GSB

PROSPECTION Ltd

GEOPHYSICAL SURVEY REPORT
2007/47

Antonine Wall Phase III
Mumrills

Client:

HISTORIC SCOTLAND

EUROPEAN UNION CULTURE PROGRAMME 2000

Cowburn Farm, Market Street, Thornton, Bradford, West Yorkshire, BD13 3HW

Tel: +44 1274 835016
Fax: +44 1274 830212

Email: gsb@gsbprospection.com
Web: www.gsbprospection.com

Specialising in Shallow and Archaeological Prospection

GSB Survey No. 2007/47

Antonine Wall Phase III: Mumrills

NGR	NS 91900 79400 (west) to NS 92400 79500 (east)
Location	Approximately 3km east of Falkirk in fields to the south of Mumrills Road (now a track) and east of Sandy Loan Road
District / Parish	Falkirk / no parish data available
Topography	Varied: plateau to west sloping steeply to east and south
Current land-use	Rough pasture
Soils	Brown forest soils and non-calcareous gleys. (SSS, 1982)
Geology	Drifts derived from Carboniferous sandstones, shale and limestones
Archaeology	Antonine Wall, Military Way, Mumrills Fort, possible associated features including an "annexe" visible on cropmarks.
Survey Methods	Magnetic (fluxgate gradiometry) and resistance

Aims

To locate, if possible, any traces of the Military Way east of Mumrills Fort; to identify any features associated with the fort, including a possible cropmark enclosure; to identify any other potential archaeology which might be related to the Wall. The work forms part of a continuing programme of research commissioned by **Historic Scotland**, as part of their proposal to promote the Antonine Wall to World Heritage Status.

Summary of Results*

The characteristic responses produced by the Antonine Ditch along other sections of the Wall are not present at Mumrills, where the feature is barely visible in both magnetic and resistance datasets. The reasons for this are uncertain but natural factors are likely to be responsible. By contrast, the Rampart has produced very distinct magnetic and resistance anomalies, suggestive of an (at least partially) intact base. Evidence for the Military Way is highly tentative and apparent only in the resistance data for two of the survey areas.

Both survey techniques have produced generally well defined anomalies associated with the fort ditches and a formerly excavated building inside the fort; in both cases the magnetic results show the greater amount of detail.

Both datasets have detected the "annexe" enclosure, but a second cropmark enclosure has not been clearly identified. There is some evidence for a few possible archaeological features both adjacent to and further east of the fort; in all cases poor anomaly definition or other factors makes this interpretation cautious.

Project Information

Project Co-ordinator: C Stephens
Project Assistants: M Brolly, F Chester, D Shiel, J Smith & G Taylor
Date of Fieldwork: 3rd - 6th Sept & 10th - 14th Dec 2007
Date of Report: 11th April 2008

***It is essential that this summary is read in conjunction with the detailed results of the survey.**

Survey Specifications

Method

For all survey techniques: the survey grid was set out using tapes and tied in to the Ordnance Survey (OS) grid using a Trimble differential GPS system, see tie-in diagrams.

Technique	Traverse Separation	Reading Interval	Instrument	Survey Size
Magnetometer - Scanning (Appendix 1)	-	-	-	-
Magnetometer – Detailed (Appendix 1)	1m	0.25m	Bartington Grad 601-2	6.9ha
Resistance – Twin Probe (Appendix 1)	1m	1m	Geoscan RM15/MPX 0.5m probe separation	3.2ha
Ground Penetrating Radar (GPR) – 250MHz (Appendix 1)	-	-	-	-

Data Processing

	Magnetic	Resistance	GPR
Tilt Correct	Y	N	-
De-stagger	Y	N	-
Interpolate	Y	Y	-
Filter	N	Y	-

Presentation of Results

Report Figures (Printed & Archive CD):	Location, desk based information, data plots and interpretation diagrams on base map (Figures 1-10).
Reference Figures (Archive CD):	Data plots for reference and analysis at 1:500 and 1:1000. Some areas have been subdivided for display at 1:500. (See List of Figures). Tie-in information (Figure T1).
Plot Formats:	See Appendix 1: Technical Information, at end of report.

General Considerations

Conditions for survey in the field containing Mumrills Fort (Area 1) were good, the ground being gently undulating, under short and rough grass, and free from obstructions. East of this (Areas 2 to 5) the land was subdivided by fences not shown on the mapping; these, together with some steep slopes, areas of boggy ground and dense weeds hampered data collection and in some cases limited the area available for survey.

The general impact of the geology on both techniques has been detailed in previous reports (GSB 2006/11 and GSB 2006/80). At Mumrills its effects are very noticeable and particularly severe in the case of the resistance data for Areas 1 and 2. Resistance values in these areas vary between 100 Ohms to over 600 Ohms, a very broad range which is attributed to natural factors. As a result of this large variation, many smaller scale changes of likely or possible significance do not appear particularly distinct in the main data plots. While filtering has helped to remove some of the background effects and enhance the smaller changes, it can sometimes produce spurious results; thus filtered data plots are only presented in the reference figures.

Results of Survey

1. Background Information (Desk Based)

The Antonine Wall

1.1 The course of the Wall is reasonably well mapped along this section. Excavations revealed that the rampart formed the northern arm of Mumrills fort defences, before turning sharply northeastward at (A) (MacDonald & Curle, 1929). Along this section of the Wall, the rampart was constructed, not of turf but of packed earth held in by clay facings. Immediately adjacent to the fort, the stone base survived, but moving eastwards, the remains became increasingly denuded (B), finally disappearing towards the northeastern corner of the field (MacDonald, 1915 p134). A length of stone base was uncovered at approximately (C). Further to the east at (D) the Rampart base was uncovered in a sewer trench, but the position of the Ditch was not established (Keppie, 1976 p63).

1.2 Between (B) and (C), digging uncovered no evidence for the rampart (MacDonald, 1915 p134). As a result of this negative evidence, the OS 1980 survey proposed a revision of the route between these two points, based on field observation and antiquarian records. They argue that the deep cutting (E) that contains the modern road (now a track) must be an old hollow way greatly enlarged from the remains of the Antonine Ditch (OS, 1980).

The Military Way

1.3 The Military Way was identified at the west gate (F) of Mumrills fort and traced westwards in the immediate vicinity; however, at and beyond the east gate (G) it had been wholly destroyed (MacDonald & Curle, 1929 pp498-499). East of the fort, no physical evidence for the road has been recovered until (H), where the road was exposed during construction of a drain (OS, 1980; MacDonald, 1934 p117). The course of the road indicated by the OS 1980 survey between (H) and (I) was based on aerial photographs and topographic considerations and shows only slight variations from MacDonald's line (shown on OS 1950s mapping).

1.4 The course of the road between (I) and the fort is unknown and a matter of debate. MacDonald posits that the road exits the east gate (G) of the fort at a slight northeasterly angle, based on the pattern of the ditches at this point (MacDonald & Curle, 1929 pp418-21); after passing through the ditches it turns almost immediately to follow a northeasterly course parallel to the Wall.

1.5 In contrast, the OS 1980 survey states that the Military Way should run parallel with the south side of the "annexe" (J) (see paragraph 1.9 below) although the available AP evidence for this is inconclusive (OS, 1980). No suggestions are given as to whether the road might cut through the "annexe" or extend the full length of its southern side; the latter course would represent a substantial deviation from MacDonald's postulated line.

Mumrills Fort

1.6 Mumrills fort was systematically excavated over a period of four years, starting in 1923 (MacDonald & Curle, 1929). The main fort defences were mapped and a number of internal features elements investigated, including an area (K) where a complex of features indicated several phases of residential quarters (the Commandant's House) part of which was replaced by a suite of baths.

