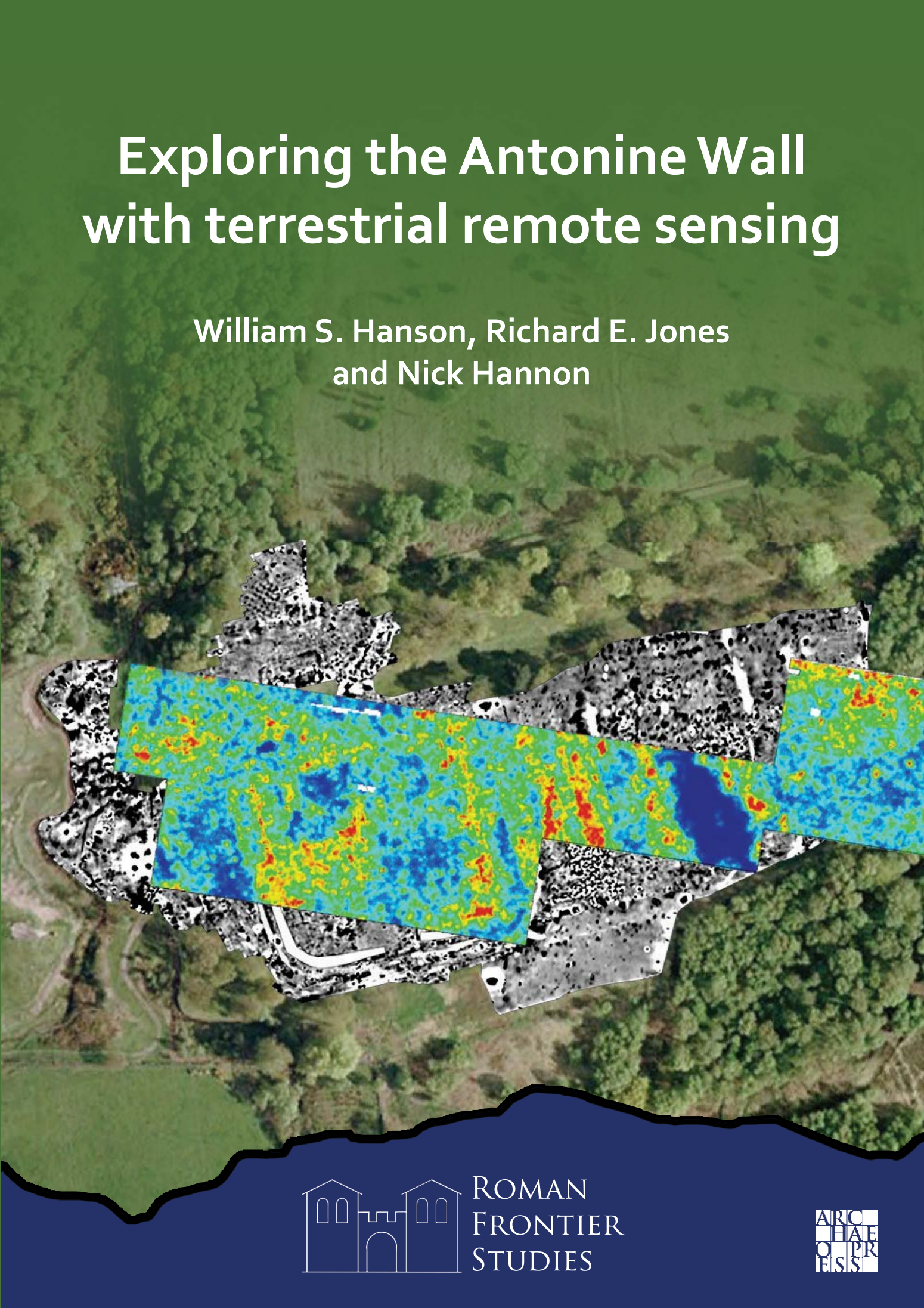
Exploring the Antonine Wall with terrestrial remote sensing

William S. Hanson, Richard E. Jones
and Nick Hannon



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Chapter 1

1.1 The development of archaeological understanding of the Antonine Wall

The Antonine Wall is Scotland's largest ancient monument and, since 2008, a UNESCO World Heritage Site (WHS) (Figure 1.1). Its remains have been visited and recorded since the 16th century, antiquarian interest continuing intermittently thereafter until the mid-19th century (below). More systematic examination by excavation did not begin until the very end of that century and continues to this day, though most of it now in the form of relatively small-scale rescue work in advance of development.

Modern research interest in the Wall began with the work of the Glasgow Archaeological Society who undertook a sustained programme of excavation and survey of the linear barrier in the early 1890s, their published results accompanied by a brief overview of previous ancient and antiquarian accounts (GAS 1899). The first overall synthesis of knowledge about the Wall – *The Roman Wall in Scotland* - was published by George (later Sir George) Macdonald in 1911. It included not just a descriptive account of the visible remains and the results of the early excavations at fort sites such as Castlecary, Rough Castle and Bar Hill, but a consideration of the literary sources, historical context and associated inscriptions, with a particular focus on the distance slabs, a unique feature of the Antonine Wall that record the lengths of Wall built by particular legions.[1] The volume was fully revised and expanded in 1934 to include archaeological investigations which had taken place in the intervening years, many of them Macdonald's own. Indeed, these years had seen a considerable expansion of knowledge with, as Macdonald himself notes in the preface (1934: vii), more than a doubling of the number of forts that had been subject to excavation, including Old Kilpatrick, Balmuildy, Cadder, Croy Hill, Westerwood and Mumrills. Of particular note was the inclusion of a series of pull-out extracts from the Ordnance Survey six-inch to the mile maps on which the line of the Wall and its associated features was traced in red.

The next landmark was the publication in 1960 of *The Antonine Wall: a handbook to the Roman Wall* by Anne Robertson, which provided a site-by-site account of the remains with a fairly lengthy general introduction to the monument and its context. This went through three editions until 1979. Then came something of a sea change with the appearance in 1983, followed by a slightly revised paperback edition in 1986, of *Rome's North-West Frontier: the Antonine Wall* by William Hanson and Gordon Maxwell. This set out not 'to provide a guide to the Wall as it survives today, nor to give a detailed description of its physical remains as understood from archaeological excavation', even though elements of the latter inevitably were included, but was 'concerned to locate the frontier within its historical background, to try to explain why and how it was built, how it functioned, and to assess what effects it had upon the later history and development of the northern frontier' (1986: xi). This book was able to take into account not only important large-scale excavations undertaken in the 1970s at two forts (Bearsden and Croy Hill), but smaller scale excavation at several new fortlets (Cleddans, Wilderness Plantation, Croy Hill, Seabegs Wood and Kinneil), the identification and examination of a new type of site, the minor enclosure, and a review of all the known construction camps. As a result, it was rapidly to become the standard work on the subject and remains the most comprehensive and detailed modern account of the Wall.

Lawrence Keppie, who had himself undertaken extensive fieldwork on the Wall, finding new fortlets and paying particular attention to the evidence for variations in its construction (e.g. Keppie 1974; Keppie and Walker 1981), took over editing Robertson's handbook in 1990. He maintained the same general format (and, indeed, attributed authorship) while expanding the content, updating the illustrations and slightly amending the title. He produced two more editions, the most recent in 2015 (Robertson 2015). Meanwhile, stimulated by the proposed nomination of the Wall as a World Heritage Site (below), David Breeze produced a more popular synthetic overview, setting out 'not just to describe the Wall, but to place it in its British and Roman imperial setting and consider its importance and significance' (2006: xii).

As well as continuing to edit the handbook, Lawrence Keppie had undertaken a major review of the epigraphic and sculptural evidence, including a detailed analysis of

[1] This long-standing standard term for this group of inscriptions has recently been challenged on the grounds that it 'conjures an outmoded and inappropriate notion of this body of material as bland, uninspiring, functional blocks of stone devoid of any character or intrinsic cultural significance' (Campbell 2020: 176). The Shorter Oxford English Dictionary defines slab as 'a flat, broad and comparatively thick piece or mass of anything solid' and it is commonly used to describe other building inscriptions or tombstones that fit such a definition. Thus, the term distance slab is simply a conveniently precise and descriptively accurate term that need not carry any of the ascribed implications and so does not require to be changed.

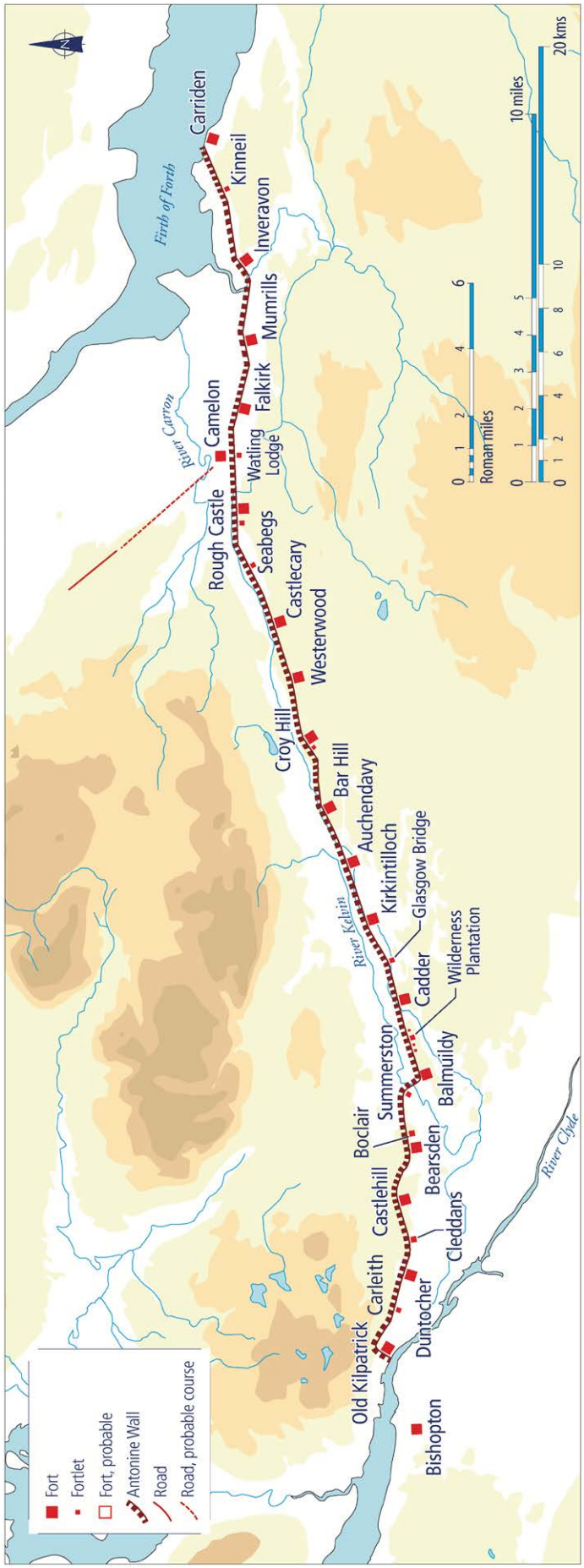

Figure 1.1. Map of the Antonine Wall as completed (© D.J. Breeze).

the distance slabs (1998: 49-58 and 72-130). It is fitting, therefore, that the most recent synthesis, a collection of papers by some 30 specialists summarizing the most up-to-date work on the Wall, should be dedicated to him (Breeze and Hanson 2020).

Finally, the detailed account of all the excavations and small-scale interventions undertaken by Geoff Bailey and his team of volunteers in Falkirk District appeared in 2021. This substantive volume includes reports on work in or around the forts at Carriden, Mumrills, Falkirk and Castlecary, the fortlet at Kinneil and stretches of the Wall between these sites, as well as more general discussion of selected topics.

1.2 Other non-invasive exploration of the Antonine Wall

This section briefly reviews how the Antonine Wall has been mapped and recorded over the centuries on the basis of surface observations. It also addresses the role that this data plays in enhancing our understanding of the monument, whether obtained from simple mapping of visible remains, from aerial reconnaissance, fieldwalking or from LiDAR survey.

1.2.1 Mapping and recording

The history of antiquarian interest and early mapping of the Antonine Wall has been well researched for the period up to the end of the 19th century (Keppie 2011; 2012). As early as the 13th century, the Antonine Wall featured on a map of Britain appearing in a world history created by an English monk, Matthew Paris. To Timothy Pont, however, goes the credit of listing forts he found in the course of his own fieldwork in the later 16th century, though the route he depicts of the Wall is not always fully accurate. He is given credit by Sibbald for a detailed schematic sketch of the main features of the Wall and is regarded by Keppie as a pioneer in the fieldwork and observation of its surviving remains (2011: 99). More than a century later the antiquarian, Sir Robert Sibbald, though undertaking no fieldwork himself, drew on the combined information available to him to produce a map of the Wall published in his *Historical Inquiries* (1707), in which he also included a diagram of its constituent elements derived from Pont's work (Figure 1.2).

Over the course of the 18th century William Stukeley (1720), Alexander Gordon (1726) and in particular John

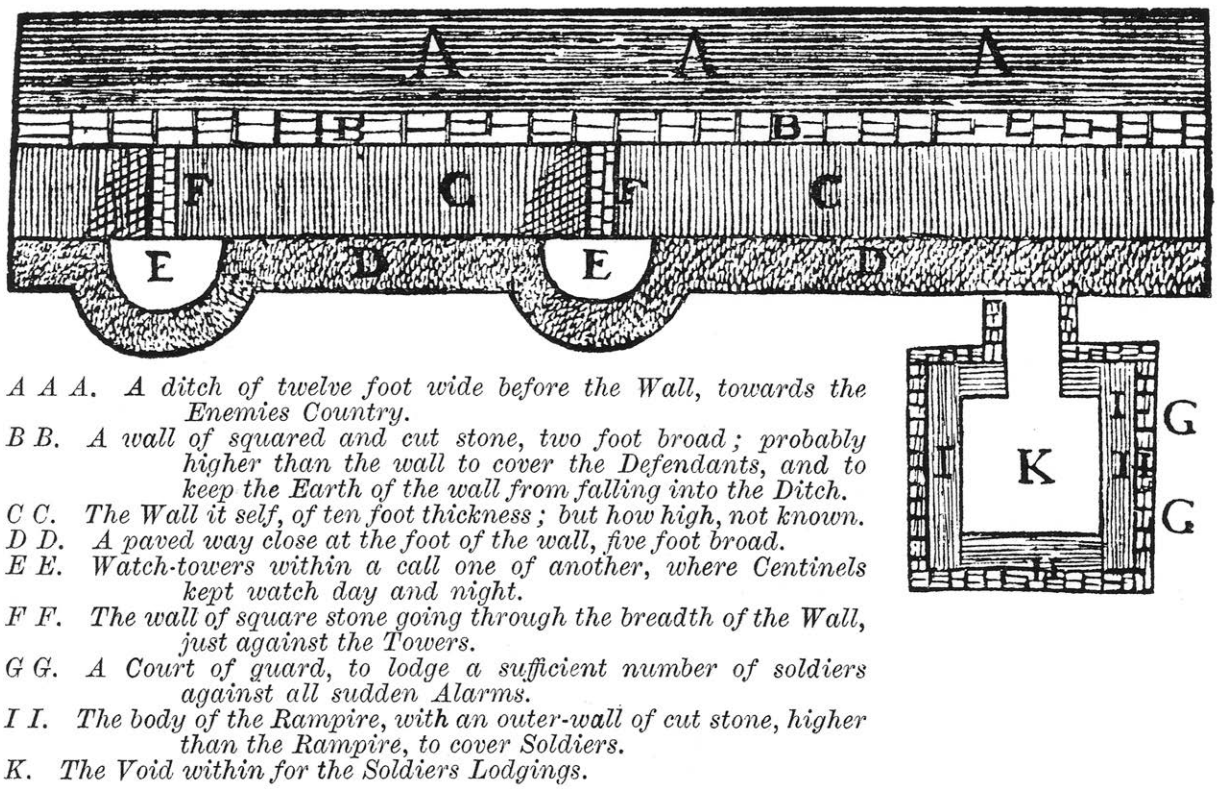

Figure 1.2. Schematic diagram of the features of the Antonine Wall produced by Sibbald, after Pont.

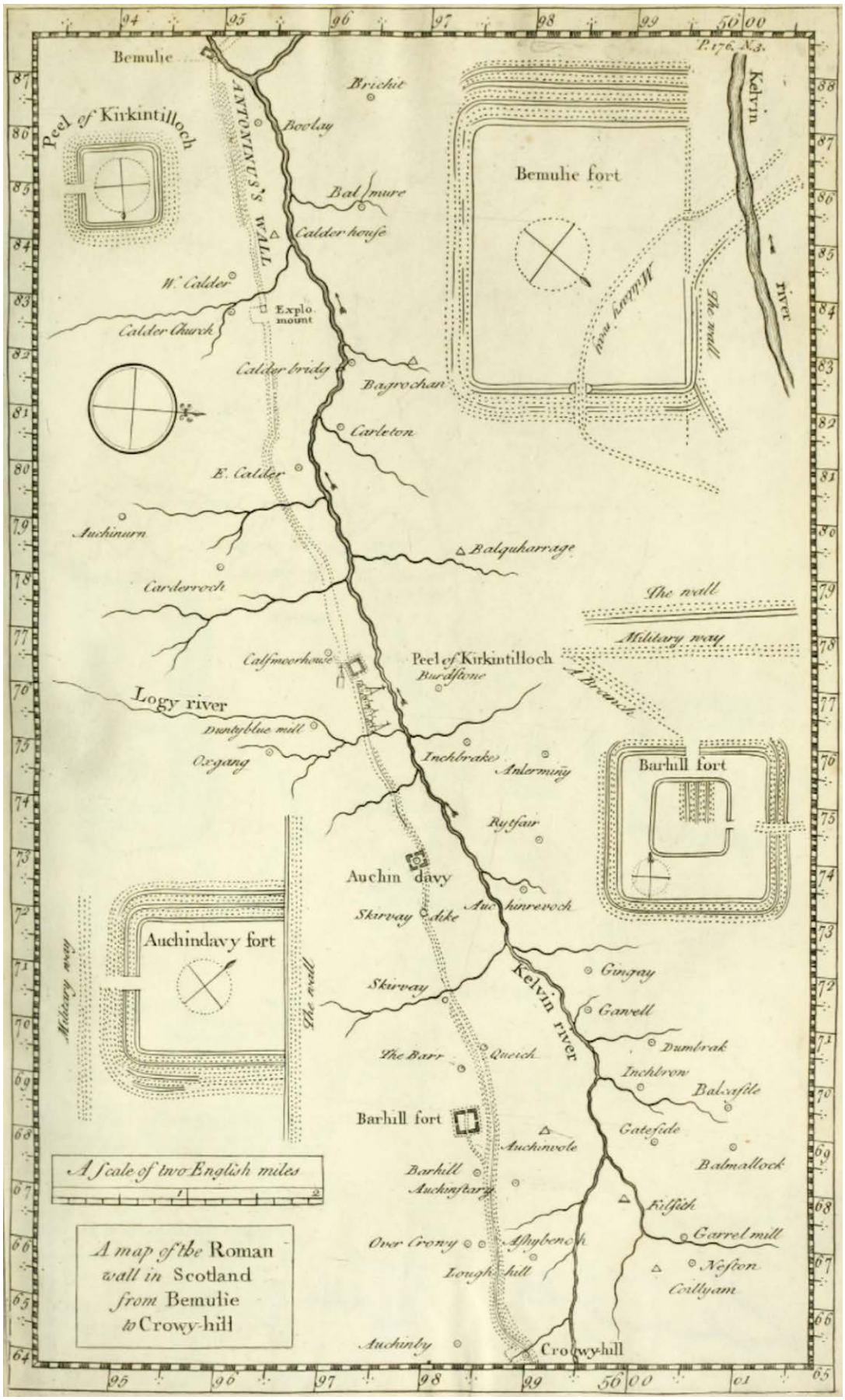

Figure 1.3. Horsley's map of the Antonine Wall between Balmuildy and Croy Hill.

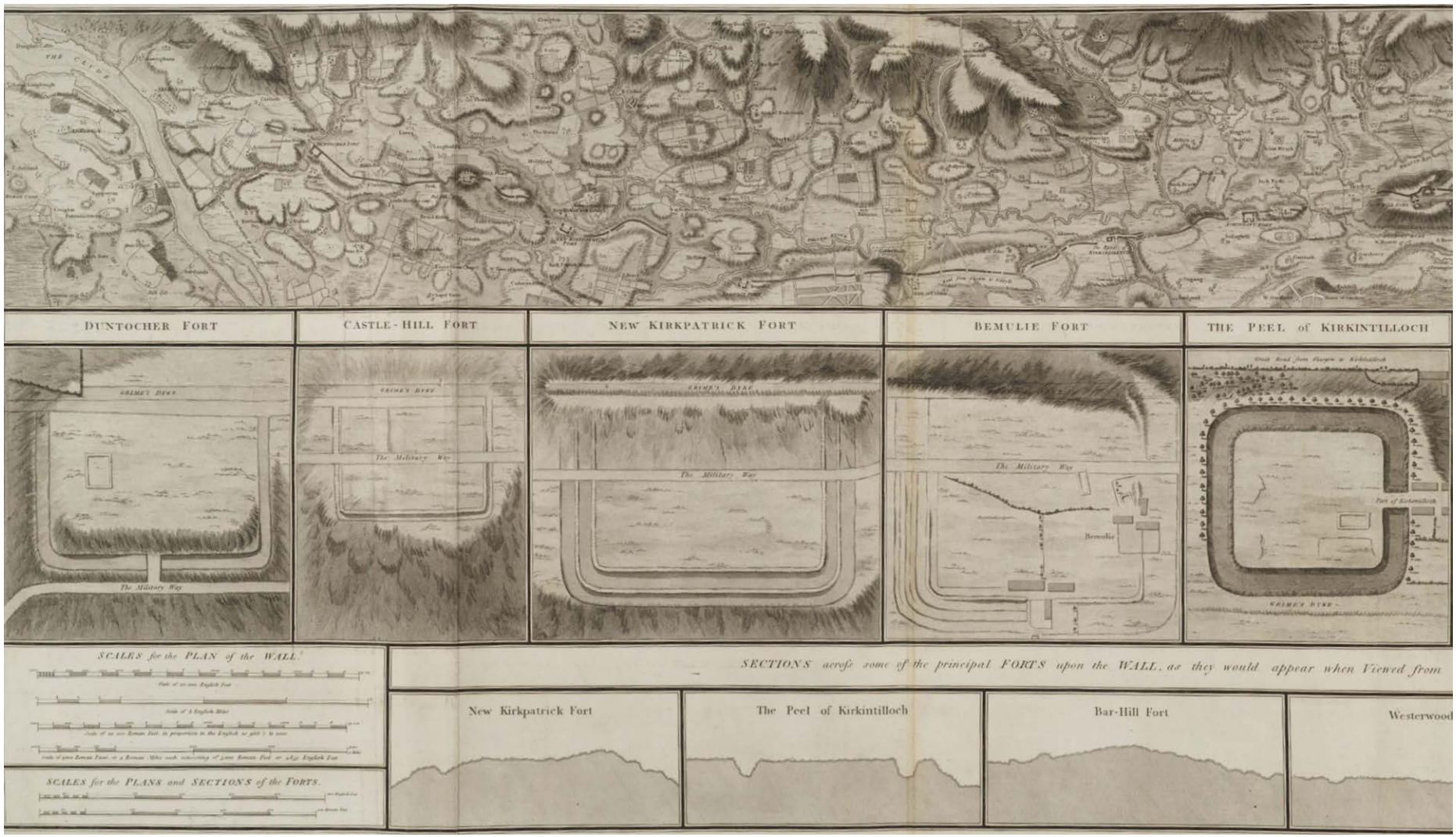

Figure 1.4. Extract from Roy's map of the Antonine Wall, showing the surviving course of the western end of the Wall and plans of the forts at Duntocher, Castlehill, Bearsden (New Kirkpatrick) and Balmuildy (Bemulie), along with the early medieval motte at Kirkintilloch (Roy 1793, Fig. 35).

Horsley (1732) produced increasingly sophisticated maps, as well as plans of individual forts and records of inscriptions, that accompanied their various accounts of the Wall (e.g. Figure 1.3). But it was General William Roy, charged with the major task of producing the Military Survey of Scotland in the aftermath of the Jacobite Rebellion (Roy 2007), who made the most significant contribution (Maxwell 1989b: 8-9: Keppie 2012: 91-92). The combination of a soldier's practical experience in managing military affairs, an understanding of the terrain, a keen interest in the Roman world and a knowledge of ancient military texts enabled him to map and record the Wall and other Roman sites in Scotland to a level of detail (at a scale of 1:36,000) and accuracy that was not to be surpassed for a century (Figure 1.4). The importance of his work, published posthumously in 1793 as his *Military Antiquities of the Romans in North Britain*, is widely recognised, and it continues to be consulted (see, for example, Chapter 2.5, below).

When the industrial revolution was already well underway in central Scotland in the early 19th century, the account of a five-day journey on foot along the Antonine Wall in September 1825 by an English clergyman and antiquarian, John Skinner, gives a snapshot view through his coloured sketches of the condition of the monument at that time. Skinner's account provides a systematic description of what he saw along the course of the Wall, the surface remains of forts, the Military Way and the presence of inscribed and sculptured stones (Keppie 2003). Skinner's observations make plain the survival of both the linear barrier and some of its fortifications at numerous places where now little is evident. Yet the effects on the monument's integrity of more intense agriculture, stone robbing and the construction of the Clyde-Forth Canal, which had opened in 1790, were already sadly apparent.

Such records were, however, more impressionistic than planimetrically accurate. It was not until the 1st edition of the Ordnance Survey's 6-inch and 25-inch maps, surveyed between 1854 and 1861, that we get a large-scale, metrically accurate topographic record of the Wall line (Figures 1.5, 2.2.2 and 5.4.10) (Jones and McKeague 2011: 147). While preservation of the linear barrier, usually represented only by its Ditch and perhaps the Upcast Mound beyond it, is consistently greater than is evident today, most of the fortifications along its line were already barely or no longer visible as earthworks. Indeed, further deterioration can be tracked through later editions of these maps, particularly where the Wall passed through expanding urban areas. For example, the line of the Wall Ditch was still visible on the 1st edition Ordnance Survey maps for most of its course from Old Kilpatrick to Balmuildy. There was also at least some indication of the ditches outlining the forts at Duntocher and Bearsden (then known as New Kilpatrick), though all trace of Old Kilpatrick and Balmuildy had already disappeared under building or agricultural development respectively. At the time of the resurvey in 1896, which broadly coincided with the first systematic archaeological fieldwork being undertaken along the Wall (GAS 1899), much of the Wall line was still visible in this sector, and the line of the ditches on the west side of the fort at Castlehill had also been recognised, but the fort at Bearsden had been almost completely built over. However, by the time of the 1914 map revision most of the line of the Wall Ditch between the Old Kilpatrick and Balmuildy had been either ploughed flat or built over, and nothing remained visible of either Bearsden or Castlehill forts. A similar pattern can be seen along much of the rest of the Wall, with variations in the chronology of destruction, leaving only pockets of good preservation by the mid-20th century. Indeed, it has been estimated that by 1973 no reasonably intelligible remains were visible on the ground for almost 80% of the linear barrier (Skinner 1973: 16-17 and Fig. 2).

As noted above, this systematic Ordnance Survey mapping provided the basis for Sir George Macdonald's detailed fieldwork and exploration of the Wall (1934). But that interaction was a reciprocal process (Linge 2004: 161; McKeague 2020: 433-34), which resulted also in the generation by the Ordnance Survey of a dedicated and large-scale map folio of the Wall based on information Macdonald provided (Ordnance Survey 1931). Interestingly, however, this information did not always sit well with their own earlier mapping, which they tended to choose to ignore in favour of Macdonald's line (Linge 2004: 162; Jones and McKeague 2011: 1417), though sometimes their deference was misguided (see Chapter 2.2, below). Nonetheless, some years later the Ordnance Survey felt sufficiently confident in their data to produce a dedicated map of the Antonine Wall which shows its entire line on a single sheet at a scale of 1:25,000 (1969).

As more information from excavations became available, however, the inconsistencies and inaccuracies evident at larger scales became increasingly problematic, exemplified by the difficulties of determining the line on the western side of Falkirk, requiring a more root-and-branch revision (Linge 2004: 162-63). Thus, shortly before the transfer of their responsibilities for archaeology to the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS), now part of Historic Environment Scotland (HES), the Ordnance Survey undertook a re-survey of the whole length of the Wall taking into account all fieldwork and excavation data then available. This resulted in a folio of 122 maps at scales of 1:1250 and 1:2500 (1980), along with a separate Reference/Field Report Folio documenting both the sources of the information and

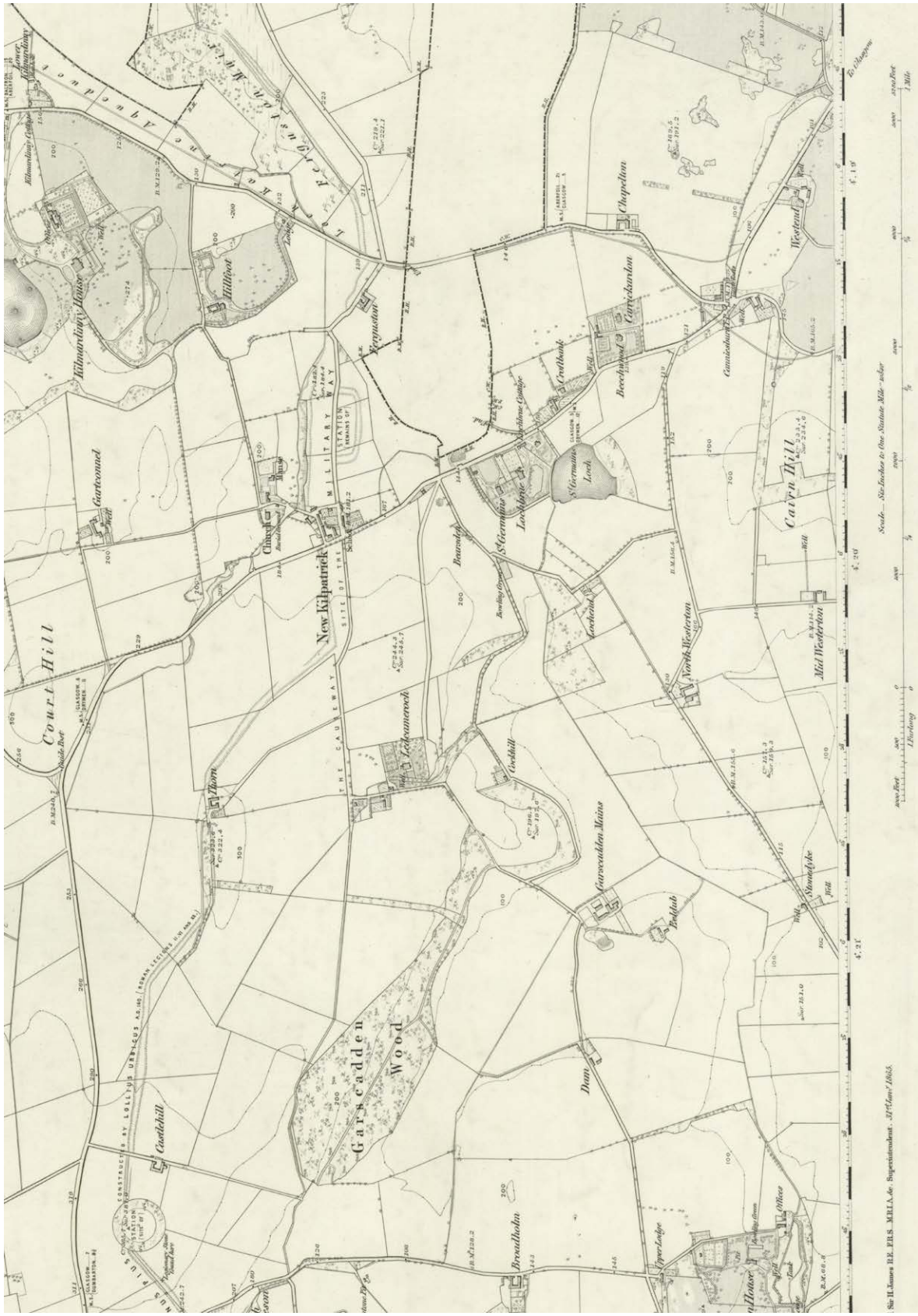

Figure 1.5. Extract from the 1st edition Ordnance Survey 6-inch map surveyed in 1861, showing the extant line of the Antonine Wall from Castlehill to Ferguston Muir (Reproduced with the permission of the National Library of Scotland. CC-BY (NLS)).

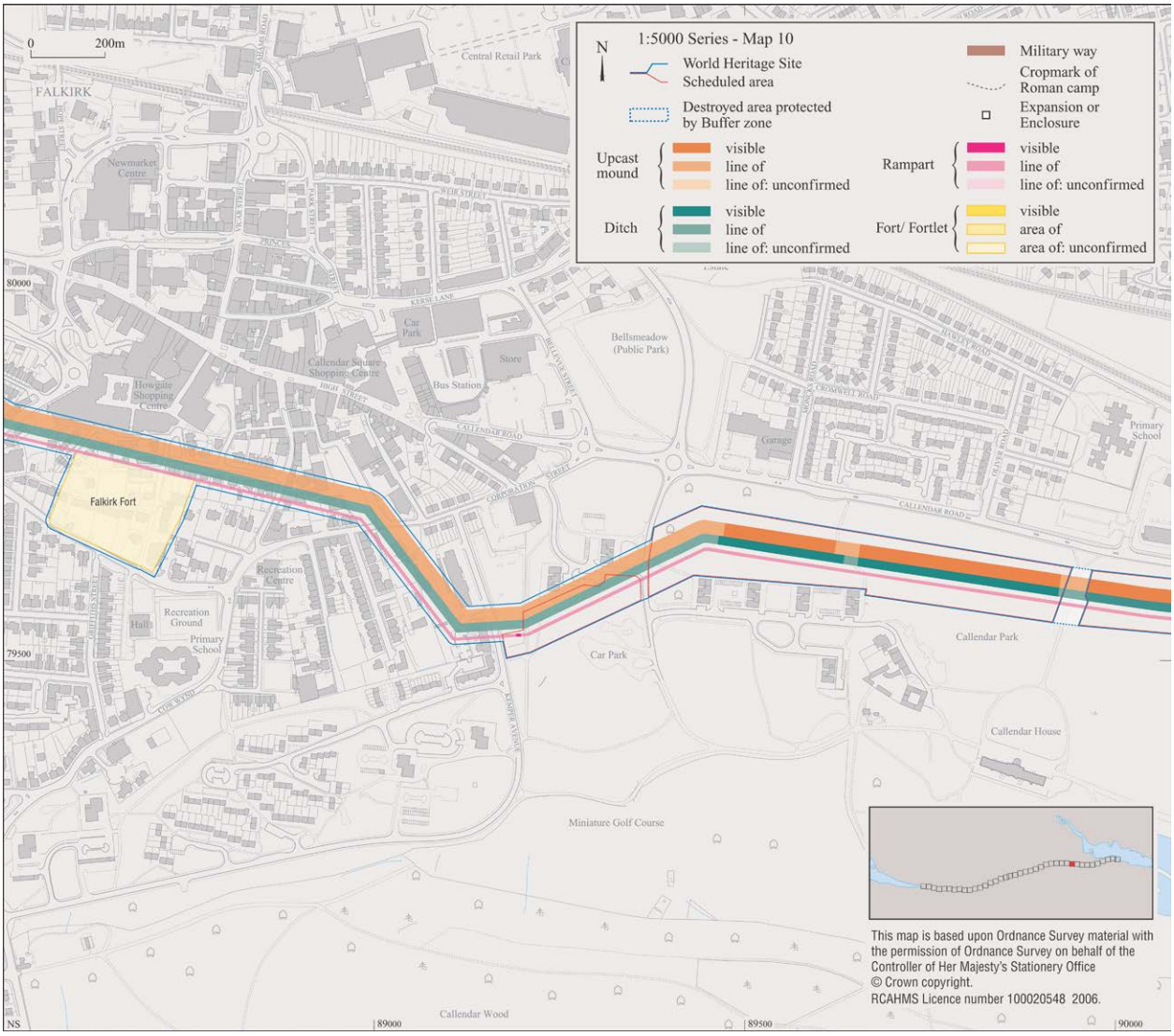

Figure 1.6. Sample map depicting the components of the Antonine Wall based on the World Heritage Site nomination documentation (after Historic Scotland 2007, vol. II, V-10-CS2 by courtesy of Historic Environment Scotland).

observations from their own fieldwork (Linge 2004: 162-66; McKeague 2020: 437-39). It is perhaps less surprising, therefore, that in the course of preparing this volume, we have encountered examples where excavators pursuing the line of the Wall, because its remains were no longer in evidence, have noted that the line recorded on large-scale Ordnance Survey maps was inaccurate. In cases where the line of the Ditch was actually visible in 1896, reliance on the 2nd edition Ordnance Survey mapping would have provided suitable correction (e.g. Chapters 2.8, 5.6 and 7.1).

There has been no further Ordnance Survey map revision to take into account the excavation and fieldwork which has taken place since 1980, and the archaeologists involved in that work seem to have been largely unaware of this important earlier resurvey data (Linge 2004: 166-67). However, as part of the preparations for the successful nomination of the Antonine Wall as an extension of the transnational *Frontiers of the Roman Empire World Heritage Site*, the data was reviewed again and a new set of 39 maps produced at a scale of 1:5000 incorporating detail from excavations and geophysical surveys undertaken up to that time, along with a comprehensive Global Navigation Satellite System (GNSS) survey of the monument conducted by Georgina Brown (Historic Scotland 2007; Jones and Brown 2007). In recognition of the variation in the level of detail available for different elements of the Wall, particularly the Upcast Mound, a somewhat stylised depiction of the various components was adopted (Figure 1.6) (Jones and McKeague 2011: 150-54; McKeague 2020: 440-41). This review also formed the basis for the publication of a revised map for use by the general public at a scale of 1:25000 (RCAHMS 2008).

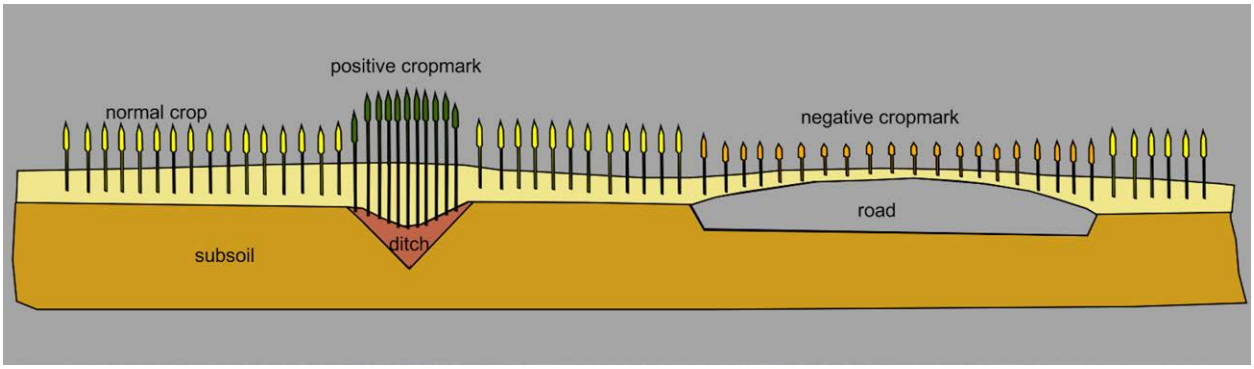

Figure 1.7. Diagram showing how cropmarks are produced.

Figure 1.8. Aerial photograph of part of the camp at Easter Cadder (left foreground) with the line of the Antonine Wall Ditch, Rampart (arrowed in white) and the Military Way (arrowed in black) beyond it to the right, all bisected by a modern pipeline. All are revealed as cropmarks, the Military Way primarily as a line of quarry pits. View from the east.

Figure 1.9. Aerial photograph of the double ditches of the fortlet at Wilderness Plantation revealed as cropmarks at the rear of the Wall. View from the south-west.

1.2.2 Aerial photography

Though O.G.S. Crawford had undertaken two pioneering flights in Scotland in the 1930s (1939), it was J.K.S. St Joseph, primarily under the auspices of the Cambridge University Committee for Aerial Photography established in 1949 (CUCAP), who developed and expanded the application of aerial reconnaissance so that it became one of the most important methods of archaeological survey in Britain. St Joseph had a particular interest in Roman military sites and from the mid-1940s undertook reconnaissance in Scotland almost every summer until his retirement in 1980 (e.g. St Joseph 1949; 1976). It was not until 1976, however, that RCAHMS established its own systematic programme of reconnaissance under G.S Maxwell, who also had a strong interest in Roman archaeology. This development was accompanied by increased activity by local flyers, including the first named author.

Figure 1.10. Google Earth image of cropmarks defining the south-east corner of the fort and eastern annexe at Mumrills in 2013 (© 2019 Maxar Technologies).

Archaeological sites can be revealed from the air in one of three main ways (Wilson 2000: 38–80). Where they are extant, even if so little survives that they are not readily appreciated from the ground, they may be revealed from the air by virtue of the pattern created by the shadows cast in low sunlight, an effect which can be enhanced by a light covering of snow. These types of photograph are used primarily for illustrative purposes in relation to well-preserved parts of the Wall (e.g. Robertson 2015: Figs 43, 53 and front cover), though they can also provide instructive information about them (e.g. Maxwell 1989a: 177 and Figs 14.9-14.11).

Since, as a result of the destructive impact of the plough (above), most of the Wall is now largely invisible above ground even where it is not built over, the most important contribution of aerial survey comes from the identification of cropmarks (Figure 1.7). Once growing plants have exhausted the water stored in their rooting zone, they begin to suffer moisture stress and to wilt. Plants growing over buried stone foundations will have a more restricted rooting zone and exhibit signs of moisture stress before other plants in the same field, so that their growth will be less luxuriant and they will ripen more quickly generating negative cropmarks. The opposite occurs where plants are growing over buried pits or ditches, producing positive cropmarks – that is, areas of relatively enhanced crop growth. However, the combination of factors which best suit cropmark production – dry weather patterns, well-draining soil types and fields of cereal crops – apply relatively infrequently to much of the line of the Antonine Wall, particularly towards its western end (Maxwell 1989a: 174).

Nonetheless, all 21 of the temporary camps associated with the construction of the Wall are cropmark discoveries (Hanson and Maxwell 1986: 117-21; Jones 2005) (e.g. Figure 1.8), as are the only three minor enclosures currently known attached to the rear of the linear barrier (Hanson and Maxwell 1983). However, only three of the known fortlets, at Summerston, Wilderness Plantation (Figure 1.9) and Glasgow Bridge (Figure 3.4.3), and one fort at Carriden were actually discovered from the air (Maxwell and Hanson 2020: 193-94; Wilkes 1974: 51; RCAHMS 1978: 134 and plate 13a; St Joseph 1949: 167-70 and pl. XXXIII). A second fort discovery, that of Mumrills, may be at least in part

attributed to the recognition of cropmarks, though in that case from the ground rather than from the air (see Chapter 6.5, below). In addition, the recording of cropmarks has further enhanced our understanding of some other forts, such as Castlehill and Auchendavy (Keppie 1980: 82-83; Keppie and Walker 1985: 29-32 and pl. I), and has helped confirm the line of the Wall and Military Way in various locations where all surface traces have been removed by the plough (e.g. Figure 1.8).

The primary source of archaeological aerial photography for the area is the National Record of the Historic Environment (NRHE) maintained by HES in Edinburgh. This holds not only the oblique photographs from its own reconnaissance, but copies of at least a representative selection of photography from other sources. Increasingly, such material is being made available directly online through the online catalogue to Scotland's archaeology, buildings, industrial and maritime heritage provided by the NRHE, currently branded as Canmore.[2] With the advent of the website Google Earth the availability of satellite imagery has further enhanced access to aerial images, though this coverage, which also includes a substantial proportion of vertical aerial photography, has only occasionally been acquired in conditions most suitable for the recognition of archaeological sites (e.g. Figure 1.10).

1.2.3 Fieldwalking

Walking over recently ploughed fields to recover artefacts, mainly pottery, is a useful way of discovering potential new sites. Though this methodology has been applied relatively infrequently along the Antonine Wall, it has been responsible for the primary discovery of the fortlets at Seabegs Wood and Kinneil, and the recovery of an important altar from outside the fort at Westerwood (Keppie and Walker 1981: 143-54; Walker 2020). Fieldwalking supported by metal detecting, with the careful plotting of the finds recovered, can also provide additional information about known sites. Work by the Falkirk Local History Society in conjunction with the Edinburgh Archaeological Society at Carriden provided support for the identification of the military enclosure recorded on aerial photographs as an annexe on the basis of the more limited recovery of Roman finds from the relevant field compared to their fieldwalking across the east side of the fort at Mumrills (Bailey 2021: 205-09 and 238-50). Comparison of the variable concentration of different types of material at the latter has also helped to suggest areas that may be linked to specific activities or buildings within the fort.

1.2.4 LiDAR

During the last twenty years, Airborne Laser Scanning (ALS), commonly known as Airborne LiDAR (Light Detection and Ranging Survey), has seen increasing application in British archaeology (e.g. Figures 2.1.2; 2.3.8; 2.5.4). This technique involves directing a pulsed laser beam at the ground and recording the reflections that bounce back (Crutchley and Crow 2018: 1-12 and 56-61) (Figure 1.11). Measuring the time differential for each pulse provides a means of recording very slight variations in surface elevation even in wooded areas, as a portion of the beam can still penetrate the tree canopy and reach the ground surface, although close-planted conifers can prove impenetrable. Using a mathematical algorithm, the reflections from the surface and the canopy can be distinguished, allowing the surface to be mapped. Digital terrain models can then be produced from this data, allowing mapping and identification of archaeological features even if they are only barely visible above ground. The potential visibility of such ephemeral archaeological remains is related to the resolution of the data, which depends on the number of points recorded per square metre. This in turn depends partly on the flying height of the aircraft housing the scanner, but also on the pulse rate of the scanner. In broad terms, the utility of LiDAR data for recording archaeological features improves with greater ground point densities, with concomitant increases in the detail that may be observed. LiDAR data can be visualised in many different ways to maximise the visibility of archaeological remains. Single and multi-direction hillshade visualisations are commonly used as they are broadly similar to the type of image obtained from low-light aerial photographs and are relatively intuitively interpreted. However, more complex visualisations may also be utilised, such as principal component analysis of multiple hillshades, or sky view factor (Kokalj and Hesse 2017).

As part of the Scottish Ten Project, in 2010 HES commissioned the acquisition of LiDAR data for the whole Antonine Wall World Heritage Site and its buffer zone. This data was captured at a density of 6-7 points per square metre and used to generate a Digital Elevation Model (DEM) at 0.5m resolution (Wilson *et al.* 2013). This data has recently been analysed by the third named author and formed the basis of his PhD (Hannon 2018). The major contributions of this work have been the recognition that the real length of the Wall, as measured on the ground taking into account changes in elevation, is slightly longer than previously appreciated (Hannon *et al.* 2017: 453-55) and that the fortlets known along the Wall (below) do seem to fit a consistent pattern of spacing at one Roman mile apart (Hannon *et al.* 2020: 69-73). Unfortunately, the data collection methodology and point density were not optimal for

[2] At the time of writing we understand that the Canmore web resource is in the process of rebranding to become 'Trove', but that the relevant reference numbers will be maintained and HES will ensure that links to Canmore numbers are maintained.

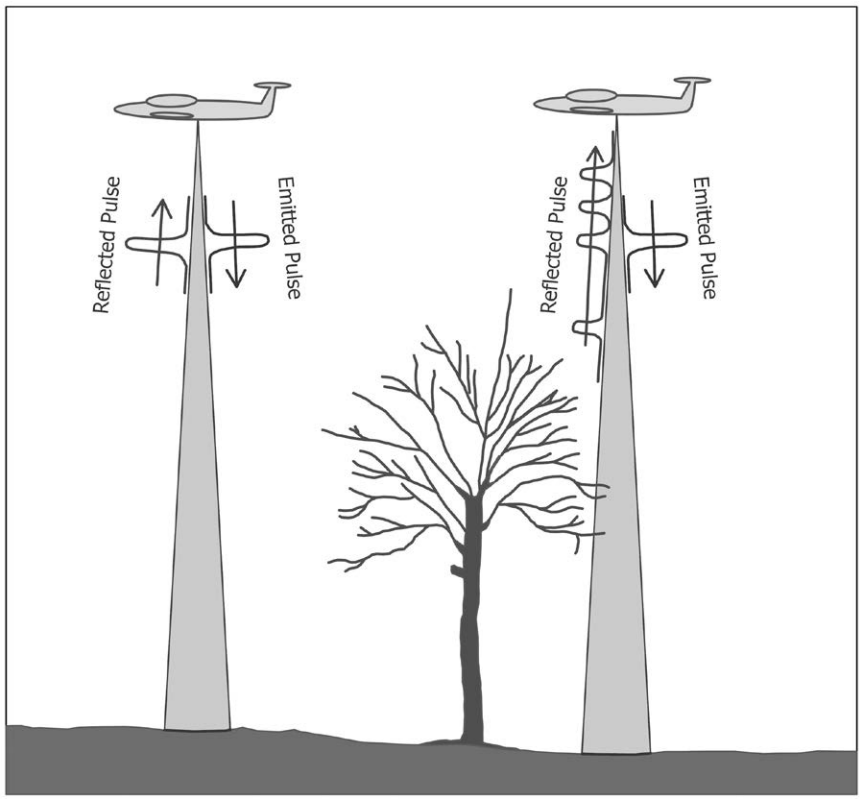

Figure 1.11. LiDAR explanation diagram.

the identification of subtle archaeological features. The project concluded that a point density sufficient to allow the generation of a 0.25m resolution DEM was preferable (Hannon 2018: 435). While the project was not able to facilitate the discovery of any convincing new sites of Roman date, it did provide additional information about the field system to the south of the fort at Rough Castle (Hannon 2018: 275-78). In addition, in 2017 the Environmental Agency released a range of LiDAR datasets including one at 1m resolution which covered most of the Central Belt (Edina 2017). These two sets of LiDAR coverage provide extremely useful sources of background and comparative data against which to view both aerial photographic and geophysical surveys (e.g. Chapters 2.5; 4.4; and 5.3 below). These datasets have now been supplemented by Scottish Public Sector LiDAR, including data initially captured by Fugro during 2020 and 2021 for the Scottish Power Energy Network to monitor their overhead power cable network (https://remotesensingdata.gov.scot/data#/map).

1.3 The context of the geophysical surveys

Historic Scotland's application to UNESCO for World Heritage status for the Antonine Wall in 2007 required up-to-date mapping of the monument. This task was accomplished by RCAHMS on behalf of Historic Scotland (now HES) (Historic Scotland 2007). Historic Scotland widened RCAHMS' remit to include the creation of a GIS to incorporate all archaeological work which had taken place from 1980 (or earlier where possible); in this way GIS would form an important tool for the proper protection and management of the monument. Also needed was the definition of a buffer zone, to be based 'on visibility to and from the proposed WHS, and analysis of the land-use setting, including urbanised areas' (Breeze 2011: 90).

Concurrently, and feeding into this exercise, Historic Scotland was managing a European Union project within the Culture 2000 programme, *The Frontiers of the Roman Empire* project (Breeze and Jilek 2008a). One of its aims was to draw on non-invasive methods, particularly geophysical survey, to resolve questions both about the courses of the Antonine Wall and the Military Way where there was uncertainty, and about the environs of forts. Traditionally the latter have not received much attention, particularly in relation to the potential locations of civilian settlement. The project provided the necessary impetus for a major programme of fieldwork, the time being right to adopt geophysical survey since it had made major contributions towards understanding the military and civil components of the Roman presence on Hadrian's Wall and its western coastal extension (Biggins and Taylor 2004a; 2004b; 2007).

The work was divided between GSB Prospection, a company that has considerable experience of geophysical survey at archaeological sites in Britain (Gaffney and Gater 2010), and the Archaeology Department at Glasgow University, which has been active in the field for several years (Jones and Sharpe 2006). The former focused on locating sections of the Ditch, Rampart and Military Way, involving both targeted transect-type and large area surveys; the latter undertook more extensive surveys, including the environs of forts, to investigate the possible locations of extra-mural settlement. Much of the fieldwork was carried out between 2007 and 2010. Stephens *et al.* (2008) gave an outline of the early results that, not unexpectedly, led to further effort at some sites and encouraged new work at others (Jones and Leslie 2015: 318-323).

In 2008 the Antonine Wall became part of UNESCO's Frontiers of the Roman Empire WHS, a transnational entity that includes the two Walls of northern Britain together with the extant German *limes*. In justifying this status, UNESCO drew attention to their high cultural value as outstanding examples of, *inter alia*, Roman military architecture and building techniques (https://whc.unesco.org/en/list/430/). Crucially, this status requires their state guardians to have suitable protection and management measures in place and to encourage new research. These measures are outlined in HES's management plan 'mapping out a five-year plan for the management and conservation for the Antonine Wall' (HES 2016) which is currently under review. As regards new knowledge about the Antonine Wall, research priorities were identified within the Scottish Archaeological Research Forum's (ScARF) Roman panel report (ScARF 2012: 3.5) and more directly by the recent Antonine Wall Research Agenda produced by HES (ScARF 2023). Of crucial relevance here is the message from both panels that integrated approaches to military landscapes should be encouraged, bringing in, where appropriate, topographical and aerial survey, LIDAR, geophysics, the use of stray and metal-detected finds, as well as fieldwalking and, ultimately, excavation. The obligation to open the Antonine Wall to a wider public is well in place offering a range of resources whether digital, in the museum or on site (https://www.antoninewall.org/).

The third main contribution to this volume concerns an ongoing programme of survey being undertaken at HES by the third named author. This programme forms part of a 5-year, Historic Scotland Foundation-funded project aimed at developing a geophysical survey capacity embedded within HES' Archaeological Survey team. Work within the World Heritage site not only addresses a range of management and research questions, but also provides ideal training opportunities for HES team members. Complementing the surveys by GSB and Glasgow University (GU), this work takes a larger landscape approach, appropriately employing the newer generation of gradiometer instrument with the multi-sensor system loaded on a cart in order better to facilitate the examination of large areas (Table 1.2).

Finally, surveys undertaken by other operators, such as the Centre for Field Archaeology (CFA), GUARD and GUARD Archaeology have been included, so that, as far as possible, all the surveys known to have been carried out along or near the Wall to date have been included (Table 1.1).

1.4 Geophysical methodology

Table 1.2 lists the instruments employed by the various operators, with associated technical detail on data gathering and processing.

Two techniques, often regarded as the workhorses of geophysical survey, have been to the fore on the Antonine Wall, as well as in the corresponding work on Hadrian's Wall (e.g. Biggins and Taylor 1999): magnetometry, in the form of the fluxgate gradiometer, and earth resistance (Figures 1.12 and 1.13). Gaffney and Gater (2010: 26-40 and 61-67) and Schmidt *et al.* (2015: 59-74) introduce the techniques and illustrate the relevant instruments. The gradiometer has usually been recognised as the technique of choice because of the speed with which it generates data and its ability to detect most structures and features associated with the Roman military presence, although it is disturbed by ferrous objects within the survey area and by the presence of igneous bedrocks. Electrical resistance survey, which complements gradiometry, is best suited to the detection of stone buildings and metalled roads, as well as ditches of the kind that surround fortifications. But the technique may be prone to yielding less information and at lower resolution than gradiometry for several reasons, most notably its sensitivity to localised soil conditions such as variable moisture content.

As the relevant instrument passes over a buried feature, the measured readings change with respect to the archaeologically sterile surrounding soil giving rise to an anomaly: a gradiometer anomaly appears as a magnetic gradient and is characterised by its strength and polarity (for example a strong positive anomaly), while a resistance anomaly manifests itself according to a scale from low to high resistance. Using specialised software (see Table 1.2), the anomalies are visualised most frequently as grey-scale displays of a kind that appear throughout Chapters 2 to 7. Accompanying the image is a palette defining what normally represents the range from high (black) through to low (white)

Table 1.1. All known geophysical surveys on the Antonine Wall

Site	Targets	Operator
Old Kilpatrick	Rampart, Ditch & Military Way	HES
Carleith	Fortlet, Rampart & Ditch	HES
Duntocher	Fort, fortlet, annexe, Rampart & Ditch, bathhouse	GU/HES
Cleddans	Rampart & Military Way	GSB
Castlehill	Fort, fortlet, Rampart & Ditch	GU
Bearsden	Fort ditches	GUARD
Boclair	Ditch	GUARD Archaeology
Summerston to Balmuildy Bridge	Ditch, Rampart, Upcast Mound, Military Way, fortlet & temporary camp	GSB
Balmuildy	Fort, annexe, Rampart, Ditch & environs	GU
Wilderness Plantation	Ditch, Rampart & Military Way	GSB
Cawder	Ditch, Rampart & Military Way	GSB/GU
Glasgow Bridge to Westermains	Ditch, Rampart, Military Way, fortlet & possible minor structures	GSB
Kirkintilloch, Peel Park	Fort	GUARD/HES
Auchendavy	Fort, Rampart, Ditch & environs	GU
Shirva	Ditch, Rampart, Military Way & potential fortlet	GSB/CFA/Strang and Walker/HES
Bar Hill	Rampart, Military Way, possible fortlet, temporary camp & environs	GU/Strang and Walker
Girnal Hill/Nethercroy	Ditch, Military Way and possible fortlet	GSB/Bradford
Croy Hill	Fort, fortlet, camp, extra-mural settlement, Military Way and bypass road	GU
Westerwood	Fort, extra-mural settlement, & Military Way	GU
Tollpark	Rampart and Military Way	GU
Garnhall	Rampart, Military Way, temporary camp and possible watchtower	Woolliscroft
Castlecary	Fort, annexe & environs	GU/GSB
Seabegs	Rampart, Berm & Military Way	GSB/HES
Milnquarter	Ditch, Rampart & Military Way	HES
Elf Hill, Bonnyside	Rampart & possible fortlet	GU
Bonnyside to Rough Castle	Rampart, Berm, Military Way, expansion & fortlet	HES
Rough Castle	Fort, annexe & field system	GSB/HES
Callendar Park	Rampart, Military Way & potential fortlet	GU
Mumrills	Fort, annexe, Rampart, Ditch, Military Way & environs	GSB
Inveravon	Fort, Ditch, Rampart & Military Way	GSB, Clark
Kinneil	Ditch, Rampart, fortlet, Military Way & environs	CFA, GSB, Hannon, HES
Kinglass Park	Rampart, Military Way & temporary camp	GSB/Edinburgh Archaeological field Society
Muirhouses	Temporary camp and putative Wall line	GU
Kinningars Park & Carriden western environs	Eastern terminus of the Wall	GU
Carriden	Fort, annexes & environs	GU

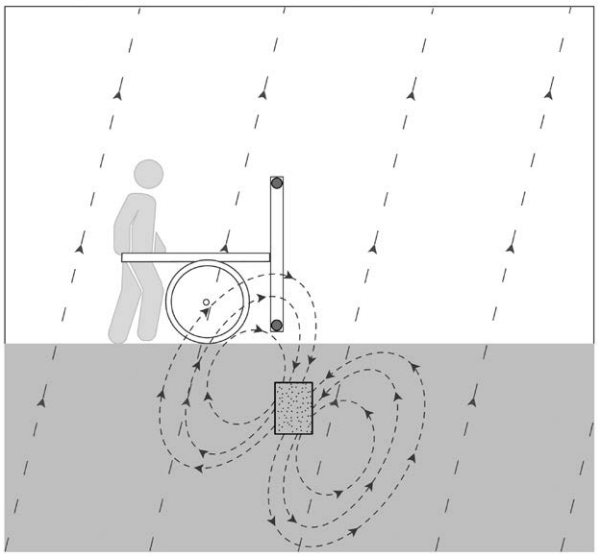

Figure 1.12. Gradiometer explanation diagram.

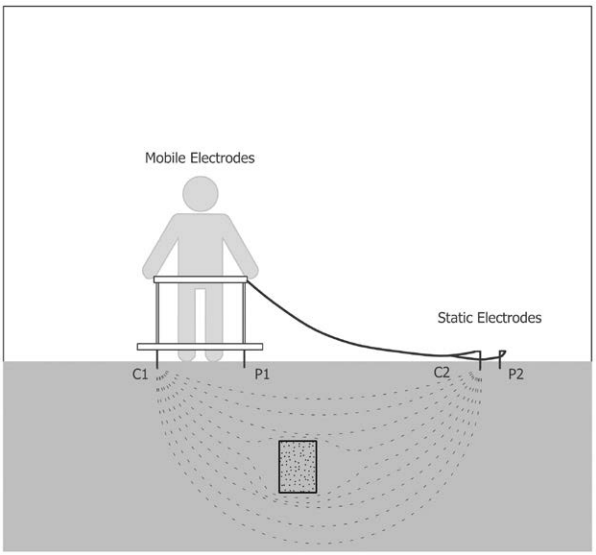

Figure 1.13. Resistance explanation diagram.

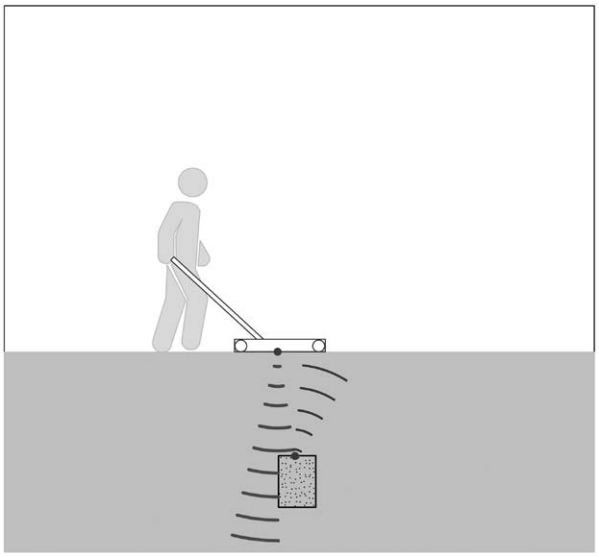

Figure 1.14. Ground-penetrating radar explanation diagram.

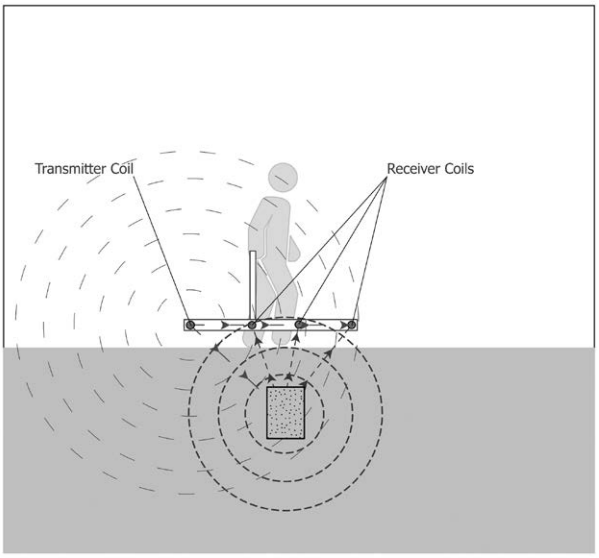

Figure 1.15. Electro-magnetic survey explanation diagram.

readings or high positive to high negative in the case of gradiometer data. Graphics employing a colour palette are sometimes useful (e.g. Figures 6.5.6 and 7.2.11). The same software offers several options for processing or treating the raw data, for instance 'destriping' to remove the effects of alternate darker and lighter bands resulting from gradiometer readings taken in, as is normally the case, a zig-zag fashion, or 'despike' where an extreme or set of extreme readings are replaced by a mean value (see Table 1.2; Schmidt *et al.* 2015: 100-104).

GSB Prospection, HES and Glasgow University also employed other techniques, but to a more limited extent. The most useful has been ground-penetrating radar (GPR) (Figure 1.14), which is capable of detecting the main features expected on the Antonine Wall (English Heritage 2008, Table 7). Not only can it estimate the depth of these features, it can also present its results graphically in different ways: first, as a scan or radargram (e.g. Figure 5.5.5) – a two-dimensional plot of response (reflector strength) as a function of distance across the ground and depth; and second, where readings have been collected over several parallel traverses, as a time slice, enabling an area to be viewed at progressively increasing depth (e.g. Figures 4.1.7 and 5.5.7).

Electro-magnetic survey (EM) is a technique that emits an electro-magnetic signal (the primary signal) from a transmitting coil that passes through the ground

Table 1.2. Operators, techniques, survey parameters and processing procedures

Operator	Magnetic (gradiometer); sample & traverse intervals; processing	Electrical resistance mapping; sample & traverse intervals; processing	Electrical resistance profiling	GPR	Other	Topographic
GSB	Bartington Grad 601-2; 0.25m x 1m; removing baseline shifts and interpolation. Foerster Ferex 4.0132 DLG	Geoscan RM15/ MPX15 multiplexed system, twin probe; 0.5m and 1.5m separations; 1m x 1m; de-spike, filtering, interpolation	Syscal Junior, IRIS instrument, dipole-dipole and Wenner array, 24 electrodes, 2m electrode spacing along 96m; RES2D-INV inversion program	Pulse Ekko 1000 with 225MHz antenna; 1m parallel traverses, continuous readings. Sensors & Software Noggin+ Smartcart, 250MHz antenna	Seismics: Geometrics Geode 24-channel recorder, 24 geophones at 2m spacing; shot spacing at 1m and 11m from each end; Interpex IXSeg2SegY software	Trimble GeoXH dGPS system (with Zephyr antenna and Geobeacon receiver)
University of Glasgow	Geoscan FM36 (1m x 1m), Bartington Grad 601-1 and 601-2 (0.25m, 0.5m); Geoplot v. 3 and 4: zero mean traverse, despike, destagger, interpolation; experimentation with Frost, Wiener and directional filters on gradiometer data from Balmuildy (Hinz 2006)	Geoscan RM15 twin probe, 0.5m; MPX 0.5m and 1.5m separations; 1m x 1m; Geoplot v. 3 and 4: despike, edge match, filter, interpolation. TR/CIA twin probe 0.5m; 1m x 1m	Geoscan RM15; Wenner array, probe separation 1m, 2m, 3m, 4m	Utsi Electronics Groundvue 3 with 240 and 400MHz antennae; 0.5m or 1m traverses. Reflex for Windows (v. 3.0, Sandmeier Software) for radargrams and time slices	Magnetic susceptibility: Bartington MS2D coil system (2m or 5m). Conductivity: Geonics EM38 with hand-held Allegro data logger	EDM total station; latterly Leica GS16
Hannon	Bartington GRAD 601-2; 0.5m x 1m; removing baseline shifts and interpolation. Terrasurveyor: destripe, destagger and despike					Leica GS16
Historic Environment Scotland	Sensys MXPDA system mounted on type-F non-magnetic cart; 0.125m x 0.5m, or 0.125m x 0.25m; Terrasurveyor: destripe/clip			MALÅ Ground Explorer system mounted on a Rough Terrain Cart Mini with single GX450 HDR Antenna; 0.1m x 0.5m, or 0.1m x 0.2m; ReflexW	GF Instruments CMD Mini Explorer for conductivity and magnetic susceptibility measurements; 0.1s x 1m, or 0.1s x 0.5m; Terrasurveyor: destripe/clip/ HPF	Leica GS16 GNSS streaming NMEA
GUARD and GUARD Archaeology	Geoscan FM36 (0.5m x 1m)	Geoscan RM15 twin probe, 0.5m; 1m x 1m				EDM total station
Centre for Field Archaeology		Geoscan RM15 twin probe, 0.5m; 1m x 1m				

Operator	Magnetic (gradiometer); sample & traverse intervals; processing	Electrical resistance mapping; sample & traverse intervals; processing	Electrical resistance profiling	GPR	Other	Topographic
Edinburgh Archaeological Field Society		TR/CIA twin probe 0.5m; 1m x 1m				
University of Bradford		Geoscan RM4				
Woolliscroft		Martin-Clark instrument				
Ancient Monuments Laboratory		Martin-Clark (dipole-dipole method)				

and buried objects and induces the propagation of a secondary signal (Figure 1.15). Both the primary and secondary signals are measured by a series of receiver coils allowing readings from multiple depths to be obtained. Changes in the amplitude of these signals can be used to detect sub-surface variations and can simultaneously measure apparent conductivity and magnetic susceptibility (Schmidt *et al.* 2015: 89-90). The technique has been deployed at Duntocher, Seabegs and Kinneil (Chapters 2.3, 5.5 and 7.2) with variable results.

Seismic refraction has found valuable application at one location – between Summerston and Balmuildy – where earth resistance had produced problematic results. This form of seismic survey (Schmidt *et al.* 2015: 94-95) is well suited to the detection of broad, relatively deeply buried structures such as the Ditch, as work on the Vallum on the south side of Hadrian's Wall at Rudchester demonstrated (Goulty *et al.* 1990; Goulty and Hudson 1994). Corresponding work with seismic reflection was carried out with some success at the ditch at Inveresk fort (Harith 1998: 33-57, Fig. 2.18).

Electrical imaging, also known as vertical electrical sounding (pseudosection), in which electrical resistance is determined as a function of depth (Schmidt *et al.* 2015: 74-75), was also usefully applied in areas between Summerston and Balmuildy (Figure 2.8.7), as well as at Auchendavy (Figure 4.1.8).

1.5 Interpretation of geophysical data

Several considerations play a role in interpreting geophysical data. Drawing on the guidelines of Schmidt *et al.* (2015: Table 4), there are the natural factors, of which the solid and drift geology, soil type, surface conditions and topography are most relevant to the land encompassing the Wall. Assessment of the geology, using information drawn either from https://digimap.edina.ac.uk/roam/map/geology or the British Geological Survey, was an essential first step in any proposed survey, resulting in the potential exclusion of gradiometry at sites situated on or close to outcrops of igneous rock. At the same time this assessment highlighted those sites where the till cover might include igneous debris giving rise to a noisy (magnetic) background. This situation occurred at a number of locations in the western half of the Wall. Soil types were taken from http://map.environment.gov.scot/Soil_maps/. The other class of factors affecting interpretation of the archaeology, notably landscape history, agricultural practices and modern interference, enter the discussion in the final chapter.

The graphical output of the three main gradiometer and resistance data sets presented in this volume – those of GSB, Glasgow University and HES – are all in the form of grey-scale images (see Table 1.2). Much smaller in number are the GPR, seismic, electro-magnetic and electrical profiling graphics which are presented in conventionally accepted manners (Schmidt *et al.* 2015; Gaffney and Gater 2003, colour plates 15-17). Together, these make up the primary data and it is from them that the nature and shape of the responses - the anomalies - can be identified.

Interpretation proceeds by highlighting with annotation primarily those anomalies that are considered likely to be Roman in origin and thereby merit discussion in the defined scope of this volume. This informed interpretation is, we believe, justified in view of our present considerable understanding of the nature of Roman military sites, and as a result, it may differ from those put forward in the original reports (e.g. Chapters 2.4, 3.1, 3.5, 4.1, 6.3). Regarding the interior of forts, that knowledge takes account of the

effects of possible reuse, alteration or decommissioning of a structure/feature. At the same time, our procedure acknowledges those anomalies arising from geology and from pre- and especially post-Roman (including modern) activity in so much as they lie close to or are associated with Roman features. For the Antonine Wall this is an important issue given the extent to which these features have been affected since burial by, for example, stone robbing, agricultural activity and modern utility pipeline construction. The responses from these pre- and post-Roman activities have not been ignored, rather they have usually received only cursory interpretative attention and are only occasionally annotated in the graphics.

1.6 Archaeological targets and their geophysical responses

The potential targets of the survey can be conveniently divided into a number of sections: the linear barrier with its different component parts (Rampart, Berm, Ditch and Upcast Mound);[3] the forts and their annexes; the fortlets; the expansions; the minor enclosures; the Military Way; the construction camps; and the extra-mural settlements. Each of these is briefly considered below and treated further in Chapter 8:

1.6.1 The linear barrier (Hanson and Maxwell 1986: 75-83; Breeze 2006: 71-78; Robertson 2015: 17-22; Romankiewicz *et al.* 2022)

The Ditch was V-shaped in profile, both sides sloping at an angle of *c.* 30° (Figure 1.16). Both its depth and width varied, the latter ranging for example from 4.3m at Croy Hill to 14.6m at Bar Hill, but typically in the central sector these dimensions were *c.* 3.6m and 12m respectively. Upcast material created from the digging of the Ditch was deposited on its northern edge. This Outer or Upcast mound was usually flattened out to a broad spread, but sometimes piled up to enhance the north face of the Ditch, as at Watling Lodge. The latter can create the impression of a second, less substantial ditch to the north, which is sometimes seen in the cropmark record (e.g. Figure 2.8.2). This same feature may have no recognisable geophysical response since it merely reflects the displacement of subsoil from the Ditch, although it is worth noting its possible detection by seismic, GPR and electrical profiling at Summerston (Chapter 2.8) and as a slight positive linear anomaly at Bonnyside (Chapter 6.2). At several forts a causeway was provided across the Ditch in front of the fort's north gate.

The gradiometer response at the centre of the Ditch is usually large, as befits the size and the depth of this feature; its polarity, however, is less consistent. In principle, the response would be expected to be positive, reflecting the enhanced magnetisation, or more specifically the greater magnetic susceptibility, of the infill with its accumulated more organic content compared to the subsoil through which it was cut. This was found to be the case for the Vallum and fort ditches at Birdoswald on Hadrian's Wall (Biggins and Taylor 2004b: 162-64), and at forts elsewhere, such as Whitley Castle in Northumberland and Llanfor in north-west Wales (Hale 2009; Hopewell and Hodgson 2012). Closely associated with the positive response may be a parallel negative one arising from the side and bank. By contrast, the magnetic response of the Antonine Ditch and fort ditches presented in this volume is reversed, the centre of the Ditch being negative usually with positives on one or both of its sides (e.g. Chapters 3.1; 3.4; 4.1; 4.2; 7.1 and 7.2). This issue is discussed further in Chapter 8.2.4.

How earth resistance responds across the Ditch depends critically on the nature of the infill and on climatic conditions; the norm is a decrease reflecting a relatively loose, well-drained infill (e.g. Chapter 3.1), but an exception has been encountered (Chapter 2.8). On the other hand, a more compacted infill with lower moisture content will register an increase as occurs in some fort ditches (e.g. Chapter 2.5). The same factors affect the GPR response, the Ditch giving a strong reflection (e.g. Chapter 2.8) and low amplitude signal (e.g. Chapter 3.2).

The Rampart had a shallow stone foundation, 4.3-4.8m wide, defined by two parallel rows of roughly faced kerbstones with unshaped stones or cobbles packed in between (Figure 1.17). Culverts, also built of roughly squared stones and both floored and capped with slabs, were built into the base at irregular intervals. Above the base would have lain some twenty or more layers of turf, each with a thickness of no more than 15cm, resulting in an overall height of at least 3m, though the character of the upper section of the Rampart is uncertain. Whether it was provided with a palisade and walkway, and how that might have been supported, has long been assumed but is much disputed (e.g. Robertson 1960: 12; Hanson and Maxwell 1986: 83). In areas where good quality turf was less readily available, such as towards the eastern end of the Wall, it has long been thought that the Rampart was made of compacted earth revetted by cheeks of clay or turf. More recent micromorphological analysis, however, suggests that turf was used throughout the structure, despite variations in its quality (Romankiewicz *et al.* 2020). Since the Rampart rarely survives as an earthwork, it is the stone foundation and crucially its physical condition that are primarily responsible for

[3] References to these linear elements of the Wall are deliberately capitalized throughout the volume to avoid any confusion with similar features related to associated structures.

Figure 1.16. One of the best surviving sections of the Ditch at Watling Lodge, where the Upcast Mound (right) was augmented. View from the north-east.

the geophysical response, observed usually as a mottled positive in gradiometer surveys (e.g. Chapters 3.1, 3.4, 6.2 and 7.2), an increase, albeit of varied strength, in resistance (see, in particular Figure 3.4.5 Areas 1B and 2) or as a moderately strong reflector in the radargram (Figure 3.2.5). The effect on the geophysical response of the occasional better preservation of the turf superstructure is discussed in Chapter 8.2.4.

The Berm, the space between the Wall and the Ditch, varies in width from 6.1m to over 9m. It may appear as an area that is relatively uniform magnetically and in terms of resistance. Pits set in a distinctive quincunx pattern (*cippi*), intended to hold multi-forked branches with sharpened ends forming entanglements similar in effect to barbed-wire, have been recorded by excavation at several locations along the Berm (Bailey 2021: 23-25), but identified only tentatively by geophysical survey (see Chapters 2.3, 5.5 and 6.2). Very similar defensive pits have long been known at Rough Castle (Buchanan *et al.* 1905: 456-58 and Fig. 1), located not on the Berm but immediately beyond the Ditch to the north-west of the fort. These, however, are interpreted as *lilia*, concealed pits intended to hold sharpened stakes (Madconald 1934: 235; Bidwell 2005: 56-63), the Roman equivalent of anti-personnel mines. It is not possible to differentiate between the different types of defensive pits on the basis of geophysics alone, other than by virtue of their location. The *lilia* are currently unique to Rough Castle and may be related to the vulnerability of its specific topographic location adjacent to the valley of the Rowan Tree Burn. Nonetheless, the possibility that other forts may have been provided with similar additional defences needs to be considered.

1.6.2 Forts and annexes (Hanson and Maxwell 1986: 86-93; Breeze 2006: 81-84 and 90-97; Robertson 2015: 22-25 and 29-30)

Seventeen forts are currently known to be located along the line of the Wall, all bar two (Bar Hill and Carriden) attached to its rampart (Figure 1.1). They vary considerably in size (0.12-2.6ha in area) (Figures 2.3.4 and 6.5.2 illustrate the extremes). All but two (Castlecary and Balmuildy) had ramparts like the Wall composed of turf, beyond which were usually at least two ditches, though these were much smaller than the Ditch in front of the Wall itself. At least nine forts (including Falkirk and Carriden) were provided with attached annexes, some by more than one, defined in the same way. Most of the forts have experienced some level of excavation, but predominantly this took place in the first half of the 20th century and usually on a small scale. Like the Wall itself, the ramparts of the forts/annexes may be expected to manifest themselves as linear positive, or mottled positive, magnetic anomalies and higher

Figure 1.17. Extant remains of the Rampart base and a culvert in New Kilpatrick cemetery. View from the east.

resistance anomalies (e.g. Chapters 2.5; 3.1; 5.1 and 5.4), though this is not invariably the case (e.g. Chapters 2.3 and 6.5). This will be discussed further in Chapter 8.2.4. Like the Antonine Ditch, the fort's ditches are normally observed as negative gradiometer and, where tested, low resistance anomalies (e.g. Chapters 2.3; 2.5; 3.1; 4.1; 5.4; 6.3; 6.5 and 7.6). The exceptions are where the ditches have been, perhaps deliberately, infilled with burnt debris and/or rubbish thereby giving a positive response (cf. Dalswinton – Hanson *et al.* 2019: 301 and Fig. 10), though none have been recorded along the Wall.

The central range of buildings within each fort was usually stone built, as was the internal bathhouse where one was provided. High resistance would be the anticipated electrical response of the walls of such buildings, while for the gradiometer they would give a negative response. Again, this was not always the case and the reasons are further discussed in Chapter 8.2.4. The barracks located to the front and rear of the forts were of timber construction, their walls usually defined by individual post-holes rather than construction trenches. These are very rarely detected in the geophysical surveys for reasons that are also discussed more fully in Chapter 8.2.4. Pits dug to contain rubbish should give a strong gradiometer response because of enhancement caused by bacterial action of their contents, but if small can be difficult to differentiate from general background noise. Cooking ovens, which are usually disposed around the perimeters of the forts, should give a thermoremanent magnetic signature and thus would usually be easily detectable, but have proved elusive.

Though several annexes contained bathhouses, little more is known of their interiors. As a result, there is considerable debate about their function. Some see annexes generally as providing protection for civilians (e.g. Sommer 2006: 123), but the broader consensus is that, in the first and second centuries at least, they served entirely military requirements (e.g. Hanson 2021). Where more extensive excavation has taken place, as at Mumrills and Falkirk, a range of features

have been found suggestive of semi-industrial activity, such as cobble surfaces, pits and metalworking, as well as some timber buildings. The pits, and particularly the pyrotechnologically based activities, should be amenable to detection by gradiometry and magnetic susceptibility methods. Kilns and furnaces give a large north-south oriented dipolar response, as do the hypocaust and other fired material relating to a bathhouse (e.g. Chapters 6.3 and 6.5). The latter, where damaged, may appear as an area of enhanced magnetic disturbance (e.g. Chapters 4.1 and 6.3).

1.6.3 Fortlets (Hanson and Maxwell 1986: 93-96; Breeze 2006: 85-86; Robertson 2015: 25-27)

It is now generally accepted that the original plan for the Wall included a complete sequence of fortlets at approximately one Roman mile intervals, though only 13 have been confirmed archaeologically, including by geophysics (e.g. Figure 1.9) (Hannon *et al.* 2020: 67-73). They were small enclosures measuring some 21m by 18m, surrounded usually by one, but occasionally by two, ditches and provided with two gateways, one through the Wall and one for access from the south. In all the examples where the relationship has been tested by excavation, they have been shown to be earlier than or contemporary with the Wall Rampart. What little is known of their interiors indicates the presence of timber buildings on either side of a central roadway. The magnetic and resistance signatures of their ramparts, ditches and internal features are similar to those of a fort (e.g. Chapters 2.2; 2.3; 2.5; 3.4 and 7.2), though internal buildings are less readily visible in the absence of stone foundations.

1.6.4 Expansions (GAS 1899: 77-79, 84-85 and 145-49; Steer 1957; Robertson 1969: 37-39; Hanson and Maxwell 1986: 97-99; Breeze 2006: 87-88; Robertson 2015: 27-29)

Three pairs of small turf platforms attached to the rear of the Rampart were recognised during fieldwork by the Glasgow Archaeological Society in the early 1890s. The function of these expansions, as they came to be called, remains uncertain, though is most likely related to long-distance signalling. They were constructed on a cobble foundation some 5.2-5.5m square that abuts the rear of the Rampart base. This should indicate that they were later additions, though this chronological relationship has been disputed as the superstructure of the most extensively excavated example at Bonnyside East appears to be bonded into the turf of the Wall. However, this observation is itself disputed (Hanson 2020: 13-14, ftnt 57) and the evidence from both of the excavated examples on Croy Hill clearly shows that their turf superstructures were secondary additions (GAS 1899: 77-79 and 84-85; Robertson 1969: 37-39). No further examples have been found since the 1890s, though one was tentatively identified during excavation at Inveravon (Chapter 7.1). Any gradiometer or resistance response should be similar to that of the Rampart, though at the one example that has been subject to geophysical survey, Bonnyside East (Chapter 6.2), the response is not entirely clear.

1.6.5 Minor enclosures (Hanson and Maxwell 1983; 1986: 96-98; Breeze 2006: 88-89; Robertson 2015: 28-29)

Small, closely spaced, ditched enclosures abutting the rear of the Wall have been recognised from the air, but in only one section of the Wall adjacent to the fortlet at Wilderness Plantation. Their function is unknown. The one excavated example indicated that the enclosure was contemporary with the Wall and defined an area 8.6m by 11.7m, though the only internal feature identified was a slight earth/turf bank (Figure 3.2.3). None have so far been identified with certainty by geophysical survey (but see Chapter 7.2).

1.6.6 Military Way (Hanson and Maxwell 1986: 83-84; Breeze 2006: 78; Robertson 2015: 22)

The Military Way ran roughly parallel to the Wall, forming an essential lateral communication component of the frontier system. Its precise course varies, but it usually runs between 15m and 45m to the south of the Wall, though bypass roads, generally positioned further south, have been recorded at several fort sites. The road was usually between 4.9m and 5.5m wide, with a pronounced camber, constructed on a base of rough stones topped by rammed gravel and smaller stones (Figure 1.18). Drainage ditches were commonly provided on either side and quarry pits associated with its construction are not infrequently recorded nearby (Figure 1.8).

In principle, the road should be clearly defined as a high resistance anomaly because of its stone construction. Gradiometer and GPR survey would also be expected to detect the structure with relative ease; but, in practice, this is not the case since the road surface has frequently been ploughed away or at least significantly damaged, as several instances reported in this volume attest (e.g. Chapters 3.2 and 7.2). The exceptions are the well-preserved sections of Military Way at Seabegs Wood, where the road surface is identifiable in the gradiometer, EM and GPR data, and to a lesser extent Bonnyside East (Chapters 5.5, 6.2 and 8.2.4). Similarly, good results have occasionally been obtained elsewhere in Scotland. At Barwhill, Gatehouse of Fleet, a *c.* 100m stretch of Roman road (running from Glenlochar to Loch Ryan), visible in aerial photographs and located just south of a Flavian fortlet, appeared as a linear *c.* 7m wide slightly positive magnetic anomaly flanked by negatives (presumably representing the road's drainage ditches) (Cowley *et al.*

Figure 1.18. Excavated section of the well-preserved Military Way bypass road to the south of the fort at Croy Hill. View from the north-east.

2019). Immediately north of the road were oval positive anomalies that were interpreted as quarry pits. The corresponding resistance data, however, was much less informative.

1.6.7 Camps (Hanson and Maxwell 1986: 177-20; Jones 2005; Breeze 2006: 32 and 66-68; Robertson 2015: 38-39)

Some 21 temporary camps have been recorded in the immediate vicinity of the Wall, mainly located to the south. Most of them are relatively small, some 2-2.5ha in area, and are widely accepted as construction camps intended to house the soldiers building the Wall. As noted above, all have been found by aerial reconnaissance as cropmarks (Figure 1.8), as a result of which more are known towards the eastern end of the Wall. That camps overlap in two locations (Dullatur and Inveravon) indicates that they were not all in contemporary use.

Since the camps are defined by the single, relatively narrow, ditches that surround them, their geophysical signature should not be dissimilar in principle to that derived from the ditches around forts. The interiors of temporary camps are increasingly being shown to contain groups of rubbish pits and/or ovens, which are particularly susceptible to magnetic survey (e.g. Hanson *et al.* 2019: 297 and Fig. 7). However, very few along the Wall line have been subject to survey (see Chapter 7.4).

1.6.8 Extra-mural settlement (Hanson and Maxwell 1986: 186-90; Breeze 2006: 129-36; Hanson 2020a; Allason-Jones *et al.* 2020)

The presence of civilians along the Wall is well attested artefactually and epigraphically, but only poorly confirmed by the recognition of associated settlement foci. Fragmentary traces of timber buildings and even occasional stone foundations have been noted in excavations at a few sites (Bearsden, Croy Hill and Westerwood), but, unlike on Hadrian's Wall, there is no coherent picture of what such settlement would have looked like. There is, however, much stronger evidence around several fort sites (Auchendavy, Croy Hill, Rough Castle and Carriden) of small land divisions or fields defined by slight ditches, banks or gullies, indicating contemporary agricultural or industrial activity. None of these features are likely to provide a strong geophysical signal and so the topic is left to Chapters 8.1.6 and 8.2.4. The best hope of identifying extra-mural activity with the gradiometer would seem to come from associated pyrotechnological activity, such as pottery manufacture or on-site cremation. Relevant evidence has not yet been forthcoming, though individual

examples may be difficult to distinguish from the general background noise.

1.7 Aims and structure of the book

The overall aims of this volume are threefold. Firstly, it sets out to make more readily accessible and widely available the data from the numerous geophysical surveys that have been undertaken at a large number of sites on the Antonine Wall over the last 20 years or more so that they may better be assimilated into our knowledge base. The results and archaeological evaluations of much of this work exist for the most part as unpublished reports, often referred to as 'grey literature', which is accessible primarily only to the institutions that funded the surveys or to specialists who know how to access them. Accordingly, the data from those sites that have been subject to geophysical survey (Figure 1.19) are illustrated and considered here in Chapters 2-7, laid out in gazetteer format in geographical order from west to east.

Secondly, this volume seeks to re-examine and re-analyse that data. Thus, it offers more focused interpretations for each site based on a wide background knowledge of the monument. Those who undertook the original surveys were, for the most part, specialists in the acquisition and manipulation of geophysical data, rather than in Roman military archaeology. It is our strong contention that analysis of this data is greatly enhanced when viewed from the perspective of those with a more detailed and intimate knowledge of the relevant subject of study, in much the same way that excavations tend to produce more informative and insightful results when the excavator is a specialist in the type of site under investigation; this view is echoed in a wider context elsewhere (Jones 2024). Thus, one of our number is co-author of one of the standard textbooks on the Wall (Hanson and Maxwell 1986), co-editor of the most recent examination of its remains (Hanson and Breeze 2020) and co-editor of the HES's Antonine Wall Research Agenda (ScARF 2023); while another, the subject of whose PhD was the analysis of a LiDAR survey of the Wall (Hannon 2018), currently leads HES' geophysical survey fieldwork.

The structure of the gazetteer chapters (2-7) follows a consistent format, where possible. A grid reference is provided to locate the survey, along with the Canmore identification number(s) where available. Relevant site-specific archaeological references are listed at the beginning of each entry to avoid cluttering the subsequent text. References to basic overviews of the Antonine Wall (Macdonald 1934; Hanson and Maxwell 1986; Breeze 2006; Robertson 2015) should be taken as standard for virtually all sites, so are not included to avoid unnecessary repetition.

The character, extent, date and source of the geophysical surveys undertaken is then summarised in tabular form. The survey techniques are gradiometry (G), earth resistance (R) ground-penetrating radar (GPR), electromagnetics (EM), magnetic susceptibility (MS), electrical profiling (EP) and seismic refection (SR). Their operating parameters are sample and traverse intervals that refer to the distances between measurement positions along a traverse and between traverses respectively. In the case of multi-sensor gradiometer systems, that information is often expressed as sample interval followed by sensor separation (ss). For the earth resistance technique the default setup is twin probe with probe separation of 0.5m. If another probe separation was also used, this is stated following the sample and traverse intervals.

In each case there then follows a brief introduction to the site, which considers how the survival of the remains has changed over time and what additional information has been provided by other forms of investigation. Site excavation plans, aerial photographs or LiDAR images are provided as appropriate. Any issues affecting the geophysical surveys (locale/terrain; geology and soils) are then considered before the results of those surveys are described and interpreted/reinterpreted. Precise location plans of the surveys are provided, along with detailed annotated plots of the gradiometer and resistance results. Each plot is accompanied by a grey-scale palette which gives the values (in nanoTesla (nT) or ohms) represented by the scale's black and white tones. The survey results are then integrated with any other relevant remote sensing, mapping and excavation data, and any enhancement to previous knowledge and understanding of the site is highlighted.

Finally, having assembled, presented and re-analysed the data in the gazetteer chapters (2-7), the third aim of the volume is to draw some wider conclusions, both archaeological and geophysical. Accordingly, Chapter 8 is divided into two parts. The first seeks to assess the often-undervalued contribution of geophysical survey to our further understanding of the Antonine Wall and its associated structures, drawing attention to a number of areas where it has enhanced that understanding. The second attempts to use the long history of the application of such survey to a single monument in a limited geographical area by a number of different practitioners to appraise the nature of the methodology itself, considering both its strengths and its weaknesses.

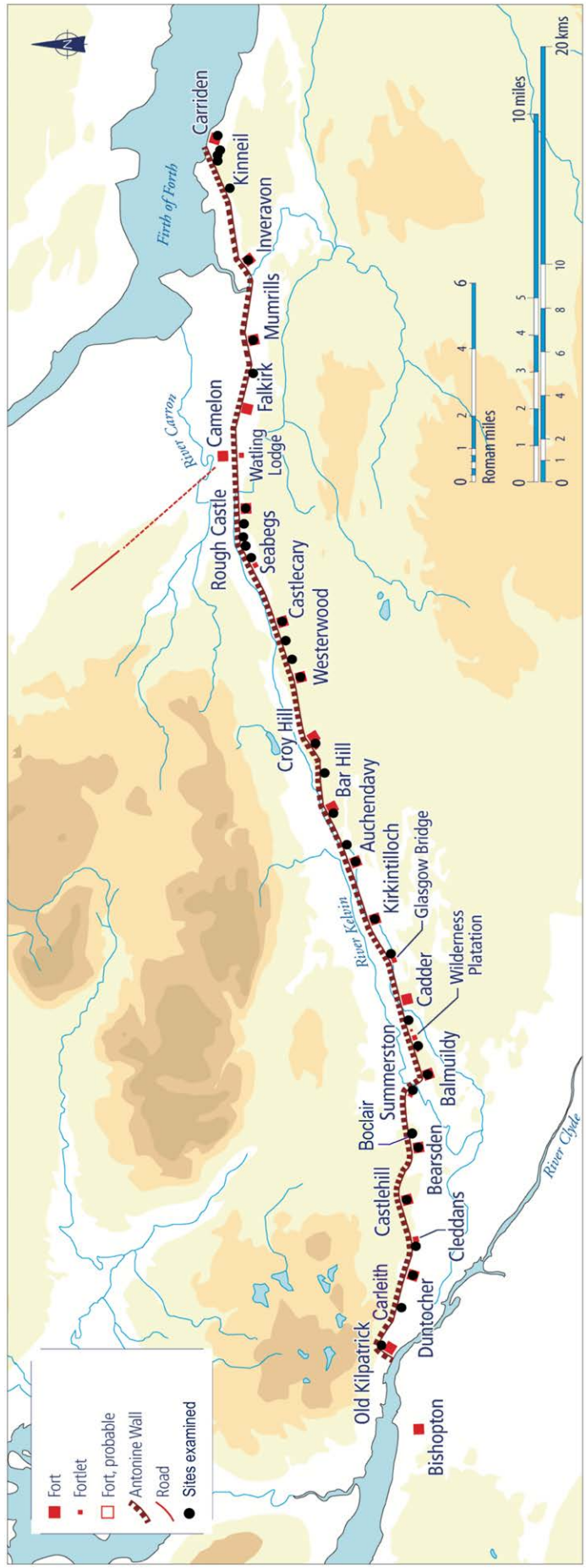

Figure 1.19. Sites along the Wall subject to geophysical survey indicated by black circles (map after D.J. Breeze, with additions).

Chapter 2

2.1 Old Kilpatrick

(NGR: NS 463 734; Canmore 43261)

Ditch and Rampart

Site-specific references

Macdonald 1915: 96-99 and pl. 1A; Hannon and Blake 2023b

Geophysical surveys (Figure 2.1.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
HES; 2023	G: Sensys MXPDA	0.95	0.125, 0.5ss

Introduction

No clear trace of the Wall is recorded in the 1st or 2nd edition Ordnance Survey mapping east of the Dalnottar Burn,[1] as it runs through heavily cultivated land before heading towards the site of the fort at Old Kilpatrick. The line later recorded by the Ordnance Survey, running under Mount Pleasant Farm and beyond along a low ridge, depends entirely on the detailed survey undertaken by Macdonald in 1913. This included an early application of terrestrial remote sensing by the tenant farmer (see also Chapter 6.5), who had noted the enhanced crop growth over the buried Ditch, backed up by multiple sample trenches. The Ditch is still very faintly visible in the LiDAR imagery towards the western end of this stretch, some 200m west of the farm, where it begins to curve southwards (Figure 2.1.2).

This general uncertainty about the line of the Wall prompted HES to undertake gradiometer survey in 2023 in the strip of land between the railway and the A82 (Great Western Road), to the north-east of the site of the fort at Old Kilpatrick, ahead of proposed tree planting next to the scheduled area. Conditions for survey were generally good in an area of rough grazing, although the eastern end of the area was too overgrown

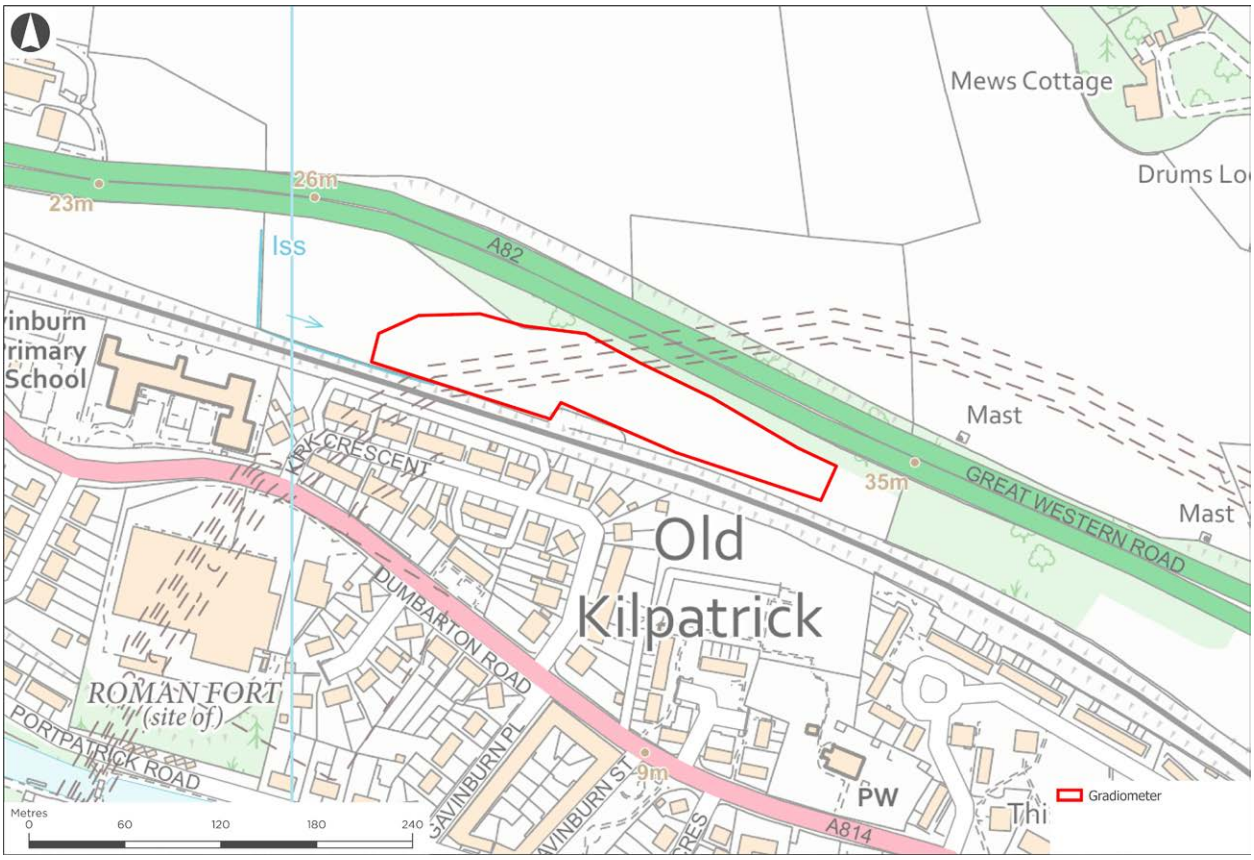

Figure 2.1.1. Extent of HES survey at Old Kilpatrick.

[1] Sometimes spelt Dalnotter, but referred to by Macdonald as the Sandyford Burn.

Figure 2.1.2. LiDAR image of Old Kilpatrick to Mount Pleasant sector.

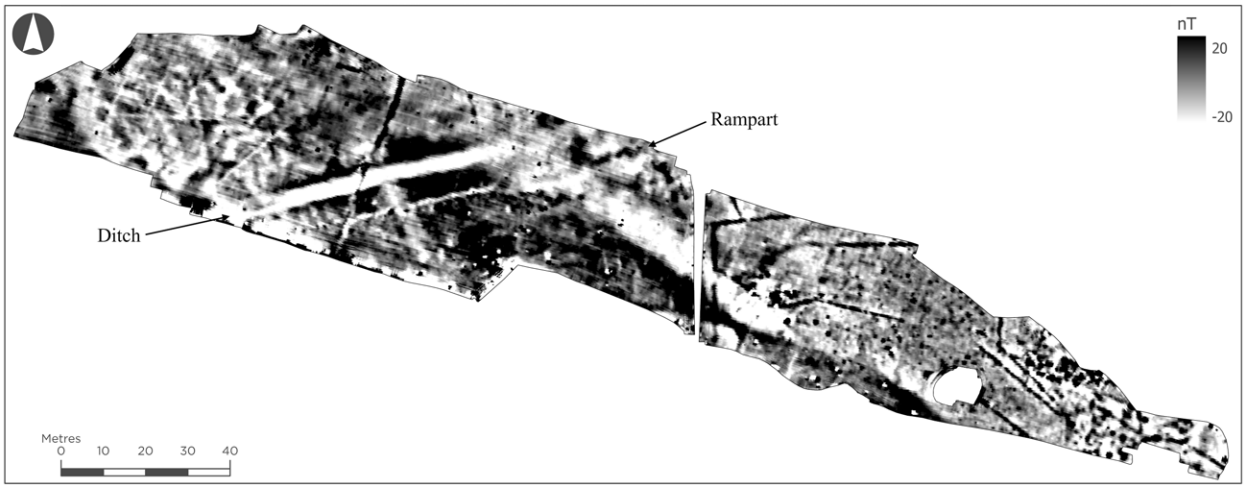

Figure 2.1.3. HES gradiometer survey at Old Kilpatrick.

to facilitate survey. However, as the underlying geology was recorded as a mix of Cochno and Strathgryfe Lava Members overlain with Till, there was doubt about how effective gradiometry would be.

Results (Figure 2.1.3)

The line of the Ditch is extremely clear in the gradiometer survey as a sharply defined, *c.* 4m wide negative band running obliquely across the western third of the survey area, fading slightly to the north-east as it crosses a broader linear negative response, presumably from an underlying geomorphological feature. The Ditch runs straight, very close to the line indicated by Macdonald. Running parallel to the Ditch some 5m behind it is a narrow negative linear anomaly, turning to a more amorphous positive one in the north-eastern third, which presumably relates to the northern

kerb of the Rampart. Macdonald records finding some kerbstones still in situ in his limited trenching in this field. There is a cluster of positive responses at the eastern end of the survey, accompanied by narrow positive linear anomalies, which are likely to reflect human activity, but they form no obvious pattern.

2.2 Carleith

(NGR: NS 4805 7299; Canmore 43261 and 43309)

Fortlet, Rampart and Ditch

Site-specific references

Macdonald 1915: 99-100; Robertson 1964: 188-93; *DES* 1971: 118; 1974: 33; 1980: 33; Keppie and Breeze 1981: 242-44; Hannon 2022a

Geophysical surveys (Figure 2.2.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
HES; 2021	G: Sensys MXPDA	0.99	0.125, 0.5ss

Introduction

For the best part of 1km on either side of Carleith Farm the Antonine Wall followed a relatively straight line along the foothills of the Kilpatrick Hills. While to the west much of this is still in farmland, to the east little has survived the expansion of the village of Duntocher. The line of the Ditch and, in parts, the Upcast Mound was still extant in 1896 when revision for the 2nd edition Ordnance Survey 25-inch map took place (Figure 2.2.2). A distance slab (*RIB* I 2204), one of the inscribed stones that record the building of the Wall, was found at Carleith in the late 17th century according to Stukeley (1720: 9), probably indicating the point at which responsibility for the construction changed from the 6th to the 2nd Legion. The slab was then built into the gate at Cochno House some 2km to the north-east before being donated to Glasgow University in the mid-18th century (Keppie 1998: 85).

By the time Macdonald was undertaking his detailed survey of the Wall in this area in 1913, much of its line on the ground seems to have become less readily comprehensible. Nonetheless, it remains faintly visible in the LiDAR data immediately to the south-west of Carleith Farm and further to the west (Hannon 2018: Fig. 6.10; F.5.1). The line recorded by the Ordnance Survey shows a slight double change of alignment to the south-west of the farm, before broadly following the bridle path and Beeches Road as it continues east towards the Duntocher Burn (Figure 2.2.2). However, Macdonald rejected this change of direction and dismissed as a natural hollow the clear line recorded to the east of

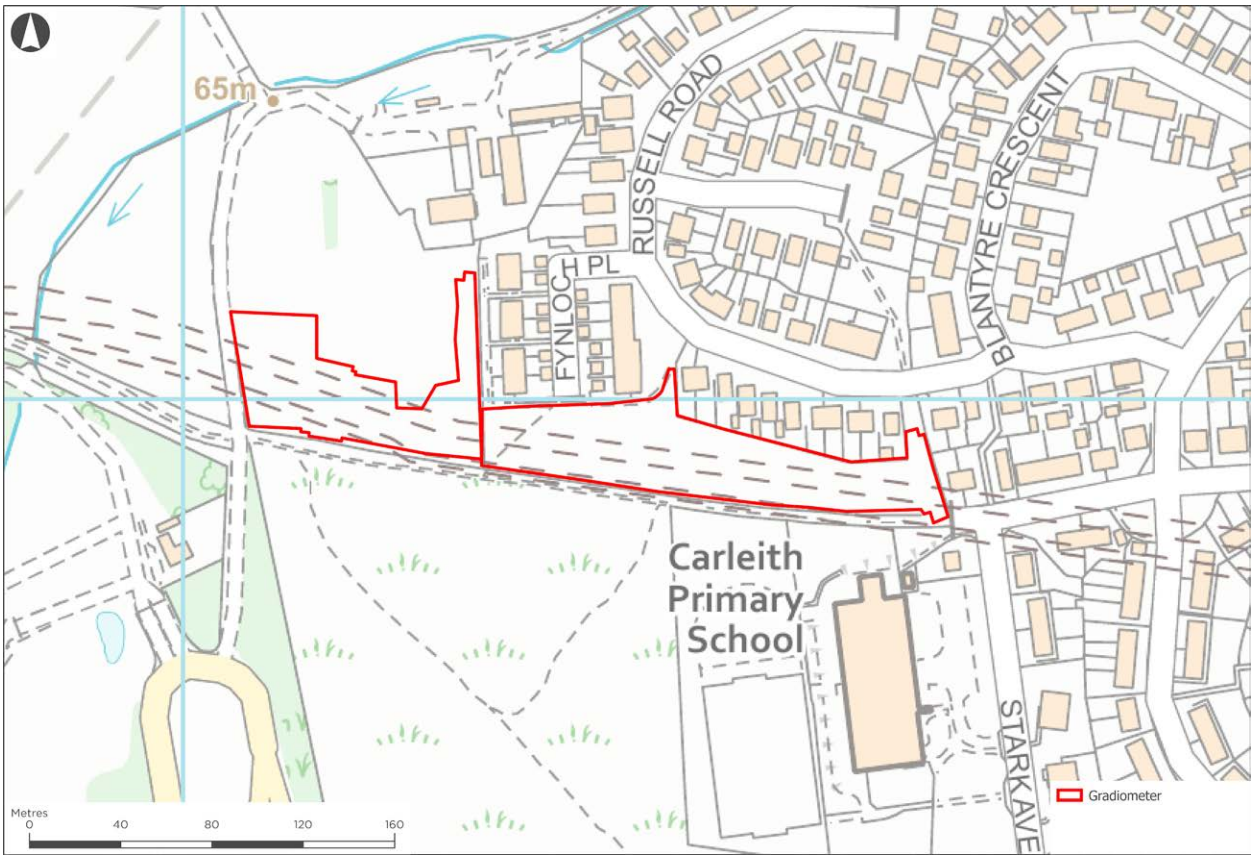

Figure 2.2.1. Extent of survey at Carleith.

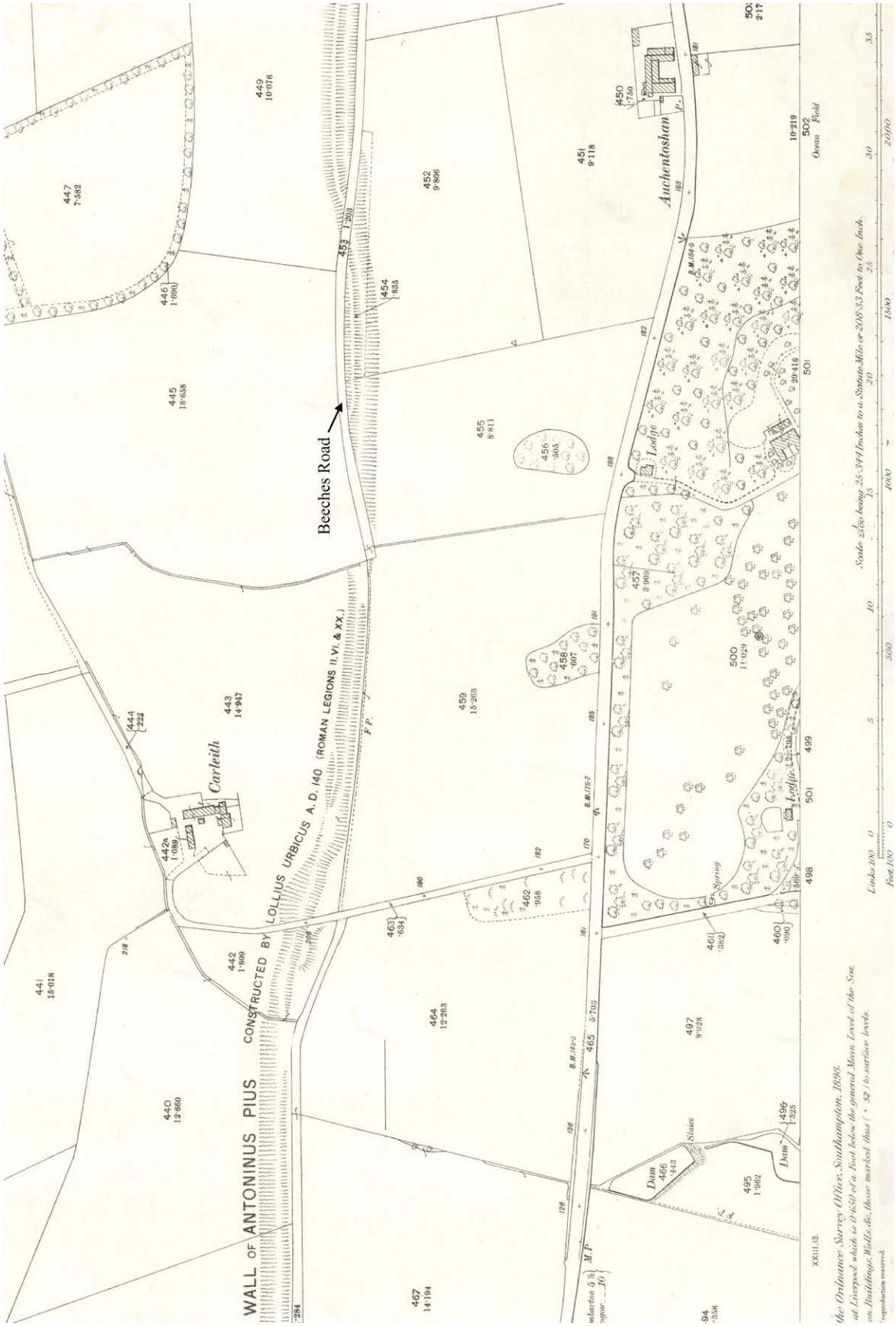

Figure 2.2.2. Extract from the 2nd edition Ordnance Survey 25-inch map surveyed in 1896, showing the line of the Antonine Wall south of Carleith Farm (Reproduced with the permission of the National Library of Scotland. CC-BY (NLS)).

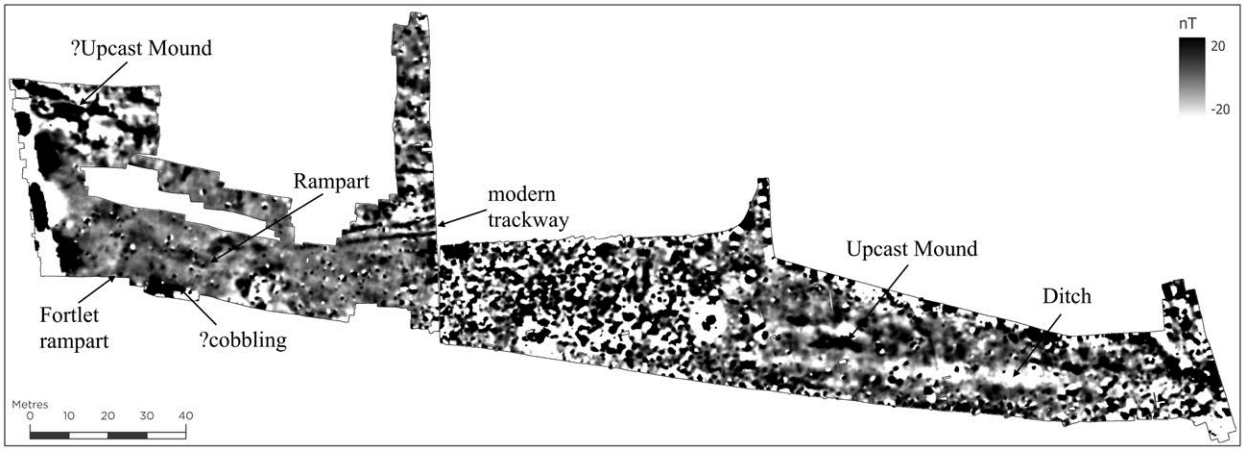

Figure 2.2.3. HES gradiometer survey at Carleith.

it that was still partially visible in the late 1950s. He claimed to have identified by excavation the correct, straight alignment some 75m further north, and his preferred line was perpetuated on Ordnance Survey maps thereafter until the early 1960s. However, when Robertson checked this line with extensive trenching to the north of Beeches Road in 1955 in advance of housing development, she could find absolutely no trace of the ditch. By this time the fields to the south of Beeches Road, along with a more limited area immediately to its north, had already been built over, but two years later she was able to confirm the original Ordnance Survey Ditch line in a small excavation to the east of the latter development.

Between 1971 and 1974 Price investigated the line of the Wall to the east of the Carleith Burn over a distance of some 200m, confirming the change of alignment originally delineated by the Ordnance Survey and recording some medieval disturbance near the burn. Unfortunately, this work was published only as a very brief summary. However, in 1980 interest came to be refocused on this location, which lies almost exactly one Roman mile west of Duntocher, as part of a wider programme seeking to identify further fortlet sites undertaken by Keppie and Walker. They were able to confirm the line of the Rampart intermittently over the area covered by Price, though provided a detailed plan of their trenching only for the area immediately south of the farm. They noted the differential survival of the base as it traversed rocky outcrops and suggested that the Ditch may not have been completed at one point. However, they were unable to identify any clear evidence of a fortlet, while still maintaining the probability of one in the vicinity.

This possibility prompted HES to undertake gradiometer survey in 2021 in the field to the south of the farm, further extending it to the east below the housing estate that has grown up there. Conditions for survey were generally good in an area of municipal parkland to the south of the housing estate, but large parts of the field in permanent pasture to the south of the farm were too overgrown or too wet to allow survey. The underlying geology was recorded as Lawmuir Formation sedimentary overlain with Till, so ideal for gradiometry.

Results (Figure 2.2.3)

South of the housing estate a *c*. 80m length of the Ditch was clearly visible in the gradiometer survey as a broad negative anomaly running parallel with the field boundary immediately to the south. The shorter strong positive linear anomalies to the north of the Ditch may represent surviving sections of the Upcast Mound. However, both ends of this visible section of Ditch were entirely masked by very noisy signals. As they do not extend into the field south of the farm, these responses were probably caused by landscaping that had spread building detritus and mixed soil from the construction of the adjacent housing.

The Ditch to the south of the farm, whose line turns slightly to the north, is less clear. A large part of it was apparent as a slight hollow with thicker vegetation cover that was too wet to survey. The extremely weak negative response to the east of the unsurveyed area may reflect the deliberate infilling of the Ditch by the farmer in recent years which is attested by conversations with local residents. The positive linear anomalies which run parallel to the Ditch at the north-western limit of the survey area seem likely to represent a section of the Upcast Mound. The Rampart, visible as a broad, slightly mixed positive linear anomaly on the same alignment, can be discerned only in part, reflecting the differential survival of the base indicated by the excavations in 1980. Significantly, there is clear indication of an offset at right angles to the best-preserved section of Rampart. This lies very close to the area examined by Keppie and Walker and would seem to represent the western side of a fortlet. While the dipolar signal to the south-east of

the fortlet rampart at the southern limit of the survey seems likely to be a response to a five-bar gate hidden in the adjacent hedgerow, this then morphs into a large rectilinear positive anomaly which could represent internal cobbling. Such cobbling is attested in a number of excavated fortlets, such as Wilderness Plantation and Kinneil (Wilkes 1974: 57 and Fig. 2; Bailey and Cannell 1996: 315 and 342).

2.3 Duntocher, Golden Hill

(NGR: NS 4953 7264; Canmore 43261 and 43265)

Fort, fortlet, annexe, Rampart and Ditch, bathhouse

Site-specific references

Robertson 1957; Newall 1998: 25-28; Swan 1999: 431-33; Jones 2001; 2016; 2017; Keppie 2004; Symonds 2018: 140; Hannon 2022b

Geophysical surveys (Figures 2.3.1 and 2.3.2)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
Glasgow University; fort, annexe, Ditch; 2016-2017 Bathhouse; 2001	G: Bartington Grad 601-2	1.4	0.25, 0.5
	R: Geoscan RM15	0.5	1, 1 2016; 0.5, 0.5 2017
	R: Geoscan RM15	0.5	1, 1; multiplexer 0.5, 1
HES; 2021	G: Sensys MXPDA	3.9	0.125, 0.25ss
	EM: GF CMD Mini Explorer	0.2	0.5, 0.1s

Introduction

The fort lies near the top of Golden Hill (Figure 2.3.3), now mainly within the park of the same name, close to the point where the Duntocher Burn crosses the line of the Wall, which follows a south-east to north-west orientation here as it seeks the higher ground. The fort sits in an elevated position, at a height of some 80m,

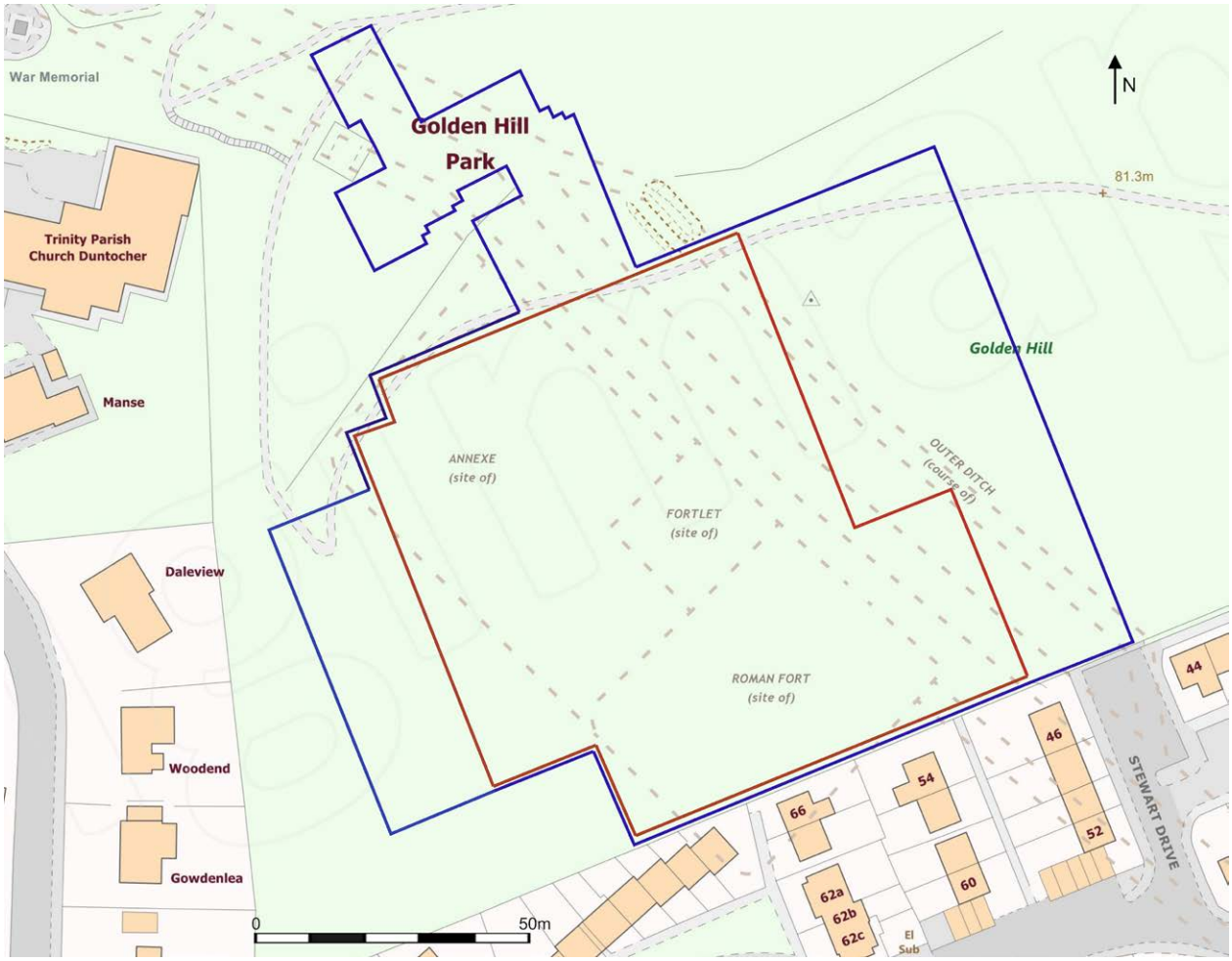

Figure 2.3.1. Location of Glasgow University survey areas at Duntocher (gradiometer in blue; resistance in red).

