GSB

PROSPECTION Ltd

GEOPHYSICAL SURVEY REPORT
2007/46

Antonine Wall Phase III
Inveravon Fort

Client:

HISTORIC SCOTLAND

EUROPEAN UNION CULTURE PROGRAMME 2000

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Specialising in Shallow and Archaeological Prospection

GSB Survey No. 2007/46

Antonine Wall Phase III: Inveravon Fort

NGR	NS 951 797
Location	A single field between the A905 and the River Avon, c.1km south of Grangemouth.
District / Parish	Falkirk / no parish data available.
Topography	High ground to the east, sloping relatively steeply down to the river in the south and west.
Current land-use	Arable; under a short grass crop at the time of survey.
Soils	Non-calcareous gleys, raised beach terraces formed from a parent of drift silt and clay deposits (SSS, 1982).
Geology	Carboniferous sedimentary: primarily sandstone with some igneous intrusions / extrusions.
Archaeology	Antonine Wall, Military Way, Fort, possible associated features.
Survey Methods	Magnetic (fluxgate gradiometry) and resistance.

Aims

To identify and accurately locate the Antonine Wall, any traces of the Military Way, the Fort at Inveravon and any possible associated features. 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 Antonine Ditch has been detected by the magnetic survey but the anomaly varies in strength and definition; it does not appear with any clarity in the resistance results. The Rampart has been identified tentatively and intermittently in the resistance data, but has remained largely undetected by the magnetic survey. Anomalies which might relate to the Military Way are apparent in the magnetic results but the interpretation is far from confident and alternative origins are equally, if not more likely.

Neither geophysical technique has successfully mapped the limits of the Fort or detected any of its main defences. Resistance anomalies within the presumed area of the fort may reflect rubble associated with collapsed buildings but no discrete wall lines have been identified. Both surveys have yielded anomalies associated with cropmarks, but the exact nature and function of these features remains unclear.

Since excavation has confirmed the presence and survival of archaeological features at Inveravon, their general under-representation in the geophysical datasets is attributed to a combination of natural and modern factors.

Project Information

Project Co-ordinator: C Stephens
Project Assistants: E Collier, R Green & G Taylor
Date of Fieldwork: 10th - 14th March 2008
Date of Report: 29th May 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 an EDM and tapes and tied in to the Ordnance Survey (OS) grid using a Trimble differential GPS system; see tie-in diagram included on the Archive CD.

Technique	Traverse Separation	Reading Interval	Instrument	Survey Size
Magnetometer - Scanning (Appendix 1)	-	-	-	-
Magnetometer – Detailed (Appendix 1)	1m	0.25m	Bartington Grad 601-2	3.3ha
Resistance – Twin Probe (Appendix 1)	1m	1m	Geoscan RM15/MPX 0.5m probe separation	1.23ha
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 1-8).
Reference Figures (Archive CD):	Data plots for reference and analysis at 1:500 and 1:625. The magnetic survey has 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 data collection were good, the ground being under a short crop and free from obstructions.

The general impact of the geology on both techniques has been detailed in previous reports (GSB 2006/11 and GSB 2006/80). To summarise: natural factors have sometimes made it difficult to isolate and interpret weaker and particularly non-linear responses with any degree of certainty. The presence of several pipes crossing the survey area has further hampered analysis of the magnetic data: these have produced dipolar (ferrous) anomalies up to 20m wide which will have totally masked any underlying weaker responses.

Results of Survey

1. Background Information (Desk Based)

The Antonine Wall

1.1 The course of the Wall across the current area of investigation is well mapped. MacDonald (1925 pp271-273) traced the line of the Ditch across the field by trenching, both close to the river and further upslope to the northeast (no detailed description of trench location is given). The OS 1980 survey made minor revisions to his line based on new excavation evidence (OS 1980). The Antonine Ditch is also clearly visible on aerial photographs.

1.2 Most recently, excavations carried out by the Centre for Field Archaeology (CFA) in advance of a pipeline revealed all the elements of the Wall (Outer Mound, Ditch, Berm and Rampart). Parts of the Rampart superstructure survived, formed of turf and clay, while the base was constructed predominantly of imported Millstone Grit with some river cobbles, bonded by stiff yellow clay (Dunwell & Ralston, 1995). The Ditch and Rampart are indicated schematically in Figure 1 and the latter appears to be offset by some 2m from OS Rampart line. It should be stressed that the positions of the excavated features shown on Figure 1 are only approximate, having been digitised from an online image.

The Military Way

1.3 The CFA excavations also uncovered a section of the Roman road, located approximately 13.2m south of the Wall. It was approximately 5.2m wide and comprised a cambered surface of pebbles overlying a cobbled foundation (*ibid.*).

Fort

1.4 Based on the conventional regular spacings of Forts along the Antonine Wall a Fort would be expected to be located somewhere in the Inveravon area. Early antiquarians placed the Fort on the higher ground close to Inveravon Farm, where a medieval tower (A) was erroneously taken to represent the site of the Fort. MacDonald (1925 pp272-273 and 1934 p194) suggested the current field as a more likely position, based on two factors. Firstly, he noted a distinct change in the alignment of the Wall on either side of the River Avon (B), which could not be explained by obvious topographical factors but might have arisen to accommodate a Fort. Secondly, his excavations uncovered stone features that could not be related to the Rampart, but rather suggested occupation. Although he was unable to date these features, he noted that a single fragment of mortarium was uncovered amongst the stones.

1.5 In 1967 excavations approximately at (C) uncovered stone wall foundations and cobbled surfaces that indicated two phases of Antonine occupation. Trenches further to the northeast at (D) yielded no evidence for Roman occupation; a section of intact Rampart base was revealed, suggesting that any other Roman stone features should also survive, if present (Robertson, 1969 summarised in Dunwell& Ralston, 1995).

1.6 Despite the limited width of the CFA trench, a number of features were revealed which indicate three phases of Roman occupation, the most prominent of which are schematically represented in Figure 1 (taken from Dunwell & Ralston, 1995). Building remains and a furnace were uncovered, together with a "southern rampart" of similar construction to the Antonine Rampart but no evidence for any associated ditch was identified. An external road, damaged by later incursions, ran immediately south of the southern rampart. It has been suggested that these remains, situated on low ground prone to flooding, represent part of an annexe, with the fort itself located on the sloping higher ground to the northeast, arguably a more logical position (Bailey, 1994 p300 & 304). However in their discussion of results Dunwell & Ralston cite the

absence of clear evidence for Roman structural remains further upslope as making this less likely and conclude that the CFA results represent parts of a small Fort.

Other Features

1.7 Aerial photographic transcriptions provided by RCAHMS show a rectilinear pattern of cropmarks (E) on the higher sloping ground, of unknown date and function. Most are aligned perpendicular to the wall, but one is parallel and is located c13m south of the Rampart, a similar distance to the spacing between the Rampart and the Military Way identified by excavation (paragraph 1.3 above).

1.8 The approximate limits of a Mesolithic / Neolithic shell midden (F) are indicated in Figure 1. Comprised primarily of oysters and c.3m deep, traces of this feature were identified by the 1967 excavations (Dunwell & Ralston, 1995).

2. Results of Magnetic (Gradiometer) survey

Labels (Mn) in the text below refer to specific anomalies annotated on the Geophysical Interpretation, Figure 4. The Archaeological Interpretation of responses is given in Figure 5.

