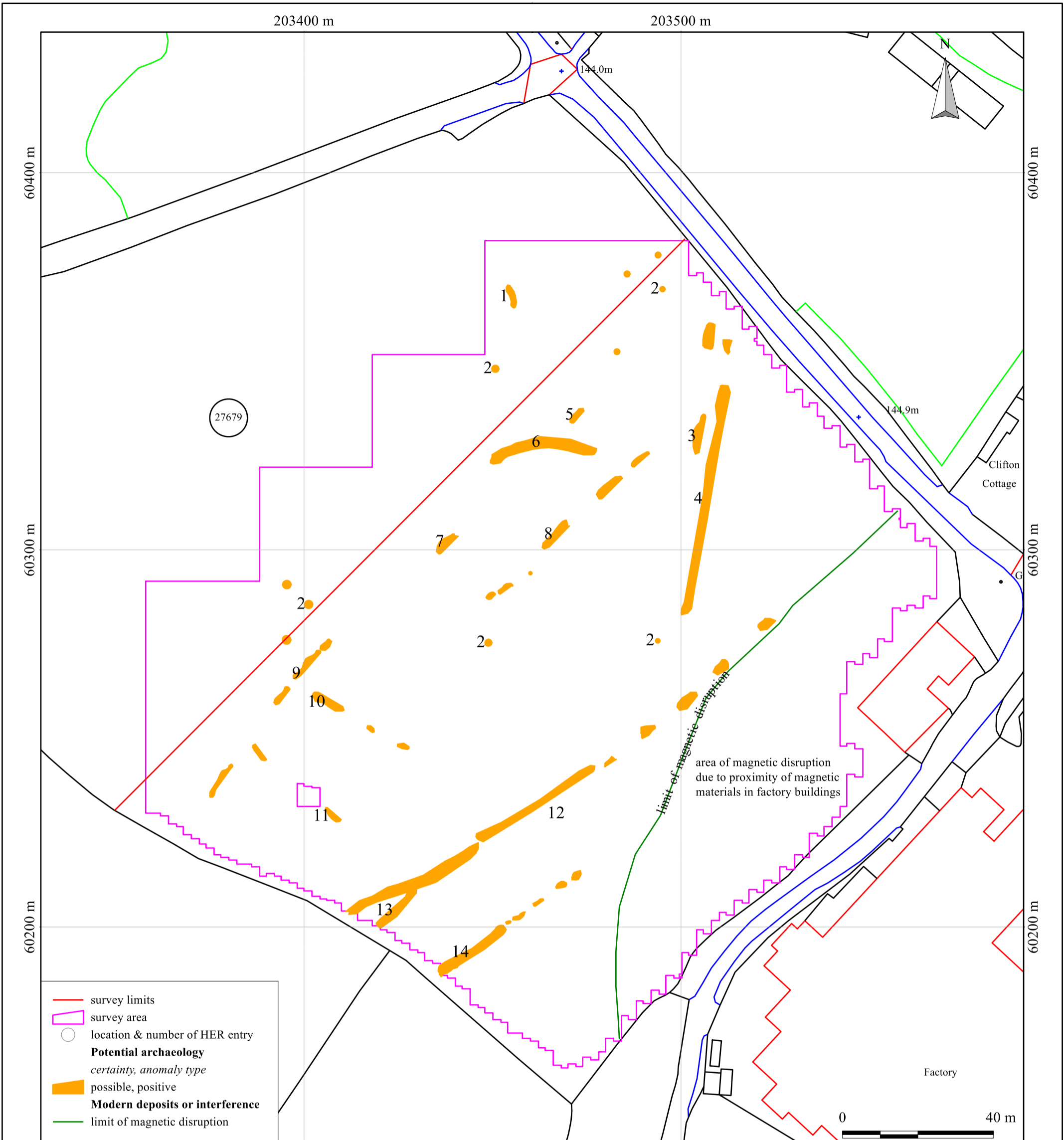
Figure 1 along with table 1 comprises the analysis of the survey data.

Plots of the processed data are provided in Figures 2 and 3 (Appendix 1).

Site: An archaeological gradiometer survey
 Land adjacent to Tulip Foods, Bugle, Cornwall
 Ordnance Survey (E/N): 203510, 60230 (point)
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anomaly group	anomaly characterisation certainty & class	anomaly form	additional archaeological characterisation	comments
1	possible, positive	linear		
2	possible, positive	oval	archaeological pits or natural features	these anomaly groups and discrete anomalies may relate to archaeological features such as pits but could equally represent natural deposits
3	possible, positive	disrupted linear		
4	possible, positive	disrupted linear		
5	possible, positive	linear		it is not clear whether the anomaly group represents linear archaeological deposits or subsoil disturbance by ploughing
6	possible, positive	curvilinear		
7	possible, positive	linear		it is not clear whether the anomaly group represents linear archaeological deposits or subsoil disturbance by ploughing
8	possible, positive	disrupted linear		it is not clear whether the anomaly group represents linear archaeological deposits or subsoil disturbance by ploughing
9	possible, positive	disrupted linear		it is not clear whether the anomaly group represents linear archaeological deposits or subsoil disturbance by ploughing
10	possible, positive	disrupted linear		
11	possible, positive	disrupted linear		
12	possible, positive	disrupted linear		
13	possible, positive	linear		
14	possible, positive	disrupted linear		

