ARCHAEOLOGICAL SERVICES
DURHAM UNIVERSITY

on behalf of

Bramham Park Estate

The Broadwalk
Bramham Park
West Yorkshire

geophysical survey

report 2844
March 2012

Durham University

Contents

Figures

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1. Summary

The project

1.1 This report presents the results of a geophysical survey conducted at the Broadwalk, Bramham Park, near Wetherby in West Yorkshire. The works comprised geomagnetic and earth electrical resistance survey to determine the location and extent of surviving 'bridge' features.

1.2 The works were commissioned by the Bramham Park Estate and conducted by Archaeological Services Durham University.

Results

1.3 A well-defined 'bridge' structure, measuring approximately 22m long, with extending 'funnelled' entrances, has been identified crossing the south-eastern part of the Broadwalk. The curving entrance walls continue along the sides of the Broadwalk, with accompanying ditches, almost certainly forming a ha-ha along each side of the Broadwalk; parts of such features have been identified in both survey areas.

1.4 The tunnel in Area 1 is lined with dressed sandstone blocks bonded with mortar and has a vaulted roof. It has been blocked by an inserted, unbound sandstone wall approximately halfway across. Other parts of the tunnel are rubble-filled and the western entrance also appears to have been blocked by a later wall.

1.5 The second 'bridge', shown to be approximately 270m north-west towards the house on Wood's 1728 plan of the park, could not be positively identified, and may have been partially destroyed by a ferrous service.

1.6 A metalled or compacted earth path, approximately 5m wide, has been identified running up the centre of the Broadwalk.

1.7 Services have been detected at the north-western end of the Broadwalk.

1.8 A programme of geophysical survey along the entire Broadwalk may help to identify any unknown archaeological or landscape features or further potential hazards.

2. Project background

Location (Figures 1-3)

2.1 The study area was located at the Broadwalk, a tree-lined walk across parkland to the south-east of the Grade I Registered House and Garden at Bramham Park, near Wetherby in West Yorkshire (NGR centre: SE 4120 4111). Both geomagnetic and earth electrical resistance surveys were conducted over the known location of one 'bridge' and the suggested location of a second.

Restoration proposal

2.2 The Bramham Park Estate is continuing a programme of restoration of its historic landscape. Part of the restoration work concerns "bridges that make the communication of the park", as depicted on a plan of the park by John Wood the Elder in 1728. These 'bridges' carry the Broadwalk over tunnels, used to enable livestock to pass from one side of the Broadwalk to the other without spoiling the vista or soiling the surface of the walk.

Objective

2.3 The principal aim of the surveys was to assess the nature and extent of any sub-surface features which might relate to the 'bridges', so that an informed decision may be made regarding the nature and scope of any further scheme of archaeological works prior to possible restoration.

Methods statement

2.4 The surveys have been undertaken in accordance with instructions from the client and to national standards and guidance (below, para. 5.1).

Dates

2.5 Fieldwork was undertaken on 31st January 2012. This report was prepared for 7th March 2012.

Personnel

2.6 Fieldwork was conducted by Duncan Hale (the Project Manager), Catrin Jenkins and Richie Villis (Supervisor). The geophysical data were processed by Richie Villis. This report was prepared by Richie Villis and Duncan Hale, with illustrations by David Graham.

Archive/OASIS

2.7 The site code is **WBP12**, for **W**etherby **B**ramham **P**ark 20**12**. The survey archive will be supplied on CD to the client for deposition with the project archive in due course. Archaeological Services Durham University is registered with the **O**nline **A**cces**S** to the **I**ndex of archaeological investigation**S** project (**OASIS**). The OASIS ID number for this project is **archaeol3-119013**.

Acknowledgements

2.8 Archaeological Services is grateful for the assistance of Bramham Park Estate's Resident Agent and other estate staff in facilitating this scheme of works.

3. Historical and archaeological background

3.1 Work to build Bramham Park began in 1698 and its grounds and park (Grade I registered) were laid out over the next 30 years by Robert Benson, 1st Lord Bingley. A plan of Bramham Park by John Wood the Elder in 1728 indicates two "bridges that make the communication of the park", approximately 270m apart, across the tree-lined Broadwalk (Figure2).

3.2 Archaeological Services Durham University have previously undertaken geophysical surveys at eight other locations on the estate as part of the ongoing historic garden and landscape restoration (Archaeological Services 2008; 2011). One of the areas from the 2008 surveys was conducted at the north-west end of the Broadwalk. No features of archaeological significance were detected.

4. Landuse, topography and geology

4.1 At the time of fieldwork the survey area comprised sheep pasture. The Broadwalk itself comprises a walkway which is flanked on each side by a line of trees and slight earthworks. Area 1 was centered on the known location of one 'bridge' towards the south-east of the Broadwalk. Area 2 was located approximately 270m away at the north-west of the Broadwalk. A 'coffin' horse jump has recently been constructed at the southern corner of Area 2. The survey areas and surrounding land has been used as a campsite for the Leeds Festival since 2003 and as part of the equestrian eventing course for the Bramham Horse Trials since 1974. Many small metallic objects were noted on the ground surface during survey, predominantly drinks cans and tent pegs.

4.2 The area was predominantly level with a mean elevation of approximately 67m OD

4.3 The underlying solid geology of the area comprises Late Permian dolostone of the Cadeby Formation.

5. Geophysical survey

Standards

5.1 The surveys and reporting were conducted in accordance with English Heritage guidelines, *Geophysical survey in archaeological field evaluation* (David, Linford & Linford 2008); the Institute for Archaeologists (IfA) *Standard and Guidance for archaeological geophysical survey* (2011); the IfA Technical Paper No.6, *The use of geophysical techniques in archaeological evaluations* (Gaffney, Gater & Ovenden 2002); and the Archaeology Data Service *Guide to Good Practice: Geophysical Data in Archaeology* (Schmidt & Ernenwein 2011).

Technique selection

5.2 Geophysical survey enables the relatively rapid and non-invasive identification of sub-surface features of potential archaeological significance and can involve a suite of complementary techniques such as magnetometry, earth electrical resistance, ground-penetrating radar, electromagnetic survey and topsoil magnetic susceptibility survey. Some techniques are more suitable than others in particular situations, depending on site-specific factors including the nature of likely targets; depth of likely targets; ground conditions; proximity of buildings, fences or services and the local geology and drift.

5.3 In this instance, the location of one bridge was already known and it was likely that a second bridge would also be present, based on Wood's 1728 plan. Other types of feature could also be present. Given the anticipated depth of likely targets, and the non-igneous geological environment of the study area, both a geomagnetic technique (fluxgate gradiometry) and an electrical resistance technique were considered appropriate for detecting the types of feature mentioned above.

5.4 Fluxgate magnetometry involves the use of hand-held magnetometers to detect and record anomalies in the vertical component of the Earth's magnetic field caused by variations in soil magnetic susceptibility or permanent magnetisation; such anomalies can reflect archaeological features. Earth electrical resistance survey can be particularly useful for mapping stone and brick features. When a small electrical current is injected through the earth it encounters resistance which can be measured. Since resistance is linked to moisture content and porosity, stone and brick features will give relatively high resistance values while soil-filled features, which retain more moisture, will provide relatively low resistance values.

