Historic England

Research Report Series 80/2023

Hadrian's Wall: Birdoswald Sector Survey

Aerial Investigation and Mapping of Birdoswald Roman Fort and the surrounding archaeological landscape

Dave Knight
With Marcus Jecock

Hadrian's Wall: Birdoswald Sector Survey

Aerial Investigation and Mapping of Birdoswald Roman Fort and the surrounding archaeological landscape

Dave Knight
With Marcus Jecock
2023

NGR: NY 615 662

Print: ISSN 2398-3841
Online: ISSN 2059-4453

Summary

Birdoswald Roman Fort is an English Heritage Trust guardianship site and scheduled monument (National Heritage List for England 1010994) that forms part of the Frontiers of the Roman Empire: Hadrian's Wall World Heritage Site (WHS). The fort, together with the stretches of Hadrian's Wall to either side ('the Birdoswald Sector'), is one of the most significant and extensively studied parts of the WHS, certainly within Cumbria.

In 2016, the English Heritage Trust (EHT) approached Historic England's then Research Department, with a request to investigate the fort and its wider landscape and gather information that would enhance the public presentation and display of the property. The overall aim of the EHT project was to better tell the story of Birdoswald by emphasising the fort's position and role within the wider WHS.

In response to this brief, in 2017, staff from Historic England's then Historic Places Investigation Team (North), in association with colleagues from the former Geospatial Imaging Team, designed and carried out a project to fly, model, map and interpret the archaeological landscape around the fort. This entailed the capture of new oblique aerial photography for 8.2sq. km, which was processed using the digital photogrammetric technique of structure from motion (SfM) to produce a digital surface model (DSM) and orthorectified photograph. This was the first instance of Historic England employing aerial reconnaissance photography to create digital surface models and orthophotographs on a landscape scale.

The mapping and interpretation elements drew on the SfM outputs of the new aerial photography, but also looked at historic aerial photographs and lidar.

A rapid walkover assessment was also conducted across much of the Birdoswald landscape in order to provide additional information and clarity on features identified and mapped from the air.

The aerial investigation mapped and recorded archaeological features visible as earthworks, cropmarks and structures ranging from the later prehistoric to post-medieval periods. Mapped features dating to the Roman period included roads, camps, turrets, milecastles, signal stations, forts and the Wall. The post-medieval landscape is dominated by extensive land improvement and enclosure which has overwritten and masked much of the earlier archaeological landscapes.

Contributors

The aerial investigation and mapping and report were produced by Dave Knight of the Aerial Investigation and Mapping team (now Aerial Survey) of Historic England. The project was managed by Marcus Jecock of the Historic Places Investigation (North) team (now Landscape Archaeology), who also led the field assessment and contributed advice and research to this report.

Acknowledgements

The author would like to express their thanks to Tim Gates for access and permission to use his aerial photographs held in the Historic England Archive and Cumbria Historic Environment Record (HER); Professor Tom Spencer for allowing use of the Cambridge University Collection of Aerial Photography (CUCAP) held in the Cumbria HER; Mark Brennand of the Cumbria HER for supplying data and for access to the photography held by the local council; Liz Williams for supply of information from the Northumberland HER; and to Historic England Archive staff for the supply of aerial photographs.

Thanks also to Patrick Rickerby of Skeye for the capture, processing and supply of digital surface model and orthophotograph from Unmanned Aircraft System photography; and David Andrews of Historic England's Geospatial Imaging team who liaised with the contractor; also to Jon Bedford from the same team for offering training, instruction and technical advice in the use of the structure from motion software.

Particular thanks to Damian Grady, Aerial Reconnaissance Manager, for taking the primary source photography for the project and advice throughout; also to Tony Wilmott of Historic England's Archaeological Excavation team for his expertise on Birdoswald.

Although too many to name in person, a special thank you to the numerous landowners throughout the project area, who not only allowed access on to their property, but also imparted useful local knowledge; additional thanks for local advice, which included Will Higgs for information on his evaluation excavation at the 'Morowes'.

Archive location

Historic England Archive Services, The Engine House, Firefly Avenue, Swindon, SN2 2EH

Archive@HistoricEngland.org.uk.

The project is recorded through OASIS, the online system for reporting archaeological investigations, as nmr1-521075.

Date of survey/research/investigation

The aerial survey mapping was undertaken between 4 April and 25 May 2017. The walkover survey took place between 12 and 16 June 2017, with subsequent amendment to the mapping completed by 25 July 2017.

Contact details

Dave Knight, Aerial Survey, 37 Tanner Row, York, YO1 6WP

David.Knight@HistoricEngland.org.uk

Contents

Illustrations

Introduction

Background

In late 2016, the English Heritage Trust (EHT) requested Historic England (HE), as part of the Shared Services Agreement, to capture new oblique aerial photography for an area of 8.2sq. km in and around Birdoswald Roman Fort and use it to produce a digital surface model (DSM) and interpretative landscape narrative that would inform a programme of enhanced site presentation and visitor engagement which EHT were planning for the visitor centre at the fort (Roberts 2016). The agreed aims of the Historic England contribution to the wider project were to demonstrate:

- that the Wall frontier shaped, and was shaped by, the landscape it crossed;
- that the frontier was far from static in the Roman period;
- that the landscape in which the Wall sits continued to develop and change after the ending of Roman Britain;
- that Birdoswald has been at the forefront of the scientific study of Hadrian's Wall.

In response to this brief, Historic England put together the Hadrian's Wall: Birdoswald Sector Survey project. The project had three main stages:

- The creation of a 3D model through the digital photogrammetry (structure from motion) of specially flown aerial reconnaissance photography;
- An aerial investigation and mapping exercise to map and record all archaeological features visible as earthworks, cropmarks, soilmarks and structures on historic aerial photographs, lidar and the outputs from the structure from motion process;
- A rapid walkover survey to check and evaluate on the ground interpretations of archaeological features observed and mapped from the air.

The survey was undertaken in 2017. Extensive oblique aerial photography was captured for the entire project area by Historic England's Aerial Reconnaissance team for photogrammetry purposes. The photography was processed using the digital photogrammetric process of structure from motion (SfM) to create a digital surface model (DSM) (3D point cloud data detailing the terrain and surface features including upstanding archaeology) and an orthophotograph (a georeferenced mosaic of all the photography).

The area was mapped using a combination of the SfM outputs, lidar and historic aerial photographs to Historic England's Aerial Investigation and Mapping Standards. The products included a detailed digital map of the landscape with accompanying attribute data and monument records in the National Record of the Historic Environment (NRHE). In addition, a rapid walkover survey was undertaken of a number of sites in the project area to enhance the dataset and records.

This report outlines the results of this survey, with an emphasis on the aerial mapping results. Where walkover survey observations added significant detail to the understanding of a monument, this is included in the text.

Birdoswald

The Birdoswald sector landscape is one of the most significant sections of the Hadrian's Wall landscape. As Wilmott (1997, 2) notes:

> The stretch of Hadrian's Wall to the east and west of Birdoswald has been one of the most productive of archaeological information as a result of works undertaken over more than a century. It is unique in that over a distance of only 6.5km every type of structure which formed part of the Wall system may be traced.

Although Birdoswald was previously mapped as part of the Hadrian's Wall National Mapping Programme (NMP) project (Oakey 2009) using many of the sources available to this project, that previous mapping did not have access to lidar or any form of digital elevation model (DEM – this includes both digital surface models and digital terrain models). These additional sources have proved crucial for the present mapping exercise, revealing levels of detail that were previously unseen.

Figure 1: Birdoswald Roman Fort is under the guardianship of English Heritage Trust. The visible remains span the Roman, medieval and post-medieval periods. 33040_044 05-JAN-2017 © Historic England Archive.

The Roman remains within the Birdoswald landscape were the key focus of the project. These begin with the Stanegate, an early Roman road that linked a number of fortified sites across northern England. The fort at Nether Denton, fortlet at Throp, and signal tower at Main's Rigg, are all associated with this early frontier, as were perhaps one or two of the temporary camps in the area based on the results of this study.

This line then became the focus for a more coherent and permanent set of defences now known as Hadrian's Wall. Begun in AD 122 under Emperor Hadrian, the Wall marked the north-west boundary of the Roman Empire for the best part of the next 300 years until the end of Roman Britain, apart from a brief interlude in the middle of the second century when the frontier moved north to the Antonine Wall. Hadrian's Wall is one of the most impressive Roman monuments constructed in Britain and even now its archaeological presence dominates the landscape between Wallsend on the River Tyne and Bowness-on-Solway, a distance of 117km (Johnson 1989, 9). Birdoswald Roman Fort (Fig. 1) is one of 16 forts constructed at regular intervals along its line and is one of the most important from an archaeological perspective thanks to the intensity of research and variety of monument types to be found in its vicinity. As well as the fort at Birdoswald there are a variety of other Roman monument types in the vicinity. These include the Wall (including the Stone Wall and extensive earthwork remains of the Turf Wall), numerous milecastles, turrets, temporary camps, the Vallum and Willowford Bridge.

Project area

The mapping area spans a 5.2km-long length of Hadrian's Wall (Fig. 2). For the purposes of the project, the Birdoswald sector of the Wall is taken as starting in the east close to Milecastle 48 (Poltross Burn) and extending to Turret 51A (Piper Syke) in the west. North of the fort, the project area takes in most of Midgeholme Moss and the start of the Birdoswald to Bewcastle Roman Road (RR865, Margary 1957, 180-1). The River Irthing bisects the project area through the centre. The south of the river marks the line of the pre-Hadrianic Stanegate frontier. The whole mapping area measures approximately 8.2sq. km.

Most of the project is located in Cumbria (parts of the parishes of Nether Denton, Upper Denton and Waterhead), but east of Poltross Burn the parish of Thirlwall forms part of Northumberland.

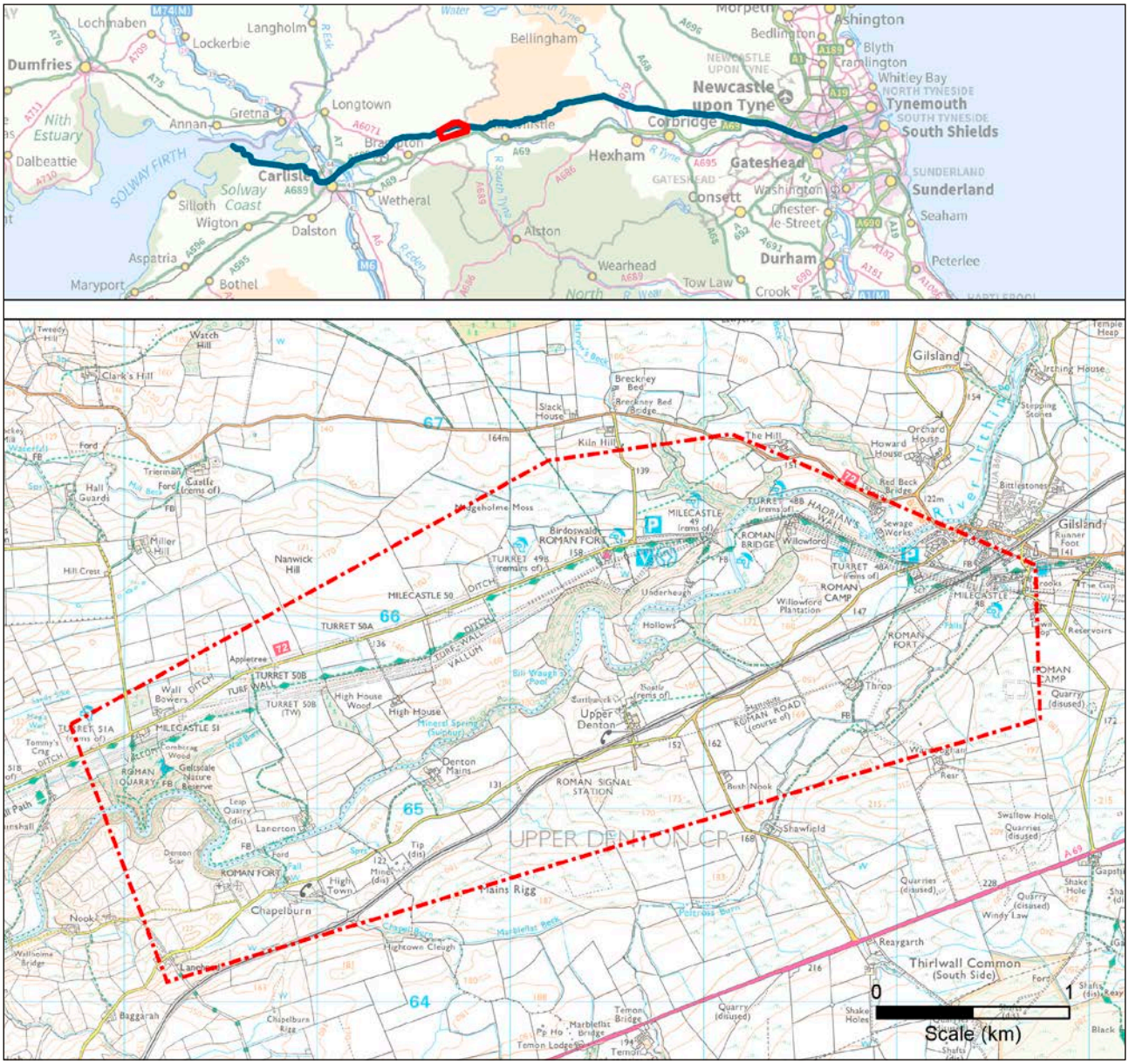


Figure 2: The Birdoswald project area (in red) in relation to the line of Hadrian's Wall (blue). Base map © Crown Copyright and database right 2023. All rights reserved. Ordnance Survey Licence number 100019088.

Geology and topography

Natural England's National Character Areas (NCAs) provide topographical descriptions, including cultural and economic aspects of the environment, for England. Most of the Birdoswald Sector Survey project area falls in the west of NCA 11: Tyne Gap and Hadrian's Wall (Natural England 2015). This region is defined by a narrow gap between the North Pennines and the Border Moors and Forests of Northumberland. The land use is predominantly rough pasture in the Birdoswald sector, with increased arable farming to the east. Mixed woodland is common, with broadleaf woodland dominating the steeper river slopes. The Roman heritage of the region defined by Hadrian's Wall has made the region a popular destination for recreational activities.

The area to the south of the River Irthing falls in NCA 10: North Pennines (Natural England 2013). This NCA is predominantly defined by remote upland moorland, though within the project area the land use is largely pastoral farming with marginal moorland on Mains Rigg.

The topography of the region was largely moulded during the last ice age. The River Irthing flows through the centre of the project area, from east to west. A number of tributaries, including Chapel Burn, Poltross Burn, Wall Burn and Harrow's Beck, form steep-sided gorges where they join the main river (Fig. 3). The shallowest crossing points are in Gilsland, where the B6318 bridges the river, and west of Lanerton where a ford crosses the river adjacent to its confluence with Chapel Burn. The flow of the river has created steep valley sides between Chapelburn and Combcrag Wood and south of Birdoswald. In both instances, the slippage of the banks and river erosion has destroyed or threatens archaeological remains.

The solid geology is part of the Tyne Limestone Formation – a combination of various limestones, sandstones, siltstones and mudstones. A fault line extends north-west from Bush Nook, to the west of Birdoswald, and along the western edge of Midgeholme Moss. The superficial deposits overlying the solid geology is mostly Devensian – Diamicton till, with fluvioglacial sand and gravel to the south of the river at Chapelburn and along Poltross Burn. River terrace sands and gravels and alluvium extend along the length of the River Irthing (www.bgs.ac.uk).

A shallow valley to the north of the project area is defined by Midgeholme Moss, a natural bog which drains into Harrow's Beck. The line of Hadrian's Wall to the north of the river and the fort at Birdoswald are located on a natural ridge between the Moss and the Irthing Valley. On the south side of the River Irthing the ground rises up on to Mains Rigg, which comprises largely reclaimed or heavily improved heathland. This heath, and the rise on which the camp at Crooks is located in the south-east of the project area, are the highest points within the project area.

Land use and settlement

Present-day land use within the project area is predominantly pastoral. The landscape is characterised by enclosed fields that have been intensively improved for pasture hay and silage. The latter is most prevalent in the south-west of the project area, on the glaciofluvial sands and gravels around Chapelburn, though does occur on the till also. Attempts have also been made to improve more marginal land in recent centuries, such as Mains Rigg and Midgeholme Moss, but much of these areas has since reverted to heath and bog.

Woodland is almost entirely confined to the steep slopes of the banks of the River Irthing or along its tributaries. This is presumably a combination of the slopes being too steep for agriculture and that the woodland aids the stabilisation of the eroding riverbanks. Combcrag Wood and High House Wood are exceptions being sited on the crest of the hill. Both comprise mixed deciduous woodland.

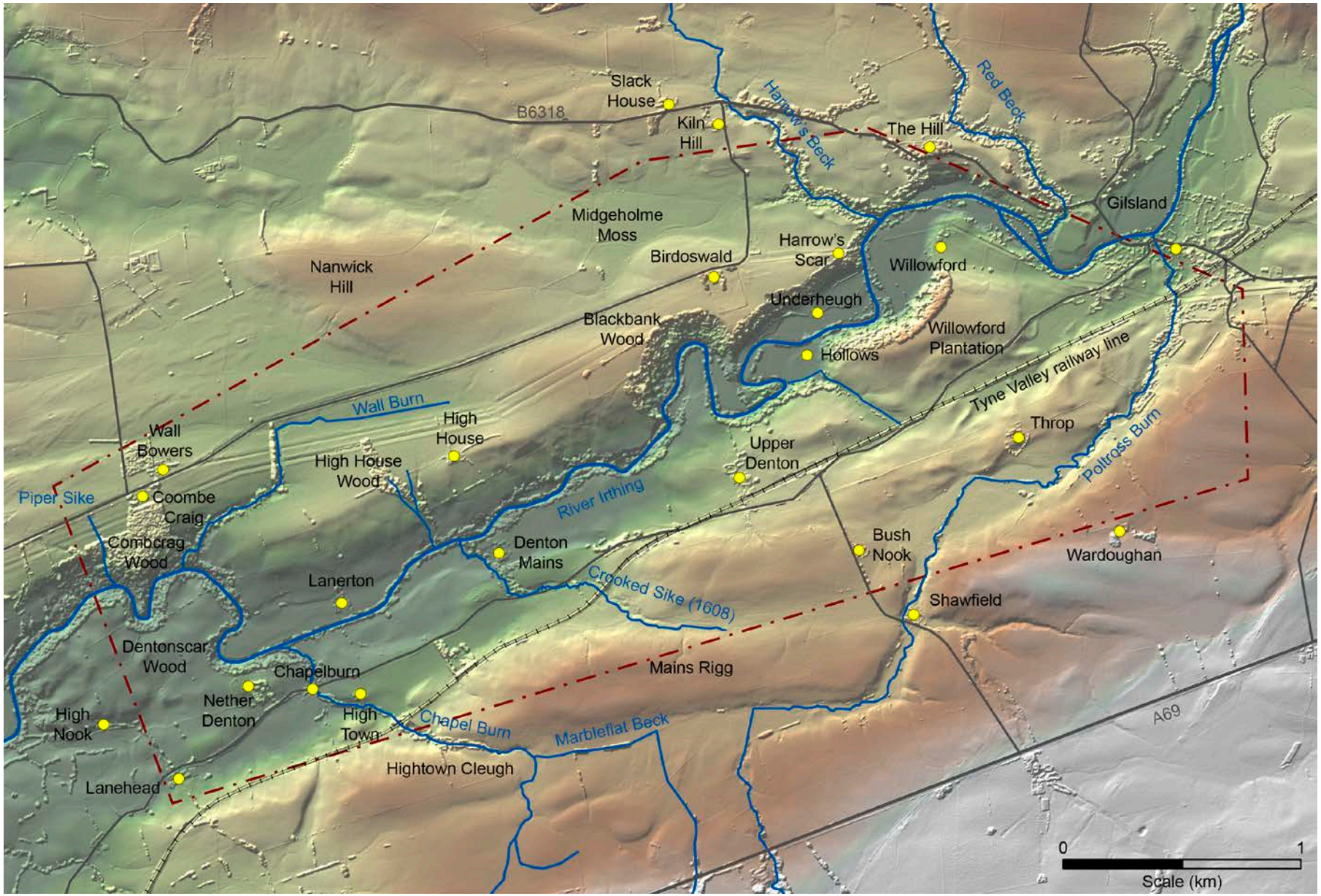


Figure 3: A topographical map of the project area denoting key place names, rivers and roads mentioned in the report. Relief model created from APGB height data © Bluesky International/Getmapping PLC.

The settlement pattern within the project area is mostly one of scattered farmsteads. Historic map evidence shows that most of these existed by the early 17th century, but it is likely that many, if not all, were already occupied by the mid-12th century (if not earlier) when Henry II granted the Barony of Gilsland to the de Vaux family. The Birdoswald tenement, for example, is referred to by name as early as 1211 (Wilmott 1997, 388). Churches at the parish centres of Upper Denton and Nether Denton also existed by at least the 12th century. Both may once have been surrounded by more nucleated settlements, but the churches are now largely isolated (Upper Denton is redundant). Today, the largest settlement in the area is the village of Gilsland (Fig. 4), located where the B6318 crosses the River Irthing. It sits on the border between Cumbria and Northumberland, the line of which follows the River Irthing and Poltross Burn at this location. The growth of this village mostly post-dates the mid-18th century when a spa was developed here. The spa became a popular tourist destination, particularly following the opening of the Newcastle and Carlisle railway in 1836.

Figure 4: Gilsland is one of the larger settlements in the area. It grew as a spa town, following the opening of the railway station in 1836. 33028_066 05-JAN-2017 © Historic England Archive.

Although the spa is now closed, tourism still remains a major industry within the area. Birdoswald Roman Fort alone has an annual footfall of approximately 36,000 visitors (J. Savage 2017, pers. Comm., 7 Sep.).

There are a number of significant routes through the Birdoswald landscape. The project area is located a little to the north of the A69, which runs parallel to most of the length of Hadrian's Wall. The B6318 skirts the north-east of the project area, from which extend the main 'minor' roads of the project area. The Birdoswald road exits the B6318 at Kiln Hill, makes a sharp bend at the fort, and continues along the route of the stone Wall as far as Banks, outside the project area. Historic map evidence suggests that this road west of Birdoswald was constructed at some point after 1603. The southern road to the project area exits the B6318 at Gilsland and continues to the south of the River Irthing as far as Low Row. Some of this road is thought to have been constructed along the line of the Roman road, the Stanegate. The Tyne Valley Line of what was once named the Newcastle to Carlisle Railway extends parallel to this road for much of the length of the project area. The railway line remains in use.

Methods

Full methods, scope and sources are outlined in Appendix 1. Appendix 2 gives a detailed breakdown and review of the use of SfM with accompanying sources for a landscape-scale survey. Below is a summary.

Scope

The aerial investigation and mapping stage of the project assessed, mapped and recorded all archaeology visible as earthworks, cropmarks, soilmarks and structures in an area of 8.2sq. km, roughly centred on Birdoswald Roman Fort. All available aerial photographs and digital elevation models (DEMs) were assessed, including digital oblique aerial photographs taken for the purpose of producing a DSM of the Birdoswald landscape through SfM. The scope of the mapping broadly adhered to Historic England's Aerial Investigation and Mapping standards (Evans 2019).

Sources

All available vertical and oblique air photographs held by the Historic England Archive in Swindon, both prints and digital, were consulted, comprising 140 vertical prints ranging in date from 1946 to 1985 and 489 specialist oblique images taken between the 1920s and 2016. Additional aerial photography included obliques taken by Cambridge University and Tim Gates, held by Cumbria HER, and recent orthorectified vertical imagery supplied by Next Perspectives through the APGB agreement and Google Earth imagery.

Composite 2010 lidar data was supplied by the Environment Agency as mosaicked 1sq. km tiles. This comprised DSMs and digital terrain models (DTM). This covered approximately 7sq. km of the project area at 1m resolution.

Nearly 1,200 aerial photographs were processed using the digital photogrammetric method of SfM to produce a DSM and orthophotograph. These outputs were the primary sources used for mapping.

In addition to this, Historic England commissioned Unmanned Aircraft System (UAS) mapping surveys of areas immediately adjacent to Birdoswald fort to provide comparative datasets at a much greater resolution.

Supporting sources including the Hadrian's Wall NMP mapping, geophysical survey plans, historic maps, monument datasets from HE and the local HERs, previous study including grey literature and published materials from previous excavations with a particular emphasis on works undertaken by HE's Tony Wilmott over the course of several decades, and geology and soils data.

Methods

All georeferenced datasets, which included SfM data and lidar, were loaded into the mapping software, AutoCAD. Aerial photographs not used for photogrammetry were rectified individually using the specialist software, Aerial, for import into AutoCAD. Elevation models were viewed as live data in Quick Terrain Reader and visualised as 2D raster images using Relief Visualisation Toolbox for import into the mapping software (Kokalj and Somrak 2019; Zakšek, Oštir and Kokalj 2011).

All archaeological features within the scope of the project were transcribed from these sources as line and polygon vector data (*see* Table 2) with associated attributes (*see* Table 3). Corresponding records were made or updated in the National Record of the Historic Environment (NRHE).

The mapping results informed a follow-up rapid walkover field survey of 35 monuments. Observations from this survey aided the interpretation of mapped features and were included in the NRHE record.

The NRHE is no longer a live database but the records are available via Heritage Gateway (www.heritagegateway.org.uk). The mapping is available via the Aerial Archaeology Mapping Explorer (https://historicengland.org.uk/research/results/aerial-archaeology-mapping-explorer/).

Previous Archaeological Study

The area of Birdoswald has been 'one of the most productive of archaeological information as a result of works undertaken over more than a century' (Wilmott 1997, 2). The sheer scale of archaeological excavation, survey and research undertaken along this section of Hadrian's Wall is too extensive to discuss in any depth. Nor would a brief evaluation of the works undertaken do them any level of justice. Therefore, the primary archaeological and historical investigations that have taken place within the sector are listed below with references searchable in the bibliography. Wilmott provides a detailed summary of the research and excavations that have taken place at Birdoswald up to 2000 (ibid.; Wilmott et al. 2009), which are also included in this list. Most recently, Historic England, in partnership with Newcastle University, have been undertaking excavation on the extra-mural settlement outside the fort to the east, west and north. These excavations are due to complete in 2024.

Table 1: List of archaeological and historical investigations that have taken place in the Birdoswald Sector.

Year	Site	Investigation type	Bibliography/ Reference
1821	Birdoswald Roman Fort	Find (altars)	Collingwood and Wright 1965, 588
1831-3	Birdoswald Roman Fort	Excavation	Hodgson 1840
1833	Turret 49B	Excavation	Simpson 1913
1837	Turret 49B	Excavation	Simpson 1913
1849	Birdoswald Roman Fort	Excavation	Wilmott 1997, 4
1850	Birdoswald Roman Fort	Excavation	Potter 1855
1851	Birdoswald Roman Fort	Excavation	Potter 1855
1852	Birdoswald Roman Fort	Excavation	Potter 1855
1859	Birdoswald Roman Fort	Excavation	Norman 1860
1868	Nether Denton Roman Fort	Excavation	Shipman 1870
1878	Upper Denton church	Documentary Research	Ferguson 1878
1886	Milecastle 48	Excavation	Anon 1888
1894	Vallum	Excavation	Haverfield 1895
1895	Turf Wall	Excavation	Haverfield 1897
1896	Vallum; Turf Wall	Excavation	Haverfield 1897
1897	Turf Wall	Excavation	Hodgson 1899
1898	Turf Wall; Vallum; Milecastle 49	Excavation	Haverfield 1899
1898	Turf Wall; Milecastle 49	Excavation	Hodgson 1899
1909	Milecastle 48	Excavation	Gibson and Simpson 1911
1909	The Stanegate	Excavation	Simpson 1913
c. 1909-12	Willowford Roman Camp	Measured Survey	Simpson 1913

c. 1909-12	Crooks Roman Camp	Measured Survey	Simpson 1913
1910	Throp Roman Fortlet; Vallum; Military Way	Excavation	Simpson 1913
1911	Milecastle 50; Turrets 49B, 50A, 50B; Stone Wall; Turf Wall; Nether Denton Roman Fort	Excavation	Simpson 1913
1912	Military Way	Excavation	Simpson 1913
1920	Birdoswald Roman Fort	Excavation	Simpson and Richmond 1934
1923	Turrets 48A, 48B; Stone Wall	Excavation	Shaw 1926
1924	Willowford Bridge	Excavation	Collingwood and Taylor 1924; Shaw 1926; Anon 1941
1927	Turf Wall; Turret 51A; Milecastle 51A	Excavation	Simpson 1928
1927-8	Birdoswald Roman Fort; Turf Wall; Turret 50B (TW); Vallum; Milecastle 48; Mains Rigg Roman Signal Station	Excavation	Richmond 1929
1929	Birdoswald Roman Fort	Excavation	Richmond and Birley 1930
1930	Birdoswald Roman Fort	Excavation	Richmond 1931
1931	Birdoswald Roman Fort	Excavation	Simpson and Richmond 1932; Simpson and Richmond 1933
1932	Birdoswald Roman Fort	Excavation	Simpson and Richmond 1934
1933	Milecastle 50 (TW)	Excavation	Simpson et al. 1934
1933	Nether Denton Roman Fort	Excavation	Simpson and St. Joseph 1934
1934	Milecastle 51	Excavation	Simpson and Richmond 1935
1934	Turrets 49B, 50A, Turret 50B (TW)	Excavation	Simpson et al. 1935b
1934	Milecastle 50 (TW)	Excavation	Simpson et al. 1936
1935	Milecastle 50 (TW); Vallum	Excavation	Simpson and Richmond 1937
1936	Vallum; Milecastle 51; Turf Wall	Excavation	Simpson and Richmond 1937
1939	Willowford Bridge	Excavation	Anon 1941
1945	Birdoswald Roman Fort	Excavation	Anon 1946
1949	Birdoswald Roman Fort	Aerial Survey	St. Joseph 1951
1949	Nether Denton Roman Fort	Aerial Survey	St. Joseph 1951
1949-50	Birdoswald Roman Fort	Excavation	Gillam 1950

1951	Vallum	Excavation	Swinbank 1952
1953	Milecastle 49 (Harrow's Scar)	Excavation	Richmond 1956
1957	The Stanegate; Military Way; Maiden Way	Publication	Margary 1957, 177-8, 180-1
1959	Birdoswald cemetery	Excavation	Wilmott 1993
1965	Combcrag quarry Roman inscriptions	Publication	Collingwood and Wright 1965, 599-600
1965-6	Milecastle 48	Excavation	Charlesworth 1967
1970	Turret 51A	Excavation	Charlesworth 1973
1971	Mains Rigg Roman Signal Station	Excavation	Binns 1972, 8
1979	Birdoswald Roman Fort	Publication	Howard 1979
1984-5	Willowford Roman Bridge	Measured Survey/ Excavation	Frere et al. 1985
1985	Willowford Roman Bridge	Excavation	Frere et al. 1986
1986	Birdoswald Roman Fort	Geophysical Survey	Walker 1986
1987	Hadrian's Wall	Measured survey	RCHME 1987
1987-92	Birdoswald Roman Fort	Excavation	Wilmott 1997
1989	Willowford Roman Bridge	Publication	Bidwell and Holbrook 1989
1995	Willowford Roman Camp, Crooks Roman Camp	Measured Survey	Welfare and Swan 1995, 51-2, 92
1995	Birdoswald Roman Fort	Publication	Wilmott 1995
1996-2000	Birdoswald Roman Fort	Excavation	Wilmott et al. 2009
1997-8	Birdoswald Roman Fort	Geophysical Survey	Biggins and Taylor 1999
1999	Turf Wall; Vallum	Excavation	Wilmott 2009
1999	Birdoswald Roman Fort	Geophysical Survey	Gaffney and Gater 1999
1999	Birdoswald Roman cemetery	Excavation	Time Team 1999
2000	Birdoswald Roman Fort	Geophysical Survey	Biggins and Taylor 2004
2005-14	Birdoswald Roman Fort	Publication	Wilmott 2014
2006	Hadrian's Wall	Publication	Breeze 2006, 285-318
2006-7	Hadrian's Wall NMP	Aerial Survey	Small 2008
2006-14	Birdoswald Roman Fort	Publication	Breeze 2014, 8-11
2008	Birdoswald Roman cemetery	Geophysical Survey	Roseveare and Roseveare 2009
2009	Birdoswald Roman cemetery	Excavation	Wilmott 2010
2010	Vallum	Environmental Analysis	Hazell and Pelling 2010
2013	Underheugh Farm	Geophysical Survey	Hale 2013

2015	Hadrian's Wall and LiDAR	Publication	Collins 2015
2015	Combcrag quarry Roman inscriptions	Inscription Analysis	O'Donnell 2015, 62-9
c. 2015	Morowes farmstead	Excavation	Personal communication with excavator (Will Higgs)
2021-*	Birdoswald extra-mural settlement	Excavation	Wilmott (ongoing. Due to complete in 2024)

* Added as a current update as some of the outcomes from the excavation have affected interpretation of features in the project area.

Summary of survey results

As outlined above, Hadrian's Wall has long been the subject of intense archaeological interest. The most extensive recent study was the aerial mapping and recording of the entire length by the Hadrian's Wall National Mapping Programme project (Small 2008; Fig. 5). The Birdoswald sector mapping assessed many of the same sources as the NMP, though had the additional benefit of more recent aerial photography and DEMs. The results from this survey have produced a handful of new records, as well as reinterpreting a number of previously known sites, based either on new evidence or on the opinion of the investigator. The biggest achievement of this survey is to combine modern methods, technology and source material to produce the most detailed and spatially accurate mapping of the archaeology of the area visible from the air to date.

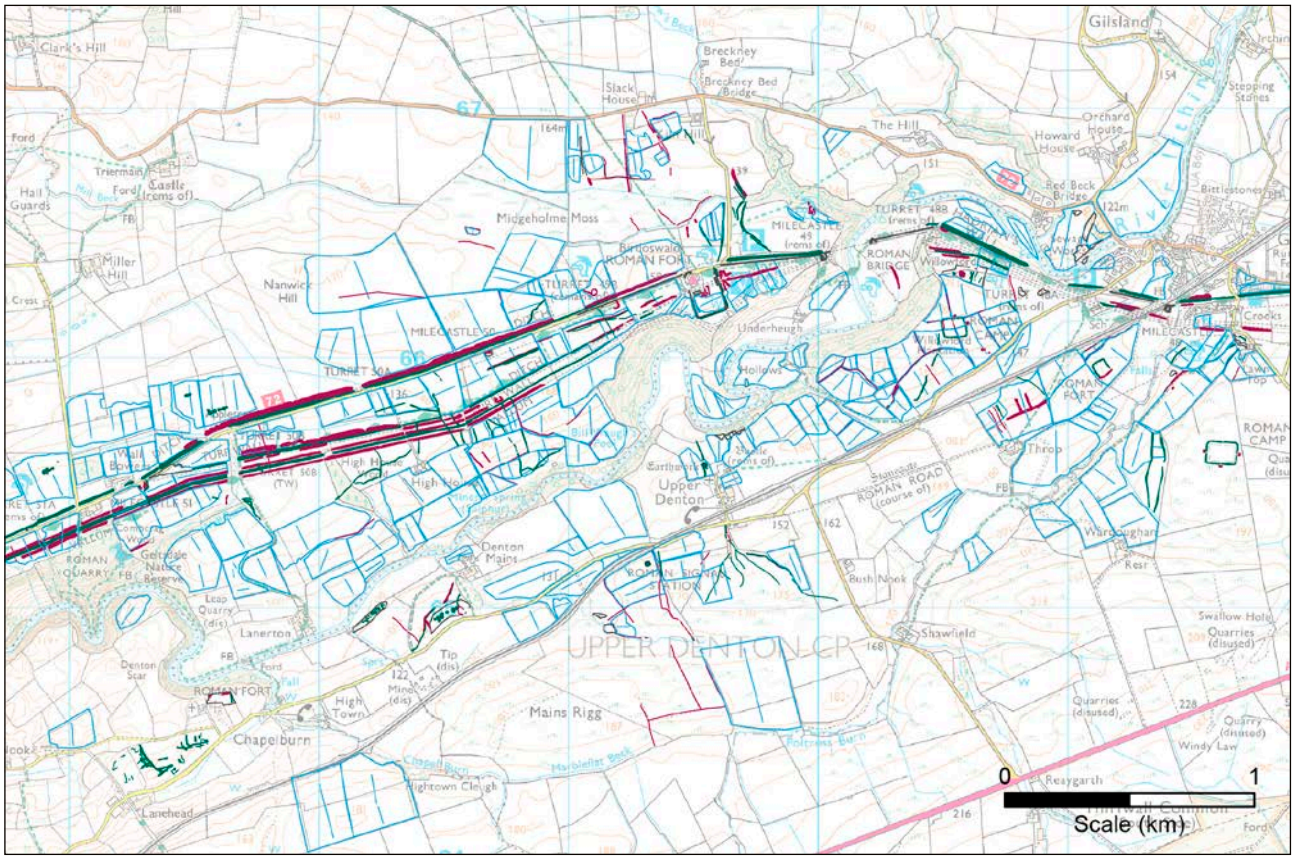


Figure 5: Birdoswald was included in the Hadrian's Wall National Mapping Programme. This figure allows an interesting comparison with the mapping results of this project in Fig. 6. Base map © Crown Copyright and database right 2023. All rights reserved. Ordnance Survey Licence number 100019088. Archaeological mapping © Historic England.

