Discovery, Innovation and Science in the Historic Environment

RESEARCH

Historic England

ISSUE 16 · ARCHAEOLOGY SPECIAL 2020

Welcome...

...to this Archaeology special issue of Research magazine.

This issue focuses on archaeological research carried out or funded by Historic England.

At the time of writing we are still in Lockdown and dealing with the challenges of working from home. In 'Archaeology at a Distance' Helen Winton shows how the Aerial Investigation and Mapping team has adapted to safely maintain its aerial reconnaissance programme.

Polydora Baker, James O Davies, Hannah Kennedy and Fay Worley previews a superbly-illustrated atlas that will provide researchers with immediate access to our collection of perintatal animal bones.

The article by Anne de Vareilles and Jessie Woodbridge on 'Biodiversity and Land Use: how ancient practices shaped Britain' examines the interplay between the natural environment, climate, and human land use, which may provide lessons from the past for current responses to climate change.

'The London wreck – a kaleidoscope of specialists, materials and artefacts' by Polydora Baker, Duncan H Brown, Angela Middleton, Sarah Paynter and Jörn Schuster is a vivid demonstration of the results of multi-disciplinary analysis of finds from the wreck of 1656. The 'Gunnes of Warship Hazardous' Prize by Dave Johnson shows how research into this wreck site has provided new information on the armament of the warship as well as telling us more about its wrecking in 1706.

A lot of our work comes from Regional teams who need to know more about sites or buildings to help protect them. Matt Bristow's article on the Priory of St John the Baptist, Latton, Essex shows how aerial investigation, analytical earthwork survey and geophysical survey have combined to give us a much better understanding of this monastic site. The article by Neil Linford, Paul Linford and Andy Payne, on Mount Pleasant, shows how modern geophysical survey, building on previous work, has given us a much better understanding of this major Neolithic henge enclosure.

Two articles come from our work for the English Heritage Trust. Tony Wilmott's article on Roman Richborough shows how small-scale research excavations, combined with reconsideration of the results of previous work, have altered our understanding of this important Roman monument. Trevor Pearson's article on Rievaulx Abbey, illustrates the development of the landscape by the monastery and the post-Dissolution iron industry.

Brian Kerr
Head of Archaeological Investigation
with Historic England.

Front cover image: Lingual view of a Soay lamb mandible (lower jaw) from the Historic England Zooarchaeology Reference Collection, showing the porous surface texture, undeveloped features, and erupting milk teeth, all of which allow determination of it's very young age. © Historic England. Photographer James O. Davies

We are the **public body** that **helps people care for, enjoy** and **celebrate**

England's spectacular historic environment

Contents..... Archaeology special issue

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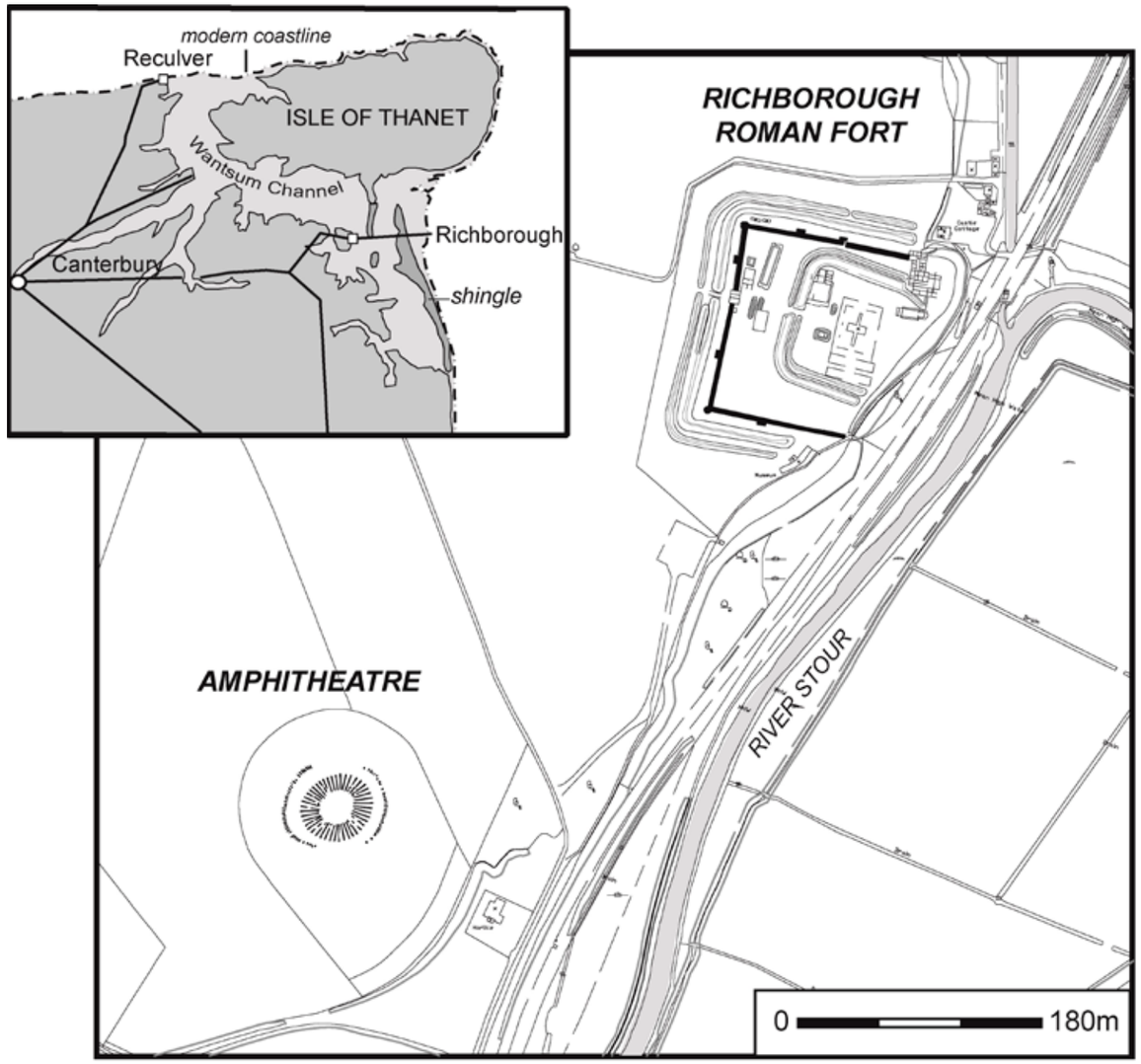


Above: Location map and plan of Richborough and the Wantsum Channel. © Historic England. Illustrator John Vallender

Roman Richborough

Revisiting early excavations.

The Roman site of Richborough has been the subject of three targeted excavations by the Archaeology Projects team. All re-examined areas that had been excavated in the past, and all contributed to new understandings of the four centuries of Richborough's Roman history

The site occupies part of what was once a small island or peninsula on the south side of the Wantsum Channel, the now silted arm of the sea, which formerly separated the Isle of Thanet from the mainland of Kent.

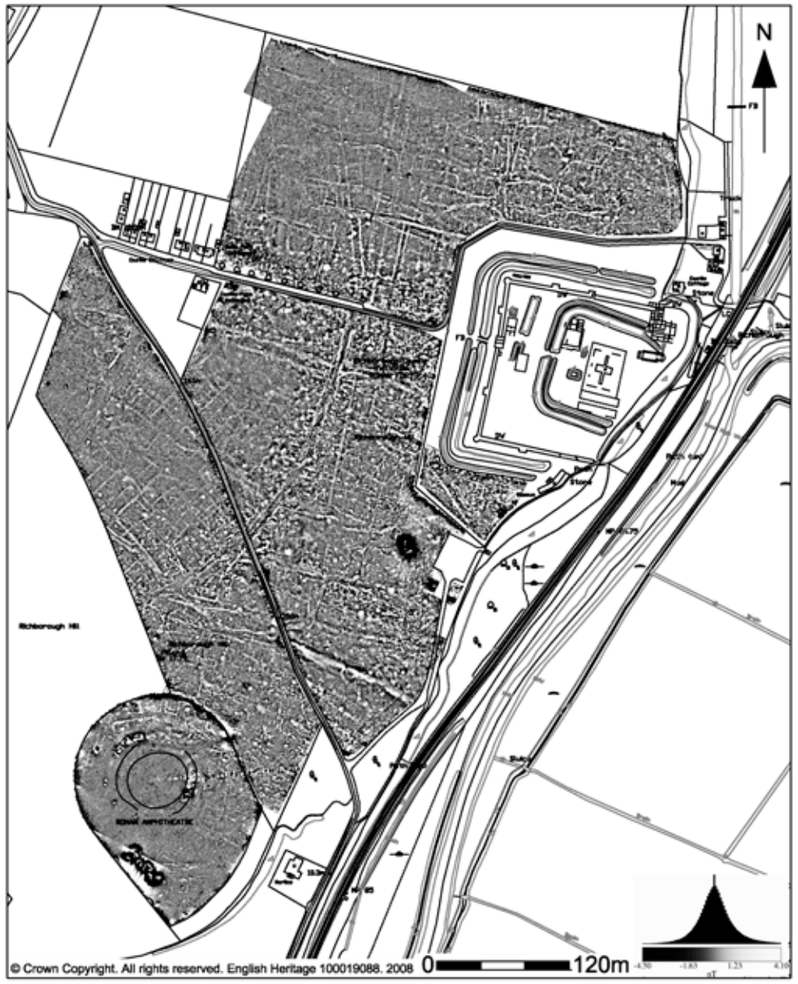
The site has a complex known Roman and medieval history, much of which derives from the results of the major excavations conducted between 1922 and 1938 by J. P. Bushe-Fox, and published in five volumes, the fifth by Barry Cunliffe in 1968. >>

The most prominent feature of the site are the walls of the late- 3rd century AD fort, which formed part of Roman defences against sea-borne raiders along the coast, known as the 'Saxon Shore'. The fort featured projecting square interval towers and rounded corner towers.

The Bushe-Fox excavations took place within these walls, but the site is much more extensive. Geophysical survey, undertaken in 2001, revealed that the fort was built within an un-walled Roman town, earlier than the fort, of some 21 hectares. On the western fringe of the town was an amphitheatre, one of the first three in Britain to be recognised as such – by the antiquary William Stukeley in 1776.

Within the town was a huge *quadrifons* or four-fronted arch placed at an intersection of roads, presenting an arched façade to the approach from all four directions. Only the foundation of this survives, but it was one of the most impressive ceremonial arches in the Roman world; an imperial project, clad in white marble from the quarries at Carrara, Italy. It stood as a ceremonial and symbolic gateway to the province of *Britannia* until it was demolished, together with six *insulae* or city blocks during the later third century in order to construct the Saxon Shore fort. >>

one of the most impressive ceremonial arches in the Roman world



Left: Geophysical survey of the area of the Roman town at Richborough. © Historic England

Above right: Reconstruction of the arch and waterfront. © English Heritage. Illustrator Peter Lorimer
https://artsandculture.google.com/asset/reconstruction-drawing-of-the-gateway-to-britannia-peter-lorimer/awFz3knQ4NMu8g?hl=en

Above left: The Roman foreshore beneath 2 metres of silting and erosion deposits. © Historic England. Photographer T Wilmott

Above right: The excavation of the Claudian gate, 2020. © Historic England. Photographer T Wilmott

The coastline and the conquest

The earliest Roman features discovered on the site were a pair of long, parallel defensive ditches which produced material dating to the reign of the Emperor Claudius.

Since these early ditches were discovered, Richborough has been identified, though not without controversy, as the landing place of the successful Roman invasion of AD 43 ordered by the Emperor Claudius. Archaeologists refer to this early period as “Claudian”.

The purpose of these ditches is linked to a long-standing problem in the understanding of Richborough; the proximity of the site to the Roman coastline.

The relationship between the ditches and the coastline is confused by the interaction between the two complex processes of erosion of the land and silting of the channel, and by the fact that the railway line runs along the base of the scarp on which the site stands.

Excavations and core sampling to the east of the site in 2001 and 2008 sought to clarify the relationship. The work indicated that open water conditions existed at the base of the scarp until the late medieval period, when silts began to accumulate. Before this an unknown amount of erosion of the scarp had caused the collapse of the east wall of the Saxon Shore fort.

At a depth of 2 metres beneath the silting and the eroded material, a foreshore deposit was discovered upon which lay waterworn Roman ceramics. Research continues on these questions, and the location of an actual waterfront remains to be discovered.

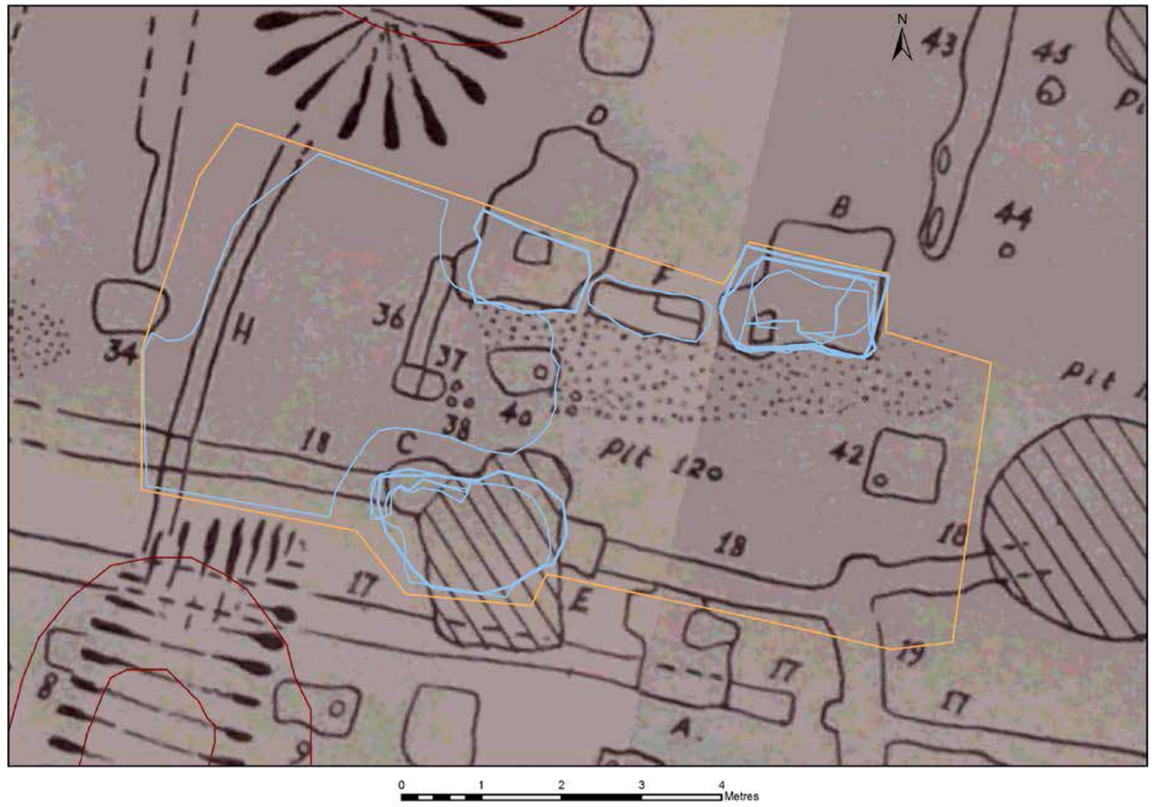
A team from Archaeology Projects undertook this work in the last few days before the general Covid-19 lockdown

However there is little doubt that the Roman shoreline was quite close to the present scarp[4].

The Claudian ditches were laid out parallel to the coast for a distance of at least 650 metres, and it is likely that the up-cast from their excavation was deployed on the eastern side as a rampart. They are now interpreted as a defended beach-head for the landing of men and materiel during the initial phase of the Roman conquest.

The only way through to the landward side of this defence was a narrow causeway which was equipped with a single-portal timber gate. This causeway established the line of the later Watling Street. The gate was built on a square plan, supported by four very substantial ground-fast posts. Bushe-Fox had excavated the components of this structure, but aspects of the recording left much to be desired.

At the request of the English Heritage Trust, and to gather information for future interpretation, a small scale excavation was undertaken in early March 2020 to confirm the shape, size and layout of this gate, to check the accuracy of Bushe-Fox’s work, and to record information which he had omitted. A team from Archaeology Projects undertook this work in the last few days before the general Covid-19 lockdown. >>



A trench was laid out to sample three of the four post positions (Bushe-Fox's B, C and D). Bushe-Fox had excavated the sockets left by decaying posts 30 centimetres (one Roman foot) square in section, and had then excavated the post pits in which they were set, but he had not recorded the shape or size of these pits. One (B) was excavated in 2020, and proved to be very substantial, measuring 1.86 x 1.01 metres on plan and 1.25 metres deep.

These pits would have been packed around the posts to resist any movement in the rather soft sand subsoil. Unfortunately Bushe-Fox did not record the nature of the packing. The position of the post in (C) is unknown, as the post pit was disturbed by the large 'Pit 120', which Bushe-Fox had left intact. This meant it was possible to sample this pit to retrieve dating evidence and the first archaeobotanical material to have been recovered from the area previously excavated.

The town

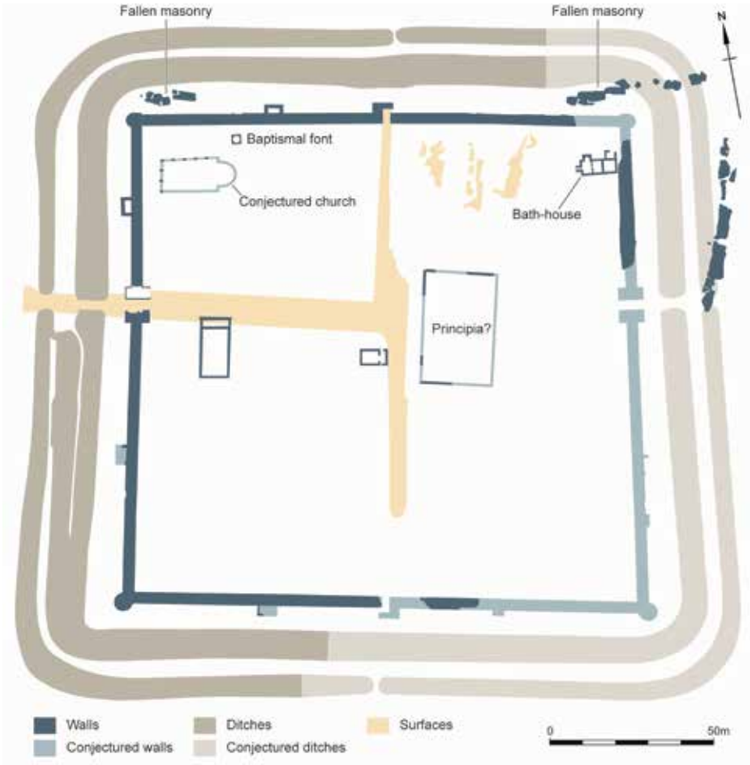
The development of the town began very soon after the conquest. As the first port of Roman Britain its growth seems to have been rapid. There is evidence that it had begun to decline and shrink in the mid- 3rd century AD. Beyond the walls of the Saxon Shore fort, it is known solely from geophysical survey, aerial photography and antiquarian observations. Important features are the amphitheatre and two Romano-celtic temples. A part of one of these, previously examined by Bushe-Fox, was re-excavated in 2001, showing that it had been an early feature of the town at its southern extent. In the 4th century AD it had been demolished, and the area turned over to rubbish pitting. >>

Above left: Plan of the 2020 excavation superimposed on Bush-Fox's original plan. © Historic England. Illustrator T Cromwell

Below left: The gate excavation. Three post holes defined by rings of cobbles. © Historic England. Photographer T Wilmott

Below right: Temple wall and Bush-Fox trenches. © Historic England. Photographer T Wilmott

Above left: The collapsed east wall of the fort © Historic England. Photographer T Wilmott



Above right: A new plan of the Saxon Shore fort. © Historic England. Illustrator John Vallender

The Saxon Shore Fort

The impressive masonry walls on the north, south and west side of the late 3rd century fort survive, in places to almost full height. However the east wall has collapsed due to erosion. In 2008, again to inform interpretation, the collapsed sections of wall were cleared of thick vegetation and properly recorded. The standard and frequently published plan of the fort places the east wall where the fallen section lies – at the foot of the scarp. Close examination, never previously done, shows that this is impossible, as the collapsed segment lies 30 - 40° below the horizontal; the wall must have fallen and then slid down the scarp.

So where was the original east wall of the fort? Bushe-Fox excavated a length of foundation on the top of the scarp which was reinforced with timber piles and was identical to the foundations of the other three sides of the fort. This was originally thought to be 'unfinished' or a 'mistake', and that no wall was ever built upon it. This idea was based upon complex arguments concerning aspects of the original excavation and its publication.

