Waterlogged Wood

Guidance on the excavation, recording, sampling and conservation of waterlogged archaeological wood

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Front cover: Excavating and recording at Must Farm.
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Summary

This guidance is aimed at those working directly with, or encountering, waterlogged archaeological wood in England's terrestrial and coastal/marine settings, such as archaeological contractors and wreck licensees. It contains relevant information for local authority archaeologists and other heritage managers responsible for approving and monitoring work in relation to the planning process. Additionally, it is applicable to landowners and site managers who want to know how to deal with waterlogged wood identified on their sites.

The document explains what waterlogged wood is and why it is important. It outlines the methods and approaches required to investigate waterlogged wood and to make decisions about how it should be managed. Specific recommendations are provided on the excavation, recording, sampling, selection, storage, assessment, analysis, conservation and curation of waterlogged wood. It is assumed that other classes of archaeological material will be discovered in association with waterlogged wood, such as the surrounding deposits and any archaeological and palaeoenvironmental remains those deposits may contain. More detailed information about these other archaeological materials can be found in other guidance documents.

This guidance is not intended to replace advice from waterlogged wood specialists, which must be sought by those excavating sites containing waterlogged wood. Rather, it sets out the main stages of an archaeological project where a specialist would need to be involved, highlighting the type of work that should be undertaken at each stage. The document is intended to be a guide to best practice, so that those dealing with waterlogged wood sites are fully prepared for what they might encounter and have the appropriate budget, specialists and experience in place.

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Introduction

What is waterlogged wood?

Waterlogged wood is wood, either in its natural state, or having been used or modified by people, that survives in a wet or waterlogged environment. It is most often found in bogs and wetlands, intertidal and maritime settings, palaeochannels (old river channels), urban waterlogged deposits, and pits and wells within otherwise 'dry' occupation sites. Finds within these contexts can vary from large complex structures – including ship remains, trackways, submerged forest deposits, building foundations and domestic assemblages – to smaller individual artefacts (*see* Figures 1a to 1j).

Although the wood may appear to be well preserved, biological and chemical degradation will have occurred, with some or all of its original hemicellulose and cellulose replaced by water. To minimise further physical and chemical degradation, waterlogged wood needs to be dealt with promptly during and after excavation.

Figure 1: A selection of images showing the diversity of waterlogged archaeological remains.

1a: The wooden wheel and palisade posts exposed during excavations in 2016 of the Bronze Age Must Farm pile dwelling settlement, Cambridgeshire. © Cambridge Archaeological Unit

1b: A collection of woodchips from the floor of an Iron Age roundhouse in Glastonbury Lake Village, Somerset.
© South West Heritage Trust

1c: An early Neolithic anthropomorphic figurine discovered under the Bell Track, Somerset. © South West Heritage Trust

1d: A side view of the late Mesolithic Boxford timber before conservation, showing the carving. Image: Angela Middleton © Historic England

1e: A multi-phase, Bronze Age, wattle fish weir under excavation in the palaeochannel at Must Farm, Cambridgeshire. © Michael Bamforth

1f: A 19th century Baltic tar cask, excavated from Kirtling Street, London. © Mary Rose Trust

1g: A 12th century hollowed out log drain, with its lid displaced, Chambers Wharf, London. © MOLA

1h: Exposure of late Bronze Age Godwin's brushwood trackway, Somerset, to assess its condition in 2015. © South West Heritage Trust

1i: Image of the wooden trackway in 2007 at Erith located within the intertidal peat and submerged forest deposit, in the Thames Estuary. The photo was taken after some limited surface cleaning, prior to sampling for radiocarbon dating.
Image: Zoë Hazell
© Historic England.

1j: wood being excavated along the shore of the Mesolithic Lake edge, Star Carr, Yorkshire, Milner et al. 2018, Figure 3.15
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Why is waterlogged wood important?

Since prehistoric times, wood has been widely used as an essential raw material for the construction and manufacture of structures and artefacts, and as fuel. As such, it forms a large part of material culture. Yet for such a widely used and ubiquitous material, its survival in the archaeological record can be rare because of the specific conditions needed to preserve it. One of the most critical factors for the survival of wood in a burial environment is the exclusion of oxygen, such as occurs in waterlogged environments.

When archaeological wood has been preserved through waterlogging, the information it provides can be exceptional. Often, this includes unique and important details about material culture, economy and trade, industry, buildings, technology, the environment and access to resources. It may also give specific insights into woodland management; the sourcing, selection and preferred uses of wood as a raw material; and imported products.

Waterlogged wood can be analysed alongside other palaeoenvironmental data sources to increase our understanding of the wider landscape and past climatic conditions. It can give direct evidence of the character of the local treescape and how this has changed over time. Naturally occurring waterlogged wood (*see* Natural deposits) can also provide supplementary information on past environments and ecologies.

Once conserved, waterlogged wood provides visible evidence of worked wooden structures and artefacts, thus furthering our understanding of past landscapes, settlements and human activities.

Waterlogged wood is valuable for precise scientific dating. Some specimens are suitable for dendrochronology (*see* New horizons in the scientific dating of waterlogged wood). Other timbers can be sampled for radiocarbon dating. The identification of some non-native wood types can also help to date sites.

Because waterlogged wood is such an informative material resource, it is imperative that project managers, together with other decision makers and stakeholders, allocate the resources and planning it deserves.

This guidance follows the principles set out in BS EN 16873 Conservation of Cultural Heritage. Guidelines for the Management of Waterlogged Wood on Archaeological Terrestrial Sites (2016) and BS EN 18056 Conservation of Cultural Heritage. Waterlogged archaeological wood. Characterization of waterlogged archaeological wood to support decision-making processes for its preservation (2025) and elaborates on many of the points therein.

1. Overview

This section provides a synopsis of the guidance within this document. Readers are encouraged to consult the specific sections for detailed advice.

Project planning (Section 2)

- Sites with waterlogged wood often require a more specific approach than their 'dryland' equivalents due to their vulnerability and complexity. They can take longer to excavate and may have additional lengthy post-excavation processes.
- Early engagement with stakeholders and specialists, in particular with a lead wood specialist, is essential.
- It is important to establish early on whether the wood is natural or archaeological (worked/modified) because this will have implications for the level of recording and for selection decisions (*see* Definitions).
- Written schemes of investigation (WSIs) and project designs (PDs) for sites known to contain waterlogged wood (or where it is suspected) should include specific strategies for dealing with waterlogged wood.
- The wood specialist(s), dendrochronologist, conservator and the collecting institution (museum/archive) should all be named in the WSI/PD. For large or complex sites, they should be involved in the production of these documents.
- Timely and rapid decisions need to be made to control costs and limit degradation of the wood.
- From the outset, projects should have a selection strategy for the archaeological archive and a data management plan, both of which should be updated throughout the project.
- Collecting institutions need to be involved in discussions with the project team about selection, conservation, display and storage.
- Unexpected discoveries of waterlogged wood require a swift response from the project manager. An assessment of the site's character and significance should inform decisions about the excavation strategy and the need for any additional specialist or conservation input.

Archaeological evaluation (Section 3 and Section 4)

- Characterising a site – its extent, date, significance and state of preservation – is key for any archaeological evaluation, including when waterlogged wood is present.

- Where an evaluation is not followed by a further phase of excavation, the wood assemblage will still need to be recorded and assessed promptly. Analysis, conservation and archiving may also be required.
- The evaluation of a site containing waterlogged wood needs to be extensive enough to identify any spatial differences in significance and preservation.
- Assessing the state of preservation relies on a visual and physical inspection, which can be enhanced by additional specialist analysis.
- It is good practice for decisions about the later management of an archaeological site containing waterlogged wood to consider the significance of the material and its state of preservation, and how future changes (natural, development, land use) may impact these.

Excavation (Section 5)

- The guidance sets out two approaches for the excavation and recording of waterlogged wood:
  - Pathway 1: Full recording on site, with sampling and selection taking place alongside.
  - Pathway 2: Targeted recording on site, with the material retained for full off-site recording.
- The excavation and recording strategies can be implemented across the whole site or at a smaller scale: by context, feature, group or individual item, for example.
- The decision to follow Pathway 1 and/or Pathway 2 should be made by the project's lead wood specialist, in conjunction with the excavation and management team.
- Pathway 1 front-loads the wood recording, sampling and some selection decisions on site, minimising the need for medium-term storage. It requires a lead wood specialist to be on site most of the time, working with a team that is familiar with waterlogged wood. The wood specialist must also work closely with the scientific dating specialists and conservation experts while on site, so as not to compromise the information potential of the waterlogged wood.
- Pathway 2 involves removing most or all the wood for off-site recording. This approach is particularly useful if a wood specialist cannot be on site on a permanent or regular basis. Some recording – such as the location/position of the wood, labelling and photography – still needs to take place before the waterlogged wood is removed (*see* 5.3 Initial on-site recording).
- As waterlogged wood is fragile and is often found in soft deposits, specific methods are required for its excavation. These include maintaining high moisture levels, avoiding the use of sharp-edged metal tools and sometimes building a temporary access infrastructure, such as a series of platforms.
- Lifting and transporting waterlogged wood needs to be done sensitively to avoid damage. Transporting the wood submerged in water (in buckets or boxes) is not recommended. Larger pieces of waterlogged wood should be packaged to minimise water evaporation and surface damage during transportation (*see* 5.7 Packaging for transportation). Smaller items or samples can be transported in water in sealable plastic bags.

Recording and sampling (Section 5)

- Every excavated piece of wood needs to be given a unique wood number, which should be recorded on site plans and elevations. Once a wood number has been assigned, a wood recording sheet should be completed for each individual piece or group.
- The following information must be recorded while the wood is *in situ*:
  - context, feature, plan, drawing and/or photography numbers
  - setting (horizontal, vertical and so on), orientation and inclination
  - surface condition, with areas of excavation and pre-excavation damage or breakage clearly identified
  - the position of significant details (for example, joints, nails, pegs, insect damage), showing how broken or fragmented pieces fit together so they can be reassembled; these can be marked on a sketch
  - relationship to other timbers
- More detailed recording should take place after lifting, either on site (Pathway 1) or off site (Pathway 2). This needs to include basic site information; appearance and state of preservation; natural features; woodworking evidence; and functional interpretation.
- Once the wood has been recorded, sampling can take place. Samples are taken for species identification, woodland management, environmental indicators and scientific dating.

Nautical archaeology (Section 5)

- The general information in this document also applies to ship or boat remains. However, working underwater or in intertidal zones requires additional input and expertise.
- A nautical archaeological specialist should be included in any project where boat and ship remains are encountered.
- Due to the nature of underwater or intertidal sites, sampling often takes place where only part of the vessel is visible, so needs to be carefully considered.

Timescales and temporary storage (Section 6)

- All waterlogged wood should be recorded promptly. The timescales noted below are maximum times.
- Recording should be completed before the written assessment is prepared, preferably within 12 months of excavation. Material should be submitted for conservation within 36 months of excavation. It is recommended that wooden artefacts are fast-tracked.

- All physical tasks relating to the wood, such as sampling and graphical recording, should be completed within 36 months of excavation. Analytical tasks, such as identifying species, establishing growth rate/season of felling and dendrochronology, should be finished within 48 months of excavation.
- The time that waterlogged wood spends in temporary storage should be minimised, because extended periods of storage, even in optimum conditions, will cause the wood to degrade. Storage is also costly.
- A range of storage options are available, and wood in storage needs to be monitored to ensure it stays wet. A storage plan should be in place from the start of the project.