The project comprised aerial investigation and mapping of an area measuring approximately 8.2sq. km, centred on the line of Hadrian's Wall between Gilsland and Wall Bowers. This was followed up by targeted rapid walkover survey to enhance monument records. The mapping was produced digitally (Fig. 6) with attached attribute data. This can be accessed via the Aerial Archaeology Mapping Explorer (https://historicengland.org.uk/research/results/aerial-archaeology-mapping-explorer). Supporting monument records were entered into the National Record of Historic Environment (NRHE), available via Heritage Gateway (www.heritagegateway.org.uk).

A total of 69 new records were added to the database and a further 75 were amended. The aerial mapping results helped inform a list of targets for ground assessment, which comprised a rapid walkover survey of 35 sites. The results of both aspects of the survey are discussed below. The archaeological monuments are discussed chronologically, and where a specific monument is described, the unique identifier number from the NRHE is quoted in brackets.

The dating attributed to archaeological features is either the result of known dating evidence derived from excavations, historic maps, or is based on the morphological traits of the feature.

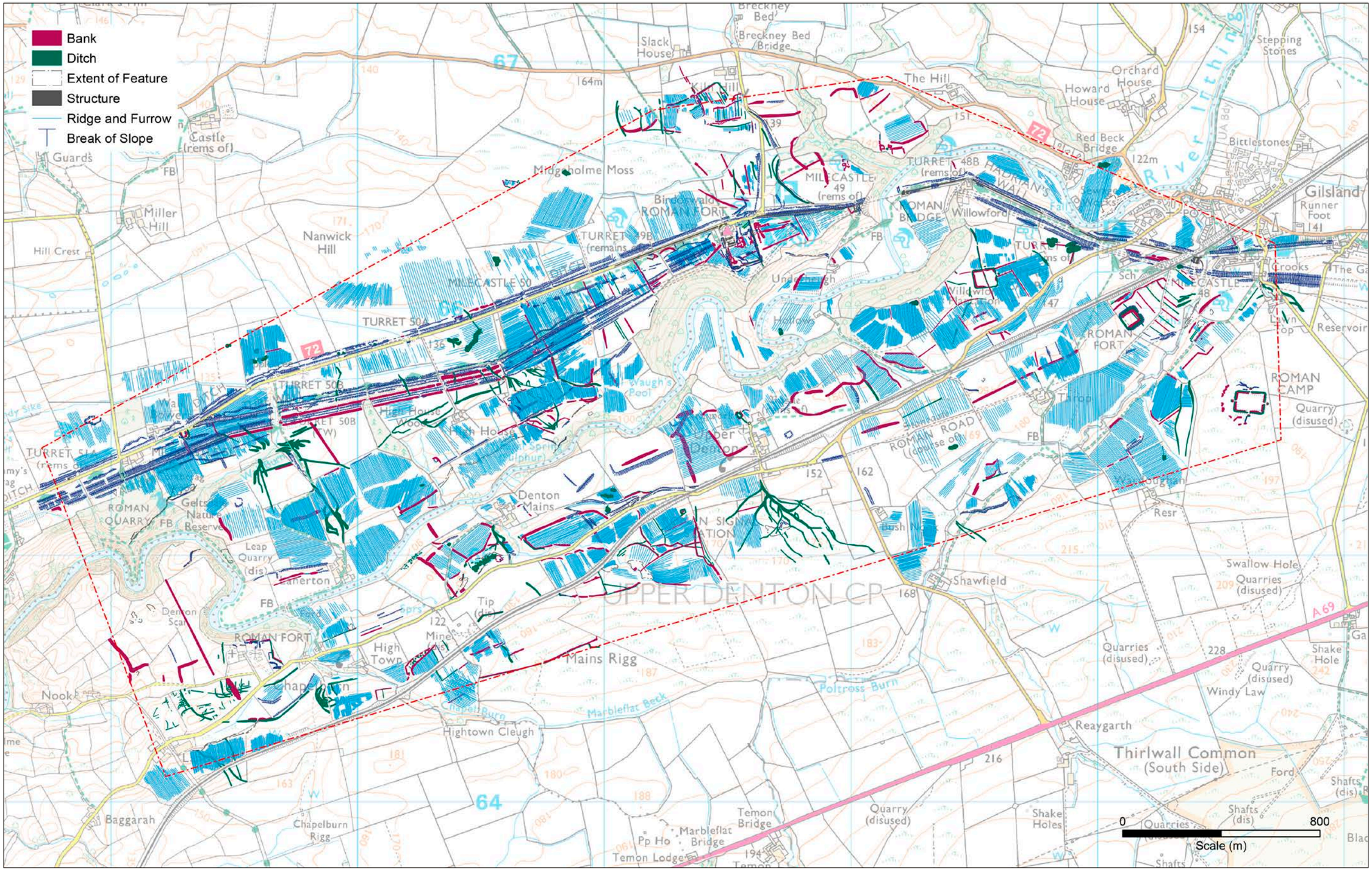


Figure 6: The Birdoswald Sector Survey aerial mapping. Base map © Crown Copyright and database right 2023. All rights reserved. Ordnance Survey Licence number 100019088. Archaeological mapping © Historic England.

Pre-Roman

The Hadrian's Wall NMP only identified one feature in the current project area as potentially later prehistoric in origin. This small 'enclosure', located to the west of Birdoswald Fort, was dismissed by this project as most likely being an agricultural mark. No other feature mapped by this project was specifically attributed a pre-Roman date. A tentative candidate for an early origin, but which has been recorded as 'uncertain' in date, is a small oval enclosure located to the west of Birdoswald (1474363; Fig. 7). This enclosure, which was first identified by the NMP, is defined by an incomplete curvilinear low stony bank with a funnelled entrance or small annexe to the east. If this feature pre-dated the Wall, the absence of the north and west sides of the feature may be attributed to disturbance from the construction of the Wall, which is located only 8m to the north, or possibly by the consolidation of the Wall in the early 20th century. Another suggestion is that it was possibly associated with the extra-mural settlement outside Birdoswald fort.

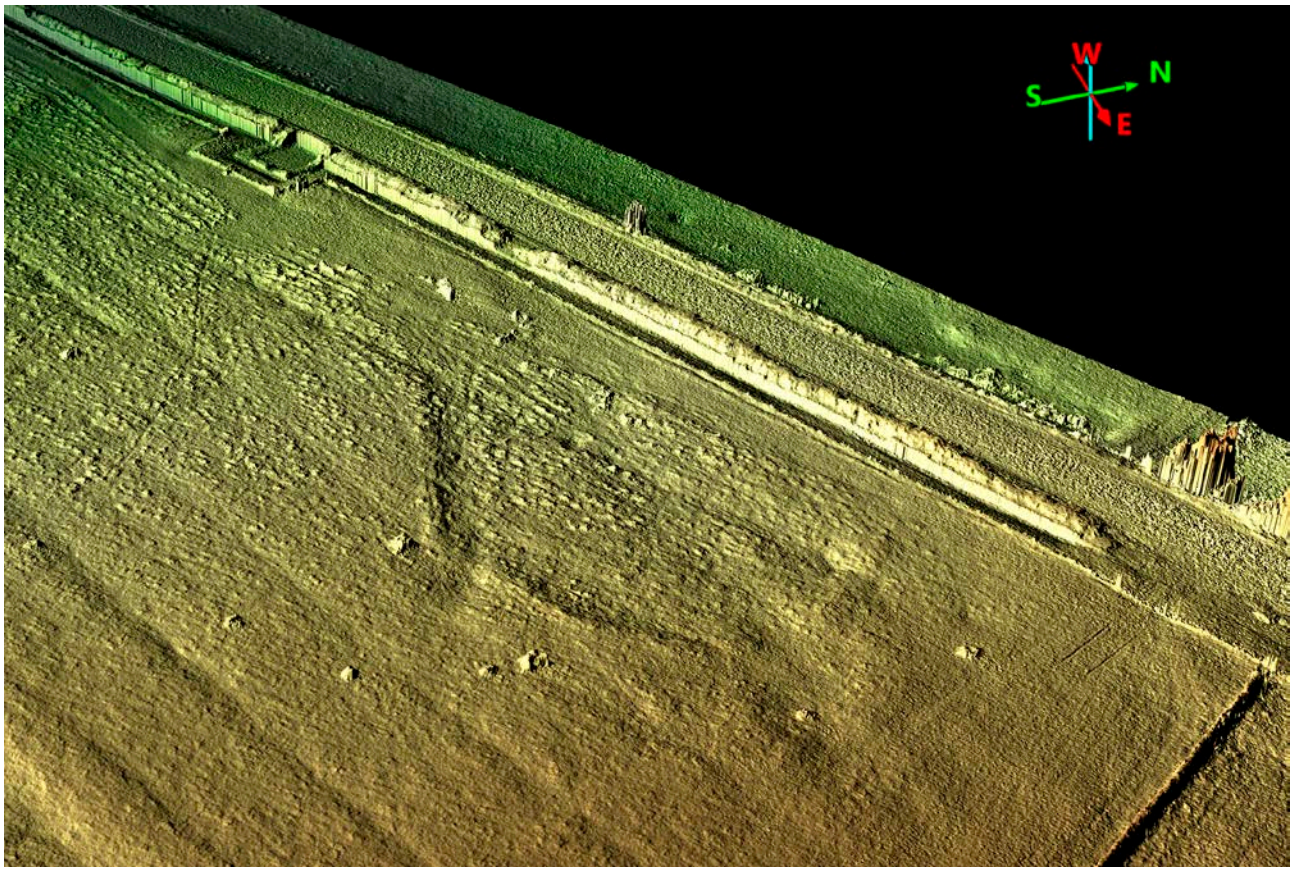


Figure 7: A small curvilinear enclosure to the west of Birdoswald is defined by an outer stony bank with sunken centre. This feature is morphologically unusual for this area. It may have been a stock enclosure. The foundations of Wall Turret 49B are visible in the background. Skeye UAS SfM DSM 21-FEB-2017 © English Heritage Trust/Historic England.

The centre of the enclosure is slightly sunken, but it is not likely to have functioned as a pond due to the ground sloping downhill to the west. A possible explanation for the hollow may be that it was used as a stockyard and that the depression is the result of livestock trample. The morphology of the enclosure is unusual for the area, though it is not possible without further assessment to attribute a definite date to it.

The Roman landscape

Roman archaeology dominates this landscape (Fig. 8). Much that is visible is largely the result of extensive excavations that have taken place over the last century, revealing structural stonework. However, extensive earthworks also remain, largely unaltered by archaeological intervention.

As Wilmott states (1997, 2), this region is unique in that it contains examples of every type of structure known along the Wall and the pre-existing Stanegate frontier. These are namely the Stone Wall, Turf Wall, Vallum, Military Way and Stanegate, milescastles, turrets, a bridge, forts and fortlets, and a signal tower. The section between Wall Bowers and Birdoswald is the only part of the Wall where the later Stone Wall deviated markedly from the line of the Turf Wall, thus preserving a remarkable section of the latter as an earthwork.

The archaeology is discussed below by monument type and organised by period. Due to the complexity of Roman remains and the subsequent numbering systems put in place during different periods of monument recording, it was decided to continue the use of numbers assigned by the NMP. These are referenced in the text

The early frontier: the Stanegate and associated fortifications

Several decades prior to the construction of Hadrian's Wall, the frontier was defined by a series of fortifications between Corbridge (*Coria*) and Carlisle (*Luguvalium*), linked by a road, now known by its medieval name of the Stanegate (literally 'the stone road') (Breeze 2014, 37). This line was south of the later Wall; in the area of Birdoswald, Stanegate was located on the south side of the Irthing Valley. This River plays an important role in the location of many features in this landscape. Generally, to the west of Gilsland, Roman features south of the river are associated with the Stanegate and those to the north are associated with the later Wall.

The Stanegate frontier remains include sections of the road itself, a fort, fortlet and a signal tower. Richmond's excavations in the 1930s proposed that there was also a signal tower immediately east of Birdoswald, on the north side of the river (Wilmott 1997, 41), but recent excavations have dismissed this interpretation, proving it to be part of the fort bathhouse (Wilmott, forthcoming).

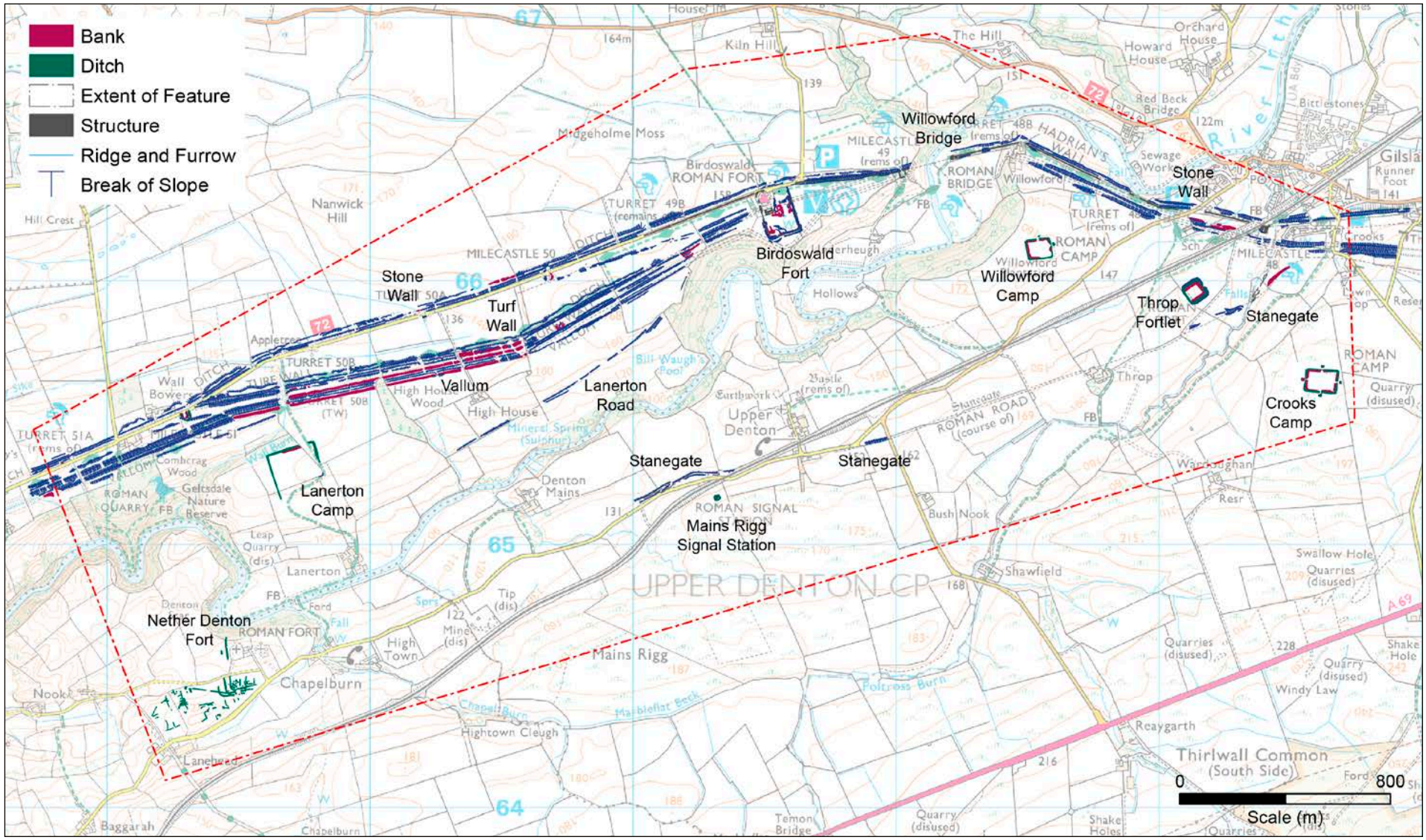


Figure 8: Excepting post-medieval land improvement, Roman features make up the bulk of the archaeological remains visible on aerial photographs and DEMs. Base map © Crown Copyright and database right 2023. All rights reserved. Ordnance Survey Licence number 100019088. Archaeological mapping © Historic England.

The Stanegate

Although sections of the Stanegate (which continued in use after the construction of the Wall) have been identified through excavation or still survive as earthworks, most of the road's alignment is conjectured from the position of modern roads and field boundaries, or a line projected between known points (Fig. 9). The course of the road within the Birdoswald sector is no exception: much of the line is presumed, projected between forts or taken as marked by a variety of linear features in the modern landscape.

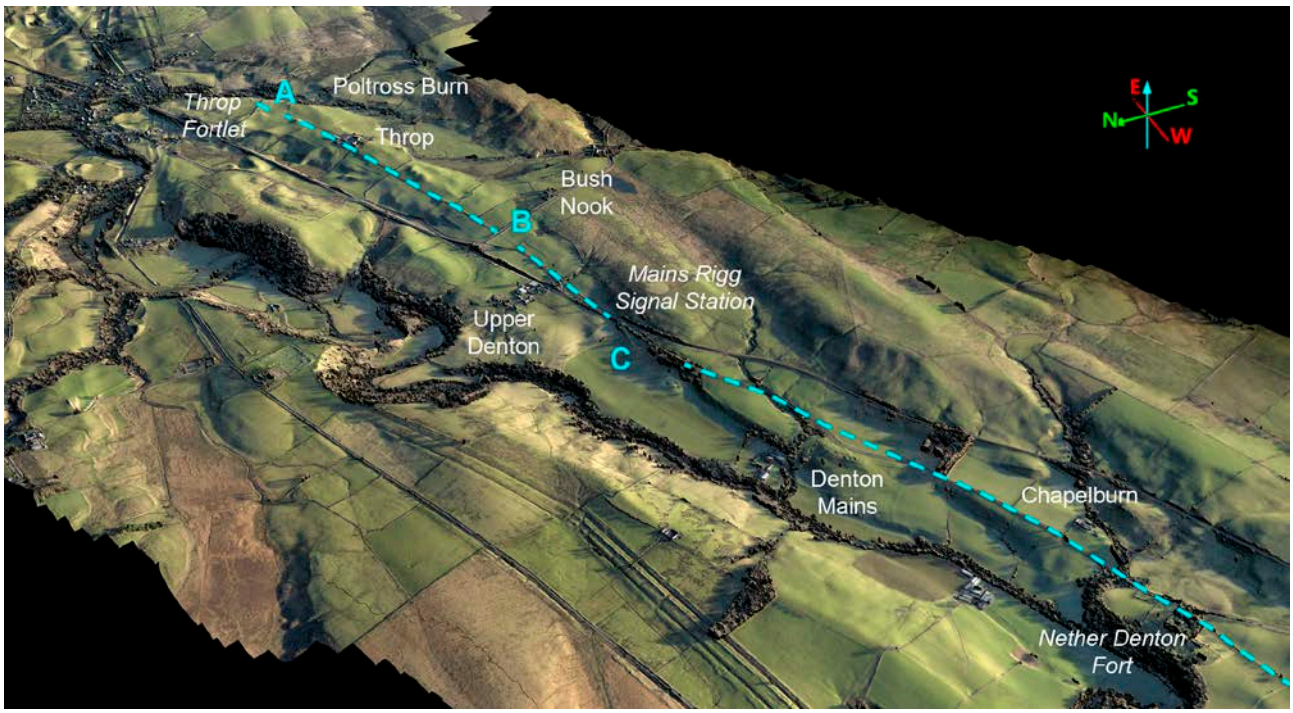


Figure 9: The line of the Stanegate can be traced through most of the project area as earthworks, field boundaries or modern road alignments. Letters A, B and C indicate where earthwork remains were mapped from aerial sources. Historic England SfM orthophotograph over DSM 05-JAN-2017 © Historic England.

The project identified four possible sections of the road surviving as earthworks (1449863), or at least earthworks on the alignment of the road which may have Roman origins. The easternmost are located on either side of Poltross Burn, a little to the south of Gilsland (Fig. 9, A). A shallow bank, slightly sinuous in plan, is visible on the east side of the burn, extending south-west from a sharp bend in the current Gapshield road, south of Crook Villa. Additional banks may be visible under the trees adjacent to the burn, but the clarity of the lidar is too poor.

West of the burn, a short length of hollow way extends upslope from the edge of the watercourse (Fig. 10). Excavation in 1910, in this general location, revealed the road to survive moderately well in places, but to have been completely removed by ploughing in the centre of the field (Simpson 1913, 382-3). The remaining earthworks have also been much denuded by post-Roman small-scale quarrying and ploughing. As the road climbed the gentle slope to the south of Throp fortlet, it becomes visible as a very shallow and spread linear bank, some 50m in length. Beyond this point and Throp farm, the course of the Stanegate probably followed the course of a modern track.

Figure 10: The Stanegate is visible as a hollow way through the slope to the west of Poltross Burn. This is believed to be the approximate location of the 1910 excavations. June 2017 © Historic England.

The Stanegate extended through Throp farm, continuing to the west along the line of a modern field boundary, to a bend in the present Gilsland to Chapelburn road, south of Upper Denton. Here, earthwork evidence for the road is mostly masked by modern field boundaries and a trackway that runs alongside. The only obvious section of the road visible on the surface lies west of the lane leading to Bush Nook (Fig. 9, B). A low earthwork bank, 90m in length and up to 13m wide, is visible on aerial photographs and elevation models. Presumably this low earthwork represents the ploughed down *agger* of the Roman road, this length of bank was still a trackway until moderately recently. Excavations in 1910 revealed the Roman road beneath, being of the same construction as that excavated at Poltross Burn (ibid., 384).

Further west, the Stanegate is presumed to largely follow the course of the modern road as far as the fort at Chapelburn. However, west of Upper Denton (just to the north of Main's Rigg signal tower) the course of this road was altered when the Newcastle to Carlisle Railway was constructed in the 1830s (Fig. 9, C). The original road, visible as an earthwork terrace, was located further down the slope. Another terrace, slightly lower down the slope, partly blocked by a line of mature oak trees lining the old road (Fig. 11), may indicated an even earlier road (Fig. 12). It is possible that this earlier alignment relates to the course of the Roman road.

Figure 11: An earlier alignment of the road between Gilsland and Chapelburn is visible as a linear terrace north of the level crossing west of Upper Denton. The parallel rows of mature trees mark the sides of the road. The original alignment appears to have been marginally downslope. Looking north-east. June 2017 © Historic England.

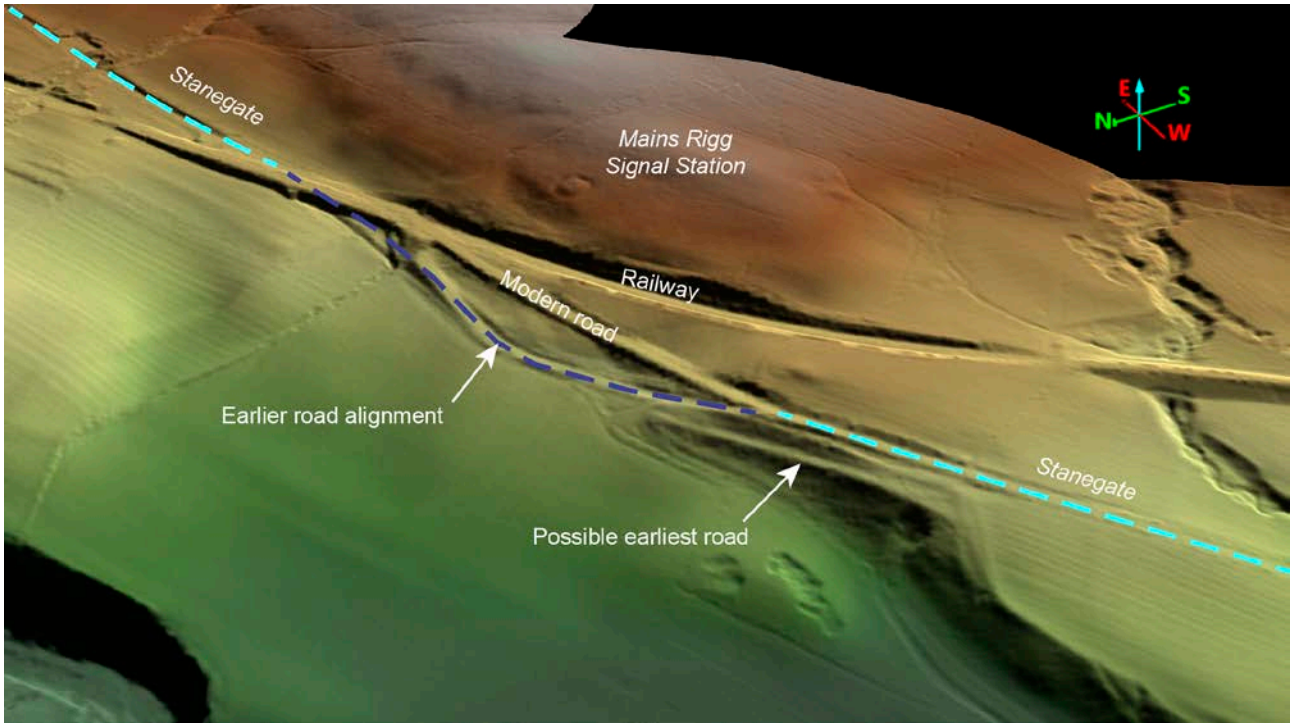


Figure 12: To the west of Upper Denton, the line of the Gilsland to Chapelburn burn road was altered when the Newcastle to Carlisle Railway was constructed. The earliest alignment might be that of the Stanegate. LIDAR DTM 21-APR-2010 © Historic England. Source Environment Agency.

Fortifications along the Stanegate

Throp Roman fortlet

The fortlet at Throp (13963) was located south-west of Gilsland, 85m north of the Stanegate. The site is defined by a much plough-levelled square enclosure with bank and external ditch, measuring approximately 83m by 84m. Due to their degraded and spread nature, the remains are best viewed on elevation models (Fig. 13). The fortlet occupies an unusual location, being on an undulating natural spur. Excavations in 1910 by Simpson (Simpson 1913, 363-81) revealed two gates and the foundations of much of the outer wall.

The position of the north-east gate is today visible as a shallow depression in the earthworks. This is presumably the result of the excavation, as in 1852 Maclauchlan recorded the form of the fortlet as already 'much worn down by the plough … and though the outline is still distinct all traces of its gateways are gone' (ibid., 363). The excavations showed that the fort had only one other entrance: in its south-east side facing towards Stanegate.

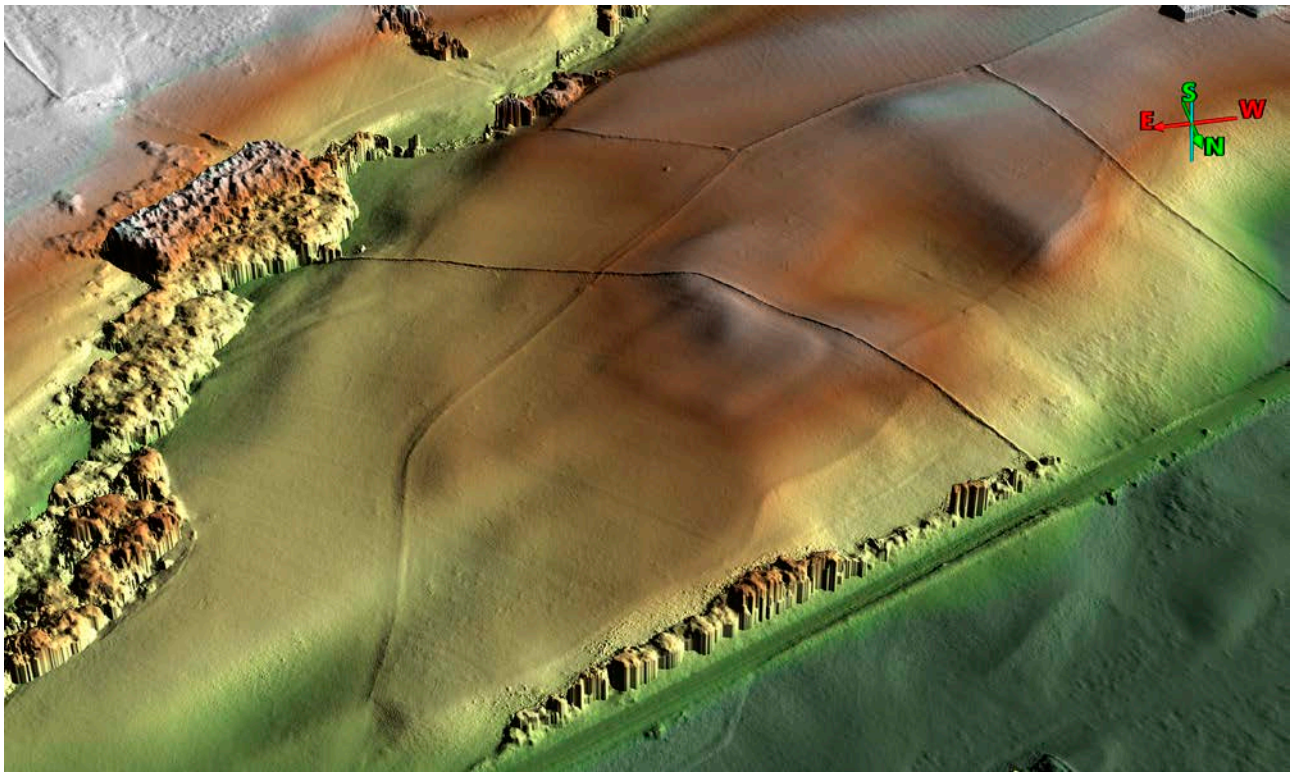


Figure 13: The heavily eroded earthworks of Throp Roman fortlet are best seen on DEMs. The hollow way rising up from Poltross Burn to the left of the fort is the line of the Stanegate. Historic England SfM DSM 05-JAN-2017 © Historic England.

Mains Rigg Signal Station

The Roman signal station (13996) on Mains Rigg (Fig. 14) is located 78m south of the Stanegate, near the junction of the modern Gilsland to Chapelburn road and railway. The earthworks comprise a broad outer ditch enclosing a small square platform on which are

the embanked remains of the tower footings. The whole enclosure measures 21m by 23m with the tower foundations being 7.2m by 7.5m. A small causeway across the south-east corner of the ditch is probably more recent in date and unrelated to the Roman feature. Collins (2015), states that the signal tower foundations sit within a broader enclosure. Current lidar (2019) does hint at a slight outer scarp to the west and north, but this is tentative. It is important to note that on the lidar (2010) and SfM model available at the time of survey, these earthworks were not visible with enough clarity to map.

Figure 14: An oblique aerial photograph showing the Roman signal station on Mains Rigg. The earthworks are well defined and the turfed-over footings of the tower are clearly visible on the central platform. 9350/6 02-MAR-1976 © Historic England (Barri Jones Collection).

Nether Denton Roman Fort

One of the main forts constructed along the Stanegate was at Nether Denton (12711) in the west of the project area. This is the earliest dated fortification in the region. Evidence from targeted excavation in 1868, 1911 and 1933 (Shipman 1870; Simpson and St. Joseph 1934) suggests that the fort was established in the late 1st century AD and went out of use early in the 2nd century, presumably when the decision was taken to move garrison forts from the Stanegate up on to the line of Hadrian's Wall. However, pottery from the *vicus* to the south of the fort dates to the late 2nd century AD which may suggest that the fort, or at least the civilian settlement, continued in use (Breeze 2006, 453).

The northern half of the fort occupied the hill on which the Church of St Cuthbert and Church Hill House now stand, extending as far east as the Old Rectory. Multi-phased southern and western perimeter ditches are visible as cropmarks on oblique aerial photographs (Fig. 15). This is the only location within the project area where cropmarks were noted. This is due to the free-draining sands and gravels which allow for soil conditions more conducive to the formation of cropmarks.

Figure 15: The south and south-west corner of Nether Denton Roman fort visible as cropmarks. 12306/18 14-JUL-1992 © Crown copyright. Historic England Archive.

The clearest cropmarks lie in the field between the Gilsland road and Church Hill House. The distinct curve of the south-west corner of the fort perimeter ditch is clearly visible, as are lengths of the southern and western sides. A second, concentric, ditch is visible approximately 16m beyond, whilst a third ditch lies 25m further west again, but appears to merge with the second ditch around the southern side of the fort. These outer ditches suggest the fort has expanded or contracted, possibly on several occasions, perhaps through the addition or removal of external annexes. Additional fragmentary cropmarks are visible clustered around these ditches, but it is difficult to say whether these features relate to the fort, the extra-mural settlement or later activity.

Part of the fort's west perimeter ditch is also visible as a cropmark on a 1949 CUCAP aerial photograph. The ditch extends north as far as the edge of the natural escarpment overlooking the River Irthing, where it begins to curve slightly towards the north-east. A projection of this ditch suggests that the northern perimeter to the fort has been eroded

by the river migrating southwards (Fig. 16). The maximum visible dimensions of the fort (including the outer defensive ditches) measure 217m by 146m. However, based on the projected line of the visible ditches and the excavation evidence it may have measured up to 245m by 180m.

Figure 16: The approximate maximum extent of Nether Denton Roman Fort based on evidence from excavations and aerial photographs. The northern perimeter ditches appear to have been lost to the migration of the River Irthing. 33031_99 05-JAN-2017 © Historic England Archive.

A series of hollow ways, boundaries and possible building platforms are visible as earthworks (1473876) to the north and east of The Old Rectory. These probably relate to the medieval and post-medieval settlement of Nether Denton. They do however follow the same alignment as the cropmark remains of the fort, perhaps signifying that they have been constructed on top of or respecting Roman remains that may have still been visible at the time. Excavations in 1933 failed to find any Roman structures in this north-eastern field (Simpson and St. Joseph 1934, 152).

The present Church of St Cuthbert was constructed in the late 19th century on the site of a 12th-century predecessor that belonged to Wetheral Priory and Lanercost Priory (Whellan 1860, 674). A Roman altar stone stands outside the church's south wall (Fig. 17). It was discovered, part-buried, in the churchyard in the 1970s (A. Welfare 2020, pers. comm., 27 Mar.) and was presumably from the fort or a nearby associated building.

Figure 17: A Roman altar stone is located outside the Church of St Cuthbert in Nether Denton. The altar was discovered in the churchyard in the 1970s. June 2017 © Historic England.

The excavations also located Roman remains outside the fort, south of the current road from Chapelburn to Lanehead. These probably relate to a civilian extra-mural settlement (*vicus*), but no features are visible here on aerial sources. Cropmarks to the south-west of the fort were interpreted by the Hadrian's Wall NMP project as elements of a *vicus*, but the fragmentary nature of the cropmarks and confusion from marks caused by the underlying geology make these features difficult to interpret and date. Additionally, a road that has been suggested as associated with the *vicus* is here reinterpreted as a hollow way and/or boundary of medieval or post-medieval date (1612677). Arcing westwards from Chapelburn, around the south side of Nether Denton, before returning north where it is visible as a cropmark, this hollow way is aligned with the medieval/post-medieval field system and is also illustrated on the 1603 map of Nether and Over Denton (*see* Fig. 49).

The line of the Stanegate is tentative for several miles west of Chapelburn (Margary 1957, 177), though Breeze (2006, 453-4) states that it may be traced where it crossed the tributary streams of Carling Gill and Pots Cleugh (west of the project area). The projected line in the NRHE database shows the road continuing roughly in a south-west direction, following the modern road between Chapelburn and Lanehead, before heading towards Naworth Parks. A more likely scenario is that the Stanegate continued in a straight line from Chapelburn, passing through the fort at Nether Denton, roughly along the line of the farm track to High and Low Nook (Fig. 18). The 1603 map of the Denton manors shows a road continuing on this projection to the west of Chapelburn, some of which still continues in use as a trackway. It was presumably this road that was revealed through excavation in 1933 and described as 'ancient' (Simpson and St. Joseph 1934, 153). Projecting this line further west (outside the project area) leads to High Nook, where Roman funerary urns were discovered in 1861 and 1909 (Simpson 1913, 385-6), and another in 1965 (Welfare 1974, 17).

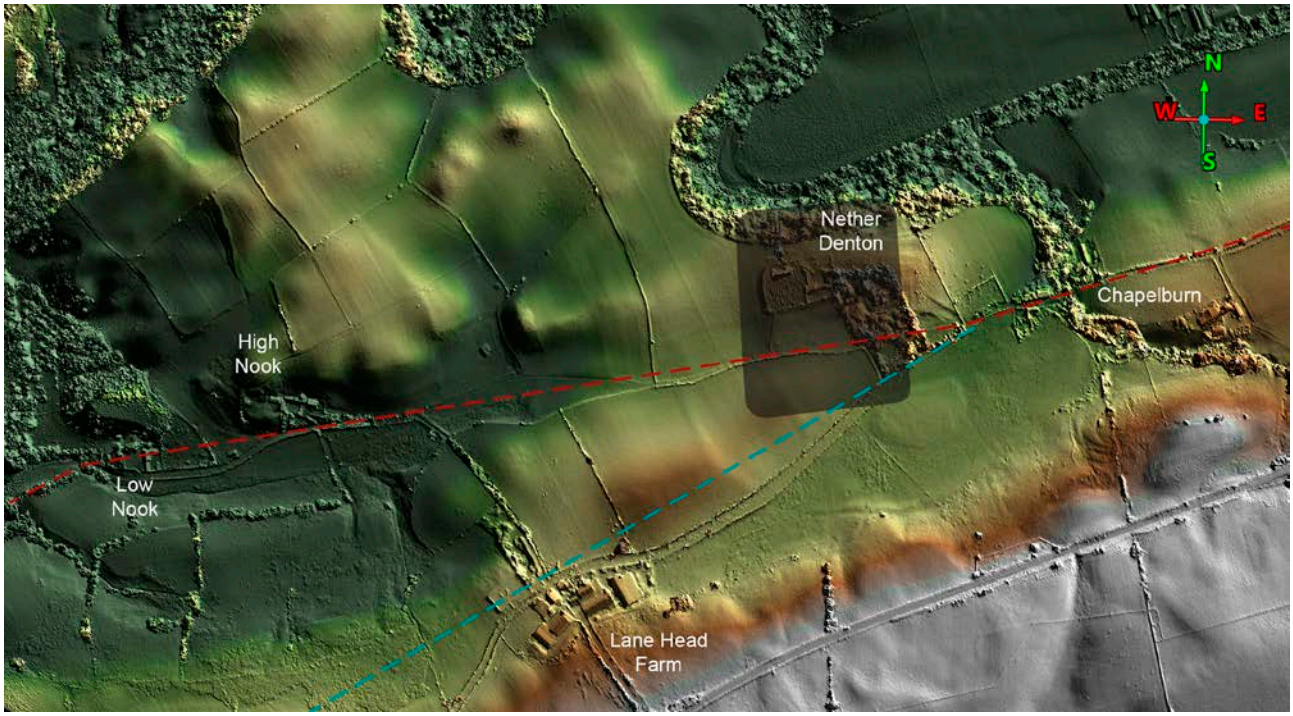


Figure 18: The Stanegate may have projected through the centre of the fort at Nether Denton (red), continuing to High Nook rather than the current projected line (blue) following the course of the modern road. Historic England SfM DSM 05-JAN-2017 © Historic England.

