# LAND AT BRACKENSGHYLL, BACK LANE, SEDBERGH, YORKSHIRE DALES NATIONAL PARK

DETAILED MAGNETOMETER & EARTH RESISTANCE METER SURVEY

Report Number: 1046

January 2014

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## DETAILED MAGNETOMETER & EARTH RESISTANCE SURVEY

Prepared for:
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For JMP Architects Ltd,
On Behalf of Sedbergh School.

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January 2014

| | | | |
|---|---|---|---|
| **Site Code** | BSS 014 | **NGR** | 365861 492111 |
| **Planning Ref.** | S/03/455E | **OASIS** | britanni1-169448 |
| **Approved By** | Matthew Adams | **Date** | January 2014 |

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***ABSTRACT***

*The detailed fluxgate gradiometer and earth resistance surveys were successful in identifying a range of anomalies which help to describe the sites taphonomy. A good degree of correlation and occasional differences within the two datasets ultimately provide a complementary result.*

*The magnetometer survey revealed that the most numerous type of anomalies were isolated dipolar responses, three areas of magnetic disturbance caused by a low garden wall and two existing perpendicular pathways were recorded. Six discrete anomalies were also recorded in the dataset, one of which was present over the centre of a negative linear trend and near to a high resistance anomaly recorded by the RM85 on the eastern boundary.*

*Two negative linear trends that lie parallel to the existing eastern and western boundary walls are perhaps the most intriguing; they also correlate well with high resistance trends recorded by the earth resistance meter. The eastern trend has been interpreted as a culvert, and the western trend as the existing boundary wall foundation, or an earlier wall or pathway.*

*Areas of low resistance were recorded in the dataset principally around the sites periphery where the ground appears to have been raised and flowerbeds are present.*

*An area of high and very high resistance was recorded to the south of the dataset where the bedrock geology is believed to lie closer to the surface due to the the removal of material to construct the two terraces.*

*High resistance linear trends, some of which correlate with negative linear trends recorded by the magnetometer, are believed to be the remains of a culvert close to the eastern boundary, and an existing boundary wall foundation, or an earlier wall or pathway to the west.*

*It would be prudent to target the linear trends, recorded with both instruments that are present on the eastern and western boundary, to discover whether they are of archaeological origin or relate to existing garden features. The discrete anomalies recorded within the southern terrace could also be further investigated along with the area of high resistance to help qualify the interpretations given within this report.*

## 1.0 INTRODUCTION

On Wednesday 15th and Thursday 16th January 2014, Britannia Archaeology Ltd (BA) undertook detailed fluxgate gradiometer and earth resistance meter surveys over *c.*0.25ha of land at Brackensghyll, Back Lane, Sedbergh, Yorkshire Dales National Park (NGR 365861 492111), over an area of landscaped garden (Figure 1).

This survey was commissioned by Chris Healey of Minerva Heritage Ltd, for JMP Architects Ltd, on behalf of Sedbergh School. The weather was overcast on day one following a period of prolonged precipitation, dry and sunny conditions prevailed on day two.

## 2.0 SITE DESCRIPTION

The survey was located within the landscaped walled gardens between Back Lane, Sedbergh to the south, and the rear of the properties along Main Street to the north (see Figure 1), the site lies at 130m AOD. Access was gained via a code-lock door on the western wall.

The bedrock geology comprised Bannisdale Formation Siltstone and Mudstone, interbedded sedimentary bedrock formed approximately 419 to 423 million years ago in the Silurian Period when the local environment was dominated by rivers depositing mainly sand and gravel detrital material in channels forming river terrace deposits, and fine silt and clay from overbank floods forming floodplain alluvium with some bogs depositing peat (BGS, 2014).

The superficial deposits are described as Devensian Diamicton Till, formed up to 2 million years ago in the Quaternary Period when the local environment was dominated by ice age conditions when glaciers scoured the landscape depositing moraines of till with outwash sand and gravel deposits from seasonal and post glacial meltwaters (BGS, 2014).

## 3.0 PLANNING POLICIES

This geophysical survey was undertaken in accordance with guidance laid down by the *National Planning and Policy Framework* (NPPF, DCLD 2012) which replaced *Planning Policy Statement 5: Planning for the Historic Environment* (PPS5, DCLG 2010) in March 2012. The relevant local development requirements are set out in *Planning Application Validation Requirements in the Yorkshire Dales National Park; Draft June 2013.*

### *3.1 National Planning Policy Framework (NPPF, DCLG March 2012)*

The NPPF recognises that 'heritage assets' are an irreplaceable resource and planning authorities should conserve them in a manner appropriate to their significance when considering development. It requires developers to record and advance understanding of the significance of any heritage assets to be lost (wholly or in part) in a manner proportionate to their importance and the impact, and to make this evidence (and any archive generated) publicly accessible. The key areas for consideration are:

- The significance of the heritage asset and its setting in relation to the proposed development;
- The level of detail should be proportionate to the assets' importance and no more than is sufficient to understand the potential impact of the proposal on their significance;
- Significance (of the heritage asset) can be harmed or lost through alteration or destruction, or development within its setting. As heritage assets are irreplaceable, any harm or loss should require clear and convincing justification;
- Local planning authorities should not permit loss of the whole or part of a heritage asset without taking all reasonable steps to ensure the new development will proceed after the loss has occurred; and
- Non-designated heritage assets of archaeological interest that are demonstrably of equivalent significance to scheduled monuments, should be considered subject to the policies for designated heritage assets.

*3.2 Planning Application Validation Requirements in the Yorkshire Dales National Park; Draft June 2013.*

The segment covering heritage assets is described in Section 4: Heritage Statement (page 14), detailing when a statement is required, what is to be included in the report and a list of the relevant bibliographic sources.

## 4.0 ARCHAEOLOGICAL BACKGROUND

Historic environment features close to the development site mostly reflect Sedbergh's developing landscape since about the middle of the 18th century. There are also some features from the medieval period; activity from earlier periods appears wholly absent.

The arrangement of properties lining the present roadways and the infill development of yards behind these street-front properties seems to respect a medieval pattern. Medieval tenements, or burgage plots, typically extend away from principal thoroughfares in thin allotments, with buildings closest to the road and various domestic functions carried out in these plots further back from the main street front. It is likely that a good deal of any archaeological material relating to the medieval periods has been lost through development of the street-front properties in the post-medieval and industrial periods.

There is still some potential for below-ground archaeological remains to survive at the proposed development site. Such remains may be remnants of medieval or post-medieval settlement and may potentially include '*evidence relating to the origins and development of Sedbergh*', '*evidence for the industries, economy and trade of the town and its trading links with the rural population that it served*'; '*Evidence of the diet and lifestyles of the inhabitants may also be present*' (CCC 2006b). Such archaeological remains may be of regional, potentially even national significance.

Additional investigation is required in order to enable a more accurate determination of the significance of development impacts by better characterising this resource. Geophysical survey was considered to be an appropriate and proportionate response given the potential scale and importance of the remains. Any intrusive below-ground archaeological investigation (which may be required in order to mitigate development impacts) should be informed by non-intrusive techniques in the first instance to identify areas where archaeological remains are likely to be present or absent. The results of these non-intrusive geophysical surveys should inform the scale and location of any intrusive works, if the results are sufficiently promising to warrant further intrusive works.

## 5.0 PROJECT AIMS & OBJECTIVES

These surveys aimed to provide further detailed information regarding the location and character of archaeological remains which may be present on the proposed development site.

Four objectives were identified:

• To determine the presence of archaeological anomalies associated with possible earlier uses of the site;

• To define the extent of any archaeological anomalies;

• To characterise, if possible, any archaeological features or anomalies recorded; and

• To inform any requirement for further archaeological works (if required).