Post-excavation assessment and analysis (Section 7)

- A post-excavation assessment is needed to evaluate the quality and character of the record generated during the excavation, and the waterlogged wood's state of preservation and significance.
- It should include a statement of potential, addressing the suitability of the assemblage for analysis – of woodworking evidence, wood technology, woodland reconstruction, for example – and its potential for scientific dating.
- The post-excavation assessment should help to establish accurate costs and timetables for the post-excavation programme of analysis and reporting.
- It should inform the analysis stage and identify possible conservation and archiving strategies (through a conservation assessment). Tasks undertaken at the analysis stage include completing graphical recording (illustration, photography and 3D modelling), data analysis, dating and identifying wood, specialist reporting, and publication.
- Once the analysis is complete, wooden items not selected for conservation and archiving should be dispersed (*see* 7.3 Options for dispersal).

Conservation (Section 8)

- Conservation treatments aim to stabilise waterlogged wood by replacing the water with a chemical and drying the wood in a controlled manner. In this way, the overall shape and dimensions of the wood should be retained, and the wood can then be studied or displayed.
- An accredited conservator with experience of waterlogged wood should select and implement any wood conservation treatments.
- The choice of conservation treatment will be determined by the size of the timbers, availability of equipment, budget and timescales.
- All recording and sampling should be completed before the conservation programme starts.

Archiving and curation (Section 9)

- The project conservator and collecting institution should be engaged as early as possible in projects with waterlogged wood that may require conservation, display, or archiving, allowing for timely identification of costs and resource allocation.
- Repositories typically include a requirement for material to be stable in their transfer/ deposition guidelines. It is highly unlikely that they will accept damp or wet materials.
- Early conversations and planning will help to reduce the time and cost of temporary storage.
- Once conserved, archaeological wood needs to be kept in stable conditions, without extremes or fluctuations of temperature and humidity.

Timescales

Throughout this document, a series of timescales is presented. They are all maximum time periods within which the respective tasks should be completed. The time taken will depend on the size and/or complexity of the site or assemblage. It will be possible to carry out the work more quickly on some smaller sites or single object finds, and there will also be some very time-consuming sites (for example, whole shipwrecks such as the Mary Rose).

It is always best to deal with the waterlogged wood as soon as possible after lifting. This is because degradation – resulting in the loss of important information – will start to happen as soon as the wood is removed from its anoxic burial conditions.

Definitions

The term ‘state of preservation’ is used throughout this document to describe an understanding of the wood’s condition/deterioration/degradation. It is the term used in the Historic England guidance Preserving Archaeological Remains (2016) and in BS EN 17652 Cultural Heritage: Assessment and Monitoring of Archaeological Deposits for Preservation *in Situ* (2022). It is defined in the British Standard as the ‘current state of the archaeological deposits, and artefacts and ecofacts that they contain, which will depend on both current and historical rates of degradation’. Although used consistently throughout this document, the term may be used interchangeably with condition/ deterioration/degradation by those working on waterlogged wood.

The term ‘selection’ describes the process of choosing which material (physical and digital) to retain for conservation and archiving, and which material should be dispersed.

Chance finds

Outside standard archaeological investigations, one-off chance finds of waterlogged wood are not uncommon. For example, farmers or landowners may discover waterlogged wood in peat (or former peat) deposits, project and site staff may encounter it during peat restoration works, or members of the public may find wood remains at the coast or in the sea while fishing. In these situations, the first point of contact should be one of the following:

- local finds liaison officer (part of the Portable Antiquities Scheme)
- local authority archaeologist
- Historic England science advisor for the region

How to handle and store chance finds in the short term

The immediate priority is to keep the wood wet. If possible, place the wood in a waterproof sealable tub or plastic bag and ensure it is submerged with enough tap water. Store it in a cool location. See First Aid for Finds, and seek specialist advice from one of the contacts listed above as soon as possible.

More information can be found in Historic England's Waterlogged Organic Artefacts: Guidelines on their Recovery, Analysis and Conservation (2018).

Natural deposits

It is important to establish as early as possible whether the wood remains are natural or archaeological, although the two are not necessarily mutually exclusive within an assemblage. This will need to be determined by a wood specialist, as ‘natural woodwork’ features (resulting from geological, weather and biological factors) can mimic woodworking by humans. For example, water erosion can create points on timber or cut grooves in it, and wood can also be shaped by animals such as beavers (Figures 2a, 2b), other rodents and birds. Weather events can create storm damage and even drop logs side by side so that they resemble human-made platforms. Although this ecofactual evidence is important, it is not always possible for non-specialists to distinguish it from assemblages of worked wood.

Where remains of natural unworked wood are present – for example, as natural woody layers in peat/fen deposits or as individual ‘bog oaks’ (Figure 2c) – the scale of recording and investigation will depend on the project’s aims and objectives. Palaeoecologists will be able to advise. Usually, recording of the deposit will be minimal (compared to that undertaken on an assemblage of worked archaeological wood). It may be appropriate to take samples of unworked wood to contribute to the development of scientific dating techniques (*see* New horizons in scientific dating of waterlogged wood). Sampling should always be carried out on the advice of scientific dating specialists.

Figure 2: Examples of natural waterlogged wood deposits.

2a: Layer of prehistoric wood showing signs of beaver chewing and debarking, Shapwick Burtle, Somerset.
© South West Heritage Trust

2b: Beaver chewed prehistoric wood from Shapwick Heath, Somerset.
© South West Heritage Trust

2c: A bog oak tree trunk recovered from peat deposits near Wicken Fen, Cambridgeshire.
Image: Zoë Hazell
© Historic England

2. Project planning

2.1 Why sites with waterlogged wood need a specialist approach

Sites that contain waterlogged wood are very different to the more common 'dryland' sites. From the moment of exposure, waterlogged wood and other waterlogged organic materials are extremely vulnerable to further and often rapid deterioration. Therefore, they require immediate stabilisation measures.

Sites with waterlogged wood often take longer to excavate than dryland sites. They require more specialist involvement and have lengthy post-excavation processes. Inevitably, this means that project costs will be higher and hard to predict accurately. It is, therefore, crucial that the cost implications are identified as early as possible in the project planning process. For commercial projects, it is important that the developer is informed of all potential costs.

At sites with waterlogged wood, it is best practice for there to be early engagement with stakeholders and specialists, particularly with a lead wood specialist who should have considerable experience of dealing with waterlogged wood. It is also important to establish early on whether the wood is natural or archaeological (worked/modified).

If waterlogged wood is unexpectedly encountered during archaeological fieldwork, the guidance outlined in this document also needs to be followed. Advice on what to do when waterlogged wood is found outside standard archaeological investigations is provided in Chance Finds.

2.2 Desk-based assessment

Carrying out a desk-based assessment in advance of fieldwork may help to predict the likelihood of finding waterlogged wood. The usual sources – for example, Historic Environment Records (HERs) – should be consulted in addition to more specialist sources. Rapid Coastal Zone Assessments and extensive wetland surveys (Somerset Levels, North-West Wetlands, Humber, Fenland and so on) provide excellent point-in-time summaries of the known resource. Data from the British Geological Survey (BGS) GeoIndex (onshore), Natural England (including the England Peat Map Portal (Figure 3a)) and aerial remote sensing (photography; lidar) are useful for identifying where waterlogged remains may be found. Examples of such contexts include alluvial, river terrace and peat deposits or palaeochannels (Figure 3b).

For marine/coastal locations, data from the BGS GeoIndex (offshore) can be used to infer the preservation/likelihood of waterlogged wood based on sediment type. Other sources include the UK Hydrographic Office and the National Marine Heritage Record. Known intertidal peat deposits (Figure 3c) are listed in Historic England's Intertidal and Coastal Peat Database.

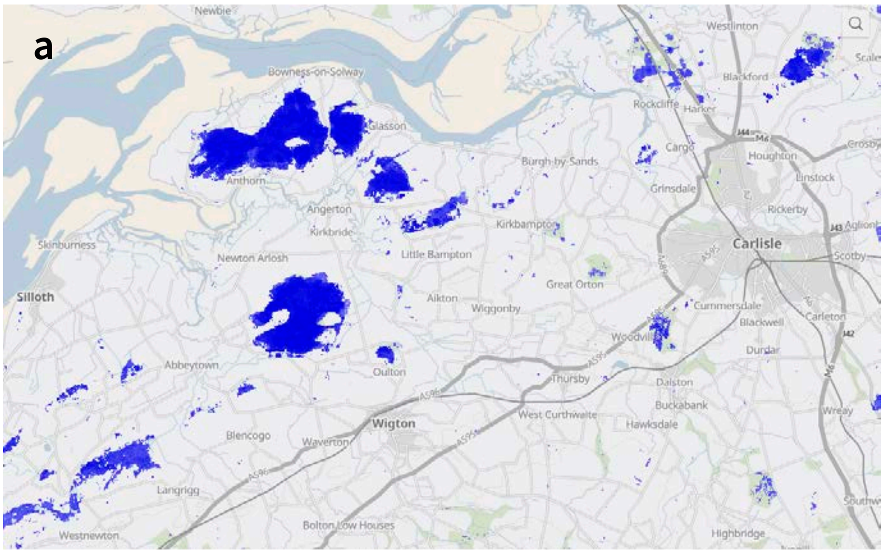
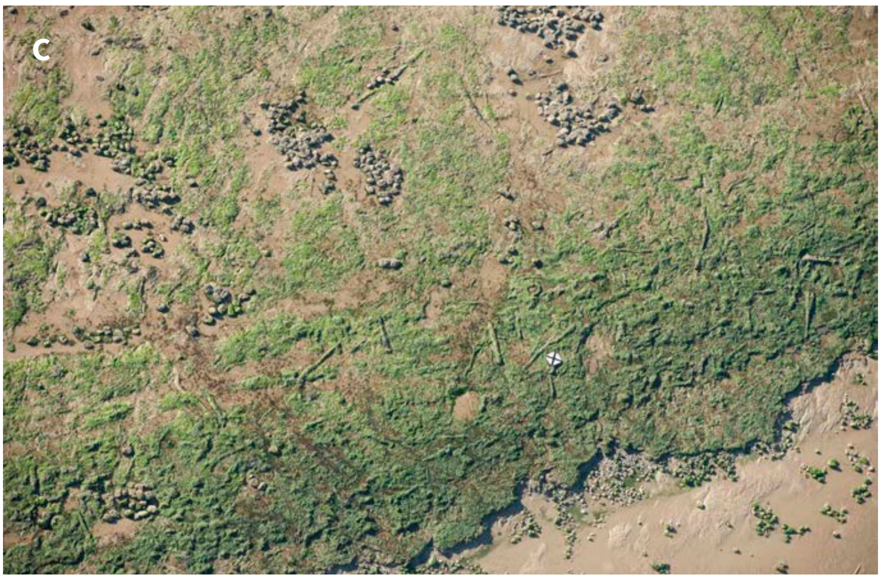


Figure 3: Examples of deposits with the potential to contain waterlogged wood.
3a: Map extract derived from the England Peat Map.
© Natural England 2025, licensed under the Open Government Licence

3b: Aerial view eastwards over Sutton Common, showing localised waterlogged patches within palaeochannels.
Image: D MacLeod (ref. 20741_044)
© Historic England Archive



3c: Aerial view of an intertidal coastal peat deposit, Pett Level, West Sussex. Note the multiple fallen tree trunks.
Image: D Grady (ref. 33069_013)
© Historic England Archive.

