Land Adjacent to Busk Lane, Sedbergh, Cumbria

Geophysical Survey Report

Client: MINERVA HERITAGE LTD

AB Heritage Project No:10741

Date:02/02/2016

Land Adjacent to Buck Lane, Sedbergh, Cumbria

Geophysical Survey Report

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1. NON TECHNICAL SUMMARY

1.1.1 AB Heritage Limited (herein AB Heritage) were commissioned to undertake a programme of geophysical survey over c. 0.5 ha of land adjacent to Busk Lane, Sedbergh, Cumbria, LA10 5DZ. The survey took place between Wednesday the 20th and Thursday the 21st of January 2016.

1.1.2 Detailed magnetometry and resistivity surveys concluded that there is a low potential for the survival of significant archaeological remains within the surveyed area.

2. INTRODUCTION

2.1 Project Background

2.1.1 AB Heritage were commissioned to undertake a programme of geophysical survey on behalf of Minerva Heritage Ltd, covering the proposed development on land adjacent to Busk Lane, Sedbergh, Cumbria, LA10 5RZ (Figure 1).

2.1.2 The purpose of this work is to identify any potential surviving archaeological remains.

2.2 Site Location & Description

2.2.1 Centred on the approximate National Grid Reference (NGR) SD 65530 91717, the proposed development site is situated 0.4km south-west of Sedbergh. Busk Lane runs along the northern boundary of the proposed development site and a track leading to a sports clubhouse forms the western boundary. There is a small wooded area to the east and playing fields to the south and further west.

2.2.2 The proposed development site comprises a sub square field covering c. 0.5 hectares and was under pasture at time of the survey. At the time of the survey a scatter of stones run across the surface of the site likely to relate to a geological outcrop.

2.3 Geology & Topography

2.3.1 The underlying solid geology comprises interbedded siltstone and mudstone of the Bannisdale Formation. A superficial deposit of Diamicton Devensian Till is recorded in the location of the proposed development site (British Geological Survey (BGS), 2016).

2.3.2 The overlying soils are freely draining slightly acidic loamy soils, with a loamy texture (Cranfield Soil and Agrifood Industry 2016).

2.3.3 These geologies and soils are not likely to have an effect on the results of the geophysical survey, with the response expected to be good to average (English Heritage, 2008).

2.3.4 The topography rises up from c. 120m Above Ordnance Datum (AOD) in the east and there is a decrease to c. 112m AOD in the south west.

3. AIMS & METHODOLOGY

3.1 Aims of Works

3.1.1 Geophysical survey is a programme of non-intrusive archaeological work. The aims of this geophysical survey were to:

- Identify any geophysical anomalies of possible archaeological origin within the specified survey area;
- Accurately locate these anomalies and present the findings in map form; and
- Provide recommendations for any further archaeological work(s) necessary to contribute to the mitigation of the impacts of proposed development on these potential features.

3.2 Methodology of Survey Works Summary

Site Specific Information

3.2.1 A geophysical survey was undertaken covering an area of c. 0.5 hectares (ha) on 20th to the 21st of January 2016. The survey was undertaken using two geophysical techniques in the form of magnetometry and Resistivity.

3.2.2 The AB Heritage staff members who undertook the works were Tom Cloherty (Archaeological Technician) and Peter Bonvoisin (Archaeological Technician).

3.2.3 The weather conditions were mild and dry throughout the survey; these conditions had no material impact upon the survey.

Equipment

Magnetometry

3.2.4 The magnetic survey equipment used was one Bartington Grad-601 (fluxgate magnetometer).Please see Appendix A, which contains a detailed methodology for the works undertaken; however, briefly, Table 1, below, shows site specific information on how the magnetometer was set up:

Table 1: Setting Parameters of Magnetometer

Grid Size	30x30 metres
Data Capture Distances	1m x 0.25m
Sensors	2
Sensitivity	0.1nT

Resistivity

3.2.5 The resistance equipment used was an RM15 manufactured by Geoscan Research incorporating a multiplexer with a four probe array. The four probes are separated by 0.5 m and the associated remote probes will be positioned approximately 20 m outside the grid. The instrument uses an automatic data logger which permits the data to be recorded as the

survey progresses for later downloading to a computer for processing and presentation. Though the values being logged are actually resistances in ohms they are directly proportional to resistivity (ohm-metres) as the same probe configuration was used throughout.