Hadrian's Wall

The line of forts along the Stanegate had only been in place for a matter of decades before the decision was made to reconstitute the frontier into a more formidable line of defences. As a result, from AD 122 the construction of Hadrian's Wall began (Breeze 2014, 37).

The line of the Wall and associated earthworks (*see* Fig. 8) can be traced throughout the entire length of the project area. Figure 19 illustrates the area to the west of High House Wood, where earthworks of all parts of the Wall (minus turrets and milecastles) are visible.

The following summary discusses the archaeological remains of individual elements of the Wall, broadly in the order of their construction and by site type, from east to west. A more detailed breakdown of the phasing of the Wall can be found in the *Evolution of the Roman Landscape* chapter.

Figure 19: The main elements of Hadrian's Wall are best preserved north-west of High House Wood, east of Birdoswald. 33037_067 05-JAN-2017 © Historic England Archive.

The Turf Wall and ditch

Hadrian's Wall was originally constructed to two different specifications. Willowford bridge, which carried the Wall across the River Irthing in the east of the project area, marked the dividing point between the two methods of construction. To the west of the bridge, the Wall and milecastles were built of turf and timber (the turrets were in stone). To the east of

the bridge, the Wall was built in stone. Before long, the turf section began to be replaced by stone. This was completed after the withdrawal from the Antonine Wall (Breeze 2014, 37-9). The Wall in the Birdoswald sector – more specifically between Milecastle 51 (Wall Bowers) and Milecastle 49 (Harrow's Scar) – is unique in that it was the only section of Wall where the stone rebuild took a markedly different line to that of the original (Wilmott 1997, 2): the line of the Stone Wall deviated up to 210m north of the old line. Elsewhere, the Turf Wall was simply levelled and replaced in stone. Where the course of the Wall deviated the turf construction was demolished, in places deposited into its ditch, though traces of the Wall footings and accompanying ditch and glacis survive as earthworks between Milecastle 51 (Wall Bowers) and Birdoswald.

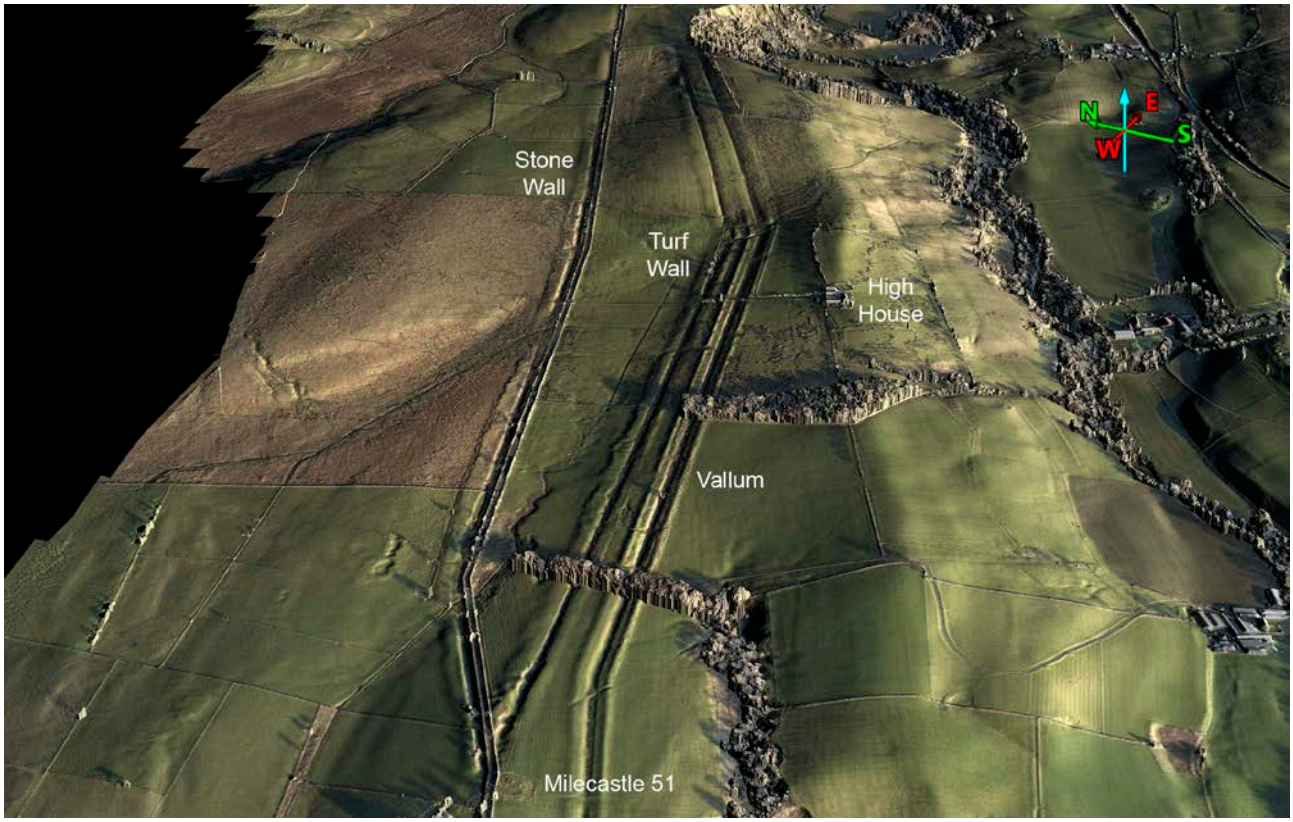


Figure 20: The Turf Wall and its accompanying ditch and glacis can be seen running through the centre of this image looking from above Milecastle 51 (Wall Bowers) east towards Birdoswald. Historic England Orthophotograph over SfM DSM 05-JAN-2017 © Historic England.

These earthwork remains are visible for over a distance of 980m (under parent records 1451822 and 1449868) (Fig. 20). The Turf Wall itself can be seen in places as a heavily truncated and often almost plough-levelled bank, best defined between Milecastle 51 (Wall Bowers) and High House where the denuded bank is up to 16m wide. North of the Wall lies a deep and broad ditch, also surviving as an earthwork. North of this is a broad and shallow, glacis bank, presumably the upcast from the ditch excavations, though possibly also a defensive feature in its own right.

The Turf Wall and ditch earthworks become less well defined closer to Birdoswald, the result of a combination of the disturbance of the later extra-mural settlement and intensive post-medieval land improvement.

The Vallum

Before the first phase of construction of the Wall had even been completed, a secondary defensive line was being dug immediately to the rear. Extending from the Tyne to the Solway (Breeze 2014, 39), the Vallum comprised a broad ditch flanked by linear banks, set back at varying distances behind the Wall. The Vallum earthworks can be traced throughout most of the project area (1451823 and 1449981).

In the east of the project area, the ditch is intermittently visible around the southern edge of Gilsland (Fig. 21), and elements of the ploughed-down banks can be seen in places, most noticeably immediately east and west of Poltross Burn. To the west of here, the Vallum was constructed almost directly behind the Wall.

Figure 21: The Vallum earthworks are less pronounced east of Poltross Burn, but the ditch and elements of the flanking banks can still be seen on the ground. Looking south-east. June 2017 © Historic England.

There are no visible Vallum earthworks between Willowford and Birdoswald, though they have been confirmed by geophysical survey between the River Irthing and the fort (Biggins and Taylor 1999, fig. 6). Excavations at Birdoswald have revealed that the Vallum originally curved around the south side of the fort, but that it was levelled shortly before the original turf fort was rebuilt in stone (Wilmott 1997, 5, 44-5) and is therefore not visible on aerial sources. Immediately west of the fort, the Vallum earthworks have been much reduced, either by the extra mural settlement or by subsequent ploughing and land improvement. Elements have been lost to the erosion of the river escarpment.

The most prominent earthwork survival is seen to the west of the fort, mostly defined by the ditch and a much-denuded southern bank. Breeze (2006, 86), suggests that the northern mound was omitted along this stretch. The evidence on elevation models however suggests that the bank is present, but much plough-levelled (Fig. 22). There is evidence of extensive post-medieval ploughing in this area which is probably largely responsible for much of this levelling.

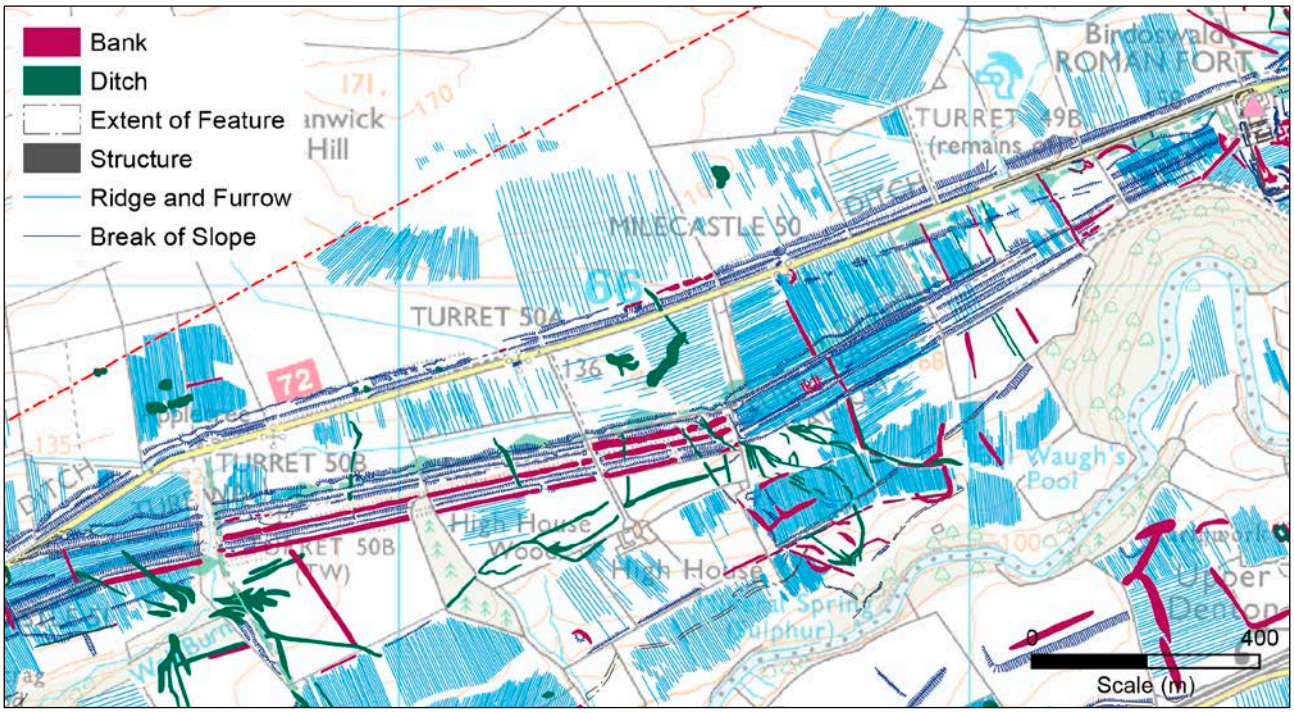


Figure 22: The survival of the Turf Wall and Vallum earthworks appear to be largely the result of post-medieval land improvement. To the east of High House, the features are considerably more plough-levelled, corresponding with the intensity of plough marks. Base map © Crown Copyright and database right 2023. All rights reserved. Ordnance Survey Licence number 100019088. Archaeological mapping © Historic England.

There is much greater survival of the Vallum earthworks to the north of High House. Here, the Turf Wall and Vallum form one coherent set of earthworks (Fig. 23). The Vallum earthworks comprise two parallel banks, each approximately 8m wide, defined as the north and south mounds. A central ditch up to 12m wide extends between the banks, separated by two flat berms of around 5m wide. A marginal mound is intermittently visible between the ditch and the south mound. These measurements are based on the part-levelled remains visible on the DSM only and therefore will not reflect the original proportions.

West of Milecastle 51 (Wall Bowers), the Vallum earthworks are less well defined though both bank and ditch elements remain visible. A series of very slight scarps (1612608) lie immediately south of the Vallum in the vicinity of Wall Bowers, overlain by narrow ridge and furrow and only visible on DEMs. These extend parallel to the Vallum, but it is uncertain whether they are Roman in date or relate to later activity.

Figure 23: A ground view looking south-west towards High House Wood shows the extensive Vallum earthworks. June 2017 © Historic England.

The Stone Wall

The Wall was initially only rebuilt in stone between Willowford Bridge and Milecastle 54 (Randylands – outside the project area). The remainder of the Wall was then rebuilt in stone following the abandonment of the Antonine Wall around AD 160 (Breeze 2006, 60). In the Birdoswald sector, lengths of the Stone Wall (1449984) were exposed through excavation in the late 19th and early 20th centuries and have been consolidated for public display.

In the east of the project area, the Stone Wall is intermittently visible from Milecastle 48 (Poltross Burn) to Willowford Bridge. The Wall ditch is also visible along this stretch, though less well defined than further west. Immediately west of Turret 48A (Willowford East), part of the ditch has been lost to the migration of the River Irthing, cutting back the south side of its valley at Hobb's Hole.

There has been some loss of the defences to the west of the Irthing, where the river has eroded the northern bank. Evidence of this was established by excavations at Willowford bridge (Bidwell and Holbrook 1989, 50), which showed that the River Irthing has migrated westwards since the Roman period.

The most complete remains of the Stone Wall are visible between Milecastle 49 (Harrow's Scar) and Birdoswald Fort (Fig. 24). Here, elements of stonework have been exposed up to a height of 2m. The Wall ditch is also visible along this length, though the glacis appears to have been flattened by a modern field boundary.

Figure 24: The exposed and consolidated remains of Hadrian's Wall are most dramatic to the east of Birdoswald Roman Fort. Looking north-east. June 2017 © Historic England.

West of the fort, the Wall is visible alongside the southern edge of the Birdoswald to Banks road for a distance of 460m before the road widens slightly and the Wall line disappears beneath it. This road appears to have been constructed after the 1603 survey of Gilsland (Cumbria Archive DHN/C/713/3). It followed the line of the Wall, but even where overlain by the road, the line of the Wall can still be traced through the turrets and milecastles.

The general line of the Wall to the west of Birdoswald can also be traced by the Wall ditch, which is visible from the fort to the western edge of the project area (1451816 and 1449965). The ditch is less pronounced to the north of Birdoswald Roman Fort, but between the fort and Turret 51A (Piper Syke), it runs a little north of, and parallel to, the modern road. To the west of Turret 49B (Birdoswald), a glacis bank is visible as an earthwork, extending parallel to the northern edge of the ditch.

A very short section of the Stone Wall is visible abutting the north-west corner of Turret 51A (Piper Sike) (12627) at the western edge of the project area. The line of the Wall to either side of the turret is not obvious on aerial photographs or elevation models, but elements of it can be traced on the ground as a raised bank extending west from the turret, on top of which the current roadside wall has been constructed. To the east of the turret, there is a distinct depression where the Wall ought to be, perhaps suggesting that much of the stone has been robbed at this point, perhaps for the building of nearby farms at Coombe Craig and Wall Bowers.

Turrets and Milecastles

The turrets and milecastles along this section of Hadrian's Wall relate to both the Turf Wall (**TW**) and Stone Wall (**SW**). Where the later Stone Wall deviated from the earlier course, the turrets and milecastles associated with the turf construction were relocated on the line of the Stone Wall. Most of the turrets and milecastles along this section of Hadrian's Wall are visible on aerial sources and were mapped as part of this project. Sites not visible on aerial sources were visited on the ground, but where no physical evidence for the feature could be detected on the ground either, they are not discussed below.

Milecastle 48 (Poltross Burn)

Having been excavated several times between 1886 and 1965-6 (Gibson and Simpson 1911, 393; Charlesworth 1967), the remains of the Poltross Burn milecastle (13969) were consolidated (Fig. 25). It is one of the best preserved milecastles on this section of Hadrian's Wall. The footings of internal structures were also revealed, as well as the base of a flight of stairs, which has been used here and elsewhere to establish an estimate for the height of the walkway to the milecastle walls and possibly to the Stone Wall itself.

Figure 25: Milecastle 48 (Poltross Burn) is one of the best preserved milecastles in the Birdoswald Sector. Internal details include two barrack blocks and the base of a flight of stone stairs, possibly leading to the Stone Wall walkway. 20995_046 02-MAR-2010 © Historic England Archive.

Turret 48A (Willowford East)

The easternmost of the Wall strongpoints in the project area, this turret (13972) was excavated in 1923 and subsequently and consolidated (Shaw 1926, 437-444) (Fig. 26). It is one of the most complete turrets in the Birdoswald Sector.

Figure 26: The consolidated remains of Turret 48A (Willowford East). Looking east. June 2017 © Historic England.

Turret 48B (Willowford West)

This turret (13977) on the Stone Wall is less complete than most examples in the area. Excavated in 1923, the turret was found to have been heavily robbed of stone, the southern wall missing completely (ibid., 431). This may have been for the construction of Willowford farm. The consolidated remains have been mapped from aerial photographs.

*Milecastle 49 **SW** (Harrow's Scar)*

Harrow's Scar milecastle (13987) was excavated in 1953 (Richmond 1956) and consolidated for public display (Fig. 27). Unlike the turrets, which were constructed prior to the Stone Wall, the sequencing of the stonework shows that the stone milecastles were built abutting the Wall. The excavations also revealed the remains of a post-medieval farmstead within the milecastle which relates to a farmstead shown on the 1603 estate map (Cumbria Archive DHN/C/713/3). The aerial mapping identified a slight L-shaped bank to the west of the milecastle; this is aligned on the post-medieval building and is probably a paddock relating to the farm.

Figure 27: The excavated and consolidated remains of Milecastle 49 SW (Harrow's Scar). The relationship between the stonework illustrates that the Stone Wall was constructed first, with the milecastle abutting the Wall. The internal structures relate to a post-medieval farmstead marked on a map of 1603. Skeye UAS Orthophotograph DSM 21-FEB-2017 © English Heritage Trust/ Historic England.

*Turret 49B **SW** (Birdoswald)*

This turret (14002) was also excavated in 1911 (Simpson 1913, 303-6) and later consolidated along with the adjoining sections of the Wall (Fig. 28). The phasing in the masonry illustrates that the turret was constructed first, with the Wall built up against it shortly afterwards.

*Milecastle 50 **TW** (High House)*

The visible earthwork remains of Milecastle 50, on the Turf Wall, (14014) are the result of excavation in 1934 (Simpson, Richmond and St. Joseph 1935a). This milecastle was constructed in turf with timber palisades and internal buildings. The outline of the south-west and south-east corners, and the central gateway are demarked by narrow banks, presumably laid out following the 1934 excavation. The north wall of the milecastle is not visible, possibly because post-medieval land improvement has plough-levelled the remains. These embanked outlines are also visible on historic vertical aerial photographs (Fig. 29).

Figure 28: The consolidated remains of Turret 49B. The Stone Wall can be seen abutting the turret. Looking west. June 2017 © Historic England.

Figure 29: The outline of Milecastle 50 TW (High House) visible on historic vertical photographs, are the results of excavation in 1934. RAF/106G/UK/1392 RP 3173 10-APR-1946 Historic England Archive (RAF Photography).

When this site was visited in the field, a large rectangular block of worked limestone was noted lying on the surface close by. The stone is not mentioned in the excavation report and is fundamentally unlikely to be associated with the turf milecastle. It is however most likely Roman and possibly brought here for safekeeping by a landowner.

*Milecastle 50 **SW** (High House)*

The High House milecastle (14005) was constructed on the Stone Wall as a replacement to its predecessor on the Turf Wall 165m to the south (discussed above). Excavations in 1911 revealed that much of it had been disturbed by a post-medieval building (Simpson 1913, 312). The later building presumably post-dates 1603 as nothing is shown here on the estate map. The earthwork remains are poorly defined, comprising an amorphous bank, thought to represent the milecastle's east wall, and part of the outer western ditch with a central platform (*see* Fig. 69).

*Turret 50A **SW** (High House)*

This turret (14008) was completely excavated in 1911 (ibid., 307-309), but was then reburied as much of it lies beneath the modern road which had been temporarily closed and dug up in order to facilitate the excavation. All that is now visible on the surface is a low mound in the field south of the road, marking the turret's southern edge (Fig. 30). On the ground, the mound is illustrated by the rise and fall in the modern field boundary wall as it passes over it.

Figure 30: The location of Turret 50A SW (High House) illustrated by the rise and fall in the modern field wall passing over the mound that marks its southern edge. Most of the turret lies under the modern road on the opposite side of the wall. Looking west. June 2017 © Historic England.

Milecastle 51 (Wall Bowers)

Elements of this milecastle (12630) were excavated in the 1920s and 1930s (Simpson 1928, 384; Simpson and Richmond 1935, 254-5; Simpson and Richmond 1937, 158). Amorphous earthworks are clearly visible on aerial sources (Fig. 31). How much of the visible remains are a result of the excavations is uncertain. It is possible that some of the earthworks might relate to the earlier turf milecastle which was at the same location and replaced by stone. Excavations to the south of the milecastle revealed a 'causeway' through the Vallum (Simpson and Richmond 1937, 158-166). A linear ditch recorded by the Hadrian's Wall NMP (1010489) was interpreted as the line of this causeway, but further examination suggests that the ditch is either a post-medieval boundary cutting through the Vallum, or remains of the excavations that took place. It is unlikely to be the excavated causeway as it does not align with the southern entrance to the milecastle.

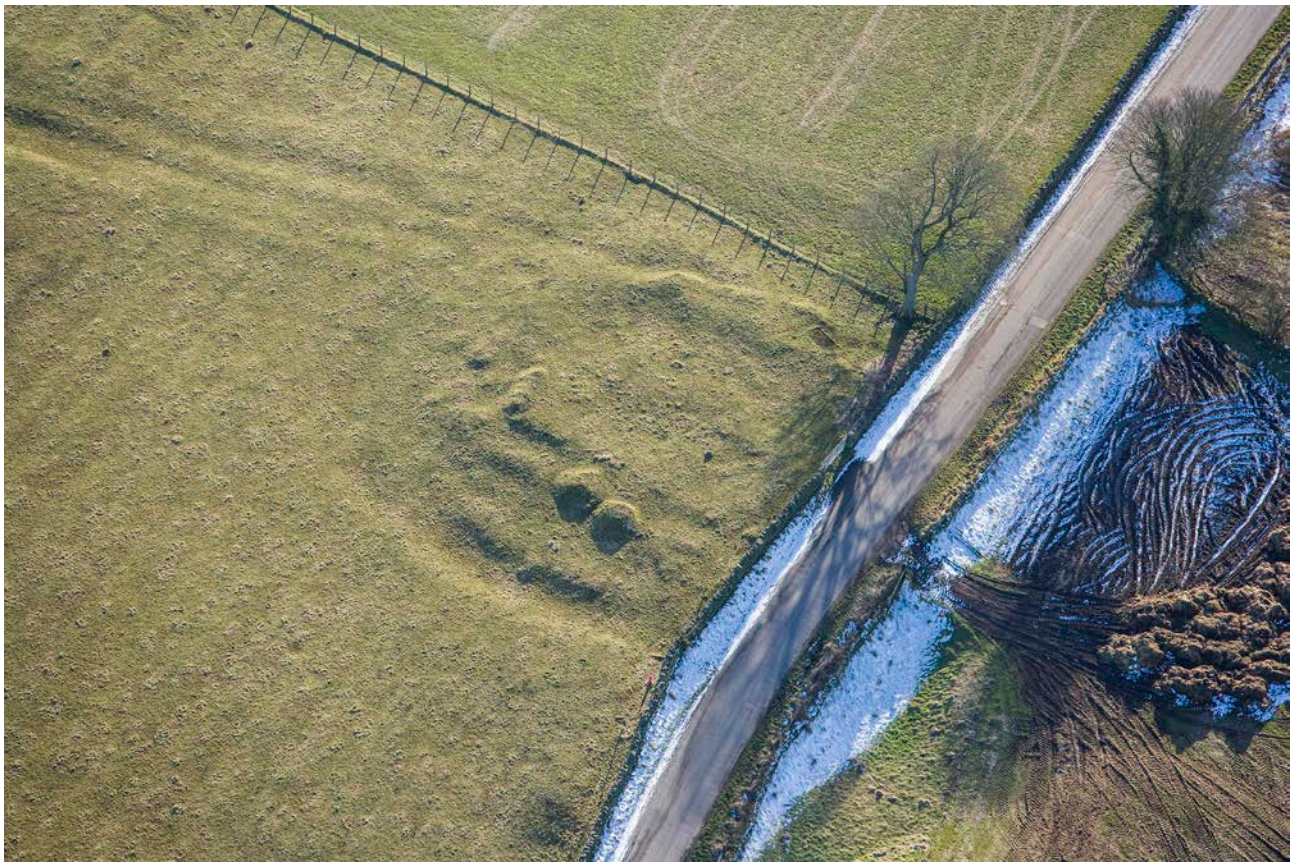


Figure 31: Milecastle 51 (Wall Bowers) visible as earthworks. The earthworks are complex and elements may relate to the earlier turf milecastle which was later replaced in stone. 20995_017 02-MAR-2010 © Historic England Archive.

Turret 51A (Piper Sike)

The stone foundations to this turret (12627) were exposed by excavation in 1970 (Charlesworth 1973) and have subsequently been consolidated for public display (Fig. 32). The turret was originally constructed as part of the Turf Wall and was retained when the Wall to either side was rebuilt in stone. This relationship is visible in the displayed remains, for the foundations of the Stone Wall abut, and are therefore demonstrably later than, the walls of the turret.

Figure 32: The consolidated remains of Turret 51A (Piper Sike). Looking north. June 2017 © Historic England.

Willowford Bridge

The bridge remains (13982) are located on the east bank of the River Irthing, a little east of Milecastle 49 (Harrow's Scar) (Fig. 33). Only the eastern elements of the bridge remain. The river has migrated westward since the Roman period, destroying or burying much of the western bridge foundations and a section of the Wall. Historic accounts suggest that more of the pier foundations were visible as late as 1599, and that much of the movement in the river's course is therefore subsequent to this date. The eastern elements of the bridge were first excavated in 1924 and re-excavated in 1940 and 1984-5 (Bidwell and Holbrook 1989, 52-4). The stonework forms some of the most impressive structures along this section of Hadrian's Wall, comprising the Wall itself, a series of abutments, sluices and base of a tower. The consolidated remains are visible on aerial sources and are accessible on the ground as part of the Hadrian's Wall walk.

Figure 33: The footings of Willowford Bridge adjoined the Stone Wall east of the River Irthing (centre-right). The bridge carried the Wall across the River Irthing (centre) which has since migrated westward across the valley floor marooning the eastern abutment whilst burying or destroying much of the bridge, its western abutment and adjoining section of Stone Wall. Milecastle 49 (Harrow's Scar) is visible centre left. 33033_521 05-JAN-2017 © Historic England Archive.

Birdoswald (*Banna*) Roman Fort

The visible remains of the fort at Birdoswald (13993), as seen today (*see* Fig. 1), are the product of multiple excavations. The present project has produced few fresh insights into the fort itself but has enabled detailed and accurate mapping as well as a better understanding of how it was integrated into its landscape.

The Roman occupation of the site at Birdoswald was multi-phased and complex. When the frontier was moved to the north of the Stanegate, the Turf Wall was constructed on the site of the fort. Birdoswald became the site of Turret 49A **TW**, but it was only a few years before a small turf fort was constructed to the rear of the wall. The Vallum was dug to go around the southern edge of this fort. This fort was later enlarged and rebuilt in stone, this time projecting north of the Turf Wall. The Wall was then rebuilt in stone and moved north, becoming flush with the north face of the stone fort (Wilmott 1997, fig. 24; Wilmott 2014, 25-8).

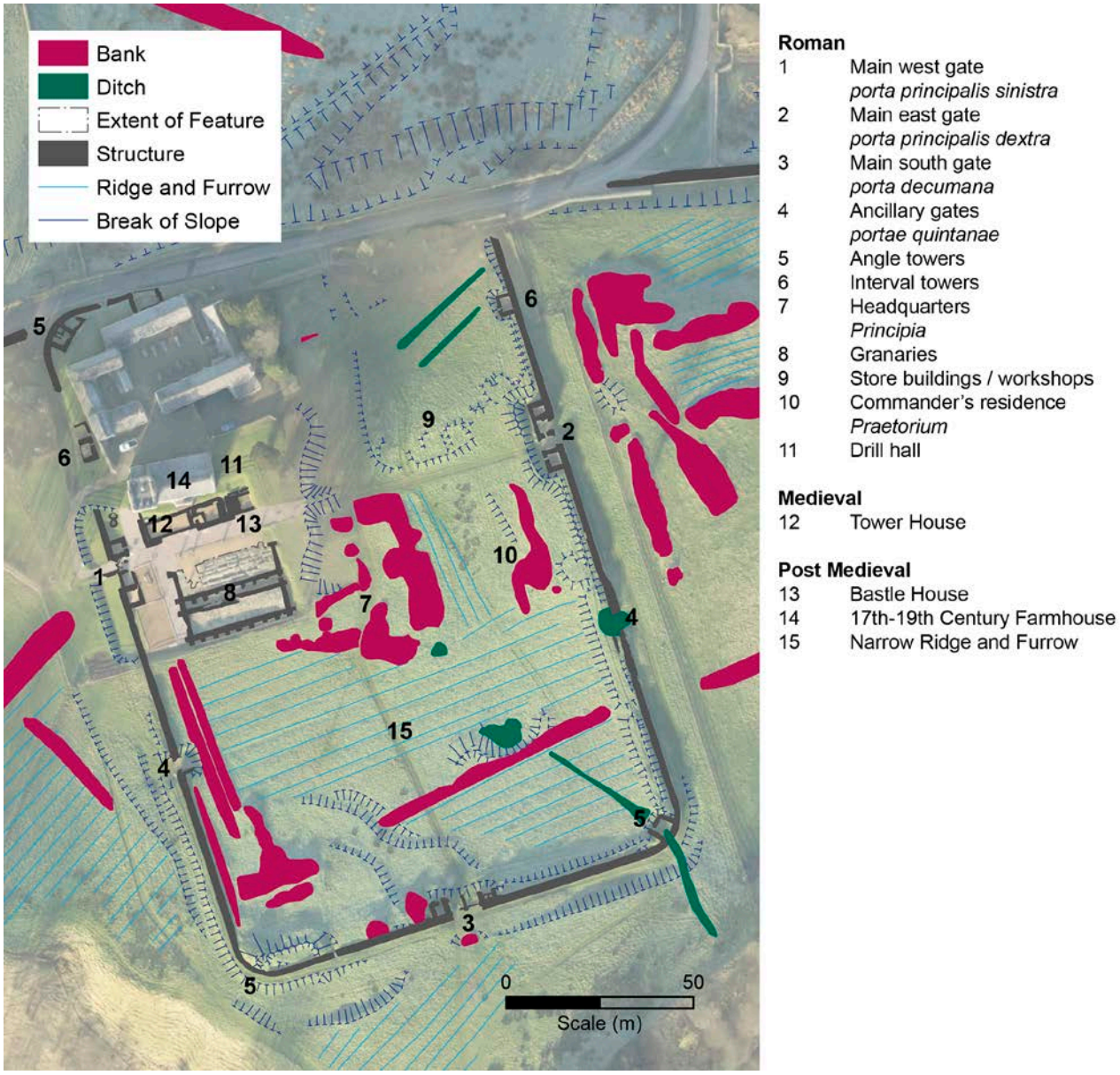


Figure 34: The principle archaeological features visible at Birdoswald range from Roman to post-medieval. Historic England SfM Orthophotograph 05-JAN-2017 © Historic England. Archaeological mapping © Historic England.

The exposed fort remains include the west, south and east walls (Fig. 34). The main east gate (*porta principalis dextra*) and west gate (*porta principalis sinistra*) which served the *via principalis* are visible, as is the main south gate (porta decumana) and the ancillary east and west gates which served the *via quintana* (Breeze 2006, 77; Wilmott 2014, 6-7). The north gate (*porta praetoria*) is believed to be buried beneath the modern road and has never been excavated. Numerous internal features are also visible, including the excavated remains of Roman, medieval and post-medieval buildings, as well as earthworks relating to the *Principia* and other internal features. Ridge and furrow, field boundary banks and trackways, all relating to the post-medieval period, are also visible within the fort. Many of the perimeter scarps and banks are simply the result of excavations undertaken in order to expose the walls and gates over the last century.

The use of DEMs has allowed the mapping of subtle earthwork features in the fields adjacent to the fort. To the north of the Wall, the ground slopes away towards Midgeholme Moss, a naturally boggy area that was presumably a considerable obstacle and natural defence during the Roman period. The slope is moderately steep, clearly one of the reasons for the siting of the fort at this location. There is a slight scarp immediately north of the modern roadside, which might hint at the buried remains of the north wall to the fort, but which could equally relate to the construction of the road. The route of the road north out of the fort was unclear at the time of the survey and most earthworks in this area north of the fort were considered most likely medieval or post-medieval. Recent evidence combined with a review of the mapping has led to new interpretations of this area north of the fort, which is discussed in the *Evolution of the Roman Landscape*.

Figure 35: A series of irregular earthworks to the east of Birdoswald Roman Fort are a mix of buried archaeology and spoil heaps from 19th-century excavations. 33040_060 05-JAN-2017 © Historic England Archive.

A series of linear and amorphous earthwork banks to the east of the fort (14023) are often overlooked when discussing the earthworks at Birdoswald (Fig. 35). The linear banks extending parallel to the fort wall are dismissed as spoil heaps resulting from excavation, possibly by Potter in 1850 (Simpson and Richmond 1934, 130). Biggins and Taylor (1999, 106), note that the linear banks interfered with the geophysical survey readings. The longest of the mounds is a linear bank extending 100m east, perpendicular to the east gate

(*porta principalis dextra*), broadly on the line of the Military Way exiting the fort. Excavation in 2021 showed this to comprise the road *agger* constructed on the line of the remains of the Turf Wall. The shorter bank, parallel to the north, was shown to comprise the north (rear) wall of a row of strip buildings fronting onto the road. These walls still stand almost a metre high (T. Wilmott 2023, pers. comm. 22 Aug.). There is evidence of ridge and furrow between these banks, which excavation indicates respects the banks.

The Military Way

The Military Way was the last major feature to be added to the Hadrian's Wall frontier zone. The road is thought to have been built to link all the forts on the Wall (Breeze 2014, 39). In the Birdoswald sector, it is one of the least visible of all the remains associated with the Wall. The recorded line of the road, as with many Roman roads, is mostly conjectural – simply a projection between known points where it has been picked up through excavation or survey. The road is known to have run between the Wall and Vallum however and can be partially traced throughout the project area.

It is not visible east of the River Irthing. Here, the gap between the Vallum and the Wall is as narrow as 25m, but the Roman earthworks are generally quite denuded, and if the road did pass through this narrow stretch, there are no earthworks visible on aerial sources.

The road is best illustrated on DEMs immediately west of Birdoswald (1449986), where the course has also been confirmed through geophysical survey (Roseveare and Roseveare 2009). The earthwork evidence is extremely slight, but shows the road was partly sunken at its east end nearest the extra mural settlement outside the fort but was raised up on an *agger* further west. However, the earthworks are so denuded in nature, that we are only seeing slight vestiges of the true form of the road. These fragmentary earthworks are intermittently visible for 550m.

Another newly identified length of the road can be seen as an extremely shallow earthwork in the west of the project area, between Milecastle 51 (Wall Bowers) and Craighead (Fig. 36). Although only visible as a series of slight, fragmentary, broad banks that extend for some 750m parallel to and between the Wall and Vallum, this is the first time the Military Way has been identified in this sector. The reports on the excavations at this milecastle in 1934 (Simpson and Richmond 1935, 254-6) and the neighbouring section of Vallum in 1936 (Simpson and Richmond 1937, 158-66) made no mention of having located the road here, but it seems the area between the Vallum and milecastle was not trenched.

Figure 36: A very slight linear bank situated between the Wall and Vallum probably represents the line of the Military Way between Craighead and Milecastle 51 (Wall Bowers). Historic England Orthophotograph over SfM DSM 05-JAN-2017 © Historic England.

Birdoswald to Lanerton Road

Two previously unrecorded routeways were mapped extending north-east to south-west obliquely down the north side of the valley of the Irthing, between High House and Blackbank Wood. Perhaps the most significant of these is a moderately straight section of track (1612650) that extends for nearly 930m from the western corner of Blackbank Wood to a small gorge in High House Wood (*see* Fig. 39). The eastern end is defined by a shallow hollow way (Fig. 37) which gradually flattens out into a terrace extending obliquely along the hillside. The western 360m appears to run alongside a linear post-medieval field boundary south of High House.

Although particularly visible on elevation models, the terrace is very slight when viewed on the ground, best discerned at an oblique angle (Fig. 38). It is both truncated by a medieval/post-medieval hollow way and overlain by a broad, almost plough-levelled bank, possibly part of a medieval field system (1612634) (*see* Fig. 46).

