Substrata
Archaeological Geophysical Surveyors

An archaeological gradiometer survey

Land adjacent to Cumberland Way

Monkerton, Exeter, Devon

Ordnance Survey E/N: 296200,93700 & 296870,93980 (points)

Report: 130913
Ross Dean BSc MSc MA MIfA
13 September 2013

Substrata
Archaeological Geophysical Surveyors
15 Horizon View, Bath Hotel Road
Westward Ho!
Bideford
Devon EX39 1GX
Mob: 07788627822
Email: geophysics@substrata.co.uk

Client:
AC Archaeology Ltd
4 Halthaies Workshops
Bradninch
Nr Exeter
Devon EX5 4QL
Tel: 01392 882410

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Accompanying CD-ROM

1 Survey description and summary

Type of survey: twin-sensor fluxgate gradiometer
Date of survey: between 19 March and 5 April 2013
Area surveyed: 10.5ha.
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 Cumberland Way
Town:	Monkerton, Pinhoe
District:	Exeter
County:	Devon
NGR:	SY 962 937
Ordnance Survey E/N:	296200,93700 & 296870, 93980 (points)
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 was produced by Substrata in preparation for submission of a forthcoming planning application.

The magnetic contrast across the survey area was relatively low but was sufficient to distinguish between larger anomalies representing potential archaeology and natural deposits. Under such conditions it is likely that, if present, smaller archaeological deposits and features may go unrecorded.

Twenty-six magnetic anomaly groups were identified as representing potential archaeological deposits. One of these is likely to denote a small sub-rectangular enclosure, seven groups may represent late-Medieval or later phases of field enclosure while the remainder may denote former field boundaries and/or enclosures from earlier phases of archaeological deposition.

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.

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).

2 Site description

Landscape
The survey area comprised 8 fields of undulating ground between approximately 25m and 45m O.D. on either side of Cumberland Way. The field boundaries comprised of banked hedges with wire fencing.

Land use at the time of the survey
Grass pasture and rough ground.

Geology
The site is located on a solid geology of mudstones of the Dawlish Sandstone Formation which comprises reddish brown sands and sandstones, cross-bedded, with intercalated thin lenses and beds of breccia and mudstone (British Geological Survey, undated).

Historic Landscape Characterisation
Medieval enclosures based on strip fields.
This area was probably first enclosed with hedge-banks during the later middle ages. The curving form of the hedge-banks suggests that it may have been farmed as open strip-fields (Devon County council, undated).

Known archaeological sites within or adjacent to the survey area
Please refer to figure 1 for the location of the survey areas.
Within the survey area, the Devon County Council Historic Environment Record (HER) entries comprise an Edward I coin (HER MDV61428) from area 2, a Roman coin (MDV63492) from area 3 and a Post-medieval quarry also in area 3 (MDV65419). To the west of area 1 is a concentration of entries recording a former Medieval settlement with a similar concentration to the north and west of area 8.

3. 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 4.

3.1 Results

Figure 1 (this section) shows the interpretation of the survey across all survey areas and 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 and table 1 comprise the analysis and interpretation of the survey data.

Larger scale maps of the survey interpretation and processed data plots are provided in figures 2 to 8 of appendix 1.