2.1 Anomalies (M1) to (M3) represent the Antonine Ditch; all are well defined and primarily negative in form although (M1) appears to have positive elements bounding the negative response. At its southwestern end (M3) deviates from the line indicated on the OS mapping, curving towards the river and the line of the Wall on the opposite bank.

2.2 Between (M1) and (M2) there is a stretch some 40m long where the Ditch is not clearly represented but appears only as weak incoherent negative responses and trends. This change is difficult to explain satisfactorily. Natural factors are a possible cause, but there is no evidence in the data for any obvious natural variations at this location (e.g. linear "bands" of response or changes in background magnetic levels). Furthermore, results from other geophysical surveys along the Wall illustrate that very obvious natural and topographic changes can have no impact on the anomaly produced by the Ditch (e.g. at Glasgow Bridge GSB 2007/45). The reduced response may reflect damage to the feature by historic or modern activity but it is difficult to conceive of any interventions that would have affected only this particular stretch and to such an extent as to severely impact on the resulting magnetic anomalies. The shell midden may be responsible, since shell has no inherent magnetic properties and, at up to 3m deep, would therefore provide a neutral magnetic medium through which the Ditch was cut. However, anomaly (M1) lies within the limits of the shell midden as indicated on Figure 1; without precise mapping of the exact limits of the midden (and more detailed information on its depth throughout), a strong element of caution is attached to this interpretation.

2.3 There are hints of a smaller break in response between (M2) and (M3). Anomaly (M2) runs into a dipolar (ferrous) anomaly produced by a pipe and the magnetic "shadow" cast by this modern feature has severely hampered the definition of (M3). Nonetheless there appears to be a "gap" of some 6m between the end of (M3) and the pipe response and there are hints of negative and positive responses (M4) curving away from the Ditch at this point. If this gap is real and not simply a further effect of the pipe, then together (M3) and (M4) could suggest a deliberate break to form a causeway over the Ditch. Alternatively (M4) may represent a continuation of broad sinuous negative and positive responses (M5), suggesting a natural feature (? a former water channel) which could be responsible for the apparent break. It must be stressed that, because of the pipe disturbance, both these interpretations are highly cautious.

2.4 Millstone Grit (the primary construction material for the Rampart base - see paragraph 1.2) is inherently non-magnetic. As such, the Rampart base at Inveravon might be expected to produce distinct linear bands of negative or reduced response, depending on preservation and depth below surface. No clear well defined anomalies of this form are present in the data. At (M6), immediately adjacent to the excavated section of rampart, there are hints of a band of reduced response, with a weak positive anomaly on its southern edge, but this extends only a short distance and is not present southwest of the pipe anomaly. Covering an even shorter distance,

the anomalies at (M7) comprise a weak negative seemingly bound by two positive trends that correspond roughly with the OS mapped Rampart line. Based on their alignment and positions, (M6) and (M7) are attributed to the Rampart, with the positive elements possibly reflecting magnetic material within the rampart structure or an accumulation of same at the edges. It should be stressed that the limited length and relatively poor definition of these anomalies makes the interpretation very cautious; without the corroborative excavation data (particularly regarding the use of non-magnetic Millstone Grit) the significance of (M6) and (M7) would be highly questionable. An additional element of doubt surrounds the interpretation of anomaly (M7), as it does not follow the possible curve of the Wall suggested by Ditch response (M3).

2.5 Two areas of increased magnetic response (M8) and (M9) form broad rectilinear patterns on either side of the Antonine Ditch. Zone (M8) covers the Berm and Rampart while (M9) lies partially over the Ditch edge and the Outer mound. They may reflect material associated with the Wall and as such have been classified as *Areas of Possible Archaeology*; however none of the discrete responses identified within these areas give any clue as to the precise nature of (M8) and (M9) and their archaeological significance, if any, remains in doubt. Part of zone (M8) may reflect material associated with anomalies (M18) described in paragraph 2.12 below.

2.6 Anomaly (M10) is strong and well defined and coincides with a high resistance anomaly of the same shape. As such it may be of interest, possibly reflecting a structure on the Berm, though its precise function remains unknown.

2.7 No anomalies have been identified that can be definitively related to the Military Way. The response expected by this feature is dependent on the magnetic properties of the cobbles used in its construction. No positive or negative linear anomalies are present in the correct position adjacent to the excavated section of the road. A short positive linear (M11) is present roughly 3.5m north of the road line but as this is even weaker than response (M6) above and only 2m wide, any archaeological interpretation is tentative. A relatively well defined negative linear (M12), roughly 4m wide, corresponds with a cropmark and less well defined negative and reduced response band (M13) might represent a continuation of this feature; both are on the same line as anomaly (M11). Running parallel to the Wall and c13m to the south, (M12) and (M13) are in a "suitable" position to represent the Military Way and might have been produced if the cobbles used in the road were non-magnetic. However, given the lack of similarly coherent responses over the Rampart, this interpretation is tentative at best. In fact, towards its eastern end, anomaly (M12) is particularly strong, more suggestive of a substantial cut feature such as a ditch, and terminates very distinctly; both factors would support an alternative origin for (M12) and (M13), possibly related to the other cropmark features.

2.8 The southern Rampart of the Fort has not been identified by the magnetic survey. As it is of similar construction to the Antonine Rampart, its absence in the data is likely to have a similar cause (see Conclusions). A curvilinear negative anomaly (M14), could indicate a length of ditch that might be related to the Fort defences; although no evidence for defensive ditches was identified by the survey, (M14) has an alignment that would place it just south of the excavation trench. However, definition of the response is hampered by pipe disturbance and the anomaly does not appear west of the pipe; both factors make the interpretation tentative.

2.9 Positive responses immediately east of (M14) appear to form a rectangular pattern and on this basis they have been interpreted as *?Archaeology*; however their exact function cannot be determined and this interpretation is tentative.

2.10 No anomalies have been identified within the presumed area of the fort, that can be clearly defined and attributed to internal features. Although the apparent rectilinear pattern of responses (M15) suggests archaeological potential, this interpretation is highly tentative due to their proximity to the pipe disturbance. Given the context other responses in the vicinity may have been produced by archaeological deposits, but they form no patterns that would enable any archaeological interpretation and they are therefore not represented in Figure 5.

2.11 An area of magnetic disturbance (M16) coincides with a high resistance response (see paragraph 3.5 below); its significance is difficult to determine. Such disturbance, comprising a concentration of very strong dipolar anomalies, is often suggestive of modern debris in the

topsoil and may be the case here. However, given its position, close to a water source and the wider archaeological context, it could indicate brick or other industrial / fired debris of possible archaeological interest.

2.12 The anomalies labelled (M17) and (M18) coincide with cropmarks; all are negative and they vary in strength and definition. The strongest and most coherent response (M17) could suggest a substantial ditch cut feature. Other weaker negative responses and faint positive trends are present in the vicinity of (M17/18) and share a similar alignment. Although an anthropogenic origin for them seems likely, the patterns they form have not helped to clarify their precise function and archaeological potential.

2.13 A discrete narrow positive linear anomaly (M19) is likely to be anthropogenic in origin, but whether recent or of greater antiquity cannot be determined. Evidence from the resistance survey (paragraph 3.9 below) could indicate it represents a drain. Its position and alignment suggests it is not associated with the Wall.

2.14 The data in the vicinity of (M19) display a number of generally amorphous positive and negative anomalies and trends suggesting a natural origin, possibly associated with flooding of this low lying ground. A similar interpretation is attributed to the anomalies running along the southern edge of the grid, parallel to the river.