## 6.0 METHODOLOGY

### 6.1 Instrument Type Justification

*6.1.1 Fluxgate Gradiometer*

Britannia Archaeology Ltd employed a Bartington Dual Grad 601-2 fluxgate gradiometer to undertake the survey, because of its high sensitivity and rapid ground coverage. The surveyors noted that that the site had a fairly high magnetic background susceptibility possibly due to the amount of apparent ground disturbance caused by the landscaping of the formal garden.

*6.1.2 Earth Resistance Meter*

A Geoscan Research RM85 was employed to undertake the earth resistance survey, because of its on-board functionality and relative stability. It was noted during the set-up that the southern terrace had very high resistance readings compared to the northern terrace, owing to a shallow layer of topsoil overlying near-surface solid bedrock geology.

## 6.2 Instrument Calibration

*6.2.1 Fluxgate Gradiometer*

One hour was allowed in the morning for the magnetometers sensors to settle before the start of the first grid. The instrument was zeroed after every three grids to minimise the effect of sensor drift. An area with a relatively low magnetic reading was chosen to calibrate the instrument; this same point was used to zero the sensors throughout the survey providing a common zero point. Sensor drift did not occur due to prevailing overcast conditions on day one.

*6.2.2 Earth Resistance Meter*

A single (twin pole-pole) 0.5m probe separation was considered to be most appropriate over the entire site, predominantly for ease of movement within a fairly constricted area that contained plenty of garden furniture. The Gain was lowered (X1) because of high resistance and over-range readings (due to near-surface siltstone and mudstone geology on the southern terrace) and the Frequency was set to 122.5Hz which allowed the readings to stabilise. Output voltage was programed at 45v because of the saturated ground conditions, the auto-log delay was adjusted to 1250ms to allow for greater resistance settling (and therefore a better overall average reading), the high pass filter was set at 13Hz which also proved to be most stable.

An area of relative low resistance was chosen for the set-up station (located on the northern terrace), when the drum was moved to allow for survey progression this same set-up station was employed to equalise the probes reading. The same figure was gained via widening the remote probe separation, allowing a consistent dataset to be collected.

## 6.3 Sampling Interval and Grid Size

*6.3.1 Fluxgate Gradiometer*

The sampling interval was set at 0.25m along 1m traverse intervals, providing 4 readings a metre, the magnetometer survey was undertaken on 20 x 20m grids, both geophysical surveys were undertaken on the same grid.

*6.3.2 Earth Resistance Meter*

To allow for speed of survey a 1m sampling interval was set along 1m traverse intervals, providing 1 reading a metre, the earth resistance survey was undertaken on 20 x 20m grids.

### 6.4 Survey Grid Location

The survey grid was set out to the Ordnance Survey OSGB36 datum to an accuracy of ±0.1m employing a Leica Viva Glonnass Smart Rover GS08 differential global positioning system (DGPS). Data were then converted to the National Grid Transformation OSTN02 and the instrument was regularly tested using stations with known ETRS89 coordinates. The grids were positioned on a NNW-SSE alignment (Figure 1).

### 6.5 Data Capture

Both instruments record readings on internal data loggers that were downloaded to a laptop at lunchtime and then also at the end of the day. The grid order was recorded on a BA pro-forma to aid in the creation of the data composites. Data were filed in job specific folders. These data composites were checked for quality on site by BA, allowing grids to be re-surveyed if necessary. Data were backed up onto an external storage device in the office and finally a remote server at the end of the day. The location of trees, hedges, garden furniture and paths (see Figure 1) did hinder the collection of data.

### 6.6 Data Presentation and Processing

Data are presented in both raw and processed data plots in greyscale format (Figures 3, 4, 7, 8). An XY trace plot of the processed data has also been included (Figures 5 and 9).

#### *6.6.1 Fluxgate Gradiometer*

The raw data is presented with no processing, and was clipped to produce a uniform greyscale plot. The processed data schedule is displayed below.

*Raw Data:*

**Data Clipping**: 1 standard deviation.
**Display Clipping**: 3 standard deviations.

*Processed Data:*
**De-spike**: X diameter = 3, Y diameter = 3, Threshold = 1, centre value=mean, replace with = mean;
**Data Clipping**: 1 standard deviation;
**Display Clipping**: 3 standard deviations.

An interpretation plan characterising the anomalies recorded can be found at Figure 6, it draws together the evidence collated both from the greyscale and XY trace plots (Figures 3, 4, and 5). All figures are tied into the National Grid and printed at an appropriate scale.

*6.6.2 Earth Resistance Meter*

The raw data is presented with no processing. The processed data schedule is displayed below.

*Raw Data:*
No processing.

*Processed Data:*
**Interpolate**: X and Y = doubled.

An interpretation plan characterising the anomalies recorded can be found at Figure 10, it draws together the evidence collated both from the greyscale and XY trace plots (Figures 7, 8, and 9). All figures are tied into the National Grid and printed at an appropriate scale.

### 6.7 Software

Raw data were downloaded using DW Consulting's Archeosurveyor v2.0 and will be stored in this format as raw data. The software used to process the data and produce the composites was also DW Consulting's Archeosurveyor v2.0. Datasets were exported into AutoCAD and placed onto the local survey grid. Interpretation plots were then produced using AutoCAD, a combined magnetometer and earth resistance meter interpretation plot can also be found at Figure 11.

### 6.8 Grid Restoration

Britannia Archaeology Ltd did not position any reference stations on the site due to its use as a formal garden. The grid can be relocated using the geo-referenced stations printed in Figure 2, this can also enable the accurate location of the geophysical anomalies.

## 7.0 RESULTS & DISCUSSION (FIGURES 3 – 11)

### 7.1 Fluxgate Gradiometer (Figures 3 – 6, 11)

The surveyors noted that the sites overall magnetic background was relatively high, however a suitable zero station was found with no particular difficulty and located on the southern terrace. Isolated dipolar ('iron spike') responses (yellow discs) were the most numerous anomaly recorded in the dataset and probably indicate the presence of modern cultural ferrous debris deposited within the topsoil, rather than buried archaeological artefacts. These responses seem to be fairly evenly spaced throughout the garden area with no apparent clustering.

Three linear areas of magnetic disturbance (yellow hatching) were recorded in the dataset. The first is located in the centre of the plot, running east-north-east to west-south-west over an existing gravel path. A second linear area also present in the centre of the survey, but on a perpendicular course (north-north-west to south-south-east) that demarcates the location of a second path extending to the northern boundary. The third area of magnetic disturbance (curvi-linear in plan) is caused by the bricks that comprise an existing low garden wall.

Two negative linear trends (both running north-north-west to south-south-east) were recorded during the magnetometer survey, the first is located near to and perpendicular with the western boundary wall. It is possible that this response is caused by a buried (possible stone) path or wall foundation or may relate to the construction of the existing boundary wall. The second negative linear trend runs from the northern boundary to the centre of the site and perpendicular with the eastern wall. Its northern terminal is located very close to the water source in the north-eastern corner of the garden. The negative readings are potentially caused by the presence of a stone culvert or pipe (Figure 1) for channelling the water underneath the surface. Its course is not recorded on the southern terrace and appears to deviate out of the site to the east. Both of these negative linear trends correlate well with two high resistance anomalies present on the earth resistance meter plots (Figure 10 and 11).

Six positive discrete anomalies have been recorded in the dataset, five of which are present on the southern terrace and are commonly interpreted as being of geological origin or archaeological rubbish pits. In this case the anomalies could be rubbish pits or material deposited to create a flat surface for the southern terrace. The discrete present on the northern terrace does have a slight degree of correlation with a small area of high resistance recorded with the RM85 (Figure 11). This discrete is present in the centre of the linear trend and therefore may be related to the culvert.

