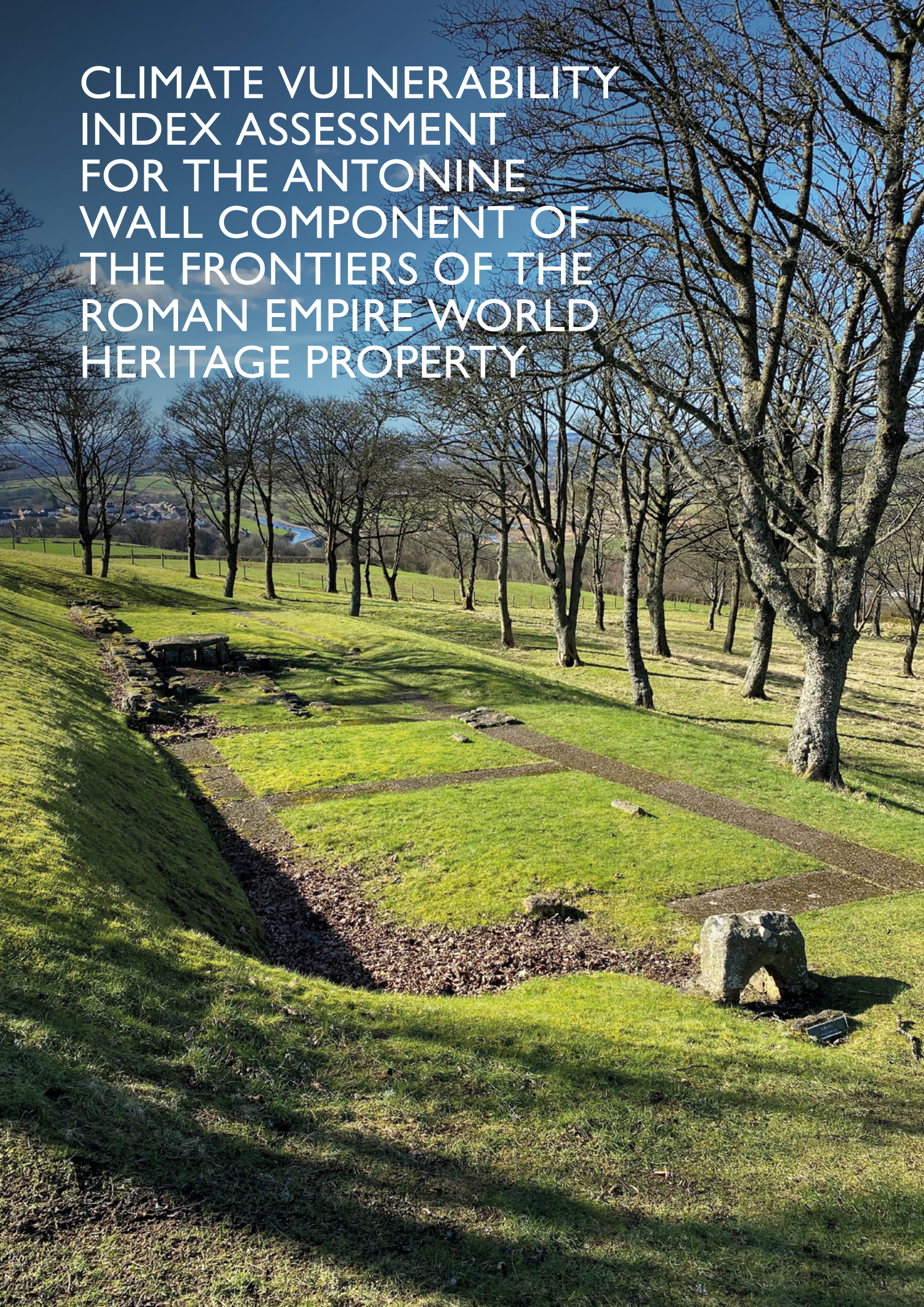
CLIMATE VULNERABILITY INDEX ASSESSMENT FOR THE ANTONINE WALL COMPONENT OF THE FRONTIERS OF THE ROMAN EMPIRE WORLD HERITAGE PROPERTY



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Cover General view of Bar Hill bath house with hot room (caldarium).

EXECUTIVE SUMMARY

Entrance to Auld Kirk Museum, Kirkintilloch

We are living through a global climate emergency. The impact of climate change is the biggest threat to World Heritage (WH), and we are already witnessing degradation and damage to sites across the world. There is irrefutable evidence that these observed trends are expected to continue and accelerate as climate change intensifies. WH properties will remain vulnerable to the impacts of climate change such as rising temperatures, sea level rise, extreme precipitation, coastal erosion, drought, and worsening wildfires. Understanding the impact of climate change has become critical in identifying possible solutions and helping to monitor impact and manage future outcomes.

This report describes the outcomes from an online workshop in February 2022 to apply the Climate Vulnerability Index (CVI) to the Antonine Wall, one of three component parts of the transboundary Frontiers of the Roman Empire (FRE) World Heritage property. The CVI is an established values-based, science-driven, and community-focused methodology designed to rapidly assess climate impacts – both to Outstanding Universal Value (OUV) and the associated 'community' (local, domestic, and international) – for all types of WH properties (natural, cultural, or mixed).

Historic Environment Scotland will integrate the findings from the CVI workshop into the forthcoming revision of the Antonine Wall Management Plan; the impact of climate change on the monument will continue to form part of the future monitoring and management of the property.

There is also potential scope to employ the CVI methodology across the remaining components of the FRE WH property (Hadrian's Wall and the Upper German-Raetian *Limes*), as well as in the two newer FRE WH properties (inscribed in 2021) – the Lower German *Limes* and the Danube *Limes* (Western Segment) – and potential future partners. The results of the Antonine Wall CVI workshop were presented to international colleagues as a poster at the 25th International Congress of Roman Frontier Studies in Nijmegen, Netherlands in August 2022.

The Antonine Wall is the third WH property in Scotland to undertake this assessment and the first globally for a component part of a transboundary property. The Antonine Wall is the most northerly Frontier of the Roman Empire and the most complex frontier constructed by the Roman Army. It ran for about 40 Roman miles (around 60 km) across central Scotland. Constructed of a turf rampart on a stone base fronted by a wide and deep ditch, it had forts and fortlets along its length which housed soldiers stationed at the frontier. Many of the remains are no longer visible above ground, but the ditch and, in places, the bank, remain extant as features cutting across the central Scottish landscape.

The CVI workshop for the FRE: the Antonine Wall

- involved experts, site managers from across the FRE, academics, responsible management agencies, and other stakeholders (around 38 attendees)
- identified the three key climate stressors that present the greatest threat: Precipitation Change; Temperature Change; and Intense Precipitation events over a time scale to c. 2050
- determined that the OUV Vulnerability is in the highest category (High), indicating the potential for major loss or substantial alteration of most of the values that comprise the OUV
- assessed the Community Vulnerability to be in the middle category (Moderate).

Unlike other Scottish World Heritage properties, the Antonine Wall is not yet a major visitor destination or a major contributor to the local economy. Recent initiatives such as the 'Rediscovering the Antonine Wall' project have demonstrated the potential of the property to support community regeneration through placemaking and tourism initiatives.

INTRODUCTION

A visitor at Rough Castle on the Antonine Wall

1.1 Background to this report

This report outlines the results of applying the Climate Vulnerability Index (CVI) to assess the Antonine Wall, part of the Frontiers of the Roman Empire (FRE) World Heritage (WH) property*, one of six World Heritage properties in Scotland.

"...climate change has become one of the most significant and fastest growing threats to people and their heritage worldwide..."
ICOMOS 2017[1]

Climate change is the fastest growing global threat to WH properties[1,2], many of which – natural, cultural, and mixed – are already being impacted. The Intergovernmental Panel on Climate Change (IPCC) has predicted with 'high confidence' that *"Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate"*[3]. The IPCC has therefore stated that *"Climate-related risks for natural and human systems (will)... depend on the magnitude and rate of warming, geographic location, levels of development and vulnerability, and on the choices and implementation of adaptation and mitigation options"*[3].

This was the first time the CVI had been applied to a component part of a transboundary WH property (other component parts of the FRE being Hadrian's Wall in England and the Upper German-Raetian *Limes* in Germany), although a successful application of the CVI methodology for Outstanding Universal Value vulnerability was made to the transboundary natural Wadden Sea WH property in 2020[4]. Historic Environment Scotland (HES) was keen to apply the CVI process following the success of similar CVI workshops for two other Scottish WH properties: the Heart of Neolithic Orkney (2019)[5], and the Old and New Towns of Edinburgh (2021)[6]. The CVI co-developers, Dr Scott Heron and Dr Jon Day from James Cook University, Australia, were therefore engaged to apply the full CVI framework to the Antonine Wall, following a successful bid to the Royal Society of Edinburgh for Research Network funding.

The CVI process is best undertaken through a workshop of diverse stakeholders (including site managers, researchers, community representatives, dependent business owners, management agency representatives, and other stakeholders). Due to the pandemic and time zone differences between Australia and Scotland, a virtual workshop over six mornings was undertaken with around 38 attendees from different sectors engaged in the process.

1.2 Overview of the Climate Vulnerability Index (CVI)

The Climate Vulnerability Index (CVI) is a systematic and rapid assessment tool that is values-based, science-driven, and community-focused. It was initially developed to assess the impacts of climate change upon all types of WH areas, considering the Outstanding Universal Value (OUV) and the associated 'community' (local, domestic, and international).

The CVI methodology is based on a risk assessment approach and builds upon the vulnerability framework described by the Intergovernmental Panel on Climate Change (IPCC)[3]. The CVI process works sequentially through the steps outlined in Chapter 5, enabling a systematic evaluation of the threats of climate change. Unlike the IPCC approach, the CVI comprises two distinct primary outcomes (see Tables 5.3 and 5.4), assessing:

+ **OUV Vulnerability,** evaluating potential impacts to the values and attributes for which the property has been internationally recognised; and
+ **Community Vulnerability,** assessing the level of economic, social, and cultural dependence that associated communities (local, national, and international) have on the WH property (collectively referred to as 'ESC dependencies') and their adaptive capacity to cope with climate change.

* In this report we use the international convention of referring to World Heritage 'properties' whilst acknowledging local usage of 'sites'

Both of these assessments of vulnerability are highly relevant for key stakeholders, including site managers, responsible management agencies, businesses that are dependent on the property, and the local communities that live around the property. The Community Vulnerability component of the CVI is an integral and fundamental component and is one key aspect that distinguishes the CVI from other risk assessment approaches. Through its application, the CVI enables managers and stakeholders to consider, in conjunction with the community, what may be appropriate adaptive capacities for the management of their natural, cultural, and community assets.

While the CVI was initially developed in Australia, input and guidance for the CVI has subsequently come from many experts around the world. This includes the International Council on Monuments and Sites (ICOMOS) and the International Union for Conservation of Nature (IUCN), two of the advisory bodies for the WH Committee.

1.3 Why was the Antonine Wall chosen for the CVI?

Following the successful trial of the CVI on the Heart of Neolithic Orkney (HONO) World Heritage property in 2019[5], HES stated its intention to hold CVI workshops for all six WH properties in Scotland and build the results into future management planning.

HES, together with James Cook University, submitted an application to the Royal Society of Edinburgh's Arts and Humanities Research Networks fund in autumn 2020. This application was successful with the grant award running from 2021-23. The network is intended to both aid the refinement of the CVI methodology as well as provide a platform to build capacity and train those involved in managing Scotland's WH properties as well as support their global partner networks. Two workshops were planned in Scotland in 2021-2 – the Old and New Towns of Edinburgh (ONTE), and the FRE: the Antonine Wall. Together, these two sites represent different challenges in terms of understanding and managing the threats of climate change, as well as representing very different characteristics of heritage (e.g. from different time periods, different local and international partners).

The workshop for ONTE took place as a virtual workshop in May – June 2021. Following the success of this virtual format, the workshop for the Antonine Wall took place over six mornings in February 2022. It was selected as the third site in Scotland to undertake the CVI assessment in order to tie into the management planning cycle for the Wall plus take advantage of the increased interest in the Wall as a result of the 'Rediscovering the Antonine Wall' project.

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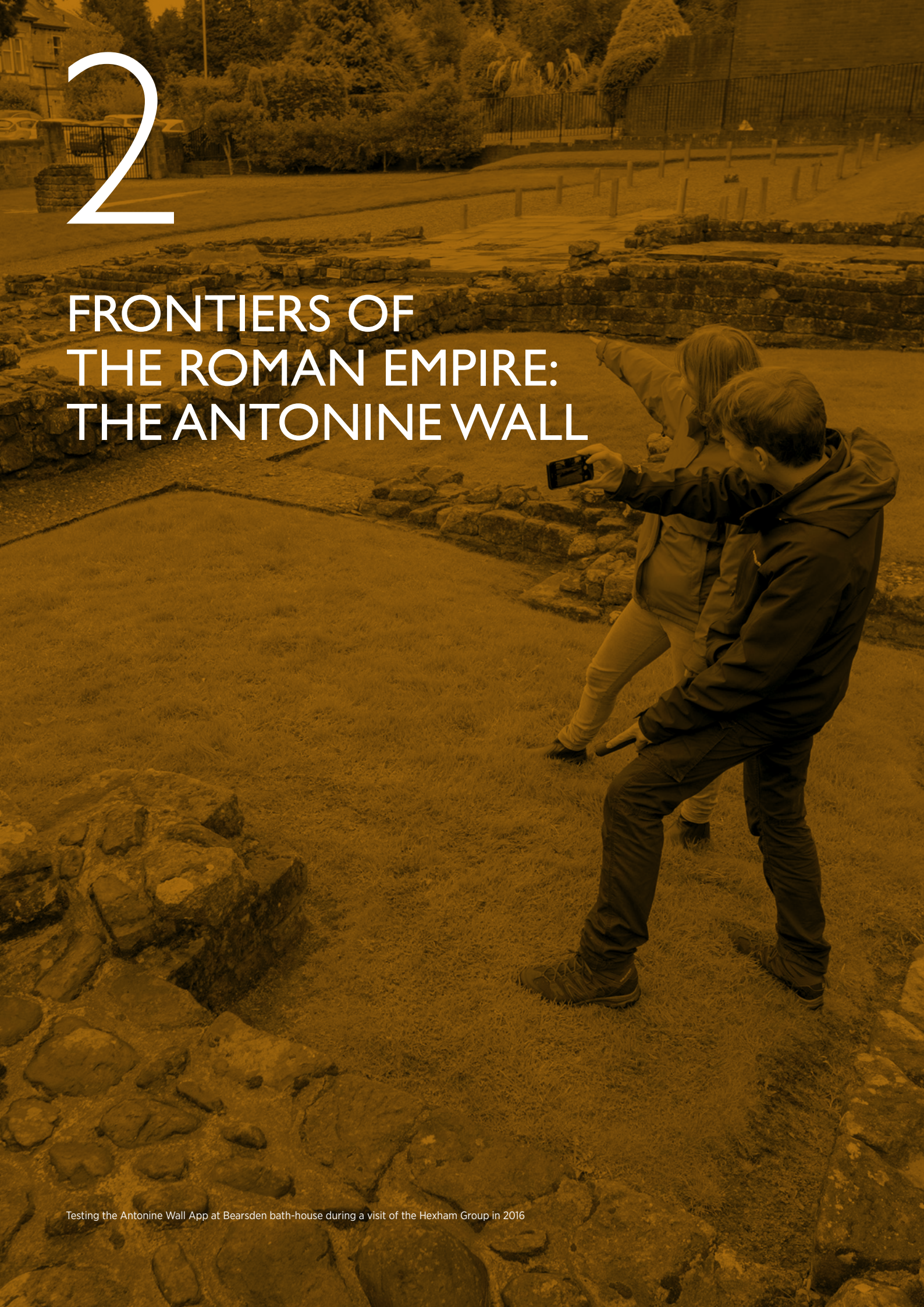
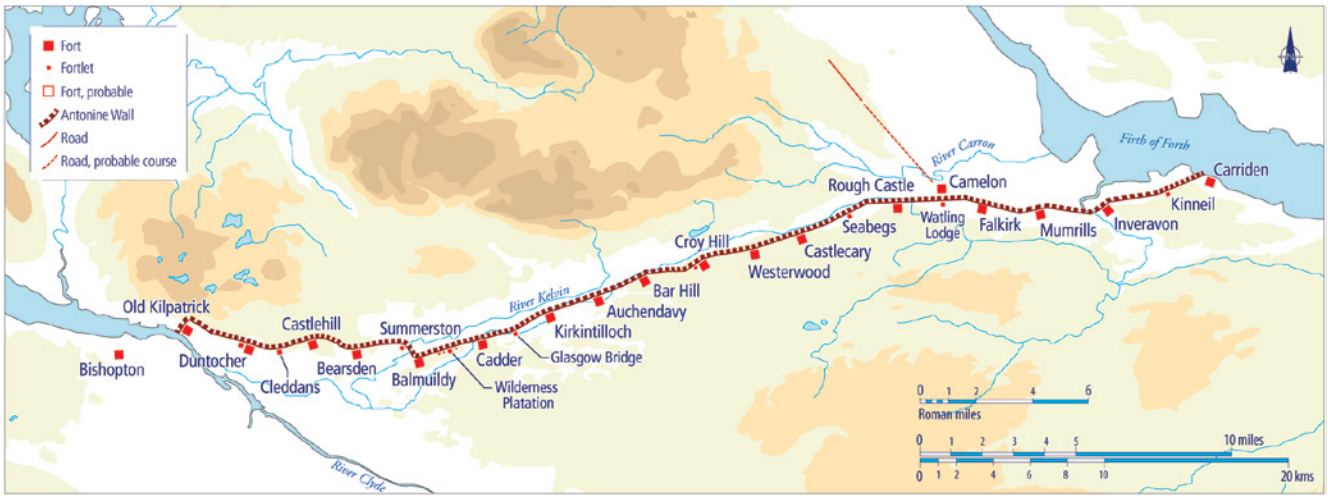
2

FRONTIERS OF THE ROMAN EMPIRE: THE ANTONINE WALL



Testing the Antonine Wall App at Bearsden bath-house during a visit of the Hexham Group in 2016

Figure 2.1 The location of the Antonine Wall running between the Firths of Clyde in the West to the Forth in the East



2.1 Location

The Antonine Wall runs for just under 40 miles (60km) between the Firths of Forth and Clyde across the narrowest part of central Scotland (Figure 2.1). It was constructed in the AD 140s on the orders of the Emperor Antoninus Pius and was, for a generation, the north-west frontier of the Roman Empire.

The Wall was built around 20 years after its southern, more famous neighbour, Hadrian's Wall (between the Tyne and Solway estuaries) and has many similar features, although is less regimented in design and about half the length. It consists of a linear barrier Wall (constructed of turf on a stone footing) fronted by a ditch and accompanied by a number of forts (many with annexes), fortlets and occasionally other structures, with a road known as the Military Way running to the rear. The deep, wide ditch in front of the rampart is the most apparent element of the monument to have survived today (Figure 2.2). Pits have occasionally been recorded on the berm, the area between rampart and ditch, and an upcast mound, created from the excavated material from the ditch thrown to the north of the monument, is visible in places.

It was only occupied for about a generation, the Romans withdrawing back to the line of Hadrian's Wall in the late AD 150s / early AD 160s.

Several of the best surviving stretches of the frontier are 'Properties in Care' managed by HES on behalf of Scottish Ministers, but the majority of the Wall is in private ownership and is managed through a partnership between HES and the five local authorities through which the Wall runs: West Dunbartonshire Council; East Dunbartonshire Council; Glasgow City Council; North Lanarkshire Council and Falkirk Council.