3.2.6 The resistivity has a depth penetration of 0.5 m to 1 m. Table 2 below, shows briefly the site specific information on how the resistivity meter was set up:

Table 2: Setting Parameters of the Resistivity (RM15)

Grid Size	30 x 30 metres
Data Capture Distances	1m x 1m
Probes	4 spaced 0.5m apart
Current	1 MA
Frequency	137 HZ
High Pass Filter	13 HZ
Main Frequency	50HZ
Output Voltage	40V
Baud Rate	9600

GPS

3.2.7 A Trimble Geo XR GPS was used to setup the geophysical survey. This has sub-centimetre accuracy suitable for this survey.

3.3 Known Constraints

3.3.1 There are no known constraints within the site area however the road to the north and the track to the west may cause magnetic disturbance in the data within a 2-5m range.

4. RESULTS

4.1.1 For the purposes of this detailed magnetic survey, results for the geophysics data have been shown within Figure 2, 3 & 5 with interpretations shown in Figures 4 & 6.

4.1.2 Below is a factual account of the results.

4.2 Magnetometry Survey Results

*Weak Positive linear features **GP1***

4.2.1 Two weak positive linear features are present to the south of the surveyed area [**GP1**] which extends to a distance c. 28m [**GP1a**] and c. 25m [**GP1b**] respectively. Both weak positive linears features are orientated south west to north east and have readings of between -1 nanoteslas (nT) to 5 nT.

*Low Positive Feature **GP2***

4.2.2 A low positive circular feature [**GP2**], of 1-5nT, is located in the centre of the surveyed area and has a diameter of c. 7m.

*Magnetic Disturbance **GP3***

4.2.3 A buffer zone [**GP3**] of magnetic disturbance with a width of up to 7m from the north and western boundary the readings are between -5nT to 100nT.

*Di-polar Anomalies **GP4***

4.2.4 A small number of di-polar anomalies [**GP4**] have been identified within the surveyed area in an amorphous pattern.

4.3 Resistivity Survey Results

4.3.1 There is a large area measuring c. 400m^2 of high resistivity between c. 900ohms to c. 1100ohms to the north of the site.

5. INTERPRETATIONS & DISCUSSION

5.1.1 Interpretation of the results of geophysical survey is based on professional judgement as to the likely/probable cause of an anomaly or reading. For example, strong dipolar discrete anomalies of small size are often associated with ferrous debris or similarly magnetic debris. In addition, where a positive linear anomaly is recorded, which has a negative anomaly associated alongside either side of it, is often likely to relate to the line of a modern service.

5.1.2 GP numbers have been used to place interpretations into categories. Below is a discussion of the results, there has also been applied a confidence rating to the features identified (See Appendix 1). As with Historic England 2008 guidelines for geophysical survey for archaeological field evaluation, this is an acceptable additional option only on the clear understanding that such ratings are subjective and potentially fallible assessments which can only really be tested through excavation.

Table 3: Interpretation of Magnetometry Anomalies

AB No	Appearance	Potential Cause
GP 1	Weak Positive Linear Feature	Geological origin or ground disturbance
GP 2	Low Positive Area	Geological feature or ground disturbance
GP 3	Magnetic Disturbance	Disturbed ground or nearby metallic objects
GP 4	Di-polar Anomalies	Amorphous magnetic debris

5.2 Magnetometry Interpretations and Discussion

5.2.1 There is a medium confidence that features [**GP1**] identified in the south of the surveyed area are most likely related to geological variations of the site or ground disturbance.

5.2.2 A low positive circular feature [**GP2**] identified in the centre of the site has a medium confidence that it is likely to relate to ground disturbance.

5.2.3 Also a di-polar anomaly [**GP4**] found c. 5m to the north east of [**GP2**] is of note due to its size, there is a medium confidence this is likely due to metallic debris.

5.2.4 Overall the geophysical survey has shown the site to be fairly disturbed [**GP3**] most likely due to roads and tracks surrounding the site.

5.3 Resistivity Survey Interpretations and Discussion

5.3.1 An area of high resistivity to the north of the survey area has a high confidence to be related to a geological outcropping close to the surface, the cause of the close vicinity of the outcrop is unknown.

6. CONCLUSION

6.1.1 AB Heritage undertook a programme of geophysical survey including magnetometry and resistivity over c. 0.5 ha of land adjacent to Busk Lane, Sedbergh, Cumbria, LA10 5DZ on Wednesday the 20th and Thursday the 21st of January 2016, ahead of a proposed development.

6.1.2 The purpose of this work was to understand the potential for any archaeological remains to survive within the site, and, where possible, identify the form, function and extent of any potential remains.

6.1.3 Based on this geophysical survey it is likely that there is a low potential for the recovery of significant archaeological remains, with the majority of features likely to relate to geological variation and ground disturbance.