Examination of the original site notebooks by Philip Smither has shown that serious errors were made in interpretation. Correction of these errors combined with the revelation of the angle of repose of the collapsed wall has reversed the previous interpretation, and makes it clear that the east wall must have been built on the so-called 'unfinished' foundation, and this has enabled a new plan of the fort to be presented.

The Roman remains at Richborough have been studied for centuries, but still our knowledge and understanding of the site – its chronology, its features, its internal relationships – remain partial. Town and fort present opportunities for further discovery, in particular through the use of modern archaeological techniques and each new investigation will help to build up a better appreciation of the significance of the remains. Our recent work will enable a new plan of the fort to be presented and will contribute to the management and understanding of a site of great national and international importance ■

The author

Tony Wilmott MA, FSA, MCIfA
Senior Archaeologist with Historic England.

Tony joined English Heritage/ Historic England in 1987, originally to direct excavations on the Hadrian's Wall fort at Birdoswald. Since then he has run many excavations, at Whitby Abbey, the Chester Roman Amphitheatre, Richborough, and a further 15 sites on the Hadrian's Wall frontier. He has published many excavation reports, other books, and articles in archaeological journals and conference proceedings. His main interests lie in the Roman and early medieval periods.

Further information

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Archaeology from a distance

Some old and new ways of working for aerial investigation and mapping in the time of Covid-19.

This article explores some old and new ways of working by the Historic England Aerial Investigation and Mapping team in response to changing technology and the major changes in office working due to the Covid-19 pandemic.

Getting a bird's-eye view

One of the major themes of recent months is social distancing. Aerial archaeology is by its very nature 'at a distance' – both physically and temporally.

Aircraft, from balloons to satellites, can take us far above the ground, and even into space, so that we can observe from the bird's, or even astronaut's, eye view.

Cameras record the aerial experience capturing recent views but also creating a library of images that can take us back in time. The Historic England Archive and other repositories have vast collections of aerial photographs. A few images date from the 19th century, and many more from the last 100 years. >>

Below left: Aerial photographs of Stonehenge each taken from a balloon 100 years apart. The right-hand image was taken to celebrate the 100th anniversary of that on the left, published in the journal of the Society of Antiquaries in 1906. Note the props holding up the top right corner of the circle of stones in 1906 and the tracks made by the military. In 2006, a single path took visitors past the stones. Left hand image: Courtesy Society of Antiquaries, photographer Lieutenant Philip Henry Sharpe. Right hand image: 24182_003 1st March 2006 © Historic England Archive. Photographer Damian Grady

We can trace landscape change and discover archaeological sites by analysing and comparing aerial photographs taken at different times. The development of digital technology also allows us to share images and conclusions with people all over the world.

Each new piece of equipment or software does not necessarily replace what came before, rather we adapt them to suit our purposes and use them in a variety of different situations. Our aerial reconnaissance programme carries out a number of functions:

- discovery of buried archaeological sites as cropmarks
- monitoring and recording of scheduled monuments or registered parks and gardens, and
- illustration of historic urban and rural landscapes.

Each situation requires a different approach in terms of the type of photography and the kit used.

We use high-winged light aircraft, Cessna 172s, that allow us to get around the country quickly so we can go where the weather and ground conditions are right. We lease two aircraft, based in Yorkshire and Oxfordshire. These small aircraft are easy to manoeuvre and allow us to position the aircraft to take oblique or vertical photographs with a hand held camera through an open window. This technique for specialist aerial photography is something that is essentially unchanged since the early 20th century: it was used, for example, by Aerofilms Ltd in the 1920s. Oblique aerial photography is a core part of what we do as it provides the right angle for a range of purposes, such as close-ups of potential threats to scheduled monuments and wide views used for historic town centres and 18th-century designed landscapes.

The digital technology we use includes high-specification digital cameras. These are fitted with an Inertial Navigation System (INS) attached to the base of a Nikon camera. The INS we use was developed by a PhD student, Martin Weiser, from the University of Vienna. It comprises an Inertial Measurement Unit (IMU) attached to a global positioning system (GPS), the data from which is used to calculate the geographical position of the footprint and centrepoint of each oblique aerial photograph. This enables a digital flow line to the Historic England Archive and we are currently working on a system to allow people to explore the digital aerial photography archive online using a map.

Left: The Inertial Navigation System, developed by Martin Weiser at the University of Vienna, attached to our Nikon camera. This allows us to import the footprint of each photograph into our geographical information systems (GIS).

Opposite page left: The high-winged light aircraft provides good all-round views when searching for sites and can be positioned to provide photographs from different angles. © Historic England Archive. Photographer P Horne 24511_001 6th July 2006

Above left: South African Deputy President Cyril Ramaphosa speaking in support of the We Die Like Brothers project at Delville Wood in 2014. © Graham Scott

Safety is a primary consideration in planning and executing flights and our flying archaeologists liaise with the pilot to ensure this. Planning where to go and why relies on a combination of the experience of the aerial investigator and digital technology. This includes an understanding of the right ground and weather conditions for different kinds of photography, combined with use of a tablet with a geographical information system (GIS) loaded with air navigation charts and the latest information on the historic environment. This means that our aerial archaeologist can plan safe flight paths with the pilot, and that they have information to hand which allows them to navigate to targets, to identify whether a site is a new discovery, and to adapt flight plans if weather or ground conditions are not as expected. We usually fly with the pilot and together they may adapt the route during a flight in response to changing weather conditions or air restrictions. Therefore, we continue to use a mix of well-established and new techniques and equipment for aerial reconnaissance. >>

Safety is a primary consideration in planning and executing flights

Experimenting with vertical photography with an automatic camera

Our latest project has been to experiment with the use of an automatic camera fixed to the aircraft to allow us to carry out vertical aerial photography over individual sites or larger areas. Vertical is used as a descriptive term because the camera is pointing straight down at the ground rather than at an oblique angle. This technique will not replace our hand-held photography but we want to be able to take overlapping vertical photographs relatively easily and in a controlled fashion. Vertical photography has been taken since the early days of balloon flight and has been used extensively since the Second World War. However, it tends to involve large specialist aircraft and is not usually taken for archaeological purposes but might be taken for military training, Ordnance Survey mapping or commercial survey.

Historic England uses light aircraft and remote-controlled small aircraft (commonly called drones) for its aerial photography. We are continuing to successfully explore the use of drones, establishing that, due to their limited range of operation, they are mainly suitable for recording single sites. Our Cessna aircraft, however, have the advantage that we can get around to different sites or areas across the country quickly and undertake both oblique and vertical photography, covering large areas in a single flight.

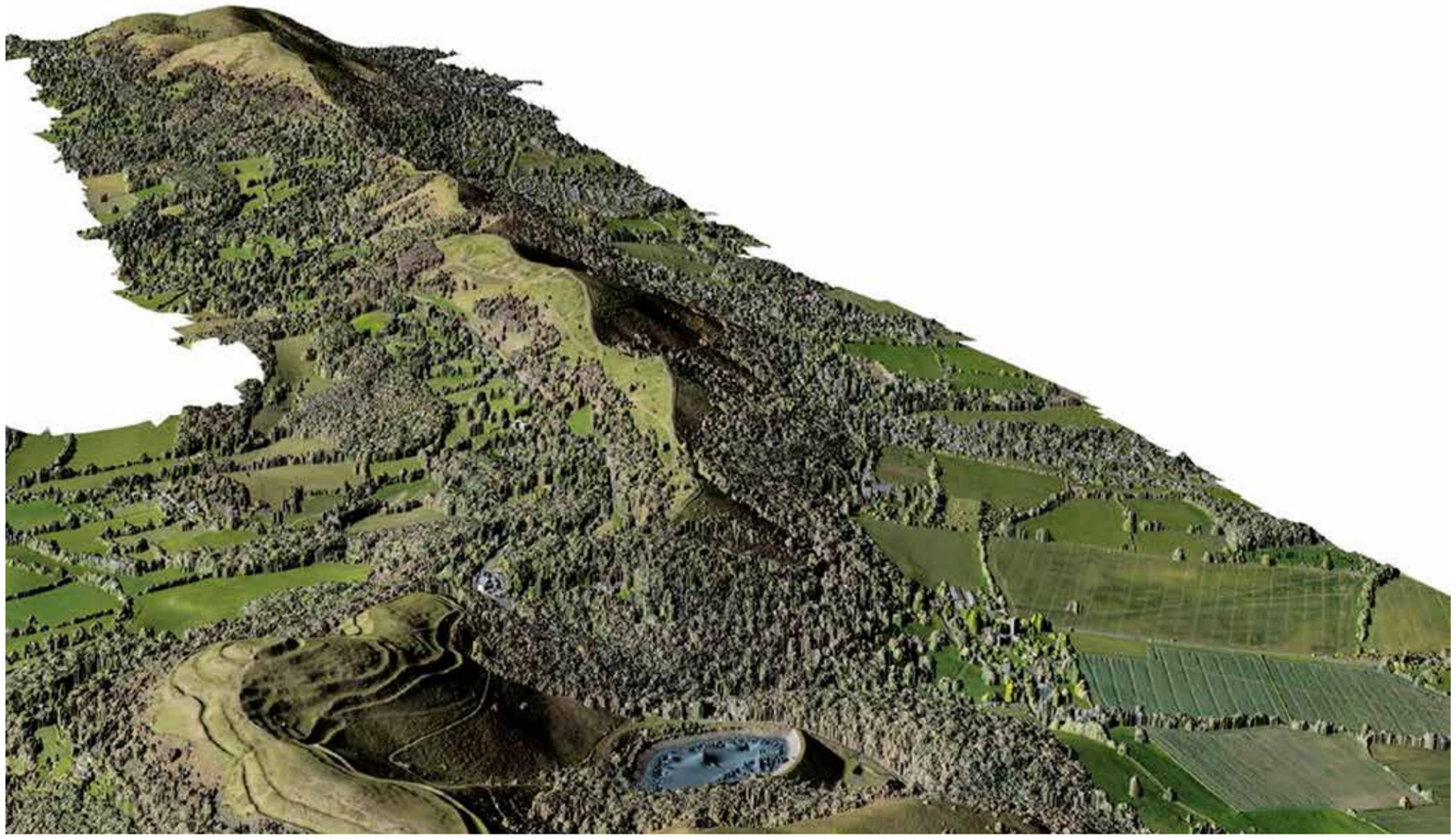
This means our aircraft set-up is ideal for extensive monuments, such as those along the ridge of the Malvern Hills or where there are continuous archaeological features. The latter includes the settlements and field systems that extend across large parts of areas such as Dartmoor in Devon or the Yorkshire Dales. Therefore, we aim to use the aeroplane or the drone for different circumstances and sometimes for work on the same site or area. So far, our trials suggest that the light aircraft photography can achieve about the same Ground Sampling Distance (a measure of scale and accuracy) as drone footage, depending on the height flown and lens used. The GSD for the Malvern Hills examples is 5 centimetres, an acceptable level of tolerance for most archaeological purposes.

By taking our own vertical photographs, we can ensure we have the right conditions and resolution for archaeological illustration and survey. We will use them to create digital 3-D visualisations to help illustrate sites and landscapes but their main application is in monitoring the condition of large archaeological monuments.

We have two different vertical automatic-camera set-ups attached to each of the Cessna-172's that we lease.

Emma Trevarthen from our York team covers the north of England from Sherburn-in-Elmet. The aircraft there uses a camera placed over a hole in the floor of the plane.

Damian Grady from our Swindon team covers the south from Oxford Airport (Kidlington) and uses a camera pod fixed to the wing strut of the aircraft. We use a Digital SLR camera (Nikon D850) linked to an Inertial Measurement Unit (IMU) and a Global Positioning System (GPS). During a vertical survey, the aircraft flies a proscribed straight course with constant height and direction and the camera automatically takes pictures at set intervals to create overlapping images. >>



Above: 3D model created from a composite of vertical photographs looking south along the Malvern Hills with British Camp and Herefordshire Beacon in the foreground. This is about half of a model that covered 23.7 square kilometres created from a 10 centimetre orthomosaic of photographs. Photographer Damian Grady, pilot Marten White, 3D visualisation by David Andrews. Date of photography 27th March 2019 © Historic England.

Right: Pilot Mick Webb checking the camera pod attached to the wing strut of our leased aircraft at Oxford airport (Kidlington) in May 2020. Photographer Damian Grady

Above left: One of the vertical photographs used to record a site in detail that can be used to create 3D visualisations over large areas. Close-up of British Camp on the Malvern Hills – compare to the 3D model above. The Ground Sampling Distance is 5 centimetres. Photographer Damian Grady, pilot Mick Web. S3282_V_0651 26th March 2019 © Historic England Archive.

We use photogrammetric software to process the photographs, using a process sometimes called ‘structure from motion’

For vertical photography using an automatic camera, a skilled pilot is required to fly the plane at a steady height and speed but it is inevitable that there will be some variation. The IMU and GPS provide the information to allow us to geo-reference the images – that is, to relate the view to an exact location on the ground.

We use photogrammetric software (Agisoft) to process the photographs, using a process sometimes called ‘structure from motion’, to create a seamless composite from the overlapping images. We can also model this in three dimensions. We aim to use this kind of photography to aid with monitoring monuments and landscapes. They will provide an accurate and measurable benchmark of possibly encroaching vegetation, erosion and other potential issues such as animal burrowing. They also provide an engaging illustration and different viewpoint of some of our iconic sites.

Adapting to Covid-19 restrictions

We also aim to use the vertical camera set-up during drought conditions if we identify areas with multiple cropmarks revealing buried archaeological remains. We were planning to do this anyway over the spring and summer but the lock-down caused by the Covid-19 pandemic also meant that we had to rethink our approach to aerial reconnaissance.

When airfields opened in May, social distancing still meant it was impossible for our flying archaeologists Emma or Damian to go up in the plane with the pilot. However, they could travel to the airfield or use video-conferencing to communicate with the pilots.

Applying social distancing, stringent cleaning and using protective clothing, we were able to set up the camera in each plane. The pilot was then briefed and sent to areas or sites on their own where they could start up the automatic vertical camera. This method relies even more than usual on the expertise of our pilots who are not only highly skilled at flying but also have an interest and knowledge of aerial archaeology through their work with us.

The vertical set-up is still in the early stages of development but it has been a great help in allowing us to carry out some limited reconnaissance during social distancing. When the lock down eases and we return to something nearer to our normal operation we will once again be able to go up in the plane with the pilot and use a mix of hand-held and automated cameras, sometimes in the same flight.

The rest of the Aerial Investigation and Mapping team (our ground crew) and our colleagues working on grant-aided aerial projects have also had to adapt to the new situation created by Covid-19. We usually work in teams based in offices where we use >>

Above right: Vertical aerial photograph taken on a solo flight using the automatic camera in the pod attached to the wing-strut. This shows cropmarks of buried remains of prehistoric settlement and funerary monuments at Drayton by the River Thames, Oxfordshire. The Ground Sampling Distance is 12cm. Pilot, Mick Webb. 19th May 2020 © Historic England Archive.

The vertical set-up is still in the early stages of development but it has been a great help in allowing us to carry out some limited reconnaissance during social distancing.

Right: Home working with equipment moved from the office – we have to work on digital-only projects for now.

Like so many we have adapted and moved our specialist equipment and software into our homes, and are concentrating on projects that make the most of digital sources.

archive aerial photographs and have the chance to discuss the archaeological remains and work on mapping projects together. We typically work on projects where we create archaeological maps using information from aerial photographs and airborne laser scanning (lidar) to promote understanding of the historic environment. This informs strategic planning and management through rural and urban casework and large-area projects. All our mapping and recording is digital and is available from the Historic England Archive or local Historic Environment Records.

Like so many we have adapted and moved our specialist equipment and software into our homes, and are concentrating on projects that make the most of digital sources.

We can communicate through video conferencing and our two teams in York and Swindon are probably seeing more of each other than usual. At home, digital technology allows us to review the results of our own aerial reconnaissance and produce records of discoveries to go into the historic environment record. We are also trialling a map-based platform that provides access to all Historic England digital aerial photographs. This is so that staff (and in future the public) can easily find and use aerial photographs and therefore have a virtual visit to the archive. We are also compiling the results from all our mapping projects into a single dataset so these can be shared online too.

Research continues into old and new sources of information. Many of our sources were produced for non-archaeological purposes but have potential benefits for archaeological survey. For example, we find archaeological sites and track urban and rural landscape change using RAF or Ordnance Survey photography taken from the 1940s onwards. Our own reconnaissance and Google Earth coverage provide a contemporary source for archaeological discovery.

Using satellite images

We are now examining that most remote of sources, satellite imagery. Many people are under the mistaken assumption that the imagery that they look at on Google Earth, or similar platforms, is satellite based, when in fact the vast majority of it is captured from aircraft. Very High Resolution (VHR) satellite imagery does exist, with resolutions as high as 30-40 centimetres. However, it generally requires up-front payment and, for England, with its particular weather, it is by no means comprehensive in its coverage of the ground due to clouds. This combination of reasons is why Historic England, like most bodies within England, has previously been limited in their investigation of the resource.

This has changed recently with the establishment of the "Space for Smarter Government Programme" (SSGP) https://spaceforsmartergovernment.uk/. This was set up by the British government to help the public sector save money, innovate and make more effective policy decisions using space-enabled services. Part of this programme, begun in 2019, aimed to look at making VHR data available, free of charge, to a selection of government bodies to assess how it might be used to improve efficiency. >>

save money, innovate and make more effective policy decisions using space-enabled services.

Above: The background image is part of a single strip of about 900 square kilometres captured by the Pleiades 1A satellite on 29-JUN-2018. The insert (showing the area circled top left) shows a pan-sharpened version of the true-colour imagery generated with a spatial resolution/GSD of about 50 centimetres. This records cropmarks of the buried remains of a well-known scheduled site near Eynsham in Oxfordshire where there are prehistoric funerary monuments, tracks and enclosures. © CNES_2018, distribution AIRBUS DS, France, all rights reserved. Data provided via SSGP.

the crucial element in all of our work is the person making the decisions on how to collect and interpret data.

A project is underway within Historic England looking at a sample of this satellite data to determine its usefulness for archaeological prospection and monitoring and how it might be incorporated into future mapping projects as an additional resource. This will inform changes to our workflows to ensure that we use satellite data in a cost effective and efficient way. The project will assess the extent to which this data complements or supplements current standard aerial sources. This will contribute to guidance and standards for use of satellite data in the wider historic environment sector.

This will be achieved by using the SSGP satellite data to compare archaeological results with those from current standard sources in a sample of different types of landscapes. The satellite imagery examined will include not only natural colour (RGB) imagery, but also data from the Near Infra-Red (NIR). This waveband can be used to recognise stress in plants and might therefore reveal traces of buried features before they appear in the visible spectrum.

The satellite data will not replace the current sources that we use but will become one among the many sources of information at our disposal. Because of the increasing number of digital sources, many of them publicly available on the internet, we have been able to adapt to home working and continue our archaeological research at a distance from each other. However, the Historic England Archive aerial photographs (analogue and digital) remain the core source for our projects so we are looking forward to when we can re-introduce the full range of sources and techniques at our disposal.

Choosing the right tools for the job

Like all other approaches to archaeological research and survey, aerial photography adapts to new circumstances and advances in ideas and techniques, exploring new technology and identifying how it can be applied to our discipline. Old and new complement each other, and the crucial element in all of our work is the person making the decisions on how to collect and interpret data. Covid-19 has offered an unexpected opportunity, in of course unwelcome circumstances, to experiment with different methods of working, and this will help us to develop new ways of presenting stories from the distant past to the present ■

The authors

Helen Winton
National Aerial Investigation and Mapping Manager with Historic England.

Helen is a landscape archaeologist and air photo interpreter. She has worked for almost 30 years on multi-period sites and landscapes across England using aerial photographs and airborne laser scanning (lidar) as the main source. She has a special interest in how aerial photographs show changes in military, urban and rural landscapes.

Damian Grady
Aerial Reconnaissance Manager with Historic England.

Damian joined the Royal Commission on the Historical Monuments of England in 1990 to map archaeology from aerial photographs and from 1998 became responsible for managing the aerial reconnaissance programme.

Simon Crutchley
Remote Sensing Development Manager with Historic England.

Simon is a landscape archaeologist and air photo interpreter at Historic England, with over 25 years' experience of mapping and interpreting features of archaeological and historical interest visible on aerial photographs and other aerial imagery. He has worked in many areas of England including the World Heritage Sites of Avebury and Stonehenge. He has a special interest in "new" technology such as lidar and satellite imagery and its application to archaeological research and investigation.