There is a secondary routeway (1612636), defined by a sinuous and almost plough-levelled hollow way further down the slope, that not only appears to terminate on the terrace, but extends along the slope in the same direction, suggesting perhaps a different phase of the same route.

Figure 37: The eastern end of the routeway is visible as a shallow hollow way – here seen extending obliquely across the image from Blackbank Wood. Looking east. June 2023 © Historic England.

Figure 38: The road extends as a linear terrace along the slope. Looking north-west. June 2017 © Historic England.

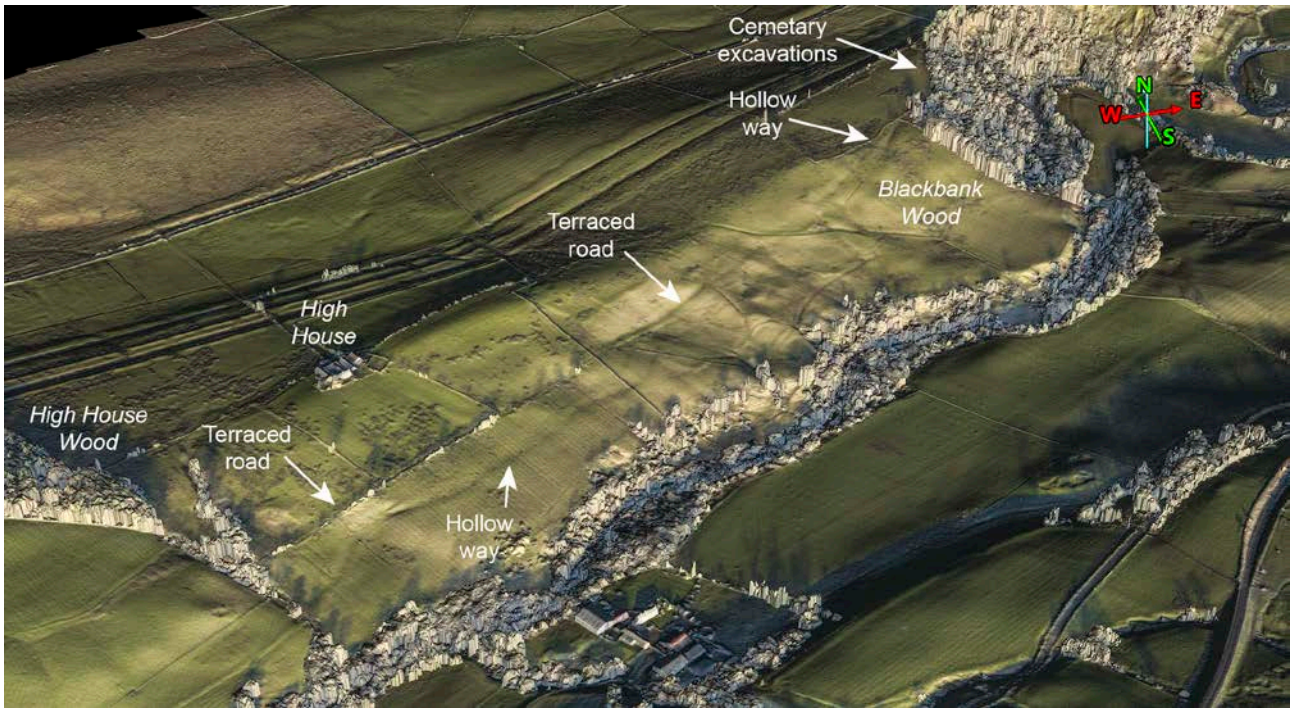


Figure 39: The road to the south-west of Birdoswald is visible as a hollow way nearer the fort and then as a terrace extending oblique across the slope. Another sinuous hollow way, broadly on the same orientation, is visible lower down the slope. Historic England Orthophotograph over SfM DSM 05-JAN-2017 © Historic England.

Further supporting evidence for a road interpretation comes from the excavation of the Roman cemetery to the west of Birdoswald in 2009 (Fig. 40). This excavation was in response to subsidence of the slope in Blackbank Wood, some of which had already claimed part of the cemetery. The excavation revealed a metalled road, parallel to the cemetery enclosure, extending from the direction of Birdoswald (Wilmott 2010, 17) towards and on the same alignment as the hollow way at the east end of the track. The southern end of the road led into a hollow way, cobbled at the base (T. Wilmott, pers. comm.).

There is no obvious trace of the road or hollow way continuing to the west of the crag. It has either been removed by intensive land improvement in the post-medieval period or was stepped further down slope and is masked by existing field boundaries. Nonetheless, it is likely that the route continued towards Lanerton and a fording point across the river.

Figure 40: Excavations of the Roman cemetery to the south-west of Birdoswald in 2009. The cobbled Roman road extends through the centre of the trench from left to right. The projected alignment would lead to the hollow way to the south-west. 20947_066 01-OCT-2009 © Historic England Archive.

Temporary Camps

As the temporary camps cannot easily be attributed to the Stanegate or Hadrian's Wall periods of defence (or earlier), they are discussed separately here.

Crooks Camp

Located on the high ground of Thirwall Common, south of Gilsland, Crooks Camp (14042) is the best preserved of the three camps in the Birdoswald sector. In plan, it exhibits the 'playing card' shape typical of Roman camps (Fig. 41); it measures 88m north-south by 127m east–west. There are gateways in the centre of each side, each with an opposing traverse visible as a short length of bank parallel to the camp entrance, with a ditch to the outside.

The bank of the western traverse has been partly dug in to at its northern end, perhaps to form a shooting butt or small animal pen (Fig. 42). A distinct 'halo' of shallow amorphous banks was mapped from lidar to the west of the camp (1612402). At the time of the survey, lidar was only available for the western half of the camp. A quick study of the current (2019) full cover lidar shows that this halo extending around the full proximity of the camp. Their purpose is uncertain. When examined on the ground they were observed to be very slight features. They don't appear to be natural and are deliberately sited on the camp. It is possible that they may be the remnants of external defences, but no parallels have been seen in the region.

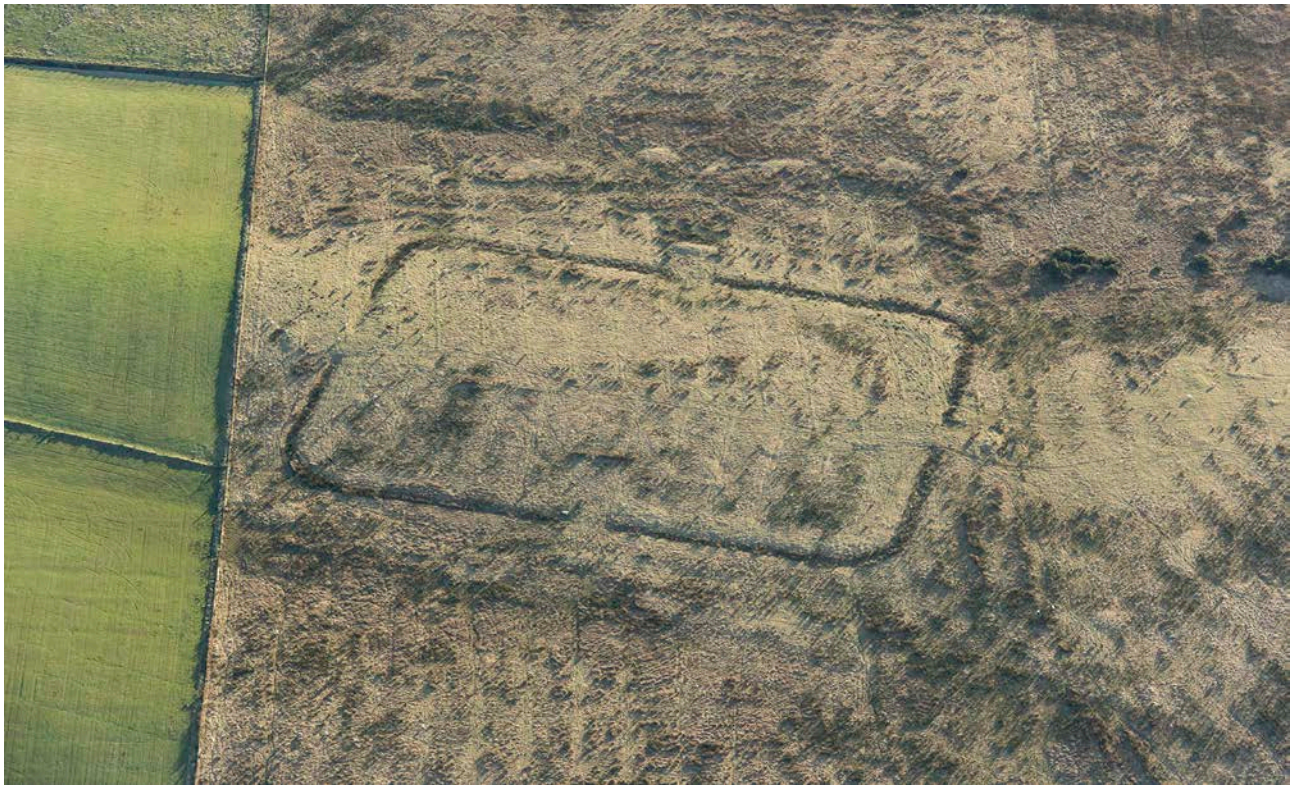


Figure 41: Crooks Camp is located on the highest point within the project area. Because it lies on marginal land that has been drained but seemingly not ploughed, it remains remarkably well-preserved. 33039_461 05-JAN-2017 © Historic England Archive.

Figure 42: The north end of the bank of the western traverse at Crooks Camp has been reworked, possibly to form a shooting butt or small animal pen. Looking south. June 2017 © Historic England.

Willowford Camp

Located on a spur of high ground to the south of the farm after which it is named, Willowford Camp (13966) commands good all-round views, particularly to the north, east and south. It is a slightly irregular rectangle in plan, defined on the ground by a ditch with a low, spread bank on the inside (Fig. 43). It measures 79m by 99m overall. It has gateways on the east and north sides, both of which are opposed by a traverse (a short, detached length of rampart set a little in advance of the gate as an added external defence). The north side of the camp is partly obscured by dense vegetation and the alignment has been reused and obscured by a post-medieval sod-cast boundary bank. Another post-medieval field boundary divides the enclosure north to south and the camp is crossed by numerous drains. More recent drains have been cut to avoid the Roman earthworks (Welfare and Swan 1995, 52).

Figure 43: Willowford Roman Camp has undergone considerable disturbance from post-medieval land division and improvement, but still survives as a readily recognisable earthwork in the landscape. 33031_039 05-JAN-2017 © Historic England Archive.

Lanerton Camp

This site was first identified by Bryn Gethin of Archaeology Warwickshire from Environment Agency lidar data in 2010-11 (B. Gethin 2018, pers. Comm., 5 Mar.) who passed the finding on to Historic England (Fig. 44). The extremely denuded camp ditch can also be traced on the SfM DSM, as well as on select aerial photographs. The camp is sited on moderately level ground overlooking Lanerton farm and the valley of the Irthing to the south. Its west, north and east sides are visible but are so levelled that it is impossible to denote any gates. The south side is not certain, but probably underlies a post-medieval sod-cast field boundary that runs along the top of the valley side, the eastern end of which curves northwards in a manner suggestive of the rounded corner of a camp. Earthworks visible on the SfM DSM suggests that the west ditch may have extended further south which may be indicative of a once larger sized camp, a possible annexe or may simply be disturbance from later hollow ways.

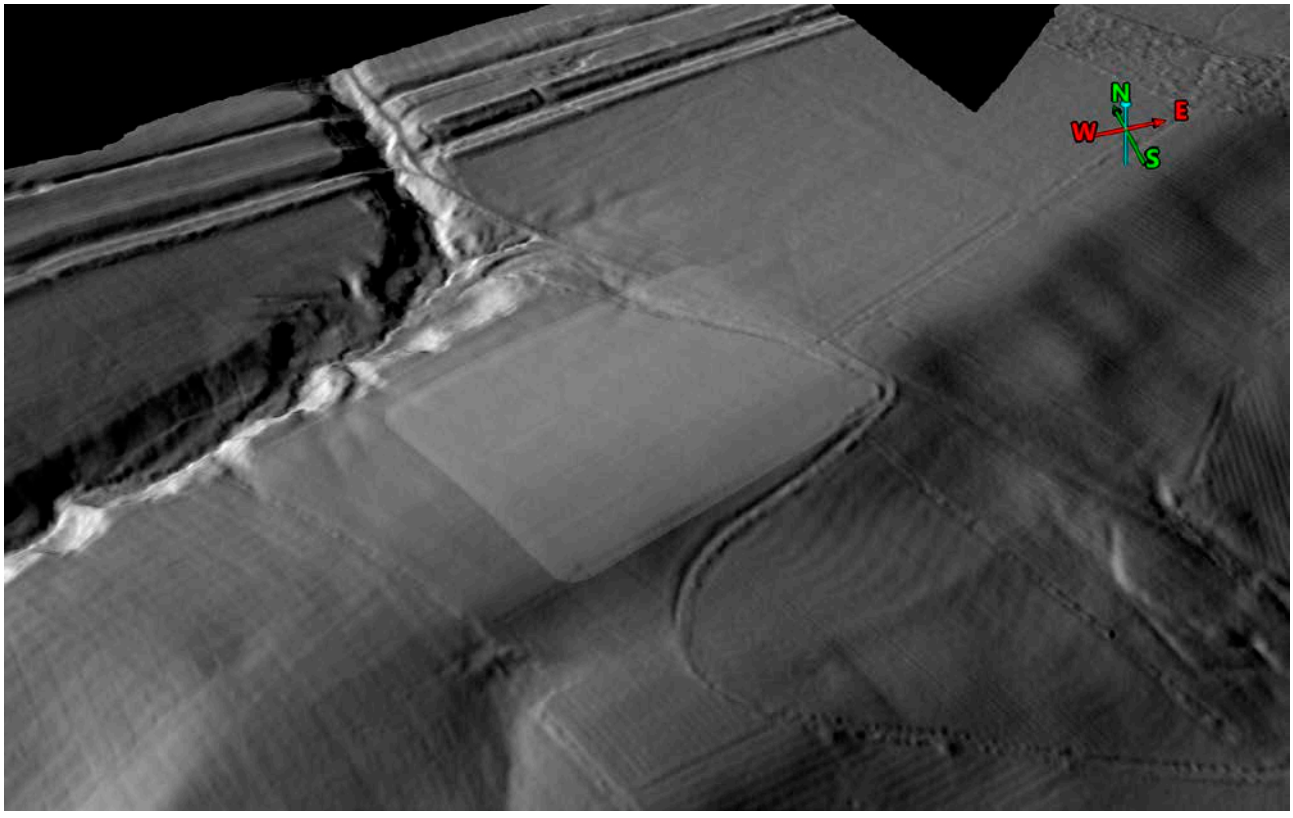


Figure 44: The Roman camp above Lanerton (highlighted) is a recent discovery. The very slight earthworks are best viewed on DEMs. LIDAR DTM 21-APR-2010 © Historic England. Source Environment Agency.

The camp ditch is so slight as to be almost impossible to discern on the ground except at one point where the north rampart is overlain by a hedge (Fig. 45). Here, the profile of both the ditch and a slight internal bank are visible.

Figure 45: The earthworks of Lanerton Roman Camp are so slight as to be barely discernible on the ground. However, the line of the northern defences is picked out by the rise of a modern field boundary across the earthwork. Looking east. June 2017 © Historic England.

The early medieval period

Evidence for early medieval activity within the Birdoswald sector is lacking in the aerial record. The only direct evidence for continuity of settlement into the immediate post-Roman (post-AD 410) period is the 5th- to 6th-century timber hall recently excavated within the fort at Birdoswald (Wilmott 1997, 218-31). This has important implications for the continued use of Birdoswald after AD 410. The location of the hall is now marked on the ground by modern columns denoting the positions of the original timber posts, but these have not been mapped by the present project.

The Stanegate probably continued in use for a time after the withdrawal of Roman soldiers from Britain; certainly it was still visible and recognised by later generations, and was given its name the ‘stone road’ in the medieval period (Crow 1995, 14). As described above, short sections of the Stanegate remain in use today as minor roads between Gilsland and Chapelburn, but map evidence suggests much of its course in the Birdoswald sector was out of use before 1603.

The medieval period

The project has assigned very few features a definite medieval date. A small area of medieval ridge and furrow (1612429) is visible as earthworks on lidar to the west of Willowford Camp, comprising broadly spaced sinuous furrows, up to 11m wide, overlain by post-medieval ploughing. Most ploughing is post-medieval land improvement, in the form of 19th-century steam-rig. The aerial mapping illustrates that this extensive later ploughing has damaged large areas of Roman earthworks and may also have removed traces of further medieval cultivation.

A fragmentary field system of possible medieval origin (1612634) is visible on the south-facing slope, east of High House (Fig. 46). This comprises very shallow earthwork field boundaries, formed of banks, much denuded through extensive later land improvement. These banks pre-date a series of post-medieval sod-cast boundary banks (1449490) that overlie them, as well as numerous hollow ways of likely medieval/post-medieval date (1612631). One of the banked field boundaries lies across the proposed route of the Birdoswald to Lanerton Roman road (1612650), suggesting the field system is post-Roman.

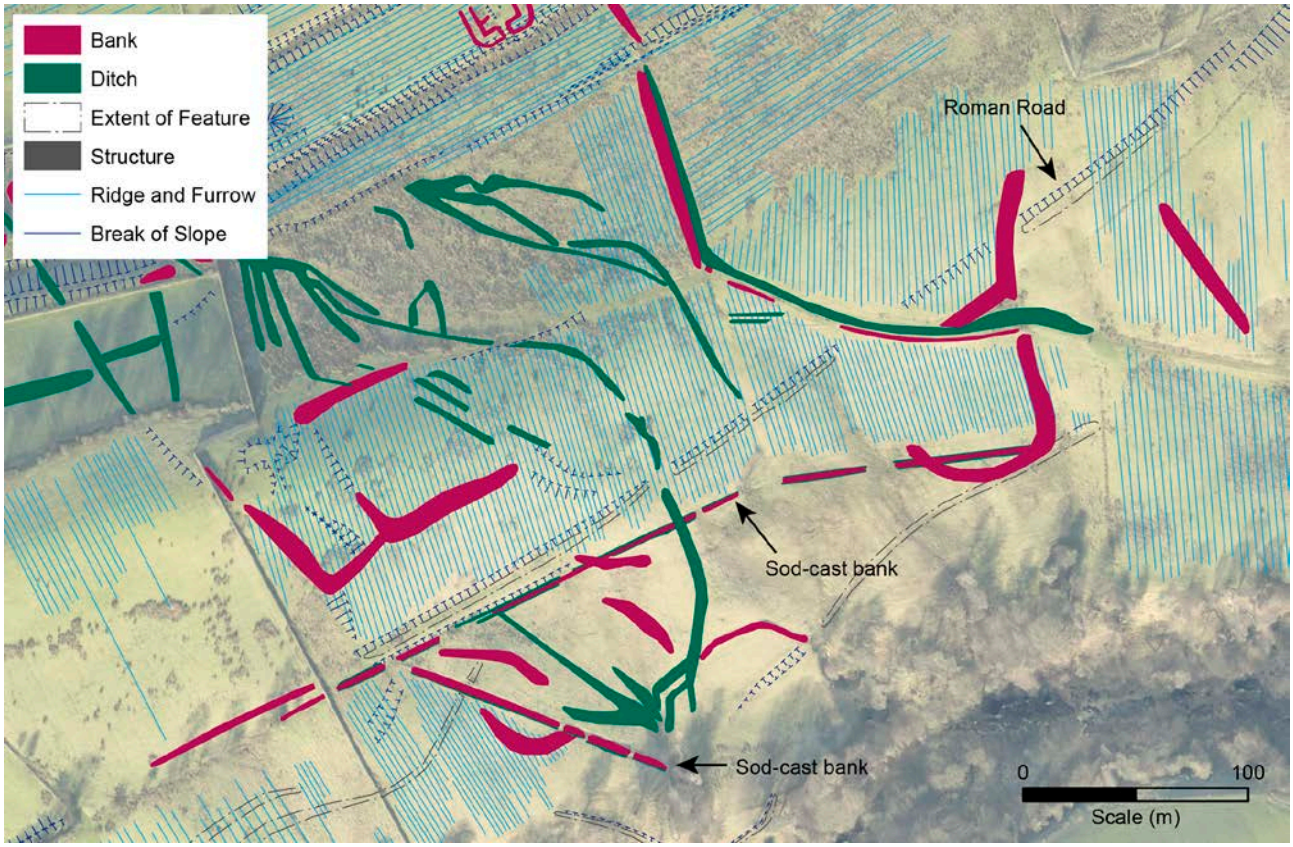


Figure 46: Elements of a possible medieval field system (1612650) are visible as denuded earthworks on the slope overlooking the River Irthing. These appear to truncate the line of the Roman road between Birdoswald and Lanerton and are overlain by post-medieval sod-cast field boundaries, hollow ways and ridge and furrow. Historic England SfM Orthophotograph 05-JAN-2017 © Historic England. Archaeological mapping © Historic England.

A medieval ‘moated’ site is located to the north of the church at Upper Denton (13951). The site is defined by a small rectangular enclosure consisting of a broad and deep ditch surrounding a platform measuring 9m by 14m (Fig. 47). There is a fragmentary bank to the outside of the enclosure. A break in the bank forms an entrance on the south east side. A hollow way leads from the entrance to the current road through the hamlet. The site is located on a slope and would not have held water. It is traditionally interpreted as the site of a medieval vicar’s fortified pele, quite possibly the predecessor to the bastle (13960) that lies 33m to the south-east (*see* Fig. 53).

Figure 47: The ‘moat’ at Upper Denton is thought to have enclosed a vicar’s pele, which was later replaced by a bastle. 20995_035 02-MAR-2010 © Historic England Archive.

The footings of another medieval tower house were discovered at Birdoswald during recent excavations, thought to have been constructed at some point during or after the 13th century (Wilmott 1997, 378). The south-west corner was consolidated following excavation and remains open to visitors to the fort (13993).

A large number of mapped features have been attributed a post-medieval date with possible medieval origins. These include numerous fragmentary field boundaries and hollow ways dispersed across the project area. The boundaries are often isolated lengths of bank or ditch – remnants of former field divisions removed by more recent land-use.

One of the best surviving field systems was mapped to the north of Midgeholme Moss, south of Kiln Hill and Slack House (1449410). This earthwork complex comprises a relatively cohesive network of field boundaries that probably have medieval origins but likely continued in use into the post-medieval period. The centre of the field system is defined by a trackway or road extending south-east from Slack House towards the Moss. An aligning and corresponding linear bank on the south of the Moss (1474393) may suggest that they connected via a causeway across the bog (Fig. 48). The line of this causeway also aligns with the base of a hollow way which extends obliquely up the slope towards Birdoswald (1612294). Though broadly considered to be associated with the medieval period, recent evidence may suggest Roman origins for this possible causeway and the hollow way adjacent to Birdoswald (*see* Fig. 76). This road does not correspond with that on the 1603 map between Kiln Hill and Birdoswald, which is roughly in the same location as the modern road, so it was out of use by this period. The northern section of the road appears to have continued in use a boundary however, with medieval and post-medieval boundaries extending from it to the west and east, as well as post-medieval ridge and furrow.

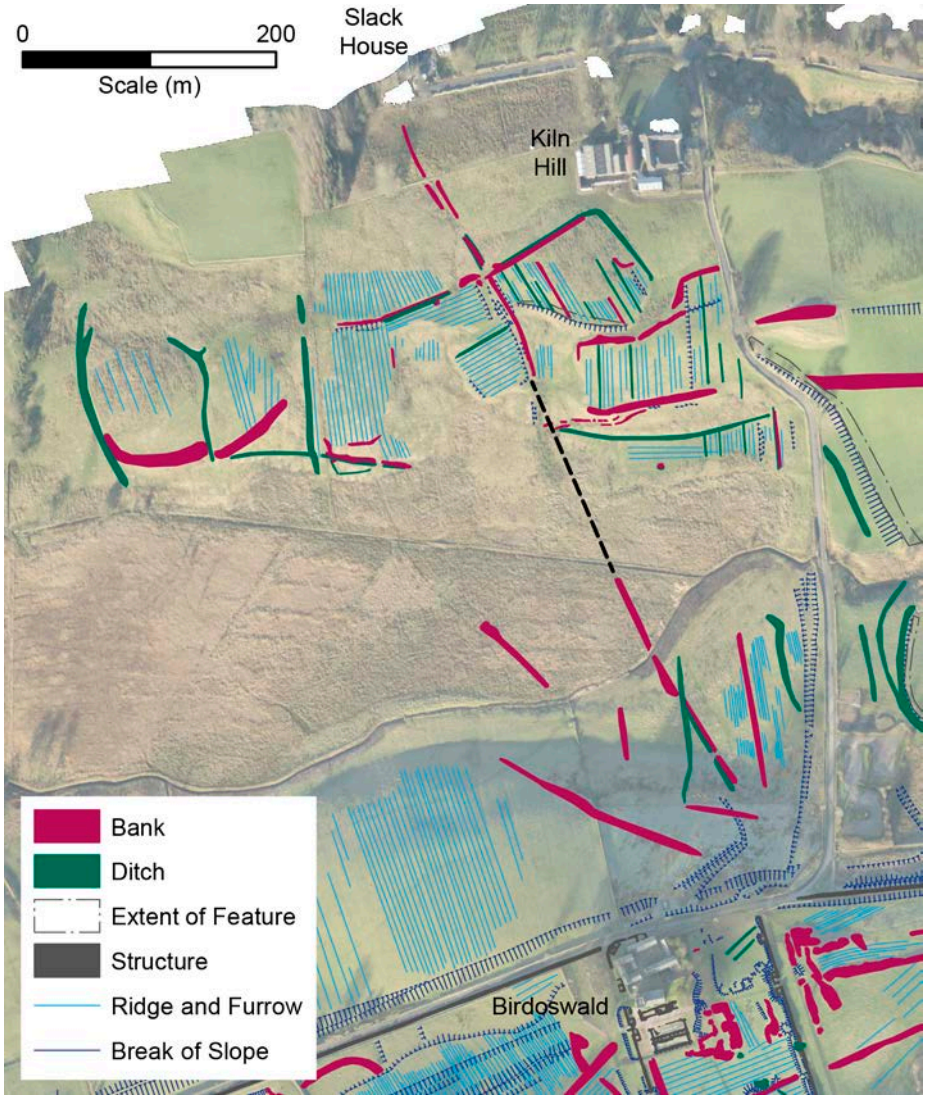


Figure 48: Earthworks to the north of Birdoswald mostly attributed to a medieval/post-medieval field system. The dashed line indicates the hypothesised route across Midgeholme Moss. Historic England SfM Orthophotograph 05-JAN-2017 © Historic England. Archaeological mapping © Historic England.

A long curving hollow way is visible as cropmarks and earthworks on aerial photographs to the south of Nether Denton (1612677). Previously interpreted as Roman, this feature, which possibly acted as both a road and a boundary to the small settlement at Nether Denton, is illustrated on a 1603 manorial map (Fig. 49). Fragmentary lengths of additional hollow ways are visible adjacent to Chapel Burn (1612564) and south of Lane Head Farm (1612557). Quite broad and braided in nature, these perhaps represent animal droveways.

Figure 49: A broad ditch encircled the settlement of Nether Denton. The boundary/hollow way was in use in 1603 and remains partly extant as earthworks. Historic England SfM Orthophotograph 05-JAN-2017 © Historic England. Archaeological mapping © Historic England. 1603 map Cumbria Archive Centre, Carlisle. Ref No. DHN/C/713/12 © Howard of Naworth collection, reproduced courtesy of the Hon. Philip Howard.

Extensive routeways for droving livestock are visible as well-preserved earthworks to the south of Upper Denton (1449676). At first glance, this dendritic pattern of ditches could be mistaken for water channels, but they clearly fork out and extend up on to Mains Rigg from a narrow entry road at the southern end of Nether Denton (Fig. 50). The hamlet dates back to the reign of Edward I at least (Whellan 1860, 675) and these hollow ways are most likely medieval in origin, related to the herding of animals to and from the common land on the Rigg. They likely remained in use into the post-medieval period, after which many of the hollows were blocked by enclosure walls.

Figure 50: The dendritic pattern of hollow ways on Mains Rigg denotes livestock droving routes between Upper Denton and the moorland. 33028_036 05-JAN-2017 © Historic England Archive.

Numerous other groups of hollow ways were noted throughout the area, mostly in regions where livestock appear to have been driven across fording points of streams, the shallowest part of gorges, or through gaps in the Hadrian's Wall earthworks. These occur north of Lanerton (1452532), at High House (1612631), by Poltross Burn (1612421) and at Denton Mains (1612591). As it is impossible to date these features exactly, they are all attributed a broad medieval and/or post-medieval date.

The post-medieval landscape

The Birdoswald area continued as a pastoral landscape into the post-medieval period. From the early 17th century onwards, the area is moderately well documented in maps and literature. The settlement and field pattern that is visible today appears to have changed very little from that which was in place by the end of the 19th century.

Farmsteads

Nether Denton, Upper Denton and Birdoswald are all known through excavation and documentary evidence to have existed in the medieval period. The tenement of Birdoswald is first mentioned in a number of charters of the late 12th-/early 13th-century (Wilmott 1997, 388). It is probable that a number of the farmsteads also existed at this time, though documentary research on these has not been undertaken as part of this project. Many of these farmsteads are illustrated on the 1603 surveys of the Gilsland and Denton manors (Cumbria Archives DHN/C/713/12). The Gilsland map depicts two buildings at Birdoswald (Fig. 51). The southern-most appears to correspond with the location of the current house and visitor centre, perhaps the site of the bastle, and the second appears to stand on the wall itself. This second building is somewhat of a mystery, and presumably lies beneath the modern road, which did not exist at the time.

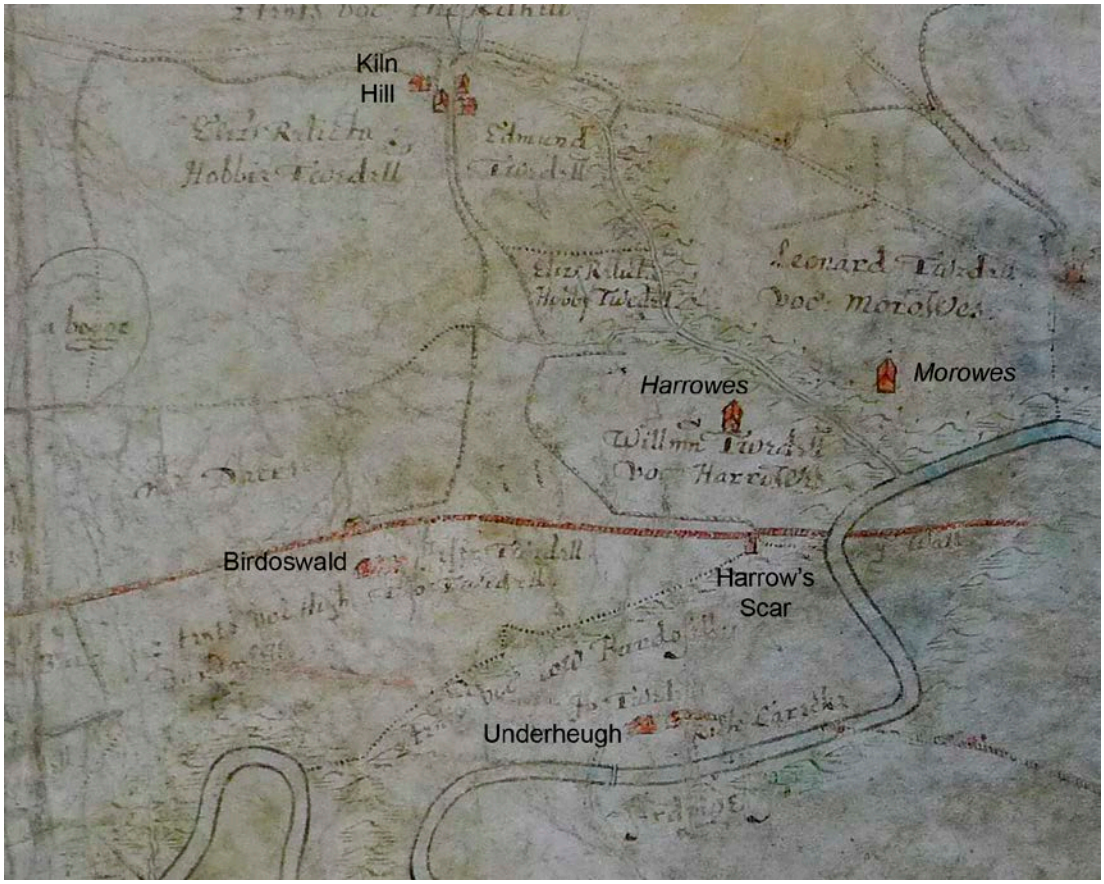


Figure 51: The 1603 survey of the Gilsland is the earliest evidence for a number of farmsteads that existed around Birdoswald. A number of these remain extant as farms, but three are only visible now as archaeological earthworks or structural remains. Cumbria Archive Centre, Carlisle. Ref No. DHN/C/713/12 © Howard of Naworth collection, reproduced courtesy of the Hon. Philip Howard.

Three additional farmsteads are marked on the map to the east of Birdoswald, all under the tenancy of the 'Twedell' family. All three are also visible in the archaeological record, either as structural foundations or as earthworks. The best defined are the stone foundations of a farmhouse (1612338) within Milecastle 49 (Harrow's Scar) (Fig. 51; *see also* Fig. 27). This building was excavated and consolidated along with the Roman remains. It is rectangular in plan, orientated west-south-west to east-north-east, and is partly built over the west wall of the milecastle. It measures 4.8m by 11.3m, has an entrance on the north face, and a possible outbuilding or porch area opposite the doorway. An L-shaped bank is visible on DEMs, abutting the west wall of the milecastle on the same alignment to the post-medieval building. This is presumed to be a small yard or pen associated with the farmhouse.

Figure 52: The earthwork remains of the farmstead named as 'Harrowes' in 1603 are visible on aerial photographs. The central rectangular enclosure is the location of the farmhouse. 33035_024 05-JAN-2017 © Historic England Archive.

A small embanked rectilinear enclosure (1449651) is visible 180m to the north of the milecastle farmhouse. Measuring 11m by 16m, the enclosure probably represents the footings of a building named as the 'Harrowes' on the 1603 map, then under the tenancy of William Twedell (Figs. 51 and 52). Fragmentary banks around the enclosure visible on air photographs and DEMs probably indicate small livestock pounds or additional outbuildings. These farmstead earthworks stand within a cliff-edge enclosure defined on the landward side by two large 'teardrop' shaped banks, depicted on the first edition OS map (1863) as 'camp (remains of)', and then 'Earthworks' on subsequent County Series

map editions. When viewed on the ground, the large banks were deemed entirely natural, probably glacial moraines. Many of the archaeological remains visible from the air could not be discerned on the ground due to the state of the vegetation, but the main rectangular enclosure, probably that of the farmhouse, was observed to consist of turf covered stonework.

Further earthworks mapped on the north side of Harrow's Beck (1612313) comprise a roughly rectangular building platform measuring 11.5m by 15m surrounded by fragmentary enclosures and field boundary banks. The location corresponds with a farmstead which the 1603 map called 'Morowes', tenanted by Leonard Twedell (Fig. 51). When examined on the ground, a number of shallow archaeological trenches were noted across the platform. Though not recent, these had been left open, revealing walls and stone-flagged floors. Local enquiry revealed the excavation to have been undertaken by Will Higgs around 2015. It remains unpublished.

The settlement at Birdoswald was presumably slightly higher in status than these surrounding farmsteads, something akin to Upper Denton. This is denoted by the presence of the medieval tower house, later replaced by a bastle (Wilmott 2014, 14). A bastle is a form of defensible farmhouse common in this part of the English/Scottish borders. Animals were housed on the ground floor whilst the family inhabited the upper floor, accessed via a removeable ladder (McDowall and Mercer 1970, 61). The bastle is probably the southern of the two buildings marked on the 1603 map. The consolidated footings of the bastle are visible with the Roman and medieval remains within the fort (13993).

The bastle at Upper Denton (Fig. 53) is also recorded on aerial photographs (13960). The building is rectangular in plan, measuring 7.7m by 8.7m. It is now derelict and ruinous, and partly supported by a modern internal steel frame. It probably replaced the vicar's pele (13951; *see* Fig. 47), 40m to the north-west, in a sequence similar to that at Birdoswald.

A number of other farmsteads are also marked on the 1603 map, many still occupied or only recently derelict and not mapped by this project. These include, Kiln Hill, Denton Mains, Lanehead, Throp, Hollows (abandoned and part ruinous) and Underheugh (which was abandoned at the time of survey and more recently reinhabited). No evidence of archaeological remains associated with these farmsteads was noted on aerial sources.

The 1603 map of Denton manor also depicts 'Crosdykes' on the southern bank of the River Irthing, opposite Blackbank Wood. This farmstead has presumably been lost to the migration of the river or levelled through subsequent land improvement as it could not be located on aerial imagery.

Figure 53: The bastle at Upper Denton is derelict and ruinous. It is the most complete example still standing in the project area. Looking south-east. June 2017 © Historic England.