The WH property is protected through scheduling under the *Ancient Monuments and Archaeological Areas Act 1979* and local area plans. A buffer zone is identified, which is the physical extent of the landscape that is visually and perceptibly linked to the WH property, and can still be practically protected or managed. In places where there is little visibility or inter-visibility, the corridor of the WH property is 50m wide, but is wider in places where it is scheduled.

Figure 2.2 The ditch of the Antonine Wall at Watling Lodge

2.2 The Antonine Wall as a component of the Frontiers of the Roman Empire World Heritage property

The FRE WH property consists of three sections of the frontier constructed as artificial barriers (elsewhere rivers, deserts and mountains were fortified). This comprises two in the UK (the Antonine Wall in Scotland and Hadrian's Wall in England), marking the north-western frontier of the Roman province of *Britannia*, and the Upper German–Raetian *Limes* (Obergermanisch-Raetische *Limes*, ORL) in Germany, marking the boundary of the provinces of *Germania Superior* and *Raetia*.

In 1987, Hadrian's Wall was inscribed on UNESCO's WH List due to its exceptional preservation, massive stone wall, and impressive array of forts and fortlets. It was on the list simply as *Hadrian's Wall*. By the late 1990s, archaeologists had started discussing the potential for the Upper German–Raetian *Limes* to be nominated (the word *Limes*, pronounced Lee-mes, is the modern term in common use for Roman frontiers, derived from the Latin for road or boundary/frontier). In 1994, UNESCO had published its Global Strategy for a representative, balanced, and credible list, following recognition that it lacked balance both in terms of site types and geography, with Europe dominating[1]. Discussions then began to move towards the concept of a multi-national WH property and agreement was reached with the UK Government to change the name of the Hadrian's Wall inscription to the Frontiers of the Roman Empire, enabling its expansion. The Upper German-Raetian *Limes* was successfully inscribed in 2005 and the Antonine Wall followed in 2008[2]. Changes in UNESCO guidance in 2010 resulted in the decision to create additional groups of Roman frontiers, with a 'cluster' model now in existence[3].

2.3 The wider Frontiers of the Roman Empire 'cluster'

By the time of the Antonine Wall's inscription in 2008, discussions had started with ten countries across Europe on a FRE WH property stretching from the north-west of Britain to the Black Sea (Figure 2.3). Yet UNESCO's guidance on transboundary properties issued in 2010[4] meant that nominations had to go forward together and additional stretches could not be added when ready (which had been the previous scenario). As a result, the partners collaborated on a Thematic Study and Nomination Strategy, which was presented to and agreed by UNESCO in 2017[5]. This led to the nomination of the western segment of the Danube *Limes*[6], which was successfully inscribed in 2021 (comprising the Danube frontier in Germany, Austria, and Slovakia) and the Lower German *Limes*[7] (comprising the lower Rhine frontier in Germany and the Netherlands), also inscribed in 2021. Thus, we now have a 'cluster' of three WH properties.

Future nominations as part of this cluster will include an eastern extension to the Danube *Limes* and the Dacian *Limes* in Romania, resulting in four FRE WH properties in Europe[3]. Discussions are ongoing with colleagues in countries in the Middle East and North Africa over their potential addition to a wider FRE WH cluster.

2.4 Identifying the values of the World Heritage property

The Statement of Outstanding Universal Value (SOUV) exists for the whole of the property with its three component parts. The full statement is in Appendix 1.

The Antonine Wall CVI represented the first time that a component part of a transboundary property had been assessed (the transboundary property of the Wadden Sea, which is a contiguous property, was assessed for OUV Vulnerability in 2020[8]).

Prior to the workshop, key excerpts from the SOUV that related to both the property as a whole and the Antonine Wall in particular were identified and grouped together in tabular form (Table 2.1). This presented challenges in that it was recognised that some parts of the SOUV, whilst applicable to the Antonine Wall, were perhaps more tangible on other frontiers. This was evident in the discussions of condition and trend (section 2.7 below).

2.5 Managing the World Heritage property

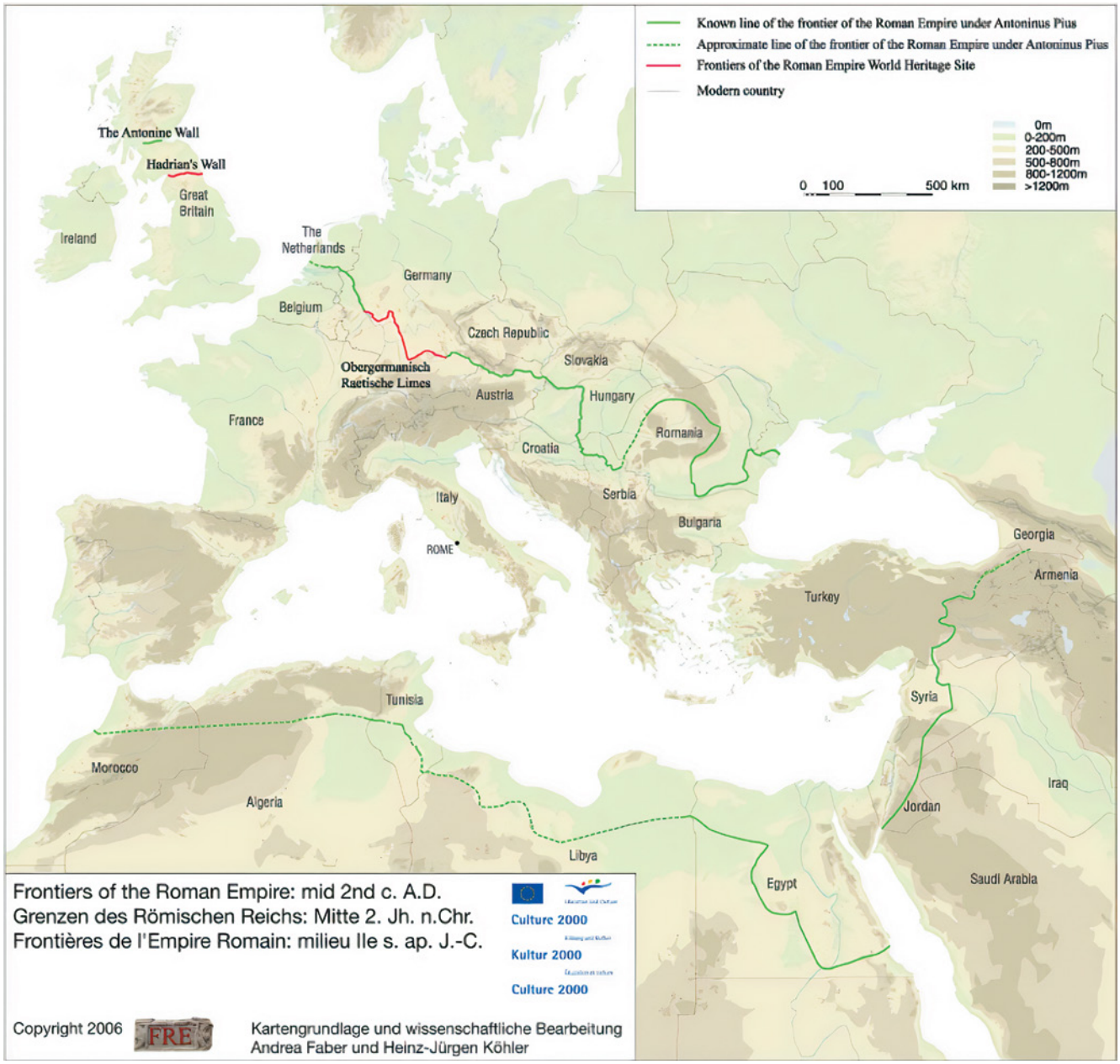
i Partnership

The Antonine Wall is managed through a partnership between HES and the five local authorities through which the Wall runs (West Dunbartonshire Council, East Dunbartonshire Council, Glasgow City Council, North Lanarkshire Council and Falkirk Council).

Nearly 7.7 km of the Wall is in state care (as Properties in Care, PiC) managed by Historic Environment Scotland; around 5.4 km is in the care of Falkirk Council; 0.6 km by North Lanarkshire Council; 2.2 km by East Dunbartonshire Council; 0.07 km by Glasgow City Council and 0.8 km by West Dunbartonshire Council. The remainder is in private ownership (often under houses and through gardens)[2].

The WH property for the Wall is a 50 m wide corridor the length of the Wall containing the three main Wall elements (line of rampart, ditch, and upcast mound

Figure 2.3 The Frontiers of the Roman Empire in the middle 2nd century AD (created in 2006 to support the nomination of the Antonine Wall component)



to the north of the ditch). It is wider where necessary to include forts, fortlets, the Military Way, and other elements of the frontier attached to the barrier. Temporary camps are also included, and the property is wider at scheduled monuments to include that full designation (particularly in areas of good or potentially good survival).

Although the current Management Plan for the property (2014-19) has expired, the partners agreed to roll it forward given the ongoing partnership project – 'Rediscovering the Antonine Wall' – now extended due to the pandemic and due to be completed in 2023. Therefore, the CVI workshop and report is timely in the management planning cycle for the Wall.

ii Conservation Management

HES monitors the physical condition of the PiC component parts of the Antonine Wall on a regular basis, including regular Conservation Audits and visits by the Field Officer. The latter regularly identifies casework issues along the Wall that are then addressed by HES's Planning, Consents, and Advice Service (which deals with Scheduled Monument consents and casework).

Rough Castle, the best surviving Roman fort on the Wall (Figure 2.4), is one of several HES properties forming part of a citizen science conservation programme called Monument Monitor[9]. Signage requests visitors to take photographs of the site to help staff to monitor the impact of increased levels of footfall on the conservation of the site.

Figure 2.4 Aerial view of the Roman fort at Rough Castle

Figure 2.5 The sign on the gate entrance to the fort at Rough Castle

iii Visitor Management

Measuring visitor numbers across the Antonine Wall has always proven challenging due to the size of the WH property and the fact that none of the sites are staffed. The Management Plan has focussed on increasing visitor numbers through improved signage and interpretation (Figure 2.5).

Two HES Properties in Care, Rough Castle and Bar Hill, have visitor counters which have indicated a perceptible increase in numbers since 2018. This is likely due to the impact of the lockdown measures where local and national visitors looked to access outdoor attractions and green space. The 'Rediscovering the Antonine Wall' project also increased awareness of the monument with both the sculptures and playparks proving very popular attractions.

This modest increase in visitors to the property is unlikely to impact significantly on the monument, but there has been evidence of erosion to some of the pathways and, in particular, to the rampart of the monument at Rough Castle.

Of additional concern is an increase in anti-social behaviour such as illegal metal detecting, vandalism, littering and off-road cycling, which all remain an issue for future management.

2.6 Case Study: Hydrological mapping of the fort at Rough Castle

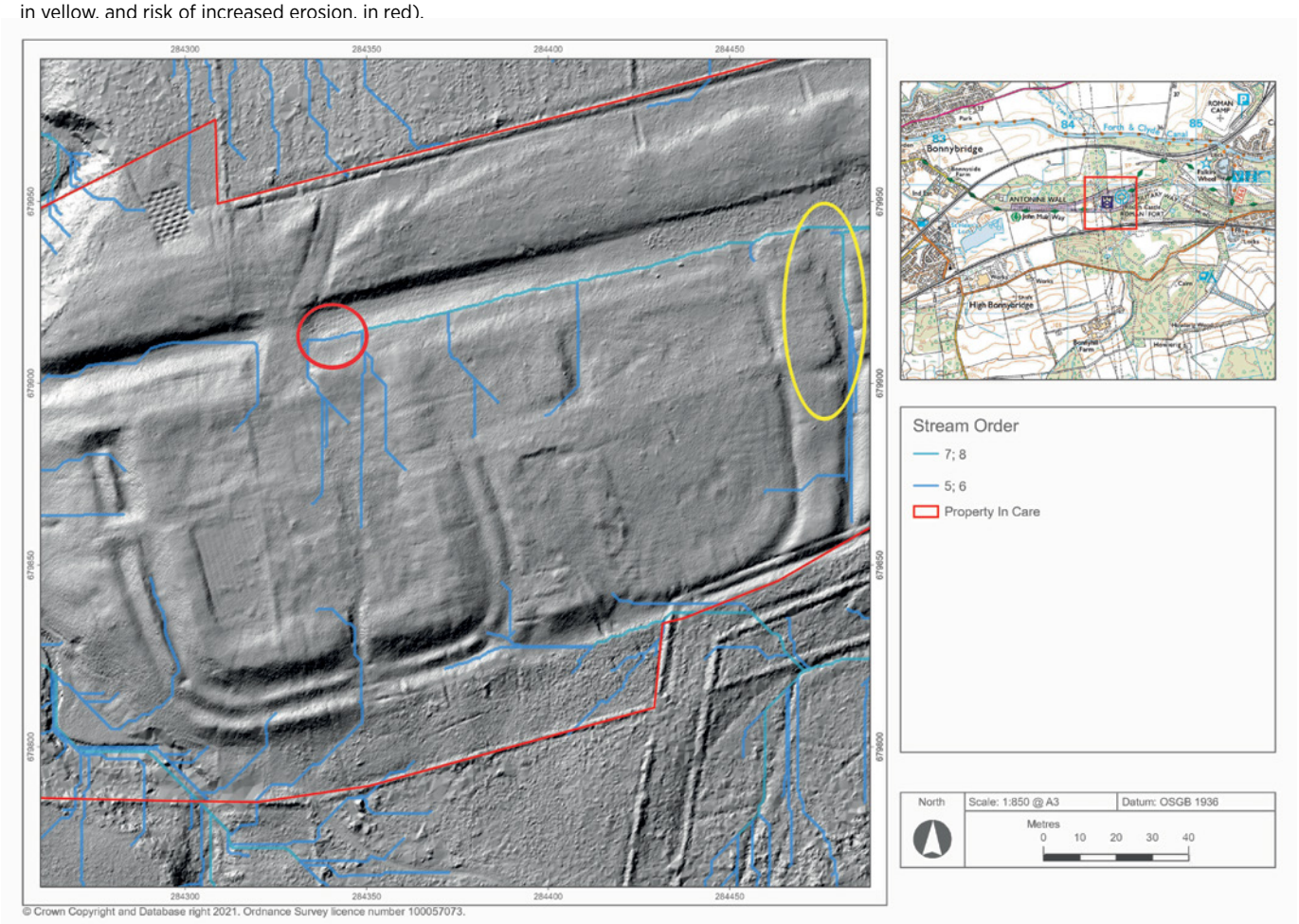
Provided by Hazel Blake

In order to be able to determine the potential impact of changes in precipitation patterns it is important to first establish the current location and extent of the hydrological networks within the property.

Surface hydrological modelling was carried out using a Geographic Information System (GIS) for Rough Castle. This was used to develop an understanding of the surface movement of water across the fort and determine the hydrological interactions between upstanding archaeological features and the hydrological networks. Stream orders are used to determine the location of surface flowing water across a site. These show the locations of the flows and how they are interacting with the archaeology. At Rough Castle, the defensive ditches are the controlling factor in influencing where the hydrological networks occur.

Within the Rough Castle fort top, the effects of the archaeological features on the hydrological network can be understood. The Antonine Wall ditch and defensive ditches of the fort are one of the biggest controlling and influencing factors of the hydrological networks at the site. They often have standing water in them after heavy or prolonged rainfall events and the hydrological network maps (Figure 2.6) show these features provide

Figure 2.6 The mapped hydrological networks at Rough Castle Roman fort on the Antonine Wall (highlighted areas indicate accumulation, in yellow, and risk of increased erosion, in red).



key parts of the drainage network. The hydrological flows in the defensive ditches on the east of the fort connect to further hydrological flows to the south to form a large hydrological network. However, there are areas where there are 'barriers' created by archaeological features, such as the Military Way, through which the hydrological networks do not flow, an example of which can be seen at the east of Rough Castle. Gaining an understanding of how these features control the hydrological networks on site it becomes possible to understand the influence that changes in rainfall patterns may have on these locations.

Through understanding where the hydrological flows occur and the directions and connections between them, it is possible to determine how an increase in rainfall may affect specific points at Rough Castle. Areas that may see standing water for more days of the year as a result of increased precipitation are likely to experience soil accumulation (highlighted in yellow on Figure 2.6). In contrast, other areas may see increased erosion (highlighted in red on Figure 2.6). Changes in wetting and drying cycles could all lead to further degradation and deterioration of the Wall's integrity. Having carried out the hydrological mapping, targeted areas of monitoring and interventions can now be assessed to ensure the integrity of the Antonine Wall is maintained.

2.7 Evaluation of current condition and recent trend of the key World Heritage values

A rapid assessment of the current condition and recent trend of the key values since the time of inscription (2008) was undertaken by the workshop participants (Table 2.1). This included considerable discussion of climate factors that had impacted the OUV of the property.

Table 2.1 Key values for the Antonine Wall, derived from excerpts of the Statement of Outstanding Universal Value for the Frontiers of the Roman Empire World Heritage property, together with their assessed current condition and recent trend by workshop participants (based on change since inscription in 2008)

Key values	Excerpts taken directly from the Statement of OUV	Assessment of current condition and recent trend (since 2008 inscription)
Most highly developed frontier	+ The Roman Empire was one of the greatest empires history has known	→
	+ physical manifestation of Roman imperial policy	
	+ outstanding examples of Roman military architecture and building techniques and of their technological development	
	+ convey the extraordinary complexity and coherence of the Frontiers of the Roman Empire	
	+ built under the Emperor Antoninus Pius in the 140s CE as an attempt to conquer parts of northern Britain	
	+ in use for only a single generation; snapshot of the frontier at a particular point in time	
	+ social and historical unit that illustrates an ambitious and coherent system of defensive constructions perfected by engineers over the course of several generations	
	+ reflects the way resources were deployed in the north-western part of the Empire	

Key values	Excerpts taken directly from the Statement of OUV	Assessment of current condition and recent trend (since 2008 inscription)
Artificial barrier	+ protecting spaces or a whole military zone	↗
	+ artificial boundaries	
	+ military and civil constructions	
	+ demonstrates cultural interchange through the extension of Roman technical skills, organisation, and knowledge	
	+ embodies a high degree of expertise in the technical mastery of stone and turf defensive constructions	
	+ walls, ditches, earthworks, fortlets, forts, fortresses, watchtowers, roads, and civilian settlements	
	+ military installations and related civilian settlements, linked through an extensive supporting network	
	+ exceptional example of a linear frontier	
Upstanding and underground remains	+ visible and buried archaeology on, behind, and beyond the frontier	
	+ one third of the Antonine Wall is visible today as a complex series of earthworks and associated structures	↗
	+ another third lies in open countryside but its line is not visible	→
	+ final third lies under urban areas	↘
	+ materials and substance of underground archaeological remains are well-preserved, as are upstanding and visible remains	
	+ form and design of each representative part of the frontier and its associated structures are clear and comprehensible	

Good
The property's values are in good condition and are likely to be maintained for the foreseeable future, provided that current conservation measures are maintained.

Good with some concerns
While some concerns exist, with minor additional conservation measures the property's values are likely to be essentially maintained over the long-term.

Significant concerns
The property's values are threatened and/or may be showing signs of deterioration. Significant additional conservation measures are needed to maintain and/or restore values over the medium to long-term.

Critical
The property's values are severely threatened and/or deteriorating. Immediate large-scale additional conservation measures are needed to maintain and/or restore the property's values over the short to medium-term or the values may be lost.