Where available, borehole data (BGS, research and commercial) will provide more details on a location's stratigraphy, which could be drawn together into a deposit model (*see* Historic England 2020; and figure 14 therein as an example). The results of previous excavations may provide information not only on the presence of waterlogged deposits, but also on the state of preservation of the wood remains – and perhaps on the burial environment. Generally, as broad an evidence base as possible should be considered.

2.3 Written schemes of investigation and project designs

Written schemes of investigation (WSIs) and project designs (PDs) for sites known to contain waterlogged archaeological wood (or where it is suspected) should include specific strategies for dealing with waterlogged wood. These should cover:

- methodologies for excavation
- recording
- sampling
- assessment
- temporary storage
- post-excavation assessment
- analysis
- selection
- conservation
- archiving

The wood specialist(s), dendrochronologist, conservator and the collecting institution should all be named in the WSI/PD. For large or complex sites, or where the intention is to conserve and archive waterlogged wood, they should be involved in the production of these documents. These same specialists, the collecting institution and stakeholders should also contribute to the selection strategy for archaeological archiving.

2.4 Timescales and costs

When working with waterlogged wood, making timely and rapid decisions is essential to keep costs down and to prevent the wood degrading. Effective planning will help to anticipate realistic costs for excavation, recording, illustration, transportation, packaging and temporary storage. Those involved in the project planning should include the wood specialist(s), archaeological consultant (if relevant), local authority archaeologist, archaeological archive manager, conservator and collections curator from the collecting institution.

Ongoing costs of storage and specialists' time need to be considered at the planning stage in case of unexpected delays. A clearly defined end goal needs to be in place, because wood cannot remain in temporary storage indefinitely. It is recommended that any wood requiring conservation is submitted within a maximum of 36 months from excavation, and as soon as the recording and sampling have taken place.

Collecting institutions need to be involved in the early stages of the project. This will ensure that any decisions made by the project team regarding selection or deselection considers the volume of material the institution can accept and how the wood will be displayed or stored post-conservation.

If excavated wood needs to be stored on site or prior to recording/assessment, the preferred method is to store it under water, in a cool dark location. Cold storage (5°C) when not submerged in water is suitable in the very short term (if the wood is packaged appropriately), but it is an expensive option and will not prevent the wood from drying out.

2.5 Unexpected discoveries

Unexpected discoveries of waterlogged wood (within an existing project rather than a chance find) will impact a project's costs and timetable and will require specialist involvement. A swift response, with input from project managers, stakeholders and where relevant clients/consultants will, therefore, be required. The state of preservation and significance of the site or assemblage will need to be investigated rapidly. The findings will inform decisions regarding the excavation strategy (or the continued preservation of the wood in the ground), and the need for any additional specialist or conservation input.

2.6 Specialisms

Waterlogged wood can be preserved in various settings (marine, intertidal and terrestrial environments; natural and anthropogenic deposits, for example), with different site types and dates (from ships to settlements; from prehistory onwards). A wide range of specialist advice may, therefore, be needed.

The availability of specialists to undertake the work and the associated costs, which may be uncertain, will need to be considered.

The following section lists the main specialisms relevant to waterlogged wood, with most detail provided on the wood specialists directly involved with the material's recording and analysis. Some individuals may have expertise in more than one field, but this cannot be assumed and must, therefore, be established as early in the project as possible. While some specialists will be involved throughout the project, others may need to be brought in part way through due to unexpected discoveries.

Lead wood specialist: Has oversight of a project's waterlogged wood. They provide advice, and lead on the recording, sampling and co-ordinating of the wood-related activities. Usually, the lead wood specialist is also the wood specialist with wood technology and morphology expertise (Figures 4a, 4b).

Wood specialist (wood technology and morphology): Records, assesses and reports on the range and character of woodworking evidence (conversion of the raw material to planks and boards etc, tool kit and so on) and woodworking technology, alongside the nature and morphology of the raw material used (*see* 7.2.2 Woodworking and wood technology). They may also report on unworked wood from archaeological contexts. This specialist often operates as the lead wood specialist and helps to co-ordinate other specialist involvement.

Wood identification specialist: Identifies wood using high power microscopy (usually up to x400). Identifications are usually to genus level and based on anatomical features, normally examined from thin sections (Figures 4c, 4d).

Other responsibilities include undertaking additional analysis and recording (*see* 7.2.3 Wood studies) to look at timber selection and woodland management. Information is gathered from tree-ring studies (such as ring counts, average ring widths and season of felling); the presence or absence of bark, pith and tyloses; and the wood's state of preservation (looking at insect damage, iron deposition and evidence of compression, for example). This specialist may also undertake sampling for radiocarbon dating in close discussion with the radiocarbon dating specialist.

Dendrochronologist: Examines wood growth rings using microscopy to reveal the age of the wood and to provide an estimate of the date of felling. Where possible, the dendrochronologist should have appropriate experience of working with waterlogged archaeological assemblages (Figure 4e).

On the samples that they receive (which is usually only a selection of the total wood assemblage), this specialist will also record and analyse wood types and anatomy (ring counts, ring widths, seasonal variation, presence of bark and so on). Samples submitted for ring-width dendrochronology may be used for blue intensity dendrochronology or further sub-sampled for oxygen isotope dendrochronology or radiocarbon dating. More detail on scientific dating is provided in Section 7.1.4 Scientific dating.

Archaeological conservator: Advises on lifting, packaging and temporary storage. Other responsibilities include determining the wood's state of preservation, stabilising timbers and artefacts for display or storage, and assisting with decision-making on selection or deselection.

Local authority archaeologist/curatorial archaeologist: Ensures compliance with planning permissions, health and safety, and archaeological regulations. In local government, this person is sometimes known as the planning archaeologist or archaeological curator.

Figure 4: Images of specialists at work.
4a: Lead wood specialist Maisie Taylor recording fragmentary, Bronze Age, Boat 7 in the palaeochannel at Must Farm, Cambridgeshire. © Michael Bamforth
4b: Lead wood specialist Michael Bamforth undertaking recording at Must Farm, Cambridgeshire. © Cambridge Archaeological Unit
4c: Thin section sampling for wood identification. Image: Angela Middleton © Historic England.
4d: Thin section examination for wood identification using high power microscopy (transmitting light). Image: Angela Middleton © Historic England
4e: Dendrochronologist Ian Tyers recovering a dendrochronological sample from an Iron Age pile recovered from the triple post alignment at Beccles, Suffolk. © Michael Bamforth

Archaeological archive manager: Ensures an archaeological archive is fully compiled and transferred to the archive collecting institution. Usually, this specialist is an in-house member of staff at the archaeological contractor carrying out the excavation.

Collections curator: Receives the waterlogged wood at the collecting institution for curation and subsequently cares for the material in permanent storage or on display. They also assist with selection decisions. This person is a staff member at the collecting institution that is receiving the archive.

Nautical archaeologist: Advises on 'the physical remains of any waterborne vessel irrespective of the material they are constructed from, the totality of the remains or the environment where they are found' (CIfA 2020a).

Radiocarbon (^{14}C) dating specialist: Provides advice on radiocarbon dating, including sample selection and submission (Bayliss and Marshall 2022). May also have expertise in wiggle-matching (*see* New horizons in the scientific dating of waterlogged wood) and Bayesian [statistical] modelling.

Materials scientist: The specialism(s) required for this role will depend on the material(s) to be investigated: for example, surface treatments (organic, inorganic), caulking, basketry, textiles (threads, fabrics) and construction/building techniques.

2.7 Contractor responsibilities

Although specialist advice is essential throughout, the archaeological contractor will carry out much of the work required to excavate waterlogged wood, including (but not limited to):

- revealing/excavating the wood
- keeping the wood wet and covered as necessary during excavation
- planning the deposits, photographing and possibly 3D modelling the deposits

The contractor's responsibilities regarding the recording, lifting, sampling and packaging of the wood will depend on the recording pathway selected (*see* 5.2 On- and off-site approaches to recording). Some of these responsibilities may fall to the relevant specialist.

The archaeological contractor will normally be responsible for transporting and storing the assemblage during the post-excavation process and then submitting the selected material for conservation or disposal.

2.8 Important considerations when planning a project

Timelines: The fragile nature of and special storage conditions required by waterlogged wood mean that it is essential to complete the recording process as soon as possible after excavation. Tasks relating to wood often need to be front-loaded and prioritised over those relating to other material types. In some cases, wooden artefacts and other significant or fragile items may have to be dealt with via a fast-track process, in a shorter timeframe than the bulk of the wood assemblage.

Early engagement: Often, multiple specialists will need to examine the same samples or objects. Managing competing demands (such as species identification, dendrochronology, illustration and photography, and submission for conservation) will be necessary to ensure tasks are completed in an appropriate order and within good time. Early engagement with stakeholders and specialists will help this process. All parties need to be consulted at the start of the project, including the receiving collecting institution, the various wood specialists and the archaeological conservators.

Data management: Every archaeological project will have a data management plan (DMP) (*see* the CIfA Dig Digital toolkit for managing digital data) written at the start. This will ensure that appropriate consideration is given to the types of data produced and how they are managed.

Archaeological projects create a wide range of data, which will be amplified by the excavation of waterlogged wood. Effective planning through use of a data management plan is the most effective way to ensure data are secure, accurate, understandable, preservable, and transfer seamlessly into the digital archive. This will reduce duplication and additional data handling at later stages.

Selection strategy: A selection strategy is the methodology detailing the project-specific selection process. Applying a selection strategy (EAC 2021) throughout the project will help inform decisions on the selection of the working project archive. These decisions will be made based on advice from the project specialists. That way, the most significant remains will be retained as the preserved archive. The rationale for keeping/not keeping remains must be documented. CIfA's toolkit for selecting archaeological archives, which includes a checklist of tasks and considerations, will help with this process.

Workflow: Figure 5 shows the workflow for a typical archaeological project dealing with a waterlogged wood assemblage. It can apply to an evaluation or a full excavation. Often, the tasks – and their respective specialist input(s) – will ebb and flow throughout a project, with some (particularly conservation) contingent on previous tasks having already been completed. It is, therefore, important to keep track of work schedules and to communicate regularly with project specialists. Although local authority archaeologists are not included in the workflow diagram, they are integral to the process. Their input ranges from discussions about the initial WSI, to ongoing engagement and monitoring, through to final project approval, as set out in the WSI and relevant planning conditions.