2.15 The northern edges of the survey are dominated by linear ferrous anomalies that have been produced by pipes. Adjacent to these, areas of increased noisy responses and magnetic disturbance are present which appear to have a clearly defined edge. These may also have a modern origin, possibly relating to the pipe installation and the construction of the gas compound in the field corner; however the possibility that some of this increased noise has been produced by natural factors and / or disturbed archaeological deposits, cannot be entirely dismissed.

3. Results of Resistance Survey

Labels (Rn) in the text below refer to specific anomalies annotated on the Geophysical Interpretation, Figure 7. The Archaeological Interpretation of responses is given in Figure 8.

3.1 The pipe crossing the centre of the survey has had only minimal impact on the resistance data, appearing as a weak narrow low resistance linear (R1).

3.2 The Antonine Ditch does not appear clearly in the results. Faint trends (R2) and (R3) demarcating bands of marginally lower and higher resistance are likely to reflect the line of the Ditch, but without the corroborative magnetic evidence this interpretation would be cautious. The results indicate a lack of contrast in the moisture content between the ditch fill and the surrounding matrix and this may be due to the low lying ground, which has probably been subject to flooding both in antiquity and more recent times. At the northern end of the grid, the trends disappear into a wider zone of low resistance (see below) and are only made visible by mathematical filtering.

3.3 It may be significant that the slightly higher resistance band and trends (R3) appear to follow a curved line away from the Ditch that roughly coincides with magnetic anomalies (M4). Lying immediately adjacent to the pipe trench, this curve could be a product of the pipeline installation but could equally reflect a feature unrelated to this modern intervention, either natural or archaeological. If the latter, this might support the interpretation offered in paragraph 2.3 above, that a causeway over the Ditch is present at this location.

3.4 Weak high resistance linears (R4) follow the OS mapped line of the Rampart, becoming increasingly indistinct as they approach the pipe anomaly. Although only some 2m wide, they seem likely to have been produced by stonework in the Rampart base, but are far less coherent than might be expected from the intact Rampart base uncovered by excavation. East of the pipe the results become even less distinct but faint parallel trends can be seen in the filtered data

which coincide either with the OS rampart line or the excavated section. The interpretation is far from conclusive but any of these trends might be related to the edges of the rampart.

3.5 Lying on either side of the Rampart, high resistance anomalies (R5) and (R6) correspond with magnetic responses (M10) and (M16) respectively. The high resistance suggests structural remains (although no detail is present that would indicate specific wall lines) or compacted ground. An archaeological interpretation is tentatively offered but the precise function remains unclear.

3.6 Bisected by the pipe anomaly, large areas of higher resistance (R7) and (R8) visually dominate the southern half of the survey area. The zone (R7) appears to form a broadly rectangular shape; the limits of (R8) are less easily defined but there hints of a rectilinear pattern to the highest resistance values. Little internal detail can be discerned in the raw data and in other contexts these zones might be assigned a natural origin. Although this interpretation cannot be dismissed, the expectation of features, in particular buildings, in this area has led to these zones being assigned some possible archaeological significance.

3.7 Mathematical filtering applied to the data has revealed some discrete anomalies within the high resistance zones. While none of them form clear archaeological patterns, their proximity to known buildings and other features tends to support an archaeological interpretation for at least some of these responses. Although no individual wall lines can be identified, the anomalies may have been produced by collapsed building rubble.

3.8 Weak anomalies (R9) coincide with a cropmark and a negative magnetic linear and are likely to represent the same feature. The high resistance form of (R9) would suggest this is a wall, drain or narrow bank; although a deep cut well drained ditch can produce high resistance responses, since the Antonine Ditch is under-represented, it is unlikely that a narrower, less substantial ditch would have produced these anomalies.

3.9 High resistance linear (R10) coincides with magnetic anomaly (M19) and could represent a narrow wall or bank but more probably, given its position and alignment, a drain. The origin of the high resistance area in the vicinity of (R10) is varied and uncertain; some of the responses may have been produce by material of the Outer Mound while natural factors are also likely to have contributed to the recorded values.

3.10 The broad relatively well defined high resistance anomaly (R11) coincides with the sinuous band of magnetic responses (M5) and seems likely to represent the same feature. The nature of this feature is not clear from the resistance results, but the magnetic data suggest it has a natural origin, possibly a bank associated with flood deposition.

3.11 A general area of low resistance is present at the northeastern end of the grid. This part of the survey occupies sloping ground and one would not normally expect a decrease in resistance over such topography. It is possible that this effect is due to the shell midden which may have changed the mineral content of the soil (it is minerals in solution which conduct the electrical current) and / or contributed to moisture retention on the sloping ground.

4. Conclusions

4.1 Given the presence of intact Ditch, Rampart, Military Way and structural occupation features, as identified by excavation, the results from both geophysical techniques are disappointing. Only the Ditch appears with any clarity, in the magnetic data and even this response is not coherent throughout the dataset. Neither technique has yielded any definitive evidence for the Rampart and Military Way or been successful in mapping the Fort. Although the resistance survey has detected areas of high resistance which might relate to occupation features, the level of detail is poor and no individual building layouts can be identified with any degree of confidence. Magnetic and resistance anomalies have been detected which correspond to cropmarks, but the exact nature and function of these features remains uncertain.

4.2 The dearth of clear archaeological anomalies in the magnetic dataset is difficult to fully explain but seems likely to be due to a combination of three factors: modern, natural and the use of non-magnetic stone as a construction material. Modern pipes have produced broad ferrous anomalies and magnetic "shadows" that have masked any underlying weaker responses and hampered the identification and interpretation of anomalies in their vicinity. The magnetic properties of the soils and subsoils have resulted in generally high levels of background fluctuation. Ordinarily, non-magnetic stone features would be expected to produce negative anomalies or areas of reduced response relative to this prevailing background. It is suggested that the background levels prevalent at Inveravon are of such a magnitude that they have effectively masked any weaker changes produced by a comparatively narrow layer of non-magnetic material. On the lower lying ground at the southern end of the survey (close to the river), flooding may also have played a part, resulting in an increased level of topsoil over the archaeological deposits.

4.3 The absence of well defined ditch-type anomalies in the resistance data indicates a lack of contrast in the moisture content between the fill of the Antonine Ditch and the surrounding soils. There are several possible reasons for this; possible flooding and / or poor drainage of the low lying ground and the presence of a deep shell midden affecting the moisture and mineral content of the higher ground. The poor levels of detail in the high resistance anomalies may in part be due to an increased topsoil overburden (anomaly resolution tends to decrease with depth from surface) but could also reflect a true picture of the features, being produce by building rubble overlying intact foundations.

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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.