Field methods

5.5 A 20m grid was established across each survey area and tied-in to known, mapped Ordnance Survey points using a Leica GS15 global navigation satellite system (GNSS) with real-time kinematic (RTK) corrections typically providing 10mm accuracy.

5.6 Both geomagnetic and earth electrical survey was conducted across Area 1, measuring 40m x 20m. Geomagnetic survey of Area 2 measured 80m x 40m, since the location of a second bridge here was not certain; targeted earth electrical resistance survey was then conducted, based on the geomagnetic results, measuring 40m x 20m.

5.7 Measurements of vertical geomagnetic field gradient were determined using Bartington Grad601-2 dual fluxgate gradiometers. A zig-zag traverse scheme was employed and data were logged in 20m grid units. The instrument sensitivity was nominally 0.03nT, the sample interval was 0.25m and the traverse interval was 1m, thus providing 1,600 sample measurements per 20m grid unit.

5.8 Measurements of earth electrical resistance were determined using Geoscan RM15D resistance meters with a mobile twin probe separation of 0.5m. A zig-zag traverse scheme was employed and data were logged in 20m grid units. The instrument sensitivity was 0.1ohm, the sample interval was 1m and the traverse interval was 1m, thus providing 400 sample measurements per 20m grid unit.

5.9 Data were downloaded on site into a laptop computer for initial processing and storage and subsequently transferred to a desktop computer for processing, interpretation and archiving.

Data processing

5.10 Geoplot v.3 software was used to process the geophysical data and to produce both continuous tone greyscale images and trace plots of the raw (minimally processed) data. The greyscale images and interpretations are presented in Figures 4-5; the trace plots are provided in Figure 6. In the greyscale images, positive magnetic/high resistance anomalies are displayed as dark grey and negative magnetic/low resistance anomalies as light grey. Palette bars relate the greyscale intensities to anomaly values in nanoTesla/ohm as appropriate.

5.11 The following basic processing functions have been applied to the geomagnetic data:

clip	clips data to specified maximum or minimum values; to eliminate large noise spikes; also generally makes statistical calculations more realistic
zero mean traverse	sets the background mean of each traverse within a grid to zero; for removing striping effects in the traverse direction and removing grid edge discontinuities
destagger	corrects for displacement of geomagnetic anomalies caused by alternate zig-zag traverses
interpolate	increases the number of data points in a survey to match sample and traverse intervals; in this instance the data have been interpolated to 0.25m x 0.25m intervals

5.12 The following basic processing functions have been applied to the resistance data:

despike	locates and suppresses spikes in data due to poor contact resistance
interpolate	increases the number of data points in a survey to match sample and traverse intervals; in this instance the data have been interpolated to 0.25m x 0.25m intervals

Interpretation: anomaly types

5.13 Colour-coded geophysical interpretation plans are provided. Three types of geomagnetic anomaly have been distinguished in the data:

positive magnetic	regions of anomalously high or positive magnetic field gradient, which may be associated with high magnetic susceptibility soil-filled structures such as pits and ditches
negative magnetic	regions of anomalously low or negative magnetic field gradient, which may correspond to features of low magnetic susceptibility such as wall footings and other concentrations of sedimentary rock or voids
dipolar magnetic	paired positive-negative magnetic anomalies, which typically reflect ferrous or fired materials (including fences and service pipes) and/or fired structures such as kilns or hearths

5.14 Two types of resistance anomaly have been distinguished in the data:

high resistance	regions of anomalously high resistance, which may reflect foundations, tracks, paths and other concentrations of stone or brick rubble
low resistance	regions of anomalously low resistance, which may be associated with soil-filled features such as pits and ditches

Interpretation: features

5.15 Colour-coded archaeological interpretation plans are provided.

Area 1

5.16 A well-defined area of anomalously high electrical resistance has been detected across the central part of this area. This almost certainly reflects the extents of the stone 'bridge' across the tunnel under the Broadwalk. A negative magnetic anomaly which was detected here corresponds to the high resistance anomaly, and similarly reflects stone. This negative magnetic anomaly is flanked by positive magnetic anomalies, which almost certainly reflect backfill around the stone construction of the bridge. At the north-eastern side of the Broadwalk the two side walls of the bridge clearly curve outwards to form a funnelled entrance. These walls then continue parallel to the walk, forming a boundary to the Broadwalk. It is likely that these walls are part of a ha-ha along each side of the Broadwalk, preventing access onto the walk by livestock.

5.17 The tunnel entrance on the south-western side is not so clearly defined in the data, however, a funnelled entrance can be discerned amongst the probable stone rubble. In addition, a blocking wall appears to have been inserted across the entrance here.

5.18 The main body of the bridge measures approximately 22m long by 4m wide, with the funnelled entrance formed by the walls extending beyond this; the distance between the flanking or ha-ha walls is approximately 30m.

5.19 The tunnel itself is constructed of dressed sandstone blocks bonded with mortar, and has a curving vaulted ceiling (Figure 10). An internal unbound sandstone wall has also been inserted at some later date, blocking the tunnel approximately halfway along. The surviving unblocked part of the tunnel, as seen on the ground, measures approximately 7m long by 2.5m wide and up to 2.5m in height.

5.20 A broad, linear high resistance anomaly has been detected roughly central to the Broadwalk, perpendicular to the tunnel. It is likely that this anomaly reflects a metalled or compacted surface, almost certainly a path up the centre of the walk.

5.21 Many small dipolar magnetic anomalies have also been detected. These are likely to reflect a high concentration of near-surface ferrous and fired waste, mostly drinks cans and tent pegs in this instance.

Area 2

5.22 Large concentrations of intense dipolar magnetic anomalies have been detected across this area. These anomalies are likely to reflect near surface ferrous and fired waste. A number of tent pegs were noted on the ground and cleared away before survey. The use of the Broadwalk and surrounding fields as a campsite for the Leeds Festival may account for this debris. Areas of quieter magnetic response are likely to reflect passages or thoroughfares through the campsite.

5.23 Two bands of intense dipolar magnetic anomalies have been detected at the north-western end of the area. These almost certainly reflect services.

5.24 Adjacent to this an area of low magnetic response has been detected, defined by a relative lack of dipolar magnetic anomalies, and a narrow positive magnetic anomaly at its south-east edge. This corresponds to an existing track, which defines the limit of the concentrations of dipolar anomalies.

5.25 The presence of so many small intense anomalies has hindered the detection of features producing weaker anomalies, however, some have been identified. Two linear positive magnetic anomalies have been detected along the edges of the Broadwalk, just beyond the line of trees. These almost certainly reflect soil-filled ditch features and may relate to ha-has separating the Broadwalk form the surrounding parkland. The ditch on the western side has also been detected in the resistance survey. A parallel negative magnetic anomaly has been detected on the eastern side of this western ditch, which probably reflects a ha-ha wall on the Broadwalk side of the ditch.