Further information

To find out more about the history of aerial archaeology see Martyn Barber 2011 *A History of Aerial Photography and Archaeology: Mata Hari's glass eye and other stories* English Heritage

To find out more about the history of the Historic England Archive see https://historicengland.org.uk/whats-new/research/50-years-flying/history-of-the-historic-england-aerial-photo-archive/

To find out more about aerial archaeology at Historic England see https://historicengland.org.uk/research/methods/airborne-remote-sensing/

To find out more about terrestrial structure from motion (using the same techniques as aerial SfM) see https://historicengland.org.uk/research/methods/terrestrial-remote-sensing/specialist-survey-techniques/

Rievaulx Abbey viewed from the west, taken May 2015. © Historic England Archive. Photographer Alun Bull, DP169422.

New survey techniques enhance interpretation of a monastic landscape at Rievaulx Abbey

A new survey for Historic England and the English Heritage Trust has provided a better understanding of Rievaulx Abbey, one of the nation's finest monastic sites.

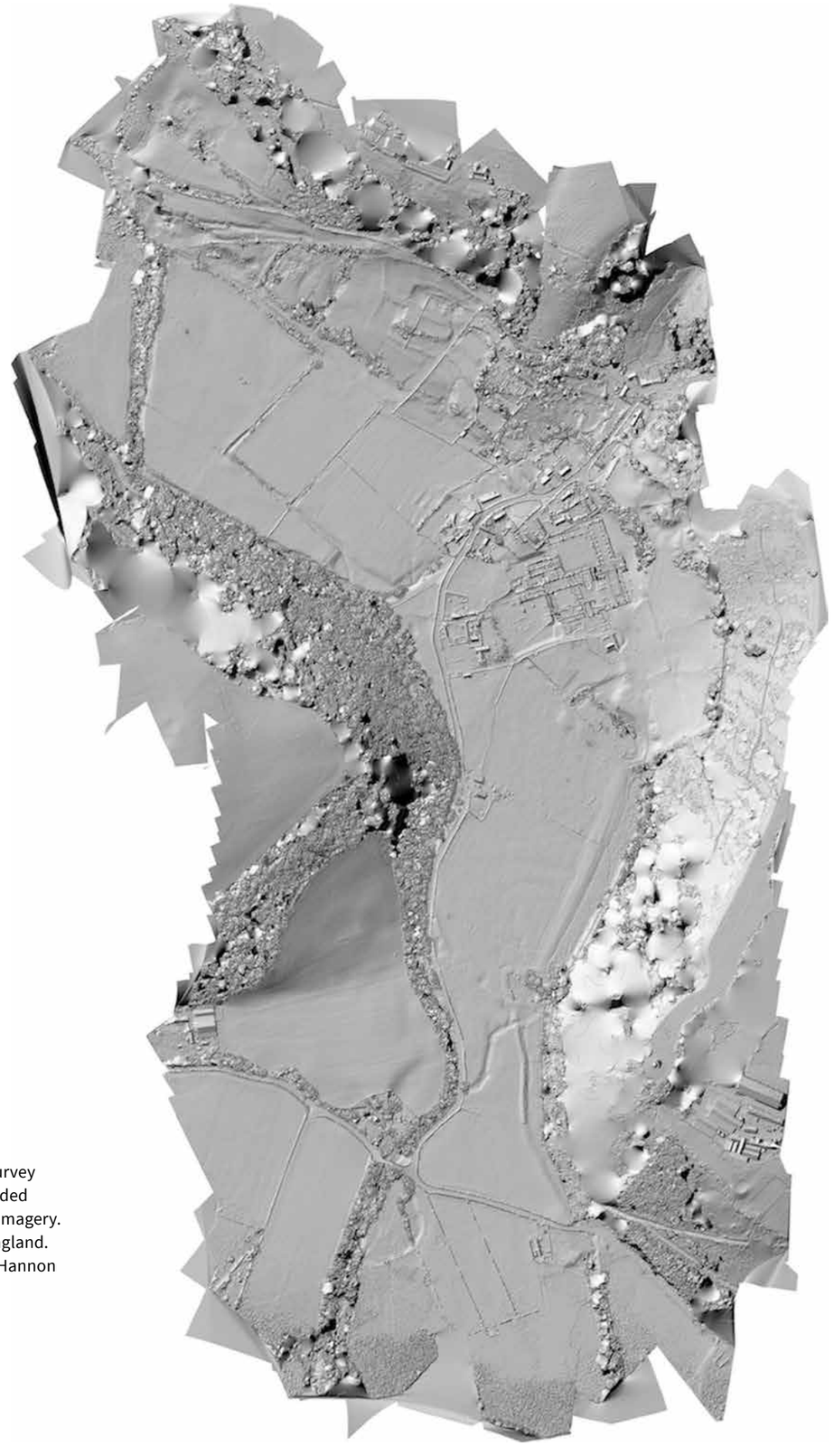
History of the abbey

Rievaulx Abbey stands in the secluded valley of the river Rye in North Yorkshire, on the south side of Rievaulx village about 3 kilometres north of the market town of Helmsley. Founded in 1132, Rievaulx was the first Cistercian abbey in the north of England and grew rapidly in importance following grants of land along the Rye valley and further afield within the North York Moors to the north and the Vale of Pickering to the south and east.

Founded in 1132, Rievaulx was the first Cistercian abbey in the north of England

As part of Henry VIII's secession from the Roman Catholic church, culminating in the Dissolution of the Monasteries the abbey was dissolved in 1538 but for a century afterwards the iron manufacturing industry begun by the monks expanded in scale with the construction of a blast furnace in the 1560s near to the abbey ruins. In the middle of the 18th century the eye-catching quality of the ruins was recognised by the Duncombe family of nearby Duncombe Park, who created Rievaulx Terrace, a long promenade on the ridge overlooking the valley giving a clear view of the abbey below. The abbey was brought into the care of the Ministry of Works in 1917 and today is managed by the English Heritage Trust, while the National Trust maintains the Rievaulx Terrace.

Above: View of the abbey from Rievaulx Terrace. Photograph courtesy T Pearson



Right: The survey area as recorded using drone imagery. © Historic England. Illustrator N Hannon

New survey techniques

The significance of the landscape of Rievaulx Abbey is reflected in its protection as a scheduled monument. Both Historic England and English Heritage Trust, however, recognize that there is a huge amount more to learn about the site. In order to better understand the abbey and its setting, in 2018 Historic England carried out a detailed landscape survey employing a new technique that produces a highly accurate map of the land surface from aerial photographs taken from a UAV (Unmanned Aerial Vehicle or drone). Very slight earthworks show clearly on the map produced from the aerial images, allowing areas to be targeted for more detailed investigation on the ground using GPS satellite receivers and an electronic theodolite. >>

The abbey precinct wall

The survey concentrated on the 37 hectares of the abbey's medieval precinct, which is mainly farmland in private ownership. The precinct stretched for about one kilometre along the valley, with the church and main monastic buildings at the centre. A enclosing wall separated the abbey from the secular world. The precinct wall followed the Rye on the west side, crossed the valley bottom on the north and south and climbed part way up the valley side on the east. The course of the wall survives in places above ground as lengths of bank or stone footings.

The precinct boundary is clearest on the north-east side of the precinct where it can be traced for several hundred metres ascending the east side of the valley. The survey made a detailed record of the wall footings and several intercutting tracks on the hill side immediately above surviving as hollow ways.

There is no evidence to suggest the hollow ways were connected with an entrance, rather they demonstrate how people passing along the valley in the medieval period were forced around the outside of the precinct to preserve the privacy of the abbey. The only known entrance is much nearer to the abbey church where a rebuilt arch in a garden on the village street is thought to have come from the gatehouse.

Top left: Using a GPS receiver to record earthwork detail. Photograph courtesy R Pullen

Top right: The wall footings on the north-east side of the precinct. Photograph courtesy T Pearson

Right: One of the hollow ways outside the precinct boundary. Photograph courtesy R Pullen

Land use within the precinct

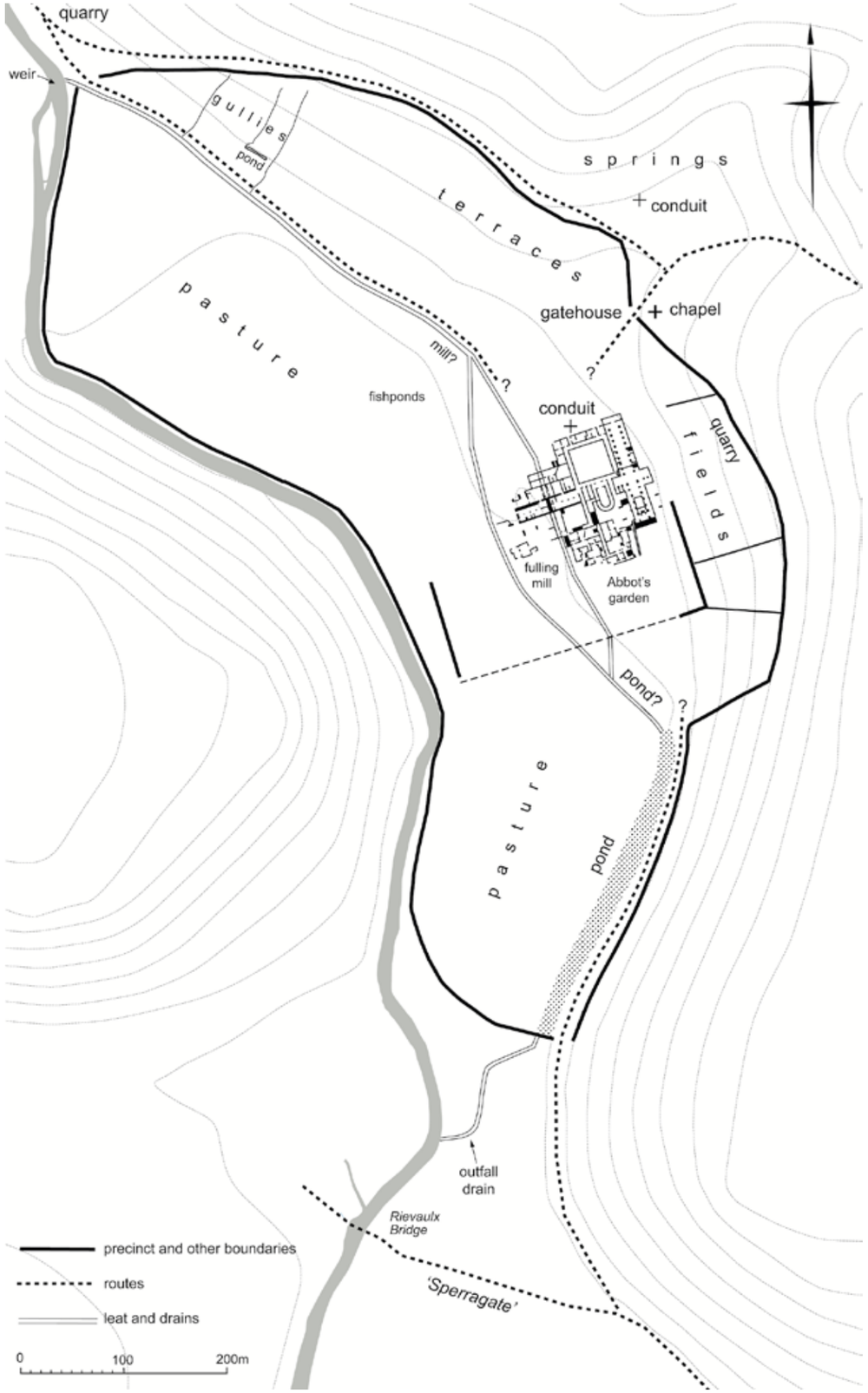
We know from documents compiled at the time of the Dissolution that parts of the precinct were given over to agricultural and industrial use including a complex of terraced platforms and enclosures surviving as earthworks inside the precinct on the east side of the valley.

These comprise three terraces, now split between two fields, stepping down the hillside. The gradient is quite steep in places so these terraces were obviously laid out on a common axis to create more level space by cutting into the uphill side while building up the land below sometimes employing a stone wall as a revetment. These terraces probably continued towards the abbey, although the ground is now built over or landscaped as gardens, leaving no visible evidence. >>

Above left: A stone wall revetting one of the terraces. Photograph courtesy R Pullen

Right: Plan showing the main features of the abbey layout. © Historic England. Illustrator T Pearson

We know from documents compiled at the time of the Dissolution that parts of the precinct were given over to agricultural and industrial use



Water Supply

Various 'ings' or meadows are recorded at the Dissolution on the low-lying ground of the valley floor and the main archaeological features of note here are connected with the supply of water to the abbey.

The monks used water from the Rye to flush the abbey drains and for industrial processes, but their drinking water came from springs closeby on the hillside to the east of the abbey. The river water was directed towards the abbey from the north along a narrow embanked leat or channel that survives at the foot of the slope on the east side of the valley. There are no surface traces of this leat close to the abbey but it is likely that the flow divided, with one arm carrying straight on to eventually flush the latrines in the reredorter to the south east of the abbey church while the second arm took a slightly more westerly course to supply the monastic fulling mill and tannery. The two arms reunited south of the abbey to create a long, linear pond down the east side of the valley as far as the south precinct boundary. From there the water drained directly back into the river along a deep 'u'- shaped outfall channel crossing the valley floor. The remains of the monastic water supply have sometimes been interpreted as an old course of the Rye left high and dry after the monks moved the river to the west side of the valley to free up land for building. However the survey established through accurate height measurement that the west side of the valley is lower than the east thus confirming that the river has not been engineered but is following its natural course.

Above left: Remains of the leat directing water to the abbey. Photograph courtesy R Pullen

The iron industry

After the Dissolution, an embanked channel over 200 metres long was constructed to direct water from the monastic pond on the east side of the valley further south to an iron forge on the site of Forge Farm. Apart from this, the post-Dissolution iron industry at Rievaulx has left few other traces in the landscape.

At the blast furnace site near the abbey church the only visible indication is that waste from the workings is thought to account for the build-up of the ground below parts of the village where fragments of slag can be seen in some of the gardens. With the demise of the industry the village expanded and the valley reverted to agriculture to create the landscape so much admired for the last 250 years.

This study has enhanced interpretation of the landscape and the new knowledge will be disseminated to increase public awareness and enjoyment of the abbey, as well as to inform management and protection. The survey also showed how useful drones are for recording archaeological landscapes ■

The author

Trevor Pearson FSA

Trevor retired as head of the graphics team in Historic England in 2016 having worked previously as a landscape archaeologist for the RCHME and English Heritage.

Further information

Pearson T, 2019 *Rievaulx Abbey, Helmsley, North Yorkshire: Archaeological Survey and Investigation of the Precinct* Historic England Research Report 7/2019 https://research.historicengland.org.uk/Report.aspx?i=16224&ru=%2fResults.aspx%3fn%3d10%26a%3d682%26p%3d3

English Heritage property web page for visitors https://www.english-heritage.org.uk/visit/places/rievaulx-abbey/

This study has enhanced interpretation of the landscape and the new knowledge will be disseminated to increase public awareness and enjoyment of the abbey, as well as to inform management and protection.

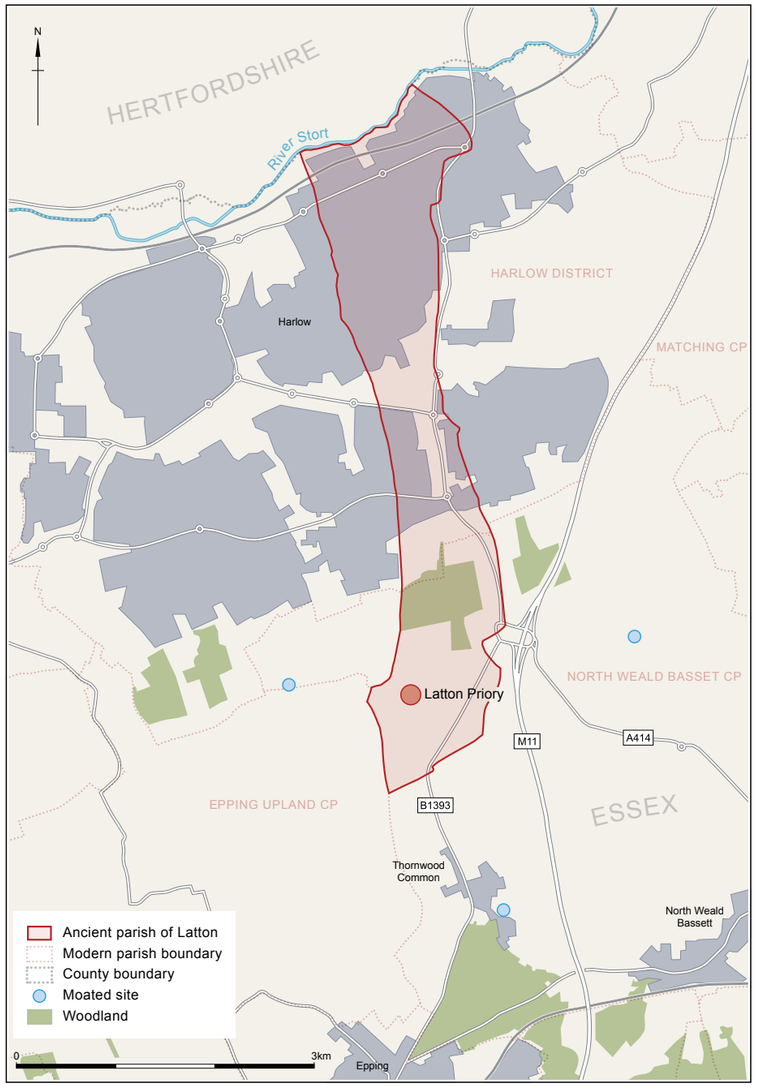
The former Augustinian priory of

St John the Baptist, Latton, Essex

Archaeological survey of the landscape surrounding the remains of Latton Priory during grant-aided repairs has identified the site of an annual fair granted by Edward III to the priory's patron in 1332.

Latton Priory Farm from the south-east in 2015. © Historic England Archive. Photographer Patricia Payne, DP173622

Above left: The location of Latton Priory shown in the context of Harlow New Town, the M11 motorway and the boundary of the ancient parish of Latton. © Historic England



Like many small Augustinian houses, Latton is poorly documented

The site is protected by three statutory designations

Above left: Oblique aerial view of Latton Priory Farm from the south in 1995. The wood-lined arms of the moat and southern pond are clearly visible as are the earthworks which define the scheduled area. The remains of the priory church occupy the south-eastern corner of the farm yard. © Essex County Council, EXC 16586/12

Location and history

Latton Priory Farm is located 4 kilometres (2.5 miles) south-south-east of Harlow town centre. It overlies the site of a small Augustinian priory and contains, within its later agricultural buildings, the remains of the early 14th-century priory church of St John the Baptist. Like many small Augustinian houses, Latton is poorly documented. Neither the date of its foundation nor the identity of its founder are known, though it is likely that a priory existed on the site from the late 12th century.

The priory church and its claustral buildings were rebuilt in the early 14th century and set within a trapezoidal precinct defined by a moat. The rebuilt priory was surprisingly grand given its small community, which had dwindled to a solitary canon (the clerical monks who formed Augustinian communities) by 1534, obviating the need for a forced suppression during the dissolution of the monasteries.