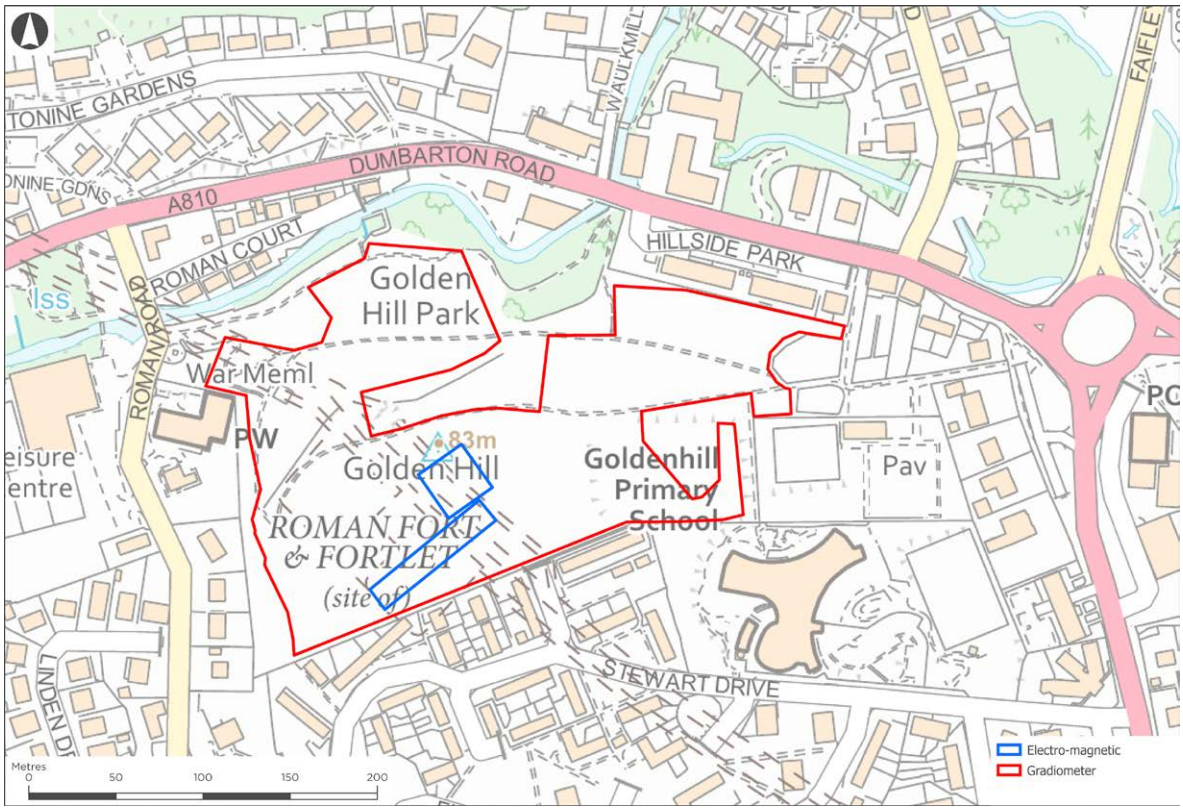

Figure 2.3.2. Location of HES survey areas at Duntocher.

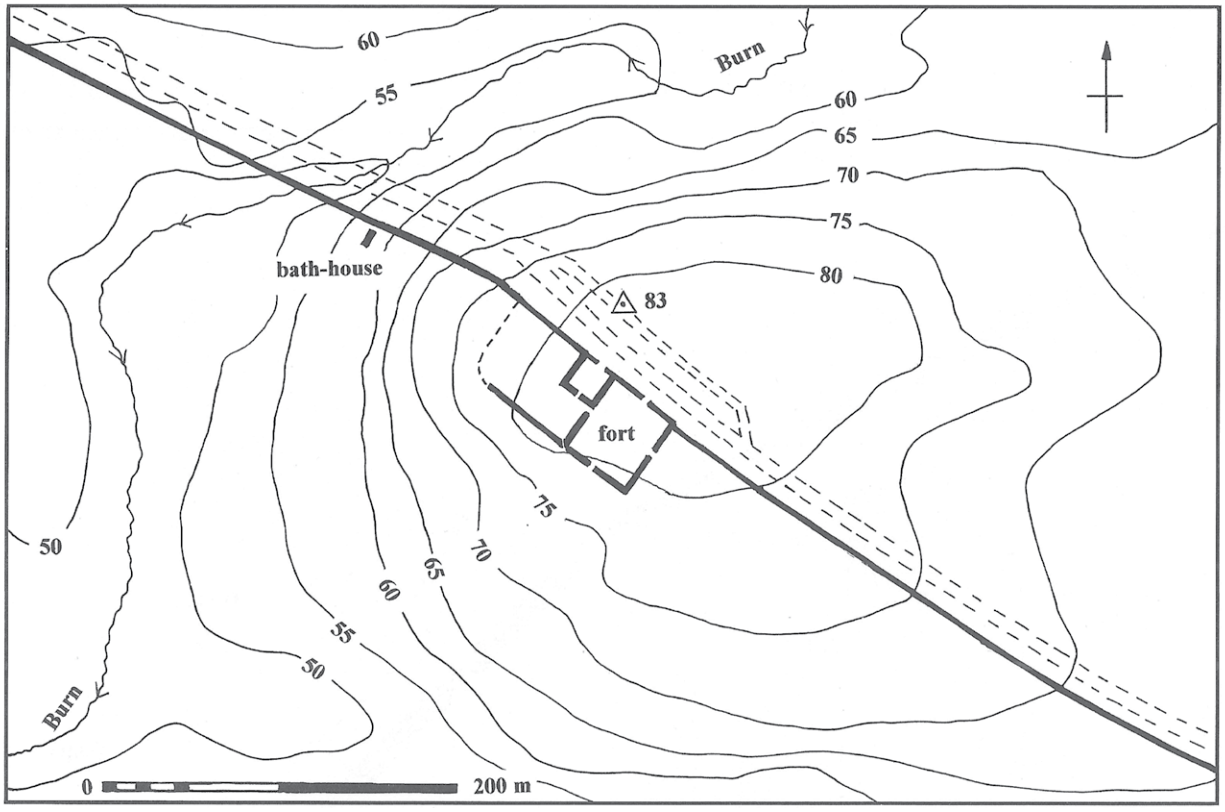

Figure 2.3.3. Contour map showing the fort and bathhouse locations at Duntocher (after Keppie 2004, Fig. 2).

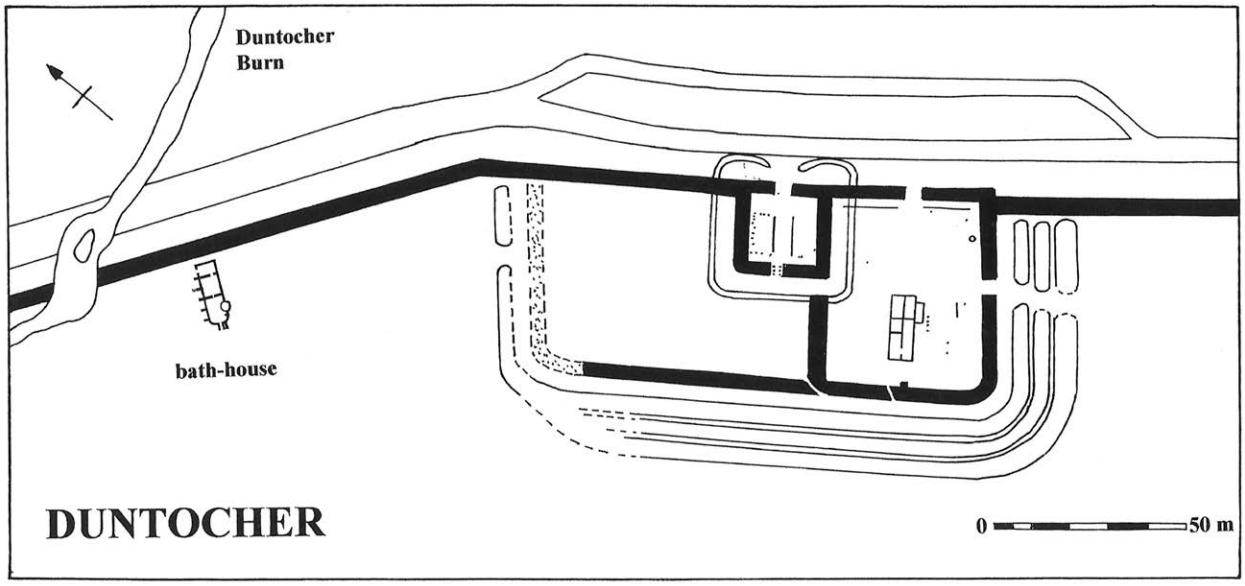

Figure 2.3.4. Excavated remains of fort, fortlet, annexe and bathhouse at Duntocher (after Keppie 2004, Fig. 12).

with good views in all directions, though constrained to the north and north-west by the Kilpatrick Hills. There is a strong antiquarian tradition of a Roman fort on the hill with early descriptions and plans of the site provided by various 18th century antiquaries (Gordon 1726: 51 and pl. 16; Horsley 1732: 164-65 and 176 N2; Roy 1793: 158 and pl. 35) (Figure 1.4). The general outline of its ditches remained sufficiently visible to be recorded in the 1st edition Ordnance Survey mapping of the area in the early 1860s and the broad hollow of the multiple ditches to the north, along with slight traces of the Upcast Mound beyond, can still be discerned in the LiDAR image (Figure 2.3.8).[2]

After exploratory trenching by Clarke in 1933, which was never published, an extensive programme of archaeological excavation was undertaken by Robertson between 1947 and 1951 (Figure 2.3.4). In keeping with the established methodology at the time, this consisted of cutting a large number of narrow trenches across the area. This process revealed the outline of a fort, the smallest on the Wall, with an internal area of only *c.* 0.2ha. It was defined, like the Wall itself, by a turf rampart on a stone base, though this was slightly narrower than the Wall base (3.9m compared to 4.8m). The fort was surrounded by triple ditches on the south-east and south-west sides, but only a double ditch was identified to the north-east, the inner of the two ditches being slightly wider than the outer. Also contained within these ditches was a further rampart, which defined an additional enclosure *c.* 0.3ha in extent attached to north-west side of the fort, interpreted as an annexe. No ditch separated the fort from the annexe and only a single ditch was recorded on its north-west side, with a gap for a gateway.

Other breaks in the ramparts for gates, though lacking associated gate structures, were identified on all sides of the fort except the south-west. A causeway was provided through the triple ditches on the north-east side, but no breaks in the ditches were identified to the north-west or the south-west. The conjoined fort and annexe appear to have been freestanding for a time, as the Antonine Wall was shown to abut the south-east rampart of the fort some 3m from its eastern corner, creating a slightly awkward disjuncture. Limited examination of the interior of the fort resulted in the identification of a single subdivided rectangular stone building of uncertain function, but more than one phase of use, located almost centrally in its southern half, along with other scattered evidence of occupation (Figure 2.3.4). Even more restricted investigation in the annexe provided some very limited evidence of occupation in the form of post-holes and shallow pits.

On level ground close to the highest point on the hill, Robertson identified an earlier freestanding square fortlet, defined by a turf rampart on a stone base like that of the fort, but even narrower (only 3.6m wide) (Figure 2.3.4). Though the post-holes for a narrow timber gate were recorded in its south-western rampart, no clear gate structure could be identified on the opposite side in the limited excavation which was possible at that time. Many years later in 1977-78 the rampart of the fortlet was completely exposed by Robertson (Figure 2.3.5), but that excavation is unpublished so it remains

[2] What appear to be elements of the line of the fort and fortlet ramparts are also faintly apparent, but this merely reflects the practice of the leaving the grass in the park longer here as part of a management plan to highlight to the general public the position of the underground remains.

Figure 2.3.5. Aerial photograph taken by Barri Jones in May 1978 showing the fortlet rampart at Duntocher exposed. The location of the excavated kilns is arrowed.

uncertain whether further evidence of a gate structure was then located.[3] The fortlet was originally surrounded by a single narrow ditch with a causeway in front of the presumed north-east gate, but no equivalent gap in the ditch was found opposite the identified south-west gate. The south-eastern rampart of the fortlet was later incorporated into the north-west rampart of the fort, at which point the ditch was deliberately infilled and the interior of the fortlet cobbled over. Post-holes and shallow construction trenches beneath the cobbling in the interior of the fortlet seem to indicate rectangular timber buildings on either side of a central road, though there is some uncertainty about their phasing.

The bathhouse, which was discovered down the slope by the Duntocher Burn to the north-west of the fort in the late 18th century, was fully uncovered at that time and the presumed site was partially re-explored in 1978 to try, unsuccessfully, to confirm its location (Figure 2.3.4). Finally, a group of pottery kilns was excavated by Newall in 1977 in the garden of a newly constructed house down the slope some 50m to the west of the fort/annexe complex (Figure 2.3.5).

Since these various field investigations there has been considerable debate about the identification of, and relationship between, the Wall, fort and annexe. For example, Swan has argued that the secondary fort took up the entire extended enclosure, which was later subdivided internally to create an annexe in a manner similar to the fort and annexe at Bearsden. Symonds, on the other hand, has suggested that the fort enclosure may have been an annexe for the early fortlet, though such an interpretation would be without parallel anywhere on the Wall and fails to address the role of the larger attached enclosure to the north-west. Given such uncertainties, and the need to search for further evidence of associated extra-mural settlement, there was ample justification for a geophysical survey to be undertaken, firstly by Glasgow University and subsequently by HES, the latter extending investigations over most of the park, including large areas to the north of the Wall.

Although the local subsoil is boulder clay overlying calciferous sandstone, the possibility of intermixing with debris from igneous rocks that make up the Kilpatrick Hills (specifically the Cochno Lava member) was originally a cause for concern in relation to the use of the gradiometer. In the event, however, a pre-survey

[3] Attempts to track down the original records of the excavation have proved unsuccessful.

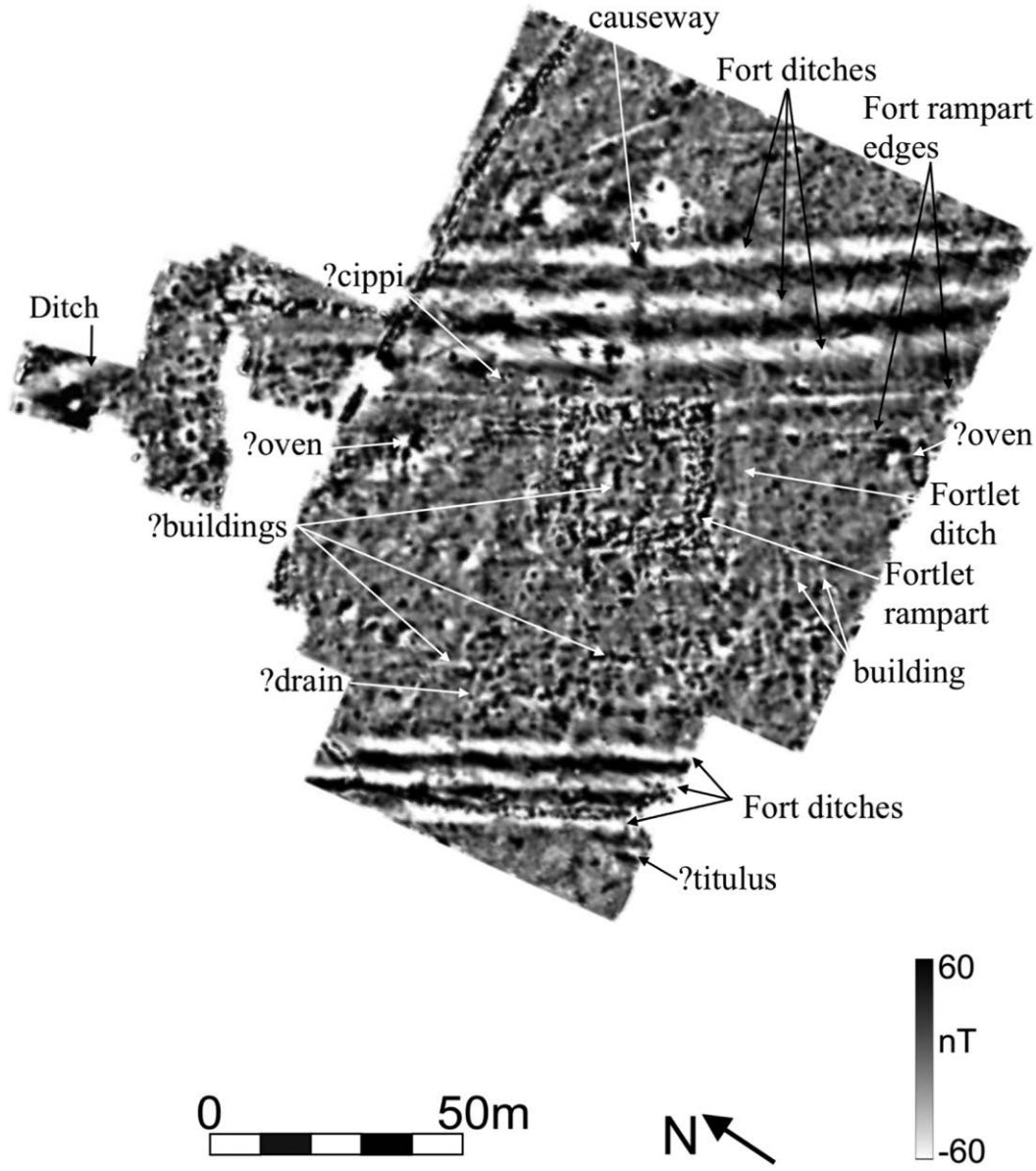

Figure 2.3.6. Glasgow University gradiometer survey at Duntocher.

assessment by Glasgow University indicated some but not serious, magnetic interference. Conditions were good for both surveys, the ground surface in the park being turf throughout. The grass delineating the Wall and fort, deliberately left longer as part of a management plan to highlight the position of the underground remains, had been cut immediately prior to the Glasgow survey. The ground slopes down steeply away from the fort to the north-west, towards the Duntocher Burn, and also to the south-west. Here the most westerly strip of parkland, adjacent to the garden where Newall located kilns in 1977, was too overgrown to allow HES to undertake survey.

Results

The gradiometer surveys (Figure 2.3.6 and 2.3.7) clearly indicate that the defences in front of the fort/annexe actually consisted of three ditches, the central one being additional to the two recorded in the 1947-1951 excavations. This is confirmed by the LiDAR data where, within the broad hollow created by these defences, two linear raised bands running parallel with the Wall line are visible between the fort rampart and the very slight Upcast Mound, thus defining three ditches (Figure 2.3.8). The ditches are revealed as parallel, linear negative anomalies of broadly similar width bounded

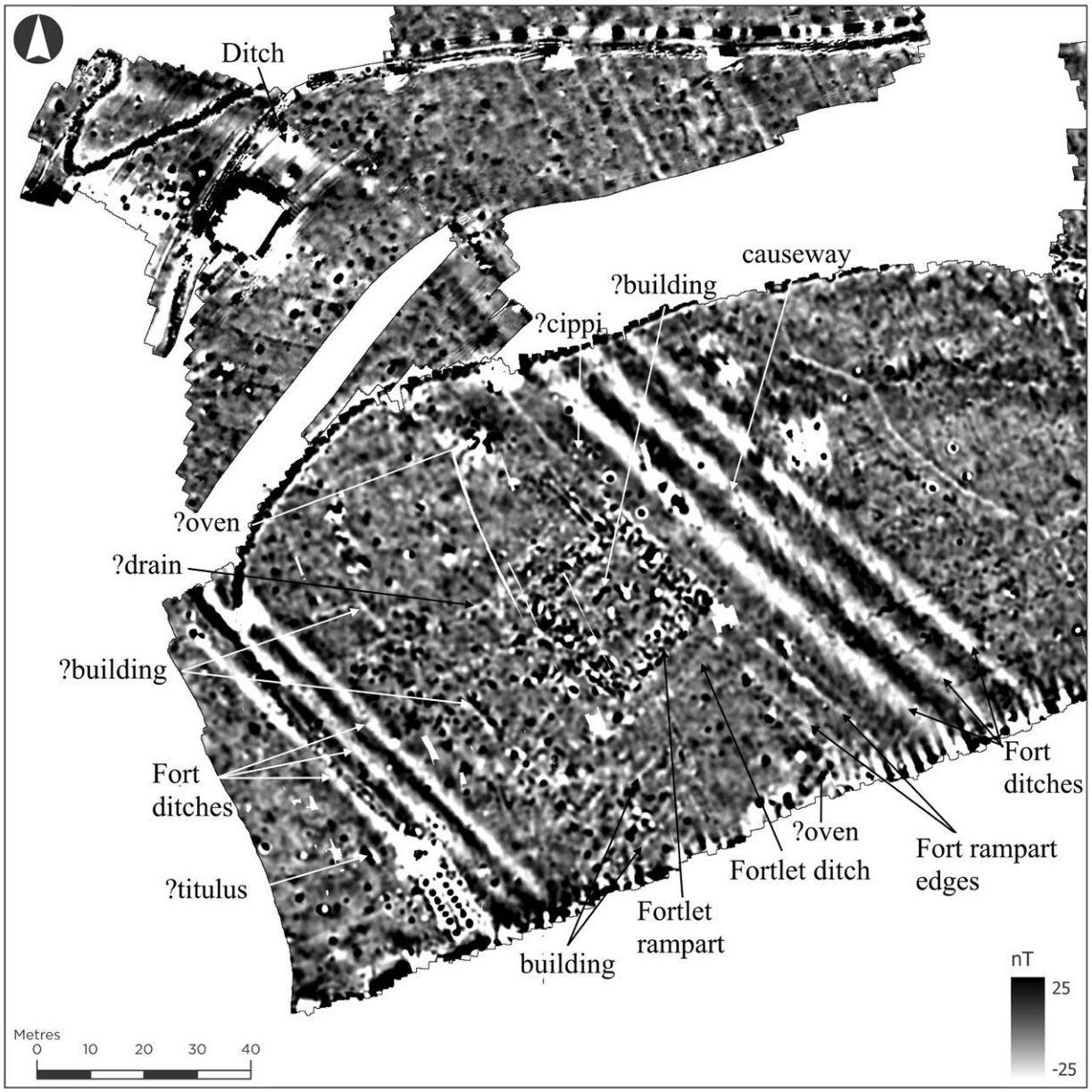

Figure 2.3.7. HES gradiometer survey at Duntocher.

by positive anomalies. The inner two can be traced further north-west to the point where they change direction and merge into the single Wall Ditch. The negative linear anomalies were interrupted by short positive ones directly in front of the north gate of the fortlet, a feature particularly apparent in the outer two ditches. These breaks in the ditches clearly indicate the presence of a causeway (discussed further below). The ditches are not as well defined in the more limited area covered by the resistance survey (Figure 2.3.9), being visible as faint bands of lower resistance separated by narrower lines of slightly higher resistance.

The south-western defences of the fort/annexe are evident in the gradiometer surveys in exactly the same way as those to the north-east, with three parallel, linear negative anomalies bounded by positive ones, though the outer ditch is somewhat masked by a modern footpath which partly overlies it (Figures 2.3.6 and 2.3.7). The ditches represented mirror those recorded by excavation and are clearly consistently narrower than those to the north-east of the fort. Again, the picture from the more limited resistance survey is less clear, with only the inner ditch readily apparent as a faint band of lower resistance with a band of slightly higher resistance inside it (Figure 2.3.9). There are no signs of breaks in the magnetic response, which might indicate a causeway, though the Glasgow survey did not quite extend to the boundary of the park on its south-east side, while the HES survey suggests considerable disturbance in this area adjacent to the concrete base of the children's swings. A *c.* 5m long dipolar anomaly just

beyond the outer south-eastern ditch, most evident in the HES survey, could be a possible *titulus.* However, on the rare occasions *tituli* formed part of fort defences, as for example at Bar Hill, such ditches blocked direct access to causeways in front of gates, so the absence of such a causeway makes this identification less plausible.

The line of the fort/annexe rampart on the north-east side of the fort is identifiable in the gradiometer surveys as a narrow, somewhat intermittent negative linear anomaly (Figures 2.3.6 and 2.3.7), presumably marking the front kerb of the stone base, with slight traces of a similar line, partly positive partly negative, some 6m inside it. This would indicate a rampart considerably wider than the norm, but seems to comply with Robertson's excavations which showed that the original fort rampart had been widened to the east of the fortlet, presumably to better align its southern side with the rear of the Wall Rampart where it abutted the fort (Figure 2.3.4). The continuation of this parallel alignment also to the west of the fortlet would suggest that the widening of the rampart may have continued beyond the area recorded in Robertson's excavations. Occasional positive anomalies between these linear ones may represent better surviving sections of the rampart base. In the resistance survey (Figure 2.3.9) the rampart appears as a band of low resistance, clearest in the higher resolution survey, augmented to the east of the fortlet by a broad band of slightly mottled high resistance, again coinciding with the area where Robertson's excavations indicated that the rampart had been broadened. The limited area on the east side of the fort/annexe subject to electro-magnetic survey further confirmed the suggested increased width of the Rampart base here, which was apparent as bands of low readings particularly in the magnetic susceptibility element, but also in the conductivity data (Figures 2.3.2 and 2.3.10). A series of discrete positive anomalies on the Berm between the rampart and inner ditch in the gradiometer survey (Figures 2.3.6 and 2.3.7) may possibly represent defensive pits (*cippi*), such as those located elsewhere along the Wall (e.g. Bailey 1995), though they do not display the quincunx pattern of distribution usually attested.

There is no clear sign of a gap in the rampart for the presumed north-east gate of the fort to the south-east of the fortlet, and it should be noted that Robertson struggled to identify one in her excavations because of the poor survival of the rampart base (1957: 45). This absence of unequivocal evidence for such a gateway, combined with the existence of a causeway across the fort ditches in front of the gateway to the fortlet, suggests that the latter may have continued to serve as the only gateway through the Wall at the site. This in turn adds considerable weight to Swan's argument that originally the entire enclosure constituted the secondary fort.

The south-western rampart of the fort/annexe is probably indicated in the resistance survey by a band of lower resistance. This is most clearly apparent in the higher resolution survey, where it seems to be bounded by discontinuous narrow lines of raised resistance (Figure 2.3.9). Though there are intermittent positive linear trends in the gradiometer survey in this area, it is difficult to discern a clear response from the rampart.

Traces of the rectangular stone building uncovered by Robertson within what she defined as the fort are faintly represented in the resistance survey by lines of high resistance (Figure 2.3.9) but more readily apparent in the gradiometer survey (Figures 2.3.6 and 2.3.7). Here the stone walls are revealed as narrow, linear negative anomalies that are particularly clear in the Glasgow survey at the north-eastern end of the building. A cluster of large positive anomalies covering much of its opposite end may be associated pits. A small dipolar anomaly towards the eastern corner of the fort may represent the oven found by Robertson at the back of the south-eastern rampart, though the adjacent hairpin-shaped positive anomaly is closer to its recorded location. The conductivity element of the electro-magnetic data shows generally lower readings within the enclosed area compared to outside it (Figures 2.3.2 and 2.3.10), possibly reflecting the extent of metalling within the fort/annexe.

Various features are revealed within what Robertson identified as the annexe on the north-west side of the fort. A concentrated cluster of positive and dipolar anomalies in its north-western quadrant (Figures 2.3.6 and 2.3.7) broadly coincide with an area where pits and postholes were recorded in the 1947-51 excavations, but the cluster lacks any distinctive pattern and is reflected in the resistance survey only as a limited area of slightly raised readings (Figure 2.3.9). Within the magnetic anomalies, one strong dipolar response could be an oven. Similarly, lines of high resistance outlining three sides of a large rectangle immediately south-west of the fortlet are probably structural and are partially mirrored by narrow positive linear anomalies in the gradiometer survey. Such a stone structure would be the right size, morphology and location for the headquarters building in a small fort, providing further support for Swan's re-interpretation of the site. Three more short lines of high resistance are apparent further to the west in the resistance surveys at both levels of resolution, all running parallel with Wall line. The two more southerly are sufficiently close together to have been located on either side of a narrow rectangular building, but are masked at the south-eastern end by

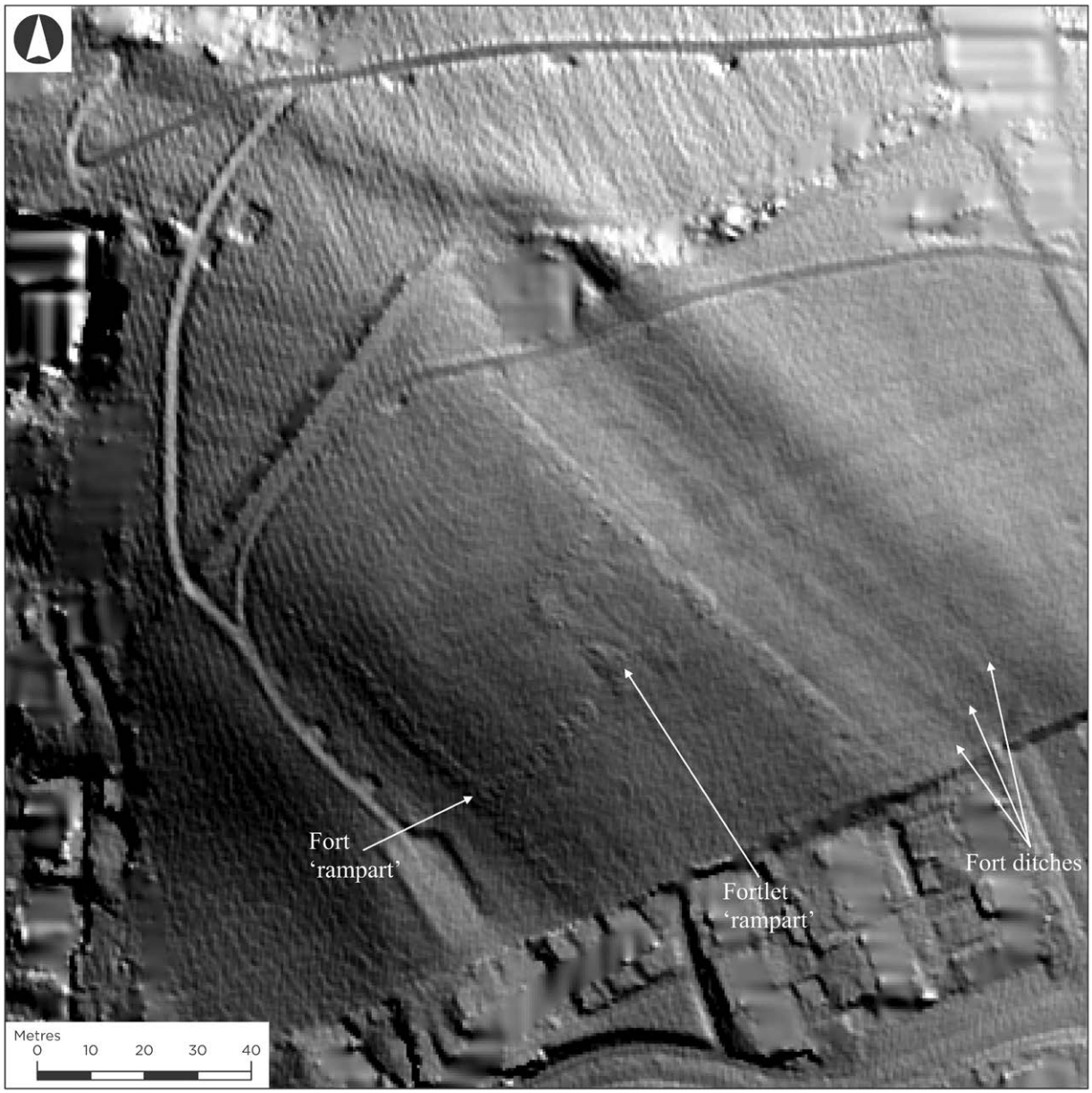

Figure 2.3.8. LiDAR image of Duntocher. Though slight traces of the fort and fortlet ramparts seem to be apparent, they actually reflect differential mowing regimes over the presumed position of the archaeological remains.

an amorphous area of high resistance. Other short, positive and negative linear anomalies on the same alignment in the gradiometer survey may also relate to structures, but no overall pattern is apparent. A narrow variable magnetic anomaly running west from the western corner of the fortlet (below) downslope as far as the fort ditches may be a drain. The resistance survey may show the same feature as a broader line of slightly lower readings, which is particularly apparent in the lower resolution survey where it runs through an amorphous area of high resistance.

The square outline of the fortlet's rampart is surprisingly well delineated in both the gradiometer and resistance surveys. In the former it shows as a speckled band of positive and negative anomalies; in the latter as an uninterrupted wide band of low resistance (Figures 2.3.6, 2.3.7 and 2.3.9). However, in all cases the response is considerably wider than the rampart width indicated in the excavation. This discrepancy may be as much a reflection of the backfilling of the trenches from the 1978 excavation, and perhaps the subsequent policy of the local Council not to cut the grass on the rampart to delineate its outline, as it is of the archaeological remains beneath the turf (Chapter 8.2.4). A slightly amorphous band of raised resistance in the eastern corner, mirrored by quite a strong linear dipolar anomaly in the gradiometer surveys, seems to indicate that the secondary thickening of the rampart recorded in Robertson's excavation along the north-

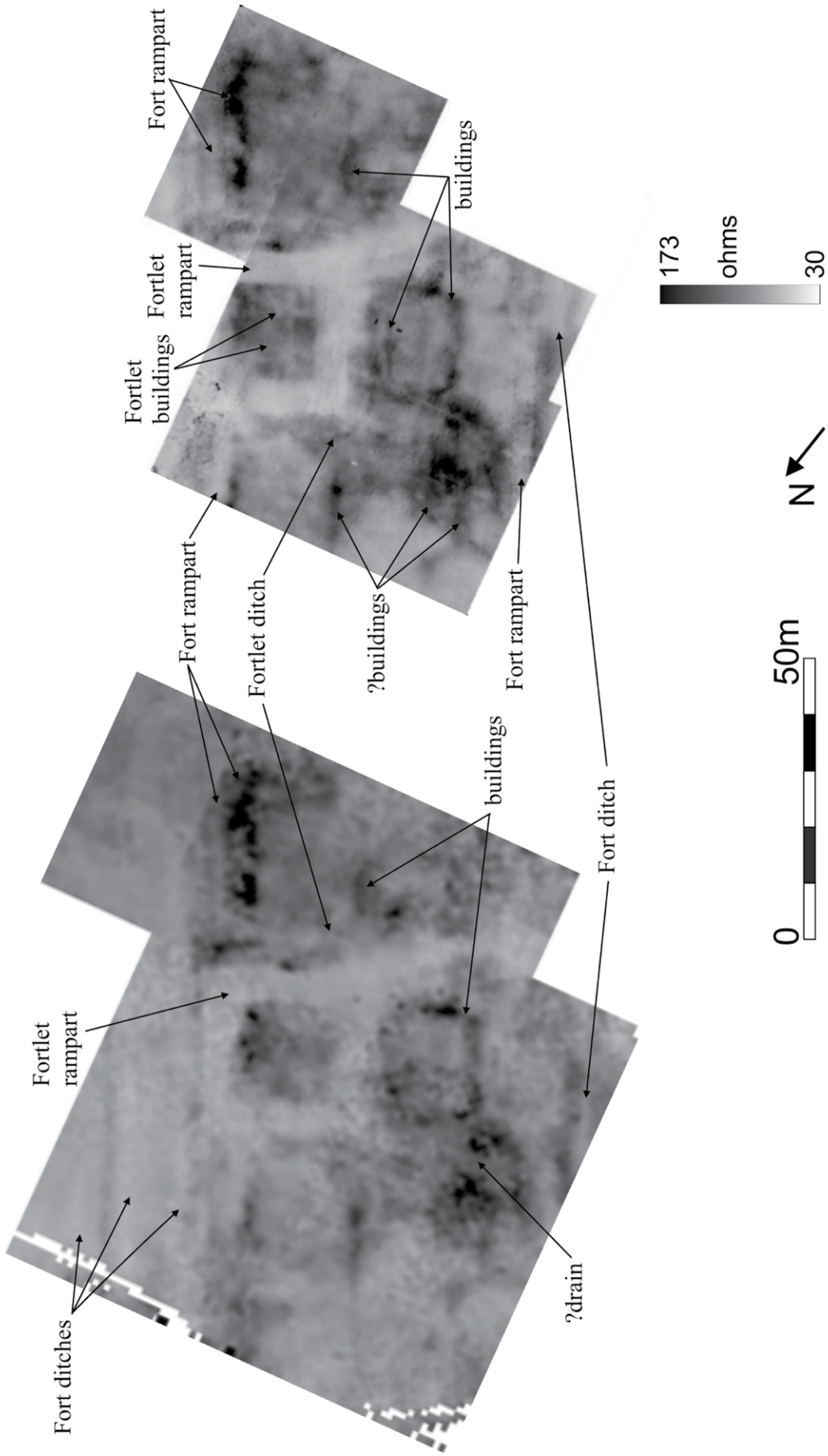

Figure 2.3.9. Glasgow University resistance survey at Duntocher: (left) 1m x 1m; (right) 0.5m x 0.5m resolution.

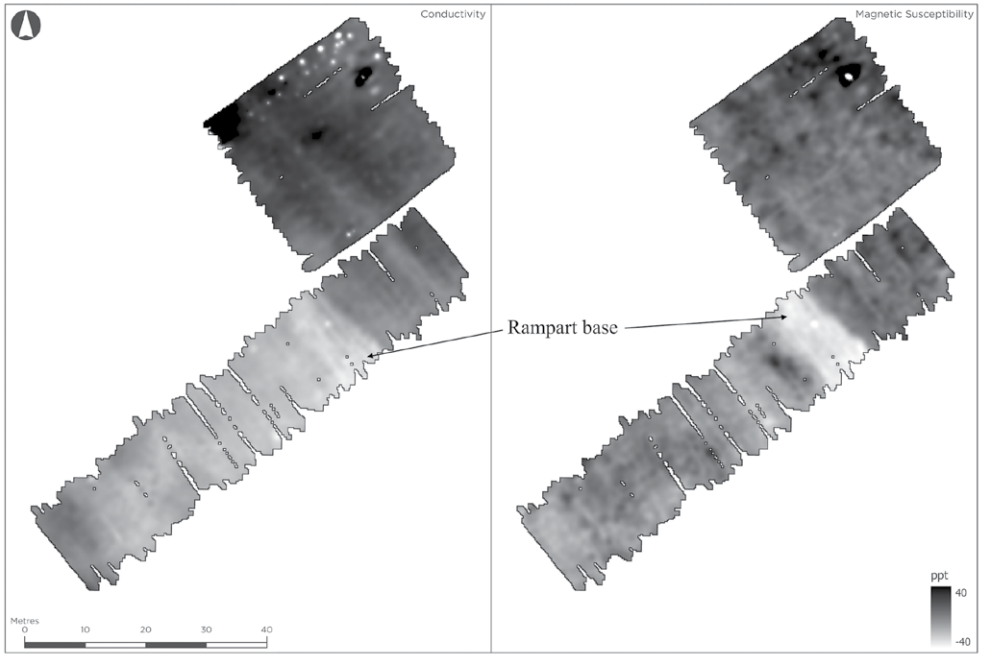

Figure 2.3.10. HES electro-magnetic survey at Duntocher - conductivity (left) and magnetic susceptibility (right).

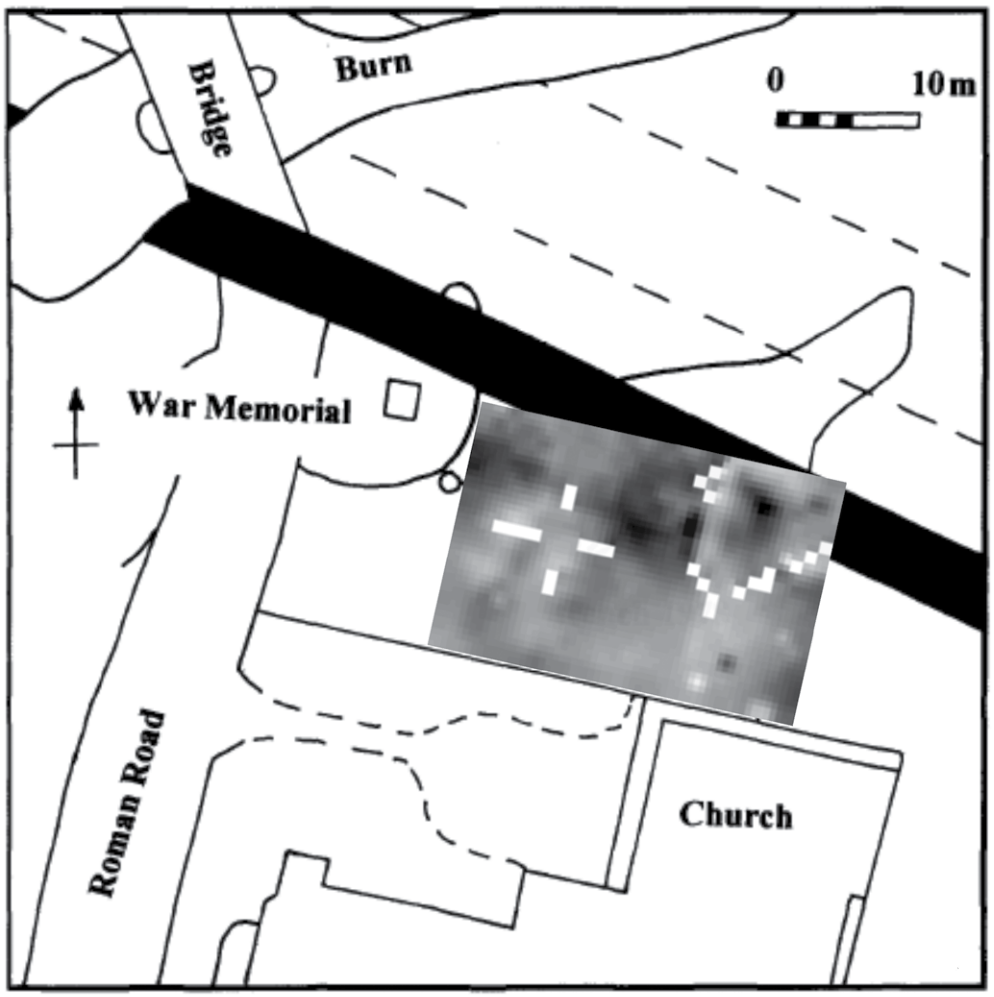

Figure 2.3.11. Resistance survey superimposed on the location plan of the bathhouse at Duntocher (after Keppie 2004, Fig. 18b with additions). Black-white palette 154-95 ohms.

eastern frontage of the fort may also have continued across the fortlet. The fortlet's single surrounding ditch is visible in both the gradiometer and resistance surveys. It shows faintly in the former as a narrow band of variable, but slightly less positive anomalies that follow the line of the fortlet rampart, particularly on its south-east and north-west sides and around its western corner (Figures 2.3.6 and 2.3.7). It is especially clear in the higher resolution resistance survey, where it is revealed as a similarly narrow band of slightly higher resistance demarcated on each side by a line of lower resistance (Figure 2.3.9).

Within the fortlet there are several short linear positive anomalies evident in the gradiometer survey (Figures 2.3.6 and 2.3.7), some of which run parallel to its rampart. These may reflect internal structures. Some are mirrored by thin lines of low resistance in the higher resolution resistance survey (Figure 2.3.9), though others may be backfilled excavation trenches. An irregular band of high resistance along the inside of the north-eastern rampart probably represents its thickening, as it is similar in character to the response visible in the equivalent location in the fort.

An attempt to locate the bathhouse more accurately using resistance survey was not entirely successful. Two areas of high resistance can be seen in the northern half of the survey, but they lack any coherent shape. They may represent the disturbed line of the Antonine Wall base and/or the stonework in the backfilling of the 1978 excavation (Figure 2.3.11).

2.4 Cleddans Road

(NGR: NS 50520 72260; Canmore 107218)

Rampart and Military Way

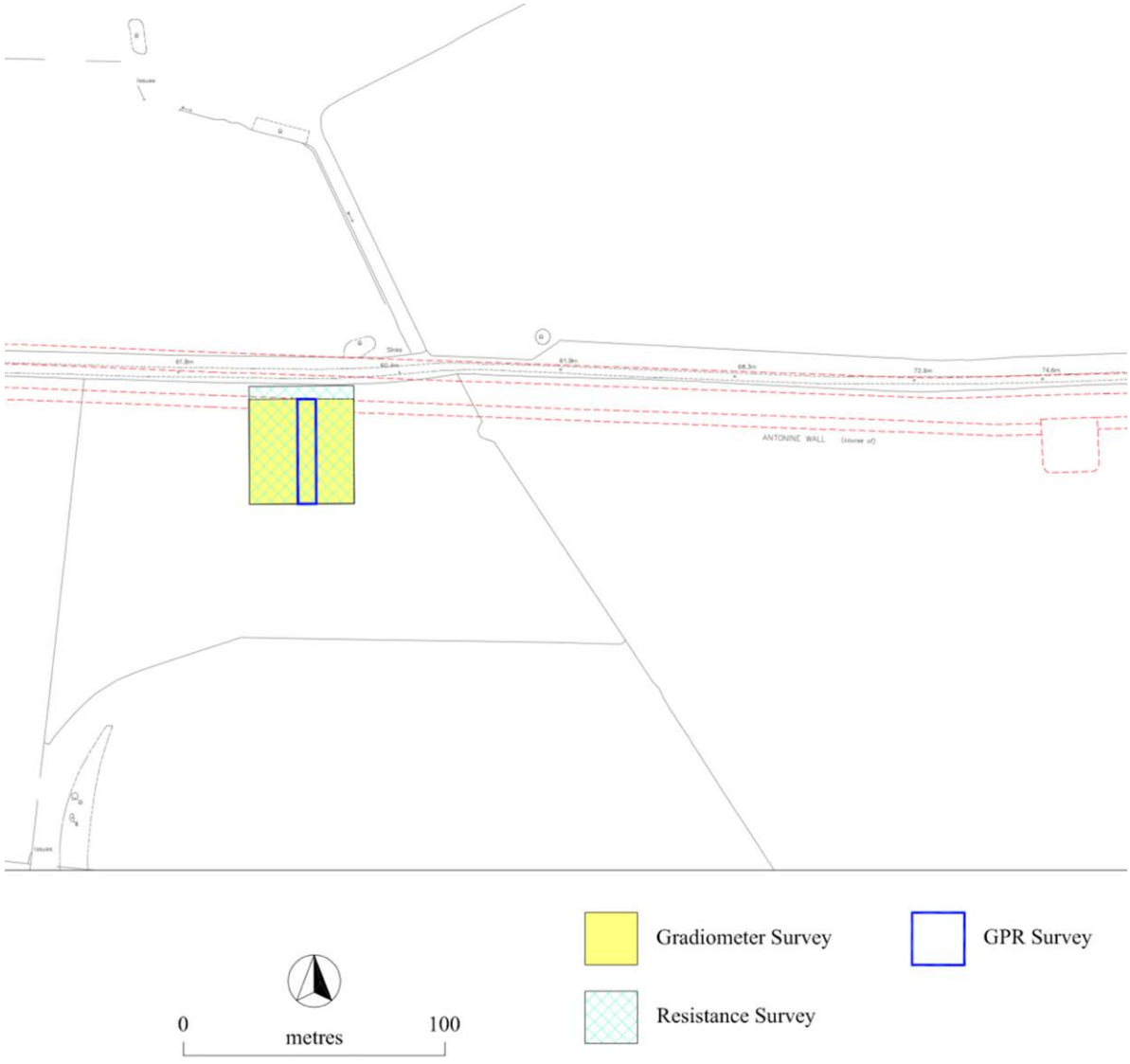

Figure 2.4.1. Location of the geophysical survey and excavation at Cleddans (after GSB 2006b, Fig. 1.3).

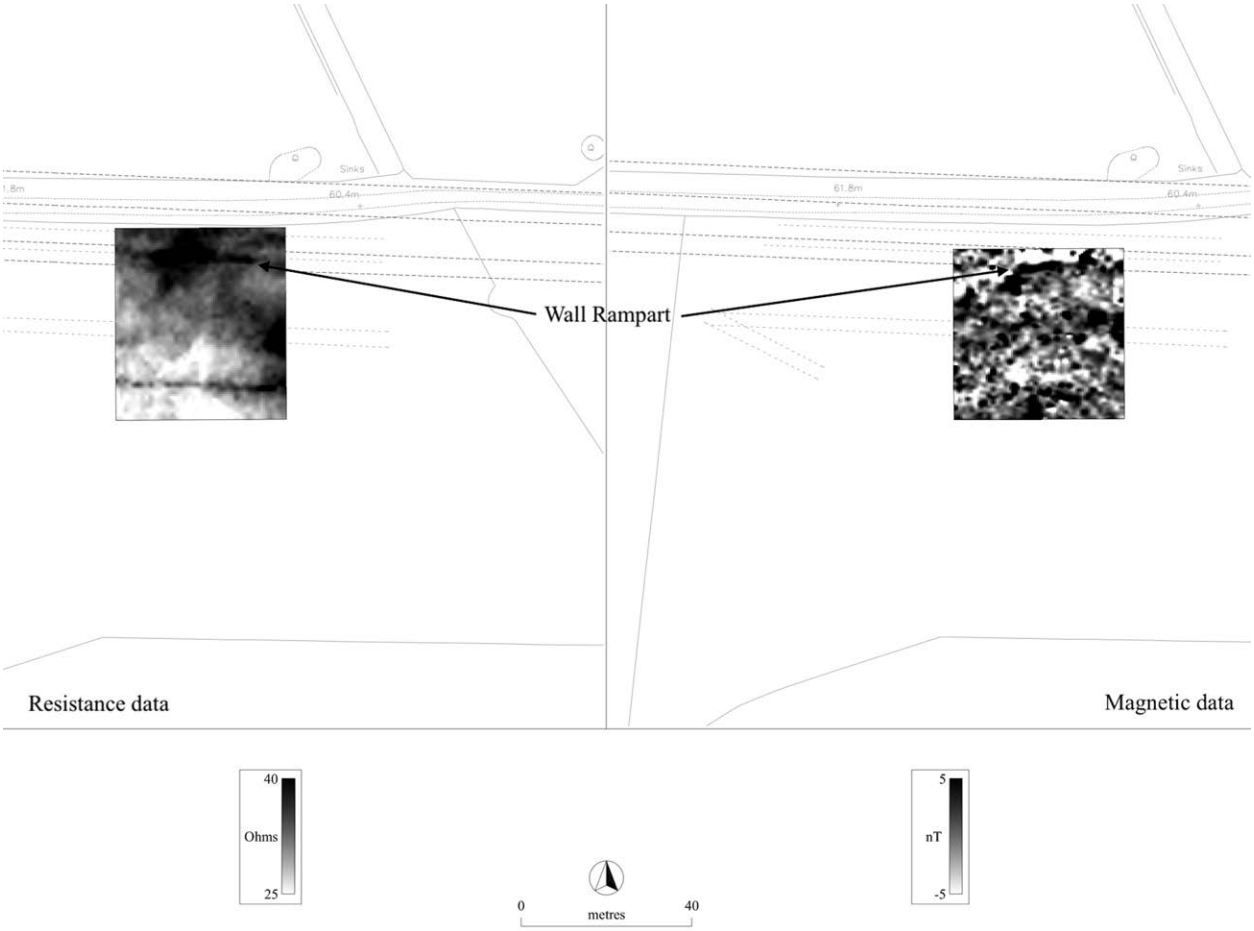

Figure 2.4.2. Resistance (left), gradiometer (centre) surveys at Cleddans (after GSB 2006b Fig. 1.4, with additions).

Site-specific references

Dunwell *et al.* 2002: 288-293; GSB 2006b

Geophysical surveys (Figure 2.4.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
GSB; 2006	G: Bartington Grad 601-2	*c.* 1.6	0.25, 1
	R: Geoscan RM15	*c.* 1.8	1, 1
	GPR: Pulse Ekko 1000	0.28	1t

Introduction

The line of the Antonine Wall between the forts at Castlehill and Duntocher has long been established, though not the precise line of the Military Way. After leaving the lower slopes of Golden Hill, Duntocher, this particular section of the Wall runs up to and along a low ridge before dropping down to the Cleddans Burn. The fortlet at Cleddans, positioned midway between the two forts, sits on the highest point of that ridge with

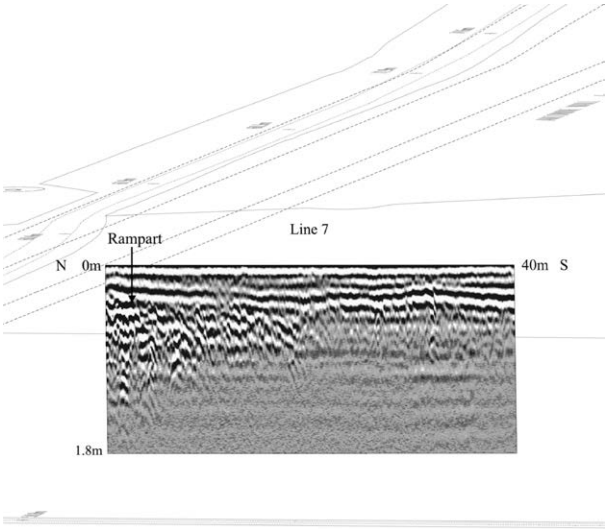

Figure 2.4.3. GPR survey at Cleddans (after GSB 2006b Fig. 1.7, with additions).

unobstructed views to both sites (Keppie and Walker 1981: 154-56).

Excavation cutting obliquely across the Wall line 350m west of the fortlet was undertaken in 2000 in advance of the laying of an underground electricity cable. This confirmed the survival in relatively good condition of the Outer Mound, Rampart and Ditch, the modern road broadly following the line of the latter. No further excavation was then required as the cable was thrust-bored beneath the remains as far as possible. A poorly defined spread of cobbles and pebbles some 18m south of the Rampart was identified as probably the remains of the Military Way.

The purpose of the geophysical survey, positioned some 50m to the east of these excavations, was to check the response of the Rampart and the alignment of the Military Way. The ground adjacent to the modern road is generally flat, sloping downwards to the southern edge of the field. The field was in rough pasture at the time of the survey and the tall grass impeded GPR data collection. The soils comprise silty clays over sandstones and conglomerates, presenting no adverse impact on the gradiometer and resistance surveys.

Results

The line of the Rampart is visible running across most of the resistance survey as a narrow band of high resistance, with some probable spreading of material indicated in the centre (Figure 2.4.2). This seems to be picked up in the gradiometer survey as a slightly broader negative linear anomaly flanked in part by a positive one, again with some possible spreading of material to the south. Similarly, strong GPR reflectors at the northern edge of the survey area coincide with the Rampart location, extending to a depth of 1.2-1.4m (Figure 2.4.3).

However, there are no obvious linear features in either the resistance or gradiometer survey which correspond with the presumed alignment of the Military Way, though there is in the LiDAR data (e.g. Hannon 2018: Fig. F.3.2 and F.5.2). A line of high resistance towards the bottom of the survey is on the same alignment as the Wall, but is too narrow to represent the Military Way and seems more likely to represent a field drain.

2.5 Castlehill

(NGR: NS 5250 7270; Canmore 44510 and 107218)

Figure 2.5.1. Location of gradiometer surveys at Castlehill (2008 in black; 2011 in blue).

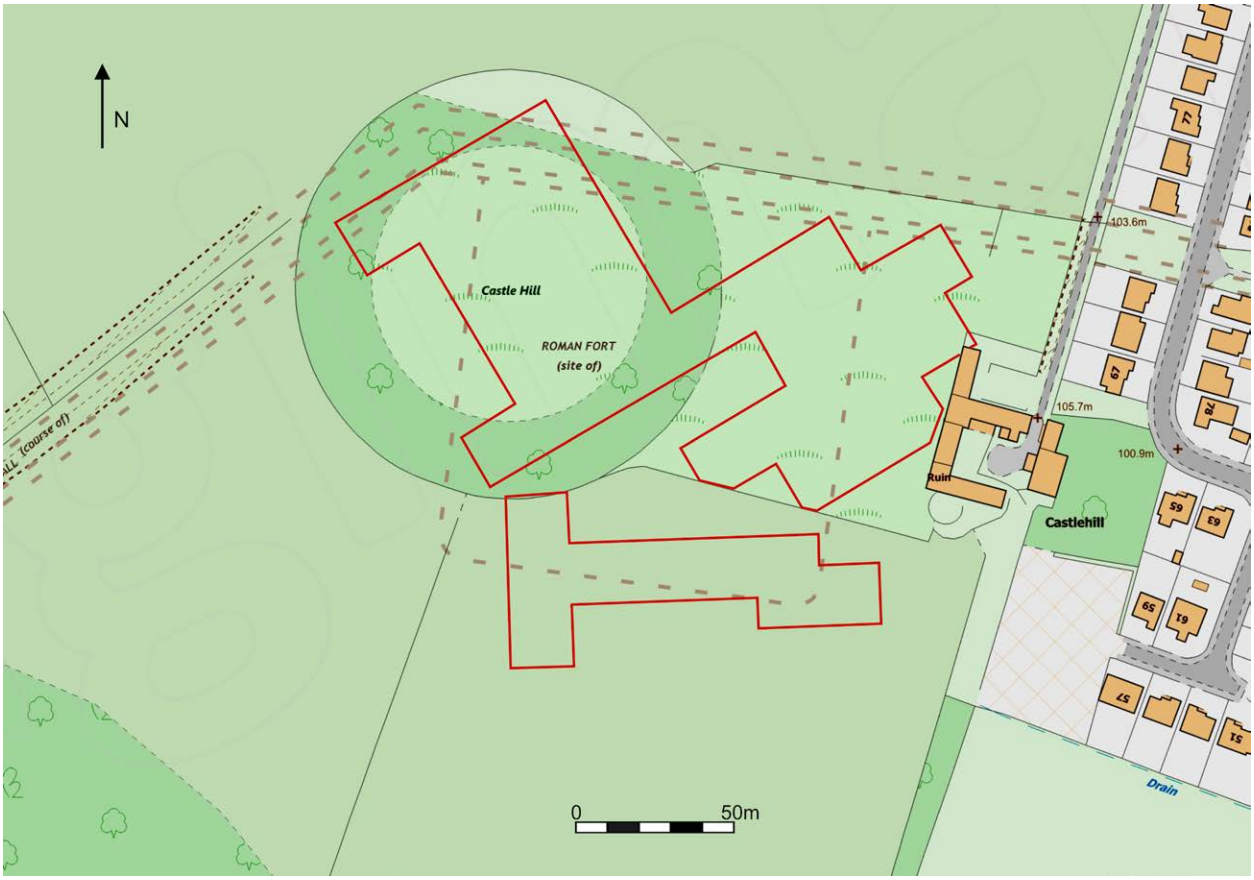

Figure 2.5.2. Locations of resistance survey at Castlehill.

Fort, fortlet, Rampart and Ditch

Site-specific references

Keppie 1980; Jones *et al.* 2009; R.E. Jones 2011; Hanson and Jones 2020

Geophysical surveys (Figures 2.5.1 and 2.5.2)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
Glasgow University; 2008, 2011	G: Geoscan G: Bartington Grad 601-2	1.88 1.32	1, 1 0.25, 0.5
2008, 2019	R: Geoscan RM15	2.2	1, 1

Introduction

The fort is situated astride the eponymous Castlehill, which rises to a height of 118m, and so occupies a remarkably commanding position with views in all directions, second only to Bar Hill along the line of the Wall. It sits at a point where the line of the Wall approaching from the east makes a marked change of direction towards the south-west. There is a long

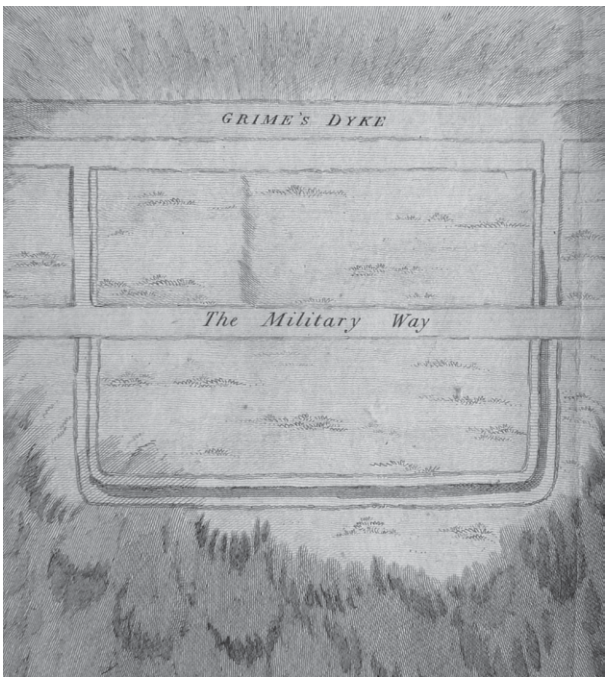

Figure 2.5.3. Roy's plan of the fort at Castlehill with the smaller enclosure in its north-west corner (extracted from Roy 1793, Fig. 35).

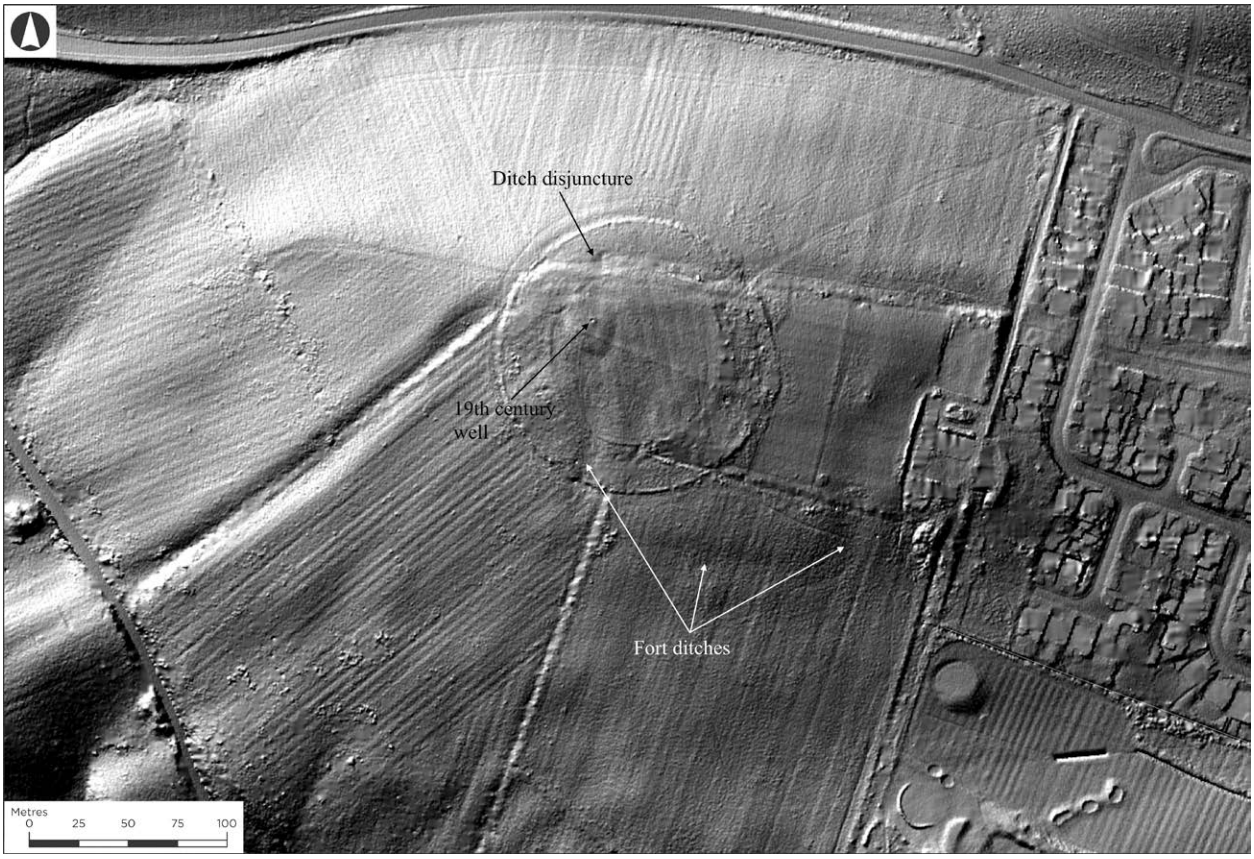

Figure 2.5.4. LiDAR image of Castlehill.

antiquarian tradition of a Roman fort here dating back to the early 18th century (Sibbald 1707: 30) and its defences were still sufficiently extant for them to be planned by various antiquaries later that century (Gordon 1726: 52 and pl. 17; Horsley 1732: 165-66 and 176, N2; Roy 1793: pl, 35) (Figure 2.5.3). Thereafter, continued ploughing effectively removed all visible traces of the fort on the ground, though its general outline can in fact still be discerned in the LiDAR data (Figure 2.5.4). The extent and precise location of the fort was not confirmed until St Joseph recorded the cropmarks of its southern and eastern ditches from the air in 1947. These indicated that it had extended rather further down the eastern slope of the hill than had previously been appreciated. Roy's plan also suggested the presence of a smaller enclosure, possibly a fortlet, in the north-west of corner of the fort on the summit of the hill (Figure 2.5.3). The nature and, indeed, very existence of this enclosure has continued to be a matter of debate. Since no excavation has taken place at Castlehill, it was a natural target for geophysical survey. The immediate environs of the site have, however, been subject to extensive trial trenching by machine more recently. This work was undertaken by GUARD Archaeology as part of the assessment of a planning application to extend Bearsden golf course. South of the Wall line only one shallow pit of uncertain date was identified (GUARD 2018).

The local geology is limestone overlain by till, so is conducive to the application of both gradiometer and resistance surveys. Surface conditions, however, were less favourable. Since at least the mid-19th century the crown of the hill has been circled by a band of trees, whose limits are defined by small earthen banks. The site is also crossed by both long-established and more recent field boundaries, and had been partially disturbed in the later 19th century by the digging of a well, now capped by a manhole cover, and the spreading around it of the excavated material. This is clearly visible in the LiDAR image (Figure 2.5.4) overlying the hollow of the ditches of the fort on its western side. Accordingly, it cannot represent the smaller enclosure recorded by Roy, as had previously been suggested.

Results

Only the gradiometer surveys of 2008 and 2011 picked up the line of the Antonine Wall Ditch, or rather ditches, which appear as narrow linear, negative with adjacent positive anomalies running along the north face of the fort (Figures 2.5.5 and 2.5.6). These are particularly clear in 2008, revealing two parallel ditches similar in width and character to those recorded on both the east and west sides of the fort. There is a slight hint in the 2011 survey that the outer ditch curves inwards as it

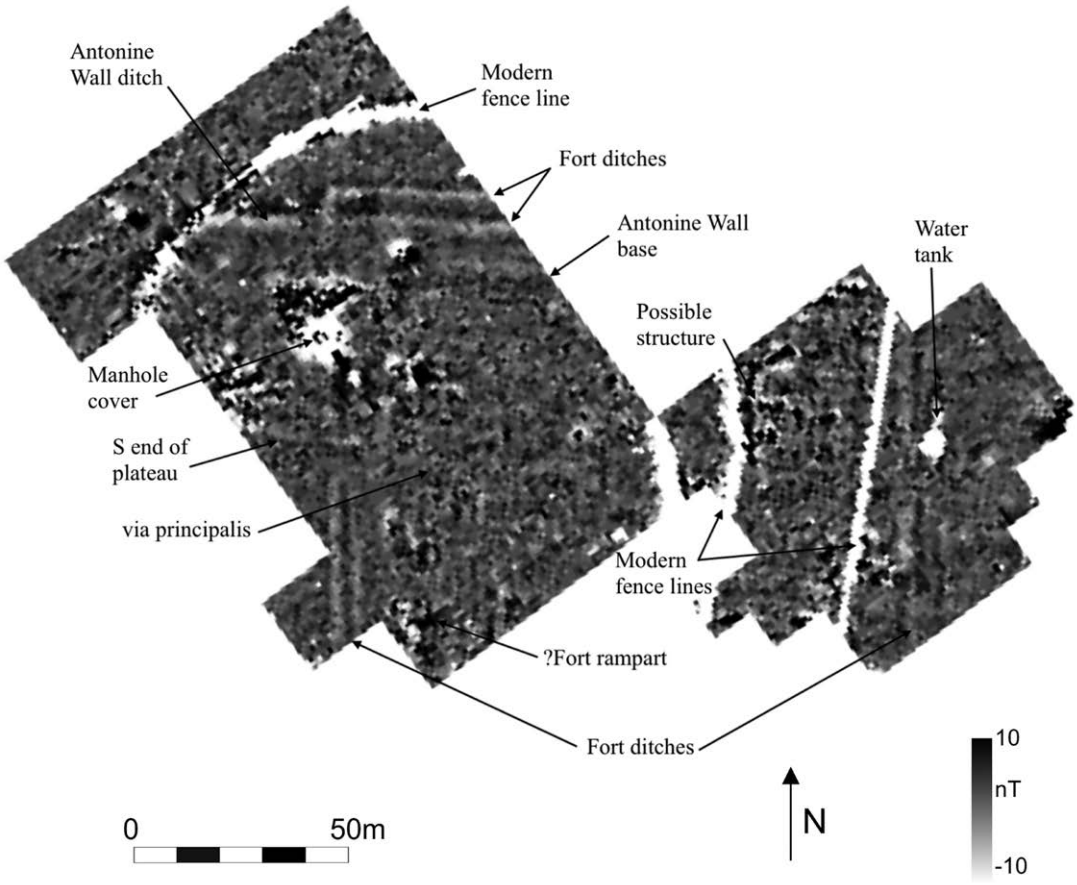

Figure 2.5.5. Gradiometer survey at Castlehill (2008).

approaches the north gate of the fort. A short length of the Antonine Wall Ditch proper is visible to the west of the fort, just inside the line of the modern fence around the copse, indicating not only that it was slightly wider (*c.* 6.8m), but that there is a clear disjuncture where it meets the ditches of the fort. The same relationship is visible also in the LiDAR image (Figure 2.5.4) and is reminiscent of that between the Wall base and fort ramparts recorded at Duntocher or between Wall ditch and fort ditches at Auchendavy (Chapters 2.3 and 4.1). Thus, it seems highly likely that the fort was originally built as a freestanding structure before the arrival of the Wall line to join it.

Stretches of its ditches were detected on all three sides of the fort to the south of the Wall. Double ditches are readily apparent along much of the west side in both gradiometer surveys, with a clear break located to the north of their mid-point marking the position of the west gate (Figures 2.5.5 and 2.5.6). Where these ditches approach the back of the Antonine Wall, however, they are masked by a large dipolar anomaly from the manhole cover and associated spread of material from the 19th century well. The resistance survey managed to penetrate this overburden rather better (see below), though only the outer fort ditch was possibly discernible as a faint linear anomaly of higher resistance (Figure 2.5.7).

Both survey techniques detected at least two southern ditches, though they were clearer in the 2011 gradiometer survey. They were more widely separated than on the west side, with a break for a gate at roughly their mid-point. There were indications, however, of a possible third ditch between them in the south-east quadrant (Figure 2.5.6), mirroring what Keppie noted in his transcription of the aerial photographs. In the resistance survey the inner of the two ditches appeared as a discontinuous line of markedly higher resistance, which could be traced until it began to curve around the south-east corner of the fort (Figure 2.5.7). A short stretch of ditch crossing in front of the gap for the south gate seems to represent the western end of the putative third, intermediate ditch, suggesting that it was probably a secondary addition. It seems to continue around the south-east corner of the fort as there is a faint indication of the outer ditch beyond it, the only point in the resistance survey where the latter seems to be visible.

The pattern of ditches on the east side of the fort is more difficult to determine, but there are at least two.

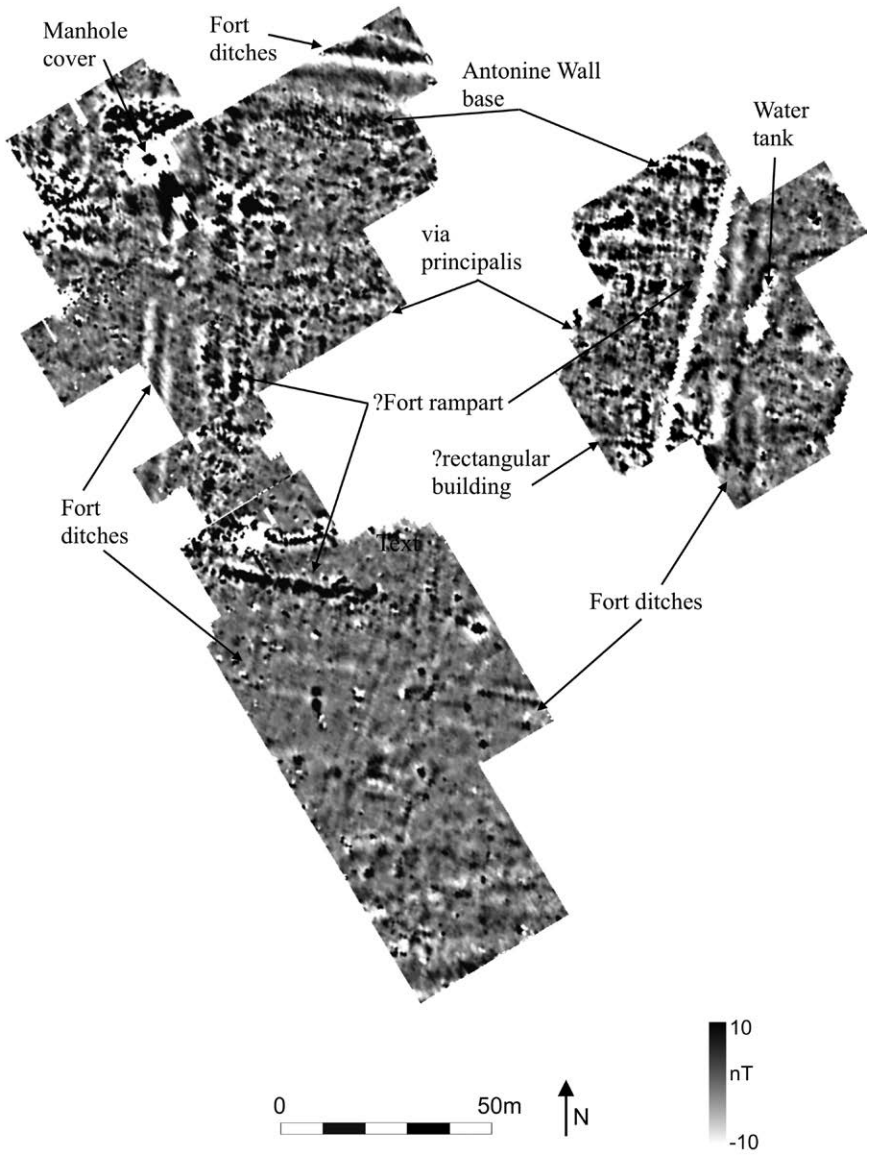

Figure 2.5.6. Gradiometer survey at Castlehill (2011).

These are readily apparent in both gradiometer surveys (Figures 2.5.5 and 2.5.6), despite the interference from a buried modern water tank. The area immediately inside them, however, broadly coincides with the line of a barbed wire fence that rather dominates the signal. The resistance survey shows four parallel bands of elevated resistance (Figure 2.5.7). The outer two clearly correspond with the ditches in the aerial photographs, in the gradiometer survey and line up with those recorded at the south-east corner; the inner one, where the resistance signal is consistently higher, seems to correspond with the rampart of the fort and can be traced back to join the Antonine Wall Rampart at the north-east corner. Just outside it the fourth line with its occasional patches of higher resistance could be either a ditch or a rampart, though, for reasons considered in the next paragraph and in Chapter 8.1.3, the latter interpretation is preferred here.

The line of the north rampart of the fort/Antonine Wall Rampart base is apparent in all the surveys. In the gradiometer survey it appears as a broad (*c.* 5.5m wide) positive anomaly, though with a slightly mottled appearance that is particularly apparent in the 2011 survey (Figure 2.5.6). This perhaps reflects the mixed nature of the large stones that make up the base. In the resistance survey (Figure 2.5.7) it was detected as an equivalent broad band of enhanced readings. As already noted, in the north-east corner of the fort this band runs into the inner, slightly broader, north-south band of higher resistance that represents the eastern rampart of the fort. However, just outside that rampart is another north-south band with occasional patches of

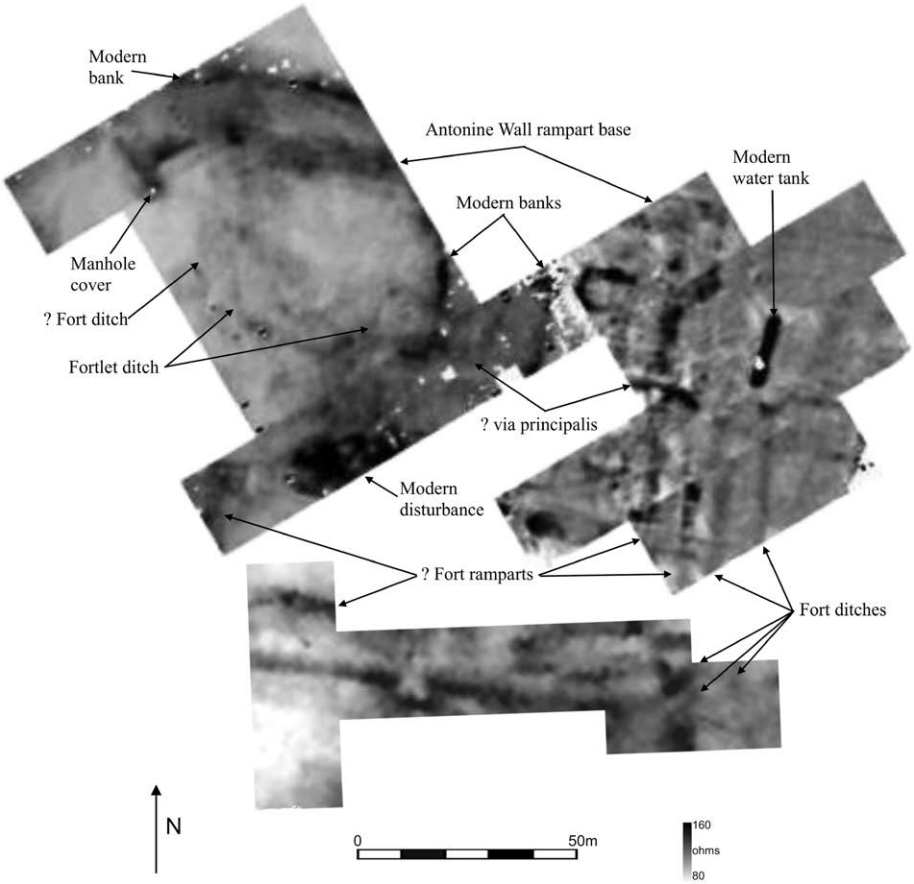

Figure 2.5.7. Composite resistance survey at Castlehill.

higher resistance that also appears to connect to the Antonine Wall base. This raises the possibility that the size of the fort was amended, perhaps when the Wall was joined to it. The gradiometer survey does not shed any further light on this interpretation because of the interference from the barbed wire fence. Elements of the western rampart of the fort may be indicated in both gradiometer surveys by wide, slightly discontinuous bands of positive anomalies running inside and parallel to the ditches, while the southern rampart seems to be represented by a strong positive linear anomaly with a clear break for the south gate opposite a gap in the ditches (Figures 2.5.5 and 2.5.6). Part of the same feature is evident in the resistance survey as a band of high values (Figure 2.5.7). The slight uncertainty about the location of the ramparts of the fort impacts on any calculation of its internal area. Assuming the above identifications to be correct gives an area of *c.* 0.92ha increasing to *c.* 1.02ha if the outer line of the eastern rampart is used.

There is no indication, either in the geophysical surveys or in the aerial photography, of further ditches to the east of the fort which might indicate that it was provided with an annexe. Nor, though there was only a limited extension of the 2011 gradiometer survey downslope to the south, was there any evidence of occupation outside the fort.

Within the fort the *via principalis* appears as a broad negative anomaly in the gradiometer surveys (Figures 2.5.5 and 2.5.6), bordered on each side in the 2011 survey by narrow but stronger positives, possibly representing infilling of adjacent drains with magnetically enhanced debris. Traces of internal buildings are, however, very slight and uncertain, though there is a hint of a rectangular building *c.* 11m wide to the south of the *via principalis* in the 2011 gradiometer survey which may represent one end of an east-west barrack block, or the infilled drain around it.

Finally, in the north-west corner of the fort, visible only in the resistance survey (Figure 2.5.7), are curvilinear anomalies of slightly raised resistance which seem to define the southern end of a small, ditched enclosure in the position indicated by William Roy. Its shape and dimensions (*c.* 30-37m east-west by 35m north-south internally) are entirely consistent with its identification as a fortlet and, in conjunction with the indications that the fort was originally freestanding, suggests a sequence of development at the site very similar to that recorded at Duntocher (Robertson 1957), with a fortlet

replaced by a small fort before the arrival of the Wall itself.

2.6 Bearsden

(NGR: NS 54622 72097; Canmore 44532 and 107218)

Fort ditches

Site-specific references

Feachem 1974; Duncan and Leslie 2003; Will and Sneddon 2010; Banks 2016; Breeze 2016

Geophysical survey (Figure 2.6.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
GUARD; 1995	R: Geoscan RM4	0.136	1, 1

Introduction

The fort at Bearsden sits on slightly undulating, raised ground fronting onto the Manse Burn shortly before it turns north-east to flow into the Allander Water. Early descriptions and plans were provided by several antiquaries (Gordon 1726: 52-53 and pl. 18; Horsley 1732: 166 and 176 N2; Roy 1793: 158-59 and pl. 35) (Figure 1.4), though such accounts name the site as New Kirkpatrick or New Kilpatrick until at least the late 1930s. A broad hollow marking the ditches enclosing the southern half of the fort remained sufficiently visible to be recorded in the 1st edition Ordnance Survey mapping of the area in the early 1860s (Figure 1.5). By the end of the century, however, most of the site had been built over, and within another 20 years no visible trace remained.

Redevelopment of the northern half of the site was the stimulus for excavations that continued for almost a decade (1973-1982) (Figure 2.6.1). These revealed that the fort originally enclosed an area of 1.48ha within a turf rampart on a stone base some 4.5m in width. No gateways were identified because of access constraints and poor survival of the ramparts. The fort was surrounded by triple ditches to the west, double ditches to the east and a single rather wide ditch to the south. The Antonine Wall Ditch formed its northern boundary. Early in the building process the fort enclosure had been subdivided to form an annexe on its eastern side, reducing the area of the fort to 0.95ha. There was no causeway across the ditch opposite the middle of the reduced fort, either to the north or south, and no ditch separated it from the annexe.

Excavation identified two stone-built granaries in the western half of the central range and a probable timber-built headquarters building positioned at the centre of the original fort enclosure. The post-holes

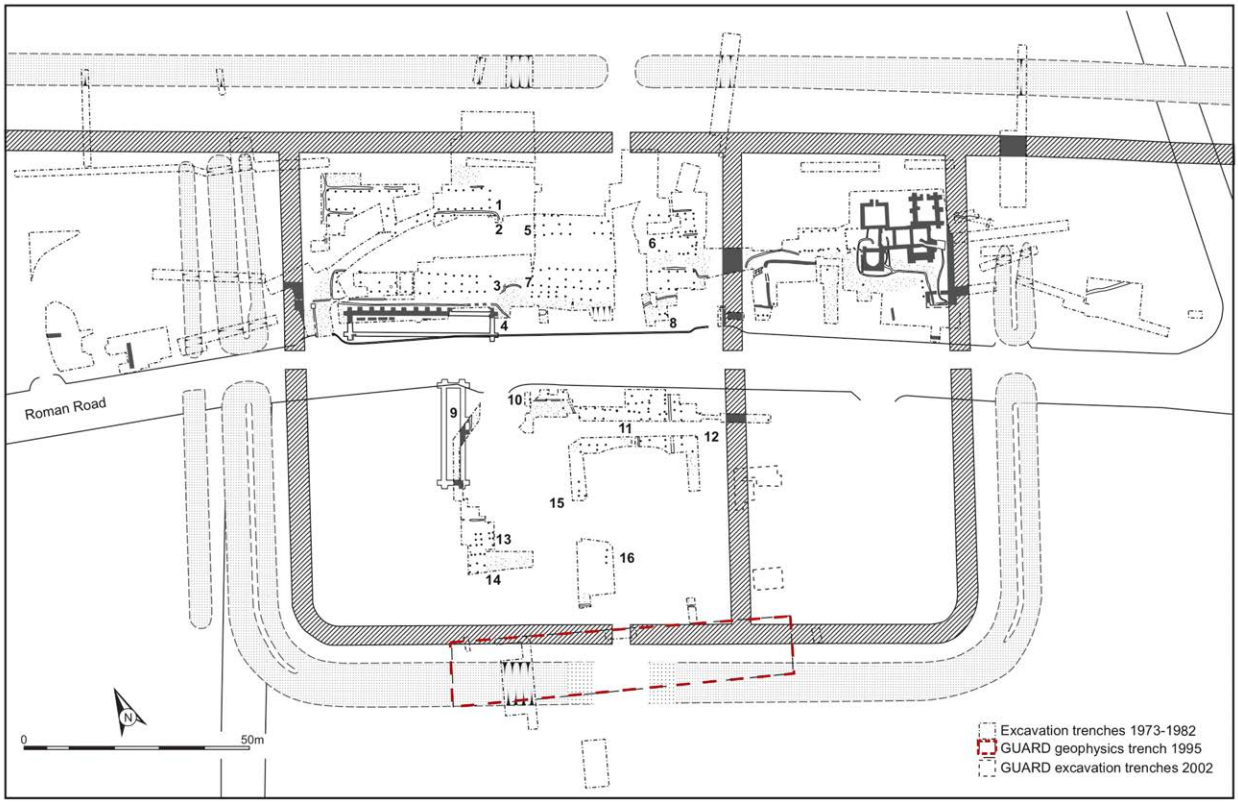

Figure 2.6.1. Plan of Bearsden showing areas of excavation and geophysical survey (after Breeze 2016, Fig. 3.2.1).

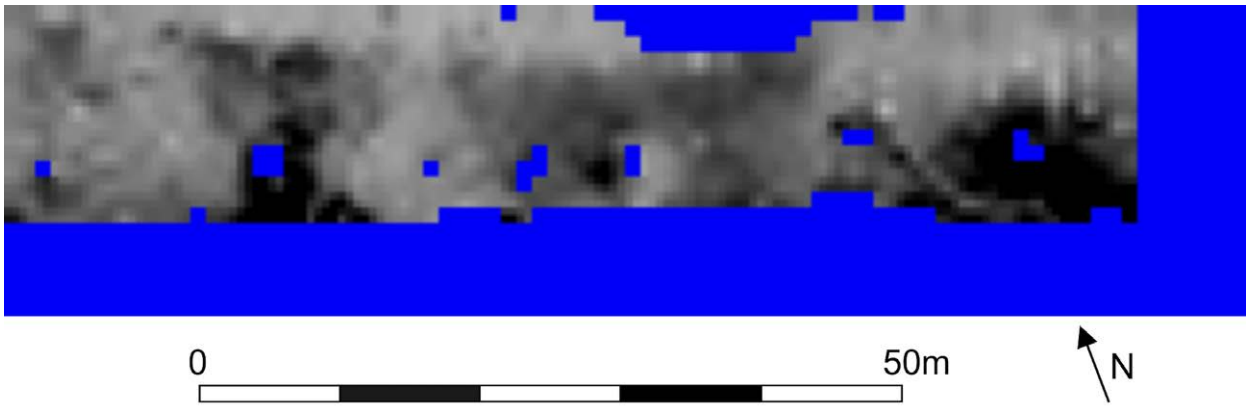

Figure 2.6.2. Resistance survey at Bearsden (after Breeze 2016, Fig. 3.5.1, with additions).

of long, narrow rectangular timber buildings were recorded across most of the area to the north of the central range, though to a lesser extent to the south where excavation was much more limited. Two of these buildings were clearly barracks, but the identification of others is less clear-cut. One at least was probably a store.

A surprisingly well-preserved bathhouse, with an attached timber changing room, and an adjacent latrine were excavated in the northern part of the annexe and consolidated for public display, along with part of an earlier bathhouse that had been demolished before its completion. Other scattered post-holes and cobble foundations in the area did not form coherent structures, and there was very little investigation of the southern two-thirds of the annexe. Limited excavation outside the fort to the west produced some evidence of building foundations.

A resistance survey was undertaken by GUARD in 1995 to try to establish whether there was an original causeway through the ditch on its southern side opposite the middle of the larger original fort. The narrow survey area, which lay within the garden of what was then the Maxholme Community Centre, presented some difficulties in the form of a substantial root system from mature trees along the edge of an adjacent path and hedge along its south side. The area was predominantly covered by a lawn and the soil was notably loose underfoot, giving rise to low readings. Subsequent excavation also by GUARD in advance of further development in the southern half of the annexe between 2002 and 2012 provided evidence only of random post-holes and demolition deposits.

Results (Figure 2.6.2)

The resistance values were low, no higher than 162 ohms. The area of higher resistance towards the western end of the survey coincides with an earlier excavation trench through the southern ditch of the fort, while that at the eastern end may be associated with a modern pipe. The central area of slightly raised resistance some 24m wide seems to represent compacted soil, which would not be inappropriate for a causeway. Combined with the central location of the probable headquarters building and the absence of causeways through the ditches opposite the north and south gates of the phase-two fort, its position lends support to the suggestion that there was probably an original causeway opposite the middle of the original larger fort.

2.7 Boclair

(NGR: NS 5530 7205; Canmore 44472)

Ditch, Fortlet

Site-specific references

Spence 2017; Kilpatrick and Rennie 2017; Rennie 2018

Geophysical survey (Figure 2.7.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
GUARD 2017, 2018	G: Geoscan FM256	0.08	0.5, 0.5
	R: Geoscan RM15 Geoplot v3	0.08	0.5, 0.5

Introduction

After crossing the southerly continuation of the valley of the Manse Burn to the east of the fort at Bearsden, the line now followed by the aqueduct from Loch Katrine, the Wall heads north-east following the higher ground until it reaches the site of New Kilpatrick cemetery. Here it changes direction, turning quite sharply to the east heading towards Summerston via Crow Hill (Chapter 2.8). East of the Loch Katrine aqueduct the

Figure 2.7.1. Location of gradiometer and resistance surveys at Boclair (after Rennie 2018, Fig. 1. Reproduced by permission of GUARD Archaeology Limited).

Wall runs along the *c.* 60m contour that defines a steep scarp overlooking Ferguston Muir and the Manse Burn beyond. The line of the Ditch and, in the north-eastern third of this stretch, the Rampart, had survived sufficiently well to be recorded in the 1st Ordnance Survey mapping of the area undertaken in 1860 (Figure 1.5). Infilling of the ground by large villas on the north side of Boclair Road had already begun at the south-western end by 2nd edition Ordnance Survey mapping in 1896, the whole stretch being divided up into plots for similar housing by the mid-1930s.[4] However, the best surviving section of the Wall continues to be preserved under tree cover in large back gardens, as is apparent in the LiDAR data (Figure 2.7.2).

The probable existence of a fortlet somewhere in this general area was variously postulated (Hanson and Maxwell 1986: 122; Woolliscroft 1996: 163 and Tables 1-2), but its location was not confirmed until June 2017. Trenching by GUARD in advance of a house extension at 9B Boclair Road revealed a short section of stone rampart base some 2.9m wide running at right angles

[4] Interestingly, the relevant plots in which remains of the fortlet were recorded were not developed until the later 1970s, as neither 9B nor 15A Boclair Road are depicted on the Ordnance Survey mapping from the early 1970s, first appearing in the early 1980s.

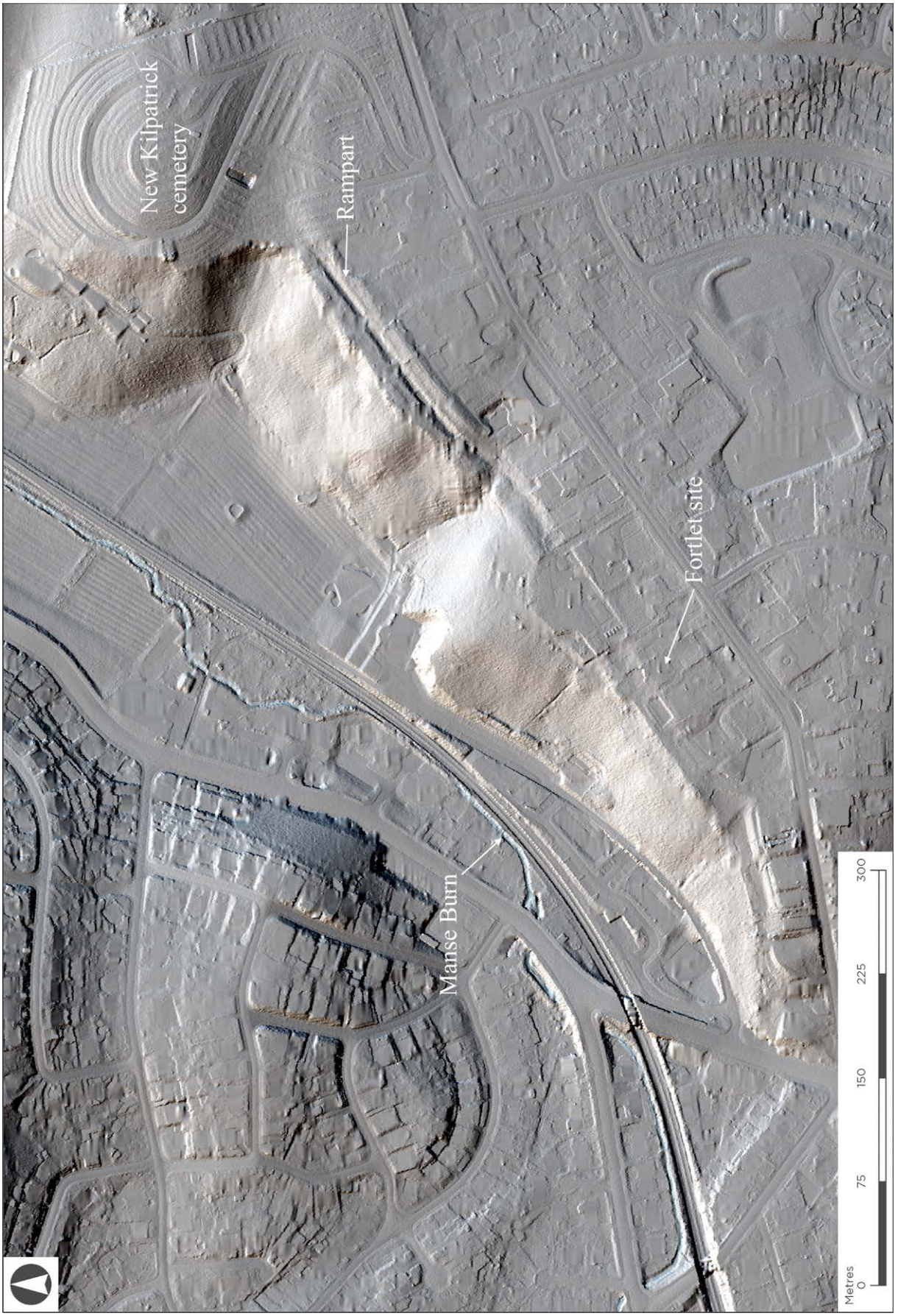

Figure 2.7.2. LiDAR image of line of the Wall between the route of the Loch Katrine aqueduct and New Kilpatrick cemetery.

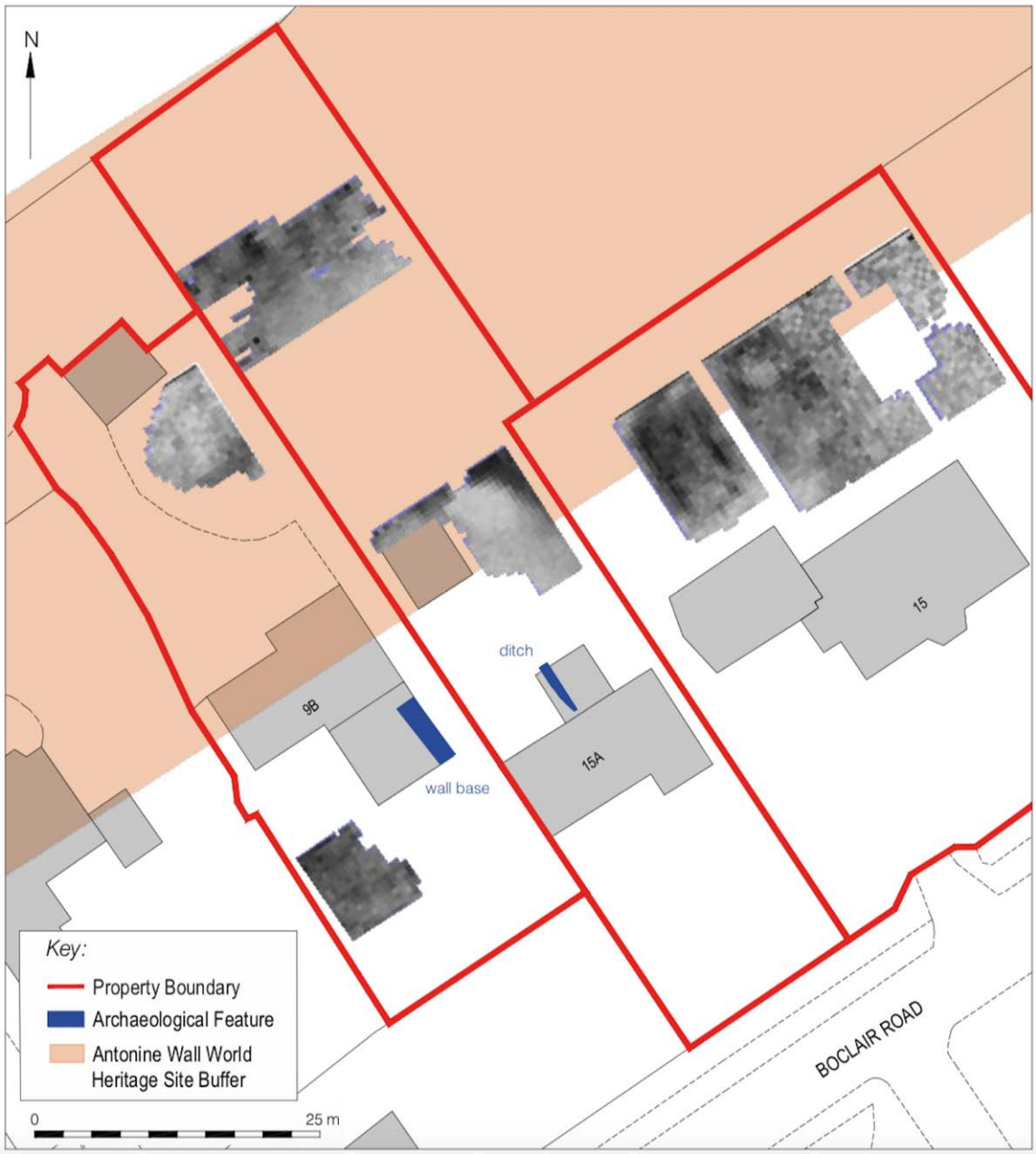

Figure 2.7.3. Resistance survey at Boclair (after Rennie 2018, Fig. 8. Reproduced by permission of GUARD Archaeology Limited).

to the line of the Wall. Interestingly, the 2nd edition Ordnance Survey 25-inch map records the place name Camphill at this precise location. Further trenching in August 2017 in advance of similar development next door at 15A Boclair Road uncovered part of a small, waterlogged ditch containing wood and other organic remains. This was located on a similar alignment to, and some 10m to the north-east of, the rampart base (Figure 2.7.3), though no relationship between the two archaeological features could be established. In an attempt to learn more about the possible extent and character of the fortlet, the opportunity was taken to undertake geophysical survey over the line of the Antonine Wall within the garden. This survey was subsequently extended into the gardens of both 9B and 15 Boclair Road. Because the work was undertaken across the landscaped gardens of three adjacent properties, there were considerable if intermittent constraints to access in the form of dense shrubbery and areas of paving. The local geology is limestone coal formation overlain by till, so is conducive to the application of both gradiometer and resistance surveys.

Results (Figure 2.7.3)

Results from the limited areas of geophysical survey were disappointing. There were no signs of the fortlet, despite GUARD's suggestions to the contrary, though arguably only one very small area of survey in the front garden of 9B Boclair Road would have encroached on it. However, even the line of the Antonine Wall Rampart and Ditch, which is known to have run across the rear gardens of all three properties, could not be clearly established, though two high resistance anomalies beyond the garage in the garden of 15A Boclair Road might represent remains of the Wall base.

2.8 Summerston to Balmuildy Bridge

(NGR: NS 5717 7255 to NS 5621 7238; Canmore 44472 and 44482)

Ditch, Rampart, Upcast Mound, Military Way, fortlet, temporary camp

Site-specific references

GSB 2006a; R.H. Jones 2011: 307; Maxwell and Hanson 2020

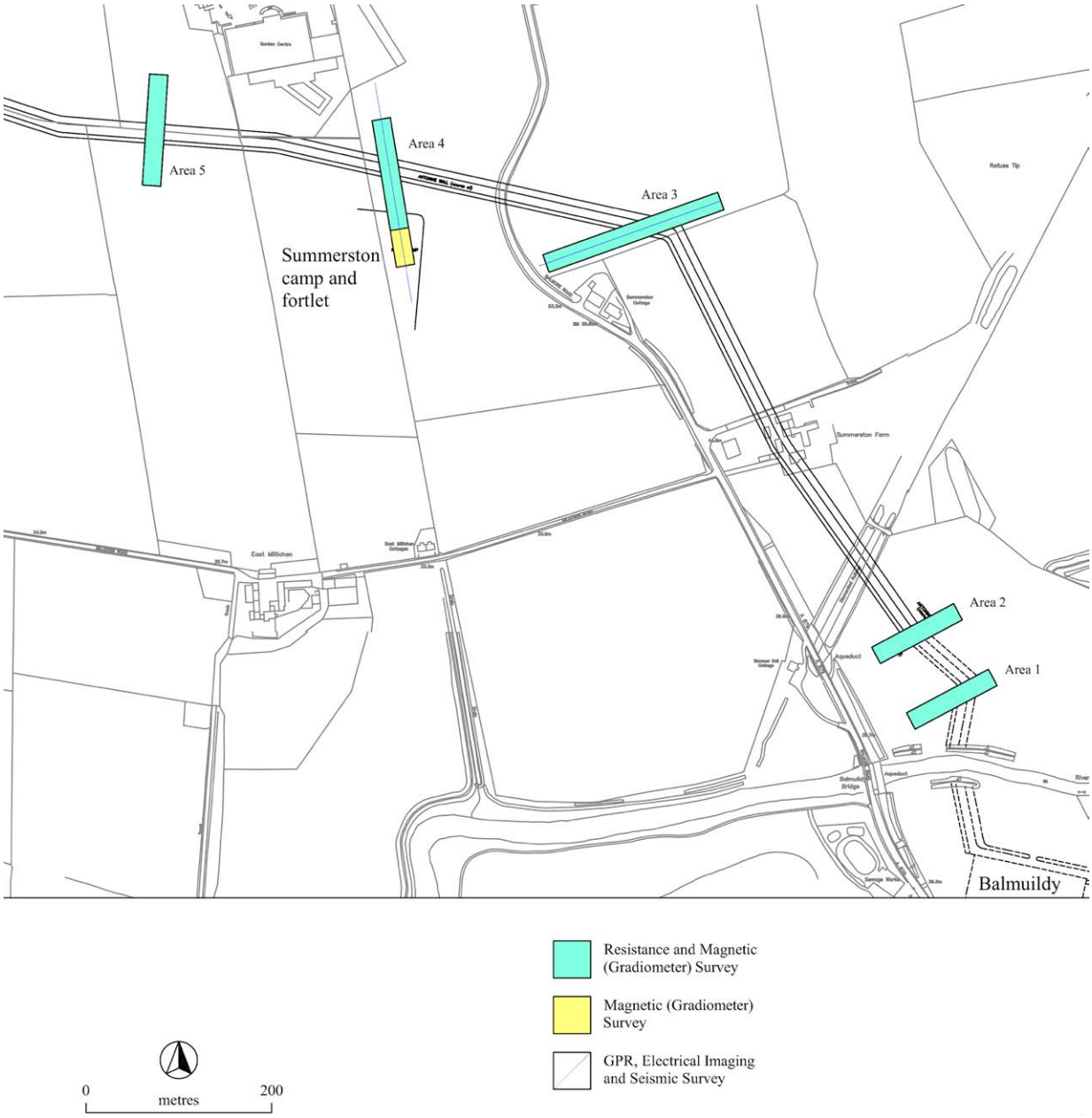

Figure 2.8.1. Location of survey areas from Summerston to Balmuildy Bridge (after GSB 2006a, Fig. 2.1, with additions).

Figure 2.8.2. Aerial photograph of the line of the Ditch changing direction at the top of the hill behind Summerston Cottages in 1992 viewed from the east. The Ditch is revealed as a broad positive cropmark. The parallel but rather fainter positive cropmark beyond it in places picks out the far side of the Upcast Mound.

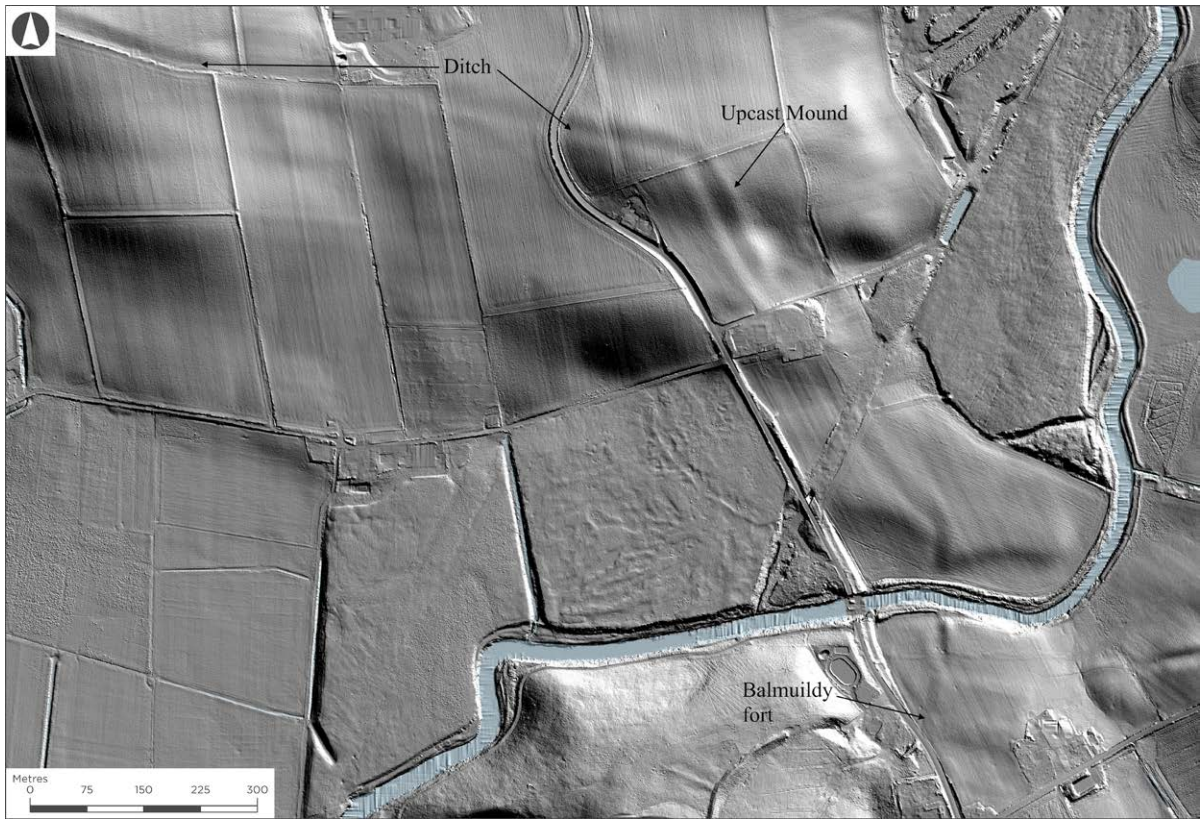

Figure 2.8.3. LiDAR image of line of the Wall between Summerston and Balmuildy.

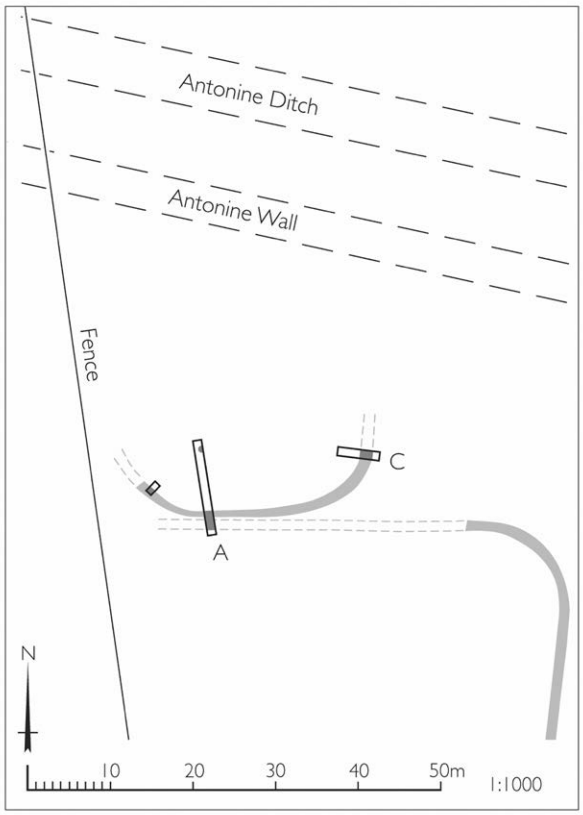

Figure 2.8.4. Outline plan of the fortlet and northern part of the construction camp at Summerston, showing the location of excavation trenches (after Maxwell and Hanson 2020, Fig. 13.3).

Geophysical surveys (Figure 2.8.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
GSB; 2006	G: Bartington Grad 601-2	1.16	0.25, 1
	R: Geoscan RM15	1.08	1, 1
	GPR: Pulse Ekko 1000	2 traverses each in Areas 3 (200m) and 4 (240m) traverses	
	Seismic refraction and electrical profiling	1 traverse each in Areas 3 and 4	

Introduction

A common feature of the western sector of the Antonine Wall, particularly between Balmuildy and Duntocher, is its frequent major changes of alignment as it makes its way from drumlin to drumlin, seeking to incorporate points of high elevation into its line. Nowhere is this more marked than in the section under consideration here. Thus, from New Kilpartick cemetery the Wall curves north-east to the summit of Crow Hill (80m OD) where it makes an almost right angled turn. It then continues eastwards past the site of the fortlet at Summerston until it reaches the top of the small hill (65m OD) behind Summerston Cottages, where it then turns sharply south-east towards the fort at Balmuildy. Just before it reaches the Kelvin it turns back on itself, so that it can cross the river at right angles, before linking up with the west corner of the fort.

This general alignment of the Wall in this area has been appreciated since the earliest Ordnance Survey mapping, and elements of it are visible on the ground, in the LiDAR data (Figure 2.8.3) or in aerial photographs (e.g. Figure 2.8.2). Nonetheless, various minor disagreements in the mapped line were apparent between that proposed by Macdonald in the 1930s and those determined by the Ordnance Survey in 1951 and 1980. Accordingly, five locations were selected for survey at or close to the points of divergence in order to confirm the line.

One of the survey areas (no. 4) also deliberately included the site of the fortlet and temporary camp at Summerston. The ditch of the camp was identified as a cropmark from the air in 1977 by Maxwell and considered to be a construction camp for the Wall because of its small size and location immediately behind the Wall. Close inspection of the photographs also revealed faint traces of part of a small ditched enclosure, partially contiguous with the northern side of the camp, which was assumed to define a fortlet. Very limited trenching by Maxwell and Hanson in 1980 demonstrated that the fortlet ditch was slightly later than that of the camp (Figure 2.8.4), but failed to recover any other evidence, apart from a single internal post-hole. The generally shallow depth of the ditches indicated that archaeological levels in the area had been severely attenuated by ploughing.

Because of the difficulty sometimes experienced in interpreting the magnetic and resistance anomalies involved, notably those obtained from the Ditch, other survey techniques were applied to provide supplementary data, including GPR, seismic refraction and electrical imaging. In addition, resistance readings were taken at two different probe separations (0.5m and 1.5m) in order to provide sensing to different depths. All the survey locations lie in undulating fields, either under arable cultivation or in pasture. The geology of the area is generally conducive to geophysical survey, comprising sandstones, with siltstones, mudstones, limestones and till.

Results

Survey Areas 1 and 2 are situated on the north bank of the River Kelvin opposite the fort at Balmuildy (Figure 2.8.6). The Ditch is clear in the gradiometer survey as a broad negative anomaly, accompanied in Area 2 by a parallel narrow positive anomaly on its outside, a feature not uncommonly attested elsewhere. In the resistance survey it is apparent as a broad band of low resistance and is slightly clearer in the results from the wider probe separation with its greater depth of penetration. Consistently in both survey methods the line of the ditch in Area 1 lies markedly to the west of the line currently recorded by the Ordnance Survey. In the resistance survey it also appears here as a very wide double band of low resistance. Both this phenomenon and the Ordnance Survey's incorrect alignment have the same explanation: they are the result of confusion caused by the outer margin of the Outer Mound simulating the appearance of a ditch, a feature which is also apparent both on the ground and in some aerial photographs (e.g. Figure 2.8.2). There is no clear indication in either survey mode of the line of the Rampart, with the possible exception of one short section of high resistance in the closer probe separation results from Area 1.

In Area 3 all of the modes of survey, including the supplementary ones, confirmed that the line of the Ditch recorded in the 1980 Ordnance Survey map revision was broadly correct. As in Area 2 the Ditch is revealed in the gradiometer survey as a broad negative anomaly, accompanied by a parallel narrow, and in this case slightly intermittent, positive anomaly on its outside (Figure 2.8.7). However, the equivalent signal in the resistance and electrical profiling surveys is the opposite of what would be expected. In the former it shows as an *increase* in resistance, a sharply defined broad band with an ill-defined band of low resistance outside it, and in the latter as a peak (E1 in Figure 2.8.5). Again there is no clear indication in either survey mode of the line of the Rampart. In the GPR and seismic refraction surveys, G1 and S1 respectively represent the Ditch (Figure 2.8.5). Although the other reflections and anomalies in the GPR and seismic results are weak, it is likely that G2, S2 and E3 probably correspond to the Rampart; and G4, S3 and E2 possibly the Upcast Mound. The wide, slightly amorphous band of high resistance at the western end of the resistance survey, mirrored by E4 in the electrical profiling, may indicate the line of the Military Way.

This reversed resistance response of the Ditch in Area 3 requires comment. Firstly, the terrain in that area differed from the other rather more heavily ploughed areas surveyed. GSB did not note what the conditions were in Area 3, other than it is sloping especially at its western end where at the bottom of the slope there

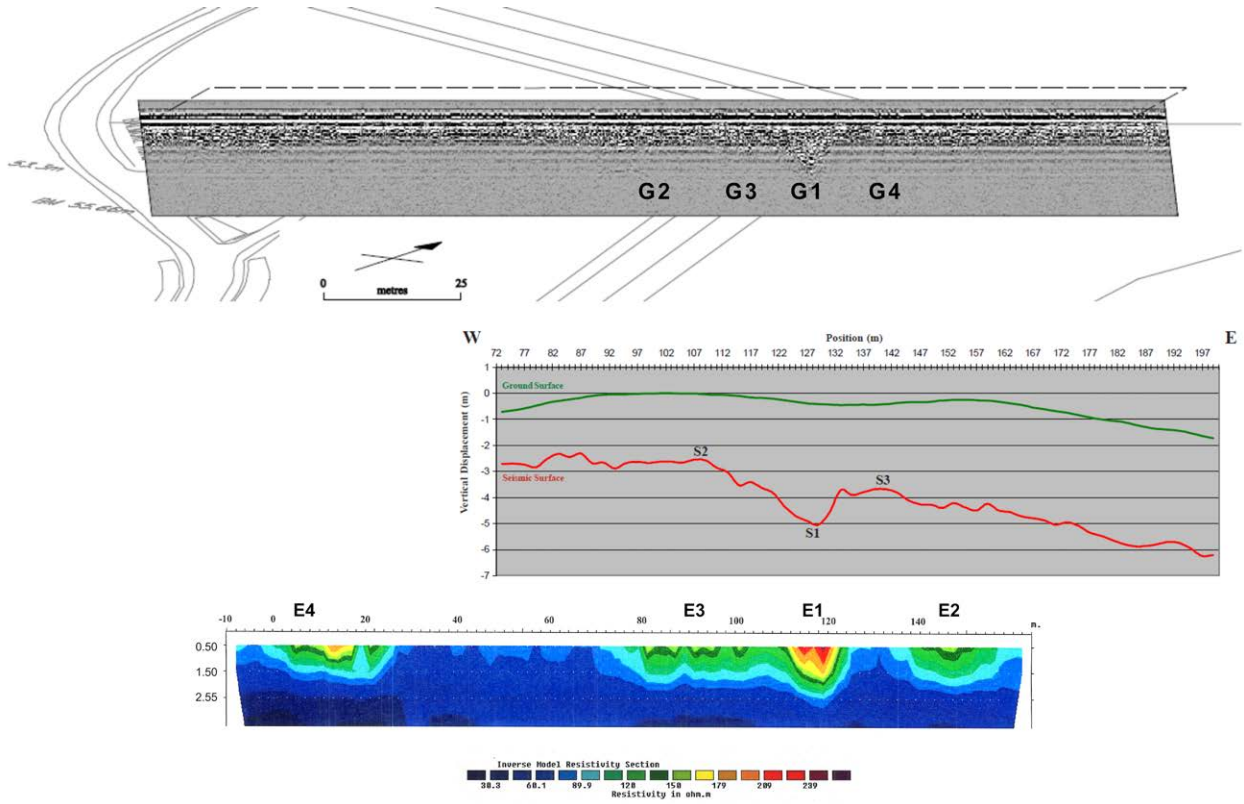

Figure 2.8.5. GPR, seismic refraction and electrical profiling survey results from Summerston Cottages, Area 3 (after GSB 2006a, Figs 2.9, 2.11 and 2.13, with additions).