→ **Stable**

↗ **Improved**

↘ **Deteriorated**

Key values	Excerpts taken directly from the Statement of OUV	Assessment of current condition and recent trend (since 2008 inscription)
Landscape and Topography	+ conspicuous part of the landscape today	↘
	+ 60km across central Scotland	
	+ River Forth to the River Clyde	
	+ settlement patterns, architecture, and landscape design and spatial organisation	
	+ variety and sophistication of the Romans' responses to the specific topography and climate	→
Conservation and Ownership	+ extensive relict landscape	↗
	+ state of survival has been researched in many areas	↗
	+ Later development overlying parts of the frontier are treated as vertical buffer zones	→
	+ remains of the Antonine Wall exist in a generally good condition and visible sections sometimes have significant heights and depths	→
	+ Conservation and consolidation measures that have been carried out in the interest of better understanding and protection fit in with the setting of the property	↗
	+ Policies to protect, promote, conserve, and enhance the property are included in local authority development plans and strategies	↗
	+ Most of the Antonine Wall is in private ownership, but some sections are in the care of local authorities and Historic Scotland	↗

Good
The property's values are in good condition and are likely to be maintained for the foreseeable future, provided that current conservation measures are maintained.

Good with some concerns
While some concerns exist, with minor additional conservation measures the property's values are likely to be essentially maintained over the long-term.

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→ **Stable**

↗ **Improved**

↘ **Deteriorated**

Key values	Excerpts taken directly from the Statement of OUV	Assessment of current condition and recent trend (since 2008 inscription)
Land-use change	+ some parts have been affected by land use change and natural processes	→
	+ Several areas of the frontier have been built over, but where significant archaeological remains have been proven to exist, they have been included in the property	
Living Communities (then and now)	+ imposition of a complex frontier system on the existing societies	↗
	+ controlled and allowed the movement of peoples	
	+ exchange of cultural values through movement of soldiers and civilians from different nations	
	+ spread of Roman culture and its different traditions – military, engineering, architecture, religion, management, and politics	
	+ large number of human settlements associated with the defences which contribute to an understanding of how soldiers and their families lived	

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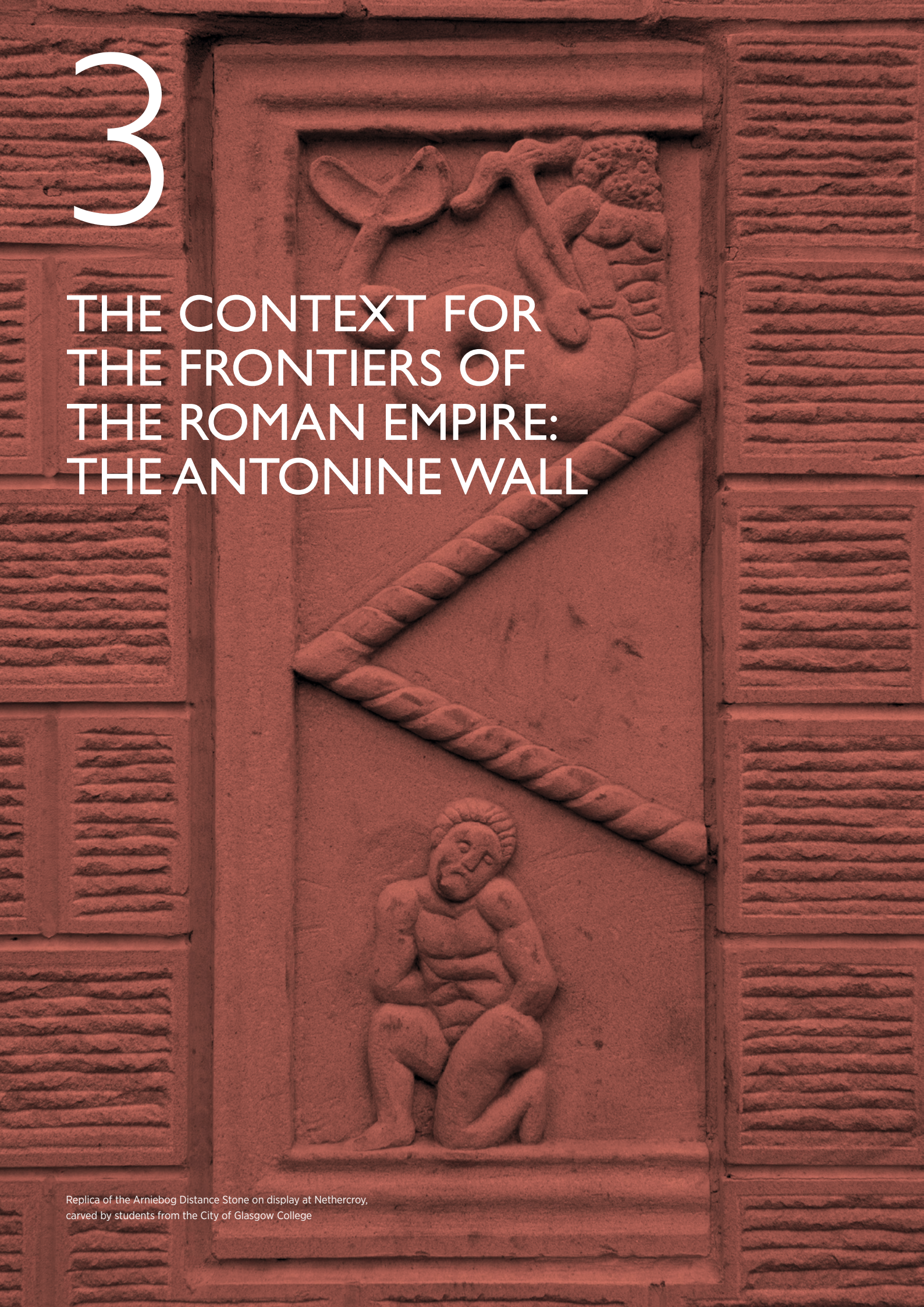
9 Monument Monitor: Monument Monitor. Historic Environment Scotland

3

THE CONTEXT FOR THE FRONTIERS OF THE ROMAN EMPIRE: THE ANTONINE WALL



Replica of the Arniebog Distance Stone on display at Nethercroy, carved by students from the City of Glasgow College

3.1 Historic environment remains

The construction of the Antonine Wall was a turf rampart some 3-4m high fronted by a wide, deep ditch. To the north of the ditch, in places, an outer mound or upcast bank is visible, representing the excavated material from the ditch thrown to the north (Figure 3.1).

Although superficially similar to the turf section of Hadrian's Wall (the western segment of the initial phase of Hadrian's Wall was built in turf, later replaced with a stone wall)[1], the rampart of the Antonine Wall was built on a stone base with culverts (Figure 3.2). The Wall is the most complex of all Roman frontiers, with forts spaced at about every two miles, closer intervals than any other frontier. Many of these forts had an annexe attached to one side, a feature not found on other frontiers. A Roman road running to the rear of the rampart, known as the Military Way, linked the frontier installations. Other unique features include enclosures and expansions, the function of which is debated[2].

Figure 3.1 Professor Anne Robertson's section through the Antonine Wall at Tentfield Plantation, east of Rough Castle, in 1959, reveals many layers of turf work erected on a stone base. This provides valuable information on the nature of the vegetation at the time the Romans started to build the Wall

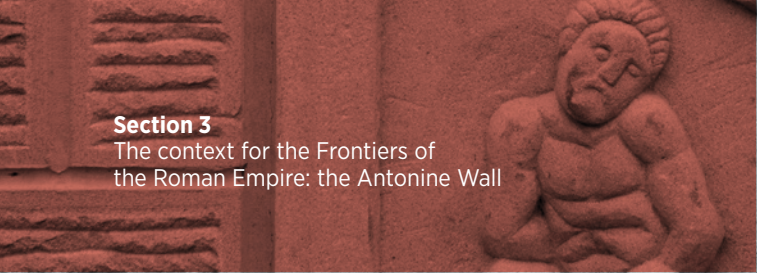


Figure 3.2 The stone base of the Antonine Wall in New Kilpatrick cemetery, Bearsden

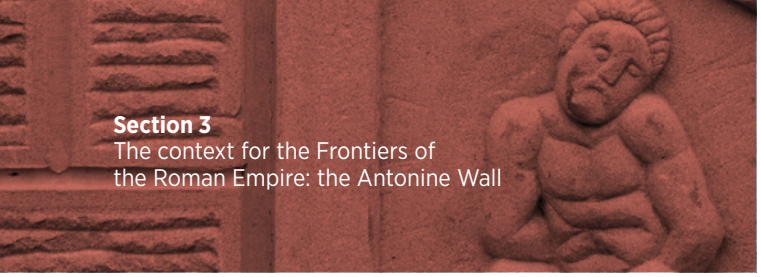
A number of temporary camps have been recorded as buried remains, visible through differential cropmarks on aerial photographs (Figure 3.3); many of these have linked to the construction of the frontier[3].

In addition to the above and below ground remains, numerous artefacts have been recovered from antiquaries' endeavours and more modern excavations revealing a huge amount of information about life on the frontier. This includes the distance stones, a collection of sculptured stones unparalleled on any other frontier, which record the building of the Wall by the three legions involved in its construction, together with scenes of victory and religion. The cavalryman logo used for the Antonine Wall is derived from the stone found in Bridgeness and now housed in the National Museum of Scotland in Edinburgh (Figure 3.4). Other artefacts include objects indicating daily life, such as a spectacular series of remains recovered during the excavations of the Well at Bar Hill fort[4], many of which are on display in the Antonine Wall gallery in the Hunterian Museum in Glasgow.

Environmental evidence for life on the Wall has also been revealed through a range of excavations, such as that at Bearsden, where the analysis of material from the latrine gives us evidence for the military diet[5]. New analysis of the earthen rampart of the Wall is ongoing (see Section 3.2 on page 24).

Figure 3.3 The temporary camp at Tamfourhill near the fortlet at Watling Lodge

Figure 3.4 The Bridgeness distance stone © National Museums Scotland. Licensor www.scran.ac.uk



3.2 Case study: New geoarchaeological and geotechnical research on the Antonine Wall[6]

Provided by Ben Russell, Tanja Romankiewicz, Christopher TS Beckett, J Riley Snyder, Benedicta Lin, Rose Ferraby with Tom Gardner as external micromorphology specialist

The Antonine Wall is the largest turf structure of the Roman world. Sections across its western part show individual turf blocks complete with the black lines of their decayed grass surfaces. Turf is an ideal earthen building material, a natural ready-mix of sand, silt and clay combined with minerals and fibres. However, excavations on the Wall east of Watling Lodge have been less conclusive about its materials. Modern development and agriculture rendered the rampart remains harder to assess. Field interpretations suggest a core of mixed subsoil retained by clay cheeks or turf facings on either side.

We tested this composition in one section at Laurieston as part of our Leverhulme project 'Earthen Empire'. This was the first geoarchaeological study of the Antonine Wall, focusing on micromorphology combined with geotechnical experiments into the structural and hydrological properties of turf. Our new pilot project *Grassroots* now assesses the potential for reconstructing environmental conditions and agricultural regimes of the time when turf blocks were cut. Here, we are collaborating with geochemists and microbiologists from Teesside University, Gillian Taylor and Caroline Orr.

The key result from our Laurieston work suggests that the Antonine Wall was built with turf throughout. We uncovered turf blocks in the core, laid at 45-degree angles to distribute their load obliquely onto the cheeks and avoid spalling. These cheeks, showing whitish in the field, were also of turf, cut from a sandy, clay-rich soil specifically selected off-site. The introduction of a stone base, set securely into a well-draining bedding layer levelled off with turf offcuts and sand, suggests that long-term stability and regulating the moisture content of the Wall were key concerns.

These results add new weight to the key values (in **bold**) that contribute to the Wall's Outstanding Universal Value. Analysing the **well-preserved upstanding and underground remains** has confirmed the Antonine Wall as the **most highly developed frontier**, in terms of Roman turf technology. The careful construction emphasises the intent to build a lasting **artificial barrier** in turf. Our comparative analyses of turf ramparts at the fort of Vindolanda south of Hadrian's Wall underpin the Roman turf building skills[7]. These seem specific to the **living communities** along the two walls. Our new analyses, with Teesside University, of soil bacteria and grazing cycles will yield new information on **land-use and changes** in the past, as well as highlighting modern impacts that can inform the **conservation** strategy for the turf monument.

More Antonine Wall sections will need to be analysed to test how representative our first results are and to expand our understanding. We also aim to monitor how climate change factors such as rising temperature and increased rainfall will impact upon the upstanding rampart at large, and its microcosms of bacteria, fungi, lipids, and sterols potentially preserved within each turf block. Only such an interdisciplinary approach can inform a comprehensive strategy for the protection of turf monuments like the Antonine Wall, under threat from climate change.

3.3 Economic context

In 2014-15, the management partners for the Antonine Wall commissioned a Socio-Economic Impact Study of the Wall from Brookdale Consulting[8]. Although this was pre-pandemic and before the work of the 'Rediscovering the Antonine Wall' project, it provided useful baseline information which was utilised for the CVI workshop to aid with understanding of the economic context (impact and community) for the Wall.

Figure 3.5: Key findings from the 2015 Economic Study

Overview of Findings

In 2014, along the line of the Wall there were:

+ 80,000 people in 34,800 households
+ 3,300 businesses employing 32,500 people
+ 5% of these people are amongst the 10% most deprived in Scotland
+ Two thirds of businesses have fewer than five staff
+ 15 large businesses in the wider area around the Wall
+ Manufacturing and wholesale/retail are the largest sectors, together employing almost 10,000 people
+ Unemployment is similar to the rest of Scotland
+ 13% of people are income deprived
+ 12% of working people are employment deprived
+ Tourism accounts for 3,100 jobs
+ 22 limited companies use 'Antonine' in their branding

Many of the businesses who completed this survey were small businesses on or near the Wall. Over 80% of these were interested in the potential to generate new business activity from the Wall. A look at the economic impact (in 2015) estimated that from annual input costs of £632k the annual benefits generated by the Wall were in the region of £3m with the potential for growth.

The economic modelling recommended that the partners explore the development of a 'string of pearls' along the line of the Wall – the development of future regeneration projects with interpretation developed bespoke to each location.

The report grouped the business into 19 main sectors. For the purposes of the workshop, these were rationalised into eight key business types: Tourism; Recreation-related; Agriculture/Forestry; Manufacturing/ Retail; Construction; Education; Government/Public sector; Non-governmental organisations.

3.4 Social and cultural context

The Antonine Wall runs through five local Councils in the most densely occupied part of central Scotland. Within the actual Wall property and its buffer zone, the estimated population was around 3,275 people in 2001[2]. In the wider Wall corridor, it was estimated at around 80,000 people in 2011, when the wider population of the five local Council areas totalled in excess of 1.2 million people. Of the population in the Wall corridor, the age distribution was close to the national average across Scotland with 18% being aged 0-15; 10% between 16-24; 25% between 25-44; 38% between 45-74; and 8% over 75[8].

Awareness of the Wall in the local area, however, was relatively low[9]. Despite a series of projects aimed at enhancing information and interpretation, these were at specific targeted audience groups, and the Steering Group partners recognised that more was needed to fully embed the importance of the Wall in its local communities. Work began on a project, co-created with local communities, in 2016, which was to become the 'Rediscovering the Antonine Wall' project (see section 3.5 on the following page).

The Wall runs through many deprived communities in Scotland, several of which fall into the 20% of the most deprived in the country. According to the Scottish Index of Multiple Deprivation (SIMD), several areas along the wall (known as Data Zones) suffer from the highest levels of deprivation; 5% of the people living along the Wall are amongst the 10% most deprived in Scotland, especially in the Glasgow area. There is, however, a disparity of wealth, with areas such as Bearsden having some of the lowest levels of deprivation in the country.

3.5 Rediscovering the Antonine Wall

The award-winning 'Rediscovering the Antonine Wall' project aims to raise awareness and relevance of the monument within the communities who live alongside it, as well as encouraging visitors to explore the area and engage with its history. This £2.2m project is funded by the partners, the National Lottery Heritage Fund and LEADER and is due to finish in March 2023.

Figure 3.6 The sculptural head – Silvanus – at Nethercroy near the Wall

The project has seen the installation of five replica distance stones alongside two large sculptures (Figure 3.6), which have proven to be popular attractions for visitors as well as providing a visual landmark which celebrates the Roman heritage of the area.

A trail of Roman-themed playparks (Figure 3.7) has been developed across the five local authorities, each unique and designed by local pupils. Each playpark tells the local history of the Romans in that area with interpretation which appeals to both adults and children[10]. The locations were decided based on the levels of deprivation and the needs of the community. Throughout the lockdown restrictions they provided an important outdoor safe space for children to play.

With low levels of community engagement along the Wall, participant led approaches were integral to the development of the project. Through thorough consultation, communities identified projects they felt would highlight the Roman heritage and bring benefit to their place. These included co-designed sculptures, graffiti projects, a Roman garden, and Roman-themed comic books. The project aims to deliver a sense of pride within the local communities of this important heritage on their doorstep, which will in turn create a sense of ownership and responsibility for the monument, which will increasingly form part of the future management of this WH property.

In order to increase awareness and understanding of the Roman frontier remains in Scotland, HES created a series of learning resources including 'Go Roman' handling boxes for use in the classroom[11]. Thanks to funding from Creative Europe (European Union), HES was a partner in a digital project with colleagues from Austria and Germany (Bavaria), which created dedicated mobile apps for Roman Frontiers. Thanks to the Advanced *Limes* Applications (ALAPP)[12], there is a mobile app for the Antonine Wall with a range of digital content including augmented reality presenting knowledge about artefacts and sites.

Figure 3.7 Kirkintilloch Play Park

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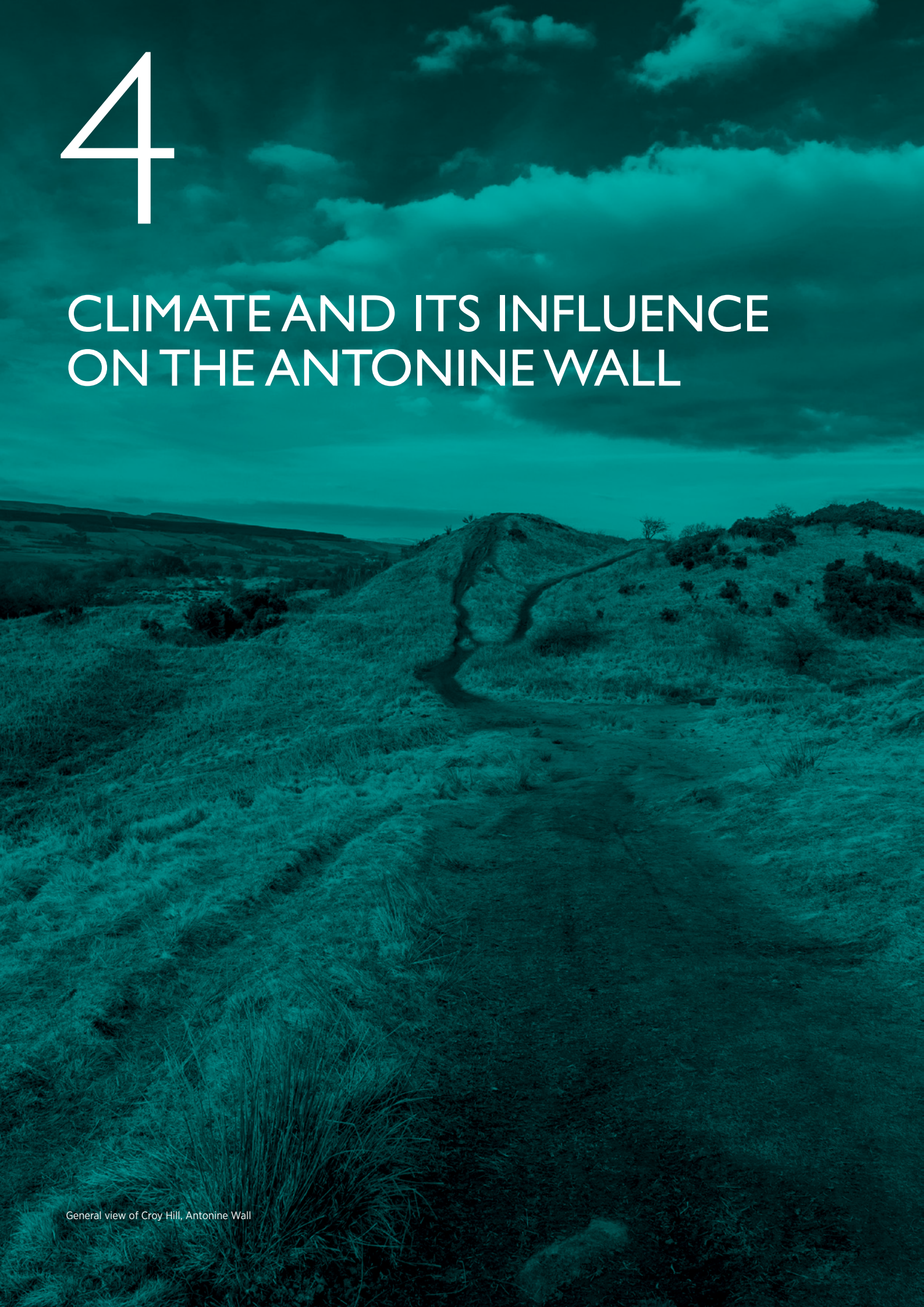
10 Weeks P (2020) 'The Antonine Wall as a World Heritage Site: People, priorities and playparks' in Breeze DJ and Hanson WS (eds) *The Antonine Wall: papers in honour of Professor Lawrence Keppie*, Archaeopress, Oxford, 455-462

11 Go Roman Handling Box | Historic Environment Scotland | History

12 alapp – edufilm
Developed by Edufilm: alapp-edufilm
https://edufilm.at/alapp/

4

CLIMATE AND ITS INFLUENCE ON THE ANTONINE WALL



General view of Croy Hill, Antonine Wall

Scotland is described as having a 'temperate maritime' climate – meaning that it has a cool and mild climate. It is influenced by different air masses, which means the weather can often be unpredictable and changeable. Regional variance in climate can be attributed to proximity to coasts, rain-bearing winds from the west and mountainous regions which shelter the east from much of the rain that the west receives.

