Castleshaw Roman Fort

Geophysical Survey Report MSSD06

For

Greater Manchester Archaeological Advisory Service

On Behalf Of

The Friends of Castleshaw Roman Fort

Magnitude Surveys Ref: MSSD06

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magnitude surveys

Unit 17, Commerce Court

Challenge Way

Bradford

BD4 8NW

+44 (0)1274 926020

info@magnitudesurveys.co.uk

Report Written by:

Graeme Attwood MSc MCIfA

Figures Produced by:

Finnegan Pope-Carter BSc MSc FGS

Report Checked by:

Chrys Harris BA MSc

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Abstract

Magnitude Surveys (MS) was commissioned to undertake a geophysical survey of the outer defences of Castleshaw Roman Fort, Saddleworth. MS surveyed a 0.4ha area of the northern defences with the magnetic method; while a 0.2ha area of the eastern defences was surveyed using earth resistance (ER) and ground penetrating radar methods (GPR), in addition to the magnetic method. The surveys aimed to expand on previous work undertaken by the Tameside Archaeological Society in 2014, which mapped anomalies relating to the fort with a low-resolution ER survey. MS' 2016 work incorporated an ER cart to collect high-resolution results for comparison, while the suitability of the GPR and magnetic methods for detecting archaeology at Castleshaw were tested.

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1. Acknowledgments

1.1. Magnitude Surveys would like to thank Norman Redhead of the Greater Manchester Archaeology Advisory Service and the Friends of Castleshaw Roman Fort for allowing us to test and compare geophysical equipment on their site. Magnitude Surveys also thanks Roger and Kathleen Walker of Geoscan Research for their kindness in coming to site to help with survey and for providing use of the Geoscan Research MSP25 for a comparative survey. Further thanks is also offered to Mike Langton of MALÅ Geoscience, for conducting the GPR survey to assess the method's suitability and providing a comparative dataset.

2. Introduction

2.1. Magnitude Surveys Ltd (MS) was commissioned by Norman Redhead of the Greater Manchester Archaeology Advisory Service (GMAAS) on behalf of The Friends of Castleshaw Roman Fort to undertake a geophysical survey on the outer defences of Castleshaw Roman Fort, Saddleworth (SD 996 092). The geophysical survey comprised:

2.1.1. Hand pulled, cart-mounted fluxgate gradiometer survey.

2.1.2. Hand pulled, cart-mounted earth resistance survey.

2.1.3. Hand pushed, cart mounted ground penetrating radar survey.

2.2. The survey was conducted in line with the current best practice guidelines produced by Historic England and the Charted Institute of Field Archaeologists (CIfA, 2014; David *et al.*, 2008).

2.3. The survey was undertaken on the 16th of October, 2015.

3. Quality Assurance

3.1. Project management, survey work, data processing and report production have been carried out by qualified and professional geophysicists to standards exceeding the current best practice (CIfA, 2014; David *et al.*, 2008).

3.2. Magnitude Surveys is a corporate member of ISAP (International Society of Archaeological Prospection).

3.3. Graeme Attwood is a Member of the Institute for Archaeologists, the Chartered UK body for archaeologists.

3.4. Finnegan Pope-Carter is a Fellow of the London Geological Society, the Chartered UK body for geophysicists and geologists.

4. Objectives

4.1. The geophysical survey aimed to expand on the results of an earlier earth resistance survey undertaken by the Tameside Archaeological Society (Rigby *et al.*, 2014) in 2014 by utilising cutting-edge cart based, high-resolution instrumentation.

4.2. A secondary objective sought to test the effectiveness of magnetic and ground penetrating radar methods for detecting the archaeology of the site.

5. Geographic Background

5.1. The underlying geology comprises Shale grit (sandstone) with no superficial deposits being recorded (BGS 2016). Historic England guidelines state grit and sandstone geology can produce average to poor magnetic responses (David *et al.*, 2008: 15).

5.2. The soils consist slowly permeable, wet, very acid upland soils with a peaty surface (Soilscape, 2016).

5.3. Survey was undertaken over two distinct areas of the fort's outer defences (Figure 2). While the long grasses and reeds had been cut in preparation for survey, layers of cut grass in small areas of the eastern defences (Area 2) did impede the ground contact with the earth resistance system, which introduced sporadic, isolated erroneous high-resistance measurements. Survey of the northern defences (Area 1) was conducted solely using the magnetic method due to ground conditions and time constraints. Area 1 was significantly steeper than Area 2 and while the grass had been cut, the area was deemed unsuitable for survey with the GPR and the cart based earth resistance system.

6. Archaeological Background

6.1. The Roman Forts of Castleshaw (SM 30359) are situated atop Castle Hill in the Castleshaw Valley, through which the Roman road from York to Chester runs. The first, and larger of the two forts, dates from *c.* 80 AD and was constructed during the Agricolan advance into what is now Scotland (Start, 1985?). Constructed from timber and turf, this fort was short-lived and abandoned *c.* 95AD. Approximately 10 years later, a second smaller fortlet was constructed within the bounds of the earlier ditches. Also constructed from timber and turf, the fortlet experienced a slightly longer occupation and was abandoned by *c.* 125AD (Heritage Gateway, 2016).

6.2. A number of recorded and unrecorded excavations have taken place across the complex. The earliest known excavation was undertaken by Buckley and Wrigley in 1897; if this work had been recorded, the details have since been lost. The first set of recorded excavations were undertaken by Bruton, Andrew and Lees in between 1907-1908 (Start, 1985?). Further excavation work was conducted in the 1950's, 1960's and 1980's. The most recent work has been led by The Friends of Castleshaw Roman Fort under the auspices of the Centre for Applied Archaeology at the University of Salford in 2014.

7. Methodology

7.1. Data Collection

7.1.1. Geophysical prospection comprised magnetic, earth resistance (ER) and ground penetrating radar methods (GPR) as described in the following table.

7.1.2. Table of survey strategies:

Method	Instrument	Traverse Interval	Sample Interval
Magnetic	Bartington Instruments 1000L fluxgate gradiometer	1m	10Hz reprojected to 0.125m
Magnetic	Sensys FGM650 mounted on Geoscan Research MSP25	1m	0.25m
Earth Resistance	Geoscan Research RM85 with MSP25 square array (alpha, beta and gamma)	1m	0.25m
GPR	MALÅ Geoscience X3M with 450 MHz Antenna	0.5m	0.05m

7.1.3. The Bartington Instruments magnetic data were collected using MS' bespoke hand-pulled cart system.

7.1.3.1. The cart system supports the magnetic and GPS instruments with a bespoke datalogger. The magnetic instruments comprise two Bartington Instruments 1000L fluxgate gradiometers operating in NMEA mode. Positional referencing is through a Hemisphere S320 RTK GPS outputting in NMEA mode. Corrections were made through Topcon TopNet. Data from both instruments were logged in a bespoke datalogger. Data were transferred to a laptop computer for processing.