Planning and designation context

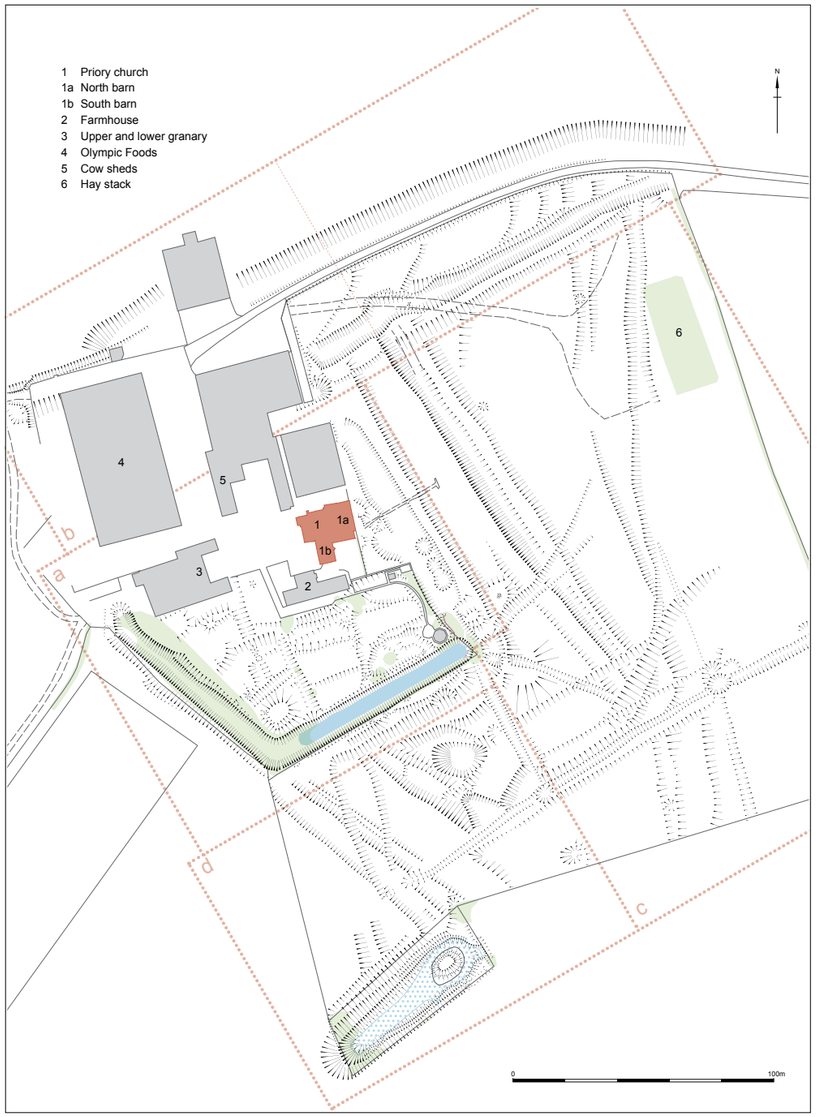
The site is protected by three statutory designations: two listings respectively cover the upstanding remains of the priory church and the 18th-century farmhouse, and a scheduled monument designation covers the wider landscape of the monastic precinct. The scheduled area is defined by the line of the northern arm of the moat and by a series of prominent linear earthworks to the south and east. The schedule description assumes that evidence for the church's lost nave and a standard claustral arrangement will survive beneath the farmyard.

The land to the north of Latton Priory Farm has been identified as part of the new Harlow and Gilston Garden Town within the emerging Local Plans for Harlow and Epping Forest. Initial proposals were likely to affect the setting of the scheduled landscape in the form of new housing proposed close to the precinct's northern boundary. >>

Heritage at Risk casework

New research into the historic upstanding remains of Latton Priory and the wider monastic landscape was initiated by a request by the Heritage at Risk team to support the grant-aided consolidation of the post-medieval barns adjoining the priory church. The deterioration of these barns had allowed water ingress to damage the soft Reigate stone of the crossing piers, leading to Latton's addition to the Heritage at Risk Register in 2014. The consolidation work on the barns and scaffolding of the crossing provided an opportunity to conduct detailed analysis of the fabric of the priory church as part of a wide-ranging, multi-disciplinary non-invasive study of the wider monastic landscape.

Beginning in 2016, architectural and archaeological investigators from our Cambridge office began work at Latton, supported by colleagues from our Remote Sensing and Aerial Investigation and Mapping teams. This project sought to interpret the numerous surviving earthworks, to reappraise the standing buildings in the light of new archival research and to locate buried elements of the lost priory plan.



This project sought to interpret the numerous surviving earthworks, to reappraise the standing buildings and to locate buried elements of the lost priory plan.

Above left: The crossing of Latton Priory looking east towards the barn which marks the location of the former presbytery. © Historic England Archive. Photographer credit Patricia Payne, DP173640

Above right: All of the features recorded during the analytical earthwork survey shown in relation to the buildings of Latton Priory Farm. © Historic England

Analytical earthwork survey

The major component of the Latton Priory project was an analytical earthwork survey covering an area of 5.7 hectares (14.4 acres) which included both the scheduled area and the visible earthworks beyond it.

A pairing of Total Station Theodolite and high–precision Global Navigation Satellite System (GNSS) equipment was used to record the earthworks across a combination of rough open pasture, gardens and the heavily wooded areas of the moat and a former monastic pond.

The surveyed area formed four distinct sections, each containing earthworks of quite different character. The inner precinct, defined by the farmyard and the remaining visible arms of the medieval moat, now survives as the farmhouse garden, characterised by a manicured lawn and less pronounced earthworks. The 'Upper Mead' to the east of the moated precinct and 'Grove Field' to the south – terms taken from historic maps – comprised rough pasture with clearly defined earthworks, some aligned uncomfortably with the precinct suggesting quite complicated phasing. To the north east, outside the scheduled area, an elongated, triangular field was seen to correspond with an area called the 'Foreberry' in the 17th century. Given this area's lack of statutory protection and the potential threat from encroaching development, interpretation of this 'Foreberry' became a priority for the project. >>

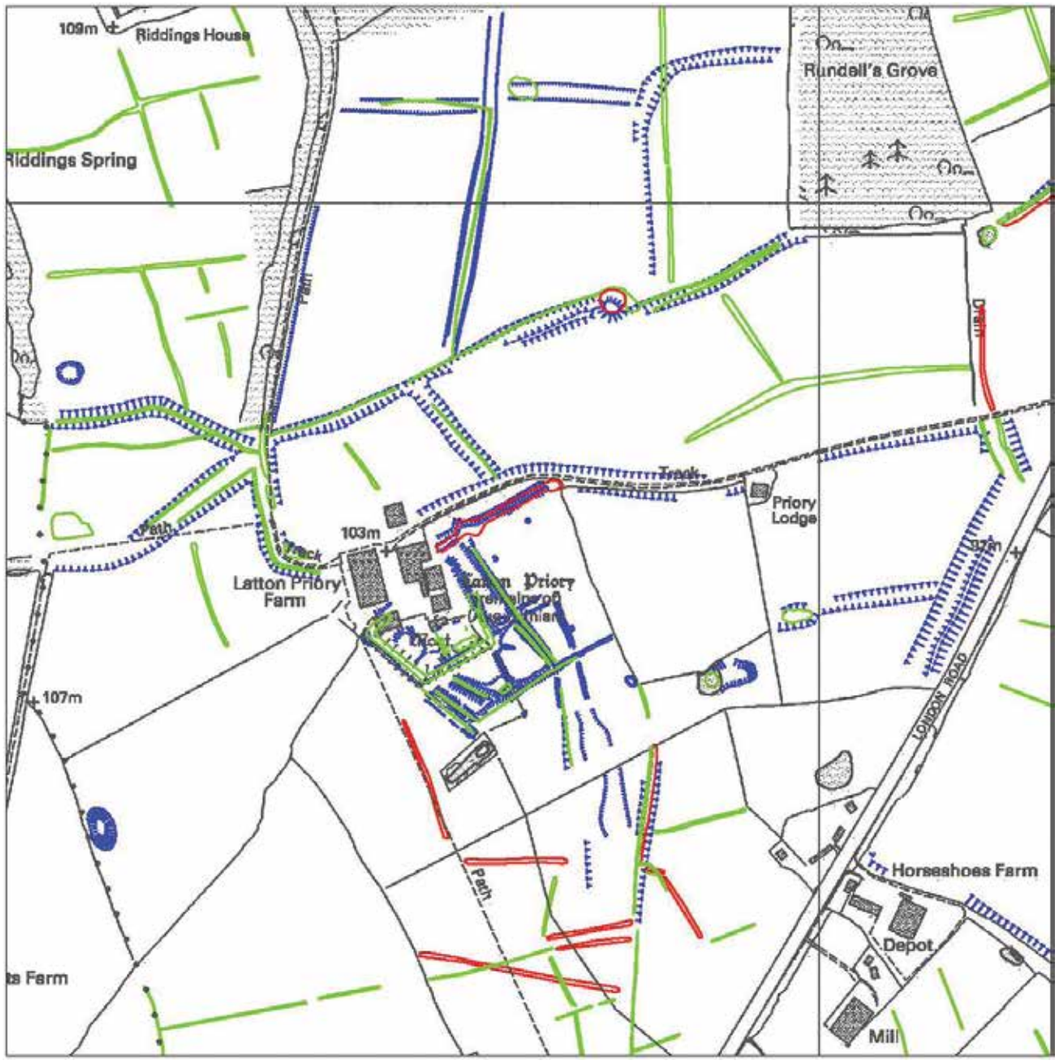
Geophysical survey and aerial mapping

In 2008, a magnetometry survey of the garden south of the farmhouse had failed to identify any significant anomalies. To complement the analytical earthwork survey, however, further geophysical survey using Ground Penetrating Radar (GPR) was conducted over the garden and the wider precinct of the priory, and most significantly over the concrete yard surfaces of the modern farmyard. The combination of GPR and Earth Resistance Survey identified clear buried deposits relating both to the lost elements of the church and priory plan and to the infilled moat and wider landscape.

This analysis of the landscape surrounding Latton priory was further enhanced by interpretation of lidar (airborne laser scanning) and aerial photographs supported by historical plans and maps. Covering an area of 9 square kilometres centred on the remains of the priory, this process identified a number of former hollow ways, ponds and medieval field boundaries, as well as evidence of earlier occupation from the prehistoric and Roman periods.

Documentary research

In the absence of monastic records relating to the foundation and endowment of the priory, documentary research focused on the secular manorial records of Latton parish. The absence of a central authority or constitutional apparatus for founding Augustinian houses and the flexibility of the Rule which the allowed the canons to adapt to the desires of their patrons, made patronage of an Augustinian house particularly attractive to socially mobile members of the 14th century English gentry. Our attention was drawn to the lords of Mark Hall manor, whose ancestors had been credited with founding the priory, and to Augustine La Waleys in particular, who acquired Mark Hall manor in 1317 together with the advowson or right to patronage of the priory church, which the Lords of Mark Hall held until the dissolution. >>

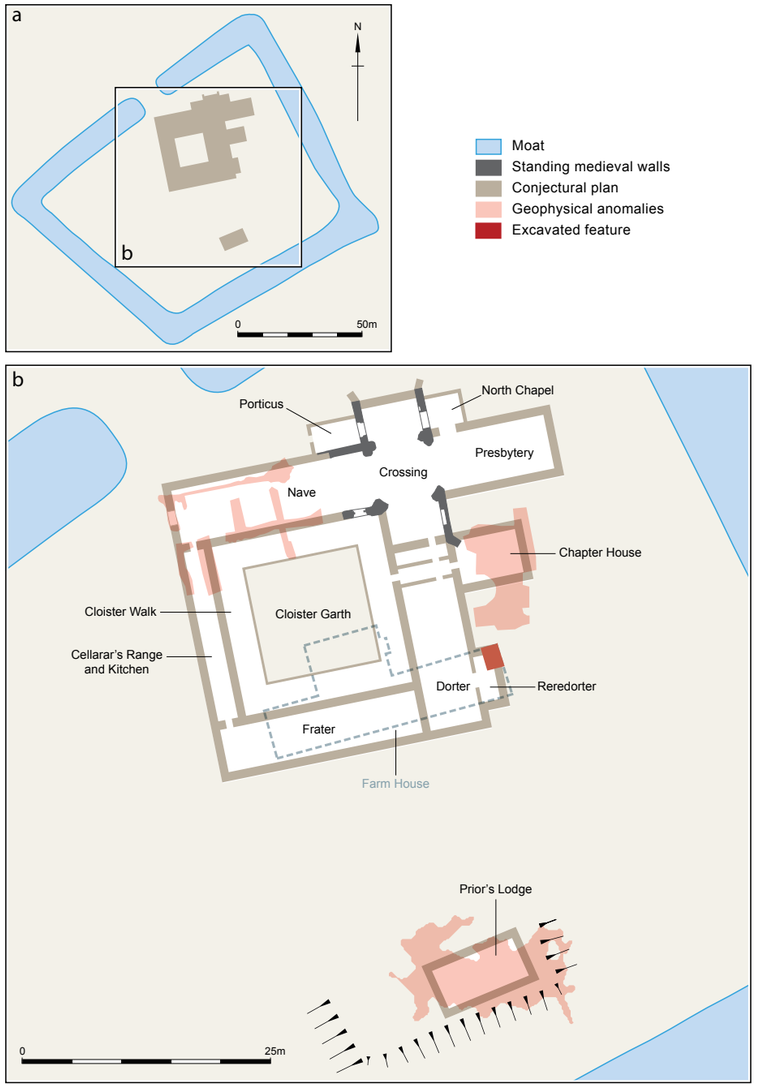


documentary research focused on the secular manorial records of Latton parish.

Far left: The remains of Latton Priory and surrounding tracks and field boundaries mapped from lidar and aerial photographs. Base map © Crown Copyright and database right 2016, all rights reserved. Ordnance Survey licence number 100024900

Near left: Extract from a 1616 estate map of Latton showing the 'Foreberry' to the north of the priory precinct. Reproduced by courtesy of Harlow Museum

Above right: Conjectural reconstruction plan of the Latton priory, plotting the upstanding remains of the priory church and significant geophysical anomalies against a standard Augustinian priory plan. © Historic England



The most significant finding from this multi-disciplinary study

Above left: The brick buttress at the south-east corner of the south transept. Although heavily altered and repaired, it is possible that it is comprised largely of bricks dating from the late-12th century and manufactured at Waltham Abbey. © Historic England Archive. Photographer Patricia Payne, DP173631

detailed analysis of the fabric concluded that a free-standing buttress was constructed of 12th century bricks of a type manufactured at nearby Waltham Abbey

Key findings

The most significant finding from this multi-disciplinary study was the realisation that the triangular enclosure delineated by significant earthworks to the north-east of the priory can be identified as the site of an annual fair. This enclosure formed part of the eastern approach to the priory via Priorie Lane, with visitors required to pass through the enclosure before reaching the causeway across the moat into the priory precinct. Controlling access to the priory in this way would have allowed the collection of tolls during the annual fair.

Depicted on the estate map of 1616 adjoining the priory precinct and labelled as the 'Foreberry', this enclosure is comparable to the 'Forbury' at Reading Abbey (Berkshire), the 'Forbury' at Leominster Priory (Herefordshire) and the 'Bury' at St Osyth's Priory (Essex). Each were sites of fairs granted by the King to those houses. At Latton, a fair, to be held on the feast day of St John the Baptist, was granted by Edward III in 1332 to Augustine La Waleys, the priory's patron. It is significant that at Latton the grant was made to the patron and not to the priory, likely providing Le Waleys with a way of recouping some of his investment and marking the date of the completion of the priory's rebuilding in 1332.

The GPR survey was also successful in locating the buried remains of the priory church's lost nave, a northern porticus ie a small room (indicating a plan comparable to that of the priory at Beeston Regis), the corner of the western range of the cloisters and more fragmentary evidence for a chapter house and a possible Prior's lodge, the latter under the gardens south of the farmhouse. These findings served to validate a number of the assumptions which underpinned the statutory protection afforded to the site.

The upstanding remains of the priory church were comparatively well understood. However, detailed analysis of the fabric concluded that a free-standing buttress was constructed of 12th century bricks of a type manufactured at nearby Waltham Abbey, possibly indicative of both the priory's original appearance and links with a larger, well-established Augustinian House. >>

Impact of the research

This wider study of Latton priory has identified the 'Foreberry' fair site as being of high significance, despite being outside of the scheduled area. The research is timely as it could inform the final Masterplan for the proposed Garden Town. The most recent proposals (early 2020) reserve the land closest to the 'Foreberry' as a 'Suitable Alternative Natural Green Space'. The Latton research also serves as a model for reconstructing the history of a poorly documented monastic house using a combination of non-invasive archaeological techniques and a reappraisal of secular manorial documentation. It has allowed the production of a reconstruction drawing of the priory, which will ultimately be presented on interpretation boards when the remains of the Priory become more accessible as part of the Garden Town landscape ■

The author

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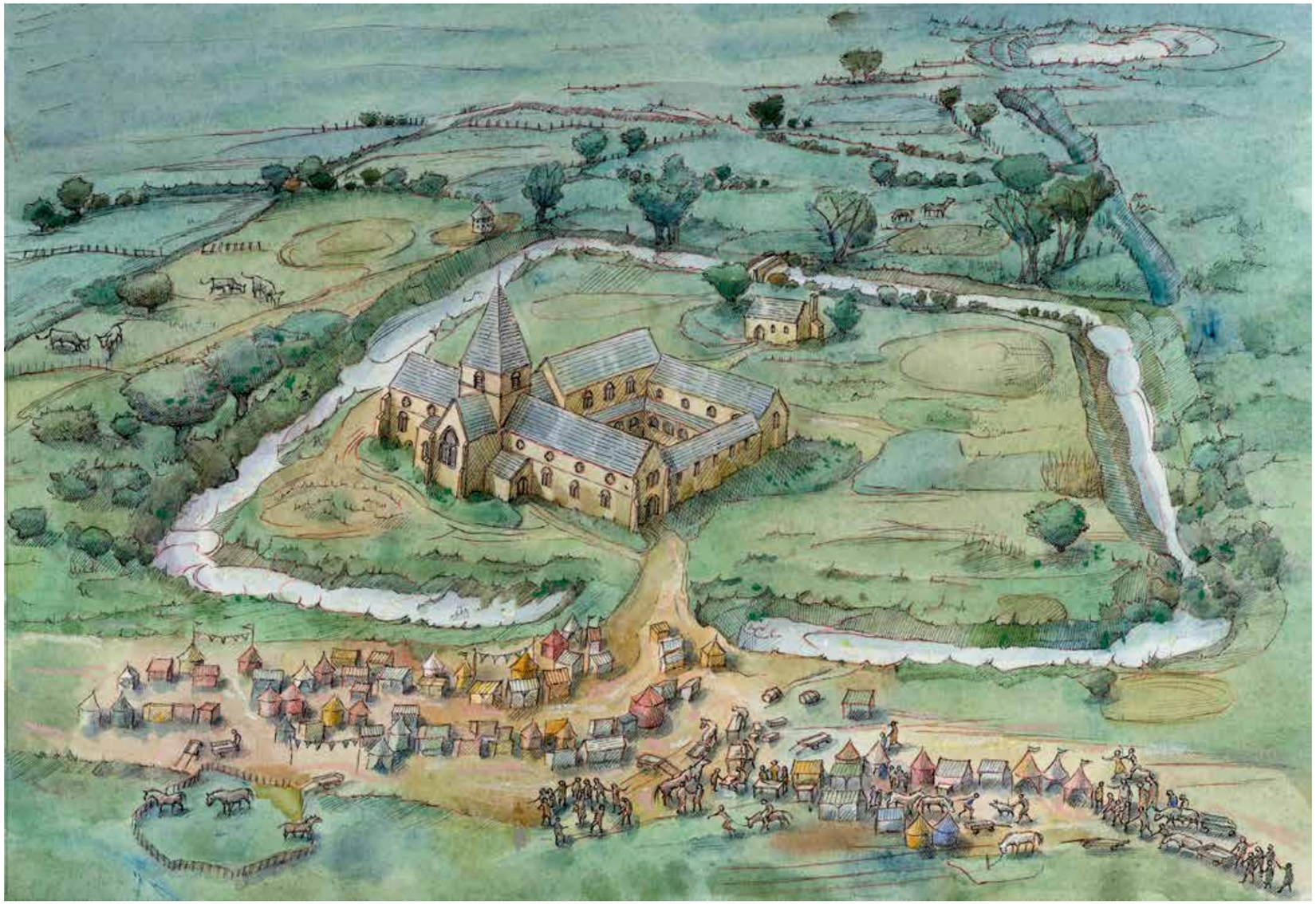
Matthew combines his Historic England role as a Senior Archaeological Investigator within the Policy and Evidence Group with a role at the Institute of Historical Research where he is a Lecturer in Landscape Studies and the Architectural Editor of the Victoria County History.



The research is timely as it could inform the final Masterplan for the proposed Garden Town.