7. ARCHIVE

7.1.1 The Site Archive will contain the following, as a minimum:

Table 3: Site Archive Data

Archive	Format
Raw Geophysical Data files	XYZ and Text
Processed geophysical data files	JPEG, BMAP
Archaeological Interpretation	Shape Files ARC GIS
Final Report	PDF
Final Images	PDF

7.1.2 A physical and digital archive will be stored in a suitable format at AB Heritage Limited offices in Taunton, Somerset.

8. REFERENCES

BGS (British Geological Society) 2016.*Geology of Britain viewer.* http://mapapps.bgs.ac.uk/geologyofbritain/home.html.

CIFA, 2014.Standard and Guidance for archaeological geophysical survey.

Cranfield Soil and Agrifood Industry, 2016.*Soilscapes viewer*, http://www.landis.org.uk/soilscapes/

Grid Reference Finder 2016 http://www.gridreferencefinder.com/

Jones, D.M. (ED) 2008.Geophysical Survey in Archaeological Field Evaluation, English Heritage.

Schmidt, A. 2002.Geophysical Data in Archaeology: a Guide to Good Practice. Oxford. Oxbow.

APPENDIX 1 TECHNICAL INFORMATION ON GEOPHYSICAL SURVEY

FLUXAGTE MAGNETOMETRY SURVEY

The magnetic survey is carried out using a fluxgate gradiometer, which is a passive instrument consisting of two sensors mounted vertically 1m apart. The instrument is carried about 30cm above the ground surface and the top sensor measures the Earth's magnetic field, whilst the lower sensor measures the same field but is also more affected by any localised buried field. The difference between the two sensors will relate to the strength of a magnetic field created by a buried feature, if no field is present the difference will be close to zero as the magnetic field measured by both sensors will be the same.

Factors affecting the magnetic survey may include soil type, local geology, previous human activity, disturbance from modern services etc.

Survey equipment

The Bartington Grad 601-2 dual magnetic gradiometer is capable of surveying to an accuracy of 0.1 nanotesla (nT).

Sample interval and depth of scan

The magnetometer data is collected in 30mx30m grids at a resolution of 1m x 0.25m. This sample density is recommended for site evaluation (English Heritage, 2008). This equates to 3600 points per 30mx30m grid. The magnetometer has a typical depth of penetration of 0.5m to 1.0m. This would be increased if strongly magnetic objects are buried within the site.

Data capture

The readings are logged continually by the data logger during the survey, which is then downloaded on site to a site laptop. At the end of each job, data is transferred to the office PC's for processing and presentation.

This 'regular xy' data is then downloaded into specialist data processing software, at user defined sample intervals (in this case 1 m by 0.25 m). This is processed as standard magnetometer data.

Processing

Standard Magnetometer data processing consists of:

Zero mean Traverse- This process sets the background mean of each traverse within each grid to zero, the operation allows for the removal of striping effects.

Destagger- The collection of geophysical data can lead to errors with time due to a slight variation in speed of traverses or time lag within the collection of data. The process corrects the erros of stagger within the data.

Non-Standard Magnetometer processing:

Interpolation- The results of greyscale geophysical data can sometimes appear blocky in nature. Interpolation is a process which calculates and inserts values between existing data to give a smoother grey scale image.

Cliping – The clipping process will clip extreme values from the data set and increase the contrast in the data values closer to the mean. As most data within a data set is concentrated around the mean clipping can produce a better visualisation of standard data sets, particularly very weak signals that tend to be lost in a myriad of grey shades.

Some degree of heading error is inevitable when using a fluxgate gradiometer with such an acute sensitivity to the direction of travel in bi directional manner i.e. zigzag traverses. The error displays as a series of alternating lighter and darker stripes in the traverse direction and the function asses and corrects the mean for each line of data to bring them in to the same mean range and remove any visible artefacts.

Display of data

Greyscale-This is display takes a range of reading and divides into a set number of classes. Each class is represented by a specific shade of grey and the higher the positive reading the darker the grey.

Colour- Colour can be applied to Greyscale plots to show high and low data collection points in a more direct way.

XY Trace Plot- Data is represented by a line, which is incremented along the Y axis. This produces a stepped effect, thus the data can be viewed to show a possible shaping of a feature. Typically features are clipped to limit odd readings.

Assigned ranges can be adjusted to give the best display of the data.

Some degree of heading error is inevitable when using a fluxgate gradiometer with such an acute sensitivity to the direction of travel in bi directional manner i.e. zigzag traverses. The error displays as a series of alternating lighter and darker stripes in the traverse direction and the function asses and corrects the mean for each line of data to bring them in to the same mean range and remove any visible artefacts.