In this section, the climate of two sites along the Antonine Wall, Bishopton (near the western end of Antonine Wall) and Falkirk (towards the eastern end), are described and compared to the expected conditions across Scotland and the UK. Bishopton and Falkirk were chosen to represent the most westerly and easterly points across the site with available climate data.

4.1 Current climate

i Temperature

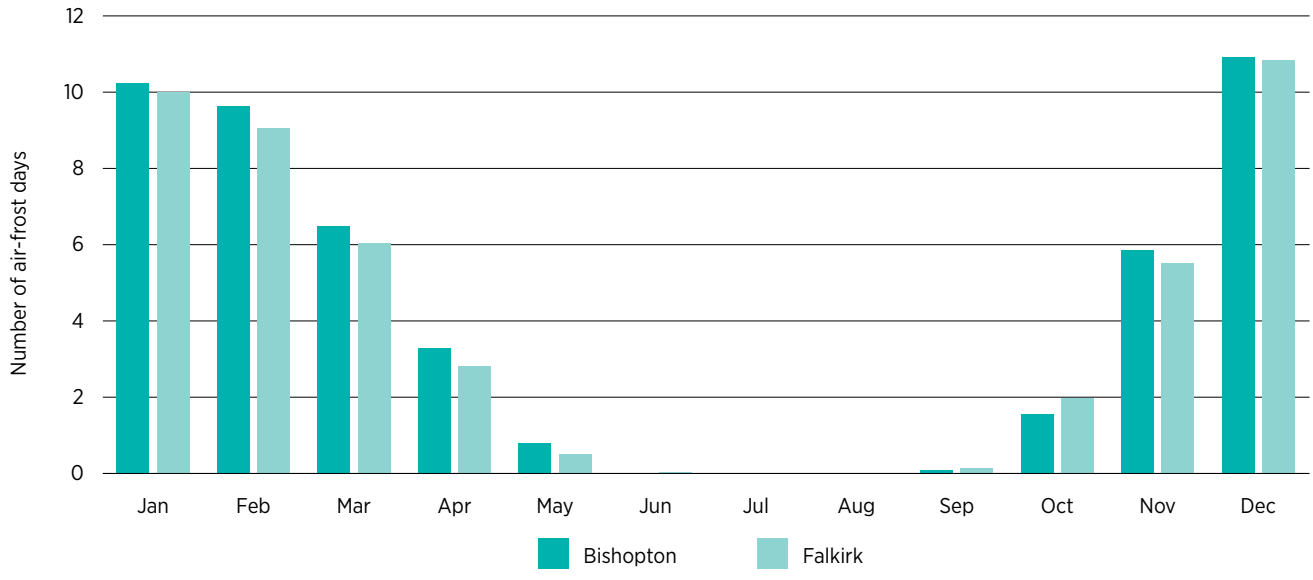
Typically, western Scotland is milder than eastern Scotland due to the stronger maritime influence. The Gulf Stream has a strong influence on western Scotland. Bishopton's annual average temperature is 8.9°C and Falkirk's is 9.2°C (Table 4.1). These are both warmer than the annual Scottish average (7.5°C), but similar to the annual UK average (8.9°C). The coolest months tend to be January and December and the warmest July and August.

On average, both sites receive around 49 days of air frost a year. This is less than the Scottish (75 days) and UK (58 days) average (Figure 4.1). January and December tend to record the most days an air frost occurs, with June to September often remaining air frost free.

Table 4.1 Average monthly temperature for Bishopton and Falkirk weather stations, 1981 – 2010 (Source: Met Office)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bishopton average temperature (°C)	3.8	4.1	5.7	7.8	10.6	13.2	15.1	14.8	12.7	9.3	6.3	3.8
Falkirk average temperature (°C)	4.0	4.4	6.0	8.0	10.8	13.5	15.5	15.3	12.9	9.5	6.4	3.9

Figure 4.1 Average monthly air frost days for Bishopton and Falkirk weather stations, 1981-2010 (Source: Met Office)



ii Rainfall

Autumn and winter are the wettest seasons, and spring and early summer are usually the driest part of the year. Much of eastern Scotland is sheltered from the rain-bearing winds from the west. Parts of the east coast receive less than 700 mm of rainfall in an average year, however the Scottish average annual rainfall is 1551 mm. The wettest regions in Scotland can receive over 4000 mm per year.

Bishopton records, on average, 1318 mm of rainfall per year and Falkirk 949 mm (Figure 4.2). Both sites therefore receive less rain than the Scottish average (1551 mm). Bishopton receives more rainfall than the UK average (1142 mm), but Falkirk receives less.

For both sites, January is the wettest month, and April and May are the driest. Bishopton, on average, records 175 days a year with rainfall totals >1 mm and Falkirk 147 days per year.

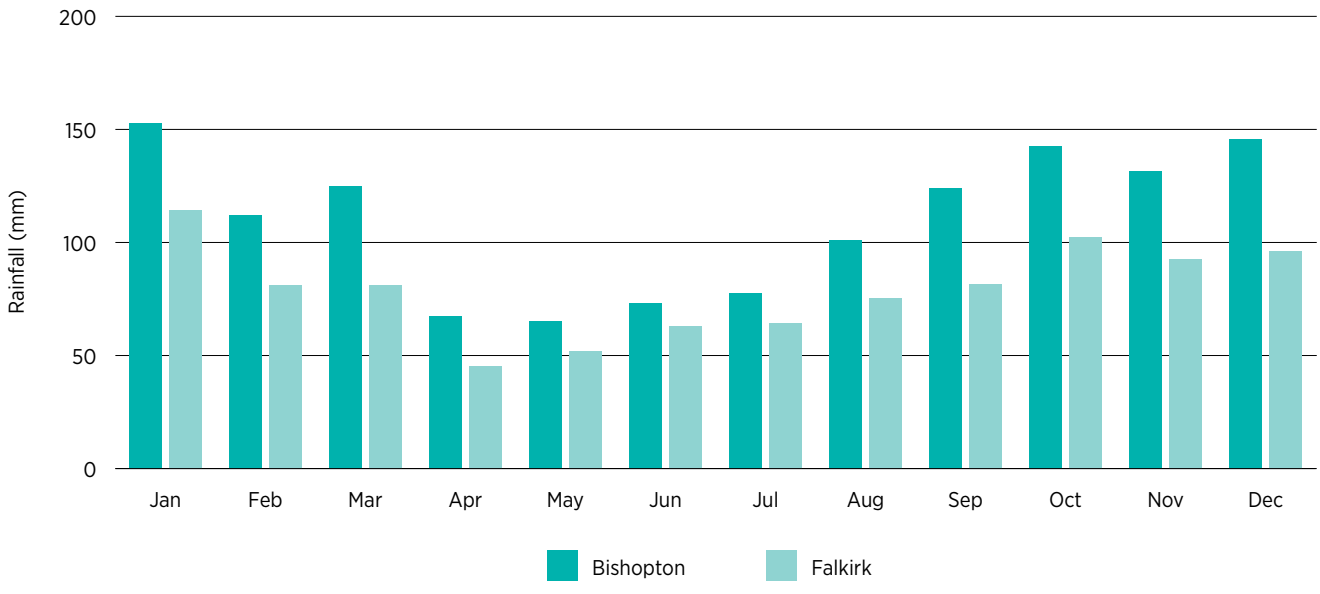
iii Other climate variables

Bishopton receives 1348 hours of sunshine on average per year, and Falkirk 1229 hours per year, both of which are sunnier than the Scottish average (1183 hours), but less sunny than the UK average (1375 hours). May is generally the sunniest month at both sites, and January is the least sunny month.

The sunniest places in Scotland are typically along the east coast, where areas may receive 1500 hours of sunshine per year on average. For the UK, the south coast of England is the sunniest where areas can receive over 1750 hours of sunshine per year on average.

Both western and eastern Scotland are windy areas of the UK, being close to the track of Atlantic depressions. This is most apparent in the winter when wind speeds and gusts are strongest. The number of days per year on which gale force winds are reached is five for both western and eastern regions (when mean wind speed reaches at least 34 knots for ten consecutive minutes, this day is classified as having a gale).

Figure 4.2 Average monthly rainfall totals for Bishopton and Falkirk weather stations, 1981-2010 (Source: Met Office)



Key message summary:

Bishopton and Falkirk are both warmer than the Scottish average and very similar to the UK average

Bishopton and Falkirk receive fewer days of air frost than the Scottish and UK average

Falkirk is drier than Bishopton, but both receive less rainfall that the Scottish average. Bishopton receives more rainfall than the UK average

Both sites are sunnier than the Scottish average but are less sunny than the UK average

4.2 Observed climate trends

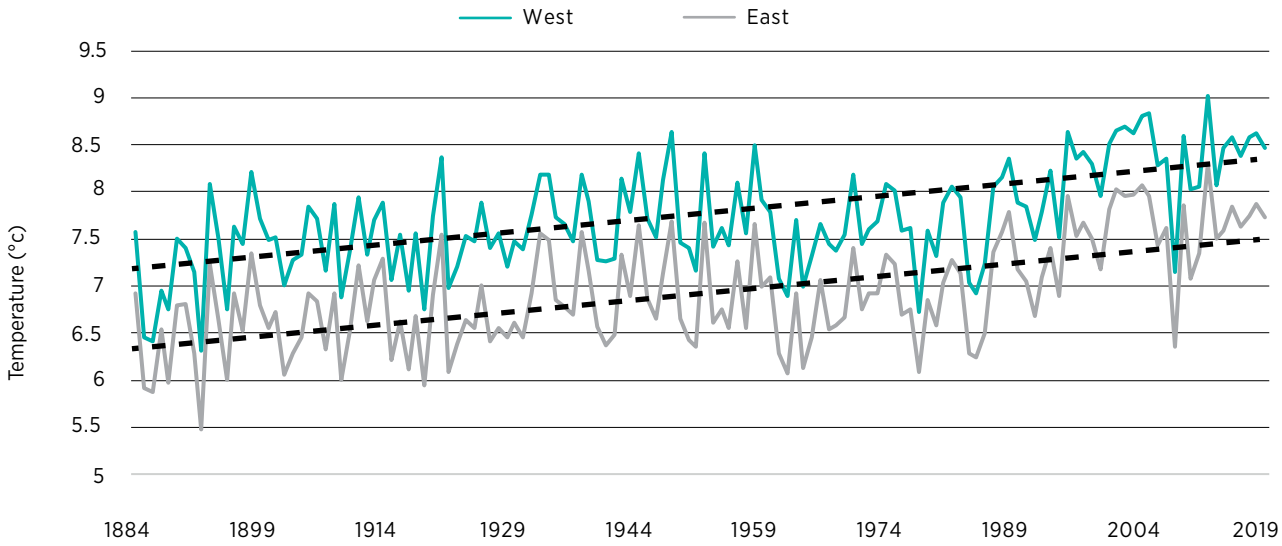
There is already evidence of a changing climate in the UK, over the 20th century and in recent decades. Temperatures have increased and rainfall patterns have changed. The 21st century has, to date, been the warmest of the past three centuries. Additionally, 2020 was the 3rd warmest, 5th wettest, and 8th sunniest since records began for each of these measures.

Specifically for Scotland, as reported in Adaptation Scotland's Climate Projections for Scotland handbook[1]:

- Scotland's 10 warmest years on record have all occurred since 1997
- The average temperature in the last decade (2010 to 2019) was 0.69°C warmer than the 1961 to 1990 average
- Rainfall totals have increased, with an increasing proportion of rainfall coming from heavy rainfall events
- The annual average rainfall in the last decade (2010 to 2019) was 9% wetter than the 1961 to 1990 average, with winters 19% wetter.

These national trends are also exemplified at a regional level. The following graphs provide temperature (Figure 4.3) and rainfall (Figure 4.4) trends for West Scotland and East Scotland, effectively spanning the sites along the Antonine Wall.

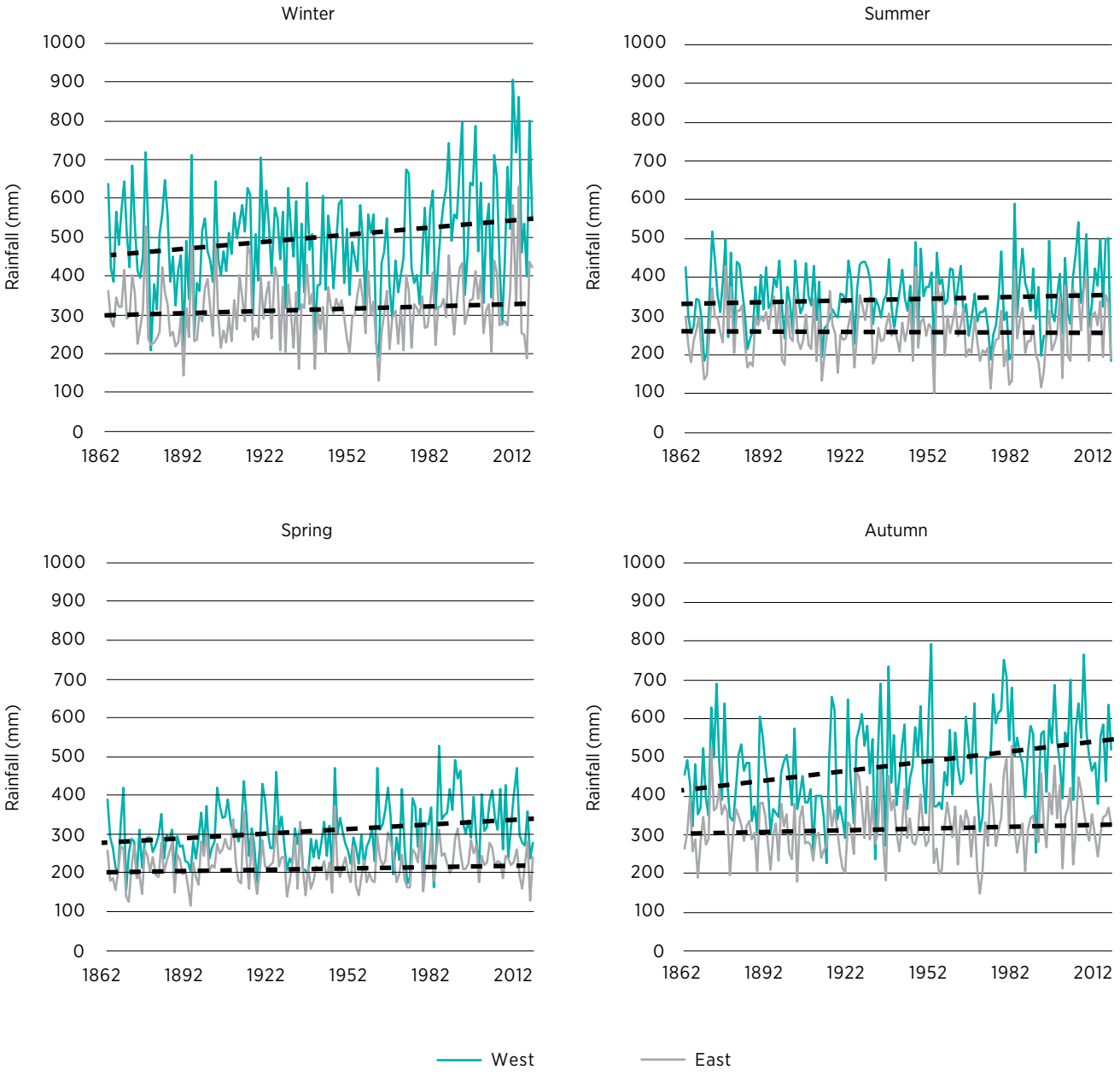
Figure 4.3 Average annual temperature for West and East Scotland regions, 1884-2021 (Source: Met Office)



Since temperature records began in 1884, both regions have experienced an increase in annual temperature (Figure 4.3). As noted in the current climate section, the west of Scotland has also historically recorded higher annual temperatures than the east.

Trends in autumn and winter rainfall show an apparent slight increase since records began in 1862/63, yet trends in spring and summer rainfall are relatively stable (Figure 4.4). As mentioned in the current climate description, the historical data show that autumn and winter receive more rainfall per year than spring and summer.

Figure 4.4 Average seasonal rainfall for Scotland West and East, 1884-2019 (Source: Met Office)



4.3 Anticipated climate change

i Global climate change mitigation and impacts

In 2016, the Paris Agreement, a legally binding international treaty on climate change, came into force. This was adopted by 196 parties at COP21 in Paris in 2015. The key goal of the agreement is for countries to reduce their greenhouse gas emissions in order to limit global warming to below 1.5°C compared to pre-industrial temperatures. The agreement was a breakthrough in international climate change cooperation, as it was the first time a legally binding treaty was implemented.

Although the Paris Agreement aims to mitigate against climate change, we are already seeing adverse impacts across the globe. According to the IPCC, global temperatures have already reached up to 1.1°C warmer than the 1850–1900 average[2].

IPCC Assessment Reports are compiled by leading global scientists to provide scientific evidence for policymakers and are an invaluable resource for global climate negotiations such as COP26, held in Glasgow in 2021. Working Group 2 focuses on the impacts of climate change, vulnerability, and adaptation, and published their section of the 6th Assessment Report in February 2022. The key impacts and risks from the headline findings are presented below[3].

- Human-induced climate change, including more frequent and intense extreme events, has caused widespread adverse impacts beyond natural climate variability
- The rise in weather and climate extremes has led to some irreversible impacts as natural and human systems are pushed beyond their ability to adapt
- Global warming, reaching 1.5°C in the near-term, would cause unavoidable increases in multiple climate hazards and present multiple risks to ecosystems and humans
- There is increased evidence of maladaptation. Maladaptive responses to climate change can create lock-ins of vulnerability, exposure and risks that are difficult and expensive to change and exacerbate existing inequalities
- The magnitude and rate of climate change and associated risks depend strongly on near-term mitigation and adaptation actions; projected adverse impacts, and related losses and damages, escalate with every increment of global warming.

ii Climate projections for the Antonine Wall

Scotland's future climate will be determined by the extent to which global greenhouse gas emissions are reduced, or not, now and in the future. Nevertheless, emissions already in the atmosphere are changing our climate and will continue to do so. If greenhouse gas emissions are not reduced, we will experience more severe shifts in our climate and experience more extreme weather more frequently.