1.7 Additionally, extensive excavations were carried out in the annexe (L) immediately west of the fort (postulated also to be the site of an earlier Agricolan fort). Pits containing pottery attested to occupation, but no clear structural features were found. However, there was evidence of Roman quarrying in this area with zones of packed sand capped with boulders suggesting the ground being made good in preparation for later use (*ibid.*).

1.8 Parts of the fort and annexe were excavated again in 1958-1960. The results generally corroborated / complemented the earlier findings with regard to the Antonine fort and annexe, but the investigations found no evidence to support the existence of an earlier Agricolan fort (Steer, 1961).

Other Features

1.9 The OS data for the site shows a roughly triangular enclosure (J) appended to the eastern side of the fort labelled as the site of an "annexe". It is to this that the OS 1980 survey refers when discussing the possible line of the Military Way (see paragraph 1.5 above). The feature appears on aerial photographs, but there is no reference to it in any of the earlier literature and no discussion in the OS notes (or elsewhere) of why the fort should have two annexes (the notes also refer to the western annexe). The position of the feature suggests a likely relationship with the fort but its precise function is less certain.

1.10 A cropmark enclosure (M) was investigated in 1958-60 and found to be "a temporary Roman work, bounded by a single ditch"; pottery finds from the ditch fill providing dating evidence. Internally several widely spaced postholes were uncovered but not all of these were Roman in date. The enclosure was thought to have served as a storage area rather than for occupation (Steer, 1961).

1.11 A Roman pottery kiln was discovered in 1913 approximately at (N) (MacDonald, 1915 pp124ff).

2. Results of Magnetic (Gradiometer) survey

Labels (Mn) in the text below refer to specific anomalies annotated on the Geophysical Interpretation, Figure 5. The Archaeological Interpretation is given in Figure 6.

Area 1

2.1 The Antonine Ditch is poorly represented in the dataset, appearing only as a short, somewhat ill-defined negative linear (M1). This is in marked contrast to the responses produced by the fort ditches (see paragraph 2.5 below). The reasons for this are uncertain, but it may reflect a localised change in soils / geology.

2.2 A roughly 4m wide discrete band of noisy (increased magnetic) responses (M2) represents the Antonine Rampart; this is the most coherent representation of this element detected by the surveys to date and suggests an intact Rampart base. The form of the anomalies would indicate that the cobbles of the base are strongly magnetic, an interpretation supported by findings elsewhere (GSB 2007/45). The responses become less well defined towards the northeastern corner of the field and this ties in well with MacDonald's findings (paragraph 1.1 above).

2.3 The linear / rectilinear pattern of trends (M3) coincide with the mapped line of the Antonine Ditch and Rampart, but the responses are too ill-defined to enable any firm interpretation and they have, therefore simply been categorised as *?Archaeology*.

2.4 No anomalies have been identified that can be obviously linked with the Military Way. As discussed in paragraphs 1.3 to 1.5 above, the course of the road exiting the east gate of the fort is uncertain. If, as the OS 1980 survey suggests, it respects the "annexe", rectilinear anomaly (M4) may be of interest due to its alignment and position with respect to the Wall and "annexe". However, the anomaly extends only a short distance and its form seems more suggestive of a ditch rather than a cobbled road base; as such its significance remains unclear and it has been assigned to the *?Archaeology* category.

2.5 The eastern ditches of the fort appear as mostly well defined negative anomalies (M5) and the level of detail, particularly at the east gate, accords well with excavation plans.

2.6 Inside the fort, the anomalies (M6) represent the Commandant's House. The pattern indicates individual wall lines, and although positive anomalies are more commonly associated with ditch features, they can be produced by foundations constructed of brick or strongly magnetic stone. That said, the resistance data show low resistance (i.e. ditch type) responses over the building (see paragraph 3.6 below). There is a remote possibility (M6) represent the lines of excavated features, backfilled with magnetic material. The level of detail is reasonable in the northern range, but decreases to the south, where excavations showed several phases of building and reconstruction.

2.7 Although a few other discrete (primarily positive) anomalies have been identified within the fort, for the most part they do not form any patterns which would enable a firm archaeological interpretation.

2.8 Negative and positive anomalies (M7) represent the "annexe" enclosure and correspond more closely with the cropmarks than the OS mapping of this feature. The responses are ill defined along the east-west arm and do not extend fully to the edge of the fort. No anomalies have been identified within the "annexe" which can be assigned any archaeological significance.

2.9 The strong responses (M8) are roughly rectilinear and correspond with anomalies in the resistance data (see paragraph 3.11 below); as such, they may be of archaeological interest, possibly indicating structural remains. They are on broadly the same alignment as the fort, but not the southern arm of the "annexe"; however their relationship, if any, with either cannot be determined.

2.10 There are hints of a narrow rectangular enclosure (M9) appended to the fort ditches; the poor definition of the responses makes an archaeological interpretation tentative.

2.11 The anomalies (M10) are dipolar (strong positive/negative); such anomalies are normally attributed to unstratified ferrous debris in the topsoil and assigned a modern origin. However, debris from a kiln can produce dipolar responses and, given that a pottery kiln was noted at approximately this location, the possibility that (M10) reflect associated material cannot be ignored. That said, the anomalies do not seem to be consistent with an intact kiln feature.

2.12 Broad zones of increased magnetic response (M11) and (M12) have been detected; although they have different forms, both are thought to be natural in origin. Responses (M11) are positive and appear to form an intermittent band across the survey area. Zone (M12) comprises strong positive and negative anomalies and has a distinct curving edge. It lies on the highest part of this field and it may be the bedrock is closer to the surface at this point (an interpretation supported by the resistance results). However, there is no distinct topographic change to suggest a natural cause for this edge which may, therefore, have been caused by a deliberate "cut". Evidence for Roman quarrying is present west of the fort and it may be that the edge reflects similar activity here, although this interpretation is highly speculative.

2.13 The cropmark enclosure noted in paragraph 1.10 above lies within zone (M12). Although some trends (M13) occupy roughly the correct position, they are difficult to define within the high background noise levels and an archaeological interpretation is tentative. Further to the west, hints of rectilinear trends can just be discerned; an archaeological interpretation for these is similarly cautious.

2.14 Strong negative anomalies (M14) represent the continuation of a probable natural feature in Area 2 (see paragraph 2.18 below).

2.15 A number of other anomalies and trends have been highlighted on the geophysical interpretation. With the exception of a possible circular trend on the line of the Rampart, none form patterns which would support an archaeological interpretation; while their precise origin remains unclear, a combination of natural, agricultural or modern factors seem probable.

Area 2

2.16 No anomalies consistent with the Antonine Ditch or Rampart have been detected in this area. The OS mapping places the Ditch just outside the survey block under the road, while the projected line of the Rampart runs along its northern edge. However, given the poor representation of the Ditch in Area 1, this absence of evidence cannot be taken as definitive proof for the OS line.

2.17 No responses suggesting an intact road surface have been identified. The negative and positive anomalies at (M15) occupy a position closest to the projected line of the Military Way but they correspond to the edge of a high resistance zone that suggests they have a natural origin, probably representing an outcrop of bedrock.

2.18 The responses at (M16) lie on sloping ground and are likely to reflect a similar outcrop; they continue in to Area 1 (paragraph 2.14 above). South of (M16) an area of increased response and several discrete responses and weaker trends are all thought to reflect natural variations or modern factors.