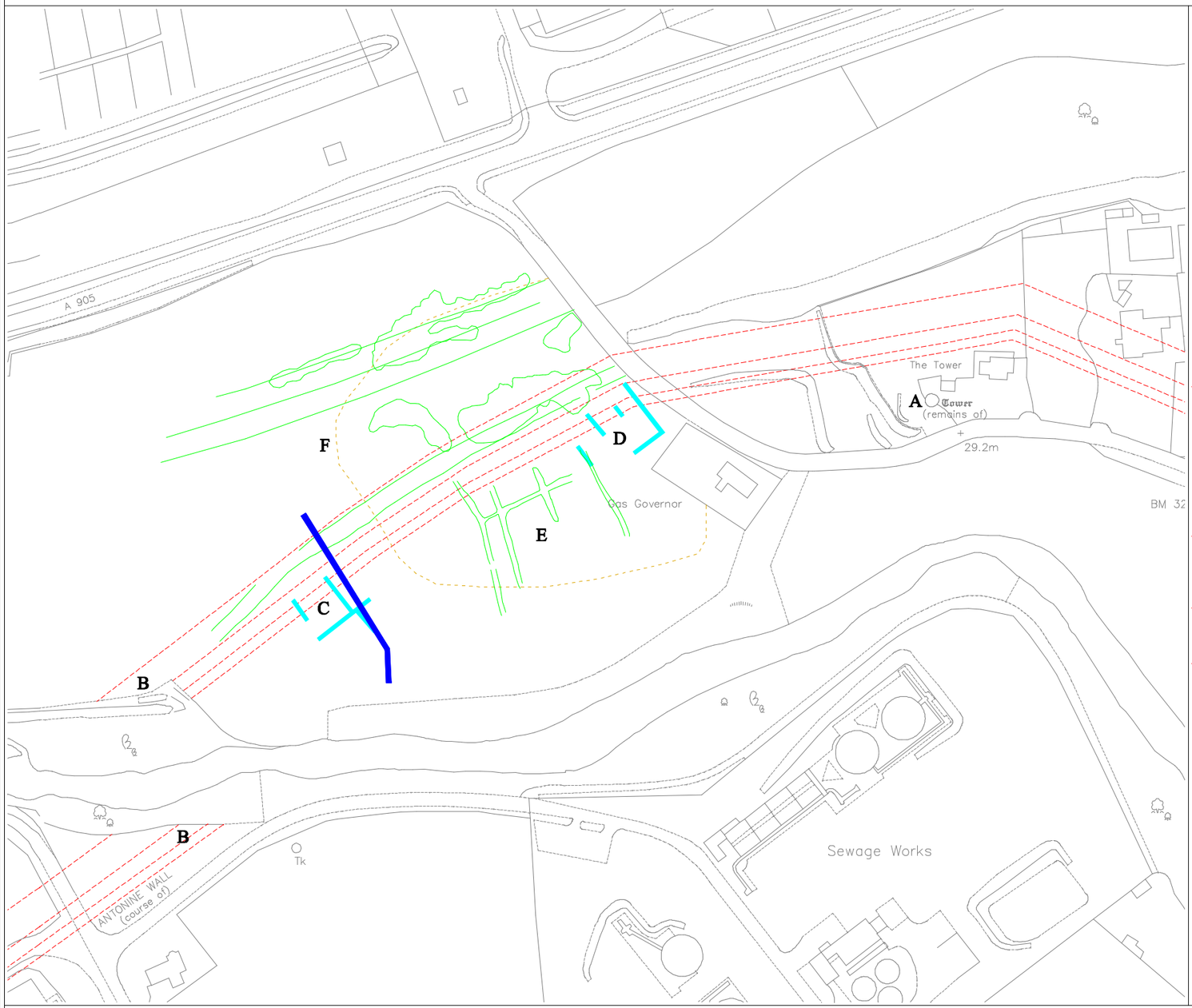
Radargram

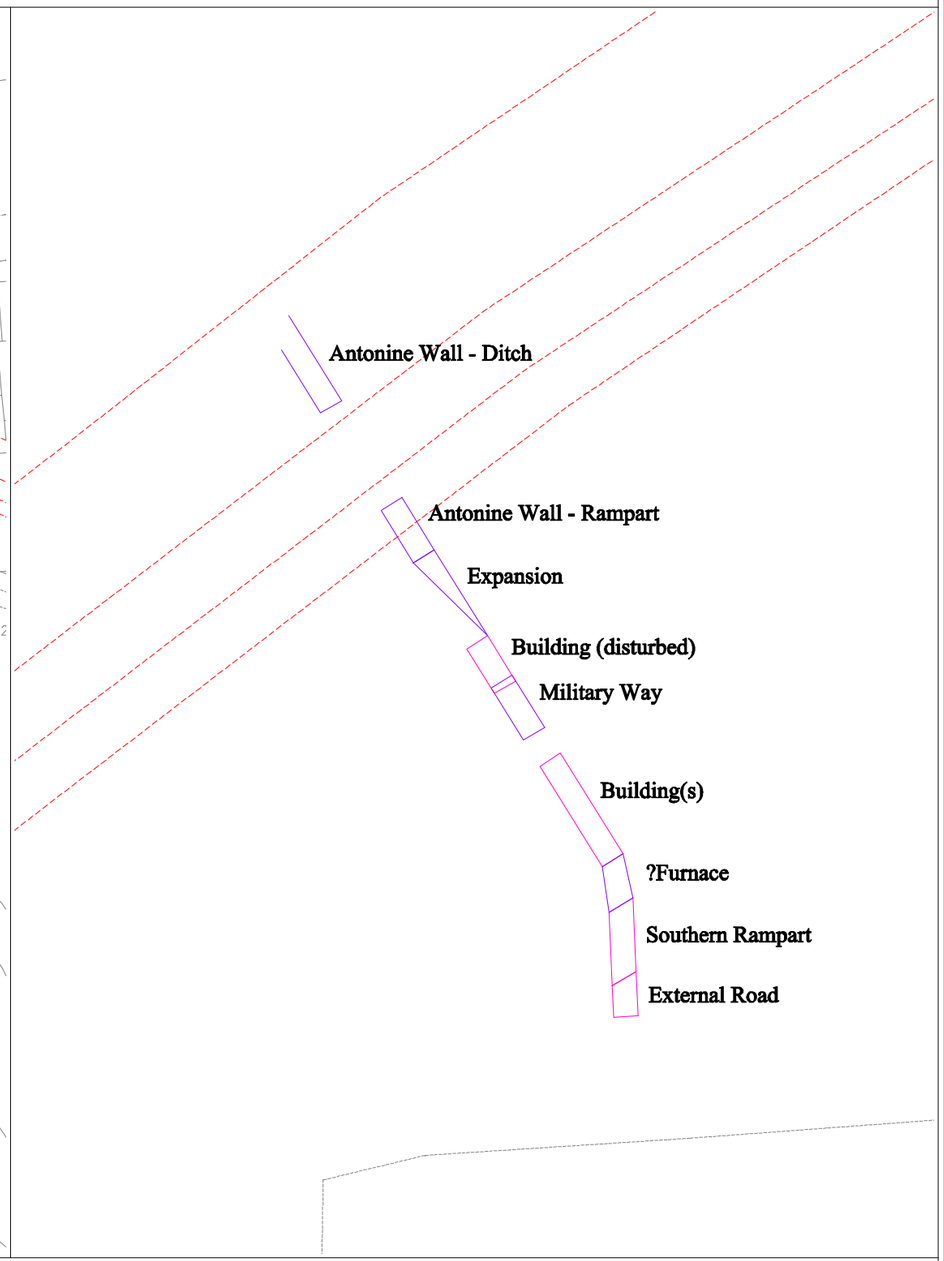
Radar data comprise a record of reflection intensity against the time taken for the emitted energy to travel from the transmitter down to the reflector and back to the receiver. The resultant plot is effectively a vertical section through the ground along the line of the traverse, with time (depth) on 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: 2007/46 Antonine Wall III - Inveravon Fort	TITLE: Desk Based Assessment





Schematic representation of selected features excavated by CFA, 1991 at 1:500

Line of Antonine Wall - OS 1980 (current)

Aerial Photographic transcriptions (RCAHMS)

