REPORT ON GEOPHYSICAL SURVEY AT CASTELPORZIANO

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Geophysical Survey at Castelporziano 2009

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1. Introduction

The following report is a brief summary of the geophysical survey undertaken at the Castelporziano estate as part of the AHRC project: *The evolution of Rome's maritime facade: archaeology and geomorphology at Castelporziano*. The work was carried out during 9-23 April 2009 under the overall direction of Amanda Claridge. The survey was undertaken in the area of the *Vicus Augustanus* after a preliminary survey in 2008 had located possible evidence for surviving structures in the vicinity of Building Y and Z (Evans 2008).

2.1. Location

The present character of the survey area is of dense woodland and low-level vegetation with large quantities of building debris – both stone and fired clay – over the surface at large. These agents have severely hampered previous efforts at remote-sensing and geophysical surveys at other sites on the Castelporziano estate (see Evans 2006; Evans 2008). However, a recent period of drought and an increase in local wildlife have significantly reduced the density of much of this low-level vegetation.

Survey grids (using a standard 20×20m) were located to allow the greatest possible coverage of the areas within the constraints applied by the presence of substantial areas of dense vegetation. It should be noted that transposing a rigid 20m grid to a densely covered forest floor to sub-centimetre was not always possible; in some cases grid pegs were located as much as 0.2m from their original position to avoid obstacles such as trees and road tarmac.

The survey was split into two distinct areas (Figure 1):

- **Area 1:** in the NW sector of the *Vicus Augustanus*, measured c.140×80m, extending from the western limit of the Vicus, over building Z and across the modern road – the *Via del Telefono* - to encompass a small part of zone S beside the ancient *via* Severiana and the NW corner of Building A, together with the northern part of zone H to the South. The area also included the small 20×30m area surveyed in 2008.
- **Area 2:** a smaller area, measuring c.50×60m, to the N and NE of Building A to overlap with the known route of the *Via Severiana*.

2.2. Methodology

A fluxgate magnetometer (also referred to as a gradiometer) survey of the *Vicus* and CPS sites D5/D6 in 2008 had produced positive results (Evans 2008). It was hoped that a larger scale survey in this area would clarify the nature of sub-surface features relating to the occupation of the *Vicus* site.

Given that features such as concrete foundations and upstanding structures faced with brick, tufa or basalt were likely to be present, at shallow depths (as witnessed by previous seasons' test excavations) and given the non-igneous geological environment of the study area, a fluxgate magnetometer survey was again considered appropriate. This technique involves the use of hand-held magnetometers to detect and record anomalies in the vertical component of the Earth's magnetic field caused by variations in soil magnetic susceptibility or permanent magnetisation (Clarke 1996).

The survey was carried out using a single Geoscan FM36 Fluxgate Gradiometer with integral data logger. This technique can – in normal conditions – identify features up to a maximum depth of one metre (Gaffney *et al* 2002, 12). Its speed means large areas are covered quickly, and anomalies are reasonably easy to interpret (*ibid*).

Data was collected with a sampling interval of 0.25 m along transects spaced 1.0m apart. Traverses were collected in a parallel configuration at a resolution of 0.1 nT combined with a gain setting of ×1.

A full record of the technical details of the survey can be found in the Digital Archives Record Sheets, which comprise Appendix A of this report, produced to the standards recommended by the Archaeological Data Service (ADS).

2.3. Processing

Data processing was performed using Geoscan Research Geoplot v.3 for the production of raw data composites, and processing and display of the initial data. Greyscale plots were produced of the raw composite data from all areas. The following processing was then applied to the raw data:

1. Zero Mean Grid: sets the background mean of each grid to zero and is useful for removing grid edge discontinuities. *Geoplot parameters:* Threshold = 0.25 std. dev.
2. Clip to three Standard Deviations off the median average;
3. De-spike: useful for display and allows further processing functions to be carried out more effectively by removing extreme data values.

Geoplot parameters: X radius = 1, y radius = 1, threshold = 3 std. dev.
Spike replacement = mean

Finally, data was pixel-interpolated within Golden Software Surfer 8, to create a smoother appearance to facilitate interpretation. Surfer 8 was then used to convert the data to other formats and to allow the production of wireframe, 3D surface and colour transform plots of the processed data.

3. Results

Results were successfully obtained from all areas of the survey at a resolution adequate for the definition of a wide series of potentially interesting anomalies. Results are divided by area below for detailed discussion.

3.1. Overview of results - Area 1

The survey is dominated by the present course of the *Via del Telefono* running across the full width of the area from east to west. Surprisingly, although the road surface (tarmac and hardcore) shows up as a dense concentration of dipoles it does not impact at all on the surrounding survey. This permitted the survey to extend right to the edge of the road without the loss of important data.

In the south-west corner of the area is a series of positive linear anomalies (an average reading of 12nT) intersecting at right angles to one another. These appear to be associated with the known, partly visible remains of bath Building Z, and extend southwards to Building Y, and westwards outside of the survey area. There are also possible lower-strength features extending eastwards from Building Z towards Area H. One is a low-positive linear located on the very edge of the survey grid near Building Y, the other a curious negative linear c.12m to the north. (see Figures 4 and 5).

The extreme south-east corner of the survey area, in the region of the northern limit of Building H4, contains a clipped east-west anomaly, possibly corresponding with the same edifice (this is discussed in more detail below).

North of the *Via del Telefono* the picture is somewhat less clear, due in no small part to the presence of heavy ‘plough marks’ across the centre of the area, caused by recent forest management (Claridge pers. comm.). These marks obscure any possible archaeological features, although the edge of the *Via Severiana* is still evident as a strong dipole/mix of high readings at the very northern limit of the survey area. East of the plough marks – on a noticeably higher area of ground – is a concentration of possible linear anomalies. These are relatively weak (on average 6-7nT), which could indicate a significant vertical depth towards the limit of the instrument’s capabilities.

In the north-west corner of the area the survey included a prominent mound. Here the results are masked by a huge dipole, undoubtedly caused by a sizeable ferrous object in the subsoil.

The clearest features in Area 1 are located at the Northeast corner, to the North of bath Building A. Here the survey has picked up the extant corner of one wall, but also a series of very strong linear anomalies projecting northwards from the known remains. The strength of these readings – on average c.24nT – is probably due to the use of basalt in the construction (it was noted during survey that isolated pieces of basalt on the surface produced a strong signal). Of interest are the relatively weaker anomalies continuing to the Eastern and Northern extent of this area, if these are walls then they could be constructed of less magnetic materials.