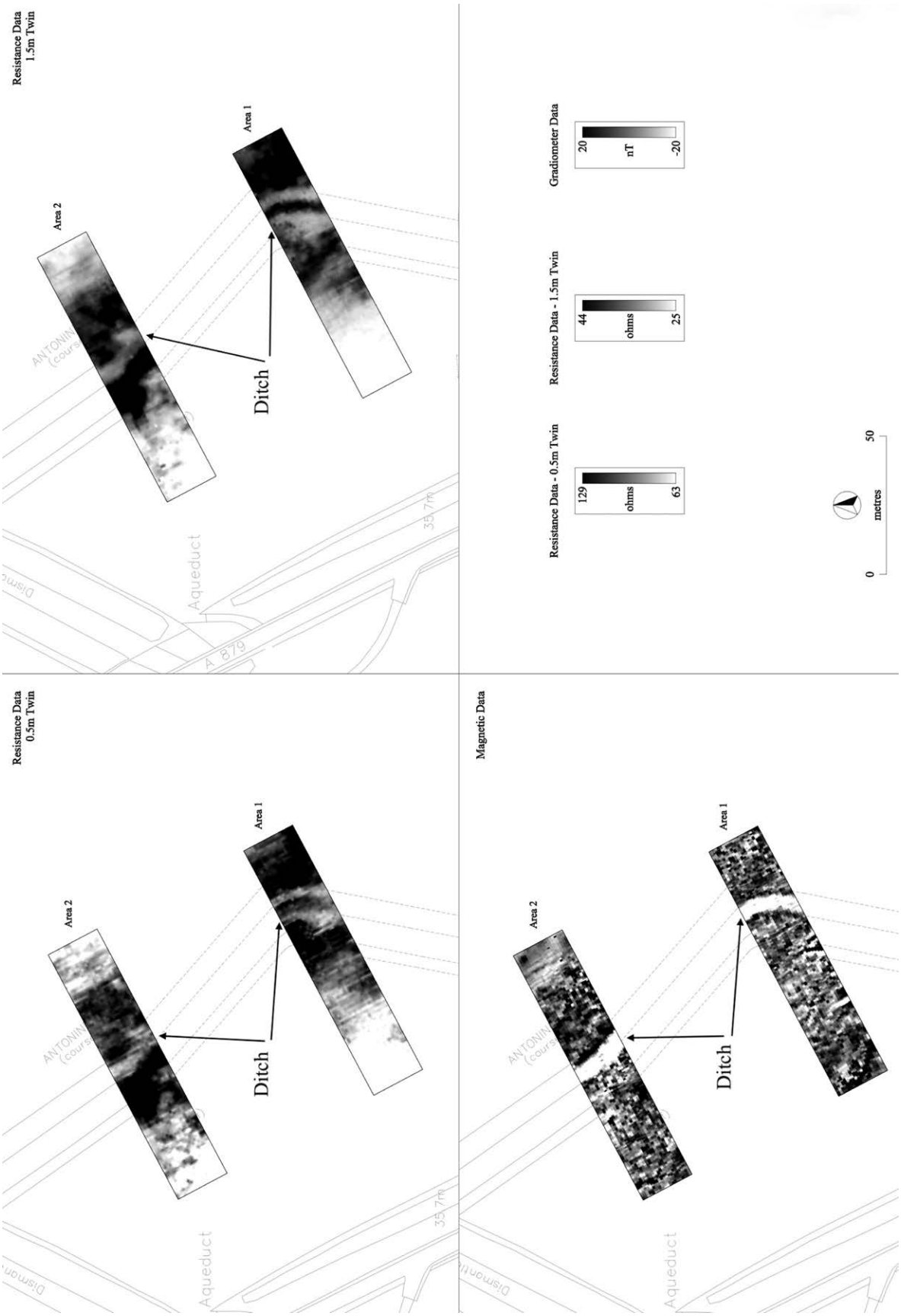

Figure 2.8.6. Resistance (0.5m and 1.5m probe separation) and gradiometer survey results from Balmuildy Bridge, Areas 1 and 2 (after GSB 2006a, Fig. 2.3, with additions).

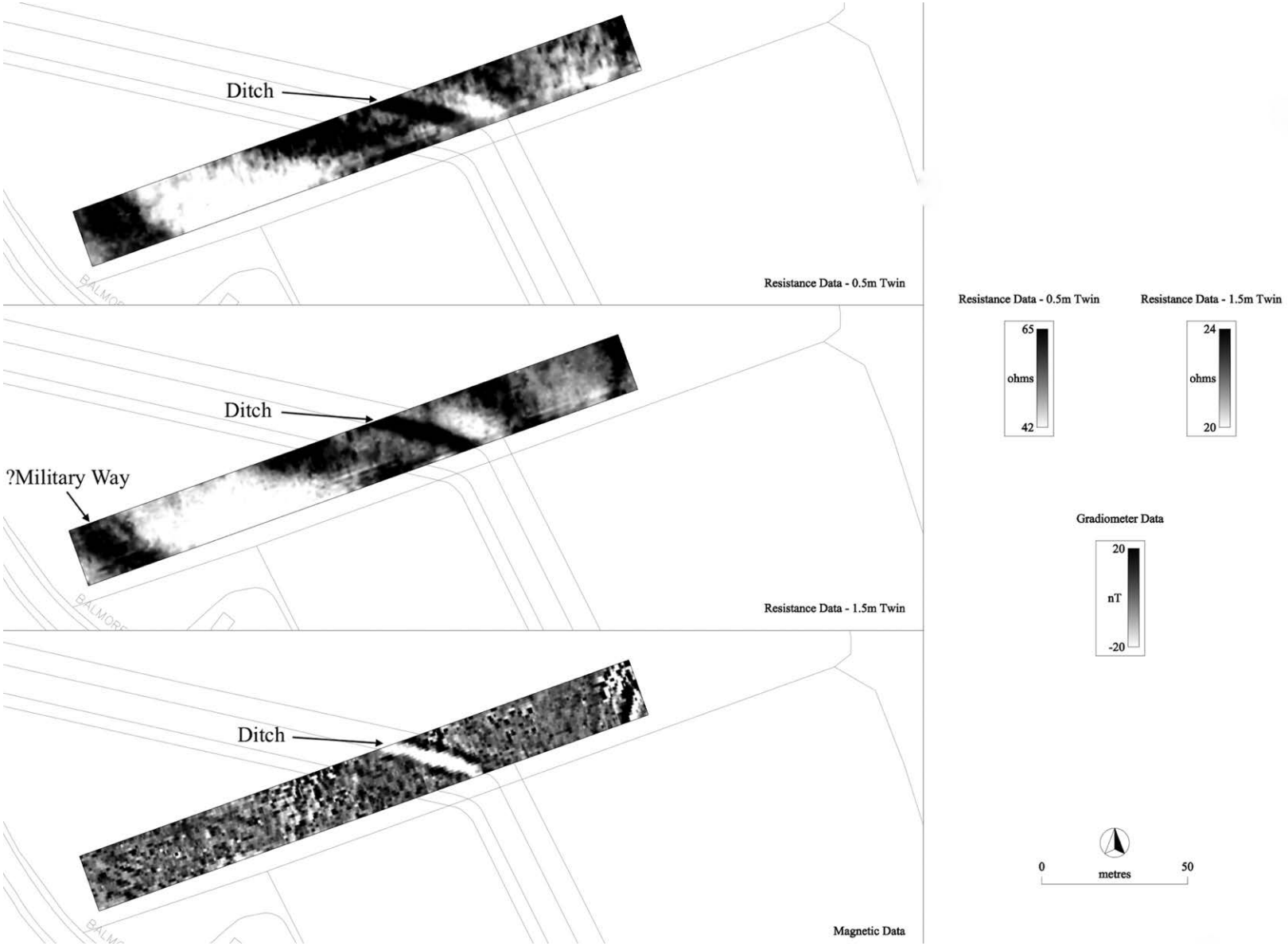

Figure 2.8.7. Resistance (0.5m and 1.5m probe separations) and gradiometer survey results from Summerston Cottages, Area 3 (after GSB 2006a, Fig. 2.7, with additions).

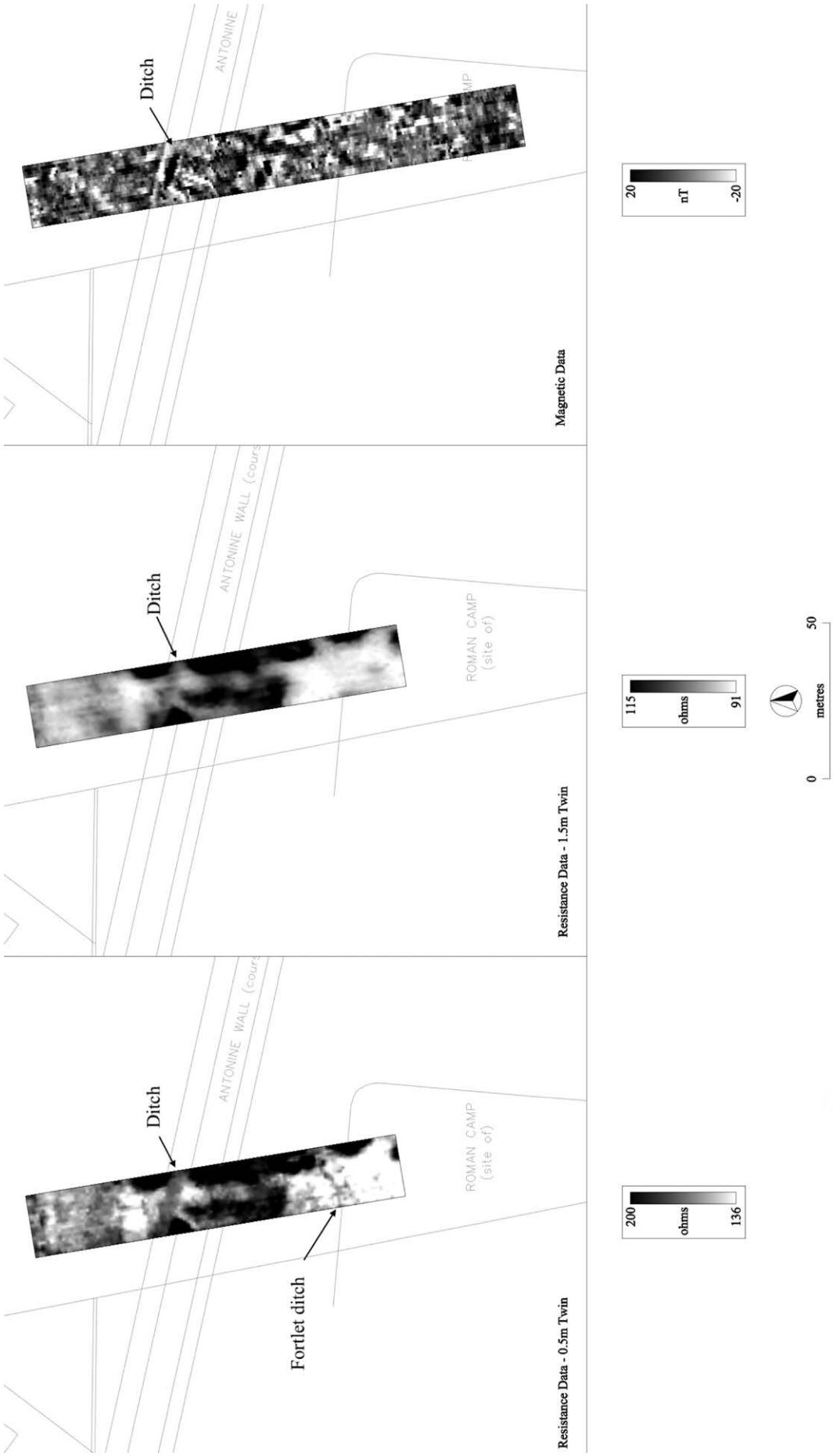

Figure 2.8.8. Resistance (0.5m and 1.5m probe separations), and gradiometer survey results from Summerston, Area 4 (after GSB 2006a, Fig. 2.14, with additions).

was much hill wash accumulation, but the LiDAR image indicates relatively better preservation of both Ditch and Upcast Mound. Secondly, as the black-white palette bars indicate (Figure 2.8.7), the resistance values in Area 3 are not only significantly lower than in the other areas, indicating that the soil here was more porous, but their ranges are much narrower than elsewhere. This resistance response, which also occurred in the Glasgow Bridge to Westermains sector (Chapter 3.4), is discussed in Chapter 8.2.4.

The resistance and gradiometer survey in Area 4 is disappointingly uninformative, perhaps reflecting the poorly surviving state of the remains indicated by excavation. The Ditch can be detected as a band of very slightly enhanced resistance in the resistance survey, but is barely distinguishable in the gradiometer survey (Figure 2.8.8). There is no sign of the temporary camp, though the curvature of the ditch around the south-east corner of the fortlet seems to be visible as a thin line of slightly enhanced resistance in the survey employing the closer probe separation. The results from Area 5 are even less convincing, the sharp demarcation in both the resistance and magnetic readings at the apparent location of the Ditch explained by it coinciding with a substantial modern field boundary.

Chapter 3

3.1 Balmuildy

(NGR: NS 5811 7169; Canmore 44472 and 44476)

Fort, annexe, Rampart, Ditch and environs

Site-specific references

Miller 1922; RCAHMS 1978, 114-17; Baker 1997; Jones *et al.* 2006b; Duncan 2004; Leslie *et al.* 2007

Geophysical surveys (Figure 3.1.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
Glasgow University; 2005 (4 periods, March to September)	G: Geoscan FM36 M	11.6	mainly 1, 1; occasionally 0.5, 0.5
	R: Geoscan RM15 and TR/ CIA	9.2	1, 1

Introduction

Situated on a small plateau overlooking a crossing of the River Kelvin, the fort is one of the largest on the Wall, enclosing an area of 1.6ha. There is a long antiquarian record of a Roman fort here, including the discovery in the late 17th century of the famous building inscription naming the governor, Lollius Urbicus (Sibbald 1707: 49; *RIB I* 2191). Early 18th century descriptions by both Gordon (1726: 53) and Horsley (1732: 167 and 176 N3) compare the remains at Balmuildy to those of a town, and its enclosing ditches remained sufficiently clear to be mapped by Horsley and later in the century by Roy (1793: pl. 35) (Figure 1.4). Although any obvious surface remains had disappeared under the plough by the time of the 1st edition Ordnance Survey mapping of the area a hundred years later, the outline of the northern half of the fort's rampart is still faintly discernible in the LiDAR data (Figure 2.8bed.3).

A major programme of archaeological investigation was undertaken by Miller from 1912-14 (Figure 3.1.2).

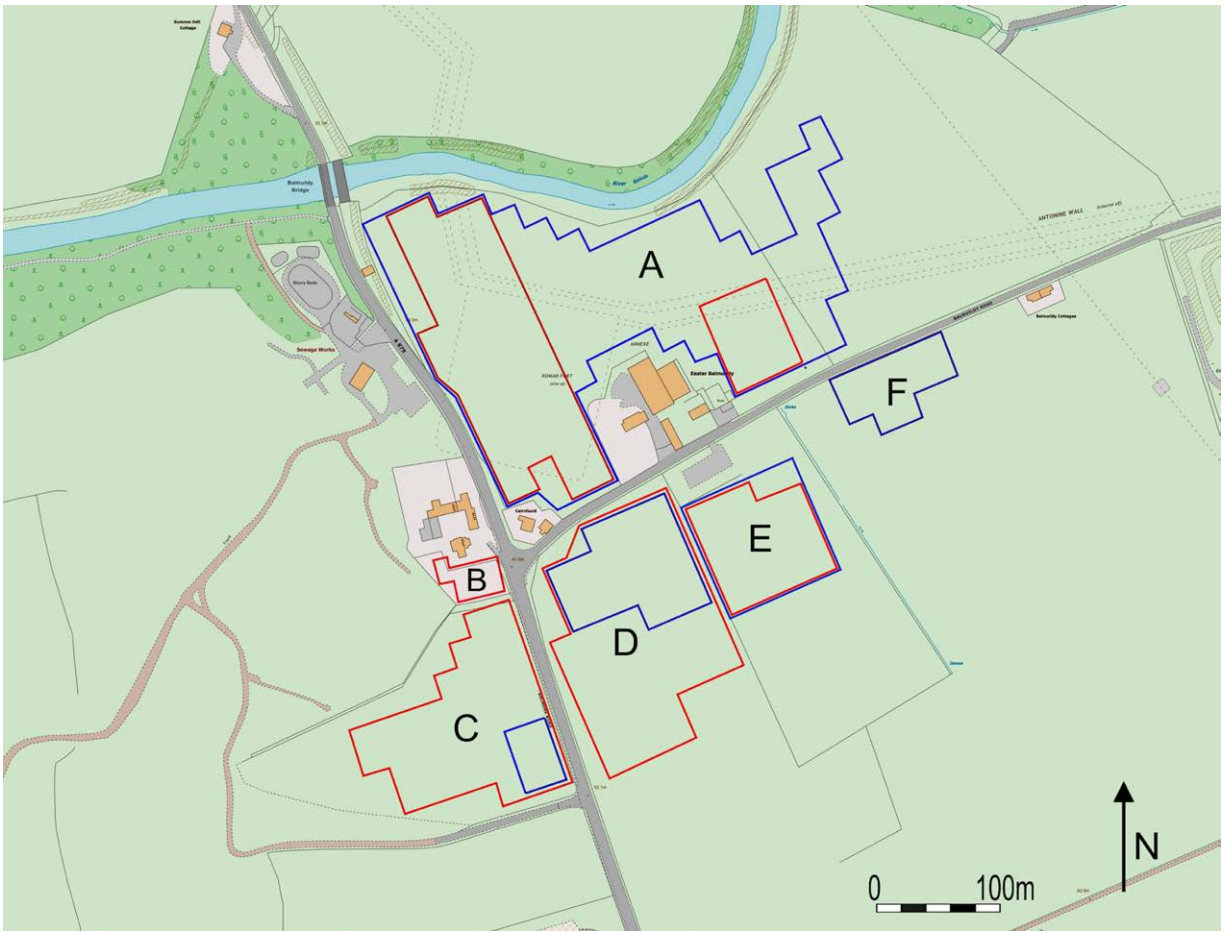

Figure 3.1.1. Extent of the survey areas at Balmuildy (resistance outlined in red, gradiometer in blue).

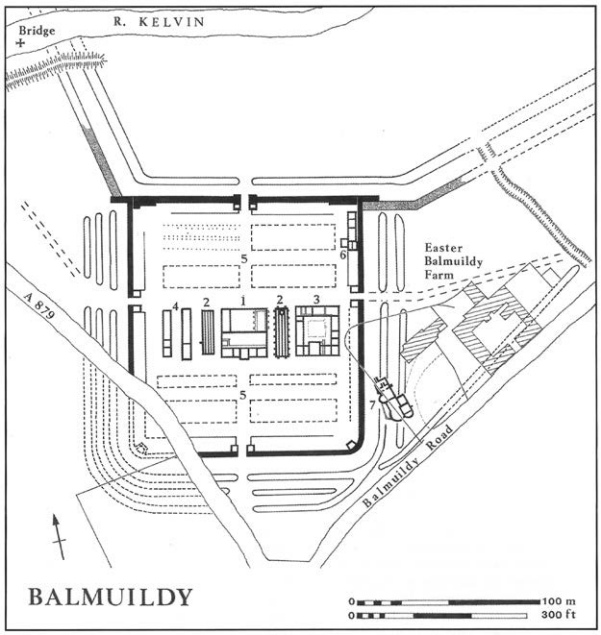

Figure 3.1.2. Balmuildy: excavation plan of the fort and annexe (after Robertson 2015, Figure 64).

This indicated that the fort's rampart was stone-built, with an earthen bank to the rear, one of only two such examples on the Wall. It was surrounded by multiple defensive ditches: three to the west and south, two to the east facing the annexe (see below), but apparently only one to the north. The fort had originally been freestanding, but was provided with projecting wing-walls at its northern corners to facilitate subsequent connection to the Antonine Wall rampart. Gates flanked by guard chambers were identified in each of the four sides opposite causeways through the ditches, and a stone tower was recorded immediately behind the rampart in the south-east corner. A stone platform in the north-west corner may have served a similar function.

The central range of stone buildings, which was fully uncovered, followed a fairly standard pattern (Figure 3.1.2), with a central headquarters building (1) flanked by granaries (2) and a commanding officer's house (3) to the east. Further to the west were two long narrow buildings (4), probably workshops or stores. Timber barracks (5) were provided to front and rear, though only two, in the north-west corner, were excavated in any detail. In addition, a small bathhouse (6) was located at the rear of the rampart in the north-east corner.

An annexe, approximately triangular in shape, was identified immediately to the east of the fort, apparently defined by a single ditch on its north-east and south-east sides. A second, larger bathhouse (7) was located within the annexe just outside the south-east corner of the fort. This was clearly a later addition as it overlay the two defensive ditches on this side of the fort. The interior of the annexe was 'trenched pretty thoroughly' where it was not encumbered with farm buildings, but no substantial structures were identified and the occasional post-holes recorded provided no coherent plan.

Any subsequent excavation has been very small scale in response to specific localised threats. Excavation by GUARD in 1999 confirmed the location of the inner two ditches immediately west of the south gate, which, contrary to expectations, had not previously been excavated. An evaluation conducted by GUARD in 2004, in an area not examined by Miller on the other side of the main A879 road, revealed what appeared to be a continuation of one of the fort's southern ditches. Further to the south-west (towards the Summerston landfill site – Figure 3.1.1 Area C) in 1997, excavation by Firat Archaeological Services indicated evidence for prehistoric and potentially Roman-period activity in the immediate hinterland of the fort.

The geophysical survey at Balmuildy was one of the first and most extensive to be carried out on the Antonine Wall by Glasgow University. It was specifically designed to encompass as much of the fort and its immediate environs as possible, notwithstanding the lack of evidence of possible Roman activity in the latter from the aerial photographic record. The local geology is generally conducive to such survey, with carboniferous limestone underlying glacial sands, gravels and boulder clay. The majority of the fort site and the still-visible course of the Antonine Ditch to the west lie in pasture, the terrain sloping steeply to the River Kelvin. Obstacles to survey in this area were the Easter Balmuildy farm buildings and a marshy area north-east of the fort close to the river. To the south-east the ground is primarily given over to intensive agricultural activity. This applies to a lesser extent to the west and south-west, where large areas were occupied by the buildings of Wester Balmuildy farm and the remains of earlier industrial activity (a colliery and brickworks).

Results

The stone walls of the fort are quite well defined in both the gradiometer and resistance surveys. In the former (Figure 3.1.3) they are represented by a fairly clearly demarcated positive linear band in all of the areas where the survey encountered the defences, except for some 15m to the south of the north-east corner, where a faint negative linear anomaly may indicate that the fort wall had been robbed away, and a section of similar length to the east of the south gate. Immediately to the east of that gap the wall line seems to be enhanced in width with an elongated strongly positive anomaly. This is probably an *ascensus* designed to facilitate access to

Figure 3.1.3. Gradiometer survey of the fort and annexe at Balmuildy.

the rampart top. There are similar examples along the northern wall at the north-west and north-east corners (below), though the strength and dipolar character of this anomaly suggests the presence of burning. The angled end of the anomaly may indicate one side of the corner tower recorded in Miller's excavation. Though less sharply defined in the resistance survey, obtained with two different instruments covering dissimilar sized areas (Figures 3.1.4a and b), the line of the fort wall is clear as a band of high values, and once again nothing is visible immediately to the east of the south gate. As already noted, thickening of the wall is apparent in the gradiometer survey along the northern rampart as it approaches both the north-west and north-east corners, though in these cases the character of the anomaly matches that of the rampart itself. These anomalies reflect the excavation evidence of expansion in the width of the wall at these points, and should also be interpreted as *ascensus* rather than artillery platforms as originally suggested by Miller. Traces of three of the gates are apparent in the gradiometer survey. At the west gate this is no more than an inward return of the outer wall on one side, while at the north gate there is slight thickening of the ends of the rampart on both sides. At the south gate, however, the outline of a square gate tower is discernible on the west side of the entrance gap. Only the latter is also reflected in the resistance survey.

Again, wherever the gradiometer survey encountered the defences, the ditches of the fort are clear as parallel bands of negative linear anomalies (Figure 3.1.3). The three in the north-west quadrant are particularly obvious, though only two of them are visible to the south of the gap opposite the west gate. Similarly in the south-east quadrant the inner two ditches are readily apparent, in this case the negative anomalies being mirrored by thin positives on their inner sides. The innermost ditch can also be discerned, primarily as a positive anomaly, as it runs around the south-east corner of the fort, with a faint hint of bifurcation (see below), but then disappears as it approaches the eastern limit of this part of the survey and the site of the later bathhouse. In all cases the ditches are much

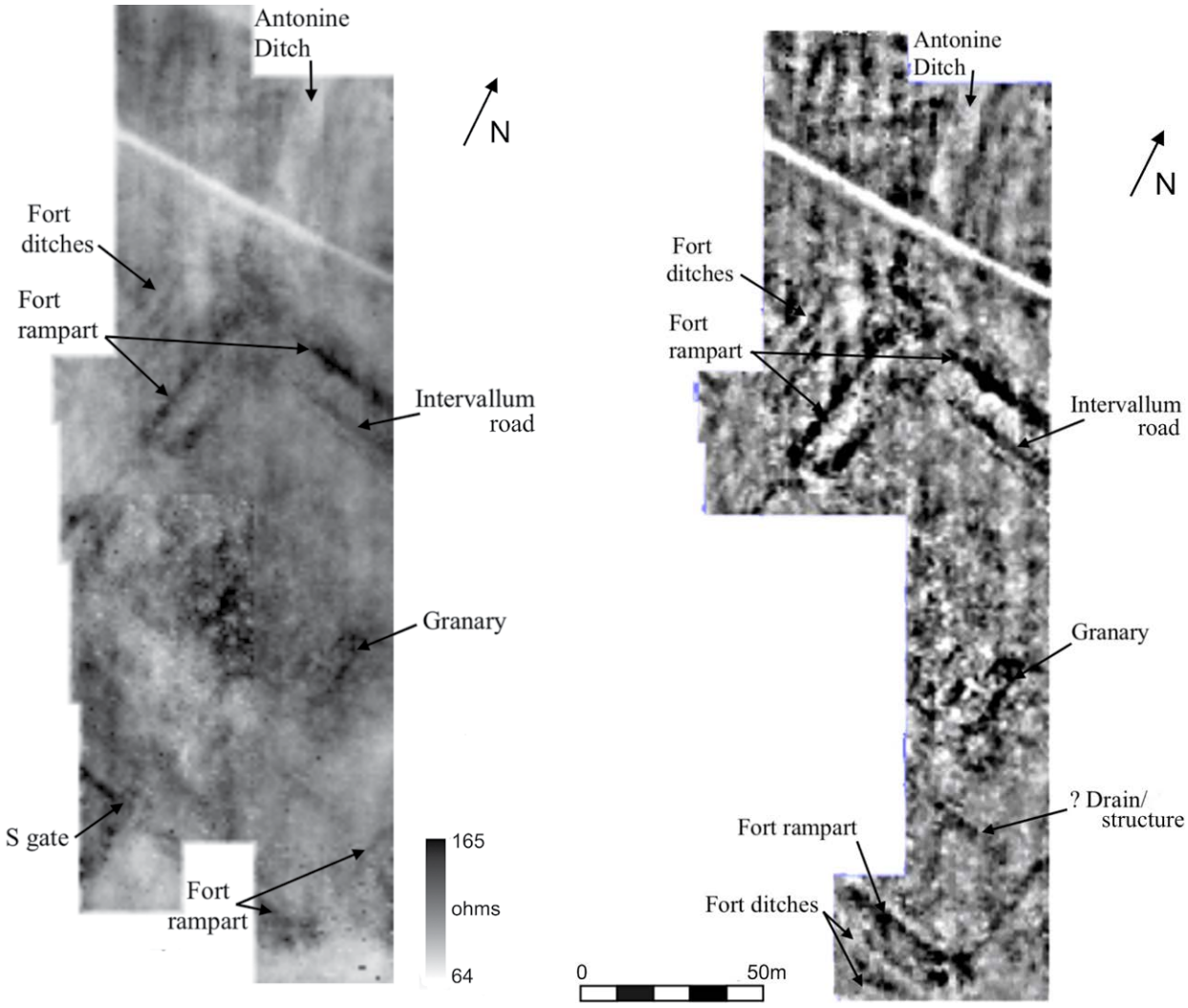

Figure 3.1.4. Resistance survey of the fort at Balmuildy: a. (left) grey scale (from Geoscan instrument); b. (right) relief plot (from TR instrument).

less readily apparent in the resistance survey, though two faint, parallel lines of low readings are relatively clear in the north-west quadrant and in the south-east corner (Figures 3.1.4a and b).

The pattern of ditches recorded in the limited area examined by gradiometry outside the north-east corner of the fort does not quite comply with the excavation record. The excavation plan shows two ditches running parallel with the rampart, both coming to a butt end at the back of the Antonine Wall, though the outer one is described in the report as turning from a normal V-shaped ditch into a 'double ditch divided by a midrib' as it approaches the line of the Wall. In the gradiometer survey, however, the outer ditch not only follows a slightly more oblique course, but appears to run under the line of the Wall to continue round the north-east corner of the fort (Figure 3.1.3). Furthermore, there are strong hints that its line, visible as a narrow negative anomaly immediately outside the fort wall, continued right across the northern face of the fort, though leaving a wide gap in front of the north gate. Here the inner ditch turns outwards at right angles on either side of the road leading out of the fort to join a wider outer ditch, which is clearly visible as a negative linear anomaly and whose existence was confirmed by excavation. Thus, the gradiometer survey suggests that the fort was originally surrounded on all sides by its own double or triple ditches, rather in the manner of Old Kilpatrick. That in turn may indicate that the period of time before it was expected to become physically integrated into the frontier line may have been longer than has tended to be assumed.

There are clear signs of some of the roads within the fort, visible in the gradiometer survey as positive linear anomalies and in the resistance survey as lines of higher readings (Figures 3.1.3 and 3.1.4a and b). In both cases these are similar to, but broader than, the response from the fort walls. The intervallum road along the northern frontage, which Miller notes was well preserved, and down the west side as far as the gate is particularly

Figure 3.1.5. Gradiometer survey of all areas at Balmuildy.

clear. It runs parallel to the line of fort walls some 3.5-4m behind them, the gap being taken up by the earthen bank attested in Miller's excavation. Rather than another road line, a more muted positive anomaly running south from the north-east corner seems to represent the remains of the interior bathhouse, which was located immediately inside the fort wall at this point. The bathhouse had been demolished during the fort's occupation.

Parts of the central range of stone buildings can be readily discerned in the gradiometer survey as thin lines of positive linear anomalies (Figure 3.1.3). The headquarters building is particularly clear in the centre of the fort, including its standard internal subdivisions, confirming that the fort faced north. The double line of strong positive anomalies in its north-eastern corner seems to correspond to the buttresses of the later granary that was inserted there according to Miller. In the resistance survey, however, the building shows only as a large, ill-resolved high resistance feature. Narrow rectangular buildings on either side of it are also apparent in the gradiometer survey, corresponding with the granaries recorded in Miller's excavations, though the resolution is insufficiently clear to discern either buttresses or the internal supports for raised floors. A strong positive anomaly towards the northern end of the more easterly granary probably represents the site of the kiln noted by Miller. This had presumably been inserted into the structure much later, perhaps when some of the extant foundations may have provided the basis for a small post-medieval

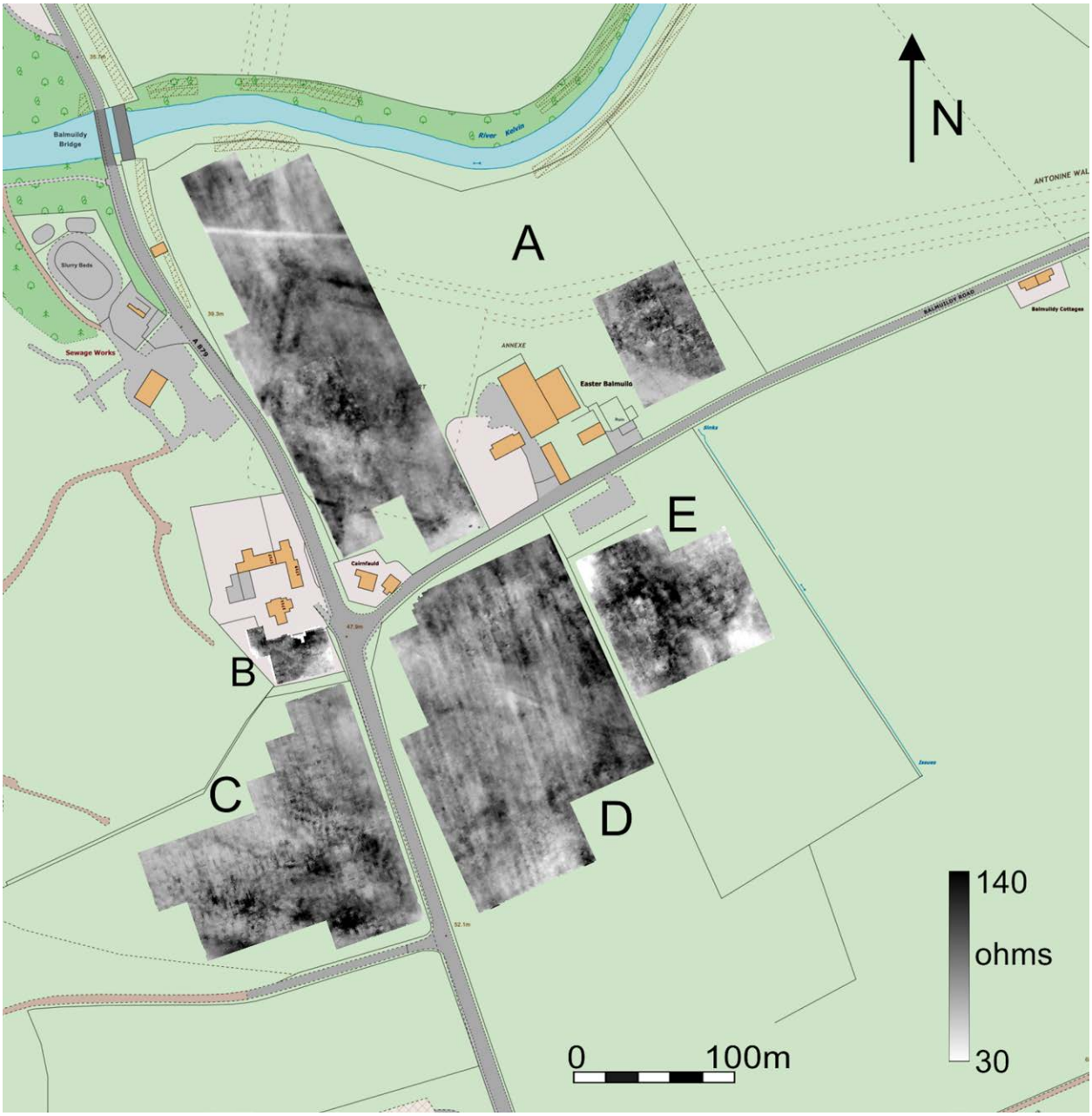

Figure 3.1.6. Resistance survey of all areas at Balmuildy. The palette bar shown applies to all areas except Area A (western part) (see Fig. 3.1.4).

settlement that, according to Roy's plan (1793: pl. 35), concentrated in the area of the south and east gates. The more easterly granary is also reasonably clear in the resistance survey. Further to the east the general outline of three of the ranges of rooms around a central courtyard within the commanding officer's house can be faintly discerned in the gradiometer survey, with hints of the western range of rooms just visible also in the resistance survey. Further to the west, however, no clear pattern of structures is apparent in either survey.

In the *praetentura* to the north of the central range there is again no clear pattern of structures in either survey. There is, however, a large magnetically noisy area of amorphous shape divided from a *c.* 4-5m diameter sub-circular dipolar anomaly, probably a large pit, by a quieter zone where the *via praetoria* would have cut through on its way to the north gate (Figure 3.1.3). That these features appear to respect the line of that road suggests they may be of Roman date, possibly relating to the demolition of the fort. Two further strong dipolar anomalies are apparent, one in the north-west quadrant just to the south of the intervallum road behind the northern rampart and one towards the north-east corner of the fort. Both hint at areas of burning, but in what context is not clear. There

are several narrow positive linear anomalies in the *retentura* to the south of the central range apparent in the gradiometer survey. They are broadly aligned with the orientation of the fort, but are insufficiently clear to allow the identification of buildings, though some could be drains. However, one appears to continue beyond the fort rampart, which would tend to indicate a later date and perhaps an agricultural origin. Another may be reflected in an east-west aligned band of slightly raised readings in the resistance survey (Figures 3.1.4a and b). This seems to define the southern side of the *via quintana*, which is apparent as a wide linear zone of lower resistance to the south of the central range of buildings, and is most likely to be a stone-lined drain at the edge of the road.

The line of the Antonine Wall Ditch to the east of the fort is very clear in the gradiometer survey as a broad negative linear anomaly with a parallel narrow positive immediately beyond it (Figure 3.1.3). The line is least clear to the east of a break in the survey that marks a modern field boundary, where, ironically, the ditch is still visible as a topographic feature. The signal is also disrupted by the line of a former stream bed opposite the centre of the annexe. This can be traced back obliquely across the annexe as a narrow linear positive anomaly, which bifurcates as it approaches the southern limit of the survey and is flanked by a broad negative band, particularly to the west. Though recognising it for what it was, Miller seems to have assumed that it represented the eastern limit of the annexe, or at least subsequent commentators have interpreted his account in that way. In fact, Miller records no Roman ditch on this line and, as its relationship with the Antonine Wall makes clear, this is an entirely natural feature. The gradiometer survey makes explicit for the first time that the eastern limit of the annexe is actually demarcated by a double ditch line, revealed as two adjacent wide negative linear anomalies running almost parallel with the eastern rampart of the fort. The resistance survey in this area (Figure 3.1.6), however, does not seem to have been very responsive to ditch lines. It not only failed to confirm the eastern annexe ditches, but also the line of the Antonine Wall Ditch itself. The Rampart of the Wall as it approaches the fort from the east is not so readily visible in the gradiometer survey as the Ditch, but is intermittently apparent as a positive linear anomaly in the form of a broad, slightly speckled band, both its edges defined by a thin negative anomaly. It is best seen closest to the fort to the west of the relict stream bed and for a short distance to the east of the modern field boundary. It is also visible immediately to the north of the eastern annexe ditches, which appear to end at its rear face, though there are signs of possible disruption at this point. The two ends of the single ditch which Miller identified as demarcating the south-eastern side of the annexe are also apparent in the gradiometer survey: reasonably clearly to the east, but only faintly to the west, where the annexe ditch may run into the inner ditch at the south-east corner of the fort. Accordingly, the annexe can now be seen to be slightly less irregular in shape and almost 1ha in size, somewhat larger than has previously been assumed.

Within the annexe one possible structure can be identified in the gradiometer survey (Figure 3.1.3). A subrectangular, negative anomaly of variable strength, largely outlined by a very thin positive linear positive, can be seen just behind the Wall to the east of the relict stream bed, and could represent an open-ended building facing south-east. Towards the centre of the annexe there is a scatter of positive anomalies, some quite strong, which may represent pits. In the resistance survey there are two central clusters of high values which may represent structural remains (Figure 3.1.6), but they lack any clear pattern and, as already noted, there is no sign of the double ditches which are clear in the gradiometer survey.

Large areas outside the fort, particularly to the south-east, were surveyed in search of remains of a possible civil settlement or *vicus*, but with limited success (Figures 3.1.5 and 3.1.6). A short double positive linear alignment is apparent in the gradiometer survey to the east of the annexe and west of the modern field boundary (Figure 3.1.3). This terminates to the north in a small cluster of strong positive and dipolar anomalies and may be structural, as it is broadly at right angles to the presumed line of the Military Way according Miller. Though short lines of positive anomalies were recorded in the adjacent field on the other side of the main road (Figure 3.1.5 Area F), they followed a different alignment and lacked any clear pattern. Neither the gradiometer nor resistance surveys in the adjacent fields to the west (Areas D and E) were any more productive, other than revealing occasional localised positive anomalies or small areas of higher or lower resistance.

An aerial photograph taken in 1983 (Canmore SC 1724936) recorded a small rectangular enclosure some 200m to the south of the fort. Limited excavation by Firat in the same field in 1997, though not encompassing that enclosure, revealed remains that suggested a fairly extensive settlement, probably with more than one phase of activity, possibly extending into the Roman period on the basis of carbon-14 dating (Keppie 1999: 331). Geophysical examination of the relevant field (Figures 3.1.5 and 3.1.6, Area C) failed to detect the rectangular enclosure or any other indication of structures, though in the resistance survey amorphous areas of high readings were noted, while in the more limited gradiometer survey occasional strong positive anomalies were apparent.

Though the geophysical survey failed to provide convincing evidence for a *vicus* outside the fort, this does not mean that there was no civilian settlement in its environs. On the one hand, the focus of such activity may have been located to the west in an area no longer accessible because of modern development; on the other, such remains have proved no less difficult to identify by excavation and where they have been demonstrated, as at Croy Hill, the remains are both scattered and ephemeral (Hanson 2020a: 333-39; Hanson 2022: 43-82). The recognition of timber buildings, particularly when founded in post-holes rather than post-trenches, which seems to have been the norm in the Antonine period, presents challenges even for the excavator. It is not insignificant that even where barracks built on post-holes are known to have existed within the fort at Balmuildy they were not detected in the geophysical survey.

3.2 Wilderness Plantation

(NGR: NS 59550 72100; Canmore 44472 and 44483)

Ditch, Rampart and Military Way

Site-specific references

Hanson and Maxwell 1983; GSB 2006b

Geophysical surveys (Figure 3.2.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
GSB; 2006	G: Bartington Grad 601-2	0.4	0.25, 1
	R: Geoscan RM15	0.576	1, 1
	GPR: Pulse Ekko 1000	0.44	1t

Introduction

Between Buchley and Wilderness Plantation the line of the Ditch and, unusually, the Military Way were sufficiently extant to be recorded in the 1st edition Ordnance Survey mapping of the area in the late 1850s. With one slight deviation from a straight line, the Wall runs along a low, flat-topped ridge, the ground sloping gently down to the River Kelvin some 550m to the north. Though the Military Way had disappeared from that mapping by the 2nd edition mapping 40 years later, this revision was sufficiently precise to identify the Upcast Mound as an earthwork. However, ploughing continued to take its toll, so that within some 35 years the Wall line was no longer considered to be sufficiently extant to be mapped, though one short section of Ditch at the far western end of this stretch remains extant and is not infrequently filled with water. Nonetheless, both the Ditch and outer edge of the Upcast Mound are regularly visible from the air as cropmarks, as any perusal of

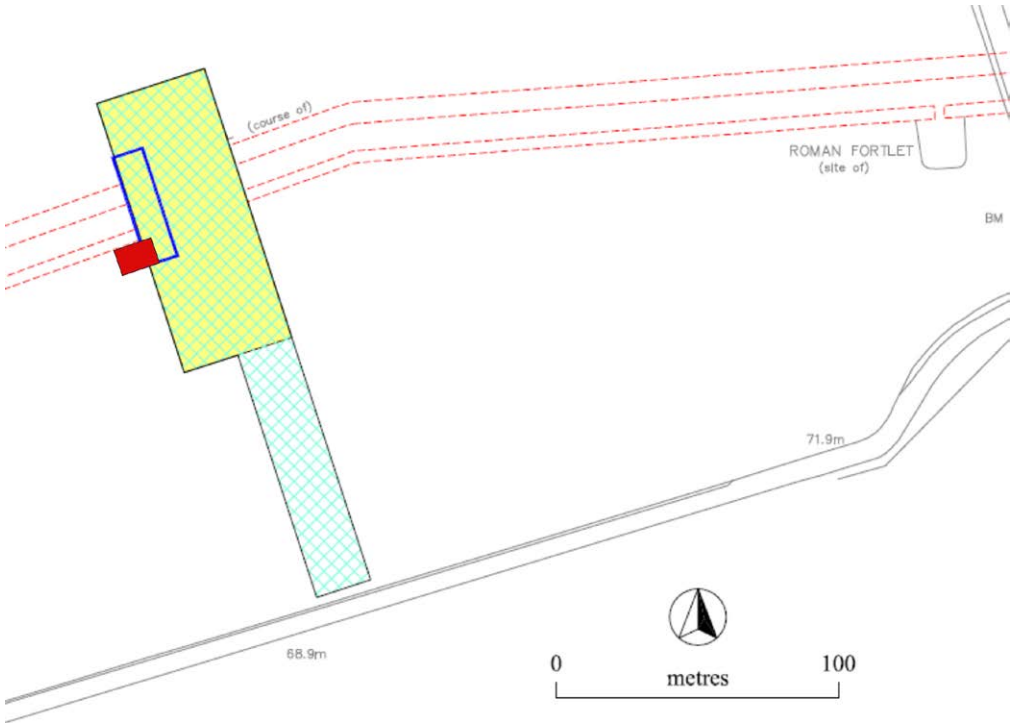

Figure 3.2.1. Location of the survey at Wilderness West (resistance hatched; gradiometer in yellow; GPR blue outline). The approximate location of the minor enclosure is indicated in red (after GSB 2006b, Fig. 3.2, with additions).

Figure 3.2.2. LiDAR image of line of the Wall between Buchley and Wilderness Plantation.

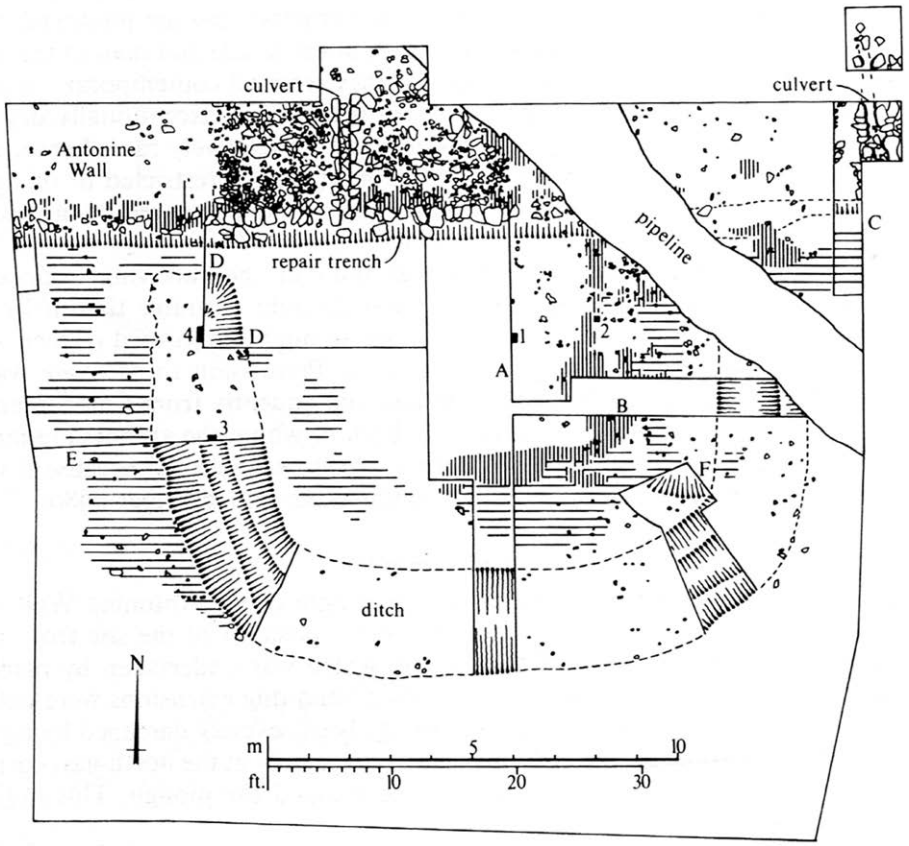

Figure 3.2.3. Plan of the excavated minor enclosure at Wilderness West (after Hanson and Maxwell 1983, Fig. 2).

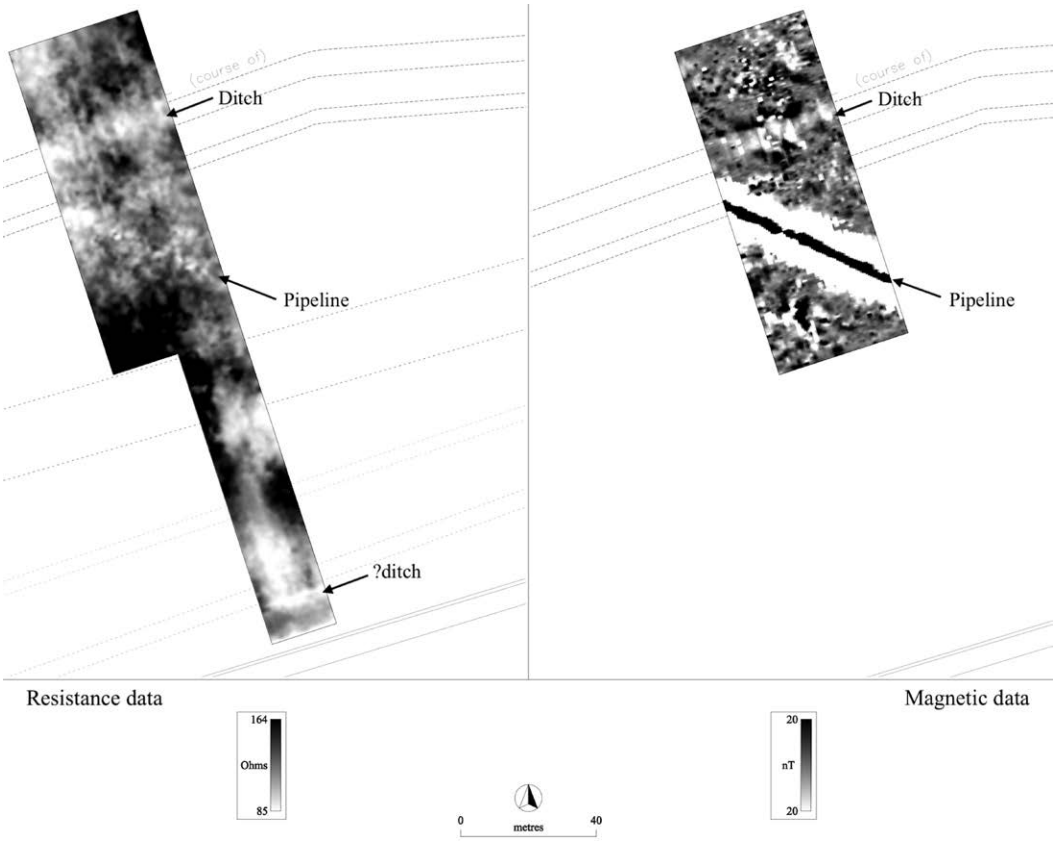

Figure 3.2.4. Resistance and gradiometer surveys at Wilderness West (after GSB 2006b Fig. 2.5, with additions).

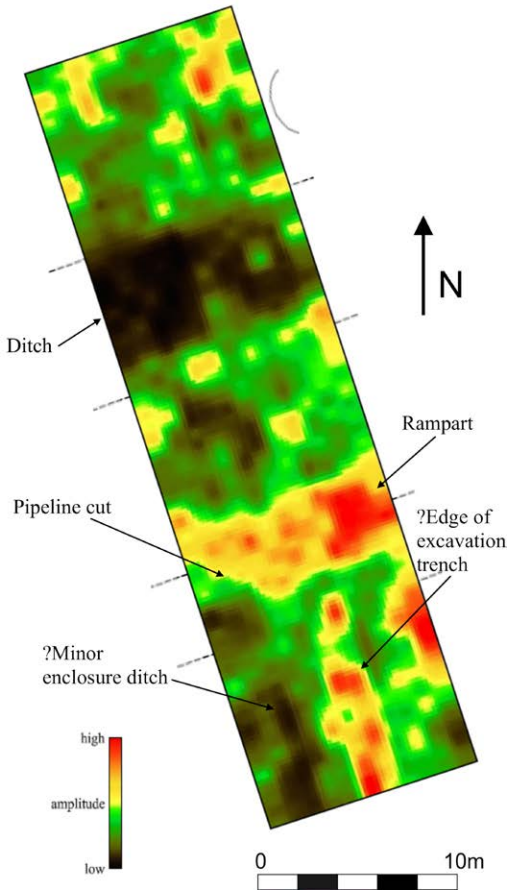

Figure 3.2.5. GPR timeslice at *c.* 0.7–0.8m depth at Wilderness West (after GSB 2006b, Fig. 2.8, with additions).

Google Earth coverage will confirm. Indeed, this stretch of Wall has been particularly productive in terms of cropmarks, with the discovery of a fortlet at Wilderness Plantation by St Joseph (1951: 61; Wilkes 1974) (Figure 1.9) and the identification of minor enclosures by Maxwell in 1977 (e.g. Figure 3.2.3), which had either previously been unrecognised or were newly discovered from the air. Despite the centuries of ploughing, the slight undulation of the Ditch and Upcast Mound are still clearly visible in the LiDAR survey (Figure 3.2.2), though Hannon's suggested visible line of the Military Way (2018: Fig. F.4.7) is less convincing and does not coincide with that depicted in the earliest mapping.

An area in short pasture, overlapping with and extending to the east of the excavated minor enclosure at Wilderness West, of whose existence GSB seem to have been unaware, was surveyed to check the line of the Ditch and Wall (Figure 3.2.1). The resistance survey was extended to the south so as to cross the possible course of the Military Way, whose line was considered to be more problematic. GPR survey was positioned to clarify the nature of resistance and magnetic responses in the main part of the survey block. Here brown forest soils, gleys and alluvial soils lie over fluvioglacial sands and gravels derived mainly from Carboniferous rocks, making the ground good for geophysical survey and particularly so for aerial survey, as already noted.

Results

The magnetic results (Figure 3.2.4) were dominated by the strong dipolar linear signal from a modern pipeline that overwhelms any response from the excavated minor enclosure. However, the Ditch is clearly represented as a broad, rather weak negative linear anomaly with indications of an irregular, narrower positive line on its north side. Both the Ditch and the pipeline are similarly, if rather faintly, apparent in the resistance survey as bands of lower readings. In neither case, however, is the base of the Wall readily visible, though its survival in the north-east corner of the excavation of the minor enclosure had been poor.

The GPR timeslice (Figure 3.2.5) revealed the Ditch as a broad band of low amplitude and the remains of the Rampart as a slightly narrower band of high amplitude. The latter signal is interrupted on its west side by a slightly oblique section of average amplitude that reflects the clay infilling of the modern pipe trench. The narrow band of high amplitude at right angles to the Rampart lies just outside the ditch of the small enclosure and may represent differential backfilling along the eastern edge of the excavation area. The broader parallel band of lower amplitude to its west probably represents the shallow ditch on the eastern side of the minor enclosure.

There is no convincing indication in the southerly extension of the resistance survey of the line of the Military Way, though a narrow east-west band of lower resistance near its southern limit could be the line of a narrow ditch (Figure 3.2.4).

3.3 Cawder

(NGR: NS 60400 72300; Canmore 45239)

Ditch, Rampart and Military Way

Site-specific references

Macdonald 1915: 107-12; Robertson 1964: 194-96; GSB 2006b; Maldonado 2017; Jones 2022b

Geophysical surveys (Figure 3.3.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
GSB; 2006	R: Geoscan RM15	0.24 (Area 3A), 0.32 (Area 3B)	1, 1
	G: Bartington Grad 601-2	0.08 (Area 3A)	0.25, 1
	GPR: Sensors and Software Noggin® Smart-cart	0.056 (Area 3A)	
Glasgow University; 2017 2022	G: Bartington Grad 601-2	0.24	0.25, 1
	R: Geoscan RM15	0.21	1, 1

Introduction

The line of the Ditch and upcast mound remained sufficiently extant across the western half of the grounds of Cawder House to be recorded in the 2nd edition Ordnance Survey mapping of the area in the late 1890s. Here it continues to run in a fairly straight line along the same low, flat-topped ridge that it followed to the north of Wilderness Plantation, though the River Kelvin is now closer, only some 260m away, with the ground again sloping gently down towards it. Despite the construction of a golf course within the grounds of Cawder House in the mid-1930s, the line of the Ditch is still traceable in some sections and faintly visible, along with parts of the Upcast Mound, in the LiDAR coverage (Figure 3.3.2). On the lower ground in the eastern half of the golf course, however, all trace of the Wall seems to have disappeared long before the earliest mapping. Here the Bishopbriggs Burn, now largely canalised, cuts through the low east-west ridge on its way to the river. The gap so created is also followed by the Forth and Clyde canal as it turns sharply south on the west side of the fort at Cadder.

In 1913 Macdonald confirmed that the line of the Wall recorded by the Ordnance Survey was correct. He uncovered the Rampart in places, and traced both the Ditch and parts of the Military Way, identifying a northward salient on the east side of the Bishopbriggs Burn, though he does not map his excavation trenches. Subsequently in 1963 Robertson confirmed the line towards the west end of the golf course by uncovering the base of the Rampart at four points. She too failed to map her trenches, though some can be traced in the surviving woodland.

Since the latter section of the Wall had ceased to be readily visible on the ground by the 1980s, it was considered desirable to check its course here, as well as to investigate the line of the Military Way. Thus, two GSB survey areas (3A and 3B) were laid out on the golf course

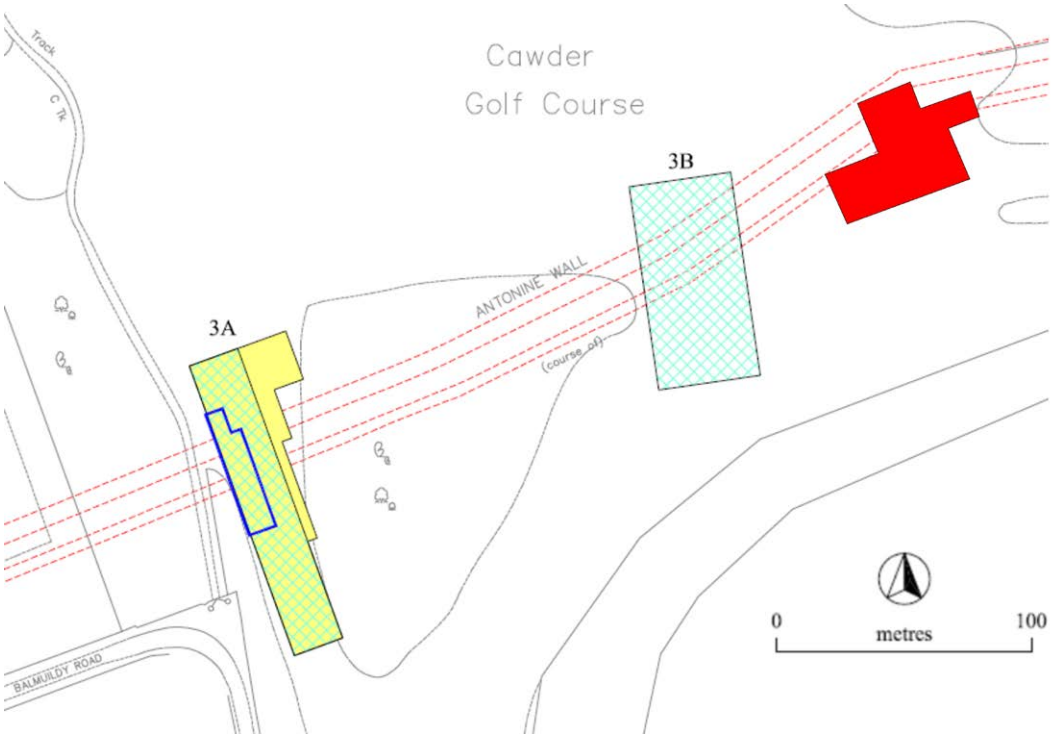

Figure 3.3.1. Survey areas at Cawder: GSB resistance hatched; gradiometer in yellow; GPR outlined in blue; Maldonado and Jones surveys in red (after GSB 2006b, Fig. 3.2, with additions).

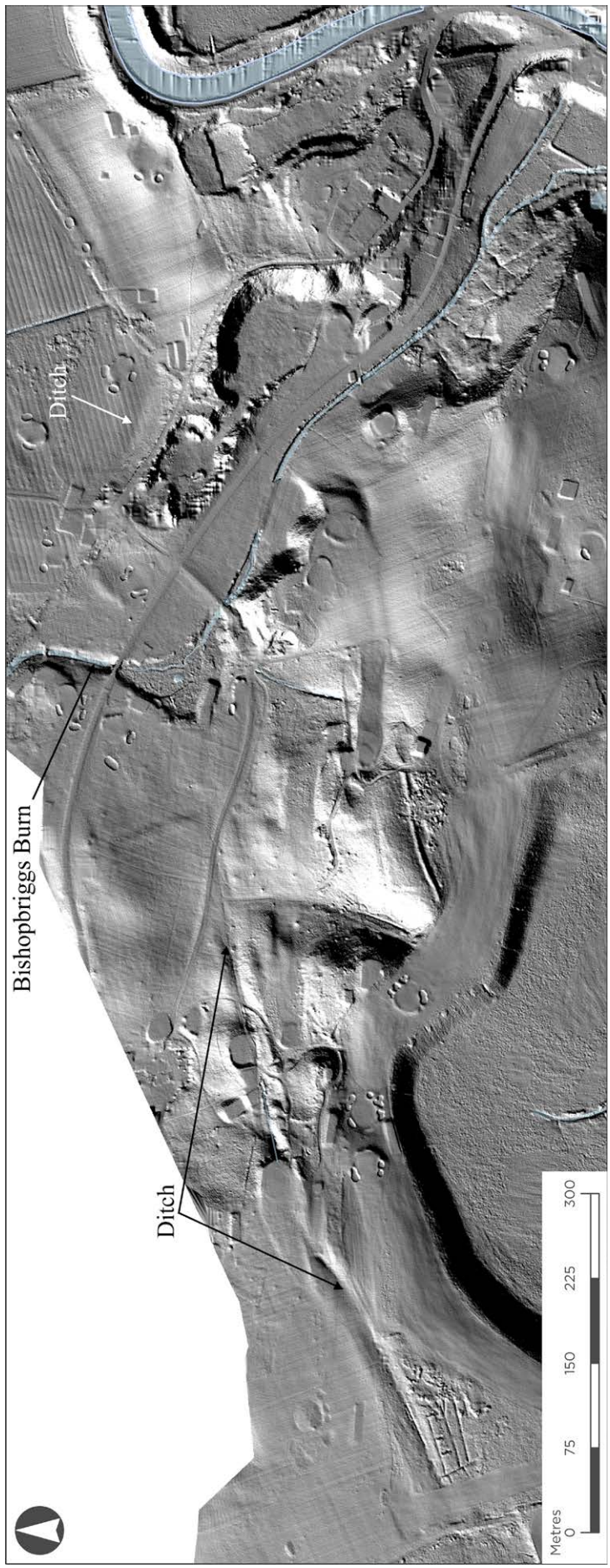

Figure 3.3.2. LiDAR image of line of the Wall through Cawder golf course.

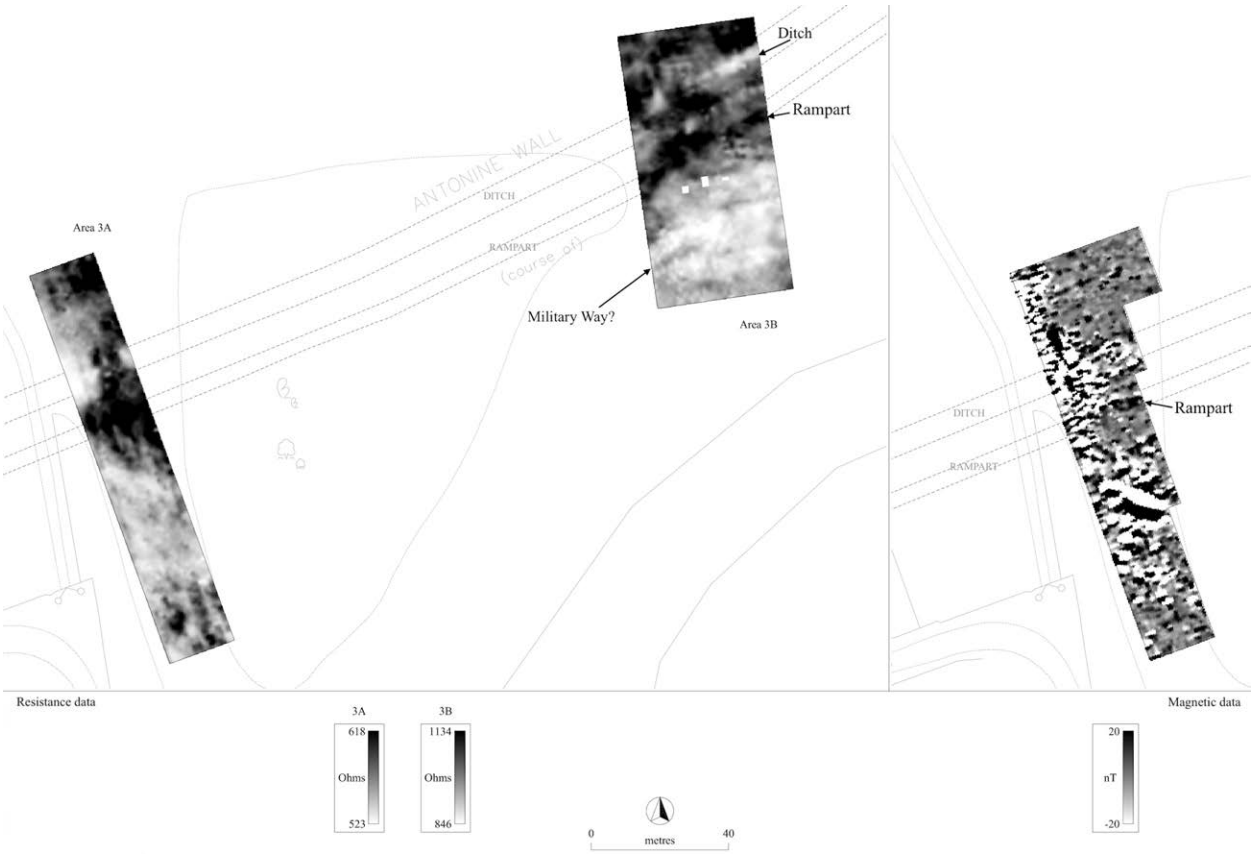

Figure 3.3.3. GSB resistance and gradiometer survey at Cawder (after GSB 2006b, Fig. 3.4, with additions).

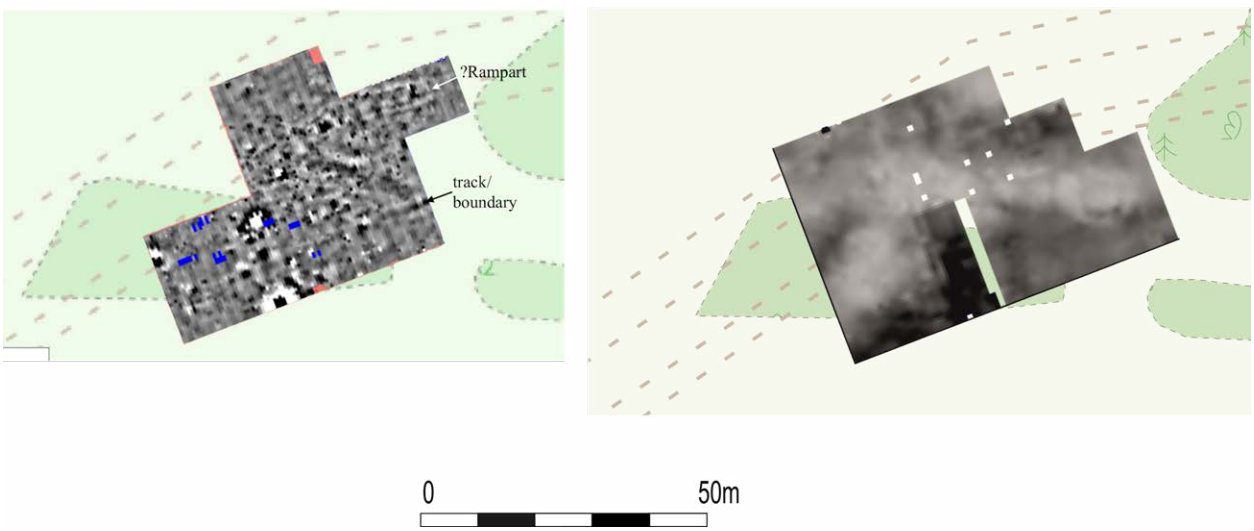

Figure 3.3.4. Results of Glasgow University gradiometer (left) and resistance (right) surveys in the eastern sector at Cawder.

fairway some 150m apart on either side of a wooded copse (Figure 3.3.1). Although the soils, which comprise brown forest, gleys and alluvial soils over fluvioglacial sands and gravels, were suitable for survey and the well-manicured grounds were readily accessible, modern landscaping had had a detrimental effect on both the remains and on the geophysical responses that they generated. Maldonado's subsequent survey sought to confirm the line of the Wall at a point where it seems to have diverged slightly from its generally straight alignment and where the earthworks recorded by the Ordnance Survey revealed some additional complexity.

Results

Results of the GSB survey were disappointing. Neither the line of the Ditch nor that of the Rampart were clearly defined in either of the survey areas whatever the methodology, though a narrow low resistance band on the eastern side of Area 3B may represent the line of the Ditch (Figure 3.3.3). A parallel higher resistance band to its south and equivalent disjointed positive linear anomaly in the gradiometer survey corresponds with the line of the Rampart, though its central section has been badly disturbed. Similarly, there were no obvious signs of the Military Way in either survey area, though a narrow band of slightly raised resistance was noted in the right position behind the Wall. The resistance readings are surprisingly high in both areas, which GSB attributed to landscaping and natural factors; those obtained in 2022 were similarly high in the areas away from the fairway (Figure 3.3.4).

Maldonado's gradiometer survey recorded several linear anomalies of uncertain identification. A broad, curving speckled band, partly defined both to the north and south by narrow weakly negative anomalies, may represent the line of the Rampart base (Figure 3.3.4), though Jones' corresponding resistance survey provided only limited support. The narrow positive anomaly, running approximately east-west towards the bottom of the gradiometer survey, seems more likely to be a post-medieval track or field boundary than a Roman feature. Maldonado's suggestion that a small enclosure can be recognised attached to the rear of the Wall is unconvincing.

3.4 Glasgow Bridge to Westermains

(NGR: NS 63600 73100 to NS 64300 73500; Canmore 45239 and 45253)

Ditch, Rampart, Military Way, fortlet and possible minor structures

Site-specific references

RCAHMS 1978: 134; GSB 2006b; 2007c; R.H. Jones 2011: 195-96

Geophysical survey (Figure 3.4.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
GSB; 2006	G: Bartington Grad 601-2	9.6	0.25, 1
	R: Geoscan RM15	0.56 (2006), 2.5 (2007)	1, 1

Introduction

The line of the Wall seems to have survived well as an earthwork in the section between Glasgow Bridge and Westermains until the early 1930s. The Wall follows the northern edge of a low, east-to-west sloping ridge overlooking the River Kelvin on its meandering course, now largely canalised, some 600m to the north-west. The western end of this section of Wall is delimited by the Forth and Clyde canal, where it cuts through that ridge following the line of an unnamed burn depicted on Roy's Military map from the early 1750s. Its eastern end is defined by the now heavily canalised line of the Park Burn where it crosses the Wall as it makes its way to the river. Beyond the Park Burn the Wall line is now completely built over by the western suburbs of Kirkintilloch.

The slightly more detailed mapping of the 2nd edition Ordnance survey from 1896 recorded the extant remains of both the line of the Ditch and the Upcast Mound, but by the time the 25-inch map was revised after resurvey in 1939 only the general course of the Wall was recorded here. Nonetheless, despite continued ploughing activity in the modern era, the Ditch and Upcast Mound are still recognisable in the LiDAR data (Figure 3.4.2) and sections of the Ditch, Rampart base and Military Way can still be seen in the cropmark record when conditions are suitable (e.g. Figure 1.8). Aerial survey by St Joseph in the 1950s is also responsible for two further discoveries in this section: a construction camp behind the Wall at Easter Cadder on the summit of the ridge to the east of the Park Burn and a fortlet attached to the rear of the Wall on the east side of Glasgow Bridge (Figure 3.4.3). Neither has previously been subject to excavation or any other form of investigation.

The aim of the extensive geophysical survey here was to confirm the line of the Antonine Wall, identify

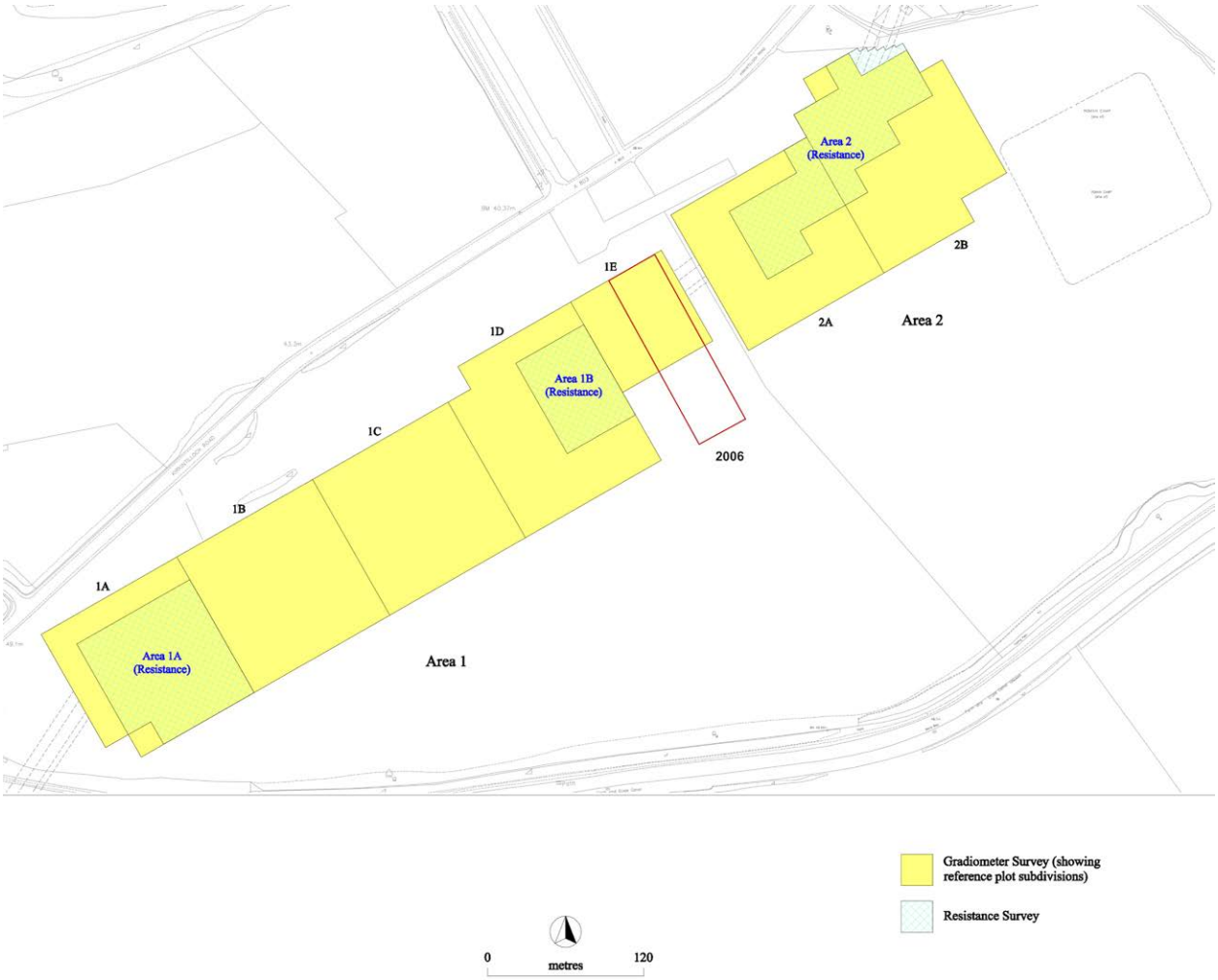

Figure 3.4.1. Location of the survey areas between Glasgow Bridge and Westermains, the 2006 gradiometer and resistance survey area outlined in red (after GSB 2006b, Fig. 4.2 and 2007c, Fig. 2).

and accurately locate the course of the Military Way, enhance knowledge of the fortlet at Glasgow Bridge and seek traces of any other features which might be associated with the Wall. In particular, the gradiometer survey of a long uninterrupted stretch of the linear barrier provided an opportunity to assess whether towers or other minor structures could be identified along the line of the Rampart. However, the survey did not extend over the construction camp. Only the results from the resistance element of a small preliminary survey have been included in the discussion here as those from the equivalent gradiometer survey were superseded by the later more extensive work.

The underlying geology consists of well-drained carboniferous sandstones, shale and limestones that are generally favourable to both cropmark production and geophysical survey. Small sand quarries are recorded in the early Ordnance Survey mapping on the line of the Wall immediately to the east of the Park Burn. The soils are brown forest with gleying. The ground is gently undulating and under regular, long-term arable cultivation extending across two large fields, so was readily available for survey; it was under a young crop at the time of the main survey in 2007, but in short stubble in 2006. Piles of cobbles were observed in rough ground at the field edges, a reasonable proportion of which seem likely to have been ploughed out from the Rampart base. On testing with the gradiometer, they were found to be highly magnetic.

Results

The line of the Antonine Wall Ditch is extremely clear across the whole of the area in the gradiometer survey (Figure 3.4.4), revealed as a continuous broad negative linear anomaly, usually mirrored immediately to the north by a slightly less regular narrow positive. There is no causeway opposite the presumed north gate of the fortlet confirming the picture provided by the cropmark evidence (Figure 3.4.3). The only break in the Ditch is that created by a modern pipeline towards the eastern end of this section (Area 2), which shows as a strong dipolar anomaly and is also clearly visible as a

Figure 3.4.2. LiDAR image of line of the Wall between Glasgow Bridge and Westermains.

Figure 3.4.3. Aerial photograph of the broad curving line of the Antonine Wall Ditch and the ditch (arrowed) on the west side of the adjacent fortlet at Glasgow Bridge in July 1977, both revealed as positive cropmarks. View from the south-west.

positive cropmark in the aerial photographs (Figure 1.8). The Ditch line is no less clear in the more selective areas covered by the resistance survey (Figure 3.4.5), but the response is not consistent. In the western sector (Area 1A) to the north of the fortlet, the Ditch is visible as a sharply defined broad band of low resistance as it runs across the general background of high readings. As in the gradiometer survey, the Ditch clearly continues unbroken across the front of the fortlet. In the most easterly area (2) the Ditch appears in part as an even more sharply defined band of low resistance, with some variation where it is crossed by a modern pipeline or passes through a zone of much higher resistance in the subsoil. In the two adjacent areas in the central sector however, the Ditch is revealed either as a weakly-defined broad band of raised resistance flanked by two narrow bands of slightly lower values (Area 2006), or as a well-defined broad band of high resistance (Area 1B). This remarkably variable electrical response, also observed at Summerston (Chapter 2.8), probably relates to localised differences in the subsoil, the central sector on the slope being drier because it is much better drained (see Chapter 8.2.4).

The line of the Rampart in the gradiometer survey is less obvious, but still visible in sections as an intermittent positive linear anomaly running parallel with, and some 8-9m to the south of, the Ditch (Figure 3.4.4). It is particularly clear to the north of the fortlet where it can be traced for *c.* 140m running eastwards across the front of the enclosure and extending over what seems to be a broad stream bed. In the centre of the survey the line is more disjointed, reminiscent of the mottled signal produced by the Rampart base at several fort sites (e.g. Castlehill and Mumrills, Chapters 2.5 and 6.5), presumably reflecting the magnetic signal from surviving cobbles. A similar picture apparent at its eastern end (Area 2) is occasionally enhanced by thin negative lines perhaps marking the stone kerbs of the Rampart base. However, there are no features along the over 650m of the Wall line surveyed to the east of the fortlet that are suggestive of any associated minor structures, though the resolution of the survey would seem to preclude the ready recognition of post-based structures. The picture in the resistance survey is similarly variable (Figure 3.4.5). Superficially, the Rampart seems most obvious in the central sections

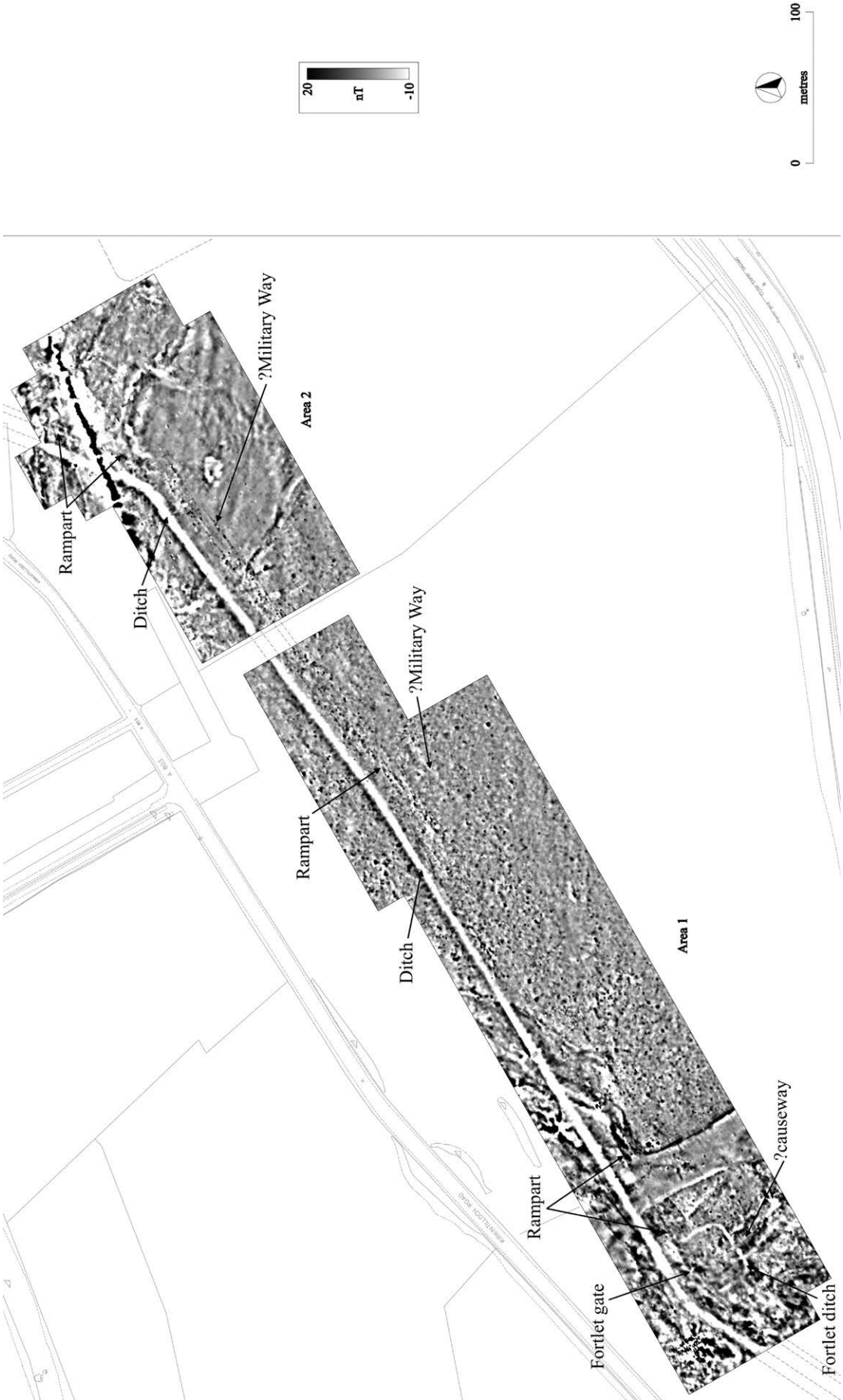

Figure 3.4.4. Gradiometer survey between Glasgow Bridge and Westermains (after GSB 2007c, Fig. 3, with additions).

Figure 3.4.5. Resistance survey between Glasgow Bridge and Westermains (after GSB 2006, Fig. 4.4 and 2007c, Fig. 6, with additions). The black-white palettes for the 2006 and 2007 surveys are 573-544 ohms and +1/-1 s.d. respectively.

(Areas 1B and 2006) as broad bands of high resistance, though they seem too wide, unless the cobble stones which made up the Rampart base have been spread by ploughing. There are faint traces of the Rampart mirroring the line of the Ditch on either side of the fortlet enclosure (Area 1A) and across much of Area 2. In all these cases the Rampart is revealed as a broad band of slightly enhanced resistance, though this is sometimes difficult to discern against the stronger response from the background geology.

What is probably the line of the Military Way is visible in the central section of the gradiometer survey as a faint negative/positive linear anomaly running some 20m behind the Wall at a very slightly oblique angle, presumably to enable it to skirt the ditches of the fortlet to the west (Figure 3.4.4). In Area 2 the line of what may be one of its drainage ditches is visible as a narrow, slightly positive linear anomaly running just to the south of the Rampart. However, nowhere is it clearly picked up in the resistance survey.

It is instructive to compare what is visible of these various linear elements of the Wall system in the geophysical survey with what is apparent in the cropmark record where the two overlap at the eastern end of this section. In the latter (Figure 1.8) the Ditch is clear as a broad positive cropmark, particularly well highlighted as it passes through the drier, sandier subsoil at the top of the ridge. The line of the rampart is apparent only in the western half of the field, where the stone kerbs are picked out as a single, or occasionally double, narrow negative cropmark. Finally, particularly towards the eastern half of the field, the Military Way can be seen running close behind the Wall, picked out either by lines of quarry pits or by a rather ill-defined ditch.

Finally, some further detail is provided for the fortlet. Its surrounding single ditch, butting up against the rear of the Rampart, is clear as a curving narrow negative anomaly or as a band of low resistance, though the latter is washed out along most of the east side by the low-lying wetter subsoil here (Figures 3.4.4 and 3.4.5). A break in the ditch located centrally in the south-east side is clear in both the gradiometer and resistance surveys. There are also hints of a possible causeway leading up to it in the former, defined by irregular negative and positive linear anomalies on each side. What is probably the line of the fortlet rampart is visible as a narrow band of higher resistance within the ditch on the west side, and there are faint indications in both the gradiometer and resistance data of a gap for a gate in the Wall Rampart to the north. There are no clear signs of any internal buildings, though a large positive anomaly just inside the north gate coincides with an area of higher resistance perhaps linked to structural remains immediately behind the gate.

3.5 Kirkintilloch

(NGR: 6513 7396; Canmore 45204, 73919 and 205694)

Fort

Site-specific references

Macdonald 1925: 290-95; Robertson 1964: 180-88; *DES* 1975: 21; Keppie *et al.* 1995: 650-56; Leslie and Rennie 2006; Bateson 2020; Hannon and Blake 2023c

Geophysical survey

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
GUARD; 2006	G: FM36 R: Geoscan RM15	0.7 0.7	0.5, 1 0.5, 1
HES; 2023	G: Sensys MXPDA	1.2	0.125, 0.5ss

Introduction

There is a long tradition of a Roman fort at Kirkintilloch located on the eastern shoulder of a low hill within Peel Park on the west side of the town. Early antiquarians consistently equated it with the impressively surviving rectangular earthworks there, the so-called Peel of Kirkintilloch. Indeed, Roy included a plan of the Peel in his illustration of the surviving forts on the Wall (1793: Fig. 35) (Figure 1.4). However, the morphology of this enclosure with its massive single ditch is not typical of Roman forts and limited excavation on the site in 1899 confirmed that it was, in fact, an early medieval motte with a central stone keep.

There are no records of any inscriptions recovered from Kirkintilloch which might help to characterize the Roman occupation, though there are various references to probable Roman masonry being re-used in later buildings, including the Peel, while a coin hoard of Antonine date was found in 1893 some 450m to the south-east, possibly from a burial deposit. The site of the Peel would, indeed, have been an excellent position for a Roman garrison post as it overlooks the confluence of the Luggie Water and the River Kelvin some 500m to the north-east, while the ground slopes down quite steeply to the north.

Despite a number of archaeological investigations over the last century, however, the precise location and exact nature of the presumed Roman fort site remains unclear. This is primarily because of the destructive impact of later occupation in the area, not least the construction of the motte in the 12th or 13th century,

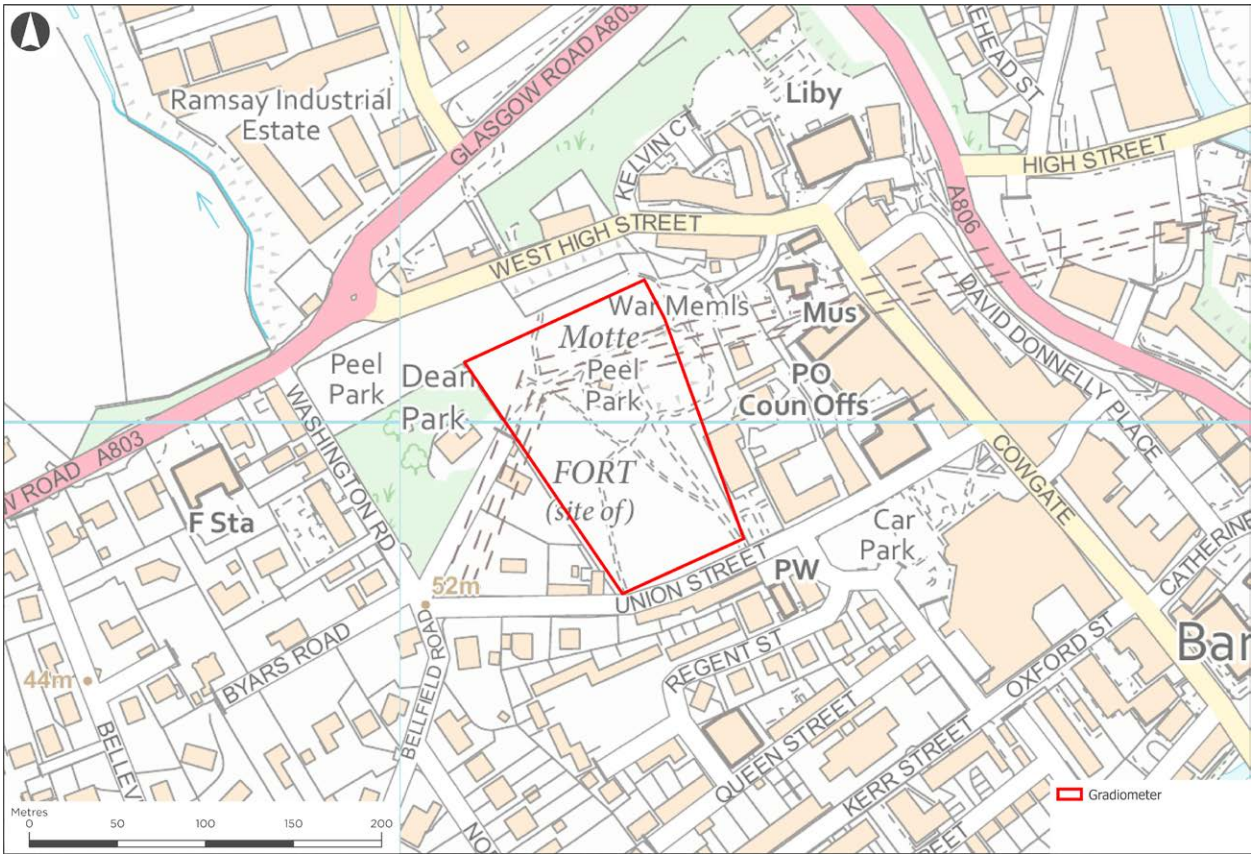

Figure 3.5.1. Location of HES geophysical survey at Kirkintilloch.

the building of a large church in the later 19th century, the substantial landscaping undertaken when the Peel Park (originally named Victoria Park) was created at the end of that century, and the digging of air raid shelters within the park during the Second World War. Indeed, even the substantial earthworks of the motte, still readily visible in the 2nd edition Ordnance Survey mapping, are now heavily masked by landscaping and the erection of a bandstand in 1905.

In 1914 Macdonald excavated on the west side of Peel Park in search of the Roman fort. He discovered a road and hearths, along with tiles and pottery of Roman date, but the work was interrupted by the onset of the First World War and never fully published. Robertson carried out further excavations between 1953 and 1961. She located the Rampart Base, Ditch and a road, presumably the Military Way, in the north-west corner of the park. Further trenching in gardens immediately outside the Park to the south-west confirmed that the Wall here ran on a north-east/south-west alignment. Significantly, the natural topography dictates that this alignment could not have continued much further north before the Wall would have had to turn sharply to the east, hinting at a layout reminiscent of Castlehill (see Chapter 2.5, above) where a fortlet, subsequently replaced by a fort, was located on a hill at the point where the line of Wall markedly changed direction. In excavation of a larger area towards the centre of the park Robertson uncovered a range of evidence of Roman occupation, including rows of postholes, shallow gullies, areas of cobbling and amorphous hollows, but these revealed no clear pattern of activity, so whether the remains relate to occupation within or outside a fort could not be confirmed.

Rescue excavations beyond the park to the south in 1978-9 under the auspices of the Manpower Services Commission and a decade later by the Scottish Urban Archaeological Trust identified segments of ditches, one of which was associated with Roman finds, including leather shoes and a javelin head. These ditches have generally been taken to mark the southern defences of the fort, indicating the position of its south gate and south-east corner, and so allowing an estimate of its size (*c.* 1.4ha). The north-south dimension of 110m suggested for the fort, however, would place its southern rampart at least 50m inside the most northerly of these ditches. This would be entirely unprecedented, so that either the fort was considerably larger (closer to 2ha), making it the second largest on the Wall, or the ditches relate to something else, perhaps an annexe. Moreover, the limited data available from the 1978-9 excavations indicate that the inner ditch cut through occupation layers containing Antonine pottery. While this does not preclude it from enclosing a fort or annexe, this could

Figure 3.5.2. HES gradiometer survey at Kirkintilloch.

not have been the primary Roman structure on the site. Another short section of curving ditch found further to the west in 1975 is less convincingly linked with Roman activity, both in terms of its alignment and associated finds. Finally, small-scale evaluation trenches excavated by GUARD in the south-west quadrant of the park in 1999 were able to provide only further confirmation of Roman and Medieval activity there.

The aim of the geophysical surveys was to determine the character and condition of the Roman remains known to lie within Peel Park. The underlying drift geology consists of glacial till. Conditions for survey were good since it was restricted to the well-maintained grassed areas of the park.

Results (Figures 3.5.2-3.5.4)

In terms of the Roman remains the results from the geophysical surveys undertaken by GUARD and HES were very disappointing, though perhaps unsurprising given the history of the park. Alternating broadly spaced lines of high and low resistance or weak positive and negative anomalies running on a north-north-west/south-south-east alignment extend across most of the area surveyed and are clearly the remains of rig and furrow cultivation. Indeed, the GUARD survey draws attention to two of these lines that reflect visible ridges. However, GUARD's suggested identification of a curving double ditch towards the centre of the Park on its western side is unconvincing, not least because no Roman ditches were identified in Robertson's

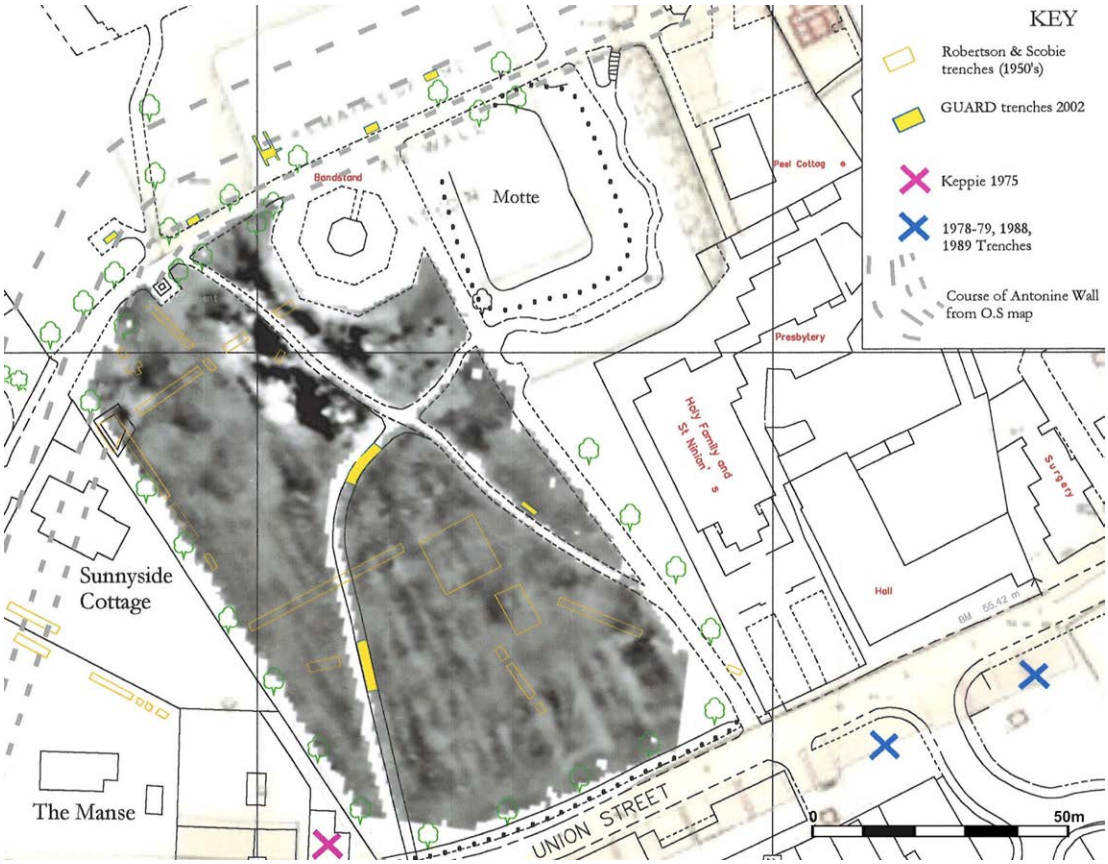

Figure 3.5.3. GUARD resistance survey at Kirkintilloch (after Leslie and Rennie 2006, Fig. 4).

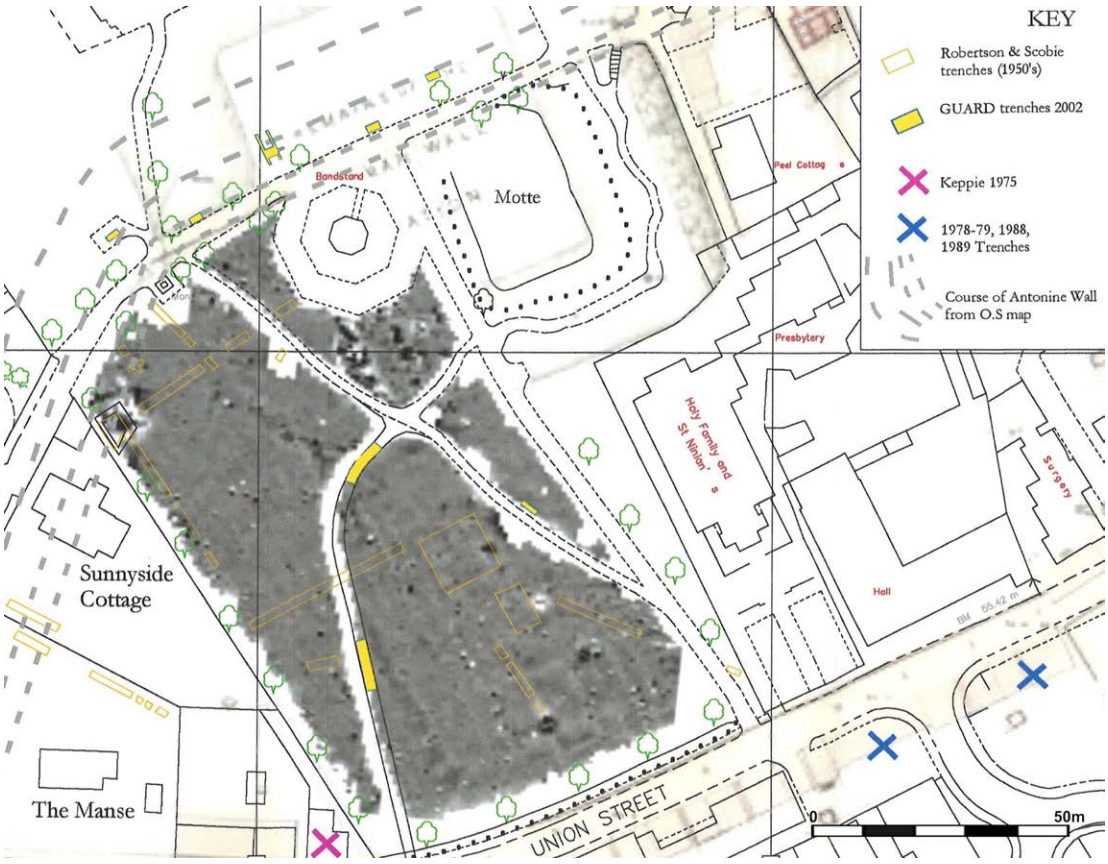

Figure 3.5.4. GUARD gradiometer survey at Kirkintilloch (after Leslie and Rennie 2006, Fig. 5).

excavations, one of whose trenches had cut across their supposed line. Their hesitant identification of two barrack-like rectangular structures in the resistance survey on the east side of the Park is no more convincing for similar reasons, and is more likely to be a further reflection of the pattern of post-medieval agriculture. A broad positive band running north-south on the east side of the path in the south-west corner of the park, which is particularly clear in the HES gradiometer survey, is of a character and location appropriate for the rampart base of a fort behind the Wall. However, it is on the same alignment as the rig and furrow and there are no signs of the negative responses from any associated external ditches that would be expected, so again a more agricultural explanation is preferred. Two large rectilinear features, defined by broad lines of low resistance or negative magnetic anomalies, fronting onto Union Street are apparent in all the surveys, but these were identified by local residents as the remains of air raid shelters or emergency water tanks from World War II. The only feature of archaeological note is the faint, broad curving positive anomaly visible in both gradiometer surveys that seems to reflect the line of the ditch of the medieval motte, whose visible traces were removed by landscaping that accompanied the building of the bandstand in 1905.

Chapter 4

4.1 Auchendavy

(NGR: NS 674 750; Canmore 45201 and 73919)

Fort, Rampart, Ditch, and environs

Site-specific references

DES 1974: 34; Keppie and Walker 1985; Dunwell *et al.* 2002: 274-79; Jones *et al.* 2006a; Jones *et al.* 2008a; Jones and Leslie 2015: 319

Geophysical surveys (Figures 4.1.1 and 4.1.6)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
Glasgow University; 1998, 2000, 2002, 2006, 2007	G: FM36 G: Bartington Grad 601-2	3.48 (Area C) 1.6 (Area A), 0.32 (B), 5.2 (D), 0.68 (E)	0.5, 0.5 0.125, 1
	R: Geoscan RM15	0.16 (Area A), 0.28 (B), 0.53 (D), 0.36 (NW of D)	0.5, 0.5 close to fort, otherwise 1, 1
	MS	0.575	5, 5
	GPR: Utsi Groundvue 3	0.265	0.1, 0.5

Introduction

The fort sits on a slightly raised platform within pasture fields on the southern edge of the flood plain of the River Kelvin. The modern course and dimensions of that river, which flows approximately east-west in an almost straight line some 140m to the north, bears little relationship to the more meandering course revealed by Roy's Military Survey of the Scottish Lowlands generated in the early 1750s (Moore *et al.* 2017). Before the extensive man-made alterations to the river, the low-lying valley in front of the fort was prone to flooding, making it rather more of a natural barrier to movement than the present landscape would suggest. Indeed, Horsley's brief account of the extant remains notes that in the early 18th century the fort's ditches were for the most part filled with water (1732: 169).

As Horsley's remarks also indicate, there is a long antiquarian record of a Roman fort here. Roy records triple ditches on two sides and curving around the south-west corner (Figure 4.1.2). The site seems to have remained reasonably well preserved until the ground was deliberately levelled in the early 19th century (Stuart 1852: 327), though the southern ditches had already been partly lost under the upcast from the construction of the Forth-Clyde canal towards the end of the previous century. The ramparts of the fort are now completely reduced, though it is still possible to trace the line of the eastern defences on the ground as a single large hollow, while the Ditch of the Antonine Wall, which forms the north side of the fort, is just visible as a slight earthwork. Both are evident in the LiDAR imagery (Figure 4.1.3).

No archaeological excavation has ever been undertaken within the fort; indeed, no modern measured plan was produced until that of Keppie and Walker in the mid-1980s, which is based on a combination of ground survey and aerial photographic transcription. Nonetheless, the fort is well known because of the recovery of a range of Roman material over the years, most notably a small hoard of ballista balls and a series of well-preserved altars, the latter from a pit discovered just outside the fort's southern defences during the construction of the Forth-Clyde canal in 1771 (Keppie 1998: 102-05). Fieldwalking in the *praetentura* after ploughing in 1974 recovered a range of artefacts, including box-flue tiles suggesting the nearby presence of an internal bathhouse. Excavation ahead of the construction of a major sewer pipeline some 150m north-west of the fort in 1999 recovered important evidence of fields defined by shallow ditches and gullies in use in the Roman period. Despite the fact that they lay just beyond the line of the Wall, these seem likely to relate to agricultural exploitation of the area by inhabitants of a *vicus* associated with the fort, whose existence is indicated by the non-military tombstones recovered from Shirva Farm nearby (Chapter 4.2, below) (Keppie 1998: 114-15).

Glacial sands, gravels and boulder clay overlie the solid geology of Carboniferous limestone, making the area suitable for geophysical survey. However, much of the interior of the fort is inaccessible as it is occupied by modern buildings and associated hard-standing, the former largely following the footprint of the earlier farm steading. Occupation of the farm goes back to at least the mid-18th century (Figure 4.1.2). In addition, the modern road (B8023) runs through the fort from east to west, roughly on the line once occupied by the *via principalis* and probably the Military Way. The gradiometer survey was the most extensive, so reference to the varying conditions for survey in the surrounding fields refers to that (Figure 4.1.1). Area A to the east of the fort presented a field of largely flat

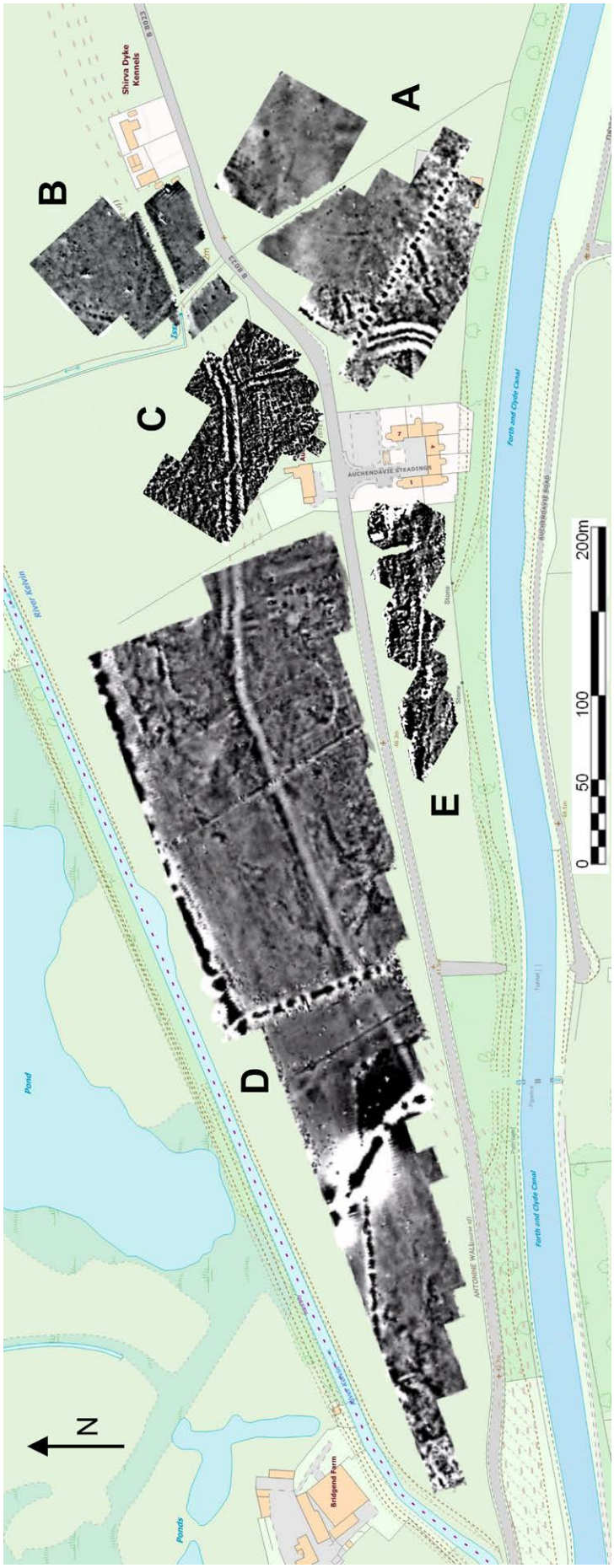

Figure 4.1.1. Location of all gradiometer surveys at Auchendavy. Area C was surveyed with Geoscan FM36 (black/white palette +/- 30nT), the other areas with Bartington Grad 601 (black/white palette +/- 10nT).

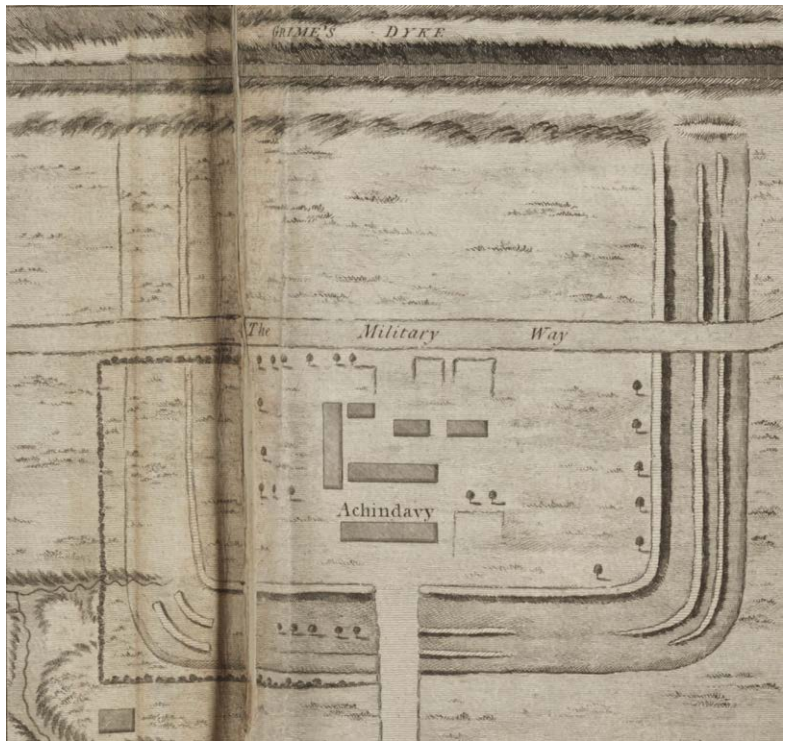

Figure 4.1.2. Roy's plan of the fort at Auchendavy (extracted from Roy 1793, Fig. 35).

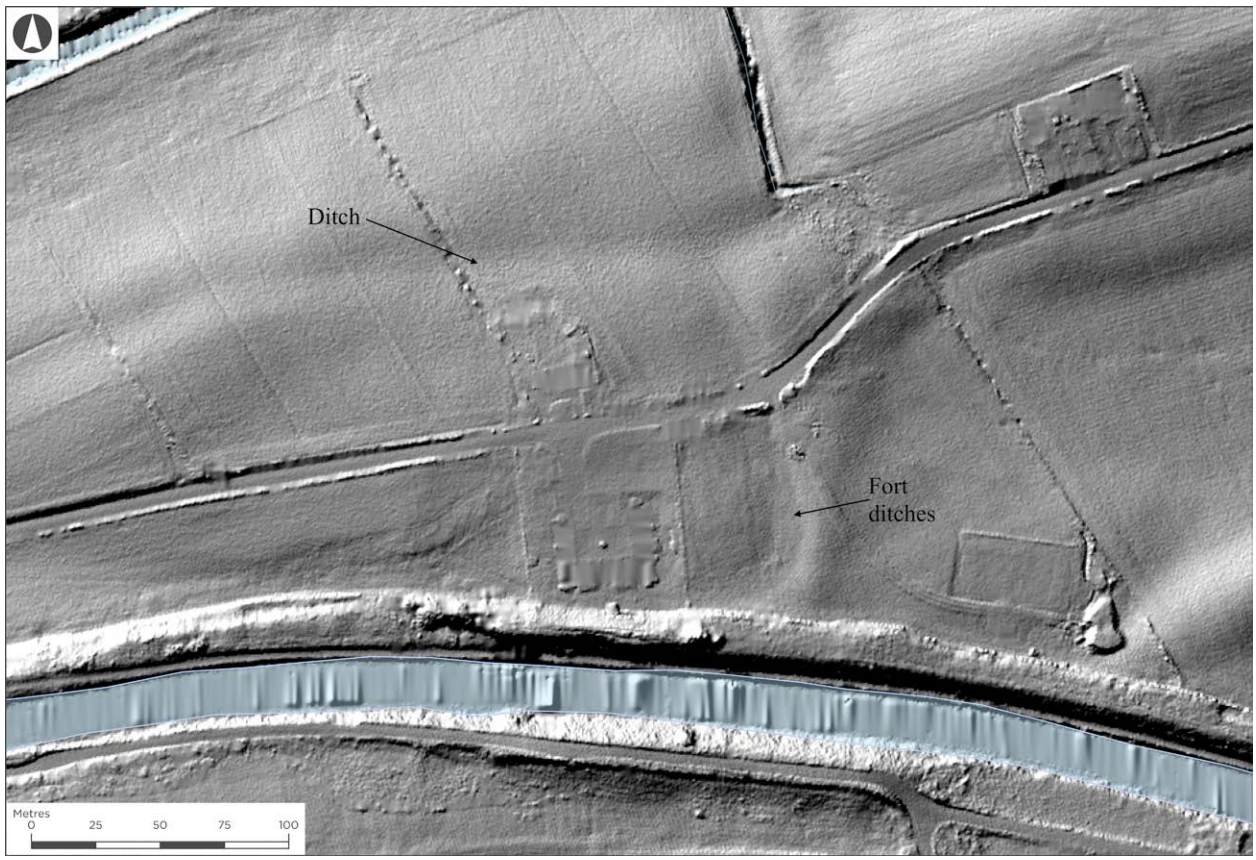

Figure 4.1.3. LiDAR image of Auchendavy.

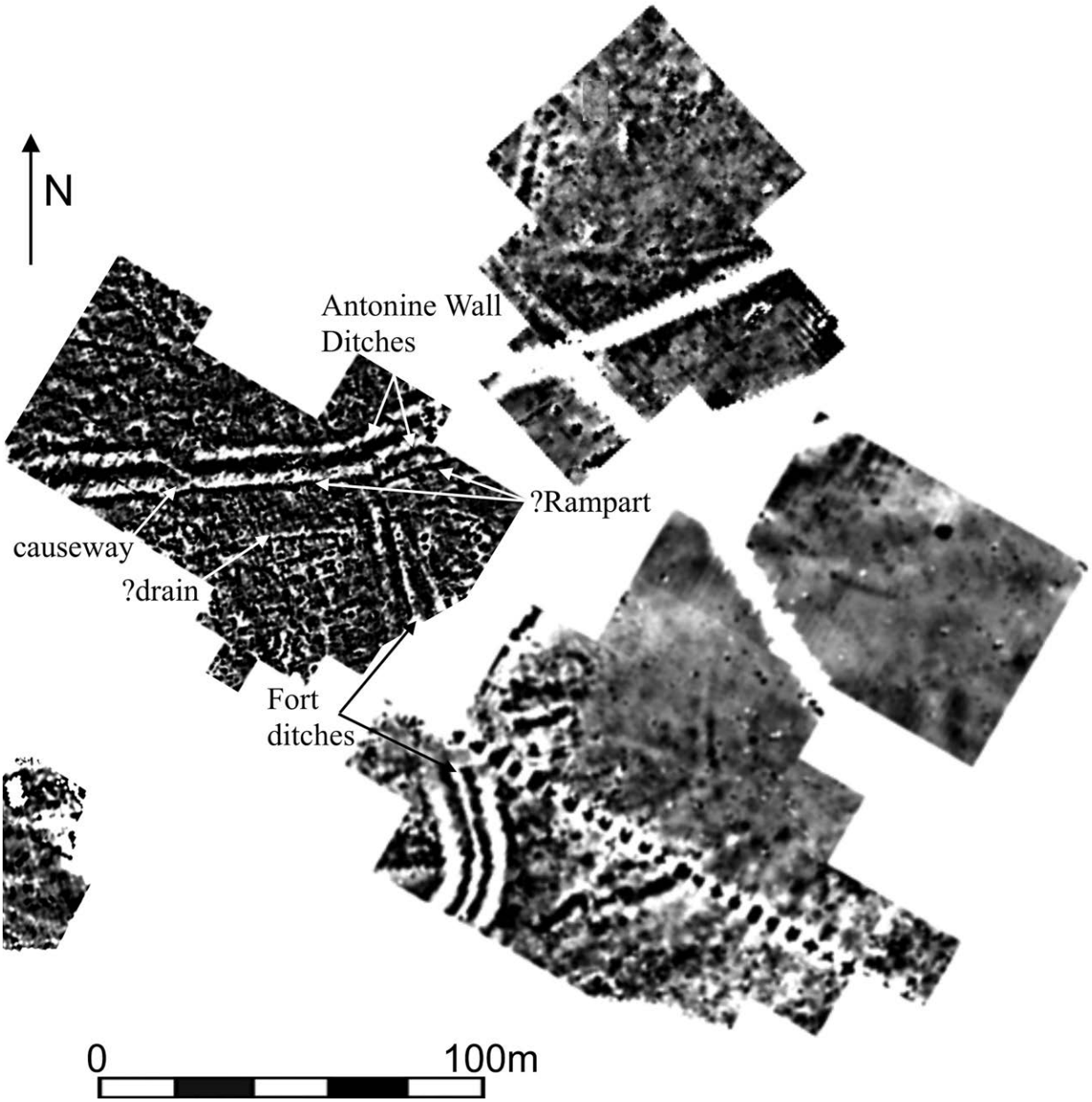

Figure 4.1.4. Gradiometer survey of Areas A-C and the eastern end of Area E at Auchendavy.

pasture. However, Area B across the main road was somewhat less amenable to survey because it straddled three fields defined by metal fences and was crossed by an overhead power cable. In the northernmost of these fields, as it sloped down to the River Kelvin, there was ample evidence of modern drainage having been constructed in the southern corner along the field's western hedge. Area C over the north-east corner of the fort lies in pasture, sloping steeply down to the river, but more gently to the west and north-west, and is crossed by a power line at its northern end. Old field boundaries were evident, as well as localised disturbances, notably in the form of large manholes, resulting from the insertion of a sewer pipeline to the north. Area D, which encompasses the north-west corner of the fort and a substantial length of the Wall Ditch to the west, is also in pasture, flat except in its south-east corner joining Area C where the ground was disturbed. Finally, in Area E the field slopes gently down from the modern road towards the canal. Although also in pasture, this field gives the impression of having been disturbed by the combined effects of cutting the canal and the insertion of utilities for the housing in the steading.