5.26 A narrow linear negative magnetic anomaly has been detected, roughly in the centre of the Broadwalk. This may reflect one edge of a metalled or compacted path up the middle of the Broadwalk. A broad band of high resistance here is also indicative of the path, as also identified in Area 1.

5.27 A north-east/south-west aligned, *c.*5m wide, area of strong dipolar magnetic anomalies has been detected in the southern half of the survey. The location, size and orientation of this anomaly, coupled with the similarities to the anomaly identified as a 'bridge' in Area 1, led to an initial on-site interpretation of this as the second 'bridge' feature. Consequently, electrical resistance survey was targeted on this feature and extending to include the probable flanking ha-has.

5.28 A region of anomalously high resistance has been detected in the western part of the resistance survey. This broadly corresponds to the area of the feature identified in the geomagnetic data, above. This area of high resistance almost certainly reflects stone or rubble.

5.29 The strong dipolar nature of the geomagnetic anomaly could reflect a metal service pipe or other ferrous materials which could possibly have been laid within a former tunnel or 'bridge' structure. The unstructured high resistance anomalies may reflect rubble associated with the former 'bridge'.

5.30 The survey area sloped gently down from south-west to north-east. This, and the presence of a probable ha-ha ditch here, may account for the region of lower resistance detected on the eastern side.

6. Conclusions

6.1 Geomagnetic and earth electrical resistance surveys were undertaken at two areas across the Broadwalk at Bramham Park, near Wetherby, West Yorkshire, in order to identify the nature and extent of two suggested 'bridges'.

6.2 A well-defined 'bridge' structure, measuring approximately 22m long, with extending 'funnelled' entrances, has been identified crossing the south-eastern part of the Broadwalk. The curving entrance walls continue along the sides of the Broadwalk, with accompanying ditches, almost certainly forming a ha-ha along each side of the Broadwalk; parts of such features have been identified in both survey areas.

6.3 The tunnel in Area 1 is lined with dressed sandstone blocks bonded with mortar and has a vaulted roof. It has been blocked by an inserted, unbound sandstone wall approximately halfway across. Other parts of the tunnel are rubble-filled and the western entrance also appears to have been blocked by a later wall.

6.4 The second 'bridge', shown to be approximately 270m north-west towards the house on Wood's 1728 plan of the park, could not be positively identified, and may have been partially destroyed by a ferrous service.

6.5 A metalled or compacted earth path, approximately 5m wide, has been identified running up the centre of the Broadwalk.

6.6 Services have been detected at the north-western end of the Broadwalk.

6.7 A programme of geophysical survey along the entire Broadwalk may help to identify any unknown archaeological or landscape features or further potential hazards.

7. Sources

Archaeological Services 2008 *Bramham Park Estate, Wetherby, West Yorkshire: geophysical surveys*. Unpublished report **1951**, Archaeological Services Durham University

Archaeological Services 2011 *Bramham Park, Wetherby, West Yorkshire: geophysical surveys*. Unpublished report **2587**, Archaeological Services Durham University

David, A, Linford, N, & Linford, P, 2008 *Geophysical Survey in Archaeological Field Evaluation*. English Heritage

Gaffney, C, Gater, J, & Ovenden, S, 2002 *The use of geophysical techniques in archaeological evaluations*. Technical Paper **6**, Institute of Field Archaeologists

IfA 2011 *Standard and Guidance for archaeological geophysical survey*. Institute for Archaeologists

Schmidt, A, & Ernenwein, E, 2011 *Guide to Good Practice: Geophysical Data in Archaeology*. Archaeology Data Service

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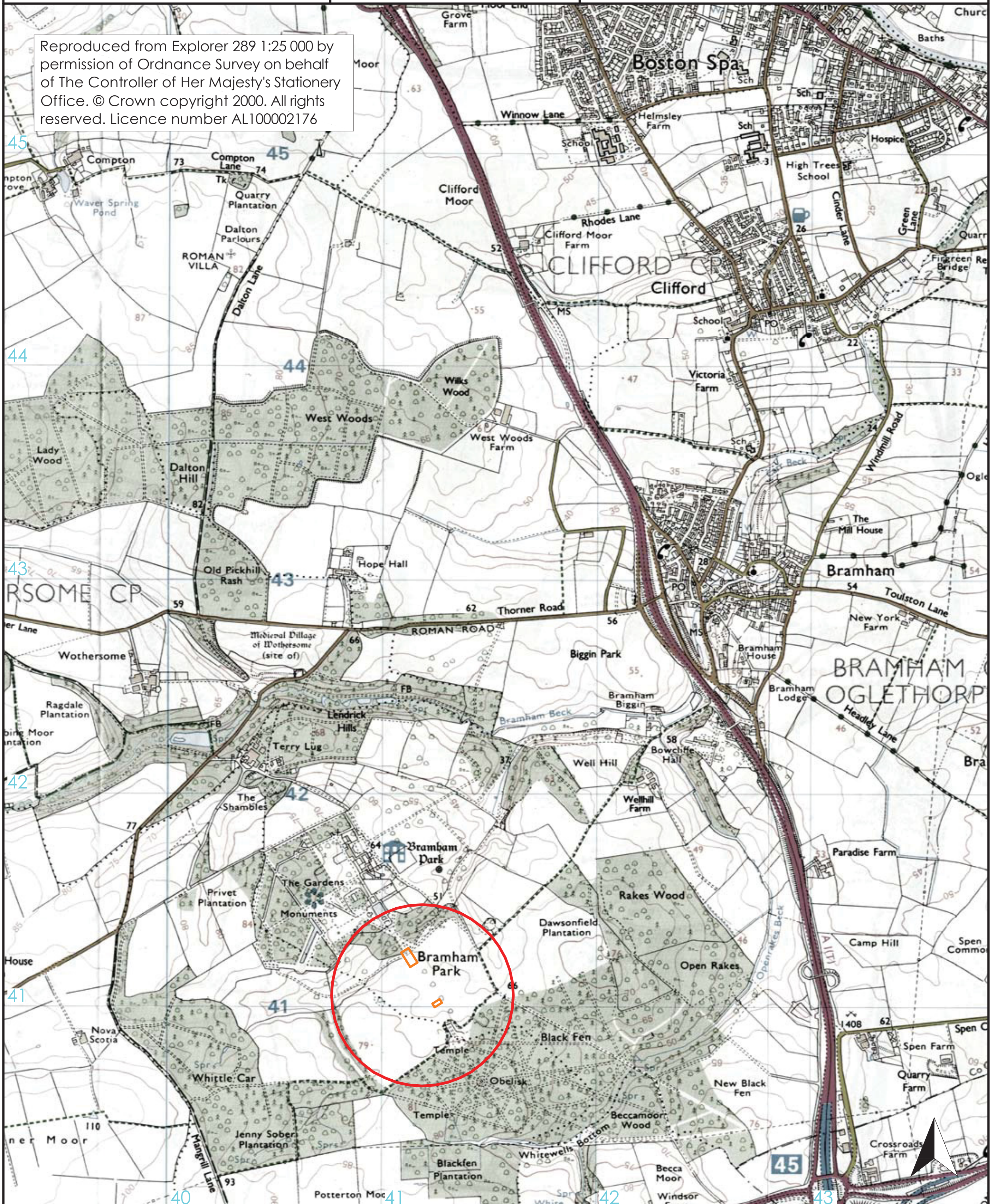
Figure 1: Site location