Table 1: data analysis



British Grid
centre X: 203460.54 m, centre Y: 60290.15 m

Scale: 1:1000 @ A3. Spatial Units: Meter. Do not scale off this drawing

Copyright Substrata 2014.
Base map: Crown Copyright & Database Right 2014

Notes:

1. All interpretations are provisional and represent potential archaeological deposits.
2. Anomalies designated "likely archaeology" have supporting evidence e.g. historical maps and or visible earthworks.
3. Anomaly group 2: representative; not all instances are mapped.
4. Anomalies likely to represent geological or other natural deposits are not mapped unless relevant to potential archaeological events or deposit

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Figure 1: survey interpretation

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6.2 Discussion

Refer to Figure 1 (this section) and Figure 2 (appendix 1). Not all anomalies or anomaly groups identified in the survey dataset are necessarily discussed below. All identified anomaly groups are recorded in the GIS project on the accompanying CD-ROM. Those anomaly groups possibly representing archaeological deposits are included in the data analysis (Table 1).

General points

The underlying solid geology is granite (Section 4). This typically reduces the magnetic variation recorded by magnetometers although, as in this case, the magnetic variation is usually sufficient to allow potential archaeological deposits and structures to be identified with some loss of subtlety. Such low variations in readings inevitably highlight very small changes in the magnitude of the readings recorded due to the orientation and balance of the instrument sensors. These are shown in Figures 2 and 3 as north-south orientated stripes. These stripes have not interfered with the identification and assessment of magnetic anomalies representing potential archaeological features.

Anomalies thought to relate to natural features were not mapped. Recent man-made objects such as manholes, water management equipment or drains have not been mapped except where they comprise significant magnetic responses across the dataset.

Data collection along the field edges was restricted as shown in Figures 1 to 3 due to the presence of magnetic materials and objects in and adjacent to the field boundaries. This is especially so along the south-eastern survey boundary where the presence of significant quantities of magnetic material in the adjacent factory buildings dominated the data collected in this area.

Data relating to historical maps and other records

Historical Ordnance Survey maps show that the field and its boundaries have remained as they are since at least the publication of the 1881 1:2,500 Ordnance Survey map. No anomalies were recorded that relate to historical maps and other records.

Data with no previous provenance

The majority of the magnetic anomaly groups highlighted as representing possible archaeological deposits or features have patterns typical of anomalies representing former field and enclosure boundaries of unknown date and archaeological provenance. Of these, groups **3, 4, 6, 12, 13 and 14** are distinct in the dataset and are likely to represent linear deposits of possible archaeological significance and may relate to more than once phase of land use. Given the evidence for historical field systems in adjacent fields (HER entries 75365 and 75368, discussed in Section 4), such features are not unexpected.

Groups **1, 10 and 11** may also represent linear archaeological deposits such as field or enclosure boundaries.

Groups **5, 7, 8 and 9** are less clear and may represent either linear archaeological deposits or subsoil disturbance by ploughing at some time in the past.

The various groups and single anomalies labelled as group **2** are distinct in the dataset and may represent either archaeological pits or possibly natural deposits. While not all instances are mapped, those shown in Figure 1 are unambiguous. No archaeologically significant trends in the distribution of these anomalies were discernable.

6.3 Conclusions

The magnetic contrast across the area was relatively low but sufficient to be able to differentiate between anomalies representing possible archaeological features and background magnetic responses.

Fourteen magnetic anomaly groups were identified as pertaining to archaeological deposits or structures. The majority of these groups have patterns typical of anomalies representing former field and enclosure boundaries of unknown date and archaeological provenance although some may relate to subsoil disturbance by ploughing. Some anomalies were identified as possible pits although natural origins for these could not be ruled out.

While there is an Historical Environment Record entry suggesting the presence of prehistoric hut circles within the field although outwith the survey area, no evidence for any form of settlement was recorded in the survey dataset.

7 Disclaimer and copyright

The description and discussion of the results presented in this report are the authors, based on his interpretation of the survey data. Every effort has been made to provide accurate descriptions and interpretations of the geophysical data set. The nature of archaeological geophysical surveying is such that interpretations based on geophysical data, while informative, can only be provisional. Geophysical surveys are a cost-effective early step in the multi-phase process that is archaeology. The evaluation programme of which this survey is part may also be informed by other archaeological assessment work and analysis. It must be presumed that more archaeological features will be evaluated than those specified in this report.