7.1.3.2. A series of temporary sight markers were established in each survey area to guide the surveyor and ensure full coverage with the cart. Data were collected by traversing the survey area along the longest possible lines, to ensure that the data was efficiently collected and processed.

7.1.4. The Geoscan Research MSP25 cart system was used to collect earth resistance data and Sensys FGM650 magnetic data simultaneously.

7.1.4.1. The Geoscan Research MSP25 base is formed by an a = 0.75m square electrode array. Current is injected and potential difference is measured continuously through the wheels. Measurements are logged in the Geoscan Research RM85 at regular distance intervals, triggered by the optical encoder wheel. The odometer wheel is calibrated for the traverse length at the beginning of survey. Square alpha, beta and gamma configurations were collected simultaneously with a sampling interval of 0.25m along lines spaced 1m apart. The square alpha, beta and gamma configurations are three unique datasets:

7.1.4.1.1. Square alpha – current path in-line with the direction of traverse.

7.1.4.1.2. Square beta – current path normal to the direction of traverse.

7.1.4.1.3. Square gamma – current path 45° to direction of traverse.

7.1.4.2. The Sensys FGM650 was mounted on the Geoscan Research MSP25. Operating in trigger mode, measurements are logged in a Geoscan Research DL256 datalogger. Measurements are collected at regular distance intervals, triggered by the optical encoder wheel. The odometer wheel is calibrated for the traverse length at the beginning of survey. Data were collected at a sampling frequency of 0.25m along lines spaced 1m apart.

7.1.4.3. The Geoscan Research MSP25 system collected data in grids 20m x 40m. Grids were set-out using the Hemisphere S320 RTK GPS.

7.1.5. Ground penetrating radar data were collected using a cart mounted MALÅ X3m 450 MHz antenna.

7.1.5.1. GPR data were collected along lines, using the system's encoder wheel to position sampling points. Fibreglass tapes were laid adjacent to the traverses, to ensure positioning was accurate by comparing the end position on the tape to the encoder wheel's position. No significant deviations between the tape and encoder end positions were encountered.

7.1.5.2. The MALÅ X3m collected data in the same grids as the Geoscan Research MSP25.

7.2. Data Processing

7.2.1. Bartington Instruments magnetic data were processed in bespoke in-house software produced by MS. Processing steps were limited to:

Zero Median Traverse – The median of each sensor traverse is calculated within a specified range and subtracted from the collected data. This removes striping effects caused by small variations in sensor electronics. Assessment between filtered and unfiltered data ensures linear trends running parallel to the survey direction are not removed.

Projection to a Regular Grid – Data collected using RTK GPS positioning requires a uniform grid projection to visualise data. Data are rotated to best fit an orthogonal grid projection and are resampled onto the grid using an inverse distance weighting algorithm.

Interpolation to Square Pixels – Data are interpolated using a bicubic algorithm to increase the pixel density between sensor traverses. This produces images with square pixels for ease of visualisation.

7.2.2. Sensys FGM650 data were processed using a commercial software package, Geoplot 4.0 (Beta Version). Processing steps were limited to:

Zero Median Traverse – The median of each sensor traverse is calculated within a specified range and subtracted from the collected data. This removes striping effects caused by small variations in sensor electronics. Assessment between filtered and unfiltered data ensures linear trends running parallel to the survey direction are not removed.

Interpolation to Square Pixels – Data are interpolated using a sin x/x algorithm to increase the pixel density between sensor traverses. This produces images with square pixels for ease of visualisation.

7.2.3. Geoscan Research RM85 data were processing using a commercial software package, Geoplot 4.0 (Beta Version). Processing steps were limited to:

Despike—Erroneous measurements (“spikes”) due to high contact resistance or poor electrode-to-ground contact are corrected by analysing the mean of measurements in a specified window size and replacing measurements outside a defined threshold with the average measurement of neighbouring positions.

Low Pass Filter—High frequency background responses are removed to reduce data noise and spikes by averaging the weighted average from the central reading in a specified window.

Interpolation to Square Pixels – Data are interpolated using a sinx/x algorithm to increase the pixel density between sensor traverses. This produces images with square pixels for ease of visualisation.

7.2.4. GPR data were processed were processed using a commercial software package, ReflexW 2D.

7.2.5. GPR Processing steps were limited to:

Bandpass Filter – Frequencies outside the normal range of the measuring antennae are filtered out to remove errors from external sources.

Gain Adjust – A gain curve is determined to account for signal attenuation with depth. This allows features at depth with a weaker signal to be resolved at the same plotting scale as near surface features.

Hyperbola fitting – Manual fitting of hyperbola curves is conducted to calculate the velocity of the wave. This allows the calculation of response depth from response time.

7.3. Data Visualisation

7.3.1. Magnetic greyscales should be viewed alongside the accompanying XY trace plots (available on the accompanying archive disk). XY trace plots visualise the magnitude and form of the geophysical response, aiding in anomaly interpretation.

7.3.2. The combined earth resistance greyscale is an average of the alpha and beta configurations, reducing the directional biases of the individual configurations. The gamma configuration did not provide any additional interpretation information beyond the averaged alpha and beta configurations, and is not included in the body of the report.

7.3.3. Ground penetrating radar data has been visualised as greyscale time slices through the three-dimensional data cube. Time slices are akin to depth slices, however, since no strong hyperbola were detected it has not been possible to convert time to depth.

8. Survey Considerations

Survey Area	No. Survey Blocks	Surveyed Y/N	Ground Conditions	Further notes:
1	1	Y	Grass (15-20cm), thick density, many divots and holes	The area sloped steeply down from south to north. A utility access point or similar was present in the northwestern corner. Wire stock fencing ran along the western boundary atop the dry stone walling.
2	1	Y	Short grass, recently cut grass on surface	Flat area towards the edge of the field. The area was beside the only available space to park cars. While the majority of cars were moved before the end of survey, some remained when survey was completed. The site had been recently excavated.

Refer to Figure 2 for survey area locations.