### 7.2 Earth Resistance Meter

The overall background resistance readings were found to be fairly high over the site and probably indicate the close proximity of the underlying bedrock to the surface.

Seven areas of low resistance (blue hatching) were recorded in the dataset, of these five are located on the periphery of the southern terrace, where the ground appears to have been raised and flowerbeds are present. The topsoil here is also believed to lie to a greater depth, with material removed and deposited from the southern terrace raising the area to provide a more level northern terrace. A low resistance anomaly running parallel to the eastern boundary on the northern terrace is present over the location of a modern flower bed. The remaining discrete area of low resistance in the north-western quadrant was recorded over the site of a modern fire-pit.

A large area of high resistance (red hatching) recorded to the south, is likely to relate directly to the construction of the southern terrace. The bedrock here would be near to the surface providing readings of high resistance, compared with the relatively low resistance readings witnessed on the topsoil rich northern terrace. An area of very high resistance (red-lined hatching) was also present in its north-western corner where the bedrock geology lay closest to the mobile probes.

A linear area of high resistance (red hatching) readings (running NNW-SSE) along the centre of the northern terrace demarcates the presence of an existing garden path. The small area of high resistance on the north-eastern corner of the southern terrace may relate to dumps of masonry material buried close to the boundary wall, or perhaps the roots of one of the trees present nearby.

One discrete area of high resistance (red hatching) on the eastern boundary of the northern terrace does show some correlation with a discrete positive anomaly recorded during the magnetometer survey, both of which may relate to the potential buried culvert.

Five high resistance linear trends (red lines) have been recorded during the earth resistance meter survey. A series of three interconnecting trends are located along the western boundary that appear to relate to the high western boundary wall and the low garden wall depicted in Figure 1. The trend that runs perpendicular to the western boundary is similarly located to a negative linear trend recorded by the magnetometer. It is likely that both are caused by the close proximity of the existing boundary wall, however they may also be evidence for an earlier boundary or a buried path.

Two discontinuous high resistance linear trends (red lines) have also been recorded parallel to the eastern boundary that correlate with a negative anomaly present within the magnetometer dataset. The high resistance readings suggest the presence of buried stone or similar, interpreted as a culvert channelling water from a source on the north-eastern boundary and exiting site midway along the eastern boundary.

## 8.0 CONCLUSION

The detailed fluxgate gradiometer and earth resistance surveys were successful in identifying a range of anomalies which help to describe the sites taphonomy. A good degree of correlation and occasional differences within the two datasets ultimately provide a complementary result.

It would be prudent to target the linear trends, recorded with both instruments that are present on the eastern and western boundary, to discover whether they are of archaeological origin or relate to existing garden features. The discrete anomalies recorded within the southern terrace could also be further investigated along with the area of high resistance to help qualify the interpretations given within this report.

## 9.0 PROJECT ARCHIVE AND DEPOSITION

A full archive will be prepared for all work undertaken in accordance with guidance from the *Selection, Retention and Dispersion of Archaeological Collections,* Archaeological Society for Museum Archaeologists, 1993. Arrangements will be made for the archive to be deposited with the Yorkshire Dales National Park Authority.

## 10.0 ACKNOWLEDGEMENTS

Britannia Archaeology Ltd would like to thank Chris Healey of Minerva Heritage Ltd for his help throughout and for Sedbergh School for funding the project.

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## APPENDIX 1 – METADATA SHEETS

### Magnetometer Data

### Raw Data

| | |
|---|---|
| Filename: | Sedbergh Mag Raw.xcp |
| **Description** | |
| Instrument Type | Grad 601-2 (Magnetometer) |
| Units | nT |
| Surveyed by | MB on 1/15/2014 |
| Assembled by | TPS on 1/15/2014 |
| Direction of 1st Traverse | 90 deg |
| Collection Method | ZigZag |
| Sensors | 2 @ 1.00 m spacing. |
| Dummy Value | 32702.00 |
| **Dimensions** | |
| Composite Size (readings) | 160 x 60 |
| Survey Size (meters) | 40.00m x 60.00 m |
| Grid Size | 20.00 m x 20.00 m |
| X Interval | 0.25 m |
| Y Interval | 1.00 m |
| **Stats** | |
| Max | 11.23 |
| Min | -21.32 |
| Std Dev | 8.11 |
| Mean | -4.49 |
| Median | -3.51 |
| Composite Area | 0.24 ha |
| Surveyed Area | 0.14 ha |
| **Program** | |
| Name | ArcheoSurveyor |
| Version | 2.5.16.0 |

| **Source Grids: 6** | | | |
|---|---|---|---|
| 1 | Col:0 | Row:0 | grids\01.xgd |
| 2 | Col:0 | Row:1 | grids\02.xgd |
| 3 | Col:0 | Row:2 | grids\03.xgd |
| 4 | Col:1 | Row:0 | grids\04.xgd |
| 5 | Col:1 | Row:1 | grids\05.xgd |
| 6 | Col:1 | Row:2 | grids\06.xgd |

**Processed Data**

| | |
|---|---|
| Filename | Sedbergh Mag Pro.xcp |
| **Description** | |
| Instrument Type | Grad 601-2 (Magnetometer) |
| Units | nT |
| Surveyed by | MB on 1/15/2014 |
| Assembled by | TPS on 1/15/2014 |
| Direction of 1st Traverse | 90 deg |
| Collection Method | ZigZag |
| Sensors | 2 @ 1.00 m spacing. |
| Dummy Value | 32702.00 |
| **Dimensions** | |
| Composite Size (readings) | 160 x 60 |
| Survey Size (meters) | 40.00m x 60.00 m |
| Grid Size | 20.00 m x 20.00 m |
| X Interval | 0.25 m |
| Y Interval | 1.00 m |
| **Stats** | |
| Max | 6.36 |
| Min | -17.19 |
| Std Dev | 6.30 |
| Mean | -4.51 |
| Median | -3.45 |
| Composite Area | 0.24 ha |
| Surveyed Area | 0.14 ha |
| **Program** | |
| Name | ArcheoSurveyor |
| Version | 2.5.16.0 |

| **Source Grids: 55** | | | |
|---|---|---|---|
| 1 | Col:0 | Row:0 | grids\01.xgd |
| 2 | Col:0 | Row:1 | grids\02.xgd |
| 3 | Col:0 | Row:2 | grids\03.xgd |
| 4 | Col:1 | Row:0 | grids\04.xgd |
| 5 | Col:1 | Row:1 | grids\05.xgd |
| 6 | Col:1 | Row:2 | grids\06.xgd |

## Earth Resistance Meter Data

### Raw Data

| | |
|---|---|
| Filename | Res Raw.xcp |
| **Description** | |
| Instrument Type | RM85 (Resistance) |
| Units | Ohm |
| Surveyed by | TPS/MB on 1/16/2014 |
| Assembled by | TPS on 1/20/2014 |
| Direction of 1st Traverse | 0 deg |
| Collection Method | ZigZag |
| Sensors | 1 |
| Dummy Value | 2047.50 |
| **Dimensions** | |
| Composite Size (readings) | 40 x 60 |
| Survey Size (meters) | 40.00m x 60.00 m |
| Grid Size | 20.00 m x 20.00 m |
| X Interval | 1.00 m |
| Y Interval | 1.00 m |
| **Stats** | |
| Max | 320.50 |
| Min | 54.50 |
| Std Dev | 71.71 |
| Mean | 149.19 |
| Median | 120.00 |
| Composite Area | 0.24 ha |
| Surveyed Area | 0.14 ha |
| **Program** | |
| Name | ArcheoSurveyor |
| Version | 2.5.16.0 |

| **Source Grids: 6** | | | |
|---|---|---|---|
| 1 | Col:0 | Row:0 | grids\05.xgd |
| 2 | Col:0 | Row:1 | grids\06.xgd |
| 3 | Col:0 | Row:2 | grids\04.xgd |
| 4 | Col:1 | Row:0 | grids\01.xgd |
| 5 | Col:1 | Row:1 | grids\02.xgd |
| 6 | Col:1 | Row:2 | grids\03.xgd |