Results

The line of the Antonine Wall Ditch can be followed very clearly in the gradiometer survey in Areas C and D. This extends across most of the northern face of the fort and beyond it for over 300m to the west. Survey

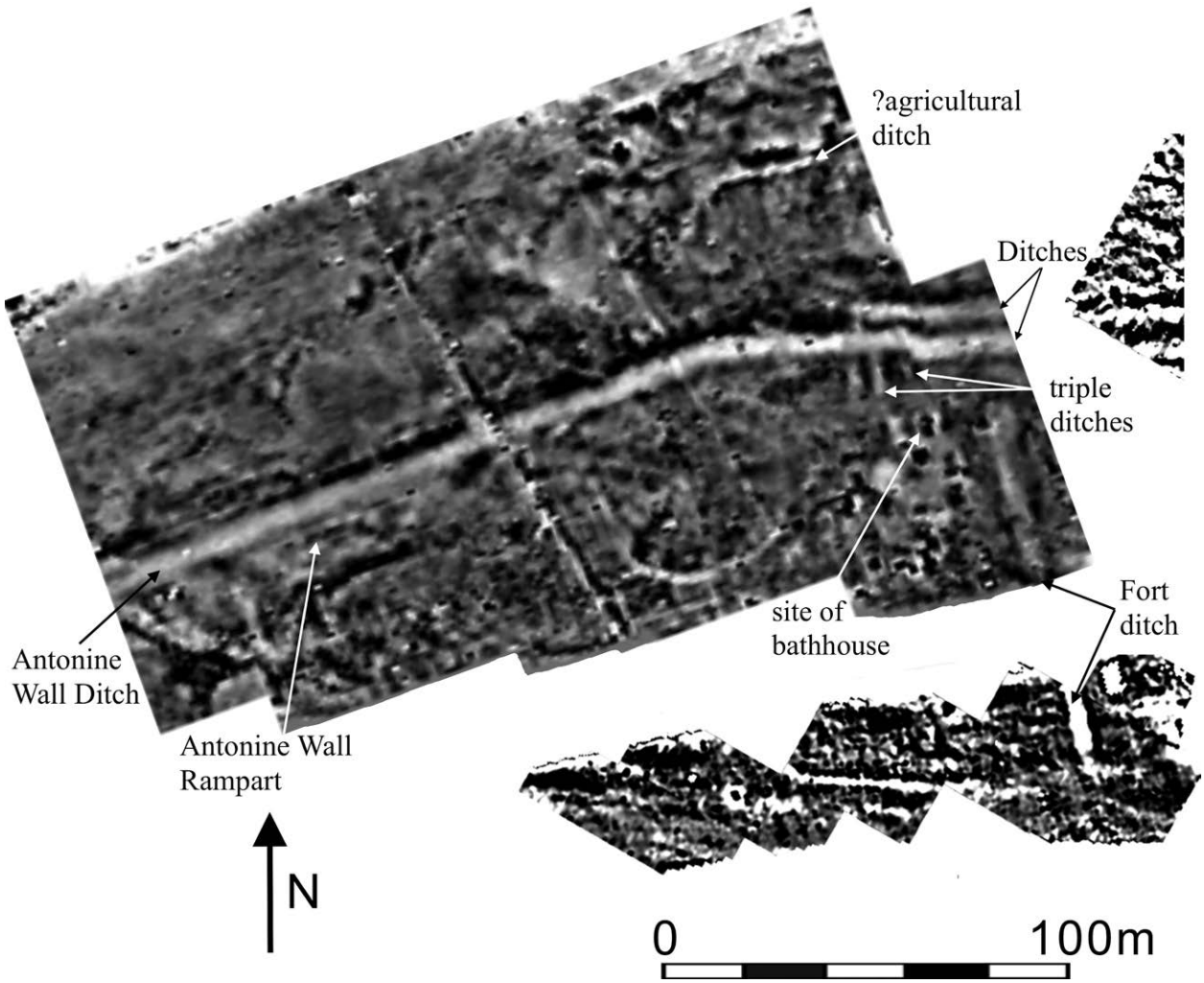

Figure 4.1.5. Gradiometer survey of the main eastern section of Area D, Area E and part of the west side of Area C at Auchendavy.

in Area D usefully confirms the alignment of the Wall indicated on the 2nd edition Ordnance Survey 6-inch and 25-inch maps, though rather than the Ditch curving gradually to the south-west it indicates a slightly sharper change of direction a short distance outside the fort (Figures 4.1.1 and 4.1.5). The Ditch manifests itself as a broad negative linear anomaly, usually with a parallel narrower positive immediately to its north and sometimes a fainter positive to the south. In front of the fort, however, the signal is rather different. Here the Ditch appears as a two broad negative linear anomalies separated by a positive of similar width, but still with narrow positives immediately to both north and south, the latter being quite sharply defined within the fort (Figure 4.1.1 and 4.1.5). Auchendavy was one of the earliest sites on the Wall to be surveyed with geophysics and the interpretation of this multiple anomaly was originally both unclear and much debated. In the light of the extension of the survey to the west of the fort and work at other sites, however, the solution now seems quite clear. As at Castlehill, Balmuildy and Mumrills (Chapters 2.5, 3.1 and 6.5), the defences to the north of the fort actually consisted of two ditches that seem, for the most part, to have been slightly narrower than the single Wall Ditch recorded further to the west. Furthermore, at a point near the centre of the fort there is a clear break in the outer ditch, where the ground is undisturbed. This represents an original causeway opposite the north gate, though the situation is less clear for the inner ditch where the narrow positive anomaly on its south side would have cut across such a causeway (discussed below).

The picture is further complicated, however, as the double ditches continue for a short distance beyond the fort on both sides. To the east in Area C (Figure 4.1.4) they turn to the north-east and then continue on to the limit of that part of the survey.[1] It was not possible to check

[1] Minor discontinuities in both ditches seem to coincide with junctions between survey grids and may simply reflect slight

Figure 4.1.6. Location of all resistance surveys at Auchendavy. Black/white palette 480-130 ohms (Area A), 167-40 ohms (Area B), 300-133 ohms (Area D west of fort) and 700-100 ohms (Area D pipeline).

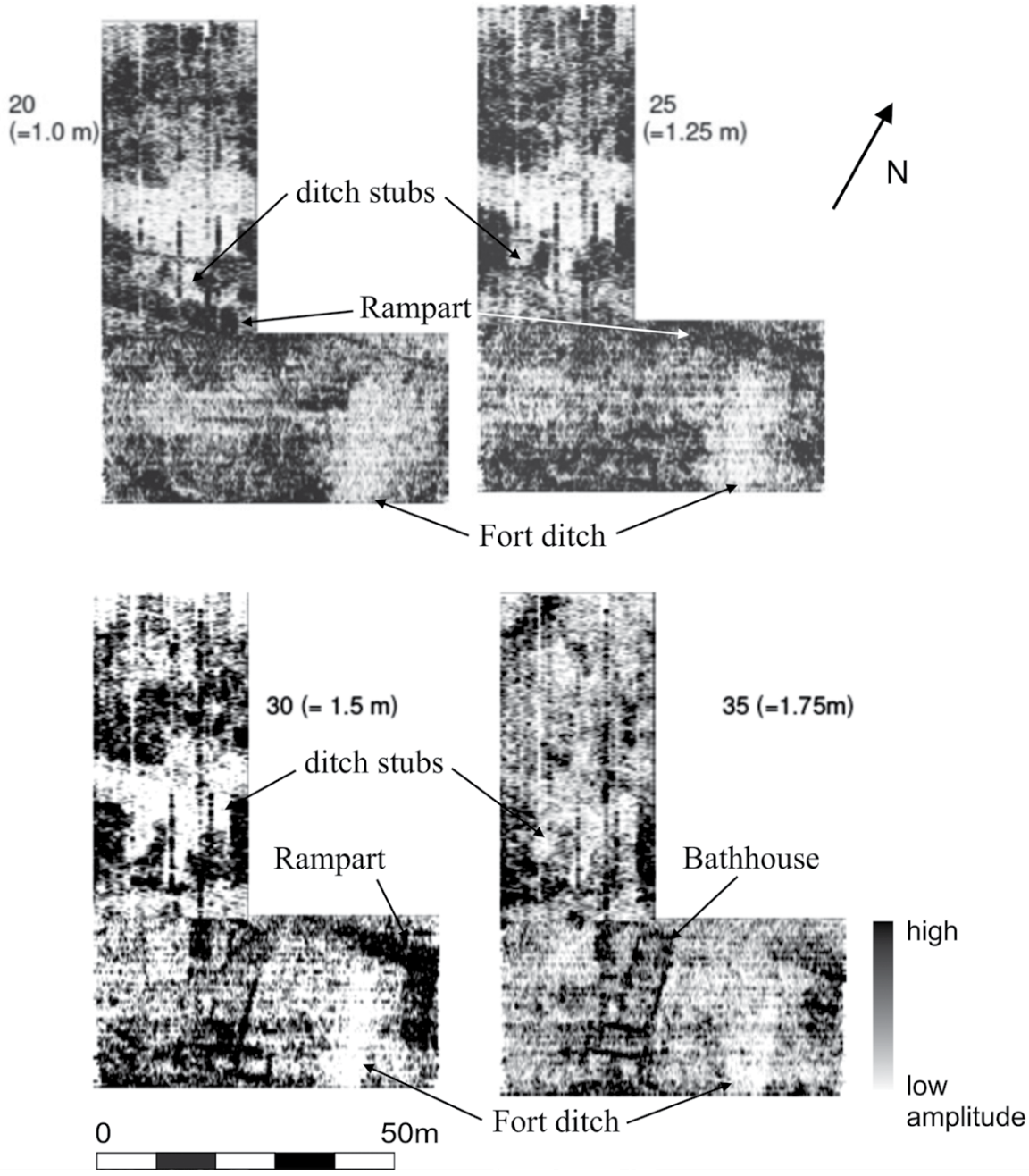

Figure 4.1.7. GPR time slices at Auchendavy at 1m, 1.25m, 1.5m and 1.75m.

at what point they came to an end as the line of the Wall Ditch in Area B coincided with a field boundary defined by a metal fence. To the west the double ditches are readily apparent in both the gradiometer and resistance surveys as parallel broad negative linear anomalies or wide bands of low resistance respectively (Figures 4.1.5 and 4.1.6), extending over 30m beyond the western ditch of the fort (discussed below). The inner ditch exhibits a slight zig-zag half way along this length, most apparent in the more extensive gradiometer survey, before it merges with the Wall Ditch as it continues to the west; the outer ditch turns through 90 degrees forming a disjuncture that is highly reminiscent of the relationship seen at the north-west corner of the fort at Castlehill (Chapter 2.5, above). At this point the stubs of three narrow ditches, the shortest and most easterly coinciding with the zig-zag, can be seen extending to the south for up to 10m, as if originally intended to join triple ditches on the western side of the fort. Again they are visible in both the gradiometer and the resistance surveys, though the shortest and most easterly is more evident in the former where it coincides with the

inaccuracies in their relative recording on the steep slope.

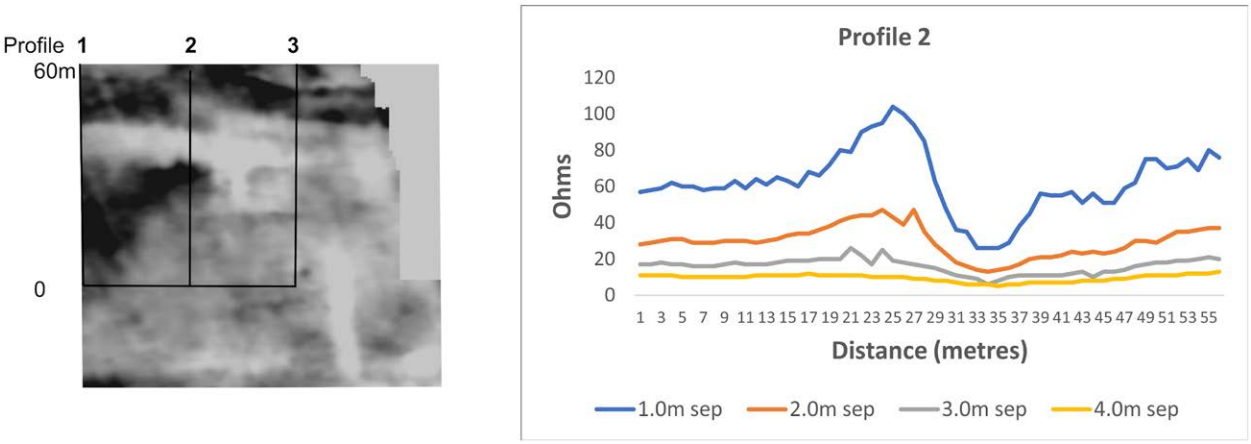

Figure 4.1.8. Location of Electrical profiles 1-3, each 60m in length, overlain on resistance graphic of the same area at Auchendavy (left); Resistance values in Profile 2 according to position (0-60m) and probe separation (1.0 to 4.0m) (right).

change of direction in the inner fort ditch. Similarly, in the limited area covered by the GPR survey (Figure 4.1.7) the three stub ditches are particularly apparent in the time slices representing depths of 1.0, 1.25 and 1.5m, coming to an end immediately in front of the line of the Wall Rampart base (discussed below).

Following the experience gained with electrical profiling at Ardoch (Jones *et al.* 2006a: Figs 2.5 b and c), this technique was employed along three traverses at the point to the west of the fort where the double ditches along its frontage give way to the single broad Antonine Wall Ditch (Figure 4.1.8). In profile 1 (not illustrated) the Ditch appeared at *c.* 35m at a depth of between 1m and 2m. To its south was a plateau (*c.* 70-80 ohms at 1m separation), but resistance rose markedly and sharply to the north, perhaps representing the Upcast Mound. The Ditch is more constrained and better defined in Profile 2 between 30m and 39m, this time with the sharp rise of resistance coming immediately to the south at 25m, presumably representing the Rampart base.

There is some trace of the Wall Rampart visible in the gradiometer and GPR surveys. A strongly defined, narrow positive linear anomaly in the former runs through Area B into Area A, stopping at the north end of the fort ditches (Figure 4.1.4). It runs broadly parallel to, and lies *c.* 5m behind, the double ditches to the north of the Wall as they approach the north-east corner of the fort. This seems likely to represent the Rampart even though it appears rather narrow. A similar narrow positive anomaly on the southern edge of the inner ditch may be its continuation, though slightly offset, forming the north rampart of the fort. Much clearer is the line of the stone base of the Wall Rampart at its junction with the west rampart of the fort in the GPR survey in the time slice representing a depth of 1.5m (Figure 4.1.7). Its western continuation on the same alignment is similarly apparent at a depth of 1m running immediately to the south of the triple ditch stub-ends. A short discontinuous stretch of a broad positive linear anomaly in the gradiometer survey some 120m further to the west (Figures 4.1.1 and 4.1.5), which runs parallel to the Ditch and *c.* 4m behind it, presumably also represents the Wall Rampart. However, the parallel wider positive linear anomaly a further 8m to the south seems more likely to be part of a broader pattern of largely geological effects apparent to the north-west and west of the fort (Figure 4.1.1).

It has been appreciated since at least the 2nd edition Ordnance Survey mapping that the Antonine Wall changed its alignment on both sides of the fort at Auchendavy. As Keppie and Walker noted in 1985, there is no compelling local topographic reason for the resulting zig-zag in its line, which, in combination with the hints of a causeway across the ditch that they observed both on the ground and in the aerial photographs, supported the suggestion that the fort construction preceded that of the Wall. The geophysical survey has made the character of the zig-zag in the Wall line both more explicit and more marked; confirmed the existence and primary nature of the causeway in front of the fort; and demonstrated that the fort was provided with two ditches to the north. In combination this evidence leaves little doubt that the fort, or at least it north face, was built in advance of the Wall. Moreover, the fact that the double ditches extend well beyond the fort to the west, culminating at three ditch stub-ends projecting to the south, suggests that when this frontage was built, it was intended that the fort should be wider.

When the remainder of the fort came to be constructed, however, only one ditch seems to have been dug on its west side. This is located some 20m east of the ditch stub-ends mentioned above, running at a slightly oblique angle to the double ditches of the Wall. It is

clearly visible in the gradiometer survey as a fairly broad negative linear anomaly, outlined on both sides by somewhat irregular positives, and in the more limited resistance survey as a quite well-defined broad band of low resistance (Figures 4.1.5 and 4.1.6). The ditch starts just to the south of the proposed line of the Wall Rampart (discussed above) and continues to the southern limit of both the resistance and gradiometer surveys north of the modern road. It is then picked up in the gradiometer survey on the south side of that road (Area E), where the line of the associated inner positive anomaly is much stronger, but disappears before the southern limit of the survey area is reached. GPR (Figure 4.1.7) detected the same ditch in all the time slices illustrated, but with varying degrees of resolution. That it came to a butt end just to the south of the Wall Rampart is particularly clear at a depth of 1.5m.

The multiple ditches on the eastern side and around the south-east corner of the fort have always been the best known. Their combined outline is depicted in both the 1st and 2nd edition Ordnance Survey mapping, and they were clearly defined in the earliest aerial photographs of the site from 1953. They are particularly apparent in the gradiometer survey at the south-east corner (Area A) as three curving negative linear anomalies, the middle one less wide than the other two (Figures 4.1.1 and 4.1.4). They have distinctive narrow positive anomalies on each side, as seems to be the case for all the major ditches recorded in gradiometer survey on the site. On the north side of the modern road (Area C) the pattern is similar, though the anomalies are less prominent. As on the west side of the fort, the ditches stop short of the presumed line of the Wall, though there are hints that the inner two are beginning to curve inwards, an impression reinforced by the line of the outer ditch which appears to narrow and gradually merge into the middle ditch. The ditches reveal the basic shape of the fort to be a regular parallelogram rather than a rectangle, though the ditch stub-ends outside the north-west corner hint that this may not have been the original intention. There is no indication that the fort was provided with an annexe on either its east or west sides (but see discussion of the bathhouse below). The prominent narrow negative anomaly running east/west across Area E is a more recent, extant ditch line (Figure 4.1.5).

Because the farm and the housing which had developed from its steading occupied most of the interior of the fort, there was very little opportunity to understand its internal arrangements. The best evidence comes from the earlier, lower resolution gradiometer survey in the north-east corner (Area C) (Figure 4.1.4). A narrow positive linear anomaly running parallel to, and some 15m behind, the northern frontage of the fort could be structural though, given the consistent use of timber buildings in the *praetentura* of Antonine Wall forts, if it is a Roman feature it is perhaps more likely to reflect a stone-lined drain. Various short, mainly positive, linear alignments, some at right angles to each other, are visible further into the fort. These are suggestive of structures, but are insufficiently clear to offer identifications. Some of the discrete positive anomalies also visible may be pits. Though anomalies are apparent elsewhere in Areas A and E, their extent is limited and their orientation and/or relationship with the ditches suggest that they probably do not relate to the Roman fort.

The strongest evidence for an associated external structure comes from just outside the north-west corner of the fort. There are strong hints of activity in this area and slightly further south in the gradiometer survey in the form of groups of largely positive sub-circular anomalies (Figure 4.1.5). They do not define the form of a structure, but may represent large pits or furnace-like features. The GPR survey, however, clearly reveals a stone-walled, rectilinear building here that is particularly evident in the time slices representing depths of 1.5m and 1.75m (Figure 4.1.7). The building is at least 22m in length and apparently L-shaped. It is irregularly subdivided into small rooms and seems best interpreted as a bathhouse. Though bathhouses at forts on the Antonine Wall are commonly found in annexes, some were simply located outside the fort, as at Duntocher and Croy Hill. However, that this example lies immediately to the south-east of the line of the ditch stub-ends may suggest that it had originally been intended to create, from a larger fort enclosure, an annexe to the west of the fort to contain the bathhouse.

Though excavation ahead of a major sewer pipe installation in 1999 had demonstrated the existence of a rectangular field system some 150m north-west of the fort beyond the line of the Wall, gradiometer survey immediately to the south of that excavation failed to identify any obvious continuation of these features. These were presumably either too slight to register or were drowned out by the strong dipolar signal which defines much of the northern limit of the survey in Area D (Figure 4.1.1). Parallel bands of low resistance *c*.7 m apart on a similar alignment were apparent in the much more limited resistance survey that extended over the pipeline to the river bank (Figure 4.1.6). However, they are both too broad and too closely spaced to be field ditches, and are more likely to represent later rig and furrow cultivation. There are numerous other magnetic anomalies to the west of the fort in Area D, some of which run parallel to the Wall line in places, but there are no clear indications of what might reasonably be identified as Roman extra-mural activity. Some features may be easily dismissed as modern field boundaries or pipelines, others are less readily identifiable, such as the

curving negative linear anomaly some 60m south-west of the triple ditch stubs, but most seem best explained either by the effects of the underlying geology, earlier agricultural activity or metal debris.

4.2 Shirva

(NGR: NS 68700 75200 to NS 69000 75500; Canmore 45157, 45164 and 45162)

Ditch, Rampart, Military Way and potential fortlet

Site-specific references

Strang and Walker 1995; Keppie 1998: 15-18, 67-68, 93-94 and 113-18; Glendinning 1998a; Glendinning and Cressey 1999; Dunwell *et al.* 2002: 271-274; GSB 2007a; *DES* 1995: 92; 2018: 68; Lowther 2018; Hannon and Blake 2023e

Geophysical surveys (Figures 4.2.1 and 4.2.2)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
Strang and Walker; 1995	R	-	Series of widely spaced single traverses
CFA; 1998	R: Geoscan RM15	1.62	1, 1
GSB; 2007	G: Bartington Grad 601-2 R: Geoscan RM15	3.9 1.1	0.25, 1 1, 1
HES; 2022	G: Sensys MX-PDA	0.35	0.125, 0.5ss

Introduction

Though famous because of the large number of inscribed and sculptured stones found there in the early 18th century (below), the line of the Wall at Shirva is perhaps one of the least well-known rural stretches, presumably because it crosses an area of very low-lying, boggy farm land and was bisected by the Board Burn. The now heavily canalised course of the River Kelvin runs less than 250m away to the north-west and the Forth and Clyde canal cuts through the Wall to the east. Apart from one small curving section of Ditch immediately to the east of Wester Shirva farm, whose significance was not fully recognised until the 2nd edition, all trace of the line between the farm and the canal had already disappeared by the time the 1st edition Ordnance Survey mapping was undertaken in 1859. Though Roy does record the line here in his Military Survey Map of

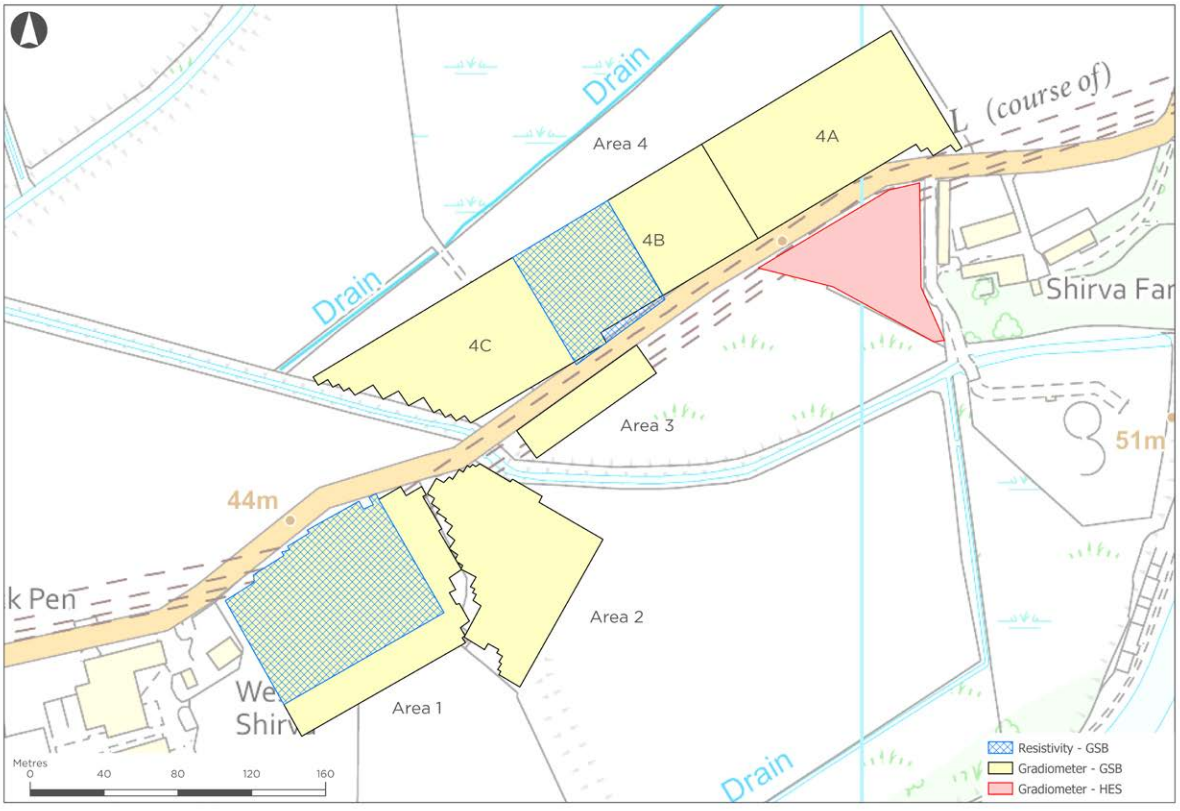

Figure 4.2.1. Location of GSB and HES surveys at Shirva (after GSB 2007a, Fig. 2 with additions).

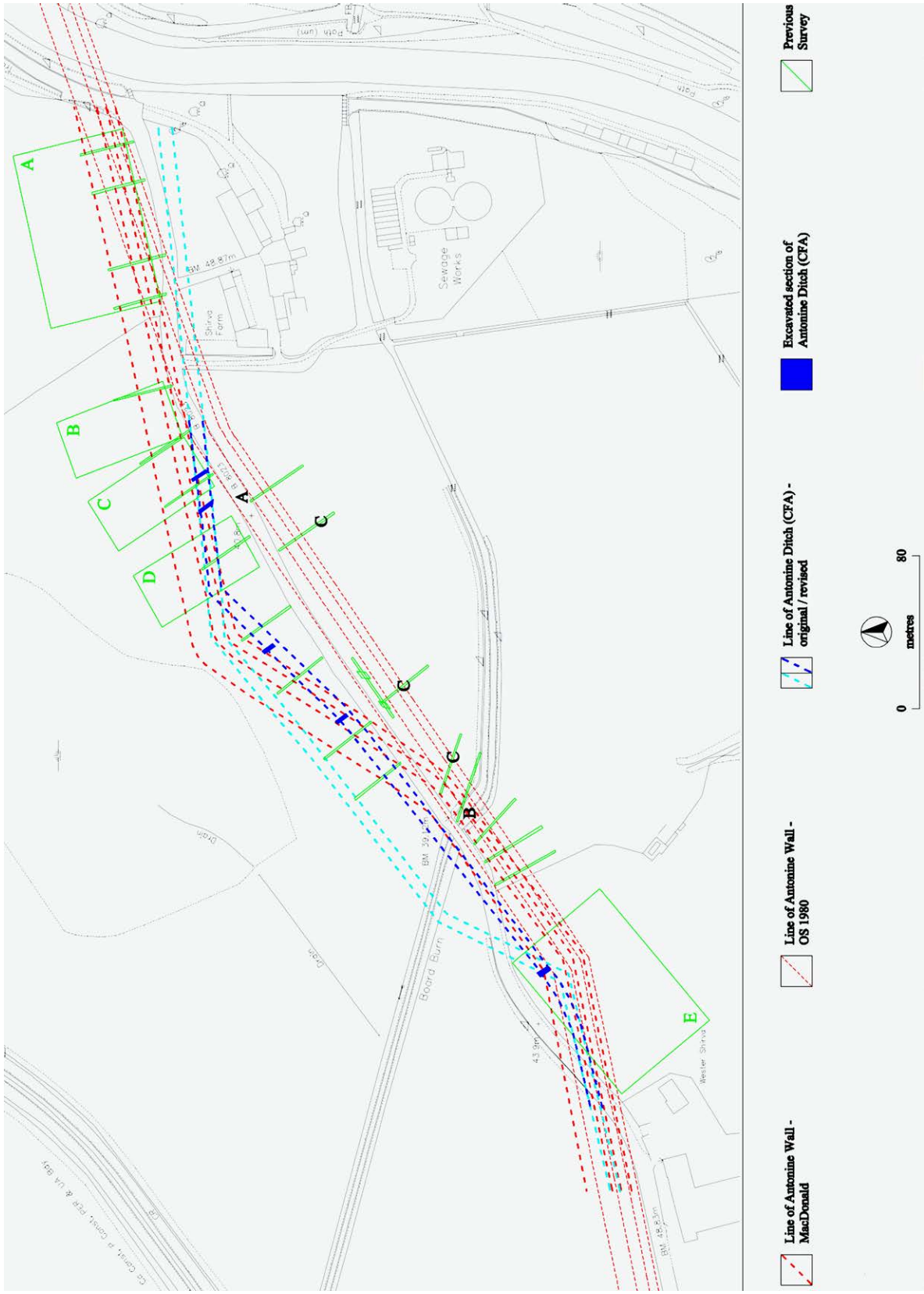

Figure 4.2.2. Location of CFA and Strang and Walker surveys at Shirva along with various alternative suggested Wall lines (after GSB 2007a, Fig. 1).

Figure 4.2.3. LiDAR image of the Wall line from Wester Shirva to Shirva.

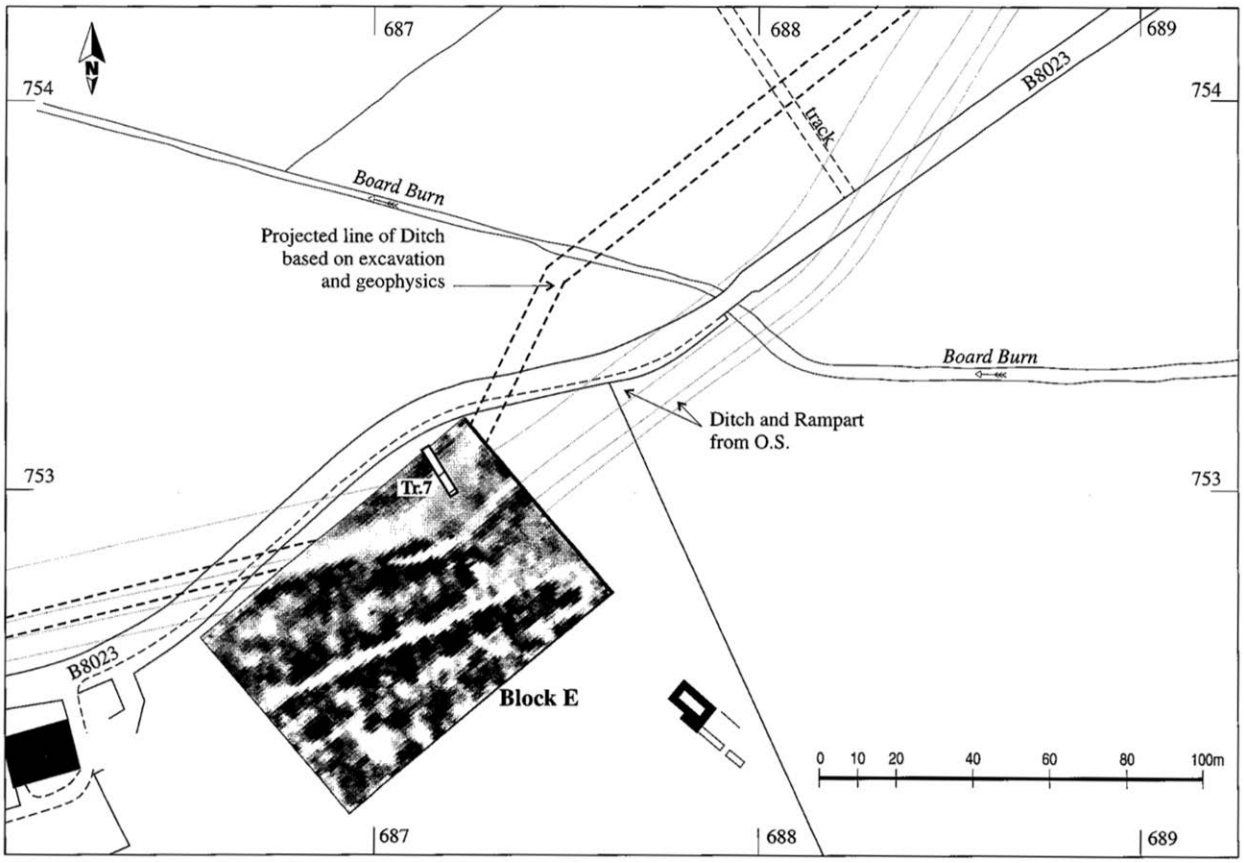

Figure 4.2.4. CFA resistance survey at Shirva, Block E, showing high (dark) and low (light) resistance values (after Glendinning 1998a, Fig. 3).

Figure 4.2.5. GSB resistance survey at Shirva (after GSB 2007a, Fig. 6 with additions).

Scotland (1752-55, Lowlands Strip 5, Section 6c), it does not feature in the more specific illustration of the Wall published posthumously (1793: Fig. 35) (Figure 1.4). Beyond the short section east of Wester Shirva farm, nothing is currently visible in the LiDAR data (Figure 4.2.3) or on the ground and, because of the alluvial soils and general dampness of the ground, the area is not conducive to the production of cropmarks.

Between 1726 and 1731 several inscribed and sculpted stones, along with a variety of other Roman dressed stonework, were recovered from the line of the Wall at Shirva in the course of farming activity and subsequent delvings. At the time they were thought to derive from a Roman tumulus, but the range and character of the material involved, including funerary sculptures and building stones, along with the circumstances of their recovery from an elongated structure within the Ditch, make clear that they had been re-used, almost certainly within an Iron Age souterrain. Though the possibility of a fortlet at Shirva has been suggested on grounds of spacing (Hanson and Maxwell 1986: 127), given their character there is no reason to believe that the inscribed stones would have come from it. Rather, they are likely to have derived from one of the adjacent forts and its cemetery, most probably Auchendavy.

Because of uncertainty about the line of the Wall here, it has been checked several times in recent years both by geophysical survey (considered in more detail below) and by excavation. In 1998 and 1999 the Centre for Field Archaeology was able to confirm the location of the Ditch in several narrow trenches between Shirva Farm and the Board Burn, as well as to the east of Wester Shirva farm, though the final suggested line did not always entirely comply with that indicated

Figure 4.2.6. GSB gradiometer survey at Shirva (after GSB 2007a, Fig. 3 with additions).

in their resistance survey. No other elements of the Wall were identified, apart from possible traces of the Upcast Mound in one trench. A section cut across the probable Ditch line slightly closer to the Board Burn by AOC Archaeology in 2001 failed to detect the ditch, presumably because it coincided with a palaeochannel. Finally, most recently in 2018, excavation within the farmyard and to the north of the farmhouse at Shirva, also by AOC Archaeology, identified the stone base of the Wall and its adjacent ditch.

Glacial sands and gravels, as well as alluvium, make up the area; such deposits should have no significant impact on the outcome of the gradiometer and resistance surveys. The areas of survey (Figures 4.2.1 and 4.2.2) were variable in character. GSB's Area 1 immediately to the east of Wester Shirva Farm, corresponding with CFA's Block E, consisted of rough pasture with much surface iron debris. The latter caused some difficulties for the gradiometer survey. Survey conditions in GSB's Areas 2 and 3, which also incorporated some six of Strang and Walker's resistance traverses, were challenging. Area 2 was low lying, boggy and steeply sloping in places, and Area 3 was similarly boggy and also severely overgrown. By contrast, GSB's extensive Area 4, corresponding with CFA's Blocks B-D and a further eight of Strang and Walker's traverses, was undulating and under pasture, conditions similar

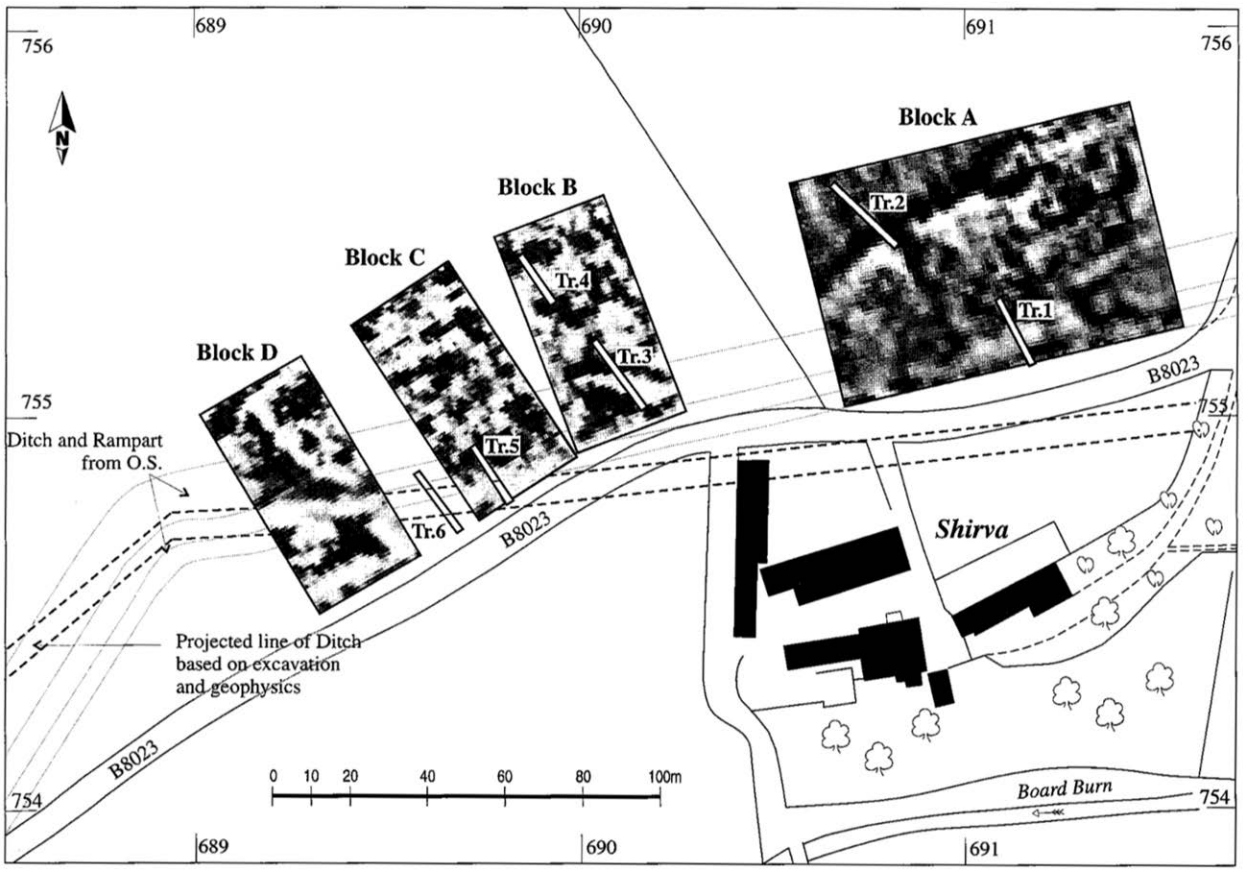

Figure 4.2.7. CFA resistance survey at Shirva, Blocks A-D, showing high (dark) and low (light) resistance values (after Glendinning 1998a, Fig. 2).

to those in CFA's Block A, whose coverage incorporated four more of Strang and Walker's traverses. Finally, HES's limited survey in 2022 sought to confirm the line and investigate the potential location of a fortlet on the higher ground on south side of the main road immediately to the west of Shirva Farm.

Results

The Ditch is visible in the CFA survey (Block E) as a broad, low resistance anomaly on the south side of the main road to the east of Wester Shirva Farm (Figure 4.2.4). This short section is also recorded in the 2nd edition Ordnance Survey 25-inch mapping and is very faintly visible in the LiDAR data. The Ditch is clearly changing direction at this point, curving to the north-east and crossing the line of the modern road. The same phenomenon is recorded in the later, higher resolution GSB resistance survey and also in their gradiometer survey, where it appears as a broad negative anomaly (Figures 4.2.5 and 4.2.6). The Ditch was confirmed in CFA's excavation (Trench 7), though the relevant section did no more than trace the uppermost fills. However, the suggested revised alignment of the Ditch in the published plan (Dunwell *et al.* 2002: Illus 11) seems at odds with the geophysics. The detailed interpretation of the gradiometer survey is more complicated. There are strong dipolar signals caused by various forms of modern intrusion, including scattered iron debris and underground utility supply pipes, traces of the latter also readily visible in the resistance survey. Nonetheless, in the north-western corner of the GSB's Area 1 a *c.* 3.5m wide mottled band of positive and negative anomalies can be traced for at least 35m running parallel with the ditch and some 11m behind it. The characteristics of the signal are similar to those produced by the Rampart base at several fort sites, such as Duntocher, Castlehill and Mumrills (Chapters 2.3, 2.5 and 6.5). Given its location the same interpretation seems the most likely here, rather than it being the line of the Military Way as suggested in the original report. More problematic is the inverted Y-shaped negative anomaly in the north-east corner of Area 1. This is also visible in the resistance survey, though only very faintly on its south side, suggesting that it may be a less substantial feature. Close examination of the LiDAR data (Figure 4.2.3) would seem to indicate that this Y-shaped anomaly reflects variations in the local micro-topography and is of geomorphological origin.

The CFA survey picks up the line of the Ditch on the north side of the main road across Blocks C and D,

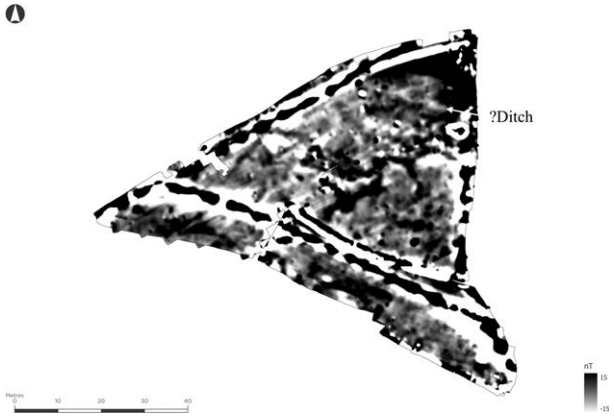

Figure 4.2.8. HES gradiometer survey at Shirva.

again visible as a broad low resistance anomaly (Figure 4.2.7). This was confirmed in two excavated sections (Trenches 5 and 6), though again these examined only the uppermost Ditch fills. The Ditch shows only faintly as a relatively narrow band of lower resistance mirrored by a band of slightly raised resistance running north-east/south-west along the southern side of the limited area of the GSB survey (Area 4), its south side partially masked by a band of high resistance of more recent origin along the field edge (Figure 4.2.5). However, the line is very clear as a broad negative linear anomaly across most of their gradiometer survey (Figure 4.2.6), broken only by the broad magnetic disturbance where it is crossed by the trackway into the field. It follows a slightly undulating course continuing the alignment established in Area 1. There is no indication of any adjustment of the line on either side of the Board Burn, which has been postulated.

Some 120m west of Shirva Farm the Ditch line turns quite sharply back eastwards (Figure 4.2.6). Approximately 10m beyond this change of alignment a short negative linear anomaly can be seen running at right angles to the rear of the Ditch for some 17m before it too turns through 90 degrees to the east. Given the position on slightly raised ground overlooking the crossing of a waterway at a point where the Wall makes a substantive change of alignment, it is tempting to suggest this represents the western ditch of a fortlet. However, it encroaches too close to the Wall Ditch, leaving no room for the Wall Rampart, and does not enclose a sufficiently large area to be confidently identified as such. Excavation by AOC Archaeology immediately to the north of Shirva farm in 2018 confirmed that the Wall continued on the east-west alignment established by gradiometer survey to the west. HES's gradiometer survey (Figure 4.2.8) was badly affected by the masking effect of various dipolar signals from service trenches and ferrous fencing. It is only because the line of the Ditch had been established by earlier survey to the west, and the orientation of the Rampart confirmed by excavation to the east, that the line of the Wall could tentatively be identified.

As the various previously postulated alignments illustrated in Figure 4.2.2 make clear, it is only through the application of extensive geophysical survey, with confirmation from limited trenching, that the line of the Wall between the farms of Wester Shirva and Shirva has been established with any degree of confidence. So far, at least, the postulated fortlet in the vicinity has not been identified, though a location on the higher ground, largely occupied by Shirva Farm, remains a strong candidate.

4.3 Bar Hill

(NGR: NS 70746 75926; Canmore 45872, 45899 and 45920)

Rampart, Military Way, possible fortlet, temporary camp and environs

Site-specific references

Macdonald and Park 1906; Robertson *et al.*1975; Keppie 1985; Keppie and Walker 1989: 151-53; *DES* 1974: 34; 1976: 70; 1995: 92; Jones *et al.* 2008c; Jones 2022a

Geophysical surveys (Figure 4.3.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
Strang and Walker; 1995	R	-	Series of widely spaced single traverses
Glasgow University; 2006;	G: Geoscan FM36	3 (Areas A-D)	1, 1
	R: Geoscan RM15	0.4 (within Area A)	1, 1
2022	G: Bartington Grad 601-2	0.56 (Area E)	0.25, 1

Introduction

The fort is located on sloping ground straddling the top of Bar Hill at an elevation of 150m, the highest point of any fort on the Wall line. It commands good views to the north as well as along the Wall in both directions, though partially blocked to the north-east by the Iron Age fort situated on the adjacent higher summit of Castle Hill (Figure 4.3.1 and 4.3.2). Bar Hill is the only fort on the line not to be attached to the running barrier, which may suggest that there is a

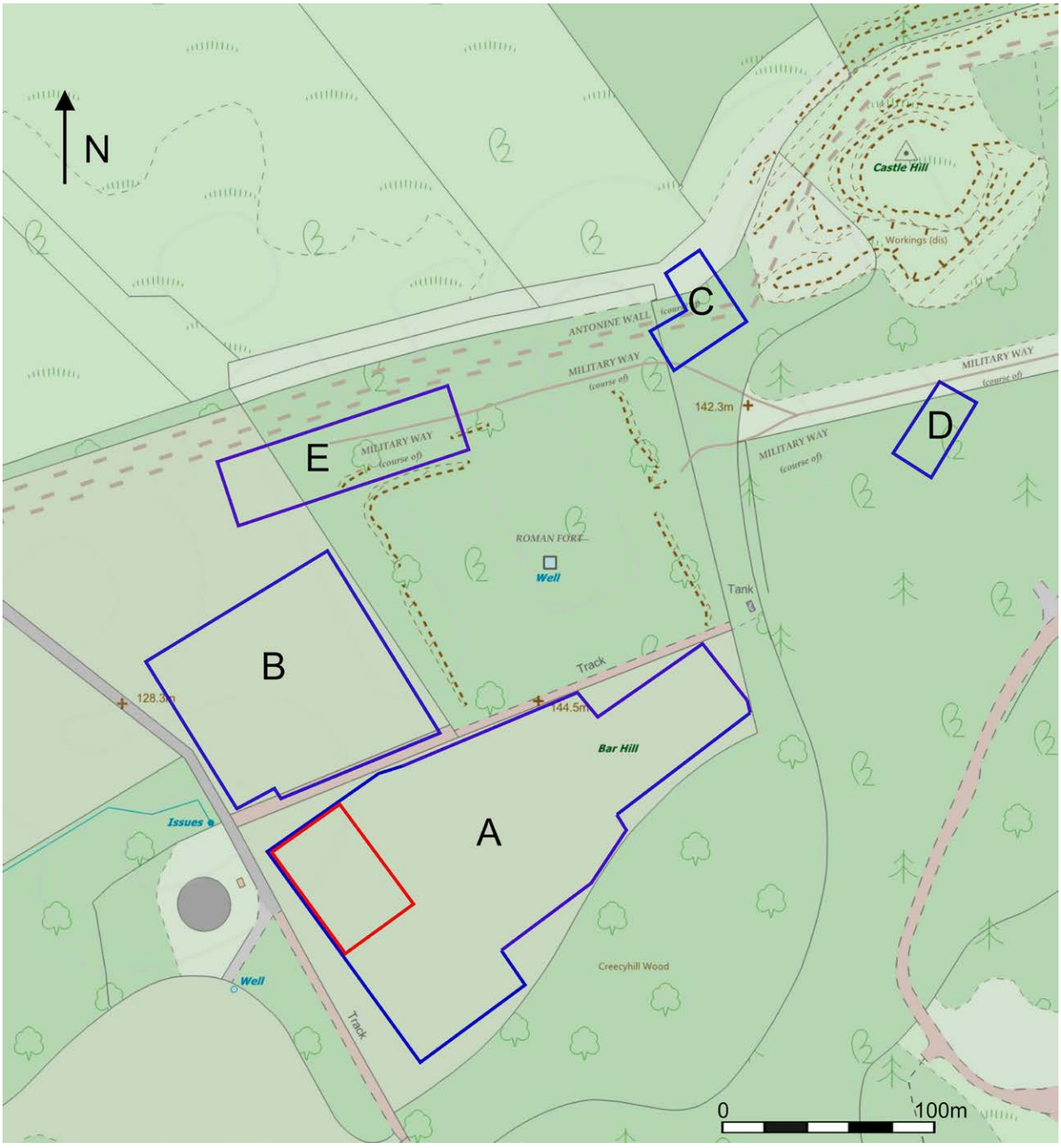

Figure 4.3.1. Location of Glasgow University survey areas at Bar Hill. The resistance survey within Area A is outlined in red.

fortlet nearby, yet to be discovered, which would have provided essential access to the north through the Wall (Hanson 2020: 7-8).

Existence of the Roman fort was noted by various antiquaries in the 18th century (e.g. Sibbald 1707: 29), most of whom were able to provide plans (Gordon 1726: 54 and pl. 22; Horsley 1732: 169 and 176 N3; Roy 1793: 160 and pl. 35). Its outline remains largely extant, as is clear in both aerial photographs and LiDAR images (Figure 4.3.2), and some of the excavated stone internal buildings have been consolidated for public display.

Extensive excavations were undertaken by Macdonald and Park between 1902 and 1905 (Figure 4.3.3). These revealed a turf rampart on a cobble base, enclosing an area of 1.3ha, with simple timber gateways in each side. The fort was surrounded by double ditches, except to the north where, facing the back of the Wall, there was only one. In the central range the headquarters building (1), with its famous deep well, and a granary (2) were uncovered, along with part of another building of uncertain function (3), all stone-built. The waterlogged preservation of timber uprights still in their post-holes facilitated the identification of at

Figure 4.3.2. LiDAR image of the fort and immediate environs at Bar Hill.

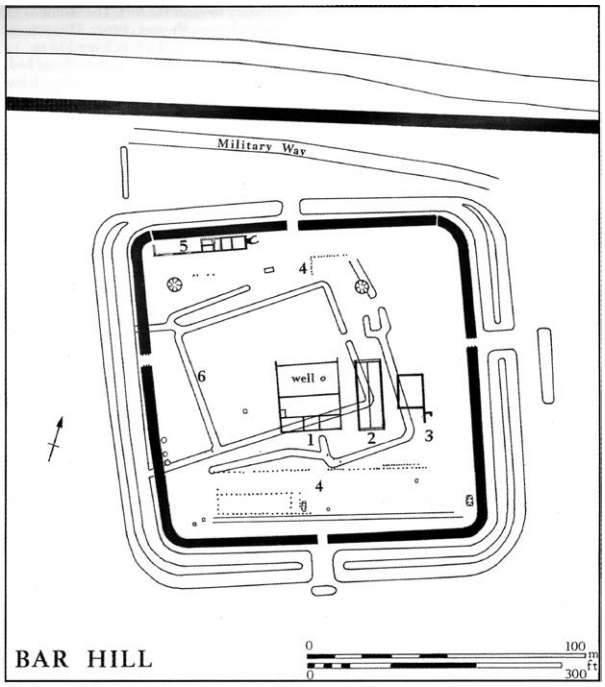

Figure 4.3.3. Bar Hill: excavation plan of the fort (after Robertson 2015, Fig. 55).

least three timber barracks in the *retentura* and other more fragmentary buildings, probably also largely barracks, in the *praetentura* (4). Tucked into the back of the rampart to the west of the north gate were remains of a long narrow bathhouse (5). A much smaller, rectilinear, largely double-ditched enclosure was noted beneath the fort, lying at a slightly oblique angle to its successor (6), which continues to be visible in the LiDAR data (Figure 4.3.2). Though Macdonald claims the discovery was both accidental and unexpected, the plans made by both Gordon and Horsley (e.g. Figure 1.3) suggests its general outline was still visible in the early 18th century. This earlier enclosure was thought by Macdonald to relate to the Flavian occupation of the isthmus, though its ditches were packed with rubble where they ran beneath the wall foundations of the headquarters building.

Further excavation between 1978 and 1982 by Keppie, in advance of consolidation of the headquarters building and bathhouse for public display, discovered a pottery kiln built into the stoke-hole of the latter. They also indicated that, prior to construction of the former, the ditches of the earlier enclosure showed no sign of silting and had been deliberately packed with brushwood and turf. Accordingly, this enclosure, along with that beneath the nearby fort at Croy Hill (below, Chapter 4.5), is now interpreted as relating to the surveying or perhaps construction of the Wall (R.H. Jones 2011: 323 and 330).

Macdonald and Park undertook only limited examination of areas outside the fort. The line of the Military Way was confirmed approaching from the north-east, with a bypass road running between the fort's northern rampart and the back of the Wall. Both these alignments are still faintly visible in the LiDAR data (Figure 4.3.2). Macdonald also noted a short stretch of ditch south of the bypass road that he thought served to drain away any overflow from the ditches at the north-west corner of the fort. Limited indications of presumed civilian settlement, in the form of hearths associated with abundant pottery, were recorded to the north-east on the ridge between Castle Hill and the fort in an area where an altar to Silvanus had been recovered in 1895 (*RIB I* 2167).

Roman activity to the south of the fort is variously attested. In 1825 Skinner records seeing pieces of buried amphora, possibly a cremation burial, recently recovered from this area (Keppie 2003: 218-19), while Macdonald notes the discovery of an otherwise imprecisely located section of ditch in *c.* 1908 (1934: 281). More recently fieldwalking in the mid-1970s recovered small finds of Roman date, including pottery, glass and even a small bronze statue, while aerial survey in 1979 by RCAHMS identified what was subsequently confirmed by excavation as the east side of a temporary camp.

The general aim of the first Glasgow University geophysical survey was to detect features that might be associated with Roman extra-mural settlement and/or annexes. Though accumulated information seemed to favour the location of civilian settlement alongside the Military Way to the east of the fort, most of that area has long been afforested and, despite extensive felling to the south of the fire break that marks the line of the Military Way not long before the survey, debris littering the ground rendered the prospects for successful geophysical survey remote, so that only a limited area (Area D) was selected for trial grids. The bulk of the effort was invested in prospecting within the more accessible and open areas to the south and west of the fort (Areas A and B respectively).

Subsequent survey focused on the area to the north of the fort. A limited area (Area C) was examined running across the line of the Wall at a point where it changed direction quite sharply after skirting the bottom of Castle Hill and where the line of the Ditch is less clear. The last area to be examined (Area E) was located in the gap between the Wall and the north rampart of the fort in search of the fortlet that has been postulated here to provide a gateway through the Wall for the garrison of the fort, whose secondary character is indicated by the Antonine enclosure lying beneath it (Hanson 2020: 209-10). This search centred on the small stretch of

ditch running at right angles away from the north-west corner of the fort that had been recorded by Macdonald and Park. The western limit of Area E seems likely to have coincided with part of the area surveyed by Strang and Walker, which was designed to confirm the route of the Antonine Rampart to the north-west of the fort and to test whether any evidence of possible southward extensions of the Wall-base could be detected.

North and west of the fort are limestone coal formation mudstone, siltstone and sandstone as well as till, which are generally conducive to geophysical survey. Close to the south and east of the fort lie igneous rocks of the Mid Valley sill complex of quartz and microgabbro, which are less favourable to gradiometer survey. The soils are brown earths and the fields to the south and west had clearly been regularly ploughed, removing all obvious trace of the northern defences of the fort in the former. Both fields were in pasture so survey conditions there were good. Area A was delimited to north by the fort and the public path leading to it, and to the south and east by a stone wall and woods. The northern edge of Area A was damp and boggy with water draining out of the field at the north-west corner. There is a steep slope down to the west and north in Area B. Conditions at Area D were difficult because of the debris from recent logging. Survey in Area C was constrained by the fence to the north delimiting the guardianship site and by trees to the south, while Area E was on sloping ground with significant tree cover.

Results

The most obvious features in Area A (Figure 4.3.4) are the double ditches of the southern defences of the fort, visible in the gradiometer survey as parallel negative anomalies, though slightly masked by the strong positive and associated negative anomaly which represents the line of the modern trackway and fence running along much of the northern edge of the survey. The *titulus,* offset in front of the south gate, may also be visible, but only very faintly. Further to the west the eastern ditch of the known temporary camp is apparent as a thin negative anomaly orientated north-south.

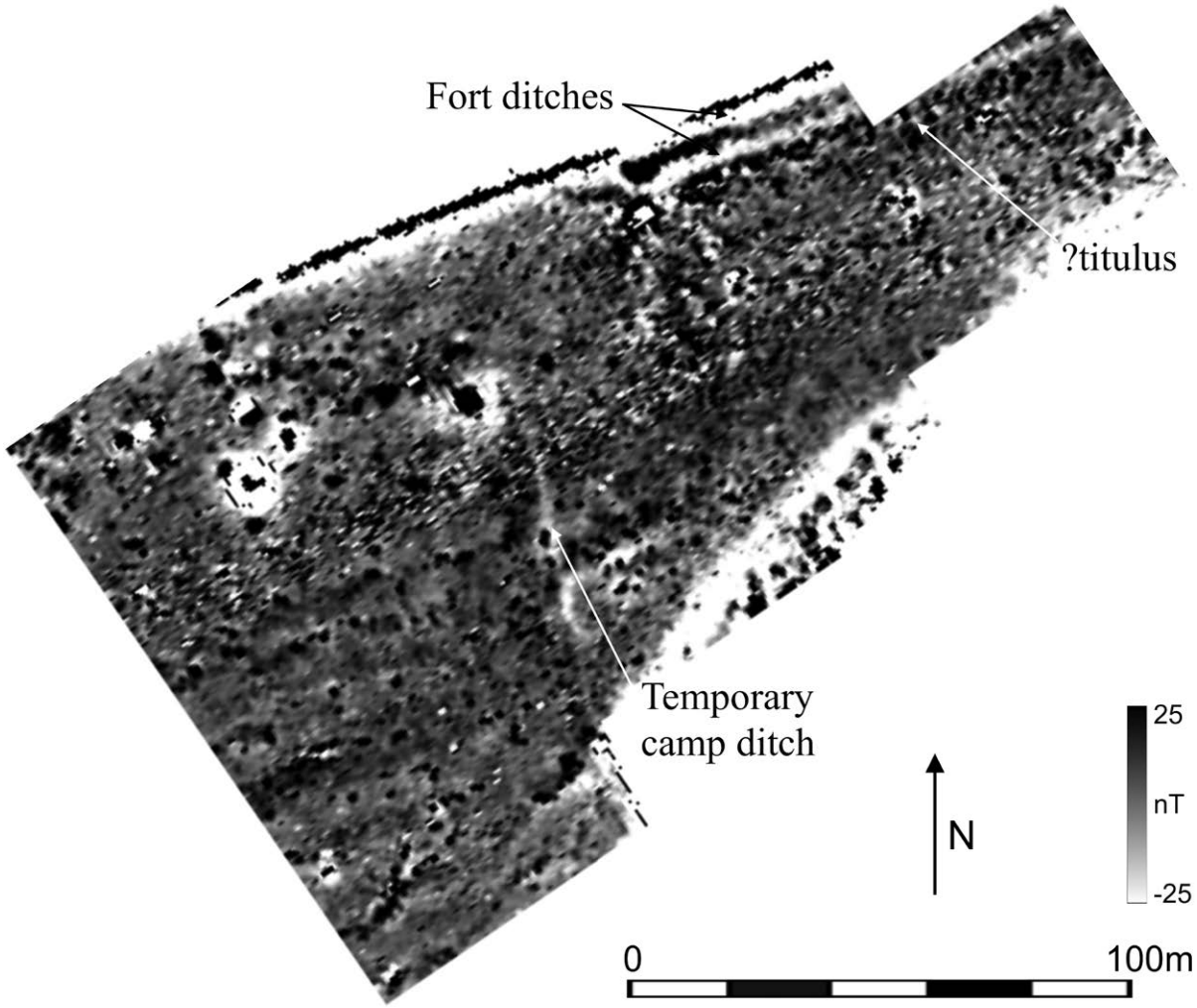

Figure 4.3.4. Gradiometer survey of Bar Hill, Area A.

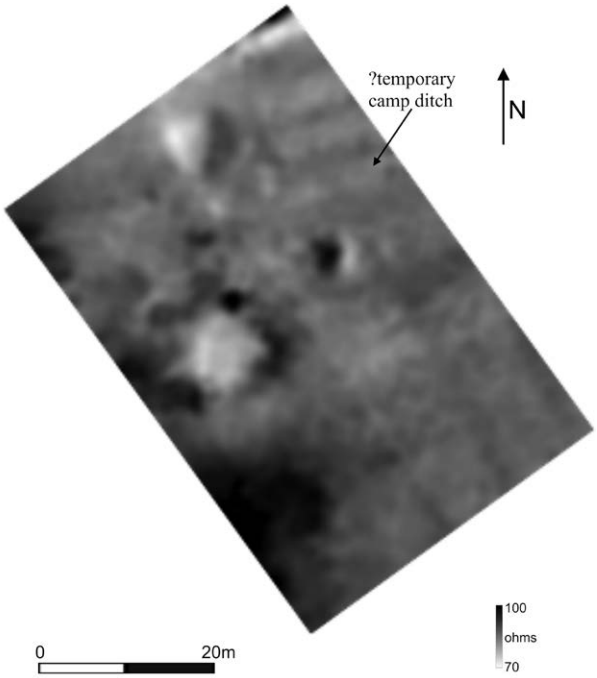

Figure 4.3.5. Resistance survey of Bar Hill, Area A.

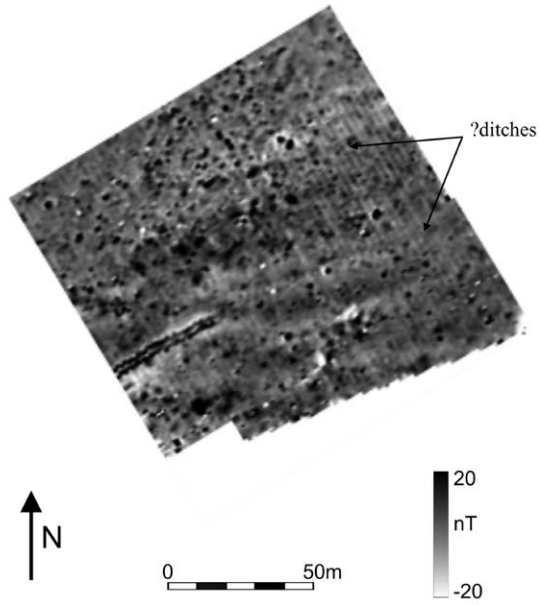

Figure 4.3.6. Gradiometer survey of Bar Hill, Area B.

Though it runs through some areas of disturbance, it can be traced as far as the southern limit of the survey. The beginnings of the curve defining its north-eastern corner are just apparent, but any westward continuation is lost amid strongly positive and dipolar magnetic anomalies. It may be faintly apparent in the limited resistance coverage as a thin band of slightly raised resistance running between discrete subcircular areas of both low and high readings, though similar bands to the north of it may indicate that they all merely reflect later ploughing (Figure 4.3.5). Some of the numerous discrete, large magnetic and resistance anomalies scattered across the north-west quadrant of Area A could be ovens, but could as easily be the result of surface mining activity or other modern disturbance. Indeed, the whole survey area is quite magnetically noisy, largely the result of the proximity of igneous geology, most apparent as a 20m wide speckled band running from north-east to south-west across the entire field.

Area B (Figure 4.3.6) is similarly magnetically noisy with a slightly curving sequence of banding apparent on an east-west alignment, presumably reflecting the underlying geology. However, there are two narrow parallel, slightly positive anomalies on the same general alignment some 40m apart. These may be ditches, the more northerly perhaps related to the line of the road leaving the west gate of the fort. Unfortunately, the most obvious man-made feature is a short linear alignment made up of two narrow but strongly positive anomalies on the western side that seem most likely to be field drains.

Though there is a small concentration of discrete positive anomalies towards its centre, there are no obviously recognisable archaeological features visible in Area D. Similarly, the most dominant features in Area C are almost certainly modern. However, a curving slightly positive band some 5m wide, defined on each side by very thin negative lines, seems too wide to be the remains of a cart track and may represent the stone base of the Antonine Wall where the kerbs have been robbed out.

According to the Strang and Walker's summary report, significant variation in resistance occurred at several points along the southern edge of the Wall base, but we have not been able to access a plot of these results. They concluded that the Military Way appeared to run about 8m to the south of the Wall, on a line consistent with a continuation of the bypass line recorded by Macdonald and Park, but possibly converging towards the Wall near the western gate of the field. Similar results were obtained from Area E (Figure 4.3.7), where the Wall was represented by a largely positive linear band of varying width and consistency, mirrored on its north side by a narrow negative anomaly. Indications of a linear negative, presumably the southern side of the Ditch, ran along the northern limit of the survey, indicating a Berm width of some 8m. The large, strong positive anomaly on the line of the Ditch to the west of the field

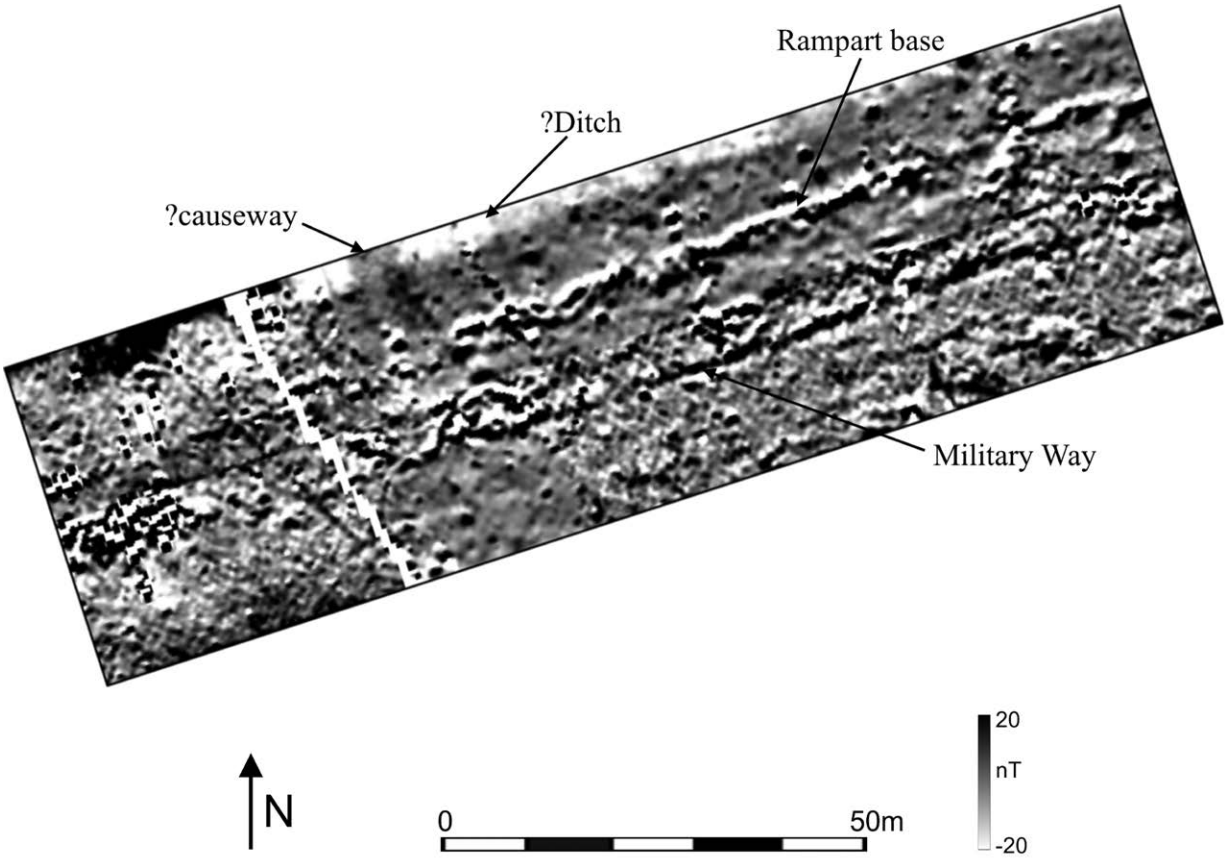

Figure 4.3.7. Gradiometer survey of Bar Hill, Area E.

boundary defining the guardianship area suggests that the Ditch there may have been infilled with stones. To the south of the Wall, the somewhat speckled, *c.* 6m wide band, defined on both its north and south sides by a narrow positive linear anomaly, clearly represents the Military Way. It runs rather closer to the Rampart, only some 4m behind it, and at a slightly less oblique angle to the Wall line than was indicated by Macdonald and Park. There were no clear signs of either a rampart or ditch(es) that would identify the site of a fortlet, though neither was there any trace of the 'overflow' ditch recorded by Macdonald and Park. However, there were indications of a break in the line of the Ditch in the right position for a causeway, with slight hints of an equivalent break in the line of the Rampart behind it.

4.4 Girnal Hill/Nethercroy

(NGR: NS 720 761; Canmore 45872, 45902 and 108953)

Ditch, Military Way and possible fortlet

Site-specific references

GSB 1994; Keppie *et al.* 1995: 643-49; Hannon 2018: 308-10

Geophysical survey (Figure 4.4.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
Bradford University; 1989	R: Geoscan RM4	-	1, 1
GSB; 1994	G: FM36	*c.* 1.25 in several parallel sections extending S from the AW; *c.* 0.5 at location of possible fortlet	0.25, 1

Introduction

From a point some 250m east of Castle Hill, the line of the Wall runs down a gentle east-facing slope in a straight line to Girnal Hill. It is then lost for some 200-300m on either side of the modern Kilsyth Road (B802) before broadly the same alignment is picked up to the east of Nethercroy Road on the lower slopes of the ridge leading up to Croy Hill. The partially extant remains of the Ditch and/or Upcast Mound to the west of Girnal Hill were recorded in the 1st edition Ordnance Survey mapping, though by the time of the 2nd edition the

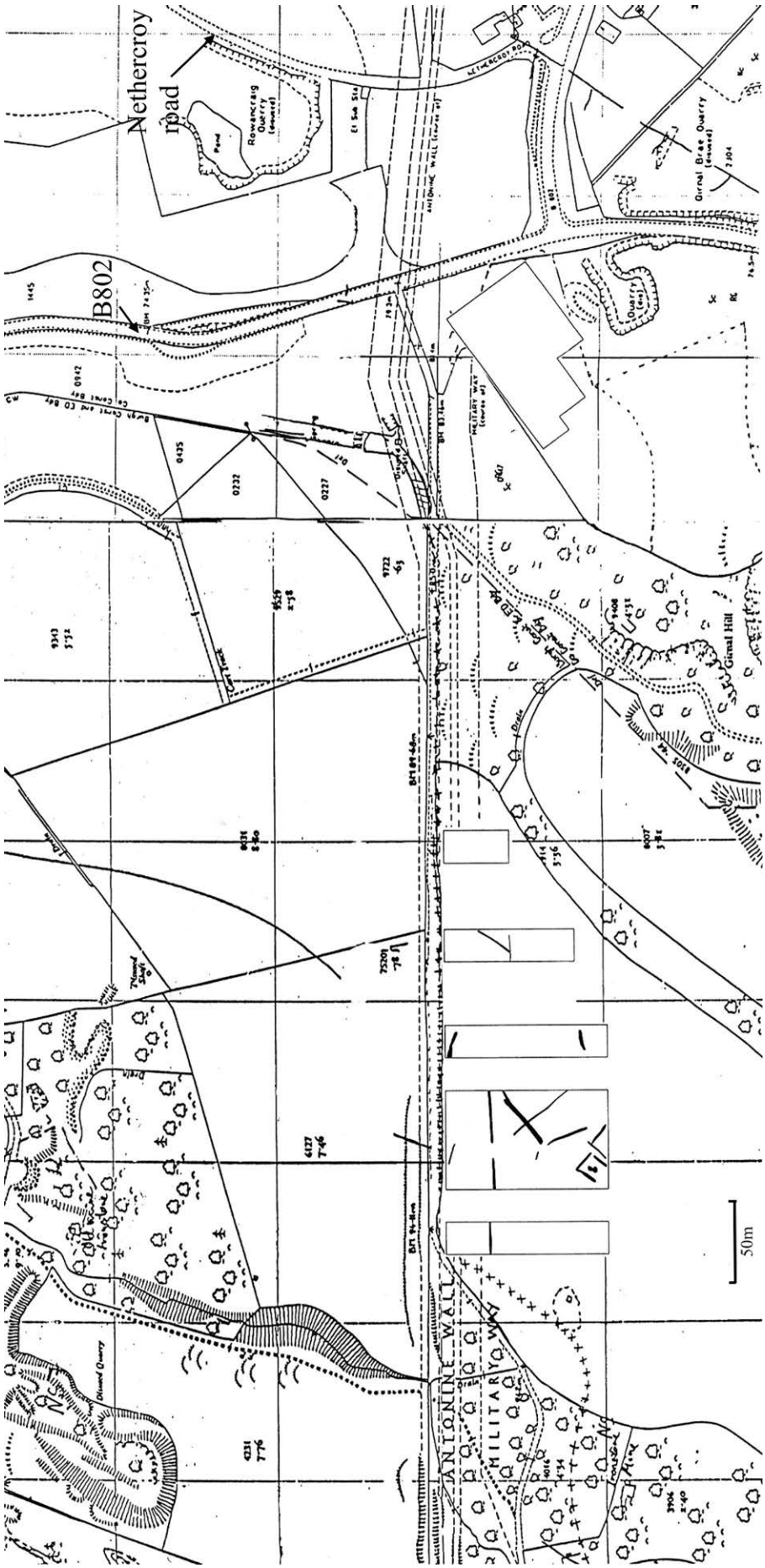

Figure 4.4.1. Location and original summary archaeological interpretation of GSB's gradiometer surveys at Girnal Hill (after GSB 1994, Fig. 2b).

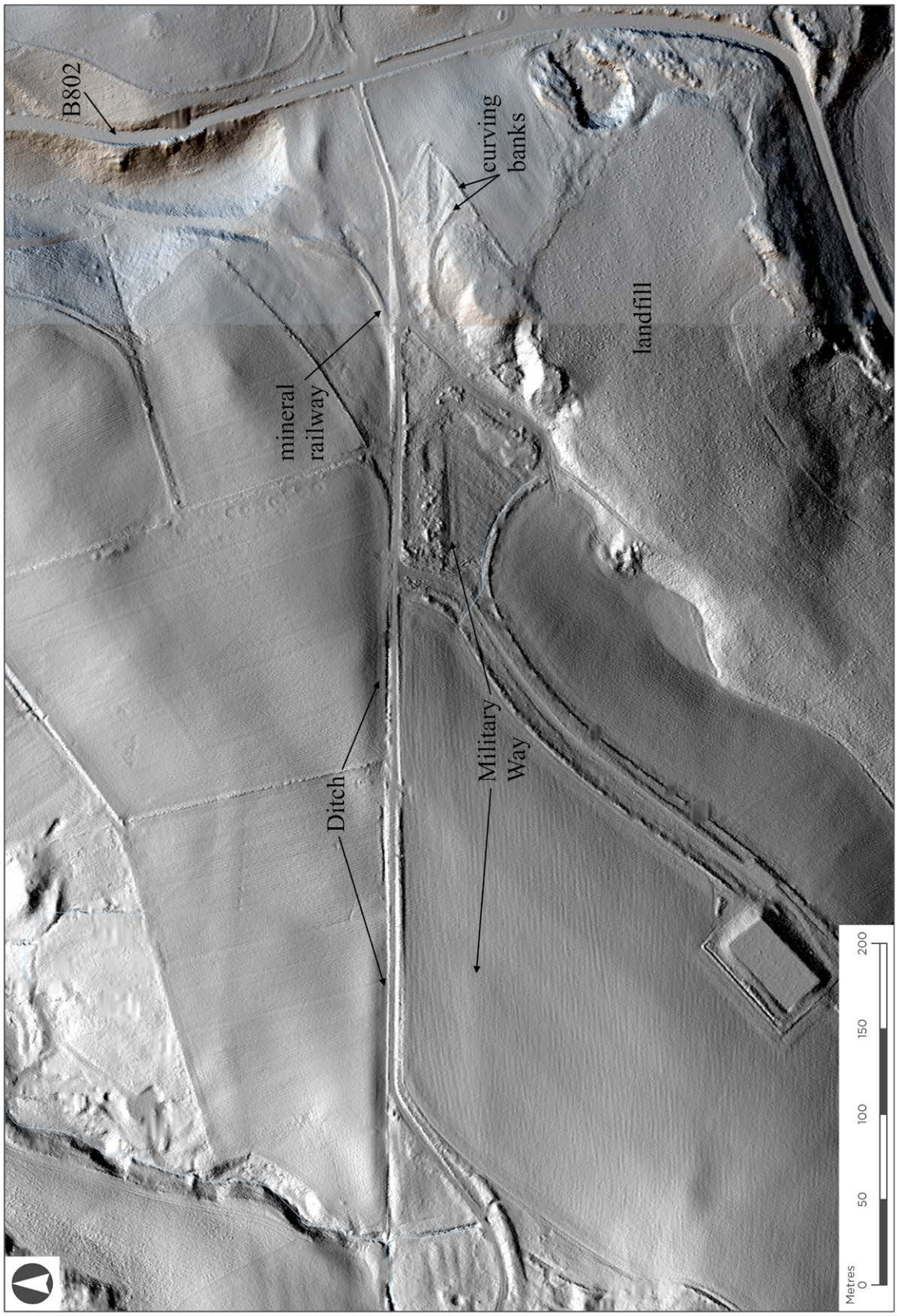

Figure 4.4.2. LiDAR image of the slightly extant line of the Ditch and Upcast Mound to the north-west of Girnal Hill. The broadly parallel line of the Military Way to the south is clearly visible as a cutting or as a very slight linear mound in the adjacent field. Curving banks appear to overlie the cutting on the northern slope of Girnal Hill.

Figure 4.4.3. Aerial photograph from 1980 looking west towards Girnal Hill with Hope Park quarry still open to the south. The general topography of the hill is more readily visible without its usual tree cover. The line of the Military Way is apparent as a negative cropmark in the cultivated field in the centre of the photograph. The line of the Wall is represented by the track on the left side of that field (© Historic Environment Scotland SC1725430).

most easterly 100m had ceased to be sufficiently clear to be included. At the eastern end of this stretch the line of the Ditch was followed by a mineral railway line, which subsequently became a farm or forestry track, as it remains today. The line of the Ditch is not easily followed on the ground, but is relatively clear in in the LiDAR imagery (Figure 4.4.2).

Macdonald attempted to trace the Wall across the gap on either side of the Kilsyth Road by selective small-scale trenching, though sadly this is reported on in only summary fashion. He concluded that the line first diverged northwards immediately to the north of Girnal Hill, before returning to the original alignment to the east of Nethercroy Road. This change of direction for no apparent reason, combined with the location midway between the forts at Bar Hill and Croy Hill, has led various authors to suggest that a fortlet may have been sited here. The Wall line was further checked by Keppie in 1988 and 1990 at Nethercroy on the east side of the Kilsyth Road where he was able to confirm the alignment indicated by Macdonald.

Though not recognised by the early surveyors of the Ordnance Survey, the line of the Military Way on the northern slope of Girnal Hill was and still remains extant, set within a quite distinct cutting or terrace. Macdonald recognised this and sectioned the road in several places, though again this is reported on only in summary form. The line of the Military Way as it continues across the cultivated field immediately to the west is occasionally visible on aerial photographs (e.g. Figure 4.4.3). Where it has been protected by its usual covering of trees, the extant remains of the terrace, both on the northern slope of Girnal Hill and continuing slightly further to the west, is particularly clear in the LiDAR imagery (Figure 4.4.2). The western continuation of the Military Way running broadly parallel with the

Figure 4.4.4. The surviving excavated remains of the Military Way on the east side of Kilsyth Road looking south (© James Walker).

Wall line is also still faintly visible in the LiDAR as a very slight variation in elevation in the adjacent heavily cultivated field. To the east, on the other side of Kilsyth Road, Keppie picked up the line of the Military Way in 1990 (Figure 4.4.4), though located slightly further to the south.

The LiDAR image also provides new and potentially significant information. The terrace for the Military Way on the northern slope of Girnal Hill appears to be overlain by a bank or possibly banks curving around the apparently flat-topped hill (Figure 4.4.2). Superficially, these might appear to represent the ramparts of a previously unrecognised later prehistoric defended enclosure, which would have to have been built after the Antonine occupation. However, examination of aerial photographs from the 1970s (e.g. CUCAP BRI30), when the large infilled quarry was still operational, suggests the more prominent inner bank relates to a track curving down the hill from the top of the quarry face.

Several areas were examined by gradiometer survey in the easily accessible cultivated fields on either side of the tree-covered summit of Girnal Hill. Conditions for survey were generally good. A series of long strips of varying width and length located immediately behind the Wall to the west of the hill sought to establish the line of the Military Way, while a large area of the sloping ground to the east beside the Kilsyth Road was investigated to test for the possibility of a fortlet. The Limestone Coal Formation of mudstone, siltstone and sandstone prevails, but in the immediate environs lies the Midland Valley Sill Complex with quartz and microgabbro which would be expected to impact detrimentally on the gradiometer survey. Indeed, the area on the south side of Girnal Hill had been largely quarried away by 1980 (Figure 4.4.3), its subsequent use as a landfill site apparent in the LiDAR image (Figure 4.4.2). The soils in the area are brown earths.

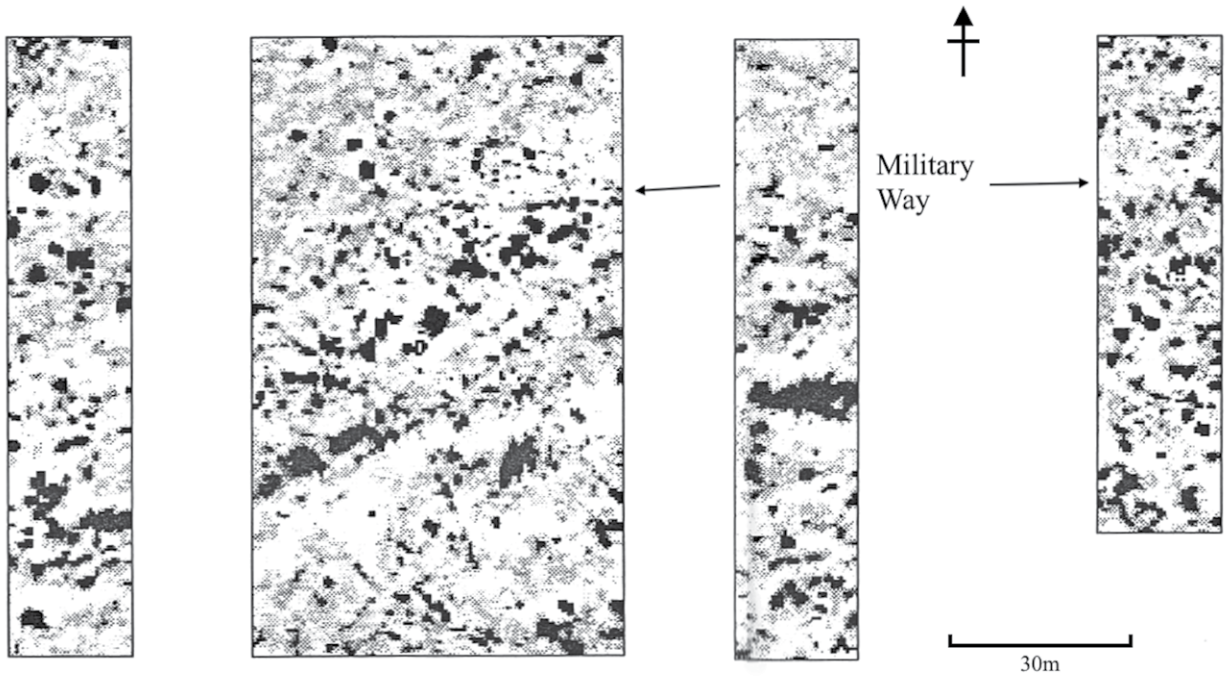

Figure 4.4.5. GSB gradiometer survey strips in the cultivated field to the west of Girnal Hill (after GSB 1994, Fig. 4 with additions).

Results

Limited resistance survey by Bradford University on both sides of the Kilsyth Road, the detailed results of which we have been unable to access, suggested that the Wall followed a much more marked divergence from the line suggested by Macdonald, particularly on the west side. However, excavation by Keppie in 1990 on the east side indicated that the feature that had been recorded was a ridge of natural rock that came close to the surface at this point.

Similar problems were encountered by the later and more extensive gradiometer survey by GSB to the west of the road and further to the west of Girnal Hill, where readings were affected by the igneous geology which obscured anomalies that might have archaeological significance. In the latter area the one possible exception was a faint, narrow east/west linear anomaly, partly positive, partly negative, running across at least three of the surveyed strips some 30m south of the Antonine Wall (Figure 4.4.5). Its course agreed well with the line of the Military Way recorded in aerial photographs (e.g. Figure 4.4.3) and subsequently by LiDAR (Figure 4.4.2).

There was no sign of a fortlet immediately to the west of the Kilsyth Road, though the area surveyed was slightly too far south of the line of the Wall to be confident of picking up any remains of such an installation, all the more so when the geological conditions were not ideal for gradiometer survey.

4.5 Croy Hill

(NGR: NS 7335 7652; Canmore 45872 and 45875)

Fort, fortlet, camp, extra-mural settlement, Military Way and bypass road

Site-specific references

Macdonald 1925, 288-90; 1932, 243-76; 1937; Jones 2020; Hanson 2022

Geophysical surveys (Figure 4.5.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
Glasgow University; 2017, 2019	R: Geoscan RM15	0.86	1, 1 (0.5, 0.5 in area of extra-mural settlement)

Introduction

The Roman fort at Croy Hill is located on a small, sheltered plateau at a height of 126m above sea level (Figures 4.5.2 and 4.5.3), with good views in most directions, though partially blocked to the south-west by rising ground. The fort site is directly overlain by the ruins of a small farmstead, still partially extant, whose existence goes back at least to the early 18th century (Gordon 1726: 56). The line of the Wall running north-east to south-west across the hill is still clearly demarcated by the well-preserved Ditch and Upcast Mound to the north (Figure 4.5.4); the site of the fort, however, though noted by early antiquaries, such as Gordon, was already too denuded to plan by his time and its precise location was not confirmed until excavation in the 1920s and 1930s by Macdonald.

Macdonald established that the fort was only 0.6ha in internal area, one of the smallest on the Wall (Figure 4.5.2). It was defined by a turf rampart on a cobble base whose construction was clearly secondary to the line of Wall. The fort was surrounded by double or triple ditches, except to the east where none at all were recorded for the most part, with only one immediately to the south of the external bathhouse. In the interior he identified two of the central range of stone buildings, the headquarters building and a granary, along with an unusual, deep stone cistern in the north-east corner, whose demolition preceded the construction of the eastern rampart of the fort.

Beneath and aligned at a slightly oblique angle to the fort, Macdonald uncovered the outline of a small, subdivided rectangular enclosure extending beyond the fort to the south (Figure 4.5.2). It was defined by a single ditch, which enclosed a total area of some 0.6 ha. He considered this, like the similar enclosure he found at Bar Hill, to be one of the first-century garrison posts across the Forth-Clyde isthmus built by Agricola (Tacitus: *Agricola* 23), but excavation by Hanson in the late 1970s demonstrated that it was Antonine in date. Like the enclosure at Bar Hill (Chapter 4.3, above), it is generally now considered to relate to the surveying or perhaps construction of the Wall (R.H. Jones 2011: 323 and 330).

Hanson's excavations focused on the areas to the south and east of the fort that were potentially threatened by quarrying (Figures 4.5.2 and 4.5.3). He was able to trace some 275m of the line of a bypass road running around the fort, which showed several phases of use. To the east of the fort he found a combination of fence lines and ditches on both sides of the bypass road, dividing up the area into small rectilinear plots. At least one, which contained a pottery kiln and associated large pit, was for industrial purposes; another contained a cremation. To the south-west of the fort two large drainage ditches, apparently flanking a trackway, followed a sinuous course leading down the slope to the bypass road. Part of one timber building found at

the top of the slope, combined with the large quantity and wide range of the finds from these drainage ditches, confirmed that the main focus of the *vicus* was located within the guardianship area on the well-sheltered, flat plateau immediately to the west/south-west of the fort.

Finally, Hanson postulated, and subsequently confirmed by excavation, the existence of a fortlet on a small, elevated plateau some 80m to the west of the fort. Unlike the fort, its rampart was structurally contemporary with the Wall and its discovery provides one of the cornerstones supporting the hypothesis that the design of the Antonine Wall underwent a major change during the course of its construction (Gillam 1975; Hanson 2020b: 4-6), though this interpretation is not universally accepted (Graafstal *et al.* 2015) (see Chapter 8.1.5).

Various factors were highly detrimental to effective geophysical survey on the site. First and foremost, it lies on a major outcrop of igneous rock, the Mid Valley sill complex of quartz and microgabbro, which largely accounts for the multiple quarries attested in the area. Surface outcropping is apparent, for example, around the fortlet and at the point immediately to the east of the fort where the Wall Ditch was left incomplete (Figures 4.5.2 and 4.5.3). Thus, it was necessary to rely entirely on resistance survey without recourse to gradiometry. The soils are brown earth, generally very thin and stony, and have been heavily ploughed since at least the late medieval period. The whole area has been given over to rough pasture since the abandonment of the farmstead in the late 1930s, though a change in the grazing regime since Hanson's excavations has resulted in increased growth of thorn bushes. As a result some areas of investigation required considerable cutting

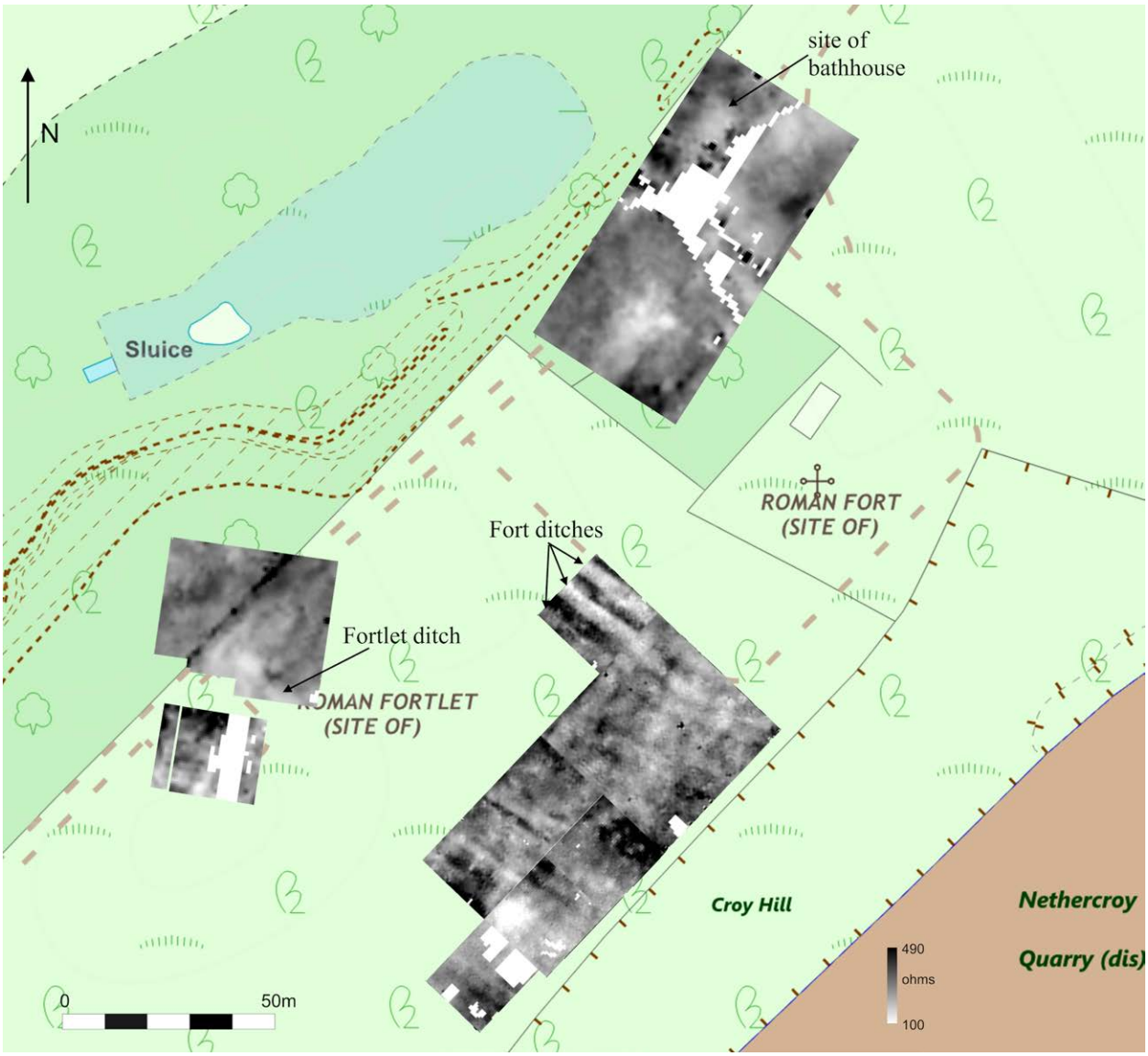

Figure 4.5.1. Resistance survey at Croy Hill. The range of resistance values across the three survey areas was 200-574 ohms.

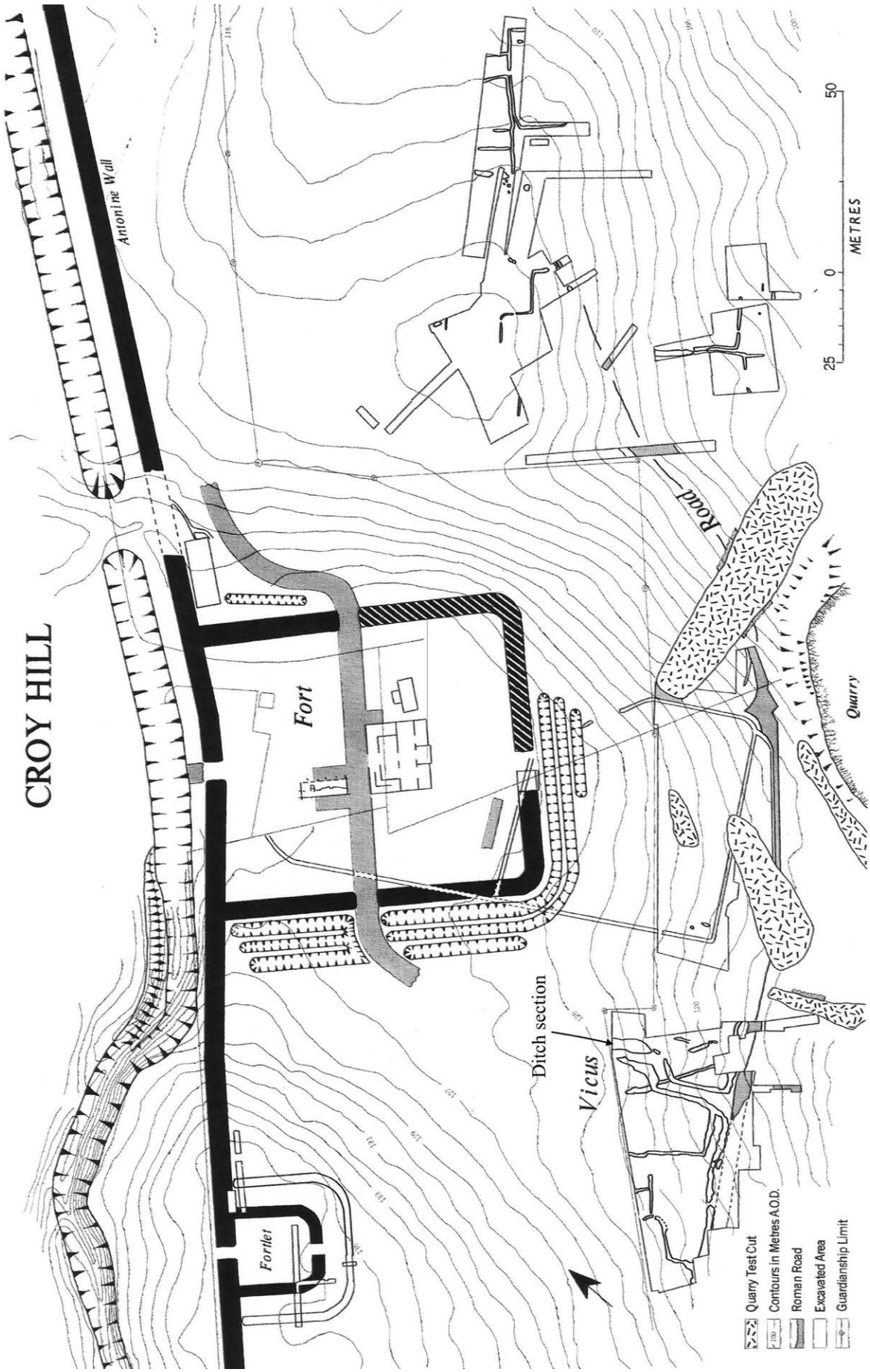

Figure 4.5.2. Plan of the fort at Croy Hill and its environs. The location of the ditch section illustrated in Fig. 4.5.5 is marked with an arrow.

Figure 4.5.3. Aerial photograph of the fort at Croy Hill and its environs from the north-west during excavations in 1977. The extant remains of the Wall Ditch and Upcast Mound are visible in the foreground running at an angle from bottom right to mid left; the site of the fort lies beneath the ruined farmstead in the centre, with the unfinished section of Wall Ditch to the left of the large trees; the hand-dug excavation trench on a raised plateau in the right foreground runs across most of the interior of the fortlet as far as its western ditch.

back of thick vegetation and some were still inaccessible (hence the dummy readings apparent in the southern part of the survey) (Figure 4.5.1). Finally, one area of interest, the northern quadrant of the fort, was heavily encumbered with the partially extant remains of the farmstead yard and overshadowed by two mature trees.

The aims of the survey were various. Since the relationship of the Wall with the eastern rampart of the fort was considered contentious, and the possibility had even been raised that the fort was originally intended to be located slightly further east (Graafstal 2020: 167-70), that area was targeted for investigation. Secondly, an attempt was made to learn more about the plan and location of the fortlet; and thirdly an area over the postulated focus of the civil settlement within the guardianship area immediately to the west of the fort was investigated. In the latter two cases, changes to local reference points since the 1970s resulted in the slight misplacement of some grids.

Results (Figure 4.5.1)

Overall the results were very disappointing. A small section of the Rampart base in the north-east corner of the fort may be represented by an area of higher resistance, but the signal did not continue either to the north-east or south-west. The site of the bathhouse appears as an area of low resistance, suggesting that it may have been largely robbed out. This may explain why Macdonald records it only in outline without identifying any of its walls. To the south-east of the bathhouse at the edge of the survey another larger area of higher resistance seems to coincide with the line of the Military Way, while in the south-west corner the location of the granary is perhaps indicated by a rather amorphous area of high resistance. However, the survey offers no additional information and even these tentative identifications are heavily reliant on prior knowledge gained from earlier excavation.

The eastern ditch of the fortlet is probably reflected in the broad band of lower resistance running north-south. The only new information is the suggestion of possible stone building debris or cobbling in the northern corner of the fortlet, indicated by linear spreads of high resistance.

The larger area of survey to the south-west of the fort does appear to have picked up the three fort ditches

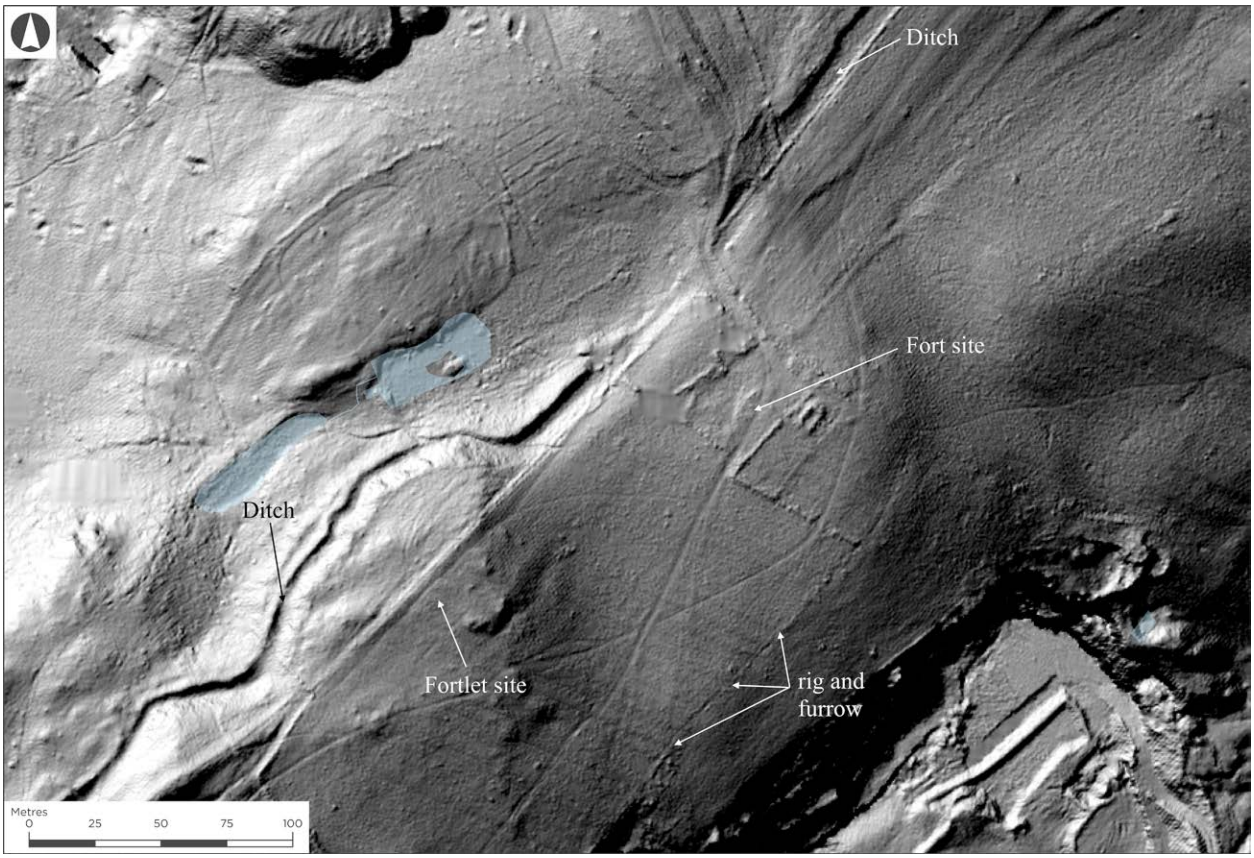

Figure 4.5.4. LiDAR image of Croy Hill.

Figure 4.5.5. Large recut drainage ditch to the south-west of the fort at Croy Hill disappearing into the section at the limit of the 1978 excavation on the edge of the guardianship area. View from the south.

curving around the southern corner of the fort. They are visible as clear, wide bands of low resistance, the inner two clearer than the outer, particularly towards the northern limit of the survey. Beyond them to the west, however, similar but much less clear banding on the same broad orientation seems to represent later medieval rig and furrow cultivation, which is still clearly apparent in the LiDAR survey (Figure 4.5.4). The large areas of high resistance towards the centre of this survey probably reflect backfilling and spreading of a spoil heap at the northern corner of Hanson's excavation, though the subsoil at this point was also very stony. None of the features recorded disappearing into the guardianship area at the northern limit of these excavations, including one large drainage ditch on the east side of the trackway (Figure 4.5.5), were picked up by the resistance survey. It would seem that any electrical responses were too weak by comparison with those of the later farming activity, despite lying less than 0.5m below the ground surface. Should future survey be considered in this area, it would be worthwhile to increase the probe separation from 0.5m to 1m to give greater sensing depth penetration.

Chapter 5

5.1 Westerwood

(NGR: NS 76070 77353; Canmore 45870 and 74532)

Fort, extra-mural settlement and Military Way

Site-specific references

Macdonald 1933: 277-86; Keppie 1978; 1995; Keppie and Breeze 1981: 240-41; Jones *et al.* 2008c

Geophysical surveys (Figure 5.1.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
Glasgow University; 2006	G: Bartington Grad 601-2	3.2	0.125, 1

Introduction

The fort lies on a very slight north-facing slope amid what was low-lying arable farmland with quite wide views over the upper reaches of the Kelvin valley. The ground originally sloped fairly steeply northwards down to Dullatur Bog and the Bonny Water, where the Forth-Clyde canal now runs. The existence of the Roman fort has been known since the early 18th century, with plans and descriptions produced by several antiquaries (Gordon 1726: 56 and pl. 24; Horsley 1732: 169 and 176 N; Roy 1793: pl. 35) (Figure 5.1.2), though its outline is now only faintly discernible on the ground, as indicated in the LiDAR survey (Figure 5.1.3). A farmhouse with its garden and steading has occupied the north-east corner of the fort since at least the beginning of the 20th century, though the 1st edition Ordnance Survey maps show that in the late 1850s the farm buildings lay just outside that corner of the fort. In the late 1980s most of the surrounding farmland was converted into a golf course, while the associated farm buildings, which still remain, have experienced a varied history of use.

Macdonald undertook limited investigation of the site in 1932, confirming that the fort was defined by a turf rampart on a cobble base, whose construction was clearly secondary to the line of Wall in the north-west corner where this relationship could be examined (Figure 5.1.4). The fort proved to be one of the smaller examples on the Wall, enclosing an area of 0.79ha, which sits somewhat awkwardly within its double ditches. A third ditch was identified only to the north of the Military Way on the west side. Gaps in the rampart for gateways were identified in each side except the east, but not further examined. Similarly, there was minimal investigation of the interior. This served to identify only the location of a probable bathhouse in a similar position to that at Bar Hill at the rear of the northern rampart west of the gate, and one other fragment of stone walling. Outside the ditches in the south-east corner a section of possible road bottoming

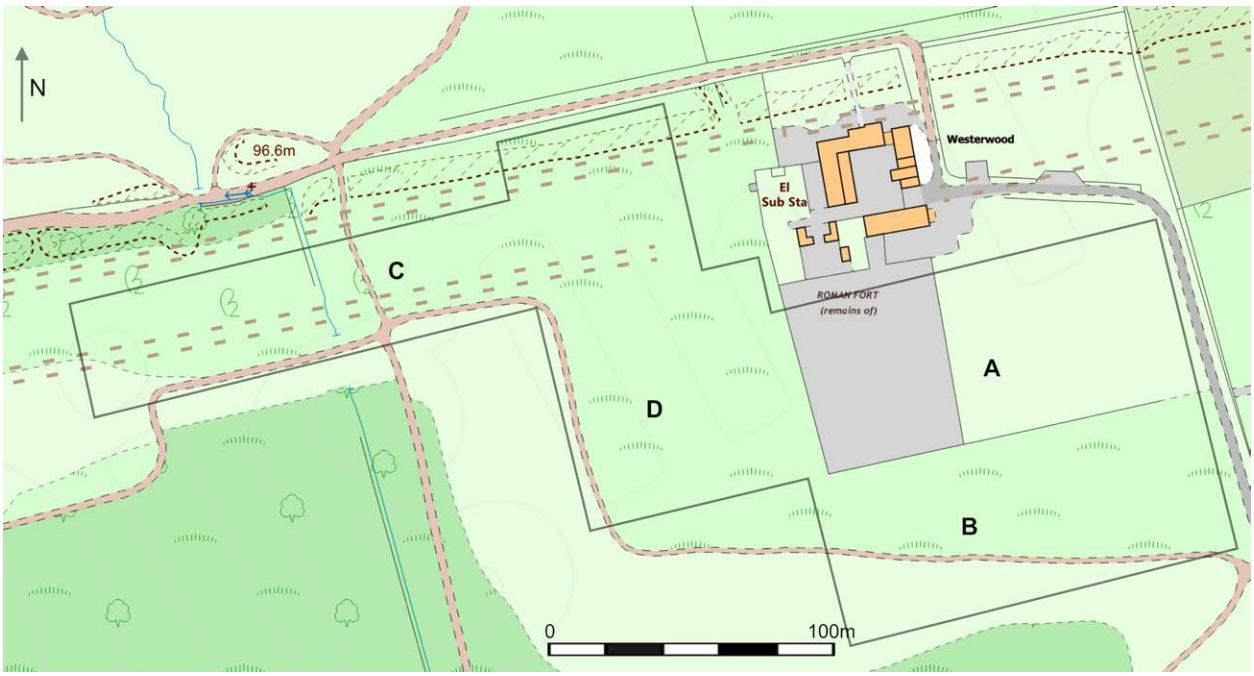

Figure 5.1.1. Location of gradiometer survey at Westerwood.

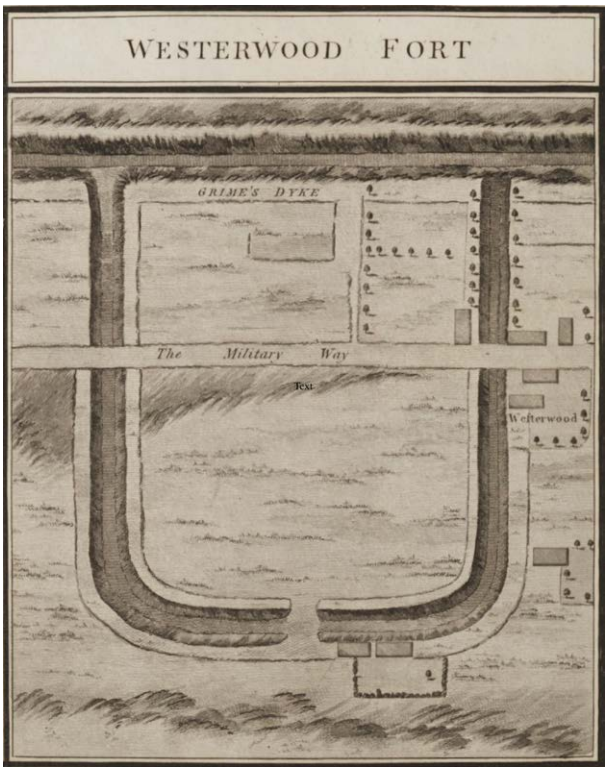

Figure 5.1.2. Roy's plan of the fort at Westerwood (extracted from Roy 1793, Fig. 35).

recorded (but not on the plan) may indicate the line of a bypass road.

A series of watching briefs and small-scale rescue excavations were undertaken by Keppie at various times in the 1970s and 1980s, focused mainly on areas outside the fort. In 1974-75 he investigated an area to the south, ahead of the proposed construction of a Young Offenders' Institution, but found no clear evidence of Roman settlement. In 1978, along with Walker, he identified the remains of a masonry structure with associated hypocaust-brick fragments in a very narrow trench beneath the farmyard in the north-west corner of the fort. Between 1986 and 1988, as the laying out of the golf course progressed, this rescue work concentrated to the west of the fort, though he also confirmed the identification of the internal bathhouse. He was able to demonstrate the line of the Military Way running *c.* 25m behind the Wall, some 5m further north than expected, over a distance of some 330m, though its state of preservation was generally extremely poor. Larger-scale excavation some 40m beyond the western ditches of the fort revealed a scatter of post-holes, overlying the remains of slight field ditches, adjacent to an area of burnt debris including window glass. Although the post-holes could not readily be assigned to specific buildings, they seemed to indicate north-

Figure 5.1.3. LiDAR image of the fort at Westerwood.

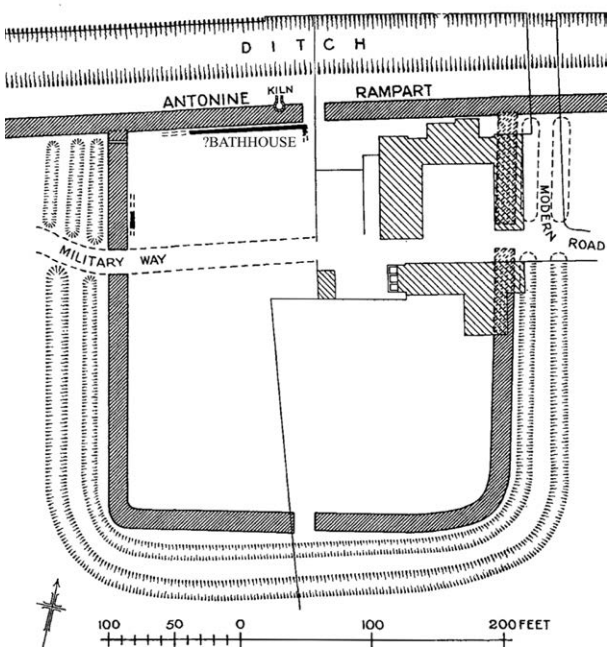

Figure 5.1.4. Excavation plan of the fort at Westerwood (after Macdonald 1933, Fig. 13, with additions).

south alignments. However, the whole area had been heavily truncated by cultivation since medieval times, as indicated by recognition of the remains of rig and furrow. Some 200m further west an altar to the wood nymphs and goddesses of the cross-roads, dedicated by the wife of the legionary centurion commanding the fort, had been found in 1963 during ploughing (Walker 2020: 186-87), giving an indication of the potential geographical extent of associated extra-mural activity.

The primary aim of the geophysical survey was to prospect for evidence of such activity in the immediate environs of the fort (Figure 5.1.1), particularly to the west (Area C), but also to the south and east (Areas A and B). Given the very limited history of previous investigation, the opportunity was also taken to survey the southern and western halves of the fort's interior (Areas A and D). The area surrounding the fort had altered dramatically in the preceding thirty years, mainly as a result of the landscaping required to create the Westerwood Golf Course. Other than occasional tracks and fence lines, and the earlier farm buildings, there were no substantial landscape features restricting survey. Because of its cultivation history the ground is generally open and flat, even if no longer tended.

The geological conditions - glacial sands, gravels and boulder clay overlying Carboniferous limestone - presented no difficulties for gradiometer survey. Less favourable were the effects of the probable use during the landscaping of the golf course of clinker or fired material that has a small thermoremanent magnetisation. On the other hand, the potential spread of igneous debris from a nearby east-west dyke of quartz-microgabbro traversing the limestone appears not to have affected the survey. The soils are non-calcareous gleys.

Results (Figure 5.1.5)

Parts of the areas surveyed have a noisy, mottled appearance that has an adverse effect on the identification of the main archaeological anomalies. This is most pronounced in the southern sector of the survey. Here and elsewhere the landscaping for the golf course may have introduced fired material, as noted above.

The general outline of the double ditches surrounding the fort are reasonably clear all around its perimeter in the areas examined, though the third ditch north of the Military Way on the west side less so. The ditches appear as slightly negative broad linear anomalies bordered by narrow more positive lines in a generally quieter magnetic zone. The line of the fort rampart inside the ditches is intermittently traceable as a discontinuous speckled positive band, particularly on the west side, though slightly narrower than might be expected. Within the limited area of the survey that extended sufficiently far north, the Antonine Wall Rampart is also evident as a slightly broken double positive linear alignment. It appears somewhat narrower than the norm, no more than 3.5m in width, perhaps reflecting its poor preservation in this area as recorded by Keppie. The Wall Ditch is visible as a broad clean, marginally negative band beyond it.

Most striking, however, is the line of the Military Way, which is apparent to various degrees across the whole of Area C and the western half of Area D. In the latter it is apparent as a strongly positive *c*. 6m-wide band located some 20m behind the Wall and further demarcated, particularly on its north side, by a narrow negative anomaly that may be a road ditch. There is no doubt that it continues in a straight line across the ditches towards the interior of the fort, as Roy recorded (Figure 5.1.2), with no sign of the southward deviation indicated in Macdonald's excavation plan (Figure 5.1.4). This results in the location of the west gate, identified by Macdonald only as a gap in the rampart, being several metres further north than he indicated, placing it rather closer to the Wall rampart than might be expected in the normal tripartite division of a fort interior. This, in turn, may lend further support to the suggestion (above) that the fort was a secondary addition, its internal layout having been adjusted to minimise any change to the pre-existing line of the Military Way. Its continuation to the west is readily picked up across Area C as an intermittent broad positive band or, more commonly, as two narrow, strongly positive, parallel

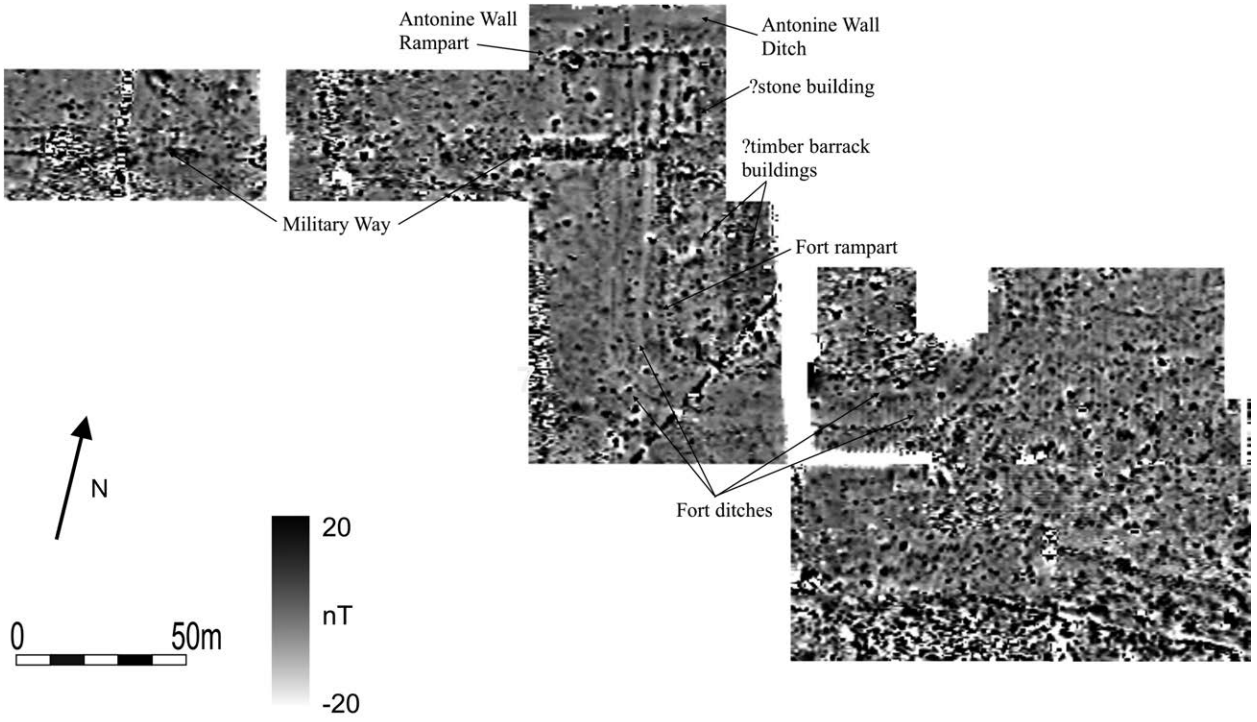

Figure 5.1.5. Gradiometer survey at Westerwood.

lines some 7m apart, the latter perhaps reflecting the kerbs at the road edge which are commonly recorded in better preserved sections of the road. These might more readily survive the effects of ploughing because of the slight protection provided by the camber of the road surface. Though there are scattered anomalies recorded both to the north and south of the road, some of which may derive from archaeological remains, none offer clearly recognisable patterns other than those that derive from modern features or intrusions.