Across the UK, we are expected to receive warmer, wetter winters and hotter drier summers, with an increase in the frequency and intensity of extreme weather events. Rainfall patterns will remain variable geographically, but we will likely experience an increase in the intensity of heavy summer rainfall events. Sea levels will rise and there will be reduced frost and snowfall[4].

For the Antonine Wall, the projected changes in key climate variables, under a high emissions scenario in which greenhouse gas emissions continue to rise rapidly, are summarised on page 34 (Table 4.2).
The projections are for the Clyde and Forth River Basins which span the length of the Antonine Wall. Each value is an average for the period noted. The values present the lowest and highest probable change for each climate variable, compared to the 1981 – 2010 baseline.

Table 4.2 Projected changes compared to 1981 to 2000 baseline (Winter = Dec/Jan/Feb and Summer = June/July/Aug). The ranges provided are for the Clyde and Forth River Basin Regions and for a high-emissions scenario (Source: Met Office)

Bishopton

Climate Variable	2030 (2020 to 2039)	2050 (2040 to 2059)	2080 (2070 to 2089)
Mean annual temperature (°C)	0.3 to 1.7	0.6 to 2.8	1.4 to 5.1
Mean winter temperature (°C)	-0.1 to 2	0.1 to 3.1	0.6 to 5.3
Mean summer temperature (°C)	0 to 2	0.3 to 3.4	1 to 6.5
Mean winter rainfall (%)	-9 to 26	-8 to 38	-6 to 66
Mean summer rainfall (%)	-24 to 13	-30 to 4	-44 to 2

Falkirk

Climate Variable	2030 (2020 to 2039)	2050 (2040 to 2059)	2080 (2070 to 2089)
Mean annual temperature (°C)	0.3 to 1.8	0.6 to 2.9	1.5 to 5.2
Mean winter temperature (°C)	-0.1 to 2.1	0.1 to 3.2	0.7 to 5.5
Mean summer temperature (°C)	0 to 2.1	0.4 to 3.5	1.1 to 6.7
Mean winter rainfall (%)	-7 to 29	-3 to 40	-5 to 61
Mean summer rainfall (%)	-22 to 13	-31 to 4	-47 to 3

Key message summary:

- Scotland is expected to experience warmer, wetter winters and hotter, drier summers

- For both river basins, change in all temperature and precipitation variables increases towards the end of the century

- Annual, winter and summer temperatures increase towards the end of the century
- The change in mean summer temperature is marginally greater than the change in mean winter temperature

- Winter rainfall largely increases, and summer rainfall largely decreases
- For the Clyde River Basin, winter and summer precipitation increase and decrease at a similar rate
- The same is also true for the Forth River Basin, but this increase grows more significant from the 2070s

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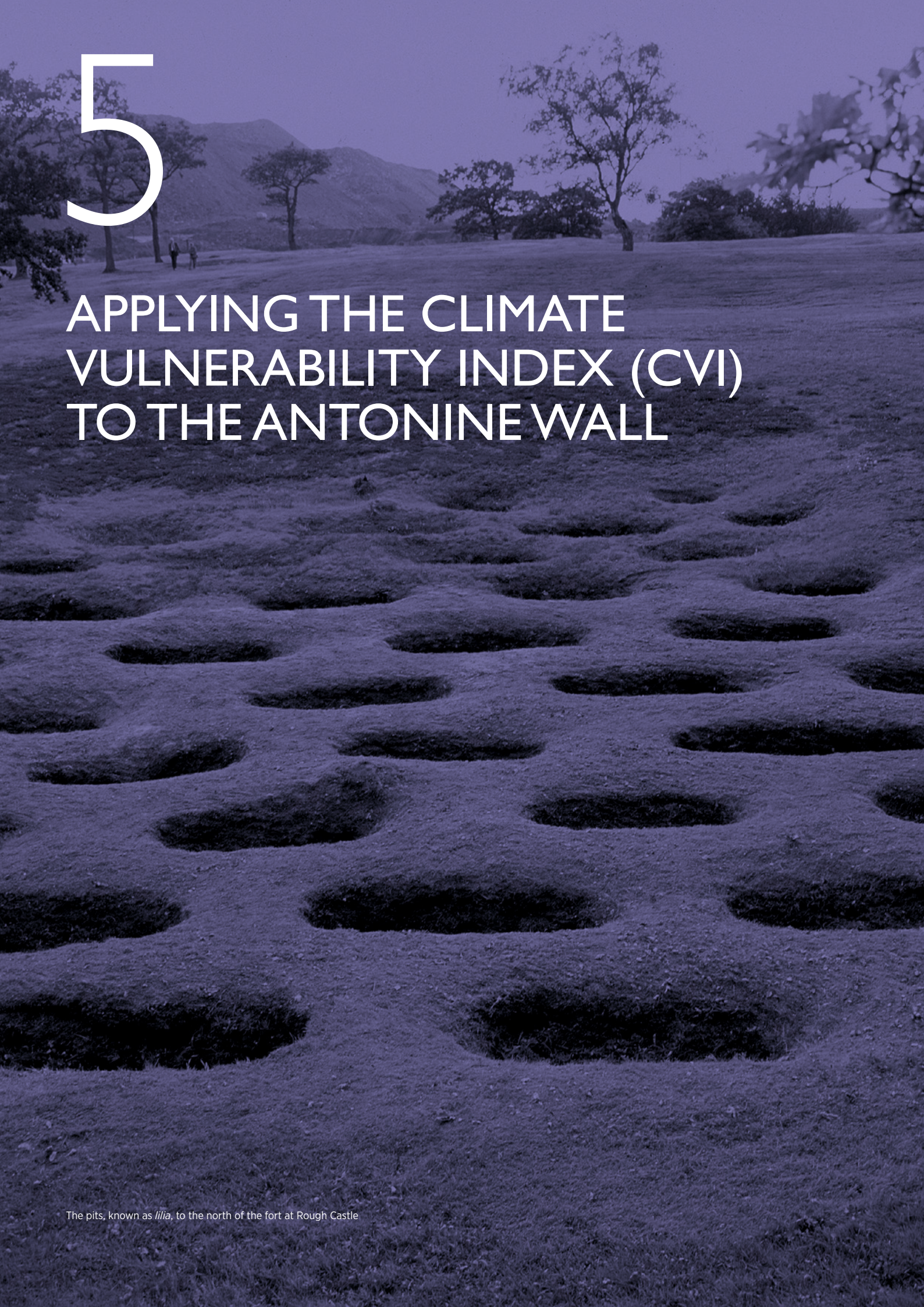
5

APPLYING THE CLIMATE VULNERABILITY INDEX (CVI) TO THE ANTONINE WALL



The pits, known as *lilia*, to the north of the fort at Rough Castle

The Climate Vulnerability Index (CVI) is a rapid assessment tool originally developed for application to all types of WH properties, but which has applicability for other types of heritage areas. The CVI framework builds upon the vulnerability framework approach described in the Intergovernmental Panel on Climate Change's 4th Assessment Report[1]. Vulnerability of OUV is determined by assessing the exposure, sensitivity, and adaptive capacity with respect to determined key climate stressors. The OUV Vulnerability becomes the exposure term to assess the vulnerability of the community associated with the property, combining with assessments of economic, social, and cultural dependency (sensitivity) and adaptive capacity (Figure 5.1). A customised spreadsheet-based worksheet is used to determine outcomes based on participant inputs. A more detailed outline of the CVI methodology is provided in the 2019 HONO CVI report[2]. The process for FRE: the Antonine Wall was undertaken in an online workshop over six half-days: 1-3 February (OUV Vulnerability) and 8-10 February (Community Vulnerability) 2022.

The CVI process employs plenary sessions and breakout groups. Plenary sessions were used for presentations, discussions and to compile information from the breakout groups. Breakout groups were conducted using the breakout feature within Zoom, the platform used for the online workshop. In all cases, outcomes from the groups were brought together in plenary to resolve any differences and reach the final conclusions.

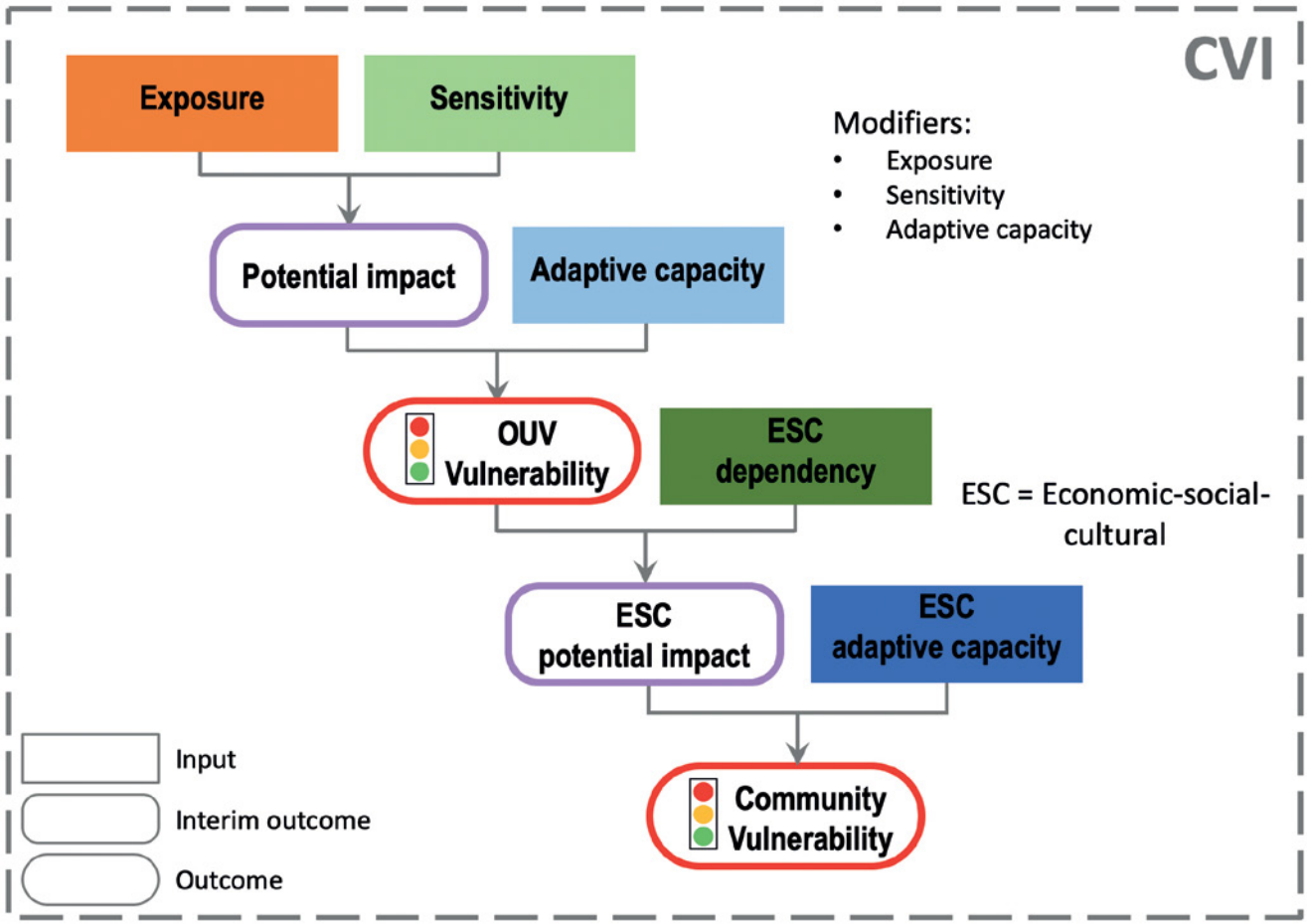
Workshop participants from a range of expertise and interest areas related to Antonine Wall worked through the following foundational steps:

+ Confirmed the key values for the FRE: the Antonine Wall (Table 2.1) derived from the Statement of OUV (Appendix 1)
+ Expanded the list of other Significant Property Values (SPVs; Appendix 5)
+ Identified the three key climate stressors that would be most impactful on the FRE: the Antonine Wall OUV; and
+ Identified the current condition and recent trend of the attributes of OUV (Table 2.1).

The following eight steps aligned with the CVI framework (Figure 5.1) were then conducted for the Antonine Wall:

1 Undertake a high-level risk assessment (**exposure** and **sensitivity**) to OUV of the chosen three key climate stressors within the agreed time frame (i.e. by 2050). This process also considered the influence of important **modifiers** that may vary these assessments
2 Use the spreadsheet-based worksheet to identify the **potential impacts** of the three key climate stressors on the attributes
3 Consider the likely **adaptive capacity** of OUV in relation to the three key climate stressors
4 Use the worksheet to determine the **OUV Vulnerability** to the three key climate stressors
5 Consider, and assess separately, the relevant **economic, social** and **cultural (ESC) dependencies** upon the WH property
6 Use the worksheet to determine the **ESC potential impact** to the ESC dependencies upon the WH property
7 Consider, and assess separately, the level of **ESC adaptive capacity** for the same ESC components considered above; and
8 Use the worksheet to determine the **Community Vulnerability.**

Figure 5.1 The CVI framework to undertake rapid assessment of climate change vulnerability of World Heritage properties and associated communities.

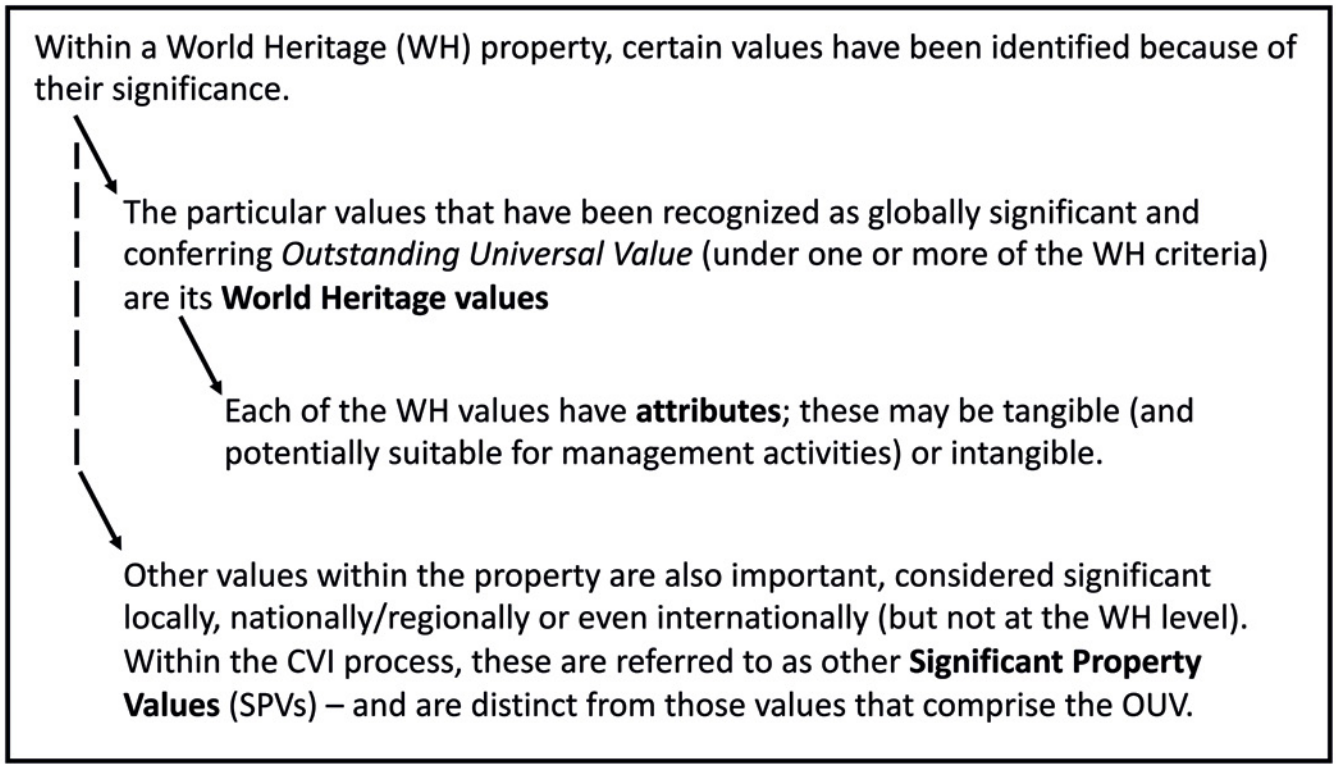


5.1 Preparatory steps

The narrative within the Statement of OUV (SOUV) for the FRE describes the values and attributes of the property in broad terms, with text elements specific to the Antonine Wall component. An initial list of key values for the Antonine Wall was derived by grouping excerpts from the SOUV by the project Steering Committee in advance of the workshop (Table 2.1). While these key values encapsulate aspects of the Roman Empire, its network of frontier walls, and their associated architecture and engineering, there are also values focused on the Antonine Wall component of the property, such as the stone and turf construction and the interchange of skills through the construction. Each of these key values are associated with attributes that can be tangible (and therefore manageable) or intangible. Attributes are derived from excerpts from the SOUV (or refer directly to excerpts from the SOUV) and express the key values in a more quantifiable way.

In addition to those values and attributes represented in the SOUV, there are typically other values that are not part of the Statement but have significance locally, at a national or regional scale, or even internationally, but not recognised as part of the UNESCO WH values. Within the CVI methodology, these are referred to as other Significant Property Values (SPVs). These key values, attributes and other SPVs can be considered to sit within a hierarchy of values (Figure 5.2).

Figure 5.2 Hierarchy of terminology describing World Heritage and other values and attributes as applied within the CVI process (after Heron *et al.* 2020)[3].



Pre-workshop tasks

Prior to the workshop, participants were asked to:

- read the FRE Statement of Outstanding Universal Value (SOUV)
- understand how the breakdown of key values and attributes was developed for the Antonine Wall component from the FRE SOUV
- review the Antonine Wall Management Plan (2014-2019) and relevant sections of the HES Climate Change Risk Assessment
- watch a descriptive overview video of the CVI process; and
- go through information provided regarding economic, social, and cultural connections with the Antonine Wall.

5.2 Climate scenario and timeframe

Presentations were given during the workshop by David Harkin to provide background on global climate change and summarise climate projections relevant to the Antonine Wall. Information from these has been included in this report (Section 4). These presentations also informed the selection of a future timeframe to use during the vulnerability assessments as c. 2050, noting that the importance of longer-term considerations would be captured with regular reviews of outcomes (e.g. on a 5-10 year basis). Participants selected a high-emissions climate projection scenario, as given by Representative Concentration Pathway (RCP) 8.5, noting uncertainty in policy adherence to lower emissions trajectories and a precautionary approach of planning based on the worst-case scenario.

A list of 15 climate stressors had been provided to participants before the workshop (Table 5.1). Definitions of these were clarified during the workshop and the likely magnitude and rate of change, as well as level of certainty in the predictions, were based on information provided in the climate projections presentation.