3.2. Discussion of results - Area 1

Building A

The clearest results from Area 1 are for the positive anomalies directly north of Building A. As previously discussed, these would appear to represent a sequence of structures incorporating basalt that may continue beyond the northern limit of the survey area. It is possible that these features relate to a later, medieval, phase of building on the site using basalt from the *Via Severiana* (Claridge pers. comm.). The relatively lower strength features in this area could indicate the earlier non-basalt structures.

The vicinity of Buildings Y and Z

The linear anomalies between Buildings Y and Z seem to form a sequence of buildings on the same orientation as the *Vicus* plan, continuing to the west and possibly east, in the direction of towards H. It should be noted that the features are far from continuous, and represent a far-from complete ‘building plan’. In particular, features on an East-West alignment seem less defined than those on a North-South. The reasons for this could be down to:

- Errors in data collection (as mentioned above).
- The sampling strategy employed. As mentioned in the methodology, the FM36 is restricted to traverse intervals of 1m on the X-axis which in detecting smaller features is far from ideal (more modern instruments can be set to 0.125m).
- The survey has also traversed the site on an East-West basis, the same as a lot of the possible features.

It is thus; highly possible that all three of these actors have resulted in East-West features being only partially identified.

In order to test these results, two small test trenches were located (see Figure 6) over probable features. An overall discussion can be found in the 2009 excavation report (Claridge 2009) but the results and their relation to the geophysics will be summarised here.

Test Trench 1

The trench was originally sited on a suspected inter-section of two linear features (Figure 7). The trench located a relatively small North-South wall (c.0.45m) but was slightly misplaced and failed to pick up the corresponding East-West feature. However, an area of compacted material was located at the Northern extent of the trench; this could correspond to wall collapse from this feature (Claridge pers. comm.). It should be noted that the top of the wall was located at a depth of c.0.5m below ground level, towards the maximum range of the FM36.

Test Trench 2

The trench was sited at a suspected corner between two walls, just to the South of the *Via del Telefono*. During clearance a large iron survey pin was located in the soil; with hindsight this could well explain the large dipole in the survey results (Figure 3). The excavation revealed the suspected North-South wall (Figure 8) but did not quite extend to pick up any trace of the East-West wall. In fact, an East-West wall was located but 0.6m North of where it was thought to be. The reason for this could simply be that the dipole has distorted the results in this area.

The excavations have therefore added some substance to the initial interpretation. In addition they have also added further highlighted the difficulty in precisely mapping the East-West anomalies in the dataset. Solutions to this problem will be discussed later in the report.

Building H4/H5
The survey has, arguably, picked up the Northern extent of Buildings H4 and H5 (Claridge 2007, 4). Unfortunately, due to the presence of a considerable level of surface debris - including building materials - the survey was not extended over the rest of this area; leaving a small gap in the dataset between the known structures in H and the possible features identified in the survey.

Finally, a series of possible linear features have been identified opposite area H to the North of the *Via del Telefono*. Whilst modern interference obscures some parts it is possible to suggest at least three partial sides of a square enclosure (see Figures 4 and 5). The results are not as clear as other parts of the site, but the survival of some structures in this area should not be discounted.

3.3. Overview of results - Area 2
The survey in this area was designed to provide more information on the relatively open area to the north-east of Building A, running up to the known course of the *Via Severiana*. Plough marks – identical to those already discussed in Area 1 – were evident in the field and these can clearly be seen in the results (Figure 10). The course of the *Via Severiana* is shown by two strong, albeit interrupted, linear anomalies on a roughly East-West axis; the interruption undoubtedly due to the ploughing of this area. Isolated fragments of basalt derived from the road bed were evident in the plough troughs and can be seen as the occasional strong signal in the data. The ploughing stops halfway through the survey area, and a footprint is left by a linear band of high strength signals (identified on Figure 11). This is surely caused by an accumulation of sub-surface and surface detritus which, as previously indicated, derives from the road but also perhaps less obvious structures which have been masked by the ploughing.

To the south of this area is a marked concentration of dipoles and high strength signals, it possible to make out possible linear features within this (see Figure 10 and 11), although with relatively little confidence.

The clearest results are shown by two high strength linear anomalies to the north of Building A. The high readings (c. 30nT) are comparable with the results from Area 1.

3.4. Discussion of results: Area 2
The clearest results are provided from the survey behind Building A. These are likely to represent substantial walls similar to those identified in Area 1. The north-south wall would appear to be bigger than those in Area 1, c. 1m. thick. The strength of these readings can perhaps again be attributed to the use of substantial amounts of basalt in the wall makeup, which in turn suggests that the structures belong to the medieval re-occupation of the site.

The concentration of high strength readings in the centre of Area 2 is something of an enigma. There is no clear-cut definition suggestive of construction and it could, pessimistically, represent one of the modern dumps of material that appear sporadically across the *Vicus* site.

4. Discussion – the effectiveness of geophysical survey at Castelporziano
The three seasons (2006, 2008 and 2009) of survey work at Castleporziano have produced an interesting set of results that prompt some brief discussion of the relative failures and successes of geophysical techniques on the site. At a fundamental level it has been shown that the two

techniques employed – resistivity and magnetometry – do indeed 'work', in the sense that above and below ground conditions do not prohibit the use of the instruments.

However, the results from resistivity work were somewhat disappointing, due in no small part to the high background resistance of the sand-based subsoil at Castelporziano (Evans 2006). However, although investigations with the Geoscan RM15 model have been unsuccessful on this occasion, recent developments in this field (for example resistivity profiling) should not be ruled out for future use.

Conversely, the sand-based subsoil has meant that gradiometer/magnetometer surveys have, for the most part, worked well and in some places exceeded expectations. The contrast in magnetic properties between the background subsoils and the archaeological features (such as walls) is evident, and small test excavations suggest that the results are detecting archaeology towards the one metre limit of the Geoscan equipment used. This is hardly surprising as magnetometry is a standard surveying technique throughout Europe and the Mediterranean (Gaffney *et al* 2000, 82; Ciminale *et al* 2007)

The two seasons of magnetometry survey at Castelporziano were undertaken with the (older) FM36 Geoscan model which is restricted to traverse intervals of 1m. Results from survey and excavation have shown that many walls are less than 0.5m wide (Claridge pers. comm.) and it is therefore entirely possible that some features have been missed or only partially located. Discussion of the results from the 2009 survey at the *Vicus* has shown that the traverse interval, combined with collection error can possibly reduce the effectiveness of locating features, especially when traversing on a similar alignment. The best way to counter this in future surveys is to consider using a more modern instrument and a denser sampling strategy. The site could also be surveyed in different directions, perhaps at 45 degrees to the known alignment of buildings in this area.