Land division and improvement

The most dominant form of visible post-medieval archaeology is ridge and furrow ploughing. The landscape is almost entirely pastoral, and as a result this ploughing is unlikely to have been for cultivation but instead for drainage and/or land improvement for pasture. Today, grass is grown for hay across the project area, a pattern which likely continues from the post-medieval period. The plough ridges are linear and narrow, between 2.5m and 4.5m apart. This narrow ridge and furrow is typical of post-medieval farming practices, and dates largely between the later 18th and the early 20th century. The regularity of much of the ploughing suggests that it was largely undertaken by steam- or horse-driven plough engines in the latter half of the 19th or early 20th century. In many instances, ploughing was difficult to differentiate from more recent drainage; where drains were identified, they were not mapped.

The extensive ploughing and drainage of the landscape have had a dramatic levelling effect on the archaeology. One of the most obvious examples of this is the current condition of the Vallum and Turf Wall earthworks to the west of Birdoswald. The Roman earthworks are considerably more denuded where ploughing has taken place. In places, the ridge and furrow extends parallel and butting up to the Roman earthworks, such as along sections of the Turf Wall. This has levelled much of the remains of the Wall itself and associated milecastle and turrets.

Further east, the ploughing runs mostly perpendicular to the Roman activity, riding up and over the linear features, reducing them considerably. The different levelling effects of this post-medieval land use is illustrated to the north of High House, where the different ploughing regimes have resulted in different levels of survival of the Roman earthworks (Fig. 54).

Figure 54: The dramatic effects of post-medieval land improvement can be seen on the Roman Vallum and Turf Wall earthworks to the north of High House. The field to the left was heavily ploughed in the 19th century, as denoted by the earthwork remains of narrow ridge and furrow. This has almost completely levelled any evidence of the Turf Wall or Vallum embankments. 33033_082 05-JAN-2017 © Historic England Archive.

The earthworks of Willowford Camp (13966) are comparatively shallow compared with the huge works of the Vallum and Turf Wall to the north and west. Despite this, the shallow ditched enclosure has been largely respected by later cultivation (*see* Fig. 43). The ridge and furrow abuts the north, east and south sides of the camp, with the Roman earthworks being partly incorporated into the post-medieval field system (1612428). The Roman signal station on Mains Rigg (13996) similarly appears to have been avoided by ploughing despite this marginal heathland being exposed to extensive land improvement in the post medieval period.

There is limited evidence for ploughing around Lanerton camp (1581200). No plough furrows were detected on aerial sources within the confines of the camp itself. That which is visible is to the south of the camp and is post-medieval in date (1452427). However, the Roman remains are extremely denuded in nature. This lends the question of whether other forms of land improvement, less visible in the archaeological record, such as extensive harrowing or recent intensive ploughing, may have resulted in the levelling of some of the Roman archaeology?

The effect of land improvement, whether ploughing, harrowing or the cutting of drains, has clearly had a dramatic impact on the earlier archaeology. Many other Roman features in the project area are likely to have been levelled entirely, and as modern land-use is largely pastoral rather than arable, do not reveal themselves as cropmarks and so are now invisible in the aerial record.

Most of the current layout of field boundaries were put in place as a result of the enclosure awards of the 18th and 19th centuries. The earthwork/cropmark remains of post-medieval field boundaries were generally only mapped if not illustrated on historic and current Ordnance Survey (OS) maps. Most of these linear boundaries again probably relate to 19th-century enclosure, but some of the more sinuous field boundary banks, such as those to the north of Birdoswald (1474810), east of Upper Denton (1449681), and west of Denton Mains (1449681) may have had earlier origins.

Many field boundaries comprise stony, sod-cast turf embankments. Although these boundaries are regionally important, most are illustrated on OS maps and were therefore not mapped. One of the most complete mapped field systems of sod-cast boundaries combined with ridge and furrow is on Mains Rigg (1612538). This heathland crosses the southern boundary of the project area, confined between Hightown Cleugh, Marblefleet Beck, Poltross Burn, the Shawfield road and the Newcastle to Carlisle Railway. Some of this common is now enclosed, though the hollow ways to the south of Upper Denton (1449676) suggests that the heathland was originally more extensive than it is now.

Figure 55: Extensive land improvement on Mains Rigg. Once open common, this area was enclosed and ploughed, only to revert back to common. In more recent years, extensive drainage has been cut through the earthwork remains of the post-medieval field system. 33029_050 05-JAN-2017 © Historic England Archive.

The north-west quarter of the heath was enclosed with sod-cast boundaries and ploughed during the post-medieval period (Fig. 55). This ridge and furrow is less regular than most of that recorded by the project. The width of the ridges ranges between 2m and 9m, and much of the ploughing is sinuous rather than linear. This suggests a marginally earlier origin, presumably pre-dating the enclosure award of 1800. Although the field boundaries were no longer in use by the time of the 1868 OS map, most of the area remains as heavily improved pasture, and only the peripheral areas display evidence of the encroachment of moorland vegetation. This field system may have been an attempt to improve or perhaps even cultivate marginal land in a time of pressure for farming land, but subsequently reverted to common.

Another possible small attempt to cultivate marginal land is visible in the north of the project area. Here, a small trapezoidal enclosure with maximum dimensions of 28m by 71m and defined by an outer ditch with hints of an internal bank, occupies a shoulder of higher ground overlooking Midgeholme Moss (1449428) (Fig. 56). The enclosure contains a series of plough ridges. The exact purpose of the enclosure is uncertain, although the Hadrian's Wall NMP suggested it may have been lazy beds. There are no comparable examples in the project area, and the enclosure is remotely located, on a sheltered edge of a broad and shallow valley.

Figure 56: Possible lazy beds overlooking Midgeholme Moss. The peaty Moss is visible to the bottom of the photograph. 28131_040 18-MAR-2011 © Historic England Archive.

Additional field boundaries (1612425) were mapped to the east of Throp Fortlet. These consist of a series of linear alternating bank/ditch boundaries but may be little more than elaborate drainage. On the south side of Poltross Burn, between Wardoughan and the Burn, are another series of fragmentary banks (1612416). The most dominant of these is a terrace, which appears to be an enhancement of the natural slope. Possibly originating in the medieval period, this terrace forms a boundary to post-medieval ridge and furrow.

A small mound (1612417) located adjacent to the terrace may well be a clearance mound, presumably associated with the ploughing of the neighbouring fields. An additional mound (1449697) was mapped a short distance to the north, and three more (1449685) south of Willowford Camp. These mounds range between 3m and 7m wide and are all sited on top of the narrow ridge and furrow suggesting they are recent.

Quarrying and Mining

There are surprisingly few areas of extraction in the project area. Most of those that were mapped are very small scale, and all are considered post-medieval in date. One of the largest areas of quarrying visible from the air is located along the line of the Wall itself, where the Turf Wall earthworks meet the stone Wall, east of Milecastle 51 (1473637) (Fig. 57). This linear area of extraction heavily truncated a 180m length of Turf Wall earthworks (1451822).

Figure 57: Quarrying of probable post-medieval date extended along the line of the Turf Wall ditch, heavily truncating the intersection between the Roman Turf Wall and Stone Wall adjacent to Milecastle 51 (Wall Bowers; centre-left). 33034_046 05-JAN-2017 © Historic England Archive.

A number of isolated shallow quarries are visible either side of the road between Milecastle 51 (Wall Bowers) and Birdoswald, all of which were presumably for limestone extraction for localised use (1473631, 1612607 and 1612624). Smaller extractive pits along the Wall ditch are probably also moderately recent in date, perhaps associated with the construction of the modern road.

One of the most extensive quarries in the project area is located in Combcrag Wood, a short distance to the south of Milecastle 51 (Wall Bowers). The earthwork and structural remains of this quarry are not visible on aerial photographs, and there was not enough definition on the lidar to map them. A brief visit on the ground however revealed the distinct chisel marks along the fault lines of the limestone where quarrying had taken place (Fig. 58). It is questionable when this quarry was in use. The quarry is not marked as active on historic Ordnance Survey maps, but the path that leads to it is marked on the 1868 Ordnance Survey map. The site is most well-known for a series of Roman inscriptions carved into the exposed rock-face (Collingwood and Wright 1965, 599-600), suggesting a Roman origin to the quarry, but it is likely that it was still being used in the post-medieval period.

Figure 58: It is difficult to date the chisel marks in Combcrag quarry. Roman inscriptions on stone faces suggest the area may have been quarried since the Roman period, though it seems likely that the quarry was still being used into the post-medieval period. June 2017 © Historic England.

Additional quarrying was mapped at Gilsland (1449612), on Midgeholme Moss (1449676 and 1453396), and at Denton Mains (1453855). Quarrying at Denton Mains comprises a series of curvilinear pits dug into a natural knoll (Fig. 59). On the east side of the quarry

is a small embanked curvilinear enclosure measuring 24m by 29m. The footings of a rectangular building are visible cut into the rock, forming the south-east corner of the enclosure. A possible second building is visible 80m to the south-west of the extraction site, which may be associated. The series of extractive pits with a possible processing area and buildings may suggest this was a mineral extraction site, rather than a stone quarry. However, the geological data does not suggest that there is any change from the usual limestone at this location.

Figure 59: Extractive pits to the south of Denton Mains were sited on a natural knoll. The turfed over remains of a small enclosure and building located on the edge of the quarry may be a processing area. 33031_080 05-JAN-2017 © Historic England Archive.

A number of very small extractive pits were mapped to the west of Denton Mains (1453852) and east of High Town (1612542). Ranging between 1.5m and 6m in width, these clusters of dozens of small pits are dug into north-facing slopes. Those to the west of Denton Mains are located on an area of sandy river terrace deposits, whereas those to the south, by High Town, are glaciofluvial sand and gravels. Presumably, these pits were therefore for the extraction of pockets of sand for local use.

A small area of peat cutting is visible on Midgeholme Moss (1612328). This is the only definite area of peat extraction noted in the project area.

Routeways

Many of the hollow ways described in the above sections have possible medieval origins, but probably continued in use into the post-medieval period. Numerous additional trackways and paths were noted on the aerial photographs and lidar which appear to be more obviously post-medieval in date. These include many trackways, elements of which are illustrated on historic Ordnance Survey maps, or that remain in use today and were generally not mapped. Other examples include a trackway leading to the quarry in Combcrag Wood from the north-east (1612614), which has been partly truncated by narrow ridge and furrow. Additional tracks extending down the steep valley sides of the River Irthing were noted adjacent to Dentonscar Wood (1612567), south-east of High House (1612631), and between Birdoswald and Underheaugh (1612339). Others, such as north of Shawfield (1612527), west of Throp (1612438), and east of Lane Head Farm (1612677) appear to lead to more well-established trackways, streams, or to farms, and probably remained in use until recently.

Evolution of the Roman Landscape

The immense study, excavation and survey that have taken place along this section of Hadrian's Wall allows us one of the most detailed views into Roman Britain. But the archaeological evidence alone does not tell the full story of the setting and relationships between monuments. The following discussion will partly build on what has been done before, telling the story of how the Roman Birdoswald sector developed over time, and will use the findings from this study and new methods to attempt to enhance our understanding of the landscape.

As before, this discussion will follow a chronological order with the exception of the temporary camps and routeways which are difficult to phase due to the lack of study that has taken place on them.

Viewshed analysis

A key aspect to this discussion is examining the 'viewsheds' of features. Using a geographic information system (GIS), modern terrain models and calculations based on archaeological excavations, the viewshed illustrates the approximate area of view for a monument.

This comes with many caveats. Firstly, although the terrain is likely to not have changed much over the last two thousand years, the land-use no doubt has. The single biggest factor to consider here is the amount of tree cover during the Roman period which would have greatly affected views. The elevation model on which all the viewsheds have been produced is the APGB 5m DTM, which has removed all current upstanding features in the landscape such as tree cover, field boundaries and buildings. The data is however low resolution which will have impacted the results. The 1m lidar data available at the time of survey did not cover the entire project area

Secondly, in order to undertake any accurate analysis of the viewsheds of features, it is important to know the maximum height from which a person might have been looking. This is potentially a complex calculation that requires estimates for both the height of the observer and the elevation of their vantage point. None of the Roman archaeology survives to its original height, nor do we know the original height of ramparts, gates or towers, or whether there was a wall walk along the Wall itself; therefore all the measurements are estimates, though sometimes based on approximate calculations from the archaeological remains.

The calculations of the height of a human are based on Charlotte Roberts' studies into the average height of adult males in Roman Britain (Roberts 2009, 144; fig. 75). Average male height has been specifically chosen due to the military nature of the Roman landscape. The figure Roberts gives for the height of the average Roman male is approximately 1.69m (not including the minor difference to eye-level). This is the minimum value by which any of the viewsheds were based, and is the basic measurement used for viewsheds from the roads and temporary camps which are assumed to have had little in the way of elevated views.

The height of Hadrian's Wall has been calculated using the archaeological evidence from Milecastle 48 (Poltross Burn), where the base of a series of steps estimates a calculated walkway height of 3.66m, though this is assumed that the steps went to the Wall walkway, rather than a tower above the gate or just the walls to the milecastle. Writing in the 8th century AD, Bede also stated that the height of the wall was 12ft (3.66m) (Miller 1999, 23). Wilson (Historic England 2018a, 4) suggests that the wall-walks on the fort were 4.5m high.

The average viewing height is calculated as being the Wall walkway height plus the average height of a male = 5.35m. This value has been used as an average calculation from an elevated point, including the Wall and the forts at Birdoswald, Nether Denton and Throp, despite the elevation differences between the forts and the Wall. It is important at this stage to note that various tests of increased and decreased values for the viewshed analysis caused minimal variance in the results – the primary point being that the general gist of view for all sites is demonstrated using this method.

It could be surmised that the turrets (and possibly the milecastle and fort gateways) stood higher than the Wall, allowing for more distant views (Johnson 1989, 32). But at what height is uncertain. Research in Europe has suggested that watch and signal towers could stand to a height of 7.5m-10m (van Dierendonck 2004, 80). This is an estimation and does not account for the viewing height of the structure which was probably approximately 1.5m-2m below the top of the tower but can be used as an approximate value. As stated above, varying the height by a metre or two makes very little difference to the final viewshed. Therefore, for features considered to be more elevated, an approximate viewing height of 8.75m has been used for calculations. This viewing height was also extended to the gateways for the milecastles and the north gate to Birdoswald Roman fort.

The signal tower on Mains Rigg has considerably broader foundations than the turrets along the wall (7-7.5m for the tower and 5m for the turrets) and presumably stood to a great height. A very rough ratio calculation could potentially put the signal tower viewing height at around 13m. This is an extremely broad estimate but conveys something of an understanding as to how the signal tower may have operated (see below).

The Pre-Hadrianic frontier

By the end of the 1st century or start of the 2nd, the Roman occupation of Britain south of the Tyne-Solway isthmus had been largely secured. A line of fortifications had been established along a broad frontier zone separating the Roman province of *Britannia* from the unconquered tribal lands of northern Britain (*Caledonia*), all linked by the road later known as the Stanegate (Fig. 60; *see* also Fig. 9). It would be wrong, however, to think that this 'Stanegate frontier zone' was laid out all at the same time as a single preconceived system: for example, forts seem to start at different dates and it is still not clear whether the Stanegate itself pre- or post-dates many of the outposts along it (Symonds and Mason 2009, 10-19).

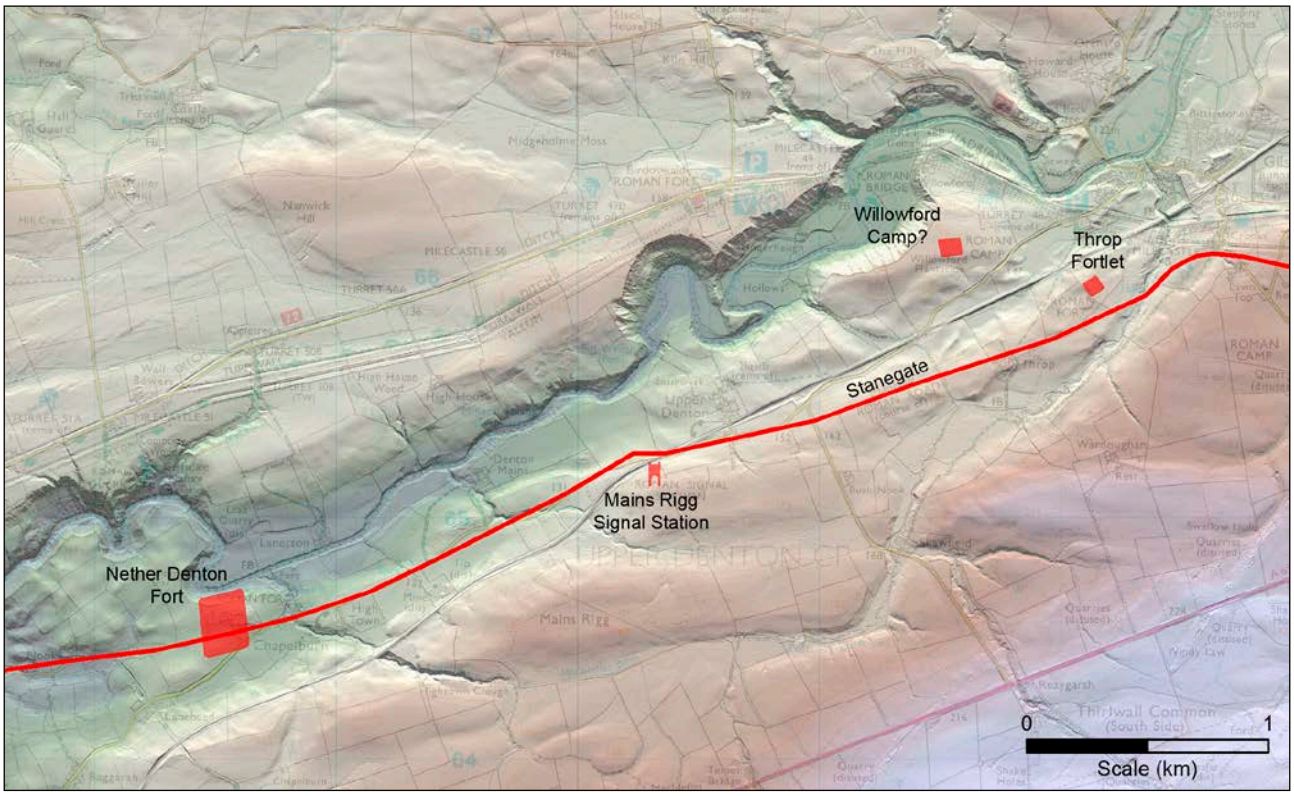


Figure 60: The earliest, pre-Hadrianic, phase of the Roman frontier in the Birdoswald sector consisted of the Stanegate with fortified sites at Nether Denton and Throp, and the signal station at Mains Rigg. Base map © Crown Copyright and database right 2023. All rights reserved. Ordnance Survey Licence number 100019088. Relief model LIDAR DTM 21-APR-2010 © Historic England. Source Environment Agency.

It has been possible to trace the probable line of the road through the Birdoswald sector, including the earthwork survival at Poltross Burn, west of Throp and a suggested re-alignment of the current road north of Mains Rigg. The project has also suggested that the road may have projected directly through Nether Denton fort (Fig. 61), showing a direct relationship. However, the association with the fortlet at Throp and Main's Rigg signal station are less direct – based purely on the close proximity of the features to one another.

There is little doubt that the Stanegate continued in use after the construction of Hadrian's Wall north of the river, but the archaeological evidence in this project area is scant. The newly identified Lanerton road may provide a link between the two. The road may have directly linked the fort at Birdoswald with the Stanegate via a ford across the Irthing adjacent to Nether Denton.

Figure 61: The Stanegate is presumed to passed through Nether Denton fort, approximately where the modern track and gate are today. The northern half of the fort was sited on a plateau on which the church is now located. Looking north. June 2017 © Historic England.

Located on a low hill on the southern bank of the River Irthing, Nether Denton fort was first exposed in the 1860s when the construction of a rectory revealed wall foundations, cobbled floors and numerous finds (Shipman 1870, 88). Further excavations in 1911 and the 1930s found additional evidence of intensive Roman occupation in the area south of the current road and south-west of Church Hill (Simpson and St Joseph 1934), now interpreted as signifying an extra-mural *vicus*.

The excavations suggested that the site was occupied from the mid-1st century until the early 2nd century and then abandoned around the time Hadrian's Wall was constructed. However, the full size of the fort was not appreciated until the 1940s when aerial photographs revealed the cropmarks of the south-west corner and western perimeter ditch. The complexity of the cropmark evidence suggests that although occupied for at-most 75 years, the fort was remodelled on a number of occasions. With an estimated internal area of 2.8ha, Nether Denton was not much larger than Birdoswald (2.2ha) and was presumably superseded by that fort when troops were moved up on to the line of the Wall in the early 2nd century. There is however evidence for the continued occupation of the *vicus* outside the fort (Breeze 2006, 453).

Nether Denton is tucked into the confluence of the River Irthing and Chapel Burn, and although on a low hill, is not in a particularly defensible position, being located in the valley. The viewshed analysis shows views limited along the valley only (Fig. 62). The fort would have been intervisible with the signal station on Mains Rigg, and on a clear day may also have been able to see as far as the south-west corner of Throp fortlet, 3.75km away.

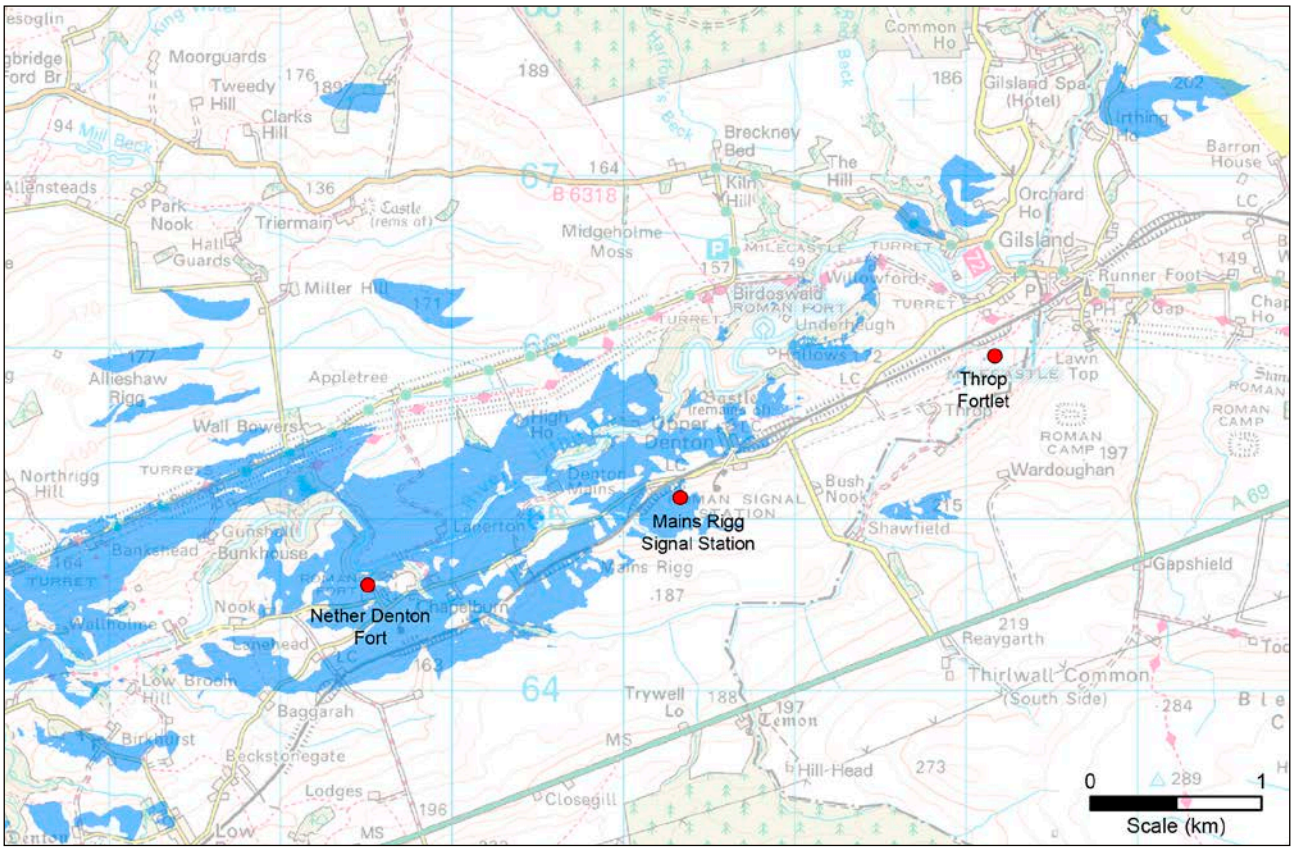


Figure 62: The computer-generated viewshed for Nether Denton fort illustrates views to east and west along the valley. Base map © Crown Copyright and database right 2023. All rights reserved. Ordnance Survey Licence number 100019088.

The steep drop-off to the north would have offered a defensible position on this side, but the northern ramparts have been lost to river migration. 180m to the north-east, the valley flattens out and there is a fording point across the Irthing. There is little evidence that the course of the river has migrated much here, so it is reasonable to suggest that this point may also have been fordable during the Roman period.

The signal station on Mains Rigg was excavated in 1928 revealing the square foundations of the tower on a platform surrounded by a ditch. Although there were no datable finds (Richmond 1929, 314-5), the tower is normally assumed to be pre-Hadrianic due to its location on the south side of the river and proximity to the Stanegate. Located part way up the hillside, the tower would have afforded excellent views along the valley for 2-3km in either direction and direct visual communication with Nether Denton and possibly with Throp. Surprisingly, the tower also allowed for sporadic views to the north of the river towards Allieshaw Rigg and Waterhead Common (Fig. 63).

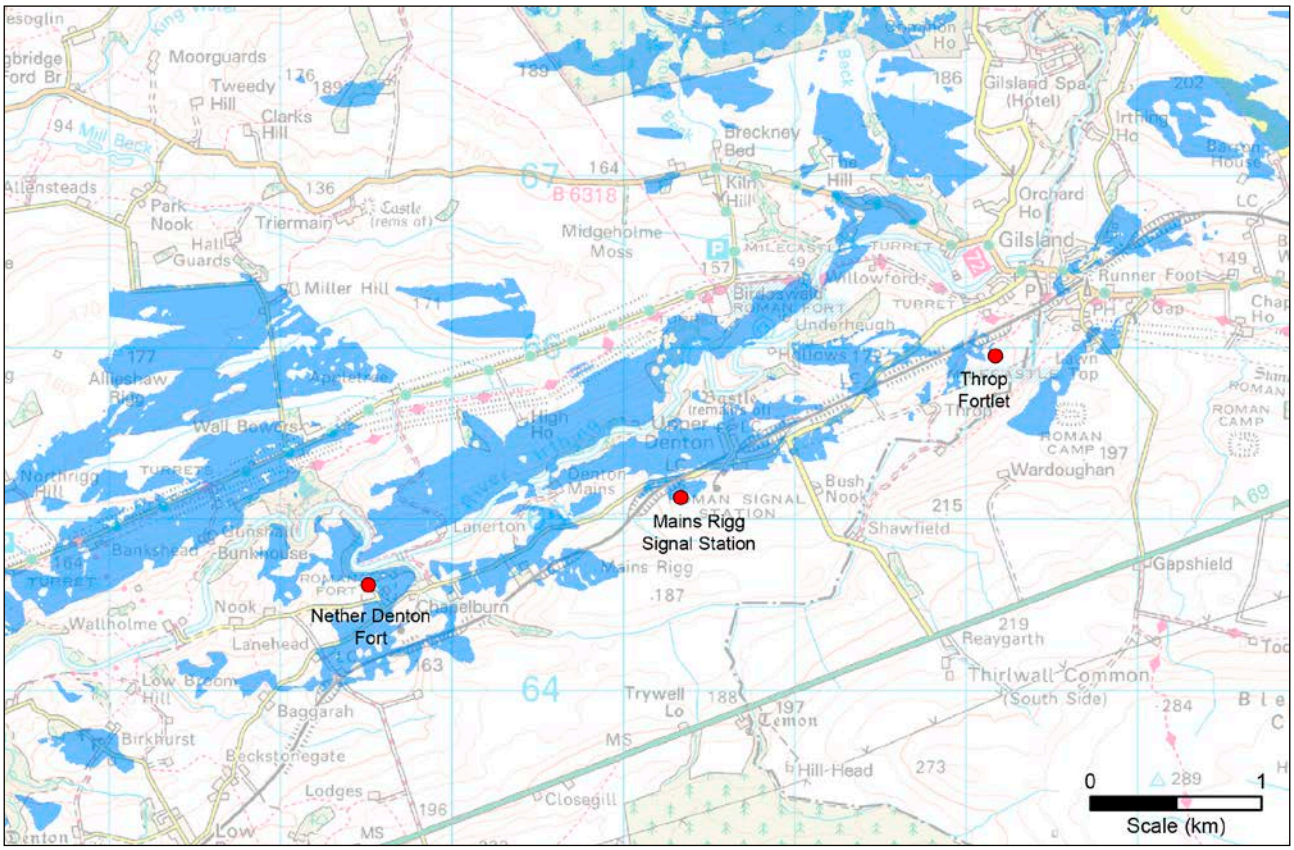


Figure 63: The viewshed analysis from Mains Rigg suggests that there would have been excellent views up and down the Irthing valley along the Stanegate. Base map © Crown Copyright and database right 2023. All rights reserved. Ordnance Survey Licence number 100019088.

The fortlet at Throp was much smaller than Nether Denton, having an internal area of only 0.36ha (Symonds and Mason 2009, 32). The fortlet was located on undulating ground, on a knoll between Poltross Burn and the River Irthing. Unlike Nether Denton, there is no evidence of a physical link between Throp and the Stanegate. The date of its construction has been argued to be Trajanic by Symonds and Mason (ibid.,19) and Hadrianic, immediately pre-dating the Wall, by Simpson (1913, 379-381). There is also evidence for reuse in the fourth century (Symonds and Mason 2009, 32).

Throp, or at least the upper ramparts, may have been intervisible with Mains Rigg and Nether Denton. However, the viewshed shows limited views to the west or east along the line of the Stanegate from the fortlet. More importantly, Throp afforded excellent views to the north of the river as far as Waterhead Common, and crucially overlooked the crossing point at Gilsland (Fig. 64). It therefore seems likely that the fortlet played a defensive role of this river crossing, and its association with the Stanegate may have been limited, if there was any at all.

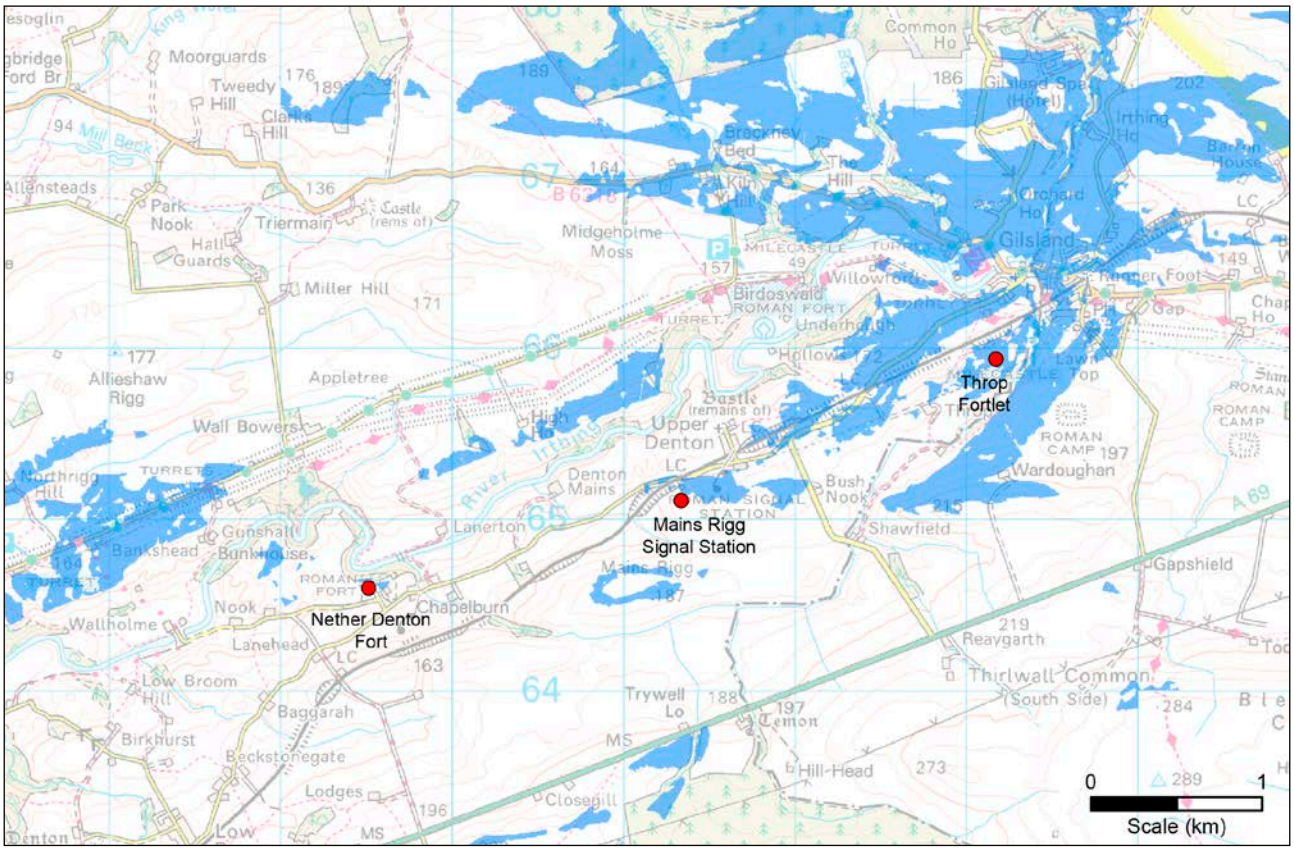


Figure 64: Viewshed analysis shows that the Roman fortlet at Throp afforded excellent views to the north and north-east It may have been specifically sited to control the river crossing at Gilsland. Base map © Crown Copyright and database right 2023. All rights reserved. Ordnance Survey Licence number 100019088.

North of the River: Hadrian's Wall

It was in the 120s during a tour of Britain that the Emperor Hadrian ordered the construction of a wall to separate the Roman province of *Britannia* from the barbarians outside the Empire to the north. The wall followed the general line of the existing Stanegate frontier, although locally it deviated from it according to the terrain. In the Birdoswald sector, the Wall closely follows the line of the Stanegate as far west as Poltross Burn, but from here, while the Stanegate continues in a south-westerly direction south of the River Irthing, the Wall crosses the Irthing at Willowford to run along the higher ground north of the river (Fig. 65). Whilst this could be interpreted as illustrating the basic defensive intent of the Wall, detailed topographical analysis of the line of the Wall as a whole suggests that actually the view to the south was more important than that to the north. This suggests the Wall's primary purpose was to act as an observation platform from where signals could be sent back to forces stationed along the Stanegate and elsewhere, rather than first and foremost as a defensive barrier (Symonds and Mason 2009, 36-7).

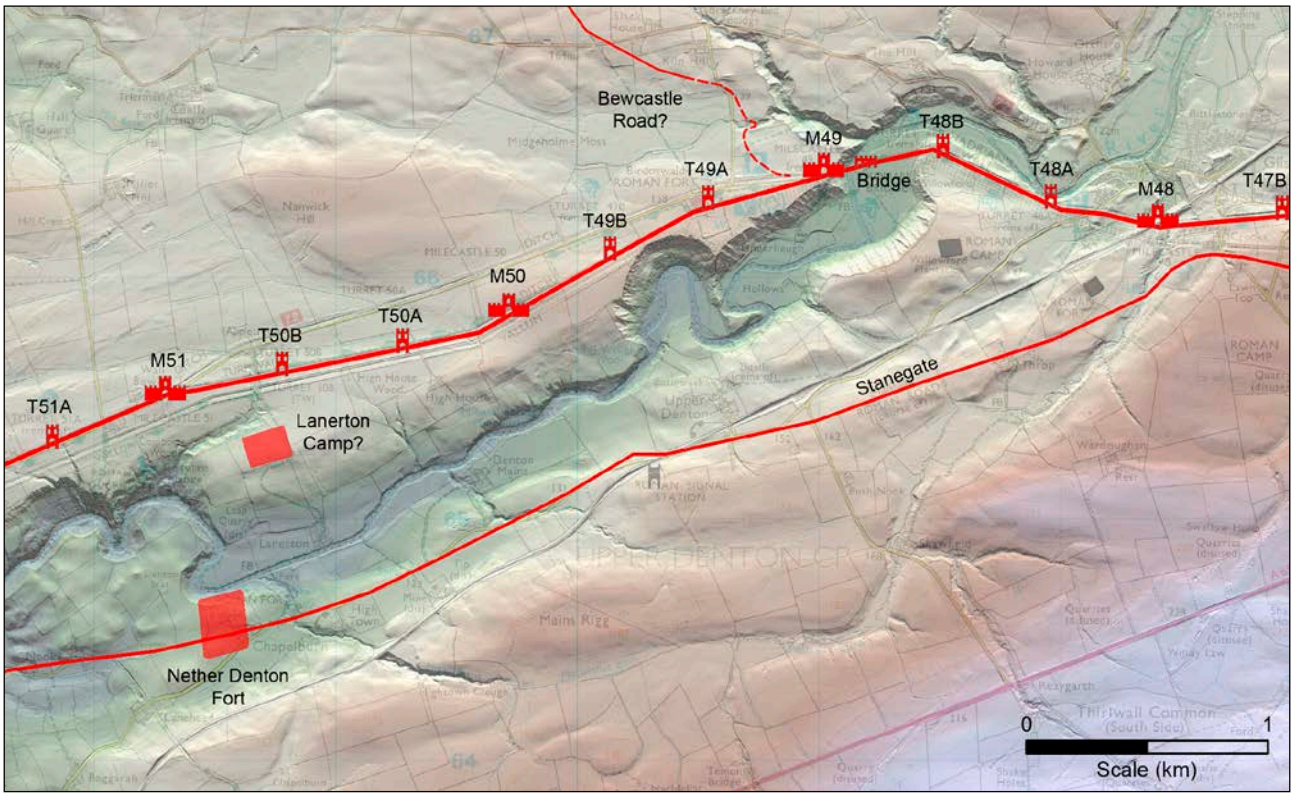


Figure 65: The initial phase of Hadrian's Wall comprised a Stone Wall as far as the bridge across the River Irthing and a Turf Wall to the west. The turrets (T) are thought to have been built in stone throughout. The milecastles (M), which were used to garrison the Wall, were turf-built to the west of the river. Base map © Crown Copyright and database right 2023. All rights reserved. Ordnance Survey Licence number 100019088. Relief model LIDAR DTM 21-APR-2010 © Historic England. Source Environment Agency.