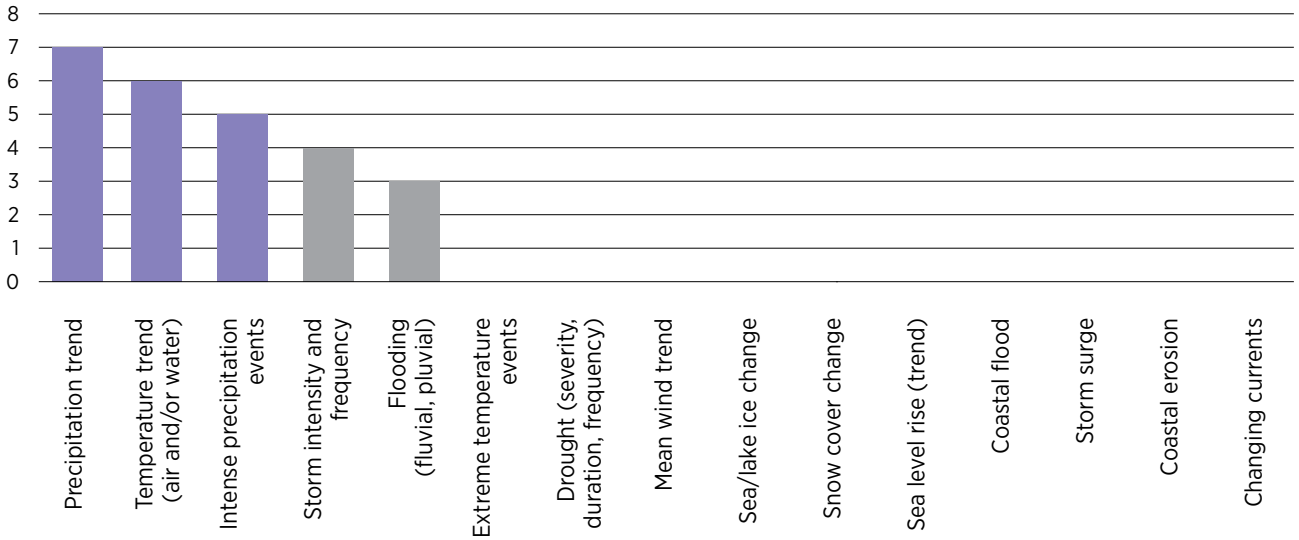
In breakout groups, participants analysed which climate stressors would be likely to have the most impact on each of the key values of OUV (Table 5.1) within the c. 2050 timeframe. Results from the breakout groups were compiled and climate stressors within the top three selected for each value (including equal-third) were used to rank the stressors (Table 5.1, Figure 5.3). Implicit within the methodology used to determine the three key climate stressors is an equal weighting across all attributes of OUV. Participants discussed in plenary the comparative importance of key values and attributes, and the level of impact of climate stressors upon these. Workshop participants determined the three key climate stressors to consider in the CVI analysis as:

+ Precipitation Trend
+ Temperature Trend (air and/or water); and
+ Intense Precipitation Events.

Table 5.1 Climate stressors identified as likely to have the greatest impact for each of the eight key values of OUV for c. 2050. Marked cells indicate that the climate stressor was in the top three responses (including equal-third) for each key value.

	Temperature trend (air and/or water)	Extreme temperature events	Precipitation trend	Intense precipitation events	Flooding (fluvial, pluvial)	Drought (severity, duration, frequency)	Mean wind trend	Storm intensity and frequency	Sea/lake ice change	Snow cover change	Sea level rise (trend)	Coastal flood	Storm surge	Coastal erosion	Changing currents
Key values of OUV	**Climate stressors**														
Most highly developed frontier	X		X	X				X							
Artificial barrier	X		X	X				X							
Upstanding and underground remains	X		X	X				X							
Landscape and Topography			X	X	X										
Conservation and Ownership	X		X		X										
Land-use change	X		X		X										
Living Communities (then and now)	X		X	X				X							
Total	6	0	7	5	3	0	0	4	0	0	0	0	0	0	0

Figure 5.3 Histogram of the number of key values assessed as having a high likelihood of impact from each of 15 assessed climate stressors by c. 2050.



5.3 OUV Vulnerability

For the three identified key climate stressors (Precipitation Trend, Temperature Trend, and Intense Precipitation Events), assessments of **exposure** and **sensitivity** of the OUV system to each stressor were undertaken using a five-point categorical scale, adapted from categories used by IPCC and IUCN analyses (see [2] for details). Modifiers were also assessed to include effects of temporal scale and trend (for exposure), and spatial scale and compounding factors (for sensitivity). These assessments were undertaken in breakout groups, which provided the potential for a range of responses that were then discussed in plenary to resolve the final assessments.

Exposure to each of the key climate stressors was determined as **Very Likely** (>90%), with breakout groups showing a high degree of consistency for the initial assessment and modifiers. Sensitivity of OUV to all three stressors was initially assessed as **Moderate**. The **Moderate** level was maintained for Precipitation Trend after application of the modifiers (spatial scale and compounding factors), indicating that loss or alteration of some key WH values will occur, but not leading to a significant decline in OUV. In contrast, the modifiers raised the sensitivity to a **High** level for both Temperature Trend and Intense Precipitation Events, which are indicative of the potential for loss or significant alteration of many key WH values. Combining the exposure and sensitivity assessments, the **potential impact** was determined as **Extreme** (on a four point scale, Low to Extreme) for all three key climate stressors.

The capacity of a system to adapt to stress can mitigate (i.e. reduce) the potential impacts of that stress. **Adaptive capacity** of the OUV system was assessed for each key climate stressor by considering the levels of local management response and scientific/technical support (four-point scale), as well as the effectiveness of these to address impacts from each stressor (four-point scale).

In preparation for these assessments, participants were asked to brainstorm potential adaptive capacity options to mitigate climate impacts, and to identify associated key values (Table 5.2). These were subsequently prioritised by the level of feasibility and likelihood of undertaking. The prioritisations were categorised as High (for strategies already being considered), Potential (for those feasible but not yet in consideration) and Low (not currently feasible). The assessments of adaptive capacity were informed by these strategies, principally by those in the High category.

Table 5.2 Strategies considered in the assessment of adaptive capacity, prioritised into categories (see text), noting relevant key climate stressors and key values for each (refer to Figure 5.3 for the key climate stressors and to Table 2.1 for the key values)

Feasibility/ likelihood	Adaptive strategy	Relevant key climate stressors			Relevant key values						
		PT	TT	IPE	1	2	3	4	5	6	7
High	Formalise path network	x		x							
	Monitoring – citizen science/app, community engagement, soil sensors	x	x	x		■	■		■		■
	Reinstate previous drainage (unfill ditches), install underground system within and upstream of the property	x		x		■	■	■	■		
	Change tree management and plant vegetation to limit walking in ditch	x		x				■		■	
	Improve engineering solutions through research findings										
Potential	Farming incentives	x								■	
	Bank stabilisation	x		x		■	■		■	■	
	Build canopy over part of monument	x		x							
	Boardwalk at Rough Castle	x		x							
	Aerial viewing platform/ bridge over site at Rough Castle	x		x	■	■					
Low	Skyline (zip line)										
	Rebuild monument – modern materials would increase resilience	x	x	x			■		■		■
	Take ownership of all the Wall back into national care	x			■	■	■	■	■	■	■

For Precipitation Trend and Temperature Trend, the adaptive capacity was determined to be **Low** (second lowest on a four-point scale, Very Low to High), whilst for Intense Precipitation Events was assessed as **Moderate**, based on a higher level of effectiveness of the strategies considered. Incorporating these assessments within the CVI framework, **OUV Vulnerability** (three-point scale, Low to High) was determined to be **High** for Precipitation Trend and Temperature Trend, and **Moderate** for Intense Precipitation Events. The combined OUV Vulnerability for the Antonine Wall was determined as **High** (Table 5.3).

Table 5.3 Rapid assessment of OUV Vulnerability to identified three key climate stressors. Assessed values of exposure, sensitivity and adaptive capacity contribute to derived outcomes for potential impact and OUV Vulnerability. Colours refer to the elements of the CVI framework (Figure 5.1)

Key Climate Stressors:	Precipitation trend	Temperature trend (air and/or water)	Intense precipitation events
Exposure	Very likely	Very likely	Very likely
Temporal scale	On-going	On-going	Frequent
Trend	Moderate increase	Slow/Moderate increase	Moderate increase
Exposure	**Very likely** ○○○○●	**Very likely** ○○○○●	**Very likely** ○○○○●
Sensitivity	Moderate	Moderate	Moderate
Spatial scale	Localised/Extensive	Widespread	Localised/Extensive
Compounding factors	High probability	High probability	High probability
Sensitivity	**Moderate** ○○●○○	**High** ○○○●○	**High** ○○○●○
Potential impact	**Extreme** ○○○●	**Extreme** ○○○●	**Extreme** ○○○●
Local management response	Low	Low/Moderate	Low
Scientific/technical support	Moderate	Moderate	Moderate
Effectiveness	Low	Low	Low/Moderate
Adaptive capacity	**Low** ○●○○	**Low** ○●○○	**Moderate** ○○●○
OUV Vulnerability	**High** ○○●	**High** ○○●	**Moderate** ○●○
Combined OUV Vulnerability	**High** ○○●		

5.4 Community Vulnerability

Vulnerability of the community associated with the WH property was assessed through the consideration of economic, social and cultural (ESC) components of dependency (i.e. the sensitivity term) and adaptive capacity:

+ **Dependency** reflects the extent to which a decline in WH values due to the key climate stressors will affect economic, social and cultural connections in the future, using the previously defined timeframe (i.e. c. 2050). Note that these effects may be positive or negative (four-point scale in each direction, High-negative to Minimal-negative then Minimal-positive to High-positive) in their nature (e.g. some business types may experience an increase in value under projected climate change).
+ **Adaptive capacity** reflects the current level of capacity within each component to adapt in the face of a decline in WH values due to the key climate stressors (four-point scale, Minimal to High). Note that adaptive capacity only has a positive directionality.

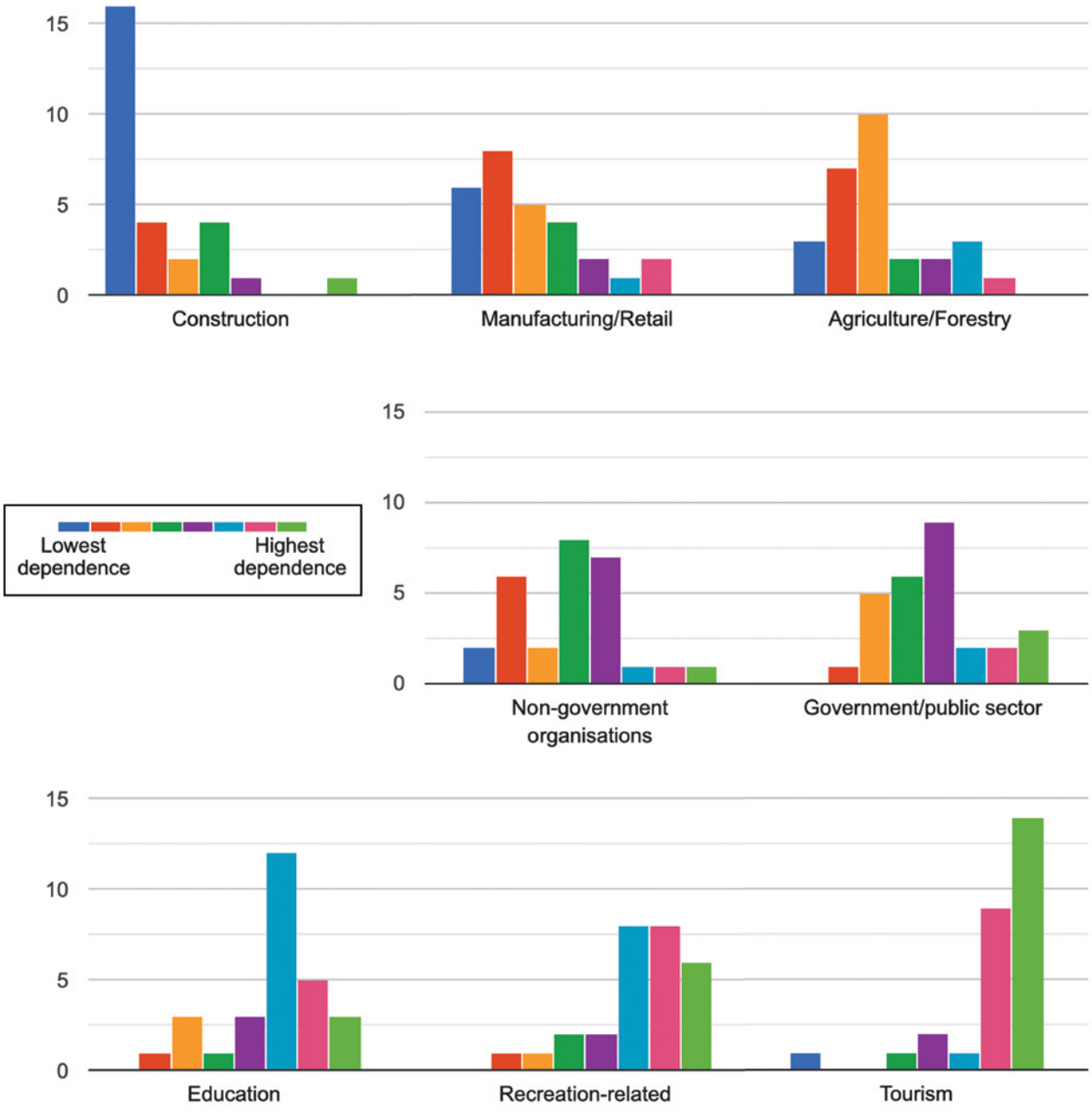
Assessments were undertaken in small breakout groups and resolved in plenary.

A specific scenario was presented to participants for discussion, the purpose of which was to guide assessment of likely climate change impacts on the economic, social, and cultural aspects. The selected scenario elements were

i Precipitation Trend: wetter winters and drier summers, trending towards torrential rain rather than Scottish drizzle
ii Temperature Trend: warmer winters & hotter summers (1-1.5°C above 1981-2000 baseline, c. 2050); and
iii Intense Precipitation Events: increased frequency of heavy (torrential) rainfall events – summers with heavier bursts between dry spells; and winters with increased intense rain events.

The economic component includes only tangible (i.e. market or direct) economic effects on business types that are directly dependent upon the WH property. As noted in Section 3.3, eight groups of business types were considered: Tourism; Recreation-related; Agriculture/Forestry; Manufacturing/Retail; Construction; Education; Government/Public sector; and Non-government organisations. Participant responses to an online poll, conducted on the days between the OUV and Community Vulnerability workshop sessions, ranked these business types by their dependence upon the WH values, revealing Tourism, Recreation-related and Education as the most dependent; and Construction, Manufacturing/Retail, and Agriculture/Forestry as the least dependent (Figure 5.4).

Figure 5.4. Participant rankings of the eight business types by their dependence upon World Heritage values.



Assessments of economic dependency and adaptive capacity were undertaken by each breakout group, drawing upon the baseline information on economic valuation that had been presented to the workshop (Figure 3.5). Economic dependency was assessed for each business type on an eight-point scale ranging from High-positive down to Minimal-positive then Minimal-negative down to High-negative; adaptive capacity was assessed only with a positive directionality with the four-point scale from High down to Minimal. Participant rankings of relative dependency (Figure 5.4) were considered for the final assessment (in plenary). Overall, the economic dependency was assessed as **Minimal-negative** (i.e. a negative impact at a Low level), whilst the adaptive capacity was **Moderate** (Table 5.4).

Intangible effects (e.g. social cohesion, aesthetics) were considered within the social and cultural components. An important distinction between these components is that social connections require a physical interaction with the property (i.e. visit), whereas cultural connections can exist without a physical interaction. For each component, three groupings of people were considered to assess dependency and adaptive capacity: local, domestic, and international.

Social indicators used to inform the assessments can be considered within four categories: Human capital; Social capital; Natural capital; and Built capital (after [4]). Social connections were considered by workshop participants to be predominated by local people, and this was taken into consideration for the final assessment. Social dependency (eight-point scale) was assessed as **Moderate-negative**, whilst the adaptive capacity (four-point scale) was **Moderate** (Table 5.4).

Cultural indicators can also be considered within four categories: Self-centric; People-centric; Environment-centric; and Pleasure-centric (after [5]). Cultural dependency (eight-point scale) was assessed as **Moderate-negative**, whilst the adaptive capacity (four-point scale) was **Moderate** (Table 5.4).

Combining the three components, the overall ESC dependency was determined as **Low-negative**, which, combined with the OUV Vulnerability (as the exposure term), resulted in the ESC potential impact being assessed as **Moderate** (three-point scale, Low to High; Table 5.4). The combined ESC adaptive capacity was assessed as **Moderate** (three-point scale, Low to

Table 5.4 Rapid assessment of Community Vulnerability to identified three key climate stressors. Assessed values of economic, social and cultural (ESC) dependency (sensitivity, ranging from negative to positive) and adaptive capacity contribute to derived outcomes for ESC potential impact and Community Vulnerability

Economic	Minimal-negative
Social	Moderate-negative
Cultural	Moderate-negative
ESC dependency	**[-] ○ ○ ● ○ Low-negative ○ ○ ○ ○ [+]**
ESC potential impact	**Moderate ○ ● ○**
Economic	Moderate
Social	Moderate
Cultural	Moderate
ESC adaptive capacity	**Moderate ○ ● ○**
Community Vulnerability	**Moderate ○ ● ○**

High). These outcomes determined the Community Vulnerability as **Moderate** (three-point scale, Low to High; Table 5.4).

It is of note that the CVI process focuses the analysis on the greatest level of impacts, such as through selecting the three climate stressors considered to be most impactful. This is appropriate as the loss of integrity and/or authenticity of one component of OUV is contrary to the tenets of WH – to preserve and maintain the property for the values described in the Statement of OUV. Furthermore, there will always be uncertainties in future impacts of projected climate change, and especially in how interactions between impacts may occur (synergistically, antagonistically, independently). Given both the high standard required within WH and the uncertainty of future impacts, the described bias within the CVI process is consistent with the precautionary principle[6].

5.5 Summary

Precipitation Trend, Temperature Trend and Intense Precipitation Events were identified as the three climate stressors likely to most impact the Antonine Wall. Potential impact from each of these key stressors was scored as **Extreme**. With adaptive capacity to mitigate impacts being assessed as **Low** for the two Trend stressors, their OUV Vulnerability was assessed as **High**, whilst a **Moderate** level of adaptive capacity with respect to Intense Precipitation Events led to a **Moderate OUV Vulnerability**. Overall, the OUV Vulnerability was determined to be **High**. Impacts from the key climate stressors were judged as likely to lead to a negative future impact on the economic (Minimal level), social (Moderate) and cultural (Moderate) aspects of the community associated with the Antonine Wall, resulting in a **Moderate** level of potential impact on the community. As the adaptive capacity of the community was determined to currently be at a **Moderate** level, the overall **Community Vulnerability** was assessed to be in the **Moderate** category.

With a length of ~60km, there will be variations in vulnerability of both values and communities along the span of the Antonine Wall; however, this assessment provides an overall perspective on future risks from climate change. Though around only one-third of the property is visible, cascading impacts from the assessed key climate stressors can affect various values above and below ground, e.g. increased temperature and rainfall can alter soil structure and stability, which would lead to amplified impacts on archaeological and arboreal property values. Looking beyond the Antonine Wall, the outcomes here provide insight for the other components of the FRE property, with the acknowledgement that the other locations could face impacts predominated by other climate stressors or with different projected trajectories of change. A full picture of climate vulnerability for the FRE property, as assessed using the CVI process, would require complementary applications for the other components.