Ross Dean, trading as Substrata, will assign copyright to the client upon written request but retains the right to be identified as the author of all project documentation and reports as defined in the Copyright, Designs and Patents Act 1988 (Chapter IV, s.79).

8 Acknowledgements

Substrata would like to thank Andrew Passmore of AC Archaeology Ltd for commissioning us to complete this survey.

9 Bibliography

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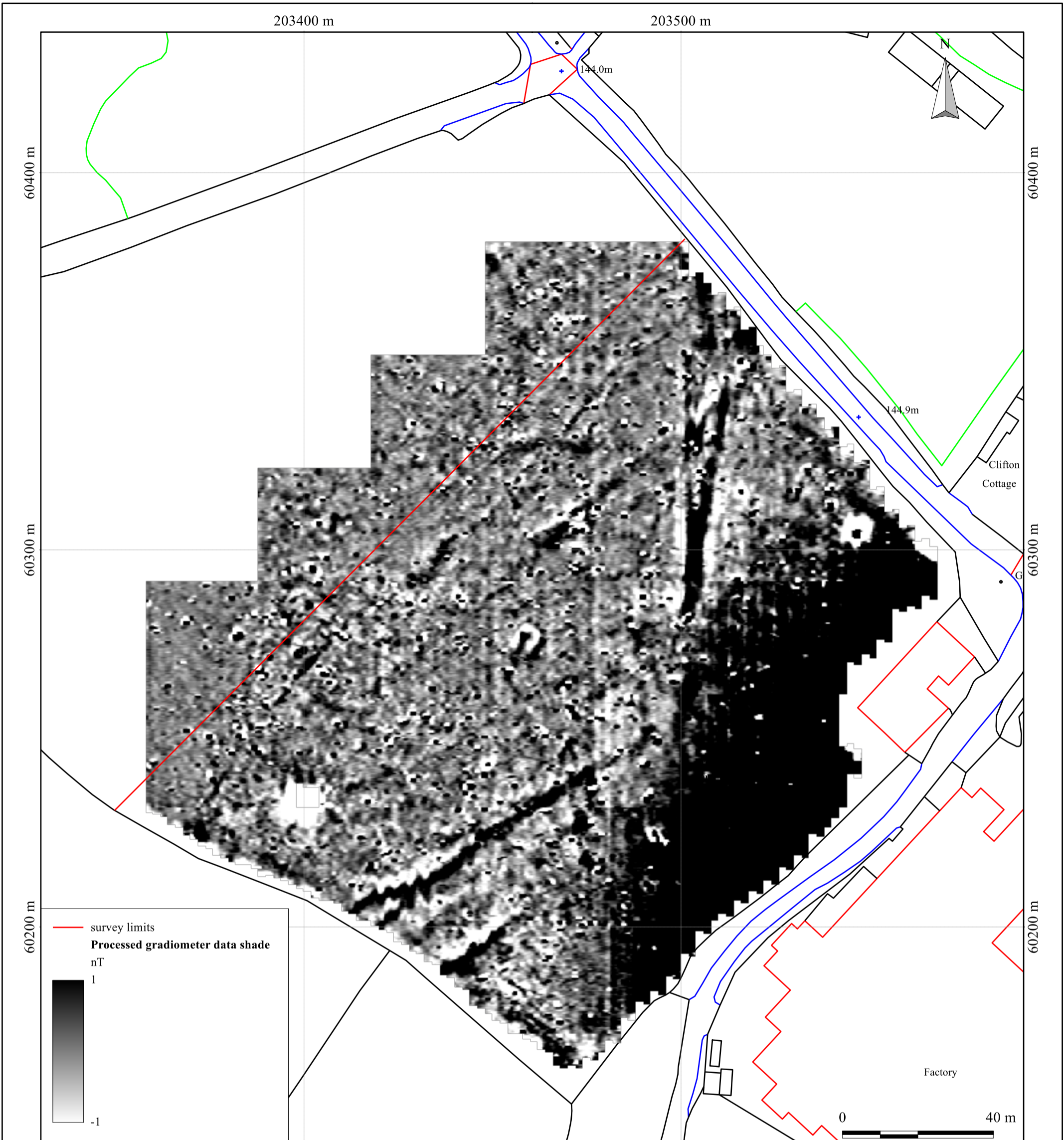
Institute for Archaeologists (2008) *Code of approved practice for the regulation of contractual arrangements in archaeology*. Reading: Author [Online], Available: http://www.archaeologists.net/sites/default/files/node-files/ifa_code_practice.pdf [March 2014]

Appendix 1 Supporting plots

General Guidance

The anomalies represented in the survey plots provided in this appendix are magnetic anomalies. The apparent size of such anomalies and anomaly patterns are unlikely to correspond exactly with the dimensions of any associated archaeological features.