Figure 5 (page 21): Diagram setting out the workflow for a project involving waterlogged wood. It demonstrates how lots of tasks happen in parallel, some with concentrated phases of activity, and some – such as the selection strategy – requiring consideration throughout the project. It also indicates whose expertise and input is required at the various project stages. © Historic England

TASKS

	SELECTION STRATEGY	PROJECT PLANNING	EXPERTISE AND INPUT
	Formulate initial Selection Strategy with specialists, based on anticipated material types, quantities and significance	Produce and agree on WSI/PD/method statements; in collaboration with stakeholders; Devise a Selection Strategy; Produce Data Management Plan (DMP); Formulate clear project aims, objectives and research questions	Project manager Lead wood specialist Archaeological conservator Archaeological archive manager Collections curator PLUS Wood identification specialist, Dendrochronologist, Graphics

PROJECT STAGES

PROJECT STAGES	SELECTION STRATEGY	WOOD RECORDING	GRAPHICAL RECORDING	SUB-SAMPLING	SPECIES IDENTIFICATION	SCIENTIFIC DATING	CONSERVATION	EXPERTISE AND INPUT
FIELDWORK	Revisit and update the Selection Strategy based on recovered material types, quantities and signficance. Discard wood as and when appropriate, to avoid unnecessary costs. Document the decision making	Start wood recording (including macroscopic wood identifications). Wood recording should be carried out as soon as possible after revealing the wood, and could take place on- and/or off-site (Pathway 1 or 2)	Start the graphical recording of the wood remains. Carry out all recording before any subsampling takes place	Undertake sub-sampling (for wood identifications and scientific dating) alongside the wood recording. Do not subsample if further work is required (eg illustration, conservation)		Identify any early need for spot dating	Identify material requiring fast track to conservation, and action these as soon as possible	Project manager Excavators Lead wood specialist PLUS Archaeological conservator, Dendrochronologist, Graphics
POST-EXCAVATION RECORDING	Revisit and update the Selection Strategy. Discard as necessary	Continue with the wood recording, to completion	Undertake graphical recording (illustration, photography, 3D modelling) of the wood remains	Continue sub-sampling as necessary. For artefacts, specialists need to consult with the project conservator			As work on the assemblage progresses, items selected for retention should be conserved by the project conservator as soon as possible	Project manager Lead wood specialist PLUS Graphics, Archaeological conservator
ASSESSMENT	Revisit and update the Selection Strategy. Discard as necessary	Ensure all wood recording is complete before the written assessment is prepared **12 months**	Continue the graphical recording of the wood remains	Carry out final subsampling as necessary	Start laboratory-based microscopic wood identifications and recording of other characteristics, as led by the project's research questions	Assess the suitability of material for scientific dating		Project manager Lead wood specialist Archaeological conservator PLUS Wood identification specialist, Dendrochronologist, Archaeological archive manager
ANALYSIS	Revisit and update the Selection Strategy. Discard as necessary		Complete the graphical recording of the wood remains **36 months**	**36 months**	Undertake the bulk of the laboratory-based wood identifications and additional recording **48 months**	Carry out the bulk of the dendrochronological analysis and other scientific dating. For large dendro-suitable assemblages, this can start earlier **48 months**	**36 months**	Project manager Lead wood specialist Wood identification specialist Dendrochronologist Graphics
RETENTION/DISCARD	Material selected for disposal is to be discarded or dispersed, as agreed and documented			Discard sub-samples that have been recorded/analysed			Material in the Working Project Archive that is not selected for retention can be discarded	Project manager Lead wood specialist Wood specialists - multiple Archaeological conservator Archaeological archive manager
ARCHIVE DEPOSITION	Material selected for retention will be deposited as part of the Project Archive.	Deposit the wood recording sheets (paper, digital) and the wood database (digital).	Deposit graphics (drawings, photos; physical, digital)		Deposit the specialist's recording sheets and digital dataset	If the parent timber has been selected for conservation, reunite the conserved, dendrochronological sub-sample (slice) with its originating artefact/timber, ready for deposition Deposit the specialist's recording sheets and digital dataset	Conserved timbers and artefacts will form part of the Project Archive	Project manager Archaeological archive manager Collections curator

The suggested time frames are maximum values, and will vary depending on the size and complexity of a site / assemblage. Conservation should have started, but may not be completed, within 36 months.

Costs: Be aware that excavation and post-excavation work (including planning deposits, photography and 3D modelling) at a waterlogged site may be more expensive than a 'standard' excavation. Costs include recording/analysing organic materials and other specialist conservation requirements. The project will, therefore, need to be costed accordingly.

Documentation: It is essential to prepare a written strategy (WSI/PD) for the excavation and post-excavation processes and workflows. This should include the excavation technique, preservation strategy during excavation (covering and watering *in situ* material to keep it wet) and drawing up plans (manual/3D recording). It is also important to identify named individuals to cover each specialist area. These people should be involved in preparing the written strategy if required (wood technology, dendrochronology, species identification, illustration, for example).

3. Archaeological evaluation

The purpose of an archaeological evaluation is to characterise the site, understand its extent and date, and assess the significance and state of preservation of the remains.

This is true whether the presence of waterlogged wood is expected or not. An archaeological evaluation may or may not be followed by a full excavation; either way, the wood assemblage will still require prompt recording and assessment. It may also require analysis, conservation and archiving.

In relation to waterlogged wood, an archaeological evaluation involves investigating the character of the exposed wood and undertaking targeted recording and sampling (Figure 6). The aim is

Figure 6: An evaluation trench at Flag Fen, Peterborough exposing timbers of the Bronze Age post alignment. © Cambridge Archaeological Unit.

to answer initial questions about the remains' state of preservation, origin (anthropogenic/natural), date, function and so on. This will inform the excavation strategy (if excavation is deemed necessary and/or appropriate) or the site's continued preservation. The evaluation will require input from an on-site lead wood specialist – one with wood technology and morphology expertise.

It is useful to establish as early as possible whether a wood assemblage has an anthropogenic origin, is naturally accumulated or is a mixture of both. This will help determine the amount of recording and post-excavation analysis needed. Naturally accumulated material can be of significance in its own right – helping set the scene of contemporaneous human activities by providing evidence of the plants and animals inhabiting the landscape (for example, beaver-gnawed wood). It may also include worked wood that has been transported from where it was initially used. The project's scope and research questions and the significance of the material will determine the level of detail of recording and sampling of waterlogged wood from natural deposits.

3.1 Archaeological evaluation of sites with waterlogged wood

An evaluation of a site containing waterlogged archaeological wood needs to be extensive enough to be able to make appropriate decisions on subsequent actions.

If waterlogged wooden artefacts are identified, they should be excavated immediately to prevent rapid deterioration. Where larger structures such as worked wood platforms are encountered, enough material needs to be excavated to understand the depth and character of the deposit. If complex sites or structures are found in evaluation trenches, discussion between the site archaeologists, wood specialists, conservators, local authority archaeologists and the collecting institution may be required to determine the amount of evaluation needed.

A lead wood specialist will be needed on site to characterise and assess the significance of the waterlogged wood and advise on further action. For sites with complex or extensive waterlogged wood assemblages, early consideration should be given to how the wood will be recorded (*see* 5.2 On- and off-site approaches to recording).

Archaeologically significant waterlogged wood deposits will usually be sampled for scientific dating, species identification and assessment of the state of preservation based on the advice of the project specialists. Samples for assessment should cover a range of material from across the site. Sampling for the state of preservation should be carried out after discussions with and under the guidance of the project's (wood) conservator.

For the purposes of scientific dating (for example, to get a spot date for an undated assemblage to help understand its significance), expert advice should be sought from the radiocarbon dating specialist and/or dendrochronologist.

4. Assessment and decision-making following evaluation

The results of the evaluation and investigation of the waterlogged wood, both on site and from the samples recovered, are used to assess the significance of the remains and their state of preservation. They are also used to consider the impact of any future development or land use changes on waterlogged wood *in situ*.

More detailed guidance on these topics can be found in the Historic England guidance Preserving Archaeological Remains (2016).

A further key part of this assessment stage is producing a catalogue of the material excavated.

4.1 Significance

Assessing the significance of waterlogged wood (alongside the other evidence from the site) is critical for making decisions about how to deal with the wood. A lead wood specialist will be required to oversee this work, seeking advice from relevant specialists. Guidance on assessing significance is given in the Historic England Advice Note: Statements of Heritage Significance and Good Practice Advice: Managing Significance in Decision-taking in the Historic Environment.

One way to assess the significance of waterlogged wood is to consider whether the wood has archaeological interest, as set out in the Government's National Planning Policy Framework.

Additionally, the values set out in Historic England's conservation principles allow for further consideration of a wider range of attributes. The principles are grouped into four categories:

- evidential value: the potential of a place to yield evidence about past human activity
- historical value: the ways in which past people, events and aspects of life can be connected through a place to the present – it tends to be illustrative (demonstrating past purposes, influences or activities) or associative (connecting with past people, places or events)
- aesthetic value: the ways in which people draw sensory and intellectual stimulation from a place
- communal value: the meanings of a place for the people who relate to it, or for whom it figures in their collective experience or memory

Assessing the waterlogged wood using these criteria will influence subsequent actions. For example, if the wood assemblage has a high level of evidential value (or archaeological interest), it will be treated differently to wood that has aesthetic value only. Such differentiation may provide a useful focus for selection strategy discussions.

4.2 State of preservation

Understanding the state of preservation of any wooden element is essential for:

- establishing how it should be handled on site
- determining its potential for subsequent investigation and analysis
- advising on a conservation approach
- assessing the likelihood of further degradation (for example, during temporary storage)

High and Penkman's (2019) report gives a comprehensive review of the methods available to determine the state of preservation of wood. A summary of the techniques is presented in Section 4.2.2 Specialist analytical methods to assess the state of preservation. A wood specialist and/or conservator should advise on the most suitable approach, and in most cases a multi-analytical strategy is recommended. Table 1 summarises the techniques discussed in this section.

Table 1: Summary of the routine and specialist techniques used to assess the significance and state of preservation of waterlogged wood remains, and when they are usually carried out.

Technique	When to use	Information provided
Visual assessment	On site, during evaluation	Structural integrity; archaeological significance
Pin test	On site, during evaluation	Structural integrity; extent of deterioration
Thin section microscopy	Off site, during species identification	Species identification; assessment of physical structure; presence of fungi; presence of inorganic deposits
Scanning electron microscopy (SEM)	Off site, prior to conservation decisions	Assessment of physical structure; presence/absence of celluloses; presence of fungi; presence of inorganic deposits
Maximum water content, density, wood shrinkage	Off site, prior to conservation decisions	Loss of wood substance (cellulose content)
Thermogravimetry	Off site, prior to conservation decisions	Cellulose content; inorganic content; lignin damage
SEM-EDX	Off site, prior to conservation decisions	As for SEM, but additional information on inorganic content
FTIR	Off site, prior to conservation decisions	Cellulose content; inorganic content; lignin damage
X-ray imaging	Off site, prior to conservation decisions	Internal decay; presence of internal features such as nails or voids
Py-GC-MS or EGA-MS	Off site, for detailed molecular analysis	Cellulose content; detailed analysis of lignin modifications
Residual ash analysis	Off site, prior to conservation decisions	Inorganic composition (by mass, individual elements not identified)
XRF	Off site, prior to conservation decisions	Inorganic composition (including identification of elements)

4.2.1 Visual and physical assessment

Initial visual and physical assessment techniques can be carried out on site during the evaluation (or later excavation) stage. One of the aims of such assessments is to establish the structural integrity of the wood and devise an excavation and lifting strategy.