2.19 The positive anomalies and trends at (M17) show hints of rectilinearity and may therefore be of archaeological interest. Together with a short linear in Area 3 (paragraph 2.21 below) they could form part of an enclosure, possibly appended to the Wall. It must be stressed, however, that this apparent pattern is incomplete; an archaeological interpretation is cautious and a combination of natural and modern factors must be equally considered.

Area 3

2.20 No anomalies which can be clearly related to the Antonine Ditch or Rampart have been identified in this block. The projected line of the Military Way runs outside the area to the south; unfavourable ground conditions precluded expansion of the survey to cover this feature.

2.21 A short positive response (M18) may be related to anomalies (M17) above and therefore be of archaeological interest; however, its position may be fortuitous and its archaeological significance is questionable.

2.22 None of the other anomalies in this survey block form patterns that would support an archaeological interpretation; a combination of natural, agricultural and modern factors are thought to be responsible.

Area 4

2.23 This area is magnetically noisy throughout and most of the responses are thought to arise from natural or modern factors. This background fluctuation, together with the limited size of the survey block, has made it difficult to ascertain patterns in the data that might be significant.

2.24 An indistinct band of negative response (M19) may have been produced by the Antonine Ditch, but this interpretation is based largely on the position of the anomaly, relative to the predicted line, rather than the clarity of the results. Even more inconclusive is the interpretation of a few short positive linears (M20) which might reflect material from the Rampart, but they are unlikely to indicate a fully intact Rampart base.

2.25 Elsewhere within the background noise, a positive anomaly that shows hints of rectilinearity has been highlighted as *?Archaeology*, although a natural origin for this is equally tenable.

Area 5

2.26 Severe magnetic disturbance is present throughout this low lying survey block. Several orders of magnitude stronger than the "natural" responses recorded elsewhere, these anomalies are consistent with a spread of ferrous material presumed to be modern in origin; they may have been deposited during construction of the adjacent road junction, though this is speculative. The

magnetic disturbance will have masked any (comparatively) weaker archaeological type responses if present.

2.27 Although several trends have been highlighted within the magnetic disturbance, these reflect alignments of ferrous type responses and are not thought to be archaeologically significant.

3. Results of Resistance Survey

Labels (Rn) in the text below refer to specific anomalies annotated on the Geophysical Interpretation, Figure 9. The Archaeological Interpretation is given in Figure 10.

Area 1

3.1 The northern edge of the survey area displays generally lower resistance values; within this no discrete anomalies (either low or slightly higher resistance) can be discerned that could be definitively assigned to the Antonine Ditch. While faint trends (R1) do follow the "correct" alignment, they are far from obvious, even in the filtered data; given a similar lack of clarity in the magnetic data (see paragraph 2.1 above), this interpretation remains cautious.

3.2 High resistance linear (R2), roughly 4m wide is likely to represent the Rampart; the nature of the response suggests an intact (or partially intact) base. There are hints in the filtered data of the turn and continuation of the Rampart along the northern edge of the fort.

3.3 There is no clear evidence in the resistance data for the Military Way. Low resistance anomaly (R3) corresponds to magnetic anomaly (M4) discussed in paragraph 2.4 above. Low resistance is more usually associated with ditch features; although it could occur if moisture collected in a slight depression left by the remnants of a road, such an interpretation is highly speculative. As with its magnetic counterpart, it has been classified simply as *?Archaeology*.

3.4 The eastern ditches of the fort appear as low resistance anomalies (R4); the responses are less well defined than their magnetic equivalents and display less detail. This is not simply a function of the broad range of readings described in the *General Considerations*, as filtering has not enhanced the anomaly definition. The lack of clarity is attributed to an insufficient contrast in moisture retention between the ditch fill and the surrounding soils.

3.5 Despite its low resistance form, anomaly (R5) does not represent the ditch but corresponds with the internal rampart shown on excavation plans. A rampart might normally be expected to produce higher resistance values; there are two possible explanations for the low resistance, both arising from the fact that the site was excavated. It may be that intact foundations survive but that water has collected in the soil backfill above them. Alternatively it could be that the foundations were removed leaving slight depressions in which moisture has collected.

3.6 Anomalies (R6) represent parts of the Commandant's House. The pattern indicates individual wall lines but, as with (R5) above, the responses are low, not high resistance. The area of lower resistance immediately south of the building detail covers the part of the complex that was remodelled in antiquity (from residential to bath house); the absence of detail here is likely to arise both from the sheer density of features and their excavation.

3.7 Elsewhere within the fort a few faint trends can be discerned which, by virtue of their apparent patterns, may be of archaeological interest, though no firm interpretation can be given.

3.8 Low resistance anomaly (R7) represents the "annexe" enclosure and the form indicates a ditch feature. It is better defined than its magnetic counterpart and again corresponds well with the aerial photographic evidence (rather than the OS mapping of the feature).

3.9 No discrete anomalies have been identified within the "annexe" that might help to clarify its function. High resistance anomaly (R8) is broadly rectilinear and could therefore be of interest, but its position and alignment could, arguably, suggest a relationship with the Rampart rather than the "annexe". The response seems too broad to represent discrete wall lines, but could

indicate an area of building debris. However it is not especially well defined and an archaeological interpretation is tentative.

3.10 Broad areas of higher resistance (R9) and (R10) visually dominate the central and southeastern portion of the dataset. Zone (R9) corresponds to the increased magnetic response (M12) described in paragraph 2.12 above and has the same distinct edge. The edges of zone (R10) are also fairly well defined and seem to be broadly rectilinear, with an alignment roughly parallel to the fort. Between them (apart from one smaller "bridge" of higher resistance) is a clear lower resistance band that gives the impression of a channel. A completely natural origin - e.g. a riverborne or glacial channel (lower resistance) between two rock outcrops (high resistance) - for this pattern of responses cannot be entirely dismissed, but the apparent rectilinearity of the outline of (R10) might support an anthropogenic interpretation. The results could represent a deliberate cut through a single natural outcrop. Alternatively, the edge of (R9) could indicate the limits of quarrying activity, in which case (R10) might represent an area of ground that was deliberately consolidated/landscaped for some reason. It should be noted that the "annexe" anomaly appears to "cut" through (R10). If the latter interpretation is correct, this suggests the landscaping predates the construction of the "annexe", though it is very difficult to date phases of activity based on geophysics alone.

3.11 While several discrete anomalies have been identified within the areas of higher resistance, only a few of these display patterns that might support an archaeological interpretation. High resistance responses (R11) partially correspond with magnetic anomalies (M8) and are broadly rectangular which could indicate the rubble remains of a building. However it is difficult to determine their exact shape, making an archaeological interpretation tentative. Even more cautious is the archaeological interpretation of trends (R12), barely visible within the general background and with no magnetic counterparts.

3.12 Anomaly (R13) comprises a roughly oval shape of very high resistance readings, roughly 20m by 16m along its axes, with a distinct circular "hole" of comparatively lower resistance, approximately 5m in diameter, in the centre. It lies just to the west of the cropmark enclosure described in paragraph 1.10. Although the shape of the high resistance could suggest an anthropogenic origin (building rubble or an area of highly compacted ground) a natural cause seems equally if not more likely. However, it is the "hole" that may be of interest. It is difficult to see what natural feature could produce such a response and the impression is of a deliberate cut, possibly for a well. However, no clear corresponding anomalies can be discerned in the magnetic dataset, making an archaeological interpretation cautious at best.

Area 2

3.13 The projected line of the Antonine Ditch lies just outside the survey area under the road; that of the Rampart along the northern grid edge. No anomalies suggestive of a Rampart have been identified; however surface obstructions limited data collection at this point.