A rough rule for interpreting magnetic anomalies is that the width of an anomaly at half its maximum reading is equal to the width of the buried feature, or its depth if this is greater (Clark, 2000: 83). Caution must be applied when using this rule as it depends on the anomalies being clearly identifiable and distinct from adjacent anomalies. In northern latitudes the position of the maximum of a magnetic anomaly will be displaced slightly to the south of any associated physical feature.



British Grid
 centre X: 203460.54 m, centre Y: 60290.15 m

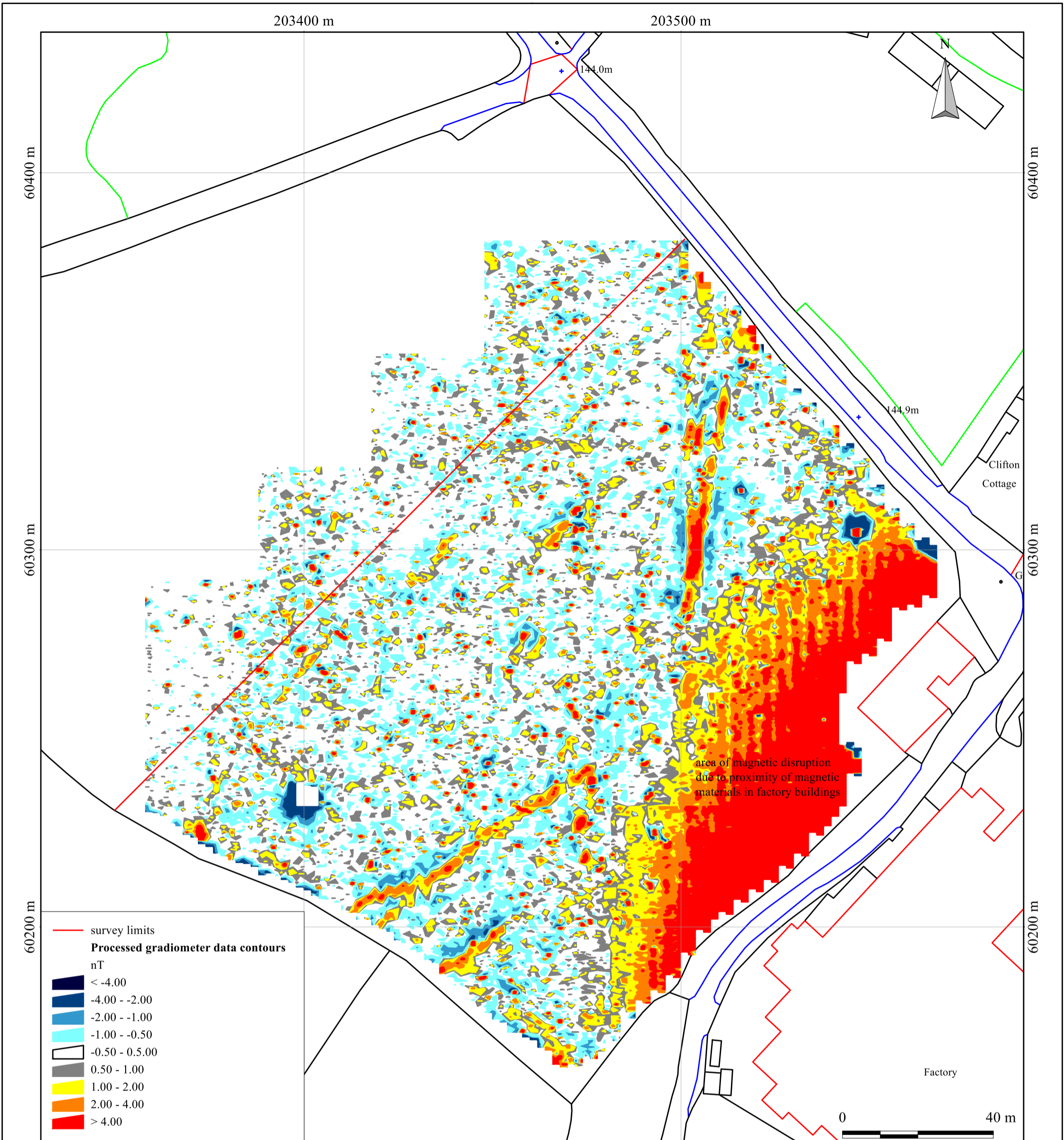
Scale: 1:1000 @ A3. Spatial Units: Meter. Do not scale off this drawing

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 Base map: Crown Copyright & Database Right 2014

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Figure 2: shade plot of processed data

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British Grid
centre X: 203460.54 m, centre Y: 60290.15 m