**Processed Data**

| | |
|---|---|
| Filename | Res Pro.xcp |
| **Description** | |
| Instrument Type | RM85 (Resistance) |
| Units | Ohm |
| Surveyed by | TPS/MB on 1/16/2014 |
| Assembled by | TPS on 1/20/2014 |
| Direction of 1st Traverse | 0 deg |
| Collection Method | ZigZag |
| Sensors | 1 |
| Dummy Value | 2047.50 |
| **Dimensions** | |
| Composite Size (readings) | 40 x 60 |
| Survey Size (meters) | 40.00m x 60.00 m |
| Grid Size | 20.00 m x 20.00 m |
| X Interval | 1.00 m |
| Y Interval | 1.00 m |
| **Stats** | |
| Max | |
| Min | 42.80 |
| Std Dev | 71.21 |
| Mean | 149.78 |
| Median | 123.07 |
| Composite Area | 0.24 ha |
| Surveyed Area | 0.14 ha |
| **Program** | |
| Name | ArcheoSurveyor |
| Version | 2.5.16.0 |

| **Source Grids: 6** | | | |
|---|---|---|---|
| 1 | Col:0 | Row:0 | grids\05.xgd |
| 2 | Col:0 | Row:1 | grids\06.xgd |
| 3 | Col:0 | Row:2 | grids\04.xgd |
| 4 | Col:1 | Row:0 | grids\01.xgd |
| 5 | Col:1 | Row:1 | grids\02.xgd |
| 6 | Col:1 | Row:2 | grids\03.xgd |

## APPENDIX 2 – TECHNICAL DETAILS

### MAGNETOMETER

The magnetometer differs from the 'active' magnetic susceptibility meter by being a 'passive' instrument. Rather than injecting a signal into the ground it detects slight variations in the Earth's magnetic field caused by cultural and natural disturbance (Clark).

Thermoremanent magnetism is produced when a material containing iron oxides is strongly heated. Clay for example has a high iron oxide content that in a natural state is weakly magnetic, when heated these weakly magnetic compounds become highly magnetic oxides that a magnetometer can detect.

The demagnetisation of iron oxides occurs above a temperature known as the Curie point; for example haematite has a Curie point of 675 Celsius and magnetite 565C. At the time of cooling the iron oxides become permanently re-magnetised with their magnetic properties re-aligned in the direction of the Earth's magnetic field (Gaffney and Gater). The direction of the Earth's magnetic field shifts over time and these subtle alignment differences can be recorded. Kilns, hearths, baked clay and ovens can reach Curie point temperatures, and are the strongest responses apart from large iron objects that can be detected. Other cultural anomalies that can be prospected include occupation areas, pits, ditches, furnaces, sunken feature buildings, ridge and furrow field systems and ritual activity (David, 2011). Commonly recorded anomalies include modern ferrous service pipes, field drainage pipes, removed field boundaries, perimeter fences and field boundaries.

### Fluxgate Gradiometers

Fluxgate gradiometers are sensitive instruments that utilise two sensors placed in a vertical plane, spaced 1 metre apart. The sensor above reads the Earth's magnetic (background) response while the sensor below records the local magnetic field. Both sensors are carefully adjusted to read zero before survey commences at a 'zeroing' point, selected for its relatively 'quiet' magnetic background reading. When differences in the magnetic field strength occur between the two sensors a positive or negative reading is logged. Positive anomalies have a positive magnetic value and conversely negative anomalies have a negative magnetic value relative to the site's magnetic background. Examples of positive magnetic anomalies include hearths, kilns, baked clay, areas of burning, ferrous material, ditches, sunken feature buildings, furrows, ferrous service pipes, perimeter fences and field boundaries. Negative magnetic anomalies include earthwork embankments, plastic water pipes and geological features.

The instruments are usually held approximately 0.30m to 0.50m above the ground surface and can detect to a depth of between 1-2metres. Best practice dictates that the optimal direction of traverse in Britain is east to west.

**Magnetic Anomalies**

**Linear trends**
Linear trends can be both positive and negative magnetic responses. If they are broad, relatively weak or negative in nature they may be of agricultural or geological origin, for example periglacial channels, land drains or ploughing furrows. If the responses are strong positive trends they are more likely to be of archaeological origin. Archaeological settlement ditches tend to be rich in highly magnetic iron oxides that accumulate in them via anthropogenic activity and humic backfills. Conversely surviving banks will be negative in nature, the material is derived from subsoil deposits that is less likely to be positively magnetic. Curvilinear trends can also be recorded and are indicative of archaeological structures such as drip-gullies.

**Discrete anomalies**
Discrete anomalies appear as increased positive responses present within a localised area. They are caused by a general increase in the amount of magnetic iron oxides present within the humic back-fill of for example a rubbish pit.

**'Iron spike' anomalies**
These strong isolated dipolar responses are usually caused by ferrous material present in the topsoil horizon. They can have an archaeological origin but are usually introduced into the topsoil during manuring.

**Areas of magnetic disturbance**
An area of magnetic disturbance is usually associated with material that has been fired. For example areas of burning, demolition (brick) rubble or slag waste spreads. They can also be caused by ferrous material, e.g. close proximity to barbwire or metal fences and field boundaries, buried services, pylons and modern rubbish deposits.

**EARTH RESISTANCE METER**

The earth resistance meter is classified as an 'active' instrument, it utilises probes to pass a small electric current through the ground measuring the variance in soil resistance present within the soil matrix.

Soil resistance is measured using two pairs of electrodes; the current electrodes pass electricity into the ground that is measured by the potential electrodes. Precipitation allows the current to pass through the ground by reacting with soil minerals forming electrolytes, which in turn break down and become positive and negative ions. When the electric current is switched on the ions either repel or attract the current, driving it at varying depths through the soil matrix on its journey to find the path of least resistance.

Archaeological features have varying soil moisture capacity. A buried wall for example has low soil moisture content due to the density of the material it is constructed with, the current will not pass easily through this type of feature causing a reduction in the current density as the flow finds an alternative route. This increases the potential gradient that is measured by the instrument and a high resistance anomaly is recorded. Conversely a soil backfilled pit or ditch will have a relatively higher moisture holding capacity than that of the surrounding natural geology. The electrical current can pass with ease through this medium causing an increase in the current density and a corresponding decrease to the potential gradient, the instrument will then record a low resistance anomaly within the dataset.

**Earth Resistance Meters**

Modern earth resistance meters employ four probes/electrodes in two distinct sets. Each set has one current and one potential electrode. The first set are the remote probes and as their name suggests are placed outside the survey area and remain static throughout the survey. They act as the control that the remote probe readings are measured against. The second set are the mobile probes and are mounted on a frame set 0.5m apart. These probes are pushed into the ground causing an electrical circuit to form between the current electrodes of the remote and mobile probes; the potential gradient between the remote and mobile probes is then recorded automatically by the instrument. Every time the mobile probes are removed the instrument resets itself ready to take the next reading.