3.14 A band of marginally higher resistance and trends (R14) roughly 4m wide occupies an alignment and position that corresponds to the OS projected line of the Military Way. As a result of natural factors (see *General Considerations* and paragraph 3.15 below) the responses are not visually prominent, but may, nonetheless, represent the remains of a road. If a cobbled surface survived completely intact one might expect a more coherent high resistance response; however the results could have been produced by compacted ground on which the cobbles had been laid. It should be stressed that this interpretation is cautious and based as much on the expectation of a feature as the nature of the responses themselves.

3.15 A zone of very high resistance (R15) coincides with a topographic change and is likely to be natural in origin, suggesting a reduction in depth of soil over bedrock. Other higher and lower resistance responses in this block are thought to reflect a combination of natural and modern factors.

Area 4

3.16 The highest resistance values recorded in this block form a discrete rectilinear band (R16) which lies within a wider zone of higher resistance which also forms a rectilinear pattern. The east-west arm of (R16) lies on the edge of the mapped line of the Antonine Ditch. Although the Ditch has produced higher resistance anomalies along other sections of the wall, the values of (R16) are particularly high compared to the general background. The apparent rectilinear patterns of (R16) and the wider high resistance zone might suggest an anthropogenic rather than a natural origin and have been tentatively classified as *?Archaeology*; however a more recent origin is equally tenable. In either case the responses seem unlikely to relate to any element of the Antonine Wall.

3.17 A few other higher and lower resistance anomalies are present; these do not form any obvious patterns and no firm interpretation can be assigned.

Area 5

3.18 This block was positioned specifically to investigate the line of the Military Way at a location closest to an excavated section of this feature, some 100m to the east.

3.19 No anomalies are present along the OS projected line of the Roman road. Higher resistance anomalies and trends (R17) have the correct alignment and lie some 10m to the north, coinciding with the line shown on earlier mapping. The anomalies are ill-defined; if they do represent the Military Way they are likely to reflect denuded remains rather than a fully intact road surface.

3.20 A strong element of caution is attached to the above interpretation, as (R17) appear to merge with a wider mostly rectilinear pattern of high resistance responses that extends across most of the dataset. This rectilinear pattern would suggest an anthropogenic origin and the anomalies have therefore been classified as potential archaeology. However, given the widespread ferrous disturbance recorded in the magnetic results, it seems equally, if not more likely that these higher resistance linears reflect modern features.

4. Conclusions

4.1 Unlike many of the other sections of the Wall that have been investigated, the Antonine Ditch at Mumrills is poorly represented in both magnetic and resistance datasets. By contrast, the current survey has yielded the clearest evidence to date for the Rampart base. Also generally well defined in both datasets, are anomalies associated with the fort ditches and a formerly excavated building inside the fort; in both cases the magnetic results show the greater detail.

4.2 Evidence for the Military Way is highly tentative and apparent only in the resistance data in two of the survey areas. Both datasets have detected the "annexe" enclosure, but a second cropmark enclosure has not been clearly identified. There is some evidence for a few possible archaeological features both adjacent to and further east of the fort; in all cases poor anomaly definition or other factors makes this interpretation cautious.

4.3 The reasons for the poor responses over the Ditch are not fully understood, particularly in light of the relatively coherent anomalies over other features. It seems unlikely that the Ditch has become too denuded to produce readily identifiable anomalies; rather it is suggested that a localised change in the soils and geology may be responsible.

References

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List of Figures

Report Figures

Reference Figures on CD

Appendix 1: Technical Information

Instrumentation

Fluxgate Gradiometer: Geoscan FM36/256 and Bartington *Grad*601-2

Both the Geoscan and Bartington instruments comprise two fluxgate sensors mounted vertically apart; the distance between the sensors on the former is 500mm, on the latter 1000mm. The gradiometers are carried by hand, with the bottom sensor approximately 100-300mm from the ground surface. At each survey station, the difference in the magnetic field between the two fluxgates is measured in nanoTesla (nT). The sensitivity of the instrument can be adjusted; for most archaeological surveys the most sensitive range (0.1nT) is used. The fluxgate gradiometer suppresses any diurnal or regional effects. Generally, features up to 1m deep may be detected by this method. Having two gradiometer units mounted laterally with a separation of 1000mm, the Bartington instrument can collect two lines of data per traverse.

Resistance Meter: Geoscan RM15

This instrument measures the electrical resistance of the earth, using a system of four electrodes (two current and two potential.) Depending on the arrangement of these electrodes an exact measurement of a specific volume of earth may be acquired. This resistance value may then be used to calculate the earth resistivity. The most common arrangement is the Twin Probe configuration which involves two pairs of electrodes (one current and one potential): one pair remain in a fixed position, whilst the other measures the resistance variations across a grid. The resistance is measured in ohms and, when calculated, resistivity is in ohm-metres. The resistance method as used for standard area survey employs a probe separation of 0.5m, which samples to a depth of approximately 0.75m. The nature of the overburden and underlying geology will cause variations in this depth.

GPR: Sensors & Software Noggin Smartcart

The Noggin system includes an onboard digital video logger (DVL III), 250 MHz or 500MHz antenna, an odometer wheel and battery. It is, therefore, a fully integrated system. The built-in software uses the integrated odometer to provide an accurate distance measurement to the response. The data are recorded in digital format and can be processed to produce depth slice maps, 2D sections or 3D cubes.

Display Options

XY Trace

This involves a line representation of the data. Each successive row of data is equally incremented in the Y axis, to produce a stacked profile effect. This display may incorporate a hidden-line removal algorithm, which blocks out lines behind the major peaks and can aid interpretation. The advantages of this type of display are that it allows the full range of the data to be viewed and shows the shape of the individual anomalies. The display may also be changed by altering the horizontal viewing angle and the angle above the plane. The output may be either colour or black and white.

Greyscale

This format divides a given range of readings into a set number of classes. Each class is represented by a specific shade of grey, the intensity increasing with value. All values above the given range are allocated the same shade (maximum intensity); similarly all values below the given range are represented by the minimum intensity shade. Similar plots can be produced in colour, either using a wide range of colours or by selecting two or three colours to represent positive and negative values. The assigned range (plotting levels) can be adjusted to emphasise different anomalies in the data-set.

Relief Plot

This is a method of display that creates a three dimensional effect by directing an imaginary light source on a given data set. Particular elements of the results are highlighted depending on the angle of strike of the light source. This display method is particularly useful when applied to resistance data to highlight subtle changes in resistance that might otherwise be obscured.

3D Surface Plot

This is similar to the XY trace, but in 3 dimensions. Each data point of a survey is represented in its relative position on the *x* and *y* axes and the data value is represented in the *z* axis. This gives a digital terrain, or topographic effect.