9. Results

9.1. Qualification

9.1.1. *Geophysical techniques are not a map of the ground and are instead a direct measurement of subsurface properties. Detecting and mapping features requires that said features have properties that can be measured by the chosen technique(s) and that these properties have sufficient contrast with the background to be identifiable. The interpretation of any identified anomalies is inherently subjective. While the scrutiny of the results is undertaken by qualified, experienced individuals and rigorously checked for quality and consistency, it is often not possible to classify all anomaly sources. Where possible an anomaly source will be identified along with the certainty of the interpretation. The only way to improve the interpretation of results is through a process of comparing excavated results with the geophysical reports. MS actively seek feedback on their reports as well as reports of further work in order to constantly improve our knowledge and service.*

9.2. Discussion

9.2.1. The geophysical results, both greyscale images and XY traces, were interpreted in consideration with historic mapping (*c.*1882-1913 2nd edition OS 6" from maps.nls.uk), satellite imagery (©2016 Infoterra Ltd. and BlueSky from Google Earth) and 1985 ground disturbance plan (Start, 1985?).

9.2.2. While the magnetic survey has detected anomalies relating to archaeological deposits and processes; agricultural features; and modern soil disturbances, the overall greyscales reveal an area of poorly enhanced soils. A number of anomalies have been detected and classified as *Undetermined*; these anomalies exhibit characteristics of anomalies potentially of archaeological, geological and/or pedological origins. They are difficult to classify further due to their sometimes isolated nature and the disturbed nature of the subsurface caused by previous invasive archaeological excavations.

9.2.3. The earth resistance survey was undertaken over a targeted area and expands on Tameside Archaeological Society's 2014 results. The square array has responded well to the ground conditions and features of an archaeological origin have been detected.

9.2.4. The ground penetrating radar survey obtained the poorest results of the three techniques. There are a number of possible reasons for the lack of anomalies in the data, including the local soil and geology, the prevailing weather conditions both prior and during survey, and nature of the targeted archaeological deposits (i.e. the forts were of largely timber and turf construction and may have a reduced contrast against the surrounding soil). The lack of success with the GPR is likely due to a combination of all these factors.

9.3. Interpretation

9.3.1. General Statements

9.3.1.1. Each technique will be discussed separately; geophysical anomalies will be discussed broadly as classification types across the survey area. Only anomalies that are distinctive or unusual will be discussed individually. Specific anomalies discussed within the text have been assigned numbers, which are emboldened within square parenthesis e.g. [**1**].

9.3.1.2. **Undetermined** – Anomalies are classified as Undetermined when the anomaly origin is ambiguous through the geophysical results and there is no supporting or correlative evidence to warrant a more certain classification. These anomalies are likely to be the result of agricultural, geological or pedological processes; although an archaeological origin cannot be entirely ruled out. They are generally not ferrous in nature.

9.3.1.3. **Ferrous** – A number of discrete ferrous-like anomalies have been mapped throughout both survey areas. These responses are likely to be the result of modern metallic disturbance on or near the ground surface. The various campaigns of excavation will inevitably have caused disturbance in both the areas of excavation and the former spoil heaps. Broad ferrous responses from modern metallic features such as fences, gates, vehicles and services may mask any weaker underlying archaeological anomalies.

9.3.2. Magnetic Results - Specific Anomalies

9.3.2.1. **Archaeology (Probable)** – Broad, parallel, linear anomalies [**1**] have been detected at the centre of Area 1. These are orientated at right angles to the traverse direction and are relatively weak in response, exhibiting positive and negative magnetic contrast. These anomalies correlate with the alignment of the outer ditches to the earlier Agricolan Fort when are interpreted in comparison with the georeferenced 1985 ground disturbance plan (Start, 1985?); however, these anomalies exhibit characteristics similar to agricultural responses, albeit broader than the agricultural anomalies detected further down the slope (See para. 9.3.2.4)

9.3.2.2. **Archaeology (Possible) –** A positive magnetic linear anomaly **[2]** on a north-south alignment has been detected at the western edge of Area 1. This, like **[1]**, could be archaeological in origin; however, it is also possible that it forms the headland to the ridge and furrow anomalies detected to the east.

9.3.2.3. **Archaeology (Former Trench) –** The position of a former archaeological trench has been detected at **[3]**. This particular trench is marked on the 1985 Ground Disturbance Plan as of unknown date and is visible in the data as a narrow negative magnetic anomaly. This trench can also be seen in the Earth Resistance data (see 9.3.3.2).

9.3.2.4. **Agricultural** – Magnetically weak, parallel linear anomalies **[3]** orientated northeast – southwest have been detected in the norther half of Area 1. Analysing the nature of the geophysical responses, these anomalies are almost certainly the remains of ridge and furrow ploughing.

9.3.2.5. **Undetermined –** A large number of detected anomalies have been categorised as having an undetermined origin. As stated in 9.3.1.2, these anomalies are difficult to classify due to their often isolated positions.

Furthermore, the form of these anomalies' responses exhibit characteristics of an archaeological response, but often lack the archaeological shape or groupings. The numerous archaeological trenches and excavations across the site may also introduce anomalous responses that mask or appear similar to Roman archaeological responses. Those at **[4]**, for example, appear in the correct orientation for internal features of the Agricolan Fort, but are also on a comparable alignment to the Rosser Box trenches of the 1957-60 scheme of excavation. Furthermore, anomalies **[5]** are located in an area marked as "visible disturbance" and "recorded disturbance" on the 1985 Ground Disturbance Plan (Start, 1985). It is probable in this case that some of these anomalies are resultant of archaeological deposits, while others are indicative of the locations of trenches and spoil heaps. Discerning one from the other with any degree of certainty is difficult.

9.3.2.6. **Drain –** A drain or small pipe has been detected on the western edge of Area 1.

9.3.3. Earth Resistance Results - Specific Anomalies

9.3.3.1. **Archaeological (Probable) –** A number of high resistance anomalies **[6]** towards the centre of the survey area has been detected. These anomalies correlate with defences mapped on the 1985 Ground Disturbance Plan (Start, 1985) and is therefore likely indicative of the rammed earth and turf bank that would have formed the outer defences of the larger fort.

9.3.3.2. **Archaeology (Former Trench) –** A weak linear anomaly has been detected **[3]** that correlates with the location of a former archaeological trench (Start, 1985). This trench was also identified within the magnetic survey (see 9.3.2.3).

9.3.3.3. **Archaeological (Probable) –** An 'L' shaped low resistance anomaly **[7]** has been detected within the area interpreted as the earthen bank. It is possible that this demarcates an unmarked archaeological investigation into the outer defences.

9.3.3.4. **Undetermined –** The anomalies within this category are primarily identified along the western survey boundary, along the alignment of the fort's outer bank and ditch. It is plausible that some, or all of these anomalies, pertain to the fort's outer defences; however, due to the limited size of the survey area, it is difficult to confidently determine their origin. If further survey was to be undertaken to the west, it may be possible to further categorise these anomalies.