There are also advances in geophysical/remote survey outside the single instrument fluxgate range to be considered for future use. For example high sensitivity magnetic surveys such as caesium vapour have shown not only to match fluxgate systems for well-magnetized causative features but also to possess a superior ability to detect very weak anomalies under 0.1nT (Linford *et al* 2007, 165). In addition, certain products now boast the capability to mount multiple gradiometers or sensors – often in carts or harnesses - enabling faster acquisition of data (Ciminale *et al* 2007, 172).

However, nearly all these techniques, well illustrated at Forum Novum (Gaffney *et al* 2004, 201), are best suited to open/greenfield sites, which allow the smooth collection of data. The site at Castelporziano, as has been noted, is covered in a dense forest which in practice makes it difficult to traverse 20 metres without encountering multiple obstacles. The ground level is also far from flat, with the natural and unnatural contours of the terrain combined with the large amount of surface detritus providing a significant challenge for the surveyor. The presence of numerous collection errors within the unprocessed and processed results from the 2008-2009 seasons clearly illustrates these problems. Whilst to some extent advocating the potential use of recent advances in remote survey, nearly all these need smooth, uncluttered terrain. Even smaller multi-instrument arrays such as the latest Geoscan models and caesium vapour gradiometers rely on the unhindered movement of the surveyor, whereas overhead branches and stumbles will impede if not prohibit the application of these techniques in practice.

Finally, a note on an important factor for all magnetometer surveys – the setting up and balancing of the instrument. It was observed that the very best results (the 2008 survey at D5/D6) and the 2009 *Vicus* survey came when a stable point with little or no background noise was used. This wasn't always easy to find on the site due to the concentration of ancient and modern magnetic detritus in the subsoil. A good case study are the two *Vicus* surveys in 2008 and 2009; the former used an area to the north of the site towards the *Via Severiana* whilst the latter an empty space (with a known subsoil typical of the site) within the peristyle garden of Building C was used. The difference in the clarity of the results between the two seasons is significant and is undoubtedly due to this factor.

5. Bibliography

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Linford, N., Linford, P., Martinda, L. and Payne, A. 2007. 'Recent Results from the English Heritage Caesium Magnetometer System in Comparison with Recent Fluxgate Gradiometers', *Archaeological Prospection* 14, 151-156.

Appendix A: Project Metadata (ADS standard)

Field Name	Description	Relevant Types	Required	Metadata
Survey Name	Name of the survey or project	**All**	**Yes**	The evolution of Rome's maritime facade: archaeology and geomorphology at Castelporziano.
Survey Puprose	A brief description of the project including its aims and objectives.	**All**	**Yes**	Geophysical survey in the vicinity of the *Vicus Augustanus* at Castelporziano. The survey was located at the Northern extent of the *Vicus* following indications in an earlier survey of unrecorded structures.
Bibliograhic References	Any relevant references to the work or project.	**All**	No	**Evans,T. 2009. Geophysical Survey at Castelporziano 2009. Unpublished report for AHRC.**
Survey Keywords	Keywords related to the survey or project	**All**	No	Magnetometry, vicus, roman
Spatial Coverage	Coordinates of the survey area or areas. Include coordinate system.	**All**	**Yes**	N/A
Administrative Area	Political or administrative place names where work was conducted	**All**	**Yes**	LL 41.703,12.358 (estimate)
Country	Country or Countries of work	**All**	**Yes**	Italy
Solid Geology	The underlying bedrock of the site	**All**	**Yes**	Not known
Drift Geology	The presence of transported rock debris or geological deposits	**All**	No	Wind blown sand
Duration	The dates which the survey took place	**All**	**Yes**	9th-23rd April 2009

Weather	Weather conditions during the survery	**All**	No	Fine, occasional light shower
Land-use	A description of the land use	**All**	**Yes**	Forest
Monument Type	The type of site or monument, preferably based on a controlled vocabulary (such as MIDAS). If it is a Scheduled Ancient Monument type include the SAM number (UK only)	**All**	No	Vicus
Surveyor	The individual(s) or unit which conducted the survey	**All**	**Yes**	Tim Evans
Client	The client for which the survey was conducted	**All**	No	N/A
Depositor	Depositor of the survey data	**All**	No	Amanda Claridge
Copyright	Copyright owner of the survey data	**All**	**Yes**	Amanda Claridge and Tim Evans
Survey Type	The type of survey (ie. Gradiometry, Resistivity, GPR, etc)	**All**	**Yes**	Gradiometry
Instrumentation	The model or equipment employed in survey	**All**	**Yes**	Geoscan FM36
Number of Files	The number of output or data files	**All**	**Yes**	109
File Extensions	The extension types of the files and description	**All**	**Yes**	Original files collected as Geosacan Grid files comprising a .dat / .grd / .grs All files exported as ASCII text files (.txt) with composite files saved as (.tif)
Area Surveyed	The size of the area surveyed	**All**	**Yes**	
Method of Coverage	The track or path taken for the survey (ie. Zigzag, Regular Grid)	**All**	**Yes**	Parallel traverse
Traverse Separation	Distance between traverses	**All**	**Yes**	1m
Sample Interval	Distance between taken readings	**All**	**Yes**	0.25m

Position of First Traverse	A general location of the first line of the square/survery	**All**	**Yes**	0.5m
Direction of First Traverse	A general direction of the first line of the square/survery	**All**	**Yes**	West
Probe Configuration	Configuration of instrument used during survey	Resistivity	**Yes**	N/A
Probe Spacing	Distance between probes	Resistivity, Gradiometry	**Yes**	N/A
Antenna	The antenna frequency of the survey	GPR	**Yes**	N/A
File Format	Type of data files	GPR	**Yes**	N/A
Instrument Specific	Any other information that is relevant to the data collection stage of the survey. For example GPR: Antenna separation, Pulsar voltage, Number of stacks, etc.	**All**	No	Zero Log drift / Averaging were NOT enabled
Additional Remarks		**All**	No	
Report Title	Title of related report(s)	**All**	No	**Geophysical Survey at Castelporziano 2009**
Report Author	Author of report	**All**	No	Evans,T.
Report Holder	Holder of report. For example, could be unit or County Council.	**All**	No	