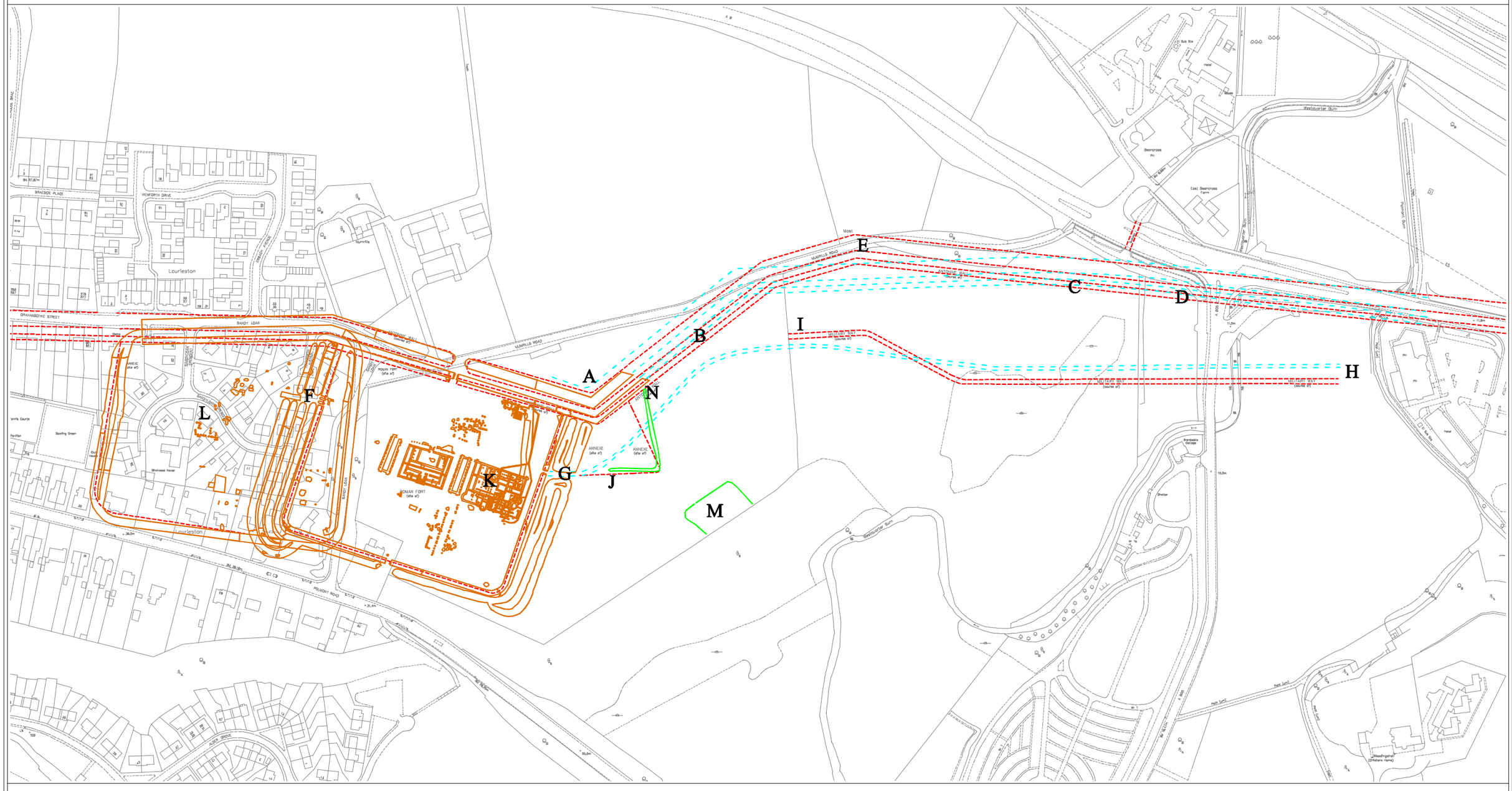
Radargram

Radar data comprise a record of reflection intensity against the time taken for the emitted energy to travel from the transmitter down to the reflector and back to the receiver. The resultant plot is effectively a vertical section through the ground along the line of the traverse, with time (depth) on the vertical axis, displacement on the horizontal axis and reflection intensity as a grey or colour scale.

Time Slice

If a number of radargrams are collected over a grid, or in conjunction with GPS data, it is possible to reconstruct the entire dataset into a 3D volume. This can then be resampled to compile 'plan' maps of response strength at increasing time (or depth) offsets, thus simplifying the visualisation of how anomalies vary beneath the surface across a survey area.

GSB PROSPECTION Ltd.	PROJECT: 2007/47 Antonine Wall III - Mumrills	TITLE: Desk Based Assessment



Antonine Wall and related features - OS 1980 (current)

Antonine Wall and related features - MacDonald / OS 1940s

Fort Plan (excavations)

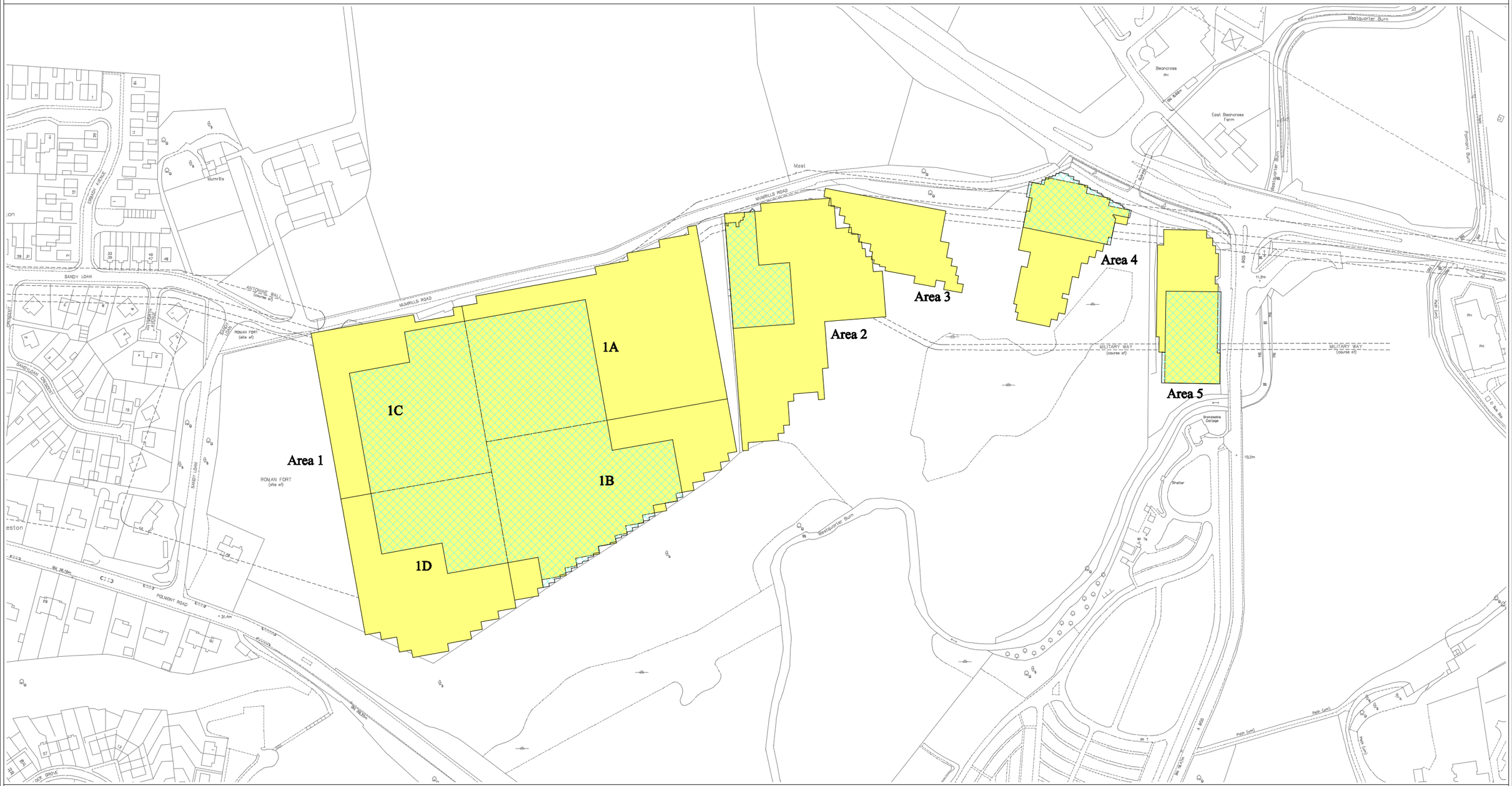
Cropmarks (approximate)