9.3.3.5. **Undetermined –** Anomalies **[8]** on the eastern side of the survey area almost certainly relate to rubble spread from a cottage that has been demolished near this point. The cottage can be seen on the historic mapping and in archive photographs.

9.3.4. GPR Results - Specific Anomalies and Features

9.3.4.1. As discussed above (9.2.4) the GPR has not detected any anomalies of archaeological potential. Anomalies marked as **[9]** are likely due to the rubble spread from the demolition of the neighbouring cottage; while those at **[10]** are near surface noise. The cause of the noise is unknown, however as this was close to the location of the cabins during the recent excavations and within the entrance way which receives the most traffic, it seems likely that it is a combination of these modern factors.

10. Conclusions

10.1. The MSP25 Earth Resistance survey successfully identified a number of features in the eastern defences, including anomalies possibly associated with the outer ramparts, and a backfilled archaeological trench. The majority of the anomalies were categorised as undetermined, however, these were along the edge of the survey area and it is likely that an expansion of the survey would clarify a number of these. The results are broadly similar to those undertaken by the TAS in 2014, although the increased sample density has resolved the anomalies to a far higher degree and allowed the detection of subtle changes in the soil.

10.2. While further survey of the Fort with the MSP25 would be possible around the eastern and western ramparts the land to the north would not be suitable. To the south of the fort, in the adjoining field the land is grazed and open and would be suitable for large area survey.

10.3. The magnetic surveys, although successful in identifying features did not add too much to the overall picture. In the interior of the Agricolan fort, where one would expect the most activity to have taken place the results were more complex; however, they were somewhat confused by the increased archaeological activity that had taken place. The slopes to the north of the fort, although not impossible, were difficult to traverse and it would seem this is where the results were least impressive. Any further magnetic survey may best be focused on the surrounding landscape rather than the field containing the forts themselves.

10.4. The GPR survey was the least impressive. This is almost certainly due to a combination of factors including, the soil conditions, makeup of the targets and the weather conditions immediately preceding the survey. MS would advise against perusing a radar survey, at least until other options have been exhausted.

11. Archiving

11.1. MS maintains an in-house digital archive, which is based on Schmidt and Ernenwein, 2013.

11.2. MS contributes all reports to the ADS Grey Literature Library subject to any time embargo dictated by the client.

11.3. Whenever possible, MS has a policy of making data available to view in easy to use forms on its website. This can benefit the client by making all of their reports available in a single repository, while also being a useful resource for research. Should a client wish to impose a time embargo on the availability of data this can be achieved in discussion with MS.

12. Copyright

13. References

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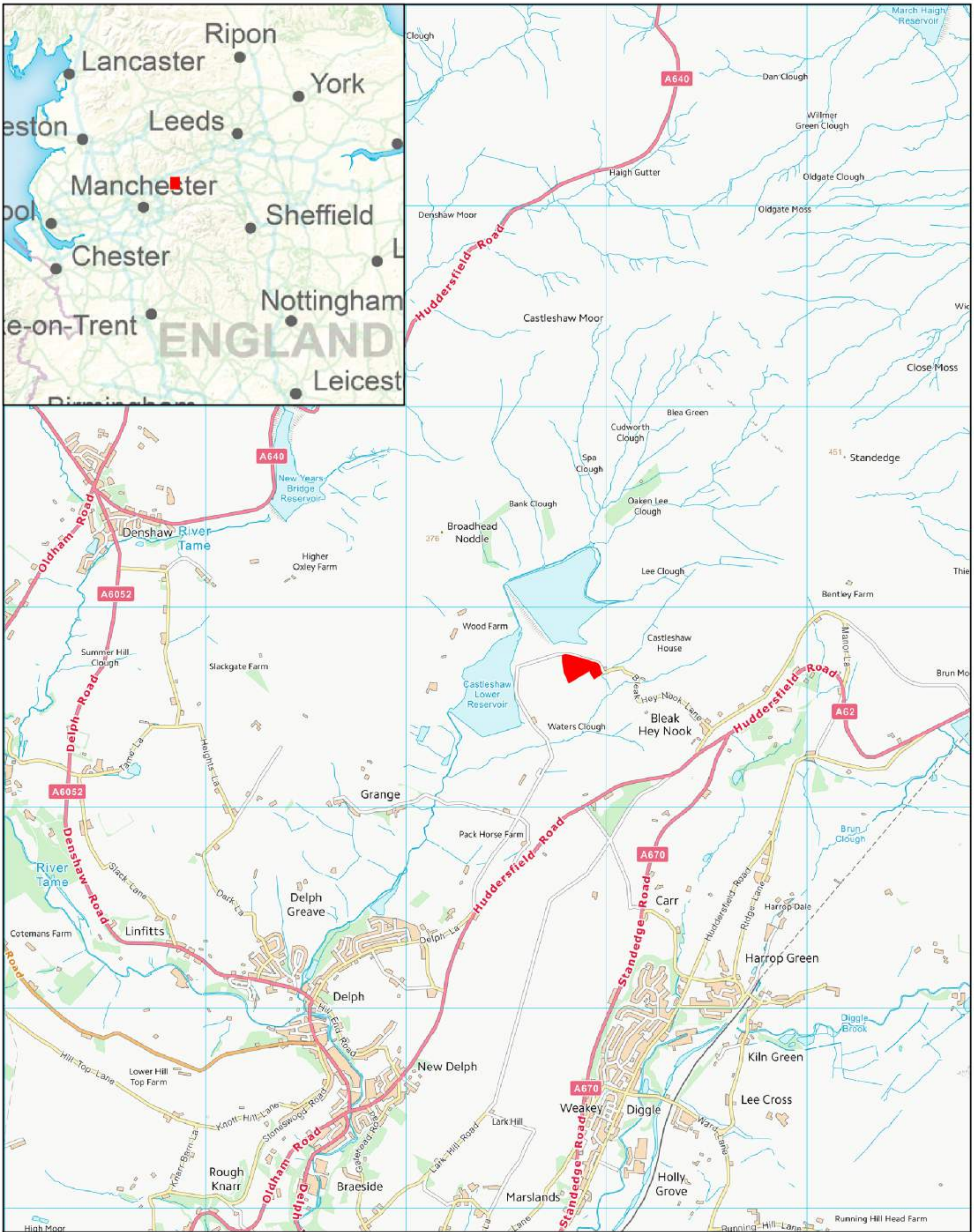
Start, D., 1985? Survey and Conservation Work at Castleshaw Roman Forts 1984 -5, need the rest of the reference.