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6 NEXT STEPS

Road signs for the Antonine Wall

6.1 Findings from the CVI process

The Antonine Wall was determined to have High vulnerability to the impacts of the three key climate stressors identified by the workshop participants. By c. 2050, there is the potential for loss or significant alteration of many key WH values that comprise the OUV of the property. Each of the key climate stressors was considered in terms of how it would be expressed (acute or chronic) and the degree of confidence in the climate projections.

i OUV Vulnerability

The three key climate stressors identified to have the greatest potential impact on the heritage values of the Antonine Wall were:

+ Precipitation Trend: A High level of vulnerability of the WH values to increased rainfall, particularly in winter, that is projected to come in fewer, more-intense downpours. In recent history, rainfall has increased across the area (greater increase in the west than the east) leading to increased erosion and loss of tree cover through windthrow. The Very Likely probability of exposure combined with Moderate sensitivity, led to the assessment of Extreme potential impact on OUV from this stressor.
+ Temperature Trend: A projected increase of 1-1.5°C from 1981-2000 levels in 2050 has a high level of confidence in the climate models. Potential impacts are anticipated on both the frontier landscape and the archaeology at an extreme level, based on assessments of Very Likely exposure and High sensitivity of the values.
+ Intense Precipitation Events: Projected increases in the frequency and intensity of heavy rainfall events underpinned the assessments for this key climate stressor. Combining the Very Likely exposure to events with a High level of sensitivity of the values indicated an Extreme potential impact.

The capacity to adapt in the face of potential impacts from each of the stressors was considered to be Low or Moderate, which led to the overall OUV Vulnerability determined as **High**.

ii Community Vulnerability

Economic, social, and cultural aspects were determined to have a **Moderate** vulnerability. This was derived from the High OUV Vulnerability, the economic dependence of key business types upon the property, the local population's connection with the property, and the assessed Moderate level of adaptive capacity across the ESC components.

6.2 Gaps Identified

i Research gaps

It was noted that the new Research Agenda for the Antonine Wall was almost complete and likely to be published in 2023[1]. Therefore, there was the opportunity to add gaps identified during the CVI workshop to the forthcoming Agenda, including climate research, particularly the impacts of climate change on turf structures.

Research gaps identified ranged from archaeological through to management. In the area of archaeological research, it was recognised that a better understanding of the turf superstructure of the monument is needed (see section 3.2), including soil fauna (microbes and bacteria) which may be sensitive to changes in temperature and rain; and hydrological movement (building on the research presented by Hazel Blake for Rough Castle – section 2.6), including how visitor footfall affects the soil system.

Management research includes trying to understand if areas of slumping around the monument can be attributed to deforestation; and the impact of mining and open casts on and near the site (particularly if affected by flooding). Additional climate research (e.g. the impact of temperature trend) is needed. It was noted that orange mould occurs at the Rowantree Burn and this should be tested to see if the water contains rust or iron. A better understanding of the natural capital of the site would also be useful.

Understanding the interaction of people with the monument is an under-researched area: what motivates the visitors to the site? Who is local and using it as an amenity area and who is a tourist coming from further afield? Intangible connections to the site are largely unknown; research into understanding social media uses and interaction is ongoing (by PhD student and workshop participant Alex Hiscock) which will aid with monument management in the future.

ii Policy and guidance gaps

It was recognised that, due to the length of the Wall with multiple owners and managers (five Local Authorities and HES), there were different interpretations of handling development approvals (sometimes governed by local political will) and different capacities and capabilities for management. A review of the policy and practice (e.g. application of the 1979 act[2]) would be necessary to enable more consistent management approaches.

The overall profile of the monument needs to be raised, both at the local and national level. Better understanding of visitors (see Research Gaps – section 6.2i) would enable support and political buy-in for the ongoing investment in the monument and its communities. A landscape management and biodiversity officer will enable better integration of historic and natural environment concerns.

6.3 Lessons for other properties and recommendations for Scottish World Heritage properties

The CVI for the Antonine Wall was the third CVI workshop in Scotland after the successful cultural pilot at the Heart of Neolithic Orkney in April 2019[3] and the online workshop for the Old and New Towns of Edinburgh in May-June 2021[4]. Thanks to a successful application to the Royal Society of Edinburgh for their Arts and Humanities Research Network grants, a project was set up by Historic Environment Scotland and James Cook University to further apply the CVI to WH properties in Scotland, leading to the assessment of Edinburgh in 2021, the Antonine Wall in early 2022 and St Kilda in the Autumn of 2022.

The application of the CVI to the Antonine Wall was an online CVI with two 'control rooms' established: in James Cook University in Townsville, Queensland; and in Historic Environment Scotland in Edinburgh. Due to the time zone differences, the workshops were held over six mornings across two weeks with the first week (three mornings) focusing on OUV Vulnerability and the second week (three mornings) on Community Vulnerability.

The results proved invaluable for various reasons, including:

+ Bringing together a range of stakeholders with different interests and different perspectives to discuss the climate impacts on the Wall (including the natural as well as the historic environment)
+ Providing an assessment which will feed into the new Management Plan for the Wall
+ Included representatives from the other two component parts of the FRE WH property: Hadrian's Wall and the Upper German-Raetian *Limes*
+ Identifying knowledge gaps required in order to manage the climate impacts on the monument in the future.

The values-based, science-driven, and community-focused approach of the CVI application works well within current Scottish Government agendas and is likely to fit well with the forthcoming new *Our Place in Time* Historic Environment Strategy for Scotland (due 2023). The CVI has a valuable role to play in the development of Management Plans for Scotland's WH, ensuring a consistent approach to the impacts of climate change.

As the first application to the component part of a transboundary property, the workshop highlighted some of the difficulties in creating the key values from a SOUV which covers three different component parts. Furthermore, in order to manage the whole of the FRE consistently, it would be important to have further CVI workshops for the other two component parts, with a recommendation that the CVI for the Upper German-Raetian *Limes* be conducted in German in order to maximise participation.

6.4 Revisiting the CVI process

The CVI workshop was extremely timely, coming towards the end of the 'Rediscovering the Antonine Wall' project as the Steering Group and co-ordinator work on the creation of the new Management Plan.

The rapid assessment approach of the CVI means that it can be periodically repeated to determine if changes have occurred to the condition of the values or attributes (and hence to the vulnerability of OUV) and to the community associated with the Antonine Wall. It is also recommended that the CVI process be undertaken to enable systematic input into WH Periodic Reports (approximately every six years).

A review of the current Antonine Wall Management Plan is underway. In order to ensure that trends and results are easily comparable, it is recommended that the same or similar CVI methodology be applied in any follow-up climate-related workshops, and prior to the inception of the 2023+ Management Plan review process. Re-assessment may also occur if there is any updated release of climate change projections.

6.5 Future applications

The successful implementation of the CVI process in the context of the Antonine Wall demonstrates the capability of this tool to be applied to a component part of a non-contiguous transboundary property. It is recommended that the CVI be applied to the other two component parts of the FRE property, and the other two WH properties within the Frontiers cluster.

Due to similarities in climate, the results presented in this report may also be of interest to other WH properties and heritage sites in the UK and Ireland.

Finally, this report will benefit other WH properties worldwide that are considering undertaking a rapid climate change vulnerability assessment to provide evidence and support the management of their site.

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Sculptures at Duntocher Fort Playpark in Goldenhill Park, Clydebank

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Many people contributed to the success of the CVI workshop for the Antonine Wall:

- The Steering Group was established:
  - Scott Heron and Jon Day – the CVI developers from James Cook University
  - Rebecca Jones, Ewan Hyslop, Mairi Davies, and David Harkin from Historic Environment Scotland
- Preparation in advance of the workshop was undertaken by Rebecca Jones and Patricia Weeks (formerly the Antonine Wall coordinator) with support from Laura Mackenzie. After the workshop, Riona McMorrow (Antonine Wall coordinator since February 2022 whose second day in the job was the first day of the CVI workshop) has made a major contribution to this report, and will be implementing it through the new Management Plan (in development)
- The break-out group leaders: Mairi Davies, Stefan Sagrott, Lisa Brown, Kevin Grant and Lyn Wilson
- The six note-takers, without whose detailed notes this report would not have been possible: Aura Bočkutė, Rachel Nicholson, Alex Hiscock, Amy Baker, Roland Laposi, and Molly Harkins
- Rachel Nicholson prepared the draft list of other Significant Property Values used as the basis for the workshop discussion (Appendix 5)
- Technical support for the Edinburgh control room was provided by Max Carnie from Mallard Productions, who celebrated his 21st birthday during the workshop
- Technical and logistical support at James Cook University, Townsville, was provided by Riccardo Losciale
- Laura Mackenzie from Historic Environment Scotland undertook all the administrative coordination for the workshops, helped by Mike Elliot; she also coordinated the production of this report and all the images
- Michelle Moore from Historic Environment Scotland undertook the copy editing of this report
- All the participants listed in Appendix 4 gave their time and expertise to the workshop which greatly benefited from the diverse range of perspectives and views about the Antonine Wall.

APPENDICES

Aurelius Roman head sculpture at Lambhill Stables, Glasgow

APPENDIX 1

Frontiers of the Roman Empire: the Antonine Wall: Statement of Outstanding Universal Value
This is the statement for the whole of the Frontiers of the Roman Empire (FRE) World Heritage property, and therefore includes Hadrian's Wall and the Upper German–Raetian *Limes*. It has been approved by UNESCO as the reason for the inscription of the property / site.

The segments in bold are the sections of text which were used to create the key values for the Antonine Wall CVI application – therefore it is only one part of the property (the Antonine Wall) that has been highlighted, plus relevant parts of the overall sections.

Brief Synthesis

The Roman Empire, in its territorial extent, **was one of the greatest empires history has known**. Enclosing the Mediterranean world and surrounding areas, it was protected by a network of frontiers stretching from the Atlantic Coast in the west to the Black Sea in the east, from central Scotland in the north to the northern fringes of the Sahara Desert in the south. It was largely constructed in the 2nd century CE when the Empire reached its greatest extent. This frontier could be an artificial or natural barrier, **protecting spaces or a whole military zone**. Its remains encompass both **visible and buried archaeology on, behind and beyond the frontier**.

The property consists of three sections of the frontier: Hadrian's Wall, the Upper German–Raetian *Limes* and the Antonine Wall, **located in the northwestern part of the Empire**, constituting the **artificial boundaries** of the former Roman provinces Britannia, Germania Superior and Raetia: running 130km from the mouth of the River Tyne in the east to the Solway Firth, Hadrian's Wall was built on the orders of the Emperor Hadrian in 122 CE as a continuous linear barrier at the then northernmost limits of the Roman province of Britannia. The frontier extended a further 36km down the Solway coast as a series of intervisible military installations. It constituted the main element in a controlled military zone across northern Britain. The Wall was supplemented by the ditch and banks of the *vallum*, supporting forts, marching camps and other features in a wide area to the north and south, linked by an extensive road network. It illustrates an ambitious and coherent system of defensive constructions perfected by engineers over the course of several generations and is outstanding for its construction in dressed stone and its excellent use of the spectacular upland terrain through which it passed.

The Upper German-Raetian *Limes* covers a length of 550km and runs between Rheinbrohl on the Rhine and Eining on the Danube, built in stages during the 2nd century. With its forts, fortlets, physical barriers, linked infrastructure and civilian architecture it exhibits an important interchange of human values through the development of Roman military architecture in previously largely undeveloped areas thereby giving an authentic insight into the world of antiquity of the late 1st to the mid-3rd century CE. It was not solely a military bulwark, but also defined economic and cultural limits. Although cultural influences extended across the frontier, it did represent a cultural divide between the Romanised world and the non-Romanised Germanic peoples. In large parts it was an arbitrary straight line, which did not take account of the topographical circumstances. Therefore, it is an excellent demonstration of the Roman precision in surveying.

The Antonine Wall was **built under the Emperor Antoninus Pius in the 140s CE as an attempt to conquer parts of northern Britain** and extends for some **60km across central Scotland** from the **River Forth to the River Clyde**. Through its **military and civil constructions**, it **demonstrates cultural interchange through the extension of Roman technical skills, organisation and knowledge** to the furthest reaches of the Empire. It **embodies a high degree of expertise in the technical mastery of stone and turf defensive**

constructions. As it was in **use for only a single generation**, it provides a **snapshot of the frontier at a particular point in time** and offers a **specific insight into how the frontier was designed and built**. Together, the remains of the frontiers, consisting of vestiges of **walls, ditches, earthworks, fortlets, forts, fortresses, watchtowers, roads and civilian settlements**, form a **social and historical unit that illustrates an ambitious and coherent system of defensive constructions perfected by engineers over the course of several generations**. Each section of the property constitutes an **exceptional example of a linear frontier**, encompassing an **extensive relict landscape** which r**eflects the way resources were deployed in the northwestern part of the Empire** and which displays the unifying character of the Roman Empire, through its common culture, but also its **distinctive responses to local geography and climate**, as well as political, social and economic conditions.

Criterion (ii): The extant remains of the fortified German *Limes*, Hadrian's Wall and Antonine Wall constitute significant elements of the Roman Frontiers present in Europe. With their forts, fortlets, walls, ditches, linked infrastructure and civilian architecture they exhibit an important interchange of human and cultural values at the apogee of the Roman Empire, through the **development of Roman military architectur**e, extending the technical knowledge of construction and management to the very edges of the Empire. They reflect the **imposition of a complex frontier system on the existing societies** of the northwestern part of the Roman Empire, introducing for the first time **military installations and related civilian settlements, linked through an extensive supporting network**. The frontiers did not constitute an impregnable barrier, but c**ontrolled and allowed the movement of peoples**: not only the military units, but also **civilians and merchants**. Hence, they triggered the **exchange of cultural values through movement of soldiers and civilians from different nations**. This entailed profound changes and developments in the respective regions in terms of **settlement patterns, architecture and landscape design and spatial organisation**. The frontiers still **today** form a **conspicuous part of the landscape**.

Criterion (iii): As parts of the Roman Empire's general system of defence the German *Limes*, Hadrian's Wall and the Antonine Wall have an extraordinarily high cultural value. They bear an exceptional testimony to the maximum extension of the power of the Roman Empire through the consolidation of its northwestern frontiers and thus constitute a **physical manifestation of Roman imperial policy**. They illustrate the Roman Empire's ambition to dominate the world in order to establish its law and way of life there in a long-term perspective. They witness Roman colonisation in the respective territories, the **spread of Roman culture and its different traditions – military, engineering, architecture, religion management and politics** – and the **large number of human settlements associated with the defences which contribute to an understanding of how soldiers and their families lived** in this part of the Roman Empire.

Criterion (iv): The fortified German *Limes*, Hadrian's Wall and the Antonine Wall **are outstanding examples of Roman military architecture and building techniques and of their technological development**, perfected by engineers over the course of several generations. They demonstrate the **variety and sophistication of the Romans' responses to the specific topography and climate** as well as to the political, military and social circumstances in the northwestern part of the Empire which spread all around Europe and thereby shaped much of the subsequent development in this part of the world.

Integrity

The inscribed components **convey the extraordinary complexity and coherence of the Frontiers of the Roman Empire** in northwestern Europe. Although **some parts have been affected by land use change and natural processes**, the integrity of the property is demonstrated through its visible remains and buried archaeological features. **Their state of survival has been researched in many areas. Several areas of the frontier have been built over, but where significant archaeological remains have been proven to exist they have been included in the property**.

About four-fifths of the line of Hadrian's Wall runs through open country. Within the central 45km of its course, the remains are in an exceptionally good state of preservation, surviving as part of a landscape which still contains significant visible traces of the Roman military presence. Even outside this central zone, many individual sites are well-preserved.

As a whole, the Upper German-Raetian *Limes* is preserved in its historical form. About half of its length is still visible or identical with a current border or way. As with the majority of archaeological monuments, its value lies in the combination of visible earthworks and buried remains.

About **one-third of the Antonine Wall is visible today as a complex series of earthworks and associated structures**. Roughly **another third lies in open countryside, but its line is not visible. The final third lies under urban areas.**

Authenticity

The inscribed component parts have a high level of authenticity, with each having been verified through extensive study and research. The **materials and substance of underground archaeological remains are well-preserved, as are upstanding and visible remains**. The **form and design of each representative part of the frontier and its associated structures are clear and comprehensible. Later development overlying parts of the frontier are treated as vertical buffer zones**. There are a number of reconstructions of elements of the frontier, such as forts and watchtowers. Reconstructions since 1965 are not considered as part of the serial property, but also act as vertical buffer zones.

The form and design of Hadrian's Wall, in particular its linear character, and its architectural and military elements are still easy to understand, and its location and setting in the landscape can be clearly appreciated. Upstanding parts of the property have been conserved in accordance with the highest standards and are in a good state of repair.

Much of the Upper German-Raetian *Limes* is underground, never excavated or backfilled. Excavated parts have then been properly conserved and presented by symbolic delineation above ground, protecting their authenticity as well as the setting and integrity of the surroundings. In some cases the authenticity has been compromised by reconstructions erected before the site was inscribed.

The **remains of the Antonine Wall exist in a generally good condition and visible sections sometimes have significant heights and depths. Conservation and consolidation measures that have been carried out in the interest of better understanding and protection fit in with the setting of the property** and do not diminish its authenticity.

Protection and management requirements

At the international level, the States Parties have established an integrated management system consisting of three closely cooperating and interacting bodies: the Inter-Governmental Committee (IGC) to oversee and coordinate the overall management at an international level; the Management Group which assembles those directly responsible for the site management of the property and provides the primary mechanism for sharing best practice; and the Bratislava Group, an international advisory body with expert members from States Parties, with inscribed or potential parts of the Frontiers of the Roman Empire World Heritage property.

At the national level, each State Party protects its part of the property through appropriate national legislation and regulation. The national management systems address identification and definition of the site's significance, its conservation, access, the interests and involvement of all stakeholders and its sustainable economic use.

Within each State Party's existing legislative and management systems an appropriate management system has been developed, expressed through a regularly updated Management Plan for the identification, protection, conservation, and sustainable use of the respective component part.

All parts of Hadrian's Wall within the World Heritage property are protected by designation under the Ancient Monuments and Archaeological Areas Act 1979 and through the Town and Country Planning Act 1990, and the Planning (Listed Buildings and Conservation Areas) Act 1990 that control planning and development in England. Hadrian's Wall is also covered by the guidance given in the National Planning Policy Framework 2012 and the National Planning Practice Guidance 2013. Local Plans produced by the local planning authorities on the line of the Wall contain appropriate policies to protect the World Heritage property. The site benefits from other designations such as National Parks, Areas of Outstanding Natural Beauty and the Roman Wall Escarpment Site of Special Scientific Interest. Parts of the property are managed by eight different bodies for public access, but the vast bulk is in private ownership. The Hadrian's Wall Partnership Board brings together key national and local stakeholders and sets the strategy for the effective management of the property and oversees a network of specialist topic groups.

Within Germany's federal legal systems, the cultural heritage is protected by the different monuments protection laws of the Länder (Federal States). These ensure protection, promotion, conservation, and enhancement of the World Heritage property. All inscribed elements and their buffer zones are respected within the spatial planning system. On the basis of a general Management Plan, detailed *Limes* Development Plans form the background for actions within each of the Länder. For coordination across the Länder, the Deutsche Limeskommission was founded in 2003. Most parts are in private ownership, but increasing parts are owned by the public.

The Antonine Wall is protected by designation under the Ancient Monuments and Archaeological Areas Act 1979, and through the legislation that guide planning and development in Scotland –the Town and Country Planning (Scotland) Act 1997, the Planning etc. (Scotland) Act 2006, and the Planning (Listed Building and Conservation Areas) (Scotland) Act 1997. It is covered by national policy for the historic environment set out in the Scottish Historic Environment Policy and Scottish Planning Policy. **Policies to protect, promote, conserve and enhance the property are included in local authority development plans and strategies**, supported by Supplementary Guidance. **Most of the Antonine Wall is in private ownership, but some sections are in the care of local authorities and Historic Environment Scotland.**

APPENDIX 2

The Climate Vulnerability Index (CVI) process for the Antonine Wall

The CVI workshop for the Antonine Wall component of the FRE WH property followed the process outlined in the reports for Orkney[1] and the Wadden Sea[2]. The workshop was conducted online using the Zoom platform, due to travel restrictions related to the Covid-19 pandemic. The six workshop sessions spanned two consecutive weeks, with each session approximately four hours in duration. The Zoom platform enabled plenary and breakout sessions to be conducted within a single video-conference event. Inputs from breakout groups were collected via Google Sheets. Workshop registration prior to, surveys conducted as part of the process during, and participant feedback following the workshop were undertaken using Google Forms.