survey location

0 1km
scale 1:25 000 for A4 plot

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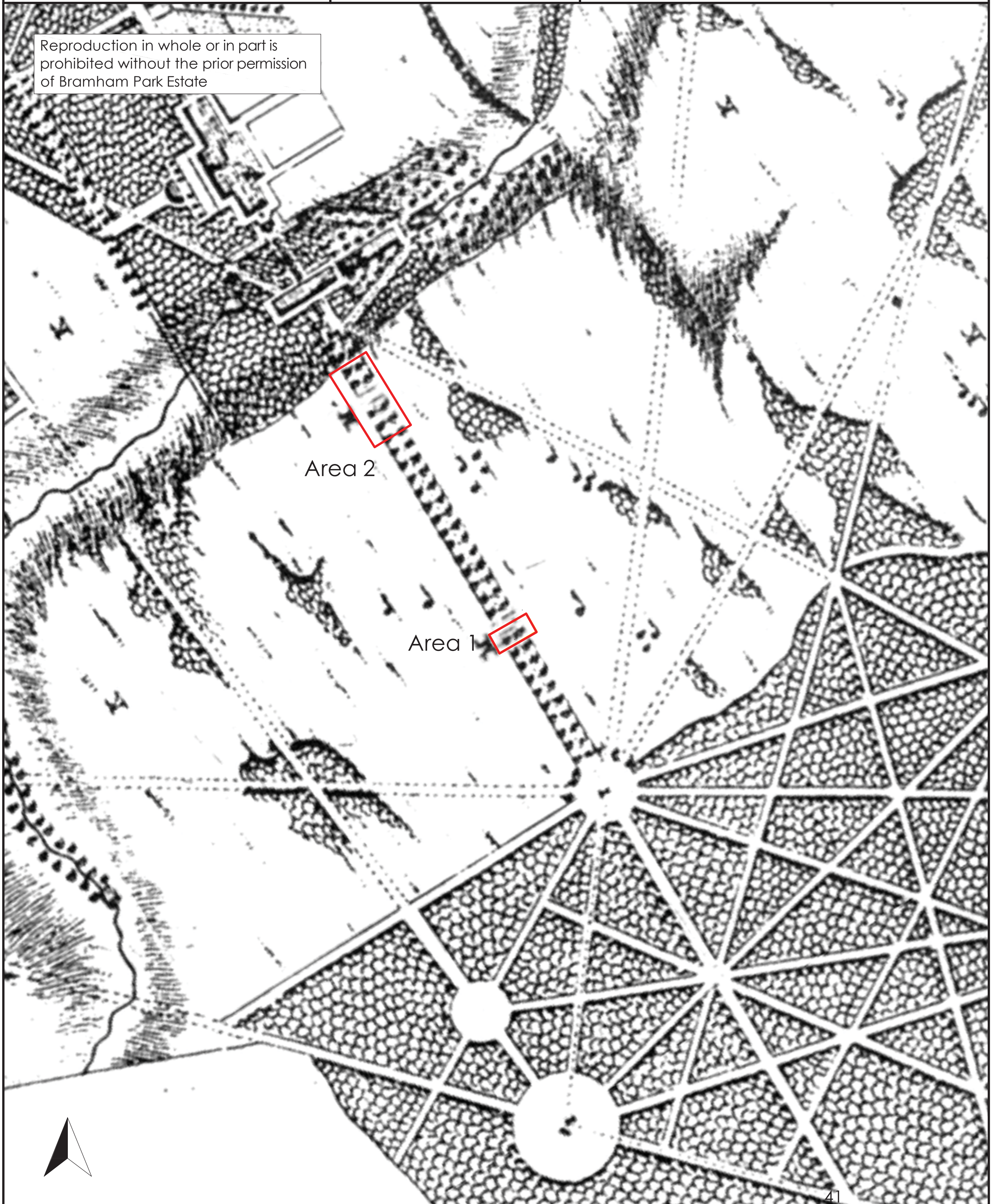
Figure 2: Extract from Wood's The Plan of Bramham Park in the County of York, 1728, with survey locations



survey areas

not to scale

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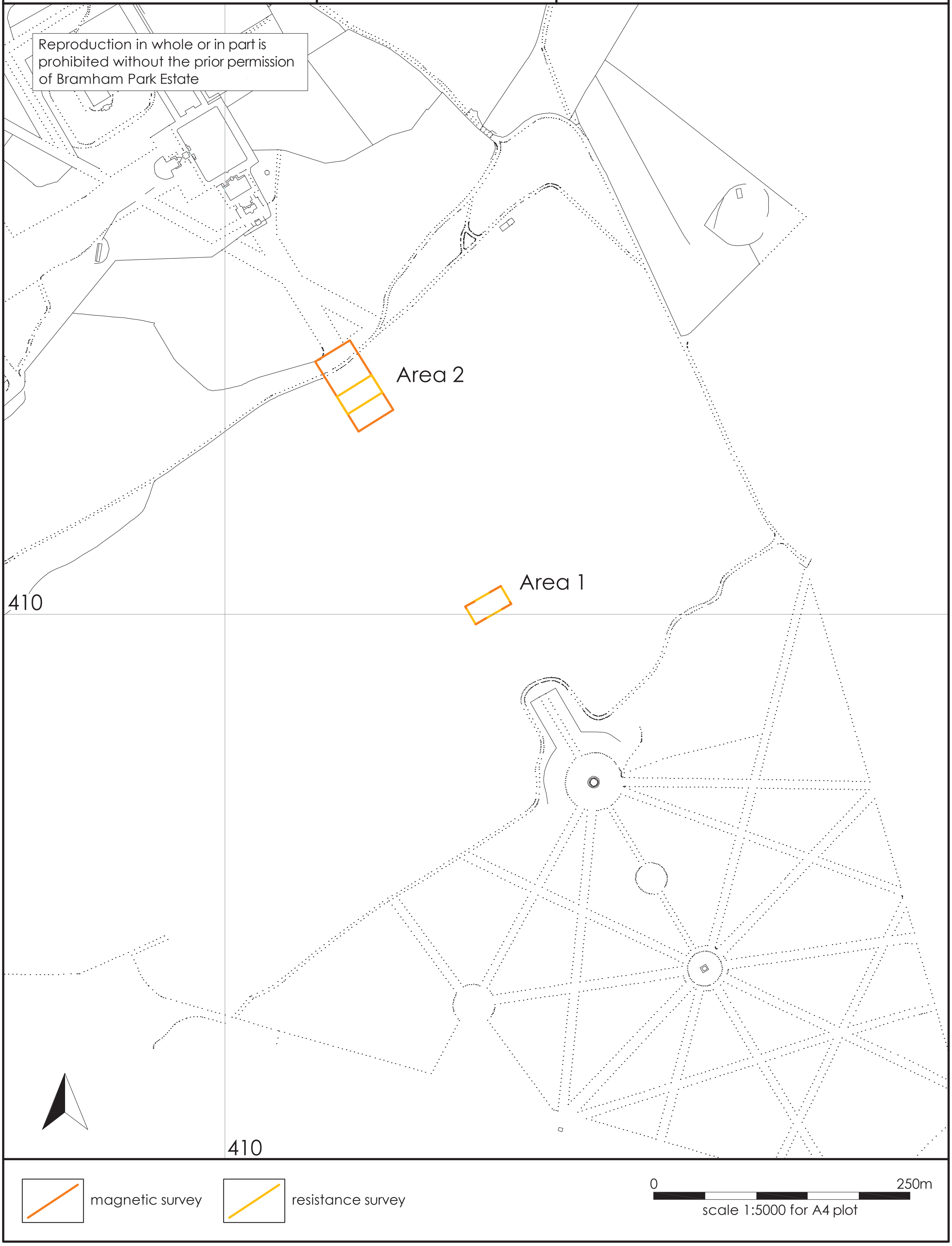
Figure 3: Survey areas