An Archaeological Gradiometer Survey
Land adjacent to Cumberland Way, Monkerton, Exeter, Devon
National grid coordinates: 296200,93700 & 96870,93980 (points)
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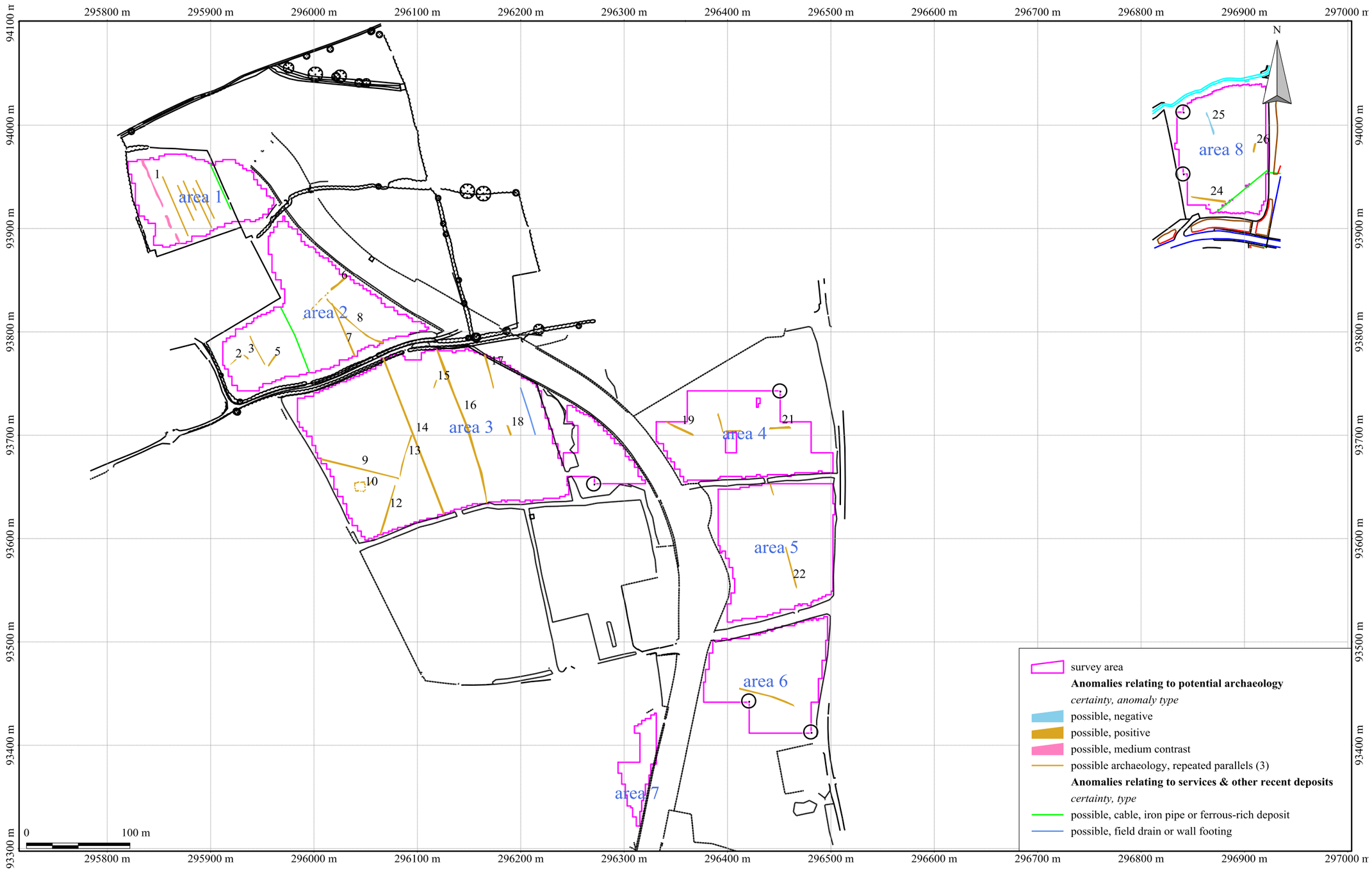
area	anomaly group	anomaly characterisation certainty & class	anomaly form	additional archaeological characterisation	comments
1	1	possible, medium contrast linear	linear	brick-lined drain or culvert or wall footing	
2	2	possible, positive	disrupted linear		
2	3	possible, positive	linear		
2	4	possible, positive	linear		
2	5	possible, positive	linear		
2	6	possible, positive	disrupted linear		
2	7	possible, positive	linear		
2	8	possible, positive	curvilinear		
3	9	possible, positive	linear		
3	10	possible, positive	sub-rectangular		clear anomaly group in the data set
3	11	possible, positive	disrupted linear		
3	12	possible, positive	linear		
3	13	possible, positive	linear		
3	14	possible, positive	linear		
3	15	possible, positive	linear		
3	16	possible, positive	linear		
3	17	possible, positive	linear		
3	18	possible, positive	linear		
4	19	possible, positive	linear		
4	20	possible, positive	linear		close to wet area and may relate to recent drainage
4	21	possible, positive	disrupted linear		
5	22	possible, positive	disrupted linear		
6	23	possible, positive	linear		
8	24	possible, positive	linear		
7	25	possible, negative	linear		
7	26	possible, positive	linear		
1	27	repeated parallels		cultivation traces	possibly associated with an orchard or tree plantation mapped on OS 1889-90 1:2500 map