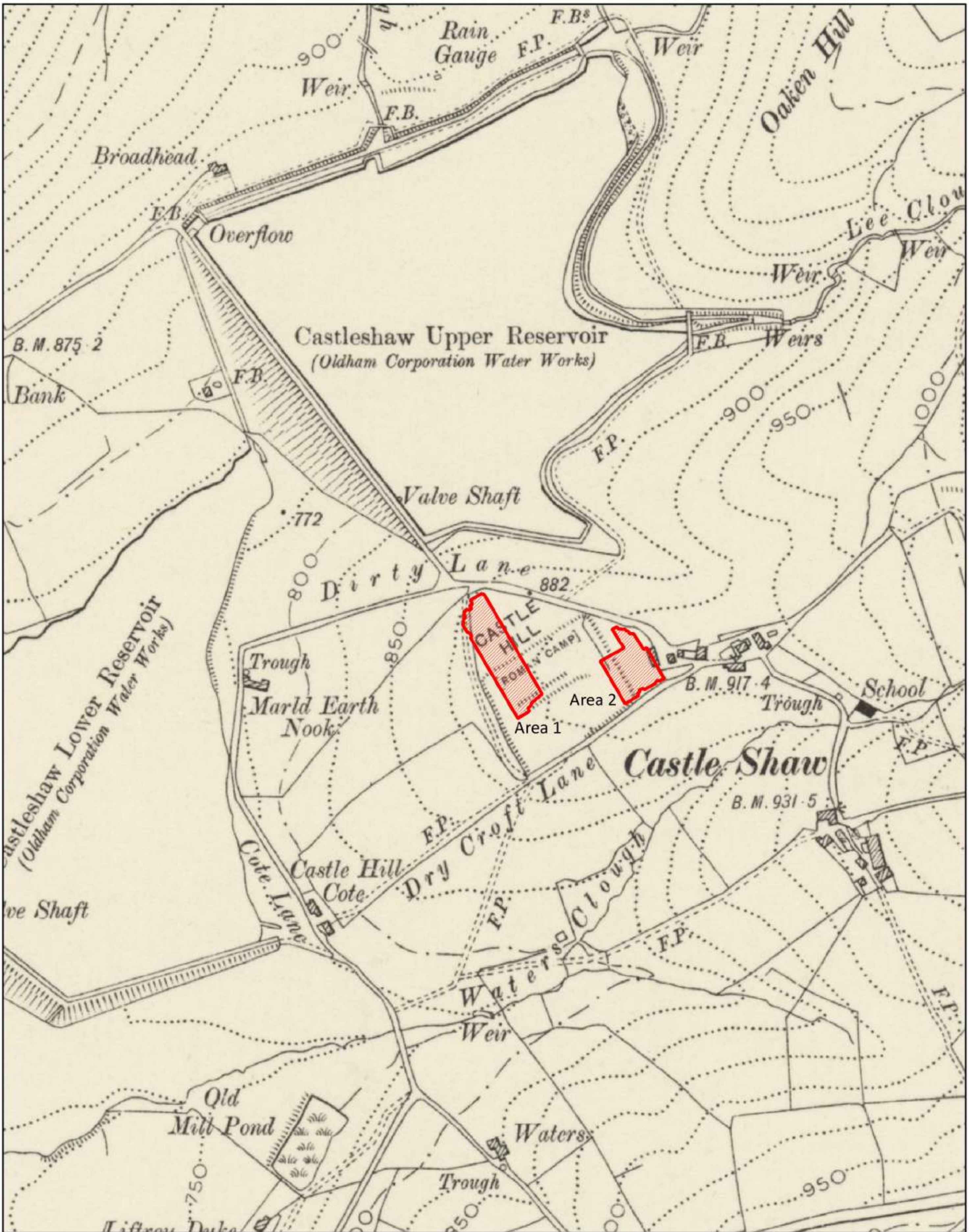
MSSD06 - Castleshaw Roman Fort
Figure 1 - Site Location
1 : 25,000 @ A4

Area of Geophysical Survey

N W E S

0 0.5 1 km

magnitude surveys



MSSD06 - Castleshaw Roman Fort
Figure 2 - Location of Survey Areas
1 : 5,000 @ A4
Copyright Magnitude Surveys Ltd 2016
Background mapping courtesy of NLS.gov.uk

Survey Areas

N S W E

0 50 100 150 200 m

magnitude surveys

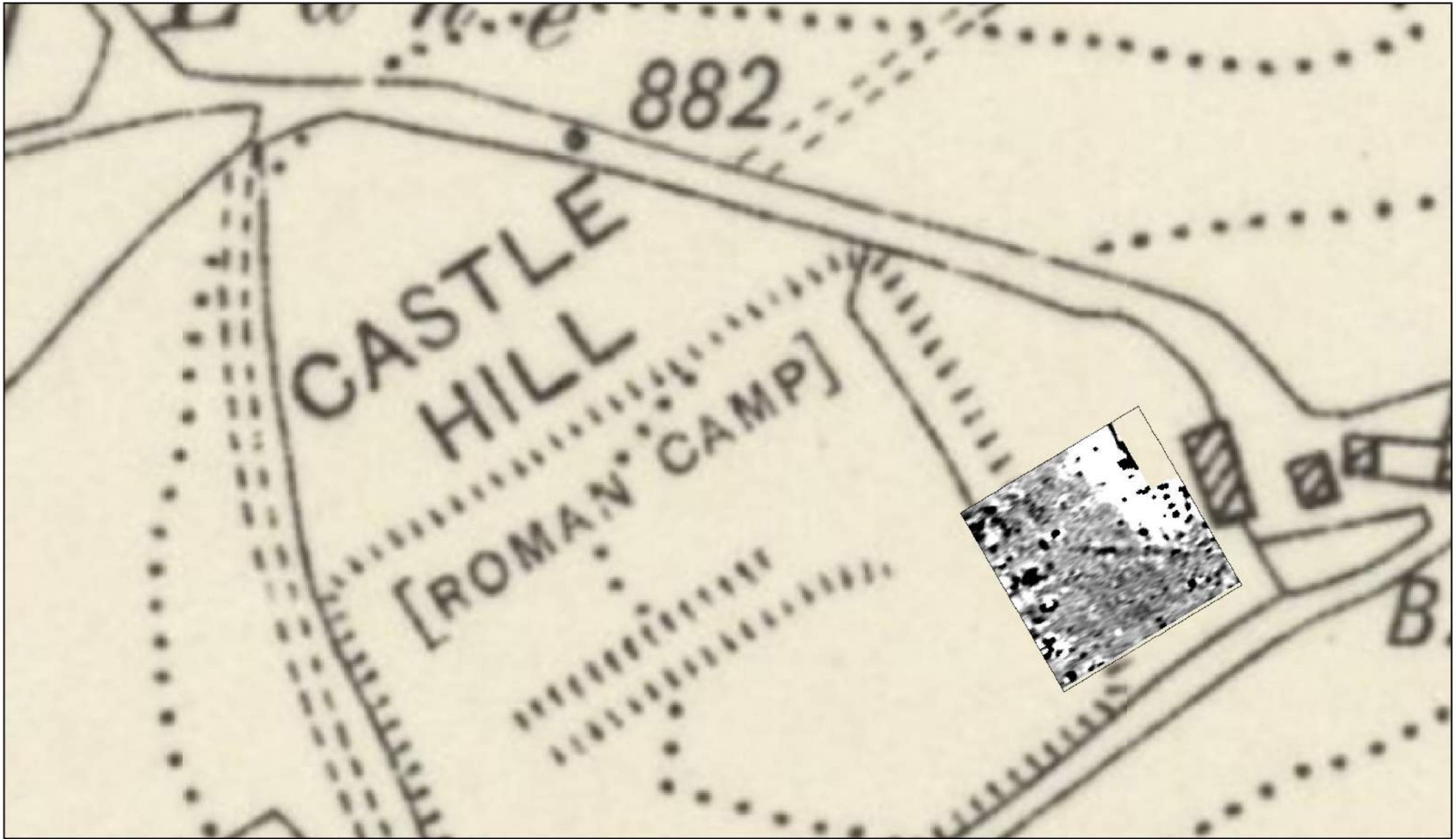
MSSD06 - Castleshaw Roman Fort
Figure 3 - Bartington-1000L Greyscale
1 : 1000 @ A4