Approximate Extent of Shell Midden

Excavation Trench - (1967 / 1991)

Phase 1

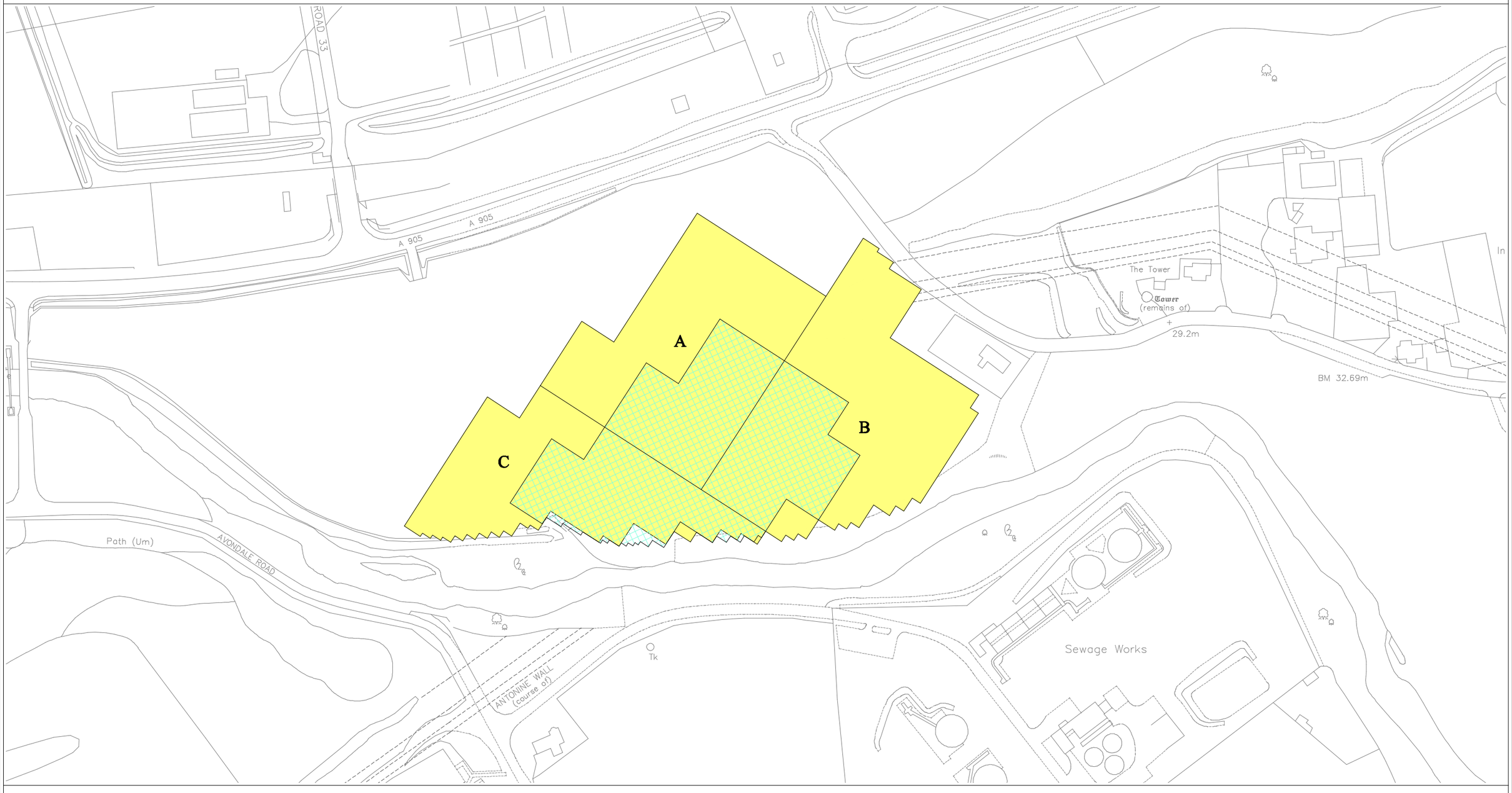
Phases 2 and 3

0 metres 80

N.B. The positions of trenches and excavated features are approximate: they have been digitised from low resolution images taken from a pdf copy of the excavation report (Dunwell, Ralston et. al., 1995) held at the Archaeology Data Service's PSAS online archive.

Figure 1

GSB PROSPECTION Ltd.	PROJECT: 2007/46 Antonine Wall III - Inveravon Fort	TITLE: Location of Survey Areas



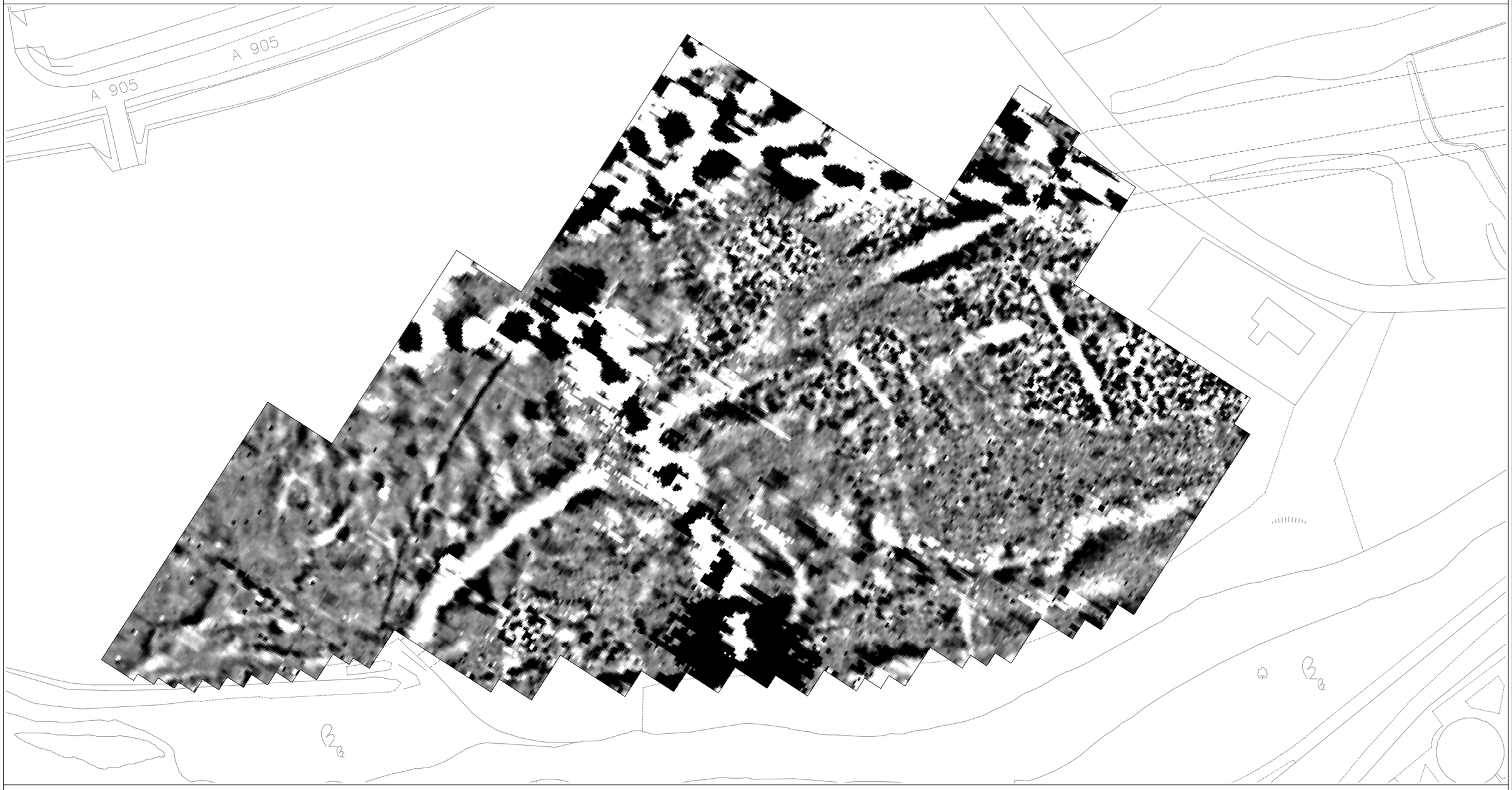
Gradiometer Survey (showing reference plot subdivisions)