The picture is slightly better within the fort. The continuation of the Military Way forming the *via principalis* is apparent more as an absence than a presence of positive anomalies. To the north of it narrow positive linear anomalies appear to define a rectangular stone building some 5m wide aligned north-south positioned hard up against the western rampart. This lies to the west of the probable bathhouse identified by excavation though it might reasonably be an associated structure. South of the *via principalis* the configuration of intermittent positive anomalies is suggestive of possibly two narrow rectangular, presumably timber, buildings separated by a road, their long axes oriented north-south. The available space would be just enough for two rather short barrack blocks, on analogy with examples recorded by excavation at Bar Hill and Bearsden (Robertson *et al.* 1975: 17; Breeze 2016: 26-9 and 32-3). However, there is insufficient information to even speculate on the internal arrangements in the south-east quadrant of the fort.

Similarly, though the gradiometer graphic is quite busy, there are no clear patterns of activity outside the fort to the south-east (Areas A and B), other than broadly parallel narrow linear alignments that reflect different stages of relatively recent land use.

5.2 Tollpark

(NGR: NS77266 77819; Canmore 74532 and 226008)

Rampart and Military Way

Site-specific references

Keppie and Breeze 1981: 230-31 and 239-40; Keppie and Walker 1989: 150; Jones 2019

Geophysical surveys (Figure 5.2.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
Glasgow University; 2019	G: Bartington Grad 601-2	0.24	0.25, 0.5

Introduction

Between Arniebog and Garnhall (see Chapter 5.3, below), to the north of Cumbernauld Airport and the Wardpark Industrial Estate, the Wall follows the crest of an east-west ridge overlooking the Kelvin valley.

Towards the western end of this stretch, the prominent knoll of Hag Knowe attains a height of 108m. For almost a kilometre to the east of that high point the outer half of the Ditch and the Upcast Mound are still masked by a belt of trees. This has served to protect them from agricultural erosion and they are in the guardianship of the State. The Ditch is extant, varying in width between 12-14m, its depth reaching up to 3m, while the Upcast Mound survives to a height of up to 2m. This protected section is referred to as Tollpark after the nearby farm of that name, which is now lost beneath the Industrial Estate.

Excavations in the vicinity of Hag Knowe in 1964 by MacIvor and then Wilkes confirmed that the Rampart base was well preserved over a distance of some 30m and uncovered evidence of repairs involving the replacement of the rear stone kerb. Further excavation in the same area by Keppie and Walker in 1979 uncovered a 12m long narrow stone platform of uncertain function that had been added to the back of the Rampart. Continuation of that work in the next field to the east in 1982-3 found further evidence of a repair to the back of the Rampart and confirmed the line of the Military Way some 25m to the south. There was no trace, however, of either the possible watchtower seen in the 19th century (Buchanan 1872: 472) or of a fortlet thought, on the basis of an early antiquarian reference (Sibbald 1707: 29), to lie in the vicinity.

According to the 2nd edition 6-inch and 25-inch Ordnance Survey maps, the line of the Military Way was followed by an access track that approached Tollpark Farm from the north-east. Sections dug in 1964 across the continuation of the line of the road to the west that is visible in vertical aerial photographs held by the Ordnance Survey failed to locate it, though plough damage may have reduced its remains to little more than a scattering of stones.

The survey reported on here was designed as a training exercise for Glasgow students and aimed to ascertain the survival of the Rampart adjacent to a location where excavation had already confirmed its presence. The ground immediately to the south of the Wall here is in flat, rough pasture so that there were no substantive hindrances to survey apart from some thick outcrops of sedge which resulted in the insertion of a number of dummy values. The geology (Upper limestone formation: mudstone, siltstone, sandstone and till) and the soils (non-calcareous gleys) were also favourable to survey.

Results (Figure 5.2.2)

Running east-west across the survey area, the line of the Rampart is clear as a broad mottled band of largely strong positive anomalies with some gaps. This suggests that the Rampart base is reasonably well

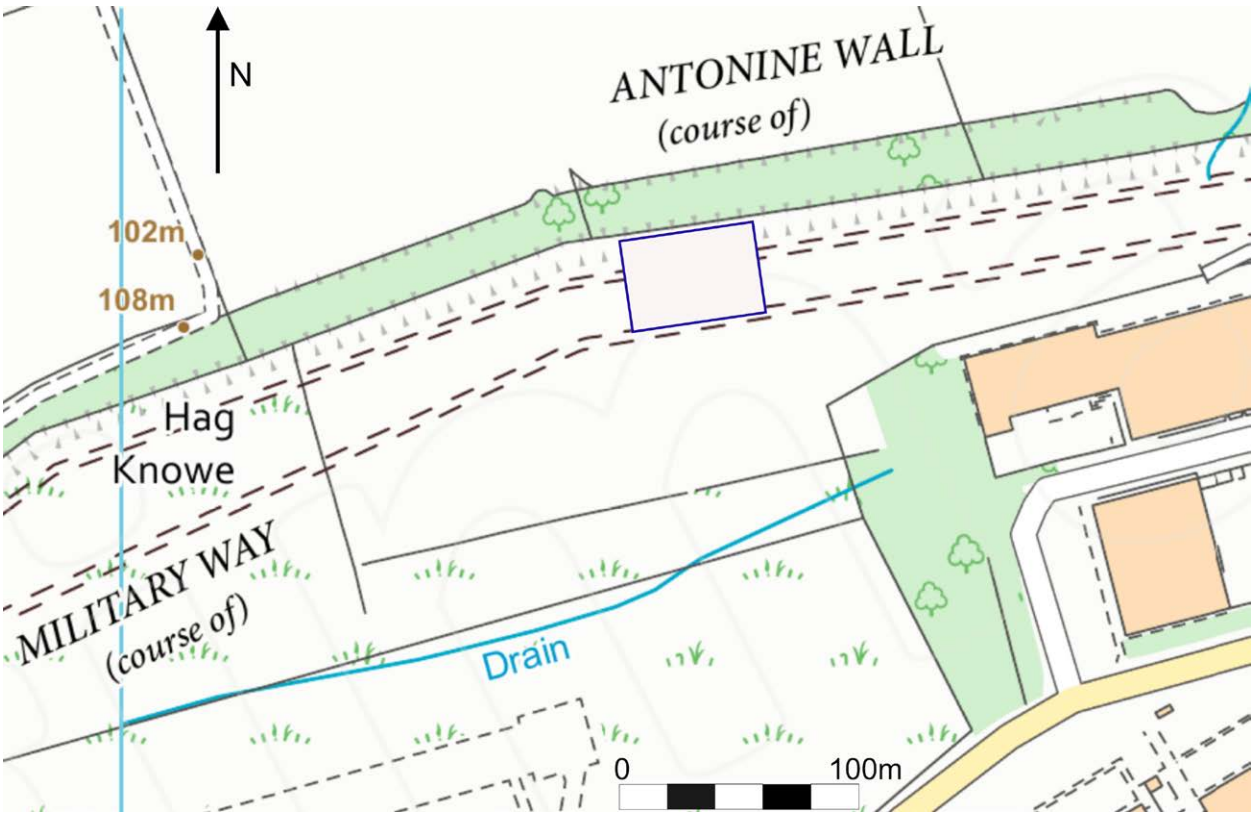

Figure 5.2.1. Location of gradiometer survey at Tollpark marked in blue.

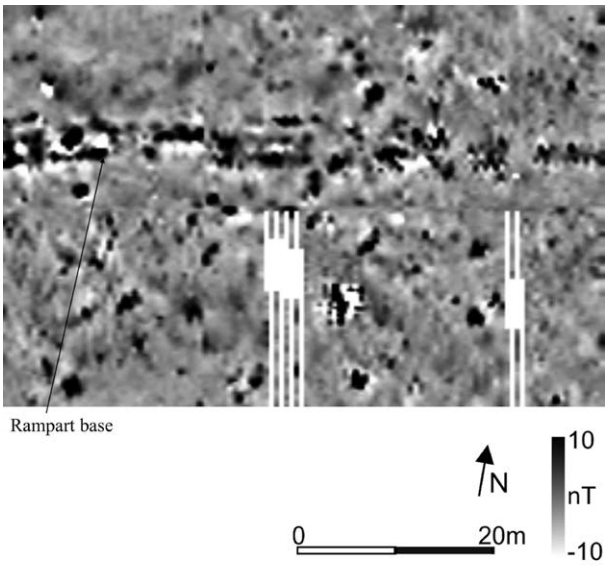

Figure 5.2.2. Gradiometer survey at Tollpark.

preserved, perhaps with some breaks, as recorded in the excavation further to the west. No other linear features that might represent the line of the Military Way were apparent, though the survey extended only some 25m to the south of the Wall. The narrow anomaly running just to the south of the Rampart is an artefact of processing.

5.3 Garnhall

(NGR: NS 78300 77900; Canmore 45826; 45836 and 74532)

Rampart, Military Way, temporary camp and possible watchtower

Site-specific references

Keppie and Breeze 1981: 237-39; Woolliscroft 2008; R.H. Jones 2011: 210-11

Geophysical survey

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
D Woolliscroft; 1991	R: Martin-Clark	Not known	Not known

Introduction

Beyond Tollpark (Chapter 5.2, above) the Wall continues to follow the crest of the east-west ridge past the site of Garnhall Farm (demolished in the 1980s). It then changes direction slightly to the north-east before it is crossed by the main Edinburgh to Glasgow railway line, after which it turns back to the east as it descends into the valley of the Red Burn (Figure 5.3.1). The line of the Ditch was still well preserved at the time of the 1st edition Ordnance Survey mapping in 1859, though much of the Upcast Mound had already been covered by the access road to Garnhall Farm, and most of the Ditch line beyond the railway was subsequently lost to late 19th century industrial development. Though agricultural activity has eroded the remains rather more than in the Tollpark sector, the line of the Ditch to the south-west of the railway is still readily discernible on the ground, in the LiDAR data (Figure 5.3.2) and, occasionally, as a cropmark. This sector is also in the guardianship of the State.

The line of the Military Way seems to have continued in use into the early 20th century. It is marked by a trackway that ran across the whole of this sector, as recorded in the early Ordnance Survey mapping. The line is also visible in the LiDAR data (Figure 5.3.2). This indicates that the road had been slightly terraced into the sloping ground in places, which may help to explain why it continued in use.

Parts of two sides of a temporary camp (Garnhall II) were discovered from the air in the 1960s in the fields to the west of Garnhall Farm (Figure 5.3.1). It lay immediately to the rear of the Wall, though its chronological relationship with the frontier was considered a matter that needed to be established. A second camp (Garnhall I), now mainly covered by housing, had been identified further to the east in 1952. A ring ditch immediately to the south of the Wall within camp II and a circular pit-like feature overlapping the Military Way were also recorded from the air, the latter clearly visible also in the LiDAR data.

Limited excavation in 1977 by Keppie to the north-west of Garnhall Farm exposed the well-preserved base of the Rampart at three points over a distance of 70m and confirmed more precisely the edges of the Ditch, which had been marked by lines of cobbles. Cobbling was recorded on the Military Way to the east of the farmhouse, though whether this derived from Roman use rather than more recent refurbishment of the farmtrack could not be established.

More extensive excavations were undertaken by Woolliscroft between 1991 and 1995 at three locations in the western half of the sector (Figure 5.3.1). He used resistance survey (below) to supplement the evidence from aerial photography and probing that was guiding his programme of work. The Rampart base was partially uncovered in several places (e.g. Figure 5.3.3). It proved to be quite well preserved, particularly along its southern side, and provided at one point with a secondary stone platform of uncertain function to the rear. Examination

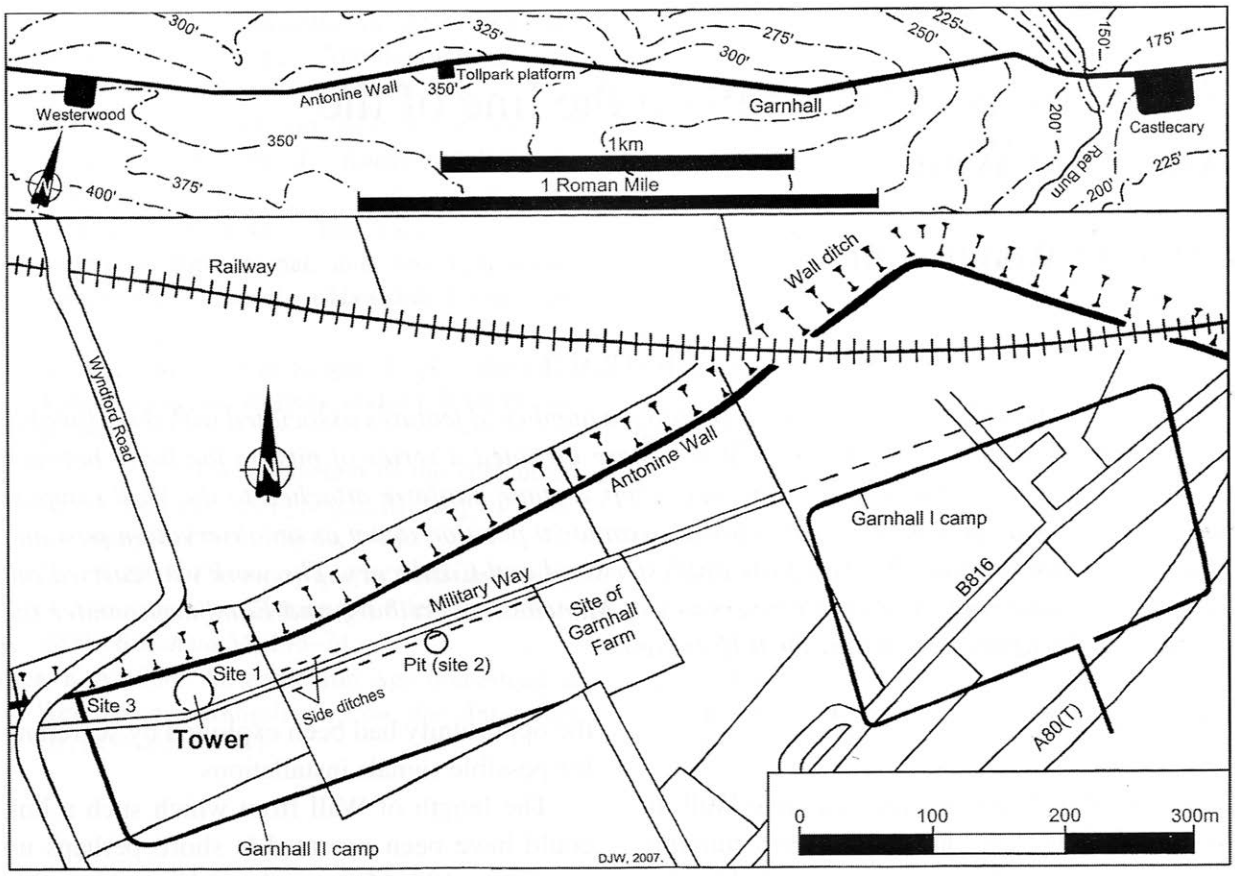

Figure 5.3.1. Garnhall location plan (after Woolliscroft 2008, Illus. 1).

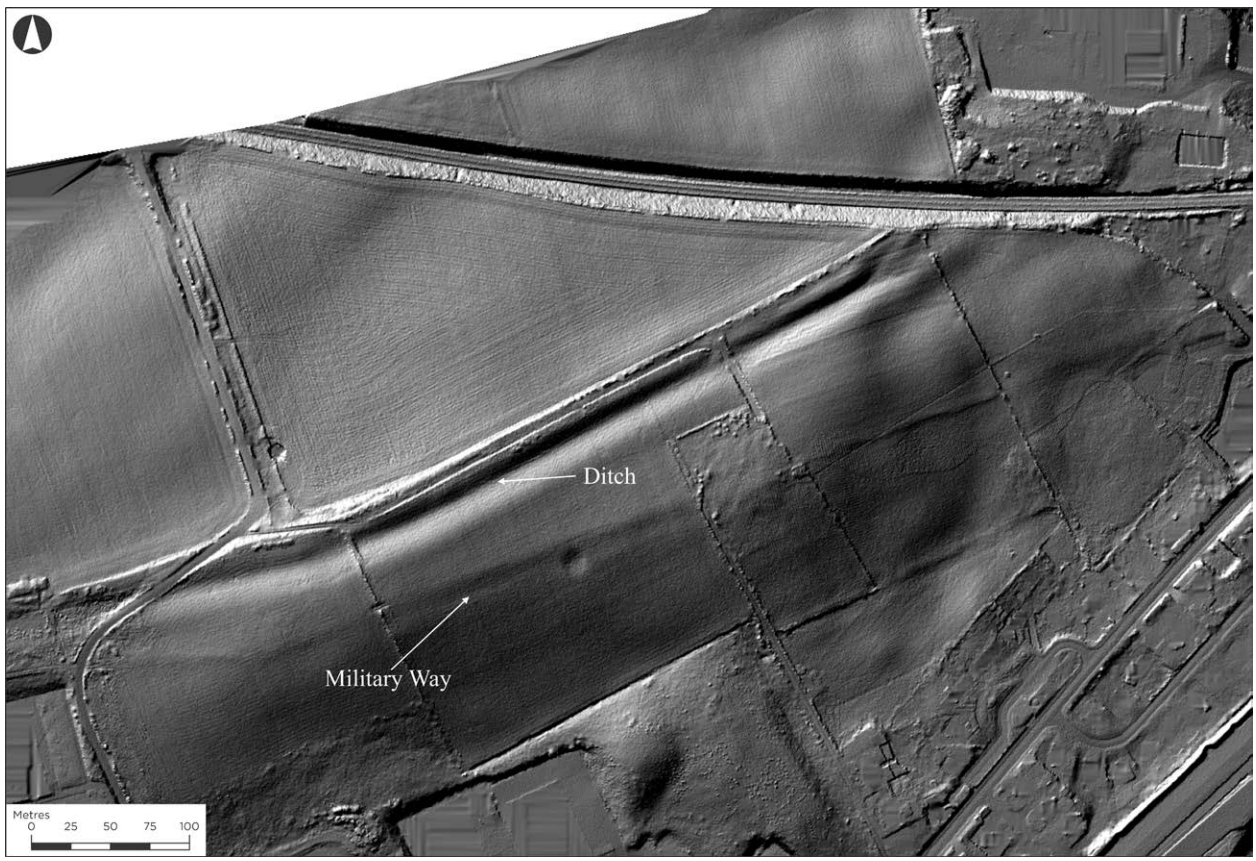

Figure 5.3.2. LiDAR image of the line of the Ditch at Garnhall.

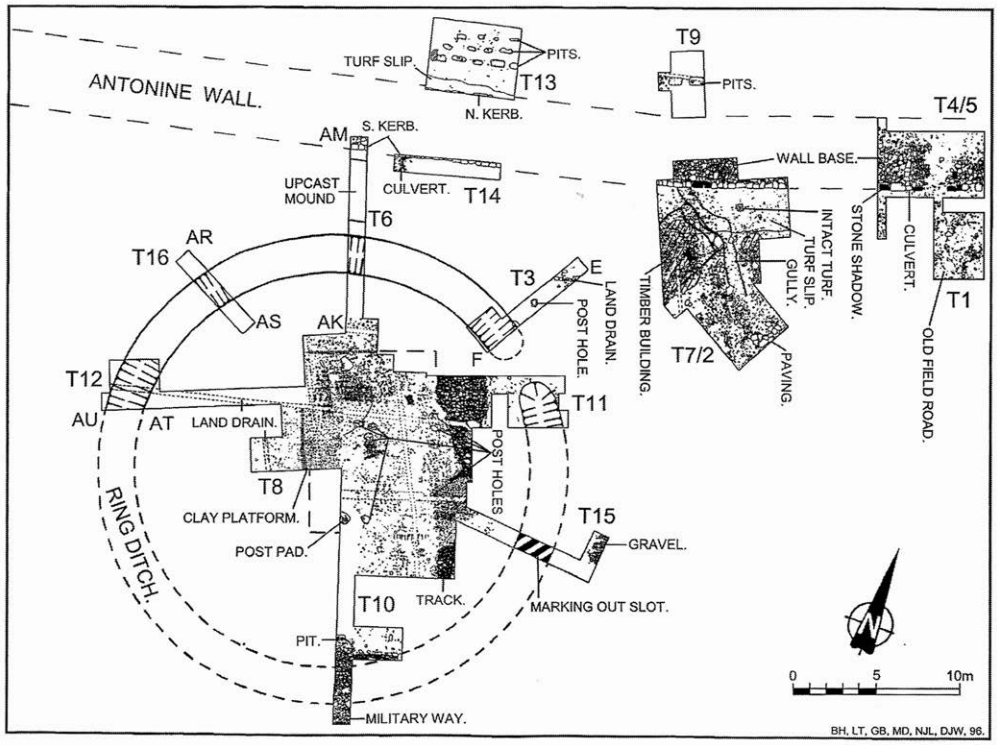

Figure 5.3.3. Plan of the Woolliscroft's excavations at Garnhall (after Woolliscroft 2008, Illus. 4).

of the Berm uncovered a series of defensive pits in a quincunx pattern, now readily paralleled at a number of other locations on the Wall (Bailey 2021: 23-27). The ditch of the Garnhall II temporary camp was shown to post-date both the Rampart and the later platform, coming to a butt end at the rear of the Wall and not continuing beyond it.

The ring ditch proved to be a later prehistoric settlement enclosure and was presumably associated with adjacent timber structures that also pre-dated the Wall (Figure 5.3.3). A nearby hearth produced a pre-Roman Iron Age carbon-14 date. The southern side of the ring-ditch had been removed by the terracing for the Military Way, some of whose rammed gravel surface had survived in the resultant depression. Though the excavator argued for the Roman re-use of the ring ditch to enclose a timber watchtower, the relevant post-holes were neither centrally positioned therein nor sufficiently deep to have supported such a structure.

The Wall and associated features lie in arable fields so were readily accessible for survey and excavation. The predominant geological features are mudstone, siltstone and sandstone, together with till, and the soils are (non-calcareous) gleys and brown earths.

Results

Because of difficulties with the balancing potentiometer in the Martin-Clark instrument (Clark 1990: 30, Fig. 17), Woolliscroft considered his resistance survey unsuitable for publication. However, he outlined the main results from the three areas examined and highlights their contribution to understanding the structures revealed.

The Rampart base and Military Way appeared as high resistance anomalies, as did the adjacent ring ditch. This unexpected reading from the latter, whose response is usually low resistance, was explained as the result of there being a high stone content in its fill. The second circular feature was revealed by low readings, as was an east-west linear feature corresponding with a probable ditch on the southern side of the Military Way that was also visible on the aerial photographs. The line of the Military Way produced higher readings with indications that it was cut into by the circular feature, as later excavation confirmed. Finally, at the intersection between the Rampart base and the temporary camp defences the former was revealed by high values, the latter by a faint strip of low readings. To the east of the camp ditch, and parallel to it, was a band of higher readings which were thought might indicate the remains of a rampart, though this was not confirmed in the subsequent excavation. Where the temporary camp approached the Wall there was an area of still higher readings some 2.5m wide running along the back of the Wall for at least 11m, which on excavation appeared to be the remains of a secondary stone platform similar to that found by excavation at Tollpark (Keppie and Breeze 1981: 239-40).

5.4 Castlecary

(NGR: NS 7924 7836; Canmore 45828)

Fort, annexe and environs

Site-specific references

Christison *et al.* 1903; RCAMS 1963: 103-06; GSB 1994; 2006b; Jones *et al.* 2008d; Bailey 2021: 107-30 and 517-40

Geophysical surveys (Figures 5.4.1 and 5.4.2)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
GSB; 1994	G: Geoscan FM36	0.73 (Area D), 0.92 (E)	0.25, 1
GSB; 2006	G: Barting-ton Grad 601-2 R: Geoscan RM15 GPR: Pulse Echo 1000	0.4 0.4 10 traverses in 2 locations (40m, 30m) and 3 tra-verses in third location (30m)	0.25, 1 1, 1
Glasgow University; 2006	R: Geoscan RM15 G: Barting-ton Grad 601-2	1.2 (Area A), 0.24 (B) and 1.7 (C) 1.6 (C)	1, 1 0.125, 1

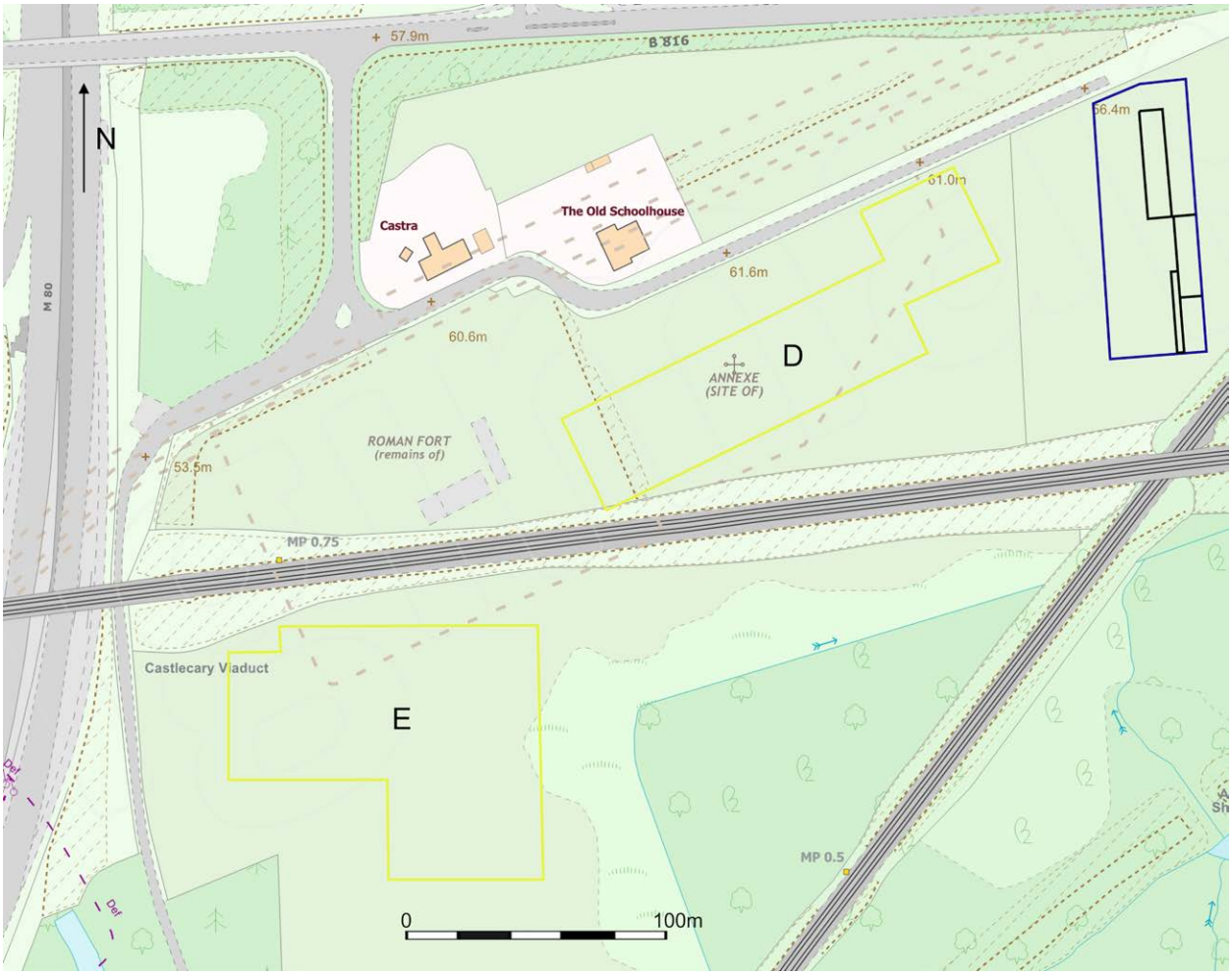

Figure 5.4.1. Location of GSB's surveys at Castlecary in 1994 (yellow outline) and 2006 (gradiometer: blue outline; GPR: black outline) (after GSB 2006b, Figs 5.1 and 5.2).

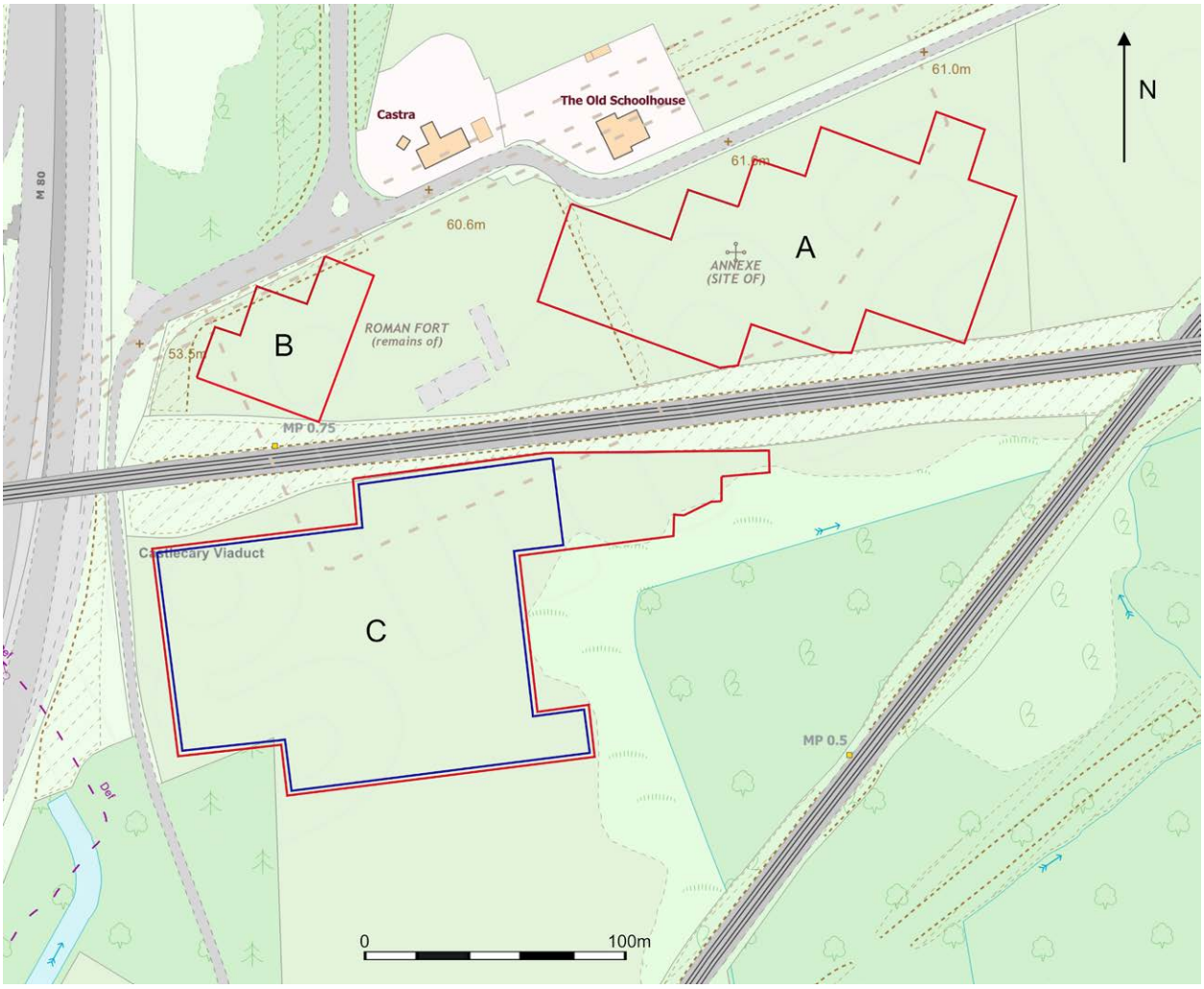

Figure 5.4.2. Location of the Glasgow University geophysical surveys at Castlecary (gradiometer in blue; resistance in red).

Introduction

The fort occupies the highest point at the western end of a low boulder clay ridge, the ground sloping down sharply to the Red Burn immediately to its west. To the north it overlooks the valley of the Bonny Water, the line now followed by the Forth-Clyde canal, and the Denny Gap, a natural corridor through which by M80 motorway now runs. The area to the south-east of the fort seems to have been dominated by peat moss until much of it was drained in the 18th and 19th centuries.

The well-preserved remains of the Roman fort have been commented on since the end of 17th century, with plans and brief accounts produced by various antiquaries in the 18th century (Gordon 1726: pl. 24; Horsley 1732: 170-71 and 176 N4; Roy 1793: 161 and pl. 35). However, by the mid-19th century little remained that was visible after the ravages of stone robbing and various local infrastructure projects, culminating in the construction of the Edinburgh to Glasgow railway line that diagonally bisects the southern half of fort (Figure 5.4.10). This close juxtaposition with modern rail and road transport links highlights the strategic importance of the fort's location. The bulk of the site has been in permanent pasture for many years, with a small central copse of trees in which traces of the excavated buildings may still be seen on the ground, though the northern front of the fort and a section across the eastern annexe are masked by a modern access road and an early 20th century school house. The south and east sides of the fort platform survive sufficiently well to register in the LiDAR coverage, as does much of the line of the eastern annexe ditch (Figure 5.4.3).

Castlecary was one of the earliest forts on the Wall to be excavated, in 1902 (Figure 5.4.4). These excavations demonstrated that it was one of only two forts to be defined by a stone wall, which enclosed an area of 1.4ha. The fort was provided with stone gateways, one in each side, and corner towers, at least to the south. It may originally have been freestanding as its northern corners seem to have been squared in anticipation of them subsequently abutting the Wall rampart. This

Figure 5.4.3. LiDAR slope visualisation image of the fort and annexe at Castlecary.

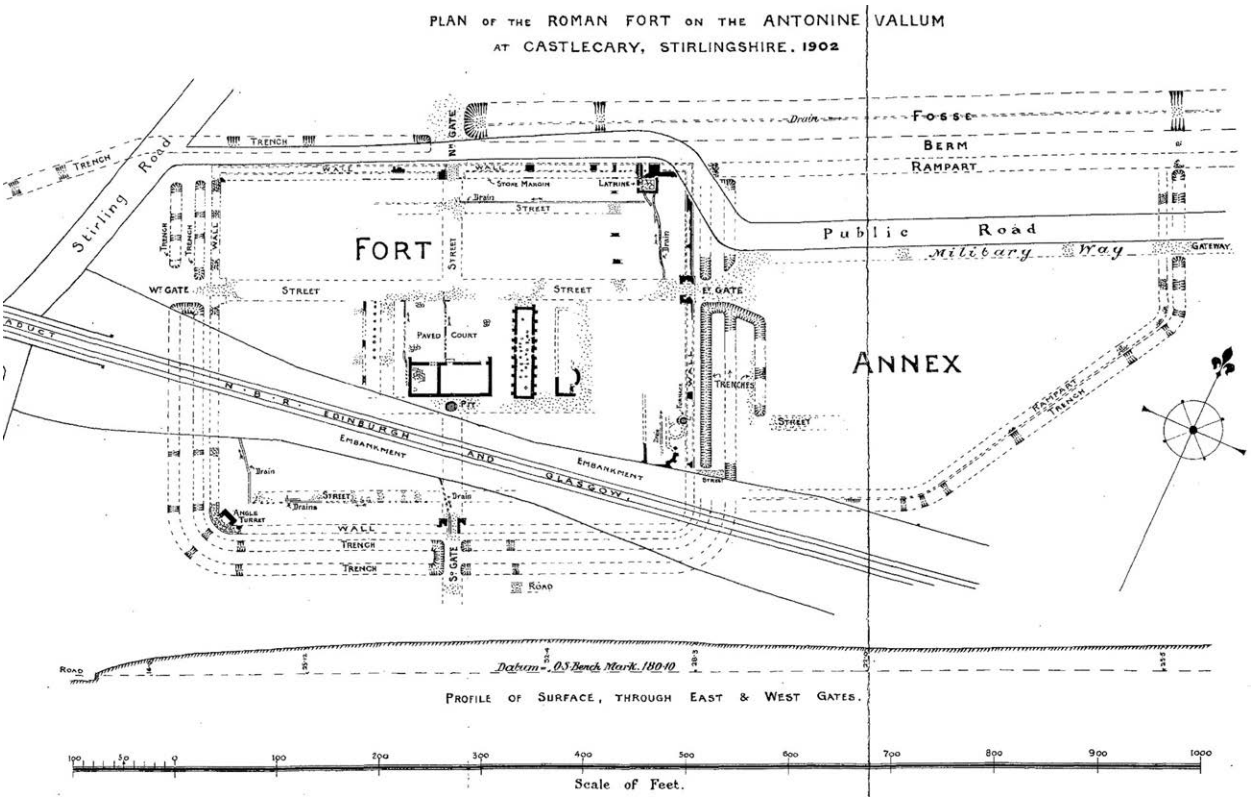

Figure 5.4.4. Plan of fort excavation at Castlecary (after Christison *et al.* 1903).

relationship was further examined in small-scale excavations just outside the north-east corner by Bailey in 2011. He suggested that the line of the Wall approaching the fort was probably located slightly further south than previously assumed, though the remains were very poorly preserved, and he identified a possible continuation of the outer fort ditch to the north of it. The fort was surrounded by double ditches, except for part of the east side, where a third ditch was added, and to the north, where the Antonine Wall Ditch formed the outer defence. To the west of the causeway opposite the north gate, however, that Ditch was reduced to about half its normal width, which hints at an arrangement similar to that at Balmuildy and Mumrills (Chapters 3.1 and 6.5), where the geophysical survey suggests that originally the fort was surrounded by its own ditches on all sides.

The early excavations identified only stone buildings, including much of the headquarters building, a granary, what may have been part of the commanding officer's house and another unidentified building with a veranda, all in the central range (Figure 5.4.4). The only other structures identified were a latrine in the north-east corner, several fragments of walling to the south of it and a bathhouse at the back of the rampart towards the south-east corner. The walls of the latter, exposed at the time of the construction of the Forth-Clyde canal in 1769, had been planned by Roy shortly thereafter (1793: pl. 39). Elsewhere in the fort various stretches of internal roads and drains were traced.

An annexe, defined by an earth rampart on a stone base with a single ditch outside it, was identified on the east side of the fort, but its interior was not further investigated other than to identify sections of the Military Way and another parallel road running through it. The annexe was pentagonal in shape, enclosed an area of 1.1ha and was provided with a single entrance in its shortest eastern side, through which the Military Way entered. Both the outer and inner fort ditches facing the annexe were partially overlain by cobbled road surfaces. This may indicate that, as at Balmuildy, the ditches had been filled in when the annexe was constructed, though antiquarian mapping suggests the presence of medieval settlement in this area.

Finally, the road leaving the south gate of the fort was traced for some 300m, including identification of a bifurcation in its line. In 2010 Bailey undertook small-scale excavation immediately to the south of the fort where he confirmed that road line and recovered quantities of Roman pottery and box flue tile, but no other obvious structural features.

GSB's 1994 gradiometer survey was carried out with the general aim of accurately locating features identified in aerial photographs and defining any other anomalies

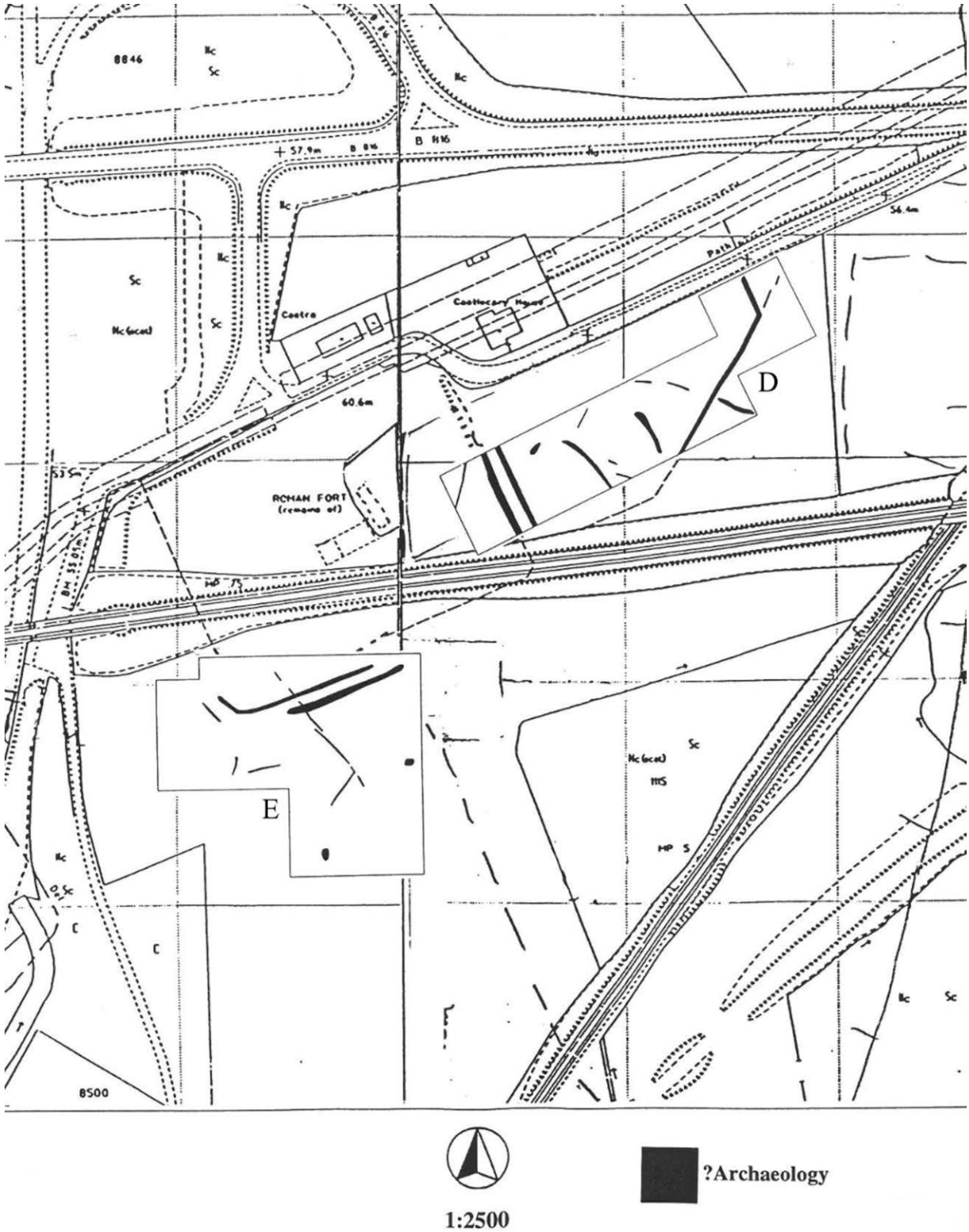

Figure 5.4.5. GSB 1994 gradiometer survey interpretation at Castlecary (after GSB 1994, Fig. 2c).

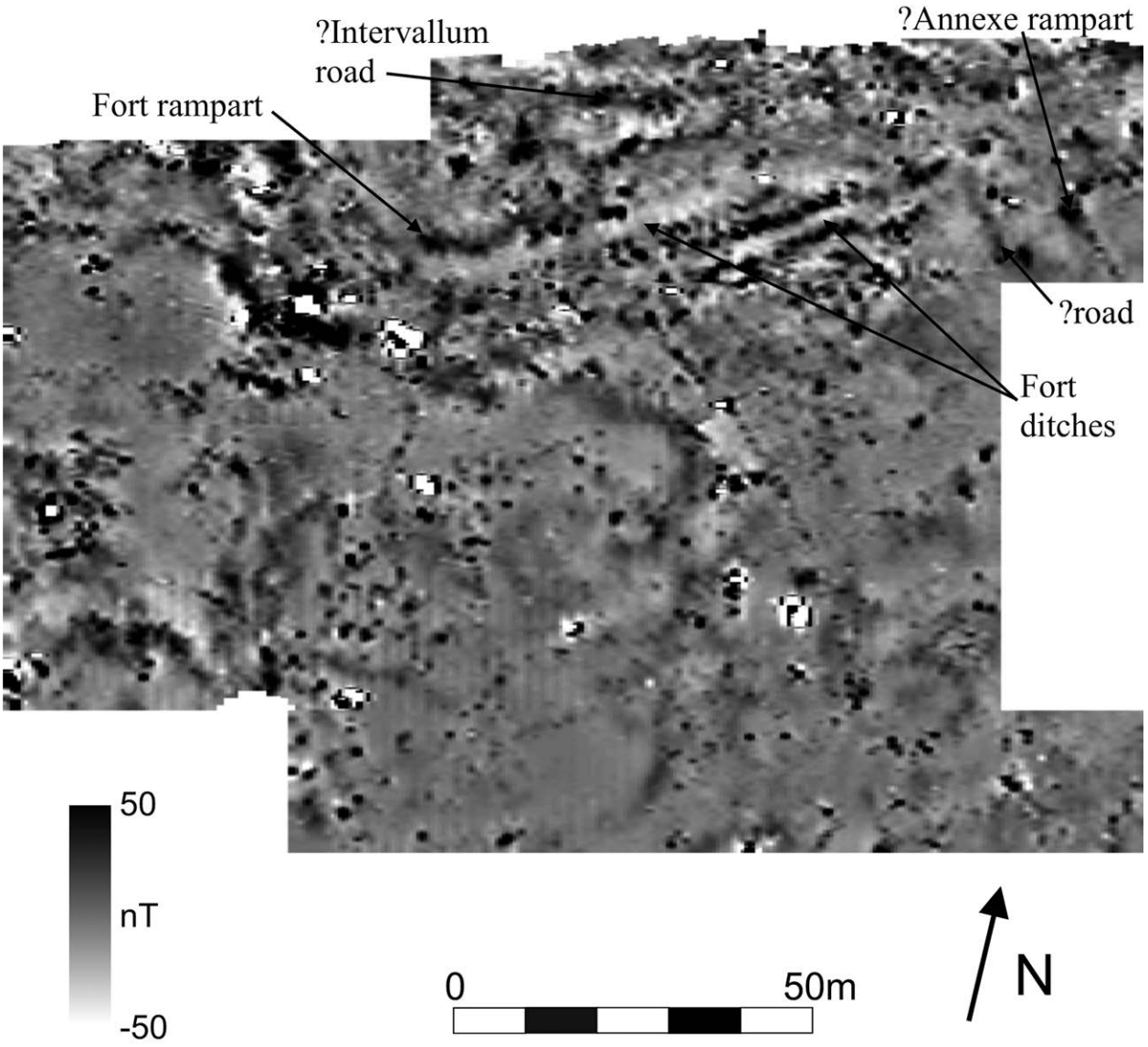

Figure 5.4.6. Glasgow University gradiometer survey in Area C at Castlecary.

of archaeological interest in advance of the proposed extension of the M80 motorway (Figure 5.4.1). Survey focused on the eastern annexe (Area D), along with an area across the south-west defences of the fort and beyond (Area E) in search of the road leaving the south gate and any potential extra-mural settlement. GSB's 2006 survey was located to the east of the annexe and sought to identify any evidence of the Military Way. The main objectives of the three Glasgow University surveys in the same year (Figure 5.4.2) were to investigate the interior of the annexe (Area A) and the immediate surroundings of the fort, again seeking evidence of possible civilian settlement (Areas A and C). Opportunity was also taken to examine limited areas within the fort (B and C).

The underlying drift geology consists of glacial sands, gravels and boulder clay, while the solid geology consists of Carboniferous limestone with basalts occurring extensively to the north of the Denny Gap. Because of the nearby presence of igneous rocks, it was recognised that gradiometry would have to be supplemented with resistance survey, and the latter predominated in 2006. The soils are brown earths; peat occurs to the immediate south-east of the fort. Survey conditions were good in the area of the fort and annexe, though the terrain in the north-west corner of the fort slopes steeply northwards. South of the railway line is rough grazing land that is occasionally boggy and slopes gently southwards.

Results

The southern defences of the fort are reasonably clear in both the gradiometer and the resistance surveys, running at a slightly oblique angle across the top of

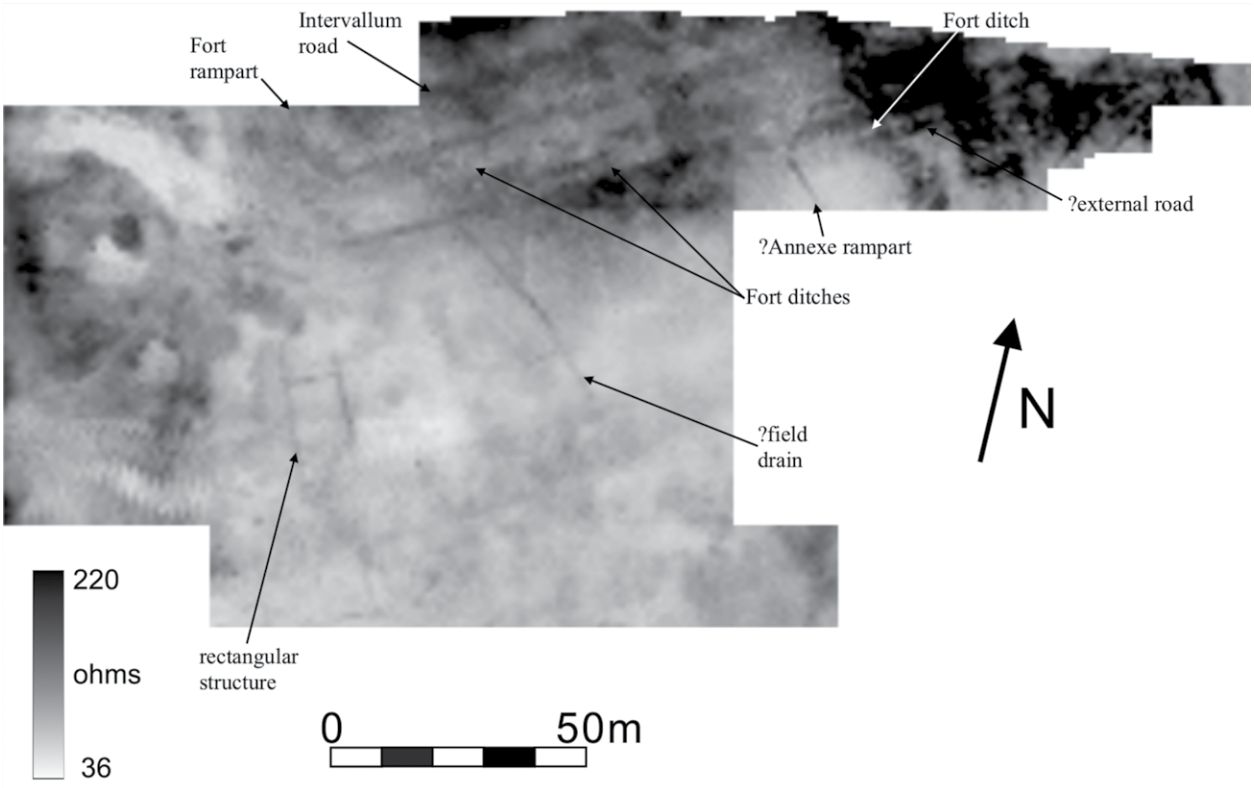

Figure 5.4.7. Glasgow University resistance survey in Area C at Castlecary.

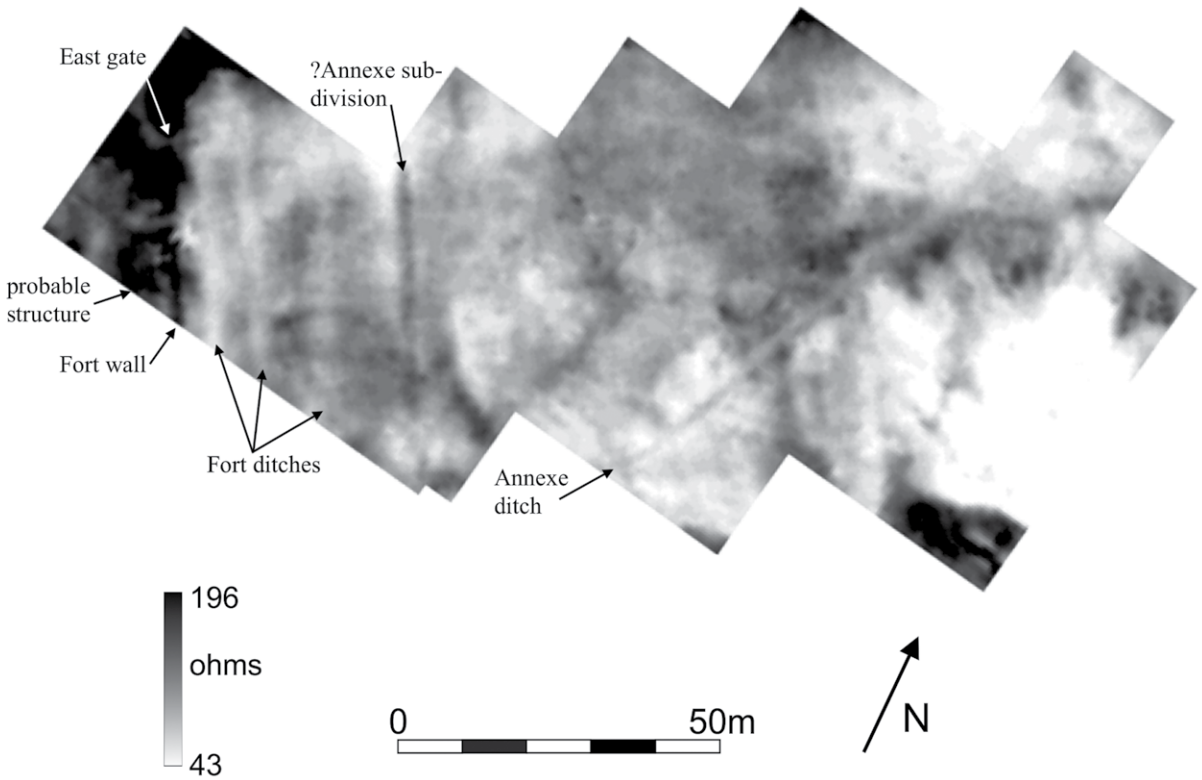

Figure 5.4.8. Glasgow University resistance survey in Area A at Castlecary.

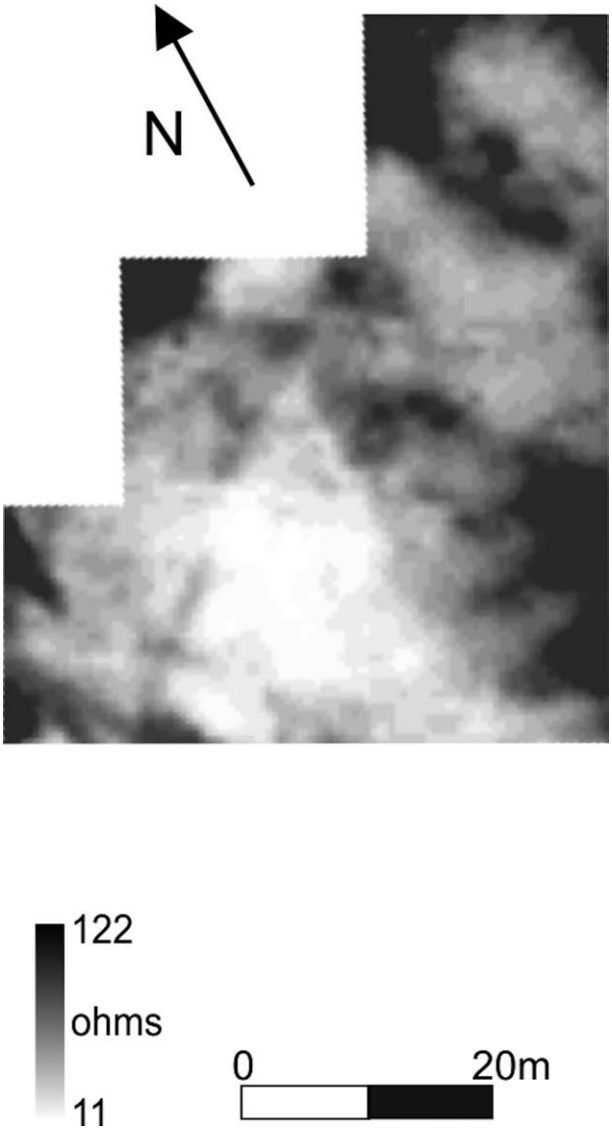

Figure 5.4.9. Glasgow University resistance survey in Area B at Castlecary.

the relevant survey areas. Despite the noisiness of the data, the two ditches were observed in GSB's 1994 gradiometer survey (Area E) as parallel negative linear anomalies, though only the inner one could be traced around the south-west corner of the fort (Figure 5.4.5). Glasgow University's later gradiometer survey (Area C) provided slightly more detail, despite the relative coarseness of the image resolution (Figure 5.4.6). Again the ditches are revealed as parallel negative linear bands, both of which continue around the south-west corner of the fort, with a fairly clear break towards the eastern limit of the survey marking the south gate. The negative anomalies are accompanied for parts of their length by contiguous inner, but sometimes also outer, positive ones. Similarly, in the resistance survey adjacent alternate high and low resistance bands depict the two fort ditches, which again can be traced only faintly around the south-west corner of the fort (Figure 5.4.7). After a barely detectable gap for the south gate, the ditches appear to continue east through an area of generally raised resistance as far as the north-eastern limit of the survey, where there are indications of a third, outer ditch not previously noted, though visible in the LiDAR imagery (Figure 5.4.3). Inside the ditches a slightly narrower band of raised resistance represents the line of the stone rampart, which can clearly be followed as it curves around the south-west corner of the fort (Figure 5.4.7). Inside that, a slightly irregular broad band of high resistance is the intervallum roadway as recorded in the 1902 excavations. In the gradiometer survey the rampart seems to be represented by a rather irregular positive linear anomaly where it approaches the south-western corner of the fort and the intervallum road may be indicated by a slightly disjointed linear anomaly combining both positive and negative signals (Figure 5.4.6).

The defences are more clearly defined on the east side of the fort, where the different surveys combine to cover almost the whole of their accessible length. However, only two of the three ditches recorded in the 1902 excavation were recognised in GSB's 1994 gradiometer survey (Area D), visible as parallel negative linear anomalies (Figure 5.4.5), while all three were apparent in Glasgow University's later resistance survey (Area A) (Figure 5.4.8), showing as parallel bands of lower resistance, though the outermost was broader and less clear-cut. The stone wall of the fort is in evidence as a well-defined narrow band of high resistance, a short gap towards the northern limit of the survey coinciding with the position of the east gate. Outside the gate there are faint hints of the short length of ditch that joined the ends of the inner two according to the excavations of 1902 (Figure 5.4.4). The broadening of the high resistance signal on either side of the gap for the east gate probably reflects the spread of stone from the gate structure itself. There are indications of a second gap in the fort wall *c.* 10m to the south whose significance is uncertain.

It is noticeable that the response from the small section of the interior of the fort revealed in Area A indicates a general pattern of much higher resistance (Figure 5.4.8), which presumably represents stone spread from the wall and/or internal structures. More detailed patterning is limited, but a rectangular block of high resistance towards the south-western extent of the survey lies immediately to the north of the internal bathhouse first recorded by Roy and may represent a continuation of that structure. Results from the resistance survey within the north-west quadrant of the fort (Area B) were somewhat disappointing (Figure 5.4.9). The small areas of very high resistance sampled across the northern and western limits of the survey

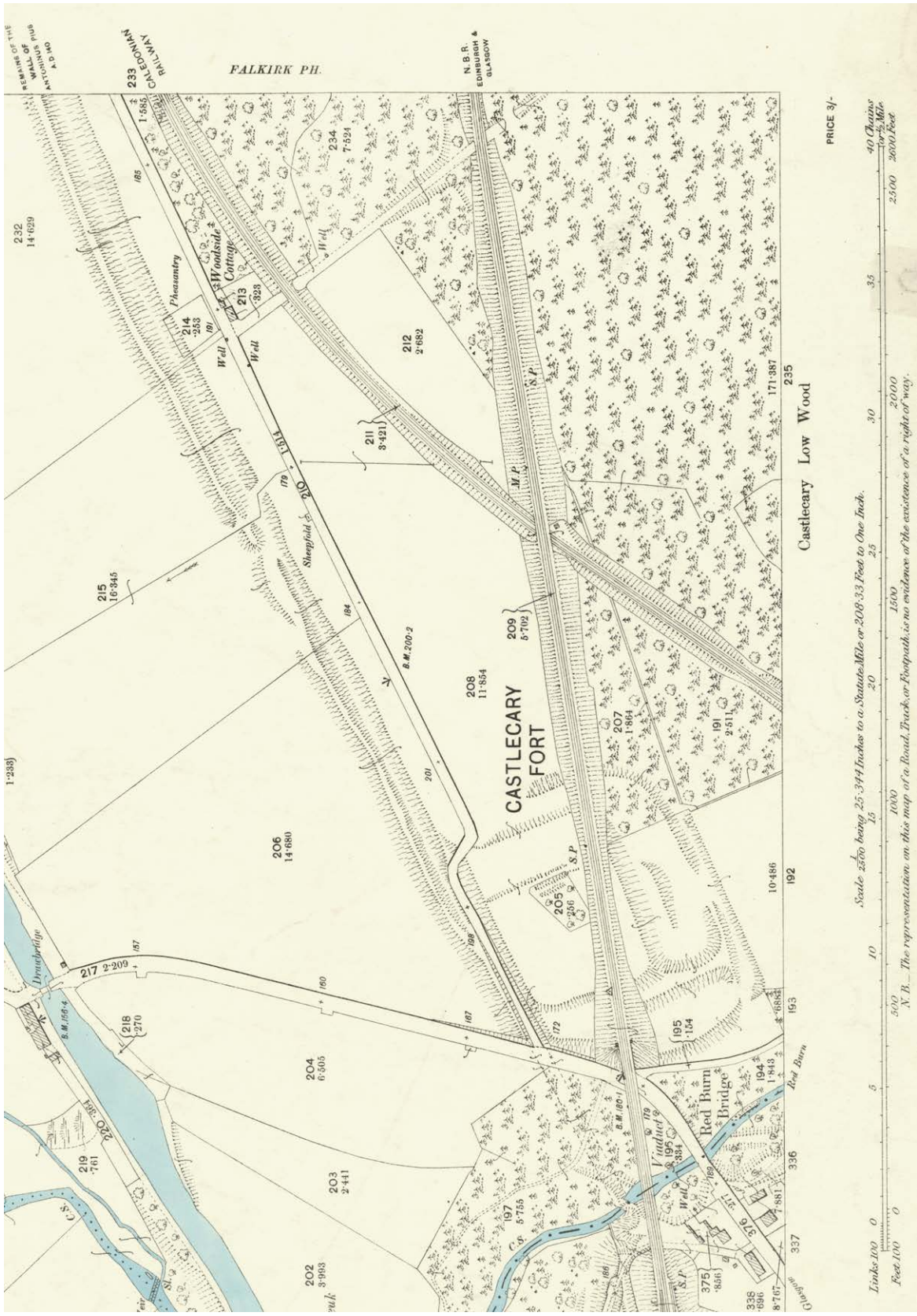

Figure 5.4.10. Extract from Ordnance Survey 2nd edition 25-inches to the mile map, Stirlingshire sheet XIX.7, published in 1898 showing the earthworks to the south of the fort at Castlecary (Reproduced with the permission of the National Library of Scotland. CC-BY (NLS)).

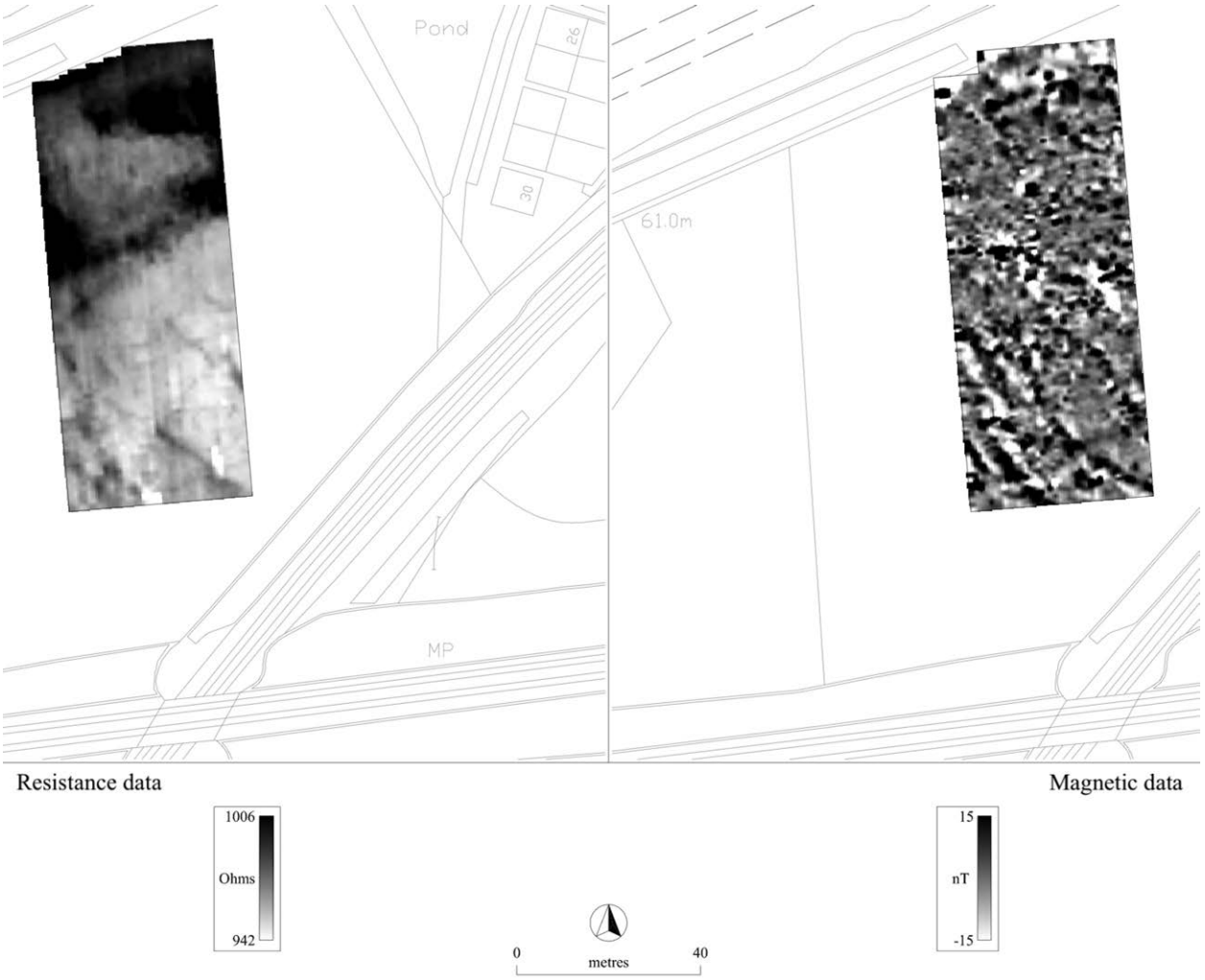

Figure 5.4.11. GSB 2006 resistance and gradiometer survey east of the annexe at Castlecary (after GSB 2006b, Fig. 5.4).

reflect the line of the north and west rampart of the fort, the clear gap in the west side perhaps marking the site of the west gate. An area of high resistance in the southern corner of the survey presumably reflects stone spread from a further building in the central range to the west of those excavated in 1902. The narrow, curving line of slightly raised resistance running south-west/north-east across the centre of the area may represent a Roman drain heading towards the west gate, but could as easily be a more recent field drain.

A lengthy stretch of the ditch defining the south-east and east sides of the fort's eastern annexe is readily apparent in the GSB's 1994 gradiometer survey (Area D) as a clear negative linear anomaly (Figure 5.4.5). So too in Glasgow University's later resistance survey (Area A) where it appears as a line of slightly enhanced resistance (Figure 5.4.8). There is no obvious sign of the rampart inside it nor of any structures within the annexe. However, running parallel with the defences of the fort some 12m beyond the easternmost fort ditch is a narrow band of higher resistance with occasional slight hints of a contiguous band of lower resistance beyond it. That this represents either a previously unrecognised sub-division of the annexe or an earlier smaller annexe is the probable explanation, as the alignment corresponds with an external earthwork mirroring the curvature of the south-east corner of the fort which is recorded in the 2nd edition 6-inch and 25-inch Ordnance Survey mapping (Figure 5.4.10) (see below) and faintly in the LiDAR image (Figure 5.4.3).

Immediately outside the fort, the line of the road from the south gate seems to be apparent in the gradiometer survey as a broad positive linear anomaly running at right angles across and beyond the ditches (Figure 5.4.6). A parallel narrow positive linear anomaly 10m to its east may relate to the postulated southern annexe (below), though it does not correspond with any of the banks recorded in the early Ordnance Survey mapping (Figure 5.4.10). The same feature is also apparent as a narrow band of raised resistance that comes to an end in line with the third fort ditch (Figure 5.4.7). Outside

and parallel to that fort ditch a further band of high resistance seems most likely to represent a road line running around the outside of the fort, a small section of which was noted here in the 1902 excavations.

Outside the south-west corner of the fort there are clear indications in the resistance survey of a probable stone structure. Narrow lines of raised resistance define a subdivided rectangle some 10m wide and at least 15m long (Figure 5.4.7). Gradiometer survey in the same area fails to provide clear confirmation, though there are a series of discrete positive anomalies in the immediate vicinity. However, this may not provide confirmation of an external civil settlement as the structure seems likely to be contained within a second annexe enclosure, an identification suggested by the earthworks alluded to above that extend out from the fort to encompass an area up to 50m deep along the whole of its south side and to a lesser depth around its south-east corner according to the 2nd edition 6-inch and 25-inch Ordnance Survey mapping (Figure 5.4.10). Apart from the narrow band of higher resistance recorded within the eastern annexe (above), there is no clear indication of these earthworks being visible in either the resistance or gradiometer surveys. The structure immediately outside the south-west corner of the fort may best be interpreted as a bathhouse, though a stronger magnetic response might reasonably have been expected. There is some independent support for the existence of a bathhouse to the south of the fort as fieldwalking and limited trial excavation some 65m further east recorded quantities of Roman pottery and box flue tile (Bailey 2021: 536-37). A narrow curving line of raised resistance some 40m to the east of this rectangular structure, apparent also as a disjointed positive linear anomaly (Figure 5.4.6), seems most likely to be a field drain as it cuts across the line of the fort defences.

Finally, in their survey in the field to the east of the annexe, GSB found generally high resistance in the northern third, giving way abruptly to lower values to the south (Figure 5.4.11). Since this division coincides with a break of slope apparent in the LiDAR survey (Figure 5.4.3), and is not reflected in the gradiometer survey, it seems most likely to relate to differential soil drainage. Hints of a band of high resistance at the northern extremity of the survey are on the right alignment for the southern side of the Military Way, as indicated by excavation in 1902, though there is no obvious counterpart in the gradiometer results and the resistance survey here comes very close to the southern edge of the, now disused, modern access road.

5.5 Seabegs

(NGR: NS 81760, 79440; Canmore 46786, 46800 and 227074)

Rampart, Berm, Military Way and postulated fort site

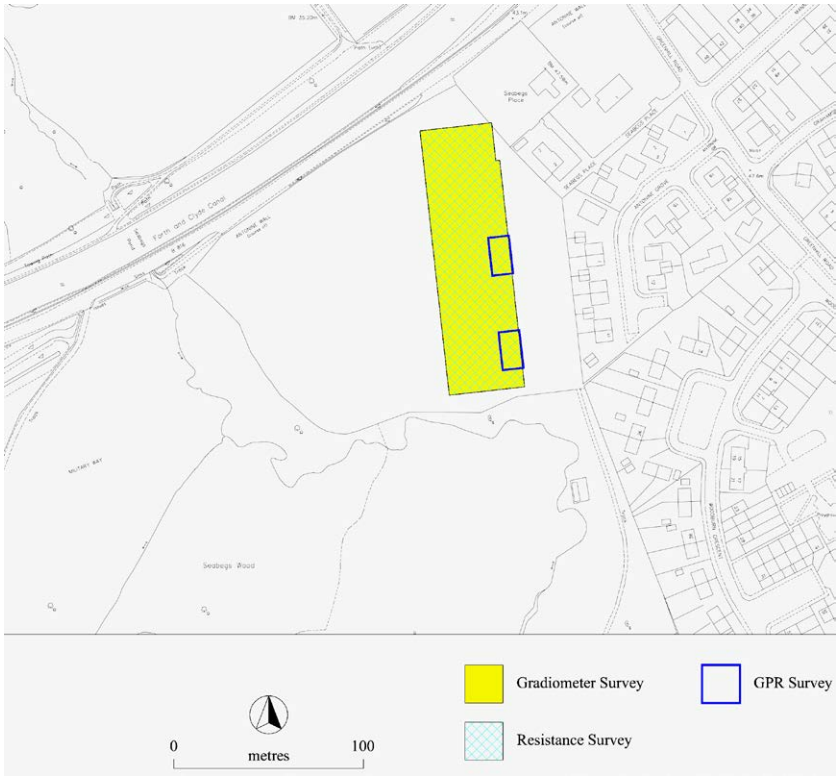

Figure 5.5.1. Location plan of GSB resistance, gradiometer and GPR survey areas east of Seabegs Wood (after GSB 2006b, Fig. 6.2).

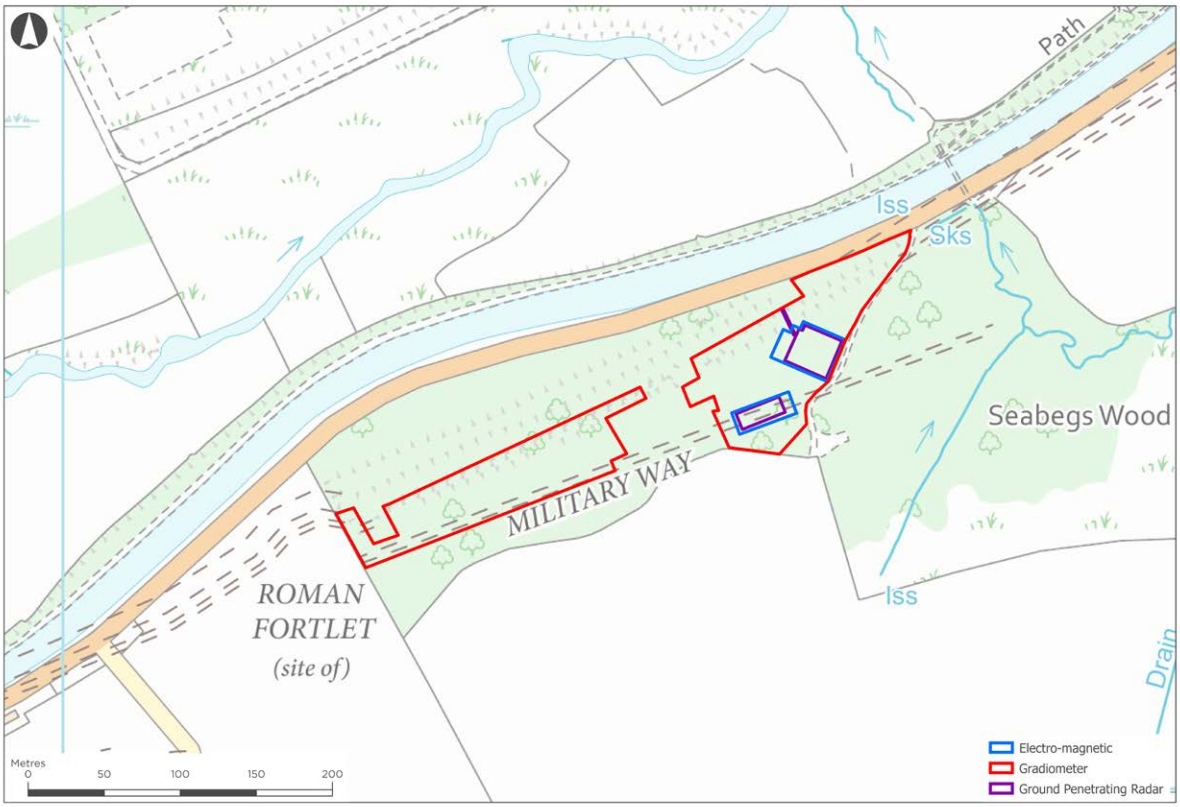

Figure 5.5.2. Location plan of HES gradiometer, electro-magnetic and GPR survey areas at Seabegs Wood.

Site-specific references

DES 1968: 44; 1972: 40-41; 1973: 51; Keppie *et al.* 1995: 629-30; GSB 2006b; Walker 2020: 187-8; Bailey 2021: 506-10; Hannon and Blake 2023d

Geophysical survey (Figures 5.5.1 and 5.5.2)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
GSB; 2006	G: Bartington Grad 601-2	*c.* 0.5	0.25, 1
	R: Geoscan RM15	*c.* 0.5	1, 1
	GPR: Pulse Echo 1000	0.02 each in 2 locations	1t
HES; 2022, 2023	G: Sensys MXPDA	1.35	0.125, 0.25ss
	EM: GF CMD Mini Explorer	0.20	0.5, 0.1 sec
	GPR: MALÅ Ground Explorer	0.12	0.5, 0.1

Introduction

The 400m stretch of Wall through Seabegs Wood, one of the best preserved and most picturesque along the whole line, is in the guardianship of the State. It occupies a gentle, north-facing slope overlooking the Bonny Water, a tributary of the River Carron. The Rampart survives to a height of up to 1.4m, while the Ditch is some 12m wide and up to 2m deep, with the Upcast Mound flattened out to enhance its outer lip. Seabegs Wood is also one of only three or four places along the Wall where the Military Way itself can be readily traced on the ground as an earthwork (see also Chapters 6.1 and 6.2, below). It consists of a *c.* 6m-wide, low, cambered mound running some 25-45m behind the Wall at a slightly oblique angle. This is particularly clear in the LiDAR data (Figure 5.5.3), which also shows the site of the fortlet discovered by Keppie and Walker (1981: 143-49). This lies immediately to the west of the guardianship area where the Ditch diverges to the north creating a small salient.

There also is a long tradition of a missing fort in this general area. Seabegs lies close to the mid-point between the forts at Castlecary and Rough Castle (Chapters 5.4 and 6.3) in a gap (5.74km) that is longer

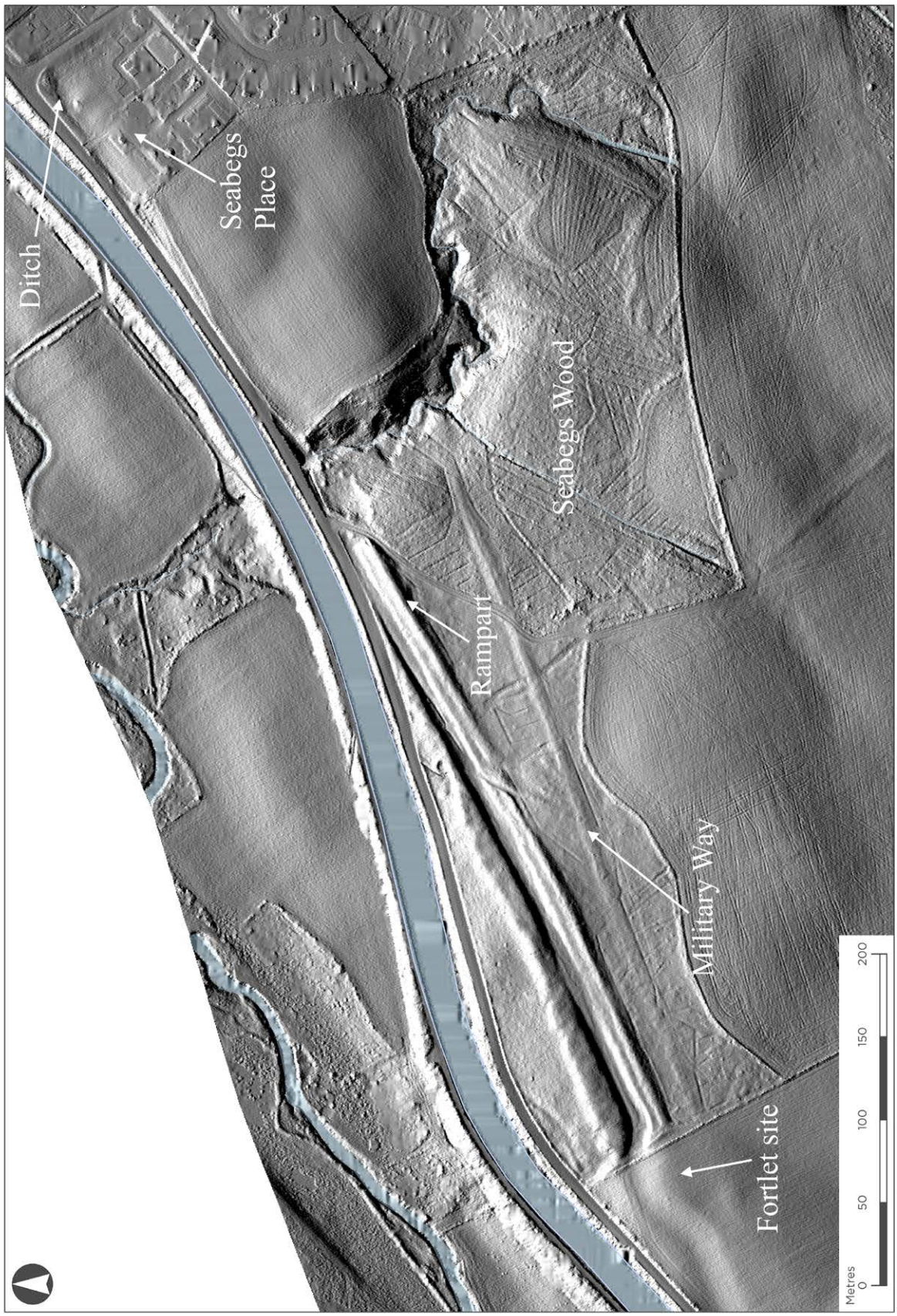

Figure 5.5.3. LiDAR image of Seabegs Wood and environs.

Figure 5.5.4. HES gradiometer survey at Seabegs Wood.

than usual. Irvine, who journeyed along the Wall in *c.* 1680, observed two 'forts' in the vicinity of Seabegs Wood (as recorded by Sibbald 1707: 30): that at the western end is almost certainly the site of the now known fortlet, but Irvine's 'great fort' at the eastern end of the wood remains unidentified. Roy maintains the idea of a missing fort (1793: 161), but is less precise about its location as by his day there were no traces left that he could map. Between 1968 and 1973 quite extensive but small-scale trenching was undertaken within the garden of Seabegs Place Farm and across the fields to the west and immediately to the east. However, this failed to find any evidence of a fort (see also Chapter 5.6), though they did confirm the line of the Rampart in several places.

According to the 2nd edition Ordnance Survey mapping undertaken in 1896, the Ditch remained just visible at the northern edge of the field between Seabegs Wood and Seabegs Place Farm, most of it hidden under the modern road or removed by the Forth Clyde canal. It then reappeared to pass immediately in front of the farm, the line still faintly detectable in the LiDAR data (Figure 5.5.3). Shortly thereafter the Ditch made a slight change of direction to the east (see Chapter 5.6). Though the line here is now lost under early 20th century housing, it was confirmed in small-scale excavations by Bailey in 2013 in gardens to the north of Mannfield Avenue.

Despite its excellent preservation through Seabegs Wood, there are no traces of the Military Way continuing to the east of Seabegs Pend, where the stream runs under the canal. Horsley mentions that it had passed through the garden on the south side of Seabegs Place Farm, though it had already ceased to be visible (1732: 171). Excavation by Bailey in 1989 ahead of housing development did find remains of a cobbled surface slightly further south, on the south side of Seabegs Place, though he was unable to confirm a Roman date for the remains. Accordingly, in an attempt to identify the line of the Military Way, a 40m wide and 140m long transect running from north to south was laid down by GSB across the east side of the field (Figure 5.5.1). There were no impediments to the survey, which lay in heavily cultivated ground given over to rough pasture at the time. The field straddles a high ridge, the ground sloping down relatively steeply to both north and south. Carboniferous sandstones shales and limestones prevail in the subsoil, with brown forest soils (with gleying), presenting no constraints on the survey.

Subsequently, HES undertook survey along the well-preserved stretch of the linear barrier in Seabegs Wood to test for the presence of defensive pits on the Berm and any minor structures that might be attached to the Rampart (Figure 5.5.2). The survey extended to the south over the extant remains of the Military Way in order to establish the character of response obtained from different survey techniques, as HES had been unable to identify this element of the monument elsewhere on the frontier. The linear monuments here lie in maintained grassland, so the only impediments to survey were the substantial areas covered by trees, which tended to block the global navigation satellite system signal, and a protected area of bluebells.

Results

Despite, or rather because of, the excellent preservation of the Wall Rampart through Seabegs Wood, its line is barely visible in the HES gradiometer survey (Figure 5.5.4), particularly in its eastern section. The *c.* 1.4m depth of the surviving turf superstructure means that the gradiometer does not tend to receive much of a response from the stone base. To the west narrow linear trends of positive anomalies are occasionally apparent within a broad band of average responses, presumably representing the kerb stones at the front and/or rear of the Rampart where the turf coverage is less deep. Similar features are much more clearly defined in some equally well-preserved stretches of the Wall on either side of the fortlet at Bonnyside (Figure 6.2.3). A small-scale GPR survey was also conducted across the line of the well-preserved Rampart and Ditch towards the eastern end of the site. The resulting radargram showed the base of the Rampart at around 40ns from the surface (Figure 5.5.5), equivalent to a depth of *c.* 1.6m, and revealed the profile of the Ditch, although the 450MHz antenna employed was unable to reach its base probably due in part to the cold weather conditions at the time of survey.

There is considerable magnetic activity evident along the Berm in the form of diffuse positive anomalies, concentrated in the western section of the survey (Figure 5.5.4). Various explanations are possible, including modern disturbance and spikes from buried ferrous objects. However, the frequency and location of their occurrence suggests that some may be defensive pits (*cippi*), even though a clear quincunx pattern is not immediately apparent. In the central sector, the rear of the Rampart is marked by a wide linear dipolar anomaly with oblique lines branching off it, which relates to the installation of modern drainage. One large dipolar anomaly at the back of the rampart near the eastern end of the survey may relate to a lightning strike on one of the trees.

The line of the Military Way is the most obvious archaeological feature running across the southern side of the HES gradiometer survey, though it shows somewhat differently in the two main sections (Figure 5.5.4). To the east it appears as a *c.* 6m wide band of positive anomalies, against a general background of average responses, which tend to concentrate towards

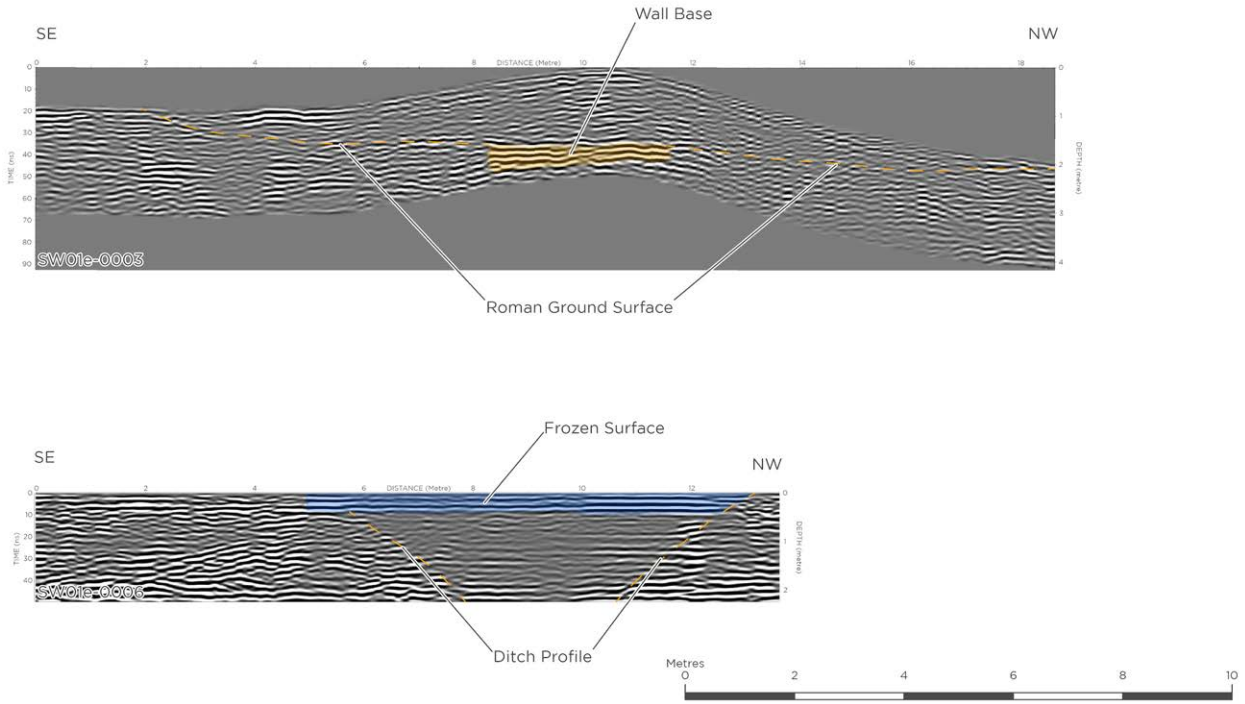

Figure 5.5.5. HES GPR radargram across the Ditch and Rampart at Seabegs Wood.

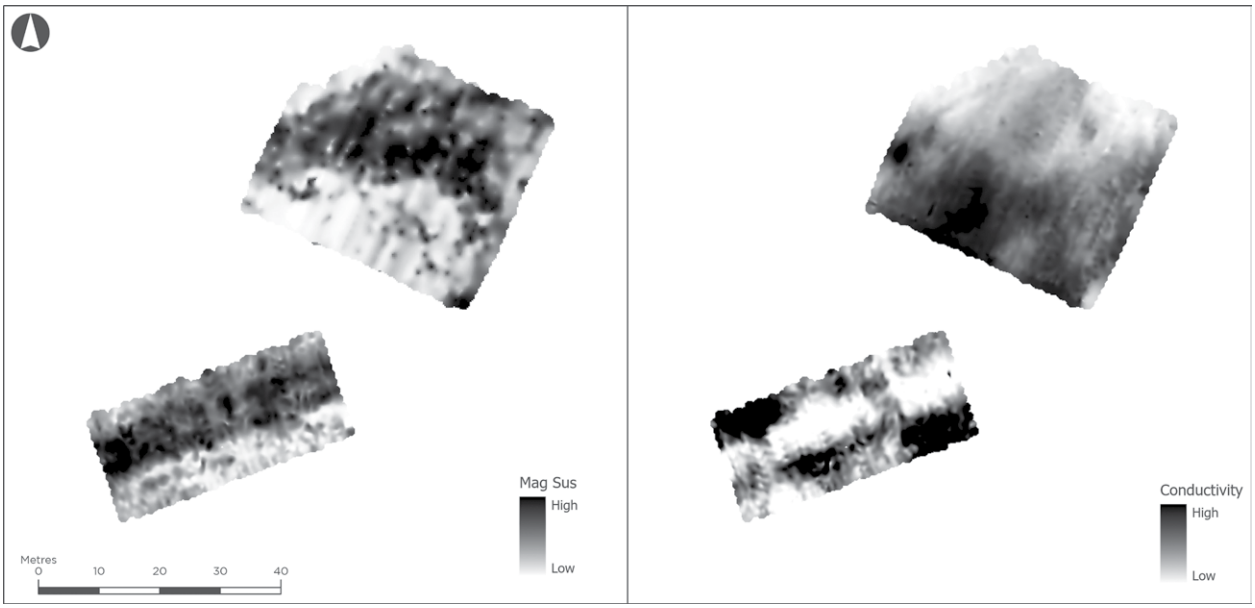

Figure 5.5.6. HES magnetic susceptibility and conductivity surveys at Seabegs Wood.

the edges of the road and perhaps reflect the response from larger kerb stones (as seen in Figure 1.18). To the west the positive anomalies are more frequent, occasionally accompanied by strong negatives where they seem to be linked to the burning of branches after tree-felling that is known to have taken place in the later 20th century. Along a 40m stretch of the western section of the Military Way conductivity and magnetic susceptibility survey clearly revealed it as a *c.* 8m wide band at a range of depth settings, the detailed character of the response varying according to the instrument settings (Figure 5.5.6).

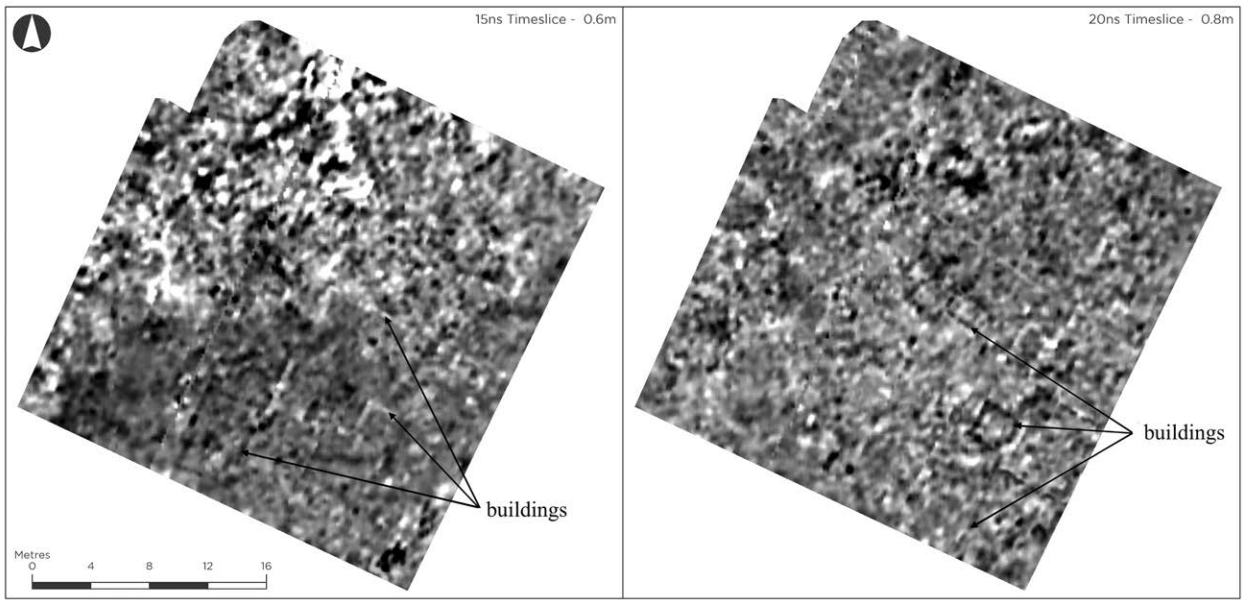

Figure 5.5.7. HES GPR survey at Seabegs Wood showing 15ns and 20ns Timeslices.

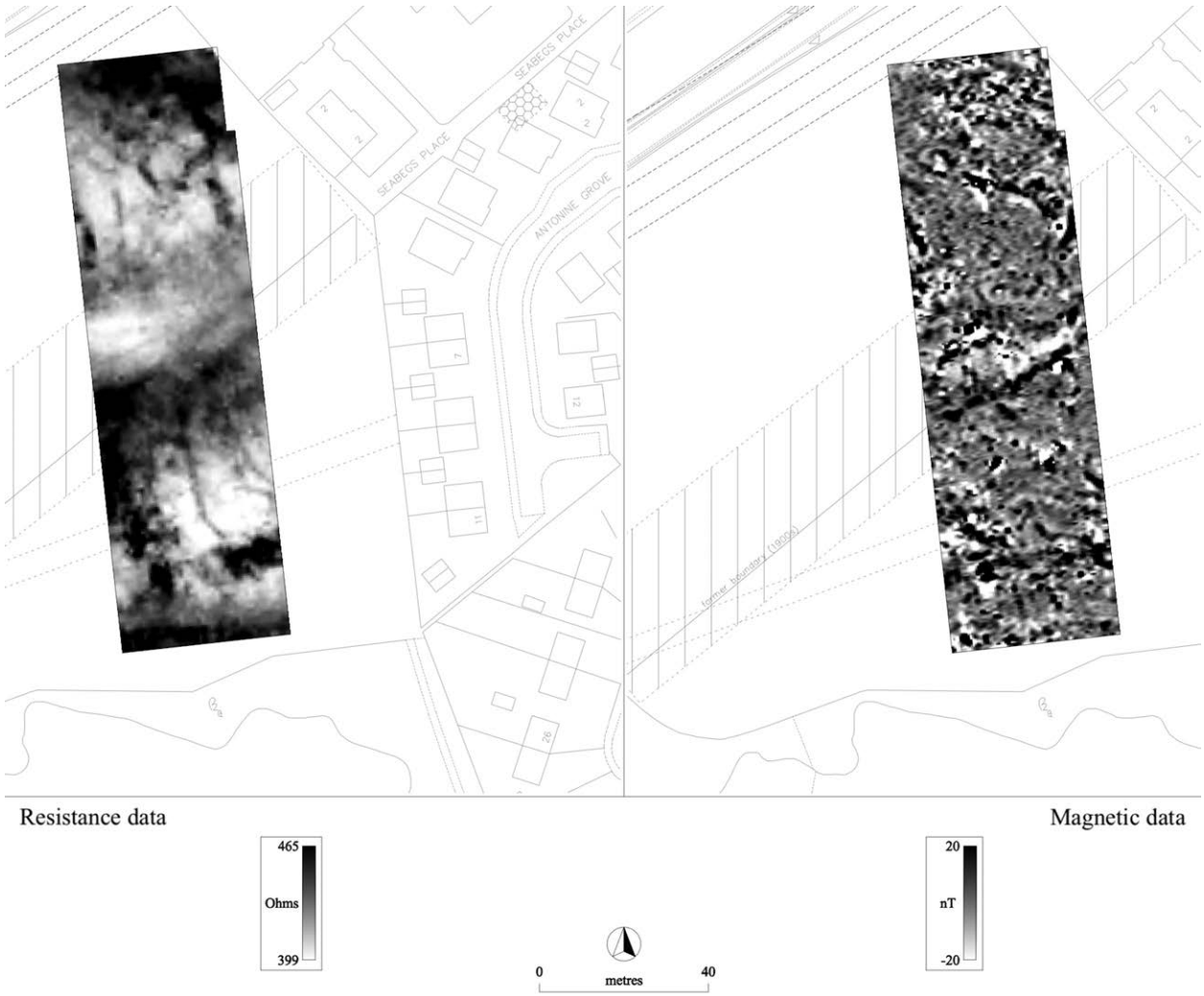

Figure 5.5.8. GSB gradiometer and resistance survey at Seabegs (after GSB 2006b, Fig. 6.4).

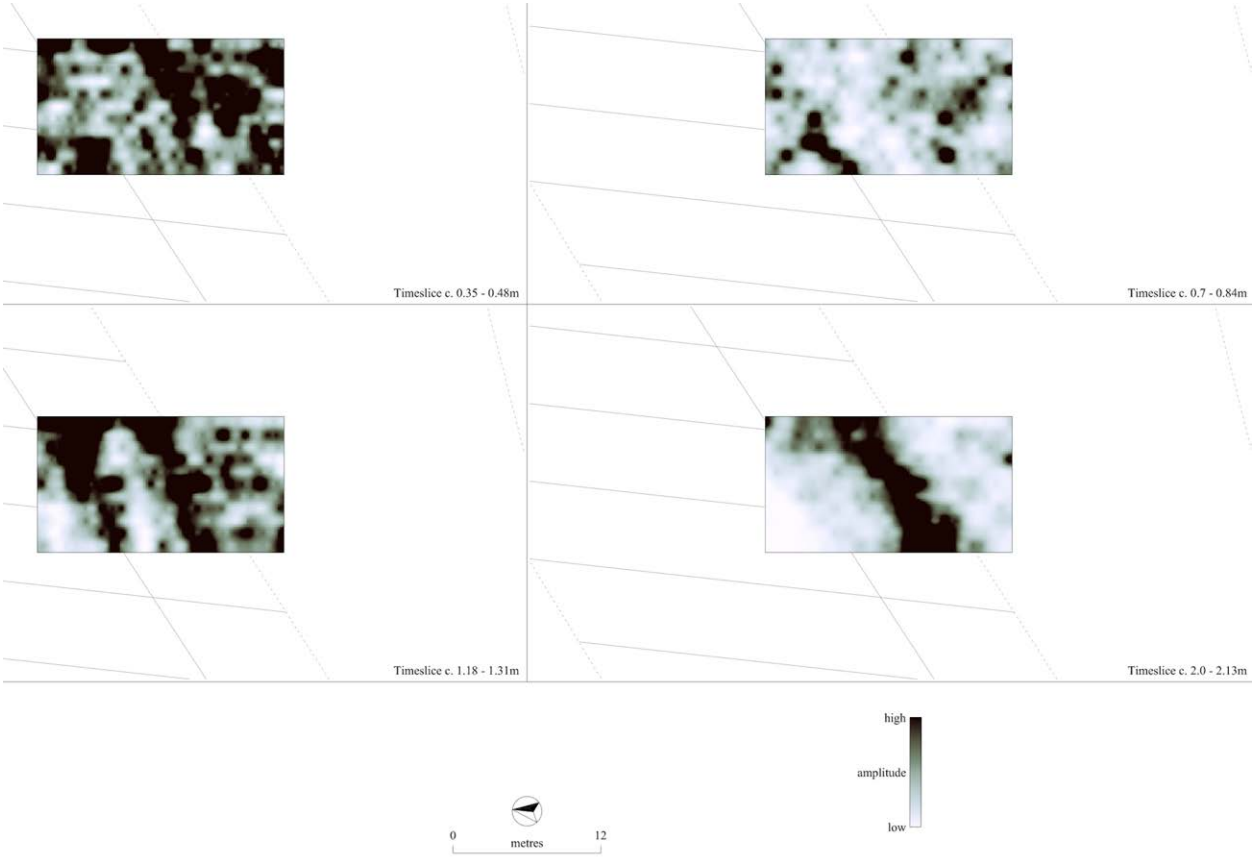

Figure 5.5.9. GSB GPR survey data at Seabegs (after GSB 2006b, Fig. 6.7).

A small, sub-rectangular, possibly L-shaped, area of high positive anomalies just to the north of the Military Way at the eastern end of the gradiometer survey (Figure 5.5.4) seems likely to represent activity, including burning, associated with a structure. This is not quite directly reflected in the GPR survey, though there is some overlap. The GPR survey reveals ranges of rooms of varying size around three sides of a rectangular walled enclosure in the south-east corner of the survey area, broadly corresponding with the most southerly part of the magnetic anomalies (Figure 5.5.7). Given the structure is oriented at right angles to the modern trackway through the wood, this seems best interpreted as the remains of a medieval/post-medieval farmstead rather than a building of Roman date.

None of the survey methods employed by GSB in the field to the east of Seabegs Wood provided definitive indications of the line of the Military Way. There is a clear positive linear anomaly running at a slightly oblique angle across the centre of the gradiometer survey, partially mirrored by a negative anomaly immediately to its north (Figure 5.5.8). However, the positive anomaly is too narrow to represent a road surface and similar closely paired responses elsewhere tend to reflect ditch lines. The resistance response is even less clear, though the same feature seems to be picked up in different timeslices in the more northerly area of the GPR survey (Figure 5.5.9). While it is reasonable to suggest a linear feature of some kind, the responses are insufficiently clear to characterise it as a road surface, and it is perhaps more likely to represent the field boundary that is attested on this alignment from the later 19th century until *c.* 1970. There are no responses that would support the identification of a fort at this location, confirming the negative evidence from trial trenching in the late 1960s.

5.6 Milnquarter

(NGR: NS 8216 7969; Canmore; 46798)

Rampart, Ditch, possible fortlet and Military Way

Site-specific references

Anon 1917; Smith 1934; Keppie and Breeze 1981: 237; Keppie and Walker 1989: 147-48; Walker 2020: 187-8; Hannon and Blake 2023a

Geophysical survey (Figure 5.6.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
HES; 2021, 2022	G: Sensys MX-PDA	0.9	0.125, 0.5ss

Introduction

The line of Ditch between Seabegs Place Farm (Chapter 5.5, above) and Broomhill Road was still sufficiently extant to be recorded in the 1st edition Ordnance Survey mapping of the area undertaken in 1860, even if depicted on the subsequently published map only as a dotted line. Bearing slightly to the north-east shortly after passing the farm, it continued in a straight line following a slight ridge through farmland before turning east, just after the site of Seabegs (aka Bonnybridge) motte. This medieval earthwork had made use of the Wall Ditch to define its south side, leading some antiquarians to consider it to be Roman (e.g. Horsley 1732: 171). Here the line had already been punctured by the construction of small reservoir serving Broomhill Distillery, a sign of worse to come. By the time of the more detailed 2nd edition Ordnance Survey mapping, surveyed in 1896, the line had also been bisected by a substantial railway cutting for a multi-track terminus serving the iron foundry and chemical works at Bonnybridge. Gradually thereafter the Wall was almost entirely built over, either by further industrial development, housing or other re-development. As a result, apart from the mutilated remnants of the motte now hidden under trees and contained within the grounds of the Antonine Primary School, no archaeological remains are still visible on the ground. However, the northern lip of the Ditch is just discernible in the LiDAR data (Figure 5.6.2) as it crosses gardens immediately to the west of the two small survey areas considered below.

There has been a surprising amount of excavation and other less formal recording in this sector of the Wall. A brief anonymous account noted the accidental removal by over-enthusiastic plot holders of much of the stone from the Rampart base to the east of the railway cutting when the land was turned over temporarily to garden allotments in 1917. During investigation of Seabegs motte in this same section in advance of construction of a minor road in 1933, Smith recorded that the Ditch was *c.* 13-15m wide and 3.6m deep. There was very limited survival of the Rampart superstructure in one section, but complete removal of even the base in a second. Limited trenching in a continued search for the missing fort at Seabegs (Chapter 5.5, above) was undertaken

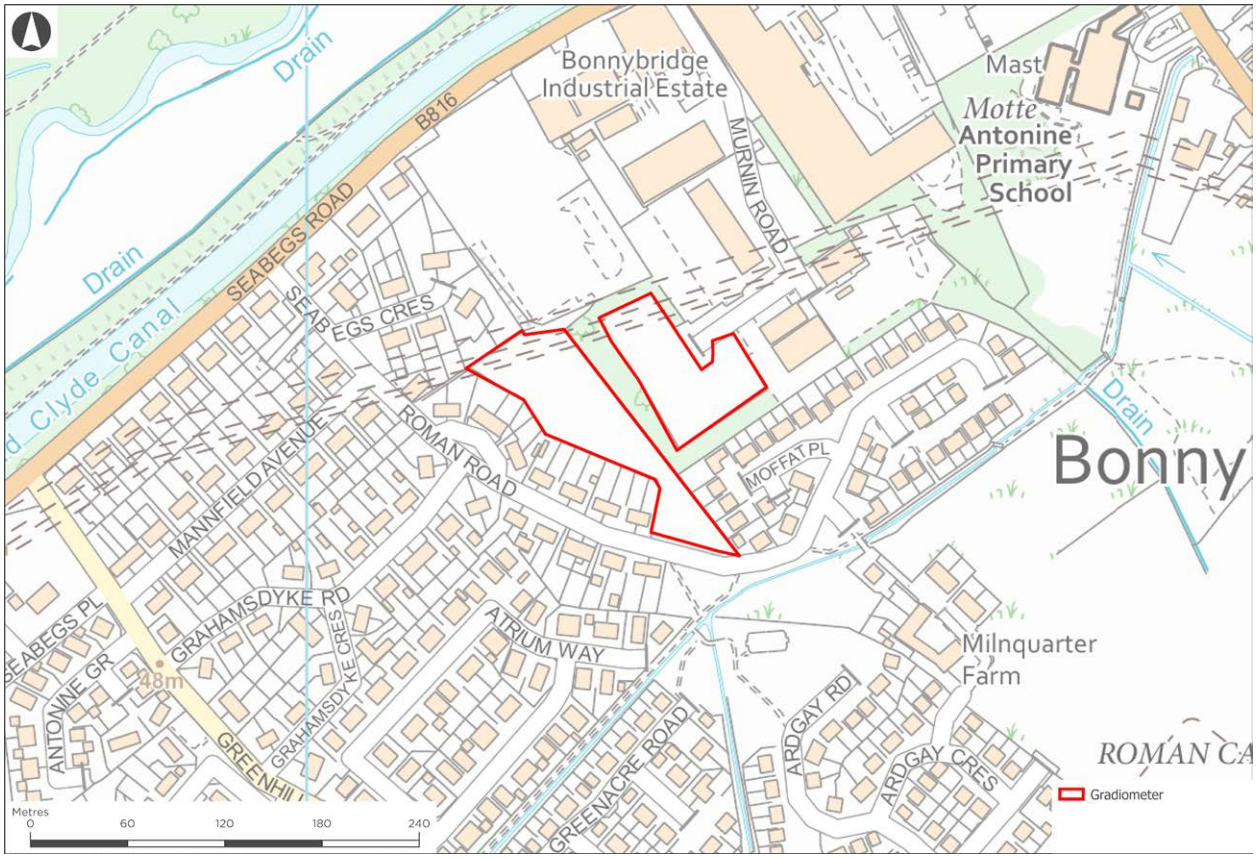

Figure 5.6.1. Location plan of HES gradiometer survey at Milnquarter.

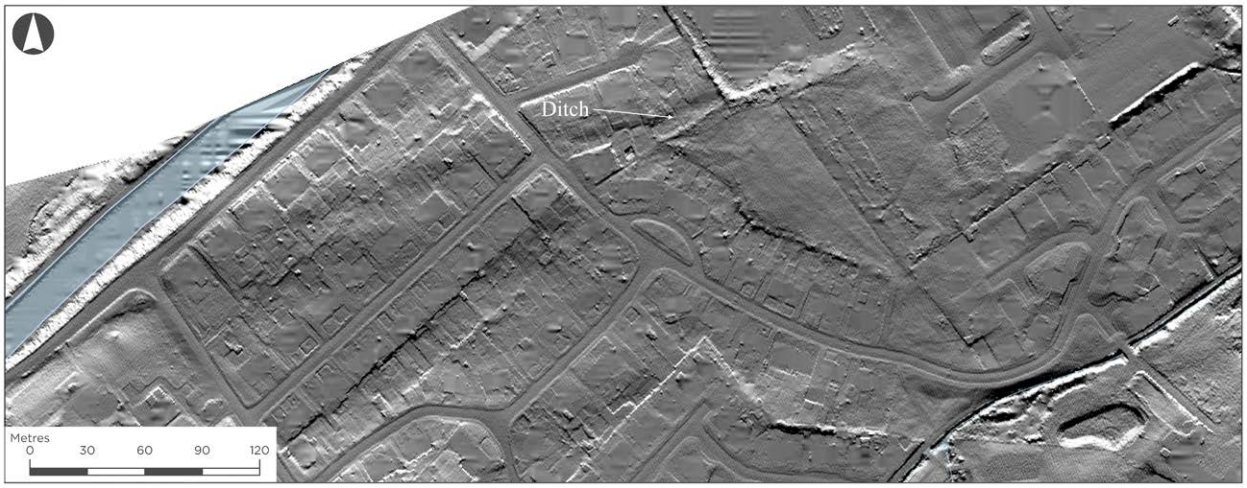

Figure 5.6.2. LiDAR image of the line of the Wall between Seabegs Place Farm and Broomhill Road.

by the Cumbernauld Historical Society in 1972 across two fields south-west of the motte, the more easterly of which had seen long service as a sports field. This work recorded only layers of slag and ash above, or field drains cutting through, natural sand and gravel. Indeed, aerial photographs from the 1960s (e.g. CUCAP G98412 PO) suggest extensive dumping of industrial waste across the fields west of the railway immediately to the south of the Wall.

Re-examination of the motte by Keppie in 1977 during the rehabilitation of what had become derelict land, confirmed the line of the south side of the Ditch. Despite the much-disturbed state of the Rampart base, he was able to trace elements of it over a distance of 5.5m. Slightly further to the west in 1979, again prior to the redevelopment of disused industrial land, Keppie established the line of both Rampart and Ditch some 6m south of the position recorded on contemporary Ordnance Survey mapping. He noted that the whole area had been much disturbed, with the remains of the Wall entirely removed in some parts. Subsequent excavation by Murray ahead of pipe laying alongside Murnin Road in 1982, and again some 50m further west by Bailey in 1984, recorded the Ditch as 8-9m in width, sealed by modern industrial waste in the latter case.

Given the poor survival of the Wall in this area and the slight discrepancy between the line indicated on current Ordnance Survey maps and that recorded by excavation in the 1970s, the opportunity was taken to investigate one of the few areas in the vicinity still accessible to survey. The possibility of a fortlet at Milnquarter has been suggested by several authors (e.g. Hanson and Maxwell 1986: 122; Woolliscroft 1996: 156, 160-61) primarily on the basis of spacing considerations, while the possibility of a missing fort somewhere in this general area has long been considered (see Chapter 5.5, above), so the survey was extended to the south to check for any remains. The solid geology is recorded as Passage Formation Sedimentary, overlain with Till and the soil type as Brown Earths. There were no physical constraints to survey as both small areas were under maintained grass, but the dumping of industrial waste, particularly slag and clinker, attested in excavations in 1972 and 1979 in the eastern part of the surveyed area and immediately beyond, was potentially highly detrimental to gradiometer survey.

Results (Figure 5.6.3)

There are no obvious signs in either of the gradiometer surveys of the line of the Wall or of any associated structures. However, the northern limit of the survey areas should have just overlapped the south side of the Ditch as recorded in the 2nd edition Ordnance Survey mapping. The scattered positive anomalies recorded running across the top of the surveys would be an unusual response from the Ditch, which is consistently revealed elsewhere as a broad negative band, but may indicate that it had been backfilled with industrial debris here. Indeed, both areas offer very busy responses entirely in keeping with the industrial history of the immediate locality. The southern end of the more westerly survey area is quieter, and narrow positive linear anomalies clearly outline a rectangular structure. This corresponds with a building, presumably the Seabegs Community Hall, which is recorded on Ordnance Survey mapping from the 1960s.

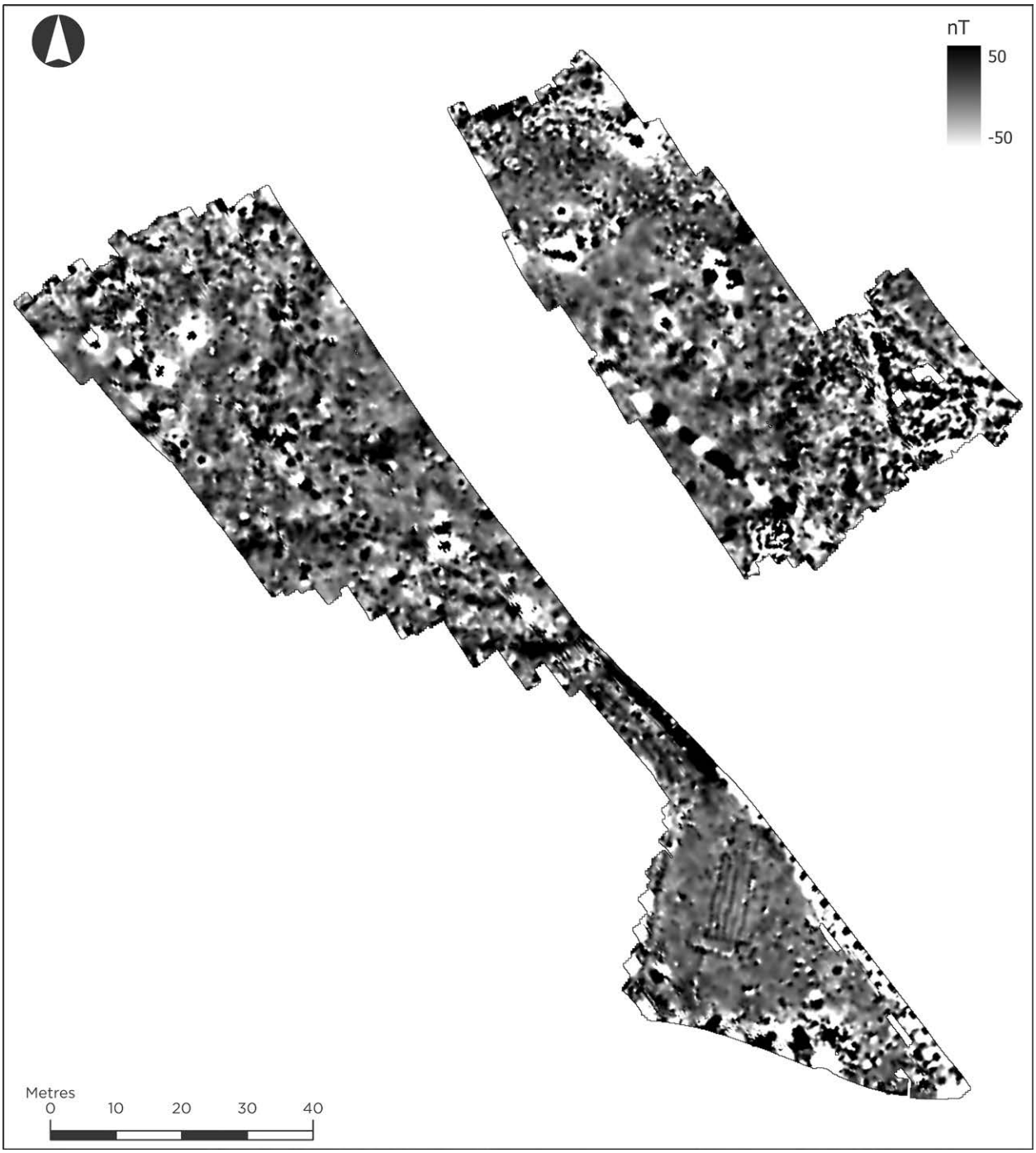

Figure 5.6.3. HES gradiometer survey at Milnquarter.