Scale: 1:1000 @ A3. Spatial Units: Meter. Do not scale off this drawing

Copyright Substrata 2014.
Base map: Crown Copyright & Database Right 2014

Figure 2: shade plot of processed data

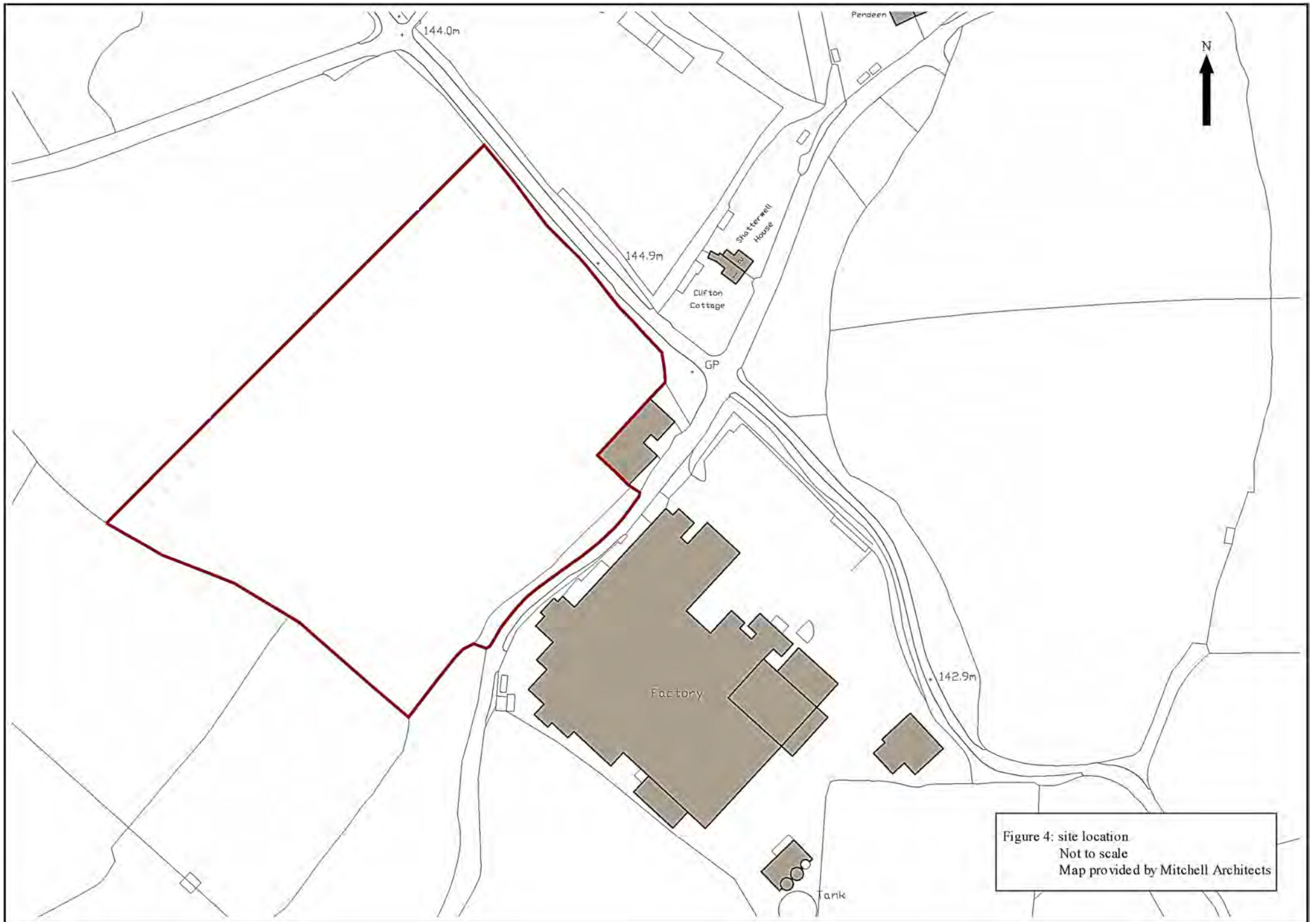
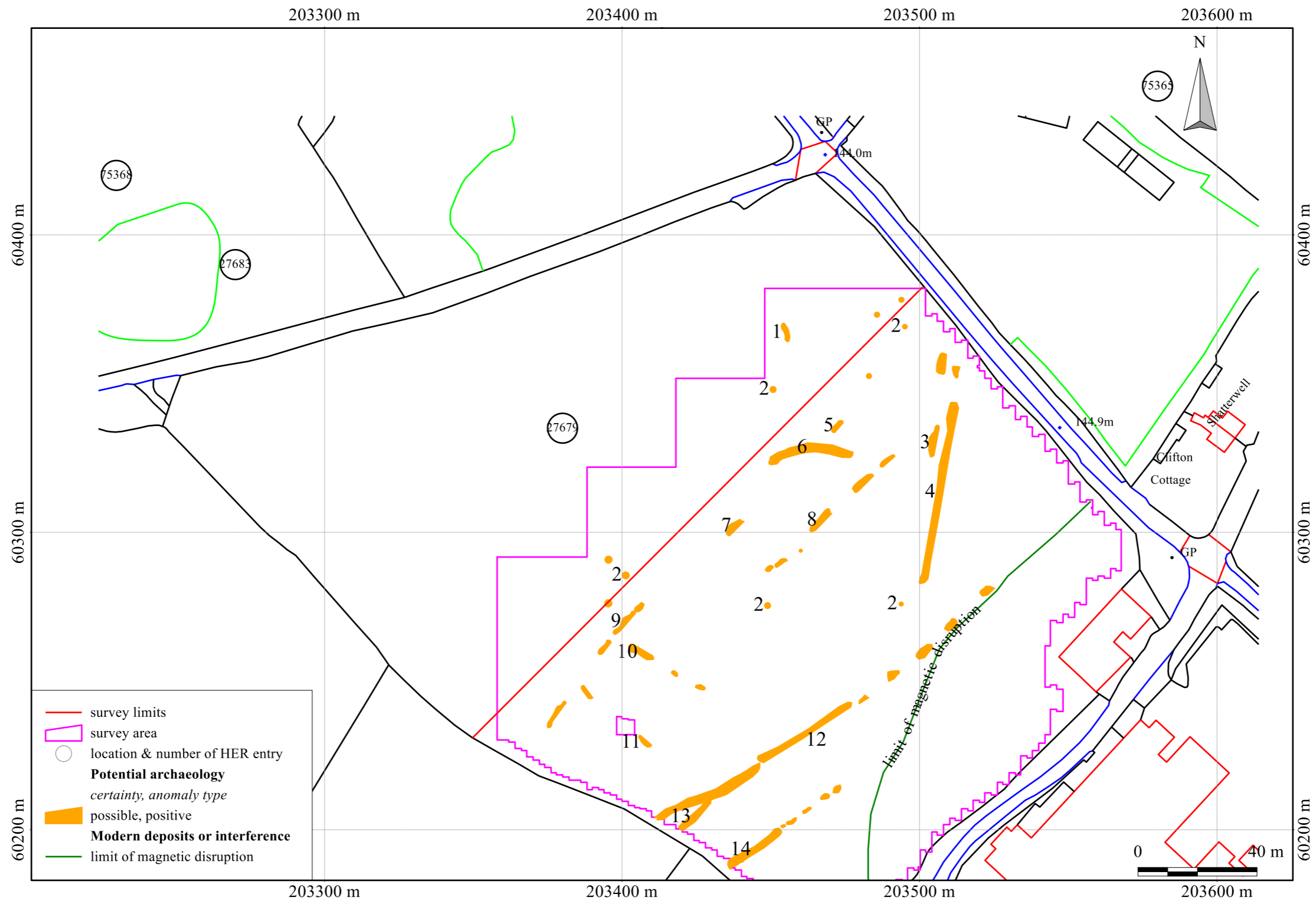