Ordnance Survey six-inch to the mile, 1888-1913 Courtesy of the National Library of Scotland (nls.gov.uk)

-5 nT 10

0 10 20 30 40 m

magnitude surveys



MSSD06 - Castleshaw Roman Fort
Figure 4 - Sensys FGM650 Greyscale
1 : 1000 @ A4

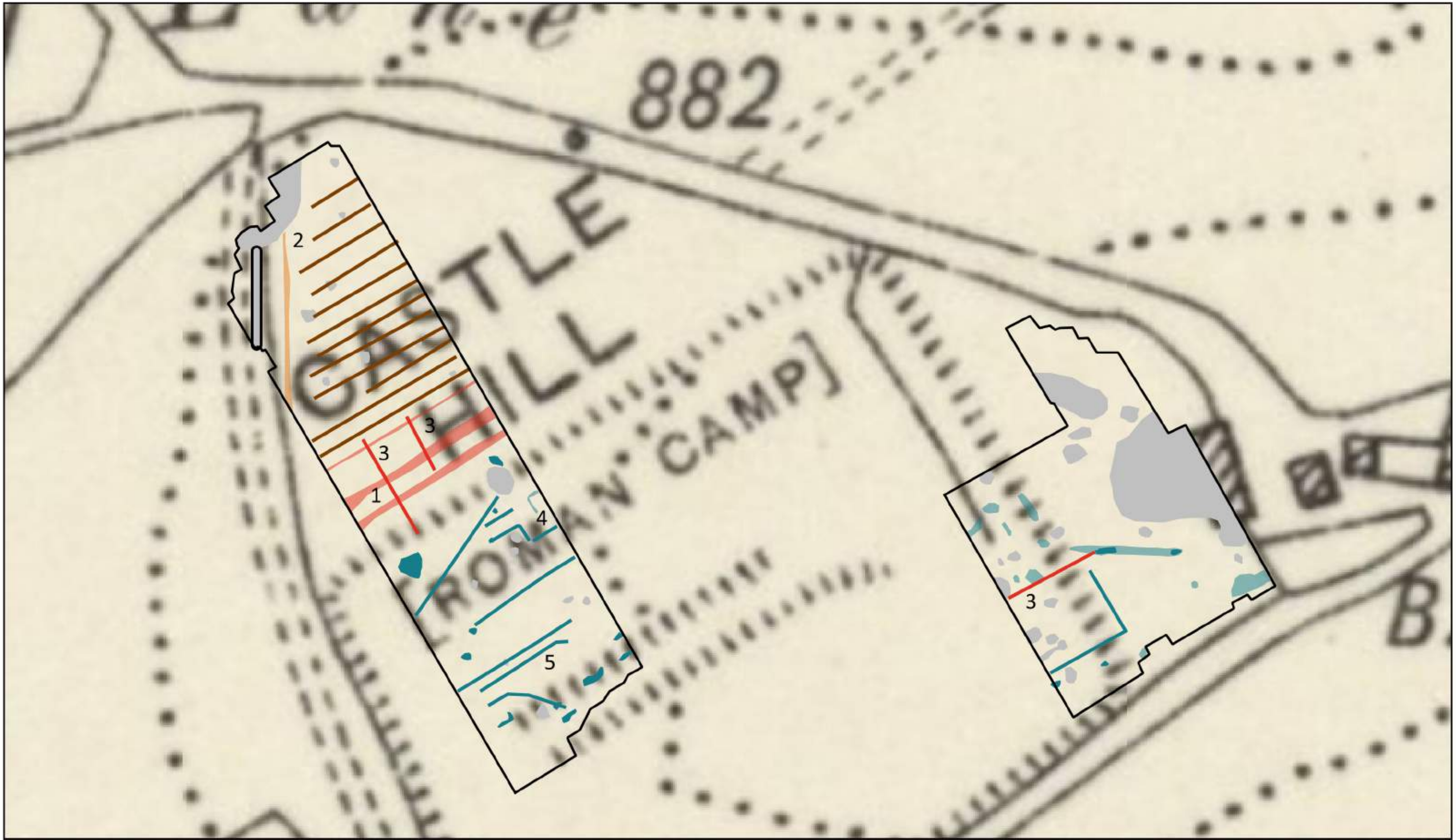
Ordnance Survey six-inch to the mile, 1888-1913 Courtesy of the National Library of Scotland (nls.gov.uk)