RESISITIVITY METHODOLOGY

The resistance meter is an RM15 manufactured by Geoscan Research incorporating a mobile Twin Probe Array. The Twin Probes are separated by 0.5m and the associated remote probes will be positioned approximately 20m outside the grid. The instrument uses an automatic data logger which permits the data to be recorded as the survey progresses for later downloading to a computer for processing and presentation. Though the values being logged are actually resistances in ohms they are directly proportional to resistivity (ohm -metres) as the same probe configuration was used through-out.

The Resistivity data is collected in a 30m x 30m grid at a resolution of 0.5m x 1m. The Resistivity has a depth penetration of 0.5m to 1m. This would be increased strongly in areas of high resistance.

GPS METHODOLOGY

An RTK GPS (Real-time Kinematic Global Positioning System) can locate a point on the ground to sub-cm accuracy, a far greater accuracy than a standard GPS unit. An RTK system uses a base station receiver and a number of mobile units (rovers). The base station takes measurements from satellites in view and then broadcasts them along with its known position to the rover receivers. The rover receiver also collects measurements from the satellites in view and processes them with the base station data. The rover then computes its location relative to the base.

During such a survey a Trimble GeoXR Differential Global Positioning System (dGPS), capable of Real Time Kinematic (RTK) is used to set out a nominal grid prior to the survey. This increases the accuracy and efficiency of the survey. The data is then downloaded from the unit on the day, using a USB stick.

CONFIDENCE RATING OF INTERPRETATION

Categories for interpretations when there is corroborative evidence from mapping/desk based or excavation data can be assigned to magnetic anomalies (for example, Utility, Road, Wall, etc.) and where appropriate, such interpretations will be applied.

Table 2: Table of Confidence with interpretation

Interpretation Confidence	**Evidence**
High	Backed by mapping/desk based work/ excavation. A clear feature with a clear form.
Medium	A feature which has an unclear structure though has grouped potential or associated potential.
Low	Unknown provenance entirely based on form.

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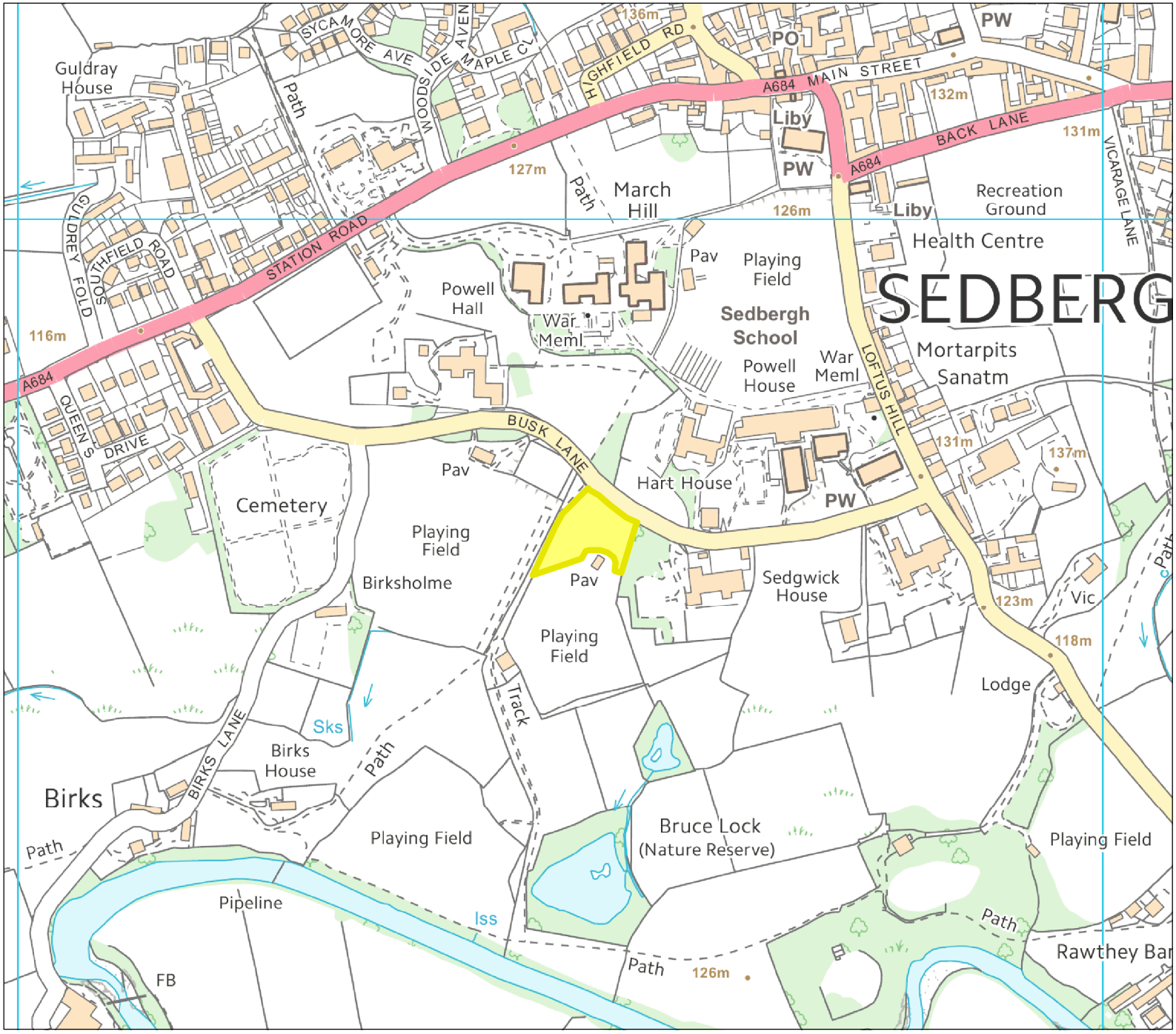