Table 1: data analysis



British Grid
centre X: 296359.22 m, centre Y: 93699.16 m

Scale: 1:3800 @ A3. Spatial Units: Meter. Do not scale off this drawing

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

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Figure 1: survey interpretation, all areas

Substrata
15 Horizon View, Bath Hotel Road
Westward Ho!, Bideford, Devon EX39 1GX
Tel: 07788627822
Email: geophysics@substrata.co.uk
Web: substrata.co.uk

3.2 Discussion

Refer to figures 1 (this section) and 2 to 4 (appendix 1).

Not all anomalies or anomaly groups identified in the survey dataset are 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 data analysis table 1.

Of the 26 magnetic anomaly groups characterised as representing possible archaeological deposits, none can be related to former and current features recorded on historical and modern Ordnance Survey maps. Most are linear anomaly groups which are likely to represent former field and enclosure boundaries. Some of these, for example groups **3** and **7** in area 2, groups **14**, **16**, **17** and **18** in area 3 and group **22** in area 5 are on the same orientation as the extant field boundaries and so may be indicative of late Medieval enclosure field boundaries as discussed in section 2. The remaining groups, with the exception of those discussed below, are linear and curvilinear anomaly groups that do not conform to extant boundary patterns and so could represent older field and enclosure boundaries of more than one phase of construction.

Group **1** (area 1) may represent a brick-lined drain or culvert, a number of which were observed by the survey team in area 1.

Group **10** (area 3) is distinct in the data set and is likely to represent a relatively small sub-rectangular enclosure.

No anomaly groups characterised as representing possible archaeology were recorded in area 7.

3.3 Conclusions

The magnetic contrast across the survey area was relatively low but was sufficient to distinguish between larger anomalies representing potential archaeology and natural deposits. Under such conditions it is likely that, if present, smaller archaeological deposits and features may go unrecorded.

Twenty-six magnetic anomaly groups were identified as representing potential archaeological deposits. One of these is likely to denote a small sub-rectangular enclosure, seven groups may represent late-Medieval or later phases of field enclosure while the remainder may denote former field boundaries and/or enclosures from earlier phases of archaeological deposition.

4 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.

5 Acknowledgements

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

6 References

Archaeology Data Service/Digital Antiquity Guides to Good Practice (undated): *Geophysical Data in Archaeology* [Online], Available: http://guides.archaeologydataservice.ac.uk/g2gp/Geophysics_Toc [July 2013]

British Geological Survey (undated) *Digital Geological Map of Great Britain (DiGMapGB-625) dataset at 1:625 000 [Online], Available: http://www.bgs.ac.uk/discoveringGeology/geologyOfBritain/viewer.html* [September 2013]

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Institute for Archaeologists (2009) *Code of conduct*. Reading: Author [Online], Available: http://www.archaeologists.net/sites/default/files/node-files/code_conduct.pdf [September 2013]