-3 nT 5

0 10 20 30 40 m

N E S W

magnitude surveys



MSSD06 - Castleshaw Roman Fort
Figure 5 - Magnetic Interpretation
1 : 1000 @ A4

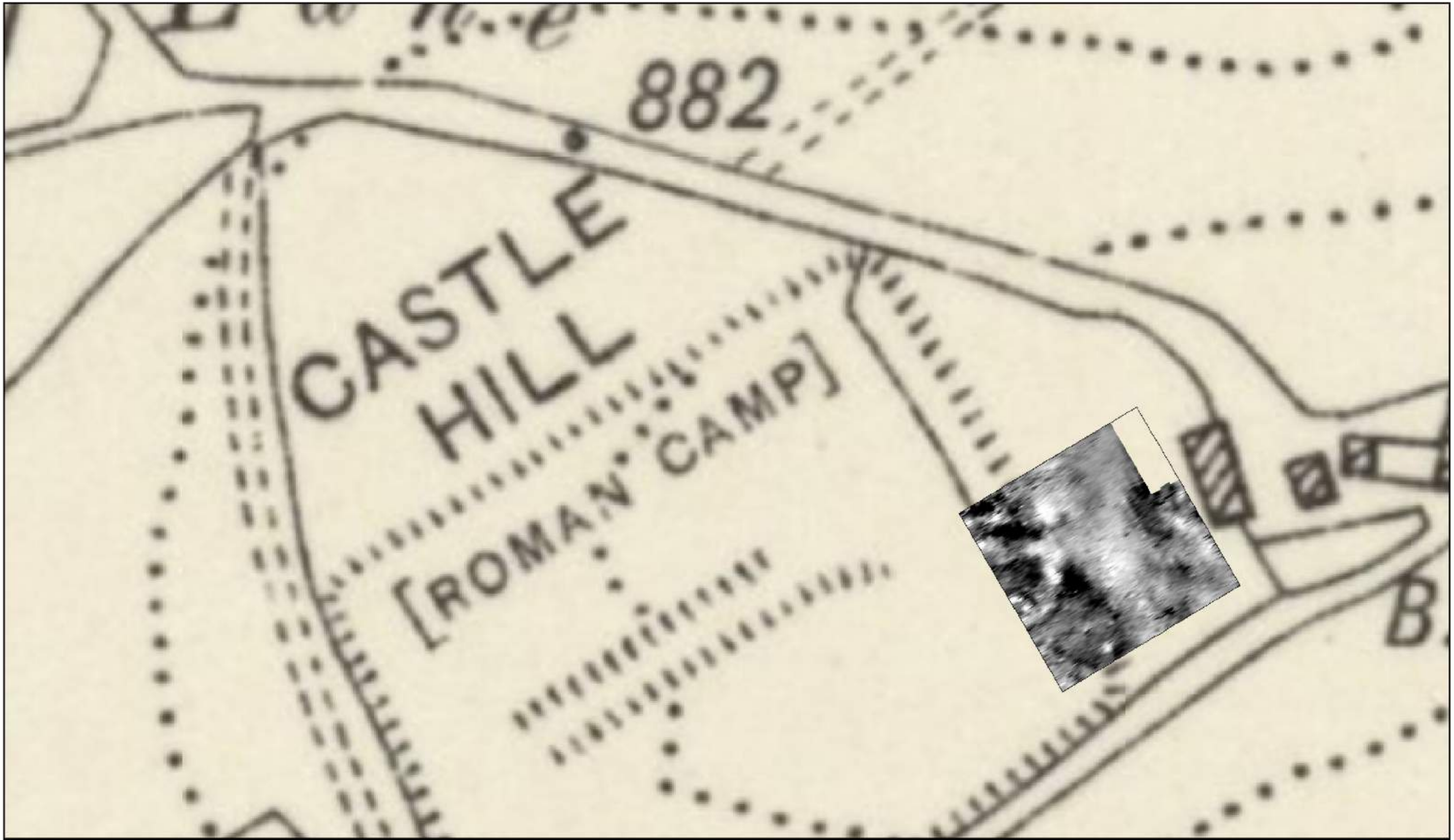
Ordnance Survey six-inch to the mile, 1888-1913 Courtesy of the National Library of Scotland (nls.gov.uk)

Archaeology Probable (Weak) | Agricultural (R&F) | Undetermined (Strong) | Possible Trench | Survey Area
Archaeology Possible (Weak) | Ferrous (Dipolar) | Undetermined (Weak) | Drain

N W E S

0 10 20 30 40 m

magnitude surveys



MSSD06 - Castleshaw Roman Fort
Figure 6 - MSP25 Alpha + Beta Greyscale
1 : 1000 @ A4

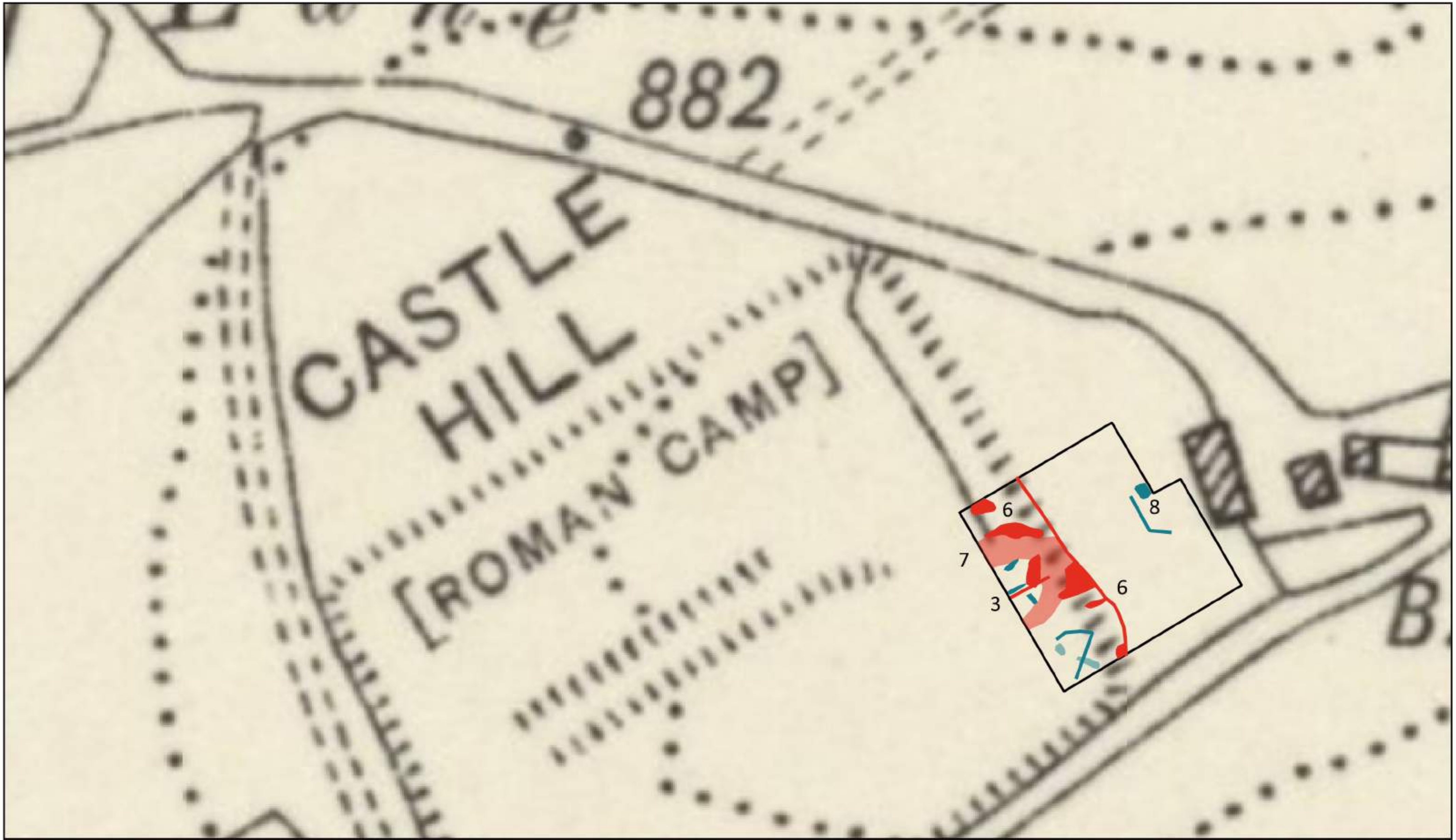
Ordnance Survey six-inch to the mile, 1888-1913 Courtesy of the National Library of Scotland (nls.gov.uk)