Left: Latton Priory as it may have looked on the 29th August 1335. This followed the rebuilding of the priory church, its inner precinct and its claustral buildings after the acquisition of the priory's patronage by Augustine Le Waleys in 1317. Waleys was in 1332 granted a license to hold an annual fair on the feast day of the Decollation of St John the Baptist. The fair likely took place in the 'Foreberry', a triangular enclosure to the north of the moat which defined the inner precinct containing the priory church, cloisters and the Prior's lodgings. © Historic England. Artist Judith Dobie

Further information

Bristow, M. et. al. 2017, *Latton Priory, North Weald Bassett, Essex*, Research Report Series 23/2017 (Swindon) ISSN 2059-4453 https://research.historicengland.org.uk/Report.aspx?i=15867

Linford, N., Payne, A., & Pearce, C., 2016 *Latton Priory Farm, North Weald Basset, Essex: Report on Geophysical Surveys, April 2016,* Research Report Series 29/2916 (Swindon) ISSN 2059-4453 https://research.historicengland.org.uk/Report.aspx?i=15521

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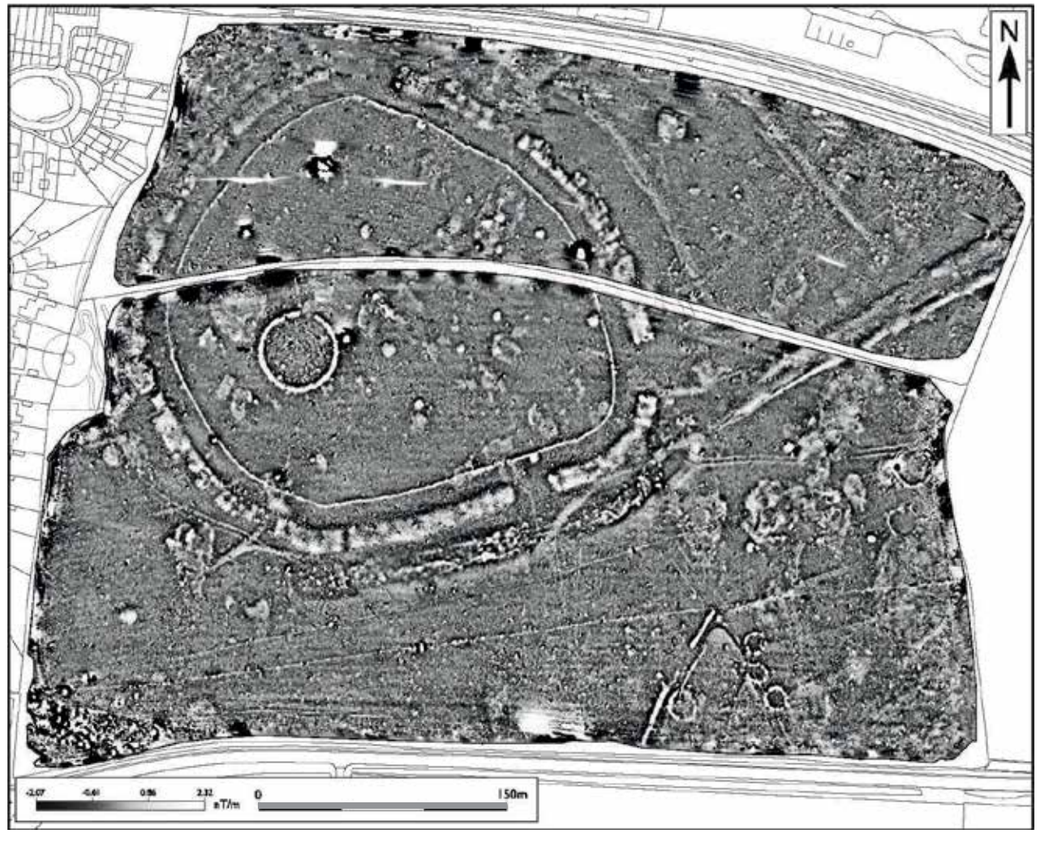
Returning to Mount Pleasant fifty years on

Fifty years after geophysics was first used at Mount Pleasant new results reveal a more complex monument, demonstrating the value of continued research to monitor its condition.

Mount Pleasant is a large, Neolithic, ditch and bank monument comparable in size to other 'mega-henges', such as Avebury and Durrington Walls in Wiltshire, but it remains almost hidden from view under arable fields to the east of Dorchester, Dorset.

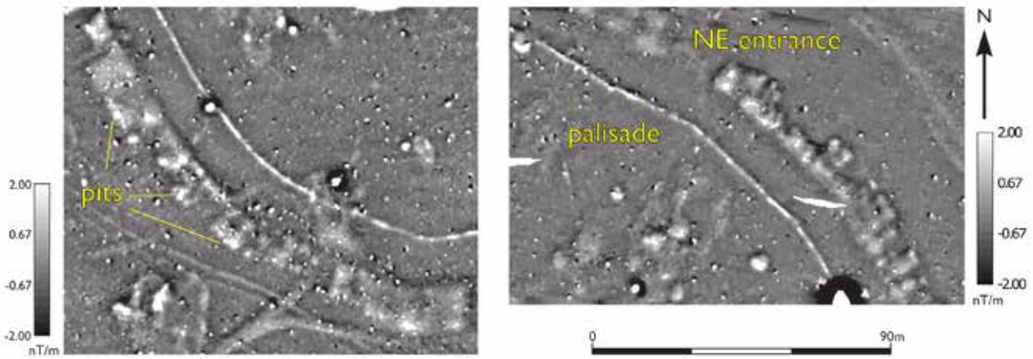
Much is known about the henge owing to Geoffrey Wainwright's excavations between 1970 and 1971, informed by Tony Clark's contemporaneous geophysical surveys. Martyn Barber's more recent analysis of aerial photography has further enhanced the picture. This research has established a broad understanding of the phases of its development, and recognition of the relationship between the henge and the surrounding archaeological landscape. The Conquer Barrow, a substantial earthwork probably dating to the late-Neolithic and currently covered with trees, is situated adjacent to the west entrance of the henge and a number of prehistoric barrows lie to the south and east.

Recent aerial photographs show extensive areas of chalk exposed on the raised banks to the south of the henge where the thin, overlying soils have been eroded. Geophysical survey was suggested to assess the survival of the prehistoric remains and variation in the depth of soil cover protecting the archaeology from the plough. As there were only a few days available to conduct the fieldwork in March and then later in August 2019 after the harvest, a vehicle-towed magnetometer array was used to cover the whole site. Ground Penetrating Radar (GPR) coverage concentrated on the main henge and obvious areas of soil erosion. >>



Top right: Vehicle towed magnetometer array working around the harvest. © Historic England

Bottom right: Magnetic survey data showing the whole of the main henge. © Historic England



Above: Detail of main henge ditch showing evidence for "gang digging". © Historic England

Gang digging

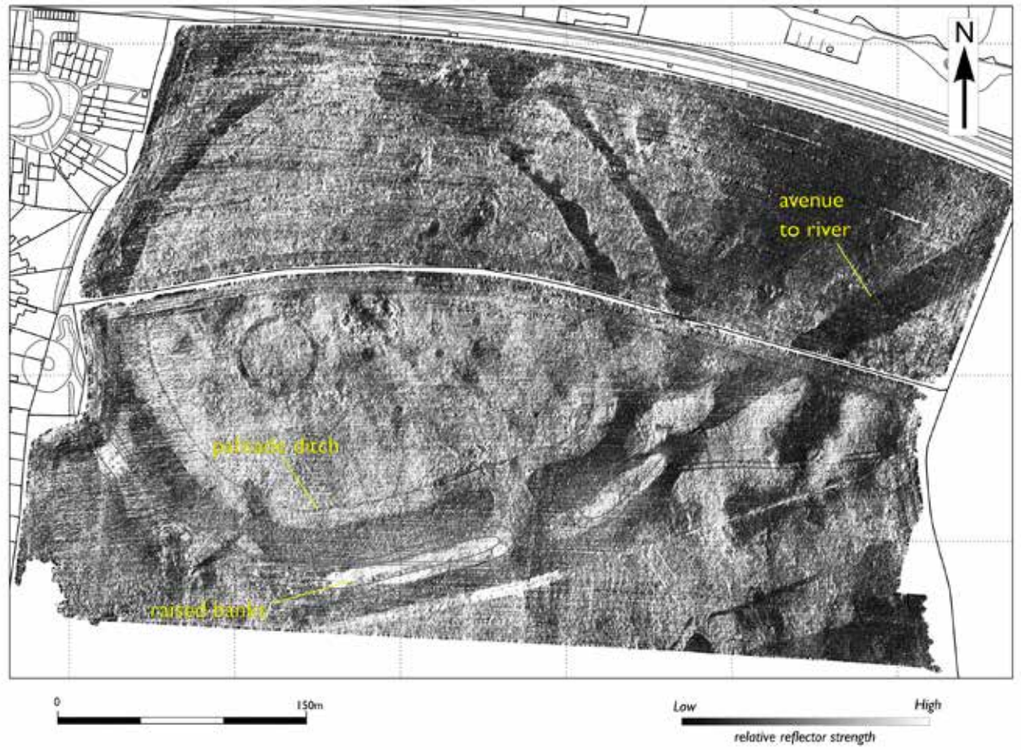
The magnetic survey has mapped the main ditch and internal palisade of the henge with exceptional detail including sections of apparent 'gang-digging' where the ditch appears to have been constructed in an irregular, segmented form, perhaps representing episodic building of each section. When viewed in detail it appears each segment may have been enlarged from an original circle of pits, shown above, marking out the course of the ditch.

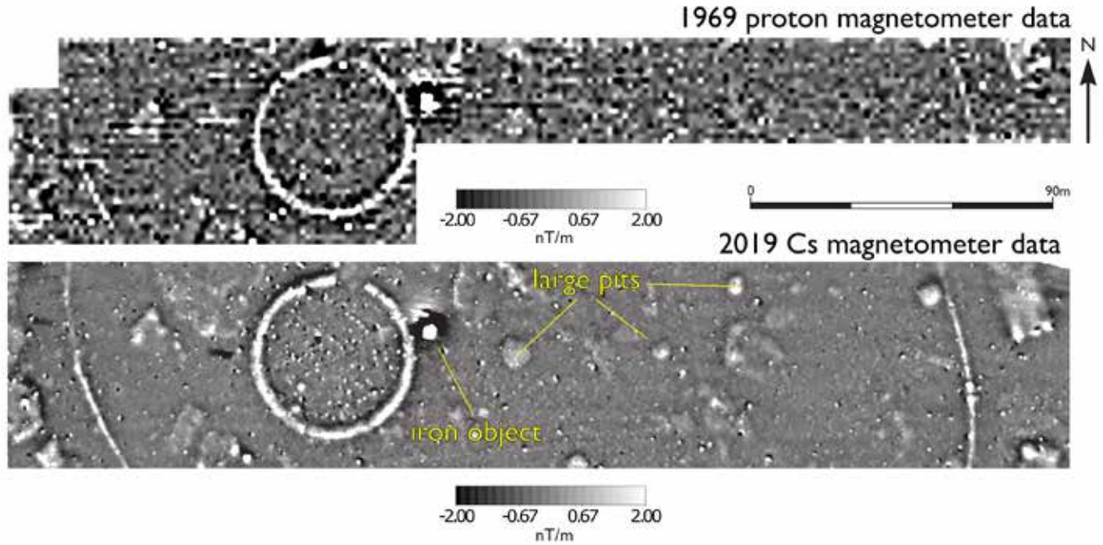
There is also evidence to suggest additional entrances where breaks are found in the henge ditch and bank. One of these entrances to the south west was previously identified from aerial photography, but the apparent entrance revealed to the north east has not previously been detected and is most evident in the magnetometer data, which also indicate a possible outer work formed by a second ditch and bank. The later construction of an internal palisade inside the entire circuit of the henge ditch may have created a deliberate, more complete, enclosing structure to conceal views of the monument from those outside.

Avenue to the river

Other larger henge monuments tend to be associated with linear avenues and there are crop mark indications that Mount Pleasant was linked in some way to the River Frome. Both geophysical techniques support this suggestion and show a broad, linear anomaly heading north east from the henge down towards the river. Further investigation of the approach beyond the current survey area over the railway line to the north would be useful to better understand the potential relationship between the monument and the river valley. >>

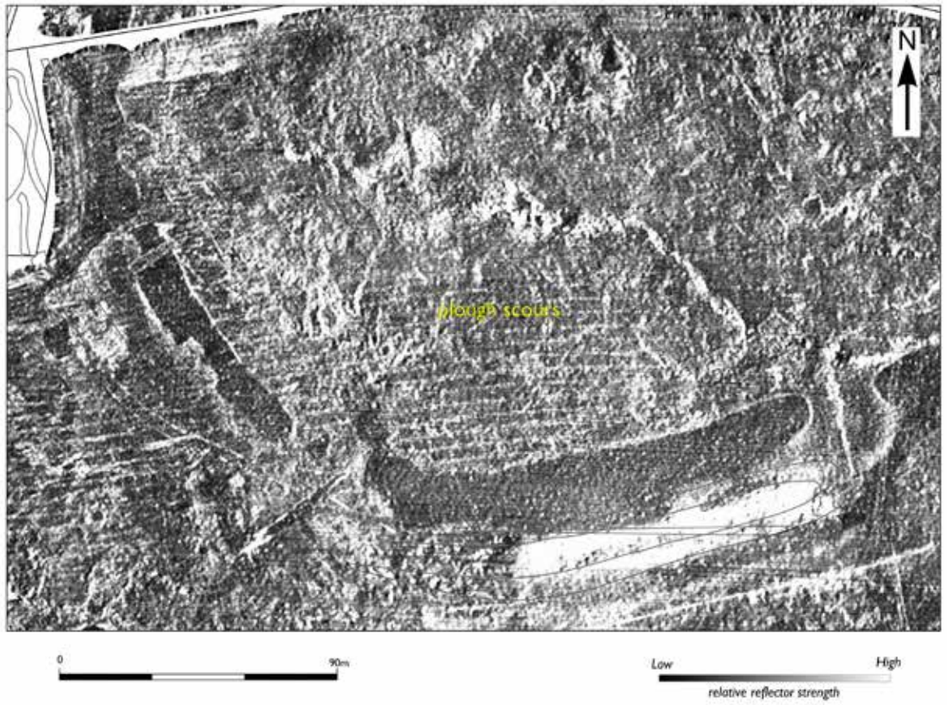
henge monuments tend to be associated with linear avenues and there are crop mark indications that Mount Pleasant was linked in some way to the River Frome.

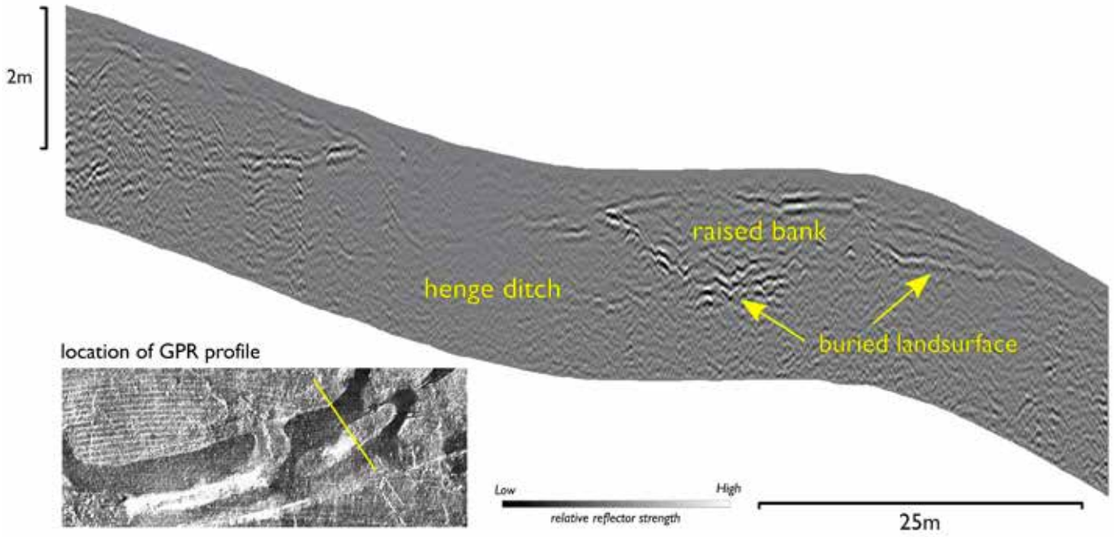




Top: GPR data over the henge at a depth of 0.3 metres. © Historic England

Bottom: Comparison of magnetic survey from 1969 and 2019 over Site IV. © Historic England





Opposite page left: Plough scours revealed in the GPR data at 0.4 metres. © Historic England

Top: GPR profile through the henge ditch and raised bank. © Historic England

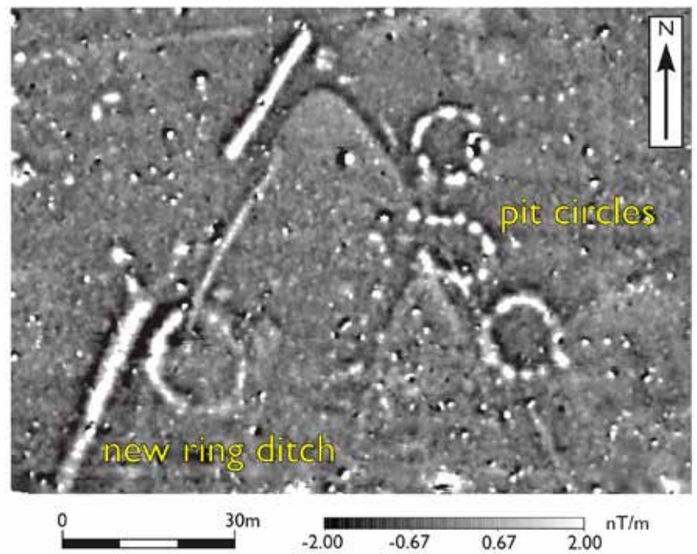
Survival under the plough

Comparison of the geophysical survey with the excavation evidence confirms that the majority of features still survive.

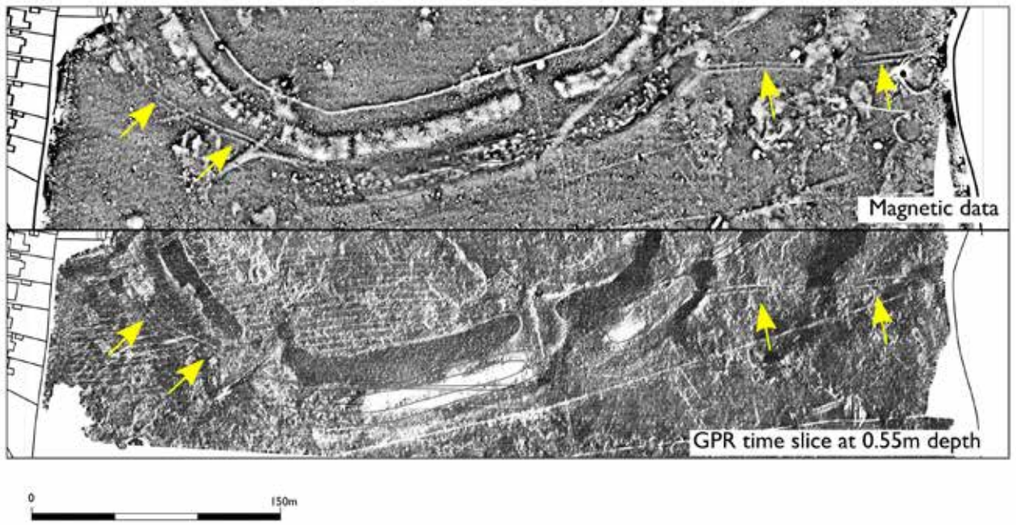
A good example from the excavation is the penannular (ie a broken circle-shaped) ditched feature with internal post-holes known as Site IV, located on a raised plateau within the centre of the main henge. This circular structure, initially of five broadly-concentric rings of timber posts within a pennanular ditch appears to have been replaced by a structure of sarsen stones in around 1700 BC. The GPR data suggests, however, that the topsoil protecting the archaeology is quite shallow in places, perhaps as little as 0.2 metres in depth, and there is a pattern of damage from deeper plough scours visible in the underlying chalk immediately to the south. Historic mapping shows the scour pattern is limited to one of the former fields before all the hedge boundaries were removed, suggesting this might be due not to the modern agricultural regime but, perhaps, to an episode of nineteenth to early twentieth century steam ploughing.

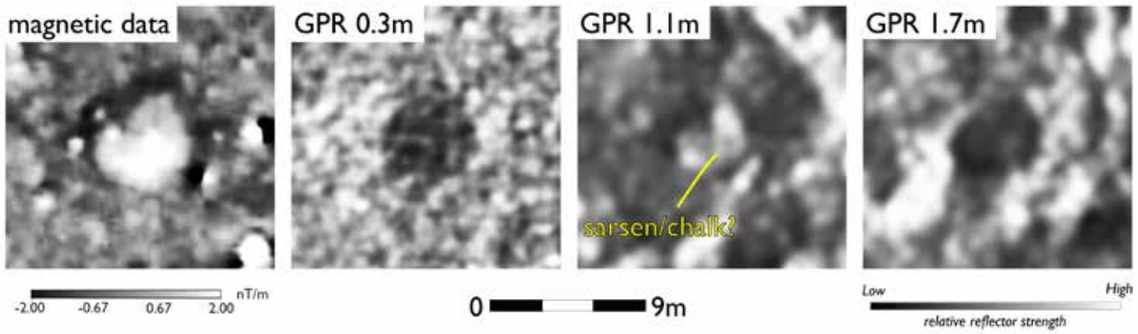
A partial inner palisade, hitherto identified on a single aerial photograph only in the north- west quadrant of the henge inside the main palisade, has been replicated in both the magnetic and GPR data sets. It does not appear to be any more extensive than suggested by the aerial photography and, perhaps, either never continued inside the full circuit of the main palisade or has simply not survived.