## APPENDIX 3 – OASIS FORM

### OASIS ID: britanni1-169448

| | |
|---|---|
| **Project details** | |
| **Project name** | Land at Brackensghyll, Back Lane, Sedbergh, Yorkshire Dales National Park |
| **Short description of the project** | Detailed fluxgate gradiometer and earth resistance surveys were successful in identifying a range of anomalies which help to describe the sites taphonomy. A good degree of correlation and occasional differences between the two datasets ultimately provide a complementary result. The magnetometer survey revealed a plethora of isolated dipolar responses, three areas of magnetic disturbance caused by a low garden wall and two existing perpendicular pathways. Six discrete anomalies, one of which was present over the centre of a negative linear trend and near to a high resistance anomaly recorded by the RM85 on the eastern boundary. Two negative linear trends that lie parallel to the existing eastern and western boundary walls correlate well with high resistance trends recorded by the earth resistance meter. The eastern trend has been interpreted as a culvert, and the western trend as the existing boundary wall foundation, or an earlier wall or pathway. Areas of low resistance were recorded on the sites periphery, where the ground appears to have been raised and flowerbeds are present. An area of high and very high resistance is present where material has been removed to construct the two terraces. High resistance linear trends, some of which correlate with negative linear trends recorded by the magnetometer, are believed to be the remains of a culvert close to the eastern boundary, and an existing boundary wall foundation, or an earlier wall or pathway to the west. |
| **Project dates** | **Start:** 15-01-2014 **End:** 16-01-2014 |
| **Previous/future work** | Yes / Yes |
| **Any associated project reference codes** | P1050 - Contracting Unit No.<br>BSS 014 - Sitecode |
| **Type of project** | Field evaluation |
| **Site status** | National Park |
| **Current Land use** | Other 5 - Garden |
| **Monument type** | NONE None |
| **Significant Finds** | NONE None |
| **Methods & techniques** | '"Geophysical Survey"' |
| **Development type** | Small-scale (e.g. single house, etc.) |
| **Prompt** | National Planning Policy Framework – NPPF |
| **Position in the planning process** | After full determination (eg. As a condition) |
| **Solid geology (other)** | Bannisdale Formation, Siltstone and Mudstone |
| **Drift geology (other)** | Devensian Diamicton Till |
| **Techniques** | Magnetometry |
| **Techniques** | Resistivity – area |
| **Project location** | |
| **Country** | England |
| **Site location** | CUMBRIA SOUTH LAKELAND SEDBERGH Land at Brackensghyll, Back Lane, Sedbergh, Yorkshire Dales National Park |
| **Study area** | 0.25 Hectares |
| **Site coordinates** | SD 658 921 54.3231785307 -2.52587710743 54 19 23 N 002 31 33 W Point |
| **Height OD /Depth** | **Min:** 130.00m **Max:** 130.00m |
| **Project creators** | |
| **Name of Organisation** | Britannia Archaeology Ltd |

| | |
|---|---|
| **Project brief originator** | City/Nat. Park/District/Borough archaeologist |
| **Project design originator** | Timothy Schofield |
| **Project director/manager** | Timothy Schofield |
| **Project supervisor** | Martin Brook |
| **Type of sponsor/funding Body** | Landowner |
| **Name of sponsor/funding body** | Sedbergh School |

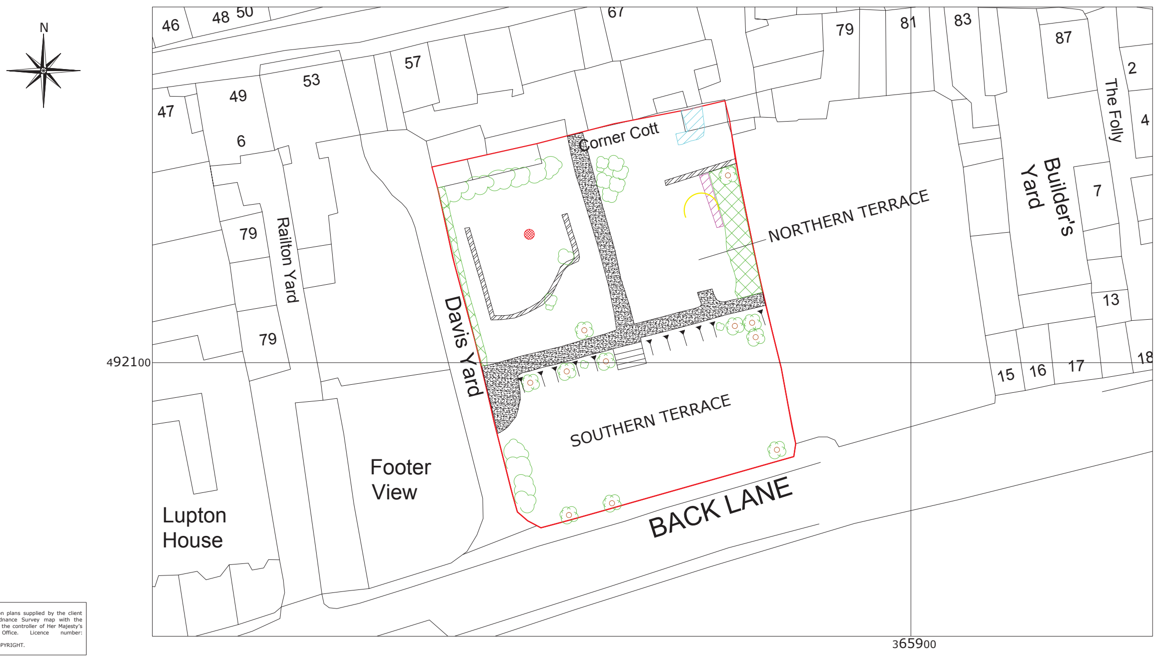
**Project archives**

| | |
|---|---|
| **Physical Archive Exists?** | No |
| **Digital Archive recipient** | Yorkshire Dales Historic Environment Record |
| **Digital Contents** | "Survey" |
| **Digital Media available** | "Database", "Geophysics", "Images raster / digital photography", "Images vector", "Survey", "Text" |
| **Paper Archive recipient** | Yorkshire Dales Historic Environment Record |
| **Paper Contents** | "Survey" |
| **Paper Media available** | "Drawing", "Map", "Photograph", "Plan", "Report", "Survey ", "Unpublished Text" |

**Project bibliography 1**

| | |
|---|---|
| **Publication type** | Grey literature (unpublished document/manuscript) |
| **Title** | Land at Brackensghyll, Back Lane, Sedbergh, Yorkshire Dales National Park |
| **Author(s)/Editor(s)** | Schofield, T.P. |
| **Other bibliographic details** | R1046 |
| **Date** | 2014 |
| **Issuer or publisher** | Britannia Archaeology Ltd |
| **Place of issue or publication** | Stowmarket, Suffolk |
| **Description** | A4 Bound Report with A3 fold-out Figures |
| **URL** | www.britannia-archaeology.com |
| **Entered by** | Tim Schofield (tim@britannia-archaeology.com) |
| **Entered on** | 25 April 2014 |








| Key |
|---|
| Area of Modern Burning |
| Water |
| Possible Concrete Culvert? |
| Temporary Structure |
| Walls |
| Steps |
| Bank |
| Paths |
| Bushes |
| Flower Beds |
| Trees |
| Site Boundary |