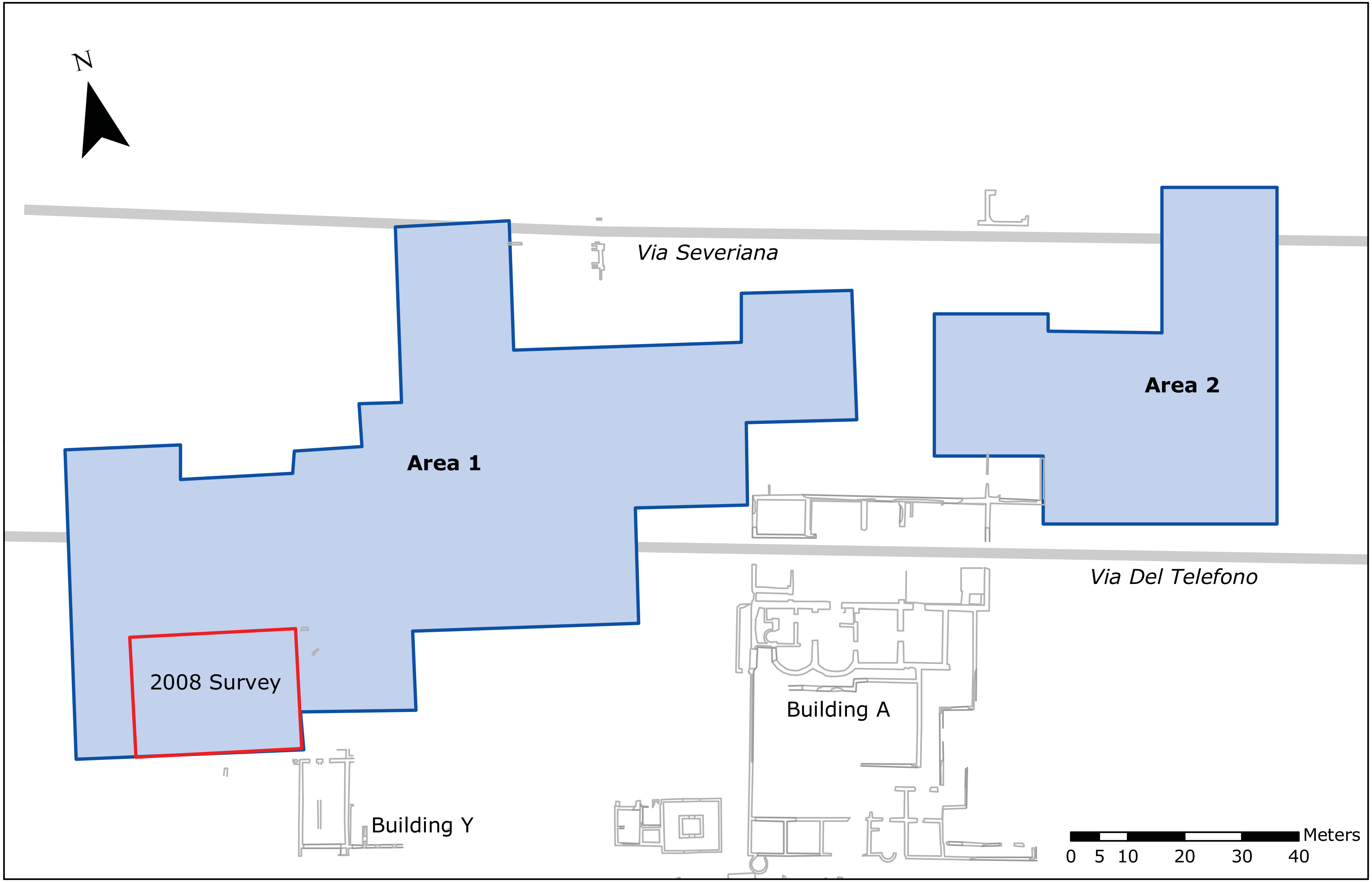

Figure 1: Location of the 2009 Survey Areas

Figure 2: Area 1 - unprocessed results

Figure 3: Area 1 - processed results

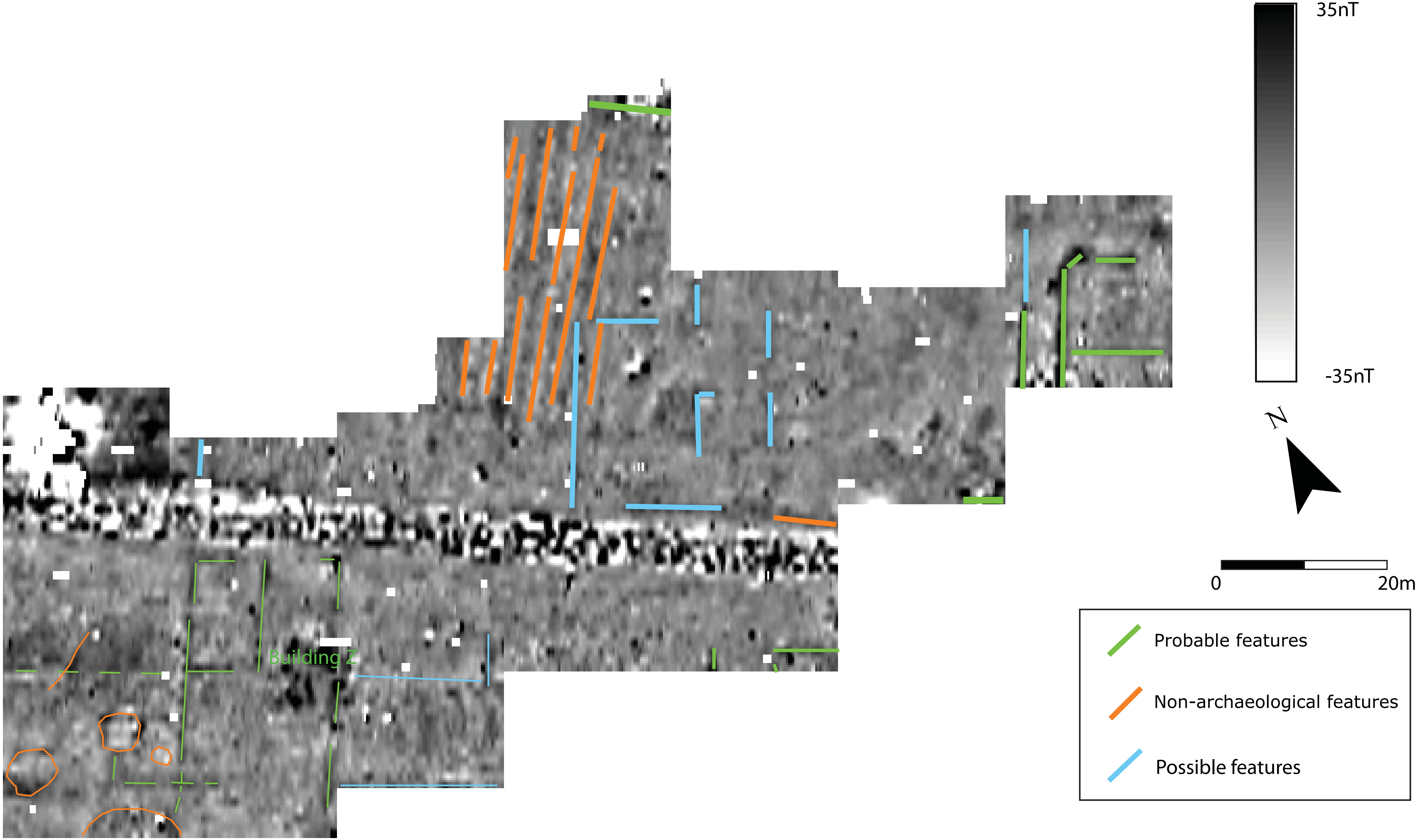

Figure 4: Area 1 - processed results with interpretation