Resistance Survey

0 metres 80

Figure 2

GSB PROSPECTION Ltd.	PROJECT: 2007/46 Antonine Wall III - Inveravon Fort	TITLE: Magnetic Data - Greyscale

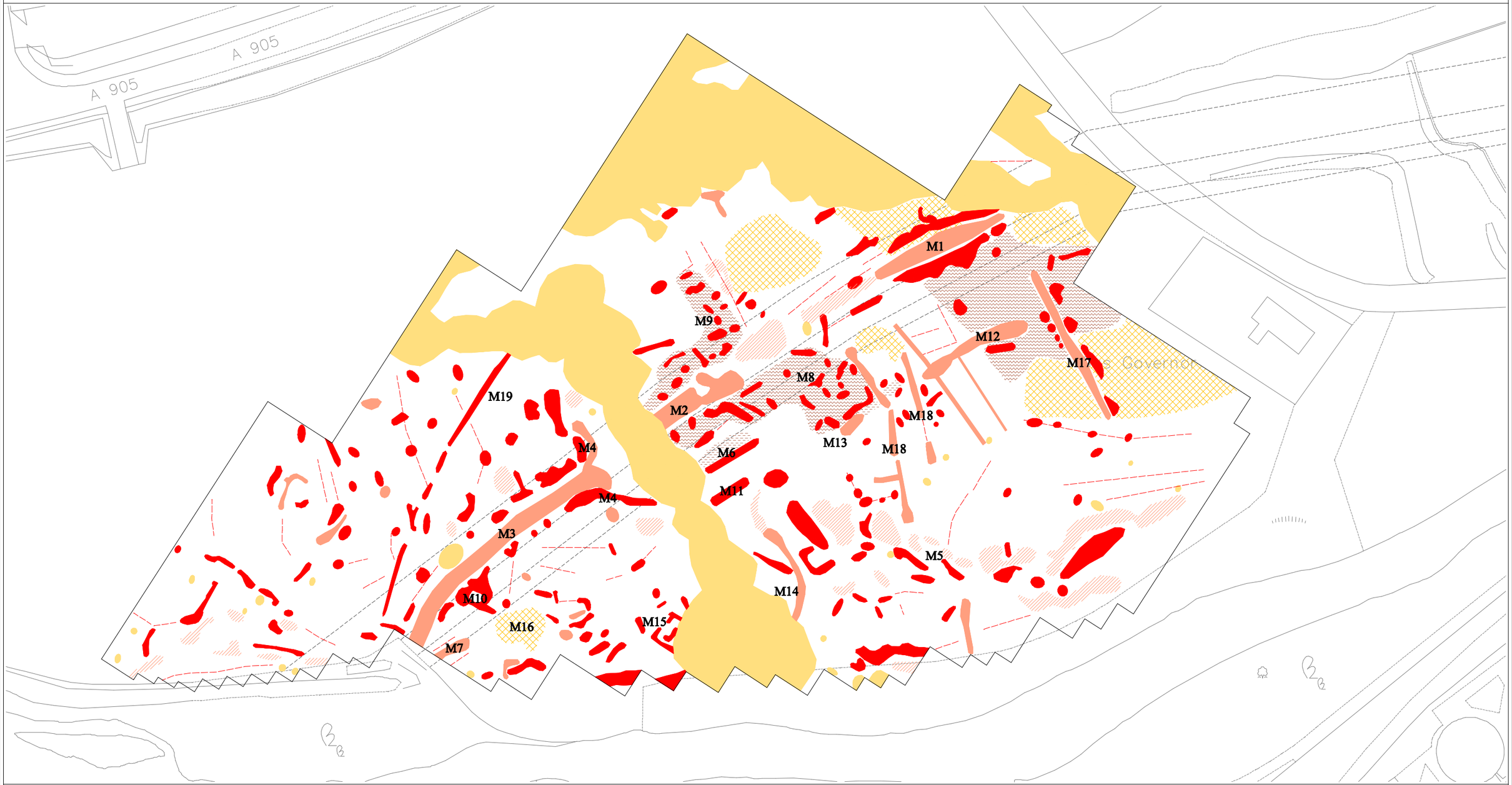


20
nT
-20

0 metres 40

Figure 3

GSB PROSPECTION Ltd.	PROJECT: 2007/46 Antonine Wall III - Inveravon Fort	TITLE: Magnetic Data - Geophysical Interpretation



Positive Magnetic Anomaly

Negative Magnetic Anomaly (Discrete / Amorphous)