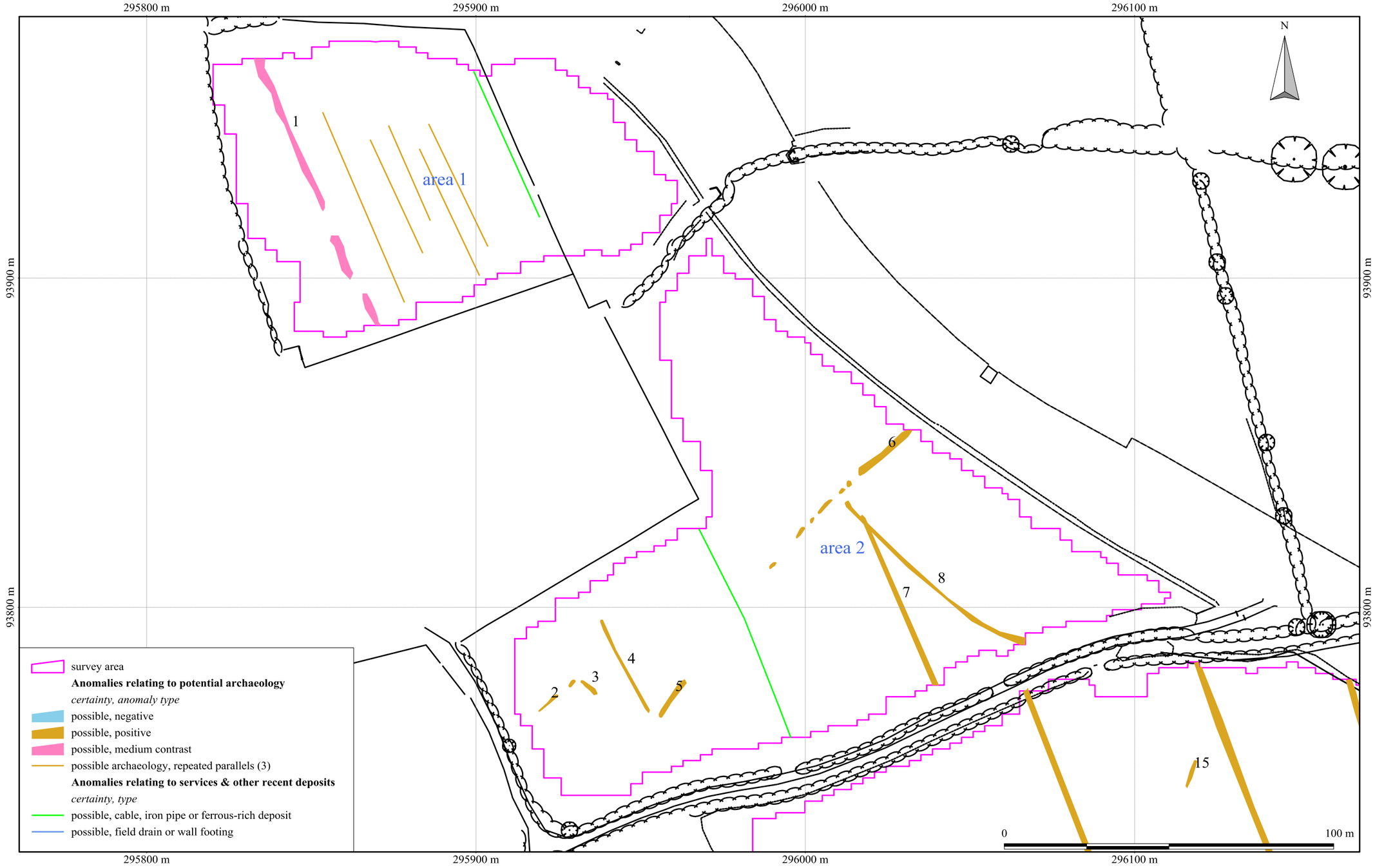
Institute for Archaeologists (2008) *Code of approved practice for the regulation of contractual arrangements in archaeology*. Reading: Author [Online], Available: http://www.archaeologists.net/sites/default/files/node-files/ifa_code_practice.pdf [September 2013]

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: 295964.82 m, centre Y: 93852.56 m

Scale: 1:1200 @ A3. Spatial Units: Meter. Do not scale off this drawing

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

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Figure 2: survey interpretation, areas 1 and 2