A - geophysical survey

magnetic survey

-5 nT 5

resistance survey

40 ohm 80

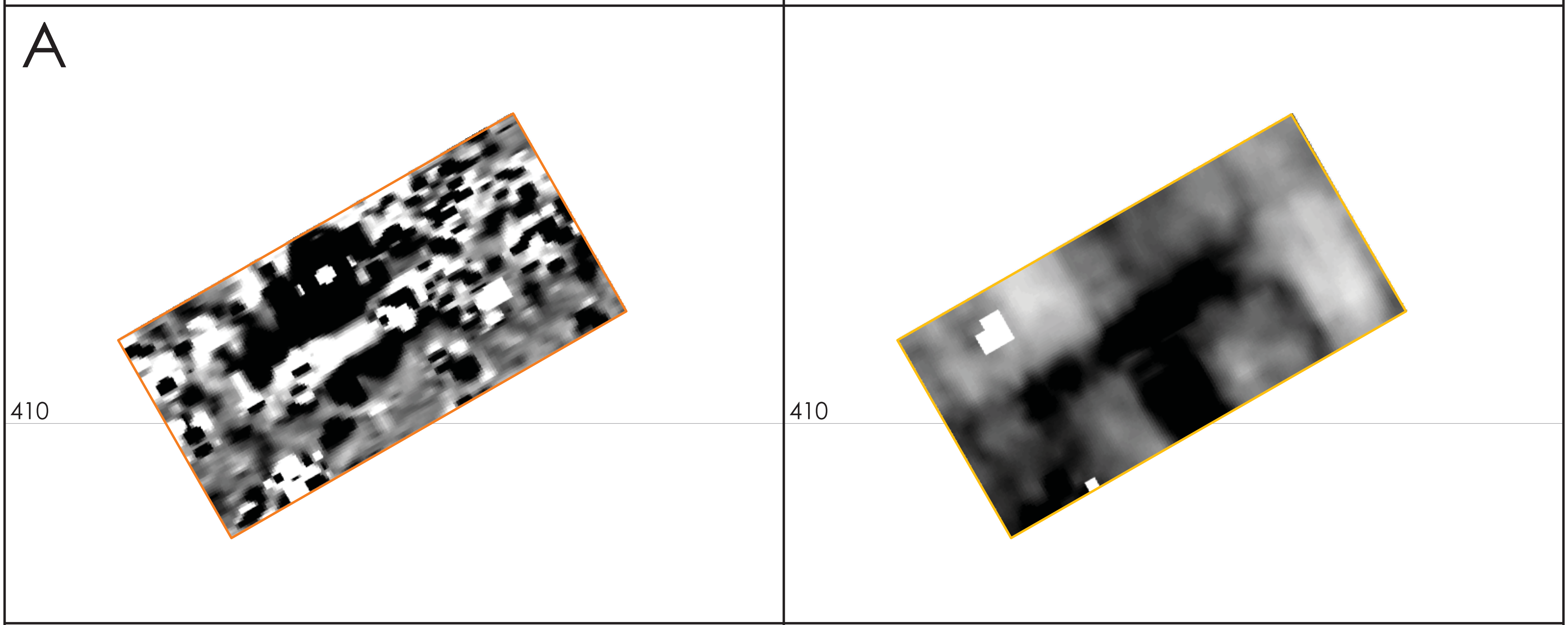
B - geophysical interpretation

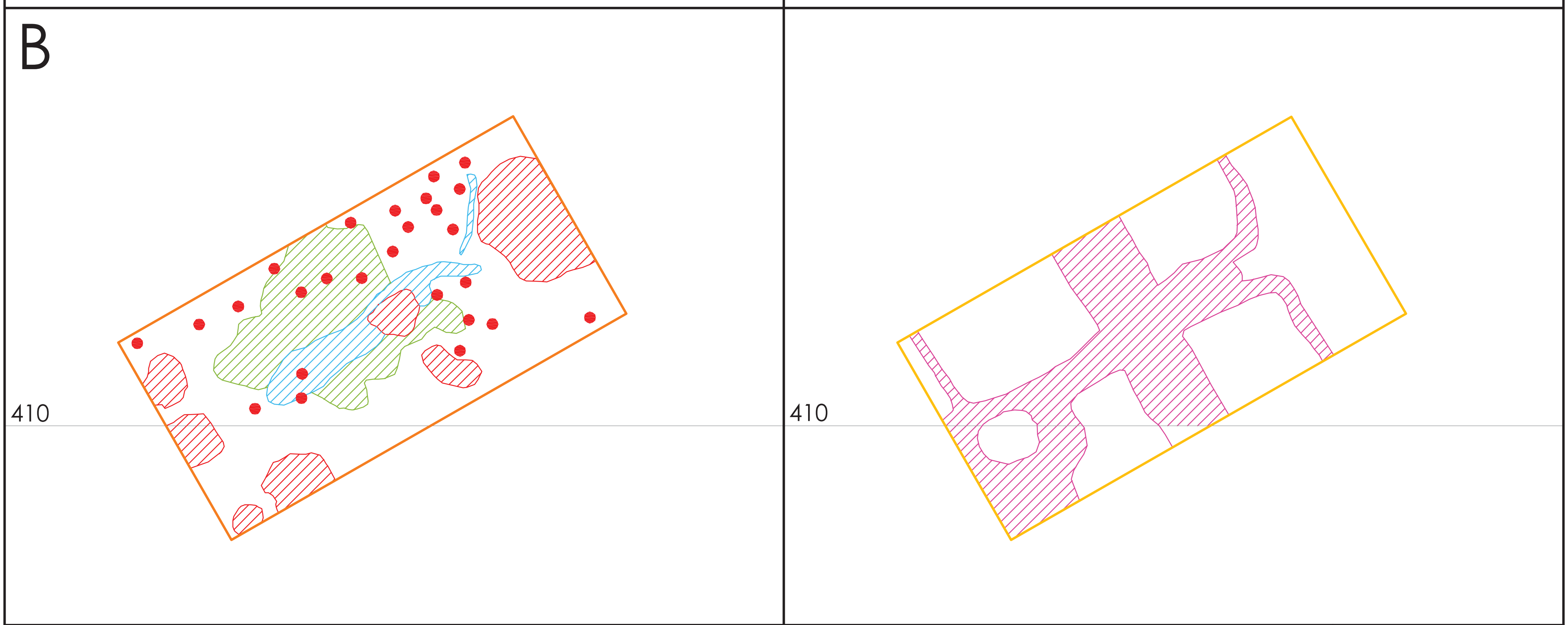