Trend

Increased Magnetic Response

Decreased Magnetic Response

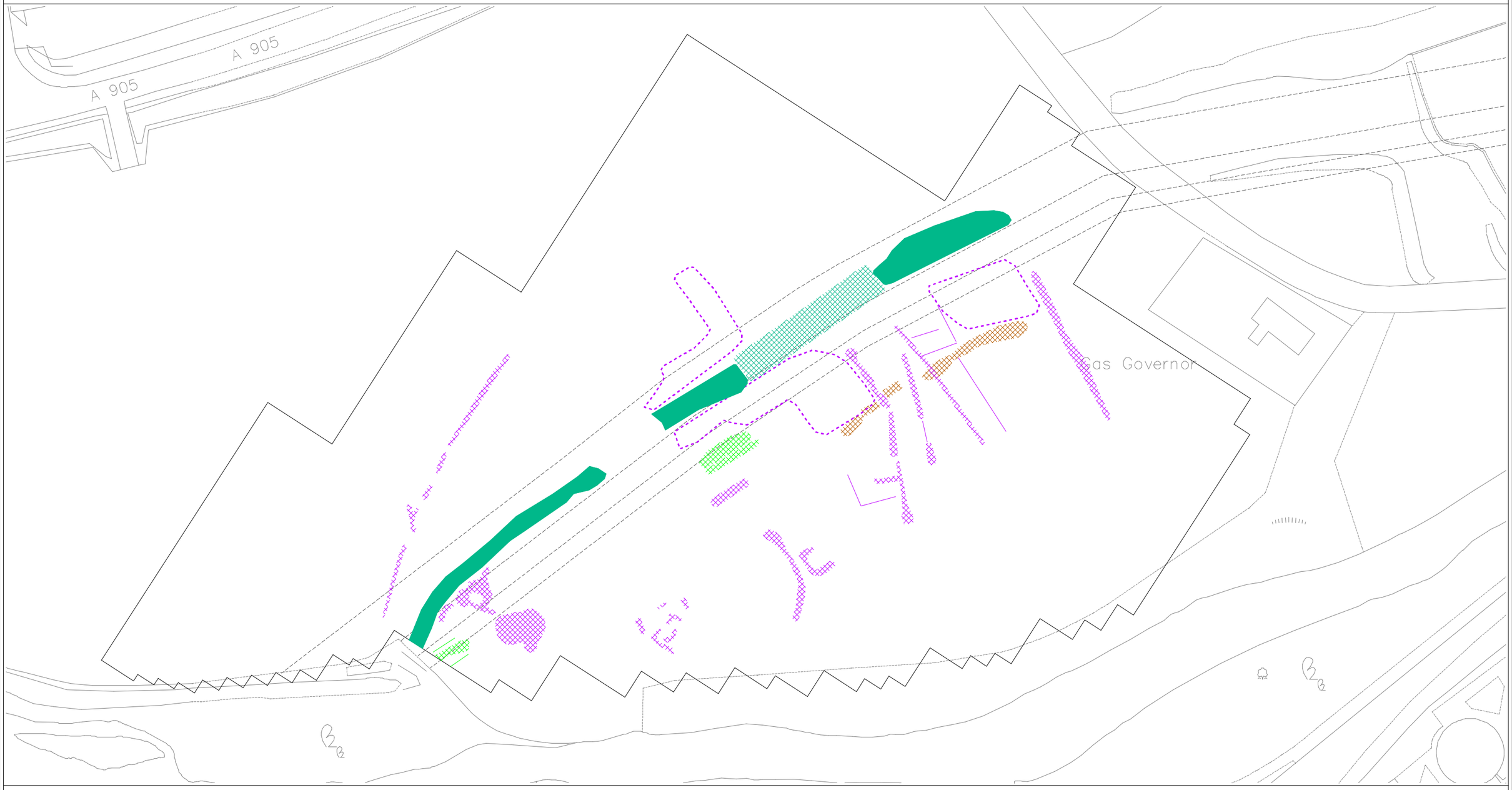
Magnetic Disturbance

Magnetic Dipole (Ferrous)

0 metres 40

Figure 4

GSB PROSPECTION Ltd.	PROJECT: 2007/46 Antonine Wall III - Inveravon Fort	TITLE: Magnetic Data - Archaeological Interpretation



Antonine Wall - (Ditch / ?Ditch)

Antonine Wall - ??Rampart

Antonine Wall - ??Military Way

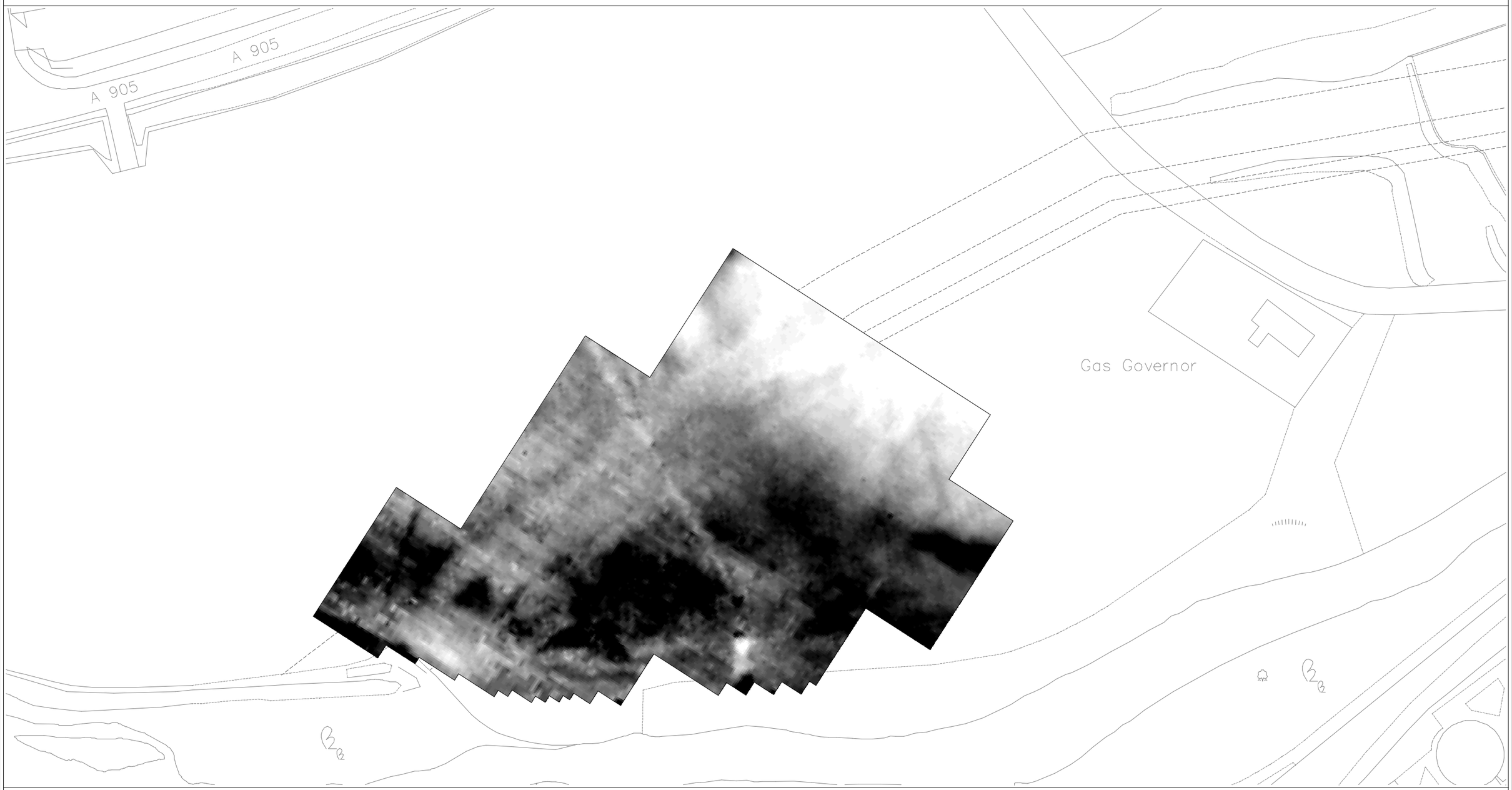
?Archaeology

Area of Possible Archaeology

0 metres 40

Figure 5

GSB PROSPECTION Ltd.	PROJECT: 2007/46 Antonine Wall III - Inveravon Fort	TITLE: Resistance Data - Greyscale