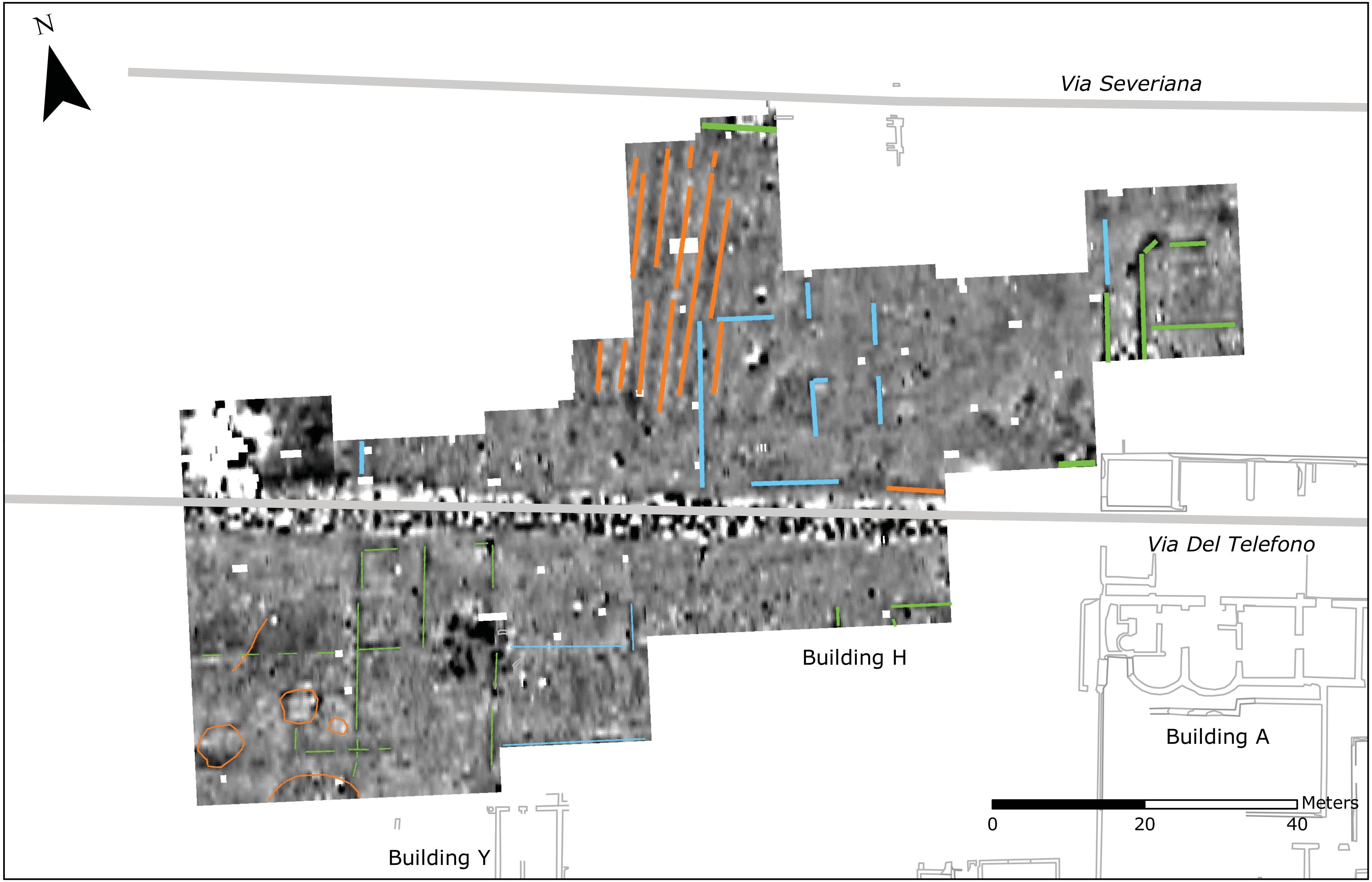

Figure 5: Area 1 - interpretation in context

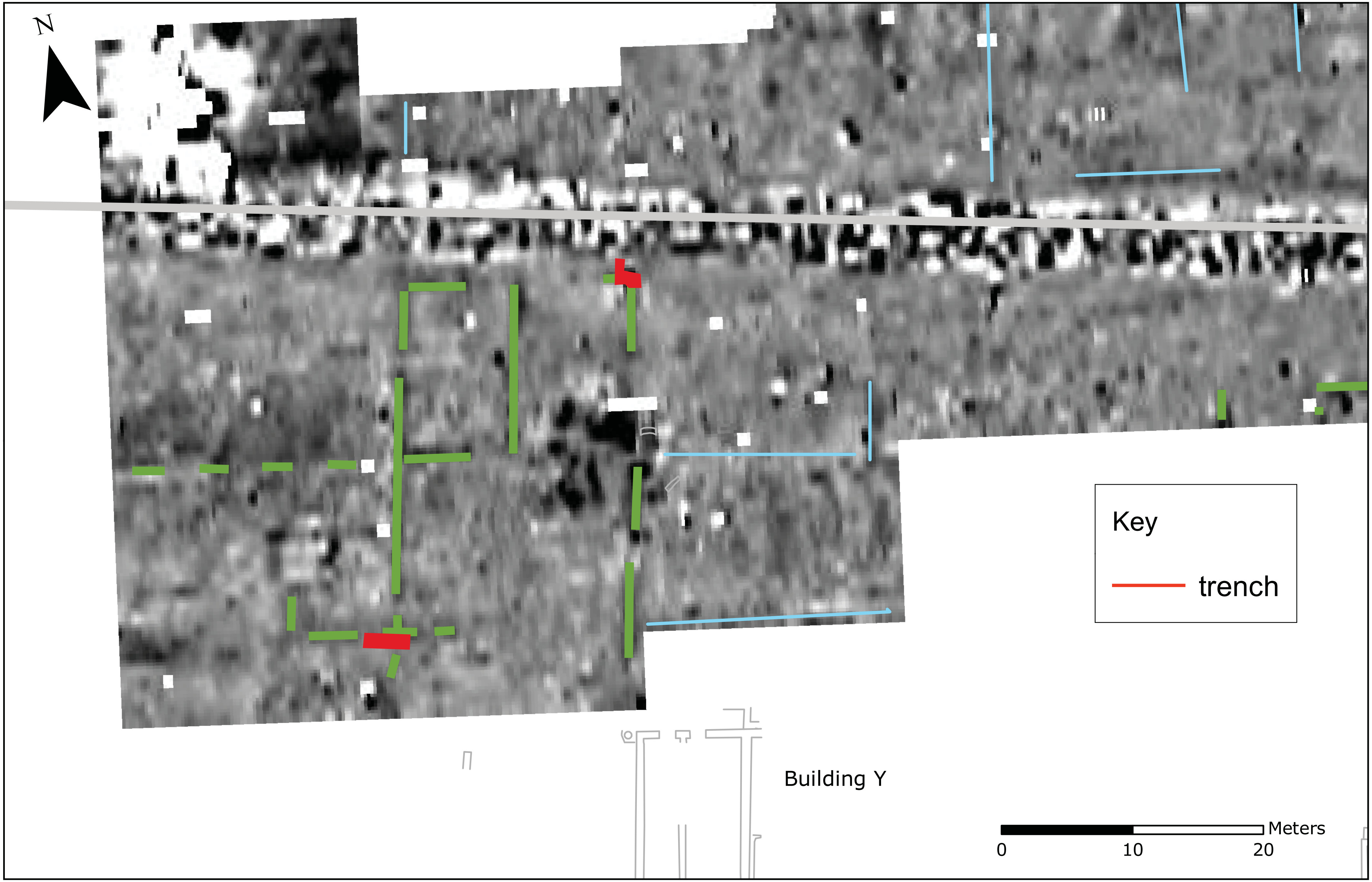

Figure 6: Location of test trenches

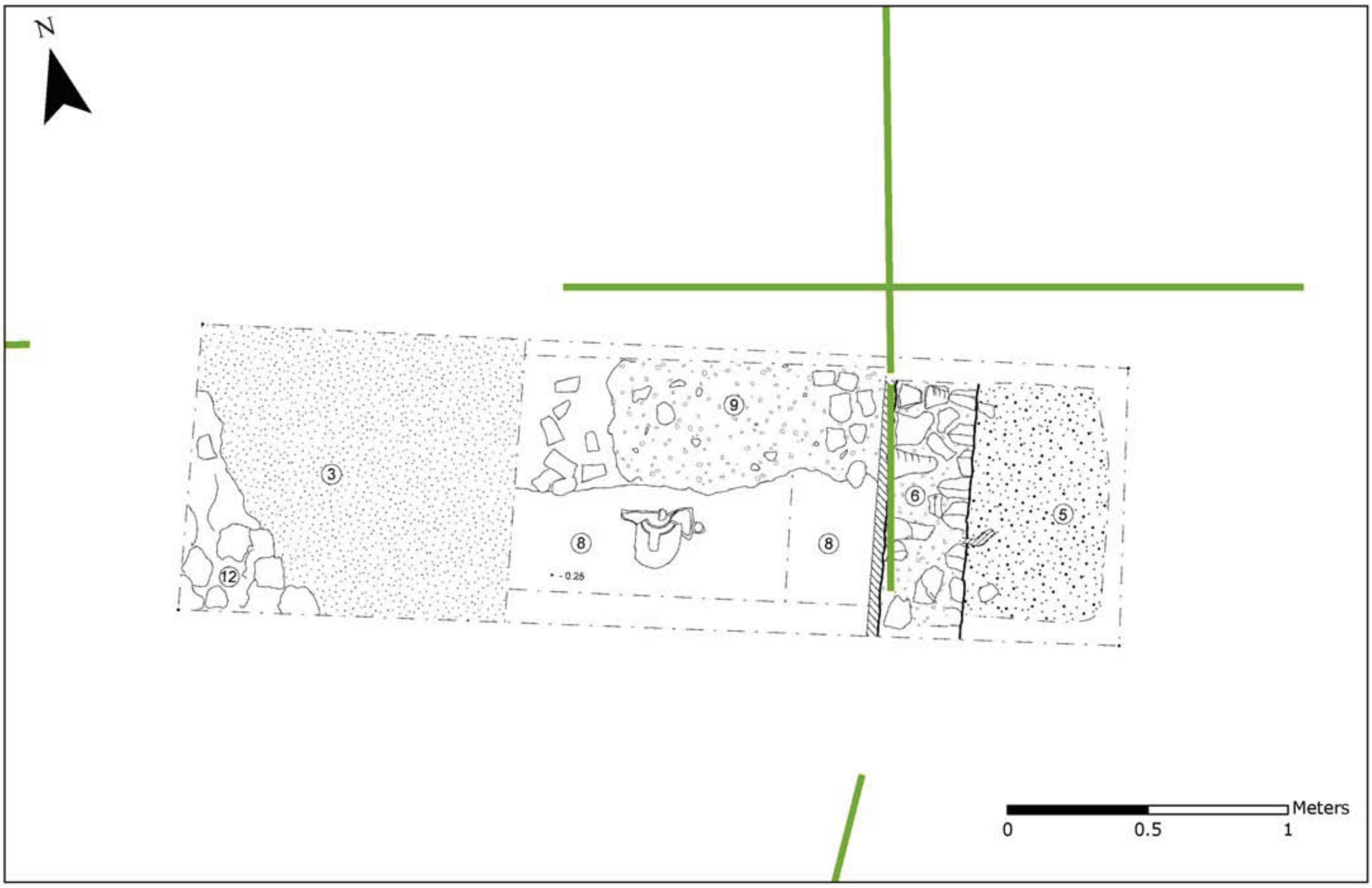

Figure 7: Trench 1 with original geophysics interpretation