Substrata
15 Horizon View, Bath Hotel Road
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Tel: 07788627822
Email: geophysics@substrata.co.uk
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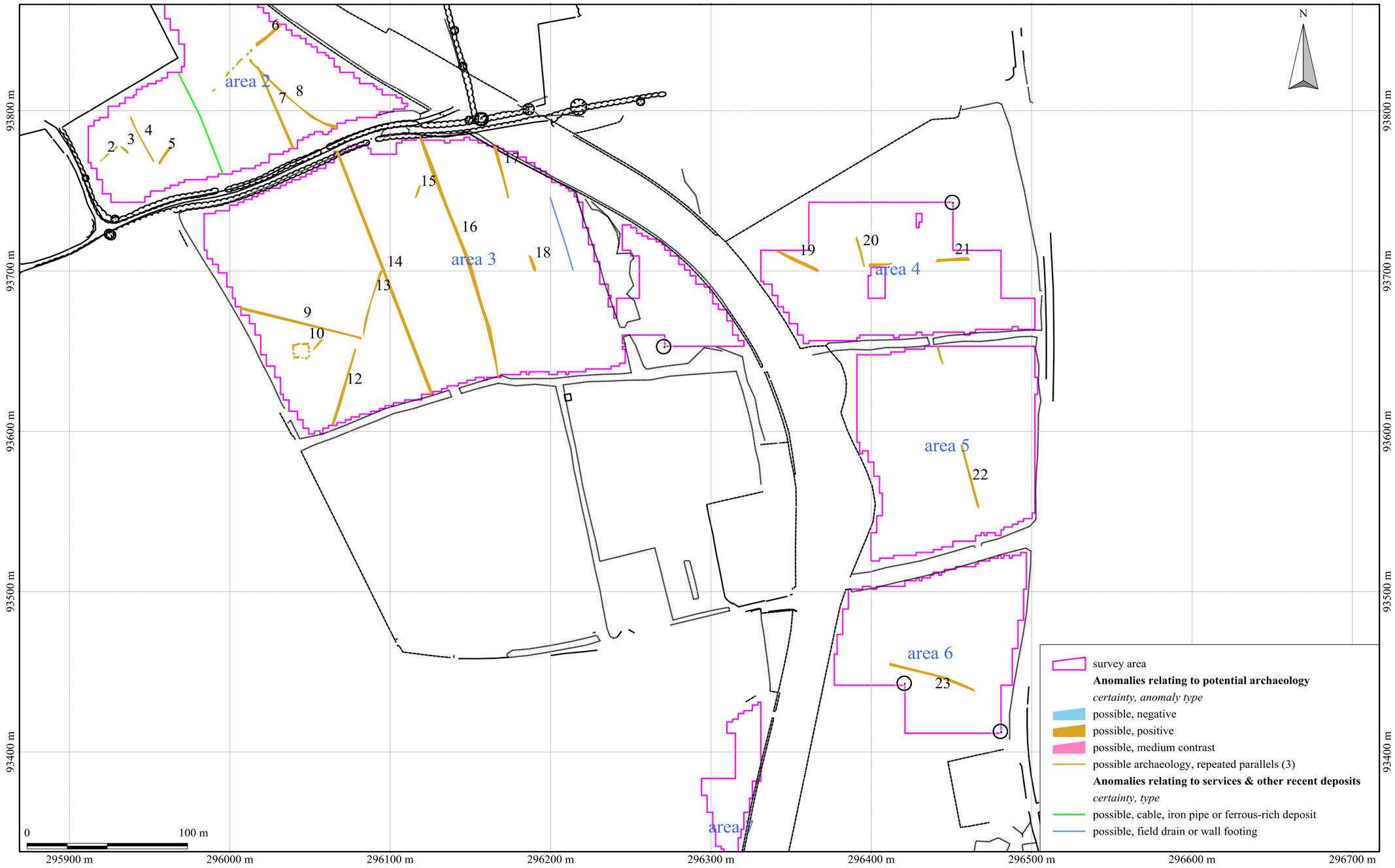

British Grid
centre X: 296292.84 m, centre Y: 93602.06 m

Scale: 1:2500 @ A3. Spatial Units: Meter. Do not scale off this drawing

Notes:
1. All interpretations are provisional and represent potential archaeological deposits.
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Figure 3: survey interpretation, areas 3, 4, 5 and 6