Chapter 6

6.1 Elf Hill, Bonnyside

(NGR: NS 83361 79788; Canmore 46786)

Rampart and possible fortlet

Site-specific references

GAS 1899: 101-07; Jones 2015; Hannon 2018: 315-16

Geophysical survey (Figure 6.1.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
Glasgow University; 2014	G: Bartington Grad 601-2	0.416	0.25, 0.5
	R: Geoscan RM15	0.28	1,1

Introduction

In some antiquarian accounts the substantial raised mound known as Elf Hill, a natural glacial moraine, was considered to be the site of a Roman watchtower (Roy 1793: 161), but it lies to the south of the Wall which skirts its steep northern slope. There are extant structural remains on its flat summit, but these reflect defensive preparations by the Home Guard during World War II (Figure 6.1.2).

The short stretch of the Wall here, between Bonnyside Road and the main Glasgow-Edinburgh railway line, remains quite well preserved, as is evident in aerial photographs and in satellite and LiDAR imagery (Figures 6.1.2 and 6.1.3). The Ditch is the most obvious feature, sufficiently deep at the eastern end of the stretch to hold standing water regularly, while the Upcast Mound has been flattened and spread out to the north; but there are also clear, if intermittent, traces of a low mound defining the Rampart. A section across the Wall in the early 1890s less than 20m to the east of this stretch recorded the Rampart surviving to a height of 1m above the base, a Ditch some 12m wide and still over 2m deep, and an Upcast Mound 18m wide and at least 1.2 high. A substantial section towards the centre of this stretch, adjacent to the remains of a disturbed Roman culvert through the Wall base, has been washed away by regular outflow from the middle of St Helen's Loch. This small natural loch, which appears on Roy's mapping for his military survey of Scotland (2007: Strip 6, Section 7, Part d), was slightly enlarged and regularised to serve as 'Reservoir' to supply local industrial demand in the 19th century.

Roy also maps the Military Way skirting round the south side of Elf Hill (1793: pl. 25), its line still partly visible on the ground as noted by the Ordnance Survey in 1957 (NRHE DP 051457) (Figure 6.1.2). The line is also clear in the LiDAR imagery, along with its continuation

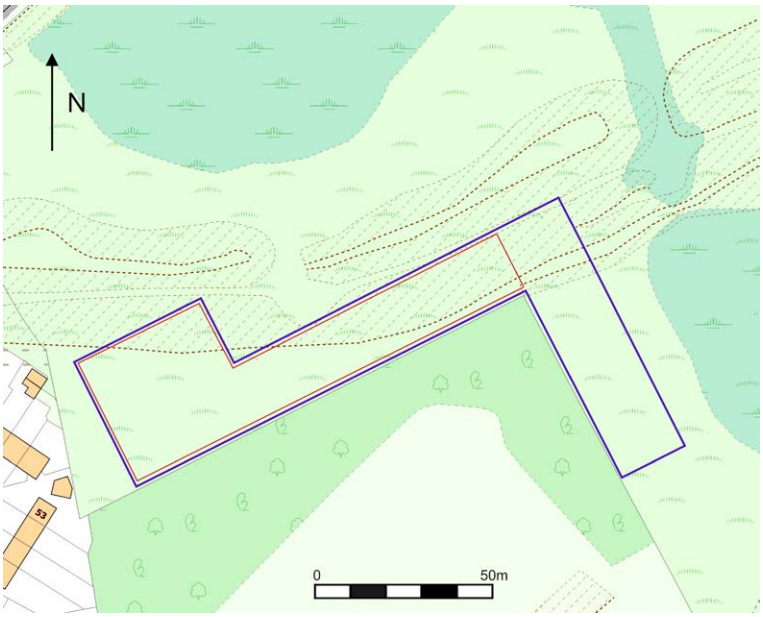

Figure 6.1.1. Location of surveys at Elf Hill (gradiometer in blue; resistance in red).

Figure 6.1.2. Aerial photograph of the extant line of the Ditch and Upcast Mound at Bonnyside from the west. Elf Hill lies to the south of the Wall in the centre of the image, with the line of the Military Way running between it and St. Helen's loch (© Historic Environment Scotland SC 1725941).

to the west identified by Hannon (Figure 6.1.3). The latter had not previously been noted.

The line of the Wall doglegs, changing direction within the grounds of nearby Bonnyside House and again just after it passes Elf Hill in order to resume its east/west alignment. These changes, located over 1200m from the postulated site of a fortlet at Rough Castle (Chapter 6.3, below), led Hanson and Maxwell to investigate the possibility of a further fortlet on the higher ground adjacent to the railway line, but excavation of two small trenches behind the Wall there in 1984 failed to find any Roman remains. Similar considerations, combined with observation by James Walker over a number of years of an area of red discolouration in the soil immediately south of the Wall, which elsewhere has been found to be associated with Roman structures (Walker 2020), prompted the geophysical survey recorded here.

The survey area encompassed the Rampart and a small part of the Ditch around the point where the Wall changes its alignment, along with a limited area behind it. The extent of the latter was restricted by a fence defining an area of woodland immediately to the south of the Wall. There were no other constraints to the survey as the field is in permanent rough pasture.

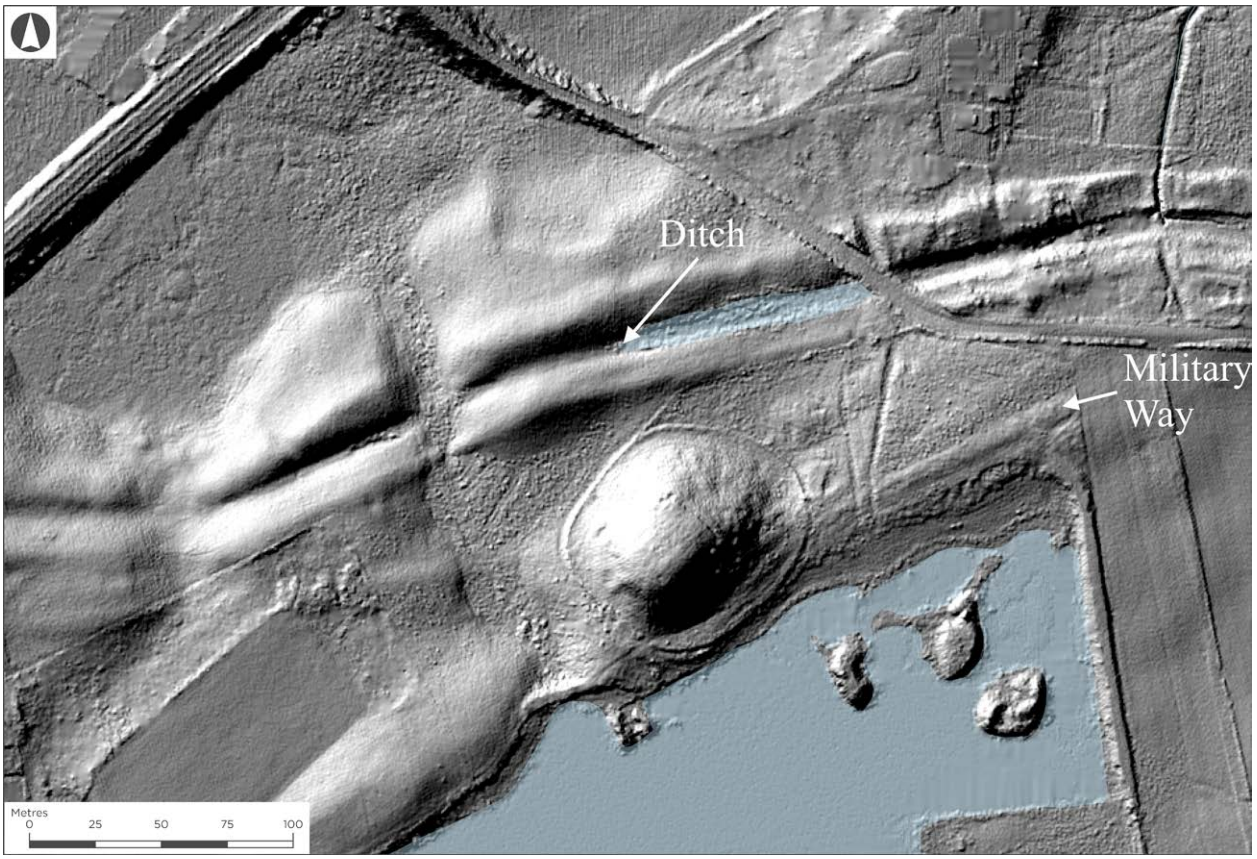

Figure 6.1.3. LiDAR image of Elf Hill.

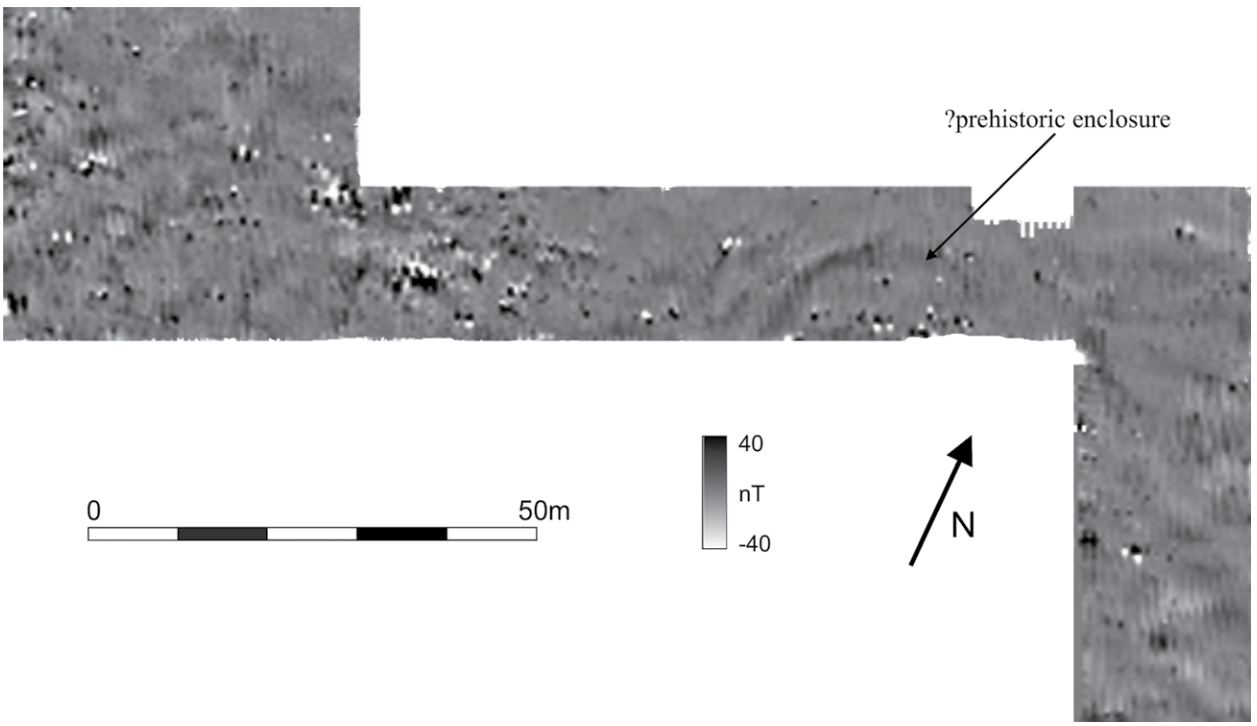

Figure 6.1.4. Gradiometer survey at Elf Hill.

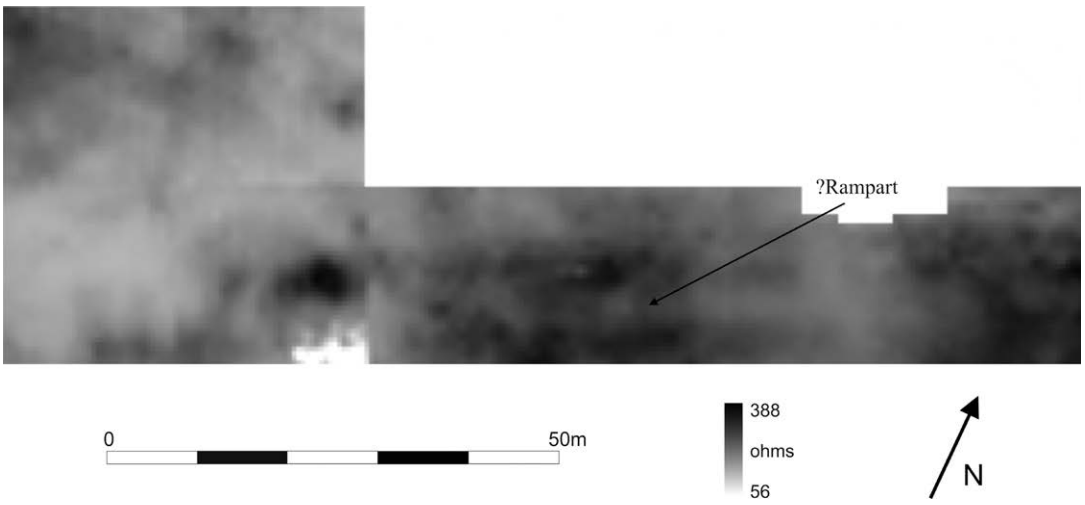

Figure 6.1.5. Resistance survey at Elf Hill.

The geological conditions were favourable to survey. Mudstone, siltstone and sandstone prevail in the subsoil, with some glacial deposits, and the soils are brown earth.

Results

Given the visible preservation of the Wall in this area, the results from the geophysical surveys were quite disappointing and far from clear-cut. There is no obvious regular banding in the gradiometer survey results (Figure 6.1.4) such as has been recorded elsewhere to demarcate the Rampart base (see, for example, Chapters 3.4 and 5.1 above), though the scattered positive and associated negative anomalies towards the centre of the survey area could possibly represent its disturbed remains. Certainly, where the survey extends over the southern edge of the Ditch it is noticeable that these anomalies are no longer present. A semi-circular positive anomaly towards the eastern end of the survey could well be of archaeological significance, perhaps a prehistoric enclosure and as such unlikely to relate directly to the Wall. There were no signs of any features that might be associated with a fortlet. The very recent discovery of one less than 1000m away (Chapter 6.2, below) would make it highly unlikely another would be located here.

The resistance survey revealed a different picture (Figure 6.1.5). There are linear clusters of high resistance in the central section, but they do not mirror convincingly the distribution of the positive magnetic anomalies. These may represent the Rampart base, though as they extend eastwards they seem to encroach onto the line of the Ditch. A linear band of low resistance immediately behind them would better correspond with the visible alignment of the Rampart here, the decrease in resistance perhaps reflecting the lesser density of the Rampart superstructure. Another area of lower resistance occurs in the vicinity of the possible prehistoric enclosure, though its outline is less readily discernible.

6.2 Bonnyside to Rough Castle

(NGR: NS 8400 7980; Canmore 46786 and 46801)

Rampart, Berm, expansion, fortlet and Military Way

Site-specific references

GAS 1899: 107-114; Steer 1957; RCAMS 1963: 94-6; DES 1970: 48; Keppie 1976: 63-64; Hannon and Blake 2023f

Geophysical survey (Figure 6.2.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
HES; 2022, 2023	G: Sensys MX-PDA	2.59	0.125, 0.5ss

Introduction

The *c.* 650m long stretch of Rampart and Ditch running west from the Rowan Tree Burn is one of the best preserved and most readily visible anywhere along the length of the Wall, as is clear from the LiDAR data (Figure 6.2.2). As such, along with the earthwork remains of the

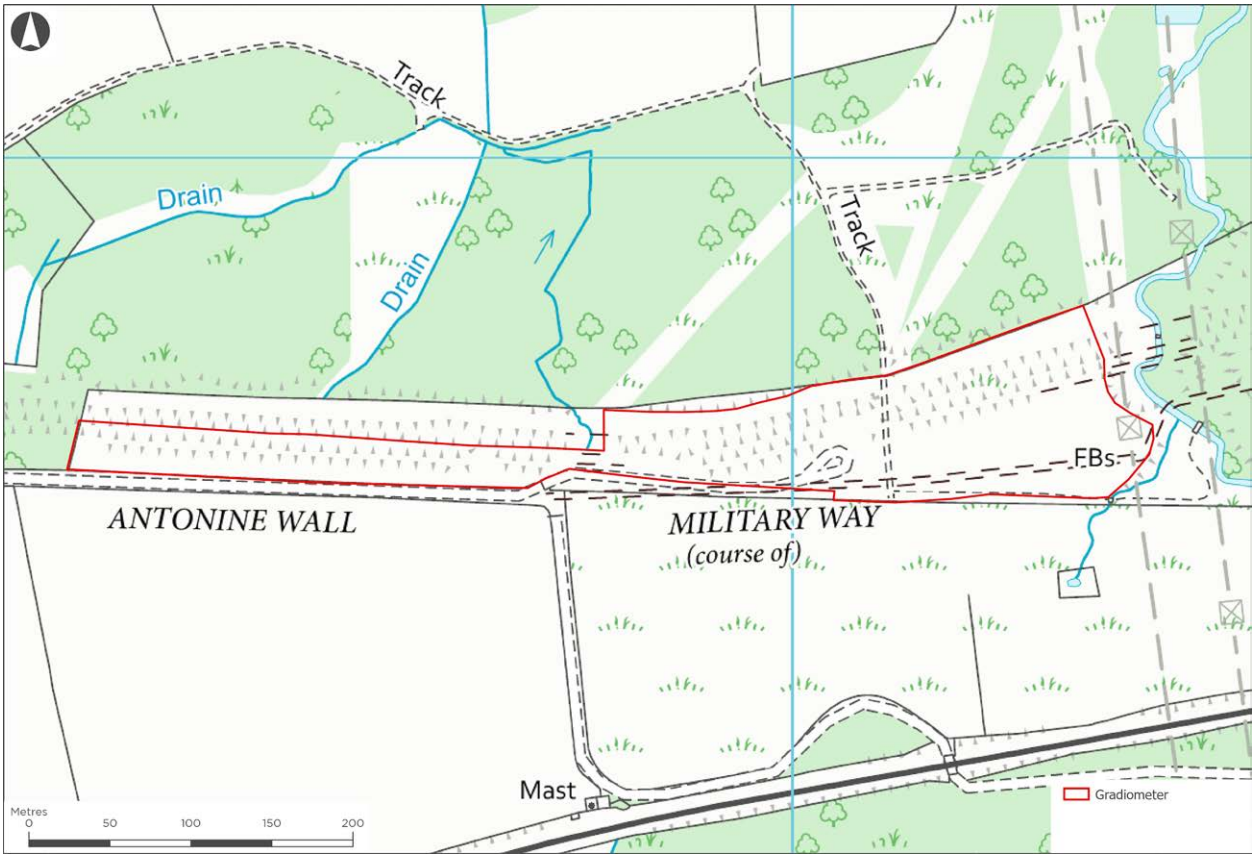

Figure 6.2.1. Location of survey between Bonnyside and Rough Castle.

fort at Rough Castle to the east of the Burn (Chapter 6.3, below), it was taken into guardianship in 1953.

Three sections were dug across the Rampart along this stretch by the Glasgow Archaeological Society in the early 1890s, two of them re-opened and re-recorded in more detail in the early 1970s by Robertson. She noted that the Rampart had survived to a height of up to 1.5m, its turf construction clear from the multiple dark organic laminations that were visible in section. An undisturbed stretch of Rampart nearby survives to a height of 2 m, measured from the Berm, the best preserved anywhere on the Wall. The Ditch remains some 12m or more wide and over 3m deep in places, while beyond it the Upcast Mound, having been spread and flattened to enhance the counterscarp, is up to 16m in width. Because of the excellent preservation of both Rampart and Ditch,[1] the 7-8m wide Berm between them is unusually clear.

The Glasgow Archaeological Society's survey also recorded two expansions. One, at Bonnyside East, is located immediately to the west of the access track into the guardianship area, the second (Bonnyside West) lies just outside that area within the trees in the grounds of Bonnyside House. Bonnyside East was completely excavated by Steer in 1957, along with a further section through the Rampart. The latter survived here to a height of 1.2m above the stone base, with 20-22 turf laminations visible in section. The cobble base of the expansion, which overlay a probable quarry pit for the extraction of stone for the Military Way, abutted the rear of the Antonine Wall base, indicating that it was added later. The relationship between their respective turf superstructures, however, was thought by the excavator to indicate contemporaneity of construction, though this is disputed (Hanson 2020: 13-14, fn. 57).

The eastern end of the survey area is one of only three or four places along the Wall (see also Chapters 5.5 and 6.1, above) where the Military Way can be traced on the ground as an earthwork. It consists of a *c.* 7m-wide, low, cambered mound running some 30-50m behind the Wall at a slightly oblique angle until it disappears under the site car park (an area previously occupied by a small cottage and its yard). This is particularly clear in the LiDAR data (Figure 6.2.2). Excavation by Keppie in 1975, linked to the tunnelling of gas pipelines under the

[1] A small section of rampart that had been flattened immediately to the north of the demolished farm was restored some years after this stretch was brought into guardianship, but this does not detract from its overall excellent state of preservation.

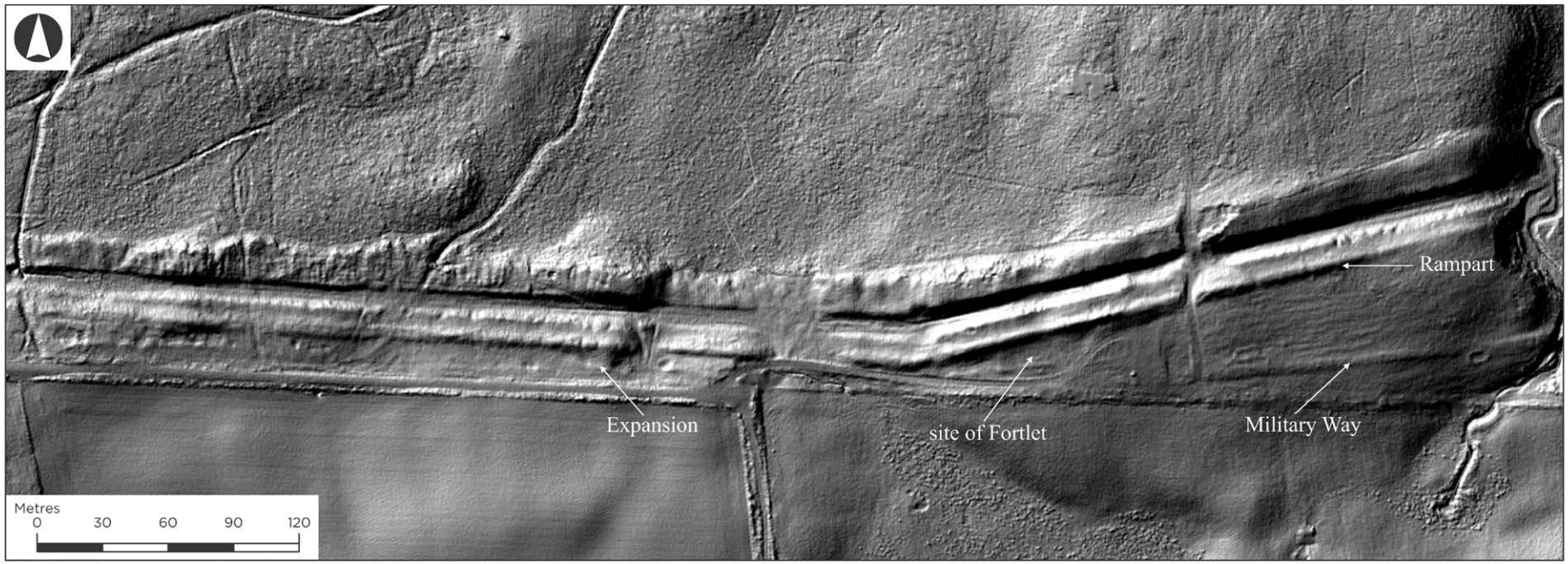

Figure 6.2.2. LiDAR image of the Rampart, Ditch, Upcast Mound and Military Way between the Rowan Tree Burn and Bonnyside.

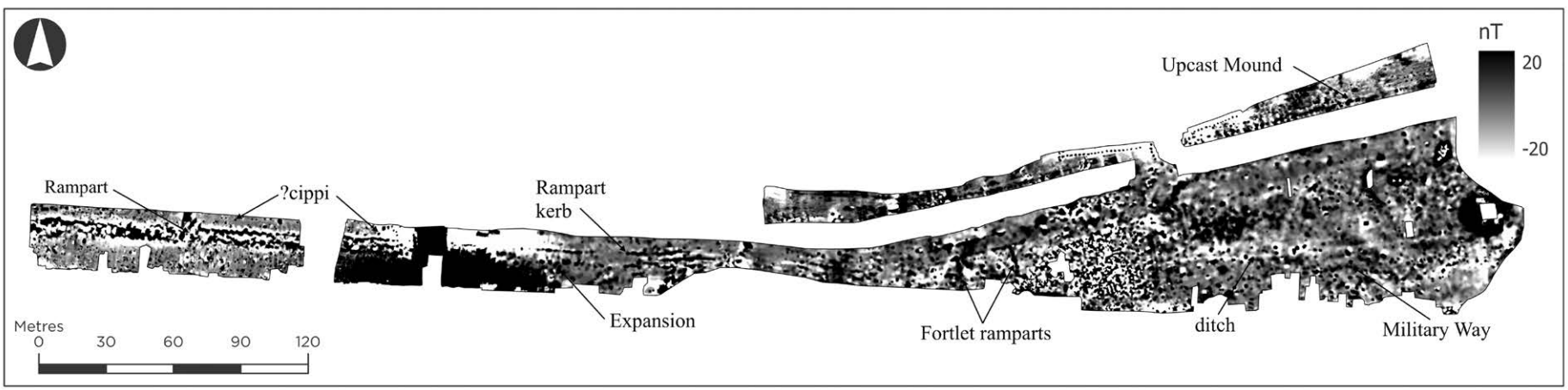

Figure 6.2.3. Gradiometer survey between Bonnyside and Rough Castle.

Wall, recorded the Military Way slightly further to the west running below and extending south of the modern access road to the guardianship site.

The gradiometer survey area extended west from the slope above the Rowan Tree Burn to the western limit of the guardianship area. It encompassed a stretch of the Upcast mound, the Berm and the Rampart, and extended behind the Wall up to the southern limit of the area in state care, including a lengthy section of the Military Way and the site of Bonnyside East expansion. Apart from the site access track, the parking area, a large electricity pylon and occasional trees, there were no constraints to the survey as the area is in maintained grassland. The geological and soil conditions were also favourable to gradiometry. The solid geology is recorded as Clackmannan Group, Passage Formation Sedimentary Rock overlain with Devensian Till; the soil is formed of non-calcareous gley.

Results (Figure 6.2.3)

In the main central section of the gradiometer survey the Rampart line is visible as two thin, slightly discontinuous, parallel positive linear anomalies some 4.5-6m apart. These clearly represent the kerb stones picked up at the edges of the Rampart base where the surviving turf superstructure is less deep (see Chapter 5.5, above). At the western end of the survey these linear anomalies get stronger and wider, the magnetic responses from the Rampart base increasing as the overall depth of the turf superstructure decreases. In the eastern quarter of the survey, where the Rampart superstructure survives to its greatest extent, the indications are less clear-cut, though the general line can be identified as a slightly more positive linear band.

There are a number of discrete positive anomalies at various locations on the Berm, which could represent defensive pits (*cippi*), but there is no consistent pattern to their distribution. On the other side of the Ditch at the eastern end of the survey the southern edge of the Upcast Mound is marked by a slightly discontinuous positive linear anomaly. This probably marks the location of a band of rough stonework on the outer lip of the Ditch similar to that recorded in a section cut across the Wall line on the other side of the Rowan Tree Burn during excavation of the fort at Rough Castle in 1903 (Buchanan *et al.* 1905: 454-55 and pl. I).

The position of the Bonnyside East expansion is identifiable as a cluster of discrete positive and dipolar anomalies at the rear of the Rampart. This lies immediately to the east of a massive dipolar anomaly caused by the underground passage of gas pipelines installed in 1975.

Just to the west of the car park, which is distinguishable as an area of noisy, slightly dipolar signals, the site of a previously unknown fortlet is apparent, partially overlain by the slight extant remains of a trackway to the farm that is visible in the LiDAR data (Figure 6.2.2). Its ramparts are revealed as two parallel positive linear anomalies *c.* 2m wide extending at right angles from the back of the Antonine Wall Rampart to the southern limit of the survey area. They indicate that the fortlet was *c.* 23m wide and at least 14m long internally. This is slightly wider than other known examples, most of which are square or of long-axis type, that is with their north-south dimensions longer than their east-west ones, but would be entirely appropriate for a potential short-axis fortlet (see Hanson and Maxwell 1986: 93-95). There is no sign of an external ditch, but good indications of possible internal structures, with various strong positive anomalies in the centre and a line of small discrete positive anomalies, potentially postholes, running parallel with the back of the Rampart. A gap in the positive anomaly that defines the rear kerb of the Rampart base presumably marks the north gate, though it lies slightly to the east of the centre of the fortlet.

The line of the Military Way at the eastern end of the survey area is visible as a narrow linear cluster of discrete positive anomalies, similar to, but less well demarcated than, the line of the Military Way in Seabegs Wood (Chapter 5.5, above). Running approximately parallel and some 6-7m to its north is a narrow negative alignment. While this could be an associated drainage ditch, the distance between it and the Military Way is considerably larger than would be expected and it seems to be heading directly towards the post-medieval farmstead on the same alignment as the trackway which overlies the fortlet further west.

6.3 Rough Castle

(NGR: NS 8435 7985; Canmore 46803 and 46790)

Fort, annexe, defensive pits and field system

Site-specific references

GAS 1899: 114-19 and pl. 5; Buchanan *et al.* 1905; Macdonald 1925: 285-7; 1933: 243-77; RCAMS 1963: 100-02; MacIvor *et al.* 1980; Maxwell 1989b: 169-74; Máté 1995; GSB 2008b; Kirkdale Archaeology 2011; Hannon and Blake 2023g; Hanson forthcoming

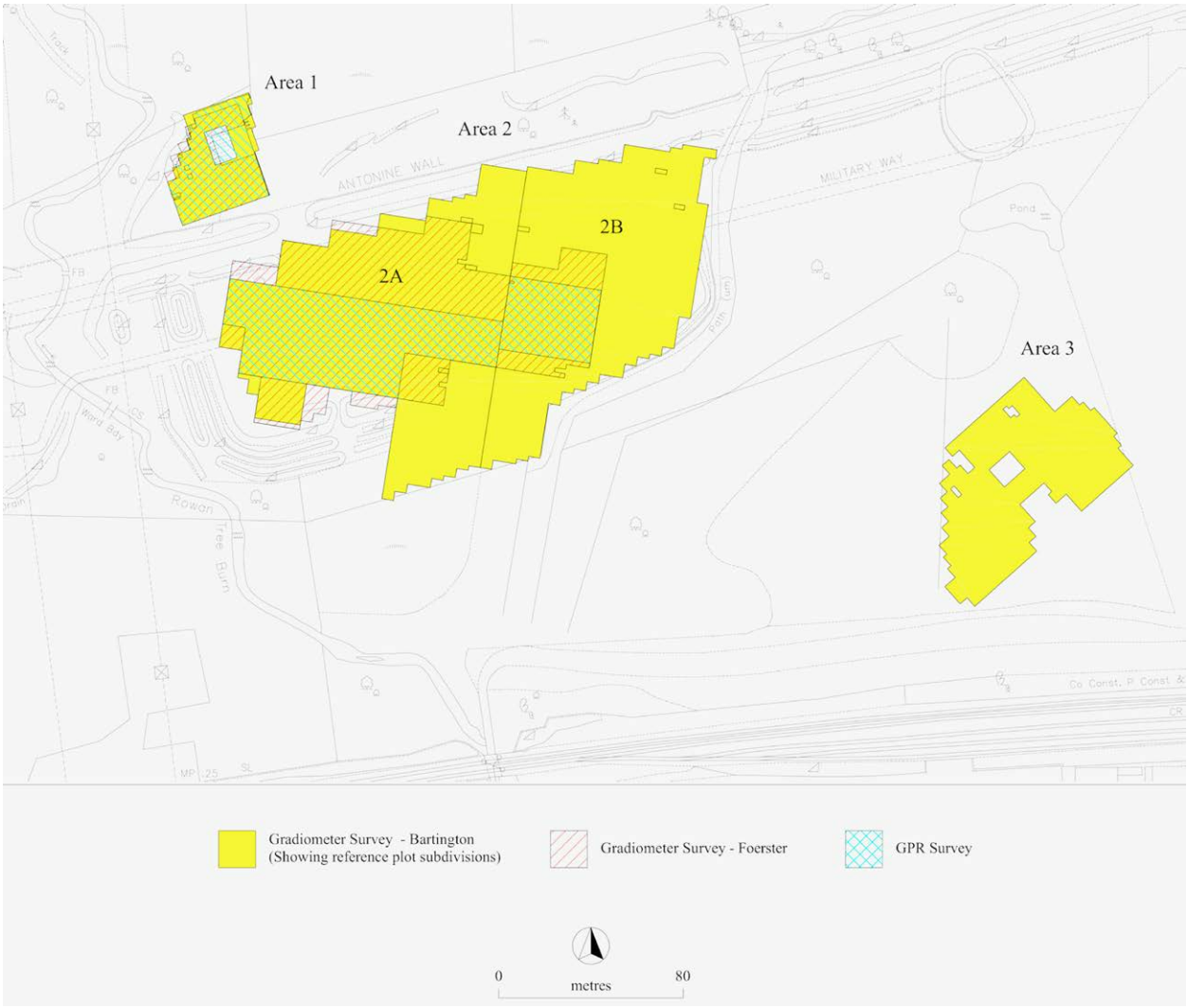

Figure 6.3.1. Location of GSB survey at Rough Castle: Area 1, defensive pits; Area 2, fort/annexe; Area 3, field system (after GSB 2008d, Fig. 2).

Geophysical survey (Figures 6.3.1 and 6.3.2)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
GSB; 2008	G: Bartington Grad 601-2	2.56 (Areas 1-3)	0.25, 1
	G: Foerster Ferex 4.0132 DLG	1.2 (Areas 1-2)	0.25, 0.5
	GPR: Sensors and Software Noggin+ Smartcart	0.7 (Areas 1-2)	0.05, 0.5
HES; 2022	G: Sensys MXPDA	2.8	0.125, 0.5ss

Introduction

The fort at Rough Castle is situated on the east side of the Rowan Tree Burn at the point where the burn breaks through a *c.* 60m high ridge that overlooks the gentle descent to the River Carron a mile to the north. Several antiquaries, notably Gordon (1726: 59 and pl. 25) and Roy (1793: 161 and pl. 35), were able to produce quite detailed plans of the fort and its attached annexe in the early 18th century, and much of that detail remains clear on the ground (Figure 6.3.3). It continues to be the best-preserved fort on the Wall (Figure 6.3.3), though the current visibility of its earthworks has been much enhanced by the landscaping undertaken over a number of years by HES and its predecessors after the site was taken into the guardianship of the State in 1953. This work was substantial and involved the removal of trees, dense bracken and a dry-stone field wall that ran across the fort from north to south, as well as the infilling of those trenches left open from the early excavations. Clearance of silt from the Ditch in front of the fort was attempted with limited success in the mid-1960s, but abandoned when it began to result

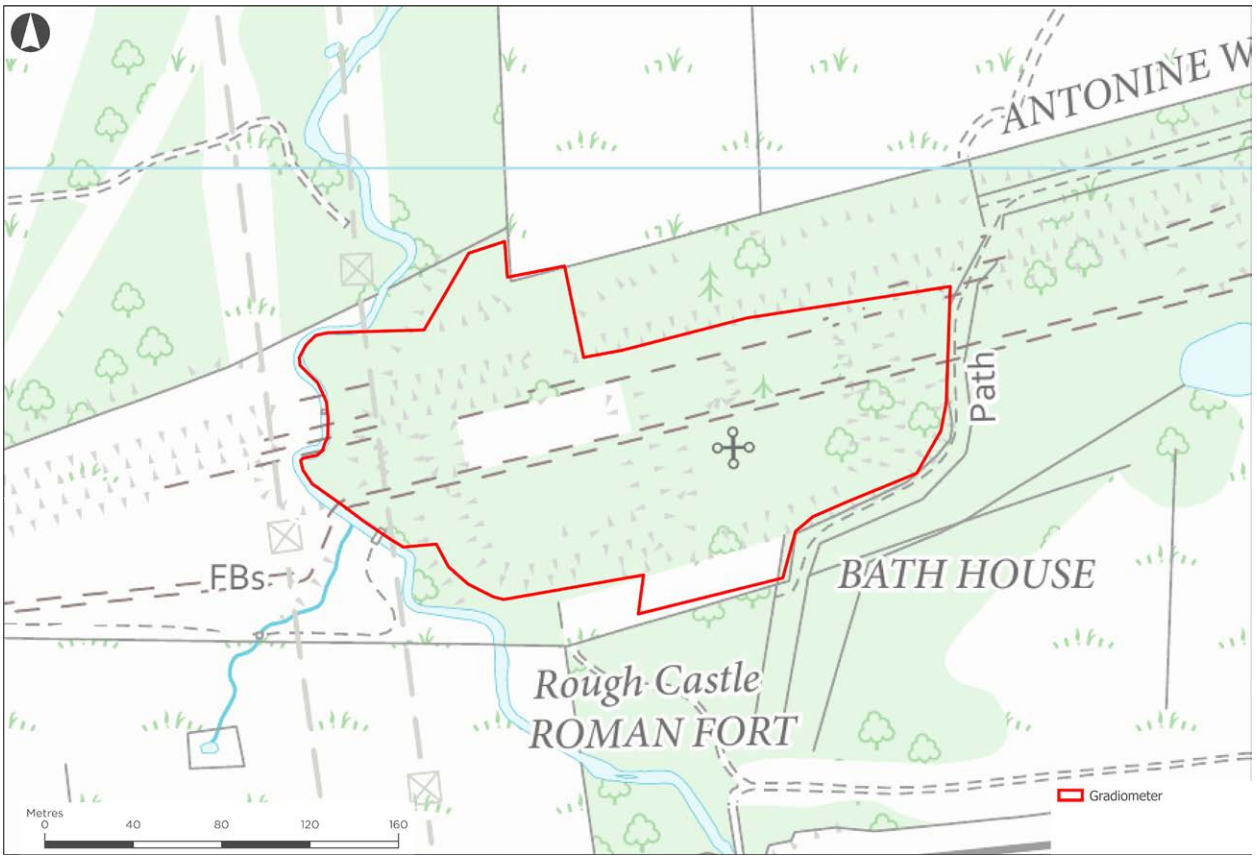

Figure 6.3.2. Location of HES survey at Rough Castle.

in the collapse of the Ditch sides. This was checked in a watching brief in 2011, which confirmed that the Ditch had been partially truncated on each side.

Glasgow Archaeological Society included Rough Castle in their programme of excavation and survey along the linear barrier in the early 1890s. They cut two sections through the Wall Rampart, where it survived to a height of up to 1.4m above its stone base, and one through the western rampart of the fort, whose surviving height was even greater (1.75m). More extensive excavations were undertaken at the site in 1903 under the auspices of the Society of Antiquaries of Edinburgh, making it one of the first forts on the Wall to be so investigated (Figure 6.3.4). This work revealed that unusually wide turf ramparts enclosed an area of 0.46ha, making it one of the smallest forts on the Wall, with gaps for gateways in all four sides. Double ditches surround the fort except to the north, where the Wall Ditch serves that function, and in the north-east quadrant where there is no ditch facing the annexe. The fort appears to be a secondary addition to the Wall as its rampart clearly abuts the back of the Wall Rampart.[2] However, the provision of an apparently original causeway across the Ditch in front of the north gate implies that the intention to build the fort was already known when the Ditch was being dug, though there seems to have been some indecision concerning the alignment of that causeway.

Rare additional defensive measures were provided some 25m beyond the Ditch to the north (Figures 6.3.3 and 6.3.4). Ten rows of long, narrow pits, each row some 60m long, helped protect the fort from potential surprise attack from an approach along the valley of the Rowan Tree Burn. The pits were set out in a regular pattern, their position in each row offset from the rows on either side, so that it was not possible to walk across them in a straight line. They are usually interpreted as *lilia* (lilies), concealed pits intended to hold sharpened stakes, the Roman equivalent of anti-personnel mines. A *c.* 10m-wide section across the ten rows has been left open for public display. No examples are known from any other fort on the Wall. However, small groups of pits have been recorded on the Berm at various locations elsewhere along the Antonine Wall and on Hadrian's Wall (Bailey 2021: 23-25; Bidwell 2005), though these are thought to have housed above-ground forked wooden entanglements (*cippi*) creating an effect similar to barbed wire.

Because it was so small, a disproportionate area of the fort's interior was taken up by the standard complement

[2] This applies to both the rampart base and the turf superstructure, though the fact that the latter is less clear in one photograph from the early excavations has generated some dispute (Hanson 2020b: 215-16).

Figure 6.3.3. Google Earth image of the extant earthwork remains of the fort and annexe at Rough Castle immediately to the east of the Rowan Tree Burn (© 2023 Getmapping plc). The excavated *lilia* and the extant field system are arrowed.

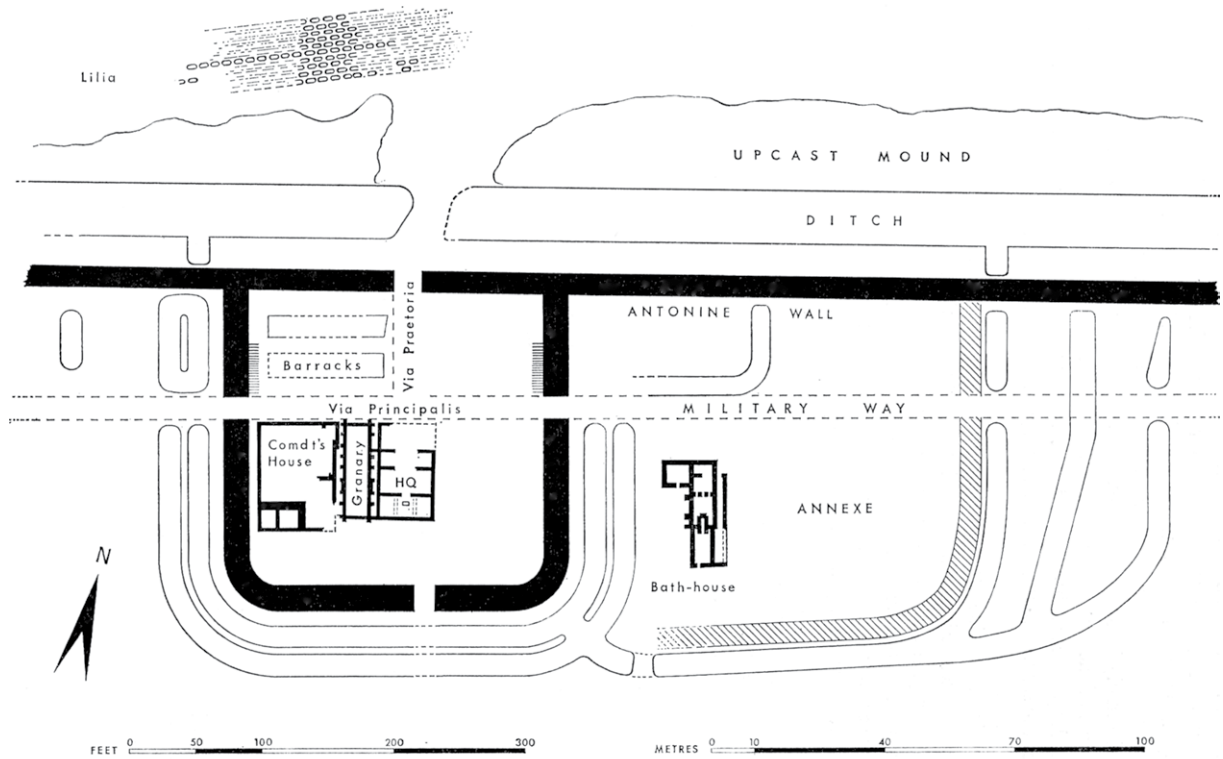

Figure 6.3.4. Plan of the fort and annexe at Rough Castle (after McIvor *et al.* 1980, Fig. 1).

of principal buildings (Figure 6.3.4): a rather narrow headquarters building, the commanding officer's house and a granary, all of stone construction. These were squeezed into the middle and west side of the central range, the commanding officer's house impinging on the line of the intervallum road to its west. It was not established what structures occupied the area to the east of the headquarters, other than that they were not stone built. The only other internal features identified were fragments of paving, drains and road surfaces. No gate structures were recognised, so they are likely to have been of timber.

The annexe to the east is slightly larger than the fort, 0.6ha internally, defined by a turf rampart similar in width to that of the Wall, with a single ditch outside it to the south, but with three widely spaced ditches to the east (Figures 6.3.3 and 6.3.4). The Military Way, some 5.5m wide, was located at various points across the annexe running on the same alignment as the *via principalis* between the east and west gates of the fort. The annexe ditch close to the south-east corner of the fort had been partially filled with stone to create a causeway for a second entrance to the annexe. The only internal building identified was a large bathhouse in the south-west quadrant. However, to the north of the Military Way, where the fort ditches were absent, was a rectangular enclosure bounded to east and south by a small L-shaped ditch. Finally, the excavation identified a roadway, effectively a bypass road, running around the outside of the annexe and past the southern defences of the fort before heading north-west to join the Military Way on the west side of the Rowan Tree Burn.

Concerned about the accuracy of some of these early excavation records, Macdonald re-examined the defences and part of the annexe interior in the early 1930s. He confirmed the absence of a ditch between fort and annexe in the north-west quadrant of the annexe, found a missing section of the outermost eastern ditch north of the Military Way and suggested, not entirely convincingly, that the triple ditches represented different phases in the use of the annexe. He identified that the small enclosure within the annexe was not additionally defined by a turf rampart, but that its interior had been twice cobbled over and contained several post-holes, some possibly defining a stockade along its eastern side. It has subsequently been suggested, noting the superficial similarity with the plan of Duntocher, that this enclosure might have been the site of a fortlet (Gillam 1975: 54), but the recorded structural evidence makes this unlikely (Symonds 2018: 139-40) (see also Chapter 6.2, above).

Further excavations were undertaken at Rough Castle by MacIvor between 1957 and 1961 in the course of preparing the site for public display. Re-examination of a section excavated in 1903 across the west side of the fort confirmed that its rampart was, indeed, wider than the norm at 6.1m. However, it was not as wide as had been thought either by the original excavators or by Macdonald, who had both been misled by the presence of a metalled surface immediately outside the rampart and their failure to identify correctly the base of an *ascensus*, which facilitated access to the rampart from the interior. MacIvor also determined the layout of the western half of the *praetentura*, confirming that the road lines were quite well-preserved and identifying two small timber-built barrack blocks (Figure 6.3.4). Limited evidence of similar post-built structures was also recorded in the eastern half, but this was not considered sufficient to be fully confident of their identification as barracks, highlighting the difficulty even in excavation of determining building plans entirely on the basis of patterns of post-holes. Further trenching[3] by the western gateway and south of the *via principalis* remains unpublished.

Finally, a series of extant earthen banks demarcating a conjoined system of sub-rectangular enclosures located some 75m south-east of the annexe (Figure 6.3.3) were examined in 1982 ahead of a potential threat from open-cast mining. The aim was to determine their date and potential association with the fort, but the results proved inconclusive. The only dating evidence recovered was a Bronze Age carbon-14 date from soils beneath one of the banks. Nonetheless, the field system is flanked by a road or track that is aligned with the branch road from the Military Way that runs along the east side of the annexe.

The GSB survey was undertaken as part of the preparations for the Antonine Wall becoming a World Heritage Site. The later HES survey sought to improve on that data and provided an ideal training site for the early use of the Sensys survey system along the Wall. There were no major physical constraints to the surveys, other than the steepness of the slopes on the south and west sides of the fort presenting problems for the cart-borne Sensys system. Most of the area, apart from the field system, is in maintained grassland with a varying density of trees. Former ironstone extraction and coal mining activity surrounds the site, the ubiquity of ironstone in the area attested by the consistent red discolouration of the Rowan Tree Burn. Overlying the Coal Measures is till made up predominantly of sandstone, presenting no immediate obstacles to survey. The soils are freely drained humus iron podzols.

[3] This is apparent in several photographs on Canmore, e.g. SC 2012356; SC 2012078; SC 2012094.

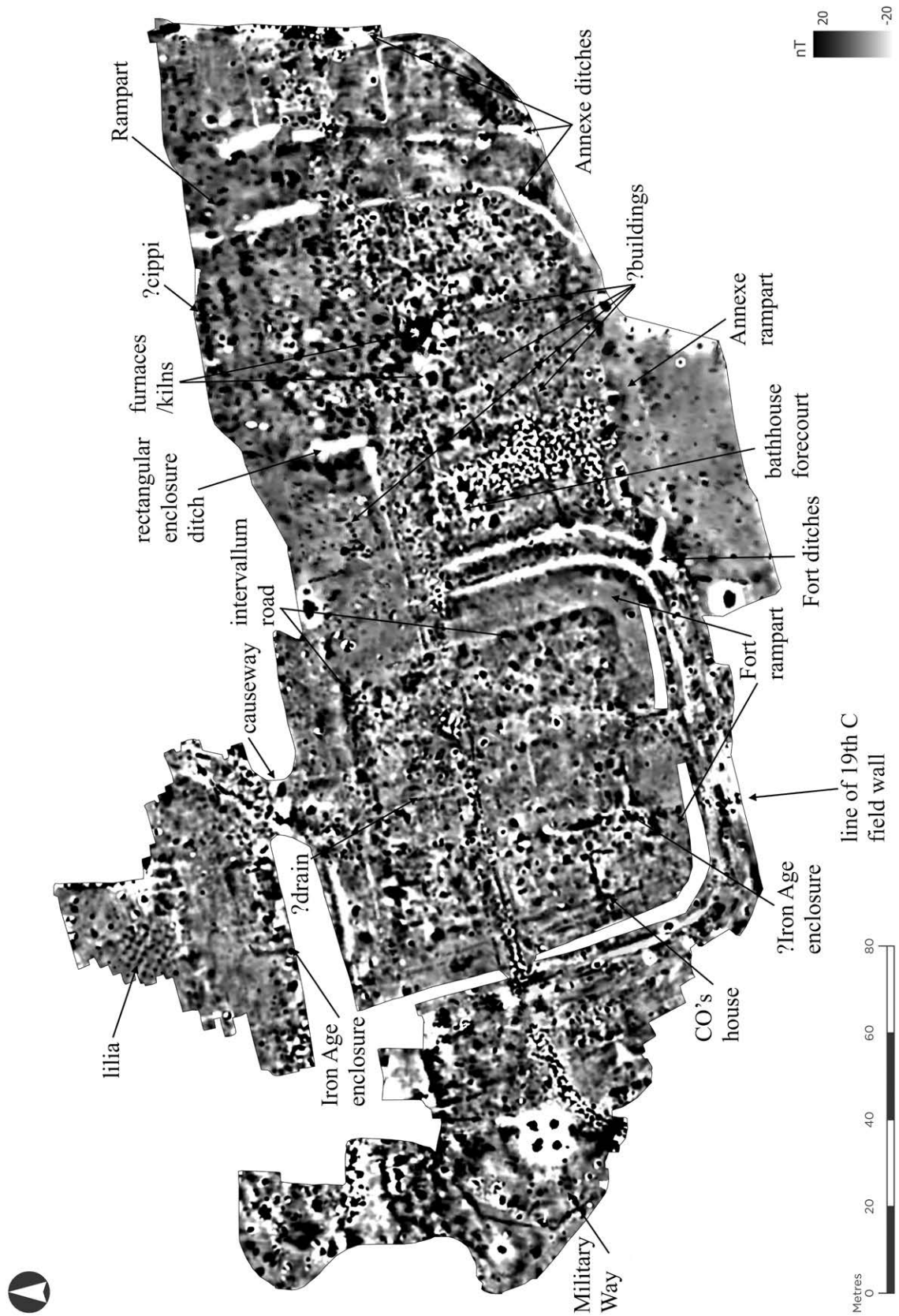

Figure 6.3.5. HES gradiometer survey at Rough Castle.

Results

The extant defensive pits (*lilia*) are readily apparent in the HES survey (Figure 6.3.5), but considerably less so in the GSB Foerster survey (Figures 6.3.6, Area 1), which covered only part of the area where they had been left open. They were largely excluded from the GSB Bartington survey (Figure 6.3.7, Area 1). All three surveys extended beyond the extant pits as far as the local topography and tree cover would allow, but only the HES survey identified a few further examples, some of which do not seem to correspond with those excavated and backfilled in 1903. Finally, the GPR survey (Figure 6.3.8 at 0.5-1.0m depth) detected a few probable examples of the pits appearing with high amplitude towards the eastern edge of the survey area.

Only the HES survey extended across the line of Wall itself, but, except for the causeway, coverage excluded the Ditch where it was extant (Figure 6.3.5). Survey to the north of the causeway clearly confirmed the north-easterly alignment of the associated road and its continuation across the Berm, apparent as an intermittent line of strong positive anomalies with associated negative ones. The survey on the causeway itself, however, produced a response with a preponderance of negative signals very similar to the small section of Ditch examined immediately to the east

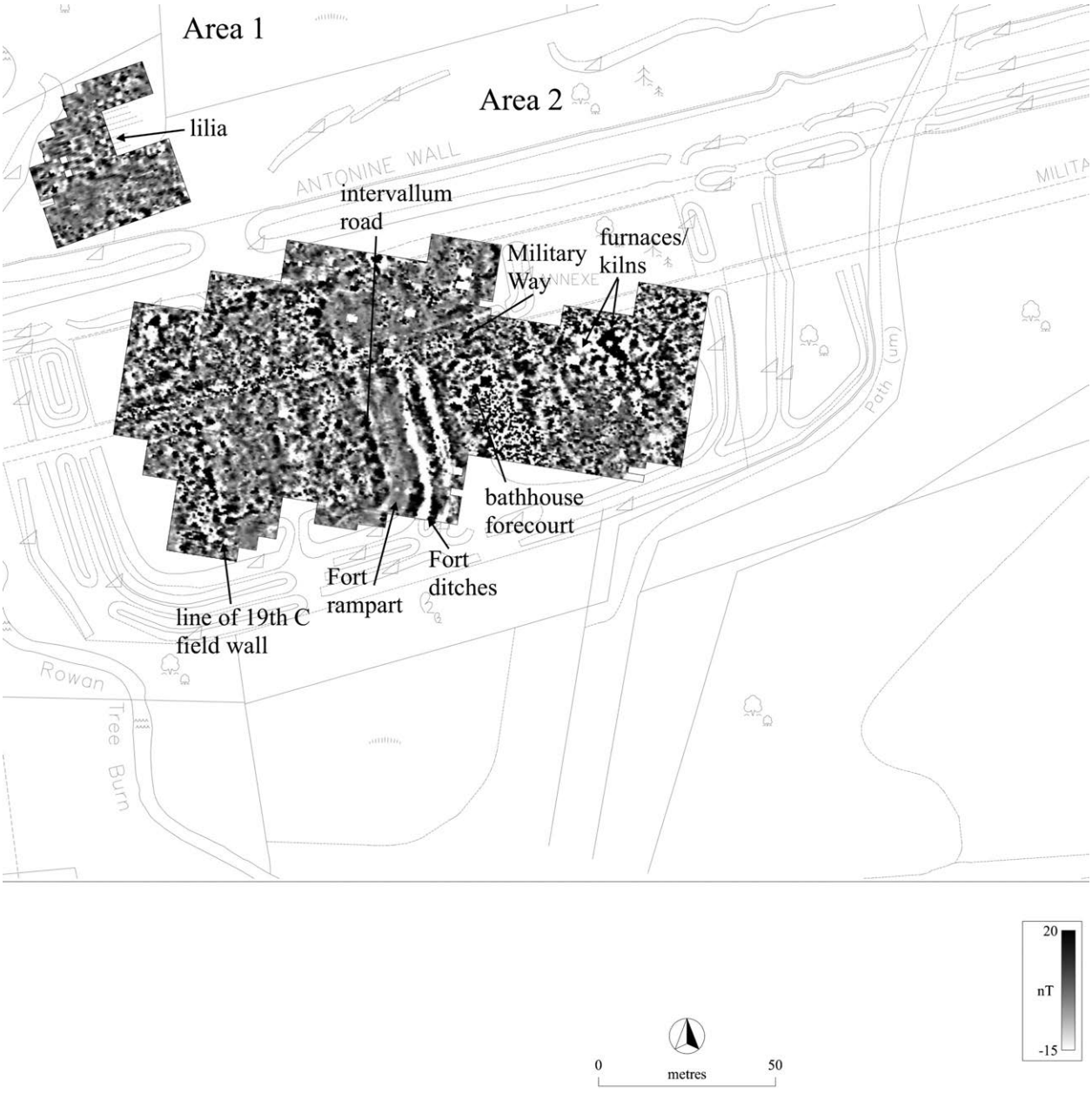

Figure 6.3.6. GSB Foerster gradiometer survey at Rough Castle (after GSB 2008d, Fig. 4).

of the Rowan Tree Burn and not dissimilar to the standard negative response from the Ditch seen elsewhere on the Wall (see Chapter 8.2.4 below). This prompted detailed investigation of the photographic record made during the clearance of silt from the Ditch in front of the fort in the late-1960s, which revealed that the causeway had, in fact, been removed in its entirety at this time.[4] This raises questions about the whole history and character of the causeway and whether it actually represented later infilling of the Ditch rather than an undug section, as has previously been assumed, which in turn casts doubt on the Roman date of the road alignment beyond it to the north (Hanson forthcoming). The excavations in 1903 certainly encountered a causeway and cut into its centre 'for the purpose of drainage', but describe its soil make-up as identical to that of the Upcast Mound (Buchanan *et al.* 1905: 455), which does not, of course, represent undisturbed subsoil.[5]

In the HES survey to the west of the causeway on the brow of the ridge overlooking the *lilia* is an almost square enclosure some 20m across, the north side of which is also faintly visible in the GSB Foerster survey. The enclosure is defined on all four sides by a narrow positive band, though its eastern side coincides with the line of the dry-stone field wall that was removed in the 1960s. On its south side, on the Berm, the positive line is complemented by a broader negative band, probably a ditch. Much of the southern half of the enclosure has been destroyed by the construction of the Ditch, clearly indicating that it predates the Wall. A possible second enclosure of similar shape and size is located nearby. Defined this time by a slightly discontinuous narrow negative band, presumably indicating a ditch, it runs at a slightly oblique angle to the fort across the site of the headquarters building and adjacent granary, its west side partially masked by remains of the dry-stone field wall. The size and, particularly, the morphology of these enclosures would not be inappropriate for homesteads of later Iron Age date in this region (Cowley 2009: 212-17). These are entirely new discoveries and rare examples of the potential direct impact of the construction of the Wall on indigenous settlement.

There are a number of discrete positive anomalies on the Berm, both in front of the fort and further east in front of the annexe. These are particularly clear in the more extensive HES survey (Figure 6.3.5), but also in the GSB Bartington survey (Figure 6.3.7). In neither case do they seem to form the regular quincunx pattern indicative of defensive pits (*cippi*), but rather a linear alignment along the southern edge of the Ditch. In this context, it is worth noting that the section cut across the Ditch and north rampart of the fort in 1903 records a band of rough stonework on both the inner and outer lips of the Ditch.

The Wall Rampart itself can be readily traced along the front of the annexe as a somewhat discontinuous double line of discrete positive anomalies (Figures 6.3.5 and 6.3.7) in much the same way, and for the same reasons, as it is in the well-preserved sector of the Rampart to the west of the Rowan Tree Burn (Chapter 6.2, above). This is particularly clear where it passes the northern ends of the ditches defining the east side of the annexe and the small rectangular enclosure within it. It is less clear further west where the Wall forms the north rampart of the fort. Here its southern edge seems to be marked by a narrow negative line (Figure 6.3.5). This line is stronger outside the fort, its visibility reinforced by a positive band to the south, and may represent metalling similar to that recorded in MacIvor's excavations fringing the outer edge of the fort rampart.

The rampart of the fort is most evident in the south-east quadrant in all three gradiometer surveys (Figures 6.3.5, 6.3.6 and 6.3.7). It appears as a relatively clean, broad band of mid-range responses, demarcated on the inside for the most part by a faint narrow negative line and on the outside by a slightly positive band, possibly representing more metalling on the Berm, that becomes stronger by the east gate and around the south-west corner. As with the Wall Rampart, the surviving turf superstructure of the rampart here is too thick for the gradiometer to sense through it down to the base. By contrast the rampart appears particularly clearly in the GPR survey as a continuous band of high amplitude at depths of 1.0-2.0m as the response is received from its cobble base (Figure 6.3.8). The band of average magnetic responses continues to the north of the east gate, but its edges are much less clearly defined. Only the HES survey (Figure 6.3.5) covered the west side and south-west corner of the fort rampart, though not in its entirety, omitting a linear segment along the outer edge where the slopes were too steep for the cart to operate. The picture is broadly similar to the east side with a central band of average responses, but the demarcation of the edges is less clear cut and consistent, with more than one narrow positive line running along the inside of the rampart.

The double ditches of the fort are also most clear outside the south-east quadrant, where they are visible in all three surveys (Figures 6.3.5, 6.3.6 and 6.3.7) as narrow negative bands with less consistent positive bands

[4] According to photographs from 1966-68 on Canmore (e.g. SC 2012301; 2012303; 2012379; 2012380; 2012391), the earthen 'causeway' was at that time supported on a wooden substructure that clearly cannot have been an original Roman feature. This bridge-like structure was then entirely removed as part of the attempt to clean out the Ditch.

[5] It is interesting also to note that the 1st edition 25-inch Ordnance Survey map shows the Ditch as uninterrupted across the front of the fort, as do the early antiquarian plans of the site (conveniently reproduced in Buchanan *et al.* 1905: Figs 2-4), though Roy's plan does depict a rather meandering trackway crossing the Ditch at this point.

Figure 6.3.7. GSB Bartington gradiometer survey at Rough Castle (after GSB 2008d, Fig. 3).

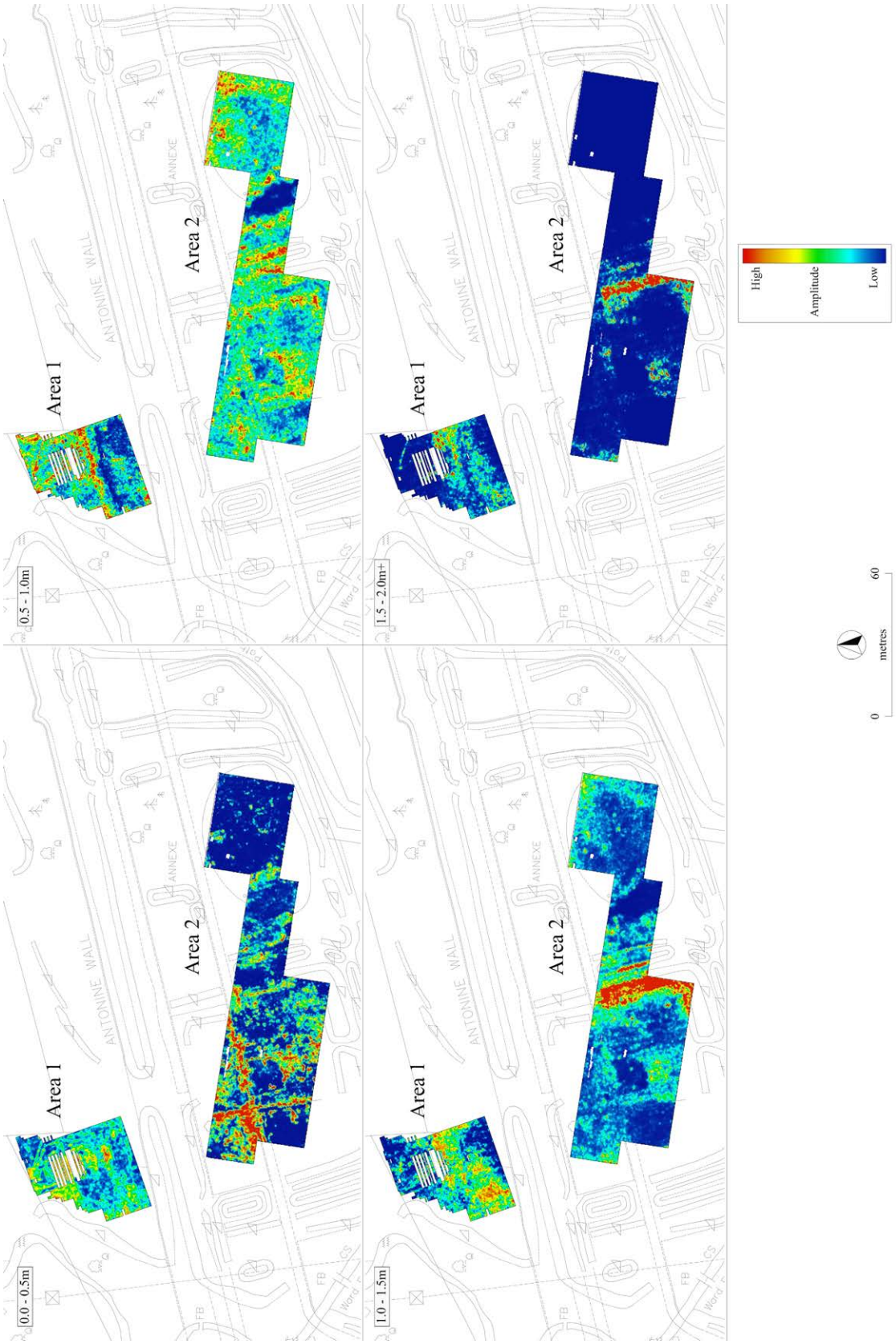

Figure 6.3.8. GSB GPR survey at Rough Castle (after GSB 2008d, Fig. 7).

on either side. Both ditches are partially picked out by high amplitude responses in the GPR at a depth of 0.5-1.0m, part of the inner ditch even more clearly at a depth of 1.0-1.5m, presumably indicating that their fills contained material from the adjacent bathhouse (Figure 6.3.8). Again, only the HES survey (Figure 6.3.5) covered the west and south-west sides of the fort's external defences. Ironically, as the ditches are best preserved in this area, they show less well in the gradiometer survey, with only the inner ditch readily visible almost as far as the line of the west gate. The Military Way in this area is superficially very clear as it leaves the west gate and curves down towards the Rowan Tree Burn, apparent as a broad, speckled positive/negative band. However, its almost dipolar character is a reflection of the modern metalled track for visitors to the fort which veers away from the line of the Military Way towards the plank bridge across the burn. The original straight line from the west gate, recorded in two sections in 1903, is largely masked by the strong dipolar signal from the buried base of an electricity pylon that was removed in 1995, though is hinted at by a cluster of positive anomalies further to the west.

The Military Way becomes the *via principalis*, running west-east through the fort. Again it appears as a speckled positive/negative band in all three gradiometer surveys (Figures 6.3.5, 6.3.6 and 6.3.7), though in the HES and GSB Bartington surveys the response is generally less strong and more discontinuous. In the GPR survey it appears as a speckled band of high amplitude at a depth of 0.0-0.5m (Figure 6.3.8), rather wider to the west of the *via praetoria* where MacIvor's excavations had recorded a greater width of cobbling surrounding a large rectangular pit. The intervallum road is similarly clear in all three gradiometer surveys, running around the north, east and south sides of the fort. It appears as a band of somewhat diffuse positive responses, its extent varying with the coverage of each survey. In the GPR survey it can be seen in the south-east quadrant as a speckled linear band of high amplitude at a depth of 0.5-1.0m (Figure 6.3.8). It may be represented on the west side to the north of the *via principalis* as a line of larger discrete positive anomalies in the HES gradiometer survey (Figure 6.3.5), including one more dipolar in character, which may mark the site of a small furnace recorded by MacIvor. To the south of the *via principalis* on this side, however, there is no trace of an intervallum road for reasons explained below. Despite the indications from excavation that other roads in the *praetentura*, including one between the timber barracks, were well preserved, there was little clear sign of them, other than a slightly positive north-south linear alignment on the west side of the *via praetoria* in two of the three gradiometer surveys (Figures 6.3.5 and 6.3.7). This may reflect a roadside drain recorded by MacIvor. The cluster of discrete positive and occasional negative anomalies by the south gate visible in the HES survey presumably represent the *via decumana*.

There are indications of structural alignments in the western part of the central range in all three gradiometer surveys (Figures 6.3.5, 6.3.6 and 6.3.7), though with varying degrees of clarity. These correspond with the area where stone buildings were excavated in 1903. The HES survey is the clearest and shows the two parallel outer walls, an end wall and one major internal cross wall of the commanding officer's house revealed as positive linear alignments of varying width. The apparent thickness of the inner side wall may suggest that the response here has merged with the east wall of the granary, though its slightly oblique alignment and continuation to the south more probably reflects the line of the dry-stone field wall. Though removed as part of the landscaping of the site, this is still discernible in the Google Earth image (Figure 6.3.3). The same alignment is visible as a medium-high amplitude signal at depths of 0.5-1.0m in the GPR survey (Figure 6.3.8). The north-south walls visible in the gradiometer survey extend to within some 10m of the southern rampart and encroach on the western rampart, confirming the evidence from excavation that indicated the absence of an intervallum road here. A sub-square patch of medium-high amplitude signals at depths of 0.5-1.5m in the GPR survey (Figure 6.3.8) may reflect flooring within the cross-hall of the headquarters building or within the postulated second Iron Age enclosure. There are no clear signs in any of the surveys of buildings either in the eastern side of the central range or in *praetentura* or *retentura,* where barracks or other post-built structures are attested or anticipated,[6] though there are a number of scattered discrete positive or dipolar anomalies visible.

The three ditches defining the eastern side of the annexe are clear in both the HES and GSB Bartington surveys, particularly the latter, as strong narrow negative bands (Figures 6.3.5 and 6.3.7), though both surveys only just encapsulate the outermost ditch. Only the inner and outer ditches are broken to allow passage of the Military Way, confirming what the 1903 excavation indicated. The innermost ditch continues beyond the Wall Rampart and was followed to the edge of the Wall Ditch. The single southern ditch, however, is only faintly visible, except where it joins the two ditches at the south-east corner of the fort. Inside the inner ditch the response from the rampart of the

[6] What appears to be a small rectangular structure, outlined by negative linear anomalies, can be discerned in the left *praetentura* in the GSB Foerster gradiometer survey (Figure 6.3.6). The equivalent feature in the GSB Bartington survey and the better resolution HES survey appears as a short negative linear between two discrete positive anomalies, and is less convincing as a structural feature. The evidence from MacIvor's excavations nearby makes it highly unlikely that there would have been stone buildings here.

annexe on its south side is similar to that from the south-east quadrant of the fort in the GSB Bartington and HES surveys (Figures 6.3.5 and 6.3.7), where it appears as a relatively clean, broad band of mid-range responses, demarcated at the rear by a thick line of discrete positive or slightly dipolar anomalies, perhaps representing an intervallum road. The mid-range responses from the rampart merge into a broad band of mainly positive anomalies at the south-east corner of the annexe, clearest in the GSB Bartington survey, that continue along its east side. There is no clear sign of the road line recorded in the 1903 excavation outside the rampart.

Within the annexe the dominant feature in all three gradiometer surveys (Figures 6.3.5, 6.3.6 and 6.3.7) is the rectilinear zone of dipolar anomalies immediately beyond the eastern ditches of the fort. This marks the site of the bathhouse that was backfilled in the 1960s with spoil from its excavation, which will have included quantities of burnt ceramic debris. Nonetheless, the negative outline of a rectangular structure at its northern end, most clearly visible in the HES survey, appears to reflect the enclosed forecourt identified in the 1903 excavation. The bathhouse is notable by its absence from the GPR data.[7] The medium to high amplitude irregular linear signals at depths of 0.5-1.0m, visible to some extent on both sides of its site, probably represent the spoil around the edges of the 1903 excavation area. A similar explanation may account for the linear band of positive anomalies immediately to the east of the bathhouse visible in all three gradiometer surveys.

The line of the Military Way running east-west through the annexe runs to the north of the bathhouse, again visible as a somewhat variable speckled positive/negative band which gets more diffuse as it progresses east (Figures 6.3.5, 6.3.6 and 6.3.7). Beyond that to the north the L-shaped ditch of the rectangular enclosure is clear as a linear negative anomaly, the response getting thinner, or weaker in the case of the GSB Bartington survey, as it approaches the fort. There is a faint indication, also most evident in that survey, of the east side possibly continuing beyond the Military Way as far as the south ditch of the annexe. Immediately within the rectangular enclosure, mirroring its eastern ditch, a series of conjoined positive anomalies may reflect some of the internal cobbling confirmed by Macdonald's excavations; while a series of small, discrete positive anomalies, apparent in both the GSB Bartington and HES surveys (Figure 6.3.5 and 6.3.7), seem to form potentially structural linear patterns. The accumulation of data about this enclosure, particularly the absence of ditches between it and the fort, raises the possibility that it served as a proto-annexe before being subsumed into the main annexe enclosure. There is no support for Gillam's suggestion that there may have been an earlier fortlet here.

In the eastern half of the main annexe all three gradiometer surveys show various concentrations of positive, sometimes dipolar, anomalies. Some to the north of the Military Way may indicate a side road running parallel with the eastern ditch of the rectangular enclosure, others immediately to its south may reflect widening of the Military Way or associated hardstanding; both features were recorded in 1903. The largest dipolar anomalies, however, clustered in a magnetically quieter area in the central southern part of the annexe, may represent kilns or furnaces of some kind. These features may also be recorded as an area of high amplitude at depths of 0.5-1.0m in the GPR survey. Finally, several narrow positive linear alignments in the south-east quadrant, visible only in the higher resolution HES gradiometer survey (Figure 6.3.5), some at right angles to each other, could indicate part of a stone structure. None of these features have previously been noted.

The GSB Bartington survey offered little insight into the field system (Figure 6.3.7, Area 3), primarily because it was focused to the east of the modern field in which the majority of the extant remains have been recorded (compare Figures 6.3.3 and 6.3.7). There is no sign of the single banked enclosure that did extend into the western side of survey area, though a faint negative anomaly does pick up the line of a 19th century field boundary running parallel to the modern one. Some of the scattered discrete positive and dipolar anomalies detected could be associated pits, but are more likely to have derived from more recent activity. According to the 1st edition 25-inch mapping by the Ordnance Survey the area was part of an extensive woodland plantation for most of the later 19th century, with several ironstone extraction pits nearby.

6.4 Callendar Park

(NGR: 9055 7955; Canmore 82858; 82862)

Rampart, Military Way and possible fortlet

Site-specific references

Macdonald 1915: 130-32; *DES* 1953: 19; Keppie and Walker 1989: 144-47; Bailey 1995; 2017; Jones *et al.* 2006a: 15-16

[7] GSB relate this to the rapid attenuation of the signal by the post-excavation backfill material (2008b: 8).

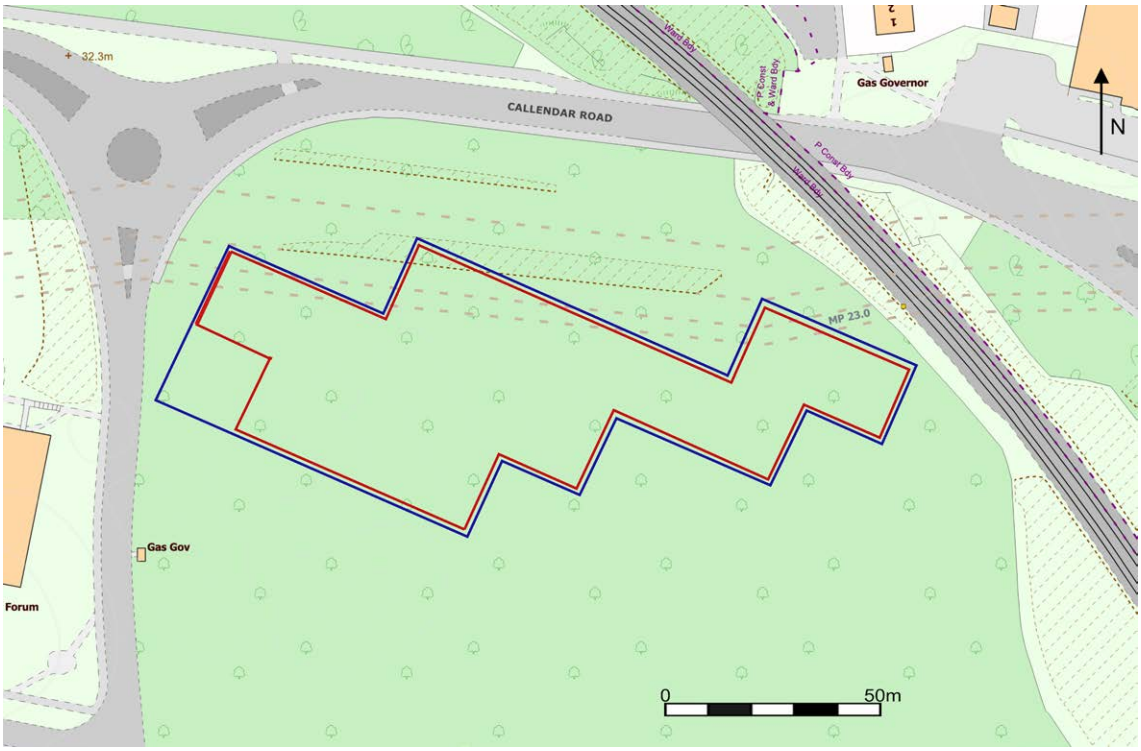

Figure 6.4.1. Location of gradiometer and resistance surveys in Callendar Park.

Geophysical survey (Figure 6.4.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
Glasgow University; 2003	G: Geoscan FM36	0.6	1, 1
	R: Geoscan RM15	0.6	1,1; multiplexer 0.5, 1

Introduction

The line of the Wall through Callendar Park follows the crest of a low, flat-topped glacial ridge with good views to the north. It is generally quite well preserved because it runs across the northern frontage of the estate that encompassed Callendar House, now the home of Falkirk Museum. Though this circumstance has largely protected the remains from the worst ravages of urban development or post-medieval and modern agriculture, it has also resulted in different forms of destruction or damage arising from the landscaping within the estate. Thus, three access roads were driven through the surviving section of the Wall at various times, the largest located immediately in front of Callendar House; all trace of the Wall along a *c.* 230m section to the north of what is now part of Callendar Business Park has disappeared, presumably removed in the course of creating the walled kitchen garden established there in the late 18th century; while at the eastern end of the Park the Rampart base and Military Way were partially uprooted around the same time to provide stone for the estate wall bordering the main road. Nonetheless, as the LiDAR image shows, the Ditch still survives across much of the Park to a depth of some 1.5m, its northern lip enhanced along the western section by the piling up of the Upcast Mound to the north (Figure 6.4.2).

In 1913 Macdonald confirmed the line of the Rampart by trenching at the western end of the Park where the Wall deviated south to a crossing of the East Burn, noting the often-disturbed state of its base. Continuing east to the extant line of the Ditch he demonstrated in two cuttings that the Rampart was better preserved, though in front of the walled garden he could find no trace, not even of the Ditch (but see below). Beyond the access road past the East Lodge (the line now followed by Callendar Boulevarde) further trenching at several points revealed the well-preserved Rampart base and vestiges of the Military Way to the south.

Antiquarian accounts record that there was a dogleg in the alignment of the Wall at this end of the Park (Sibbald 1707: 30; Maitland 1757: 172-73). This is supported by the 2nd edition Ordnance Survey mapping, which indicates that the Ditch and Upcast Mound begin to turn to the north immediately before being lost under the railway embankment and modern road. Unfortunately, the visible remains are somewhat confused by substantial delving at this point, which looks like quarrying when examined in the LiDAR image (Figure 6.4.2). This change of Ditch alignment was a factor in encouraging Keppie

Figure 6.4.2. LiDAR image of the line of the Wall across Callendar Park.

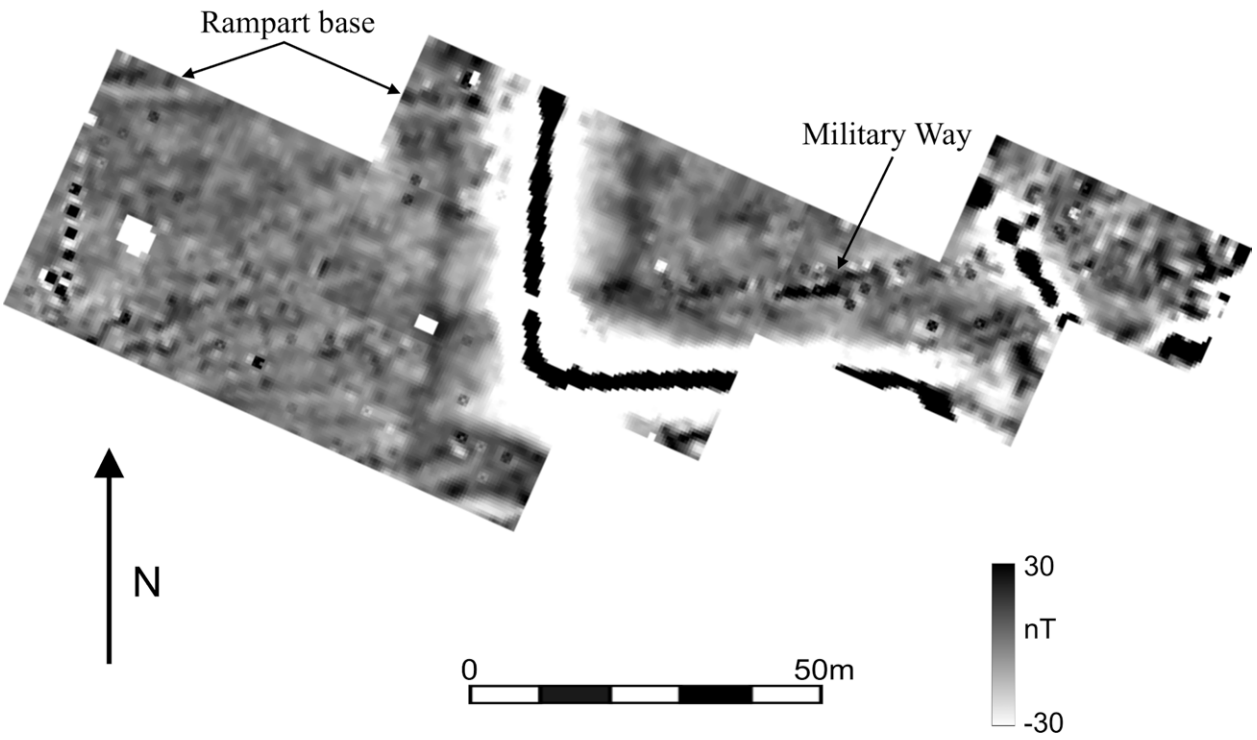

Figure 6.4.3. Gradiometer survey at Callendar park.

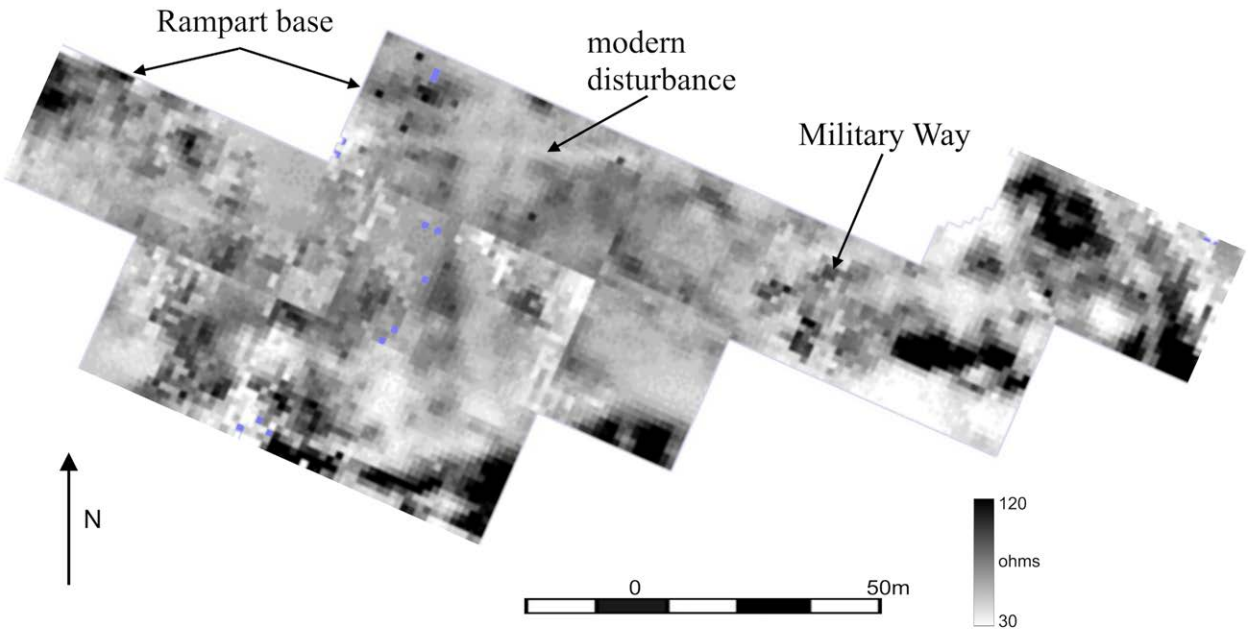

Figure 6.4.4. Resistance survey (0.5m probe separation) at Callendar Park.

and Walker to search for a possible fortlet here in 1981. Though their excavations failed to find any trace of it, they did establish that the Rampart turns more sharply to the north than had previously been considered and traced its line back westwards for a distance of some 150m by a combination of probing and trenching. This confirmed the results from limited work undertaken in the same general area by Hunter in 1953, of which there is only a very limited record. They also established the line of the Military Way, which was quite well preserved in the two sections opened up, as it curved around to follow the Wall.

Bailey recorded a section through the Wall in the same area in 1989 in a cutting for the installation of a large water main. This revealed that the 7m wide Ditch had been inserted part way down the north-facing slope of a glacial ridge, with the heavily truncated Upcast Mound spread to the north. The Rampart and Berm were located on the northern edge of the ridge, the Berm provided with a series of defensive pits (*cippi*). The section extended for some distance to the south of the well-preserved Rampart base, and Bailey recorded the remains of a clay floor and a hearth immediately behind the Wall, both associated with quantities of Roman pottery.[8] Such remains would not be inappropriate for the site of a fortlet, though no southern ditch was encountered in the excavation. Accordingly, he suggested that the occupation traces were associated with a putative watchtower,[9] though this was identified solely on the basis of one somewhat dubious post-pad on the rear kerb of the Rampart base. Bailey also undertook excavation a further 90m to the west the following year ahead of the creation of a roundabout at the north end of Callendar Boulevarde. Here he recorded a very slight change of alignment in the Ditch, which turned to the south in order to maintain its position on the crest of the ridge. The Upcast Mound had been spread to the north, but was again heavily truncated. More defensive pits were identified on the Berm, though the Rampart was poorly preserved. This change of alignment, which is apparent in the 2nd edition Ordnance Survey mapping and remains very faintly visible in the LiDAR imagery (Figure 6.4.2), may have been a factor in Macdonald's failure to locate the Ditch here.

The geophysical survey was also located in this area, extending along the top of the ridge from the eastern edge of the Park as far as Callendar Boulevarde (Figure 6.4.1). It focused on the flat top of the ridge behind the Wall in search of the Military Way and any other associated features. The whole area remains in permanent grassland with occasional trees, so there were no major constraints to the survey. Geological conditions were also favourable as the ridge appears to be a glacial end moraine adjacent to raised marine deposits, clays, silts, sand and gravel.

Results (Figures 6.4.3 and 6.4.4)

The stone base of the Antonine Wall shows reasonably clearly and consistently running across the northern edge of the survey area as a band of higher resistance, notwithstanding the poor quality of the resistance graphic. The same feature appears as a positive and associated negative linear magnetic anomaly. The parallel band of low resistance a few metres further to the south is more likely to be a modern feature, contrary to the previously published interpretation, as it seems to continue across the line of the infilled trench for the water main, which is visible as a similar band of low resistance cutting across the Wall at right angles. The water main, with its strong linear dipolar anomaly, dominates the centre of the gradiometer survey. It is flanked on either side by slightly positive linear anomalies that seem to relate to it rather than to any underlying archaeological remains. However, the line of the Military Way is picked up some 30m away from the Wall on the east side of the water main either as a discontinuous band made up of patches of higher resistance or as a broad, again rather patchy, positive linear anomaly. The road runs slightly obliquely to the line of the Wall, as was confirmed in excavation nearby by Keppie and Walker in 1981. There were no indications of a rampart or ditches of the putative fortlet.

All of the other features detected by the survey can best be explained by reference to the geological background or more recent activity. It was originally suggested, for example, that the north/south alignment of strong positive anomalies in the gradiometer survey close to its western limit might be related to inhumations found in 1840 when the estate avenue to the new East lodge was dug through the ridge, but the strength and regularity of the signal makes it more likely that they represent recent activity, perhaps associated with utility supply.

6.5 Mumrills

(NGR: NS 9185 7943; Canmore 47870, 47890 and 82858)

Fort, annexe, Rampart, Ditch, Military Way and environs

Site-specific references

Macdonald 1915: 115-34; 1925: 282-3; Macdonald and Curle 1929; Smith 1939; Robertson 1942; Steer 1961a; RCAMS 1963: 96-9; GSB 2007e; Bailey 2010; 2021: 78-9 and 231-71

[8] Though Bailey does not identify the 22 sherds of pottery found, all from the same vessel, he has confirmed to the authors that it was Black-burnished ware, which is typical of the 2nd century AD.

[9] Bailey no longer believes that the Wall was provided with a system of towers (pers. comm.), though seems still to maintain his identification of this example (2021: 60-61).

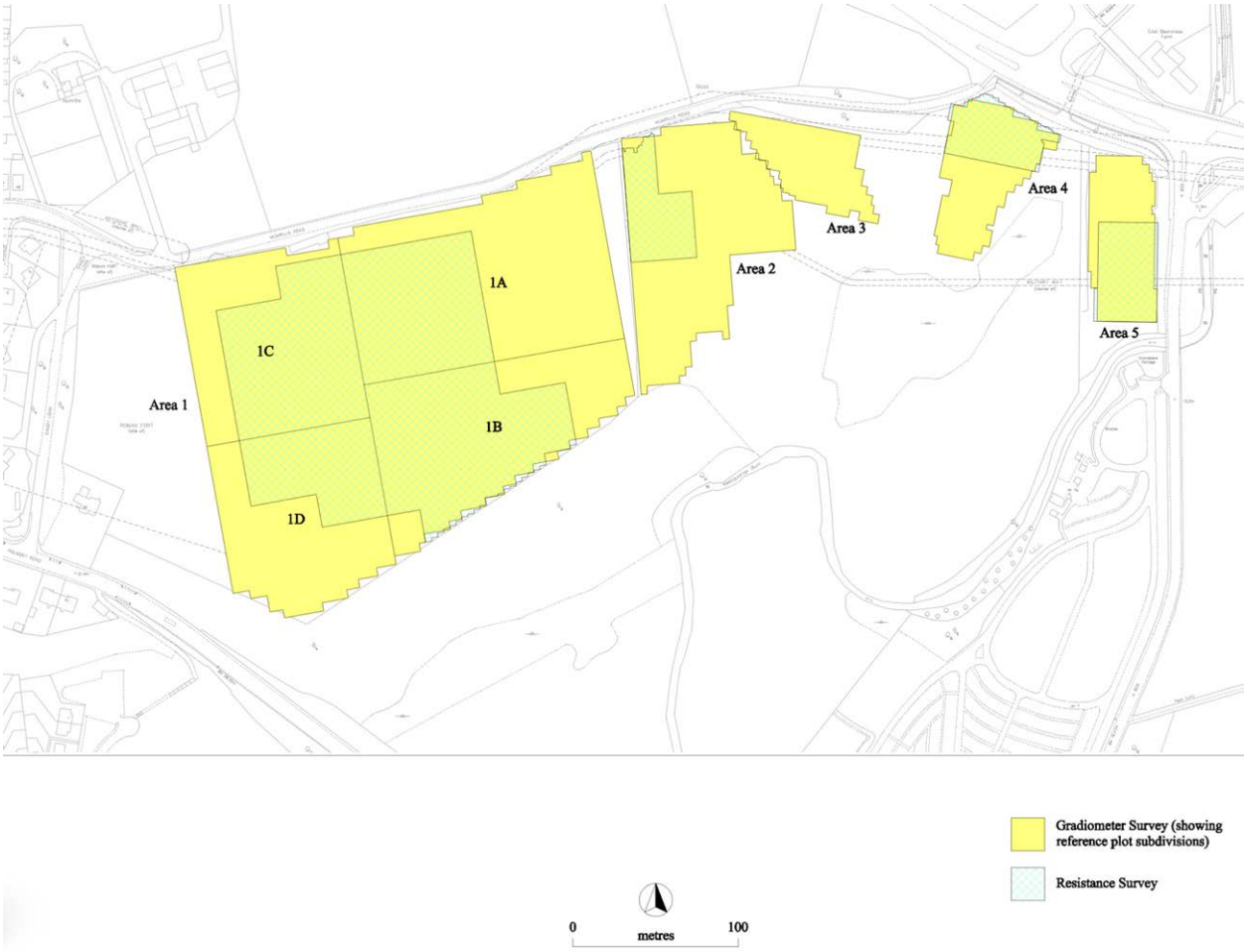

Figure 6.5.1. Location of GSB surveys at Mumrills (after GSB 2007e, Fig. 2).

Geophysical surveys (Figure 6.5.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
GSB; 2007	G: Bartington Grad 601-2	6.9	0.25, 1
	R: Geoscan RM15	3.2	1,1

Introduction

The fort sits near the eastern end of a low plateau that slopes down gently to the north, but very steeply to the south and east. It overlooks the Westquarter Burn to the south as it runs around the plateau to cross the line of the Wall at Beancross just over 500m to the east. The fort has good views to the north across the Carse towards the mouth of the River Carron. There is much debate and uncertainty about relative sea levels in this area, but if they were as much as 6m higher than at present, as has been suggested (Davies 2020: 38-40), much of the Carse would have been dominated by mudflats unsuitable for settlement. Indeed, a simulated 2.5m rise in sea level brings the shoreline within some 300m of the fort (Hannon 2018: Fig. 9.2).

The line of the Wall here had already largely disappeared (or was not recognised) by the time of the 1st edition Ordnance Survey mapping, so that much of their postulated line, particularly to the east of the fort site, is incorrect. Nor, unlike many of the other sites on the Wall, is there any antiquarian record of a fort at Mumrills, though there was a long-held suspicion that one was to be found somewhere in the vicinity (e.g. Gordon 1727: 60). Its precise location was not confirmed until 1912 when the son of the tenant farmer uncovered the foundations of a stone building and associated Roman finds. The following year he recorded the line of the fort's clay rampart in the south-east corner, revealed when he deliberately ploughed slightly deeper in that area, and in 1916, after observing a line of exceptionally luxuriant growth over the fort's ditches, he dug down to find the base of the western rampart. This provides us with one of the earliest examples of terrestrial remote sensing being applied to the discovery of sites along the Wall.

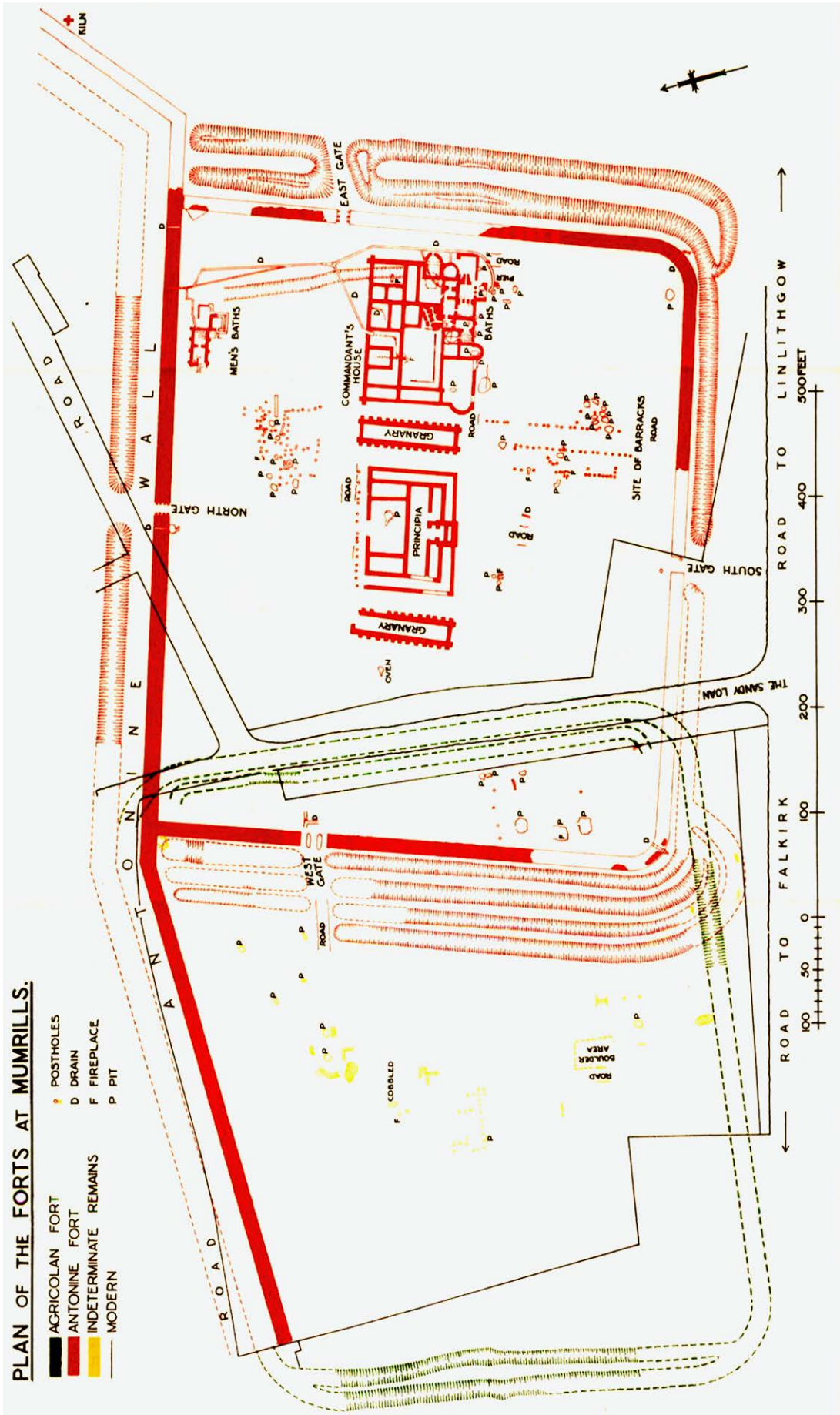

Figure 6.5.2. Plan of Mumrills fort (after Macdonald and Curle 1929).

Though Macdonald had rapidly begun excavations to verify these findings, his substantive examination of the fort, conducted with Curle, was delayed until some time after the end of First World War. These excavations ran intermittently from 1923 until 1928 and confirmed that Mumrills was the largest fort on the Wall, enclosing an area of 2.6ha within its stone-based clay and earthen rampart (Figure 6.5.2). The number of ditches that surrounded it varied: one, the Antonine Wall ditch, to the north and one to the south on the edge of the scarp, but two to the east, joined together at the gate, and four on the west, reduced to three to the north of the gate on that side. Gaps in the rampart for gates were recorded in each side, with post-holes for simple timber gateways. The line of the Wall was established on both sides of the fort and shown to have changed direction, quite markedly on the east side, to accommodate its position. That a surviving section of the Ditch was partly utilised by the old road from Mumrills to Beancross, as it cut through the eastern slope of the more northerly of the Braes, seems to have been recognised, but is not reflected in the map extracts in Macdonald's general account of the Wall.

Most of the central range of stone buildings was uncovered and shown to follow a fairly standard pattern, very similar to that seen at Balmuildy. A central headquarters building, which seems originally to have been built at least partly in timber, was flanked by granaries. Further to the east was a large commanding officer's house, which also provided evidence of an earlier timber phase and its own fairly extensive bath suite. A separate small bath building was located at the rear of the rampart close to the north-east corner of the fort. The post-holes of timber barrack buildings were recorded both to the north and south of the central range. Their remains were not pursued systematically, but sufficient were found to indicate that the barracks were of more than one period and, at least in the rear third of the fort, orientated north-south. Interspersed among them were a number of pits and hearths.

To the west of the fort Macdonald and Curle found a large annexe defined by double ditches on its west side and a single ditch to the south. Their interpretation of its relationship with the fort, however, continues to be a matter of contention. They thought that the annexe had replaced an earlier, Flavian fort because its southern ditch was cut by the outer ditches of the Antonine fort at the south-west corner and because there was no entrance-gap through its western ditches for the Military Way. They were, however, able to identify little in the interior of the fort/annexe beyond the post-holes of an unidentified building near the centre, and some scattered pits and areas of cobbling. Where these features produced dating evidence, it was Antonine. So too the pottery associated with a small field oven discovered by the tenant farmer some years later in 1941, recorded by Robertson.

Further excavation was undertaken by Steer between 1958 and 1960, prompted by the expansion of housing development across most of the rest of the western annexe. This work was limited in character and question-orientated, focusing on the relationship between fort and Wall, and the earlier putative identification of a Flavian fort beneath the annexe. Steer located an original entrance-gap in the western ditches on the line of the Military Way and argued that Macdonald and Curle had incorrectly interpreted the relationship of fort and annexe ditches in the south-west corner. So, noting the absence of supporting artefactual evidence, he concluded that the case for a Flavian fort could no longer be sustained. He also revealed that the rampart on the eastern side of the fort slightly overlapped the rear kerb of the Wall rampart, a relationship usually taken as indicative of secondary construction, and found traces of a half-timbered building in the interior of the annexe.

Subsequent excavation between 1995 and 2010 by Bailey has been occasional, arising either from very specific small-scale development activity or from his research interest. These excavations have been located entirely within the western annexe, apart from a small area just inside the south gate, though he has undertaken fieldwalking across the fort site over a period of a decade or more. Bailey confirmed that Macdonald and Curle were, in fact, correct in recording that the annexe ditch on the south side preceded the outer fort ditches, which had then been deliberately filled during the Roman occupation, but argued that they still represented an earlier fort of Antonine date. This he based on his recording of two phases in these defences in the north-western corner of the annexe, the first involving a continuous ditch beneath the second at the point where the Military Way crossed into the annexe. There is, however, no solid evidential basis for Bailey's assertion. He cut no section to demonstrate the presence of a ditch under the road at this point, nor did he find any sign of slumping in its surface to suggest that an infilled ditch lay beneath it. Moreover, the supposed associated fort rampart within the ditches consists of nothing more than a relatively slight dump of earth and clay lacking any cobble base, so the case for an earlier Antonine fort remains unproven. Bailey did, however, record more detail of the interior of the annexe, including scattered fragments of timber buildings, metalled surfaces and various industrial features, demonstrating phases of occupation, concluding that activity within it had been extensive.

Various other clear indications of Roman occupation have been recorded over the years across the plateau

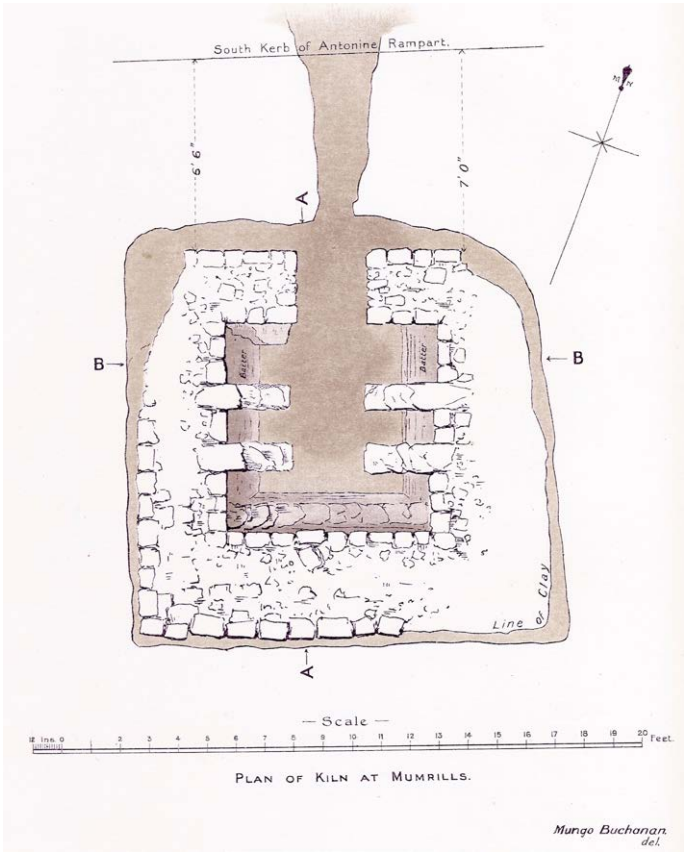

Figure 6.5.3. Plan of the Roman tile kiln from Mumrills (after Macdonald 1915, pl. 2).

outside the fort to the east, though the son of the tenant farmer involved in many of the early discoveries noted that few Roman finds were recovered from ploughing over the area compared to the site of western annexe. Nonetheless, in 1913 he uncovered remains at the back of the Wall some 36m beyond the sharp bend in its line immediately to the east of the fort which, on more detailed examination by Mungo Buchanan (reported on by Macdonald), proved to be a quite well-preserved Roman tile kiln some 4m square (Figure 6.5.3). The tenant farmer also uncovered clay, rubble and dressed stone, including one piece with a rounded face, during ploughing some 180m east of the fort near the south-east corner of the plateau. Macdonald considered this to be part of an apse-like foundation and suggested that it might be the site of an external bathhouse, but it was neither further examined nor precisely mapped. In 1937 Smith investigated a patch of cobbles and clay brought to light by the plough about 145m east of the fort very close to the southern edge of the scarp overlooking the Westquarter Burn. This revealed a line of large stone-packed post-holes and overlapping clay-and-cobble foundations some 17m long within an area of scattered pits and smaller post-holes. The structure could be Roman, but the absence of associated Roman pottery makes that less probable. However, the re-use of numerous Roman architectural fragments in the post-holes, including pieces of column drum and an altar (*RIB I* 2141), is suggestive of a date not long thereafter. In 1949 a rectilinear enclosure was identified close by from the air by St Joseph. On examination by Robertson in 1958 (reported on by Steer) this proved to be a temporary work of Roman date, but uncertain function, with scattered post-holes in its interior not dissimilar to those discovered by Smith twenty years earlier. Finally, in 1977 came a further aerial discovery, this time made by the RCAHMS (now HES), in the form of a large triangular-shaped ditched enclosure attached to the north-east quadrant of the fort and tucked into the rear of the Antonine Wall (Figures 1.10 and 6.5.4).

No trace of the fort or any of its associated features remain visible above ground even in the LiDAR data. The western annexe and adjacent part of the fort west of the modern access road (Sandy Loan) are completely built over by housing, which has accrued in phases between the 1920s and 1980s. The larger part of the fort and the whole of the eastern annexe remain in open fields, but have been ploughed completely flat. However, both can still be seen as cropmarks, even on satellite imagery, when conditions are suitable (Figures 1.10 and 6.5.4).

Figure 6.5.4. Aerial photograph of the ditches of the fort and eastern annexe at Mumrills from the south taken in 1977. Part of the temporary enclosure excavated in 1958 is faintly visible at the edge of the scarp bottom right.

Accordingly, conditions for geophysical survey across much of the fort and the eastern annexe were good, the ground being gently undulating, under short and rough grass at the time, and free from obstructions. Further east, however, data collection was hampered by a combination of agricultural fencing, some steep slopes around the Braes, and areas of boggy ground and dense weeds, which in some cases limited the area available for survey. Whereas the surface geological conditions – marine deposits and drifts derived from Carboniferous sandstones, shale and limestones - were suitable for survey, the varying depth of bedrock proved to be problematic in places.

Results

The two eastern ditches of fort are very clearly revealed in the gradiometer data precisely as indicated in the excavation evidence from the 1920s (Figure 6.5.5). They appear as quite sharply-defined, broad parallel negative linear anomalies interspersed with strong positive anomalies. Their curve around the south-east corner is clear, with a hint of convergence, and they come to a butt end just south of the Antonine Wall after a break for a causeway leading to the east gate of the fort. At that gap the two ditches are connected on either side of the causeway, which approaches the fort at a slightly oblique angle. The causeway is even more sharply defined in the slightly less extensive resistance survey, though the ditches less so (Figure 6.5.6). The inner ditch is more strongly revealed as a broad band of low resistance than the outer, which is barely apparent at its southern end.

Along the northern front of the fort, however, the picture differs from that previously recorded. Rather than the single wide Ditch of the Antonine Wall, two ditches are apparent at the western limit of the gradiometer survey, again visible as parallel negative linear anomalies between strong positive ones (Figure 6.5.5). The line of the outer ditch was subsequently observed by Bailey in a watching brief following a cable trench on the north side of Mumrills road. The eastwards continuation of the outer ditch within the survey area is partly masked by disturbance from the demolition of early farm buildings, whose northern remains are still extant but were more extensive in the later 19th century according to the 1st and 2nd edition Ordnance Survey maps. The inner northern ditch can be traced as far as the line of the outer ditch on the east side of the fort. The presence of two ditches to the north of the fort is reminiscent of the evidence from both Balmuildy and Auchendavy (above Chapters 3.1 and 4.1), and lends further support to the long-held

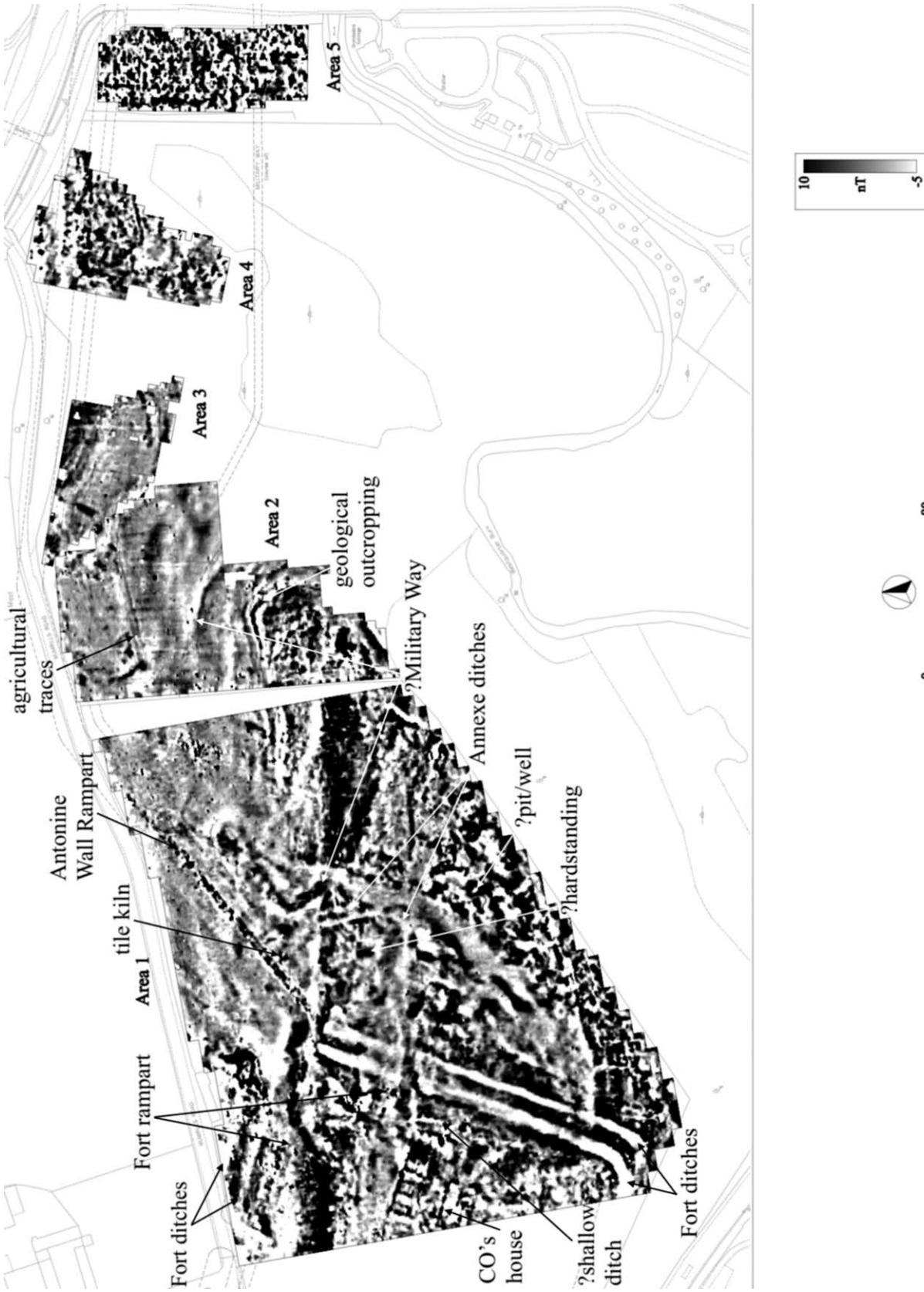

Figure 6.5.5. Gradiometer survey at Mumrills (after GSB 2007e, Fig. 3, with additions).

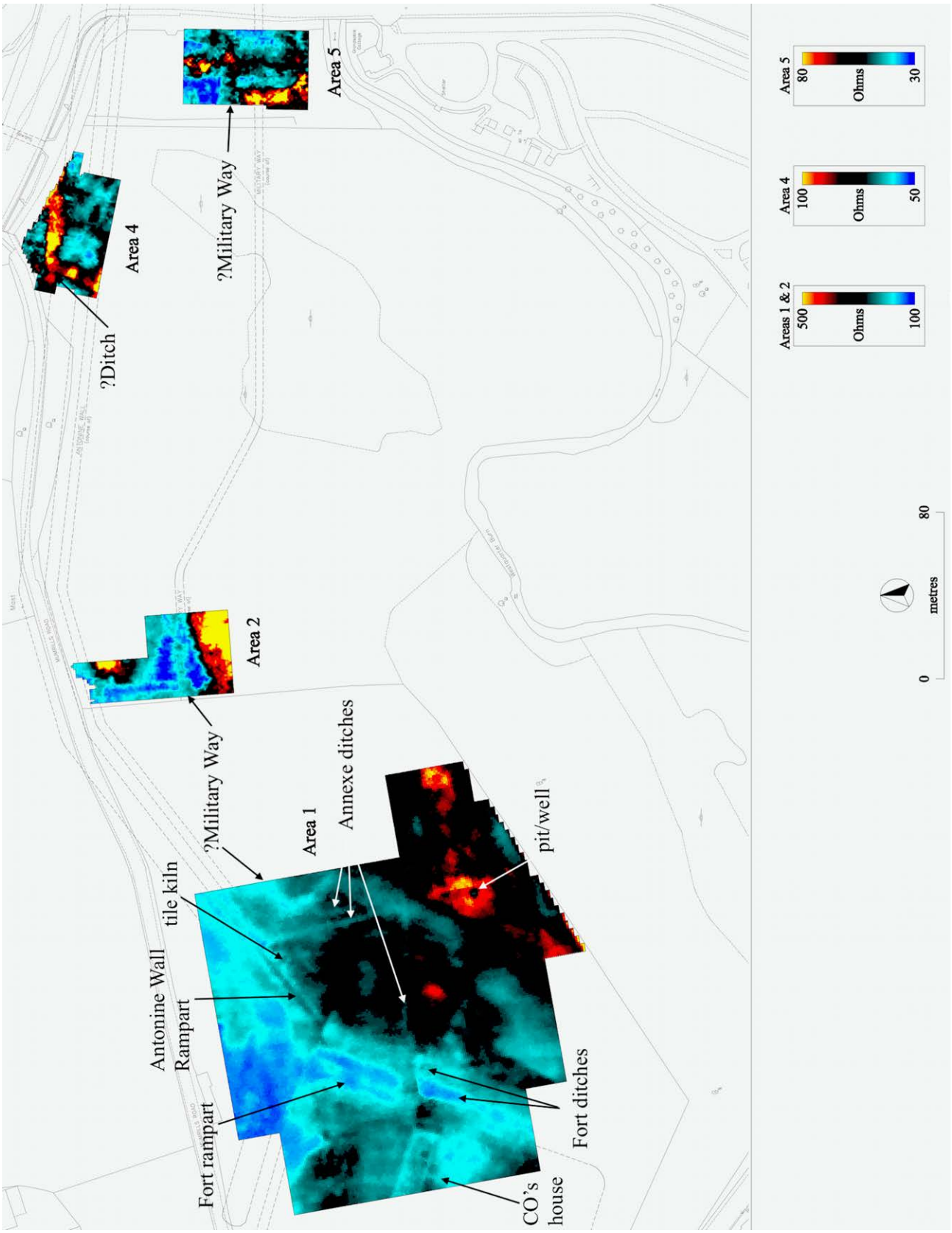

Figure 6.5.6. Resistance survey at Mumrills (after GSB 2007e, Fig. 8, with additions).

assumption, based on the change in the alignment of the Wall on either side of it, that the fort at Mumrills was built before the Wall.

This change of direction in the line of the Antonine Wall Rampart just after it leaves the fort is very clear in both the gradiometer and resistance surveys. In the former it is visible as a positive *c.* 4m wide mottled band some 140m long, the signal exactly paralleling that at Tollpark (Chapter 5.2, above), which seems to have resulted from the use of cobbles with raised magnetic properties to form the Rampart base. This was flanked on each side by a thin negative line perhaps marking where kerb stones had been robbed out (Figure 6.5.5). In the latter it appears as a band of very slightly enhanced resistance bounded by lines of low resistance (Figure 6.5.6). The continuation of the rampart across the northern face of the fort is apparent in the gradiometer survey, though the character of the signal changes to a more consistent, but only slightly positive, band. The line of the eastern rampart of the fort is less readily apparent except in one short stretch just to the north of the east gate, but is more visible in the resistance survey as a narrow band of lower readings (Figure 6.5.6).

In the fort interior much of the commanding officer's house is revealed in the gradiometer survey, though slightly less so in the resistance survey, the western limits of both cutting across it diagonally (Figures 6.5.5 and 6.5.6). It features as narrow positive linear anomalies or lines of low resistance respectively, which trace the foundations of its stone walls, though the picture is less clear in the area of the bath suite in the south-east corner of the building, whose general location seems to be marked by large positive anomalies or an area of low resistance. Some of the wall lines can also be discerned as positive cropmarks in the aerial photograph, which lends support to the suggestion that they had been excavated and backfilled (Figure 6.5.4). There are no obvious structures apparent in the south-east corner or in the north-east quadrant of the fort. In the gradiometer survey the latter seems to be largely dominated by broad banding of geological origin, though there are slight hints of a negative linear anomaly running from the north-east corner of the commanding officer's house towards the north rampart. This may reflect the line of a shallow ditch recorded by Macdonald and Curle, which they linked to the drainage of earlier timber phase of the building.