The visual assessment is an essential starting point, and particular attention should be paid to surface detail. This can be reported as a descriptive written narrative and/or by using a scoring system such as the Taylor Scale; the scoring criteria for the Taylor Scale in Table 2 relate the state of preservation to whether the wood has the potential for:

- woodworking and wood technology analysis
- conservation
- species identification and wood studies
- scientific dating (both dendrochronology and radiocarbon dating)

Across the categories, the boundary for meaningful analysis is a score of ‘3 moderate’.

A pin test, used to determine the resistance of the wood, can also be done at this point on site to provide an indication of the structural integrity of the wood.

Table 2: The Taylor Scale, visual and physical inspection grading scheme for assessing the state of preservation and analytical potential of waterlogged wood (devised by Maisie Taylor [Van de Noort *et al*. 1995], modified by Bamforth and Robinson Zeki in 2024). An object is assigned a grade between 0 and 5 (after Bamforth and Robinson Zeki 2023). This grade indicates its suitability for different types of archaeological analysis: (+) = suitable; (-) = unsuitable. A threshold for conservation is also included, with items that score ‘2 poor’ or lower generally having insufficient woodworking evidence to warrant retention on that basis alone.

State of preservation	Woodworking/ wood technology analysis	Conservation	Wood studies	Species identification	Scientific dating	
					Dendro	^{14}C
Section	7.2.2	7.1.5	7.2.3	7.2.3	7.1.4	
5 excellent	+	+	+	+	+	+
4 good	+	+	+	+	+	+
3 moderate	+/-	+	+/-	+	+	+
2 poor	+/-	-	+/-	+/-	+/-	+/-
1 very poor	-	-	-	+/-	-	+/-
0 non-viable	-	-	-	-	-	-

Key

5 All original woodworking evidence is present, clearly visible and well presented – appears ‘as new’.

4 Primary and/or secondary conversion is clear, as is fine detail such as tool facets and additional tool signatures or stopmarks. Use/wear is apparent, if present.

3 Primary and/or secondary conversion is clear, if present. Tool facets are visible if present but will not preserve fine detail. Can be sampled for species identification and scientific dating, if appropriate, and is likely to provide viable data.

2 The basic form of this material is visible (for example, roundwood, debris and so on). Conversion may be apparent, but clear faceting is not visible. Can be sampled for species identification and scientific dating, if appropriate, and may provide useful results.

1 The material is so degraded as to not be able to see its form. A piece of the item may be in a suitable condition to allow species identification.

0 Material that is barely recognisable as wood – typically occurs as ‘dust’, as a ‘smudge’ or as a ‘shadow’. Is not an entity that could be picked up and bagged.

More-detailed inspection may be needed to establish the state of preservation of the wood or to support a conservation and retention plan. For example, further analysis could demonstrate the cellulose content (loss of wood substance) and whether any inorganic salts are present. This work would typically be carried out off site, using samples that represent the spatial extent of the site.

High powered microscopy using thin sections can provide a basic idea of the state of preservation of the wood, including how intact the physical structure is. It may also identify types of decay and reveal the presence of fungal hyphae or inorganic salts. A much clearer picture of the state of the wood cells can be obtained using a scanning electron microscope (SEM), which can often reveal how much cellulose (including hemicellulose) remains within the cell walls (Figures 7a, 7b).

There are other well-established methods of determining the state of preservation of wood. Maximum water content, wood density and shrinkage metrics all reflect how much of the original wood substance has been lost; this information can be used to inform a conservation strategy.

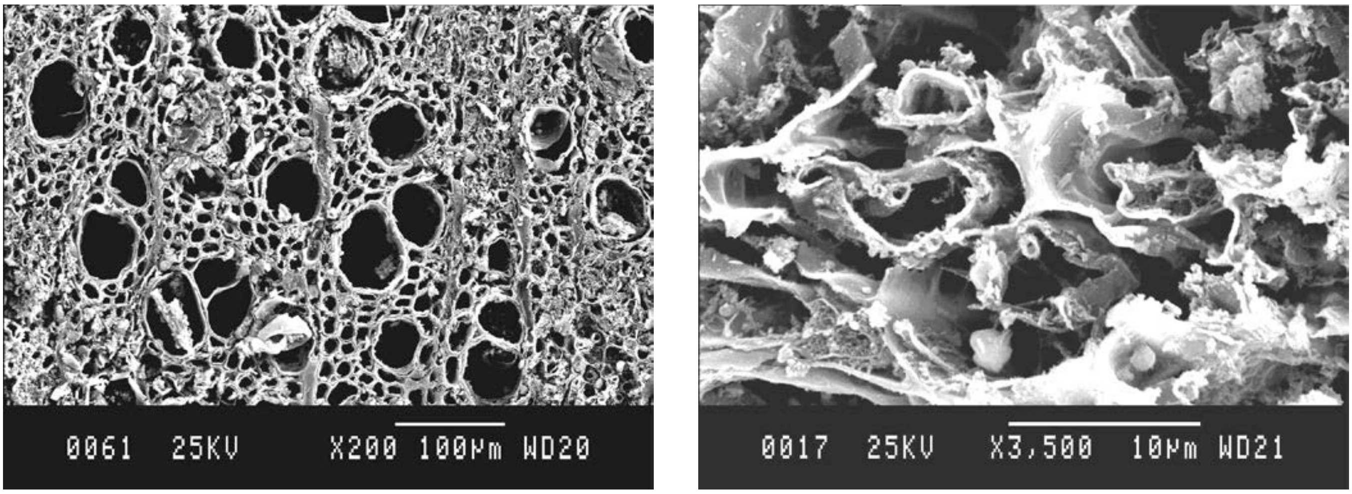


Figure 7: SEM images of degraded waterlogged wood.
7a (left): SEM image of ash wood from Neolithic Bell Track, Somerset, showing medium degradation of cell structure. Image: Mark Jones © South West Heritage Trust
7b (right): SEM image of highly degraded alder wood from the Neolithic Abbot's Way, Somerset. Image: Mark Jones © South West Heritage Trust

4.2.2 Specialist analytical methods to assess the state of preservation

Most of the specialist techniques mentioned below will not be applied routinely. An understanding of the techniques' potential and limitations is, however, useful when undertaking or commissioning specialist analyses. The list is not exhaustive because new techniques emerge all the time.

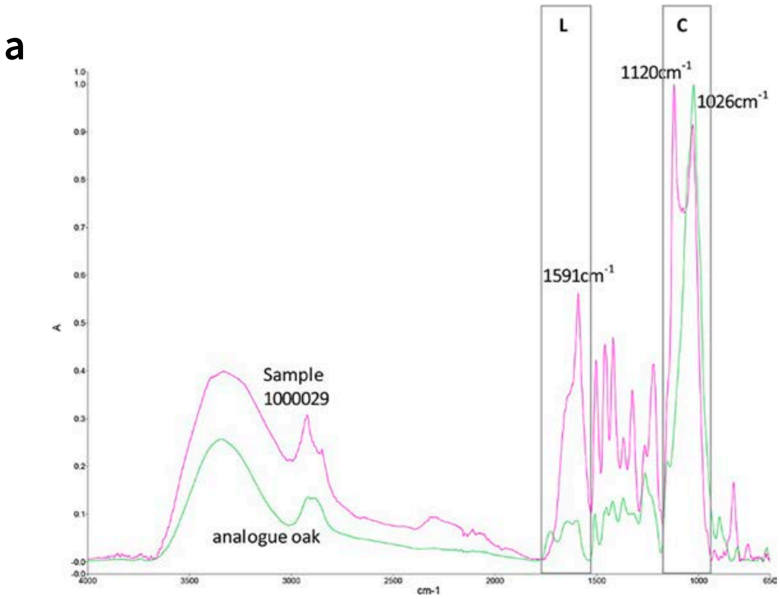
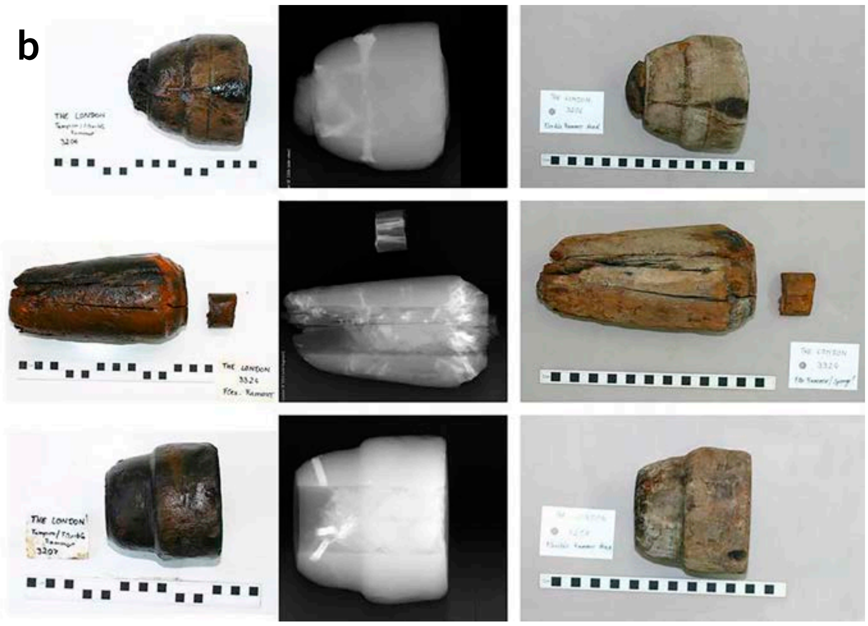
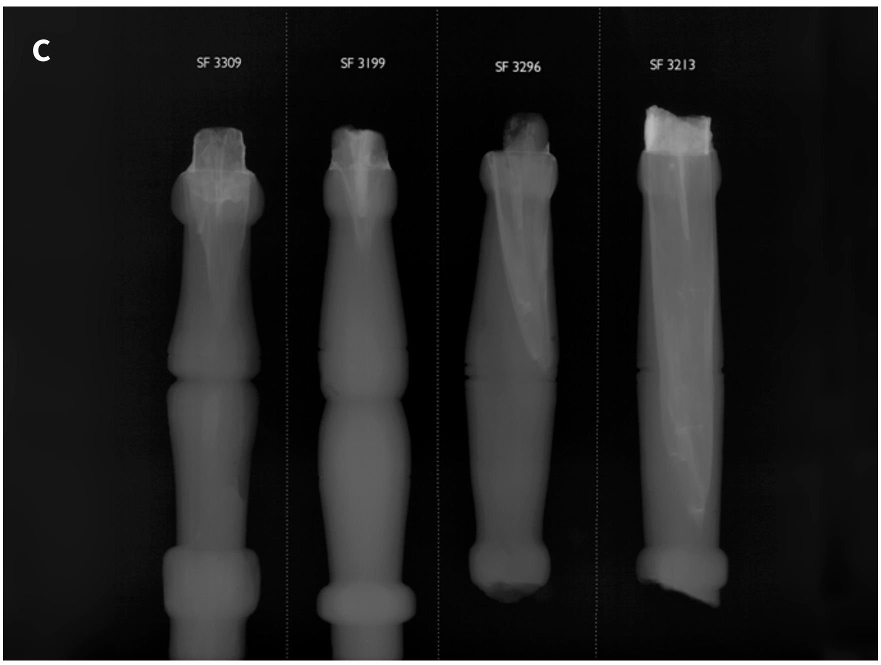


Figure 8: Examples of specialist analytical techniques.