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Email: geophysics@substrata.co.uk
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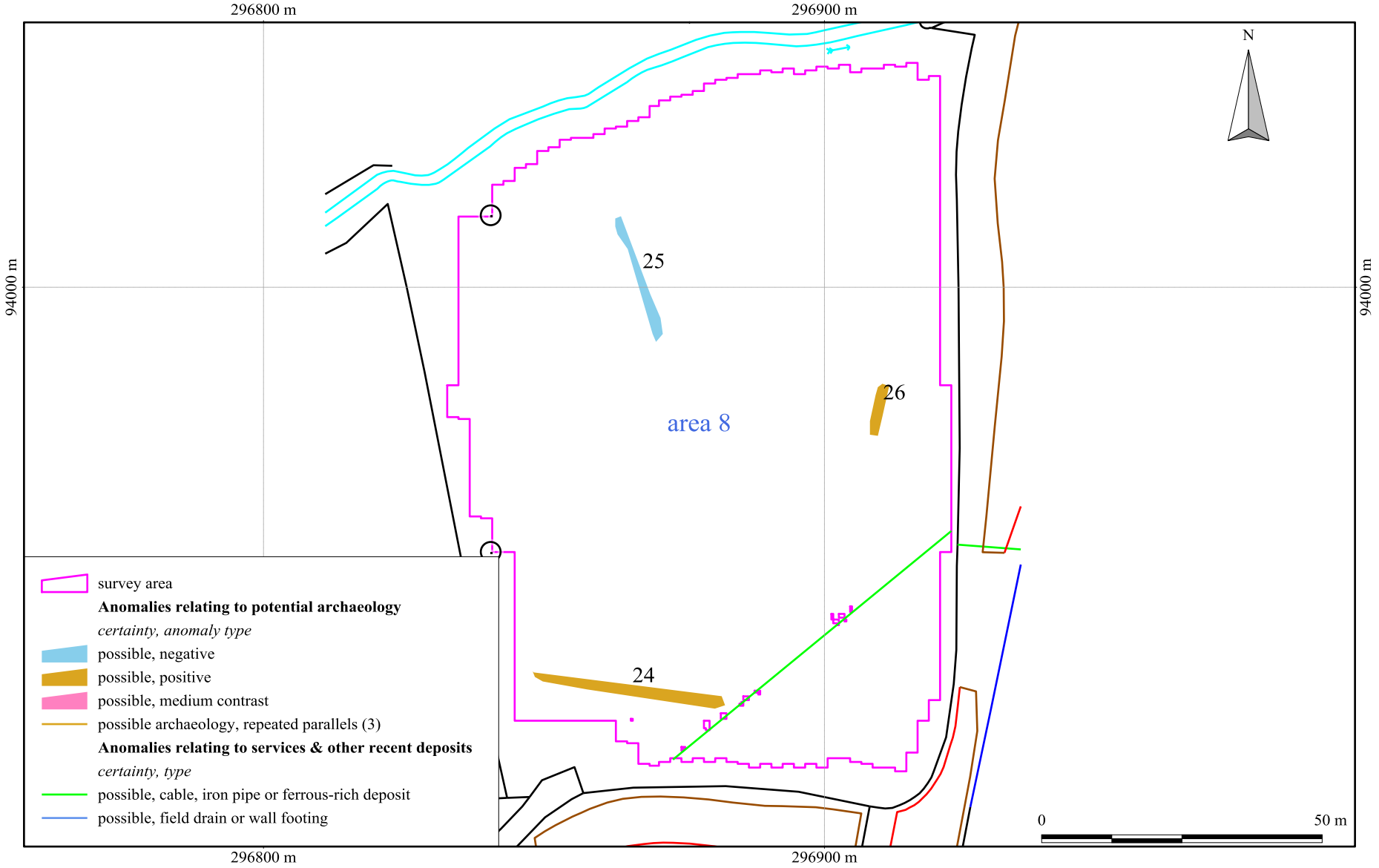

British Grid
centre X: 296875.94 m, centre Y: 9397

:: 1:1000 @ A4. Spatial Units: Meter. Do not scale off this dra

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

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Figure 4: survey interpretation, area 8

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15 Horizon View, Bath Hotel Road
Westward Ho!, Bideford, Devon EX39 1GX
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British Grid
centre X: 296359.22 m, centre Y: 93699.16 m