Figure 4: site location
Not to scale
Map provided by Mitchell Architects



British Grid
 centre X: 203413.47 m, centre Y: 60326.26 m

Scale: 1:1500 @ A3. Spatial Units: Meter. Do not scale off this drawing

Copyright Substrata 2014.
 Base map: Crown Copyright & Database Right 2014

Notes:

1. All interpretations are provisional and represent potential archaeological deposits.
2. Anomalies designated "likely archaeology" have supporting evidence e.g. historical maps and or visible earthworks.
3. Anomaly group 2: representative; not all instances are mapped.
4. Anomalies likely to represent geological or other natural deposits are not mapped unless relevant to potential archaeological events or deposits.

Figure 5: survey interpretation with relevant HER entries

Appendix 2 Methodology Summary

Table 2: methodology summary	
<p>Documents Survey methodology statement: Dean (2014)</p>	
<p>Methodology</p> <ol style="list-style-type: none"> 1. The work was undertaken in accordance with the survey methodology statement. The geophysical (gradiometer) survey was undertaken with reference to standard guidance provided by the Institute for Archaeologists (2011) and Archaeology Data Service/Digital Antiquity Guides (undated). 2. The survey grid location information and grid plan was recorded as part of the project in a suitable GIS system. 3. Data processing was undertaken using appropriate software, with all anomalies being digitised and geo-referenced. The final report included a graphical and textual account of the techniques undertaken, the data obtained and an archaeological interpretation of that data and conclusions about any likely archaeology. 	
<p>Grid <i>Method of Fixing:</i> DGPS set-out using pre-planned survey grids and Ordnance Survey coordinates. <i>Composition:</i> 30m by 30m grids <i>Recording:</i> Geo-referenced and recorded using digital map tiles. <i>DGPS used:</i> Spectra Precision PM5V2 GPS with external antenna and survey pole and DigiTerra Explorer 7 as the survey control program.</p>	
<p>Equipment <i>Instrument:</i> Bartington Instruments grad601-2 <i>Firmware:</i> version 6.1</p>	<p>Data Capture <i>Sample Interval:</i> 0.25-metres <i>Traverse Interval:</i> 1 metre <i>Traverse Method:</i> zigzag <i>Traverse Orientation:</i> GN36</p>
<p>Data Processing, Analysis and Presentation Software IntelliCAD Technology Consortium IntelliCAD 7.2 DW Consulting TerraSurveyor3 Manifold System 8 GIS Microsoft Corp. Office Excel 2013 Microsoft Corp. Office Publisher 2013 Adobe Systems Inc Adobe Acrobat 9 Pro Extended</p>	