Cited references

1 Day JC, Heron SF, Markham A, Downes J, Gibson J, Hyslop E, Jones RH, Lyall A (2019) Climate risk assessment for Orkney World Heritage: An application of the Climate Vulnerability Index. Historic Environment Scotland, Edinburgh

2 Heron SF, Day JC, Zijlstra R, Engels B, Weber A, Marencic H and Busch JA (2020) Workshop report: Climate Risk Assessment for Wadden Sea World Heritage property. Application of the Climate Vulnerability Index – Outstanding Universal Value (OUV) Vulnerability. Common Wadden Sea Secretariat, Wilhelmshaven, Germany

APPENDIX 3

CVI workshop schedule
1-3 & 8-10 Feb 2022

Tuesday 1st February 2022
08.00-12.00

1 Overview of workshop aims, explanation of sessions and how all would work, introductions by all participants (60 min)

AIM 1: Understand the Climate Vulnerability Index (CVI) framework and its application in the Frontiers of the Roman Empire: the Antonine Wall (FRE AW)

2 Overview of CVI concept (10 mins)

AIM 2: Understand the significant values that comprise the OUV for FRE AW; and assess condition and trend. Discuss other significant values (i.e. other Significant Property Values, SPVs / attributes)

3 Statement of OUV and the table of key values, presentation, and discussion (15 min)
4 Discussion of current condition of key values and recent trend (since date of inscription) (60 min)
5 Discussion of other Significant Property Values (SPVs) and the difference between these and OUV (20 min)

AIM 3: Background information on the Antonine Wall and climate change; Understand future climate change scenarios for the Antonine Wall

6 Overview of climate change scenarios: globally, across Scotland, and for the Antonine Wall – presentation (30 min)
7 Case study on hydrological interactions on the Antonine Wall (at Rough Castle) – presentation (10 min)
8 Case study on the structure of the Wall: what it was made of and how it was built – presentation (10 min)
9 Questions about the CVI process (10 min)

Wednesday 2nd February 2022
08.00-12.00

10 Overview of climate change projections for the Antonine Wall – presentation; agree on climate change scenario and timeframe for the assessment (40 min)

AIM 4: Assess the climate stressors impacting the values of FRE AW and select key climate stressors

11 Show list of climate stressors –check for (i) understanding? (ii) timescales? Demonstrate selection of op three climate stressors impacting each key value (25 min)
12 Participants in groups brainstorm the top three climate stressors impacting the key values of OUV – interactive (30 min)
13 Bring outputs from #12 back to plenary and ensure all participants agree on which climate change stressors are impacting the attributes of OUV – interactive (40 min)

AIM 5: Evaluate vulnerability of OUV to key climate stressors, considering exposure, sensitivity and adaptive capacity for a selected climate scenario (e.g. 'Business as Usual' or 'Paris Agreement').

14 Revisit process for exposure, including detail of categories; and review modifiers – presentation and discussion (10 min)
15 Participants in groups assess the exposure term (and modifiers) for each of the three key climate stressors – interactive (30 min)
16 Bring outputs from #15 back to plenary and discuss any variation in assessments of exposure – interactive (30 min)

Thursday 3rd February 2022
08.00-12.00

17 Introduction to CVI process for sensitivity (including categories; and modifiers) and review the potential impact matrix that combines sensitivity with exposure. Remind of climate scenario for analysis (*BAU 2050*) – presentation (20 min)
18 Participants in groups assess the sensitivity (thus determining potential impact) for the key Climate Change stressors – interactive (30 min)
19 Bring outputs from #18 back to plenary and discuss any variation in assessments of sensitivity – interactive (15 min)
20 Introduction to adaptive capacity and brainstorming task to identify existing strategies used to mitigate climate-related impacts and potential adaptive capacities – presentation and discussion (15 min)
21 Participants in groups brainstorm existing strategies used to mitigate climate-related impacts and potential adaptive capacities, identify which key climate stressors and key values these respond to – interactive (25 min)
22 Bring outputs from #21 back to plenary. Prioritise these in terms of feasibility. Introduce adaptive capacity assessment – interactive and presentation (30 min)
23 Participants in groups assess the adaptive capacity (thus determining OUV Vulnerability) for the key Climate Change stressors – interactive (30 min)
24 Bring outputs from #23 back to plenary and discuss any variation in assessments of adaptive capacity – interactive (30 min)
25 Discussion of assessments of exposure, sensitivity and adaptive capacity, and any effect on OUV Vulnerability – interactive (10 min)

Tuesday 8th February 2022
08.00-12.00
AIM 6: Consider economic, social, and cultural dependencies (sensitivity) and adaptive capacity, to determine Community Vulnerability

26 Revisit process for analysing economic, social, and cultural (ESC) dependency. Review the ESC potential impact matrix that combines these. Revisit process for analysing economic, social, and cultural adaptative capacity – presentation (15 min)
27 Economic study for the Antonine Wall – presentation (20 min)
28 Discussion of business types for analysis and introduction to Economic breakout group (20 min)
29 Participants in groups assess the economic dependency and adaptive capacity for the Antonine Wall – interactive (50 min)
30 Bring outputs from #29 back to plenary and discuss any variation in assessments of economic dependency and adaptive capacity – interactive (60 min)

Wednesday 9th February 2022
08.00-12.00

31 Introduction to Social dependency – presentation (10 min)
32 Participants in groups assess the social dependency and adaptive capacity for the Antonine Wall – interactive (45 min)
33 Bring outputs from #32 back to plenary and discuss any variation in assessments of social dependencies and corresponding adaptive capacities – interactive (40 min)
34 Introduction to Cultural dependency – presentation (10 min)
35 Participants in breakout groups assess the cultural dependency (thus determining ESC potential impact) and adaptive capacity (thus determining Community vulnerability) for the Antonine Wall – interactive (45 min)
36 Bring outputs from #35 back to plenary and discuss any variation in assessments of cultural dependencies and corresponding adaptive capacities. Examine the effect of these on Community Vulnerability – interactive (50 min)

Thursday 10th February 2022
08.00-12.00
AIM 7: Summary, feedback, and next steps

37 Summarise outcomes from workshop, following final analysis worksheet – interactive (60 min)
38 Recap on items that had been 'parked' during the workshop – interactive (30 min)
39 Discussion of next steps – interactive (60 min)
40 Receive feedback on CVI framework and workshop process – interactive (30 min)
41 Complete workshop evaluation forms; receive other feedback from participants (30 min)
42 Thanks and close

APPENDIX 4

List of participants in the CVI workshop (not all were able to attend all six online sessions)

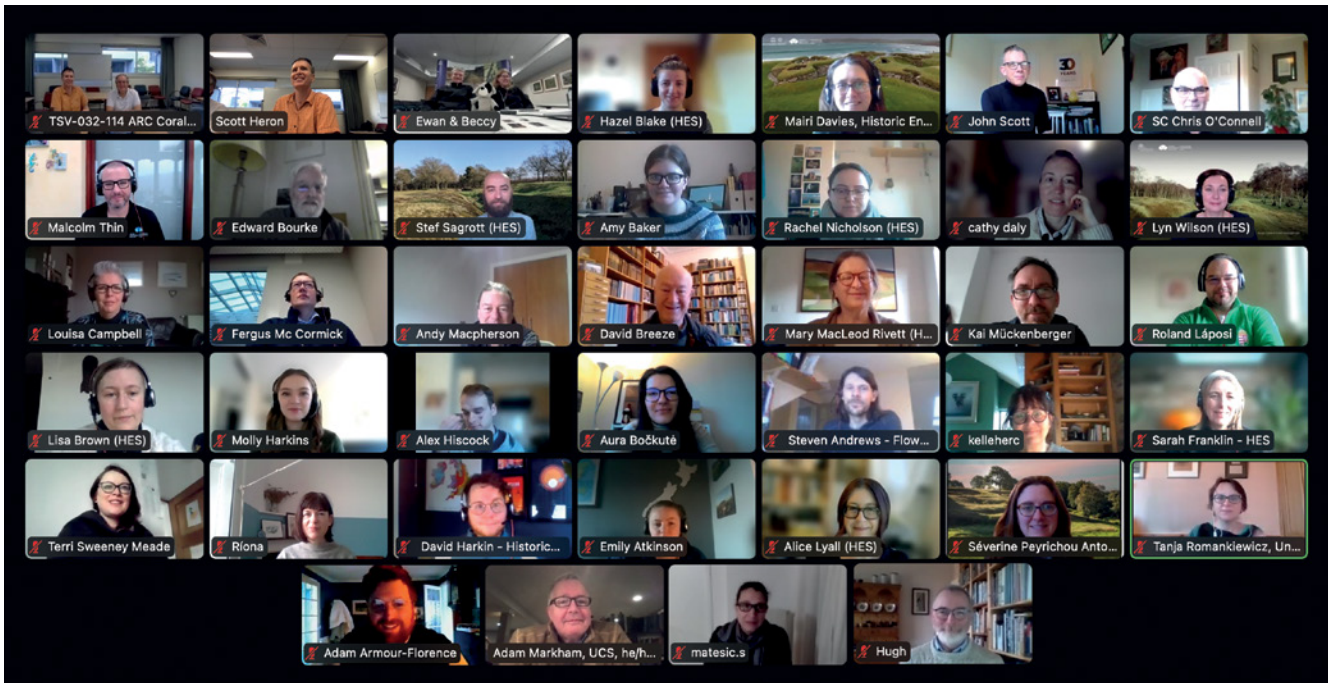
Name	Role	Organisation
Steven Andrews	Flow Country coordinator	Highland Council
Adam Armour Florence	Sustainability Officer	West Dunbartonshire Council
Emily Atkinson	Energy and Climate Change Graduate	Falkirk Council
Amy Baker	PhD Student	Newcastle University
Hazel Blake	Geophysical Survey Support Officer	Historic Environment Scotland
Aura Bočkutė	PhD student	University of Glasgow
Edward Bourke	Senior Archaeologist	National Monuments Service – Ireland
David Breeze		Retired
Lisa Brown	Archaeological Science Manager	Historic Environment Scotland
Louisa Campbell	Lord Kelvin Fellow	Glasgow University
Cathy Daly	Consultant – Carrig Conservation Ltd	Office of Public Works – Ireland (Skellig Michael)
Mairi Davies*	Climate Change Policy Manager	Historic Environment Scotland
Jon Day*	Adjunct Senior Research Fellow, ARC Centre of Excellence for Coral Reef Studies	James Cook University
Sarah Franklin	Landscape Architect	Historic Environment Scotland
Kevin Grant	Archaeology and World Heritage Manager	Historic Environment Scotland
David Harkin*	Climate Change Scientist	Historic Environment Scotland
Molly Harkins	Climate Change Trainee	Historic Environment Scotland
Scott Heron*	Associate Professor in Physics, College of Science & Engineering	James Cook University
Alex Hiscock	PhD Student	Stirling / Edinburgh University
Stuart Holmes	Regional Visitor Operations Manager – South and Central VO Manager	Historic Environment Scotland
Ewan Hyslop*	Head of Technical Research and Science	Historic Environment Scotland
Rebecca Jones*	Head of Archaeology and World Heritage	Historic Environment Scotland
Connie Kelleher	Underwater Archaeologist	National Monuments Service – Ireland
Roland Laposi	Formerly Heriot-Watt	

* member of Steering Committee

Name	Role	Organisation
Alice Lyall	Heart of Neolithic Orkney WHS Coordinator	Historic Environment Scotland
Mary Macleod	Senior Ancient Monuments Officer	Historic Environment Scotland
Andy MacPherson	Development Officer	Green Action Trust
Adam Markham		Union of Concerned Scientists
Jane Masters	Head of Heritage	New Lanark Trust
Suzana Matesic	Head of German *Limes*-Kommission	DLK, Germany
Hugh McBrien	Local Authority Archaeologist	WoSAS
Fergus McCormick	Senior Conservation Architect	Office of Public Works – Ireland (Skellig Michael)
Riona McMorrow	FRE AW Coordinator	Historic Environment Scotland
Kai Mueckenberger		State Conservation Office Hessen
Rachel Nicholson	WH Officer	Historic Environment Scotland
John Scott	Hadrian's Wall coordinator	Northumberland National Park
Chris O'Connell	Heritage Manager	Scottish Canals
Severine Peyrichou	AW Project Development Officer	'Rediscovering the Antonine Wall' Project
Tanja Romankiewicz	Chancellors Fellow	Edinburgh University
Ben Russell	Lecturer	Edinburgh University
Stefan Sagrott	Senior Cultural Resources Advisor	Historic Environment Scotland
Joseph Sellors	Tourism & Destination Development Manager Lothians & West	Historic Environment Scotland
Nikita Shah	Regeneration Officer, Regeneration and Town Centres Team	East Dunbartonshire Council
Terri Sweeney	Assistant Principle Architect	Office of Public Works – Ireland
Malcolm Thin	Regional Works Manager, Conservation South	Historic Environment Scotland
Alan Williamson	Team Leader, Planning and Building Standards	West Dunbartonshire Council
Lyn Wilson	Digital Documentation Manager	Historic Environment Scotland

Jon Day, Scott Heron, Riona McMorrow and Rebecca Jones at the *lilia* pits at Rough Castle in April 2022 (© Rebecca Jones)

Some of the participants in the online FRE AW workshop



APPENDIX 5

List of other Significant Property Values (SPVs) that are locally, regionally, or nationally significant for the Antonine Wall

Broad Groupings of SPVs	Key SPVs	Additional Justification
Biological diversity (e.g. other flora, fauna or habitats of significance in the SOUV)	Fauna	Range of fauna species along the breadth of the wall, including European Protected Species such as bats and great crested newts
	Wildlife and biodiversity corridors	Linear feature of the wall creates corridors for the surrounding areas, e.g. Bar Hill fort links two areas of woodland
	Avifauna	Range of bird species including Skylark, Spotted Flycatcher, Green Woodpecker, Kestrel, Starling, Song Thrush, Redwing, and Fieldfare Many are British Protected Species, Birds of Conservation Concern or UK Biodiversity Action Plan Priority Species
	Terrestrial flora	Marsh violet, great butterfly orchid
	Range of habitats	Woodland, heath, scrubland, seasonal ponds, marshy grassland, unimproved grassland
	Vulnerability to climate change	Range of habitats, flora and fauna are sensitive to climate change which can affect the wall
	Environmental evidence	The wall contains an important repository of evidence that can be used to reconstruct the changing vegetational history of central Scotland
Aesthetic values or phenomena (e.g. any specific scenic qualities or phenomena that are significant)	Landscape setting	There are views in all directions into the landscape from viewpoints along the wall
	Geology	Making use of topography for strategic locations / line of the wall
	Tourism	People attracted to the rare green spaces amid the urbanisation of Central Scotland
	Contemporary landscape	Now largely built up along most parts of the wall. This has caused extensive damage to parts of the wall
	Legibility of the landscape through time	Throughout the post-Roman and medieval periods, the Antonine Wall and its immediate vicinity saw continued occupation and the construction of new settlements and structures, including churches, villages, and several castles, including mottes
	Modern infrastructure	Wind turbines, electricity pylons, roads etc detract from the ability to imagine the historic setting of parts of the wall
	Routeways	Roads, canals, railways along the length of wall etc
Economic values (e.g. provide income or employment opportunities through tourism, fishing, or other commercial activities, etc.)	Employment	In local communities along the wall
	Tourism	Monuments/sites bringing visitors to the local area

Broad Groupings of SPVs	Key SPVs	Additional Justification
Recreational values (e.g. provide for recreational activities like hiking, camping, wildlife viewing etc.)	Walkers, trail runners, hikers	Range of routes along central Scotland that intersect with the wall, e.g. John Muir Way
	Tourism	Visiting monuments / sites from day trippers to organised bus tours – 'world heritage' tourism noted by local tourism providers
	Canal activities	Along the Union Canal, e.g. boating, walking
Historic/cultural values (e.g. features or locations that represent history or enable traditions or ways of life to continue)	Local myths, legends, and stories	Strong association with medieval/early modern myths and legends that accumulated around the Antonine Wall e.g. Gryme legend
	Artefact collection	The wall, and specific sites along it, have produced some of the most impressive and important collections of Roman period artefacts from anywhere in Scotland
Learning/ scientific values (e.g. opportunities for scientific research, nature interpretation etc)	Education	Many schools, universities and further education organisations use, or could use, the Antonine Wall WHS as part of their learning programmes
	Development of archaeology as a discipline	Significant scientific and methodological advances were developed between the early twentieth century, when most Antonine Wall fort excavations took place. This has allowed for the completion of important types of analysis that were not available for the Wall's major pre-war fort excavations
	Environmental evidence	Important repository of evidence that can be used to reconstruct the contemporary landscape. Sewage deposits at bath houses and latrines have provided detailed understanding of soldier's diets and health
	Distance stones	Unique to Scotland which provide great research opportunity into their importance and creation
	Unique elements of Roman frontiers	Contains structures of forts (e.g. annexes attached to them), layout of the frontier and expansions (e.g. structures for signalling) not seen at other Roman frontiers
	Short life-span	Provides specific insight into how the frontier was designed and built at a particular period of time
	Turf monument	The Wall is the largest turf monument in Britain

APPENDIX 6

Acronyms

ALAPP	Advanced *Limes* Applications
CVI	Climate Vulnerability Index
DL	Danube *Limes*
DLK	Deutsche Limeskommission
EDC	East Dunbartonshire Council
ESC	Economic, Social and Cultural
FC	Falkirk Council
FRE	Frontiers of the Roman Empire
GCC	Glasgow City Council
HES	Historic Environment Scotland
HONO	Heart of Neolithic Orkney
ICOMOS	International Council on Monuments and Sites
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
JCU	James Cook University
LGL	Lower German *Limes*
NLC	North Lanarkshire Council
ONTE	Old and New Towns of Edinburgh
ORL	Obergermanisch-Raetischer *Limes* (Upper German-Raetian *Limes*)
OUV	Outstanding Universal Value
PiC	Property in Care
RCP	Representative Concentration Pathway
RSE	Royal Society of Edinburgh
SIMD	Scottish Index of Multiple Deprivation
SOUV	Statement of Outstanding Universal Value
SPV	Significant Property Value
UNESCO	United Nations Educational, Scientific & Cultural Organization
WDC	West Dunbartonshire Council
WH	World Heritage

Glossary

Fort	A fortified Roman military base defended by (at least one) rampart and ditch, generally built for a single regiment of 500 or 1000 men and containing accommodation for troops and officers, together with stores and ancillary buildings
Fortlet	A small Roman military installation, generally built as an outpost for 80 soldiers or fewer, usually defended by a single rampart and ditch, and containing accommodation for troops and officers, possibly together with stores and ancillary buildings
Lilia	Roman pits dug as an extra form of defence and probably held a sharpened stake within
Military Way	The Roman Road constructed at the rear of the Antonine Wall for the movement of people and equipment along the Wall
Rampart	An earthen embankment built for defensive purposes
Temporary Camp	A fortified Roman camp intended for short-term occupation (a few nights /weeks) enclosed within a perimeter defence usually consisting of a ditch, bank, and possibly palisade. They were constructed by Roman troops on campaigns, manoeuvres, construction duties and training

CVI

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

JAMES COOK UNIVERSITY AUSTRALIA

THE ANTONINE WALL
FRONTIERS OF THE ROMAN EMPIRE

Falkirk Council

SCOTLAND'S ARCHAEOLOGY STRATEGY

West Dunbartonshire COUNCIL

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