dipolar magnetic anomaly

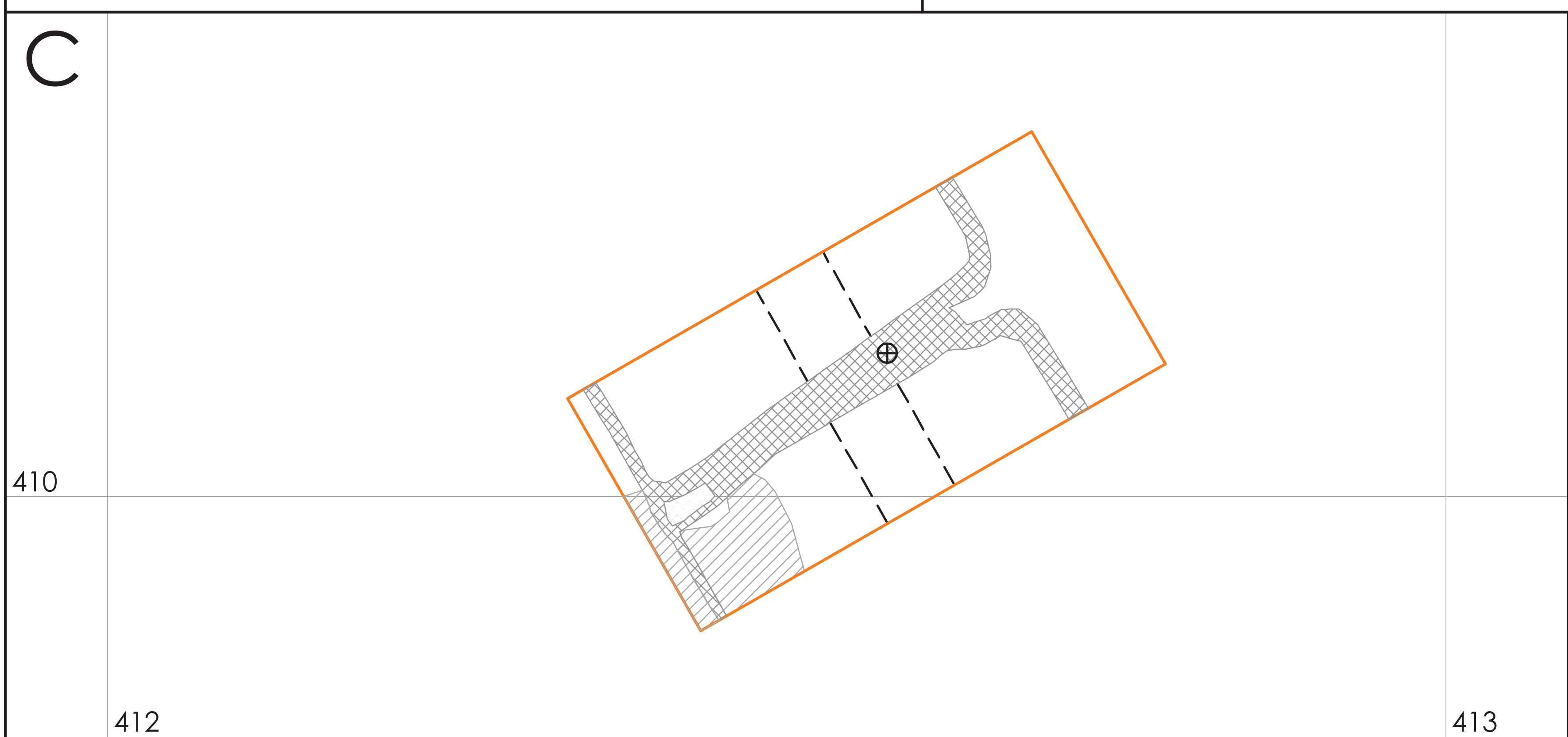
positive magnetic anomaly

negative magnetic anomaly

high resistance anomaly







C - archaeological interpretation

stone built 'bridge'