The plateau to the east of the fort was a major focus for the geophysical survey. The triangular ditched enclosure, first recorded from the air in 1977 (Figure 6.5.4), was confirmed in both the gradiometer and resistance surveys (Figure 6.5.5 and 6.5.6): it was particularly clear along its entire length in the latter, with only the east side apparent in the gradiometer survey. It was defined by a single ditch to the south, visible as a band of lower resistance, which ran out from the fort ditches immediately to the north of the east gate before turning slightly back on itself and continuing up to the rear of the Antonine Wall. Along much of this eastern side the enclosure was provided with a second, parallel ditch which appears narrower in both the aerial photography and the resistance survey. That this enclosure was another annexe does not seem to have been widely recognised until the geophysical survey discussed here began to circulate: it does not, for example, feature in any of the standard works on the Wall until the 2015 revision of the Handbook, but even then it was not specifically identified as an annexe (Robertson 2015: 60). Nor has it been appreciated until now that the large tile kiln found in 1913 (Figure 6.5.3) lay within it. This is visible in both surveys, located some 8m from the northern corner of the annexe, visible either as a *c.* 3-4m diameter oval patch of increased resistance surrounded by a halo of lower resistance or as a *c.* 5m diameter sub-circular dipolar anomaly. Recognition that this annexe housed a kiln for the production of tiles used in the construction of the fort serves to highlight that one of the functions of such annexes, which are much disputed (Hanson 2021), was to provide space for necessary associated industrial activity. There are no other features elsewhere in the annexe apparent in the resistance survey, but possible candidates in the gradiometry. These include a large subrectangular positive anomaly towards its southern end, possibly an area of hardstanding. However, similar signals immediately to its south seem more likely to be the result of variations in the geology, which proliferate to the east of the fort.

A similar problem arises in the interpretation of the *c.* 5m wide, L-shaped positive magnetic anomaly just to the east of the annexe (Figure 6.5.5), whose alignment and position with respect both to the Wall and the east side of the annexe would seem to make it a strong candidate to represent the line of the Military Way turning to take into account the annexe as it approaches the fort from the east. The resistance survey, however, depicts the same feature as a broad band of lower resistance which merges into a broader north-east/south-west alignment that is clearly geomorphological, presumably a riverine or glacial channel, as it underlies the annexe ditch (Figure 6.5.6). Attempts to identify the line of the Military Way further east were even less certain. Its presumed line on Ordnance Survey mapping, curving to the north to follow the more gentle slope between the Mumrills Braes up to the plateau, is not based on any previous archaeological discoveries, but on topographical probability. There is a slight hint of an equivalent alignment in the band of slightly raised resistance flanked by areas of low resistance in Area 2 (Figure 6.5.6), but there is no obvious correspondence

in the gradiometer survey. There the most likely candidate, a curving conjoined positive and negative linear alignment, lies somewhat further to the south, though on slightly sloping ground. The short straight double positive alignment to its north, which runs broadly parallel with the Wall, is agricultural, as it is visible in low light aerial imagery (e.g. Google Earth dated 25/5/2008) where it seems to overlie traces of rig and furrow that run north/south; while the strongly marked alternate negative and positive bands on a similar alignment to the south seem most likely to represent differential geological outcropping on the slope around the northern edge of the more southerly of the Braes.

Given the scattered archaeological remains recorded across the southern half of the eastern plateau since the early part of the 20th century, some confirmation in the geophysical survey might reasonably have been expected. This proved not to be the case. The magnetic signal generally was very mixed with some large-scale banding, both positive and negative, which should be geological or geomorphological in origin (Figure 6.5.5). As a result, little in the way of coherent pattern could be extracted from it. In the resistance survey this area, bounded to the north by a riverine/glacial channel visible as a broad curving band of low resistance, was dominated by high resistance (>200 ohms above the mean), presumably attributable to the proximity of bedrock to the surface (Figure 6.5.6). However, a small circle of lower resistance within it seems likely to represent a deep pit or well. There is an equivalent negative circular anomaly within an area of positive responses in the gradiometer survey, though it is rather lost in the general background noise.

The various areas examined further to the west were no less disappointing. A negative linear anomaly with a rather patchy positive band to its south, which runs across the northern extent of Area 4 (Figure 6.5.5), may represent the line of the Ditch and Rampart respectively, but neither are entirely convincing. The former may be the equivalent of the broad alignment in the resistance survey at this point (Figure 6.5.6), though the fact that it is high resistance feature would be unusual. The likelihood of modern disturbance in this area, which has seen major changes to the road and settlement pattern, is high. A short positive magnetic alignment running at a slightly oblique angle to the south of these features is too isolated to offer any meaningful interpretation. It is probably geological as similar lines can be traced across the southern parts of Areas 2 and 3. Finally, Area 5, the most easterly to be examined, should have crossed the line of Military Way, which had been recorded in excavation in the next field to the east. No convincing relevant features were evident in the gradiometer survey, due to a spread of what is probably modern ferrous material. However, an ill-defined east-west band of higher resistance in the same area might be the Military Way, though it runs some 10m north of the presumed line.

Chapter 7

7.1 Inveravon

(NGR: NS 9510 7967; Canmore 47799 and 82872)

Fort, Ditch, Rampart and Military Way

Site-specific references

Macdonald 1925: 271-73; Robertson 1969; 1974; Clark 1973; *DES* 1973: 58-9; 1974: 69; 1975: 61; Dunwell and Ralston 1995; GSB 2007d; Bailey 2021: 76-78

Geophysical surveys (Figure 7.1.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
Ancient Monuments Laboratory; 1973	R: Martin-Clark resistivity	single (*c.* 150m long) traverse	
GSB; 2008	G: Bartington Grad 601-2 R: Geoscan RM15	3.3 1.23	0.25, 0.5 1, 1

Introduction

We know surprisingly little about the fort at Inveravon, which sits within a cultivated field to the west of the minor road to Inveravon Farm. It is located on low-lying ground on the east bank of the Avon at the bottom of a gradual slope down to the river from the scarp that marks the line of the raised beach. Currently the fort lies 1.5km south of the modern coastline, separated from it by carse land now occupied by Grangemouth refinery. At the time of its construction, however, assuming that the sea level was some 2.5m higher (Hannon 2018: Fig. 9.2), the fort may well have been situated directly on the coast at the very mouth of the river. Indeed, it has even been suggested that the Wall may originally have been intended to start from this point, since the Wall-terminals on opposite sides of the Avon are misaligned and the Ditch (as well as the Wall base) is consistently narrower to the east of the river (Maxwell 1989b: 163).

There is some indication that the line of the Wall here remained partially extant at least until the end of the 19th century, as the 2nd edition Ordnance survey map records a 70m length of bank at the top of the slope immediately to the west of the minor road and north of a small cottage (which no longer survives). Rather than being an inaccurate record, as Macdonald suggested, this clearly represents the Upcast Mound. The cottage had, as Macdonald recognised, been built largely over the Ditch, as an aerial photograph taken by St Joseph in 1960 well illustrates (CUCAP WL 1756 PO/Canmore SC1925362), but it extended beyond it to the south, rather than to the north as he asserted. By the time of the 1914 map revision, however, all traces of the Wall had disappeared under the plough, so Macdonald's preferred line has continued to hold sway.

There is no antiquarian record of a fort at Inveravon, though there was a long-held belief that one was to be found somewhere in the vicinity to guard the river crossing. Sibbald, for example, identified the nearby Inveravon tower, part of a 15th century fortification, as the Roman fort site (1707: 33-4). Trenching by Macdonald in 1914, whilst seeking to confirm the line of the frontier to the east of the river, identified the general location of the fort from occupation material found at the rear of the Wall at the bottom of the field. While he did locate evidence of occupation towards the top of the field, he did not consider it to be Roman, though he did identify a 2nd century mortarium amongst the associated finds. It was not until 1967 that structural remains of the fort were recorded when Robertson undertook small-scale exploratory excavations. Focusing first at the top of the slope on the eastern side of the field she was able to trace the stone base of the Wall over a length of some 146m, but recovered only remains of a large Mesolithic shell midden in trenches to its rear. Eventually, as she progressed westwards, she exposed fragments of stone walling, road metalling and two phases of cobbling on the low ground beside the river. Accordingly, she postulated the existence there of a fortlet or a small fort, but was unable to identify its defences. The subsequent recovery of box-flue tiles from fieldwalking lends support to the identification of a fort, as they indicate the presence of a nearby bathhouse.

Limited excavation by the Centre for Field Archaeology in the same area in 1991 ahead of pipeline construction recorded part of a cobble foundation abutting the rear of the Wall almost at right angles to it. Dunwell and Ralston interpreted this as an 'expansion', one of the long-distance signal platforms found very occasionally, though always in pairs, at particular points along the Wall. However, neither its dimensions (at least 7.8m deep compared to a norm of *c.* 5.2m) nor its low-lying position support such an identification. Rather it should be recognised as the eastern rampart of a small fort or possibly its attached annexe. All the more so as Dunwell and Ralston identified adjacent buildings of more than one phase, cobbled surfaces and a rampart

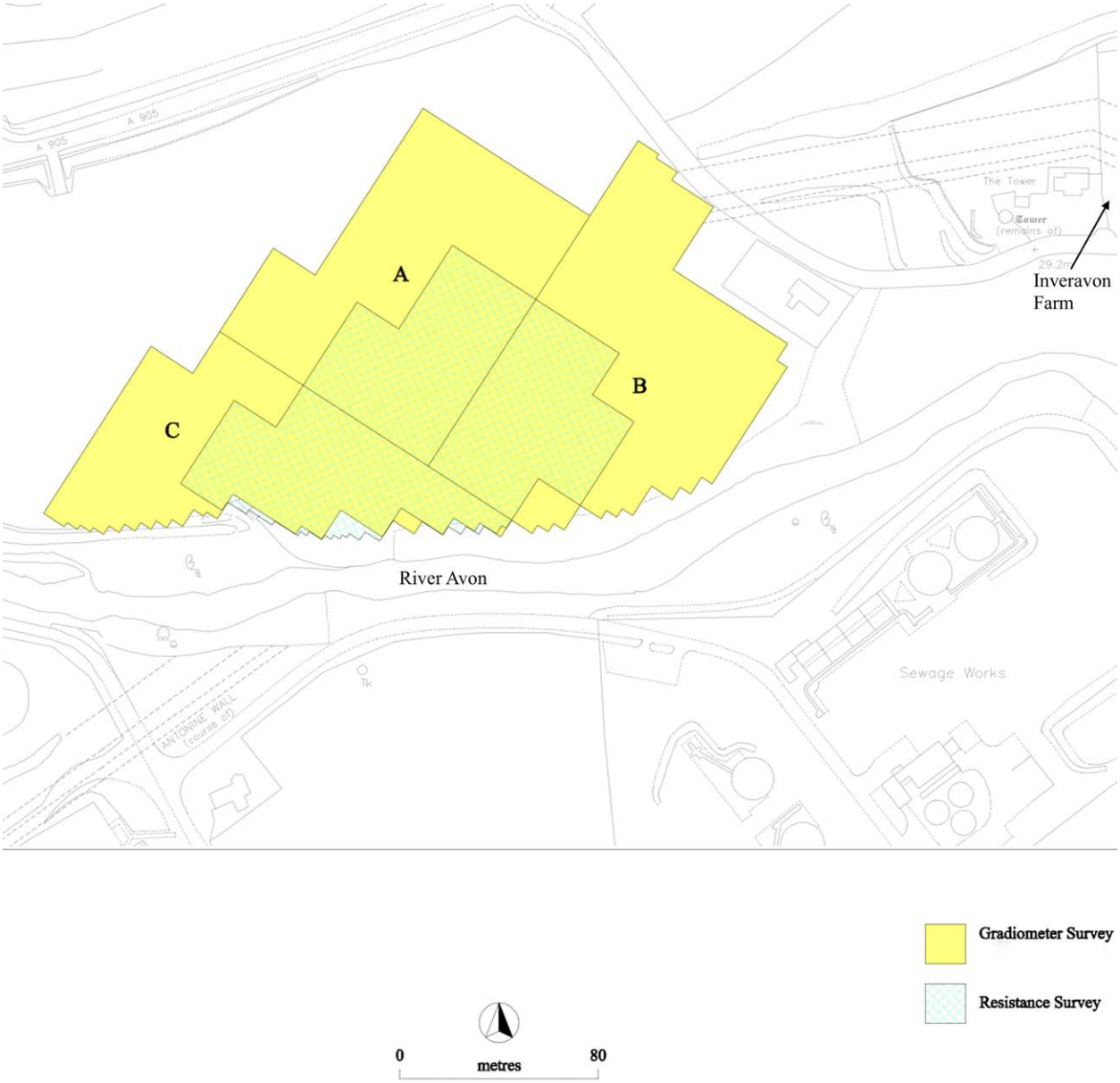

Figure 7.1.1. Location of GSB survey areas at Inveravon (after GSB 2007d, Fig. 2).

running parallel to the Wall some 34.5m to the south. This rampart had a metalled surface immediately outside it, possibly a road. The poorly preserved remains of a possible iron smelting furnace, which pre-dated the buildings just inside this rampart, might lend some support to the identification of the enclosure as an annexe, but there is so little space available before reaching the river bank that a unitary installation seems more likely. Assuming the relative position of the earlier excavation trenches has been correctly plotted, the only difficulty with this suggestion is that the south wall of Robertson's stone building would marginally overlap the extended line of the eastern rampart of the fort.

The fort site lies in a single open field, but has been ploughed completely flat. Indeed, no trace of it remains visible above ground even in the LiDAR data, though there is a faint hint of the undulation of the Antonine Wall Ditch (Hannon 2018: Fig. A.2.5). Aerial photography has proved no more successful at elucidating its remains, though the line of the Ditch is clear as a positive cropmark when conditions are suitable. The field, which slopes quite steeply down to the river, was under pasture at the time of the survey and free from obstructions. General conditions for geophysical survey across the area were good, the clays, silt, gravels and non-calcareous gleys overlying mainly sandstone presenting no problems. On the other hand, the gradiometer survey in particular was quite badly

affected by the presence of modern pipelines and the extensive shell midden.

Results

The line of the Antonine Wall Ditch is very clear in the gradiometer survey as a broad negative linear anomaly, usually flanked on each side by positive anomalies of varying strength (Figure 7.1.2). It follows a fairly straight line for the most part, the north-eastern end running slightly behind the line indicated by the Ordnance Survey, but curves markedly to the south just as it approaches the river, reaching its bank further to the east than had been thought. This change of direction has not previously been recognised and locates the Wall immediately adjacent to the site of a weir, which is no longer extant, where the river may have been fordable. As a result, its alignment with the eastern end of the Wall on the opposite bank would have been rather better than has previously been appreciated, though this does not detract from Macdonald's perceptive comment that the eastern continuation of its line was probably pushed slightly further to the north to allow room for a small fort. This also indicates that any movement of the river at this point has been minimal and, contrary to what Robertson implied, is unlikely to have removed remains of the fort. The Ditch can readily be traced across most of the field except where the signal is swamped by the dipolar anomalies of modern pipelines cutting through it at the eastern end and towards the centre, the latter representing the position of the 1991 excavations. However, one *c.* 40m long section of the Ditch between these pipelines seems to be partially obscured by a broad band of average readings. The width of that band and its continuation as an area of mottled positive and negative responses both to the north and south of the Wall, apparent also in aerial photographs as a negative cropmark zone (e.g. Canmore SC1729068), suggests a possible geological origin. However, it seems more likely to be related to variations in the nature and extent of the very large shell midden that extends across much of this area, as some aerial photographs reveal a gap in the spread of shells brought to the surface by the plough at this point (e.g. Canmore SC1729058). It is probably the presence of layers of burning apparently interspersed with oyster shells in the midden, rather than the shells themselves, that give rise to the somewhat 'busy' signature (c.f. the gradiometer response over a Mesolithic shell midden on Colonsay in Finlay *et al.* 2019).

The resistance survey covers only the western half of the field, but its northern limit extends to the fringes of the midden, revealed as an amorphous area of very low resistance perhaps as a result of changes in the moisture and mineral content of the soil (Figure 7.1.3). The position of this pipeline is more precisely indicated than in the gradiometer survey by a thin band of low resistance that crosses the Wall at right angles. The line of the Ditch appears as a broad band of reduced resistance not greatly differentiated from the background signal on either side of it. To the south, a generally thin line of higher resistance, which can be faintly traced across most of the survey area, probably marks the line of the Rampart base. There is no clear sign of the latter in gradiometer survey with the possible exception of a short, weakly positive linear anomaly immediately to the east of the central pipeline trench (Figure 7.1.2), though this seems to be located slightly further from the southern lip of the Ditch than was suggested by excavation.

A negative curving linear anomaly in the gradiometer survey immediately to the east of the pipeline seems best interpreted as a single ditch curving around the south-east corner of the fort (Figure 7.1.2). Certainly its location and alignment fits perfectly with the line of the south and east ramparts identified in the 1991 excavations. It is only faintly mirrored by an irregular, lower resistance band in the resistance survey (Figure 7.1.3). Any potential magnetic signal from an associated rampart is completely masked by the very strong dipolar signal from the pipeline. There is no clear indication in either survey of the western side of the resulting small fort, though it is likely to have been located before the Wall changes direction southwards as it approaches the river. That would indicate a total maximum width for the installation of *c.* 60m internally and, combined with the known line of the south rampart, an internal area of *c.* 0.2ha. This is directly comparable in area, though not in morphology, to the small 'fort' at Duntocher.

There is little within the interior of the postulated fort that is convincingly suggestive of buildings, though much of the area displays high readings in the resistance survey (Figure 7.1.3). The poor level of detail within these anomalies may in part be due to an increased topsoil overburden at the bottom of the slope, but could also reflect scattered rubble from stone buildings. Clark's 1973 resistance transect, the earliest example of the application of geophysical survey on the Antonine Wall, bisected this area and did detect a substantial high anomaly towards the centre, though mistakenly identified it as the line of the Antonine Wall Rampart. One area of dipolar activity in the gradiometer survey (Figure 7.1.2), which corresponds with a discrete area of high resistance at the back of the Wall, would not be an inappropriate response or location, just inside the western rampart, for the postulated bathhouse.

Further to the east the gradiometer survey is dominated by generally noisy signals from the shell midden and several negative linear anomalies of varying intensity, mostly running approximately at right angles to the line of the Wall (Figure 7.1.2). The latter are also consistently apparent as positive cropmarks in aerial

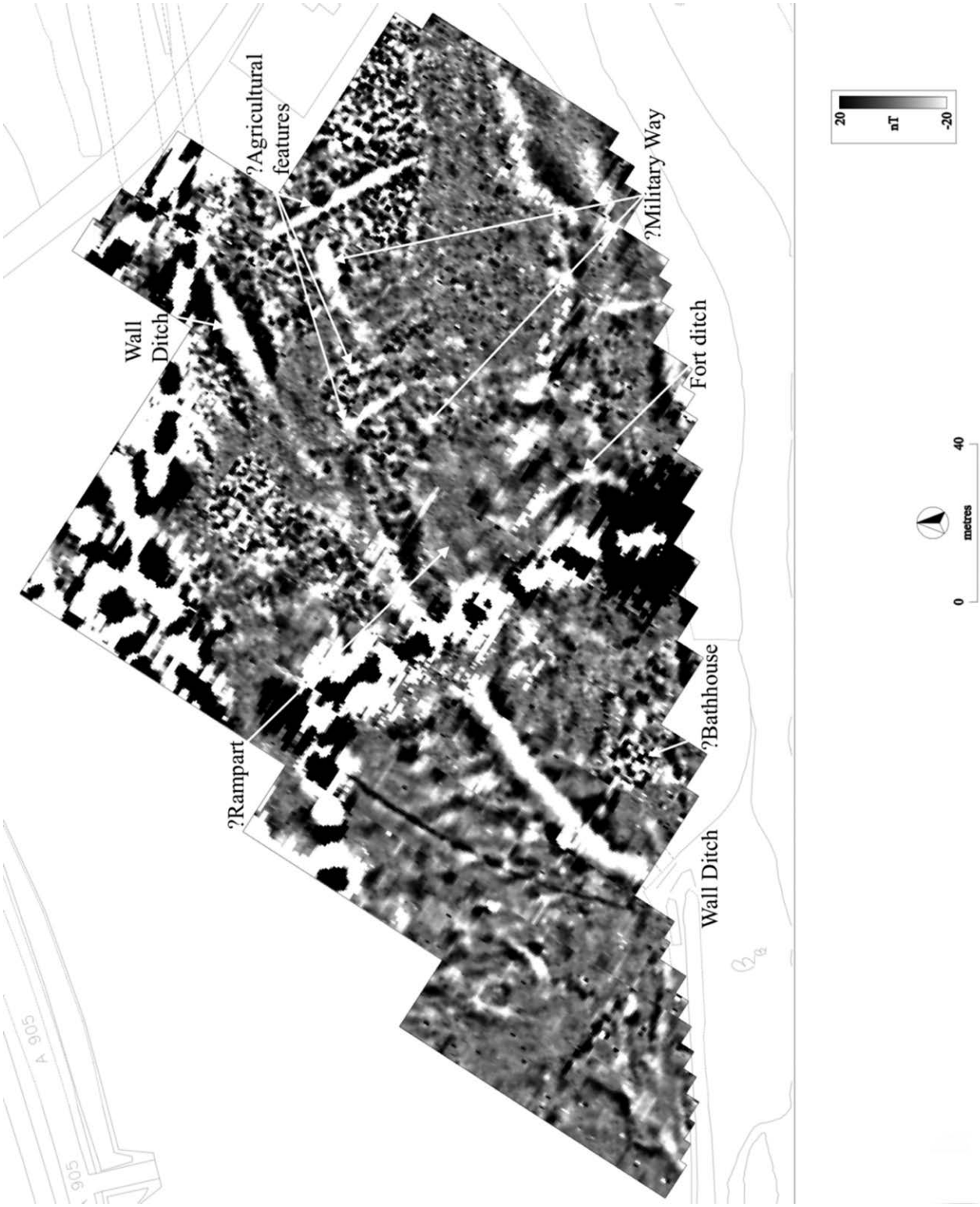

Figure 7.1.2. Gradiometer survey at Inveravon (after GSB 2007d, Fig. 3 with additions).

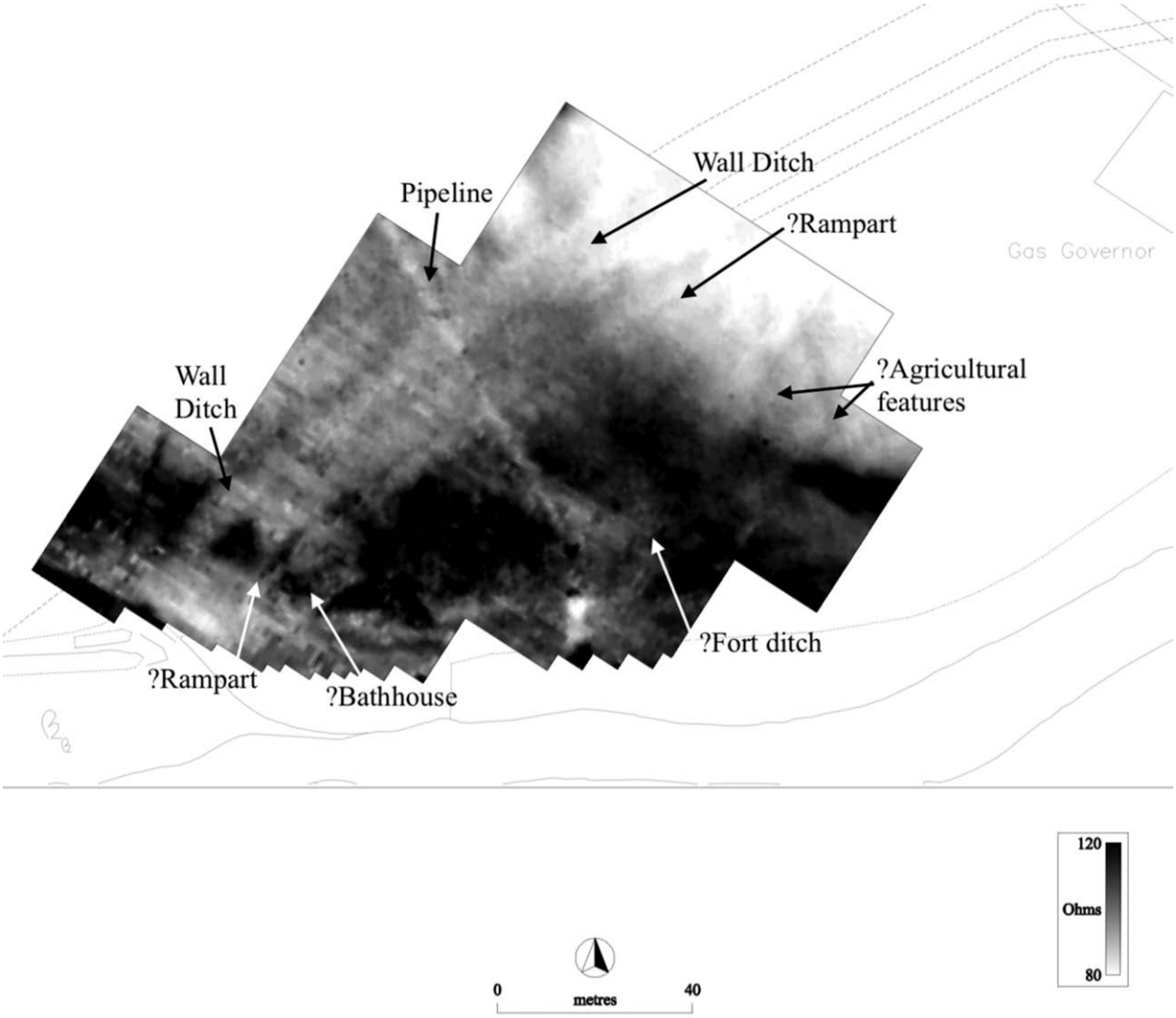

Figure 7.1.3. Resistance survey at Inveravon (after GSB 2007d, Fig. 6 with additions).

photographs of the site taken from the 1950s onwards by St Joseph (CUCAP G 99564 PO/Canmore SC1921938) or RCAHMS (Canmore SC1729036). The resistance survey (Figure 7.1.3) extends only sufficiently into the area to pick up the more westerly of these anomalies as bands of slightly raised resistance. These features have all the hallmarks of anthropogenic activity, but make little sense archaeologically. Bailey suggests that the most easterly reflects the line of a Roman ditch, presumably marking the eastern extent of an annexe, but it stops abruptly at its southern end for no clear topographical or geological reason, and at its northern end the line partially coincides with one of Robertson's excavation trenches (according to an unpublished plan in the NMRS (Canmore MS 2687)). Had it been a Roman ditch she would surely have noticed it. Nor is it insignificant that neither she nor Macdonald recorded Roman material in this area. The other linear features cannot be the remains of trenches dug by Robertson, as their first appearance in aerial photographs predates her excavations. Bailey suggests that they may relate to Macdonald's excavations, but they are far too large to represent his speculative investigative handiwork, which tended to involve very small cuttings (c.f. Hanson 2022: 8, 14 and Illus 2.1). Thus they remain enigmatic, but seem most likely to reflect some form of post-medieval agricultural intervention.

The line of the Military Way may be indicated in the gradiometer survey by a short, wide negative linear anomaly running broadly parallel to the Ditch some 22m to its south (Figure 7.1.2). There also are hints that this may continue in a somewhat disjointed fashion on a slightly curving line further to the west. The same feature is consistently visible in the aerial photographs as a strong positive cropmark, suggesting that it has been cut into the slope.

7.2 Kinneil

(NGR: NS 9774 8037 to 9849 8062; Canmore 48135 and 114529)

Ditch, Rampart, fortlet, Military Way and environs

Site-specific references

Macdonald 1925: 276-79; Steer 1961b: 323-24; Hendry 1971; Keppie and Walker 1981: 150-54; Bailey 1996: 360-64; 2015; 2021: 211-20; Bailey and Cannell 1996; Glendinning 1998b; 2000; GSB 2008a; Hannon 2016; 2021

Geophysical surveys (Figures 7.2.1 and 7.2.2)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
CFA; 1998	R: Geoscan RM15	0.6	1, 1
GSB; 2008	G: Bartington Grad 601-2 R: Geoscan RM15	4.2 1.6	0.25, 1 1, 1
Hannon; 2016	G: Bartington Grad 601-2	3.6	0.5, 1
HES; 2021	G: Sensys MXPDA EM: GF CMD Mini Explorer	8.35 0.45	0.125, 0.5ss 0.1sec, 0.5t

Introduction

The course of the Wall through Kinneil Estate follows the line of the raised beach overlooking the Forth Estuary, as it does all the way from Inveravon, though for the most part it is slightly set back from the scarp edge. Despite being contained within the policies of Kinneil House, maintained as a public park since 1922, the Wall here is very poorly preserved. The Ditch line to the east of the House is no longer visible at all and to the west was recorded in the 2nd edition Ordnance Survey mapping only as a double dotted line, which indicates the slight hollow that is still faintly visible in the LiDAR imagery (Figure 7.2.3). The reason for the difference of survival compared to the section of the Ditch running through the policies of Callendar House (Chapter 6.4, above), for example, is that the area known as the Meadows, which lies immediately to the west of the Gil Burn,[1] was the site of the medieval village of Kinneil. Occupation here can be traced back to at least the mid-12th century, the date of the first reference to the adjacent church, and probably much earlier. Cropmarks indicate that the church sat within a circular enclosure (Bailey 1996: Illus 15), a distinctive feature suggesting that it was probably an early Christian foundation. Thus, by the time that the village was cleared away at the end of the 17th century to create parkland for the Estate, the destructive impact of both cultivation and occupation had already taken its toll. As a result, numerous efforts have been required over the years to confirm or establish both the line of the Wall and of the Military Way here.

Dubious about the Ordnance Survey's record of a 45 degree southward deviation in the line of the Ditch as it approached the Gil Burn from the west, Macdonald trenched extensively across the Meadows. Picking up traces of the infilled Ditch in several places, he was able to confirm that the Wall continued its straight course; he even identified a surviving fragment of Rampart base. Aerial photographs taken by CUCAP in the 1970s also confirm that the Ditch continued in a straight line (Bailey 1996: Illus 15). Macdonald suggested that the apparent deviation, which is still visible on the ground, related to the construction of a trackway during the landscaping of the estate in the late 17th century. Support for Macdonald's interpretation was provided by excavation on the east side of the Gil Burn some years later. Trenching by Maxwell and Wallace in the grounds of Dean House in 1960 recorded the presence of the Ditch, while limited examination in the north-west corner of the field immediately to the south of the avenue leading to Kinneil House by Hendry in 1961 recorded both the Ditch and the Rampart. Thus, that the course of the Wall continued on the same straight alignment on the east side of the Gill Burn to beyond the Dean Burn seemed to have been confirmed.

However, limited excavation by Bailey within the walled garden to the south of Kinneil House in 1990 recorded the edge of a ditch-like depression running in a north-easterly to south-westerly direction. Linking this with the apparent deviation in the line of the Wall noted by the Ordnance Survey to the west of the Gil Burn (above),

[1] There is some historical inconsistency in the naming of the minor watercourses which run through the Kinneil Estate. Ordnance Survey mapping from 1897 to 1951 refers to the Dean Burn, which runs past the lodge at the eastern entrance to the Estate, as the Gil Burn, even though the defile through which it runs is named Dean Glen. This incorrect identification is followed by Macdonald in all his writings and by Robertson in the early editions of her 'Handbook to the Roman Wall' (e.g. 1960: 45). In fact, the Gil Burn runs immediately behind, that is to the west, of Kinneil House, as intimated in a children's rhyme that references the supposed suicide of Lady Lilburn who threw herself into the Gil Burn from Kinneil House in the early 17th century (we are grateful to Geoff Bailey for drawing this reference to our attention). The record of this oral tradition identifying the Gil Burn first appeared in print some 70 years before the 2nd edition Ordnance Survey mapping (Chambers 1826: 27-8). The incorrect naming of the two burns was rectified on Ordnance Survey maps from the mid-1950s. These corrected identifications are used throughout the discussion here.

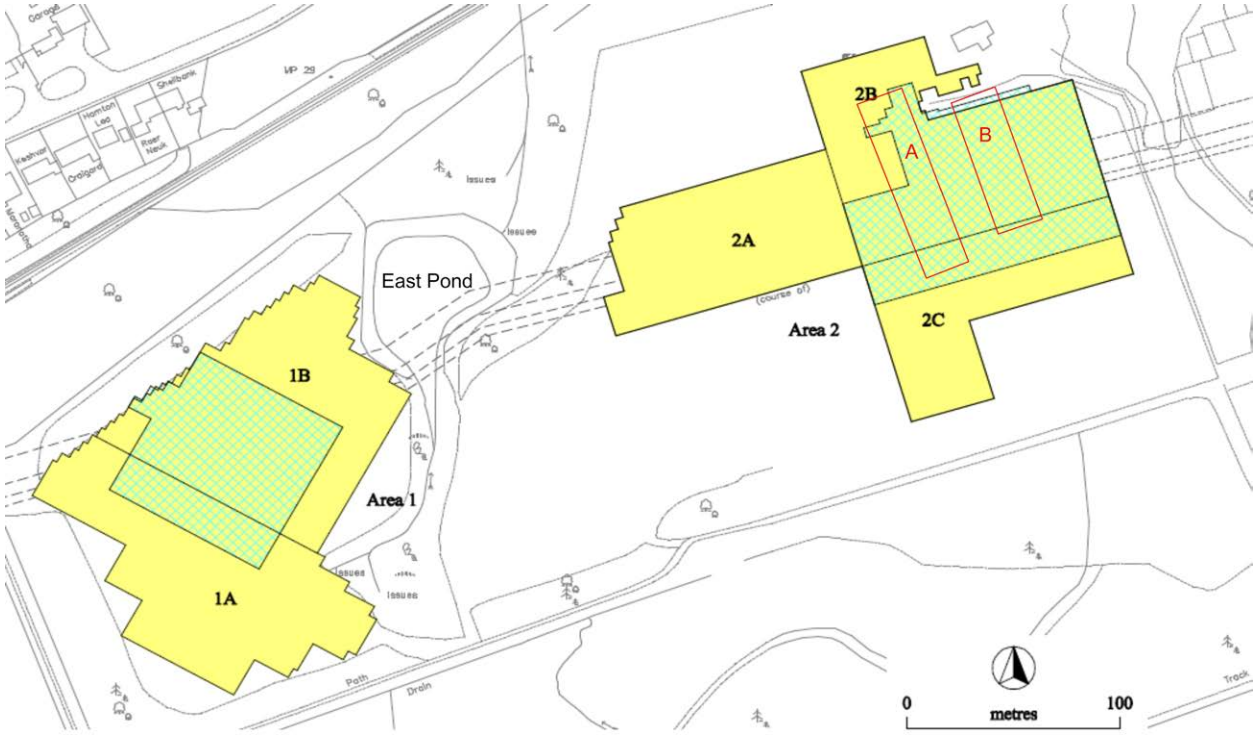

Figure 7.2.1. Location map of CFA survey Areas A and B (outlined in red) and GSB surveys (gradiometer in yellow; resistance hatched in green) at Kinneil (after Glendinning 1998b; 2000, Illus. 2 and GSB 2008, Fig. 2).

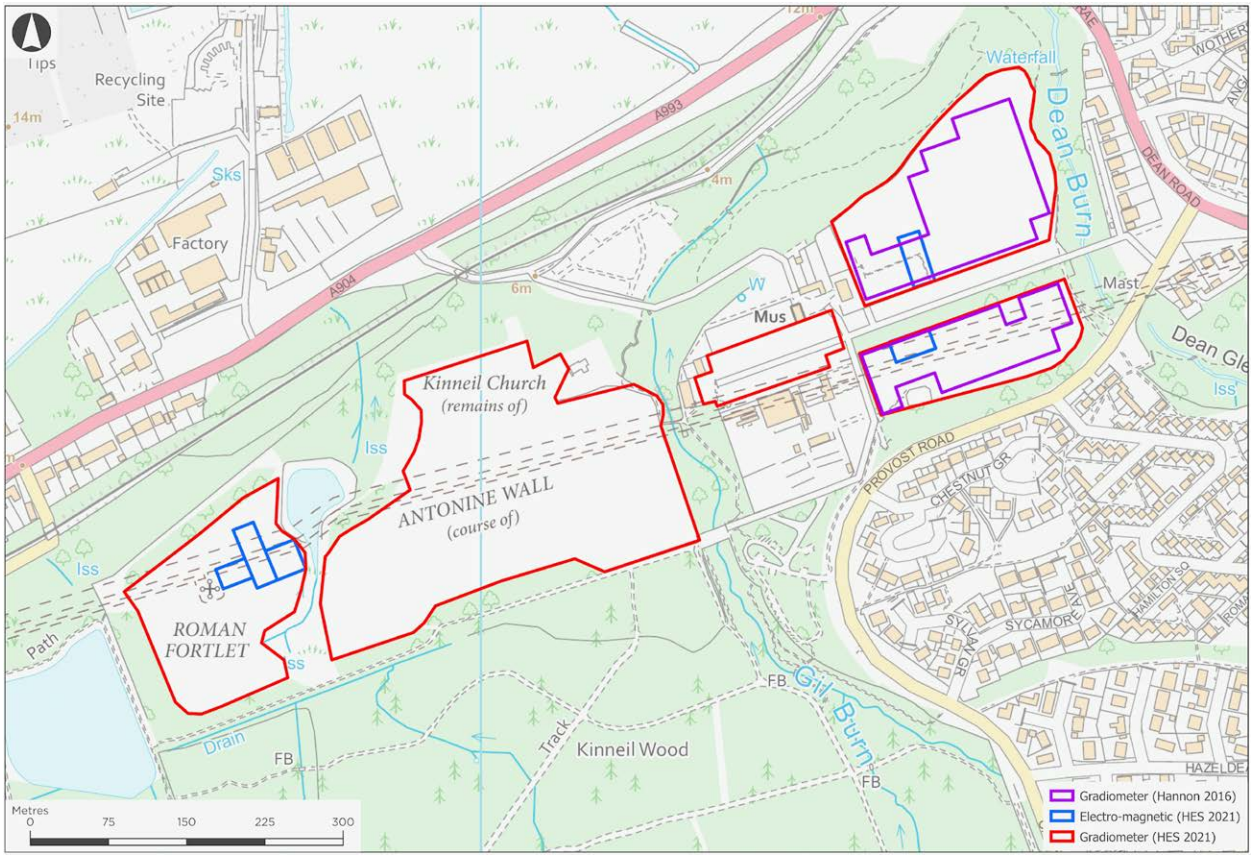

Figure 7.2.2. Location map of geophysical surveys by Hannon and HES at Kinneil.

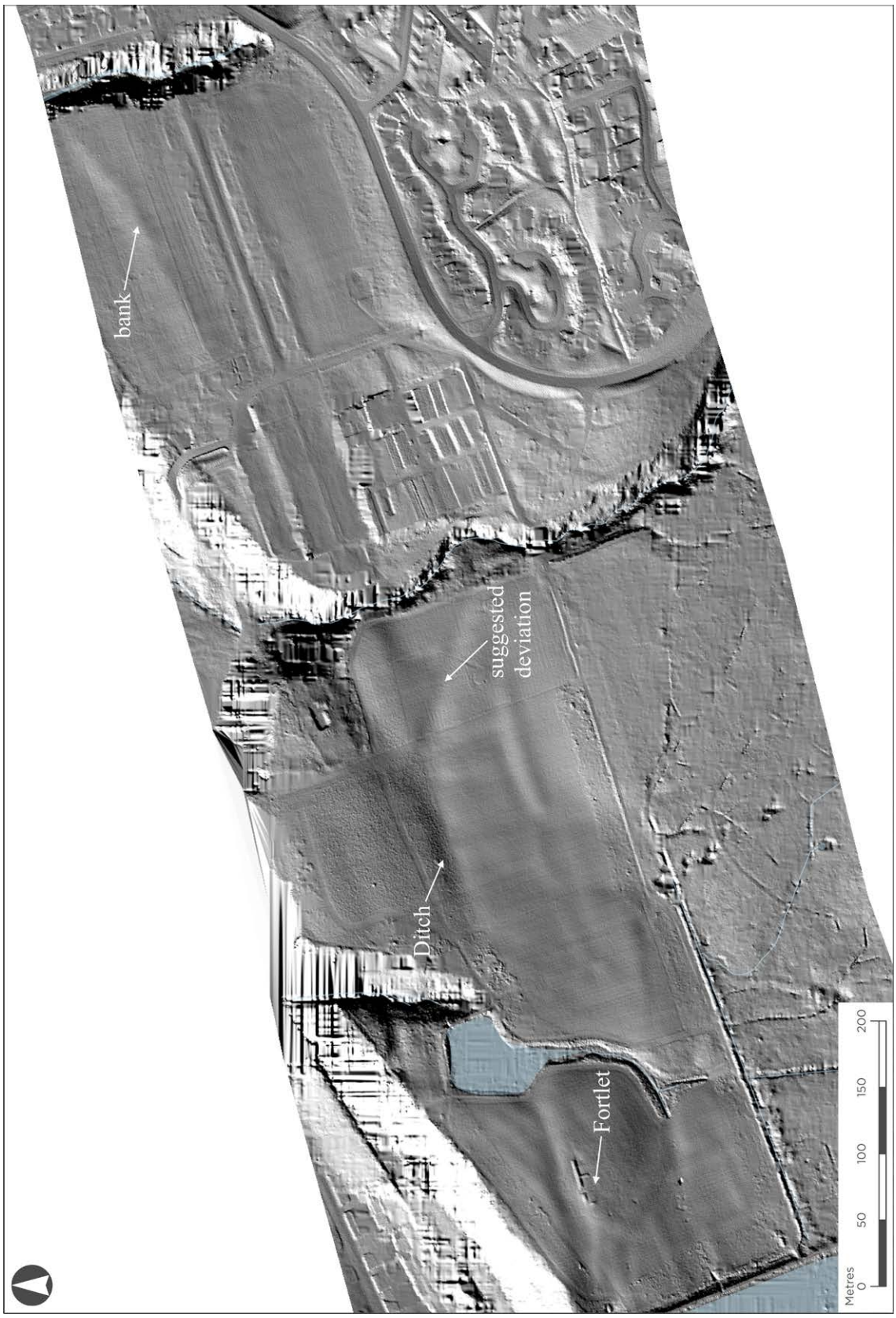

Figure 7.2.3. LiDAR image of the Kinneil Estate.

he suggested that at some point in the Wall's history there may have been a re-entrant angle in its line so as better to facilitate the crossing of the deep defile through which the Burn flowed. To test this hypothesis the Centre for Field Archaeology (CFA) undertook limited resistance survey and then excavation in the Meadows area in 1998, using results from the first to inform the second. Two trenches confirmed the presence of the Ditch on the line previously established by Macdonald, the more westerly also indicating that it was partly overlain by a cobbled or pebbled pathway. A third trench across the supposed southwards deviation did not find any sign of a ditch, only a cobbled pathway, though traces of medieval settlement were also recorded in all three trenches.

There is even greater uncertainty about the line followed by the Military Way through the Kinneil Estate, which remains unconfirmed. Macdonald thought he had located the road in trenching in 1915 just within the woods at the west end of the Estate and again in 1932 on the same general alignment immediately to the south of the walled garden of Kinneil House. That it ran unusually far to the south of the Wall he explained as a result of the intervening low-lying wet ground. Excavations by Bailey in 2011 failed to replicate Macdonald's identifications and concluded that what he had seen were the remains of much later trackways linked to the extensive landscaping of the Estate from the later 17th century onwards. Aerial photographs taken in 1997 by RCAHMS revealed a linear vegetation mark in the Meadows somewhat closer to the line of the Wall, which it was thought might represent the line of the Military Way. However, excavation by CFA the following year failed to find any features of archaeological significance.

On the basis of early antiquarian accounts (Sibbald 1707: 30; Maitland 1757: 152) and the spacing of known forts, it has long been suggested that there should be a fort in the vicinity of Kinneil House. No evidence of such an installation has yet come to light; however, a fortlet has been found some 500m west of Kinneil House, whose remains may have prompted the antiquarian references. Its location, on a small raised knoll, was originally identified in 1974 during targeted fieldwalking undertaken shortly after ploughing had taken place led by Walker, assisted by members of the Cumbernauld Historical Society, and was confirmed by small-scale excavation undertaken by Keppie and Walker four years later. In 1980-81 the site was more extensively excavated by Cannel as part of a Manpower Services Commission scheme, and the surviving remains consolidated and presented to the public. This excavation provided additional information about the gateways and other features, notably fragmentary timber buildings on both sides of the central roadway, a waterlogged well with an adjacent stone-based structure in the north-west corner and a stone platform within an L-shaped ditch in the external north-east corner. However, it failed to locate the second ditch around the fortlet identified by Keppie and Walker, though this was sought in only one trench on the east side. The northern third of the fortlet was reasonably well preserved, but the remainder had been very heavily damaged by ploughing that had removed virtually all trace of Roman surface levels.

In 2008 more extensive geophysical survey was undertaken by GSB (Figure 7.2.1). They focused on the Meadows and the site of the fortlet, seeking to locate any anomalies potentially associated with the Wall, fortlet and medieval settlement. In 2011 Bailey used this survey to inform his limited excavation to try, though without success, to identify the road leading out from the south gate of the fortlet. Finally, following survey by Hannon to the east of Kinneil House in 2016, HES undertook a comprehensive gradiometer survey in 2021 covering all of the accessible parts of the Kinneil Estate, extending beyond the line of the Wall to both north and south (Figure 7.2.2). Its aims were not only to gain further information about previously identified archaeological features, but to seek any new potential archaeological anomalies.

The Wall at Kinneil runs through grassed parkland so access for survey was largely unhindered, though occasional problems with waterlogging or denser vegetation were encountered. Upper Limestone formation sedimentary rocks prevail in the solid geology, overlain with raised marine deposits of clay, silt and sand; the soils are of brown earth type. The detrimental impact of the underlying geology on identifying archaeological remains was sometimes evident, particularly in the gradiometer survey to the south of the fortlet.

Results

The area of survey by HES to the north of the main drive entering the Estate from the east was originally surveyed by Hannon in 2016 to check possible archaeological features visible in the LiDAR data. This showed what appeared to be a low, broad linear bank running on a south-west/north-east alignment (Figure 7.2.3). Though not so readily apparent in the original gradiometer survey, this alignment shows clearly in 2021 as a narrow, sometimes double, slightly sinuous negative linear anomaly with an associated positive anomaly on one or both sides for much of its length, and is probably to be identified as a trackway (Figure 7.2.4). It is mirrored by a fainter parallel alignment a few metres to the south, which clearly relates to traces of rig and furrow cultivation to its

Figure 7.2.4. HES gradiometer survey of areas to the east of Kinneil House.

south. Given the representation of field boundaries in these approximate positions on an estate map from 1748 (Bailey 2015: Illus 12), these features are most likely linked to post-medieval cultivation. However, further to the north-west the ditch of a probable later prehistoric promontory fort and potentially associated roundhouses have been identified, with three further possible roundhouses outside it.

The grassed field to the south of the driveway was investigated by HES to check the line of the Antonine Wall Ditch, which shows very clearly in both the 2016 and 2021 surveys as a *c.* 5m broad negative linear anomaly with a narrow positive one running along its northern side and occasionally on both sides (Figure 7.2.4). There appears to be a short break in the Ditch towards the western end of this section of the survey, confirmed also by low conductivity and high magnetic susceptibility values recorded in a small targeted area of electromagnetic survey (Figure 7.2.5). Given the absence of any supporting indication of Roman occupation to the south, this would seem to be an indication of deliberate infilling at some later date, as appears also to have been the case along a considerable length of the Ditch further to the east. The northern edge of the same Ditch alignment seems to have just been picked up along part of the southern side of the additional area surveyed just to the north of the walled garden immediately in front of Kinneil House. There are, however, only limited indications of the Rampart base,

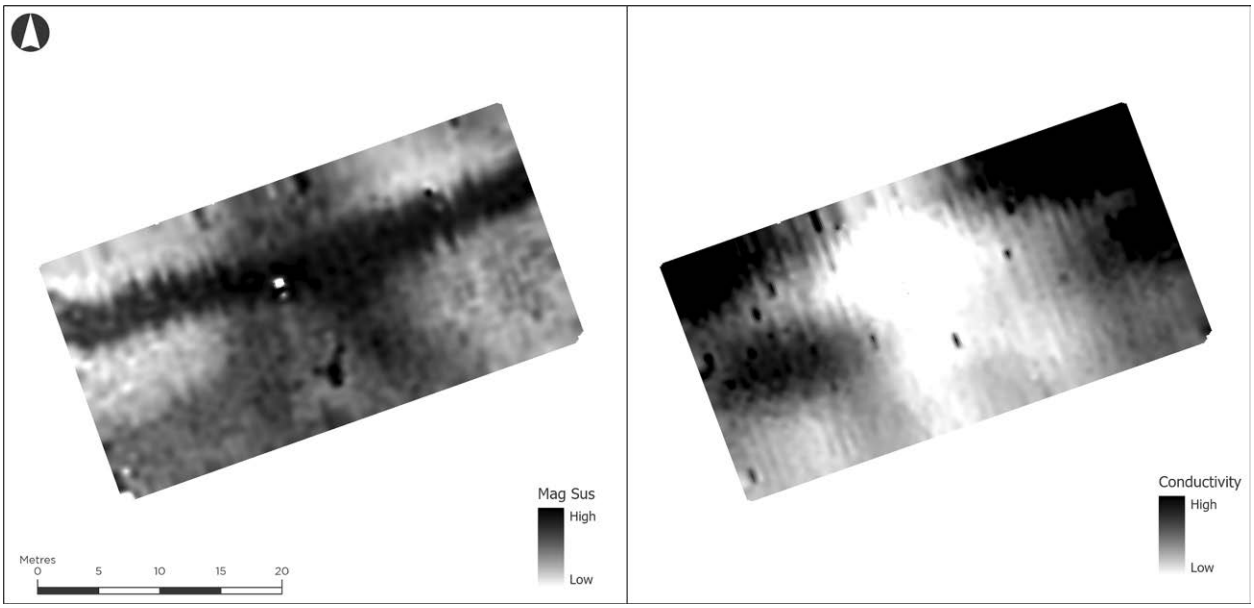

Figure 7.2.5. HES conductivity and magnetic susceptibility survey along the line of the Wall to the east of Kinneil House.

seen as a narrow positive linear anomaly in the north-west corner of the field to the south of the driveway close to the section cut by Hendry in 1961 (above). A pair of parallel very narrow negative alignments some 11m apart, running at a slightly oblique angle to the Wall line, presumably define another trackway, but are clearly post-Roman because of their relationship with the Ditch. An adjacent large oval-shaped negative feature in the middle of the area towards the eastern end may represent a quarry pit for the Military Way, though is larger than the norm for such features and could be of any date.

Moving to the Meadows on the west side of the Gil Burn, the continuation of the straight alignment of the Ditch is clear in both the GSB and HES gradiometer surveys (Figures 7.2.6 and 7.2.7), again revealed as a broad negative linear anomaly with a narrow positive one running on its northern side. The superimposition of the 17th century trackway (noted above) in the centre muddies the picture, however, and the eastern third of the Ditch is both less strongly indicated and lacks the parallel positive anomaly. Indeed, the responses from the medieval settlement attested in the eastern half of the Meadows are consistently detrimental to the visibility and ready understanding of the Roman remains generally. This effect is even more marked in the limited resistance survey (Figure 7.2.8) where the band of low resistance which marks the Ditch line at the western end of survey area 2 is no longer discernible to the east, though it is presumably represented by the band of average resistance bounded to the north and south by more extensive areas of high and low resistance respectively.

The Rampart base, which runs parallel to and some 10m south of the Ditch, is represented quite well in the western half of the HES gradiometer survey area by a slightly positive band with occasional patches of dipolar mottling towards the western limit of the survey (Figure 7.2.6). However, it is difficult to trace in the eastern half of that survey, apart from a short stretch adjacent to the Gil Burn, and barely visible at all in the GSB survey (Figure 7.2.7). Though the positioning of the Rampart would indicate a Berm width slightly greater than the norm, the alignment does correspond with that seen further west adjacent to the fortlet (below). The Rampart is not visible at all in the GSB resistance survey, nor was there any trace of the Military Way in any of the surveys, though given the combination of medieval settlement and intensive ploughing in the area, this is perhaps not surprising. The other most striking archaeological feature apparent in all the surveys, though only faintly in the resistance, is the arc of a large ditch centred on the old church (Figures 7.2.6, 7.2.7 and 7.2.8). It is visible in both gradiometer surveys either as a broad double negative band separated by a strong positive one, or as a single negative band with a matching narrower positive one inside it, probably indicating an internal bank. The double negative band hints at a double ditch, though the CUCAP aerial photograph shows only one (Bailey 1996: Illus 15). Nonetheless, it is clear that the church originally sat within a large sub-circular enclosure.

Current Ordnance Survey mapping indicates a slight change of alignment in the Wall just at the point where a section was lost to the construction of a small reservoir known as the East Pond in the early 19th century. There

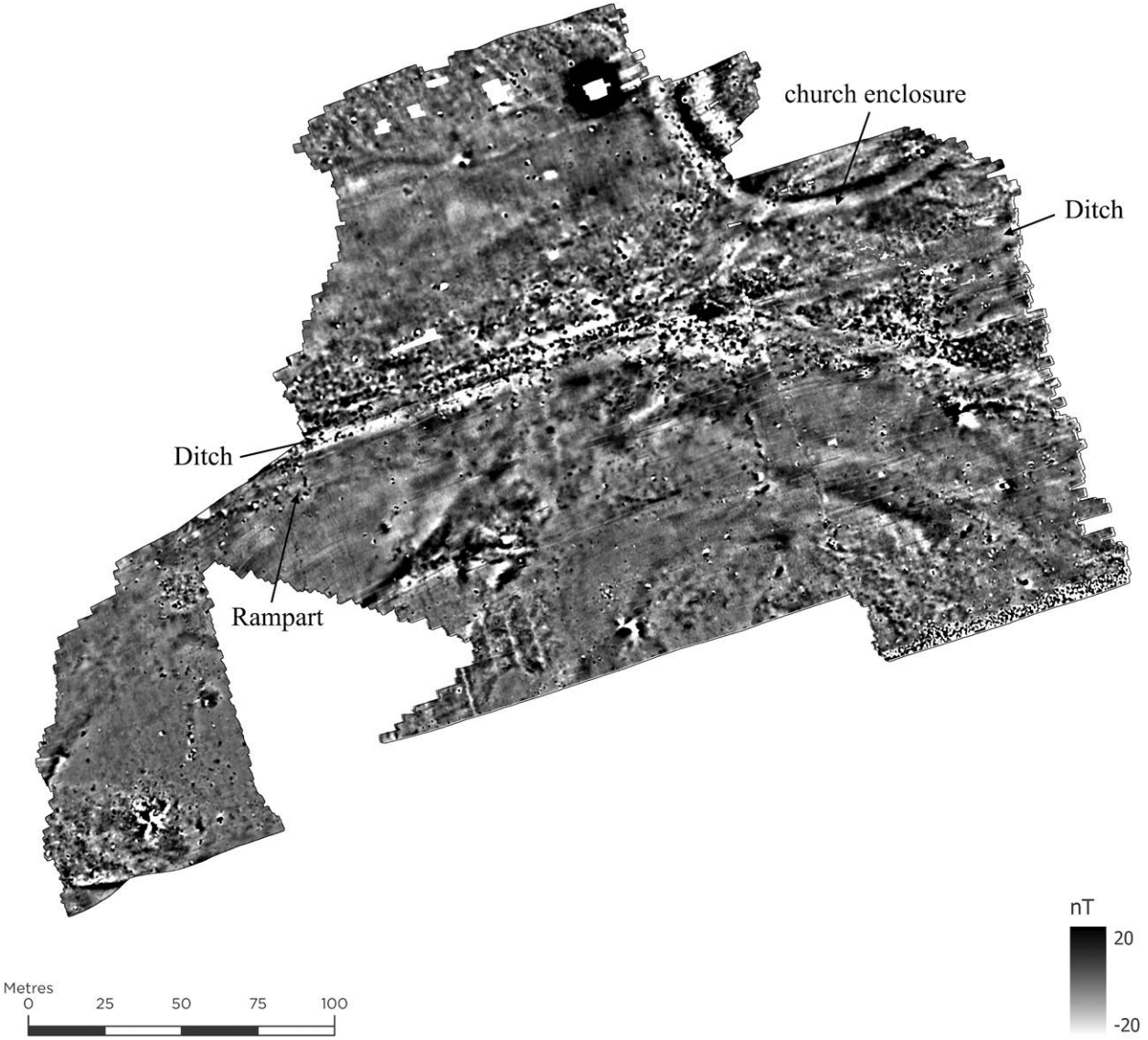

Figure 7.2.6. HES gradiometer survey of the Meadows to the west of Kinneil House.

is, however, no reason to postulate such a change as it is absolutely clear from the geophysical surveys that the Ditch continues on the same alignment on both sides of the Pond. Its remains show strongly in the large areas of gradiometer survey over the site of the fortlet to the west of the Pond undertaken by GSB in 2008 and by HES in 2021 as a broad negative anomaly mirrored by a narrow positive one to the north (Figures 7.2.7 and 7.2.9). Though still on the same alignment, the Ditch is less clear in GSB's more limited area of resistance survey as a band of lower resistance partly bounded by areas of high resistance (Figures 7.2.8 and 7.2.11). It has been suggested elsewhere by one of us that the HES gradiometer survey suggests that there may have been a minor enclosure behind the Wall immediately to the west of the East Pond (Hannon 2021: 12; Hunter 2022: 407-08), but not all the authors are convinced of this. The dimensions of the feature are too square compared to the only excavated example of such enclosures (Figure 3.2.3) and it lacks the rounded corners so typical of Roman military work. Similarly spaced linear anomalies, precisely mirroring the form and alignment of those thought to define two sides of the enclosure, can be seen immediately to its west. These are particularly apparent in the GSB survey (Figure 7.2.7), but also in the HES survey in the south-eastern corner of the Meadows area (Figure 7.2.6), and are best interpreted as reflecting post-Roman agricultural activity.

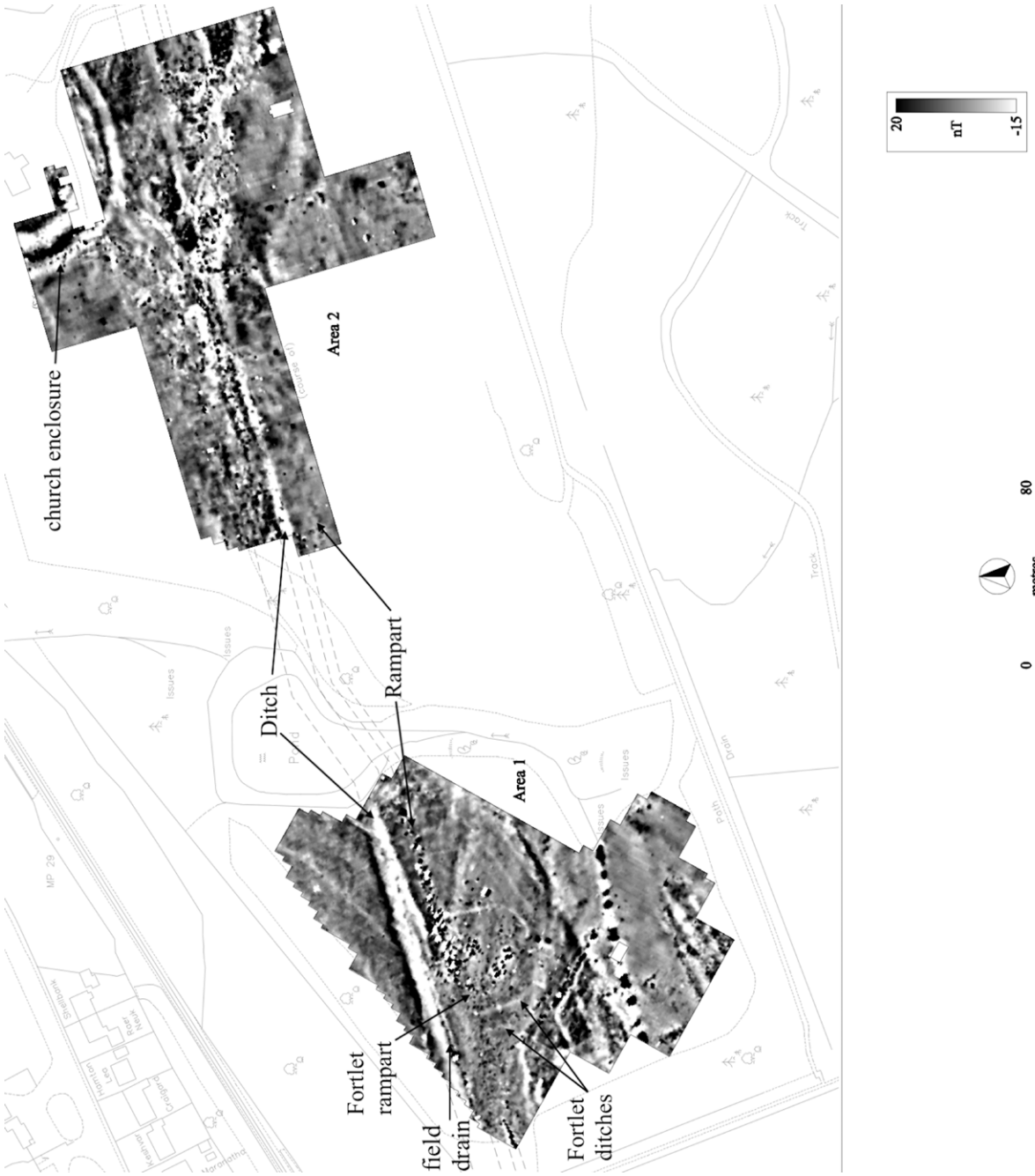

Figure 7.2.7. GSB gradiometer survey to the west of Kinneil House (after GSB 2008, Fig. 4 with additions).

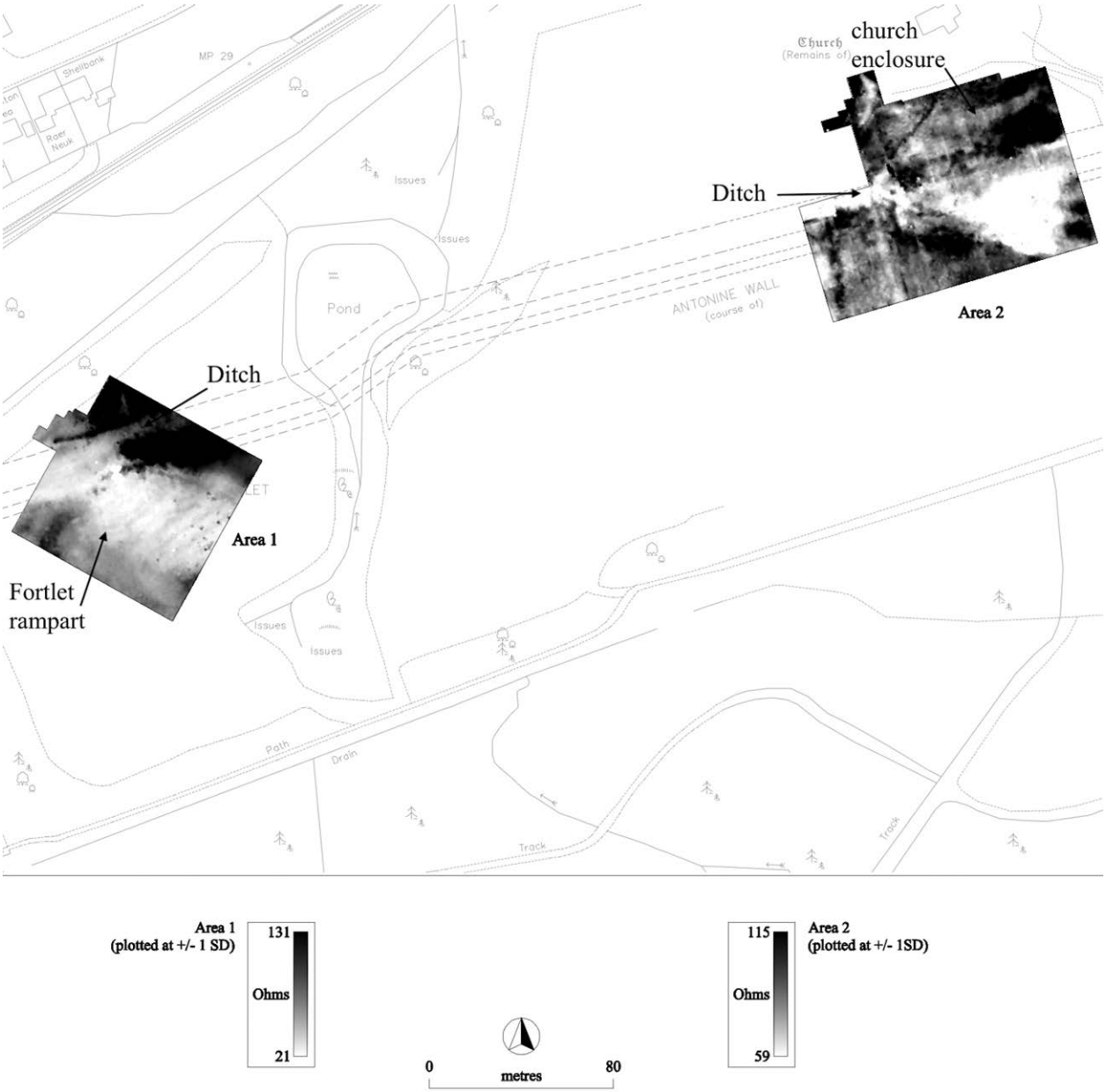

Figure 7.2.8. GSB resistance survey to the west of Kinneil House (after GSB 2008, Fig. 7 with additions).

Different claims have been made at different times about the character of the Ditch immediately in front of the fortlet. After the excavations of 1980, Bailey asserted that the Ditch here narrowed, primarily because the small trenches that located its southern edge indicated that the Berm widened at this point. He suggested that this was the result of there having been a causeway across the Ditch. After seeing the geophysical survey by GSB from 2008 (Figure 7.2.7), however, he recognised that the ditch actually got wider, particularly on the east side of the fortlet, so he now suggests that this relates to a possible halt in the construction process (Bailey 2021: 218-19). The detailed interpretation of the magnetic response from the Ditch is not straightforward. Firstly it appears to be wider in front of the east side of the fortlet and further to the east, almost as if it was diverging from the main line of the Ditch at this point, though this is not mirrored in the resistance survey, where the response from the relevant area is one of high resistance (Figures 7.2.8 and 7.2.11). Secondly, in the gradiometer survey the southern edges of the Ditch in the same area appear rather disjointed (Figure 7.2.9), suggesting that the apparent divergence may be linked to the differential impact of rig and furrow ploughing. Certainly the disjointed effects are on the same alignment as the furrows, recorded in the excavation, which had done so much damage to the southern half of the fortlet interior (Bailey and

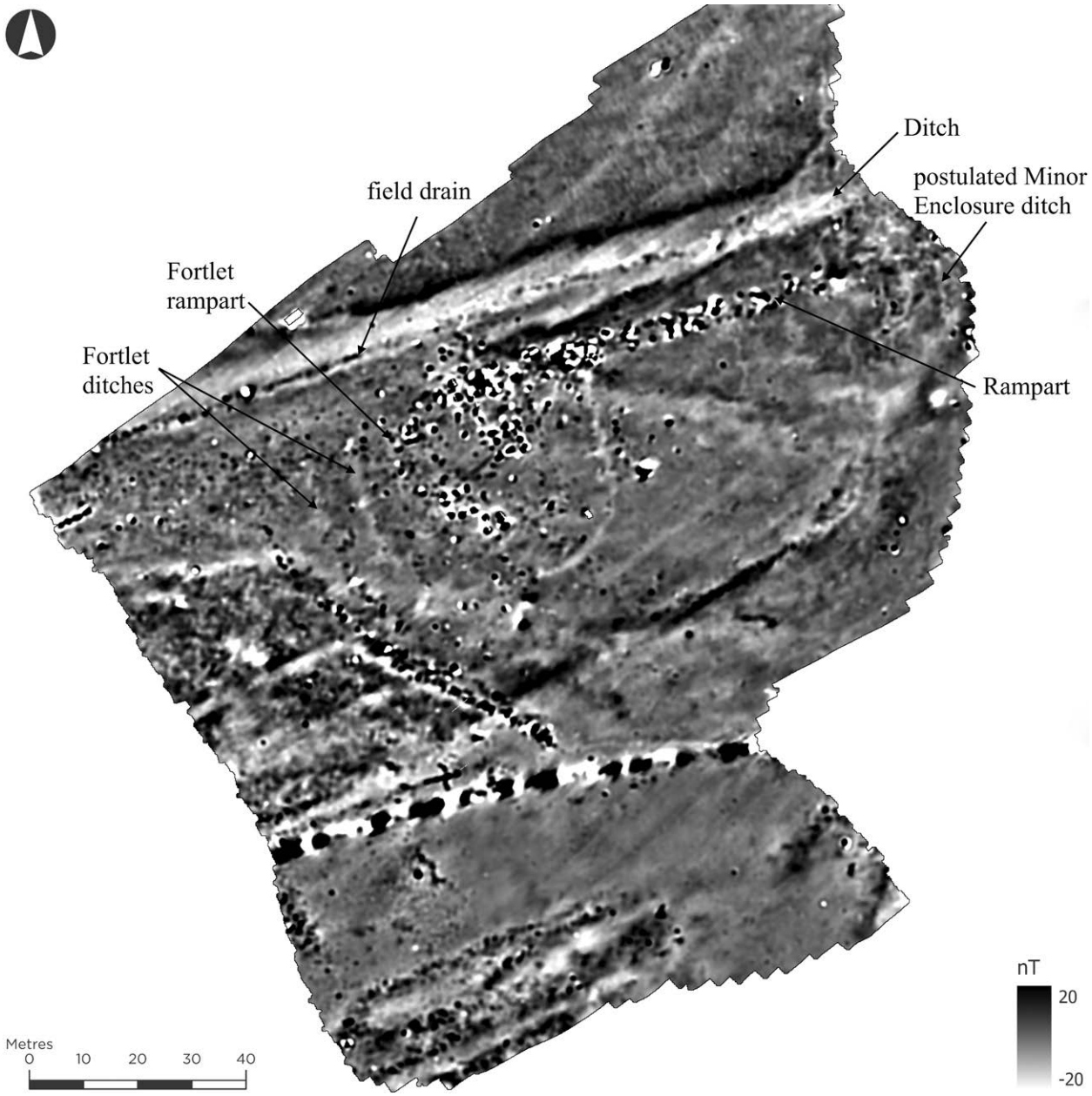

Figure 7.2.9. HES gradiometer survey of the fortlet and immediate surroundings at Kinneil.

Cannell 1996: Illus 3). Thirdly, there are indications of a much later feature, probably a field drain, revealed as a narrow positive linear anomaly cut into the fill of the Ditch. This anomaly is particularly apparent to the west of the fortlet in both gradiometer surveys, where it runs close to the southern edge of the Ditch, but may continue further east where the response is somewhat fainter. Further focused excavation would be required to clarify whether the digging of the Ditch was undertaken in phases or if there was ever a causeway across it, but neither gradiometer survey gives even the slightest indication of a break in the Ditch indicative of a causeway opposite the entrance to the fortlet. Furthermore, examination of both the aerial photographic and LiDAR images suggests that the Ditch bulges slightly to the north directly in front of the fortlet (Figures 7.2.3 and 7.2.10), rather in the way that it does at Seabegs Wood, suggesting that the fortlet's position had been determined and its construction begun before the precise line of the Wall and Ditch through the Estate had been finalised.

The line of the Rampart behind the Ditch is apparent as a mottled band of dipolar responses in both gradiometer surveys (Figures 7.2.7 and 7.2.9), as seen at other sites (e.g. Castlehill and Mumrills, Chapters 2.5 and 6.5), presumably reflecting differences in the cobbles that made up the base. The Rampart is visible from just past the East Pond and continues across most of the front of the fortlet, though it is masked to some extent by

Figure 7.2.10. Aerial photograph of the fortlet at Kinneil from the east showing the Ditch deviating northwards (© Historic Environment Scotland SC349456).

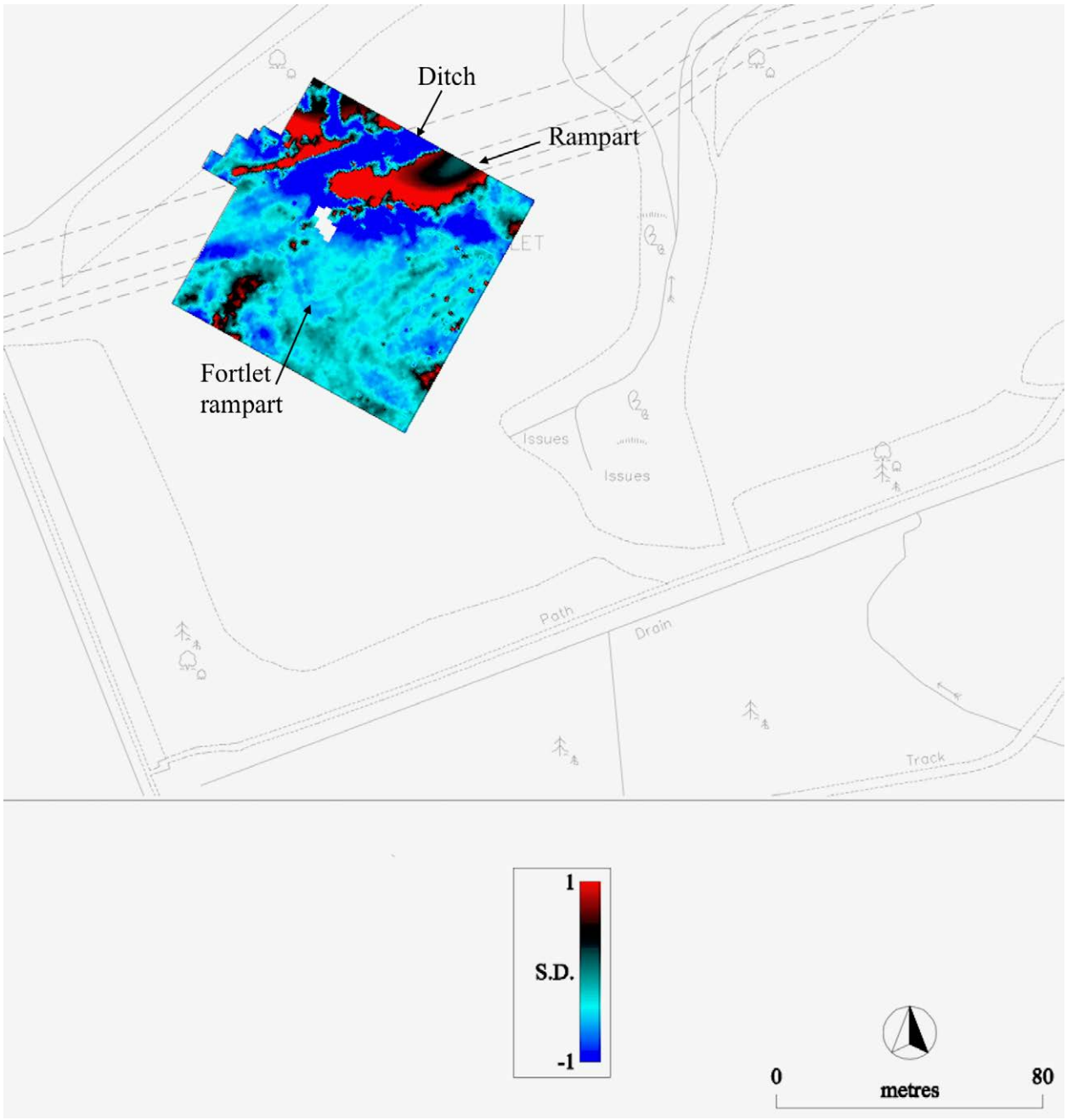

Figure 7.2.11. GSB filtered resistance survey of the fortlet (after GSB 2008, Fig. 8 with additions).

the strong dipolar signals of the exposed road surface, drains and timber gatepost-stubs restored in concrete. The same area in the resistance survey is dominated by a rather amorphous area of high resistance partly spreading over the Ditch, though the filtered results indicate a core of moderately high readings that broadly match the line of the Rampart (Figures 7.2.8 and 7.2.11). As the 1980-81 excavations suggested would probably be the case, the Rampart does not seem to have survived sufficiently to the west of the fortlet to provide a convincing response until the western limit of the gradiometer surveys, where a short narrow dipolar linear alignment may mark its southern edge.

The fortlet rampart is also picked out by strong positive or dipolar signals at its northern end and more partially where modern kerbstones have been laid for display to indicate its line. Individual restored post-stubs are similarly visible in the fortlet interior. Surprisingly, as no remains of the rampart were recorded in the southern half of the fortlet during excavation, its alignment can be seen very faintly in the resistance

survey as an irregular double line of low resistance continuing around the south-west corner (Figure 7.2.8). This is most clearly visible in the filtered data (Figure 7.2.11). Once again this may simply be a reflection of the subsequent work laying out the site for public display, where the presumed line of the inner and outer kerb was marked by intermittent concrete slabs.

The presence of a ditch curving around three sides of the fortlet is apparent as a narrow negative linear anomaly in both gradiometer surveys (Figures 7.2.7 and 7.2.9), but not at all in the resistance survey. It is particularly clear on the east side, but there is no obvious sign of the outer ditch that was recorded there in the first excavation in 1978-80. The very existence of a second, outer ditch has been contentious, as it was not seen in the second excavation in 1980-81. However, there seems no reason to doubt the original excavation results as they recorded its presence in two places some 3-4m beyond the inner ditch. That the remains were very slight - hardly more than 0.3m deep - may explain the subsequent failure to recognise it. Confidence that there was a second ditch on the east side is considerably boosted by the recognition of one in both gradiometer surveys on the west side, though located slightly further away (*c.* 6m). The narrow negative linear anomaly of this outer ditch is masked at its southern end by geological banding, so it is unclear whether it merges with, or continues alongside, the inner ditch as it curves around the south-west corner of the fortlet. However, there does appear to be a marked break in the inner ditch opposite the south gate, contrary to the implications of the report on the 1980-81 excavations, which failed to identify a causeway opposite the south gate.

7.3 Kinglass Park

(NGR: NT 0035 8114; NT 00320 81010; Canmore 49522)

Rampart, Military Way and temporary camp

Site-specific references

Macdonald 1925: 279-81; Feachem 1956: 333-35; GSB 2007b; R.H. Jones, 2011: 244; Bailey 2022

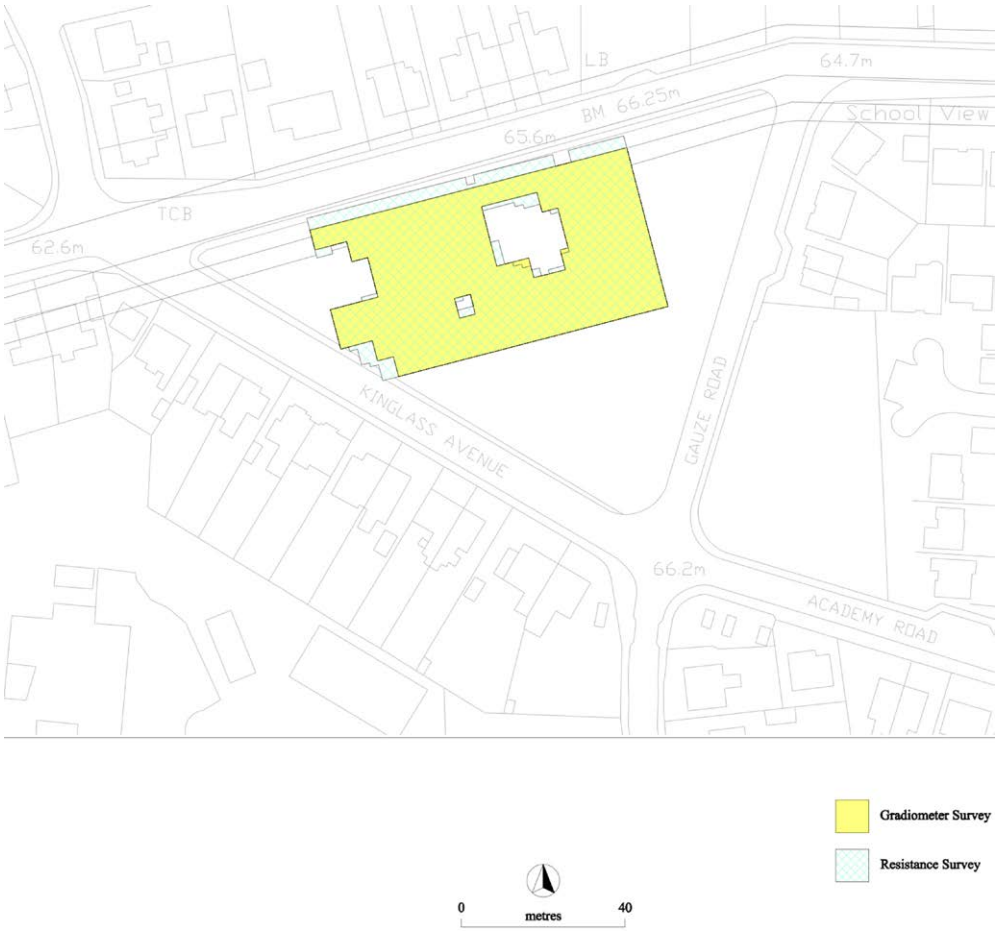

Figure 7.3.1. Location of GSB survey at Kinglass Park (after GSB 2007b, Fig. 2, with amendments).

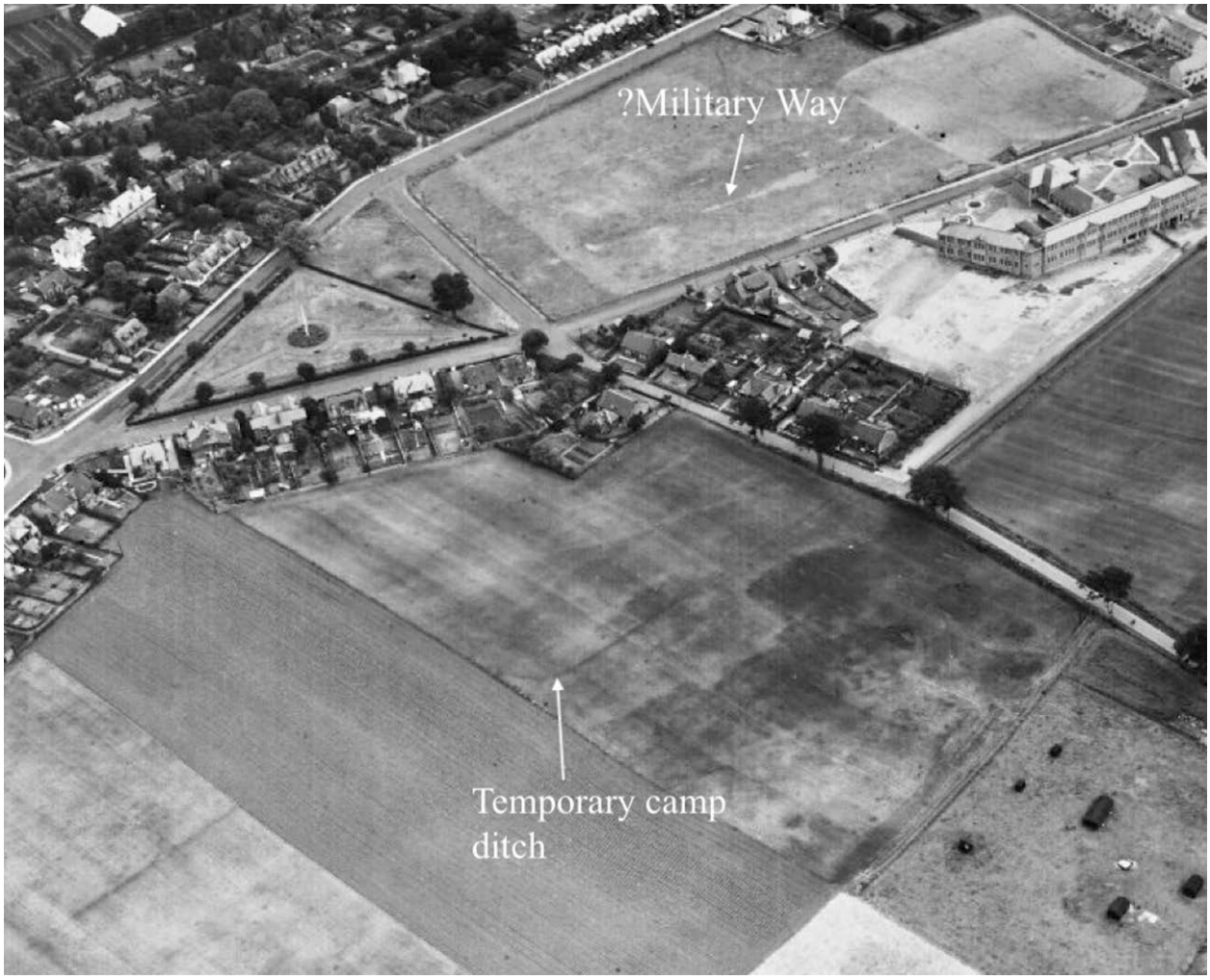

Figure 7.3.2. Aerial photograph from 1948 of the ditch on the south side and south-west corner of the camp at Kinglass from the south-west. The original triangle of Kinglass Park is visible (top left), showing that what now constitutes the eastern third of the Park has not yet been incorporated. What may be the line of the Military Way can be seen as a parchmark in the large field to the east of the Park (top right) (BD 55 Cambridge University Collection of Aerial Photography © copyright reserved).

Geophysical surveys (Figure 7.3.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
GSB; 2008	G: Bartington Grad 601-2	0.29	0.25, 1
	R: Geoscan RM15	0.30	1, 1
Edinburgh Archaeo-logical Field Society; 2022	R: TR/CIA	0.16	0.25, 0.25

Introduction

No extant remains of the Wall line are recorded in early Ordnance Survey mapping[2] immediately to the east of the Kinneil Estate (Chapter 7.2, above). Dean Road and its eastern continuation, Grahamsdyke Road, are generally presumed to follow the course of the Wall here,[3] the latter preserving the traditional name of the frontier as recorded in early historical accounts (Keppie 2012: 23). However, the line here was nowhere confirmed archaeologically until 1989 when excavation prior to the rebuilding of St Mary's Church, some 800m west of Kinglass Park, located a section of surviving Rampart base (Keppie *et al.* 1995: 606-10). More recently Bailey found what may possibly have been the northern lip of the Ditch only some 300m to the west of the park within the garden of a house on the south side of Dean Road (2021: 221-23). Thus, the line of the Rampart and Military Way, and possibly of the Ditch, would reasonably be expected to run across the northern

[2] A short stretch of bank identified on the 2nd edition Ordnance Survey mapping as a section of Wall to the north-east of Kinglass Park was dismissed by Macdonald as a natural feature.

[3] Macdonald assumed this was the Ditch line, though the Upcast Mound might be a more appropriate base for a road, as Bailey has variously noted (e.g. 2021: 223).

Figure 7.3.3. Gradiometer and resistance survey at Kinglass Park (after GSB 2007b, Fig. 3, with amendments).

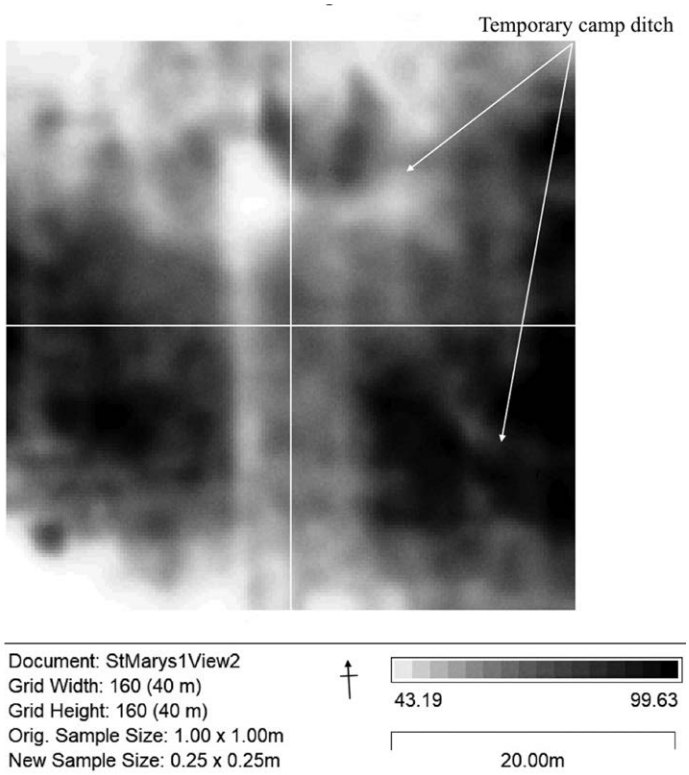

Figure 7.3.4. Edinburgh Archaeological Field Society resistance survey plot (after Bailey 2022, with amendments).

edge of Kinglass Park, which lies immediately south of Grahamsdyke Road.

Aerial survey by St Joseph in 1948 recorded the south side and south-west corner of a temporary camp visible as a cropmark in a field immediately to the south of Kinglass Avenue (Figure 7.3.2), an area now occupied by the playing field of St Mary's Primary School. The camp is generally accepted as one of the construction camps for the Wall (Jones 2005). Subsequent probing by Feachem traced the continuation of the ditch for most of the west side and identified its north-east corner. However, watching briefs ahead of house building on the presumed eastern side of the camp in 1998 and 2008 found only undisturbed ground. Limited excavation outside the postulated north-east corner of the camp was similarly unproductive. While these investigations have called into question Feachem's restoration of the dimensions and precise alignment of the camp, it remains likely that its north side would have extended across the southern end of Kinglass Park, unless it was one of the smallest such camps known.

Conditions for survey both in the Park and in the school playing fields were good since it was largely confined to the well-maintained grassed areas, though slightly constricted by dense shrubbery and a flagpole in the Park. The subsoil in the area is Carboniferous limestone, which is generally conducive to geophysical survey.

Results

Unfortunately nothing of archaeological significance was revealed in either the gradiometer or resistance survey of the Park area by GSB (Figure 7.3.3), other than the original layout of paths in the latter. The gradiometer survey was dominated by noise from ferrous materials associated either with features within the park or with 19th century industrial activity. Indeed, examination of the 1st and 2nd edition 25-inch Ordnance survey maps indicates that quarrying and coal/ironstone mining, the latter with its accompanying bing, had extended across almost the almost whole of the original area of the park, which was opened in 1910 (Falkirk, Sites and Monuments Record 1590). It is unfortunate that the survey did not focus more on the eastern third of the park that remained in farmland until much later, as the aerial photograph indicates (Figure 7.3.2). Nor did the survey extend sufficiently far south to pick up the postulated line of the northern ditch of the temporary camp.

The resistance survey by the Edinburgh Archaeological Field Society, located immediately to the south of the primary school, revealed the south-west corner of the camp. It was visible as a very faint, narrow curving line of low resistance (Figure 7.3.4), broadly confirming the line recorded in the aerial photographs.

7.4 Muirhouses Camp

(NGR: NT 0166 8067; Canmore 49524 and 49616)

Temporary camp and putative Wall line

Site-specific references

Rees 1998; Jones 2009; R.H. Jones 2011: 280-81

Geophysical surveys (Figure 7.5.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
Glasgow University; 2009	G: Geoscan FM36	0.72	1, 1

Introduction

Aerial survey by St Joseph in 1960 recorded a temporary camp in a field immediately to the north-west of the village of Muirhouses, some 900m west of the fort at Carriden. The ditches on three sides of the camp were visible as cropmarks and have been recorded similarly on a number of occasions thereafter (e.g. Figure 7.4.1). The southern side is likely to lie under the adjacent road, which detours slightly from a straight line as if to accommodate the ditch at that end of the camp. Thus, the area enclosed is quite small, almost 2.2ha, and the camp is generally assumed to be one of the construction camps for the Wall (Jones 2005).

A small circular cropmark was also noted just within the northern ditch of the camp. This was first identified as a ring ditch, probably representing the drainage gully around a later prehistoric round house rather than a burial. Indeed, there is aerial photographic evidence of an Iron Age settlement less than 150m away that on excavation produced some Roman pottery. It was suggested then that the ring ditch might have been a Roman signal station, though there was no sign of an internal tower, and it was later re-interpreted (in Canmore) as a possible souterrain because only a partial circle seemed to be represented.

The northern part of the camp and the immediate area to the north of it were surveyed as part of the programme of testing possible locations which might have been followed by the line of the Antonine Wall from Bo'ness to Carriden (see Chapter 7.5, below). The camp lies in an agricultural field that slopes down slightly to the north towards the now canalised Carriden Burn. There were no constraints to the survey as the field had

Figure 7.4.1. Aerial photograph of the ditch of the temporary camp at Muirhouses, visible on three sides, taken in July 1996 from the south-west. A probable later prehistoric ring ditch is visible by a pylon near the centre of the photograph (© Historic Environment Scotland SC 624718).

recently been ploughed. The geological context is the Limestone coal formation of sedimentary rock cycles with brown earth soils, which are generally conducive both to cropmark production and gradiometer survey.

Results (Figure 7.4.2)

The line of the northern ditch of the temporary camp is visible as a narrow negative anomaly, with an intermittent broader positive one to its north, running diagonally across the southern half of the survey area. There are indications of a gap in the ditch near the centre of the survey, presumably for a gateway, which corresponds well with the best available aerial photograph (Figure 7.4.1). Immediately to the south of the ditch is a very clear, slightly broader semi-circular negative anomaly, again with a positive anomaly mirroring it. This is clearly the ring-ditch identified from the air, though it no longer overlaps the camp as it appears to do in Figure 7.4.1 and some other earlier RCAHMS aerial photographs (e.g. Canmore SC 1731283 and 1731286 both taken in 1986). The most likely explanation for this apparent change, which stimulated the re-interpretation of the cropmark as a souterrain,

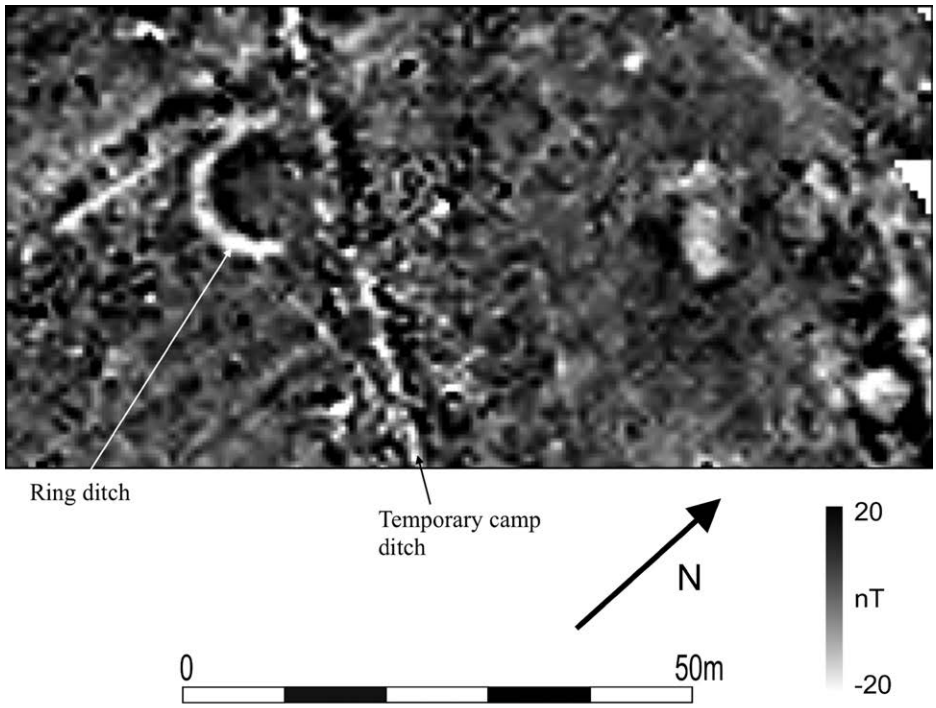

Figure 7.4.2. Gradiometer survey at Muirhouses camp.

is the differential impact of ongoing ploughing. The southern, upslope side of a circular house platform would necessarily have been dug deeper into the slope in order to provide a level surface in its interior and so would longer survive the destructive effect of ploughing. Extrapolating from the semi-circle recorded gives an internal diameter for the ring-ditch of *c.*14m, which would be not inappropriate for the diameter a large timber round house. By contrast, the remains lack the characteristics of a souterrain. These tend to taper more at one end and, though often curvilinear, are not so clearly semi-circular. No other internal features are recognisable.

At the north-eastern end of the survey area there are magnetic disturbances from a number of presumably modern features, but there is no sign of a linear feature which might correspond with the Antonine Wall Ditch. The implications of this are discussed further below (Chapter 7.5).

7.5 Kinningars Park and Carriden western environs

(NGR: NT 0134 8132; 0196 8072; 0221 8068; Canmore 49554 and 49520)

Eastern terminus of the Wall

Site-specific references

Macdonald 1925: 279-81; Keppie and Breeze 1981: 236; Bailey and Devereux 1987; *DES* 1994: 8; Jones *et al.* 2008b; Jones 2009; Hannon *et al.* 2017: 461-2

Geophysical surveys (Figure 7.5.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
Glasgow University; Kinningars Park; 2008	G: Geoscan FM36	0.40	1, 1
Glasgow University; Carriden Glen/Old Manse Wood; E of Muirhouses 2009	G: Geoscan FM36	0.60 0.60	1, 1 1, 1

Introduction

In terms of structural remains, the precise eastern terminus of the Wall remains unconfirmed archaeologically. It has long been located at Bridgeness *c.* 2km east of Bo'ness because of the discovery there in 1868 of the eponymous Bridgeness slab. This is the largest and most elaborate of the distance slabs from

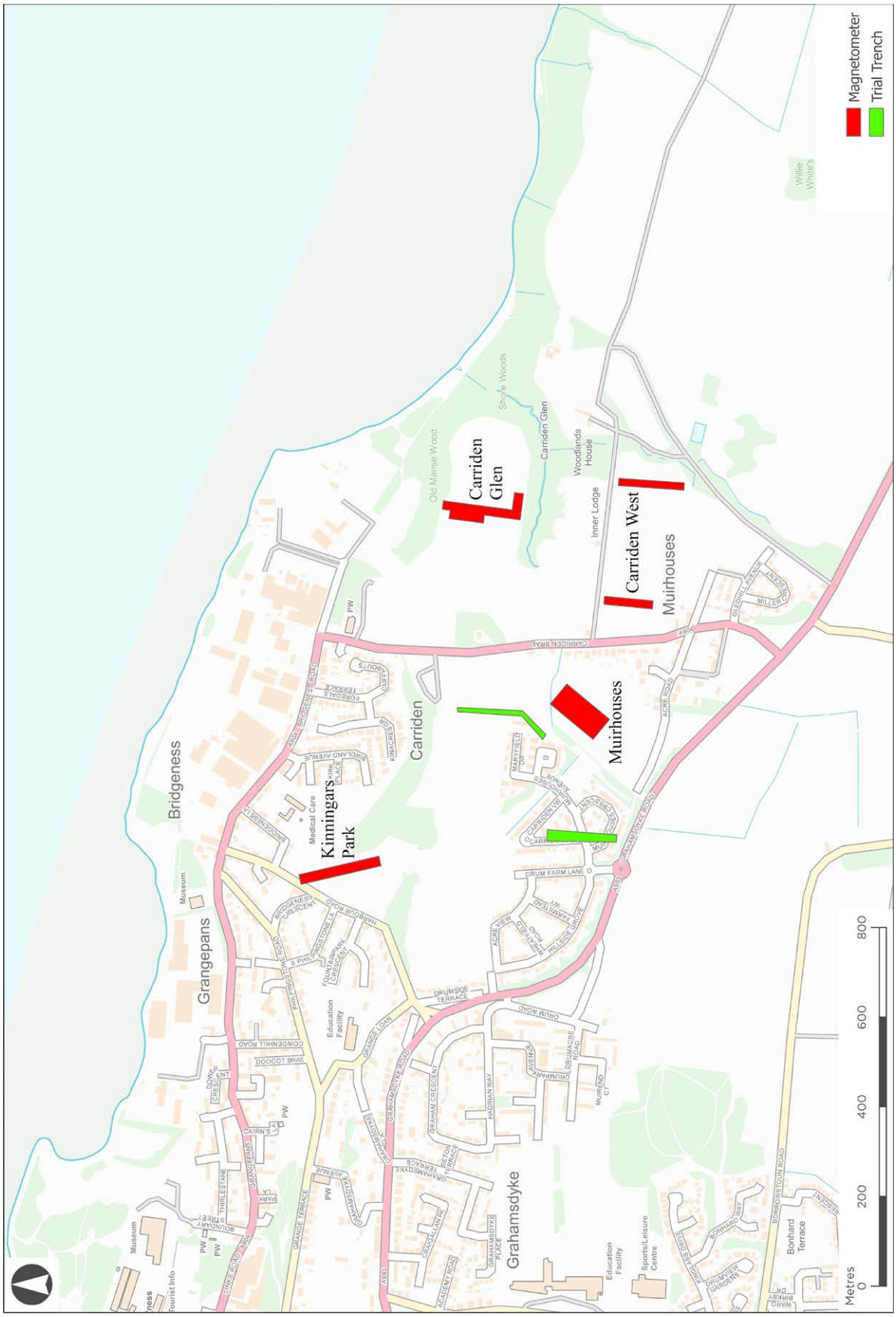

Figure 7.5.1. Location of the excavations and survey transects laid out to test the possible line of the Wall south and east of Bridgeness.

the Antonine Wall and records the building of 4652 paces by the Second Legion Augusta (*RIB I* 2139; *CSIR* 68). It was found face down within quite deep topsoil on a rocky promontory on the west side of Harbour Road, *c.* 100m from the contemporary shoreline and less than 6m above the level of the spring tide. Accordingly, it is widely accepted that it was probably buried close to the point where the line of the Wall descended to meet the Forth estuary.

However, limited excavations in the 1980s failed to confirm this. Keppie examined an area to the north of South Philpingstone Road in 1980 on the supposed line of the Wall proposed by Macdonald, who had recorded what he took to be the Ditch only some 150m to the west. Since he failed to find any trace, Keppie suggested that the Wall may have run along higher ground very slightly further to the south before turning north-east towards the Bridgeness promontory. In 1985 Bailey excavated four small trenches across the supposed Wall line on the west side of Harbour Road, two immediately adjacent to the place where the Bridgeness slab had been found and two further south along the promontory, but again did not discover any Roman remains.

The failure to identify any trace of the Wall at Bridgeness has stimulated the resurrection of a view held by some early antiquaries (e.g. Sibbald 1707: 30-1; Gordon 1726: 60; Horsley 1732: 159-60, 173 and map) that it may have continued on its more inland route as far as the fort at Carriden (Chapter 7.6, below) or even beyond. In order to test this hypothesis, Bailey excavated two long transects in open farmland in advance of housing development to the south and west of Drum Farm in 1990s. These were designed to intersect alternative routes that the Wall might have followed from Grahamsdyke Road towards Carriden, though neither produced any evidence to that effect.

In order to investigate other possible routes, several gradiometer survey transects were undertaken in 2006 and 2008 particularly seeking to pick up the line of the Ditch, as this is consistently the most readily identifiable feature in geophysical surveys of the Wall. The first transect was located in Kinningars Park whose northern edge lies less than 80m south of the location of the Bridgeness slab discovery - indeed, the western side of the park was subsequently deemed the most appropriate position for a full-scale replica of the slab to be erected. The transect was set out in gently sloping grassed parkland, carefully positioned to avoid the disused reservoirs at the south end of the park and a mine shaft to the east. A second transect was located in a steeply sloping cultivated field between Carriden Glen

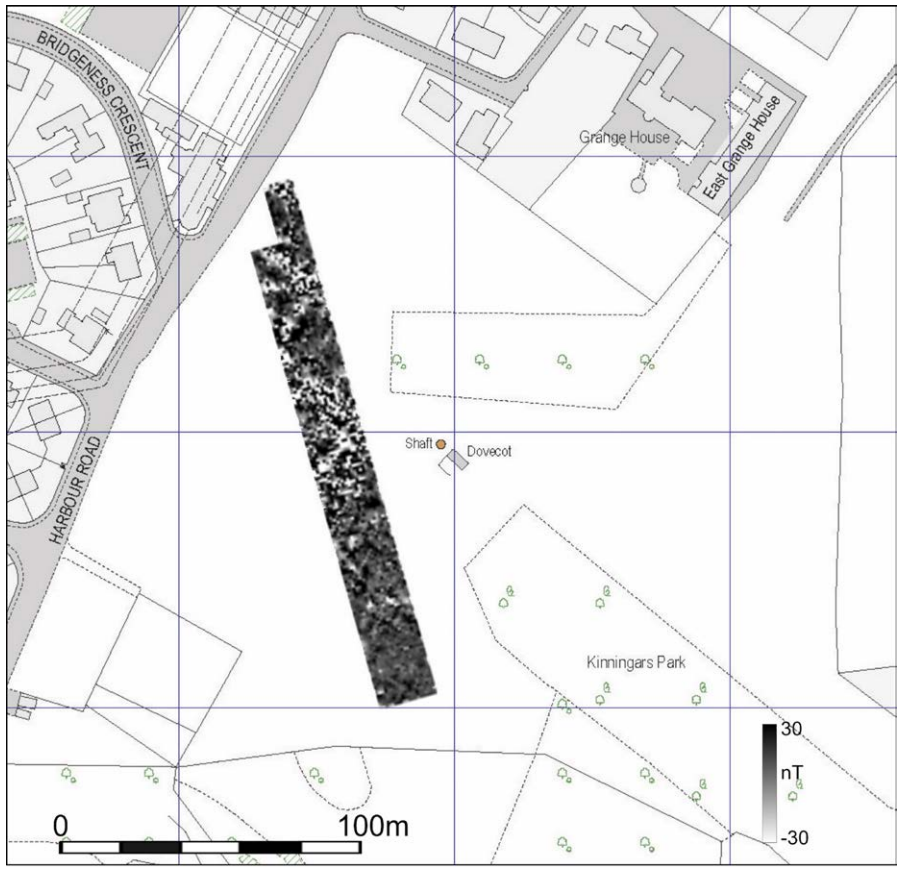

Figure 7.5.2. Gradiometer survey transect across Kinningars Park.

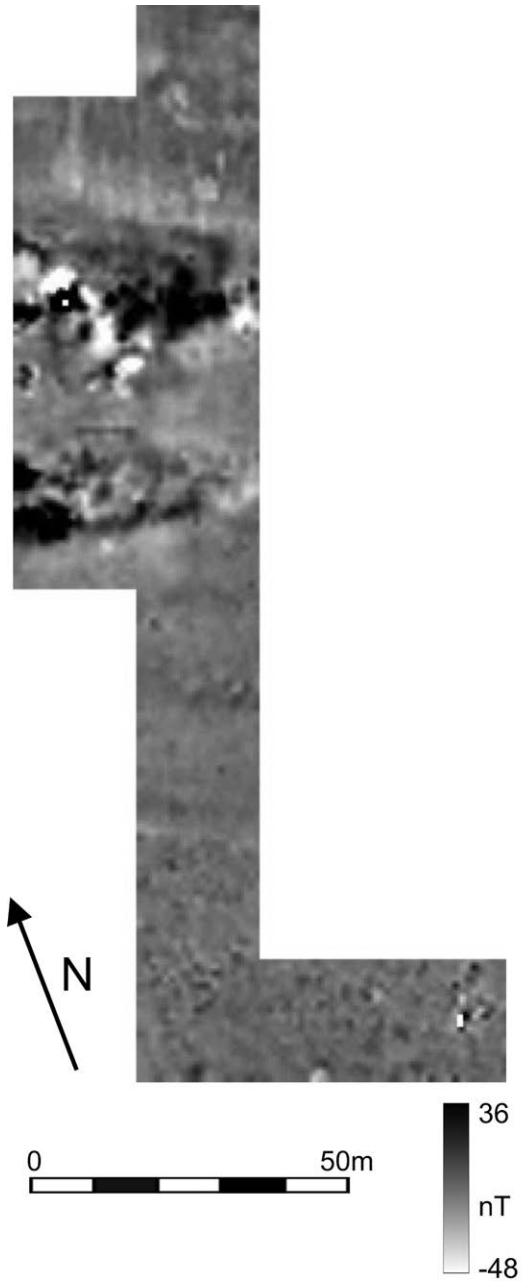

Figure 7.5.3. Gradiometer survey transect between Carriden Glen and Old Manse Wood.

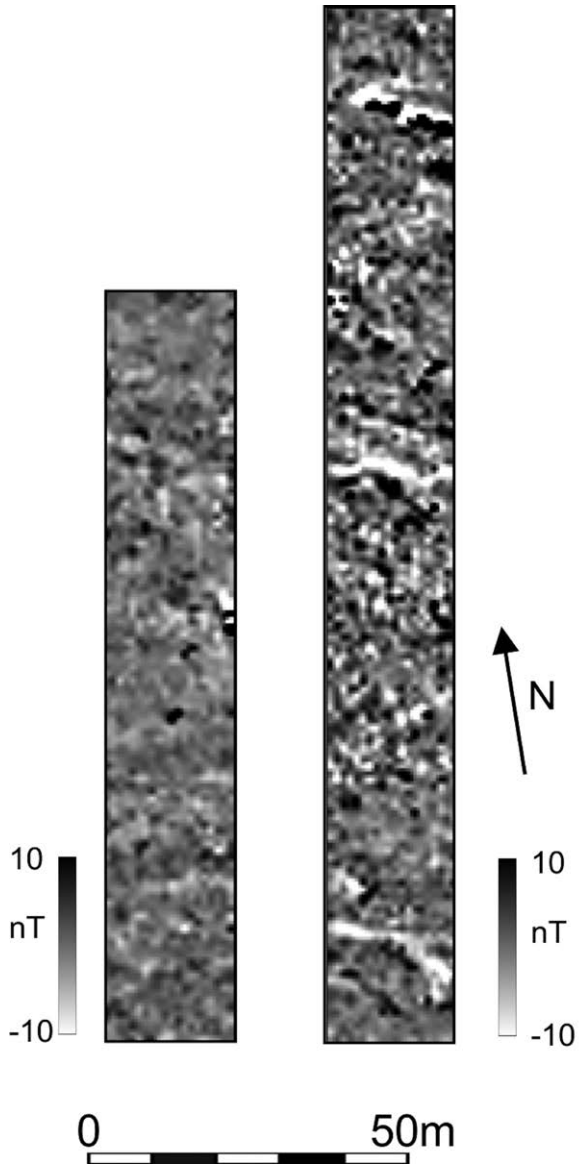

Figure 7.5.4. Gradiometer survey transects north-east of Muirhouses.

and Old Manse Wood, which was in stubble at time of the survey. Three more transects addressed the possibility of a more southerly route following the slightly higher ground through Muirhouses, one to the north-west (see Chapter 7.4, above) and two immediately to north-east of the village, the latter located in a slightly sloping field in permanent pasture.

The general area covered by these surveys lies within the Limestone coal formation of sedimentary rock cycles with brown earth soils, which are conducive to gradiometer survey. It had been intensively cultivated up to the mid-19th century, hence the removal of all visible trace of the Wall east of Kinneil by the time of the 1st edition 25-inch Ordnance Survey mapping in 1855. Later that century and thereafter the area was effected by increasing levels of mining, quarrying, housing and industrial development, the latter two focused on the coast between Bo'ness and Bridgeness.

Results

While there are magnetically noisy bands running in step-wise fashion across much of the survey area in Kinningars Park (Figure 7.5.2), which are reminiscent of metalled pathways and presumably reflect relatively recent activity, there is clearly no sign of the Antonine Wall Ditch. There is some magnetic disturbance in

Table 7.5.1 Discovery locations of distance slabs in relation to the Wall

Provenance	RIB/CSIR number	Context of discovery in relation to Wall	Reference
Bridgeness	*RIB I* 2139	lying face down within deep topsoil	Bailey and Devereux 1987: 96-7
Unknown	*RIB I* 2173	dug up in the ruins of the Wall	Keppie 1998: 72-3
Eastermains	*RIB I* 2185	in or near the Wall	Keppie 1998: 74-5
Eastermains	*RIB I* 2184	lying face down, *c.* 1m below the surface, in the centre of the Ditch	Keppie 1998: 75-6
Summerston	*RIB I* 2193	from digging up stones from the Wall base[4]	Macdonald 1934: 375 *contra* Campbell 2020: 68 and Table 1
East Millichen	*RIB I* 2194	from digging a deep drain *c.* 90m from the Wall	Macdonald 1934: 376-7; Campbell 2020: 69
Castlehill	*RIB I* 2197	on its edge in stiff clay, *c.* 1m below the surface, on the S lip of the ditch	Macdonald 1934: 381-3; Keppie 1998: 79; OS 25-inch, 2nd edn Dunbartonshire, sheet XXIII.II[5]
Hutcheson Hill	*RIB I* 2198	lying face down, *c.* 1m below the surface, in stiff 'till' on the southern slope (of Hutcheson Hill)	Keppie 1998: 80-81; Campbell 2020: 71
Hutcheson Hill	*RIB III* 3507	*c.* 3m south of the Wall lying face down in a shallow pit	Keppie 1998: 81-2
Braidfield	*RIB I* 2200	near the Wall on Braidfield Farm	Keppie 1998: 83-4
Ferrydyke (Old Kilpatrick)	*RIB I* 2208	dug out of the Wall	Keppie 1998: 87-9
Arniebog	*CSIR* 84	lying face down, *c.* 0.3m below the surface, some 30m from the line of the Wall	Keppie 1998: 89-90

northern half of the Carriden Glen/Old Manse Wood transect (Figure 7.5.3), but this appears to be geological and is perhaps linked to coal or related workings. Once again there are no features that could be interpreted as the Antonine Wall Ditch. The shorter of the survey transects north-east of Muirhouses, although quite noisy magnetically, reveals no coherent features (Figure 7.5.4). Finally, though there is a strong, almost dipolar, narrow linear anomaly at the northern end of the longer transect north-east of Muirhouses, which must represent some modern disturbance, yet again there is no sign of the Antonine Wall Ditch.

Despite the extensive coverage by both excavation and gradiometer survey transects of the hypothetical alternative lines that the Antonine Wall might have followed from Grahamsdyke Road to Carriden (Figure 7.5.1), no supportive evidence has been forthcoming. Neither can this hypothesis be supported by reference to the LiDAR data (Hannon 2018: 244-9) nor from aerial survey.[6] Closer investigation of the antiquarian accounts makes clear that there were no remains of the Wall visible beyond Bridgeness in the 18th century. Though Gordon believed the Wall had continued as far as Carriden, because of the evidence for a fort there, he notes that there was no trace of it on the ground to the east of Grange House in Bridgeness (1726: 60), which was located just to the west of the present Grange Primary School. Similarly, Horsley notes the absence of evidence beyond Grange House of the Ditch, which 'is everywhere else the most visible part of the work, and always appears where anything is visible', before somewhat reluctantly agreeing with Gordon (Horsley 1732: 159-60); while the Grange also represents the most easterly extent of the Wall recorded by Roy (1793: Fig. 35). In his account of his walk along the Wall over 40 years before the discovery of the famous distance slab, Skinner sketches the Wall apparently heading towards Bridgeness and refers to it as probably curving down to the coast thereabouts (Keppie 2003: 207-09).

[4] The brief accounts provided by Wodrow and Horsley, quoted by Macdonald (1934: 375), refer to stones being collected from a considerable length of the monument for use in the construction of a park wall. The description of the remains as a "foundation of stone" clearly refers to the base of the Wall, not to the Military Way from which only the kerb stones would have readily served for re-use in walling (*contra* Campbell 2020: 68).

[5] The 1st edition Ordnance Survey mapping, which was undertaken only 14 years after the discovery of the slab, places it on the southern lip of the Ditch some 120m due west of the fort, the line of whose western ditches were not mapped until the 2nd edition. There is no reason to dispute the location indicated in this almost contemporary record of the find-spot (*contra* Campbell 2020: 69).

[6] Hannon drew attention to a series of RAF low-level oblique aerial photographs from 1971 that show a possible dark linear feature in the fields to the north and east of Drum Farm, but the feature is unconvincing as the line of the Wall. No other aerial photographic evidence has ever been recovered in the relevant fields, which are quite conducive to the formation of cropmarks.

The Bridgeness distance slab still provides the only positive indicator of the eastern terminus of the Wall. The topographic position of the line that it implies is entirely appropriate, allowing the Wall to continue along a natural promontory in order to descend more gradually to the coast from the *c.* 50m contour that it had been broadly following up to that point. Given the combination of intensive agriculture and occupation from the medieval period onwards in the immediate vicinity, it is not surprising that traces of the Rampart have not survived, while the Ditch would more sensibly have been positioned beyond the north-western side of the promontory just inside the line of Philpingstone Road. A similar separation of Rampart and Ditch dictated by topography is attested in front of the fortlet at Croy Hill (e.g. Figure 4.5.2).

Nor does the suggestion by Bailey and Devereux that the inscription was not in its original position seem justified. The excellent preservation of many of the slabs, including Bridgeness itself, attests to their protection from the elements on the abandonment of the Wall by deliberate burial, often face down. This is confirmed in several cases where the circumstances of discovery are known in more detail (Table 7.5.1), the slabs having come to light as a result of ploughing or agricultural improvement. What is also clear from the same data is that all these slabs were found close to the Wall, the furthest away being only *c.* 90m distant. After their discovery some of the slabs were moved much further from the Wall, but these were all re-used in another structure or curated in recognition of their historical significance (e.g. Carleith, Chapter 2.1, above). In no case is there a parallel for a slab being moved considerably more than 1km and then reburied, as Bailey and Devereux suggest was the case with the Bridgeness slab, let alone buried in conditions similar to those recorded for several other distance slabs. It surely stretches coincidence too far that such a postulated reburial should also bring the slab back to a location only some 500m from the Grange, the most easterly surviving section of the Wall recorded in antiquarian accounts. Thus, Bridgeness must remain the most likely location for the eastern terminus of the Wall.

7.6 Carriden

(NGR: NT 0255 8078; Canmore 49589)

Fort, annexes and environs

Site-specific references

St Joseph 1949; Richmond and Steer 1957; Keppie *et al.* 1995: 602-06; Bailey 1997; 2021: 75-6 and 167-209; Jones *et al.* 2008b

Geophysical surveys (Figure 7.6.1)

Operator; date	Method and instrument	Area (ha)	Spatial resolution (m)
Glasgow University; 2007, 2008	G: Bartington Grad 601-1, 601-2	*c.* 12.2 (Area A), 0.32 (B), 0.5 (C), 0.24 (D), 0.24 (E)	0.125, 1
	R: Geoscan RM15	0.76 (A), 0.24 (D), 0.24 (E)	0.5, 1
	MS	1.76	5, 5

Introduction

The fort at Carriden is not attached to the line of the Antonine Wall, but located some 1.3km south-east of its probable terminus at Bridgeness. It sits on level ground beside a steep scarp down to the southern shore of the Firth of Forth to the north and the Carriden Burn to the west. There is a long antiquarian tradition of a Roman fort here, based on the discovery of inscriptions, coins and pottery (Sibbald 1707: 301; Gordon 1726: 60), all long since lost (e.g. *RIB I* 2138). The precise location of the fort was not confirmed until 1945 when triple ditches with an entrance gap, assumed to represent its east side, were revealed from the air as cropmarks in the field immediately to the east of the grounds of Carriden house. An Antonine date was confirmed by limited trial trenching, though this failed to reveal any traces of internal buildings.