8a: FTIR spectra of archaeological (purple) and modern (green) wood, comparing the lignin (L) and cellulose (C) peaks.
Image: Rosie Lansley
© Historic England



8b: Rammer heads, recovered from the London wreck (sank 1665), before and after conservation alongside their X-Ray images, showing internal construction components such as pegs, nails and rope as well as cracks.
Image: Angela Middleton
© Historic England



8c: Remains of iron components and mineralisation due to corrosion products having migrated into the wood can be visualised by X-Radiography.
Image: Eric Nordgren
© Historic England

4.3 Factors affecting the survival of waterlogged wood

The survival of waterlogged wood depends on a stable burial environment, which keeps the wood permanently waterlogged. This state excludes oxygen and so reduces biological decay.

Development or land use changes can affect the survival of archaeological remains. These include direct physical impacts (from excavating an area or constructing building foundations) and changes to the groundwater regime (lowering groundwater or changing the flow). All site proposals need to consider their potential for causing harm to the significance of any waterlogged wood.

4.4 Decision-making

Once waterlogged wood from an evaluation has been identified and recorded and an assessment of its significance and state of preservation has been carried out, a decision about how to manage the site and material will be made.

- If the waterlogged wood has no remaining evidential or other value (or no archaeological interest) and no more information will be gained from additional investigations, no further action will be needed after the recording/reporting has been completed and decisions about selection and archiving have been made.
- Where the assessment of the state of preservation demonstrates that development, land use changes or existing site use will not harm the long-term preservation or significance of the site, waterlogged wood can be left in its existing location. The site can then be managed to ensure the wood's survival. Further details are outlined in the Historic England guidance Preserving Archaeological Remains.
- Where there is still archaeological interest (or evidential value) that can be realised through excavation and analysis and the decision is taken to excavate the site, waterlogged wood should either be recorded and then disposed of, or recorded, conserved, archived and potentially displayed. At some sites, only a portion of the assemblage might be selected. Selection strategy discussions should be held as soon as waterlogged wood is found on an archaeological site (*see* Figure 5). Aspects that may influence selection decisions include:
    - significance and state of preservation of the wood
    - cost of conservation and availability of storage space
    - whether the conserved assemblage will provide opportunities for further recording to address new research questions in the future (remaining evidential value/ archaeological interest)
- Sometimes, non-artefactual wooden items are recovered that have the potential to engage the public visually (aesthetic value) but have limited evidential value/ archaeological interest. All those involved in the selection decisions to keep, conserve and display such items need to fully understand the costs and timescales involved.

5. Methods of excavation, recording and sampling

This section sets out methods for excavation, recording and sampling, using two different pathways. It covers excavation techniques, methods of *in situ* recording, and advice on lifting, packaging and transportation. The size and complexity of the wooden remains will, to a large degree, dictate the approach and also what/how much material can be recovered and conserved.

5.1 Excavation of waterlogged wood

The fragile condition of waterlogged wood presents a series of practical challenges during the excavation process. Throughout the period between exposure and lifting, wet wood will begin to desiccate, split and decay unless remedial action is taken. For this reason, the minimum area of wood should be exposed at any one time, taking into consideration the size of the excavation team and the need to understand and record the deposits.

Waterlogged wood is fragile and cannot support the weight of a person standing on it. Furthermore, wood is often found in particularly soft deposits (such as peat). Excavating in these areas can sometimes require temporary infrastructure, such as walkways and access platforms, to be installed (Figures 9a, 9b).

Figure 9: Excavations of waterlogged wood using scaffolding and raised platforms.

9a: Scaffolding platform to facilitate excavation of Late Bronze Age pile-dwelling settlement, Must Farm, Cambridgeshire. © Cambridge Archaeological Unit

9b: Raised planking and water sprays over Bronze Age post alignment, Flag Fen, Peterborough. © Cambridge Archaeological Unit

Figure 10: Ways of protecting exposed waterlogged wood from drying out, using plastic covers.
10a: Post tops regularly sprayed with water, then covered by bags to prevent moisture loss, Late Bronze Age pile-dwelling. © Cambridge Archaeological Unit
10b: Excavation underway at the Mesolithic site of Star Carr, Yorkshire with boards and planks used for access, wood deposits covered with plastic tarpaulins to prevent drying, and a temporary shelter to shade areas under excavation, Milner et al. 2018, Figure 3.11. © Sue Storey, CC BY-NC 4.0

During excavation, it is essential that the wood is kept shaded, sheltered and wet, to prevent desiccation. Exposed wood should be sprayed with water on a regular basis (Figure 9b). The frequency of re-wetting should be increased in direct sunlight and/or high winds, to mitigate the drying effect. To protect exposed wood overnight or when not directly under excavation, it should be carefully covered with an absorbent, water-soaked material (such as polyether foam or capillary matting) and then with plastic sheeting (preferably a mid-tone colour, such as blue or grey [not black]) (Figures 10a, 10b). The absorbent material needs to be sprayed regularly so that it does not wick water out of the wood. In low temperatures, an additional layer of insulating foam should be used to prevent freezing of both the absorbent material and the wood. A temporary shelter (such as a gazebo) (Figure 11) can be effective during excavation to shade the wood from direct sunlight.

Figure 11: Gazebo and water sprays, Bronze Age post alignment, Flag Fen, Peterborough.
© Cambridge Archaeological Unit.

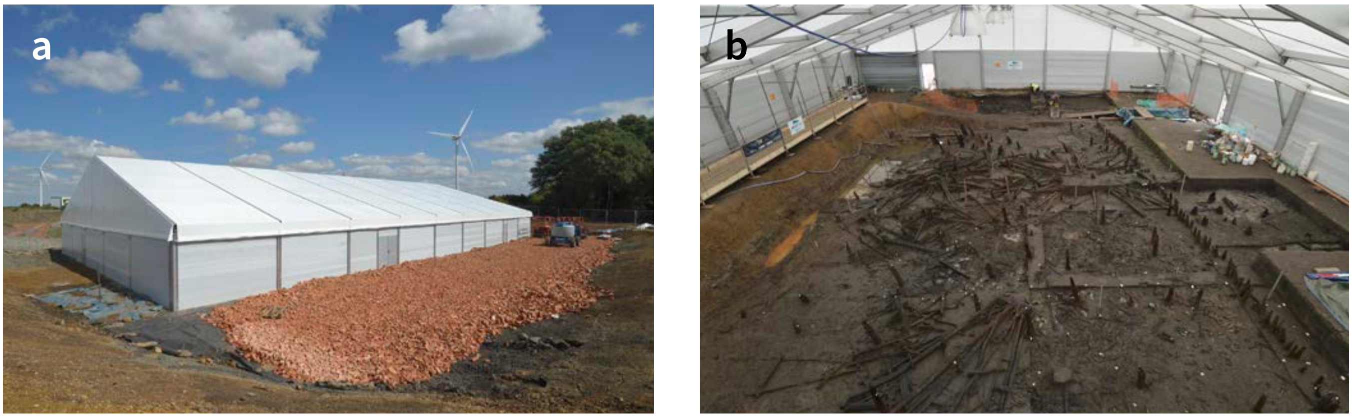


Figure 12: Photographs of the Must Farm tent.
12a: An external view of the tent used during the 2015–16 excavations at Must Farm, Cambridgeshire. © Cambridge Archaeological Unit
12b: Interior of temporary shelter erected over excavations at the Late Bronze Age pile-dwelling settlement, Must Farm, Cambridgeshire. © Cambridge Archaeological Unit

Maintaining a high moisture content on site for a long period can be very difficult. Erecting an enclosed shelter may help maintain humidity and moderate temperatures. It may also help prevent flooding from rainwater. Additionally, it can speed up on-site recording by creating better conditions for paper-based or digital work.

Most significantly, a shelter can allow a larger area of the site to be excavated and exposed at the same time. This increases the 'window' through which interconnected elements of the site can be understood, a difference that can have a radical impact on interpretation. Although erecting a large, stable, enclosed shelter (Figures 12a, 12b) can be expensive, the cost of paying staff to wrap and unwrap wood each day soon adds up. At Must Farm, Cambridgeshire, for example, the (cost of the) time saved each morning and night covered the expense of the structure. However, erecting an enclosed shelter may not always be appropriate: for example, in areas of high winds. In high temperatures, the effect of a sweltering shelter on both the waterlogged wood and the archaeologists will need to be effectively managed.

Waterlogged wood is highly susceptible to damage during the excavation process itself. If heavily degraded, it can be very soft and spongy, and surface information can be lost if the wood is not handled with extreme care. Furthermore, using sharp-edged metal tools, such as trowels and shovels, can cause irreparable damage. Such tools should not be used for uncovering waterlogged wood in deposits such as peat. Instead, wooden or plastic spatulas and sponges and gloved hands are practical alternatives (Figures 13a, 13b). In most clay and gravel sites, metal tools will be needed, but special care should be taken because even relatively robust oak (*Quercus* spp.) timbers can be badly damaged.

Preserving the softer sapwood and bark is essential for precise scientific dating. It needs to be recorded and retained, even if it has become detached (Figures 14a, 14b).

Figure 13

13a: Wooden clay modelling tools used during excavation of waterlogged wood to prevent damage to soft surfaces, Bronze Age post alignment, Flag Fen, Peterborough. © Cambridge Archaeological Unit

13b: Removal of sediment from cracks in a charred structural timber, Late Bronze Age pile-dwelling settlement, Must Farm, Cambridgeshire. Note the characteristic blocky pattern produced by the charring. © Cambridge Archaeological Unit

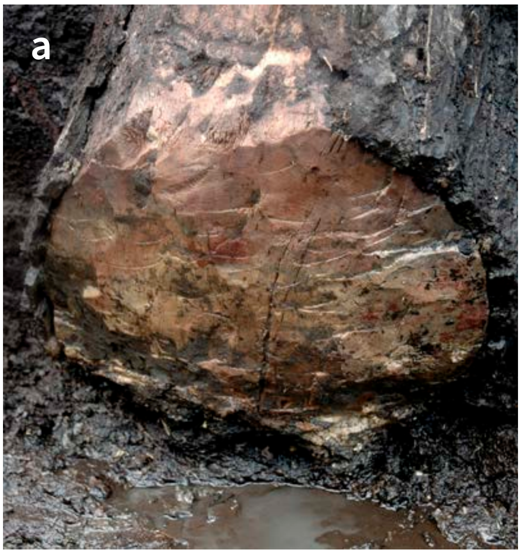


Figure 14: Examples of waterlogged wood with bark still attached.

14a: Clear tool facets and extant bark on the felled end of a Middle Bronze Age, alder, tree trunk excavated from the Thames Flood Plain, Belmarsh, London. © Michael Bamforth

14b: Dendrochronological sample from an oak pile, recovered from the Iron Age, triple post alignment at Beccles, Suffolk. © Michael Bamforth

Thorough cleaning of fragile wood surfaces should not normally be attempted *in situ*. Water sprays can be used with care in some deposits to help excavate and clean around wooden structures. Access to water is, therefore, essential.

Wood should be photographed as soon as possible after exposure and cleaning, before any details start to degrade, and before recording, lifting and sampling commences.