Figure 8: Trench 2 with original geophysics interpretation

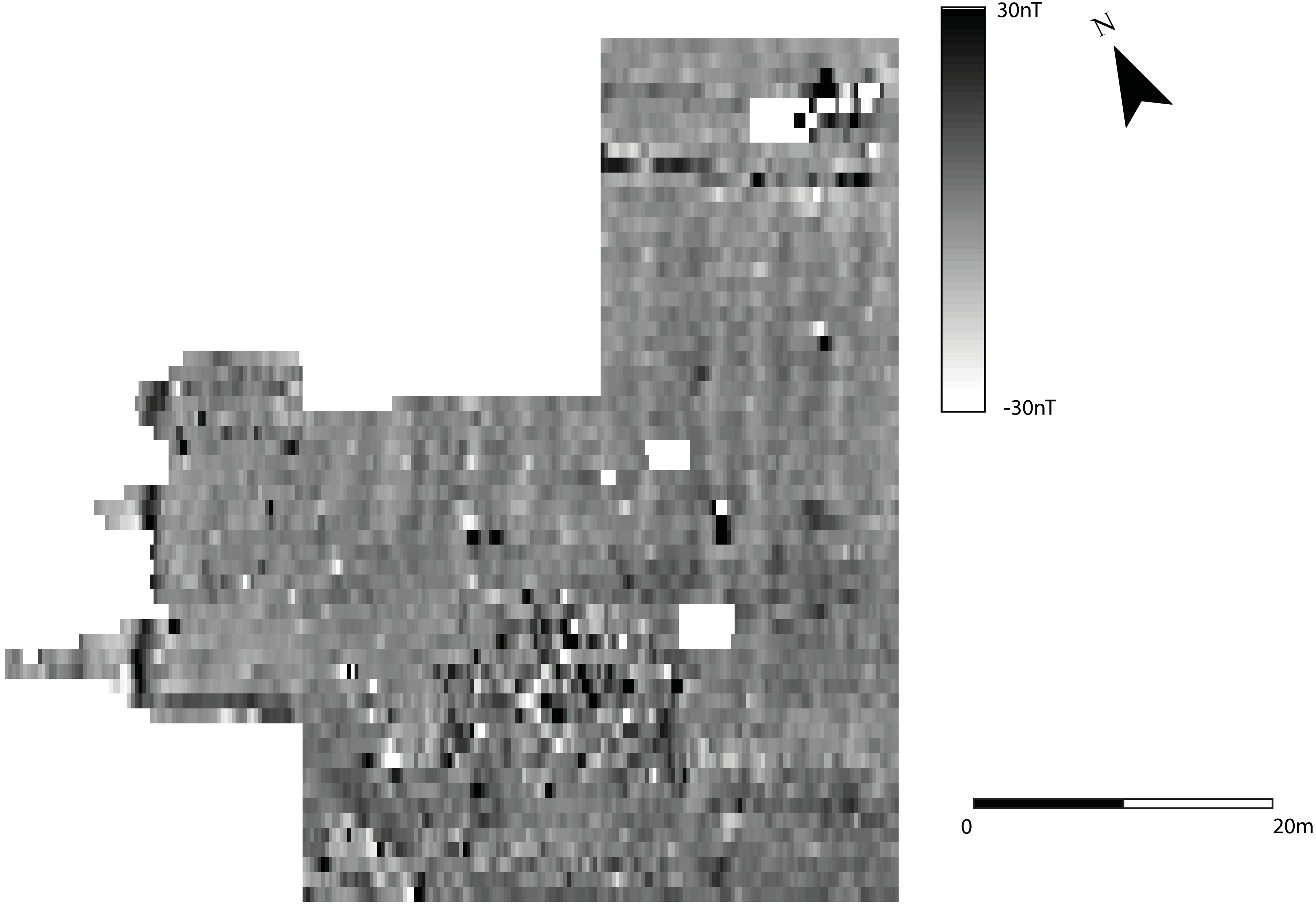

Figure 9: Area 2 - unprocessed results

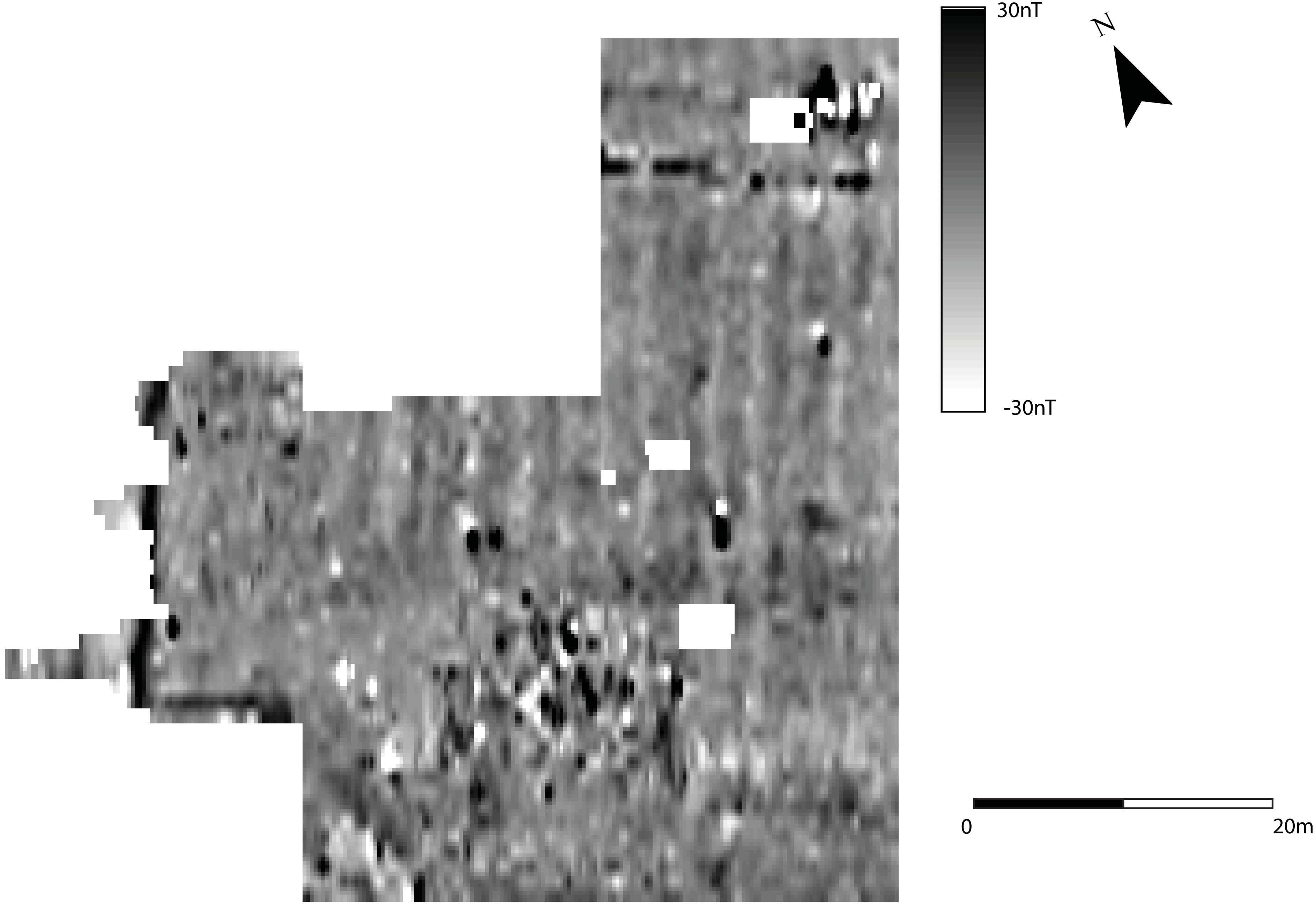

Figure 10: Area 2 - processed results