0 100 200 400 m

Legend

Site Boundary

Figure 1: Site Location

Project: Land Adjacent to Busk Lane

Date: 29/01/16	Job Number: 10741
Drawn by: ZE	Approved by: GR

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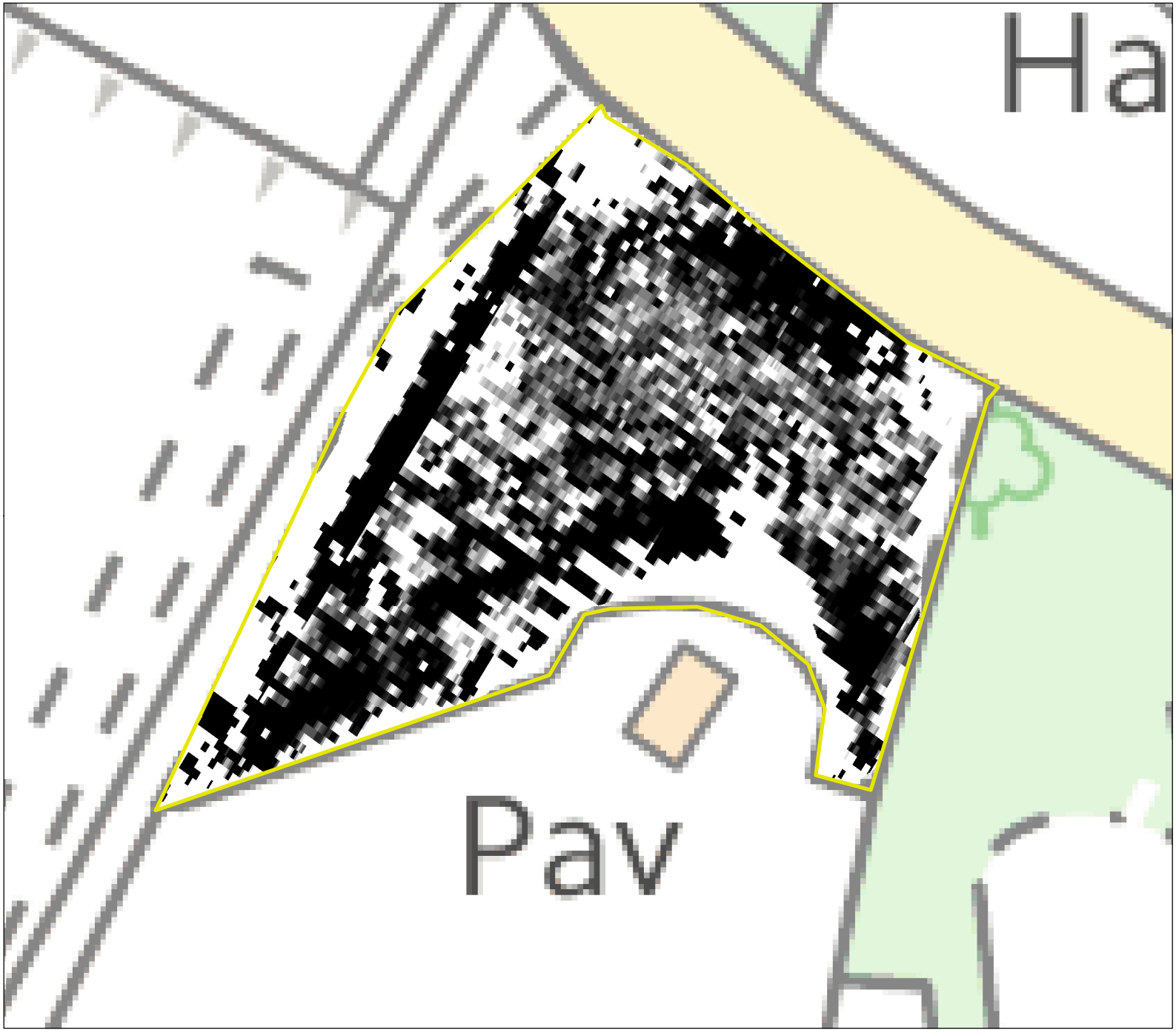