NGR: 365861 492111

REPORT NUMBER: 1046

PROJECT: LAND AT BRACKENSGHYLL, BACK LANE, SEDBERGH, YORKSHIRE DALES NATIONAL PARK

CLIENT: minerva heritage

DESCRIPTION: SITE LOCATION & TOPOGRAPHIC FEATURES PLAN

BRITANNIA ARCHAEOLOGY LTD
115 OSPREY DRIVE, STOWMARKET, SUFFOLK
IP14 5UX
T: 01449 763034
E: info@britannia-archaeology.com
W: www.britannia-archaeology.com

| SCALE: | | |
|---|---|---|
| 1:500 | 0 – 20m | |
| PLOT: A3 | APPROVED: MCA | VERSION: 01 |
| DATE: JAN 2014 | AUTHOR: TPS | FIGURE: 01 |


| STATION | EASTING | NORTHING |
|---|---|---|
| 01 | 365860.940 | 492110.928 |
| 02 | 365865.753 | 492091.516 |

Earth Resistance Meter Survey Grids

Magnetometer Survey Grids

Site Boundary

NGR: 365861 492111

REPORT NUMBER: 1046

PROJECT:
LAND AT BRACKENSGHYLL, BACK LANE, SEDBERGH, YORKSHIRE DALES NATIONAL PARK

CLIENT: minerva heritage

DESCRIPTION:
SURVEY GRIDS & GEOREFERENCING INFORMATION PLOT


BRITANNIA ARCHAEOLOGY LTD

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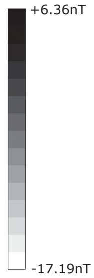
W: www.britannia-archaeology.com


SCALE: 1:500 (0 – 20m)

| PLOT: | APPROVED: | VERSION: |
|---|---|---|
| A3 | MCA | 01 |
| DATE: JAN 2014 | AUTHOR: TPS | FIGURE: 02 |


N




Site Boundary

NGR: 365861 492111

REPORT NUMBER: 1046

PROJECT: LAND AT BRACKENSGHYLL, BACK LANE, SEDBERGH, YORKSHIRE DALES NATIONAL PARK

CLIENT: minerva heritage

DESCRIPTION: RAW MAGNETOMETER GREYSCALE PLOT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| SCALE: 1:500 | 0 — 20m | |
|---|---|---|
| PLOT: A3 | APPROVED: MCA | VERSION: 01 |
| DATE: JAN 2014 | AUTHOR: TPS | FIGURE: 03 |


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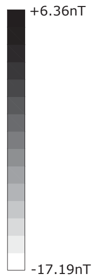


Site Boundary

NGR: 365861 492111

REPORT NUMBER: 1046

PROJECT: LAND AT BRACKENSGHYLL, BACK LANE, SEDBERGH, YORKSHIRE DALES NATIONAL PARK

CLIENT: minerva heritage

DESCRIPTION: PROCESSED MAGNETOMETER GREYSCALE PLOT


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SCALE: 1:500 (0 – 20m)

| PLOT: | APPROVED: | VERSION: |
|---|---|---|
| A3 | MCA | 01 |
| DATE: | AUTHOR: | FIGURE: |
| JAN 2014 | TPS | 04 |


| | |
|---|---|
| 45 nT/cm | Scale Interval |
| | Site Boundary |

NGR: 365861 492111

REPORT NUMBER: 1046

PROJECT:
LAND AT BRACKENSGHYLL,
BACK LANE, SEDBERGH,
YORKSHIRE DALES NATIONAL PARK

CLIENT: minerva heritage

DESCRIPTION:
PROCESSED MAGNETOMETER
XY TRACE PLOT

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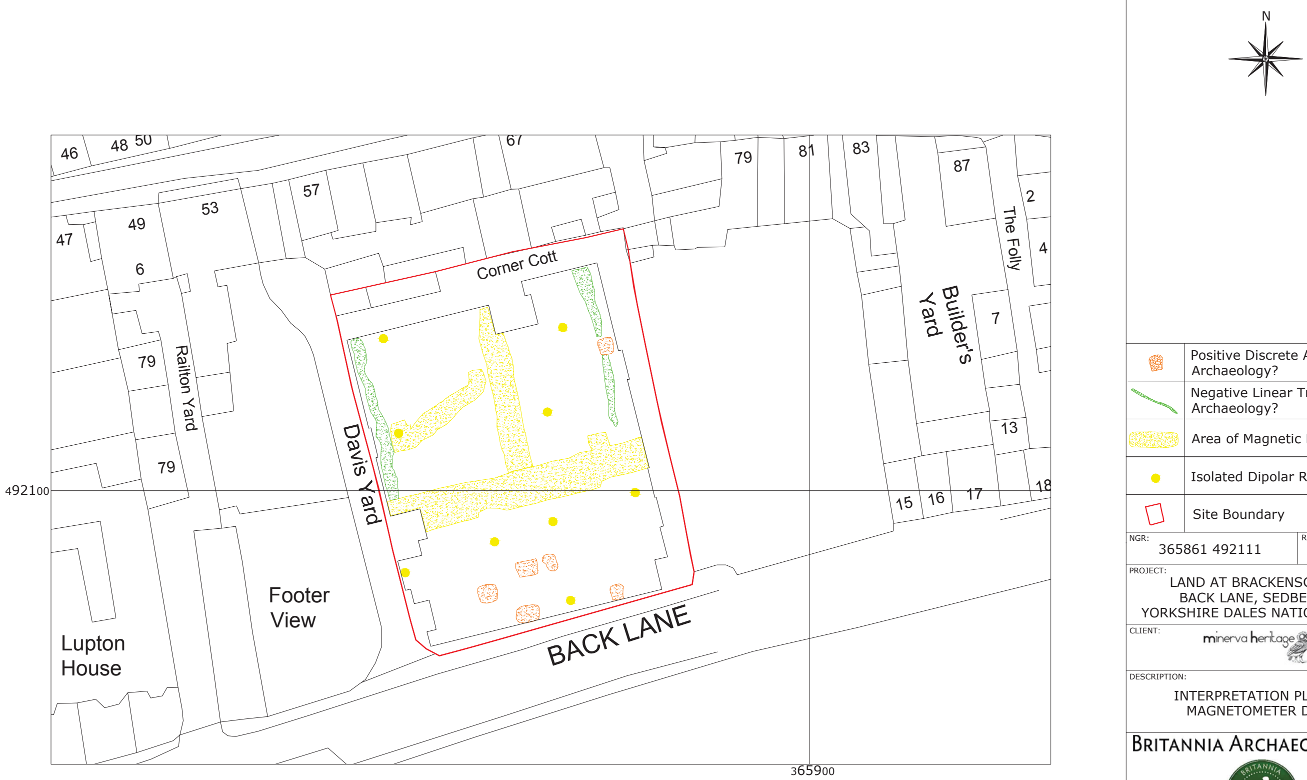
SCALE: 1:500 (0 – 20m)

| PLOT: | APPROVED: | VERSION: |
|---|---|---|
| A3 | MCA | 01 |
| DATE: | AUTHOR: | FIGURE: |
| JAN 2014 | TPS | 05 |




| Key | |
|---|---|
| | Positive Discrete Anomaly, Archaeology? |
| | Negative Linear Trend, Archaeology? |
| | Area of Magnetic Disturbance |
| | Isolated Dipolar Responses |
| | Site Boundary |