In order to take the Wall across the river, the Roman army had to construct a stone bridge at Willowford. The crossing of the Irthing also marked the point at which the construction techniques of the Wall changed. East of the bridge, Hadrian's Wall was built in stone from the outset, with a series of milecastles and turrets, also in stone, positioned along it. To the west of the bridge, the Wall was initially built in turf and timber, again with a series of milecastles (also of turf and timber) and turrets (of stone) located at regular intervals along it (Johnson 1989, 30). The exact reason behind this different method of construction is uncertain. There is no lack of building stone, as evidenced by numerous quarries in the region. Charlesworth (1973, 69) suggests that there may have been a lack of skilled stone masons working on the sector west of Willowford. She substantiated this with evidence of cracking in the wall foundations of Turret 51A, though it might be argued that this cracking could have been the result of numerous factors, and that even structures built by skilled masons can be subject to subsidence or other forms of degradation. Other suggestions have been the lack of limestone to make mortar, but this didn't impede the later replacement in stone (Breeze 2006, 59).

Some of the phases of construction are evident in the sequencing visible in the excavated stonework. Most of the phasing below comes either from excavation evidence or from the summary provided by Wilmott (2014, 23-9) in the English Heritage guide to Birdoswald Roman Fort. There appears to have been some variation in the sequence of construction of the Stone Wall. For example, Turret 48A (Willowford East) was built first, with flanking buttresses, and then the Stone Wall was built abutting it (Shaw 1926, 438). There is little doubt that this sequencing took place over a very short space of time and that the turret and Wall are broadly contemporary. Perhaps it was simply a matter of different masons constructing the more intricate turrets, whilst others were building the Wall. Conversely, there are no signs of joints or phasing between Turret 48B (Willowford West) and the Stone Wall (ibid., 431).

The bridge at Willowford would have been a considerable feat of engineering (Fig. 66). After a possible collapse in the second half of the 2nd century, it was rebuilt or remodelled several times over the next century (Bidwell and Holbrook 1989, 63, 96, fig. 44).

Figure 66: The excavated footings of the east end of Willowford Bridge have been consolidated and can be viewed as part of the Hadrian's Wall walk. Looking south-east. June 2017 © Historic England.

The construction of the Turf Wall to the west of the bridge was slightly more complex. Excavation evidence from the turrets and milecastles along this stretch of Wall (Between the Irthing crossing and Turret 51A) aids the interpretation of the phases of construction. The first features to be built were the turrets. These were built in stone with the rest of the Wall and milecastles being turf and timber. The Turf Wall was then built abutting the turrets. Evidence of the Turf Wall and this phasing was discovered in the excavations of Turret 51A (Simpson 1928, 382; Charlesworth 1973, 67) and on turrets 49B TW, 50A TW and 50B TW (Simpson et al. 1935b, 233-5) – the latter three are not visible on aerial sources. As with the turret at Willowford East, this phasing was most likely simply a matter of the sequence in which the features were laid down, but probably occurred almost simultaneously.

The milecastles were laid out at the same time, also in turf. The gate towers were built from timber, evidence of which was found at Milecastle 50 TW (High House) (Simpson et al. 1935a, 220-2). Presumably, the turf rampart would also have been topped with a timber palisade. Although later replaced in stone, evidence of the earlier turf milecastle was found in excavations at Milecastle 49 (Harrow Scar) (Richmond 1956, 18).

A broad and deep defensive ditch was dug along the length of the Wall, on the north side. The up-cast soil from this ditch was spread to the front of the earthwork, creating a broad irregular and shallow bank called the glacis.

Before long, the construction of a fort began at Birdoswald in turf and timber. This replaced Turret 49A and the north face is thought to have been flush with the Turf Wall (Wilmott 2014, 26). The Vallum was constructed shortly afterwards, skirting around the southern perimeter of the turf fort (Fig. 67). This enormous earthwork stretched for the length of Hadrian's Wall, located a short distance to the south. It comprised a central ditch flanked by two broad banks and is thought to have demarked the military zone of the Wall (Breeze 2006, 39). The Vallum earthworks remain visible throughout much of the Birdoswald sector. Between Milecastles 49 and 51, it hugs close to the Turf Wall. At Birdoswald, the Vallum arced around the south of the newly erected fort, though this soon became redundant with the rebuilding of the fort in stone in the 130s (Wilmott 2014, 26-7).

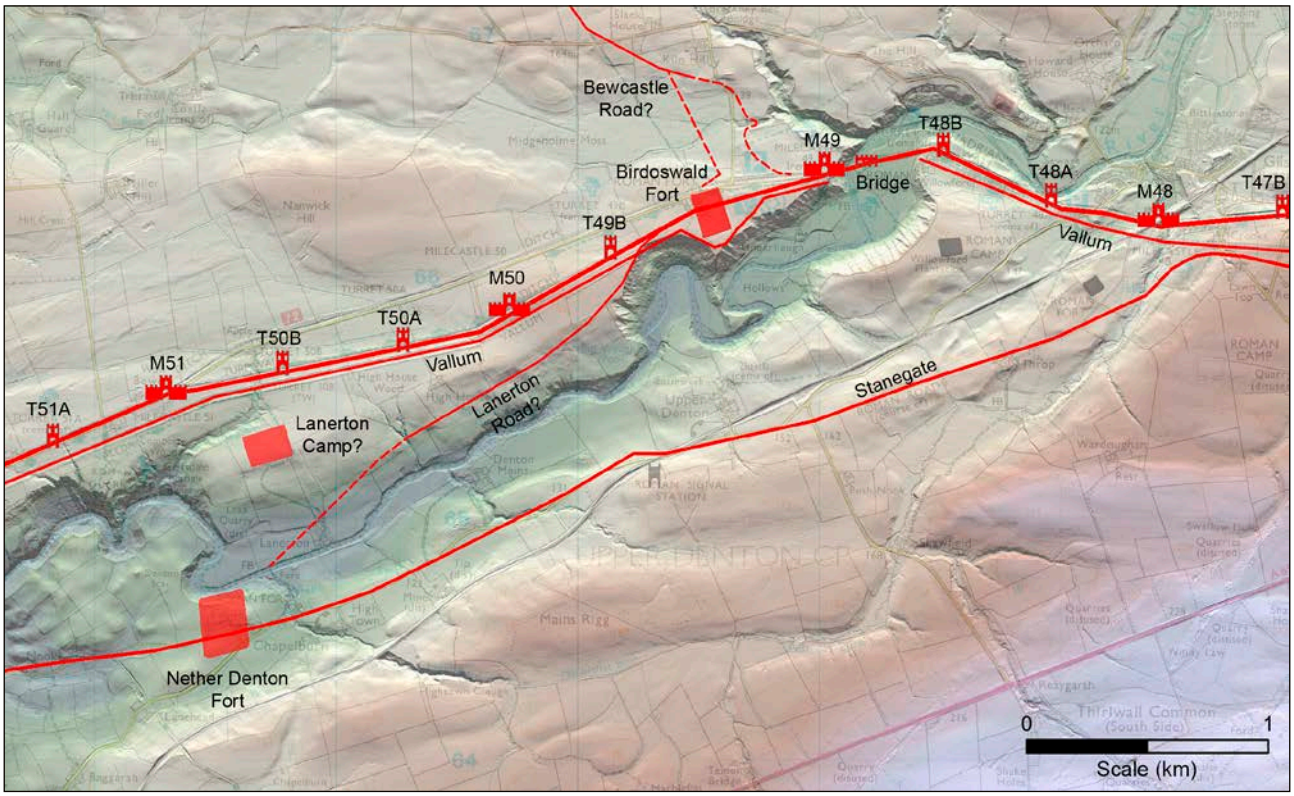


Figure 67: The second phase of Hadrian's Wall in the mapping area saw the construction of a fort at Birdoswald and the construction of the Vallum to the rear of the Wall line. The original fort is believed to have been flush with the Turf Wall. It was rebuilt larger in stone (reflected here), after which the Vallum south of the fort went out of use. Base map © Crown Copyright and database right 2023. All rights reserved. Ordnance Survey Licence number 100019088. Relief model LIDAR DTM 21-APR-2010 © Historic England. Source Environment Agency.

The Turf Wall was replaced in stone, and with that came a number of changes, including a partial realignment of the Wall (Fig. 68). The Wall line between Milecastles 49 and 51 was moved north up to a distance of 215m. At Birdoswald it brought the Wall flush with the north face of the fort. This resulted in the abandonment and demolition of Turrets 49B, 50A and 50B TW, and Milecastle 50 TW, all of which were rebuilt on the new line the Wall to the north. A new Wall ditch was also dug along this section, again with a glacis cast up to the north.

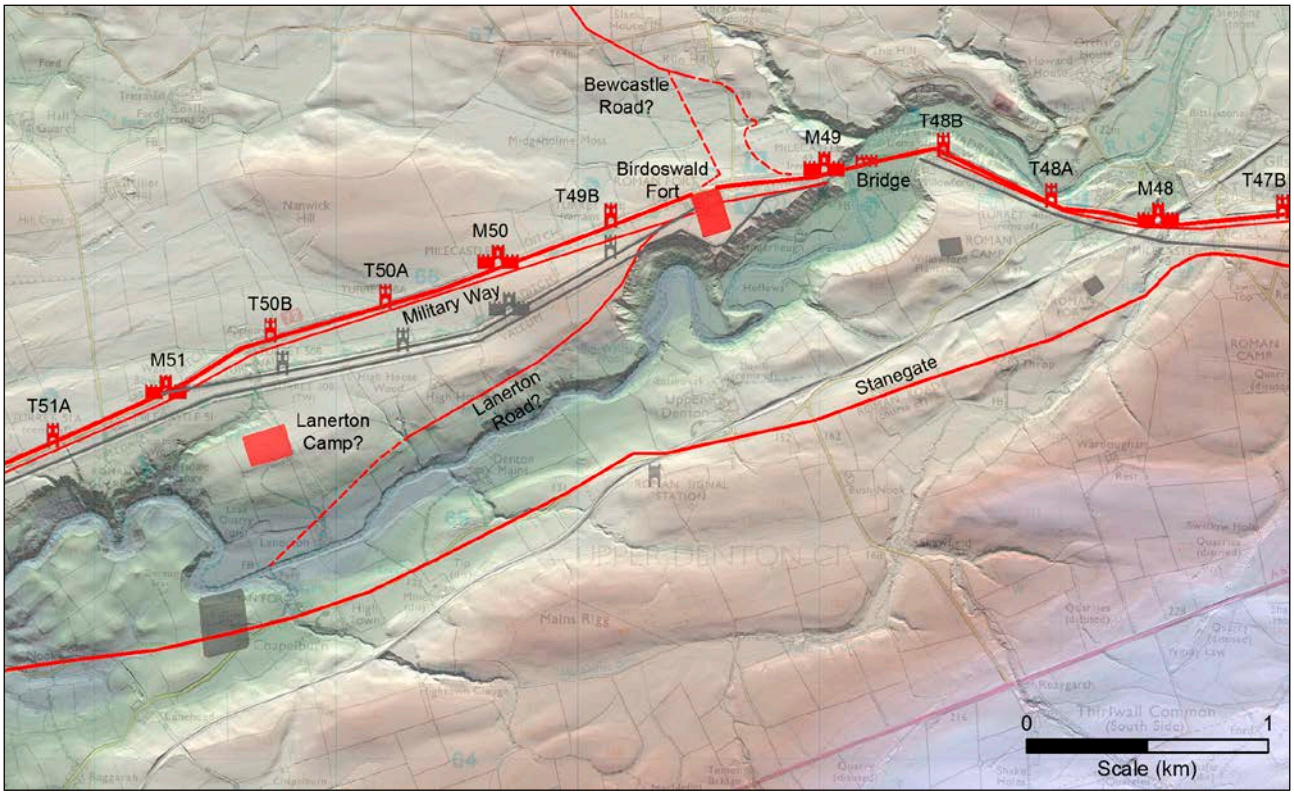


Figure 68: The final phase of Hadrian's Wall saw the Turf Wall replaced in stone with a part realignment with replacement turrets and milecastles. The Military Way was constructed to link the garrisons. Base map © Crown Copyright and database right 2023. All rights reserved. Ordnance Survey Licence number 100019088. Relief model created from APGB height data © Bluesky International/Getmapping PLC.

The sequence of this rebuilding was similar to that of the Turf Wall. Turret 51A (Piper Syke) was retained, as this remained on the line of the replacement Stone Wall. The remaining turrets were rebuilt to the same dimensions, a little to the north of their, now redundant, Turf Wall, counterparts. The new Stone Wall was then constructed abutting the turrets. The consolidated remains of Turret 49B SW (Birdoswald), a little to the west of Birdoswald fort, displays this relationship clearly. As with examples described above, this is again almost certainly just a sequence of construction rather than evidence of two entirely different phases of Wall construction, and the two were presumably built roughly at the same time.

Where the Stone Wall replaced the Turf Wall, to the west of Milecastle 51 (Wall Bowers), the earlier earthworks were levelled. Excavation at Turret 51A (Piper Syke) revealed evidence of the earlier Turf Wall rampart adjacent to the later Stone Wall foundations (Charlesworth 1973, 67). Again, the Stone Wall can be seen abutting the earlier turret foundations, but in this instance the turret had already existed for a number of years.

Milecastle 50 SW (High House) was also rebuilt on the new northern line of the Wall, again in stone (Fig. 69). The results of the 1911 excavation at this site provide one of the clearest examples of the sequence of construction of the Stone Wall and milecastles. The milecastle curtain wall abutted the main Stone Wall and was therefore constructed after the Wall. However, two drains built for and located on either side of the main north gate to the milecastle, lay below the foundation course of the stone Wall (Simpson 1913, 314). This indicates that although the milecastle was secondary in construction, the gateway was planned and implemented during the construction of the main Wall.

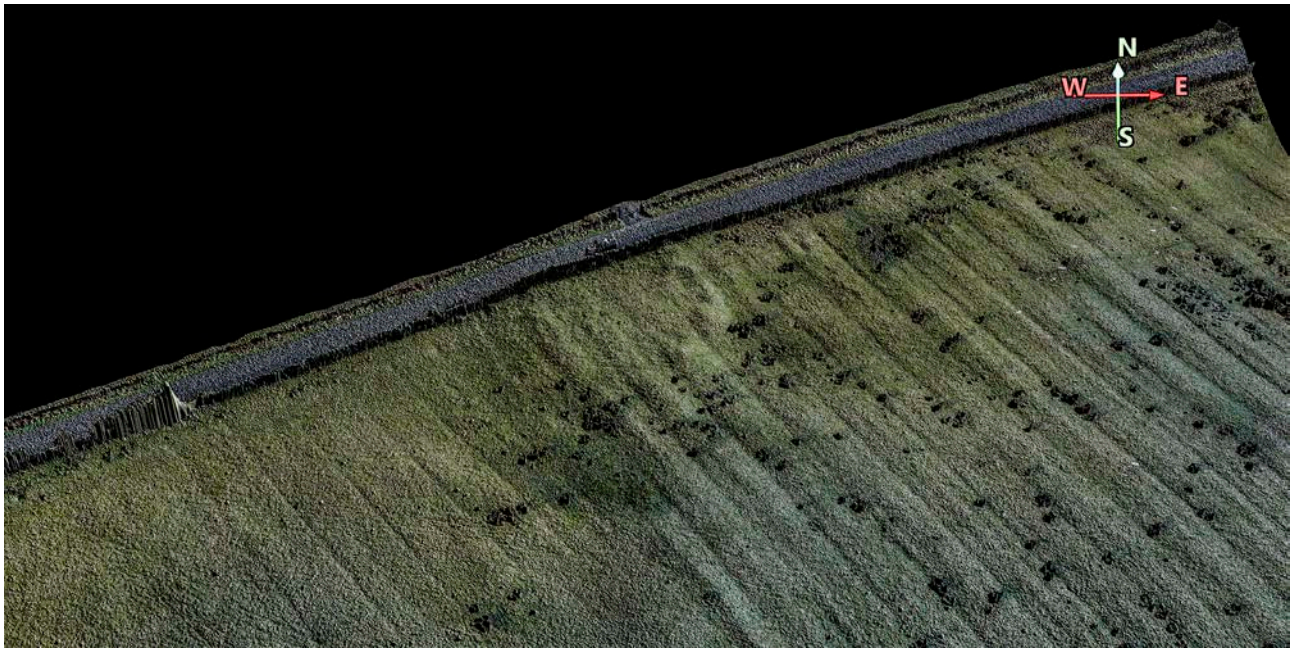


Figure 69: The buried remains of Milecastle 50 SW (High House) are only visible as very slight earthworks. Skeye UAS Orthophotograph over SfM DSM 21-FEB-2017 © English Heritage Trust/ Historic England.

The turf milecastles at Harrows Scar (49) and Wall Bowers (51) were also levelled and rebuilt in stone. Excavations at Milecastle 49 (Harrow's Scar) revealed evidence of the earlier turf milecastle beneath the consolidated stone remains visible today (Simpson 1928, 384, Richmond 1956).

It is unclear why the line of the Wall was moved north. Breeze (2006, 60) suggests the move may have been to allow better use of the plateau between Birdoswald and Wall Bowers, or to increase the visibility of the Wall from the fort. This seems unlikely however, as the ground dips to the west of Turret 49b SW (Birdoswald) and the viewshed analysis of Birdoswald fort shows equal lengths of both Turf Wall and Stone Wall visible and similar views to the north.

Hadrian's Wall was briefly abandoned around the AD 140s as the frontier moved north to the Antonine Wall. Excavated material suggests however that the fort at Birdoswald remained in use. By AD 158, the frontier appears to have predominantly moved back to Hadrian's Wall (Breeze 2006, 28). With this also came the establishment of a vicus, or civilian settlement around the fort. The extents of these extra mural settlements to the west, south and east have been established through geophysical survey (Wilmott 2014, 24-9; Johnson 1989, 71-4), and partly by recent excavation, including to the north of the fort (Wilmott forthcoming).

The final phase of Hadrian's Wall, at some point in the mid- or late-2nd century AD following the abandonment of the Antonine Wall, was the construction of a road linking the forts (Johnson 1989, 77; *see also* Fig. 68). The Military Way, as it is now known, extended parallel to and between the line of the stone Wall and the Vallum, sometimes using part of the latter. It can be intermittently traced as shallow earthworks at several locations in the project area and has been picked up through excavations at other points.

The road presumably remained in use throughout most of the Roman period, though the archaeological study of it in this sector is limited. This project has however identified a number of possible previously unknown lengths of the road, visible only as extremely shallow earthworks on elevation models. Unlike the Stanegate, Lanerton and Bewcastle roads, which presumably carried both military and civilian traffic, the Military Way was probably only for the use of troops moving between the milecastles and turrets along the Wall.

Following the demise of the Roman occupation of Britain, there is evidence to suggest that settlement continued at Birdoswald. The stone remains of the fort itself lasted for many centuries. For example, the arch to the west gate of the fort (*porta principalis sinistra*) remained intact into the medieval period, as demonstrated by the discovery of medieval pottery beneath the rubble collapse of the gate (Wilmott 1997, 371). The foundations of the 'Pight Wall' (Pict Wall), as Hadrian's Wall was termed on the 1603 maps, remained visible though heavily robbed. These 17th-century surveys are the earliest known mapping of the Wall in this area. The maps show two rectangular walled features at the approximate location of Milecastle 51 (Wall Bowers), suggesting that elements of this Roman fortified site may have remained visible in the 17th century.

Temporary encampments

The dating and function of Roman camps has long been a topic of debate. Often considered temporary features, very few have undergone little more than survey and it is difficult to conclude just how temporary they were. Welfare and Swan (1995, 1) state that they were constructed to house 'highly mobile troops'.

In this area, where the frontier passed through, there could be multiple arguments for the function of a temporary camp. They might have been constructed as marching camps during the military campaigning prior to the Stanegate or Hadrian's Wall; or as practice camps for the training of soldiers in the construction of defensive earthworks; or as construction camps for troops engaged in the building of Hadrian's Wall.

There are three temporary camps in the Birdoswald mapping area: Crooks, Willowford and Lanerton, surviving to varying degrees. Their layouts are defined by rectangular ditched enclosures with curved corners and internal ramparts. Where the earthworks survive best, they are very shallow. This is presumably a reflection on their temporary nature – that they were hastily constructed for a brief period of defence. Where entrances are visible, they are opposed by a traverse – an embanked outwork with outer ditch.

Dating camps can also be difficult. It is easy to presume that all of these camps pre-date the Wall as they are located to the south of the Wall and therefore belong to the earlier period of instability. However, it would be naïve to believe that all of the native population to the south of the Wall was tamed following the completion of the Wall. Therefore, it may be equally viable that the camps could relate to the training and temporary housing of troops on manoeuvres along and around the Wall when the forts might be fully occupied. Another option is that the camps were dug to house troops employed in the construction of the Wall, milecastles, turrets and forts. Whether training, construction or marching camps, it is possible that they could belong to almost any period.

A study of the viewsheds was undertaken as an attempt to understand the location of the camps and topography better, perhaps shedding some light on their function and therefore approximate date.

Crooks

Crooks camp is located on the eastern edge of the project area, at the highest point. With an internal area of 0.8ha, the camp may have held up to 500 soldiers. Despite the elevation, the camp's immediate views are very limited, with sporadic aspects to the south but very few along the valley bottom or along the line of Hadrian's Wall (Fig. 70). The camp is also not visible from the Stanegate, nor can it be seen from Throp fortlet, which is located less than 500m to the north-west. The site of the temporary camp at Willowford is visible. The most extensive views from the camp are to the north side of the river, but unlike Throp, does not afford views to the crossing point at Gilsland. In the distance, the camp offers views to the north of the river as far as Waterhead Common, and to the north-east on to Thirwall Common.

Although located on high ground with good distant views to the north, the camp is in a relatively poor tactical location. The ground falls away rapidly to the north and west. The nearest water source is Poltross Burn, some 350m downslope to the west. Therefore, in agreement with Welfare and Swan (1995, 92), the camp is less likely to have been located with defence in mind as originally suggested by Bennett (1980, 160). Unlikely to have been a construction camp, being nearly 440m away from the Wall, the sporadic distant views might suggest that it was sited for signalling purposes or may have been associated with Chapel Rigg Camp to the east, outside the project area. This would suggest that it was pre-Hadrianic in origin. Conversely, it may have been a training camp – it is a model example, almost perfectly rectangular with defended entrances on all four sides (*see* Fig. 41).

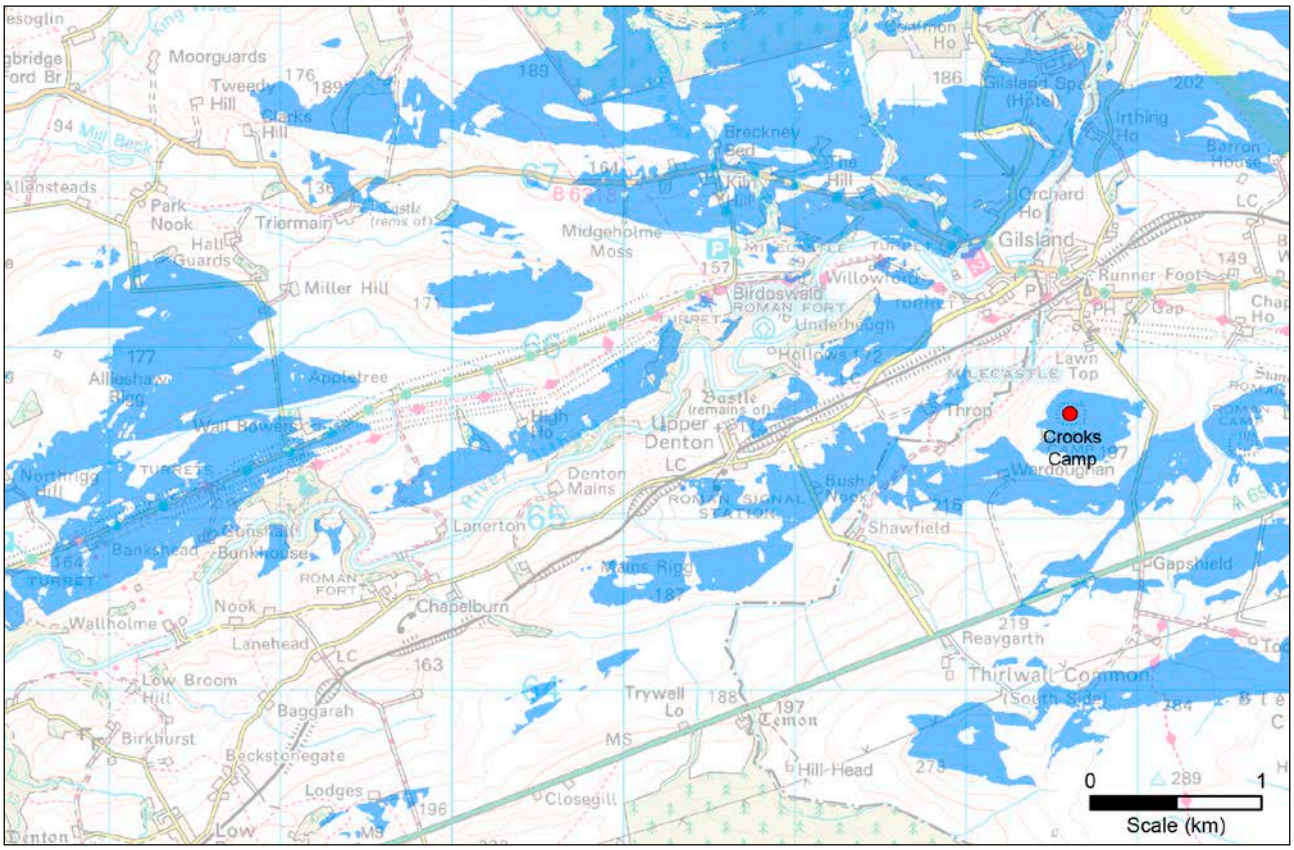


Figure 70: Crooks camp is located on the highest point of the project area. It is unlikely to have been defensive, but may have functioned as a signalling site or a practice camp. Base map © Crown Copyright and database right 2023. All rights reserved. Ordnance Survey Licence number 100019088.

Willowford

Willowford camp is located on a relative plateau with a steep slope to the north and a shallower approach from the south (Fig. 71). It is also located on a relatively high point in the landscape, but commands very different views to Crooks. Views to the west are impeded, but it does overlook a 2.1km stretch of the Stanegate and Throp fortlet to the south. It is also visible from Mains Rigg. Importantly, it also commands a good view of the north side of the river, including the crossing point at Gilsland.

The camp is in a relatively good defensive location, being on high ground to the south of the river with an aspect over the only crossing point in the area, as well as affording good visibility of the approaches to the north (Fig.72). It has two visible entrances, both facing the north and north-east (*see* Fig. 43), but curiously none to the south where the approach is easiest. The lack of association with Hadrian's Wall, but close proximity to the Stanegate and intervisibility between Throp and Mains Rigg suggest a likely association with the pre-Hadrianic frontier.

It would seem likely that the camp was established as a defensive position overlooking the river crossing, perhaps a predecessor to Throp, or maybe even a construction camp for the fortlet and/or Stanegate road.

Figure 71: A panoramic view of the south-east corner of Willowford camp. The camp is located on a natural plateau and may have been sited for defensive purposes. Looking north-west. June 2017 © Historic England.

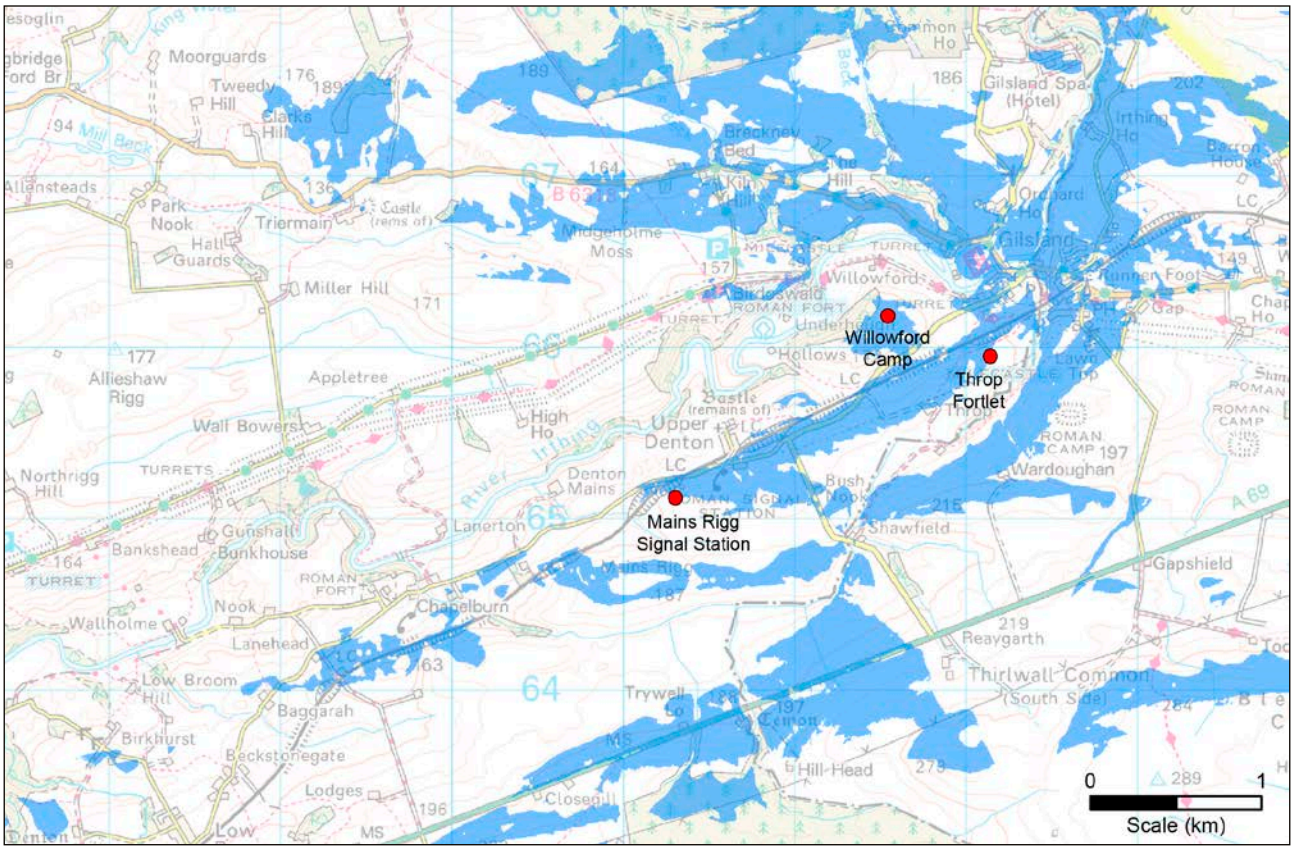


Figure 72: The camp at Willowford affords views to the north and north-east. It also overlooks the river crossing in Gilsland. It is located in a good defensive position and may relate to an early marching camp. Base map © Crown Copyright and database right 2023. All rights reserved. Ordnance Survey Licence number 100019088.

Lanerton

The earthwork survival of the camp at Lanerton is extremely poor (*see* Fig. 44), to the point where no gates can be located nor are the full dimensions be certain. However, should the camp have extended further down the slope to the south, this would have had minimal impact on the viewshed (Fig. 73). The highest point of the camp offers extensive views along the south of the Irthing Valley, overlooking the fort at Nether Denton and much of the length of the Stanegate through the project area. It could also be seen from the west rampart of the fortlet at Throp. To the north, the camp has sporadic views as far as Nanwick Hill and Allieshaw Rigg, but none to the north-east. Without the woodland to the north and west. The camp would also have had extensive views along a length of Hadrian's Wall, between Turret 50B SW (Appletree) and Milecastle 52 (Bankshead), a total length of over 2km.

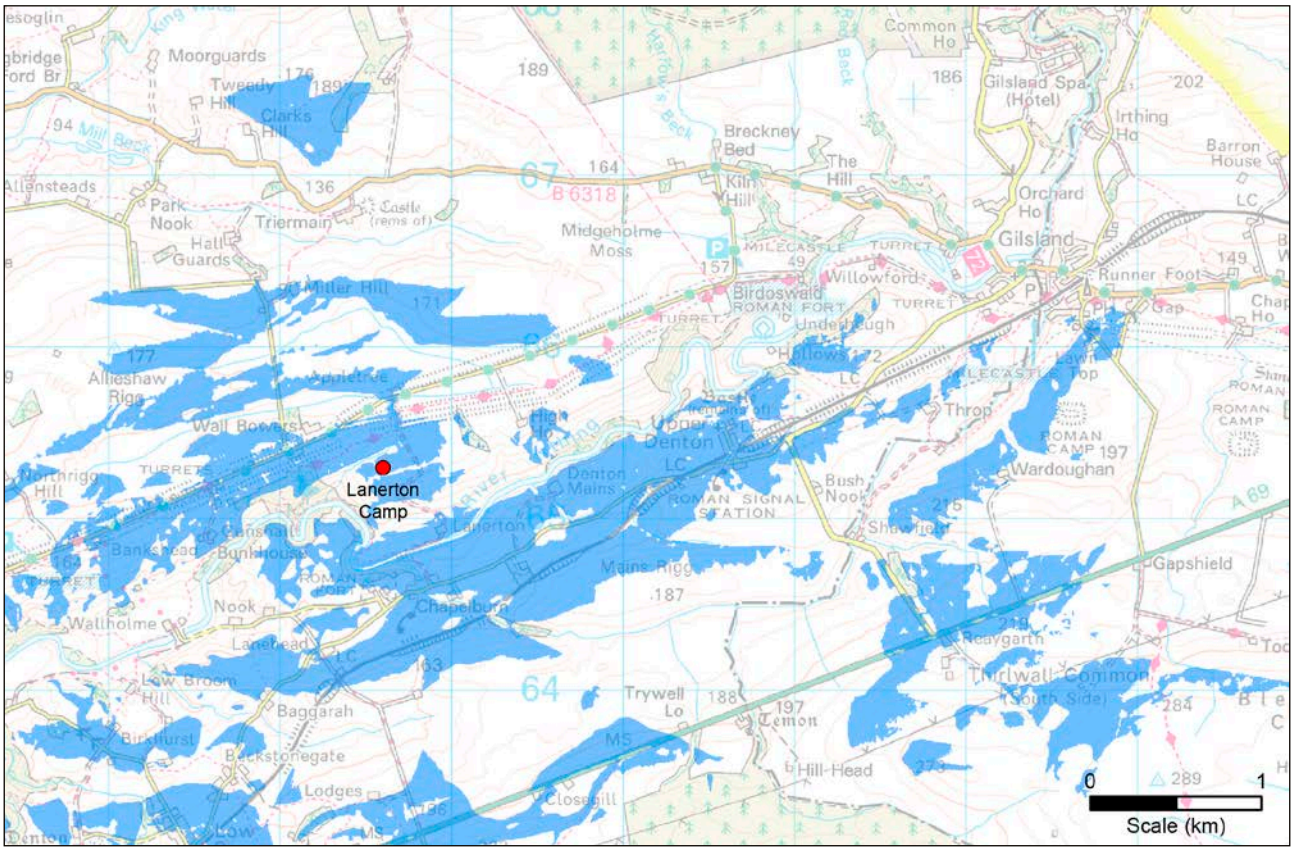


Figure 73: The Roman camp above Lanerton had very good views along the south of the Irthing Valley and along a section of Hadrian's Wall. Base map © Crown Copyright and database right 2023. All rights reserved. Ordnance Survey Licence number 100019088.

With a minimal internal area of approximately 2.2ha, this is by far the largest camp of the three and comparable in size to the forts at Birdoswald and Nether Denton. Based on Bennett's calculations (1980), a camp of this size may have held up to 1,500 soldiers. Despite Wall Burn to the north, the location lacks natural defences. The upper part of the camp is located on a plateau with poor views of the approaches to the north-east, and

a steep slope to the river on the west. The slope to the river to the south is gentler and, notably, this is also the location of a fording point across the River Irthing on the opposite side of which is the site of Nether Denton Fort – and is also adjacent to the proposed line of a road that ran between Birdoswald and this ford (*see* Fig. 74).

There is a lot of evidence to point towards this being a construction camp for the Wall. The camp is located only 150m south of the Vallum earthworks and 600m east of the Roman Quarry in Combcrag Wood. It does not make sense to locate a camp in a non-defensible position such as this to the north of the river unless it was directly linked to Wall, and it would seem reasonable to suggest that the camp was purposely sited to retain sight of the pre-Hadrianic defences south of the river whilst the Wall was being built.

Communication with Hadrian's Wall

Birdoswald to Lanerton road

The project has identified a possible previously unknown road exiting Birdoswald fort to the west. The road presumably exited Birdoswald via the west gate, joining the Military Way somewhere to the west of the fort. An element of the road was first identified through the cemetery excavations above Blackbank Wood, and has been traced by this project as continuing obliquely down the slope to the south-west (*see* Figs. 37-39). The road line stops on the east bank of a steep crag on the south side of High House Wood. How it traversed this crag and its course to the west of it are uncertain. It may be that the road was stepped further down the slope, roughly following the line of modern field boundaries towards Lanerton. It seems logical however than its destination was a fording point across the River Irthing, adjacent to the fort at Nether Denton (Fig. 74).