N

Legend

Site Boundary

+1

Plotting Perameters

-1

0 12.5 25 50 m

Figure 2: Raw Geophysical Data

Project: Land Adjacent to Busk Lane

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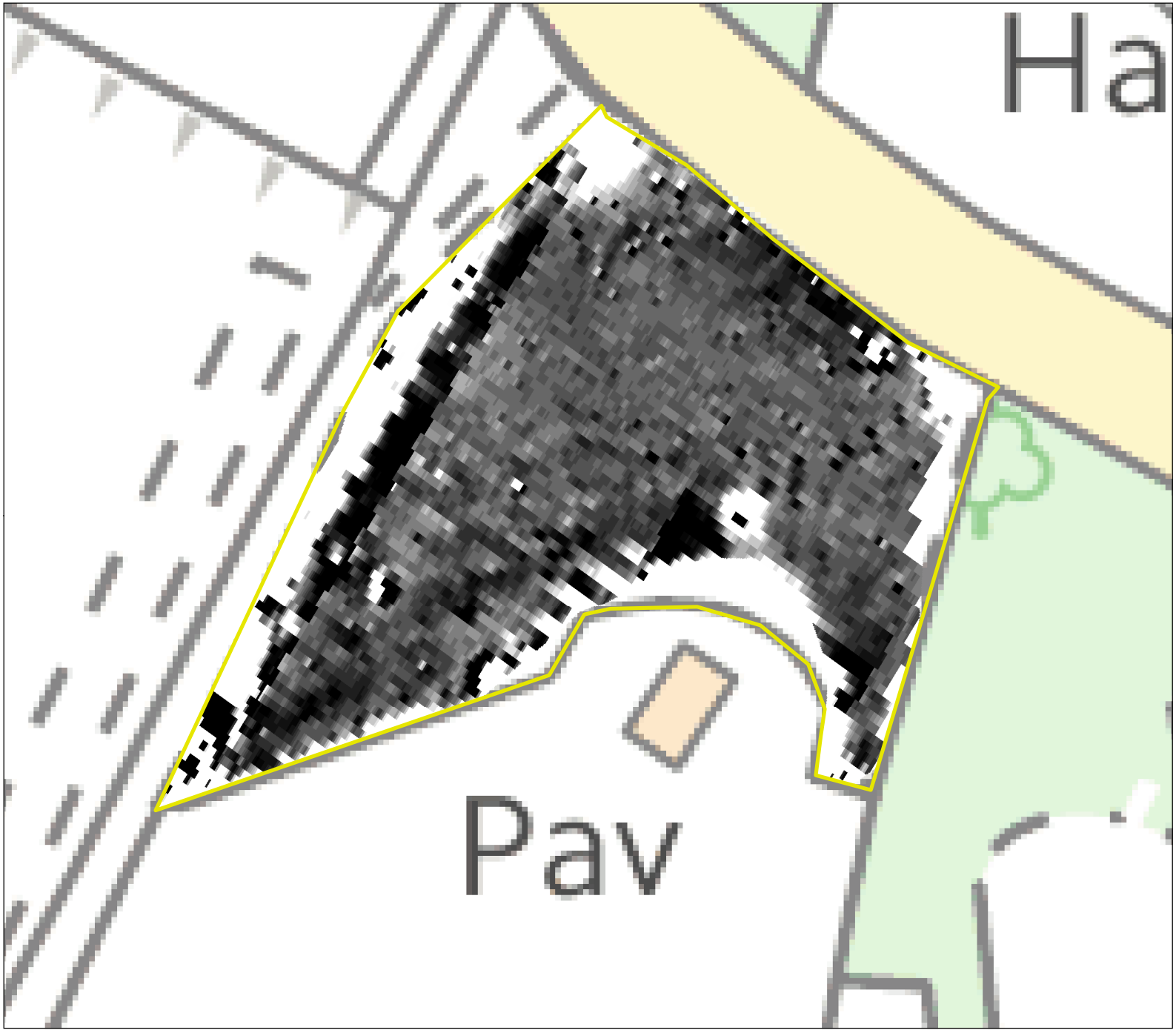