Subsequent aerial photography over several years indicated that the ditches may have continued almost to the end of the scarp and that a road ran through the interior at a slightly oblique angle to the defences. It also revealed a system of small, rectilinear, ditch-defined enclosures extending for over 350m alongside the eastward continuation of the road outside the fort (e.g. Figure 7.6.2). This field system was separated from the eastern ditches of the fort by a large open space, tentatively identified as the site of a parade ground. An altar ploughed up near its north-eastern corner in 1956, its location incorrectly plotted until recently (Hanson 2020a: 332-333), not only confirms the Roman name of the fort (Velunias or Veluniate), but indicates the presence of an associated civilian settlement, to which the field system presumably relates (*RIB III* 3503) (Figure 7.6.3). Sample excavation ahead of the erection of several telegraph poles across the field system revealed highly truncated ditches and recovered a number of sherds of pottery, one certainly and nine possibly of Roman date.

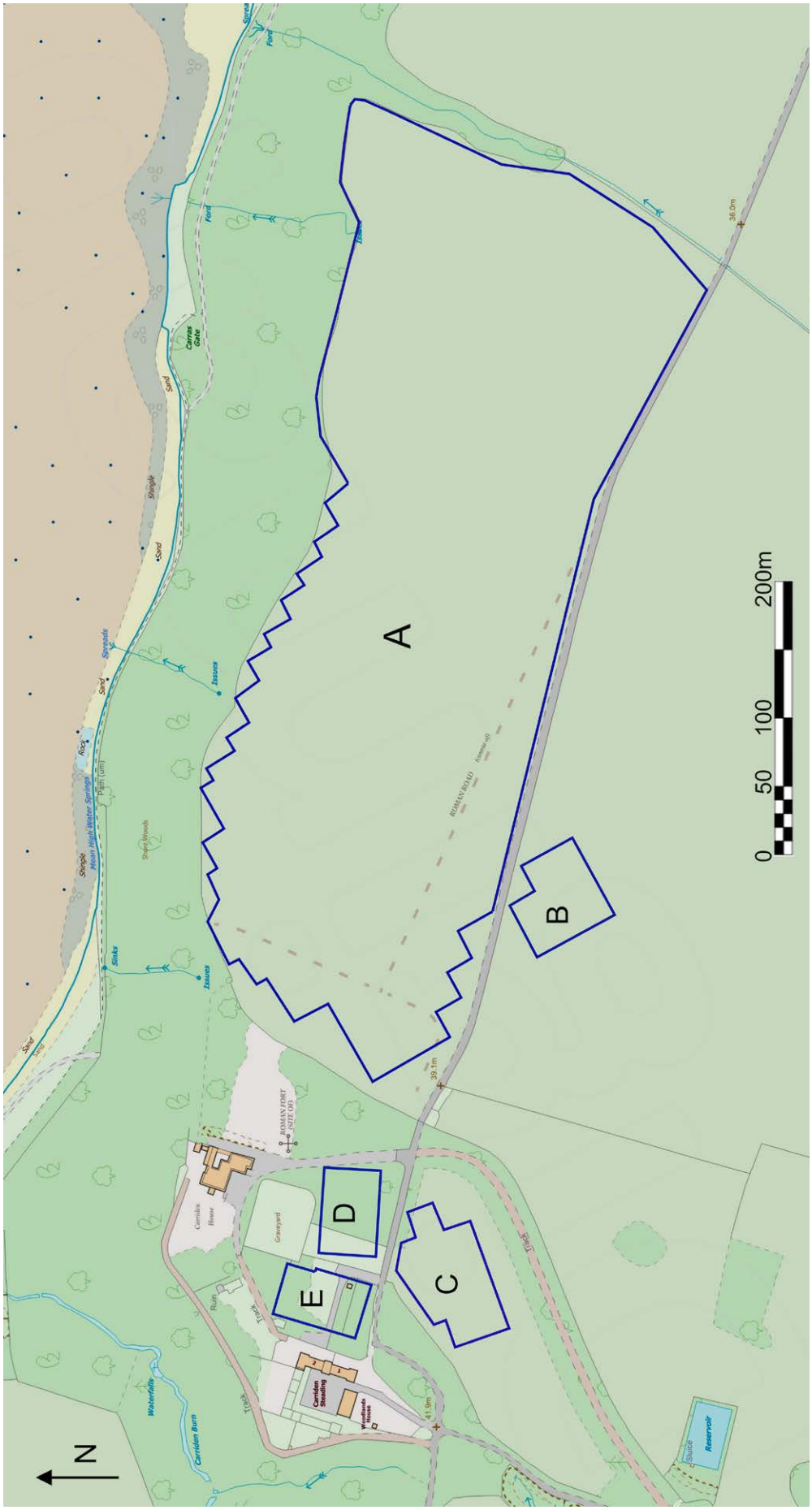

Figure 7.6.1. Plan of surveyed areas at Carriden.

Figure 7.6.2. Aerial photograph taken in 1977 of the eastern ditches of the fort/annexe, possible parade ground and field system to the east of the fort at Carriden, view from the south.

Small-scale excavation by Bailey within the grounds of Carriden House over several years between 1994 and 2009 recorded ditches on the south and west sides of the fort (double and single respectively), the former with a possible entrance gap and slight irregularities in alignment. He also identified a bathhouse situated at the end of the plateau outside the south-west corner of the fort overlooking the Carriden Burn. For a variety of reasons, notably the southerly position of the entrance gap and the oblique orientation of the internal road, he suggested that the triple ditches originally recorded from the air actually defined the east side of an attached annexe (Figure 7.6.3). Though regular fieldwalking across this eastern annexe generated second century pottery, he noted that the quantities involved were rather less than from the area of the fort at Mumrills that is under the plough, suggesting that a lower level of activity was indicated. Bailey also confirmed the line of a second smaller annexe to the south of the fort which had been identified in the geophysical survey (below), indicating some phasing in its use, and locating both an entrance and the line of the road leading to the south gate.

No trace of the fort or any of its associated features remain visible above ground. The fort itself, along with sections of both the southern and eastern annexes, are overlain by the landscaped grounds of Carriden House and its associated structures. These include a graveyard and the site of a church, the latter first recorded in the first half of the 12th century. These various remains both testify to the long history of occupation on the site and constrain access for survey. However, part of the southern annexe and a large part of the eastern annexe remain in open fields, along with the putative parade ground and field system, but all have been ploughed completely flat. The area continues to be intensively cultivated and the remains on the east side of the fort can still be seen as cropmarks when conditions are suitable (e.g. Figure 7.6.2).

Conditions for geophysical survey across much of the eastern annexe and the area outside it were extremely good, the ground being largely level and free from obstructions (Figure 7.6.1). Thus, Area A represented a single large agricultural field, which was surveyed after harvest, while Area B was a much more limited sample from a similar field, in pasture at the time, to the south of the farm access road. Area C lay within a pasture field, but Areas D and E were flat grassy areas within the landscaped gardens around Carriden House and so survey was constrained by both hedge lines and trees. Geological conditions presented no difficulties, with

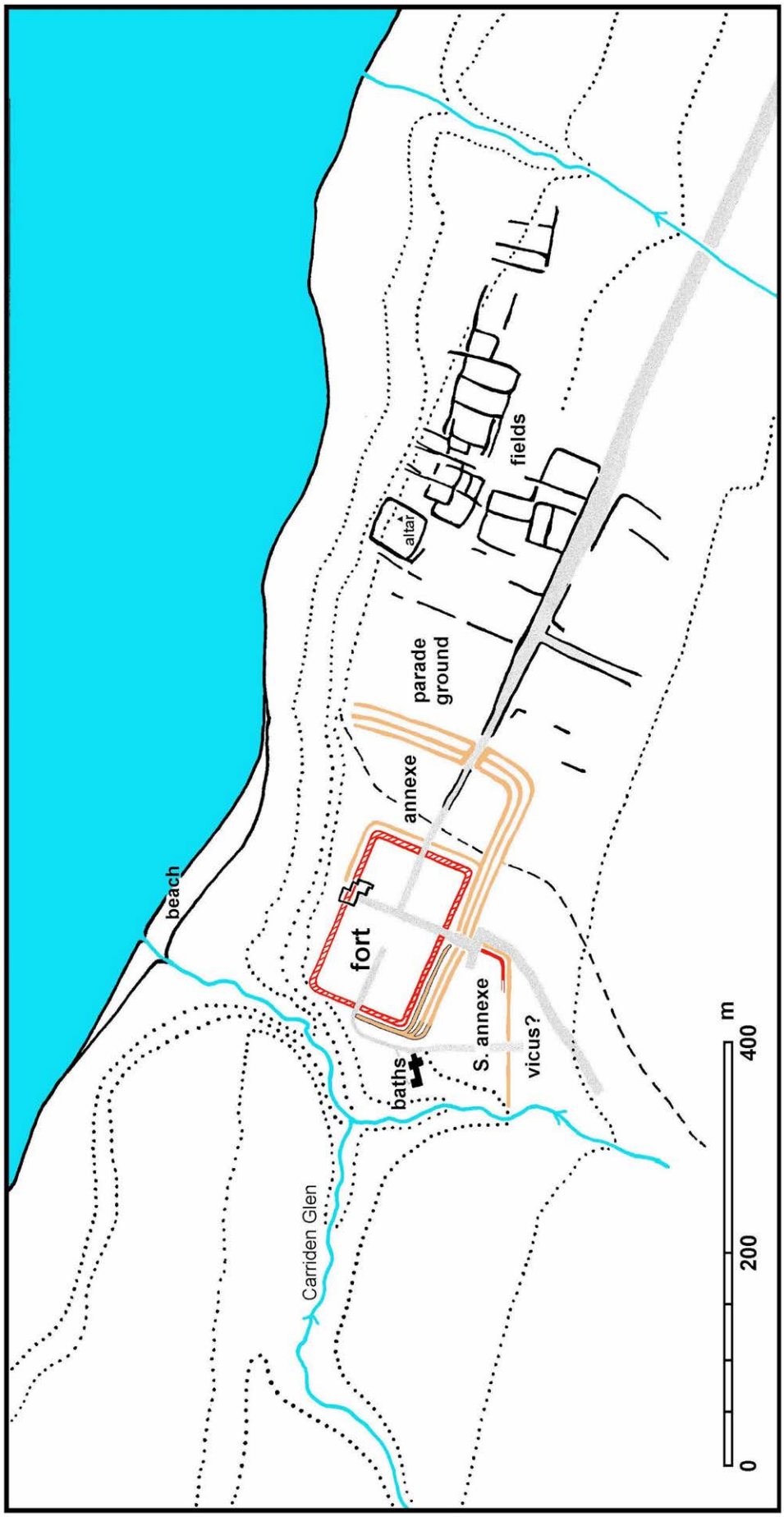

Figure 7.6.3. Bailey's suggested layout of the fort, annexes, parade ground and field systems at Carriden (after Bailey 2021, Illus 1.38, © G. Bailey). The altar is depicted in its original, uncorrected, location.

brown soils above glacial sands, gravels and boulder clay, overlying Carboniferous limestone.

Results

At the west end of the Area A the three parallel ditches enclosing what is now seen as the eastern annexe of the fort are clearly apparent in the gradiometer survey as negative linear anomalies, mirrored in places by narrower positive ones (Figure 7.6.4). They are also visible in the limited area of resistance survey as bands of low resistance (not illustrated). The gradiometer survey confirms the evidence provided by the aerial photographs, but adds or reinforces important detail. Most significantly, the northern ends of the two inner annexe ditches can be seen to extend to the limit of the survey, curving very slightly to the west as they approach the edge of the scarp, suggesting that they may originally have terminated at that point. Their depiction in this section is less sharply defined than elsewhere and seems to coincide with an area of the field that has been subject to more intensive modern drainage and, according to the 1st edition Ordnance Survey 25-inch mapping, had been separated off from the remainder of the field by an east-west field boundary. The character of the subsoil also seems to change, which may have had some negative impact on the clarity of the magnetic signal. The outer ditch, however, seems to terminate rather abruptly some 30m earlier (*contra* Figure 7.6.3), a feature that may be supported by some aerial photographs (e.g. Canmore SC1731378 and 1890084).

The three annexe ditches are conjoined on either side of the entrance gap, a characteristic hinted at, but much less clearly depicted, in the aerial photographs. However, these connecting ditches run at right angles to the line of the defences and not obliquely as suggested by the aerial photographs and in Bailey's reconstructed plan (Figure 7.6.3). Similarly, the line of the road within the annexe, defined on its north side by a ditch, visible as a negative linear anomaly of varying width, also seems to run at right angles to the defences. Though this observation contradicts one of Bailey's reasons for identifying the eastern ditches as those of an annexe, in other respects the gradiometer survey provides strong support for his argument. Confirmation that the ditches continued to the northern edge of the scarp leaves little or no room for them to curve around the north-east corner of a putative larger fort and further emphasises that the attested eastern gateway would have been positioned too far to the south to fit the normal tripartite internal arrangements of an auxiliary fort. The gradiometer survey also provides hints of other activity in the interior of the annexe. There are various linear alignments, though no clear patterns indicative of structures, with the possible exception of one small rectangular feature some 8m by 12m in size defined by positive linear anomalies positioned approximately midway between the road and the northern limit of the survey (Figure 7.6.4). Although the values varied widely, an enhanced magnetic susceptibility response suggests a focus of anthropogenic activity in and around the gateway (Figure 7.6.5).

Gradiometer survey within the grounds of Carriden House (Areas D and E) revealed that the line of the southern ditches of the annexe was continued to the west, where they are visible as much fainter negative linear anomalies sometimes mirrored by slight positive ones (Figure 7.6.6). Two ditches are visible running across Area D, with hints of a third at the south-eastern limit of the survey area. The innermost ditch continues clearly into Area E, where the second ditch is largely masked by the speckled positive signal from a modern cinder path, while the line of the outer ditch is somewhat fainter. Only two of these ditches were identified in Bailey's limited trenching. The gradiometer survey confirms that there was a break in the middle and probably the outer ditches in the centre of Area D, presumably indicating the position of the south gate. Unfortunately, this cannot be corroborated with the same confidence for the inner ditch as the position there coincides with a point where a later double positive linear alignment of uncertain origin crosses it obliquely. There are no clear patterns of activity indicated within the fort, though a slightly speckled, intermittent linear anomaly running parallel with the ditches and some 10-12m inside them may represent the line of the intervallum road.

Further to the south, gradiometer survey in Area C revealed the line of an L-shaped ditch, visible as a narrow negative linear anomaly partly mirrored by a positive one, running away from fort to the south before curving to the west. That this was the ditch of a small annexe was confirmed later in excavation by Bailey (above), who demonstrated that the magnetic signal actually encapsulated two closely parallel ditches. He locates these on the east side of the fort entrance, which would mean that the road from the south gate led directly into the annexe. However, the geophysical survey clearly indicates that the annexe ditch runs from the west side of the entrance gap apparent in Area D, so that the south gate of the fort would have opened directly to the outside world rather than into the annexe. Indeed, the broad speckled anomaly located to the east of the annexe ditch, truncated by the strong L-shaped dipolar signal from a modern pipe, would seem to represent the cobbled surface of the road leading out from the south gate of the fort. Again this was confirmed by excavation (above) just outside the south-east corner of the annexe. Excavation also indicated that the narrow negative linear anomaly running parallel with the modern

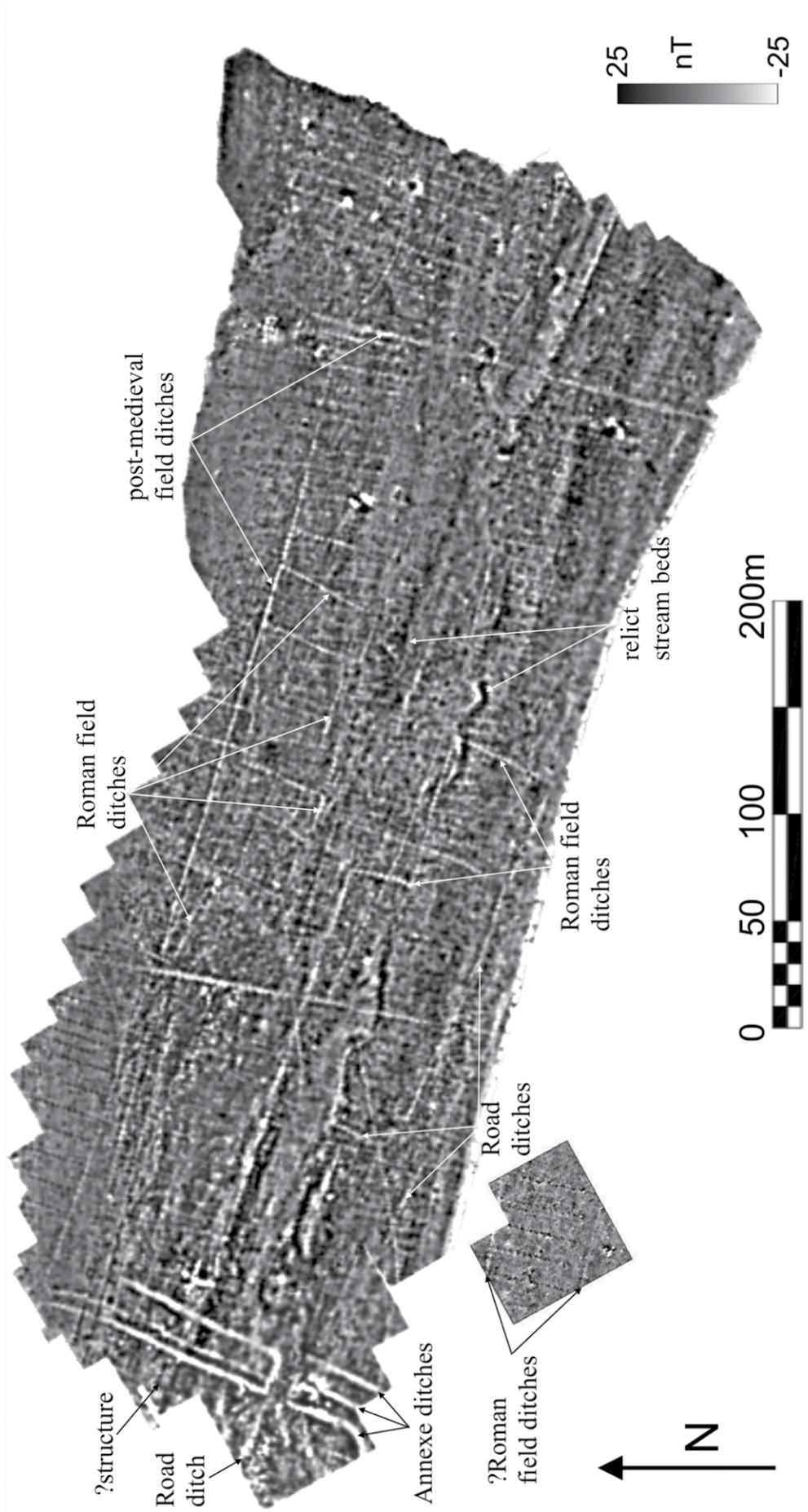

Figure 7.6.4. Gradiometer survey of East field (Areas A and B) at Carriden.

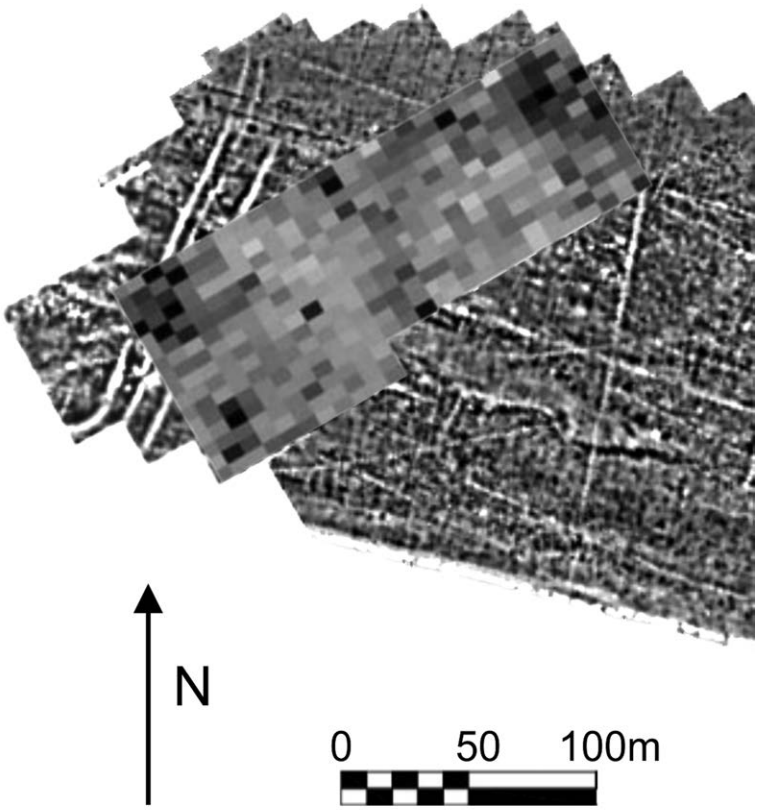

Figure 7.6.5. Magnetic susceptibility survey overlain over the gradiometer survey in Area A at Carriden, showing high (dark) and low (light) ms values.

trackway and crossing the east side of the annexe ditch at right angles was a ditch of later medieval date.

Returning to Area A (Figure 7.6.4), the Roman archaeological evidence to the east of the annexe ditches is more difficult to disentangle from the geomorphological and agricultural remains. Two widely spaced, lengthy, approximately north/south ditches, and one even longer east/west example, immediately catch the eye as narrow negative linear anomalies, but are clearly the remains of post-medieval field boundaries. Beneath them, also on an east/west alignment running across the centre of the field, are two broader and more irregular positive anomalies, which are probably relict stream beds. The first 100m to the east of the annexe triple ditches is largely devoid both of meaningful archaeological cropmarks and magnetic anomalies, other than intermittent traces of the widely spaced ditches demarcating both sides of the road approaching the fort. Their broadly east-west alignment becomes clearer and more continuous further to the east, with hints of a crossroad junction with a similarly defined north-south alignment *c.* 100m east of the annexe. The latter is particularly evident in some of the aerial photographs (e.g. Canmore SC1731376; SC1890085). In the gradiometer survey these ditches appear as narrow negative linear anomalies, at least in the part closest to the junction. The general absence of other evidence of potentially anthropogenic activity immediately to the east of the annexe, other than a second enhanced magnetic susceptibility response by the northern edge of the field (Figure 7.6.5), provides support for the well-established suggestion that it was an open area that may have been used as a parade ground. Further to the east the correlation between the aerial photographic record and the gradiometer survey becomes much stronger on the north side of the Roman road (Figures 7.6.3 and 7.6.4). There is a consistent pattern of relatively small, conjoined fields defined by ditches that are intermittently visible as rather slight negative linear anomalies. The fields are broadly rectangular in shape, their shorter dimensions aligned with the road as it approaches the fort. The geophysical survey has provided only slight enhancement of the pattern visible in the aerial photography, adding one or two potential subdivisions within the fields or further possible fields towards the eastern limit of the system.

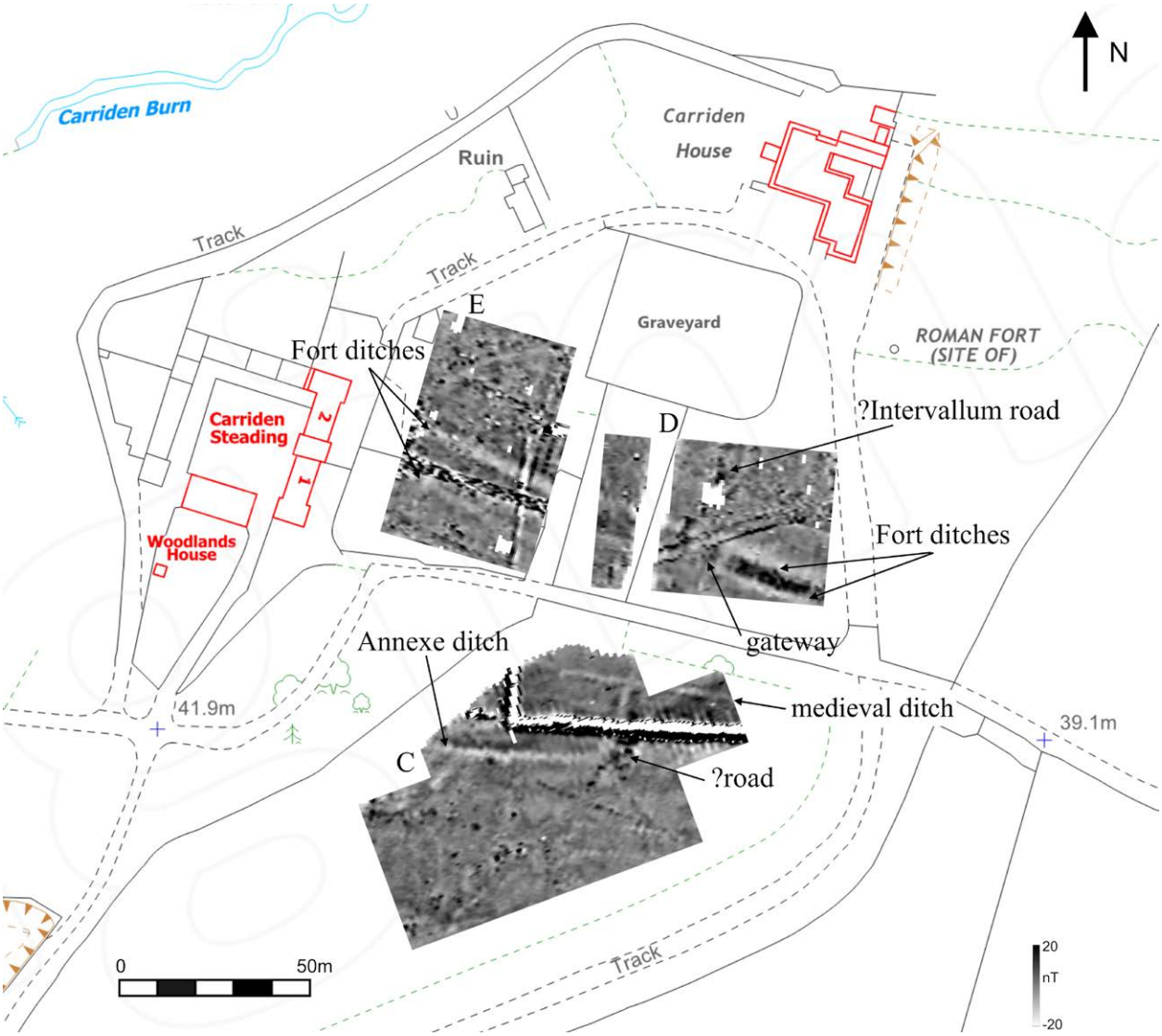

Figure 7.6.6. Gradiometer survey of Areas C, D and E at Carriden.

The aerial photographic survey hints at a similar, if much less clear, pattern of enclosures also to the south of the Roman road line. However, apart from a relatively small sample (Area B), which indicated two widely spaced, east-west linear alignments that may also represent parts of fields, this has not been subject to gradiometer survey.

Chapter 8
Discussion

8.1 Archaeology

As stated in Chapter 1, one of the primary aims of this volume is to re-assess the largely hidden contribution of geophysics to our understanding of the Antonine Wall. That contribution can be conveniently broken down under a number of sub-headings.

8.1.1 The linear barrier

One of the clear intentions behind some of the funding of geophysical survey on the Antonine Wall, particularly in relation to its establishment as a World Heritage Site (Chapter 1.3), was the need to confirm or clarify its line in various locations where this was less well understood. The precise line of the Wall between the farms at Wester Shirva and Shirva is perhaps one of the least well-known rural stretches. Almost all sign of it had disappeared from view even before the Ordnance Survey began its detailed mapping in the mid-19th century. This prompted a number of interventions over the last 25 years, including four separate episodes of geophysical survey (Chapter 4.2). It is only as a result of these, with confirmation from limited trenching in 1998-99 and 2018, that the line of the Wall here has now been established with any degree of confidence as it meanders across the low-lying ground between the two farms (Figure 4.2.6).

By way of contrast, the line of the Wall at Inveravon was thought to be well understood. However, geophysical survey offered two new insights (Chapter 7.1 and Figure 7.1.2). Firstly, at the north-east end of the survey area, the line of the Ditch lay slightly further south than indicated either on current Ordnance Survey maps, which seem to have continued to perpetuate the line proposed by Macdonald, or by HES in the World Heritage documentation (2007: Map V-6). Though the difference between the alignments is not great, it does have some impact on the projected line of the Wall to the east in the vicinity of Inveravon Farm. Secondly, at the opposite end of the survey area, the Ditch turned quite sharply to the south, so that the Rampart would have reached the bank of the River Avon immediately adjacent to the site of a weir, where the river may have been fordable. This previously unrecognised change of direction is important in relation to the more precise identification of the location of the fort (see section 8.1.3 *Forts and annexes*, below). It also removes one of the planks, the apparent misalignment of the Wall on opposite sides of the river, supporting the argument that the construction of the Wall may have begun at the Avon (Maxwell 1989b: 163).

At Kinneil geophysical survey has made a considerable contribution to clarifying the line followed by the Wall within the Estate, which has been much disputed (Chapter 7.2). The main area of debate has concerned whether the line deviated south to form a re-entrant angle at the crossing of the Gil Burn (Bailey 1996: 360-64). This hypothesis was clearly disproved by resistance survey in 1998 (Glendinning 2000), the findings reaffirmed by later gradiometer survey (Figures 7.2.4, 7.2.6 and 7.2.7), all of which clearly indicate that the Ditch continued in a straight line on either side of the burn, as Macdonald had concluded after his investigations many years earlier (1925: 276 and pl.1; 1934: 107). The same straight alignment of the Wall Ditch clearly also continued further west past the site of the fortlet (see section 8.1.4 *Fortlets*, below) (Figure 7.2.7), contradicting both the Ordnance Survey and HES mapping (2007: Map V-4). These map sources indicate that there was a slight kink just at the point where a section of the Wall was lost to the construction of a small reservoir known as the East Pond in the early 19th century. In both cases the confusion seems to have been caused by the effects of medieval occupation and later landscaping in the Meadows.

Geophysical survey has also made a considerable contribution to the debate over the location of the eastern terminus of the Antonine Wall, though entirely on the basis of negative evidence. This has long been assumed to lie *c.* 2km east of Bo'ness at Bridgeness, where the distance slab of that name, the largest and most elaborate of the stones that record the construction of the Wall (*RIB I* 2139; *CSIR* 68), was found in 1868. It had been buried near the end of a rocky promontory *c.* 100m from the shoreline at the time. However, limited excavations in the 1980s failed to find any trace of the Rampart or Ditch in the immediate vicinity (Keppie and Breeze 1981: 236; Bailey and Devereux 1987). This stimulated the resurrection of a view held by some early antiquaries (e.g. Sibbald 1707: 30-1) that the Wall may have continued on a more inland route for a further 1.6km to the south-east as far as the fort at Carriden (Bailey and Devereux 1987; Hannon *et al.* 2017: 462). This, in turn, prompted various forms of investigation to test this hypothesis. However, excavations designed to intersect alternative routes produced negative results (*DES* 1994: 8), as did several gradiometer survey transects (Chapters 7.4 and 7.5).

Like several other distance slabs, the excellent preservation of the Bridgeness slab attests to its protection from the elements on the abandonment of the Wall, and contemporary accounts of its discovery indicate that it had been buried face down in shallow topsoil (Bailey and Devereux 1987: 96-7). This is highly reminiscent of the circumstances of discovery of several other slabs that were buried in close proximity to the Wall (Table 7.5.1). In no case is there a parallel for a distance slab being moved more than 1km, re-used and then reburied, as Bailey and Devereux suggest - let alone reburied in conditions that replicate those recorded for several other distance slabs found *in situ*.

Thus, the Bridgeness slab continues to provide the best positive indicator of the eastern terminus of the Wall. The topographic position of the implied line would have allowed the Wall to continue along a natural promontory descending more gradually to the coast. Given the combination of intensive agriculture and occupation from the medieval period onwards in the immediate vicinity, it is not surprising that traces of the Rampart have not survived, while the Ditch would more sensibly have been positioned beyond the north-western side of the rocky promontory, probably under or immediately alongside the modern road.

Finally, the gradiometer survey of several long, largely uninterrupted stretches of the linear barrier provided an opportunity to assess whether other associated features could be identified along the line of the Rampart. These might include further examples of minor enclosures or defensive pits, both of which have already been attested by excavation (e.g. Hanson and Maxwell 1983; Bailey 2021: 23-25), or other postulated structural elements, such as watchtowers or the necessary support for a palisade and walkway. Between Glasgow Bridge and Westermains (Chapter 3.4), where the Wall line is no longer extant, the Ditch was extremely clear along the entire *c.* 800m length of the gradiometer survey, the Rampart base less so and more intermittent (Figure 3.4.4). However, apart from the known fortlet at Glasgow Bridge (see section 8.1.4 *Fortlets*, below), there were no features visible that were suggestive of any associated structures or additional defensive measures. For most of the *c.* 600m of Rampart surveyed at Bonnyside to the west of Rough Castle (Chapter 6.2) only its edges provided a magnetic response because of the extant character of the turf superstructure. The only associated structure confidently recorded, apart from the newly discovered fortlet (see section 8.1.4 *Fortlets*, below), was the known expansion at Bonnyside East (Figure 6.2.3). Similarly, at Seabegs no associated structures were recognised in the *c.* 300m of the well-preserved stretch of Rampart surveyed there (Chapter 5.5), though again its base did not provide a strong magnetic response (Figure 5.5.4). This negative evidence would tend to support the doubts increasingly being expressed about whether towers were constructed along the Wall at all (e.g. Breeze 2019: 96-97; Hanson 2020b: 218). Nor does it provide any supporting evidence for the existence of a Rampart walkway or, indeed, a palisade. That said, the resolution of the geophysical survey would have made it extremely difficult to identify entirely post-based structures, all the more so if they were housed largely in the body of the Rampart, and good preservation of its superstructure was masking the magnetic response from the base (see Chapter 8.2.4, below). Nonetheless, several of the longer stretches of Wall surveyed, such as at Duntocher, Seabegs and Bonnyside, did provide hints of discrete magnetic anomalies on the Berm that could represent defensive pits (*cippi*) (Figures 2.3.7; 5.5.4 and 6.2.3). However, that identification is somewhat tentative as they lacked the clear quincunx pattern recorded in excavations at Callendar Park and Garnhall (Bailey 1995: 578-81; Woolliscroft 2008: 142-45). Similarly, while the best resolution gradiometer survey was able to resolve the defensive pits (*lilia*) located to the northwest of the fort at Rough Castle (Figure 6.3.5), including a few previously unrecorded examples, no equivalent features have been noted at any of the other forts that have been subject to equally extensive survey beyond the Antonine Wall Ditch.

8.1.2 The Military Way

The Military Way is one of the more elusive and least well-known linear features of the Antonine Wall. It tends not to be visible except through excavation and, like the Rampart base, is particularly prone to damage by the plough. Thus, another of the intentions behind some of the funding of geophysical survey on the Antonine Wall was the need to enhance knowledge of the line taken by the Military Way wherever this was feasible (Chapter 1.3).

Because of the vulnerability of the remains of the Military Way to agricultural damage, this aim was not always successfully achieved. Some of the best geophysical evidence came from survey to the west of the fort at Westerwood (Chapter 5.1 and Figure 5.1.5), though the line here was already reasonably well known as a result of excavation by Keppie (1995). However, geophysical survey was able to enhance knowledge of the line of the Military Way at several sites. The gradiometer survey of the section of the Wall between Glasgow Bridge and Westermains (see section 8.1.1 *The linear barrier*, above) contributed considerably to the accurate location of the course of the Military Way in this area, which was visible in short stretches (Figure 3.4.4). Though not its primary aim, gradiometer survey at Bar Hill (Chapter 4.3) provided a slight correction to the line of the Military Way previously recorded between the north

rampart of the fort and the Wall, where it runs rather closer to the Rampart and at a less oblique angle to the Wall than indicated by Macdonald and Park (1906: pl. II) (Figures 4.3.3 and 4.3.7). The line of the Military Way as it approaches the fort at Mumrills from the east was not previously well understood, but appears to skirt the east side of the eastern annexe (see section 8.1.3 *Forts and annexes,* below) in both the gradiometer and resistance surveys (Chapter 6.5; Figures 6.5.5 and 6.5.6), and may be picked up in the latter further east some 10m north of its assumed position. Finally, at Inveravon what is probably the line of the Military Way seems to be terraced into the slope some 22m behind the Antonine Wall Ditch, cutting through part of the extensive shell midden (Chapter 7.1 and Figure 7.1.2). It is interesting to note that, where stretches of the Military Way were identified with some confidence, accompanying ditches were not infrequently notable by their absence. This was particularly clear at Bar Hill, Seabegs Wood, Bonnyside and Mumrills (Chapters 4.3; 5.5; 6.2 and 6.5).

8.1.3 Forts and annexes

While no new additions to the number of forts known can be attributed to geophysical survey, it has made a substantial contribution to our understanding of just over half of the known sites. It is not surprising that this is the case for those, such as Castlehill, Auchendavy and, for the most part, Carriden, that have not been examined by excavation and are known only from antiquarian records and/or occasional aerial photographs. But the contribution extends also to others that have been only partially examined, such as Westerwood and Inveravon, and even to those, such as Duntocher, Balmuildy, Castlecary, Rough Castle and Mumrills, which have undergone more extensive investigation by the spade. It has also provided negative evidence at two sites, Seabegs and Kinneil (Chapters 5.5 and 7.2), where forts have long been postulated. Despite quite extensive survey, particularly at the former, no trace of such structures has been revealed.

Geophysical survey has helped better to define the extent of the fort at Castlehill and required a re-evaluation of its structural and chronological relationship with the Antonine Wall (see section 8.1.5 *Design, planning and construction*, below). Double ditches on the west side of the fort were confirmed as predicted, but have also been recorded on its north side, rather than the expected single Ditch of the Antonine Wall (Figures 2.5.5 and 2.5.6). The disjuncture at the north-west corner, where the Antonine Wall Ditch joins those of the fort, indicates that the latter abutted the former. This mirrors the relationship visible in the geophysical survey at Auchendavy (below) and recorded by excavation in the north-east corner of the fort at Duntocher. Thus, like that adjacent fort, Castlehill appears originally to have been a freestanding structure before the Wall arrived to join it. In addition, the multiple linear responses from the defences along the east side of the fort (Figure 2.5.7) suggest that changes may have been made to its east-west dimensions. The outer two bands of slightly elevated resistance correspond with the known ditches. The innermost band of mainly high resistance clearly joined the Antonine Wall Rampart base at the north-east corner of the fort, so must be the previously unrecorded eastern rampart of the fort. This, combined with the probable identification of the western and southern ramparts in the 2011 gradiometer survey (Figure 2.5.5), allows a more accurate calculation of the fort's internal area (*c.* 0.92ha) than has previously been possible. Just outside this rampart, however, a fourth linear band defined by slightly raised resistance, with occasional patches of high resistance, could be either a third ditch or another rampart. However, as it too appears to merge into the line of Antonine Wall Rampart to the north, it seems best interpreted as a second fort rampart. This in turn would suggest there had been some adjustment made to the size of the enclosed area, perhaps at the time the Wall was joined to the fort. Calculating from this rampart line gives a slightly larger internal area of *c.* 1.02ha, though both calculations indicate a fort rather smaller than previously thought.

At Auchendavy geophysical survey has revolutionised our understanding of the fort and its relationship to the Antonine Wall. It has long been debated whether the fort was part of the original plan for the Wall and built before the linear barrier, like Balmuildy and Castlecary, or whether it was a secondary fort, added to the Wall slightly later in the construction process, like Croy Hill and Westerwood (Gillam 1975: 52; Keppie and Walker 1985: 32-33; Breeze 2006: 81-84) (see section 8.1.5 *Design, planning and construction*, below). The change of Wall alignment recorded by the Ordnance Survey on both sides of the fort, as if to accommodate a pre-existing installation, and the indications in the aerial photographs of an original causeway across the Ditch in front of its north gate, seemed to support its claim to be primary. However, its relatively small size and the evidence for a legionary garrison (*RIB I* 2174-7; 2179-81) would be more appropriate for a secondary fort. The gradiometer survey at Auchendavy confirmed the existence of an original causeway in front of the fort and indicated that the change of alignment of the Wall was considerably more marked than previously appreciated (Figure 4.1.1). Furthermore, it showed that the fort was fronted to the north not by a single Ditch, as had been anticipated, but by double ditches. Where they joined the Antonine Wall Ditch, by the north-west corner of the fort, they revealed the same disjuncture as was seen at Castlehill. Thus, the geophysical survey leaves little doubt that the fort, or at least its north face, had been

built before the arrival of the Wall. The double ditches which fronted it extended beyond the line of both the eastern and western ditches of the fort, but on the west side there are also clear indications in all of the survey methods employed (Figures 4.1.5, 4.1.6 and 4.1.7) that the intended width of the fort had been reduced by some 20m between the building of its north face and the digging of the fort's single western ditch. Here the double ditches to the north culminate at three ditch stub-ends that project at right angles to the south, as if in expectation of joining triple ditches matching those on the eastern side of the fort and thus defining a much larger enclosure. Finally, the Ground Penetrating Radar survey reveals a stone-walled, rectangular or L-shaped building at least 22m in length immediately to the south-east of the line of the ditch stub-ends (Figure 4.1.7). It is irregularly subdivided into small rooms and seems best interpreted as a bathhouse. This raises the question of whether it was intended to create an annexe to the west of the fort, as bathhouses are commonly found within annexes along the Wall, though such annexes are themselves generally regarded as secondary additions (Bailey 1994: 299-305; Breeze 2006: 95-7).

At Carriden debate in recent years has focused on whether the triple ditches found from the air in 1945 represented the east side of the fort or of an annexe. The former was generally assumed, but Bailey came to advocate the latter, noting firstly that the position of the entrance gap implied that the fort would have been facing south, rather than the enemy to the north or east, and secondly that the internal road ran obliquely through it rather than in the straight line that would be the norm within a fort (2021: 197-98) (Figure 7.6.3). Though the gradiometer survey showed that, in fact, the road did seem to run at right angles to the adjacent triple ditches, it also revealed that the inner two continued to the northern edge of the natural scarp (Chapter 7.6 and Figure 7.6.4). This confirmed Bailey's identification of the enclosed area as an annexe, as the attested eastern gateway would have been positioned much too far to the south of the enclosure to fit the normal tripartite internal arrangements of an auxiliary fort. The gradiometer survey also identified double, or possibly triple, ditches further to the west defining the south side of the fort. Two of these ditches had already been noted by Bailey in 1994, though at that time he thought they related to an annexe and his very limited trenching made it difficult to identify their alignment correctly (1997). Finally, the gradiometer survey was responsible for the discovery of a second small annexe, demarcated by a single L-shaped ditch running out from the west side of the south gate (Figure 7.6.6). Its identification was subsequently confirmed by excavation in 2009 (Bailey 2021: 198-205).

The general outline of the fort at Westerwood and its secondary relationship with the Wall was indicated by very limited excavation in 1932 (Macdonald 1933). Though the gradiometer survey broadly confirmed the outline of the fort, it did identify some substantial differences from Macdonald's excavation plan (Chapter 5.1 and Figures 5.1.4 and 5.1.5). There was no sign of the southward deviation of the Military Way as it entered the fort through the west gate, which was found to be located further north than Macdonald had indicated. As a result, the internal arrangement of the fort could not readily have complied with the normal tripartite layout of an auxiliary fort. This in turn lends further support to the evidence that the fort was a secondary addition to the Wall, suggesting that its internal layout may have been adjusted to comply with the pre-existing line of the Military Way.

The geophysical survey at Inveravon has brought into better focus the rather disparate evidence from three small programmes of excavation at the site. Macdonald entirely failed to locate the fort (1925: 271-73); Robertson found only scattered structural remains (1969; 1974); while CFA, constrained by the line of the pipe, the impact of whose insertion they were mitigating, were unable convincingly to piece together the varied structural remains they encountered, though they did establish the line of the fort's southern rampart (Dunwell and Ralston 1995). Two crucial new features were revealed in the gradiometer survey: a marked southerly diversion in the line of the Antonine Wall Ditch as it approached the River Avon (see section 8.1.1 *The linear barrier*, above) and the distinctive curving line of a ditch demarcating the south-east corner of the fort (Chapter 7.1 and Figure 7.1.2). Combined with the excavation evidence and the general topography, this made it possible to define the location and extent of the fort with greater confidence: it was situated close to the river immediately adjacent to a potential ford and had an internal area of not more than 0.2ha. Moreover, a cluster of dipolar anomalies behind the Wall in the lee of its western side suggests the possible location of an internal bathhouse.

Despite the wide-ranging excavation undertaken at Duntocher between 1947 and 1951 (Robertson 1957), a number of questions were left unresolved, not least which part of the enclosure that succeeded the fortlet (see section 8.1.4 *Fortlets,* below) represented the fort. The gradiometer survey clearly indicates that the entire extended enclosure constituted the secondary fort and was later subdivided to create an annexe (Chapter 2.3), as Swan was the first to suggest (1999: 431-33). Not only was a third ditch recorded along the whole of its northern frontage, augmenting the two found by

Robertson, but a primary causeway running through all three ditches was identified in the centre immediately in front of the superseded fortlet (Figures 2.3.6 and 2.3.7), indicating that this continued to serve as the only gateway through the Wall at the site. Moreover, a probable rectangular stone structure, the right size, morphology and location for a headquarters building, was visible in the resistance survey immediately to the south of the fortlet site (Figure 2.3.9).

Balmuildy represents one of the most extensively excavated forts on the Wall (Miller 1922). Nonetheless, geophysical survey has considerably enhanced our understanding of the site (Chapter 3.1). That the construction of the fort preceded the Wall has long been established, but the identification of a second ditch to its north and the manner in which the outer ditch on the east side curves inwards as it approaches the north-east corner strongly suggest that the fort was originally surrounded on all sides by its own ditches (Figure 3.1.3) (see section 8.1.5 *Design, planning and construction*, below). The geophysical survey also added some structural details to the character of the stone rampart, identifying thickening in the south-east corner (Figures 3.1.3 and 3.1.5) to match that in the north-east and north-west corners identified during excavation. These should better be identified as *ascensus*, facilitating access to the rampart top, rather than artillery platforms as suggested by the excavator (Miller 1922: 14). The gradiometer survey has also finally solved the puzzle of the location of the eastern defences of the annexe. Though recognising the line of a former stream-bed for what it was, Miller seems to have assumed that it represented the eastern limit of the annexe, or at least subsequent commentators have interpreted his account in that way (e.g. Robertson 2015: 105). Clearly defined double ditches[1] abutting the rear of the Wall some 35m to the east of where that relict stream crosses the Rampart leave little doubt that they delimit the annexe, which can now be seen to be slightly more regular in shape and almost 1ha in size, somewhat larger than had previously been assumed.

The major contribution of geophysical survey to our understanding of the fort at Castlecary, extensively excavated in 1902 (Christison *et al.* 1903), also relates to annexes (Chapter 5.4). Firstly, there is a strong suggestion in the resistance survey that the eastern annexe was subdivided or perhaps had an earlier phase (Figure 5.4.8). The latter interpretation is supported by the 2nd edition 6-inch and 25-inch Ordnance Survey mapping (Figure 5.4.10), which shows earthworks that mirror its defences positioned a slight distance beyond the east and south sides of the fort. There is only very limited direct confirmation of related features, visible in both the gradiometer and resistance surveys, where a rampart line at right angles to the fort's defences can be seen running parallel with the road leading out of the south gate. However, the resistance survey indicates the presence of a large rectangular building, possibly a bathhouse, immediately outside the south-west corner of the fort, which would have been enclosed by these postulated earthworks.

At Mumrills geophysical survey has enhanced our understanding of the relationship between the fort and the Wall (Chapter 6.5). That the fort was part of the original plan had long been assumed, despite slight inconsistencies in the stratigraphic evidence, because of the way that the Wall markedly changes direction in order to accommodate it (Figure 6.5.2) (Hanson and Maxwell 1986: 105-06; Robertson 2015: 60; Breeze 2006: 81). The identification of double ditches in front of the fort at Mumrills in the gradiometer survey (Figure 6.5.5) clearly now demonstrates that the construction of the fort preceded the Wall (see section 8.1.5 *Design, planning and construction*, below). In addition, both the gradiometer and resistance surveys have confirmed the outline of a small annexe on the plateau to the east of the fort, complementing the long-attested large annexe on its west side (Figures 6.5.5 and 6.5.6). Though recorded in aerial photographs in 1977 and even visible recently on Google Earth (e.g. Figures 1.10 and 6.5.4), identification of this eastern annexe seems to have been completely overlooked until the results of the geophysical survey began to circulate. It is less surprising, therefore, that the location within that annexe of the large tile kiln excavated in 1913 was not appreciated until now (Figures 6.5.3 and 6.5.5). Since the function of such annexes is much disputed (Hanson 2021), recognition that this one housed such an important industrial process related to the building of the fort is of some significance.

Finally, at Rough Castle the geophysical survey has broadened our understanding of both the fort and its annexe (Chapter 6.3). Survey over the causeway across the Antonine Wall Ditch in front of the fort, long considered to have been left undug in anticipation of the fort's construction, raised questions about this interpretation and stimulated detailed examination of the records of earlier work at the site. Examination of photographic images of the landscaping undertaken as part of the process of making the site both accessible and presentable to the public made two things clear: firstly, that the causeway as it stands was entirely recreated in the 1960s; and secondly, that the causeway removed in the course of the landscaping was not itself an original feature (see section 8.1.5, *Design, planning and construction*, below), as it had been provided with a large

[1] Surprisingly, their significance was not recognised in the original report (Jones *et al.* 2006b: 21 and Fig. 4a), which identified them as modern features. This is a clear example of the benefit, referred to in Chapter 1.7, that specialist knowledge of the sites involved brings to the interpretation of the geophysical survey data.

wooden substructure at its base to facilitate drainage (Hanson forthcoming). Survey within the annexe to the south of the Military Way revealed traces of possible rectangular structures and strong indications of probable kilns or furnaces, lending further support to the argument that annexes were used for industrial activity.

8.1.4 Fortlets

By the late 1950s four fortlets were known along the line of Antonine Wall at Duntocher, Wilderness Plantation, Glasgow Bridge and Watling Lodge (Robertson 1957: 14-33 and 91-5; Wilkes 1974; St Joseph 1955: 86; Breeze 1974). Stimulated by John Gillam's radical hypothesis that the original plan for the construction of the Wall involved a regular series of such fortlets (1975) (see section 8.1.5 *Design, planning and construction*, below), more were deliberately sought by several individuals, including one of the present authors. This research, involving highly focused but small-scale investigatory excavations, more than doubled the number known over the next five years with the discovery of fortlets at Cleddans, Summerston, Croy Hill, Seabegs and Kinneil (Keppie and Walker 1981; Hanson and Keppie 1978; Maxwell and Hanson 2020b). Thereafter, despite that research effort continuing for several of years, though with decreasing intensity, no more fortlets were identified until the serendipitous discovery ahead of building development of a section of rampart at right angles to and immediately behind the Wall at Boclair, Bearsden in 2017 (Hunter 2019: 412) (see Chapter 2.7, above). Thus, at the most fundamental level, geophysical survey has been responsible for the identification by the authors in a short period of time of a further three fortlets at Carleith,[2] Castlehill[3] and Bonnyside (Chapters 2.2, 2.5 and 6.2). This rapid increase in the total number known, from 10 to 13, would seem to confirm what has increasingly come to be accepted, that the Wall was constructed with a regular sequence of fortlets along it. It also strongly suggests that targeted geophysical survey may prove to be the most effective method of facilitating the discovery of yet more examples.

Furthermore, the discovery of three new fortlets has added important new evidence to the debate about their original positioning on the frontier. The new fortlet at Carleith Farm (Chapter 2.2), located almost one Roman mile west of Duntocher fortlet and two Roman miles west of Cleddans fortlet, gives us a chain of four fortlets at intervals of one Roman mile. Likewise, the fortlet at Bonnyside East (Chapter 6.2) is positioned almost exactly two Roman miles east of Seabegs Wood fortlet, thus conforming to the pattern first suggested by Gillam (1975) and adding further weight to it.[4] When examined in detail, however, it is apparent that these new fortlets are not located exactly one Roman mile apart, but that their spacing is subtlety adjusted to place them at positions with improved visibility. This may indicate that the original design was intended to produce a chain of intervisible fortlets (Hannon and Blake in preparation).

Geophysical survey has also provided more information about some of the known fortlets. Duntocher is one of the few that has been quite extensively excavated and its rampart was surprisingly well-delineated in the geophysical survey (see Chapters 2.3 and 8.2.4). For the most part the gradiometer and resistance surveys confirmed what was already known, though the former did suggest that the thickening of the north-western rampart of the fort recorded in Robertson's excavations probably also extended across the front of the fortlet. Both the gradiometer and the resistance surveys also hinted at more remains of buildings in the interior.

Glasgow Bridge fortlet, by contrast, was known only from the aerial photographs that revealed the positive cropmarks defining its surrounding ditch. The earliest of these showed a single ditch around three sides of the fortlet, broken in the middle of the south-east side, but later images have tended to reveal only the western half of the enclosure (e.g. Figure 3.4.3). The geophysical surveys, particularly the gradiometer survey, clearly revealed the full extent of the ditch running right up to the rear of the Wall, along with the break to the south-east, and additionally hinted at a causeway leading out through that break. No sign of the fortlet's rampart had previously been recognised, but some remains of it on the west side are suggested in the resistance survey, with clear evidence of the Wall Rampart forming the fortlet's north-east face. A gap for a gateway through the Wall is particularly clear in the gradiometer survey with a large positive anomaly just inside it, coinciding with an area of higher resistance, hinting at surviving structural remains. It may not be coincidental that this is one of the better-preserved areas in the completely excavated interior of the fortlet at Kinneil where a surviving road surface was flanked by stone-lined drains, the lee of the Wall Rampart having provided some additional protection from the ravages of the plough.

[2] It is interesting to note that trial trenches at Carleith by Keppie and Walker in 1980 (Keppie and Breeze 1981: 242-44), specifically in search of a fortlet there, were only a metre or so away from success.

[3] Previous suggestions that there may have been a fortlet on Castlehill assumed, incorrectly, that it was represented by a small extant earthwork plateau (Keppie 1980: 83-4). The small, ditched enclosure referred to here was recorded in resistance survey undertaken in 2008, but its potential significance was not fully appreciated until the re-assessment of those results first published in 2020 (Hanson and Jones 2020: 223-24 and 231).

[4] It is positioned somewhat closer to Watling Lodge fortlet (1.65 Roman miles), whose location had been predetermined by the existing line of the Roman road to the fort at Camelon that passes through it.

Given that full interior of the fortlet at Kinneil was excavated not long after its discovery (Bailey and Cannell 1996), it might be thought that the geophysical survey would have little to add to our knowledge of the site, all the more so as the geophysical responses, particularly in the gradiometer survey, have clearly been influenced by the restoration of elements of the site for public display (see Chapter 8.2.4, below). Nonetheless, two things stand out (Chapter 7.2). Firstly, there has long been uncertainty about whether the fortlet was surrounded by a single or a double ditch. The original limited excavation in 1978-80 indicated two ditches on its east side; the larger-scale excavation in 1980-81 identified only one. While the gradiometer survey did not locate this outer ditch, probably because its remains were very shallow, it did for the first time reveal such a ditch on the west side (Figures 7.2.7 and 7.2.9), providing confirmation that the fortlet had, indeed, originally been surrounded to the south of the Wall by two ditches. Secondly, it was suggested that the Antonine Wall Ditch narrowed in front of the fortlet, because the 1980-81 excavation noted that the Berm was wider here (Bailey and Cannell 1996: 310 and 337). Leading on from this, it has continued to be argued that there was an original causeway across the Ditch at this point (e.g. Bailey 2021: Illus 2.10). Though there are some anomalies in the character of the Ditch revealed in the gradiometer surveys, the response from it is continuous. There is no indication of a reduction in its width, rather it appears to widen or even bifurcate in front of the east side of the fortlet, and there is absolutely no sign of a causeway (Figures 7.2.7 and 7.2.9) (see section 8.1.5 *Design, planning and construction*, below).

8.1.5 Design, planning and construction

One of the most intensively debated topics in the study of the Antonine Wall in recent years has been the fundamental question of its design and planning. Traditionally it was seen as a unitary monument with its garrisons intelligently positioned in a flexible response to local conditions (Macdonald 1934: 162 and 471; Robertson 1960: 27). In 1975, drawing attention to the substantial variation in the size of the forts on the Antonine Wall, their unusually close spacing and inconsistencies in their structural relationship with the Rampart, John Gillam put forward a radical alternative hypothesis (1975). He argued that the Antonine Wall underwent major amendment during its construction and suggested that its original design was broadly based on that of Hadrian's Wall in its more developed form. He proposed that the intended plan for the Antonine Wall was to have large or medium-sized forts some eight Roman miles (11.8 km) apart with fortlets approximately every Roman mile (1.5 km) between them, but that this was changed during the construction process, as Hadrian's Wall had been, with the addition of a series of more-closely-spaced and generally smaller secondary forts to replace many of the fortlets. Gillam's hypothesis seemed to be readily capable of testing in the field by a search for more of his predicted series of fortlets. The rapidly successful response to this challenge (see section 8.1.4 *Fortlets*, above), prompted widespread acceptance of the hypothesis (e.g. Hanson and Maxwell 1986: 104-12; Robertson 2015: 39; Breeze 2006: 81-95).

More recently this consensus has been challenged, based primarily on a re-assessment of the strategic positioning of the forts and the apparent primacy of their locations in relation to the planning of the Antonine Wall line. Thus, Poulter noted that the linear barrier appeared to be curved to run up to or past known installations, including several supposedly secondary forts (2009: 117-24). Building on this argument, Graafstal and others have drawn attention to the location of some secondary forts, whose topographic positions seemed to have been carefully chosen to control potentially clandestine access routes to the Wall from both north and south, and have cast doubt on the significance of the variable structural relationships noted by Gillam and others (Graafstal *et al*. 2015; Graafstal 2020; Symonds 2018: 137-42).

The data from geophysical survey has made a considerable contribution to this debate, tipping the scales once again in favour of the Gillam hypothesis (see Hanson 2020b). Firstly, geophysical survey has been responsible for the discovery of three new fortlets (see section 8.1.4 *Fortlets*, above), adding further weight to the argument that a full sequence of such sites was intended. In itself this does not necessarily mean that there had been a major change of plan, as the sequence could have been designed to augment the gaps between the forts. However, one of the fortlets, at Castlehill (Chapter 2.5), was replaced by a small fort, providing a second example of that chronological sequence of development to match the one already known at Duntocher. Similarly, a second fortlet, at Bonnyside (Chapter 6.2), lies only some 280m west of the fort at Rough Castle and so seems to reflect the same situation as seen at Croy Hill, where the fortlet is positioned too close to the adjacent fort for them to have been part of the same strategic design. Finally, though there is no sign of a causeway in front of the fortlet at Kinneil, as was once suggested (Bailey and Cannell 1996: 337), the behaviour of the Antonine Wall Ditch here is odd as it appears to widen or bifurcate (see section 8.1.4 *Fortlets*, above). LiDAR imagery and some aerial photographs may provide an explanation for this phenomenon, as they appear to show that the Ditch bulges slightly to the north directly in front of the fortlet (Figures 7.2.3 and 7.2.10). This is highly reminiscent of the situation

at Seabegs Wood, where the fortlet sits on a small plateau that projects slightly to the north of the Wall line (Keppie and Walker 1981: 143-44), and confirms the primacy of their locations in relation to the planning of the Wall (Hanson 2020b: 211).

Secondly, geophysical survey has provided clear evidence that several of the postulated primary forts were originally designed as freestanding structures with their own northern defensive ditches (see section 8.1.3 *Forts and annexes*, above). It has long been appreciated that the fort at Balmuildy was built before the Wall as it was provided with stone wing-walls at both the north-west and north-east corners in anticipation of subsequent connection to the Antonine Wall Rampart (Chapter 3.1). However, the gradiometer survey suggests that the fort was originally surrounded on all four sides by its own double or triple ditches (Figure 3.1.3), which may indicate that it served as a freestanding fort for rather longer than has tended to be assumed. So too at Mumrills (Chapter 6.5). The primacy of that fort, the largest on the Wall, had long been assumed because of the way that the Wall markedly changes direction in order to accommodate the site, as the original excavators noted (Macdonald and Curle 1929: 406) (Figure 6.5.2), creating the equivalent of the wing-walls seen in stone at Balmuildy (Robertson 2015: 60; Breeze 2006: 81). However, some slight doubt had been cast on the primacy of the site (e.g. Hanson and Maxwell 1986: 105-06) because excavation in 1958-60 had revealed that the rampart at the north-east corner of the fort slightly overlapped the rear kerb of the Wall Rampart (Steer 1961a: 95 and Fig. 3C). The provision of double ditches in front of the fort at Mumrills, the outer ditch subsequently observed in a watching brief by Bailey (2021: 231-32), was first recorded in the gradiometer survey (Figure 6.5.5) and clearly now demonstrates that the construction of fort preceded the Wall. Finally, at Auchendavy (Chapter 4.1), not only did the geophysical survey show that the fort was provided with two ditches to the north, with a causeway in front of the gate, but that it was originally intended to be much larger in area as befitting a primary fort (Figure 4.1.1). Furthermore, the relationship between the Antonine Wall Ditch and the double ditches by the north-west corner of the fort leaves little doubt that it, or at least its north face, had been built before the arrival of the Wall (Figures 4.1.5 and 4.1.6).

Thirdly, results from the gradiometer survey at Rough Castle prompted re-examination of the long-accepted evidence for a primary causeway across the Antonine Wall Ditch in front of the fort there (8.1.3, *Forts and annexes,* above). Leaving a section of Ditch undug in order to form a causeway implies that the Ditch diggers were aware that a fort was to be built and, therefore, contradicts the otherwise clear stratigraphic evidence from sections through the ramparts that the fort had been added after the Wall Rampart had been completed (Buchanan *et al.* 1905: 459 and Figs 7 and 12; Hanson 2020b: 215-16). The strong probability that the causeway at Rough Castle represents an infilling of the Ditch, either by the Romans or more probably much later (Hanson forthcoming), removes that contradiction, making the secondary character of the fort no longer in doubt.

8.1.6 Extra-mural activity

The search for evidence of extra-mural and specifically civilian settlement around forts was a primary focus of Historic Scotland's original funded programme of survey (Chapter 1.3), most of this work being carried out by Glasgow University. That the results were very disappointing, particularly in relation to the wide-ranging surveys at Balmuildy, Auchendavy and Bar Hill, has been addressed to some extent in the relevant sections above (see Chapters. 3.1, 4.1 and 4.3) and the probable reasons are discussed further below (Chapter 8.2.4).

That is not to say, however, that geophysical survey has had no impact on our understanding of extra-mural activity. At Carriden, despite the difficulties of disentangling the archaeological evidence from both more recent agricultural features and the geomorphological background, the gradiometer survey clarified and enhanced aerial photographic evidence of the extensive field system to the east of the annexe (compare Figures 7.6.3 and 7.6.4). Finally, at Mumrills, though even more difficult geological and geomorphological conditions were encountered on the plateau to the east of the fort, which tended to obscure almost all potential archaeological responses, both the gradiometer and resistance surveys did at least identify a previously unknown pit or well (Figures 6.5.5 and 6.5.6).

8.1.7 Impact on pre-Roman settlement

While appreciating that the construction and occupation of the Antonine Wall is likely to have had a substantial disruptive impact on the indigenous population, since it ran through a zone of long-established settlement, there is surprisingly little direct evidence of the character of that impact (Macinnes 2020). The list of sites of likely later prehistoric date in the area is not long, and gets much shorter if only those for which we have evidence of occupation in the Roman period are included. Geophysical survey has contributed to the list of potential sites by identifying three previously unrecorded examples. Most important are the two small rectilinear, probably Iron Age, enclosures at Rough Castle, one on the brow of the ridge

overlooking the Rowan Tree Burn immediately in front of the Roman fort, the second beneath the headquarters building of the fort some 50m away (Chapter 6.3; Figure 6.3.5). That the first was bisected by the Antonine Ditch clearly indicates not only that it pre-dates the Wall but, assuming it was occupied at the time, that the impact of the Roman occupation on its inhabitants would have been catastrophic. The newly discovered promontory fort just to the north of the Wall at Kinneil, with unenclosed round houses nearby (Chapter 7.2 and Figure 7.2.4), may fall into the same category. If still in use on the arrival of the Roman army it can hardly have been left occupied, though such defended sites tend to have a slightly earlier date range (Harding 2004: 58-66). Insufficient evidence of the circular enclosure at Elf Hill was recovered to be certain of its identification (Chapter 6.1 and Figure 6.1.4), let alone its date. Were it in occupation when the Wall was under construction, it cannot have continued in use.

8.2 Geophysics

The surveys reported in this volume (Chapters 2-7) have primarily aimed to shed light on some aspects of the Roman infrastructure associated with the Antonine Wall. Against the background of the book's three main aims as set out in Chapter 1.7, this section responds to the opportunity to review the role and performance of geophysical survey within the World Heritage Site. It also looks ahead briefly (8.2.3, below) to consider some geoarchaeological methods that could be used in tandem with geophysical methods on the Antonine Wall.

Geophysical survey was first employed on the Antonine Wall in 1973 with surveys being conducted intermittently ever since, however, the main bulk of this work can be broken down into three main phases. The first phase of survey took place between 2007 and 2010 with funding from Historic Scotland's European Union project within the Culture 2000 programme, *The Frontiers of the Roman Empire* project (Stephens *et al.* 2008) (see Chapter 1.3). These surveys had specific well-defined aims, such as locating the course of the Wall or Military Way. Secondly, between 2014 and 2021 the University of Glasgow undertook a series of supplementary surveys. Again these were aimed at answering specific research questions, but took the opportunity to offer students training in geophysical survey. Finally, the ongoing contribution of the HES work, funded by the Historic Scotland Foundation, began in earnest in 2020. This project's aim was to imbed the use of geophysical survey in the Archaeological Survey team at HES and used the Antonine Wall as one of its key locations. These surveys aimed to demonstrate the value of geophysical survey in a Scottish context, one in which some scepticism as to its benefits still remains. Combined with this aim the surveys investigated key research and management questions, while at the same time upskilling the organisation's survey team.

These surveys have seen gradiometer survey as the method of choice, followed by earth resistance survey, ground-penetrating-radar (GPR) and electro-magnetics. In terms of instrumentation, there have been varying levels of development. Gradiometers have seen the most fundamental changes with earlier surveys being conducted using Geoscan's FM36, a single sensor device. This was superseded by Bartington's dual-sensor Grad 601 instrument, thus doubling data collection speeds. More recently, these measured-grid methodologies have been replaced by multi-sensor cart-mounted systems such as the Sensys MXPDA (see Chapters 2.1, 2.3, 5.5, 6.2 and 6.3). This methodology offers a further increase in the speed of data collection through a combination of increased sensor numbers and the use of a Global Navigation Satellite System (GNSS). This accurately positions each reading, thereby removing the need to operate in laid-out grids. In contrast to the developments observed in gradiometry, with a few exceptions Geoscan's RM15 instrument has been consistently adopted for earth resistance survey, a methodology that has remained largely unchanged since the 1990s.

8.2.1 Scale of survey

In keeping with its aim and scope, the scale of survey at individual sites has varied considerably. Of the five arbitrarily defined categories shown in Figure 8.2.1, the two smallest comprised surveys that typically encompassed stretches of Rampart, Ditch and Military Way located within a small area (e.g. Wilderness Plantation, Chapter 3.2; Cawder, Chapter 3.3 and Callendar Park, Falkirk, Chapter 6.4). Within the mode and median category (1-5ha) the aims were more ambitious, ranging from the same targets but on a larger scale (e.g. Shirva, Chapter 4.2), through forts and annexes (e.g. Duntocher, Chapter 2.3 and Castlehill, Chapter 2.5) to fort environs (e.g. Bar Hill, Chapter 4.3). Long extents of Rampart and Ditch (e.g. Glasgow Bridge to Westermains, Chapter 3.4 and Kinneil, Chapter 7.2) and large areas encompassing forts and environs (e.g. Balmuildy, Chapter 3.1 and Mumrills, Chapter 6.3) make up the 5-10ha category. The largest survey extents (15ha) were at Auchendavy (Chapter 4.1) and Carriden (Chapter 7.6).

The size of survey raises some broader issues. The maxim that bigger is better is generally accepted amongst archaeological geophysicists, on the proviso that the size is appropriate to the questions being asked. Adopting such an approach helps optimise interpretation, especially for gradiometer and resistance data, and

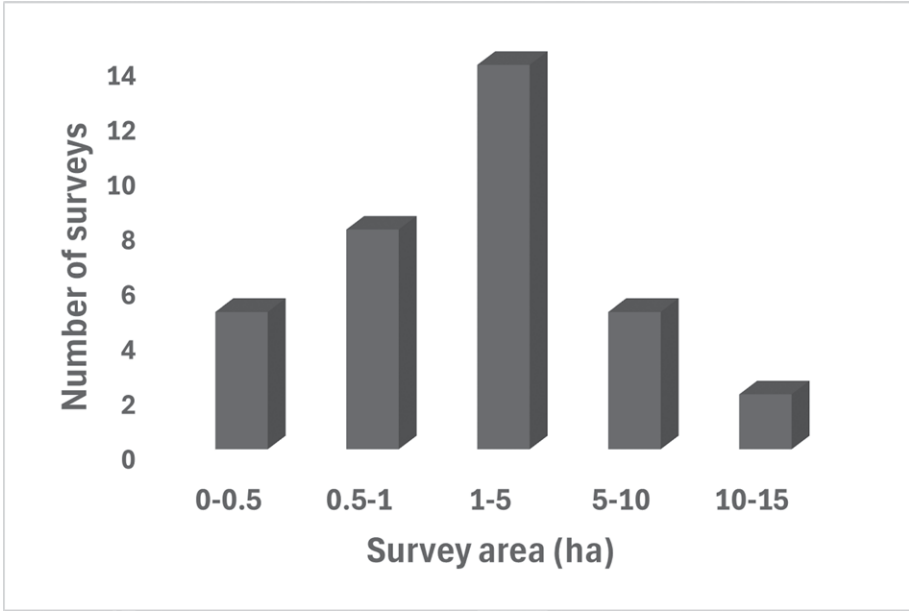

Figure 8.2.1. Geophysical surveys classified according to size in hectares.

the ability to survey large previously unexplored areas allows new and unexpected features to be identified. However, these extended survey capabilities come inevitably at a cost. As the survey area increases, so does not only the size of the dataset and the resulting archive, but also the time needed to process, interpret and report the results. Therefore, these considerations need to be balanced with the aim of each project.

The introduction of mechanically towed gradiometer and GPR systems has expanded the possibilities of this concept further now that very large areas can be surveyed at high resolution in a relatively short period of time. In the commercial sector, gradiometer surveys of over 500ha are no longer out of the ordinary and are used as an effective archaeological prospection tool; viewed in this light, even the largest surveys considered in this volume can be considered medium scale at best. In a Scottish context, large-scale surveys are less common (but see Hanson *et al.* 2019: 291-2 and Fig. 7) and no mechanically towed survey has yet been conducted within the Antonine Wall World Heritage site. There are a number of reasons why this may be the case. For this methodology to be effective the equipment ideally requires large, square, flat fields with few or no obstructions. These requirements rule out large areas of the World Heritage site. There is the additional issue of ground damage; this survey equipment, ordinarily towed by an ATV or UTV, can cause damage to the grass and archaeological topology when used on pasture or parkland, making it unsuitable for many scheduled sites. The quality of results achieved by geophysical survey can be variable and is influenced by a range of factors including equipment calibration, equipment set-up and operator care. Such issues can be exaggerated when a mechanically towed methodology is applied to cover very large areas rapidly. Large-scale prospection of about 400ha undertaken in the area between Birrens fort and Burnswark in Dumfries and Galloway between 2015 and 2022 by the Römisch-Germanische Kommission (RGK) in collaboration with HES illustrates some of the issues. The survey area is primarily set in large fields under arable and pasture, and was covered using a Sensys system towed by an ATV with a 14 sensor array spaced at 0.25m apart. With data captured at a 0.125m sample rate, this achieved a point density of 32points/m^2 creating an extremely large dataset; the raw data alone exceeds 40GB. Processing the data has highlighted issues with the project methodology. In some areas the sensor array demonstrates a degree of oscillation, in effect bouncing across the surface in areas of uneven, sometime damp ground. This creates a tank-track type effect in the data making archaeological features difficult to interpret. There are also areas where the spacing of traverses varies, in some cases causing a gap in the data, or causing the traverses to overlap. Each of these issues can be partially addressed during data processing, but this has the effect of reducing the output resolution, which again decreases the visibility of archaeological features. Some of the issues with large-area survey can be addressed during data collection, but require careful consideration of the impacts of the methodology on data quality.

Turning to the other end of the size scale, the value of small-scale survey should not be underestimated. When a specific research question is posed, the efficiency

offered by a small-scale or sampling methodology may be desirable. One such example involved confirming the course of the frontier at Tollpark (Chapter 5.2). In the case at Summerston, sampling the Wall in five neighbouring areas (Figure 2.8.1) with 20m wide surveys proved sufficient to confirm its course. On the other hand, at Cleddans (Figure 2.4.2) and Wilderness Plantation (Figure 3.2.4), detection of the frontier was partially compromised as the survey areas were too small.

8.2.2 Conditions of survey

Just as the scale of survey has varied considerably across the World Heritage site, so does the natural environment. Factors of varying ground cover, geology, geomorphology and pedology feature here as they play a part in guiding the choice of equipment and methodology. They can also have a significant effect on the quality of the resulting data.

While the permanent pasture at Balmuildy and the parkland at Duntocher, Kinneil and Calendar Park offer little restriction on the choice of methodology, being suitable for both wheeled-GNSS survey and handheld gridded survey alike, the rough grazing encountered at Croy Hill would rule out wheel-based methods. Survey in areas under arable cultivation such as those at Mumrills and Glasgow Bridge-Westermains may often be restricted to certain times of the year, leading to the possibility of sub-optimal results. Finally, in areas with extensive tree cover GNSS-based equipment can prove problematic to deploy as the tree canopy hampers the system's ability to establish an accurate position. This can lead to either extensive unsurveyable areas, as at Seabegs Wood (Chapter 5.5), or restricting survey to the winter months in the case of deciduous flora.

The predominating geological sequences along the course of the Antonine Wall are sedimentary (sandstone, limestone and mudstone), often associated with the coal measures. Much of this bedrock is overlain with glacial till, although other superficial deposits are represented. While these conditions should present few obstacles to geophysical survey, other geologies occur that are considered problematic. For example, the localised occurrence of igneous bedrock (Midland Valley sill complex with quartz and microgabbro) led to the decision not to use the gradiometer survey at Croy Hill (Chapter 4.5) and to use it only on a limited basis at Castlecary (Chapter 5.4). However, caution should be exercised before entirely excluding gradiometer survey, as recent experience has shown that the effects of igneous rock can be variable. At Old Kilpatrick (Chapter 2.1), for instance, where the igneous bedrock might have been expected to have a detrimental effect on data quality, negligible noise was experienced. Where background noise associated with igneous bedrock is not an issue, interest could focus on the three stone sedimentary types and the variations observed in the relative magnitude of the magnetic anomalies interpreted as archaeological features. However, with very limited access to raw survey data it has been impossible to attempt to correlate anomaly magnitudes with bedrock type, highlighting the importance of depositing raw survey data in an accessible archive to allow future re-analysis of the data.

Pedology can also have a detrimental effect on data quality. One such instance occurs in areas with an igneous component in the form of debris within the glacial till, giving rise to background noise in gradiometer data (e.g. Duntocher, Chapter 2.3). Another instance concerns the effects of shallow soil depth on resistance survey. This was observed to the east of the fort at Mumrills where the presence of two very high resistance areas caused by the proximity of bedrock dominated the data to the extent that it largely excluded the detection of any archaeological deposits (Figure 6.5.6). Fortunately, this has been an infrequent issue.

As the previous chapters have frequently highlighted, the integrity of the Antonine Wall has been negatively impacted by the populous and exploited landscape through which it passes. As a result, the geophysical surveys conducted along the Wall reveal a palimpsest of features. Apart from anomalies of a geological or fluvial origin, this palimpsest comprises responses from a range of sources. These include pre-Roman, medieval and post-medieval activity (e.g. Figure 7.2.4), early industrial development (Figure 5.6.2), mineral extraction (Figures 7.5.2 and 7.5.3) as well as post-industrial revolution landscape changes (see section 8.2.3, below, for pipelines and golf course landscaping). These features are in addition to what would be expected from the Roman occupation of the area.

Post-medieval activity probably accounts for the majority of non-Roman features observed within the surveys. While field boundaries, dykes and rig and furrow may be confidently recognised, other anomalies are more difficult to identify. This difficulty arises because they are commonly formed by multiple components including linear and non-linear features. An example is the area some 60m south-west of the triple ditch stubs outside the fort and south of the Antonine Wall Ditch at Auchendavy where a large, curved anomaly of uncertain identification is overlain by some linear ones (Figure 4.1.1). In any case, the focus throughout Chapters 2-6 has deliberately been on features identified as Roman; others interpreted as chronologically earlier or later have not been ignored, but are considered in less detail.

8.2.3 Methods and methodology

Performance evaluation

The surveys reported in this volume have employed a range of methods, led by gradiometry in terms of frequency (Figure 8.2.2) and its capability of covering large areas. Where other methods have been used, notably earth resistance, they have been applied on a lesser scale and have generally been employed to provide complementary information.

The choice of gradiometry as the principal survey method seems to have been justified; it has produced satisfactory results in a wide range of environments and has been capable of sensing the presence of Roman military features. Where the performance of different instruments can be compared in the field – as was possible notably at Rough Castle but also at Duntocher and Kinneil – increased data quality correlates with the increase in the number of sensors, the reduction of sensor separation, shorter sample intervals, and the removal of a need to operate within a measured grid; at these locations, the Sensys MXPDA system generally produced the best quality data (Figures 6.3.5-7; 2.3.6-7; 7.2.4; 7.2.6 and 7.2.9 respectively). Nevertheless, it is expected that the older, grid-based systems will continue to have a limited role to play in areas where hedges, tree/bush cover and other obstacles impair GNSS signal.

The resolution of a gradiometer survey is normally expressed in terms of sensor separation and sample interval. For the grid-based gradiometer surveys a sensor separation generally of 1m or 0.50m and sample intervals usually at 0.25m has normally been employed. This was considered sufficient to resolve the basic detail of most structures, the exceptions being features associated with timber buildings. However, as a sensor separation of 0.5m or 0.25m and a sample interval of 0.125m commonly used with the newer GNSS-based multi-sensor systems become the standard, a revised approach may be required. It may be more beneficial to consider replacing sensor separation and sample interval with point density as a measure of resolution. This approach provides a more consistent measure that allows a direct comparison of resolution between a range of techniques. To give an example, the University of Glasgow's Bartington Grad 601-2 collects 8 points/m^2 and HES' Sensys MXPDA a significantly higher 16 points/m^2; this applies if both are configured with 0.50m sensor separation, but with HES adopting a 0.125m sample interval instead of the 0.25m typically used by Glasgow. As the detection of features associated with timber buildings, and to a lesser extent non-linear features, would theoretically benefit from the adoption of finer sample intervals (see section 8.2.4, below), a higher point density approach should be encouraged.

Earth resistance can be highly affected by a soil's moisture level and thus more broadly by climate and drainage. Where the soil is either too dry or too wet the relative contrast between an archaeological feature and the background decreases, and in extreme cases may not be identifiable. Most earth resistance surveys along the Antonine Wall took place between spring and

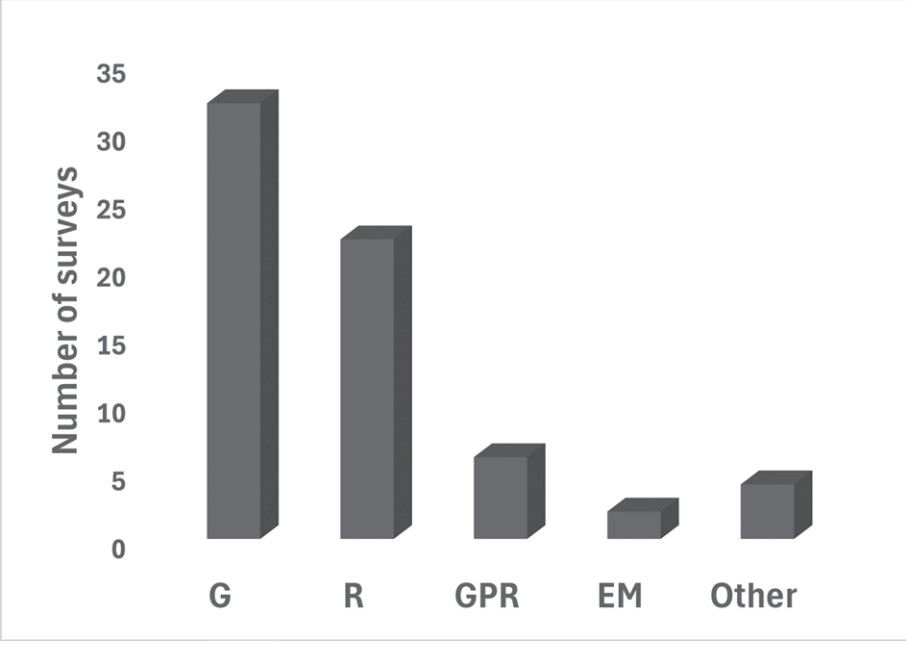

Figure 8.2.2. Number of surveys carried out by gradiometry (G), earth resistance (R), ground-penetrating radar (GPR), electro-magnetic (EM) and other (magnetic susceptibility, electrical profiling and seismic refraction).

late autumn. While this timing reduced the chance of surveying in waterlogged areas, especially low rainfall could be experienced, although, in the event, none of the surveys reported appear to have been unduly affected by this phenomenon. Nevertheless, localised unexpected results were reported at Summerston to Balmuildy Bridge and Glasgow Bridge to Westermains (Chapters 2.8 and 3.4). These were perhaps in part a consequence of measurements being taken in February so that isolated areas of waterlogging may have been experienced. A series of seasonality tests carried out in a Scottish context would be desirable, usefully complementing the well-known study in (mainly southern) England by Clark (1990: 48-56) and that in Ireland (Bonsall *et al*. 2014: 97, 101-3 and Figs 32-33).

Most earth resistance systems offer the facility to operate their probe arrays in numerous configurations (e.g. twin-probe, Wenner, Schlumberger) and for readings to be taken at variable probe separations. As would be expected, the choice of configuration, probe separation, sample interval and traverse separation affect the results achieved (Gaffney and Gater 2010: 26). The large majority of surveys on the Antonine Wall used a twin-probe configuration with 1m probe separation and sample interval (where the metadata was reported). There were a few cases of a smaller sample interval being employed to increase resolution, as in the area close to the fort at Auchendavy (Chapter 4.1). The value of adopting 0.5m and 1m probe separations in mapping the line of the Ditch was well demonstrated at Summerston (Figures 2.8.6-7) but, these examples apart, the lack of systematic experimentation with different configurations and probe separations excludes useful comment on their relative suitabilities in the context of the Antonine Wall. At only these two locations (Figures 4.1.8 and 2.8.5) was electrical profiling additionally carried out.

GPR has thus far been employed in only a limited fashion along the Antonine Wall (Figure 8.2.1). Short stretches of the Ditch and Rampart were detected at Wilderness Plantation (Figure 3.2.5) and Summerston (Figure 2.8.5), and the technique satisfactorily defined some of the roads within the fort at Rough Castle (Figure 6.3.8). The technique proved invaluable west of the fort at Auchendavy, where interpretation of the gradiometer and earth resistance data had proved difficult due to the levels of noise in the data. Here the rectangular structure of a bathhouse emerged from the GPR timeslices at 30 and 35ns depths, as did the line of the rampart (Figure 4.1.7). It also clarified and reinforced the responses obtained from the unusual ditch configuration outside the north-west corner of the fort apparent in both the gradiometer and resistance surveys, adding confidence to the interpretation (Figures 4.1.5 and 4.1.6). At Seabegs Wood the approach has been used in a supplementary fashion to gain additional information about features identified in the gradiometer data (Chapter 5.5). Specifically, timeslice data helped interpret the feature adjacent to the modern track as a post-Roman farmstead (Figure 5.5.7) and confirmed that the disturbance observed crossing the surveyed section of the Military Way was a modern drain. A small-scale survey was also conducted across the line of the well-preserved Ditch and Rampart to assess the equipment's effectiveness. Analysis of the radargram of the Ditch (Figure 5.5.5) demonstrates GPR's ability to identify its profile, although the 450MHz antenna employed was unable to reach its base, probably due in part to the prevailing weather conditions at the time of survey. Temperatures of around -4°C caused the top layer of the Ditch fill to freeze giving rise to 'ringing' in the top 10ns of the data. Similar analysis of the radargram of the Rampart (Figure 5.5.5), following topographic correction, showed its base at around 40ns from the surface, equivalent to a depth of *c*. 1.6m, which lay outside the gradiometer's detection range. The value of the GPR data at Seabegs further lay in demonstrating the quantity of colluvium that had built up to the south of the rampart, on the assumption that the rampart base indicates the original Roman ground level. With this depth of colluvium, gradiometer survey is unlikely to have been effective and so was unable to detect negative features cut into the Roman levels here.

Future potential targets for GPR survey should surely include the possible bathhouses at Castlecary (Figure 5.4.7), Mumrills (Chapter 6.5) and Inveravon (Chapter 7.1). Assessing the technique's performance as a larger-scale prospection tool on the Antonine Wall would also be desirable. The 0.7ha survey at Rough Castle (Chapter 6.3) is the largest of its kind to date. Recent work at Newstead, undertaken by AOC and commissioned by the Trimontium Trust (AOC 2022) has shown the quality of results that can be obtained, a pattern already seen from work at Roman towns in England, notably in Insulae VI and XIV at Verulamium (Lockyear and Shlasko 2017: 28, Fig. 10).

EM survey is not a new archaeological prospection method, the technology having been available since the 1980s, yet it has not been commonly employed in the UK. With Historic Scotland Foundation funding, HES has been able to purchase a GF instrument, the CMD mini Explorer, to test the suitability of EM survey as an alternative to gradiometry and earth resistance where use of those methods is precluded due to a site's remote location or ground conditions. An additional aim is to investigate what additional information EM survey can provide beyond the picture obtained by gradiometry. This work is still in its early experimental stages and so far has been limited in scale, but EM offers a new dimension to multi-technique approaches

to geophysical survey. Early results are promising: the course of the Ditch at two locations at Kinneil House (Chapter 7.2) and the rampart base at Duntocher (Chapter 2.1) have been identified, and the Military Way is clearly visible at Seabegs Wood (Chapter 5.5). These small-scale, complementary surveys should continue as they provide a valuable benchmark against more established survey techniques and, as with GPR survey, should be scaled up to cover larger sized areas.

Data processing

Following data collection, processing takes place leading to a graphical presentation of the results. For this purpose, software from a variety of sources has been employed in the work presented in this volume (Table 1.2), though it may conveniently be divided into three types: proprietary (such as Geoscan's commercially available Geoplot), open-source and developed in-house. Although such a range can sometimes render results from individual surveys difficult to compare directly, this has not been a significant problem in the programmes of survey reported on here. Some of the common algorithms employed in these software packages are well known and have been applied regularly (see Table 1.2; Schmidt *et al.* 2015: 100-104). Furthermore, there is a clear consensus from the results of this work, as well as more widely in the UK, that, in terms of presentation, grey-scale plots give a very adequate visual picture. On the debit side, it is the case that the software package and the processing steps (including the parameters) used in the Antonine Wall datasets are not always explicitly stated in the individual reports. It suffices to say that it should be normal reporting procedure for such information to be provided.

Despite most of the surveys along the Antonine Wall being processed in a fairly standard way, the accumulated datasets obtained offer the opportunity to apply more experimental procedures that can resolve difficulties in, for example, enhancing anomalies either weakly resolved or suppressed by the nearby presence of metal pipelines. To this end, Hinz (2006) usefully explored the application of directional and adaptive filtering algorithms in Image Processing Toolbox™ to the gradiometer data obtained at Balmuildy (Figure 4.1.4).

Future developments

The potential importance of excavation in confirming geophysical survey results requires consideration. Excavation cannot routinely be conducted on a scheduled monument within a World Heritage site simply to check geophysical survey results, as this would conflict with the benefit of the survey's non-invasive character. But where opportunities do arise, such as when legitimate work is required that will potentially disturb the monument's remains and a watching brief or test excavation is specified, survey should be undertaken in advance. In this way any features observed can be checked against the excavation results thus creating a feedback loop. This is recognised as an issue within the sphere of field archaeology generally (Jones 2024), bearing in mind that such validation may either not be carried out or is not reported systematically. In the case of the Antonine Wall the reality is no different. Apart from a very few instances, for example the possible presence of the Wall at Girnal Hill being subsequently shown to be a geological feature (Chapter 4.4), there has been a lack of coordination between survey and excavation programmes.

The combination of geoarchaeological methods, specifically geochemical, with geophysics has considerable potential. For example, the gradiometer and resistance (as well as cropmark) responses encountered at ditches forming Iron Age enclosures in the Upper Clyde Valley (Sharpe 2004; see section 8.2.4 below) and Neolithic ring ditches at Forteviot, Perthshire (Cuenca-Garcia 2018) have been explained in terms of the underlying soil chemistry. Such an approach could find not only a similar application along the Antonine Wall, but also one directed towards investigating how space was used, rather than simply with locating structures or features (Jones 2024). As discussed in Chapter 8.1.3 and in section 8.2.3 below, suitable targets for the latter investigation may be annexes and extra-mural settlement. In both cases, following gradiometer and electro-magnetic surveys, a programme of systematic soil sampling would provide material for multi-element and organic analysis, pH and magnetic susceptibility measurements, as well as micromorphological analysis.

To begin with multi-element analysis of soils, the first aim should be to identify locations that have contrasting distributions in more than one chemical element; where a spatial correlation can be established with the corresponding data from geophysical and other sources, these locations would merit further attention. Although in principle a next step would be to attempt to associate the location's chemical signature with a particular activity, the present consensus, based on a wide-ranging review of geochemical studies (Bintliff and Degryse 2022) including the relevant and important ones in Scotland (Wilson *et al.* 2008; 2009), is that this is usually unrealistic. Whereas the identification of areas of, for instance, iron working that had not been reused for another activity should be detectable owing to their high iron contents (and raised magnetic susceptibility values), the more common situation may be considerably weaker: an association

between chemical composition and activity that is indicative of a broad trend of activity (Bintliff and Degryse 2022: Table 1) rather than a specific one. This is due mainly to the realisation that on the one hand contrasting activities may be associated with similar elements, albeit at differing concentration levels, and on the other the influence of site-specific factors related to the local soils that need to be accounted for. In this light, the questions asked of elemental data in Antonine Wall contexts should be modest: do the geochemical anomalies correlate spatially with those observed in other measurements? Is there, for example, a correlation with magnetic susceptibility in extra-mural domestic contexts in defining potential (hearth) ash spreads (Church and Peters 2004)? Conversely, can certain activities, even if only broadly defined, be excluded?

At the practical level, attention should be given to the technique of elemental analysis. Although not without limitations, the portable version of X-ray fluorescence (pXRF) is increasingly regarded as an efficient, cost-effective and non-destructive technique (Taylor *et al.* 2023, 2). Williams *et al.* (2020) have demonstrated that it yields higher quality results when employed under controlled laboratory conditions than in the field. Of the elements that commonly feature as potential markers, such as Cu, Zn, Sr, Mn, Pb and Mg, phosphorus (P) is the most well known due to its enrichment in human refuse and waste, burials and animal products, including excreta. But, on its own, this element may be unable to define reliably an accumulation of excreta. For example, phosphate (and magnetic susceptibility) determinations failed to support the proposal that the red-brown, probably iron-rich stains observed in soils in some barrack blocks at Elginhaugh fort were the result of deposition of animal urine (Jordan 2007). However, a new approach, although not yet applied in Britain, looks promising: Abell *et al.* (2019) showed that the concentrations of Na, Cl and nitrate (NO_3) present as soluble salts in dung and midden soils at a Neolithic settlement in Anatolia could be best explained as a result of the accumulation of animal (and human) urine.

Turning to organic compounds that are capable of extraction from soils, 5β stanols are found to be a reliable biomarker for faeces. Already familiar in connection with the latrine at Bearsden fort (Knights *et al.* 1983), this marker could guide where animals were stalled or tethered within an annexe and, together with certain lipids (as well as elemental data: Davidson *et al.* 2007), the stanols are able to shed light on manuring practices (Simpson *et al.* 1999). Species differentiation of faeces is now also possible (Harrault *et al.* 2019; Taylor *et al.* 2023: Table 1).

8.2.4 Interpretation

The interpretation of archaeological geophysics is a complex task; the process relies on individual skill and judgement and is heavily dependent on experience. It requires archaeological features to be identified from a range of anomalies in the survey data, excluding those from other causes such a geology or farming practice. In some cases a feature may be formed of a single anomaly and in others from a pattern of anomalies. This recognition is achieved by analysing each anomaly's size, shape and the nature of its response. For archaeological features to be interpreted accurately the interpreter needs not only to understand geophysical survey, but also to have an understanding of the type of site that is being surveyed. In the case of this volume, with its very specific chronological focus, this is demonstrably the case (see Chapter 1, sections 1.5 and 1.7). While features of likely pre-Roman date (see Chapter 8.1.7) and, much more commonly, those of later date have been recognised, their identification has not received the same rigorous treatment here.

As set out in Chapter 1.6, examination of the Antonine Wall involves numerous different archaeological targets, ranging from the various elements of the linear barrier itself, via the Military Way and the interiors of forts and annexes, through to extra-mural settlement. Discussion of issues involved in their interpretation is outlined below.

The Antonine Wall Ditch manifests in the gradiometer data as a band of negative, usually strong readings often bordered by narrow bands of positive readings on one or both sides (e.g. Figures 3.1.3, 3.4.4, 4.1.1, 4.2.6, 7.1.2 and 7.2.4). The Ditch fill is, therefore, associated with a lower magnetic gradient than the surrounding undisturbed soil. The gradiometer response of fort/annexe and fortlet ditches is similar, but more variable in strength, as demonstrated at the forts at Balmuildy (Figure 3.1.3), Duntocher (Figs 2.3.6 and 2.3.7), Mumrills (Figure 6.5.5) and Carriden (Figure 7.6.4), and, given their less substantial nature, impressively at the fortlet at Glasgow Bridge (Figure 3.4.4), though less so at Kinneil (Figures 7.2.7 and 7.2.9). This picture concurs well with that found at Roman forts elsewhere in Scotland, such as Newstead (graphics conveniently viewed in Schmidt 2001: Fig. 1), Dalswinton, apart from ditches deliberately filled with burnt debris or rubbish (Hanson *et al.* 2019: Fig. 10), and Drumlanrig (Walker *et al.* 2005). But, as alluded to in Chapter 1.6, it contrasts with the positive anomaly frequently detected elsewhere, such as on the Vallum and in the fort ditches on Hadrian's Wall at Halton Chesters, Birdoswald, Castlesteads and Carrawburgh (Taylor *et*

al. 2000; Biggins and Taylor 2004b; Biggins and Taylor 2007; Hobson 2022). It is recognised that because of the variability of factors giving rise to the magnetic response of a ditch, irrespective of its date or form, this archaeological feature cannot be expected to exhibit a uniform response across Britain. Nonetheless, the contrast between the respective findings encountered on essentially similar features on the two Walls is striking.

Two major interrelated factors that give rise to the response over a ditch – whether positive or negative – are the magnetic contrast between topsoil and subsoil and the nature of the ditch's infill. But other factors may be equally important, including variable moisture content in the soil leading to changing reducing/oxidising (redox) conditions and thus the relative proportions of magnetic and non-magnetic iron oxides (Fassbinder 2017). These are likely to be relevant in explaining the contrasting responses (supported by corresponding magnetic susceptibility measurements) over Iron Age enclosure ditches at two neighbouring locations in the Upper Clyde Valley south of the Antonine Wall observed by Sharpe (2004: Table 6.12).

Other mechanisms, induced naturally or by human intervention, can also play a part, the former probably being dominant in the case of Iron Age enclosure sites in the environs of Traprain Law south-east of the Antonine Wall. Here the ditches were found to give consistently positive anomalies except where they had been dug through igneous-rich strata, in which case the ditch infill would naturally be less magnetic than the surrounding soils (Hale *et al.* 2006: 71; Hale and Cowley 2009). A combination of the effects of geological and other conditions may be observed more dramatically in southwest England, where survey of a prehistoric field system in Cornwall revealed a variety of responses over buried ditches (Gaffney and Gater 2010: 123-124 and Fig. 56).

Returning to Hadrian's Wall, bedrock geology alone cannot explain the contrast with the Antonine Wall since the magnetic susceptibility values of the common bedrock types – sandstone on the Antonine and limestone (other than in the sector along the Whin Sill) on Hadrian's Wall – are usually low. Taylor *et al.* (2000: 40), referring to when and how the infill occurred at Halton Chesters, explained the high positive response of the Vallum in terms of its gradual infilling with deposits that had an organic component. That circumstance, they suggested, would have resulted from the feature remaining open for a considerable period. To use the reverse of that argument to explain the situation on the Antonine Ditch – that it infilled quickly – could be justified in geophysical terms on the basis that the infilling used material other than topsoil, such as that from the Rampart (S. Ovenden pers. comm.). But that does not seem to be reconcilable with the data, given the number of sites where the Ditch remains extant, and even more examples where it was still sufficiently visible to feature in antiquarian accounts or in early mapping. Instead, the Ditch probably infilled at varying rates at different times, and yet, irrespective of location and terrain, it still gives rise to a consistent negative response, albeit with local variations.

For the time being, although the discrepant findings at the two Walls (and beyond) remain a paradox, attention should focus on what may be the critical factor, the relative proportions of magnetic enhancement in the topsoil and the subsoil in contact with the ditch infill, their ratio being subtly governed by climatic and other conditions. The process of achieving a satisfactory explanation would be helped by undertaking a programme of coring. This approach would involve taking magnetic susceptibility measurements and conducting iron oxide characterisation by X-ray diffraction of cores taken through both the Ditch (and fort ditches) and to their sides at several locations along the Antonine Wall. A similar programme would be required on Hadrian's Wall, including some locations where survey has already taken place, to allow a direct comparison. In any case, the basic point remains that the gradiometer does not seem to give a uniform response to Roman ditches in northern Britain.

The corresponding response from earth resistance may now be considered. As expected, low resistance values over the Antonine Ditch were detected at several locations usually with clarity, often sharply, as at Glasgow Bridge and Shirva (Figures 3.4.5 and 4.2.5). The double ditches in front of the fort at Auchendavy were similarly apparent and with equal clarity in the very limited area surveyed (Figure 4.1.6). But the results from Summerston and Glasgow Bridge demonstrate that this response may not be constant across the frontier. Areas 1 and 2 at Summerston (where readings were taken at both 0.5m and 1.5m probe separations) are positioned less than 200m apart. Here the Ditch appeared as double and single bands of low resistance respectively, in both cases more clearly at 1.5m probe separation (Figure 2.8.6). 500m away in Area 3 the Ditch appears as a strong high resistance anomaly and in Area 4 it alternates between low-higher-low readings, in this case better resolved at 0.5m separation (Figures 2.8.7 and 2.8.8). As the greyscale scale indicates, the resistance values in Area 3 are not only significantly lower than in the other areas, indicating that the soil here was more porous, but their ranges are much narrower than elsewhere.

The same phenomenon occurred in the Glasgow Bridge to Westermains sector. Lying between two stretches

where the Ditch was clearly recorded as low resistance (Areas 1A and 2) were two small areas (Area 1B and 2006) in which the opposite response occurred. Here, Figure 3.4.5 shows that bands of respectively well-defined high and weaker higher resistance were bordered by lines of lower values. The likely explanation for these discrepancies lies in localised variations in the subsoil, more specifically the greater drainage capacity of the upper layers of the Ditch fill. It may not be a coincidence that both surveys were carried out in February when wet weather would be expected. This phenomenon has been observed elsewhere, for instance over the ditches at one of the Iron Age enclosures in the Upper Clyde Valley investigated by Sharpe (2004: 177 and Table 5.4), as referred to above, and in the Vallum ditch at Crosby-on-Eden towards the western end of Hadrian's Wall, where the surrounding ground was waterlogged at the time of the survey (Gater 1981: 6-7). Gaffney and Gater (2010: 27 and Fig. 5) suggested that the top of the Vallum ditch had dried preferentially due to water draining to the lower part of the feature. Subsequent excavation there showed it to be flat-bottomed (unlike the Antonine Ditch), rather shallow (1.6m deep) with steep sides *c.* 7.5m wide at subsoil level with infill consisting of turves and then clay (Bennett 2009: 125-28 and Fig. 233).

Fort ditches are also recorded as low resistance anomalies, as at Balmuildy, Castlecary and Mumrills (Figures 3.1.4a; 5.4.7-8 and 6.5.6). These results are in line with those found elsewhere, for instance at the forts at Ardoch (Jones *et al.* 2006a: Fig, 2.5b), Fendoch (Woolliscroft and Hoffmann 2006: Fig. 20) and Newstead (Schmidt 2001: Fig. 1:b). An exception seems to be the case at Castlehill, where interpretation of the complex resistance graphic (Figure 2.5.7) suggests the fort's eastern and southern ditches are associated with a weak increase in resistance. The former may reflect a more compacted infill with lower moisture content, and the latter ditches, lying on the fort's sloping southern flank, may have been subject to drainage conditions of the kind mentioned above.

The Rampart of the Antonine Wall survives to varying degrees along the line of the frontier. In some areas, such as Seabegs Wood (Chapter 5.5) and Bonnyside (Chapter 5.6), it survives as an impressive earthwork, whilst at others, such as Duntocher (Chapter 2.2) and Kinneil (Chapter 7.2), there are no visible remains above ground, only stretches of its stone base hidden beneath the turf. As the line of Rampart has been surveyed in multiple areas, examples of data for varying levels of survival are available for comparison. In areas where preservation of the superstructure is poor, the line of the Rampart regularly appears in the gradiometer data as either a band of mottled mixed positive and negative, medium to high magnitude anomalies or a medium magnitude positive response, both of which are apparent at Castlehill (Figures 2.5.5 and 2.5.6). In some cases, this is associated with a negative anomaly, such as at Duntocher, Glasgow Bridge and Mumrills (Figures 2.3.6, 3.4.4 and 6.5.5). In areas covered by earth resistance a band of higher readings was observed, most clearly visible at Mumrills (Figure 6.5.6). A stretch of poorly surviving Rampart has not yet been covered with GPR. Each of the responses detailed above are best associated with survival of the Rampart's stone base beneath the turf, so in areas with no response it is reasonable to assume that little or none of the base material survives in situ. This shows that geophysical survey is well placed to establish the sub-surface survival of the Rampart base in areas where there is no associated earthwork.

If we now turn to areas where the Rampart survives as a substantial earthwork, a very different picture emerges, as is particularly evident at Seabegs Wood (Figure 5.5.4). If the line of the rampart is examined where it is clearly visible in the LiDAR data (Figure 5.5.3), no associated anomalies are visible in the gradiometer data. It is clear that, whereas the gradiometer is unable to sense the Rampart's stone base through the surviving superstructure at this location, the small sample of GPR data collected (Figure 5.5.5) shows a surviving section of stone base at a depth of around 40ns (*c.*1.6m). The gradiometer data collected at Bonnyside (Figure 6.2.3) shows a similar but more complex pattern. Again, if the LiDAR data (Figure 6.2.2) is examined, the line of the surviving Rampart superstructure can be seen clearly. Towards the east of the surveyed area a situation similar to Seabegs Wood is apparent, with no anomalies associated with the surviving superstructure. However, towards the centre of the survey two broken parallel positive linear anomalies of medium magnitude appear to mark the northern and southern edges of the Rampart base. Finally, at the western end of the survey area the situation changes again, with the Rampart represented by a band of mottled mixed positive and negative, medium to high magnitude anomalies, as it is at Castlehill.

There is a simple explanation for these variations in response. Towards the west of the survey area at Bonnyside the Rampart superstructure survives to a much lesser extent than in the east, with the situation in the centre falling somewhere in between. This data demonstrates that in areas where the turf superstructure of the Rampart survives to a limited extent, its stone base is almost entirely detectable with a gradiometer; in the central area where a greater amount of superstructure remains intact, only the kerbs at the edge of the stone base are visible where the

overburden is least; and, as at Seabegs Wood, in areas with substantial superstructure survival the Rampart base in not detectable at all.

For similar reasons the response of fort ramparts is variable. They are generally represented as positive gradiometer anomalies, whether stone-built, as at Balmuildy where they are well defined (Figure 3.1.3), or in the case of the more usual turf construction on a stone base, as at Castlehill and Westerwood (Figures 2.5.6 and 5.1.5). On the other hand, the corresponding situation at Rough Castle, where the turf superstructure survives well, is a very weak positive (Figure 6.3.5), while at Duntocher, where rampart survival is less good, the front and rear stone kerbs appear as negative and positive-negative anomalies respectively (Figures 2.3.6 and 2.3.7). This contrasts sharply with the mottled positive-negative response from the rampart of the fortlet, which is discussed later in this section. Well-defined high resistance is recorded in the cases of the stone ramparts at Balmuildy and Castlecary (Figures 3.1.4a, b and 5.4.8), and probably in the turf rampart at Castlehill (Figure 2.5.7). However, the equivalent feature at Duntocher, like the fortlet rampart, registers as a broad band of low resistance (Figure 2.3.9), though with a mottled positive band marking the line where the rampart had been broadened. Similarly, at Mumrills the section of the fort's rampart, to the north of the east gate appears as a narrow line of low resistance (Figure 6.5.6). GSB suggested that this reversal of the expected response may be a consequence of the site's excavation (2007e: 7) with the backfill retaining more moisture than the surrounding area. While this may well be the case, it is not an entirely satisfactory explanation for a stone base resting directly on the subsoil, although the authors are not able provide an alternative explanation.

Examination of the interiors of forts was included in a number of surveys, whose contribution to our understanding is discussed above (section 8.1.4). The results obtained at Balmuildy and Rough Castle are of particular interest since they can be viewed in the light of their respective excavation plans (Chapters 3.1 and 6.3). Of the two surveys at Balmuildy, the gradiometer (Figure 3.1.3) performed considerably better than the earth resistance (Figure 3.1.4a, b), the former resolving the walls of the buildings in the central range as positive anomalies, the latter detecting those of the granary to the east of the headquarters building with the expected high values. That the stone structures were not conforming to the expected negative gradiometer anomalies is surprising, yet it finds a direct parallel at Rough Castle, where part of the commanding officer's house is revealed as a positive gradiometer anomaly (Figure 6.3.5), and at Mumrills where the equivalent building is clearly revealed as a positive gradiometer and low resistance anomaly (Figures 6.5.5 and 6.5.6). GSB (2007e: 4) suggested that the gradiometer response could be explained if the foundations were constructed of brick or strongly magnetic stone. This explanation is unlikely as brick was not observed during the excavation and, if the stone was locally sourced, it would probably be sandstone or limestone, which has low magnetic properties. At Wroxeter Gaffney *et al*. (2000: 92 and Fig. 6) noted that some walls, especially in the north-east quadrant of the town (Field 5), appeared as positive anomalies possibly as a result of becoming magnetically enhanced when the building was destroyed by fire. Such an explanation might potentially be applicable at Mumrills, where the excavators record the destruction by fire of an earlier timber phase of the commanding officer's house (Macdonald and Curle 1929: 439-440), but would not apply to either the *principia* or adjacent granaries at Balmuildy, which provided no such evidence of localised burning. Whatever the full explanation, it should also apply to Rough Castle and be consistent with the low resistance encountered at Mumrills in the commanding officer's house. Again GSB suggest that these low resistance readings may be a consequence of the site's excavation (2007e: 7). That explanation seems more appropriate for the footings of a stone building than for the fort ramparts, as the wall foundations would have been dug into the subsoil so that there was a greater potential for their soil backfill to retain moisture, thereby giving rise to low resistance readings.

Where they are built on separate post-holes rather than posts set in construction trenches, as was the case generally within forts in the Antonine period (Hanson 1982: 177-78 and Table 9.2), the identification of timber-built structures such as barrack blocks is notoriously difficult. Even in cases where the positions of those buildings are known from excavation, as at Balmuildy (Chapter 3.1) and Rough Castle (Chapter 6.3), geophysical survey has failed to identify them. Pinpointing their position relies on recognising patterns of postholes within the survey data. To allow identification, each posthole needs either to contain an element of stone chocking, magnetically enhanced material (such as burnt material if the building was destroyed by fire), or to have a water retention contrast with the surrounding subsoil. No clear-cut examples have been recorded in the Antonine Wall forts, with the possible exception of Westerwood (Chapter 5.1) and within the annexe at Rough Castle (Chapter 6.3). This lack of visibility is likely to be a result of survey resolution, as gradiometer survey with a sensor separation of 1m is not suited to the detection of, and is unlikely to identify, individual postholes. If this is an aim of the survey, significantly higher resolution is required. Also high background noise may mask any anomaly reflecting the presence of a post-hole. That the detection of the larger pits dug for the *cippi/lilia*

has not been straightforward exemplifies the problem (see above, section 8.1.1). The same difficulty is echoed below with reference to similarly built structures in extra-mural settlements.

Probably because of their varying state of preservation, internal roads have not been represented consistently. At Balmuildy the intervallum road is a well-defined positive gradiometer and high resistance feature (Figures 3.1.3 and 3.1.4a), and the *via principalis* at Rough Castle (Figure 6.3.5) appears as a positive-negative anomaly and a high amplitude GPR signal (Figure 6.3.8), although this may in part be due to modern treatment of the visitor path which overlies it. On the other hand, delineating the same road at Castlehill is a weak broad negative response (Figure 2.5.5). For comparison, in southern Scotland, for instance at Dalswinton and Drumlanrig forts and in Newstead west Annexe (Hanson *et al.* 2019: 306-07, Fig. 8; Walker *et al.* 2005: Figs 2 and 4; Clarke 2000: Illus 3-4), internal roads, if recognisable, appear as negative anomalies and with higher resistance.

The relative failure of geophysical survey to locate the Military Way can be attributed to the damage caused over time by stone robbing and the effects of ploughing. Thus in the *c*.1km of the frontier surveyed in the Kinneil Estate, no trace of it was observed (Chapter 7.2). At only a few locations can it be clearly identified, albeit with somewhat contrasting responses owing to its varied condition and in particular the presence or absence of bordering ditches. To the west of Rowan Tree Burn at Bonnyside East it is barely distinguishable as a narrow band of discrete positive responses with no clear flanking ditches, despite being clearly visible as a topographic feature in the LiDAR data (Figure 6.2.3). Stretches of it close to the forts at Bar Hill (Figure 4.3.7) and Westerwood (Figure 5.1.5) display a similar response with an intermittent central anomaly bordered by narrow positive bands, although this phenomenon may be due to differential survival of the road surface, as plough damage is more likely to affect the raised central section of a cambered surface than the lower kerbed edges. In contrast to this, along another stretch immediately beyond the fort ditches at Westerwood the central positive band is more prominent, but the borders appear as negative features. Elsewhere, a short possible trace was found in resistance mapping and profiling in Area 3 at Summerston (Figure 2.8.7) and possibly at Mumrills (Figure 6.5.5). Only at Seabegs Wood have multiple survey techniques been employed to investigate the Military Way (Chapter 5.5). Here, as at Bonnyside, it survives as visible topography, as is again evident in the LiDAR image (Figure 5.5.3), so was expected to be readily identifiable. The results of the gradiometer survey (Fig 5.5.4) show the road surface as disparate positive anomalies concentrated along the edges of the road probably marking the positions of the larger kerb stones and suggesting a poorer level of survival of the metalling towards the centre of the road, but it fails to identify any flanking ditches. However, a slightly different view appears in the magnetic susceptibility and GPR data: the former shows the road as a more consistent band of high readings and corresponding low conductivity levels; in the latter the road surface appears as a band of high amplitude GPR readings observed at multiple depths. In neither case are flanking ditches readily visible. Although based on an individual example, this multi-method approach shows its value, with the gradiometer best able to map the positions of the larger kerb stones, but the EM and GPR more capable of sensing the entire road surface. Further experiment along the line of the Military Way is required to see if this pattern is mirrored elsewhere. Other communication routes outside the forts have fared little better; a notable exception is the road leaving the eastern annexe at Carriden which was detected with some confidence due to the linear negative anomaly from its associated ditches (Figure 7.6.4).

In contrast to the situation along Hadrian's Wall, where geophysical survey has found ample traces of extra-mural settlement, the corresponding evidence along the Antonine Wall is distinguished by its absence. The environs of Balmuildy received the largest survey effort in this respect (Figures 3.1.5 and 3.1.6) but failed to reveal positive results, due perhaps in part to intensive modern agricultural activity having erased remains of such settlement. Nor was it detected in the admittedly limited resistance survey at Croy Hill (Figures 4.5.1 and 4.5.2), despite having been documented there archaeologically (Chapter 4.5). Although aerial and LiDAR data indicates extra-mural activity at Rough Castle, primarily in the form of a field system to the southeast of the fort (e.g. Figure 6.3.3), the area between the field system and the fort is not readily accessible to geophysical survey because of the dense tree cover. The best geophysical evidence to date has been achieved at Carriden where the presence of a field system immediately east of the eastern annexe, originally identified from the air, is apparent as a series of negative linear anomalies (Figure 7.6.4). This contrast between the two Walls is largely due to the ubiquity of stone-built structures within the civilian settlements along Hadrian's Wall, for example at Maryport and Birdoswald (Biggins and Taylor 2004a; 2004b), whereas the known equivalents on the Antonine Wall appear to have been of timber construction with the same difficulties of recognition as barrack blocks (see above). The general absence of stone buildings in extra-mural settlements is directly linked to the time-depth of their occupation. It is now generally accepted that the Antonine frontier was occupied for less than 20 years

(Hodgson 2009), compared with over 250 for Hadrian's Wall,[5] the latter leading to a greater accumulation of occupation material and the formalisation of structures in stone, primarily from the third century onwards.

But the character of the buildings is not the only factor. At Croy Hill the high background resistance readings in the area, the stronger response from the post-Roman farming activity and the very stony boulder clay subsoil will all have contributed to the failure to detect the extra-mural activity. Had conditions been suited to gradiometer survey and so long as there was a magnetic contrast between the post-holes associated with the timber structures and their surroundings, readings taken at a sampling interval of 10cm or better would in principle be capable of resolving those features despite their shallow depths (mostly <20cm) and widths (<30cm). Detection of other features excavated in this area such as the (stone-filled) gullies and the Iron Age palisade trench may also have been capable of at least partial detection.

The area of the gradiometer survey encompassing the Military Way west of Westerwood fort (Figure 5.1.5) overlapped minimally with the location of timber structures that were probably part of an extra-mural settlement (Keppie 1995: Fig. 1: 1987-1). But despite operating at high resolution (12.5cm sampling interval), the magnetic noise encountered through the area surveyed (see below) would have made detection of those structures a challenging task. Such a sampling interval (or better), coupled perhaps with magnetic susceptibility measurements, will be required to progress this enquiry, but only so long as the location meets the crucial requirement of minimal background magnetic noise. This demanding condition greatly constrains candidate locations, but we suggest, as a start, that Carriden could be one of them in view of the field systems situated east of the fort (Figure 7.6.4) as well as the altar dedicated by occupants of the *vicus* which was erected nearby (see Chapter 7.6).

Some modern interventions have significantly impacted our ability to interpret archaeological information at a number of the sites investigated. The most striking examples are pipelines or utility trenches which affect gradiometer survey, such as at Balmuildy (Figure 3.1.4), Wilderness Plantation (Figure 3.2.4), Auchendavy (Figure 4.1.5), Shirva (Figures 4.2.6 and 4.2.8), Bonnyside (Figure 6.2.3), Callendar Park (Figure 6.4.3) and Inveravon (Figure 7.1.2). In addition to such provisions, there are a number of interventions, some aimed at helping visitors to a site, which have negatively affected the data. The modern metalling of part of the course of the Military Way just west of Rough Castle (Figure 6.3.5) has masked the underlying Roman structure, while the railings installed around the exposed section of the Rampart base at Duntocher generated a halo that prevented the gradiometer from detecting the Rampart base in the neighbouring areas (Figure 2.3.7). The recent tendency to install large pieces of public artwork can also have a detrimental impact, as in the case of the example to the west of the church in the Meadows within the Kinneil Estate which rendered its surrounding area unsurveyable by gradiometry (Figure 7.2.6).

Scotland's love of golf has also impacted detrimentally on the results of survey at several locations. Interpretation of the data obtained at Cawder was not aided by the landscaping that had taken place to create parts of Cawder golf course (Chapter 3.3), and a similar intervention at the golf course just south of the fort at Westerwood seems to have introduced some clinker-like material into the soil. This has caused high levels of noise in the gradiometer data making the detection of any potential extra-mural settlement impossible (Figure 5.1.5).

Nor should the impacts of previous excavations be underestimated. While survey has been able to clearly detect the stone base of the fortlet ramparts at Duntocher very clearly, their width is considerably greater than was indicated by excavation (Chapter 2.3; Figures 2.3.6-7 and 2.3.9). This may be due to the way the re-excavation of the fortlet in 1977-78 was backfilled with material, perhaps including clinker. Similarly, at Rough Castle the backfilling of the bathhouse excavation spread highly magnetic burnt material across the whole area effectively masking any detail of the structure and its immediate surroundings (Figure 6.3.5). The partial reconstruction of some structural elements of the fortlet at Kinneil for the purpose of public display, including the use of concrete slabs to demarcate its presumed outline, not only generated dipolar gradiometer anomalies potentially masking adjacent signals, but introduced misleading resistance readings from the rampart, even where no remains had been visible in the excavation (Figures 7.2.8-9 and 7.2.11). The lesson from all these examples is that geophysical survey should be encouraged before any future interventions take place to ensure that valuable information is not lost. This did occur recently and effectively at Old Kilpatrick, where survey was undertaken before the planting of a community woodland by Forestry and Land Scotland (Chapter 2.1).

A final point to make is the presence of a palimpsest of anomalies in many, if not most, of the graphics presented in Chapters 2-7. The majority of these

[5] However, the majority of extra-mural settlements on Hadrian's Wall seem to have come to an end by *c.* 270 (Hodgson 2017: 150-52). Nonetheless, that still represents civilian occupation lasting at least seven times longer than on the Antonine Wall.

features are in all likelihood not Roman. Some of them are almost certainly geological in origin, such as at Mumrills where the proximity of bedrock is discernible in the survey data (Figure 6.5.5). Some clearly predate the construction of the frontier, such as the native enclosure bisected by the Ditch just west of the north gate at Rough Castle (Figure 6.3.5), but most should be regarded as post-Roman. While those in the form of post-medieval field boundaries and dykes, as well as rig and furrow, may be confidently recognised, it is admitted there are others that defy ready identification. As noted above (8.2.1), one example can be seen some 60m south-west of the triple ditch stubs outside the fort at Auchendavy (Figure 4.1.1).

To conclude, of the three parameters identified at the start of this section that guide the interpretation of geophysical anomalies, their shape, size and the nature of response, the first two remain unquestioned in the way they represent the essential form of the feature. While the third also has an important role to play, it cannot be relied upon alone or uncritically. The results presented here demonstrate the complexities involved in interpreting the nature of geophysical responses and that for common features, such as ditches, walls and roads, there is now less of a sense of what constitutes the 'normal' or 'expected'. Each response needs to be considered in context.

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