Appendix 3 Data processing

Table 3: gradiometer survey - processed data metadata	
SITE	
Instrument Type:	Bartington Grad 610
Units:	nT
Direction of 1st Traverse:	0 deg
Collection Method:	ZigZag
Sensors:	2 @ 1.00 m spacing.
Dummy Value:	32702
PROGRAM	
Name:	TerraSurveyor
Version:	3.0.25.1
Stats	
Max:	5.44
Min:	-3.10
Std Dev:	1.76
Mean:	0.65
Median:	0.10
Processes: 8	
1 Base Layer	
2 Clip at 1.00 SD	
3 De Stagger: Grids: All Mode: Both By: -3 intervals	
4 DeStripe Median Sensors: b21.xgd b22.xgd b8.xgd b20.xgd bp1.xgd b1.xgd b7.xgd b9.xgd b19.xgd bp2.xgd b2.xgd b6.xgd b10.xgd b18.xgd bp3.xgd b3.xgd b5.xgd b11.xgd b17.xgd bp4.xgd b4.xgd b12.xgd b16.xgd bp5.xgd b13.xgd b15.xgd bp6.xgd b14.xgd bp7.xgd	
5 Edge Match (Area: Top 120, Left 120, Bottom 149, Right 479) to Top edge	
6 Edge Match (Area: Top 120, Left 360, Bottom 149, Right 479) to Right edge	
7 DeStripe Median Sensors: bp10.xgd bp9.xgd	
8 Clip at 1.00 SD	
Note: converting the gradiometer data into ESRI GIS files imposed an x=y interpolation on the entire dataset	

Appendix 4 Summary of relevant entries from the Devon and Dartmoor Historic Environment Record (HER)

Source: Heritage Gateway (English Heritage, undated 1).

The reader is advised that this summary should not be used outside the context of this report and is referred to the Devon HER for informed provision of the record.

HER Number: 27679

Name: BODWEN - Prehistoric round house (domestic)

Summary: A cropmark visible in the northern part of a field located SE of Bowden and is a possible roundhouse.

Grid Reference: SX 0338 6035 (survey field, approximately 50m northwest of north-western survey boundary)

Parish: Luxulyan, Restormel, Cornwall

Protected Status: None recorded

Monument Types: ROUND HOUSE (DOMESTIC)? (Prehistoric - 500000 BC to 42 AD)

Full description:

A cropmark visible in the northern part of a field located SE of Bowden and is a possible roundhouse. The cropmark consists of two circles with an inter-connecting, curving boundary, just south of a spring. They appear to be round houses or something similar. Unfortunately no such structures are immediately visible on the rough although there are two roughly circular platforms, more or less consistent with the cropmark. These platforms are cut into the gentle slope and have depths on their uphill sides of approx 0.3m. The SW platform has a maximum dimension of approx 5m and the northern a maximum dimension of approx 7m. There is no apparent sign of the inter-connecting boundary.

HER Number: 27683

Name: BODWEN - Early Medieval streamworks

Summary: Eluvial streamworks were identified during the China Clay District Project at this location

Grid Reference: SX 0327 6039 (adjacent field to the northwest, approximately 26m north of the north-western field boundary)

Parish: Luxulyan, Restormel, Cornwall

Protected Status: None recorded

Monument Types: STREAMWORKS (Early Medieval to Modern - 410 AD to 2050 AD)

Full description:

Eluvial streamworks were identified during the China Clay District Project at this location. The workings were described as a single, sinuous cutting, 2m deep and 10-25m wide. This, a second adjacent cutting, and a series of linear spoil dumps are visible on aerial photographs and were plotted as part of the NMP. The workings run for 365m in total.