0 metres 120

Fort plan data provided as DXF layers by RCAHMS.
Aerial Photographic transcription provided as unscaled image by RCAHMS: approximate positioning in drawing by GSB
Historic map images, 1951 & 1980 working Ordnance Survey maps provided by RCAHMS

Figure 1

GSB PROSPECTION Ltd.	PROJECT: 2007/47 Antonine Wall III - Mumrills	TITLE: Location of Survey Areas



Gradiometer Survey (showing reference plot subdivisions)

Resistance Survey

0 metres 100

Figure 2

GSB PROSPECTION Ltd.	PROJECT: 2007/47 Antonine Wall III - Mumrills	TITLE: Magnetic Data - Greyscales

10
nT
-5

0 metres 80

Figure 3

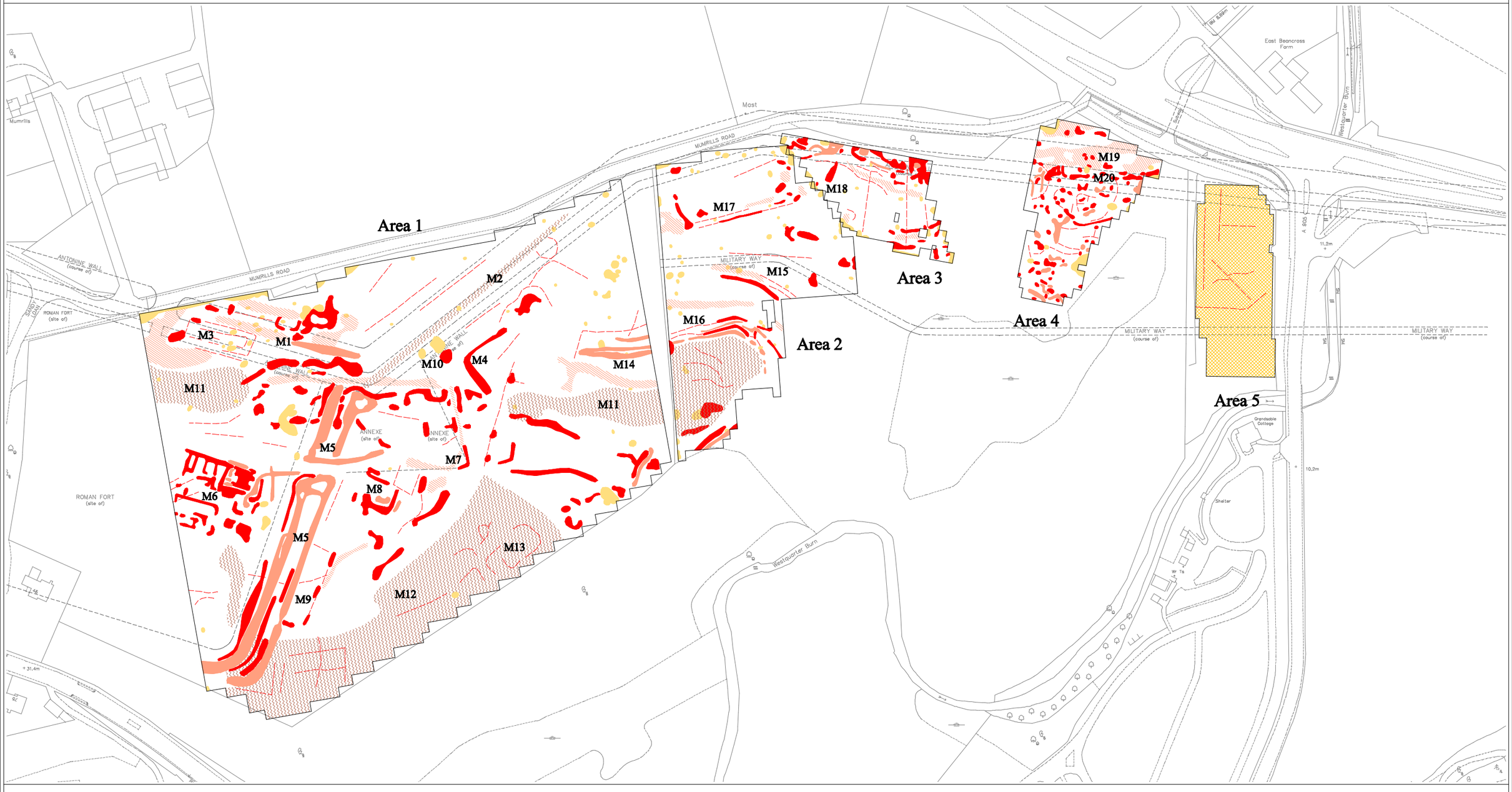
GSB PROSPECTION Ltd.	PROJECT: 2007/47 Antonine Wall III - Mumrills	TITLE: Magnetic Data - Greyscales

0 metres 80

20 nT -10

Figure 4

GSB PROSPECTION Ltd.	PROJECT: 2007/47 Antonine Wall III - Mumrills	TITLE: Magnetic Data - Geophysical Interpretation



Positive Magnetic Anomaly

Negative Magnetic Anomaly (Discrete / Amorphous)