NGR: 365861 492111

REPORT NUMBER: 1046

PROJECT: LAND AT BRACKENSGHYLL, BACK LANE, SEDBERGH, YORKSHIRE DALES NATIONAL PARK

CLIENT: minerva heritage

DESCRIPTION: INTERPRETATION PLOT OF MAGNETOMETER DATA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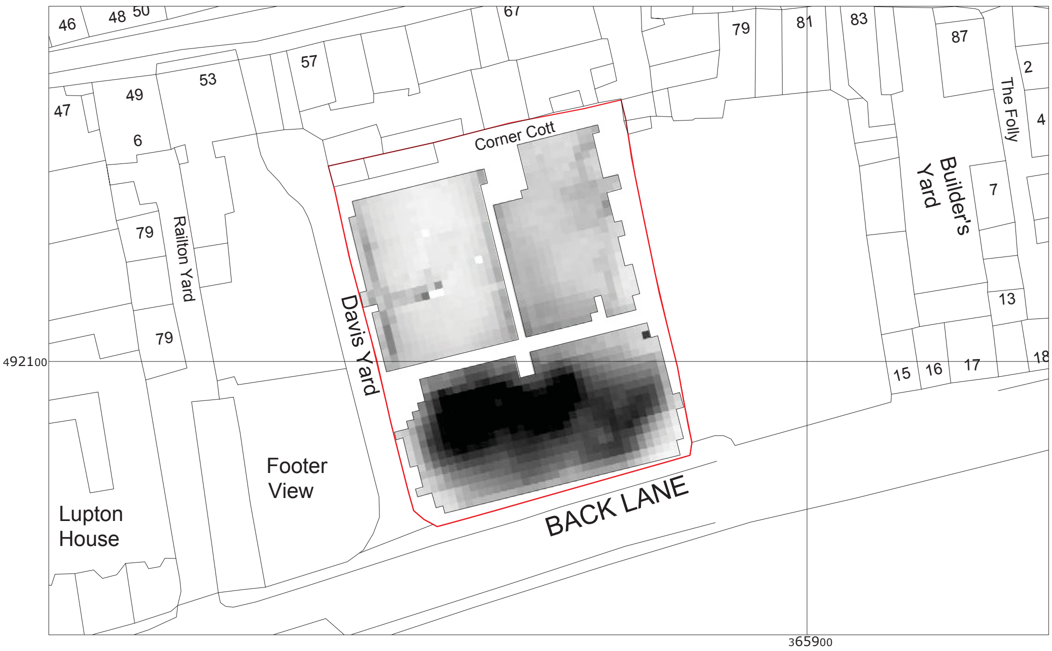
SCALE: 1:500 (0 – 20m)

PLOT: A3 | APPROVED: MCA | VERSION: 01

DATE: JAN 2014 | AUTHOR: TPS | FIGURE: 06




N

+320.50 Ω

+54.5 Ω

Site Boundary

| NGR: 365861 492111 | REPORT NUMBER: 1046 |
|---|---|

PROJECT:
LAND AT BRACKENSGHYLL,
BACK LANE, SEDBERGH,
YORKSHIRE DALES NATIONAL PARK

CLIENT: minerva heritage

DESCRIPTION:
RAW EARTH RESISTANCE METER
GREYSCALE PLOT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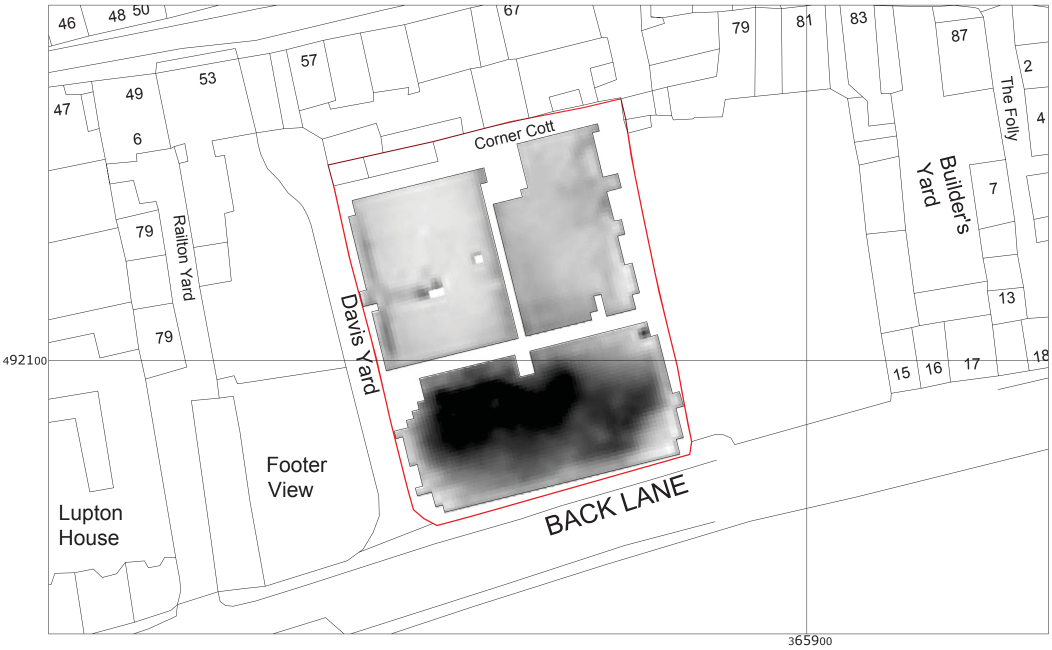
W: www.britannia-archaeology.com


SCALE: 1:500   0 — 20m

| PLOT: A3 | APPROVED: MCA | VERSION: 01 |
|---|---|---|
| DATE: JAN 2014 | AUTHOR: TPS | FIGURE: 07 |

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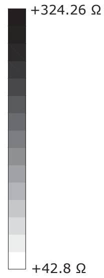


Site Boundary

| NGR: | REPORT NUMBER: |
|---|---|
| 365861 492111 | 1046 |

PROJECT:
LAND AT BRACKENSGHYLL,
BACK LANE, SEDBERGH,
YORKSHIRE DALES NATIONAL PARK

CLIENT: minerva heritage

DESCRIPTION:
PROCESSED EARTH RESISTANCE
METER GREYSCALE PLOT

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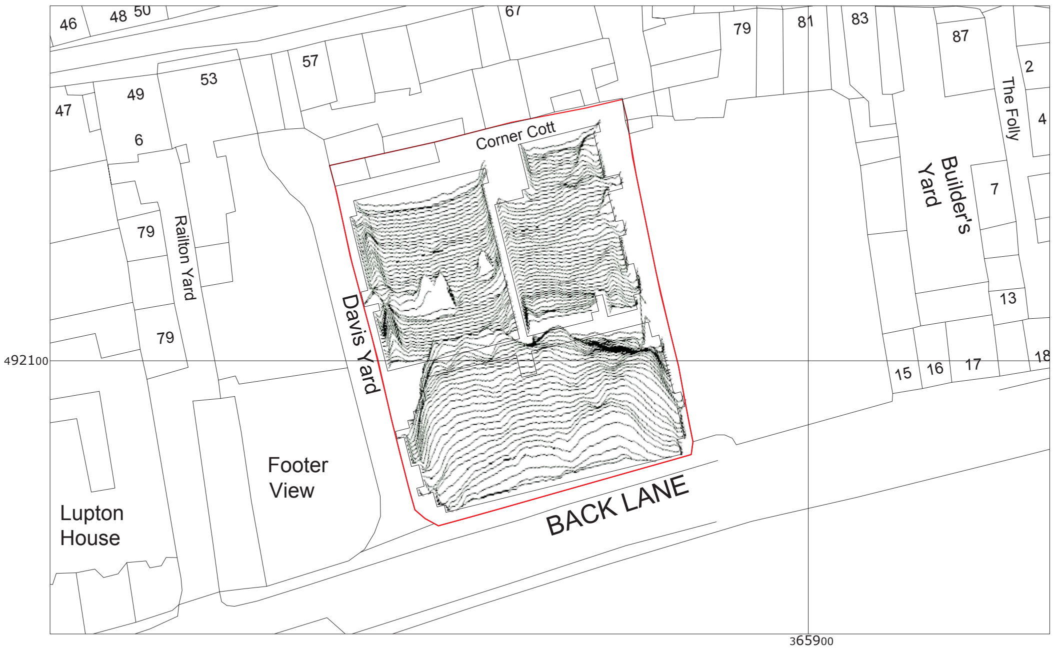
SCALE: 1:500 (0 – 20m)