HER Number: 75365

Name: BODWEN - Early Medieval field boundary, Medieval field boundary

Summary: A series of field boundaries, up to 130m long, are visible as low earth banks on air photographs

Grid Reference: SX 0358 6045 (adjacent field to the northeast, approximately 102m northeast of the north-eastern field boundary)

Parish: Luxulyan, Restormel, Cornwall

Protected Status: None recorded

Monument Types:

FIELD BOUNDARY (Early Medieval to Modern - 410 AD to 2050 AD)

FIELD BOUNDARY? (Medieval - 1066 AD to 1539 AD)

Full description:

A series of field boundaries, up to 130m long, are visible as low earth banks on air photographs and were plotted as part of the NMP. One of these, at SX 03672 60582, is double-banked, and is likely to be a trackway.

HER Number: 75368

Name: BODWEN - Early Medieval field system, Medieval field system

Summary: A series of rectangular fields, typically 52m x 24m, are visible as low earth banks on air photographs

Grid Reference: SX 0323 6042 (adjacent field to the northwest, approximately 62m north of the north-western field boundary)

Parish: Luxulyan, Restormel, Cornwall

Protected Status: None recorded

Monument Types:

FIELD SYSTEM (Early Medieval to Modern - 410 AD to 2050 AD)

FIELD SYSTEM? (Medieval - 1066 AD to 1539 AD)

Full description:

A series of rectangular fields, typically 52m x 24m, are visible as low earth banks on air photographs and were plotted as part of the NMP. The fields lie within Anciently Enclosed Land and are likely to be medieval in origin.

Appendix 5 Geophysical surveying techniques

1 Introduction

Substrata offers magnetometer and earth resistance surveying. We also provide other archaeology-specific geophysical surveys such as ground penetrating radar and resistivity. The particular method or combination of methods used depends on local soil conditions and the survey requirements. These methods are capable of delivering fast and accurate assessments of the archaeology of both large and small sites.

Further details can be found on our website at www.substrata.co.uk.

2 Magnetometer surveying

Standard magnetometer surveys are the workhorse of archaeological surveying when speed and cost-effectiveness are important. Identifiable archaeological features include areas of occupation, hearths, kilns, furnaces, ditches, pits, post-holes, ridge-and-furrow, timber structures, wall footings, roads, tracks and similar buried features.

Magnetometer surveying is used to detect and map small changes in the earth's magnetic field caused by concentrations of ferrous-based minerals within the soil and subsoil, and by materials buried beneath the surface. While most of these changes are too small to affect a compass needle, they can be detected and mapped by sensitive field equipment. During surveys the different magnetic properties of top-soils, sub-soils, rock formations and archaeological features are recorded as variations against a background value. Subsequently magnetic anomalies resulting from potential archaeology can be identified and interpreted.

Bartington grad601-2 gradiometers

A gradiometer is a type of magnetometer and is sensitive to relatively small changes in the earth's magnetic field. Our primary surveying instruments are Bartington Grad601-2 (dual sensor) fluxgate gradiometers with automatic data loggers. They are specifically designed for field use by archaeologists. The Bartington gradiometers provide proven technology in archaeological magnetic surveying and offer fast, accurate set-up and survey rates. They are sensitive to depths of between 0 and 1.5m below ground level, with optimum sensitivity at depths of 1m or less.

Multiple sensor arrays

A technique relatively new to commercial archaeological surveying but well understood in academic circles involves the use of multiple magnetometer sensors towed behind a quad bike or similar vehicle. With multiple sensors and the use of on-board GPS units, it is possible to achieve faster survey rates at competitive commercial rates when compared to the use of multiple instruments and the techniques discussed above provided the ground is suitable for the vehicle and array. Substrata is pleased to announce that we now offer this service on suitable larger sites

3 Earth resistance surveying

Earth resistance surveying is an excellent tool for detecting buried archaeology. Its relatively slow rate of survey compared to magnetometer surveys means that it is usually employed in commercial surveys when a detailed understanding of buried building remains is required. This technique measures changes in the electrical resistance of the ground being surveyed. In practice, the recording of differences in the electrical resistance of near-surface deposits and structures allows the detection and interpretation of masonry and brick foundations, paving and floors, drains and other cavities, large pits, building platforms, robber trenches, ditches, graves and similar buried features.

Resistance to electrical current flow in the ground depends on the moisture content and structure of the soil and other materials buried beneath the surface. For example, the higher the moisture content of a soil, the less resistant it is to electrical current flow. A ditch completely buried beneath the present ground surface is likely to have an infill soil different to that surrounding the ditch in terms of compactness and composition. As a result, the soil filling the buried ditch will retain moisture in a different way to the surrounding soil which means it will

have an electrical resistance at variance with the surrounding environment. By passing a small current through the ground it is possible to detect, record, plot and interpret such changes in electrical resistance.

For earth resistance surveying Substrata uses the Geoscan Research RM15 series multi-probe resistance meters and purpose-built automatic data-loggers. The Geoscan MPX15 multiplexer is an integral part to the instrument configuration and facilitates multi-probe arrays which speed up survey area coverage rates and, if required, facilitate simultaneous multiple-depth data collection.