5.2 On- and off-site approaches to recording

There are two approaches for the recording and sampling of waterlogged wood:

- Pathway 1: Full recording on site, with sampling and selection taking place alongside
- Pathway 2: Targeted recording on site, with the material removed from site and retained for subsequent recording

These strategies can be implemented across the whole site or at a smaller scale: by context, feature, group or individual item, for example. Alternatively, both approaches may be needed within the same site, and specialist input during the excavation can help to ensure the correct balance between recording and sampling on site, and packaging and retaining for off-site recording (Figures 15a to 15d).

The decision to follow Pathway 1 and/or Pathway 2 should be made by the project's lead wood specialist, in conjunction with the excavation and management teams. This decision will be informed by:

- the significance and state of preservation of the wooden remains
- research questions
- availability of staff and expertise
- site-specific timeframes
- working conditions on site (for example, weather, waterlogging, tide times)
- resources available for packaging and moving wood
- the availability of storage space

It is important to make timely decisions to avoid unnecessarily lengthy temporary storage of wood.

Figure 15. Examples of tasks being carried out on- and off-site.

15a: Wood recording on site, Bronze Age palaeochannel, Needingworth Quarry, Cambridgeshire. © Cambridge Archaeological Unit

15b: On-site cleaning, Bronze Age palaeochannel, Needingworth Quarry, Cambridgeshire. © Cambridge Archaeological Unit

15c: Excavated, labelled wood prepared for on-site recording, Late Bronze Age pile-dwelling settlement, Must Farm Cambridgeshire. © Cambridge Archaeological Unit

15d: Timbers laid out off site. Image: Angela Middleton © Historic England

5.2.1 Pathway 1: Full recording on site

This strategy requires a wood specialist to be on site most of the time, often working with a team familiar with waterlogged wood. The aim of Pathway 1 is to front-load recording, with sampling and selection decisions being made on site. This minimises the need for temporary storage. On-site recording will include a:

- written record
- drawn record (sketches are often essential; illustration and 3D recording may be appropriate)
- photographic record (it may be beneficial at this stage to make sure the quality is good enough for publication)

Using Pathway 1 can significantly reduce the time spent on recording once the team has left the site. To make this work, sampling and selection strategies need to be prepared in advance (based on the best available information) and regularly reviewed and updated by project members and stakeholders as the excavation progresses. The main drawback of this method is that the material is cleaned and recorded on site in sometimes less than perfect conditions.

Material should be retained where there is potential for further analysis or future conservation. A sufficient volume of the assemblage will need to be retained to address not only analytical tasks identified during the excavation process, but also any questions that emerge from the assessment process. All potential artefacts should be kept intact and not sampled on site (Historic England 2018).

Where selection decisions are made during excavation, it is important that sufficient sampling is undertaken. Samples may be needed for species identification, woodland management studies and scientific dating. The lead wood specialist/wood specialist(s), dendrochronologist and radiocarbon dating specialist can advise on the sampling needed for scientific dating. Remember: different selection criteria apply to radiocarbon and dendrochronology samples, see Radiocarbon Dating and Chronological Modelling (2022), and Dendrochronology (1998).

5.2.2 Pathway 2: Targeted recording on site, specialist post-excavation recording

The aim of Pathway 2 is to remove most or all the material and record it off site. This method is particularly useful if a wood specialist cannot be on site on a permanent or regular basis during the excavation. Targeted recording, such as the location/position of the wood, labelling and photography, still needs to take place before the waterlogged wood is removed (*see* 5.3 Initial on-site recording).

The advantage of this approach is that the wood can be cleaned properly before recording and sampling. Furthermore, it provides more time for strategies on sampling, analysis and selection for conservation to be developed, informed by a more complete understanding of the site stratigraphy and phasing. The main disadvantages are that temporary storage facilities will be required for the complete wood assemblage, and that the wood specialist may not see all the material *in situ*.

Due to the degradation that wood suffers in temporary storage, and to minimise information loss, it is essential that off-site recording is completed within 12 months of excavation, and prior to the written post-excavation assessment. Adequate time needs to be allocated for integrating the wood data into the site record – incorporating wood data/photogrammetry into a geographical information system (GIS) database, for example – as checking and cleaning data can be time consuming.

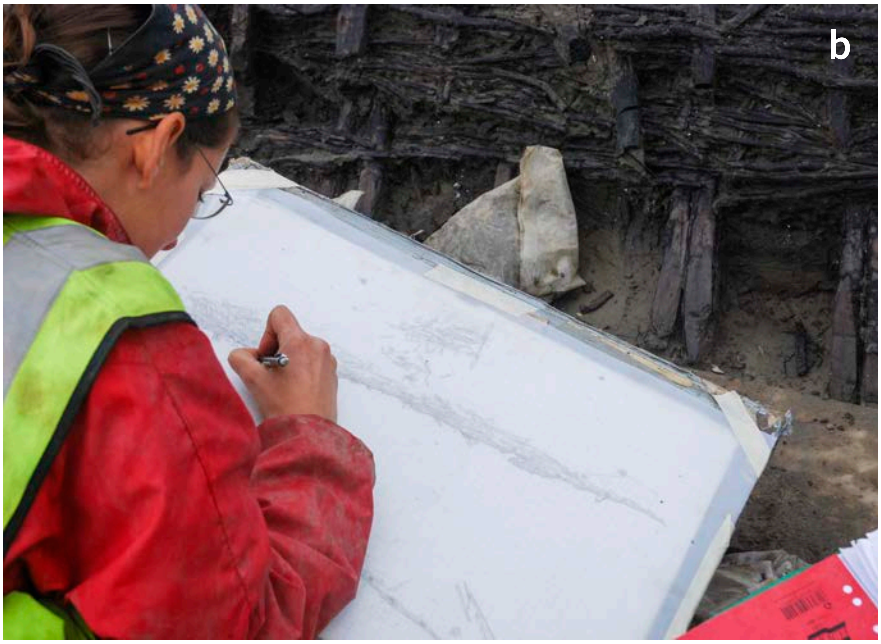
5.3 Initial on-site recording

Regardless of the excavation pathway chosen, some on-site recording is required. Every excavated piece of wood should be given a unique wood number, recorded on an index sheet. These numbers should be used on all site plans and elevations. The exceptions to this are groups of wood remains, such as wattle panels or collections of brushwood or woodchips, that are going to be described and sampled as a group rather than individually. In the case of hurdle panels, it is useful to assign one wood number to the sails (upright) and one to the weavers (horizontal). Any individual samples within a sail or weaver group can be assigned an individual identifier (a, b, c and so on) later, during analysis. A general site policy for such group numbering should be developed before the excavation begins.

It is best to use waterproof labels attached to the wood with stainless steel, corrosion-resistant pins (Figures 16a, 16b).

Figure 16: Examples of labelling.
16a: Labelling of *in situ* wood and sub-samples taken during on-site recording, Must Farm Cambridgeshire.
© Cambridge Archaeological Unit
16b: Wood samples with plasticated labels held by stainless steel pins, Late Bronze Age pile-dwelling settlement, Must Farm Cambridgeshire.
© Cambridge Archaeological Unit

Figure 17: Wattle being recorded.
17a: Recording a hurdle, Must Farm Cambridgeshire.
© Cambridge Archaeological Unit



17b: Planning a Bronze Age, wattle, fish weir in the palaeochannel at Must Farm, Cambridgeshire.
© Michael Bamforth

It is sometimes advantageous to record the location of wooden remains in plan (Figures 17a, 17b), for example where the wood is used structurally or where there is a pattern in the deposition of wood that is relevant to its interpretation (such as collapsed partially intact wattle, aligned brushwood bundles, scatters of woodchips).

Photogrammetric recording of complex structures can be highly effective (Figures 18a, 18b, 19). Orthographic images are useful, from which numbered digital plans and 3D models can be created. These techniques can save recording time on site, but they require additional time in the post-excavation stage to integrate data. A large digital dataset will normally be produced. Consequently, the application of digital recording techniques should be carefully considered and described in the data management plan and agreed with the repository for the digital data.

Figure 18: Digital recording of complex structures.

18a: A camera on a pole used to collect images for photogrammetry at the Mesolithic site of Star Carr, Yorkshire.
© Michael Bamforth

18b: An orthographic image generated from photogrammetry of Clark's Baulk at the Mesolithic site of Star Carr, Yorkshire.
© Star Carr / POSTGLACIAL project

Figure 19: Using orthographic images generated from photogrammetry to plan Clark's Baulk at the Mesolithic site of Star Carr, Yorkshire.
© Michael Bamforth

Once a wood number has been assigned, a (paper or digital) wood recording sheet should be filled in for each individual piece or group (*see* 5.5 More detailed recording). The following information must be recorded while the wood is *in situ*:

- context, feature, plan, drawing and/or photography numbers
- setting (horizontal, vertical and so on), orientation and inclination
- surface condition, with areas of excavation and pre-excavation damage or breakage clearly identified
- position of significant details (for example, joints, nails, pegs, insect damage), showing how broken or fragmented pieces fit together so they can be reassembled
- relationship to other timbers in the structure

5.4 Lifting

The lifting of waterlogged wood (usually worked wood being removed from its original location for further recording) requires careful handling because the material will often have little inherent strength. It may also have cracks and weaknesses that are not apparent on the surface. Lifting very fragile objects should be done under the guidance of a conservator.

As much of the surrounding deposit as possible should be removed, and fragile areas of sapwood and bark should be secured with pins or bandages before lifting (Figure 20a). Wood should be lifted onto a surface that can be used to support the piece for transportation to temporary storage, or to a working area if final recording and sampling is being carried out on site. Oak heartwood usually remains quite hard and strong, but it is also heavy and may have hidden cracks. Oak sapwood is softer and is highly vulnerable to damage.

Ideally, long timbers should not be sawn into shorter pieces. If this is necessary – either to disassemble a structure or to allow large or heavy items to be moved – markers should be left on both sides of the cut to indicate the correct realignment. Sawing at a slight angle will help later realignment.

In the case of extremely large pieces of wood, it may be necessary to lift them with the aid of a machine (Figure 20b). Careful consideration should be given to placement of straps and protective material, such as foam matting. A suitable area may need to be prepared for the lifted timber to be placed on, for further recording or wrapping to take place, where required.

Figure 20: Artefacts being lifted.
20a: Lifting a small artefact (base of a two-part bucket), Must Farm, Cambridgeshire.
© Cambridge Archaeological Unit
20b: A large wooden artefact, being transported on a flat-bed truck and lifted by crane.
Image: Claire Tsang © 1740Rooswijk

5.5 More detailed recording

Once the wood has been lifted, the wood specialist may carry out more detailed recording and sampling, either on site (Pathway 1) or off site (Pathway 2). Before recording, the wood should be cleaned carefully. Sponges, soft brushes, sprays and running water can all be used to remove sediment effectively. Cleaning may be undertaken by the wood specialist, or it may be better for an archaeologist with experience of working with waterlogged wood to clean the wood before the wood specialist arrives, to maximise recording time. Where artefacts have been selected to be sent for conservation, protective or supportive sediment should be left in place. Fine-grained cleaning and recording can then be carried out by the conservator at a later stage.