Trend

Increased Magnetic Response

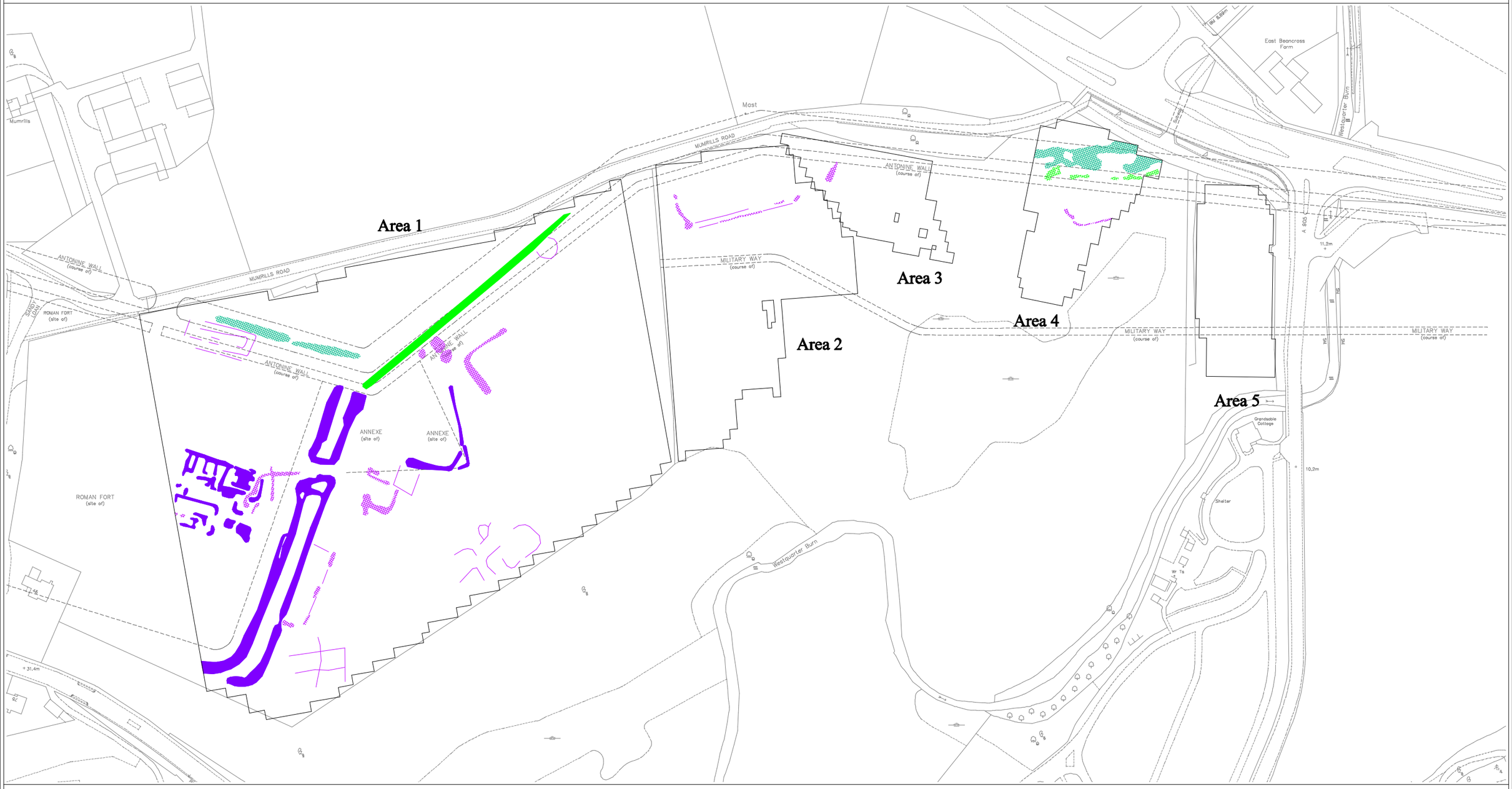
Magnetic Disturbance

Magnetic Dipole (Ferrous)

0 metres 80

Figure 5

GSB PROSPECTION Ltd.	PROJECT: 2007/47 Antonine Wall III - Mumrills	TITLE: Magnetic Data - Archaeological Interpretation



Antonine Wall - ?Ditch

Antonine Wall - Rampart

Antonine Wall - ?Rampart

Archaeology

?Archaeology

0 metres 80

Figure 6

GSB PROSPECTION Ltd.	PROJECT: 2007/47 Antonine Wall III - Mumrills	TITLE: Resistance Data - Greyscales

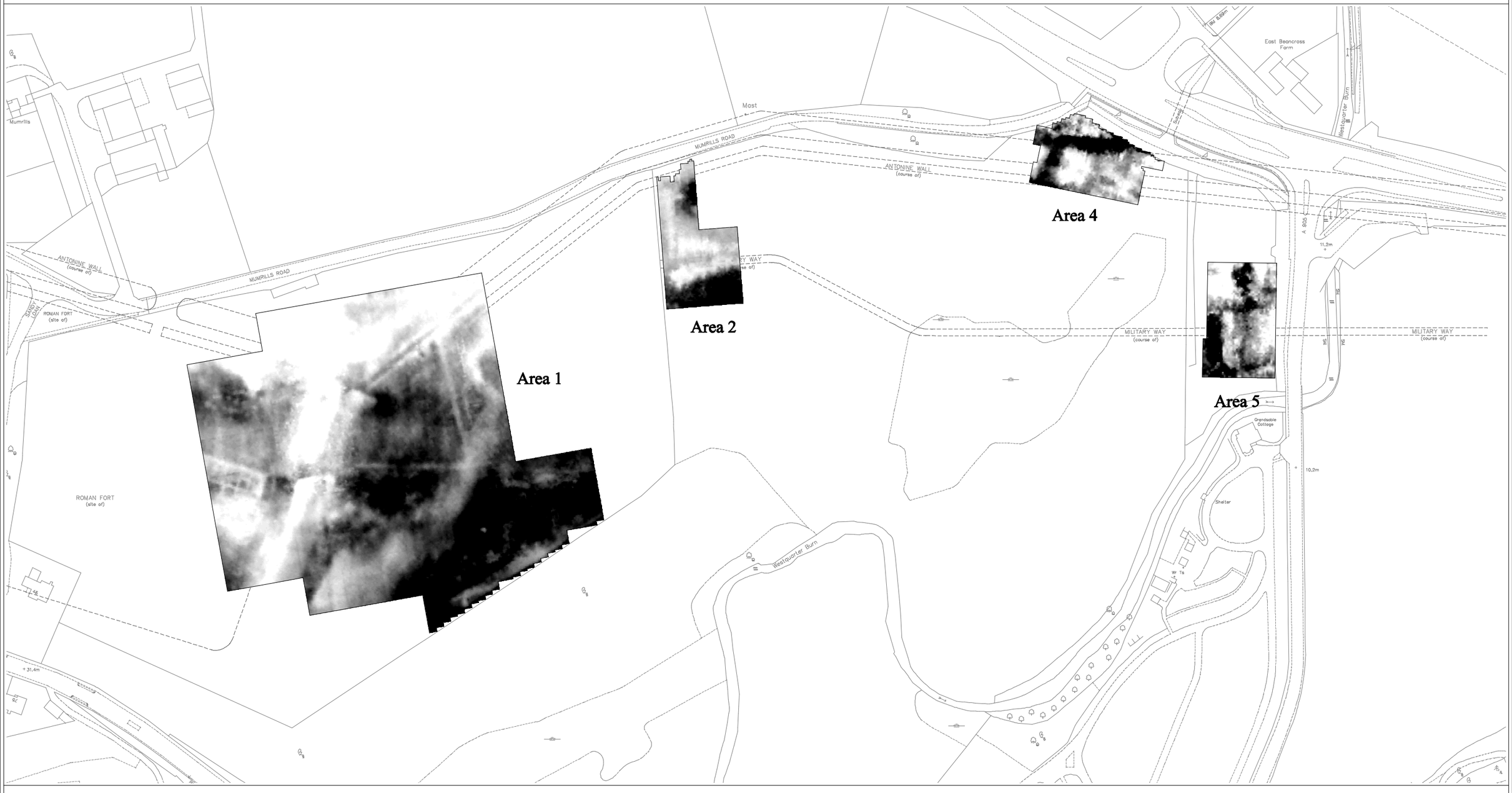
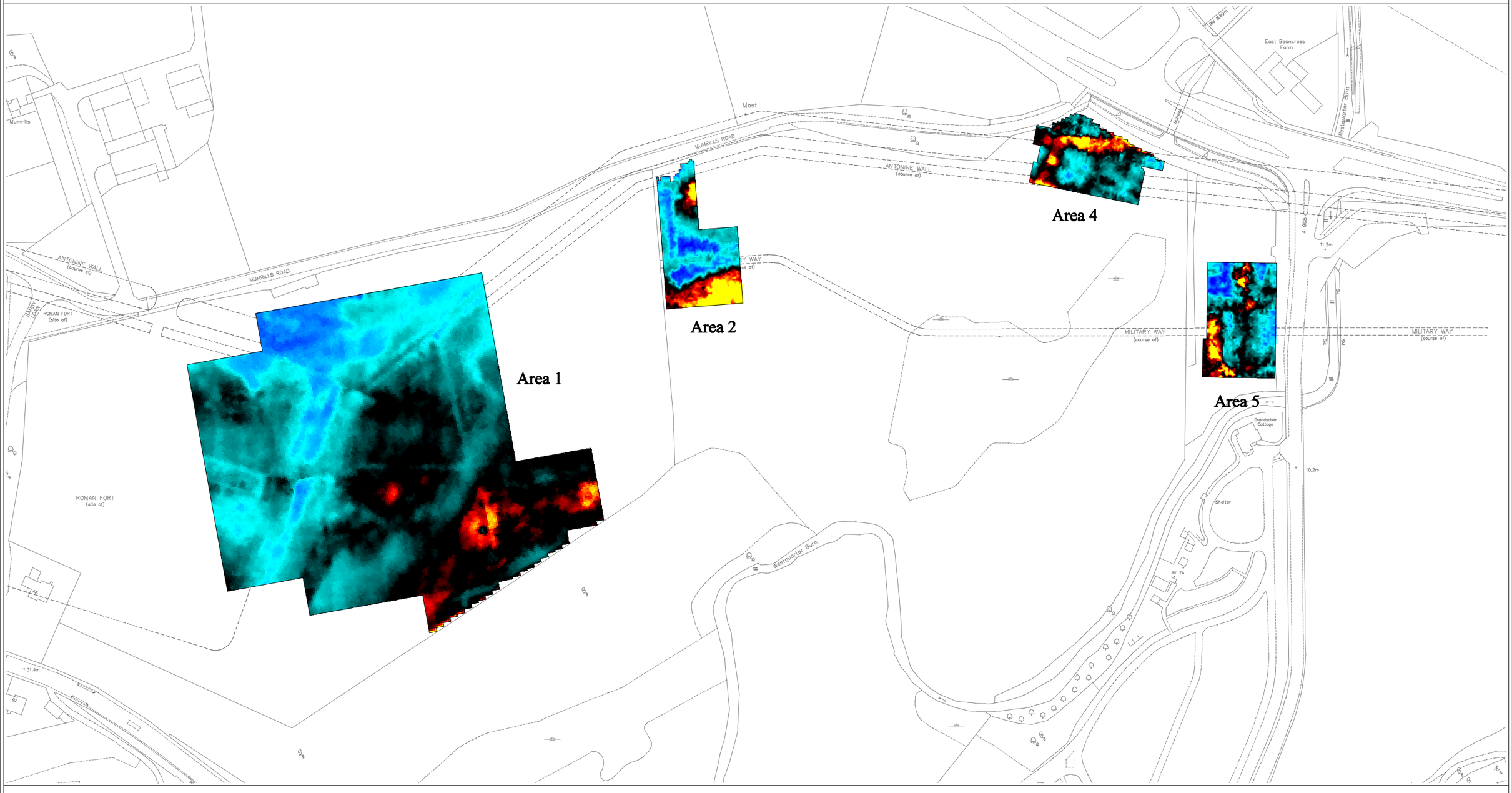