Scale: 1:3800 @ A3. Spatial Units: Meter. Do not scale off this drawing

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Figure 5: processed gradiometer data, all areas

Substrata
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British Grid
centre X: 295964.82 m, centre Y: 93852.56 m

Scale: 1:1200 @ A3. Spatial Units: Meter. Do not scale off this drawing

An archaeological gradiometer survey
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Figure 6: processed gradiometer data, areas 1 and 2

Substrata
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British Grid
centre X: 296292.84 m, centre Y: 93602.06 m

Scale: 1:2500 @ A3. Spatial Units: Meter. Do not scale off this drawing

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Figure 7: processed gradiometer data, areas 3, 4, 5 and 6

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Westward Ho!, Bideford, Devon EX39 1GX
Tel: 07788627822
Email: geophysics@substrata.co.uk
Web: substrata.co.uk

British Grid
centre X: 296875.94 m, centre Y: 9397

:: 1:1000 @ A4. Spatial Units: Meter. Do not scale off this dra

An archaeological gradiometer survey
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Figure 8: processed gradiometer data, area 8

Substrata
15 Horizon View, Bath Hotel Road
Westward Ho!, Bideford, Devon EX39 1GX
Tel: 07788627822
Email: geophysics@substrata.co.uk
Web: substrata.co.uk

Appendix 2 Methodology

<table>
<tr><th colspan="2">Table 2: methodology</th></tr>
<tr><td colspan="2">Documents
Project design: Dean (2013)</td></tr>
<tr><td colspan="2">Methodology
1. The work was undertaken in accordance with the project design. 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.</td></tr>
<tr><td colspan="2">Grid
Method of Fixing: DGPS set-out using pre-planned survey grids and Ordnance Survey coordinates.
Composition: 30m by 30m grids
Recording: Geo-referenced and recorded using digital map tiles.</td></tr>
<tr><td>Equipment
Instrument: Bartington Instruments grad601-2
Firmware: version 6.1</td><td>Data Capture
Sample Interval: 0.25-metres
Traverse Interval: 1 metre
Traverse Method: zigzag
Traverse Orientation: GN</td></tr>
<tr><td colspan="2">Data Processing, Analysis and Presentation Software
DW Consulting TerraSurveyor3
ArcGIS 9.3
Microsoft Corp. Office Publisher 2003.</td></tr>
</table>

Appendix 3 Data processing

Table 3: gradiometer survey - processed data metadata, areas 1 to 7

SITE
Instrument Type: Grad 601 (Magnetometer)
Units: nT
Direction of 1st Traverse: 0 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

Dimensions
Composite Size (readings): 3360 x 690
Survey Size (meters): 840 m x 690 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 177.61
Min: -174.27
Std Dev: 12.58
Mean: 0.02
Median: 0.00
Surveyed Area: 9.2081 ha