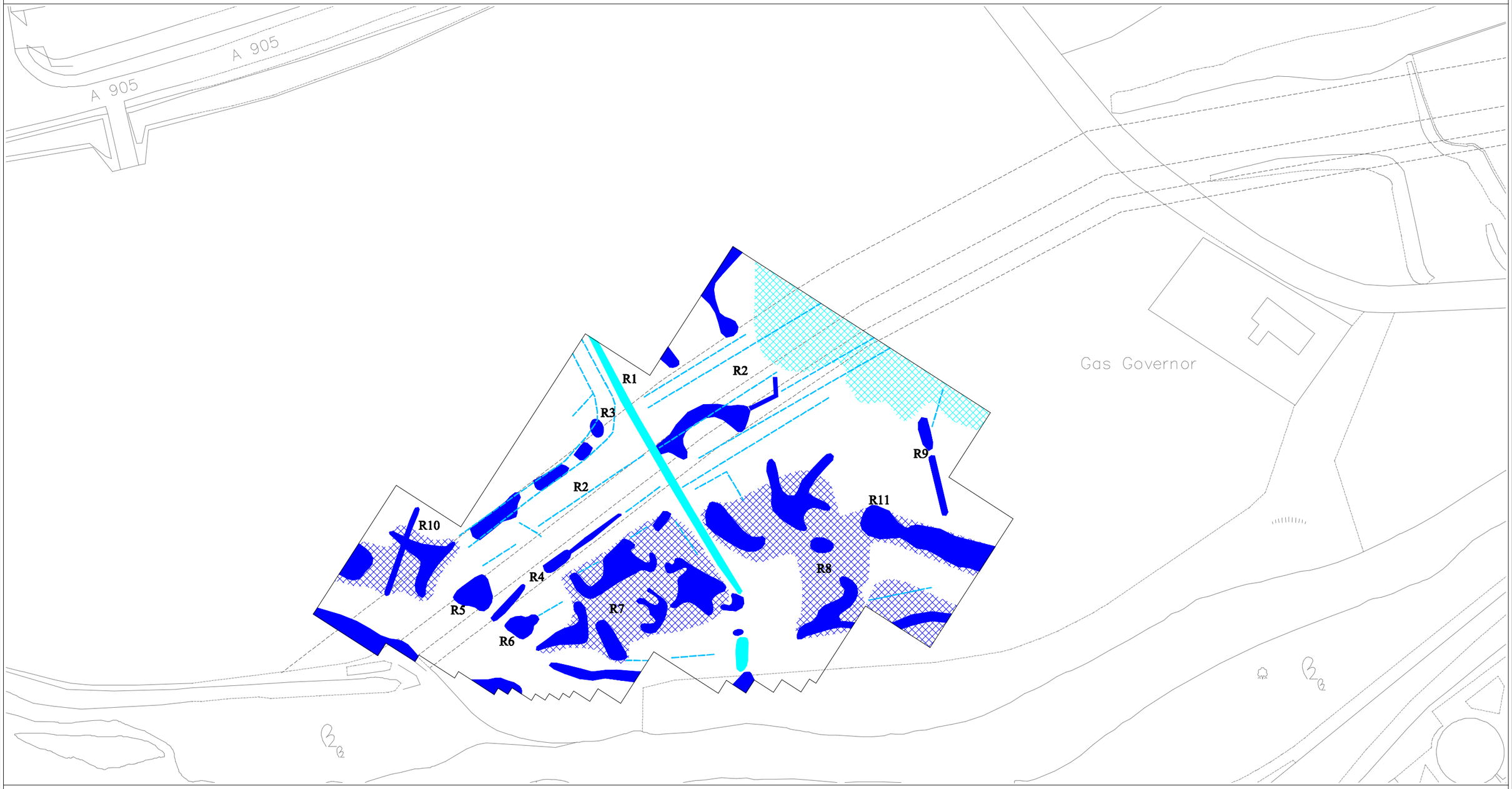


0 metres 40

120
Ohms
80

Figure 6

GSB PROSPECTION Ltd.	PROJECT: 2007/46 Antonine Wall III - Inveravon Fort	TITLE: Resistance Data - Geophysical Interpretation



Discrete High Resistance Anomaly

Discrete Low Resistance Anomaly

Area of High Resistance

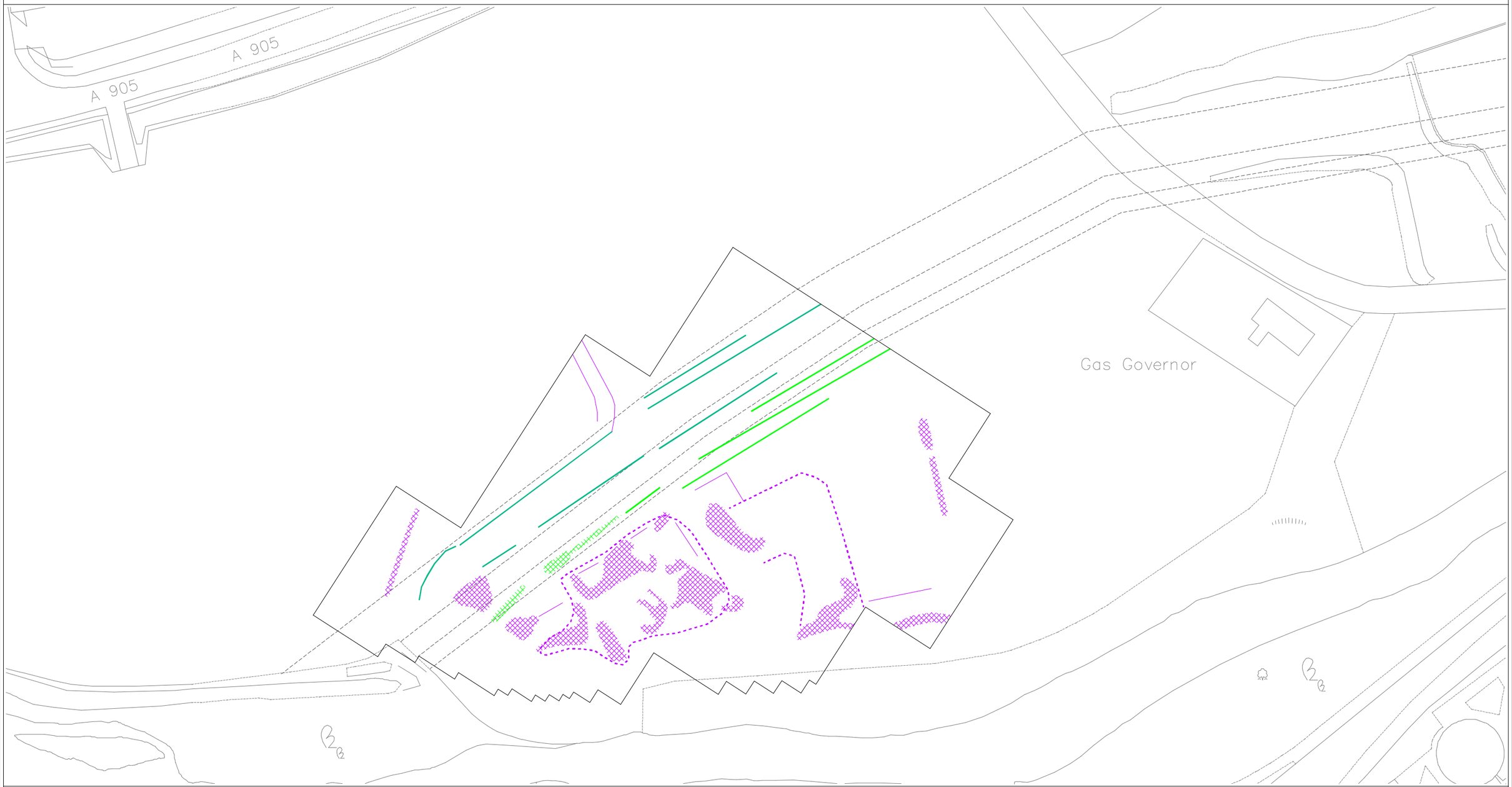
Area of Low Resistance

Trend

0 metres 40

Figure 7

GSB PROSPECTION Ltd.	PROJECT: 2007/46 Antonine Wall III - Inveravon Fort	TITLE: Resistance Data - Archaeological Interpretation



Antonine Wall - ?Ditch

Antonine Wall - ?Rampart

?Archaeology

Area of Possible Archaeology

0 metres 40

Figure 8