When the road was constructed is difficult to ascertain. It is unlikely to predate Hadrian's Wall, but it could predate the fort at Birdoswald – perhaps forming a link road from the Stanegate to the Wall or to the road from Bewcastle. Or perhaps it was constructed whilst Birdoswald was being built, linking the new fort with the older one at Nether Denton.

Although Nether Denton is thought to have been abandoned once Birdoswald had been completed, the extra-mural settlement is believed to have continued. Presumably this route also endured as a link road. Rescue excavations of the Birdoswald cemetery revealed cremations spanning the 2nd to 5th centuries AD (Wilmott 2010).

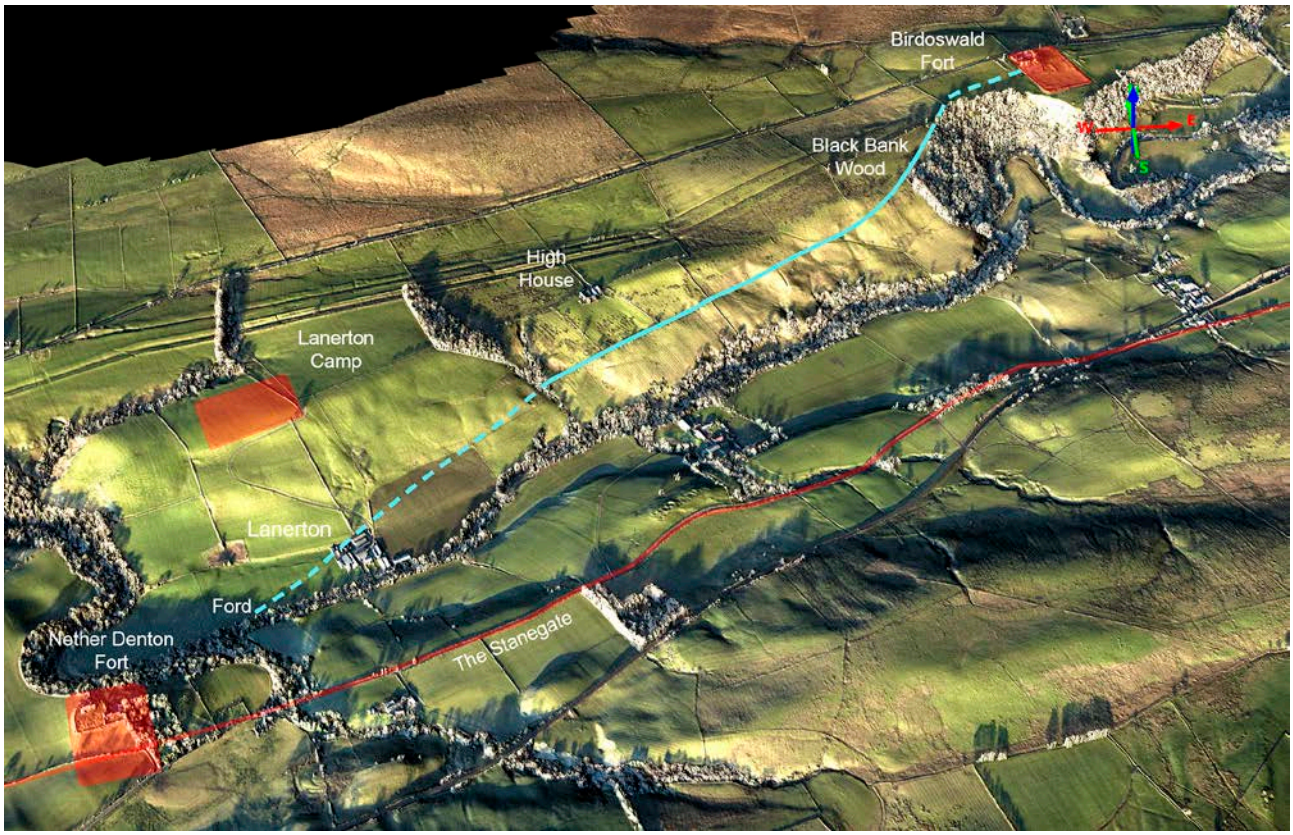


Figure 74: A newly identified Roman road extends from the direction of Birdoswald towards Lanerton, passing a Roman cemetery above Blackbank Wood. The projected line of the road suggests that it may have originated as a route between Birdoswald and Nether Denton. Historic England Orthophotograph over SfM DSM 05-JAN-2017 © Historic England.

Birdoswald to Bewcastle road

The only road in the Birdoswald Sector known to have extended north of the Wall, went to the fort at Bewcastle (Margary 1957, 180; road 865). Though known as the Maiden Way since at least the 19th century (Haverfield 1897, 186), this road has sometimes been incorrectly thought to be a continuation of the Maiden Way which passes through the North Pennines, terminating on the Stanegate at Carvoran 5km to the east (Margary 1957, 125; road 84).

The road can be traced along the edge of Waterhead Common to the B6318, west of Slack House. From here it has been projected (on Ordnance Survey maps and monument records) as continuing in a straight line across Midgeholme Moss to Birdoswald fort. However, no surface trace has been established between Slack House and the fort until recently. The boggy moss forms a considerable 300m wide barrier (Fig. 75), which was presumably less passable during the Roman period, having undergone substantial drainage in recent centuries.

The route of this road was believed to have been located during excavations for a sewage treatment plant in the field immediately north of the fort (Wilmott 1997, 411), but more recent studies are moving away from this interpretation. Alternative suggestions based upon the results of this study and more recent research is that the road either bypassed the Moss or crossed it via a causeway.

Figure 75: A view of Birdoswald looking south-east across Midgeholme Moss. The boggy ground would have formed a considerable barrier. June 2017 © Historic England.

At the time of the Birdoswald Sector Survey, the available lidar (which was composite data, dated 2010) only covered the southern half of the Moss. The clarity of the SfM DSM for this area was also poor as it was on the peripheral edge of the survey. Therefore, no elements of this north road were identified. Most of the earthworks north of the Wall were considered to be medieval/post-medieval.

The full-cover 2019 national dataset of lidar for this area was released after the completion of the aerial investigation and mapping. David Ratledge (2021, 3-5) examined this new data and identified previously unseen stretches of the road, ultimately proposing a new route for the road around the Moss.

The straight section of known Roman road, from Waterhead Common, extended towards the B6318, making a sudden sharp turn to the south-east (Fig. 76, A), passing under the modern road to the west of Slack House. Here, as Ratledge identified, the *agger* can be clearly seen on the 2019 lidar as intermittent heavily ploughed banks.

To the east of here, extensive medieval earthworks mask the Roman road. Ratledge proposed that it continued east along a terrace to the south of Kiln Hill (Fig. 76, B; Fig. 77), before passing under the current road between Kiln Hill and Birdoswald. He suggests that it continued along the line of a long curving terrace that skirts the edge of the Moss (Fig. 76, C), crossing a stream and turning south-west towards the fort. This terrace was mapped as part of the Sector Survey. It denotes the line of a road/trackway marked on the 1603 manorial survey (Fig. 78, A) and was mapped as a medieval/post medieval road because of this.

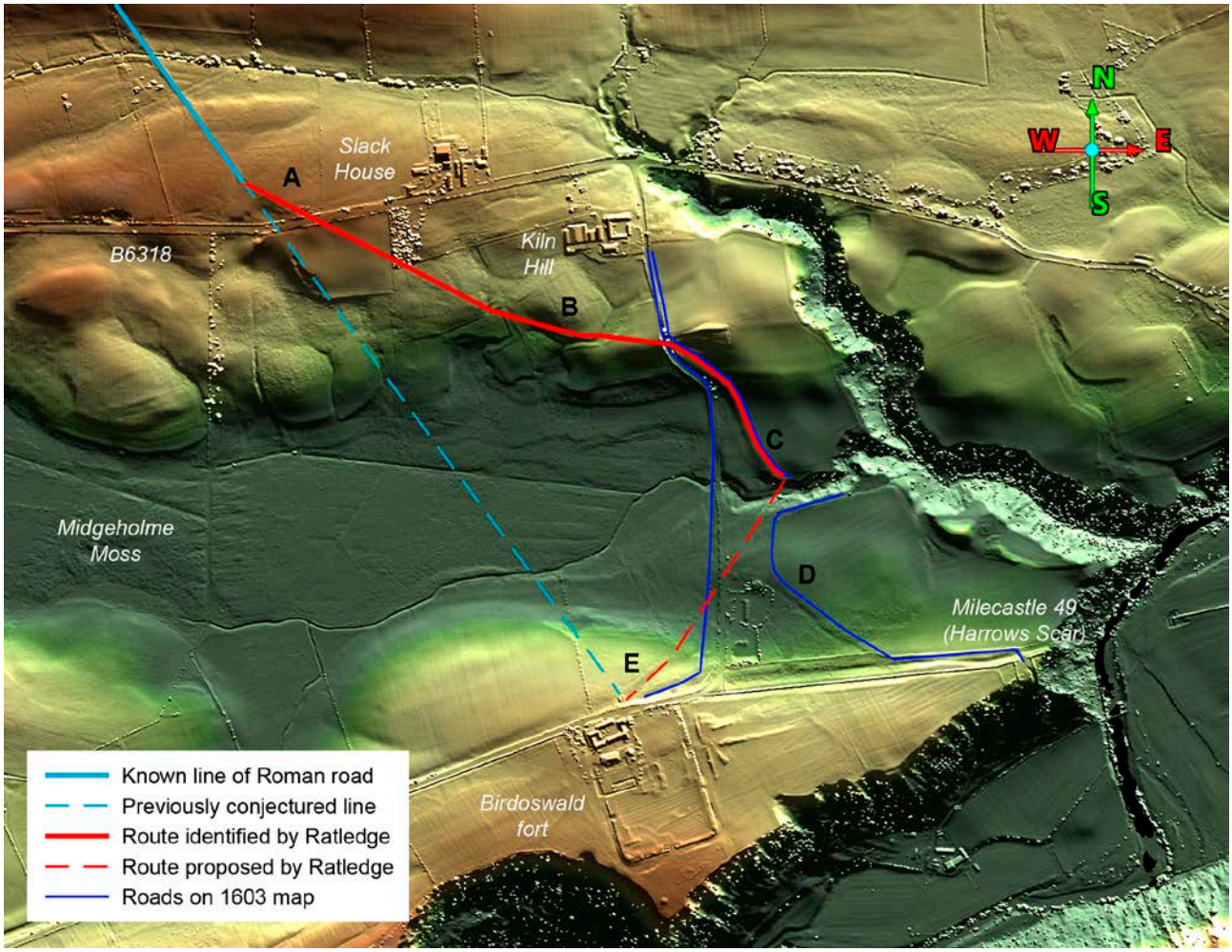


Figure 76: The original line of the Birdoswald-Bewcastle road projected across Midgeholme Moss. Ratledge identified earthwork evidence suggesting that the road skirted around the Moss. LIDAR DSM 2019 © Historic England. Source Environment Agency.

There is however no earthwork evidence of the road turning south-west. The 1603 map shows the road continuing to curve around the edge of the Moss (Fig. 78, B). This is supported by the earthwork and mapping evidence, which shows the terrace continuing south of the stream towards the south-east (Fig. 76, D). This was also mapped as medieval/post-medieval in date. However, taking Ratledge's findings into account, it now seems plausible that this originated as a Roman road (*see* Fig. 79).

The road may have skirted around the outside of the boggy ground before turning west following the line of the Wall towards Birdoswald fort. Or perhaps the road was never intended for the fort at all. The construction of the fort at Bewcastle is believed to have begun around the 120s AD (Austen 1991, 50), roughly at the same time that work began on Hadrian's Wall. If the road from Bewcastle was established prior to the first fort at Birdoswald, then perhaps it led instead to Milecastle 49 at Harrow's Scar and Willowford bridge (*see* Fig. 65).

Figure 77: The line of the Roman road from Bewcastle may be indicated by a linear terrace to the south of Kiln Hill. Looking north. UAS 22-JUN-2023© Historic England

Figure 78: The 1603 map of Gilsland illustrates the road between Kiln Hill and Harrow's Scar. Cumbria Archive Centre, Carlisle. Ref No. DHN/C/713/12 © Howard of Naworth collection, reproduced courtesy of the Hon. Philip Howard.

It is still worth mentioning the possibility, however remote, of a causeway across the Moss. The Romans clearly had the engineering capability – they constructed a monumental stone bridge across the River Irthing a short distance to the east. If the road originally led to Harrow's Scar, perhaps after the construction of Birdoswald, it was thought necessary to construct a more direct route to the fort. The author agrees with Ratledge that a hollow way extending north-east from the fort could be Roman in origin (Fig. 76, E), as it aligns with the presumed location of the north gate. This hollow way is only visible for 80m and there is no evidence that it continued towards the terraced road to the east.

The hollow way appears to have remained in use in the medieval and/or post-medieval periods as evidenced by its association with other earthworks and may have led to a potential causeway across Midgeholme Moss at this time (*see* Fig. 48). It is worth considering that this causeway may have originated in the Roman period, as a realignment of the road from Bewcastle to the fort at Birdoswald (Fig. 79; *see also* Figs. 67-8).

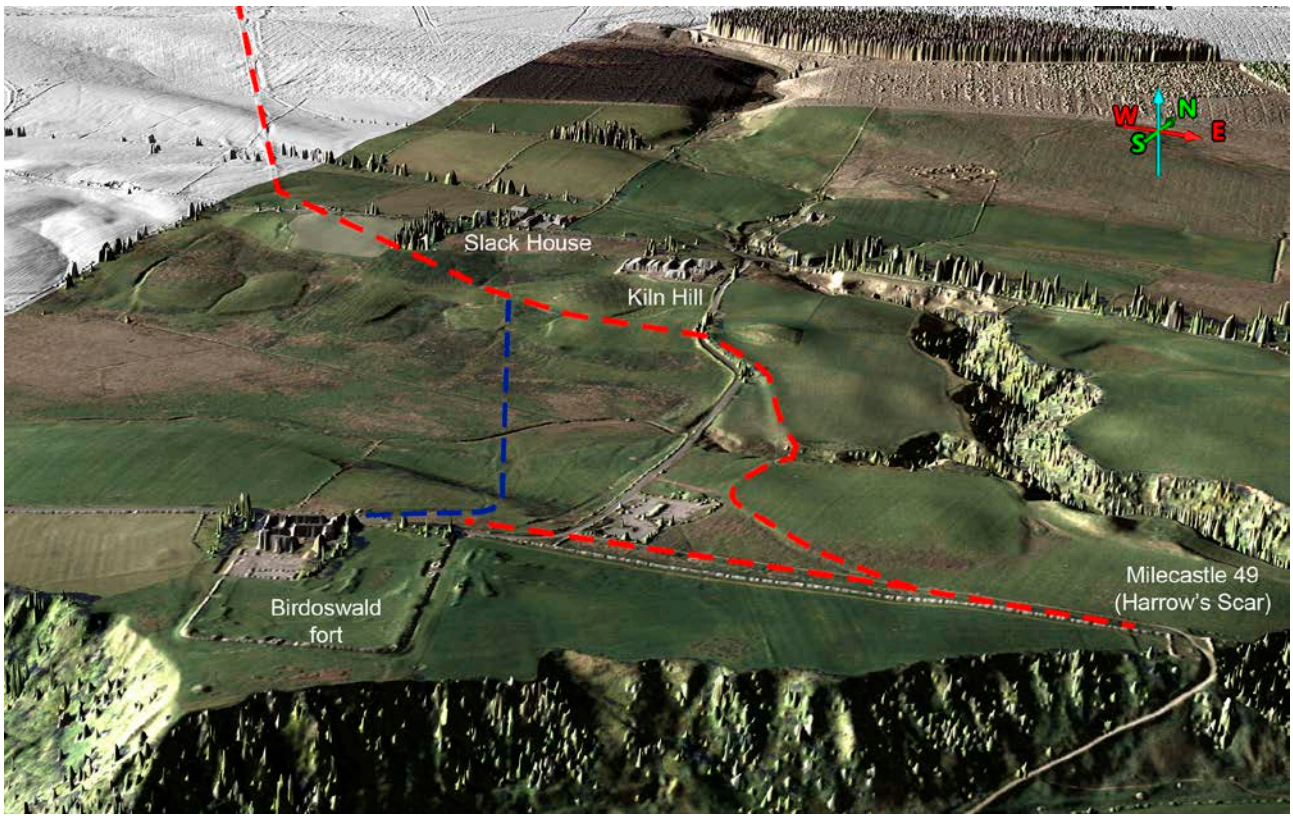


Figure 79: The road from Bewcastle (in red) may have originally led to Milecastle 49 and the bridge across the River Irthing. It is possible that a secondary route was causewayed across Midgeholme Moss towards Birdoswald fort (in blue). LIDAR DSM 2019 © Historic England. Source Environment Agency. Next Perspectives APGB Imagery 09-APR-2015 © Bluesky International/Getmapping PLC.

Conclusion

It seems remarkable that even now, after so many years of excavation and research, that the Birdoswald landscape continues to reveal its secrets. The Sector Survey was largely a technical exercise, examining the potential of creating elevation models from reconnaissance photography that were good enough quality to aid archaeological mapping to current standards. It was not anticipated that so much new information would be gleaned from an area that had already undergone previous high-quality aerial investigation and mapping. The new elevation models were key to this project's success.

The results clearly show a complexity of activity from the formation of the first frontier along the Stanegate, to the construction and occupation of Hadrian's Wall. The survey has illustrated that by using new techniques, we may be able to get a better understanding of these Roman features within their landscape setting. This includes using viewshed analysis to better understand site locations and associations between different monuments.

The study has newly identified numerous features, including numerous sections of Roman road. These include the Stanegate, which can be reliably traced through the project area; the Military Way, which is identifiable at several points; and the Lanerton road – a potential connection between the pre-Hadrianic frontier and the later Wall to the north. Building on Ratledge's observations on the Bewcastle road, a reassessment of the Sector Survey data partly supports his suggestion of the road skirting around Midgeholme Moss but also builds on this to suggest that this road may have been multi-phased.

The detail visible in the sources illustrates clear relationships between features, whether this was the sequencing of the Wall construction, or the impact of later activity. The post-Roman period is no less interesting. The re-use or continued occupation of sites is interesting. Birdoswald remained the focus of activity throughout the medieval and post-medieval periods, largely defined by the walls of the long abandoned Roman fort. Similarly, Nether Denton became the location of a small settlement and church and the milecastle at Harrow's Scar was used as the site for a farmhouse.

Despite these findings however, there remain many questions about how the landscape evolved that cannot be answered by remote survey alone. Should the opportunity arise, further investigations could be conducted into the full extents of newly identified features, such as the temporary camp at Lanerton, which may have had an annexe to the south; and the Lanerton road, of which only the eastern half can be traced. Other monuments that have illustrated unusual traits, such as the possible outworks at Crooks camp could also be further investigated. Nether Denton has undergone very little study in comparison to Birdoswald, to the degree that the full extents of the fort are still not known. Geophysical survey would no doubt be a useful technique to employ in many of these cases. Targeted excavation may also help the positive identification of some sites, such as elements of the Bewcastle road to the north of the fort or the Lanerton road.

There remains little doubt that applying similar survey and mapping methods to other areas of Hadrian's Wall would no doubt yield similarly impressive results.

Bibliography

Anon., 1941 ‘Proceedings’, *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society,* 2nd Ser., Volume 41, 209-217.

Anon., 1946 ‘Report of the council for the year ending 31st December 1945’, *Proceedings of the Society of Antiquaries of Newcastle upon Tyne,* 4th Ser., Volume 10, 274-80.

Anon., 1888 ‘Excavations on the line of the Roman Wall. Report of the Committee appointed April 20, 1886, laid before the Society at Kendal, September 8th, 1886’, *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society* 1st Ser., Volume 9, 162-77.

Austen, P. S., 1991 *Bewcastle and Old Penrith*. Cumberland and Westmorland Antiquarian and Archaeological Society Research Series No. 6 (Stroud).

Bennett, J., 1980 ‘‘Temporary’ camps along Hadrian’s Wall’, in Hanson, W. S., and Keppie, L. J. F., (eds) *Roman Frontier Studies 1979: Papers presented to the 12th International Congress of Roman Frontier Studies,* 151-172. (Oxford: British Archaeology Report International Series).

Bidwell, P. T. and Holbrook, N. 1989 *Hadrian’s Wall Bridges*. (London: Historic Buildings and Monuments Commission for England).

Biggins, J. A. and Taylor, D. J. A. 1999 ‘A Survey of the Roman Fort and Settlement at Birdoswald, Cumbria’, *Britannia*, Volume 30, 91-110. (London: Society for the Promotion of Roman Studies).

Biggins, J. A. and Taylor, D. J. A. 2004 ‘Geophysical Survey of the Vicus at Birdoswald Roman Fort, Cumbria’, *Britannia*, Volume 35, 159-78. (London: Society for the Promotion of Roman Studies).

Binns, M. 1972 ‘Mains Rigg signal tower, Cumberland’, *Council for British Archaeology Group 3. Archaeological news bulletin for Northumberland, Cumberland, Durham, Westmorland and Lancashire-north-of-the-sands*.

Breeze, D. J. 2006 *J. Collingwood Bruce’s Handbook to the Roman Wall*, 14th edn. (Newcastle upon Tyne: Society of Antiquaries of Newcastle upon Tyne).

Breeze, D. 2014 *Hadrian’s Wall*. (London: English Heritage)

Charlesworth, D. 1967 ‘Poltross Burn, Milecastle 48’, *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 67, 233-5.

Charlesworth, D. 1973 ‘Hadrian’s Wall, Turret 51A (Piper Sike)’, *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 73, 67-78.

Collingwood, R. G. and Taylor, M. V. 1924 ‘Roman Britain in 1924’, *The Journal of Roman Studies*, Volume 14, 206-51.

Collingwood, R. G. and Wright, R. P. 1965 *The Roman Inscriptions of Britain*. (Oxford: Clarendon Press).

Collins, R. 2015 *Hadrian's Wall and LiDAR. New features in an ancient frontier landscape*. (Newcastle: Newcastle University).

Crow, J. 1995 *English Heritage Book of Housesteads*. (London: B.T. Batsford).

Drury, D. and Allen, T. 2020 'New work on long barrows in Lincolnshire', in Barclay, A., Field, D. and Leary, J. (eds.) *Houses of the Dead*. Neolithic Studies Group Seminar Papers 17, 121-134.

Evans, S. 2019 *Historic England Aerial Investigation and Mapping (formerly National Mapping Programme) Standards Technical Review*. Research Report 46-2019. (Swindon: Historic England).

Ferguson, C. J. 1878 'Over Denton Church', *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 1st Ser., Volume 3, 157-66.

Frere, S. S., Hassall, M. W. C. and Tomlin, R. S. O. 1985 'Roman Britain in 1984', *Britannia*, Volume 16, 251-332.

Frere, S. S., Hassall, M. W. C. and Tomlin, R. S. O. 1986 'Roman Britain in 1985', *Britannia*, Volume 17, 363-454.

Gaffney, C. and Gator, J. 1999 *Geophysical Survey at Birdoswald*. (Bradford: Geophysical Surveys of Bradford).

Gibson, J. P. and Simpson, F. G. 1911 'The Milecastle on the Wall of Hadrian at the Poltross Burn', *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 11, 390-461.

Gillam, J. P. 1950 'Recent excavations at Birdoswald', *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 50, 63-8.

Hale, D. 2013 *Underheaugh Farm, Birdoswald, Gilsland, Cumbria. Geophysical Survey*. (Durham: Durham University).

Haverfield, F. 1895 'Report of the Cumberland Excavation Committee 1894', *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 1st Ser., Volume 13, 453-69.

Haverfield, F. 1897 'Report of the Cumberland Excavation Committee, 1896', *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 1st Ser., Volume 14, 413-433.

Haverfield, F. 1899 'Report of the Cumberland Excavation Committee for 1898', *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 1st Ser., Volume 15, 345-64.

Hazell, Z. and Pelling, R. 2010, *Appletree, near Birdoswald, Hadrian's Wall, Cumbria. Macrobotanical assessment of the Vallum Ditch fill; Sample 901, Context 15. Environmental Studies Report*. Research Department Report Series 99-2010. (Portsmouth: English Heritage).

Historic England 2017 *Photogrammetric Applications for Cultural Heritage. Guidance for Good Practice*. (Swindon: Historic England).

Historic England 2018a *Roman Forts and Fortresses*. (Swindon: Historic England).

Historic England 2018b *Guidance on Using Airborne Lidar in Archaeological Survey: The Light Fantastic*, 2 edn. (Swindon: Historic England).

Hodgson, J. 1840 *History of Northumberland, part II, volume 1*. (Newcastle upon Tyne).

Hodgson 1899 'Notes on the Excavations on the line of the Roman Wall in Cumberland, in 1898', *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 1st Ser., Volume 15, 365-76.

Howard, P. 1979 *Camboglanna, Birdoswald fort on Hadrian's Wall: a short history and guide*. (Newcastle upon Tyne).

Johnson, S. 1989 *Hadrian's Wall*. (London: B. T. Batsford Ltd).

Knight, D., Last, J., Evans, S. and Oakey, M. 2018 *National Archaeological Identification Survey: South West Cambridgeshire, Aerial Investigation and Mapping Report*. Research Report 67-2018. (Portsmouth: Historic England).

Kokalj, Ž. and Somrak, M. 2019 'Why Not a Single Image? Combining Visualizations to Facilitate Fieldwork and On-Screen Mapping'. *Remote Sensing* 11(7), 747.

Margary, I. D. 1957 *Roman Roads in Britain*. (London: Phoenix House Ltd).

McDowall, R. W. and Mercer, E. 1970 'Bastles of Cumberland and Northumberland', in Ramm, HG, McDowall, R W and Mercer, E (eds.) *Shielings and Bastles*. (London: Her Majesty's Stationary Office).

Miller, T. 1999 *The Old English Version of Bede's Ecclesiastical History of the English People*. (Ontario: In parenthesis Publications).

Natural England 2013 *National Character Area Profile: 10. North Pennines*. (Natural England).

Natural England 2015 *National Character Area Profile: 11. Tyne Gap and Hadrian's Wall*. (Natural England).

Norman, H. 1860 'An account of recent excavations at Amboglanna (Birdoswald)', *Archaeologia Aeliana*, 2nd Ser., Volume 4, 249.

O'Donnell, K. 2015 *Quarries of the Central Sector of Hadrian's Wall*. Unpublished MSc thesis, University of Edinburgh.

Oakey, M. 2009 Hadrian's Wall World Heritage Site. National Mapping Programme Project. Research Department Report Series 73-2009. (Portsmouth: English Heritage).

Potter, H. G. 1855 'Amboglanna: communicated to the Society of Antiquaries of Newcastle upon Tyne, Nov. 6, 1850', *Archaeologia Aeliana*, 1st Ser., Volume 4, 63-9.

Ratledge, D. 2021 'The Roman Road from Birdoswald to Bewcastle, Cumbria, RR865, a lidar reappraisal', *Itinera*, Volume 1. 1-14.

RCHME 1987 *NY 66 NW 14 and 26. Birdoswald (Banna) Roman Fort and Environs*. Unpublished RCHME report.

Richmond, I. A. 1929 'Excavations on Hadrian's Wall in the Gilsland-Birdoswald-Pike Hill Sector, 1928', *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 29, 303-15.

Richmond, I. A. 1931 'Excavations on Hadrian's Wall in the Birdoswald-Pike Hill Sector, 1930', *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume **31**, 122-34.

Richmond I. A. 1956 'Excavations at Milecastle 49 (Harrow's Scar), 1953', *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 56, 18-27.

Richmond, I. A. and Birley, E. B. 1930 'Excavations on Hadrian's Wall, in the Birdoswald-Pike Hill Sector, 1929', *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 30, 169-205.

Roberts, A. 2016 *Birdoswald – Sector survey – integrated plan – v5*. English Heritage Trust unpublished project proposal.

Roberts, C. 2009 *Human remains in archaeology: a handbook*. (York: Council for British Archaeology).

Roseveare, M. J. and Roseveare, A. C. K. 2009 *Birdoswald Roman Fort Western Vicus & Cemetery. Geophysical Survey Report*. (Hereford: Archaeophysica Ltd).

St. Joseph, J. K. 1951 'Air Reconnaissance of North Britain', *The Journal of Roman Studies*, Volume 41, 52-65.

Shaw, R. C. 1926 'Excavations at Willowford', *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 26, 429-506.

Shipman, T. T. 1870 'The recently discovered remains at Nether Denton Parsonage', *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 1st Ser., Volume 1, 88-93.

Simpson, F. G. 1913 'Excavations on the line of the Roman Wall in Cumberland during the years 1909-12', *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 13, 297-397.

Simpson, F. G. 1928 ‘Excavations on Hadrian’s Wall in the Gilsland-Birdoswald-Pike Hill Sector, 1927’, *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 28, 377-388.

Simpson, F. G., Hodgson, K. S. and McTintyre, J. 1934 ‘Milecastles on the line of the Turf Wall’, *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 34, 144-8.

Simpson, F. G. and Richmond, I. A. 1932 ‘Excavations on Hadrian’s Wall. I. Birdoswald’, *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 32, 141-5.

Simpson, F. G. and Richmond, I. A. 1933 ‘Excavations on Hadrian’s Wall. I. Birdoswald’, *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 33, 246-62.

Simpson, F. G. and Richmond, I. A. 1934 ‘Excavations on Hadrian’s Wall. I. Birdoswald’, *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 34, 120-30.

Simpson, F. G. and Richmond, I. A. 1935 ‘Bankshead Milecastle, 52’, *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 35, 247-256.

Simpson, F. G. and Richmond, I. A. 1937 ‘Report of the Cumberland Excavation Committee for 1936’, *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 37, 157-177.

Simpson, F. G., Richmond, I. A. and St. Joseph, K. 1935a ‘The Turf-Wall Milecastle at High House’, *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 35, 220-9.

Simpson, F. G., Richmond, I. A. and St. Joseph, K. 1935b ‘Turf-Wall turrets between Wallbowers and Harrow’s Scar’, *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 35, 232-6.

Simpson, F. G. and St. Joseph, K. 1934 ‘Nether Denton’, *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 34, 152-4.

Small, F. 2008 *Hadrian’s Wall NMP Project: Brampton to Birdoswald. National Mapping Programme Report*. Research Department Report Series 69-2008. (Portsmouth: English Heritage).

Swinbank, B. 1952 ‘Excavations in High House Paddock, Cumberland’, *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 52, 46-54.

Symonds, M. F. A. and Mason, D. J. P. 2009 *Frontiers of Knowledge. A Research Framework for Hadrian’s Wall. Part of the Frontiers of the Roman Empire World Heritage*

Site. Volume 1.

Time Team 1999 *Evaluation of the cremation cemetery and the western extramural area of Birdoswald Fort, Cumbria: Project Design*. Unpublished.

Van Dierendonck, R. M. 2004 'Five Postholes and Ditch: The Valkenburg-Marktveld Timber Watch and Signal Tower', in Vermeulen, F., Sas, K. and Dhaeze, W. (eds.) *Archaeology in Confrontation. Aspects of Roman military presence in the Northwest*. Archaeological Reports Ghent University 2. (Ghent: Academia Press).

Walker, R. 1986 *Birdoswald Geophysical Survey*. Unpublished.

Welfare, H. and Swan, V. 1995 *Roman Camps in England. The Field Archaeology*. (London: Royal Commission on the Historical Monuments of England).

Wilmott, T. 1993 'The Roman Cremation Cemetery in New Field, Birdoswald', *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 93, 79-85.

Wilmott, T. 1995 *Birdoswald: a short history and souvenir guide*. (Carlisle).

Wilmott, T. 1997 *Birdoswald. Excavations of a Roman fort on Hadrian's Wall and its successor settlements: 1982-92*. Archaeological Report 14. (London: English Heritage).

Wilmott, T. 2009 'Transection in Wall mile 50 (Appletree, Cumbria), 1999', in Wilmott, T (ed.) *Hadrian's Wall. Archaeological Research by English Heritage 1976-2000*. 102-19. (Swindon: English Heritage).

Wilmott, T. 2010 'Birdoswald Roman Cemetery', *Research News*, Number 14, 16-19. (Portsmouth: English Heritage).

Wilmott, T. 2014 *Birdoswald Roman Fort*. (London: English Heritage).

Wilmott, T., Cool, H. and Evans, J. 2009 'Excavations at the Hadrian's Wall fort of Birdoswald (Banna), Cumbria: 1996-2000', in Wilmott (ed.) *Hadrian's Wall Archaeological Research by English Heritage 1976-2000*, 203-408. (Swindon: English Heritage).

Welfare, H. G. 1974 'A cemetery at High Nook, Nether Denton', *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society*, 2nd Ser., Volume 74, 14-17.

Welfare, H. and Swan, V. 1995 *Roman Camps in England*. (London: HMSO).

Whellan, W. 1860 *History and Topography of Cumberland and Westmoreland*. (Pontefract: W. Whellan and Co.).

Zakšek, K., Oštir, K. and Kokalj, Ž. 2011 'Sky-View Factor as a Relief Visualization Technique'. *Remote Sensing* 3(2), 398-415.

Appendix 1: Scope, Sources and Methods

Archaeological scope

The mapping adhered to Historic England's Aerial Investigation & Mapping Standards. It included all archaeological features visible as earthworks, structures, soilmarks and cropmarks, including features visible as earthworks on historic photographs which have since been levelled.

The mapping shortlisted a number of sites that required further assessment on the ground. A rapid walkover survey formed the second part of Historic England's input into the Birdoswald sector survey. Observations from this second phase are incorporated where relevant in the report.

Cropmarks, parchmarks, soilmarks

All subsurface archaeological remains visible as cropmarks, parchmarks or soilmarks and as sub-surface deposits exposed by archaeological excavation were mapped.

Earthworks

All earthworks within archaeological scope were mapped. This includes features visible on historic air photographs which have since been levelled.

Buildings and structures

The foundations of ruined buildings and structures visible as earthworks or stonework were mapped. Standing roofed or unroofed buildings depicted on Ordnance Survey maps were not normally mapped. The exceptions were in specific archaeological contexts such as industrial sites, or when associated with other archaeological features within the sphere of interest.

Ridge and furrow

Medieval and post-medieval land improvement ploughing was mapped regardless of preservation. Each furrow was depicted by a polyline to show the full extent and direction of the cultivation.

Post-medieval field boundaries

Post-medieval field boundaries (upstanding or levelled) depicted on historical Ordnance Survey maps were generally not mapped. Exceptions were made where they formed an integral part of a wider archaeological landscape.

Industrial extraction

Extraction of all scales was mapped, including associated structural remains.

Natural features

Features considered geological or geomorphological in origin were not mapped. Where there was a risk of confusion between natural and archaeological features, this was highlighted in the accompanying National Record of the Historic Environment monument record.

Transport

Major transport features, such as existing roads and the railway, were not mapped.

Sources

Aerial photographs

All available vertical and oblique air photographs held by the Historic England Archive in Swindon, both prints and digital, were consulted (loan reference 103251), comprising 140 vertical prints ranging in date from 1946 to 1985 and 489 specialist oblique images taken between the 1920s and 2016.

Cumbria HER gave access to their collection of 90 oblique images for the area. Most of the photographs are reproductions of Historic England Archive photography, but they also hold a number of duplicate CUCAP photographs. The Cambridge University Collection of Aerial Photography (CUCAP), administered by the Department of Geography, is currently closed and as a result images in the collection could not be accessed directly. The HER also held a number of photographs taken by Tim Gates. Any images scanned for rectification and mapping purposes were done so with permissions from both CUCAP and Tim Gates. Vertical photographs held by the HER were not assessed due to time constraints. None of the aerial photographs held by Northumberland HER were assessed as this formed a very small part of the project area and all the imagery had been previously assessed as part of the Hadrian's Wall National Mapping Programme.

Next PerspectivesTM supplied 25cm orthophotography through the Aerial Photography for Great Britain (APGB) agreement as 1sq. km tiles in TIFF format. These covered the entire project area and dated to 2006, 2009 and 2015. This photography was not taken for archaeological survey. It was often taken when the sun was at its zenith resulting in less shadow, and therefore was not very useful for mapping. However, it was useful for control in rectification. Google Earth vertical air photograph mosaics were also routinely consulted.

Oblique digital photography captured for the purpose of structure from motion by Historic England's Aerial Reconnaissance team are discussed below.

Lidar

Composite 2010 lidar data was supplied by the Environment Agency as mosaicked 1sq. km tiles. The data used comprised a digital surface model and a digital terrain model. The terrain model is the data after the removal of trees, walls, vegetation and buildings using algorithms. The lidar data covered 7sq. km and was visualised as 2D raster images using the Relief Visualisation Toolbox.

The data was particularly useful in assessing the extent of earthwork survival under dense tree cover and as a comparative dataset for the SfM outputs.

Full cover lidar did not become available until 2019 and was not used for the mapping. It was however referenced in the discussion regarding the Birdoswald to Bewcastle Roman road, as it highlights distinct Roman activity.

Structure from Motion

Historic England's Aerial Reconnaissance team captured approximately 1,200 digital oblique aerial photographs of the project area, including a significant buffer, in order to process them through the digital photogrammetric method of SfM. This resulted in a digital surface model (DSM) of the project area which was viewed live and rasterised using the Relief Visualisation Toolbox, and an orthophotograph – a mosaic of all of the imagery stitched together and georectified to be incorporated into a GIS for mapping.

These datasets were the primary mapping sources for the project, revealing many features and detail that wasn't visible on historic aerial photography or the lidar, which had a limited resolution.