stone/rubble spreads

track/footpath

hole

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0 25m

scale 1:500 for A3 plot

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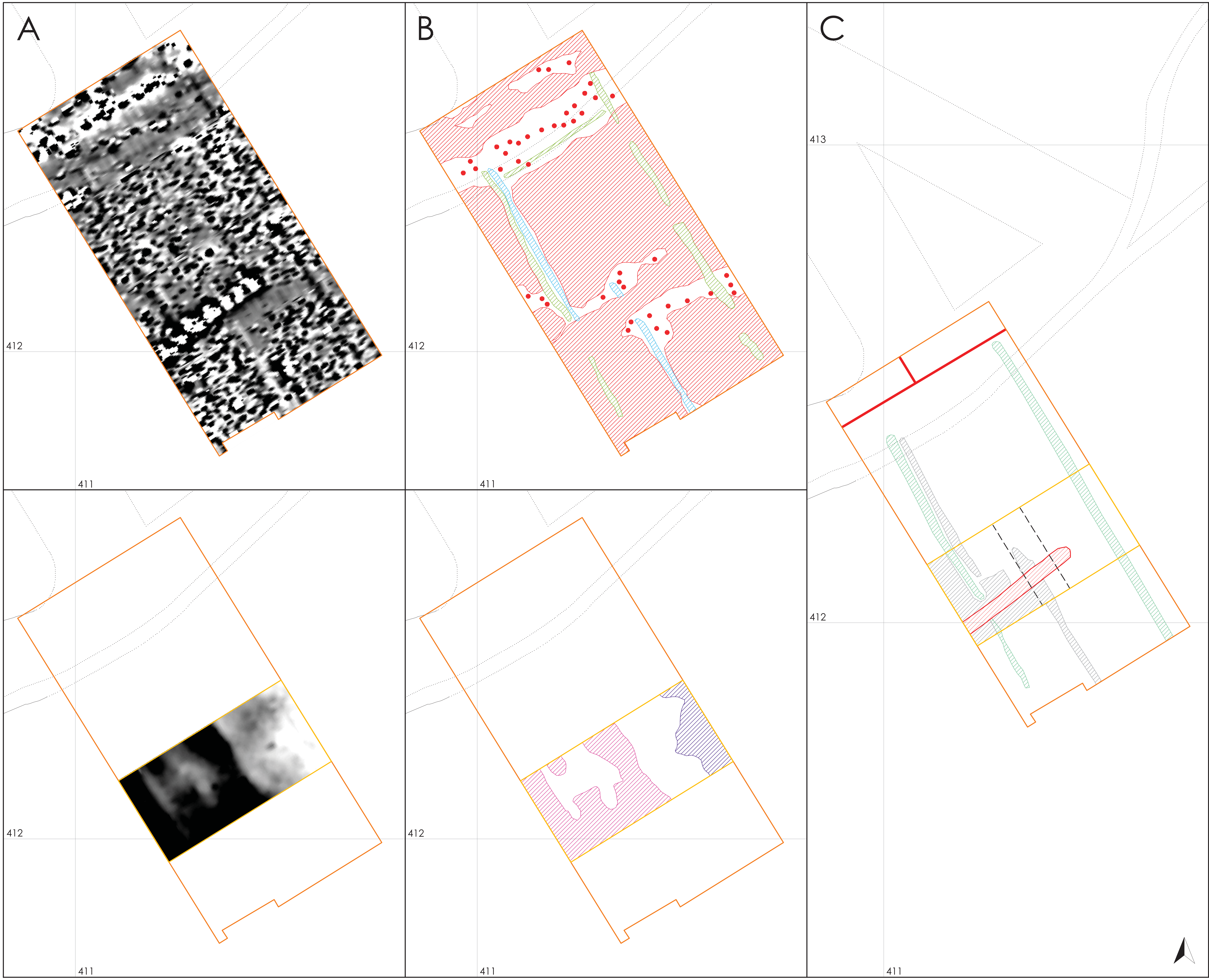
Figure 4: Area 1 geophysical survey and interpretation



A - geophysical survey

magnetic survey

-20 nT 20

resistance survey

80 ohm 100

B - geophysical interpretation

dipolar magnetic anomaly

positive magnetic anomaly

negative magnetic anomaly

high resistance anomaly

low resistance anomaly

C - archaeological interpretation

ha-ha ditch

stone/rubble spreads

service pipe

track/footpath

0 25m

scale 1:500 for A2 plot

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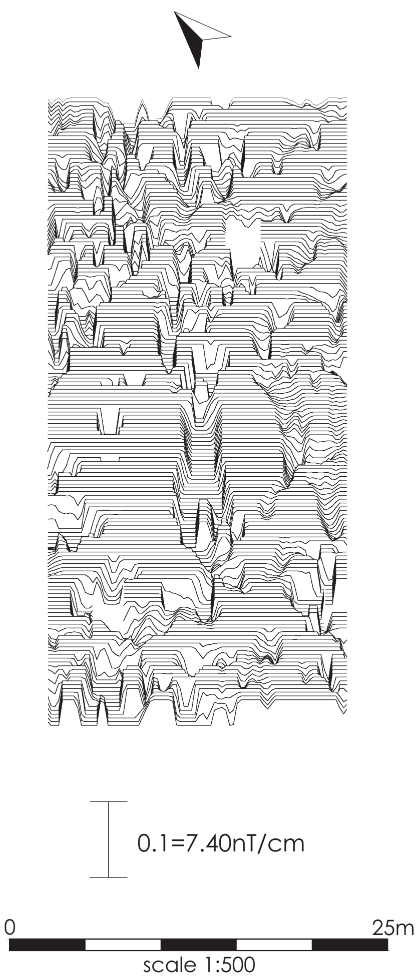
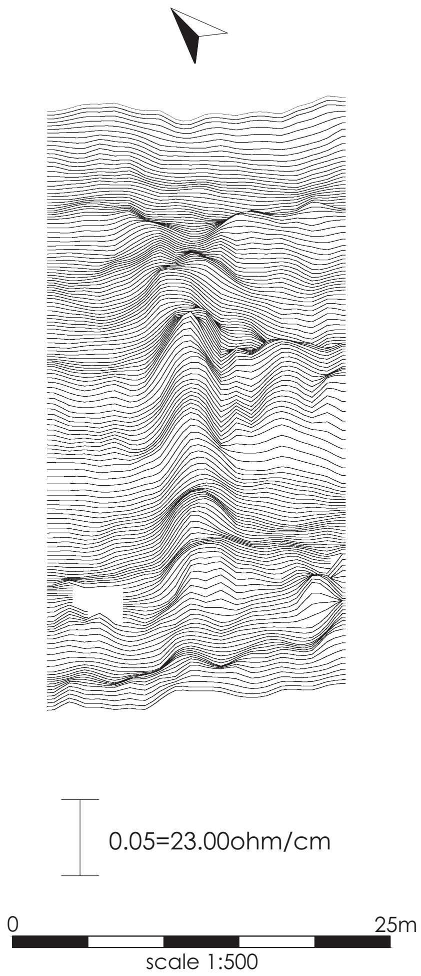
Figure 5: Area 2 geophysical survey and interpretation