The GPR has also revealed more detail over the raised banks to the south of the henge. Profiles through the bank suggest an outer weathering layer on top of chalk packing, sealing an apparent buried land surface beneath. It is possible that the area of surface topsoil erosion is due to a later phase of enlargement, represented bythe chalk packing to form a raised bank, south of the main ditch. Material to construct the raised bank may have come from deepening the main ditch or from the ditch found immediately to the south of the bank. Due to the depth of the henge ditch its full profile has not been resolved by the GPR survey beyond a depth of approximately 2 metres. >>



Bottom: Magnetic data over the southern barrow group. © Historic England





Top: Parallel linear ditch anomaly found with both techniques.
© Historic England

Bottom: Detail over one of the large pit anomalies.
© Historic England

Beyond the main henge

Several barrow groups are known from aerial photography surrounding the main henge and the geophysical survey has been able to provide some significant additional information here. For example, evidence for an additional ring ditch of a new barrow has been found to the south, and three of the known barrows now appear to have been enclosed by segmented ditches or pits rather than continuous ditches.

These features may possibly represent small henge-type monuments or mortuary enclosures, although extending the geophysical survey further to the south might help determine whether they form part of a more extensive complex.

One curious discovery is a parallel double ditch found in the results of both magnetic and GPR techniques that crosses the site from east to west, and partially follows the circuit of the henge bank to the south. The two ditches are separated by almost 4 metres, too wide to be modern vehicle tracks, and appear to be over 2 metres in depth. They also appear to be overlain by the raised sections of bank to the south of the henge, perhaps suggesting a more significant prehistoric boundary contemporary with, or even marking out, the earlier phases of the main monument. >>

Several barrow groups are known from aerial photography surrounding the main henge and the geophysical survey has been able to provide some significant additional information

Fifty years on

The new geophysical field work was conducted almost exactly 50 years after Tony Clark made his initial magnetometer survey. All of the original measurements were made with an analogue instrument with individual readings written on paper and plotted by hand. While an impressive level of detail was drawn from this original survey, it has now been possible to digitise the measurements to present the datain the same format as the modern survey.

Both magnetic surveys revealed a number of large, circular pits up to 8 metres in diameter. When excavated one of these revealed a shallow oval pit with Iron Age and Roman pottery sherds, and another two were thought to be natural clay pockets. The new geophysical survey data suggests that similar, large, deep pits are found across the site, perhaps associated with relict deposits of sarsen stone or chalk fragments.

Comparison between the 1969 and 2019 magnetic datasets also provides an additional means of assessing the survival of the archaeological remains over time. There is even an intense response to a buried iron object that has not moved over the 50 years!

The new geophysical survey provides a comprehensive plan of the monument to enhance the excavation and aerial photographic record. Despite evidence for plough levelling of the earth works in places, much of the monument survives for now beneath the immediate reach of the plough. Covering the whole of the henge with both magnetic and ground penetrating radar techniques provides an important record of the location and depth of the surviving archaeological features. Perhaps in another fifty years this data set will provide a useful comparison to future geophysical survey campaigns.

The results of the geophysical survey are available as a full research report and have been used to help with the on-going management to ensure adequate protection of the site https://research.historicengland.org.uk/Report.aspx?i=16485 ■

Comparison between the 1969 and 2019 magnetic datasets also provides an additional means of assessing the survival of the archaeological remains over time. There is even an intense response to a buried iron object that has not moved over the 50 years!

The authors

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Senior Geophysicist with Historic England.

Neil has experience across a wide range of applied geophysical techniques. Whilst his doctoral research focused on the magnetic properties of archaeological sediments, he also has expertise in all aspects of the use of GPR. He is an editor of the journal *Archaeological Prospection*, has served as the chair of the NERC Geophysical Equipment Facility, and recently co-edited "Innovation in Near-Surface Geophysics" featuring contributions on many aspects of archaeological geophysics.

Paul Linford, MSc
Geophysics Manager with Historic England.

Paul has worked as an archaeological scientist for English Heritage and Historic England since the mid-1980s and is head of the latter's Geophysics Team. He has particular interests in archaeomagnetic dating and in developing the team's caesium magnetometer array. Paul is also Treasurer of the International Society for Archaeological Prospection and a member of the Geological Society's Near Surface Geophysics Group committee.

Andy Payne
Geophysicist with Historic England.

Andy has specialised in the practice of archaeological geophysics since the early 1990s, working widely across England and occasionally in France, Spain and the Channel Islands. He has contributed to numerous reports and publications. His archaeological career has also included working on excavations in Orkney and on the site of the Roman amphitheatre in London.

Further information

You can find more information on geophysical survey, more information in our research methods pages: https://historicengland.org.uk/research/methods/terrestrial-remote-sensing/geophysical-survey/

And technical advice pages: https://historicengland.org.uk/advice/technical-advice/archaeological-science/geophysics/

Barber, M 2014 *'Mount Pleasant, Dorset. A Survey of the Neolithic 'Henge Enclosure' and Associated Features'*. Historic England Research Report Series 70-2014. https://research.historicengland.org.uk/Report.aspx?i=15340

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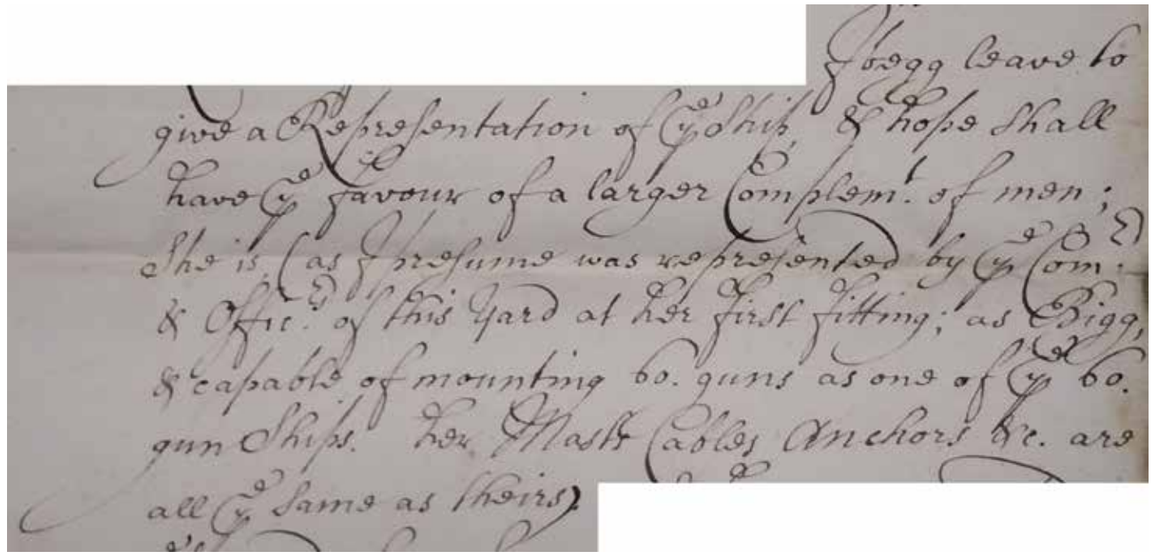
The ‘gunnes’ of Warship *Hazardous Prize*

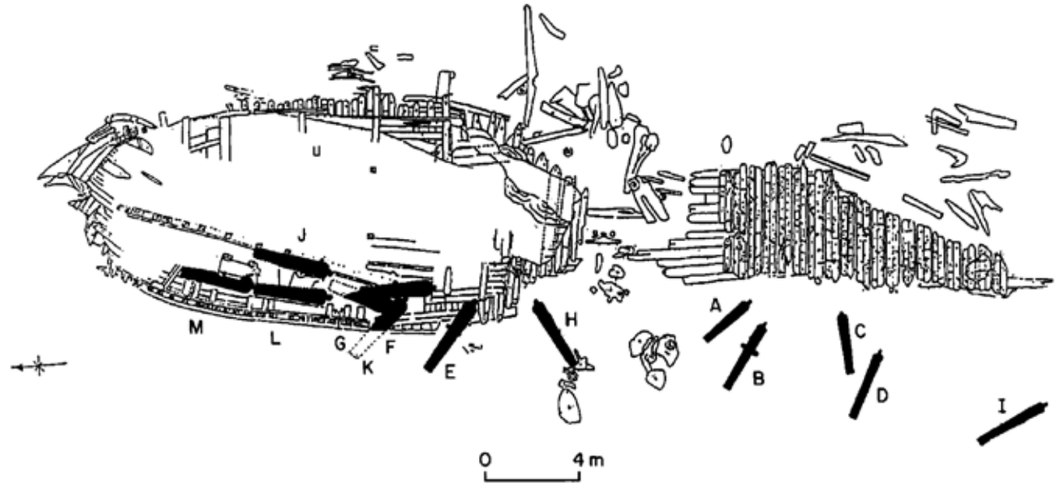
Historical and archaeological research on a protected wreck site focusing on the ship’s guns.

Historic England has been supporting the avocational team working to research, survey and document the protected site of Warship *Hazardous Prize*, which was wrecked in Bracklesham Bay, West Sussex, in 1706. New underwater discoveries and archive research have greatly enhanced our knowledge of the wrecking process and the armament of the vessel.

A modern representation of Warship *Hazardous Prize* by Sussex artist Laurie Crisp, owned by the author and based on the only known contemporary illustration, a design drawing in the Musee National de la Marine in France, annotated as showing the stern of *le Hasardeux* – however there were earlier ships with the same name so it isn’t guaranteed to be “ours”. Painting by Laurie Crisp, commissioned by Dave Johnston.



Above left: Extract from a letter from Captain Barrows Harris to the Admiralty, dated 24 December 1704 requesting additional guns for Hazardous. Copyright Public record office PRO 285 Letter dated 24 Dec 1704 Reference: ADM 106/586/285 Folio 285



Above right: Main site survey, collated from several surveys performed in the 1980s, adapted from Owen (1991). original drawing copyright The Nautical Archaeology Society, adapted with permission.

Background to the wreck

Warship *Hazardous Prize* began life as *Le Hazardeux,* built for the French Navy. Its keel was laid down in the L'Orient shipyards in Brittany in 1699 and the vessel was commissioned into the French Navy as a 50-gun, Third Rate Ship of the Line in February 1701, carrying an initial complement of 22x 18 pounder, 22x 12 pounder and 6x 6 pounder guns. In 1703 *Le Hazardeux* was captured by the Royal Navy and taken as a prize. After repair, Her Majesty's Warship *Hazardous* entered service in 1704 as a 54-gun, Fourth Rate with 24 x 18 pounder (Lower Deck), 24 x 12 pounders(Upper Deck) and 6 x 6 pounders(Half Deck) guns.

Larger than the average British Fourth rate, *Hazardous* was considered by Naval Surveyors and her Captain, Barrows Harris, to be capable of carrying 60 guns *"if her bottom proves as well as her upper Works are, that she will make a very good Sixty Gun Ship"*. Barrows Harris petitioned the Admiralty for sixmore guns but was refused. He then requested two stern chasers - backwards facing guns or cannon at the stern used to fire on pursuing vessel . We have yet to find evidence that this request was granted.

On the morning of 19th November 1706 and in severe gales, in order to save lives, *Hazardous* was deliberately ran ashore in Bracklesham Bay, West Sussex, at the end of a disastrous return from the Virginias as escort to a large merchant fleet. Within days, *Hazardous* settled and listed to port. Contemporary salvage was attempted and the wreck was partially dismantled in January 1707. Archived Admiralty letters state that 21 guns (including possibly 6 bronze guns) were recovered before the wreck was abandoned as derelict.

The precise site of the wreck was unknown for over 250 years. In 1966, a spear fisherman came across a large iron gun in the Bay but saw no sign of other wreckage. This gun was raised, desalted in Chichester Canal and delivered to Cumberland House Museum in Southsea, though its fate is currently unknown. The Main Site was discovered by members of the 308 Branch Sub Aqua Association in 1977.

Four decades of archaeological research on *Hazardous Prize*

The site has been worked since discovery, first by 308 Branch and more recently by the Warship *Hazardous Prize* Project Group.The site was designated under the Protection of Wrecks Act (1973) in 1986 and the current principal Licencee, Iain Grant, started diving the site in 1982.

The main wreck site lies in 6-9metres of water some 800 metres from the current shoreline just east of Bracklesham village and is being eroded by biological and physical processes. The bay faces south west and is at the mercy of the dominant prevailing winds, wave action, tidal flow and shifting sand banks. Site conditions place significant constraints on the archaeological process, underwater visibility is often less than a metre and diving is often cancelled at short notice because of visibility or safety concerns: wind and waves make launching, recovery and operating from a large rigid inflatable boat unsafe.

The bay faces south west and is at the mercy of the dominant prevailing winds, wave action, tidal flow and shifting sand banks

A site plan prepared in 1991 showed 2 large areas of articulated timber and 13 large guns, some partly buried, some still on their carriages.

Winter storms, particularly in 1990, destroyed the entire southern area of articulated timbers. However, the shifting sands regularly expose a diverse range of small artefacts, which are recovered under licence, conserved and recorded. The project has documented both the remains on the seabed as they have become exposed over the decades and the ever changing seabed levels. As a consequence, the site has featured on the Heritage at Risk Register on several occasions.

Historic England has supported the project group in various ways over the years. In 2015, it awarded funding for small-scale test excavations within the main site to assess the remaining artefact load. Circumstances since 2015 have been difficult. Weather conditions over the last few years have prevented all but a very few days of excavation, and furthermore several team members have been away contributing to two major maritime projects (*Invincible* (1758) and *Rooswijk* (1740): the team has, therefore, had to adapt activities according to weather and resources. It has, however, achieved a huge amount in the limited windows available to dive the site. Chance findings and recent technological advances (especially the application of photogrammetry) have shifted recent attention to the ship's guns. >>

Main Site

In 1986, two of the thirteen guns on the main site ('D' and 'I') were raised, de-concreted, and recorded. Gun 'I' had unusual rings forward of the trunnions (the projecting mounting and pivoting points at each side) but ordnance experts were unable to positively identify the country of origin or maker. At the time, guns from Prize vessels were re-used so an English Naval vessel could be armed with guns originating from more than one country. Portsmouth Museum Service attempted electrolytic conservation of these guns – using electric current to remove corrosive salts from the metal in order to stabilise it- but without success.

New discoveries made in 2014

In 2014, Historic England commissioned Wessex Archaeology to undertake a sidescan sonar survey of the area around the Main Site . This technique involves using acoustic signals pointing sideways and down from a vessel or towed unit to map the detailed topology of the seabed and any structures on it.

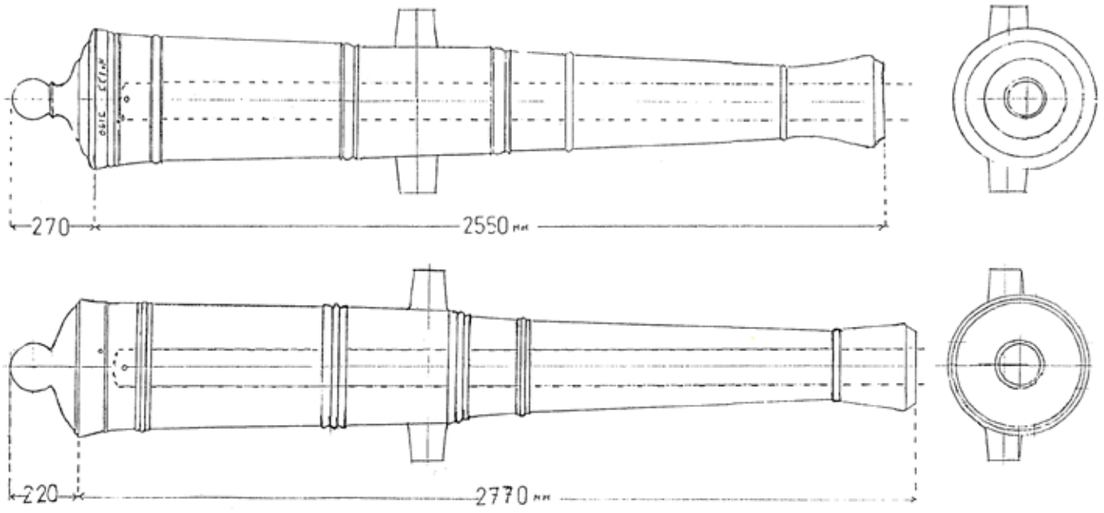
This identified several linear features in a cluster some 130 metres to the west-south-west. Since the seabed in the area naturally erodes into narrow linear ridges, any anomalies were investigated by diving to check if they were really made by human activity. A cluster of 11 large guns and a significant quantity of round and bar shot were located. Although basic measurements were taken at the time, project activity remained focused on the Main Site.

In the last couple of years, there have been a few days when visibility in the Bay improved enough to justify site recording by photogrammetry. One such occasion allowed us to revisit and record the 2014 Gun Site. This involved swimming over the entire site with a GoPro™ camera in underwater housing and powerful underwater LED video lights, continuously taking video footage of small areas from different distances and angles. Individual frames were then extracted from the video, one from every few seconds, and entered into software which pattern-matches between them to calculate relative camera positions and thus build up a full 3D model of the area. If done with care, it can generate photo-realistic, sub-centimetre accuracy surveys across large areas of which only a very small part is visible at any one time. This technique is ideal for underwater sites in UK waters, where visibility is a major issue, and represents a massive saving of time over tape-measure surveys.

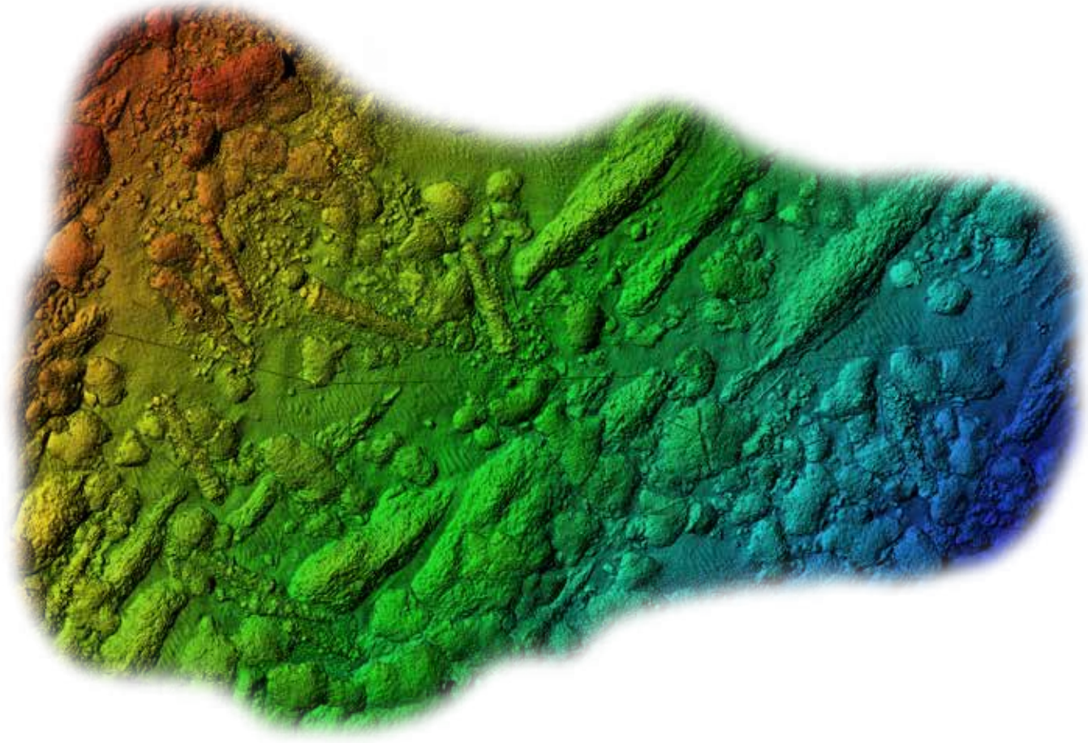
'Pete's Gun'

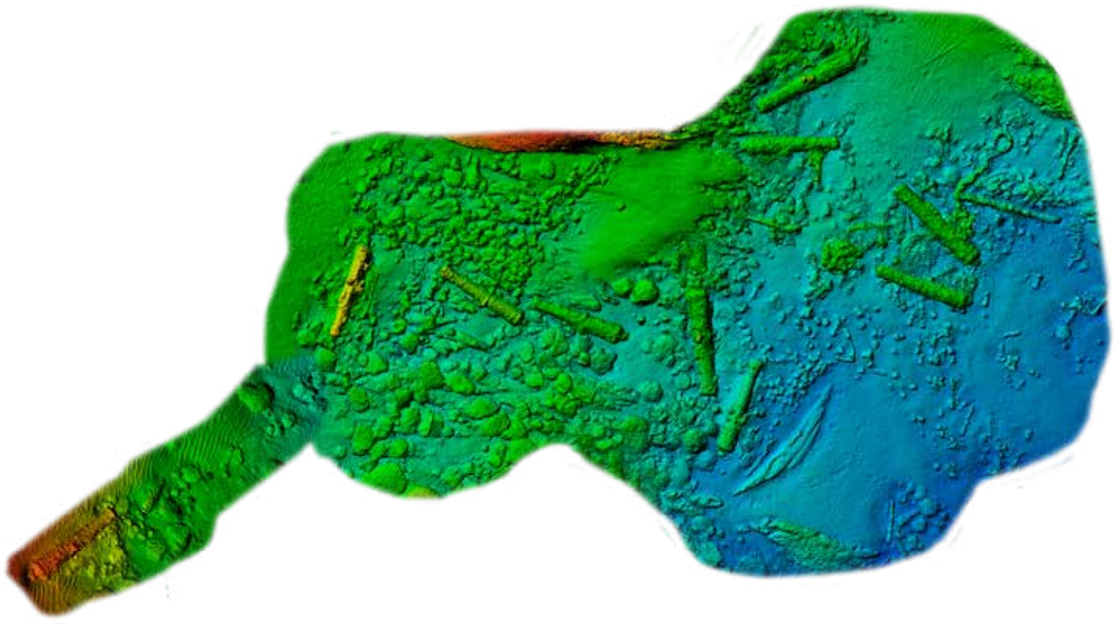
In 2008, a single gun ('Pete's Gun') was located some 85 metres north-west of the Main Site by team member Pete Jolly. Its position was marked by GPS but no further recording was undertaken at the time. In 2019, we went to check if the gun was still exposed. It was relocated and later recorded by photogrammetry. >>

Below left: Line drawings of the two guns recovered in 1986 – adapted from Owen (1991). Gun D above, Gun I below original drawing copyright The Nautical Archaeology Society, adapted with permission.