N

Legend

Site Boundary

0 12.5 25 50 m

Figure 3: Processed Geophysical Data

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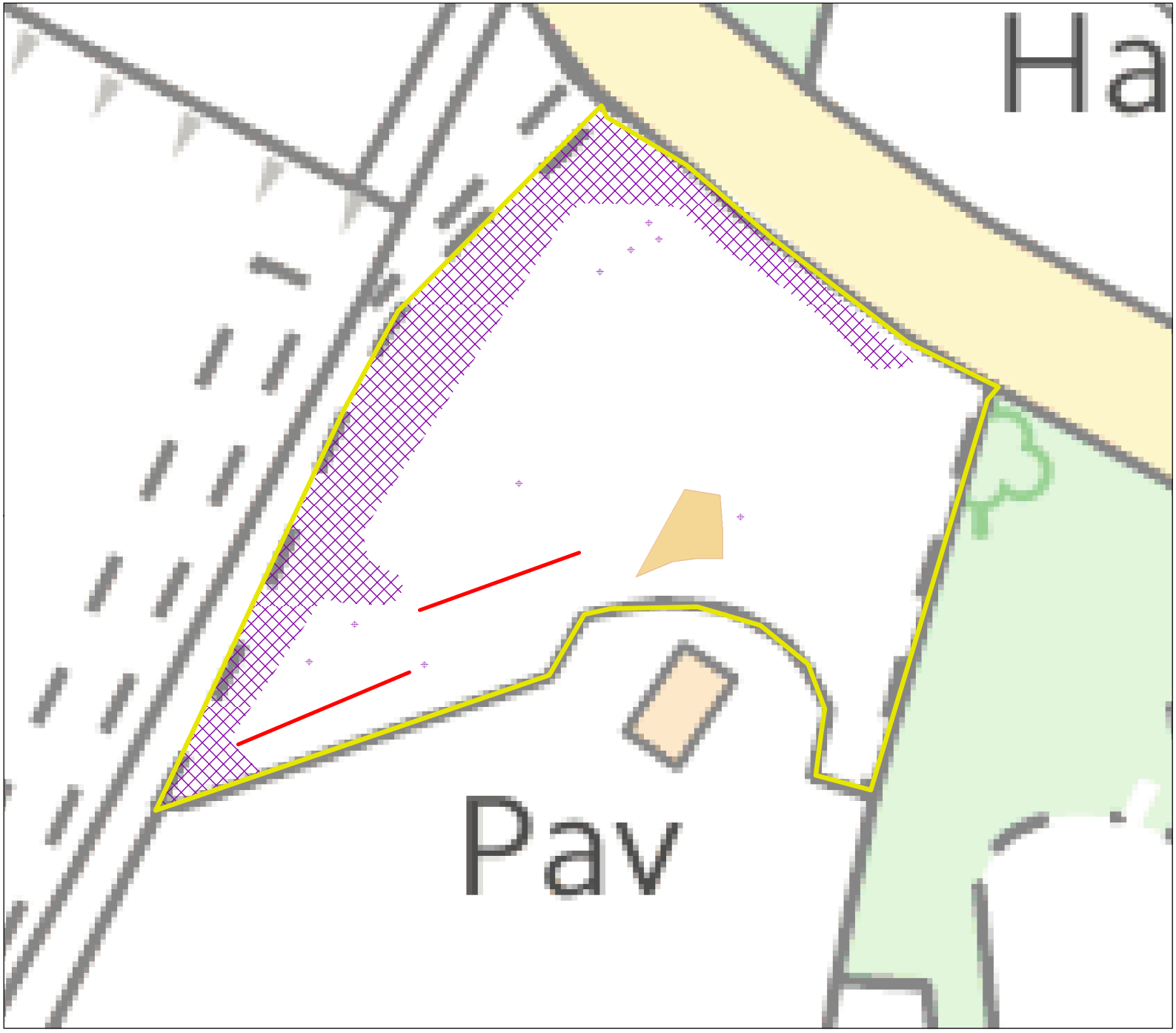