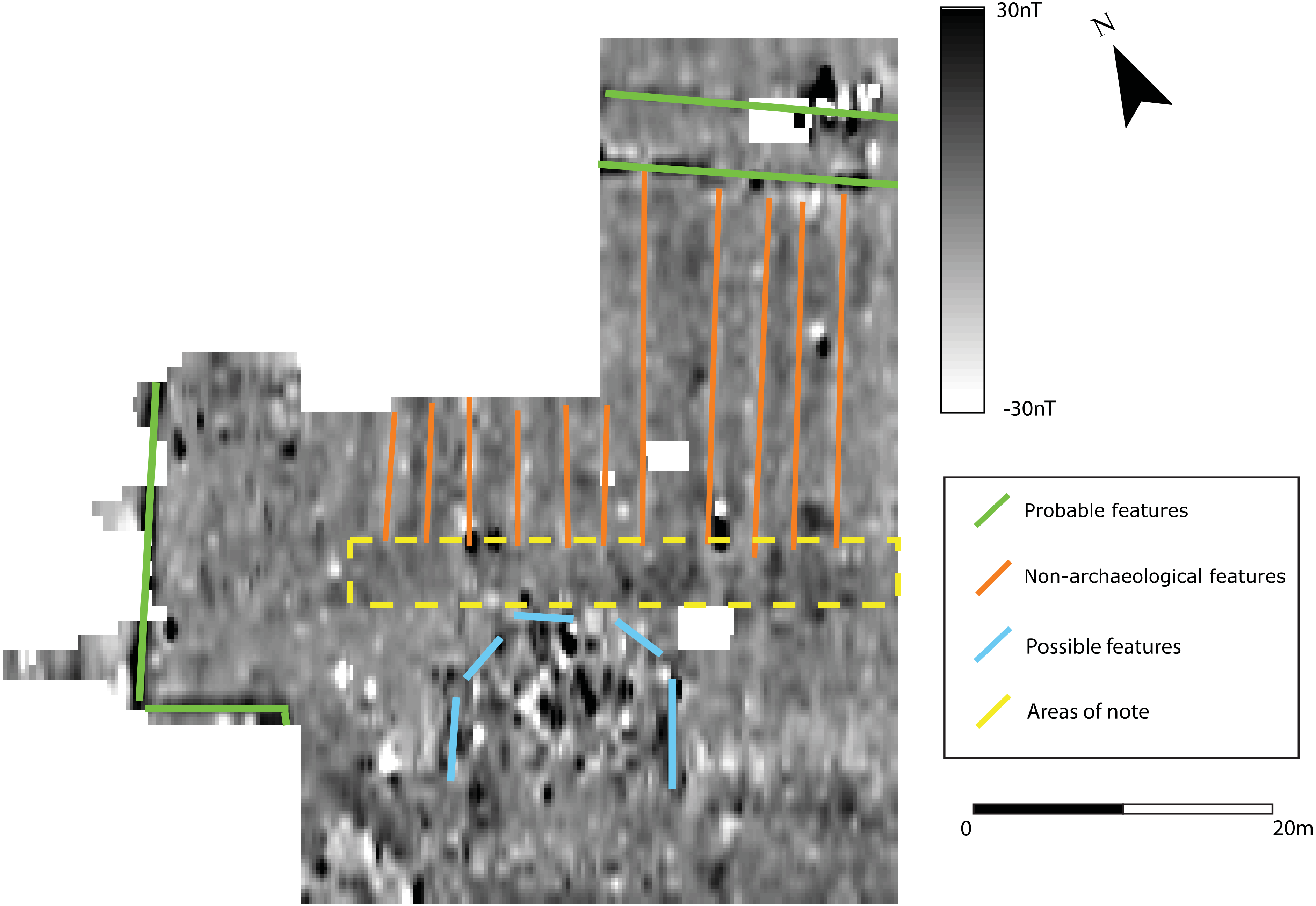

Figure 11: Area 2 - processed results with interpretation

Figure 12: Processed plots of both areas in context

Pl. 1 Vicus, magnetometer survey area 1 south of via del telefono, from north-west (Photo 6173)

Pl. 2 Vicus, magnetometer survey area 1, south of via del telefono, from south-west (Photo 6170)

Pl. 3 Vicus, magnetometer survey area 1, north of baths A, from west (Photo 6223)

Pl. 4. Vicus, magnetometer survey area 2, from south-east (Photo no. 6331)