Below right: A height colour coded (Digital Elevation Model – DEM) view of the 2014 Gun Site – data capture and assembly by Dan Pascoe and Rodrigo Ortiz, Warship *Hazardous* Project Group.





Above left: A height colour coded (Digital Elevation Model – DEM), view of the 2019 Gun Site – data capture and assembly by Dan Pascoe and Rodrigo Ortiz, Warship *Hazardous* Project Group.

Below: A 26 pound sounding weight recovered from the 2019 Gun Site (actually weighs 28 pounds) Author Dave Johnston

Further discoveries in 2019

In 2019, on the dive to relocate 'Pete's gun', team members then reeled off from the anchor line to explore the surrounding area and purely by chance came across a further cluster of 9 large guns, round and bar shot, a small anchor, a cooking pot, sounding weight and other artefacts some 110 metres from the Main Site. A few weeks later, a tenth gun was revealed, emerging from an eroding sand bank some 10 metres distant and there may yet be more to find. Again, photogrammetry has enabled the rapid surveying of a large area.

Site distribution and the wrecking process

We now have three discrete clusters of guns plus 'Pete's gun' within 150 metres of each other on the seabed. Only 2 other Naval vessels are known to have been wrecked in the Bay, both lost in the Great Storm of 1703. One was a small, 10-gun advice vessel the *Eagle*: the other, a 50 gun Fourth Rate, HMS *Newcastle* was reported to have been lost much further east. Therefore we conclude that all these guns are from *Hazardous*.

These sites are revising our understanding of the wrecking event. Sounding leads, used to measure water depth, have been recovered from both the 2014 and the 2019 Gun Sites suggesting that attempts were being made to calculate when the ship would ground. The Sailing Master's log survives in the National Archives and simply states "*ashore in Bracklesham Bay*", so we have no historical evidence of deliberate jettisoning of guns to lighten the ship in an attempt to get closer to shore. >>

Each gun weighs several tonnes, so losing the weight of multiple guns in a grounding and listing event, plus the evacuation of some 350 men, would significantly lighten the vessel, allowing it to refloat on a subsequent tide and move several times before it finally lodged where the main site is today.

Gunnery equipment

A range of gunnery-related artefacts have been recovered from the site including gun-carriage axles and wheels, rammers and mops, lead aprons and cartridge cases. When first located, some of the guns on the Main Site sat on well-preserved gun carriages, but these have since largely been eaten away by gribble, a type of burrowing crustacean.

Doing the Maths

As far as we have been able to determine from archive research, at the time of its sinking *Hazardous* carried a complement of 54 guns (possibly 56 if Harris's request for 2 stern chasers had been granted) and contemporary salvage recovered 21 guns (though the 6 bronze guns mentioned in the contemporary salvage archives remain a mystery as we have found no proof that *Hazardous* was carrying any).

Those 21, along with the 1966 recovery (1 gun – assumed *Hazardous*), the Main Site guns (13), 'Pete's gun' (1), the 2014 Site guns (11) and the 2019 Site guns (10 guns and possibly counting) = 57 guns. Although all of the guns are iron and heavily concreated, none appears to obviously have had its trunnions removed (as, we understand, would have been the case if old guns were recycled as ballast). We therefore appear to have rather too many guns!

We therefore appear to have rather too many guns!

Above left: Site Licencee Iain Grant recovering a cartridge case. This turned wooden artefact has since been conserved by the Mary Rose Trust and is destined for the collections of the Royal Navy Museum in Portsmouth. Copyright *Hazardous* Project Group , photographer, Dan Pascoe.

Left: 3D print of the 2014 Gun Site by the author.

Success despite the British weather

The project is a prime example of the contribution that avocational teams make to our maritime heritage.

As with much British diving, and many archaeological projects, things rarely go exactly to plan. Despite the problems caused by the weather over several seasons, important new historical and archaeological progress has been made and the project moves on, documenting and disseminating. One day, we will be able to finish that excavation, though with coronavirus at large, it probably will not be in 2020! ■

This article is dedicated to the memory of team member Peter Jolly, one of the original 308 team members, who sadly passed away earlier this year.

Despite the problems caused by the weather over several seasons, important new historical and archaeological progress has been made and the project moves on, documenting and disseminating

The author

Dave Johnston, PhD
Avocational diver and underwater archaeologist, Warship Hazardous Prize (1706) Project Group.

Dave is a professional biologist with a day job running microscopes in the Biomedical Imaging Unit at the University of Southampton. He is one of the many avocational underwater archaeologists who devote their time, energy and finances to research, survey and document the nation's protected wrecks. He joined the *Hazardous* Project Group in 2002 (a newcomer!) and his dive log for his first dive on the site records "Visibility very poor, lots of crabs, lobsters and small fish. Couldn't really get any impression of the site (or even that it was a wreck site!)". www.hazardousproject.info

Further information

Hazardous Prize website http://www.hazardousproject.info/

Owen, NC, (1991) '*Hazardous* 1990-1991 interim report' *The International Journal of Nautical Archaeology* 20.4: 325-334.

Captain Barrows Harris' letter: PRO 285 Letter dated 24 Dec 1704 Reference: ADM 106/586/285 Folio 285: Captain Barrows Harris, the *Hazardous*, Hamoaze.

The *London* wreck – a kaleidoscope of specialists, materials and artefacts

Scientific analysis of the archaeological assemblage from the *London* has revealed a wealth of information about life aboard a 17th-century Royal naval vessel.

The warship *London* blew up and sank in the Thames Estuary, off Southend-on-Sea on 7th March 1665. The *London* was a second rate 'Large Ship' built in Chatham in 1656. The ship suddenly blew up when being mobilised for the second Anglo-Dutch war, and over 300 lives were lost. This event was famously recorded by Samuel Pepys in his diary. The protected wreck has been on the Heritage at Risk register since 2009. Maritime archaeological investigations have resulted in the recovery of over 700 finds from the wreck. These include human and animal remains, ordnance, navigational equipment, fixtures and fittings, personal belongings and supplies.

The collaboration between various specialists has been a key component in unlocking crucial information pertaining to naval warfare and operations, but also tells the story of life on board a warship in the 17th century.

More than 20 specialists have worked on the material recovered from the *London* wreck. The results of the excavation and the post-excavation assessments and analyses are soon to be published in a monograph with the working title 'The wreck of the *London*: Archaeological investigations of a 17th century warship, 2014-2016'. >>

Left: Close up of the edge of a leather book cover, showing remnants of gold leaf decoration. © Historic England Archive. Photographer James O Davies

Material science: leather, glass and metals

The contents of the *London* were buried in silt for much of the past 355 years and leather and wood items, which normally do not survive well on land, were beautifully preserved because of reduced oxygen levels. Conservators spotted different coloured patches on some of the leather objects, and this was investigated using a non-destructive method of chemical analysis called XRF (X-ray Fluorescence). It confirmed that areas of gold and some red paint survived on a leather book cover, showing that the book cover was originally an elaborate and costly item. The red paint was the mercury-based pigment vermillion, but this was very expensive so it was often mixed with cheaper materials and in this case it had been mixed with red lead oxide.

In the mid-17th century when the *London* was lost, most windows and bottles were made of common green glass. Colourless glass was reserved for selected objects, like the best drinking glasses, lenses and mirrors. Remarkable survivals from the *London* include several examples. A small pocket sundial compass contained a colourless glass lens, which still magnifies today, and a rectangle of colourless plate glass with a bevelled front edge may be from a mirror, now lacking its metallic reflective coating. >>

The contents of the *London* were buried in silt for much of the past 355 years and leather and wood items, which normally do not survive well underwater, were beautifully preserved

Left: A bottle made of green glass, as was common in the 17th century. © Historic England Archive. Photographer James O Davies

Above: A clear glass plate, possibly used for a mirror. The bevelled edge can be seen as a line on the left and right lower edge. © Historic England Archive. Photographer credit James O Davies

Many brass and pewter objects survived in good condition, including instruments, buttons, spoons and tiny dress pins. The navigational instruments were all made from brass, and included chart dividers, calipers and the case and gnomon (the part that casts a shadow) of the pocket sundial compass.

A pewter (tin alloy) urethral syringe testifies to the medical equipment on board and would have been used in the treatment of venereal diseases by administering mercury, although none was detected in this example.

Many spoons were recovered, some made from brass and tinplated to give them a silver appearance and others from pewter.

Although historic pewter often contains some lead, only small amounts were permitted in objects used for eating and drinking, and chemical analysis found that the manufacturers of these spoons had abided by the regulations for the most part (Stroebele and Schuster 2019). Interestingly one spoon carries the mark of its owner, so this was perhaps a personal possession. >>

A pewter urethral syringe testifies to the medical equipment on board and would have been used in the treatment of venereal diseases

Below: A pair of dividers. © Historic England Archive. Photographer James O Davies

Bottom: A pewter syringe. © Historic England Archive. Photographer James O Davies

A selection of spoons: Two (top and bottom) are made of a copper alloy and the one in the centre is made of pewter. The copper alloy spoons have a round maker's mark at the base of the spoon. © Historic England Archive. Photographer James O Davies

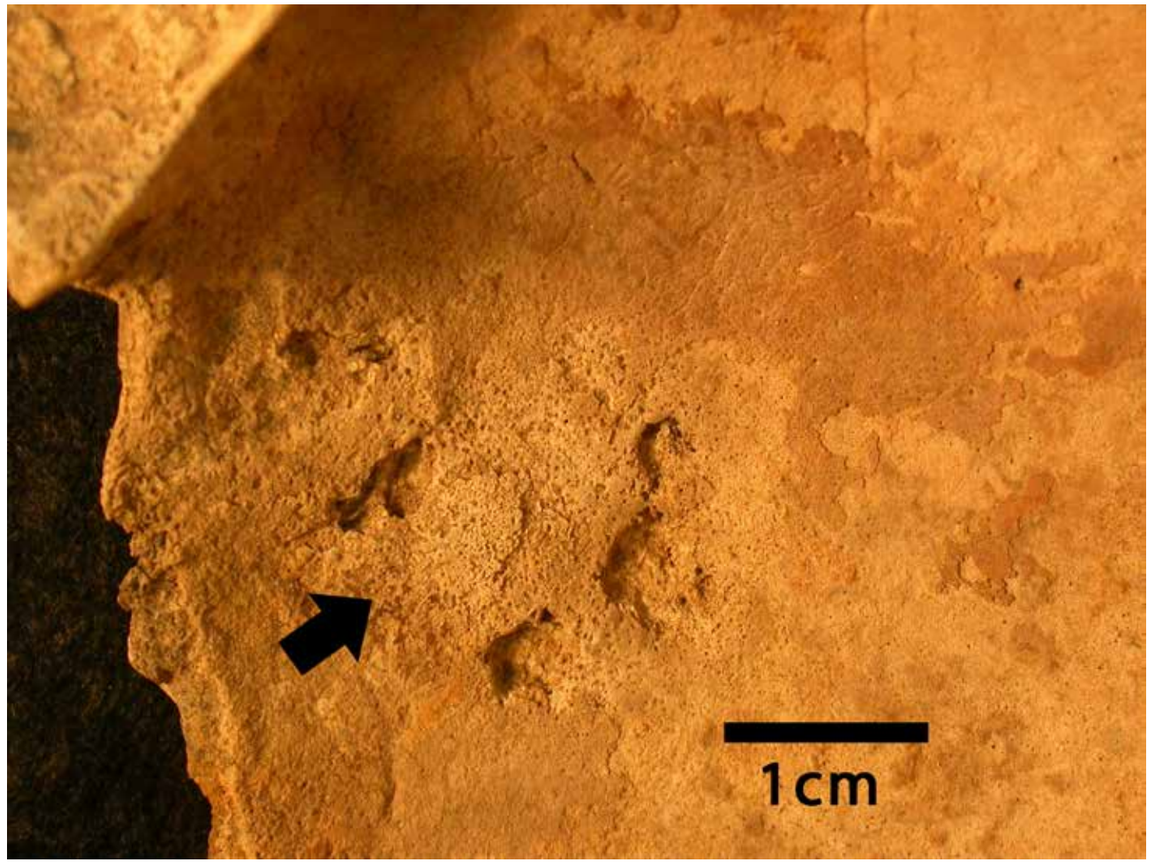
Pottery and tile

The *London* produced an assemblage of fifteen individual pots, two bricks and seven tiles. Frechen stoneware, made in the area of Cologne, Germany, is the most common type of pottery within the collection. There is a narrow-necked jug in the familiar *Bartmann* style (depicting a bearded face and often referred to as *Bellarmine*) and also a virtually complete small, plain jug. English products include fragments of post-medieval redware cooking pots and a whiteware jar. Three Seville-type olive jars are also represented.

All the types present are common finds on shipwrecks of this date and would have been available in London. The stoneware and olive jars were probably traded from North Sea ports, showing the continuation of commercial contacts even at a time of fluctuating relations with England's neighbours. All the pots found on the *London* wreck were associated with the storage or preparation of food, or with drinking. The bricks and plain tiles, similarly, are from the galley, where they would have lined the timber floor and wall against the heat of the stove. Decorated tinglazed tiles, including one showing a fox, may have been situated in a more public space, probably occupied by a senior officer. This is a small assemblage but it compares well with others of a similar date. >>

Below left: A Frechen Stoneware Bartmann jug. © Historic England Archive. Photographer James O Davies

Below right: A fragment of a tinglazed tile with central figure of a fox. © Historic England Archive. Photographer James O Davies



Left: The internal surface of the skull. The diseased area is indicated by the arrow. © Historic England. Photographer Simon Mays

Right: This ivory nit comb was identified as being made from the tusk of an African elephant. © Historic England Archive. Photographer James O Davies

Human remains

The human bones from the *London* were not articulated skeletons but had been jumbled together by water movement. They comprise 34 bones from a minimum of five people. All were probably male. Most were adults, but the youngest were in their late teens. The heights of two could be calculated, at 170 centimetres and 176 centimetres. These are about the same as heights of 17th-century London men, but a bit taller than the Tudor sailors from the *Mary Rose*. The mean height of young men today is 178 centimetres.

The most unexpected finding was evidence of infectious disease, in the form of five small pits on the inside of the frontal bone (forehead), of one of the skulls. These lesions resemble those caused by tuberculosis. To try and confirm this, a DNA analysis was conducted for traces of the bacteria that cause the disease. This was unsuccessful, but that may just mean that DNA did not survive in this case – many ancient DNA analyses fail for this or other reasons. Bone lesions take time to develop because infection normally spreads from pre-existing lesions in soft tissue (in tuberculosis these are often in the lungs), so this man must have been ill for some time. In the cramped conditions aboard ship, contagious disease would always have been a potential threat, and lesions in the human skeletal remains show that chronic sickness was indeed present amongst the crew of the *London*.

The most unexpected finding was evidence of infectious disease, in the form of five small pits on the inside of the frontal bone (forehead), of one of the skulls

Animal bone remains

Only a few animal bones were recovered from the *London*, including from cattle, sheep/goat and ribs from similar size mammals. They may derive from fresh or preserved food cargo. The cattle bones include a humerus with cutmarks and a sawn pelvis. Cattle pelves and ribs formed part of meat 'pieces' in casked meat supplies documented in historic victualling records and in assemblages from other wreck sites (eg Coy 2005; Migaud 2011). Access to preserved and fresh provisions would have varied by status of crew members as well as voyage duration and itinerary.

A double-sided comb was made of African elephant ivory, with species identified by ZooMS (Zooarchaeology by Mass Spectrometry uses collagen or other proteins to identify animals). The manufacture from ivory probably indicates the owner's high status. The comb, with a set of closely spaced teeth on one side and more widely separated teeth on the other, would have been used for grooming and personal hygiene, by removing parasites such as nits and lice (Schuster *forthcoming*). >>

The value of collaborative research in deepening knowledge of a crucial period in history

Access to artefacts by various specialists is crucial to post-excavation work and a carefully planned program of sample taking, analysis and conservation was put in place to ensure a smooth workflow. This project has been co-ordinated by Cotswold Archaeology and involved Historic England, external and freelance specialists, as well as the licensing team for the *London* wreck.

Scientific analysis of the archaeological assemblage from the *London* has revealed a wealth of information about life aboard a 17th- century Royal Navy vessel. Some evidence, relating to navigation or provisioning, has to do with the general running of the vessel. In addition, the presence of medical equipment and a comb shows concern with health care and personal hygiene.

Other aspects of the assemblage have allowed glimpses of more personal details of everyday life. Differences in quality and in the materials used for some of the more personal items perhaps indicate variability in wealth and status among those who used them.

In the wider context of the mid- 17th century, a time when the British navy changed and developed, the study of the assemblage from the *London* will contribute to our understanding of that crucial period in naval history ■

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In the wider context of the mid- 17th century, a time when the British navy changed and developed, the study of the assemblage from the *London* will contribute to our understanding of that crucial period in naval history.

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Biodiversity and Land Use – how ancient practices shaped Britain

Exploring how the interplay between the natural environment, climate and human land use has shaped the landscapes of the British Isles.

Understanding how climate and human action have affected vegetation cover and natural habitats is key to defining the complex relationships between land use and biodiversity. In this article we present our project on land use change and shifting patterns in biodiversity. At a time when human actions, climate change and habitat transformation are a growing concern, defining how ancient land use affected the natural world may provide important lessons as we face an unprecedented climate crisis. >>

Barton Meadows, Winchester. © Historic England. Photographer Dr. R. Pelling

The three-year project aims to define and understand patterns of biodiversity and land use throughout the British Isles during the Holocene

The scope of the project

The three-year project began in the spring of 2019 and aims to define and understand patterns of biodiversity and land use throughout the British Isles during the Holocene, which is the present geological epoch beginning after the end of the last Ice Age, about 11,500 years ago. It is a collaboration between Historic England, the University of Plymouth and the University of Birmingham, and is funded by the Leverhulme Trust.

The data

We are pooling and harmonising previously compiled datasets for three environmental indicators: pollen, plant macro-remains and insects. Records are mostly obtained from online databases and other published sources. The project is also reaching out to archaeological companies for data not captured in existing databases, as development-funded archaeology is generating an ever-increasing wealth of information. We aim to involve data contributors in the research and welcome new contributions. We have held two archaeobotanical workshops so far where participants have brought their own data and learnt about the database which we are using to record and standardise the information. We plan to hold a virtual workshop online this summer.

Anne de Vareilles and Ruth Pelling (Historic England) are collating archaeological records of charred and waterlogged seeds, fruits and nuts. These remains are retrieved during excavations and give us an insight into arable practices, the biodiversity of arable fields, and settlement environments. Waterlogged plant remains found in anaerobic sediments (devoid of oxygen) are informative of the vegetation and biodiversity within a past settlement.