1 Ohm (SD) 1

N W E S

0 10 20 30 40 m

magnitude surveys



MSSD06 - Castleshaw Roman Fort
Figure 7 - Earth Resistance Interpretation
1 : 1000 @ A4

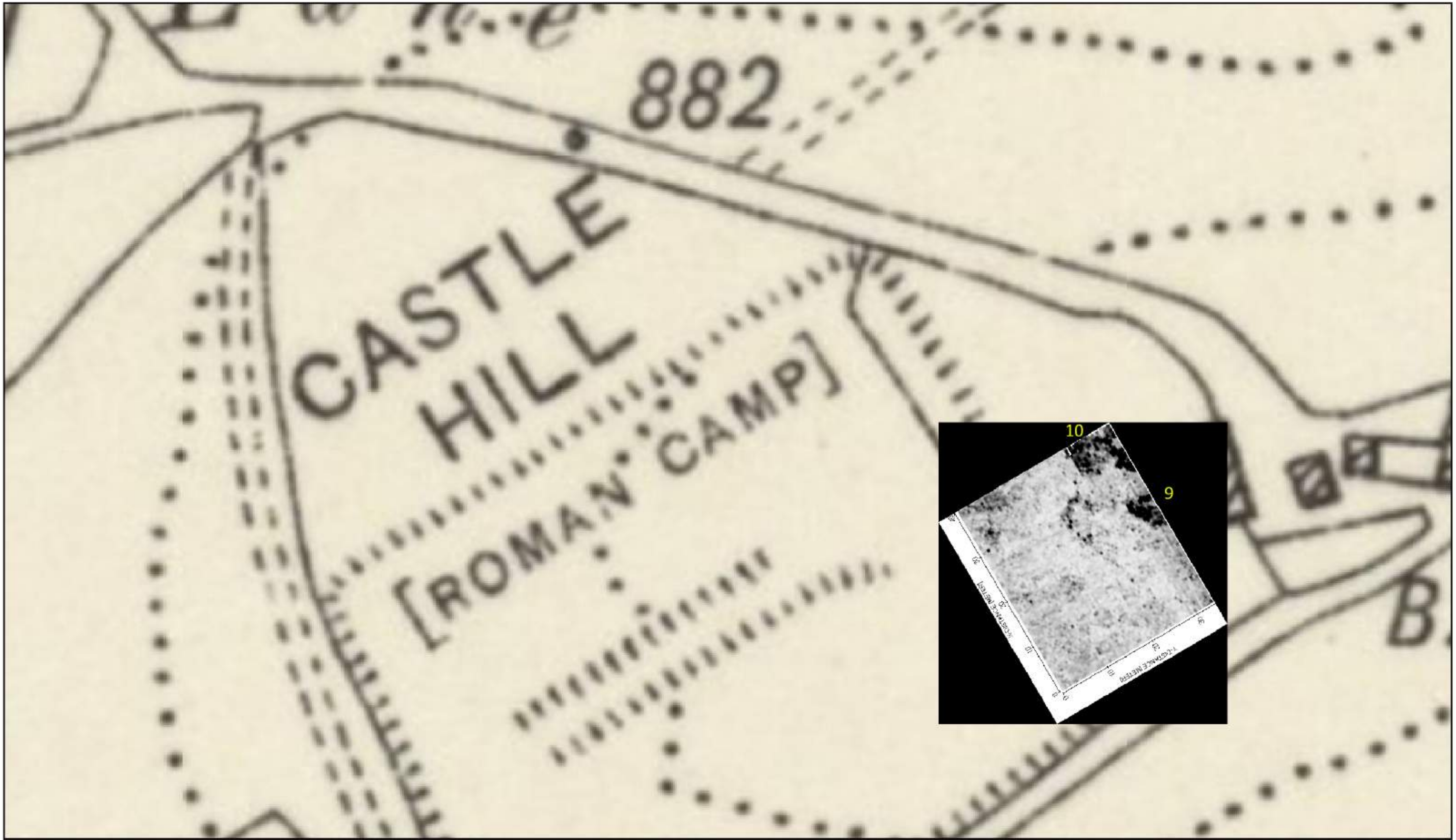
Ordnance Survey six-inch to the mile, 1888-1913 Courtesy of the National Library of Scotland (nls.gov.uk)

Archaeology Probable (High Resistance)
Undetermined (High Resistance)
Archaeology Probable (Low Resistance)
Survey Border

N
W E
S

0 10 20 30 40 m

magnitude surveys



MSSD06 - Castleshaw Roman Fort
Figure 8 - GPR Depth Slice and Interpretation
1 : 1000 @ A4

Ordnance Survey six-inch to the mile, 1888-1913 Courtesy of the National Library of Scotland (nls.gov.uk)

N W E S

0 10 20 30 40 m

magnitude surveys