| PLOT: | APPROVED: | VERSION: |
|---|---|---|
| A3 | MCA | 01 |
| DATE: | AUTHOR: | FIGURE: |
| JAN 2014 | TPS | 08 |




| | |
|---|---|
| 94 Ω/cm | Scale Interval |
| | Site Boundary |

NGR: 365861 492111

REPORT NUMBER: 1046

PROJECT: LAND AT BRACKENSGHYLL, BACK LANE, SEDBERGH, YORKSHIRE DALES NATIONAL PARK

CLIENT: minerva heritage

DESCRIPTION: PROCESSED EARTH RESISTANCE METER XY TRACE PLOT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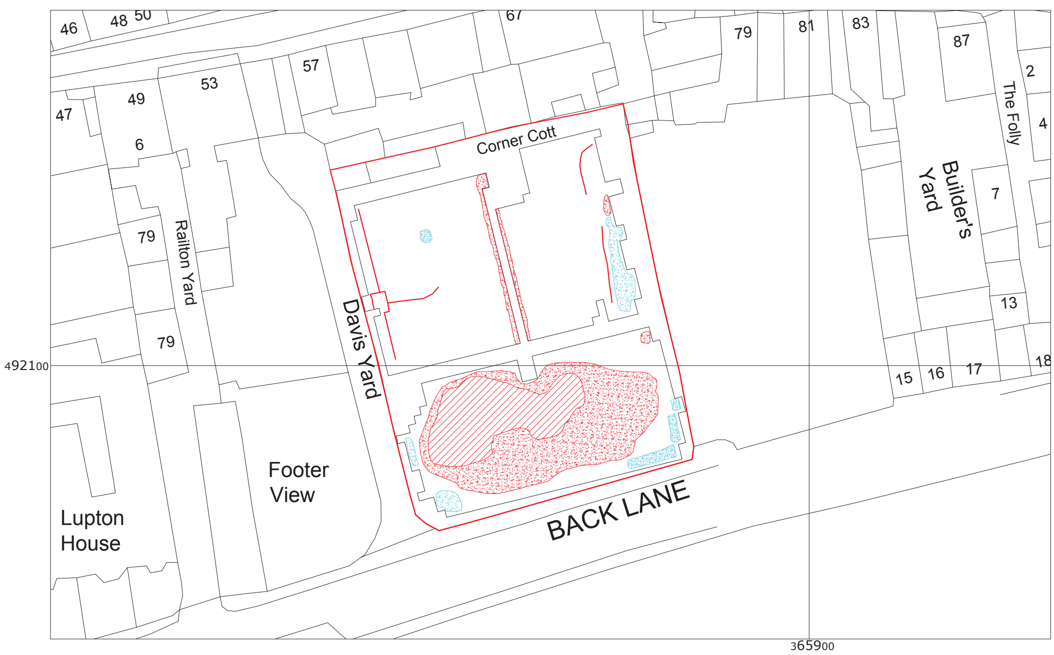
W: www.britannia-archaeology.com


SCALE: 1:500 (0 – 20m)

| PLOT: | APPROVED: | VERSION: |
|---|---|---|
| A3 | MCA | 01 |
| DATE: | AUTHOR: | FIGURE: |
| JAN 2014 | TPS | 09 |




| | |
|---|---|
| | High Resistance Trend, Archaeology? |
| | Area of Very High Resistance |
| | Area of High Resistance |
| | Area of Low Resistance |
| | Site Boundary |

NGR: 365861 492111

REPORT NUMBER: 1046

PROJECT: LAND AT BRACKENSGHYLL, BACK LANE, SEDBERGH, YORKSHIRE DALES NATIONAL PARK

CLIENT: minerva heritage

DESCRIPTION: INTERPRETATION PLOT OF EARTH RESISTANCE METER DATA

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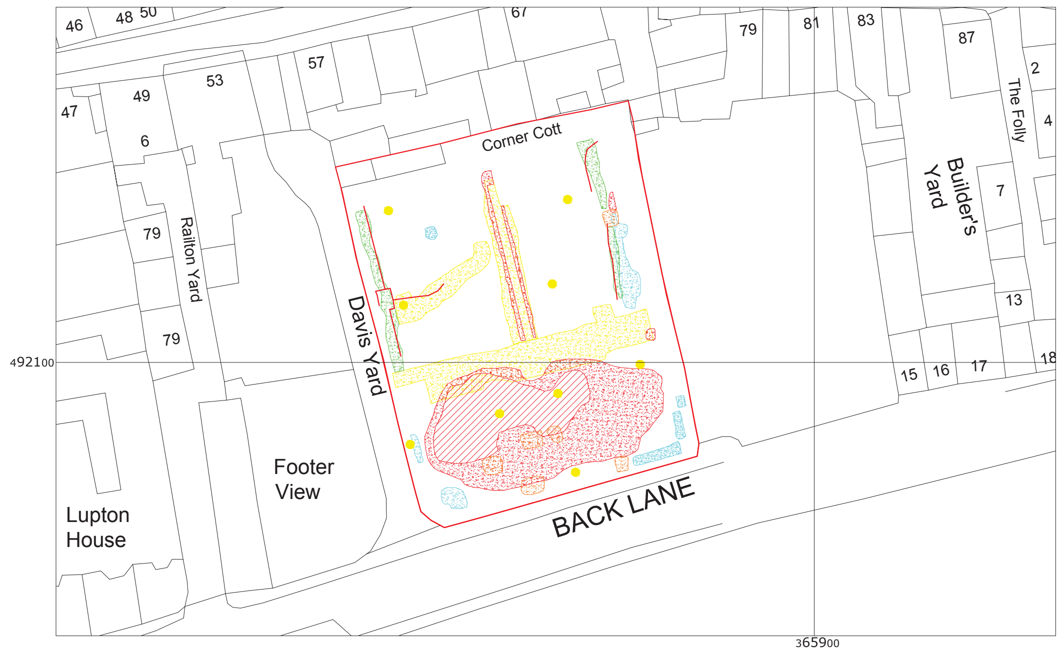
SCALE: 1:500 (0 – 20m)

| PLOT: | APPROVED: | VERSION: |
|---|---|---|
| A3 | MCA | 01 |
| DATE: | AUTHOR: | FIGURE: |
| JAN 2014 | TPS | 10 |




N

| Legend |
| --- |
| Positive Discrete Anomaly, Archaeology? |
| Negative Linear Trend, Archaeology? |
| Area of Magnetic Disturbance |
| Isolated Dipolar Responses |
| High Resistance Trend, Archaeology? |
| Area of Very High Resistance |
| Area of High Resistance |
| Area of Low Resistance |
| Site Boundary |

| NGR: 365861 492111 | REPORT NUMBER: 1046 |
| --- | --- |

PROJECT:
LAND AT BRACKENSGHYLL, BACK LANE, SEDBERGH, YORKSHIRE DALES NATIONAL PARK

CLIENT: minerva heritage

DESCRIPTION:
COMBINED INTERPRETATION PLOT OF MAGNETOMETER & EARTH RESISTANCE METER DATA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W: www.britannia-archaeology.com


SCALE: 1:500 (0 – 20m)

| PLOT: A3 | APPROVED: MCA | VERSION: 01 |
| --- | --- | --- |
| DATE: JAN 2014 | AUTHOR: TPS | FIGURE: 11 |