Below left: Team meeting during lockdown. From left to right: Anne, Jessie, Ruth, Ralph and David.

Charred plant remains are usually created when by-products from cereal processing and food preparation activities, such as crop weeds and cereal chaff, are burnt and discarded. These remains can tell us about the types of crops grown and how they were cultivated, thereby providing information on land use. The ecology of arable weeds can reveal details about the types of soils cultivated and the labour dedicated to the preparation and maintenance of fields.

As an example, small, intensively cultivated plots intrinsically interconnected within a mixed husbandry regime (as has been suggested for the Neolithic period) will not have had the same imprint upon the natural landscape and biodiversity as the large, extensively managed open-field systems (known as champion field-systems) of the medieval period.

Waterlogged plant remains found in anaerobic sediments (devoid of oxygen) are informative of the vegetation and biodiversity within a past settlement. Records of waterlogged and charred remains are uploaded into ArboDat, an Access database administered in the UK and Ireland by Historic England and designed to standardise, store and share archaeobotanical data (ArboDat). Using this programme enables us to search for patterns in land use across time and space, from the smallest site, to regional trends and wider developments within the British Isles over many millennia

David Smith (University of Birmingham) uses fossil insect remains from his own research, published sources and the BugsCEP database (built to store records of insects in the past: BugsCEP) to describe changes in site habitats, vegetation and land use.

Similarly to waterlogged plant remains, insect remains are only preserved in anaerobic conditions, and are therefore not as abundant as charred plant remains. However, they are of great interpretative value, providing refined climatic and ecological details. Some insects are very particular to their environment, living in highly specific conditions. As such, they can reveal the temperature, humidity and organic matrix (fur, grain, straw, wood, dung, and so on) of the habitat they once lived in. These details are useful in defining site environments and detecting small-scale variations in biodiversity. Such trends can also be observed for wider landscapes around settlements where another spectrum of insects reflects patterns of land use.

Jessie Woodbridge and Ralph Fyfe (University of Plymouth) are amalgamating, digitizing and harmonising published fossil pollen datasets and diagrams from across the British Isles. Their two main sources of pollen data are Michael Grant's British Pollen Database BPOL, and the European Pollen Database.

Pollen datasets are being transformed into records of vegetation diversity change using the REVEALS approach, an analytical method that incorporates information about pollen productivity and dispersal >>

Waterlogged plant remains found in anaerobic sediments are informative of the vegetation and biodiversity within a past settlement.

(Trondman et al. 2015). Diversity and 'evenness' indices reflect species richness and indicate how equally distributed species were within a landscape. Spatial patterns in diversity can reveal information about ecological 'memory' and can show how landscapes have been transformed through time. Comparisons with macro-botanical and insect datasets allow us to investigate the impacts of human land use on past and present vegetation cover and diversity. Together, pollen, plant-macrofossils and insect remains can disentangle effects of natural phenomena, like climate, from those induced by human activities.

Periods of human population increase have been associated with major land cover transformations in the past. Fluctuations in past human populations in the British Isles have been estimated by Andy Bevan and others (University College London) from the densities of securely-dated archaeological sites. These data are being used within this project to explore the relationships between population change, land use, land cover and biodiversity.

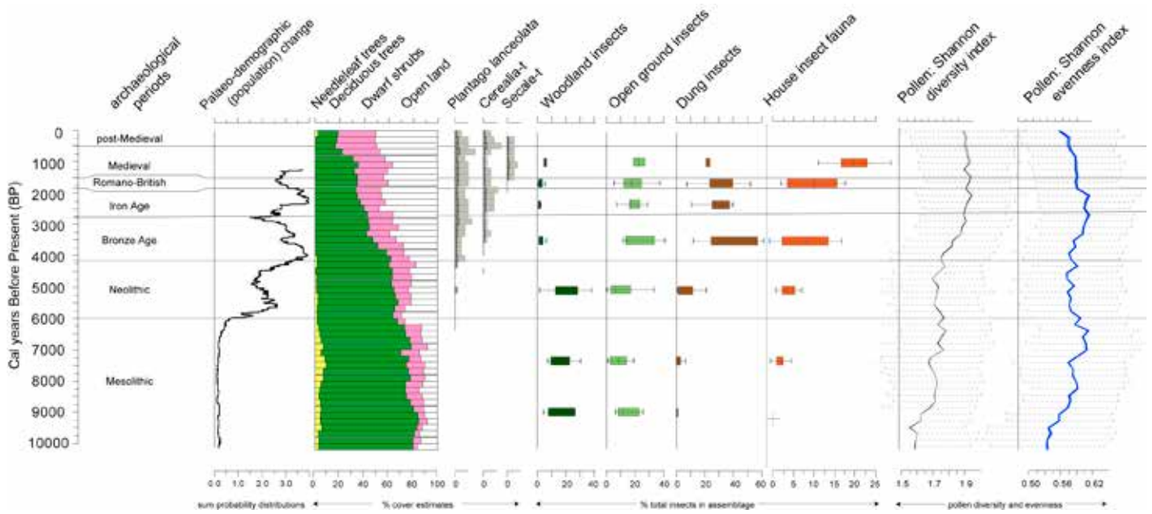
Periods of human population increase have been associated with major land cover transformations in the past.

Initial results

The project is still in the data gathering phase, although some initial results can be shared. Trends in land cover and vegetation diversity over the Holocene have been mapped using 272 fossil pollen datasets.

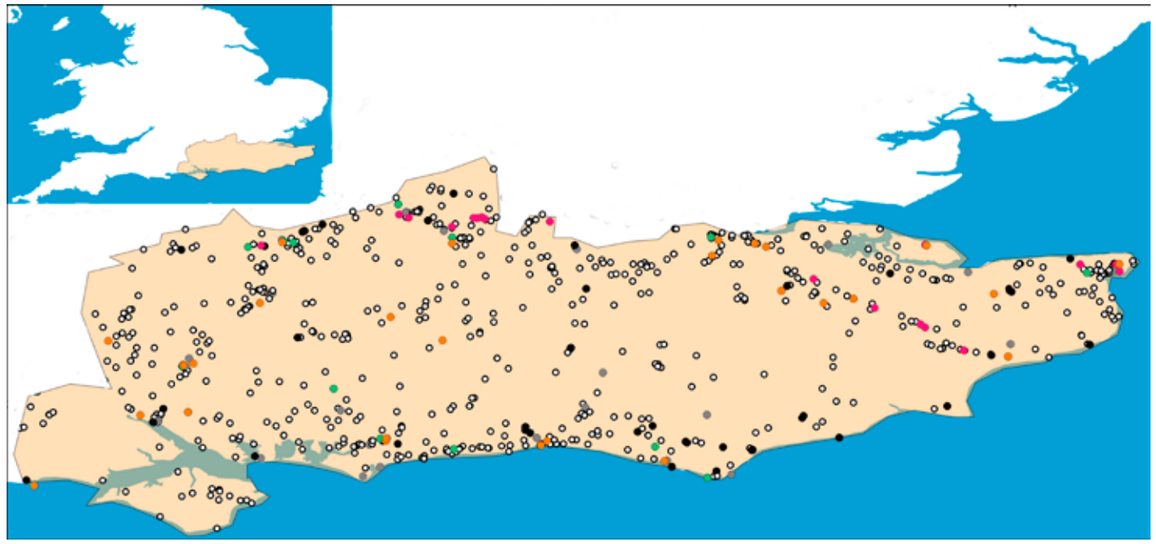
Variations between woodland cover and more open landscapes are seen in diversity and evenness indexes. For example, dense woodland cover is seen to reduce by about 30 per cent with the arrival of a new farming population at around 4000BC, leading to increased floral and faunal diversity. >>

Trends in land cover and vegetation diversity over the Holocene have been mapped using 272 fossil pollen datasets.



Left: Artist's reconstruction of Carn Euny ancient village and field-system (Cornwall). © Historic England Archive. Illustrator Judith Dobie, Ref N: N070430

Above right: Insect and pollen records against inferred human population changes throughout the Holocene.



Above left: Sites in the SE of England with seeds, fruits and nuts by archaeological period. Neolithic (pink), Bronze Age (green), Iron Age (orange), Roman (white), early medieval (grey) and medieval (black).

However, there are archaeological periods when population 'booms' do not correlate with trends in vegetation diversity, suggesting that it is not simply the number of people using the land, but rather how the land is used that affects land cover and biodiversity. The distribution of sites with charred plant macro-remains is, in itself, an indication of the extent of farming across the British Isles in any given period.

Excavations over many decades have produced an immense amount of evidence for ever changing and evolving landscapes.

The range of crops and associated weeds show variations in uniformity during the last 6000 years, with periods of greater conformity (eg. Roman) and those of greater diversity (eg. early medieval) in the range of crops and their methods of cultivation. Such practices will have affected biodiversity in the agricultural landscape, which can be described in finer detail from insect remains. Insects are a great proxy for land use and vegetation, capable of showing, for example, the development of field systems seen through the increase in open-ground and dung associated species.

Excavations over many decades have produced an immense amount of evidence for ever changing and evolving landscapes. Archaeological sciences can extract information from plant and insect remains to demonstrate changing conditions on individual sites. This information can be pooled from various locations to illustrate patterns of change at a broader scale and provide a bigger picture of how British landscaped developed through time. Collating pollen, plant macro-remains and insect datasets allows a more nuanced picture to be defined of the history of human land use, its relationship with land cover and biodiversity and the 'ecological legacies' imprinted upon modern landscapes ■

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Further information

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Creating access to reference collections – a photographic atlas of perinatal bones

A preview of work on a new animal identification resource.

Historic England zooarchaeologists, photographers and graphic designers are working together to produce a photographic atlas of perinatal animal bones, that is to say the remains of unborn (foetal), newly born (neonatal) and very young animals. This unparalleled resource will provide a key identification aid for distinguishing between the different species commonly found on archaeological sites in the UK and beyond, widening our understanding of past lifeways. The atlas builds and expands on the rare diagnostic resources currently available (for example Prummel 1987a, 1987b, 1988; Powell nd).

Making use of high resolution photography to highlight differences in shape and morphological detail between species, the resource will serve researchers in zooarchaeology, human osteology, forensics, and zoology, fields in which comparative anatomy is central to scientific practice. >>

Below: Bones from 70 individual reference specimens, mainly drawn from the Historic England Zooarchaeology reference collection and through loans, were available for study. The sheep humeri are displayed here in in size order. Shape and size can vary between breed and age groups. Young specimens in one breed may be larger than older specimens in another. © Historic England. Photographer James O. Davies

Above: Perinatal animal bones are fragile and may be damaged through repeat handling. This foetal fallow deer mandible shows paper-thin and incompletely formed bone. The atlas of images aims to improve access to perinatal reference specimens while reducing the risk of damage to this rare resource. © Historic England. Photographer James O. Davies

This unparalleled resource will provide a key identification aid for distinguishing between the different species commonly found on archaeological sites in the UK and beyond, widening our understanding of past lifeways.

Zooarchaeology (the study of animal bones from archaeological sites) is extremely active across the globe, with the International Council for Archaeozoology (ICAZ) including over 500 members from 50 countries. In the UK alone the Professional Zooarchaeology Group (PZG) counts over 100 members working in the commercial, academic and public sectors, but there are comparatively few reference collections that include bones of perinatal animals either nationally or internationally. The atlas will provide virtual access to these important assets, the majority of which are held within the Historic England Zooarchaeology Reference Collection. The photographic atlas will be available to purchase as a high quality manual or to download from the Historic England website.

Archaeological applications

Accurate identification of the remains of very young animals can lead to interpretation of site use and further inform us on how past populations were influenced by, and responded to, their environment. Foetal and perinatal animal bones can be key indicators of seasonality, husbandry and hunting practices on archaeological sites, as natural gestation and birthing cycles in wild and domestic animals are controlled by physiological responses to daylight, weather and climate. Prior to modern husbandry methods, lambing, calving and farrowing (pigs) followed seasonal farming calendars. For example, in England lambing took place in late winter and spring. Gestation and birth are risky times for both mothers and babies and natural deaths may occur throughout this period. >>

Above left: As animals grow, their bones become larger and bone shape and features become more defined. In addition, the surface becomes smoother and harder, making them more likely to survive on archaeological sites. Here we show femora (upper hind leg) of four lambs from left to right (a) Soay; (b) Manx Loghtan and Suffolk cross; (c) North Ronaldsay; (d) traditional hill breed, from foetal to neonatal age to illustrate this progression. When identifying species it is therefore important to consider size, shape and development in combination. For example, though only slightly longer than the eldest lamb femur (d), the Jersey calf femur (e) shown is less well developed, indicating that it is likely to be from a younger animal and therefore potentially a larger species. © Historic England. Photographer James O. Davies

At the Roman shrine of Great Chesterford in Essex, lambs were an important offering for animal sacrifice as evidenced by large bone deposits (Baxter 2011). Assuming traditional scheduling of births in April, in the first and second centuries lambs were selected in mid-spring when newborn to 1 month old, in summer at about 2-3 months of age, and at 9-11 months in winter and early spring. In the 3rd century AD this shifted almost exclusively to summer sacrifice. The age distributions may reflect changing ritual cycles and seasonal availability of livestock, such as natural casualties around the time of birth and culling of surplus animals not required to replenish flocks, including very young lambs in spring and summer and older animals fattened prior to winter slaughter.

The identification of foetal horse remains has provided novel insight into prehistoric horse 'ranching'. Horses formed part of the wild native fauna in the United Kingdom, but a recent review of radiocarbon dated remains suggests they disappear from the archaeological record in the early post glacial period, probably in the second half of the ninth millennium cal BC (early Mesolithic) (P Marshall pers comm). They were re-introduced in the 15th to 13th centuries cal BC, in the Middle Bronze Age (Andrews et al 2019). Their scarcity in archaeological assemblages in the Bronze Age and deposition in burials in the Iron Age may indicate their special status at this time (Bendrey et al 2013). Where preserved, the presence of perinatal horses in prehistoric sites may indicate controlled breeding of these valuable animals (Bendrey 2010).[7]

Radiocarbon dating and genetic analysis of neonatal kittens in Iron Age sites, such as Danebury, Hampshire and Gussage All Saints, Dorset, as well as Fishbourne Roman Palace, West Sussex are being undertaken to improve our understanding of when domestic cats first appeared in Britain (Jamieson 2017). The newborn kittens will provide important information about wild and domestic cat biogeography and domestication processes. For example, while the domestic cat descends from the non-native subspecies, *Felis silvestris lybica*, crossbreeding may occur with the native European wild cat, *F. s. silvestris*, and deliberate or opportunistic feeding and raising of wild young kittens by humans may potentially lead to increasing familiarity and taming (Ottoni 2017; Sykes 2017). >>

Above right: Occasionally foetal bones are found within the skeletons of their mothers like this Roman foal from Stanwick, Northamptonshire, excavated in 1988 (Project 291 image 1433), however, more often they are found as isolated skeletons or even single bones mixed into general waste. Foetal and neonatal bones are very difficult to identify to species without adequate reference material. © Historic England. Photographer James O. Davies

Right: Very young and small specimens present challenges for handling and photography. However their comparison highlights differences in shape and detail that can be used to distinguish even these bones. For example, the shafts of newborn kitten (b) and foetal mountain hare (c) are very slender compared to the 3 day old collie cross puppy (a) but each has other distinguishing features on the shaft or distal end. Access to reference specimens from a range of species and ages is vital for accurate identification. © Historic England. Photographer James O. Davies

Developing photographic techniques

Foetal and perinatal bone has a high collagen (organic) to mineral content and a porous and unstructured surface texture compared to adult bones. Morphology (the shape) and surface texture are key to recognising bones of these very young animals. Standard elevations (views) were captured for each bone in a consistent manner to allow the user to easily compare shape, size and distinguishing features between and within species.

Creating standardisation in image structure, composition and lighting for recording animal bones has a similar set of requirements to architectural approaches, for example those of Bernd and Hilla Becher for industrial structures. These are not without challenges: the variation in bone size, their morphology, lighting and positioning, all pose difficulties in maintaining a consistent approach.

It is important that a standard methodology is applied to each bone element. For example with a humerus, four main elevations of each bone are shot first, followed by the ends (distal and proximal) and any other angles required to show diagnostic features. Both minute degrees of change in lighting angle and position of bone are critical, with finished results being the culmination of honing this pairing. >>

Right: The shape of bones is used to identify species. Here, shoulder blades (scapulae) of nine animals are presented at the same size to highlight their variation. For example, dogs (b) and cats (g), and to a lesser extent wild boar (i), have a broad and rounded shape, and rabbits (e) have a projection seen at the bottom end of the bone (the suprahamate process). Cattle (d), sheep (f), red (h) and roe (c) deer, and horse (a) are very similar in this view, but the horse has less constriction at the neck of the scapula. Different views of the scapulae and other bones of the skeleton can be used to distinguish these species. © Historic England. Photographer James O. Davies

Above: The bones chosen as focus specimens are shown in six standard views, together with a scale bar and, if magnified on the page, a life size representation, as shown here for a foetal wild boar humerus (upper front leg bone). This standard layout allows accurate and easy comparison between species and age groups. © Historic England. Photographer James O. Davies

Lighting is crucial in illustrating the diagnostics and form of each elevation. Lighting is achieved with two, sometimes three lights and the use of honeycomb grids to allow for control and reduction of light spill. Both camera and bone lie level and the use of spirit levels on both horizontal and vertical planes is set as standard. Handling bones that may only be 10 milimetres long and a few millimetres wide has its own set of problems and can be a painstaking business. A shallow tray filled with sand and covered in low-reflective black velvet allows for a certain level of flexible positioning with label and scales added, set at the mean height of each elevation.

Below: Correct lighting is required to render and understand the intricate morphology and surface structure of the bones, shown here by the photography of a pig mandible with (a) single flash on camera [upper image] (b) three point grid lighting arrangement [lower image]. © Historic England. Photographer James O. Davies

Above: Studio setup showing (1) camera, spirit level and lighting set-up with tray of black sand, (2) black velvet added to surface of sand with sheep scapula and scales added, and (3) camera tethered to a MacBook Pro and shot with the use of Adobe Lightroom, direct to external hard drive. © Historic England. Photographer James O. Davies

The images are shot with camera tethered to a laptop in a dehumidified studio where white walls have been covered with black to reduce reflection, and finally, with photographer wearing dark grey to minimize any cross colour contamination. All this is required in order to produce a systematic record of each bone, sufficient to ensure that all diagnostic features are revealed clearly and consistently.

The images are processed in camera raw with further adjustments in Adobe Photoshop. The processed views are then 'cut out', removing the velvet background and replacing with dense black, scaled and assembled in a four to six view standard layout.

Preparing specimens for photography

Most of the specimens in the HE collection and loans had been prepared following similar standard procedures (Davis and Payne 1992) and were ready for photography. All bones were labelled with their unique accession code, usually a number, to ensure that their identity and source collection could be verified throughout the process. Labelling such tiny, porous bones is a challenge, with numbers sometimes only 1milimetre in height! >>

Bringing together a range of skills

The production of the atlas utilised a range of skills available within Historic England. Zooarchaeological understanding of morphology, species identification and discipline standards are required to ensure valid and comparable photographs, and accompanying text, but the imagery is at the forefront of the atlas and technical photography and graphic design skills are essential in its production ■

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Eva Fairnell prepared, cleaned and labelled multiple specimens used in the atlas. Many individuals and institutions kindly loaned perinatal specimens for photography and study, including Angelos Hadjikoumis and Umberto Albarella (University of Sheffield), Sheila Hamilton-Dyer, David Orton (University of York), Dale Serjeantson and Jaco Weinstock (University of Southampton) and Sue Stallibrass (University of Liverpool). Adrienne Powell provided access to her unpublished work on juvenile cattle and red deer. Professional Zooarchaeology Group members who attended the meeting on perinatal animal bones generously contributed their feedback on diagnostic criteria. Vicky Crosby kindly provided the archive image of the Stanwick excavation. Peter Marshall provided advice regarding latest Radiocarbon evidence for horses in the UK.

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Fay works with Polydora Baker on Zooarchaeology publications and guidance and the management of the Historic England Zooarchaeology Reference Collection. Fay's current zooarchaeology projects include a very large Roman bone assemblage from Stanwick, Northamptonshire, and animal bones and antler tools from various prehistoric sites in Wiltshire.

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James has exhibited and published widely with books on English Prisons, Tin Mining, Post War Buildings and Stonehenge to name a few. He has published in magazines all over the world including Wallpaper, AR and Blueprint. He has won numerous awards and exhibited at the National Portrait Gallery twice in the prestigious Taylor Wessing Portrait Awards. He also lectures on Architectural Photography.

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