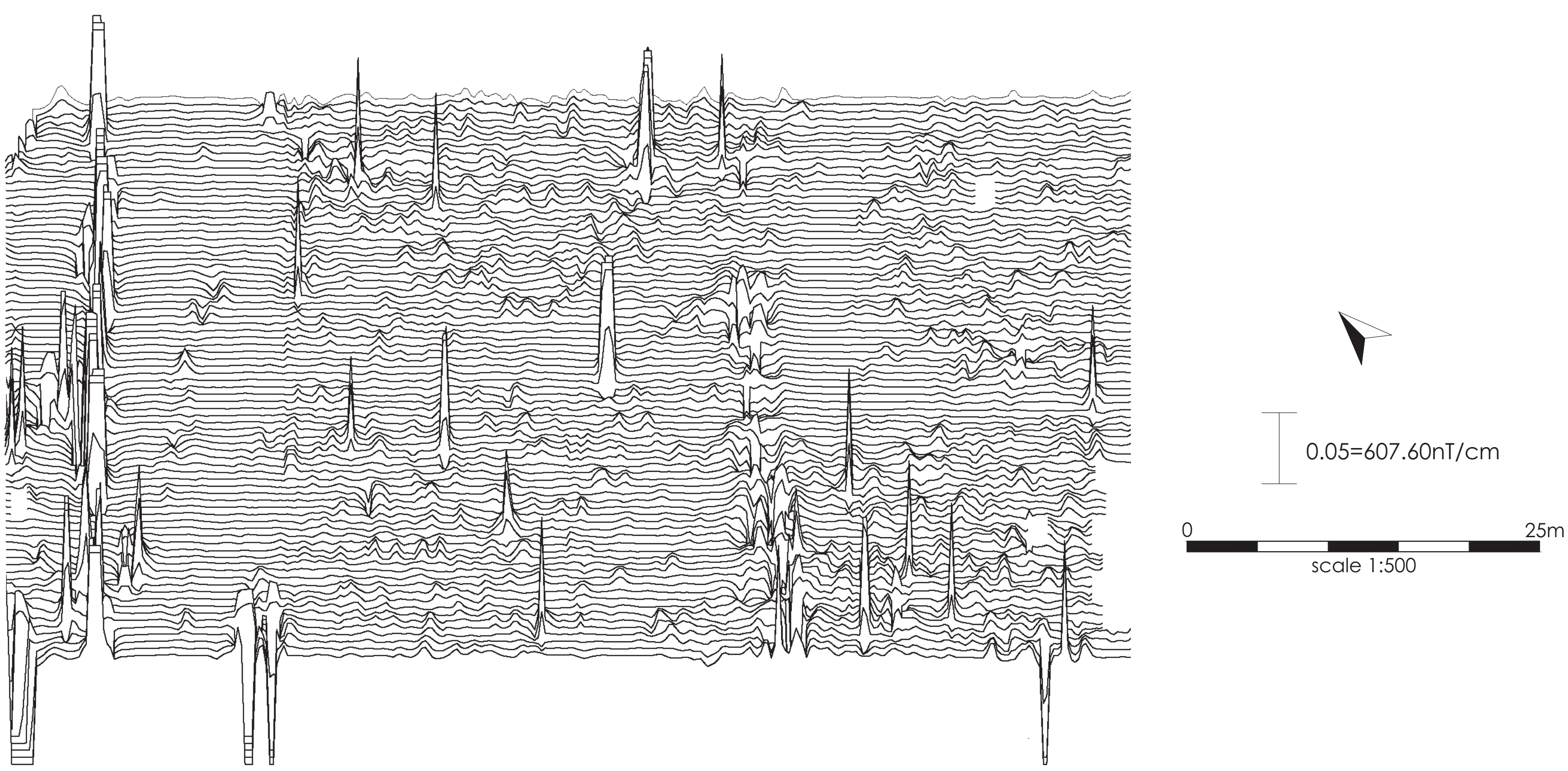
Area 1, magnetic survey



Area 1, resistance survey



Area 2, magnetic survey



Area 2, resistance survey

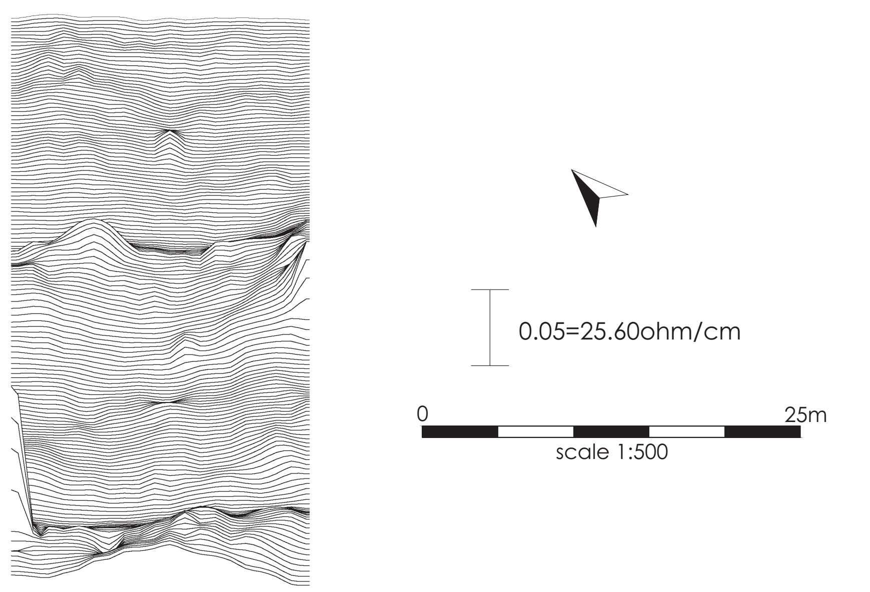


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Figure 6:
Trace plots of geophysical data

Figure 7: Looking north-west from Area 1 up the Broadwalk towards the house

Figure 8: Looking south-east from Area 1 down the Broadwalk towards the temple

Figure 9: The hole into the 'bridge' structure at Area 1

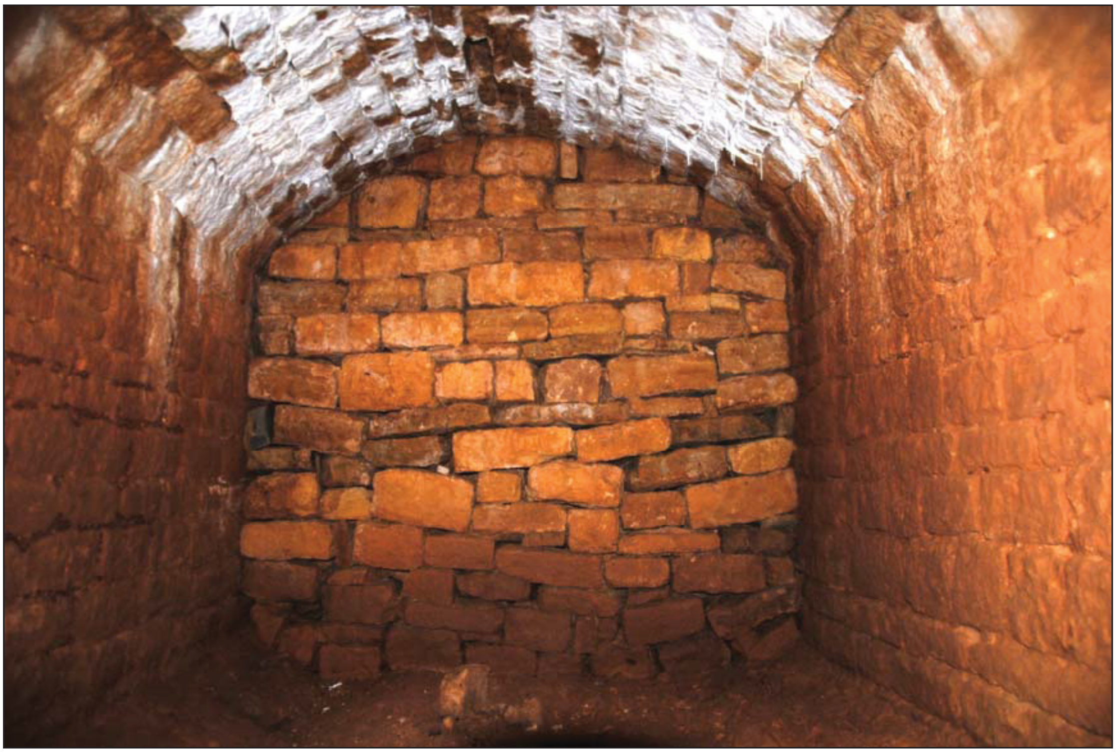

Figure 10: The 'bridge' under the Broadwalk at Area 1, looking south-west