PROGRAM
Name: TerraSurveyor
Version: 3.0.22.7

Processes: 15

1 Base Layer
2 Clip at 1.00 SD
3 Move (Area: Top 480, Left 240, Bottom 493, Right 360) to X 0, Y 16
4 De Stagger: Grids: mh139.xgd mh146.xgd mh140.xgd mh145.xgd mh147.xgd mh141.xgd mh144.xgd mh148.xgd mh142+mhl112.xgd mh143.xgd mh149.xgd Mode: Both By: -2 intervals
5 De Stagger: Grids: mh138.xgd Mode: Both By: -2 intervals
6 DeStripe Median Sensors: mhl01.xgd mhl09.xgd mhl10.xgd mhl02.xgd mhl08.xgd mhl11.xgd mhl03.xgd mhl07.xgd mhl12.xgd mhl06.xgd mhl13.xgd mhl28.xgd mhl35.xgd mhl05.xgd mhl14.xgd mhl29.xgd mhl34.xgd mhl37.xgd mhl42.xgd mhl04+mhl43.xgd mhl15.xgd mhl30.xgd mhl33.xgd mhl38.xgd mhl41.xgd mhl44.xgd mhl31.xgd mhl32.xgd mhl39.xgd mhl40.xgd
7 DeStripe Median Sensors: mhl19.xgd mhl21.xgd mhl25+mhl58.xgd mhl71+mhl27.xgd mhl18.xgd mhl22.xgd mhl24.xgd mhl26.xgd mhl17.xgd mhl23.xgd mhl16.xgd
8 DeStripe Median Sensors: mhl52.xgd mhl64.xgd mhl65.xgd mhl51.xgd mhl53.xgd mhl63.xgd mhl66.xgd mhl77.xgd mhl78.xgd mhl88.xgd mhl89.xgd mhl50.xgd mhl54.xgd mhl62.xgd mhl67.xgd mhl76.xgd mhl79.xgd mhl87.xgd mhl90.xgd mhl45.xgd mhl49.xgd mhl55.xgd mhl61.xgd mhl68.xgd mhl75.xgd mhl80.xgd mhl86.xgd mhl91.xgd mhl46.xgd mhl48.xgd mhl56.xgd mhl60.xgd mhl69.xgd mhl74.xgd mhl81.xgd mhl85.xgd mhl92.xgd mhl10.xgd mhl47+mhl20.xgd mhl57.xgd mhl59.xgd mhl70.xgd mhl73.xgd mhl82.xgd mhl84.xgd mhl93.xgd
9 DeStripe Median Sensors: mhl121.xgd mhl125.xgd mh126.xgd mh131.xgd mh132.xgd mhl122.xgd mhl124.xgd mh127.xgd mh130.xgd mh133.xgd mhl123.xgd mh128.xgd mh129.xgd
10 DeStripe Median Sensors: mhl103.xgd mh142+mhl112.xgd mh143.xgd mh149.xgd mhl104.xgd mhl111.xgd mhl113.xgd mhl120.xgd mhl105.xgd mhl110.xgd mhl114.xgd mhl119.xgd mhl106.xgd mhl109.xgd mhl115.xgd mhl118.xgd mhl107.xgd mhl108.xgd mhl116.xgd mhl117.xgd
11 DeStripe Median Sensors: mh155.xgd mh151.xgd mh154.xgd mh150.xgd mh153.xgd mh152.xgd
12 DeStripe Median Sensors: mh135.xgd mh138.xgd mh140.xgd mh136.xgd mh137.xgd mh141.xgd
13 DeStripe Median Sensors: mh139.xgd
14 DeStripe Median Sensors: mh144.xgd
15 DeStripe Median Sensors: mh145.xgd

Note: interpolation match x & y doubled is completed during export from TerraSurveyor to georeferenced ERSI format

Table 4: gradiometer survey - processed data metadata, area 8

SITE
Instrument Type: Grad 601 (Magnetometer)
Units: nT
Direction of 1st Traverse: 0 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

Dimensions
Composite Size (readings): 600 x 120
Survey Size (meters): 150 m x 120 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 140.61
Min: -137.84
Std Dev: 9.32
Mean: 0.30
Median: 0.03
Surveyed Area: 0.9463 ha

PROGRAM
Name: TerraSurveyor
Version: 3.0.22.7

Processes: 7
1 Base Layer
2 Clip at 1.00 SD
3 De Stagger: Grids: mh162.xgd mh161.xgd mh156.xgd mh160.xgd mh157.xgd mh159.xgd mh158.xgd Mode: Both By: -2 intervals
4 De Stagger: Grids: mh163.xgd mh164.xgd Mode: Both By: -2 intervals
5 De Stagger: Grids: mh165.xgd mh170.xgd mh166.xgd mh169.xgd mh167.xgd mh168.xgd Mode: Both By: -3 intervals
6 De Stagger: Grids: mh172.xgd mh171.xgd Mode: Both By: -3 intervals
7 DeStripe Median Sensors: mh161.xgd mh164.xgd mh171.xgd mh156.xgd mh160.xgd mh165.xgd mh170.xgd mh157.xgd mh159.xgd mh166.xgd mh169.xgd mh158.xgd mh167.xgd mh168.xgd
15 DeStripe Median Sensors: mh145.xgd

Note: interpolation match x & y doubled is completed during export from TerraSurveyor to georeferenced ERSI format

Appendix 4 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 magnetised 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 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.