Figure 7

GSB PROSPECTION Ltd.	PROJECT: 2007/47 Antonine Wall III - Mumrills	TITLE: Resistance Data - Colour Plots



Areas 1 & 2: 500 Ohms 100

Area 4: 100 Ohms 50

Area 5: 80 Ohms 30

0 metres 80

Figure 8

GSB PROSPECTION Ltd.	PROJECT: 2007/47 Antonine Wall III - Mumrills	TITLE: Resistance Data - Geophysical Interpretation

Discrete High Resistance Anomaly

Discrete Low Resistance Anomaly

Area of High Resistance

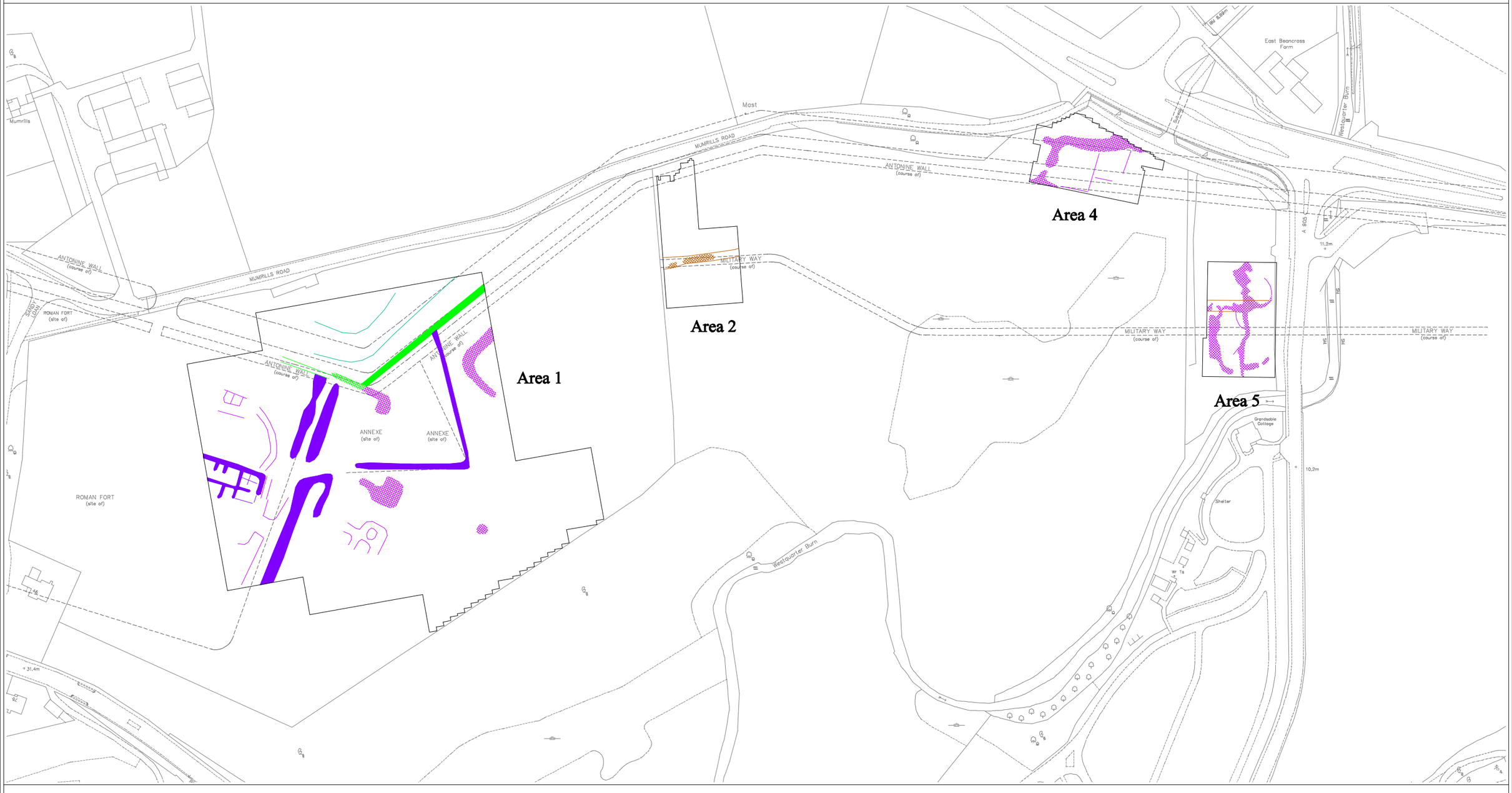
Area of Low Resistance

Trend

0 80 metres

Figure 9

GSB PROSPECTION Ltd.	PROJECT: 2007/47 Antonine Wall III - Mumrills	TITLE: Resistance Data - Archaeological Interpretation



Antonine Wall - ?Ditch

Antonine Wall - Rampart

Antonine Wall - ?Rampart

Antonine Wall - ?Military Way

Archaeology

?Archaeology

0 80

metres

Figure 10