This was the first time that Historic England undertook SfM on a landscape scale using aerial photography captured by the Aerial Survey team. A detailed discussion and assessment of the procedure and returns are discussed in Appendix 2.

Unmanned Aircraft System Survey

In addition to the DSM and orthophotography SfM output from aerial reconnaissance photography, Historic England's Geospatial Imaging team commissioned Unmanned Aircraft System (UAS) photography for three small areas bordering Birdoswald Roman Fort, covering a total of 0.69sq. km. The photography was captured on 21 February 2017 by Skeye B.V. and was processed by the contractors. The outputs were again an orthophotograph (with a ground resolution of 1.8cm), and a DSM (with a 2cm resolution).

Evaluation

Where possible, air photographs were examined under magnification and stereoscopically. Digital images, where no print was provided, and digital elevation models, were viewed on a computer monitor.

Oblique and vertical photographs were rectified using AERIAL 5.36. Control was derived from either the 25cm resolution APGB orthophotography or the 9cm resolution SfM orthophotography. Digital terrain models derived from 5m interval contour data supplied by Next Perspectives were used to improve the accuracy of the rectification.

The accuracy of rectified images was normally to within ±1m of the source used for control (10cm–15cm for APGB orthophotography), but this error may be larger in areas with large topographic variation, or where aerial photographs had poor control. Consequently, the accuracy of mapped features, relative to their true ground position, will depend

on the source used for mapping. APGB and lidar both have sub-metre accuracy. The orthophotography and DSM, from which most of the mapping was traced, have spatial accuracies of 30cm or less, resulting in most of the mapping having sub-metre accuracy. This is a significant improvement on previous surveys of the area.

In a largely pastoral landscape, historic imagery has illustrated that there was little land-use change over the last half of the 20th century. Factors influencing the visibility of features on historic vertical photographs include the quality of the negative and/or print, scale of the image, cloud cover, time of year, vegetation cover, state of the crop or pasture and angle and direction of the sun. The earliest runs of vertical images, which were mostly taken by the Royal Air Force (RAF), were useful for assessing post-medieval cultivation patterns, some of which have subsequently been levelled through land improvement. Other vertical photography included Meridian Airmaps Limited and runs from the Ordnance Survey dating from 1971 onwards. These were captured largely for surveying and mapping purposes and showed little archaeological detail.

Oblique photography provided the most archaeologically comprehensive cover. Most of the historic oblique photographs were taken for archaeological purposes but not necessarily with mapping in mind, therefore often lacked control for rectification and mapping. Where adequate control was not available, the nearest rectification possible was undertaken, sometimes with substantial errors. In these instances, a note was made in the NRHE record to state that there may be some spatial error in the resulting mapping. All cropmark sites were mapped from oblique photography.

The most commonly used datasets were the outputs from SfM. The source photography for this survey was taken with archaeological monuments in mind, on a sunny day with moderate shadow displaying features with relief with good clarity. Although shadows can impede the SfM process, the survey also resulted in a very good elevation model, which made a useful comparative dataset with the lidar.

Monument datasets

The primary datasets that were routinely consulted were Historic England's National Record of the Historic Environment (NRHE) and the Historic Environment Records (HER) for Cumbria and Northumberland.

The datasets were supplied as spatial data shapefiles which were loaded into the mapping programme to be viewed alongside other sources whilst mapping. They were accompanied by textual monument records with additional detail.

The NRHE database is no longer live, but the monument data can be accessed via the Heritage Gateway (www.heritagegateway.org.uk).

Other Sources

Historic maps were consulted throughout the mapping. These were primarily Ordnance Survey maps ranging from the First Edition, published in 1862, to the modern MasterMap.

These were particularly useful for identifying more recent land-use that is now evident as earthworks and cropmarks, such as relict medieval and post-medieval field boundaries. Earlier maps were also consulted, in particular the 1603 survey of the manors of Gilsland and Denton, held by Cumbria Archives in Carlisle (DHN/C/713/12).

The Hadrian's Wall National Mapping Programme project (NMP) mapping data (*see* Fig. 5) was viewed and routinely consulted during the mapping phase. As the current project used many of the same sources as the NMP, the attribute data to the latter was particularly useful as it listed the original source photography from which a feature was mapped, allowing for a comparison of the original source with the new photography.

The National Soil Resources Institute soilscapes and British Geological Society bedrock and superficial data were consulted, primarily to aid the understanding of the natural landscape, as well as for the identification of extraction types (https://www.bgs.ac.uk).

The Hadrian's Wall Project, a measured survey undertaken by the Royal Commission on the Historic Monuments of England between 1988 and 1993, was available as digital files. These were georeferenced for import into the mapping software as a comparative dataset.

2D raster images of the 1:2,500 analytical earthwork survey of Hadrian's Wall undertaken by the Royal Commission on the Historic Monuments of England between 1988 and 1993 were georeferenced in ArcMap 10.3.1 for import into AutoCAD.

Geophysical surveys, carried out by Alan Biggins and David Taylor in 1999 and ArchaeoPhysica Ltd in 2009, also proved particularly useful in aiding interpretation of some of the more subtle features within and around Birdoswald Roman Fort.

The published record for Birdoswald and the adjacent sections of the Hadrian's Wall is particularly comprehensive, providing an invaluable resource to aid the interpretation and recording of mapped Roman features.

Recent correspondence with Tony Wilmott, who has been conducting excavations at Birdoswald in subsequent years following the sector survey, part of which the author was involved with, has also been a useful resource for renewed interpretations of features in the landscape.

Aerial mapping methodology

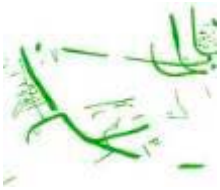
Mapping

Mapping took place in AutoCAD Map 3D 2015. Rectified and georeferenced imagery (APGB orthophotography, lidar, SfM orthophotographs and DSMs) were loaded into AutoCAD. Spatial and supporting datasets were also imported as background data.

Most archaeological features were mapped as closed polygons. Features such as scarps or large platforms were mapped using a schematic T-hachure convention. Ridge and furrow and land improvement ploughing was mapped as single lines denoting individual furrows.

Digital elevation data was also viewed live in 3D format using Quick Terrain Reader.

Table 2: AutoCAD map layer content and drawing conventions, based on NMP standards.

Layer Name	Layer content	Layer colour	Thumbnail
BANK	Closed polygons for features such as banks, platforms, mounds and spoil heaps	1 (red)	
DITCH	Closed polygons for cut features such as ditches, ponds, pits or hollow ways	3 (green)	
EXTENT_OF_FEATURE	Closed polygons outlining a feature or group of features such as an industrial complex	30 (orange)	
RIG_AND_FURROW_ ALIGNMENT	Polyline showing the direction and form of plough furrows in areas of ridge and furrow	4 (cyan)	
STRUCTURE	Closed polygon for built features including stone, concrete, metal and timber constructions	190 (purple)	
THACHURE	Polyline t-hachure convention to schematise sloped features indicating the top of slope and direction of slope	5 (blue)	

An attribute data table was attached to each individual vector feature depicted. This included data outlining the unique identifying numbers (UID), the date and interpretation of a feature, the imagery from which it was mapped, and its latest condition.

Table 3: The attribute data for all mapped features includes the following information.

Attribute	Description	Sample data
AMIE_UID	NRHE Unique Identifier (UID)	13993
LIST_ENTRY	UDS Identifier	1010994
HER_NO	HER concordance unique identifier	343
PERIOD	Date of feature (HE Thesaurus). Single or dual indexed terms	ROMAN
BROADTYPE	Monument Type (EH Thesaurus). Broader monument type to enable grouping of individual features	FORT
NARROWTYPE	Monument Type (EH Thesaurus). Specific monument type for individual features	PRINCIPIA
EVIDENCE_1	Form of remains (EH Thesaurus) as seen on PHOTO_1	EARTHWORK
PHOTO_1	Source feature was mapped from (air photograph or DEM)	CAP 8291/57 15-JUL-1955
EVIDENCE_2	Form of remains (EH Thesaurus) as seen on PHOTO_2	LEVELLED EARTHWORK
PHOTO_2	Latest available source (air photograph or DEM) to give indication of current state of preservation. Not applicable for cropmark or soilmark sites	HE SfM DEM 05-JAN-2017
LAYER*	NMP drawing layer in AutoCAD Map	BANK

* The LAYER attribute is added as an export routine only to allow the end-user to symbolise the data by form.

Recording

Existing records in the NRHE were updated to reflect the results of this project. This rarely, but sometimes resulted in a complete reinterpretation of a site, or even an update through new evidence to say a feature was no longer deemed archaeological. New records were also created in the NRHE database to Historic England data standards.

When possible, NRHE records were concorded with the associated HER record in both the mapping attribute data and the NRHE record. The NRHE records are available via the Heritage Gateway (www.heritagegateway.org.uk).

Analytical field survey

The aerial mapping flagged a total of 45 sites and areas as targets for rapid-walkover-survey assessment. Most of these were chosen because of the difficulties in interpreting them satisfactorily from aerial sources alone. In the end, only 35 of the sites were visited in the field, the remainder being inaccessible. These were down to access issues, such as fields containing calving cows or because the landowner could not be contacted.

Figure 80: Rapid walkover survey taking place at Throp Roman Fortlet. June 2017 © Historic England.

It is not the intention of this report to detail findings from the walkover survey, but where they were considered significant enough to impact the interpretation of a features, this has been incorporated in the text.

As with the aerial mapping stage, the field survey results have also been incorporated within existing NRHE records, with updates and interpretations added as required.

Data archive and dissemination

Copies of the AutoCAD drawing file are deposited with the Historic England Archive in Swindon (MD003268) and also retained by the Aerial Survey team (previously Historic Places Investigation North team, during the lifetime of the project). The spatial mapping will become available to the public via the Aerial Archaeology Mapping Explorer (https://historicengland.org.uk/research/results/aerial-archaeology-mapping-explorer).

Data will be shared with project stakeholders: the English Heritage Trust and Cumbria and Northumberland HERs, for incorporation into their respective Geographic Information Systems (GIS).

NRHE records created and amended by the project are available to professionals and the general public via the Heritage Gateway (www.heritagegateway.org.uk).

The project is recorded through OASIS, the online system for reporting archaeological investigations, as nmr1-521075.

Appendix 2: Technical Review

The primary drive behind the project was the creation of a 3D model for the English Heritage Trust. Prior to this project, the only existing digital elevation models suitable for archaeological survey was partial lidar with a resolution of 1m. As a result, Historic England's aerial reconnaissance unit undertook a reconnaissance flight, capturing nearly 1,200 new oblique aerial photographs. These were processed using modern photogrammetry software employing SfM to produce a digital surface model (DSM) and orthophotograph of the project area.

The following is an assessment of the use of SfM photogrammetry for archaeological survey on a landscape scale. The results are based entirely on the flight and processing undertaken in 2017 and not on current processes.

Structure from motion

This was the first opportunity for Historic England to use SfM on a landscape-scale and using only oblique photography as there was no in-house capability for vertical imagery at the time of survey. The area flown measured 16.8sq. km, allowing a broad boundary around the project area.

The best practice for capturing photography for photogrammetric purposes and the use of SfM photogrammetry has since been published by Historic England (2017). For the purposes of this project, the author of that guidance, Jon Bedford, provided training in the use of the photogrammetric software.

Source data

The aircraft was flown (flight number S3172, on 5 January 2017 for 40 minutes minus flight time to and from the survey area) at an altitude of approximately 690m-800m (with height above ground level being approximately 600m), along ten overlapping parallel runs aligned roughly west-south-west to east-north-east (Fig. 81). The Roman sites of Birdoswald, Crooks and Throp were circled for additional detail. The overlapping digital photography was manually taken at intervals using a Nikon D810 camera with a 24-70mm f/2.8 lens. The images were initially captured in Nikon Electronic Format (.NEF) and then converted to .TIF at 300dpi for processing in Agisoft PhotoScan (now Metashape). The ground sampling distance averaged at approximately 9cm (i.e. each pixel on the source photography represented 9cm on the ground). Location data was only captured for a small number of the images – a technical issue meant it failed to be recorded for most of the flight.

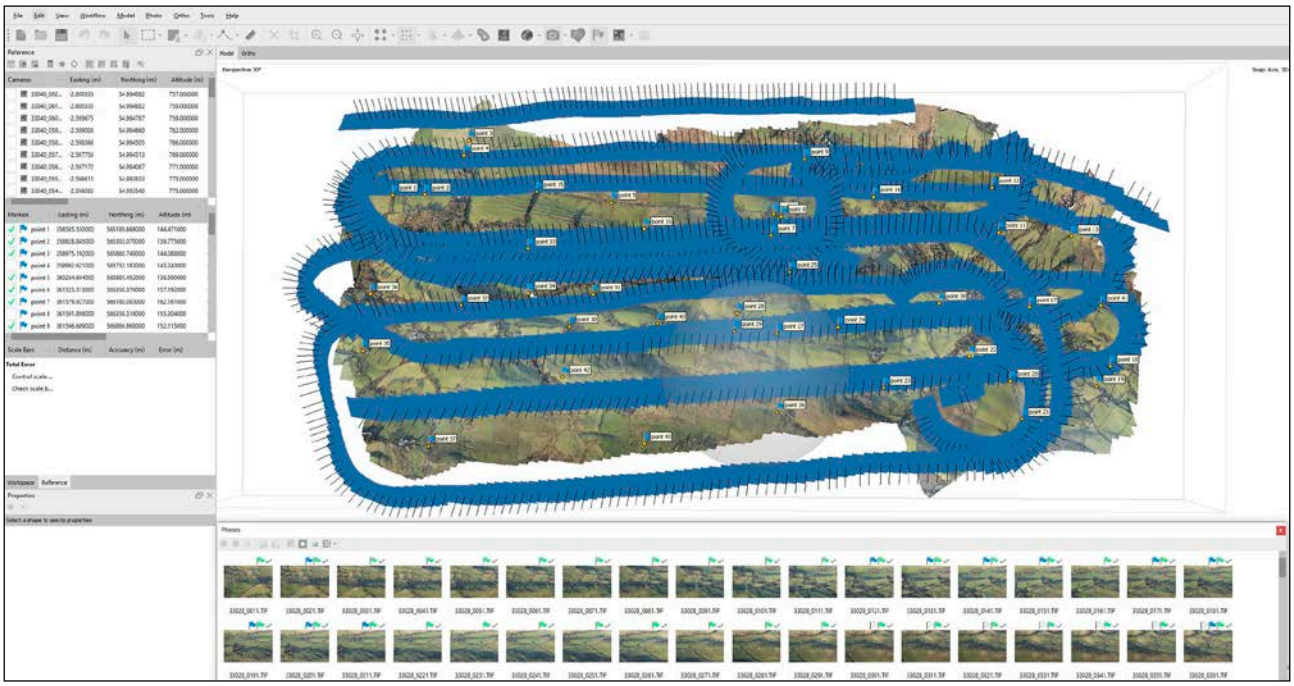


Figure 81: This extract from the SfM processing software illustrates the course of the aircraft. Each blue square denotes a photograph and the appended line shows the direction of the photography.

Control

In order to increase the accuracy of the processing, 43 control points were established across the project area (though not all were used in the processing). These consisted of hard standing points of detail in the landscape that were visible on the aerial photographs and could be surveyed on the ground. The control points were acquired using a Trimble R10 Global Navigation Satellite System (GNSS) recording OS National Grid coordinates.

Photogrammetry

SfM is part of the digital photogrammetric process. It produces 3D models from 2D images. The processing software was Agisoft PhotoScan 1.2.4 (this has since been updated to Metashape). As this was a new process to the Aerial Survey team, the processing was undertaken with the guidance of Jon Bedford of Historic England's Geospatial Survey Team.

The resulting outputs were a digital surface model (DSM) with a resolution of 18cm and an orthophotograph with a 9cm resolution (Fig. 82). The resolution is the area represented on the ground by each pixel of the raster output.

The overall accuracy of the model varies throughout the data. The error between surveyed control points and the triangulated positions of those point on the model after processing, was around 30cm. The pixel error, which shows the error for reprojected tie points between each photograph was in places as high as 1.7. This latter figure is quite high and is almost certainly the result of using oblique photography to create the model, where varying focus

and depth of field can affect the quality of the alignment between photographs. However, where any feature was mapped from the SfM outputs, the source was also compared with the APGB imagery and lidar, if available, to compare accuracy of the position.

Figure 82: The digital surface model of the project area overlaid with the orthophotograph. Both were derived from the structure from motion of Historic England aerial reconnaissance photography. 05-JAN-2017 © Historic England.

The DSM was visualised using Relief Visualization Toolbox version 1.3 (Kokalj and Somrak 2019; Zakšek et. al. 2011) to produce 2D GeoTIFF images using 16-direction hillshade, Local Relief Model, Slope and Positive Openness images for import to AutoCAD. In addition, the surface model was also viewed and manipulated live through Quick Terrain Modeler 8.

The outputs from the SfM process were the primary mapping resources for the project. The DSM showed significant additional detail of low relief archaeology that had not been recorded before, and the orthophotograph, with low light and strong shadows, was ideal for picking up some areas of much finer detail that the SfM process struggled with. A variety of visualisation methods (all using the Relief Visualisation Toolbox) allowed the maximum visible return from the dataset. The most subtle cut features, such as plough furrows, were best defined on Simple Local Relief models, whereas the embanked features were best visualised using multiple-direction hillshade outputs (16 direction as a standard).

The quality of the model varies. The best definition is in the north half of the project area, along the line of the Wall, where the flight paths were closer, allowing more overlap between the images. In the south of the project area, the photograph runs were more

spaced, which resulted in less definition within the elevation model. Where specific sites were circled by the aircraft, this allowed photography from all angles resulting in the best definition of the model. This included the forts at Birdoswald and Throp, and Crooks Camp. The resolution of the model allowed mapping of fine earthwork and structural detail that was not available on aerial photography or lidar (which was restricted to 1m resolution and only part of the project area). This includes detail of the Wall-line and the subtle earthworks of the Turf Wall, Vallum, Wall ditch and glacis. The model also allowed detailed mapping of the temporary camps at Lanerton and Crooks. The definition of the earthworks diminishes towards the peripheral edges of the model, mostly due to a lack of aerial photograph coverage from multiple directions around these areas.

Another reason for the lack of clarity in parts of the model is that the photography was taken partly with the orthophotograph in mind, to allow for an aesthetic photo overlay on to the 3D model. As a result, the flight was undertaken on a cloudless day in winter, where shadow highlights the landscape and archaeological features best. Although these conditions are optimal for showing the archaeology on photographs, the shadow is detrimental to SfM as the alignment process struggles to match tie points between photographs. However, a comparison between the various sources suggests that little detail was lost.

Mapping from multiple sources

UAS survey was conducted as a trial for comparison data. At the time of the project, this was externally commissioned, unlike now where we undertake UAS surveys regularly in-house. The UAS survey only covered 0.69sq. km of the project area, to the north, west and east of Birdoswald fort. It was the most detailed data captured, with a resolution of 2cm. At the time of survey, the Relief Visualisation Toolbox was unable to render such high resolutions, so the data was decimated to 11cm in order to create 2D raster images for mapping. Subsequent experience of UAS data has since demonstrated that the noise of vegetation at such high resolutions (2cm) is detrimental to the interpretation of archaeological features anyway, so the data is always decimated to a lower resolution.

The resulting dataset and the high resolution orthophotograph were useful for seeing very high levels of detail, but the data was limited to only 3.8% of the project area. Logistically, it would not have been practical to fly the entire project area with UAS. This would have proven time consuming and expensive, whereas the aerial reconnaissance photography took place in one flight over a period of 40 minutes.

SfM using aerial photographs will create surface models. Although it is possible to strip out landscape features of a certain height in order to create a hybrid terrain model, it is not possible to use them to view archaeology hidden beneath dense vegetation. Lidar can sometimes allow us to do this. Since the completion of the project, lidar data for the entire project area has become available, but at the time of the survey the data was incomplete. Environment Agency lidar is limited to 1m resolution, which is only suitable for mapping larger earthwork features and not fine archaeological detail. However, the data was still

useful for picking up detail where the SfM model had failed, or beneath tree canopy, such as the line of the original Gilsland to Chapelburn road. The data was also complementary to the SfM dataset, providing a secondary source for subtle features, such as the camp above Lanerton and the road to the south-west of Birdoswald.

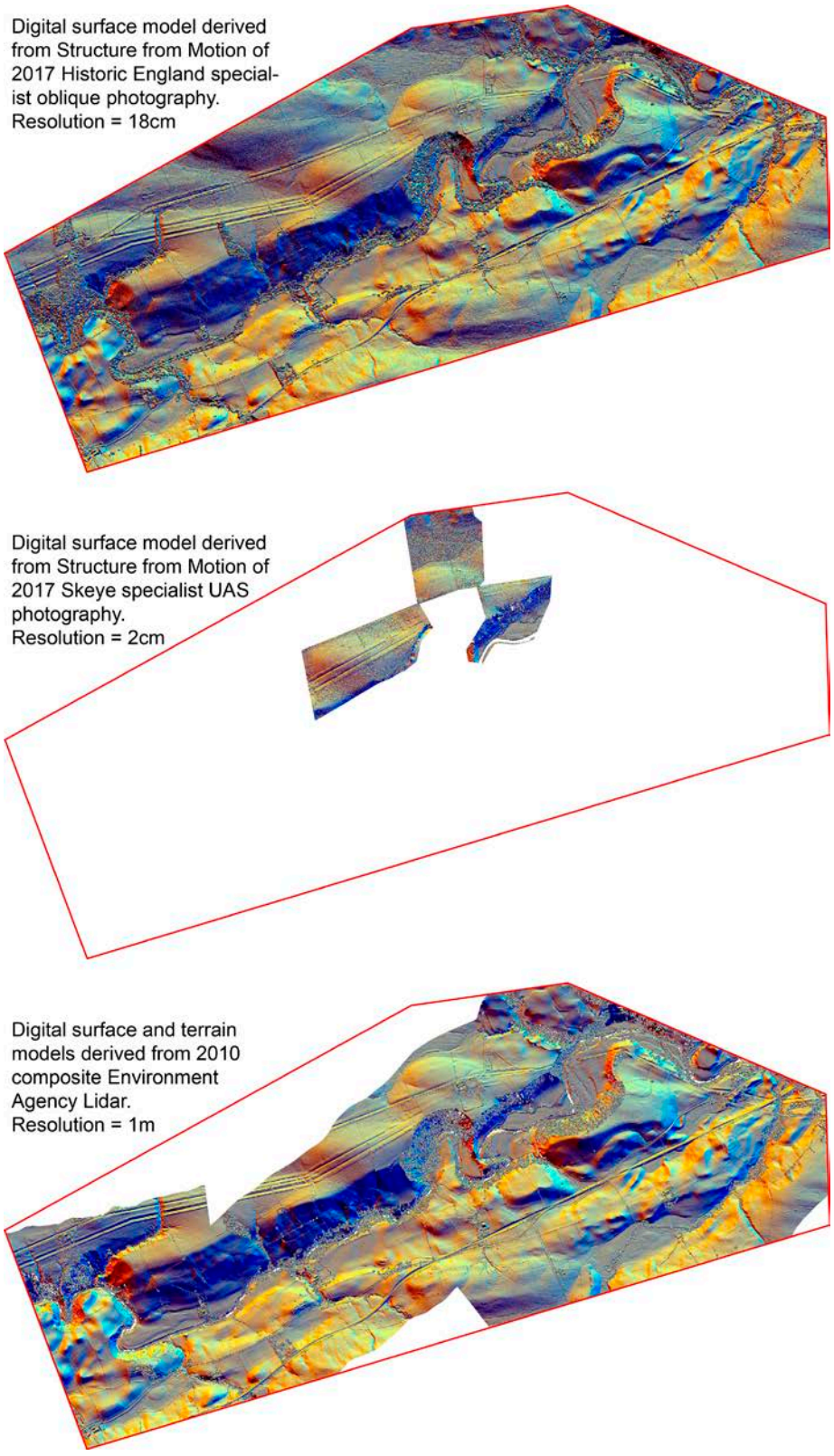


Figure 83: Digital elevation model cover for the project area. The structure from motion datasets are both surface models. The lidar was viewed as both surface and terrain models. Historic England SfM DSM 05-JAN-2017 © Historic England; Skeye UAS SfM DSM 21-FEB-2017 © English Heritage Trust/ Historic England; LIDAR DTM 21-APR-2010 © Historic England. Source Environment Agency.

The three digital elevation models provided complimentary datasets (Fig. 83). Each one has its own distinct advantages, and it was noted whilst mapping that archaeological features that showed on one source would not necessarily be visible on the others. The UAS survey was the most detailed but limited to such a small area close to the fort where there was already such extensive photography and imagery, that the data provided no significant additional detail.

The process of using aerial reconnaissance oblique photography to create photogrammetric models of a broad landscape proved to be a great success. There were limitations with the outputs, such as the level of accuracy that can be achieved and the loss of archaeological features in some areas where the process has had less success, but as an additional resource, the data proved extremely valuable for understanding the archaeological landscape.

Despite the advantages of using elevation models in an upland landscape where archaeological features as earthworks and structures are predominant, none of these can be reasonably interpreted without the use of aerial photography as a supporting source. The broad range of photography available for the Birdoswald sector ranges from large quantities of historic vertical imagery taken for non-archaeological purposes, to site-specific oblique imagery usually targeting archaeological sites. In this instance however, the orthophotograph provided the most useful accompanying photography, primarily because the SfM digital surface model was derived from the same source photography, and also because it provided the most recent imagery for assessing current land-use and condition of a site.

Birdoswald and the line of Hadrian's Wall have been captured many times on oblique photography with many of the images providing an illustrative and aesthetic view of the World Heritage Site. However, where oblique photographs exist of earthwork sites, the DSMs and orthophotographs usually provided better coverage and definition for mapping. There were some instances, however, where the detail provided on the photography added more information. The main benefit of using oblique photography was for the mapping of archaeological features visible as cropmarks. These were entirely confined to the sand and gravel deposits west of Chapelburn, where the buried remains of Nether Denton Roman fort and extra-mural settlement are visible.

Broad coverage vertical photography for England dates back to the end of the Second World War, providing a unique view of the landscape at that time. In many parts of the country, this landscape will have undergone significant change, and many of the features visible as standing earthworks or structures on the photographs will have subsequently been levelled, demolished or destroyed. Remote upland landscapes, however, often remain relatively static, seeing little change over the years. This is true of the landscape around Birdoswald, where the current pattern of field system, roads and settlement, is almost identical to that mapped on the first edition Ordnance Survey map of 1868. As a result, it was found that historical vertical aerial photographs were largely only used to map features on the peripheral edge of the project area where there was a lack of clarity on the SfM sources. Features mapped from these photographs include post-medieval ridge and furrow, field boundaries and small areas of extraction.

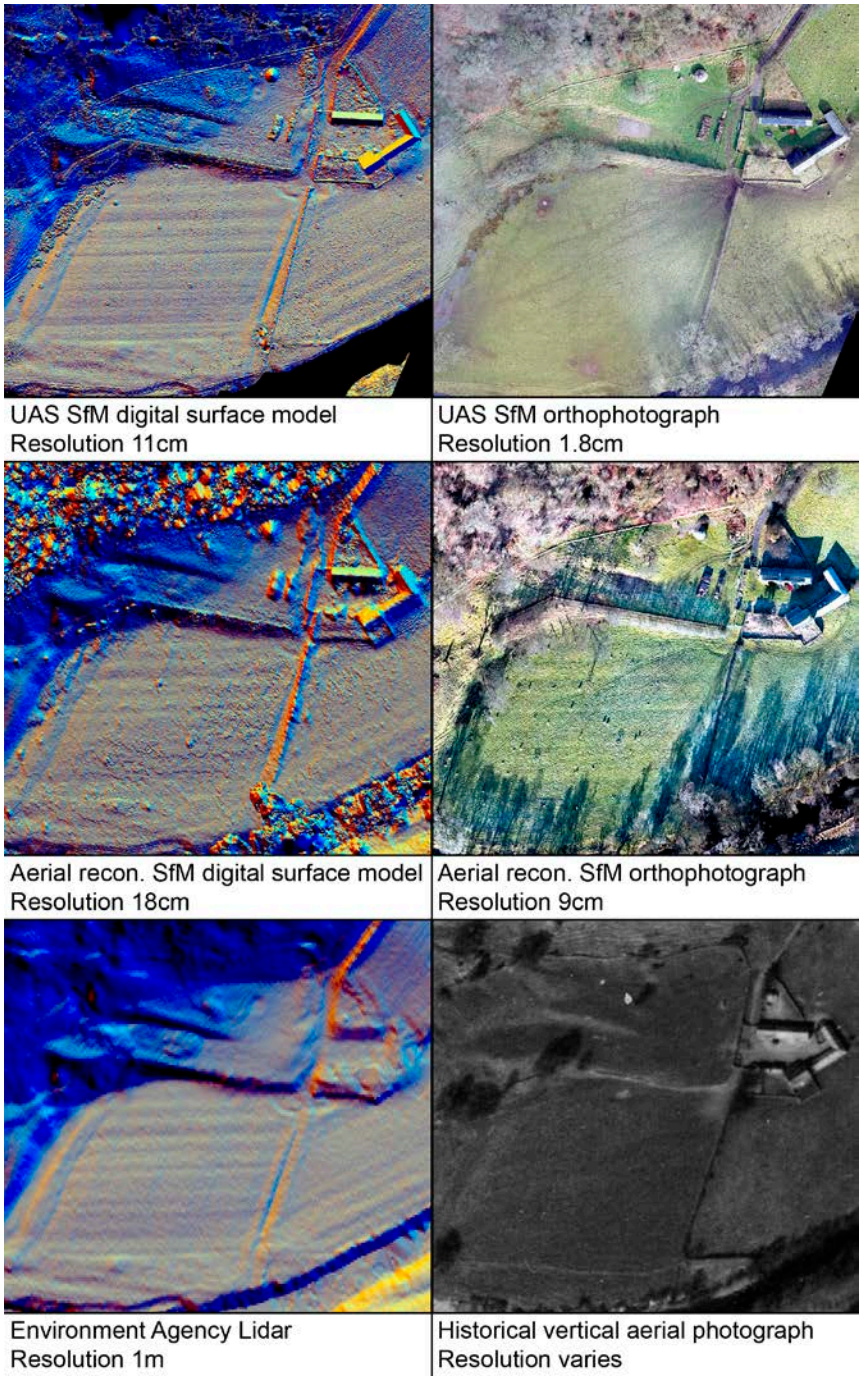


Figure 84: Each source type used for mapping had its own advantages. The resolution of the digital elevation models affected the detail of earthworks visible, and the quality of the photography varied depending on the source. Skeye UAS SfM DSM and orthophotograph 21-FEB-2017 © English Heritage Trust/ Historic England; Historic England SfM DSM and orthophotograph 05-JAN-2017 © Historic England; LIDAR DTM 21-APR-2010 © Historic England. Source Environment Agency; RAF/106G/UK/1392 RP 3175 10-APR-1946 Historic England Archive RAF Photography.

Lessons learned and further use

As has been established above, each source complimented one-another. A complete survey of the project area could not have been accurately undertaken using any one single dataset. There will never be a perfect solution for any project as there will always be unanticipated variables that mean that some sources aren't available, or technological mishaps that affect the quality of the data. However, the results of this project resonate even now at the time of publication six years later.

It was originally perceived that an ideal scenario would be the availability of high resolution lidar, 25cm or above. Past experience has however illustrated that this data will only be available through commissioning flights, which are expensive. The Environment Agency has recently completed national coverage of the country, but this remains at 1m resolution which limits its usefulness. Even a UAS-mounted lidar sensor will not address the survey of large landscapes – at least not in a time-effective manner. Additionally, ongoing studies suggest that the quality of the outputs derived from the SfM of aerial photography equals, if not exceeds, that of lidar. All the more so, when one of the primary outputs of SfM is an orthophotograph, which has been demonstrated at Birdoswald to be a primary mapping source. Therefore, if Historic England has the in-house capability of capturing hundreds of aerial photographs to process through SfM in a costly manner, then this is clearly that a process that should be developed.

One of the biggest logistical issues with using SfM at the time of the survey in 2017, was the capability of the hardware to cope with the enormous file sizes and processing power. With nearly 1,200 photographs, each 106MB in size, the processing took over eight days to complete on the most advanced PC the team had. This doesn't include having to restart the process due to an external power failure (since compensated for with a backup power unit in case of power outages). The file sizes of the outputs were particularly large, even when tiled into smaller areas, which proved difficult to use in the mapping software at the time.

The commissioned UAS data files were even larger. The digital surface models were too high-a resolution to be visualised in the Relief Visualisation Toolbox, so had to be reduced from 2cm to 11cm. The orthophotographs was also too large to be handled efficiently by the mapping packages, so were split into 0.5sq. km tiles.

Since the completion of the project, both the hardware and processing software have been updated, as have the storage methods and mapping programmes; all of which lend to a much faster and more efficient process.

The variance in the quality of the SfM outputs from aerial reconnaissance photography is down to a number of factors, all of which should be taken into consideration when taking this process forward. The primary issue is with the photography being oblique. Although capturing oblique photographs is a useful technique to create enhanced models from UAS, the main issue with doing this from photography captured manually from several hundred metres in the air is the variable depth of field. This can increase and decrease hugely, even with the slightest movement of the camera or aircraft. Another influencing factor is the amount of overlap between the runs of photography. For the Birdoswald flight, the northern half of the project area, along the line of the Wall, was covered by seven runs of photographs. The southern half was only covered by four, of which only one was south-facing and quite oblique. This matches the results from the outputs, where there is less clarity on the surface model in the southern half of the project area. Other factors that affect the quality of the imagery, include the camera and lens used, the altitude of the aircraft, the degree of shadow and also the quality of the natural light.

There must be a compromise between capturing the best quality photography the amount of photograph whilst maximising time in the air. This does not necessarily mean capturing more images, which can increase the processing time for little gain, but getting the maximum returns from the best overlap. In an ideal scenario (which has since been adopted by both aircraft), the camera would be mounted in a vertical position, either in the base of the aircraft or on the wing, and be remotely operated to capture images at set intervals (depending on height and speed) to allow an even frontal and side overlap throughout a survey. In addition, sites of specific interest can be circled and photographed obliquely as was performed at Birdoswald, Throp and Crooks.

For a project such as this, it might be beneficial to photograph the area on two separate days. Once on a cloudless day with low light in the winter in order to highlight earthwork features on the resulting orthophotograph. Then again on a day when there is thin, even, high cloud with no shadow, which will create a better elevation model. Of course, this is not always practical, nor efficient. In these instances, when photographing large landscapes where the orthophotograph will form an important mapping source, a sunny day is better than none, as it will still be possible to create an elevation model. However, on a cloudy day, the orthophotograph will be not so useful for mapping earthworks.

The physical landscape must also be considered when considering the use of SfM to process aerial photography. Topography can affect the movement of the aircraft. This can be through mechanical turbulence which physically moves the aircraft, or the need for the pilot to change altitude to maintain an approximate ground sampling distance on the photography. The direction the aircraft takes in relation to the terrain will also affect the imagery. For example, at Birdoswald, the aircraft flew following the natural contours and the Irthing Valley, which allowed roughly equal depth of focus for each neighbouring image.

To summarise, digital terrain models work best in environments where there is likely to be good earthwork survival and where the vegetation is less impeding, i.e. on pastoral and moorland landscapes mostly. Heavily farmed arable landscapes should not be wholly dismissed either, as has recently been proven with the discovery of earthwork medieval field systems in south-west Cambridgeshire (Knight et al. 2018) and the subtle earthwork survival of long barrows in Lincolnshire (Drury and Allen 2020). It is crucial to remember however, that this process cannot be used effectively to see through dense vegetation, unlike lidar. A decision tree could be applied to the use of this process, similar to that available for lidar (Historic England 2018b).

Impact

This was the first occasion that Historic England used aerial reconnaissance photography to capture a broad landscape for the purposes of photogrammetry. The positive results achieved, and methods employed, laid foundations for the development of this technique. Since the completion of this project in 2017, there have been multiple developments using the same technology. The two light aircraft employed by Historic England have both undergone modifications to take cameras in vertical setup. This, combined with

technological advances with some of the accompanying equipment, has improved the quality of the raw data captured considerably. The vertical technique has been successfully employed over landscapes larger areas than Birdoswald.

Digital photogrammetry software remains moderately cheap and accessible to the organisation and is easy to use by non-photogrammetric experts, with training. Recent procurements of several UAS have also widened the ability of the organisation to photograph and monitor sites, including the addition of a lidar sensor for wooded sites. Additionally, updates in hardware mean a much faster processing time for large datasets, and suitable storage.

To conclude, the use of SfM from aerial photographs has now become a standard within the organisation, whether captured from manned aircraft or UAS, and continual developments will only see the progression of this process as a remarkable tool.

Historic England

Historic England's Research Reports

We are the public body that helps people care for, enjoy and celebrate England's historic environment.

We carry out and fund applied research to support the protection and management of the historic environment. Our research programme is wide-ranging and both national and local in scope, with projects that highlight new discoveries and provide greater understanding, appreciation and enjoyment of our historic places.

More information on our research strategy and agenda is available at HistoricEngland.org.uk/research/agenda.

The Research Report Series replaces the former Centre for Archaeology Reports Series, the Archaeological Investigation Report Series, the Architectural Investigation Report Series, and the Research Department Report Series.

All reports are available at HistoricEngland.org.uk/research/results/reports. There are over 7,000 reports going back over 50 years. You can find out more about the scope of the Series here: HistoricEngland.org.uk/research/results/about-the-research-reports-database

Keep in touch with our research through our digital magazine Historic England Research HistoricEngland.org.uk/whats-new/research

ISSN 2398-3841 (Print)
ISSN 2059-4453 (Online)