N

Legend

- Weak Positive Linear [GP1 a-b]
- Low Positive Feature [GP2]
- Magnetic Disturbance [GP3]
- Di-Polar Anomalies [GP4]
- Site Boundary

0 12.5 25 50 m

Figure 4: Interpretaion of Geophysical Data

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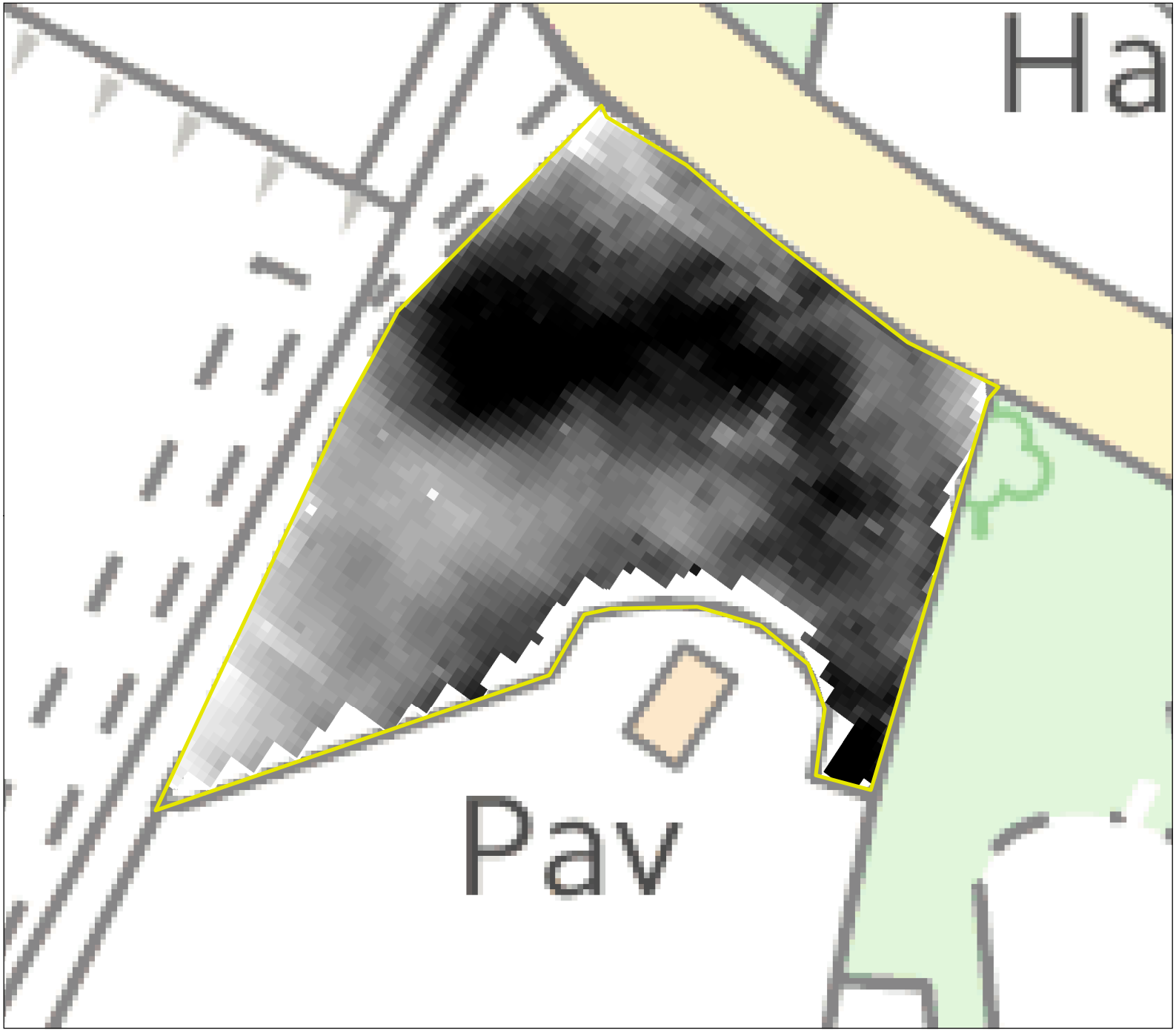

N

Legend

Site Boundary

High

Resistance

Low

0 12.5 25 50 m

Figure 5: Resistivity Survey Data

Project: Land Adjacent to Busk Lane

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N

Legend

High Resistance Area

Site Boundary

0 12.5 25 50 m

Figure 6: Interpretation of Resistivity Survey Data

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