The wood should be recorded either on paper/polyester drafting film or digitally, adding details to the information logged while the material was *in situ*. Different recording forms are appropriate for different types of wood assemblages. Examples that are suitable for recording timbers from urban contexts (based on a Museum of London Archaeology (MOLA) recording sheet) and wood from non-urban contexts (based on a Cambridge Archaeological Unit (CAU) sheet) are reproduced in Appendix 1. Other organisations and specialists may have their own recording sheets.

Completion of wood recording should be carried out by a wood specialist or by trained personnel. Where a number of individuals are involved in the recording process, it is important to ensure that the terminology and categories used are consistent.

Regardless of the pathway, the information required for more detailed recording should include:

Site information

- Context and associations
- Planning, drawing and photography numbers
- Setting (horizontal, vertical, angled and so on)
- Orientation and inclination (in degrees)

Appearance and state of preservation

- Size and shape (dimensions and sketch) (Figure 21)
- Damage, breakages and number of pieces (pre and post excavation) (Figures 22a, 22b)
- Evidence of insect, animal, fungal or plant damage (pre and post excavation) (Figure 23)
- Surface condition (from fresh to weathered) and feel (from solid to spongy)
- Surface features, wear, charring (Figure 13b), paint and presence of bark, bark edge or sapwood

Figure 21: Measurement using callipers during on-site wood recording, Flag Fen, Peterborough.

Figure 22
22a: Radial drying cracks damaging the sapwood of a Bronze Age, oak pile, excavated at Flag Fen, Peterborough. Showing the cracks (left) longitudinally and (right) radially.
© Michael Bamforth
22b: Detailed view of cross-grain cracking.
Image: Angela Middleton
© Historic England

Figure 23: A piece of wood showing marine wood borer damage: tunnels, some with calcareous lining.
Image: Angela Middleton
© Historic England

Growth features and other characteristics

- Natural growth features, growth ring estimate and pattern, and timber quality
- Features resulting from management practices, for example coppiced heels
- Evidence of animal modifications, such as beaver gnaw marks (Figure 2b)
- Taxonomic identification. Oak is distinctive and can sometimes be identified on site by the lead wood specialist or other trained personnel. Other species identifications will happen as part of the post-excavation assessment and analysis phases (as appropriate), primarily carried out by the wood identification specialist.

Woodworking and carpentry evidence

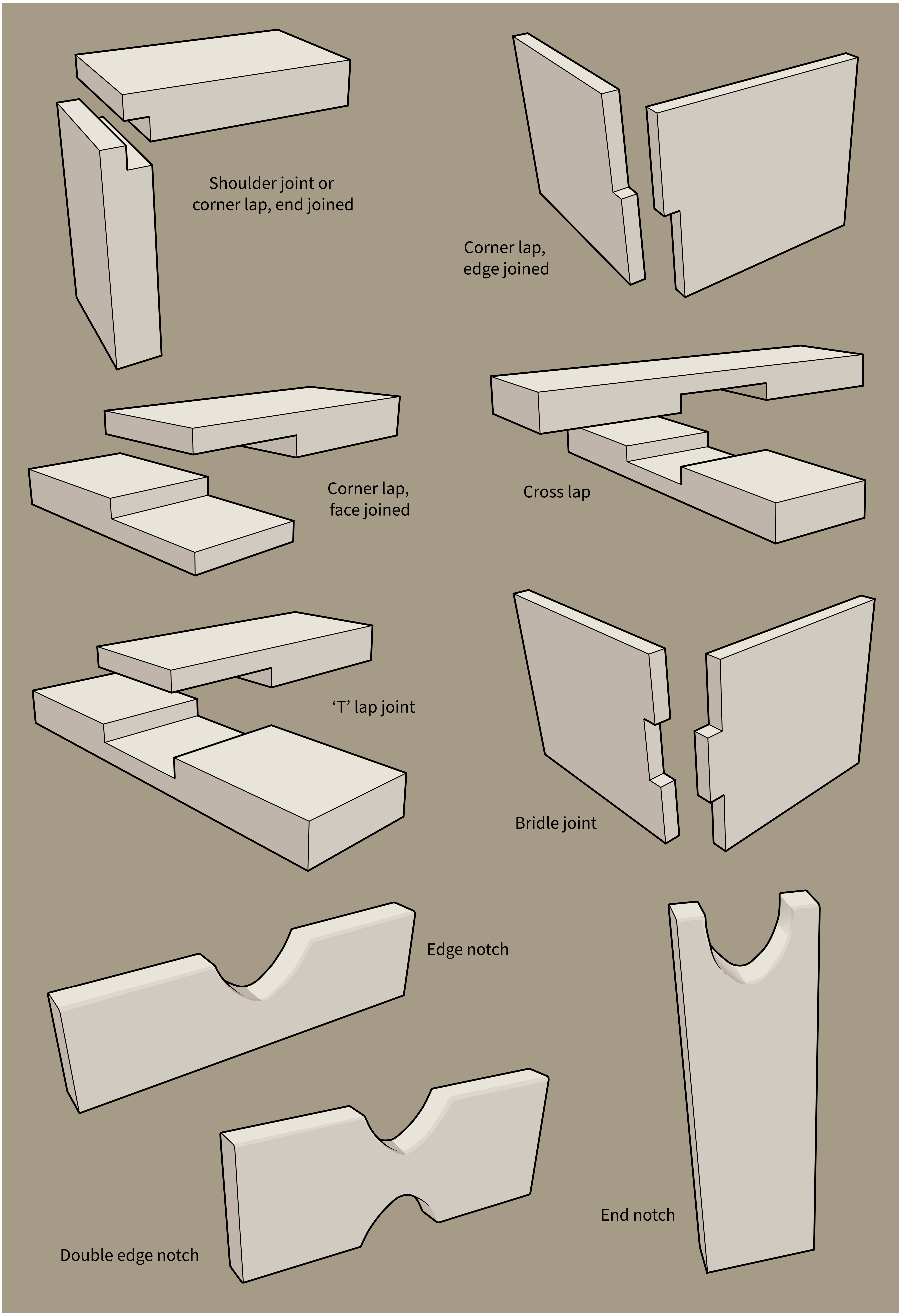
- Conversion type and method, including a sketched cross-section
- Evidence of working, degradation or damage (ancient or modern) at ends
- Evidence of felling and cutting of logs to length (e.g. Figure 14a)
- Evidence of shaping and finishing of timbers, including measuring selected toolmarks and recording stop marks and tool signatures
- Evidence of joints, nails and pegs (Figure 24a, 24b)
- Traces of wear

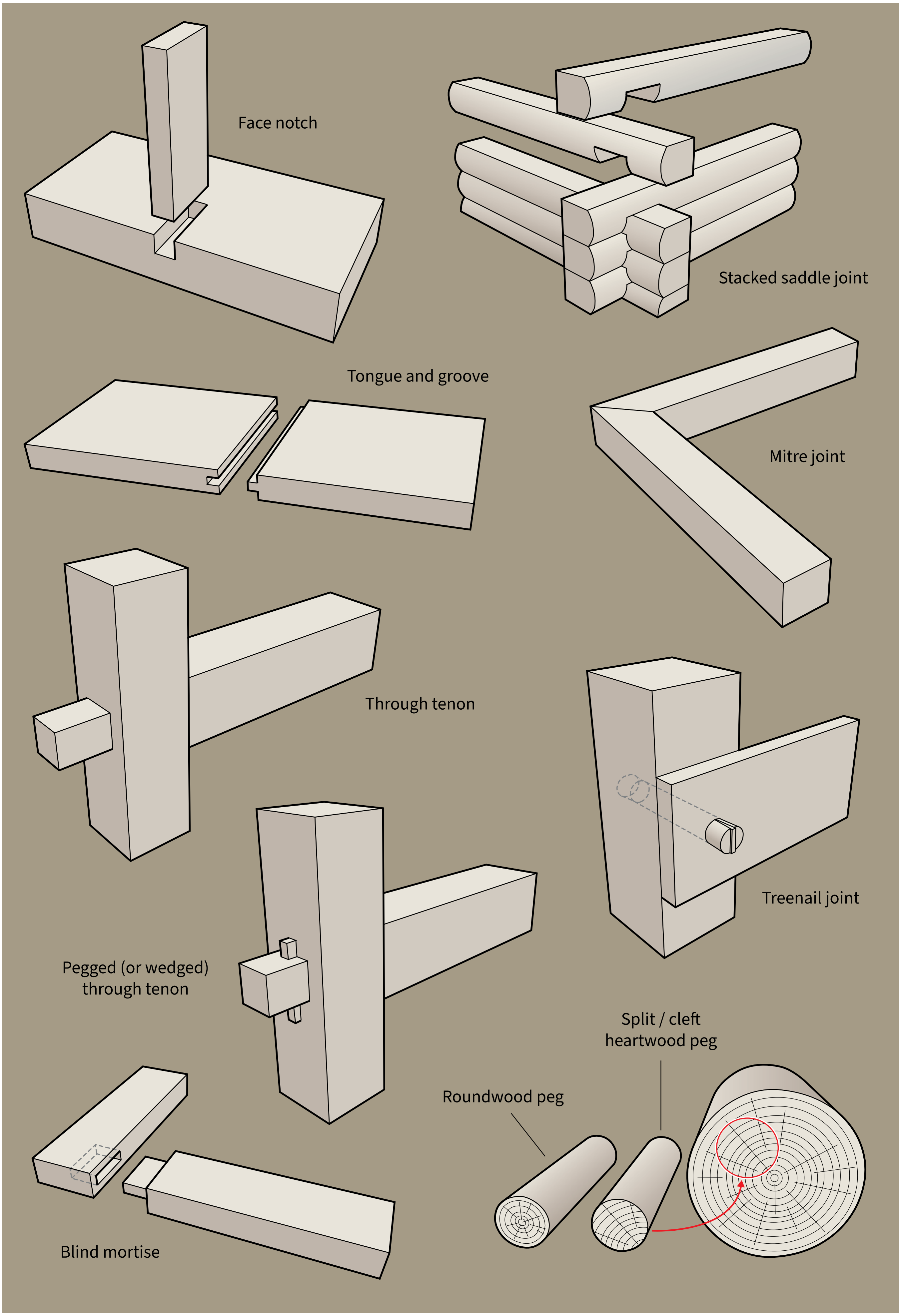
Functional interpretation

- Purpose within structure or context
- Features indicative of reuse or modification from the item's original purpose

As part of the recording process, measured sketches, technical drawings, photography, photogrammetry and/or digital recording will often be needed to efficiently document details. Some of this may be included on the wood recording sheet, but further technical drawings (face and edge line drawings), illustrations and photography/3D modelling may be necessary during the analysis phase (*see* Section 7.2.1). The lead wood specialist will determine the required approach to graphical recording to ensure that the archive is representative and proportionate. Recording should be completed within 12 months of excavation.

Figure 24a (pages 47-48): Images of commonly-encountered wood working joints, showing how multiple components fit together. Illustration: John Vallender © Historic England


Shoulder joint or
corner lap, end joined
Corner lap,
edge joined
Corner lap,
face joined
Cross lap
'T' lap joint
Bridle joint
Edge notch
End notch
Double edge notch


Face notch
Stacked saddle joint
Tongue and groove
Mitre joint
Through tenon
Treenail joint
Pegged (or wedged)
through tenon
Split / cleft
heartwood peg
Roundwood peg
Blind mortise

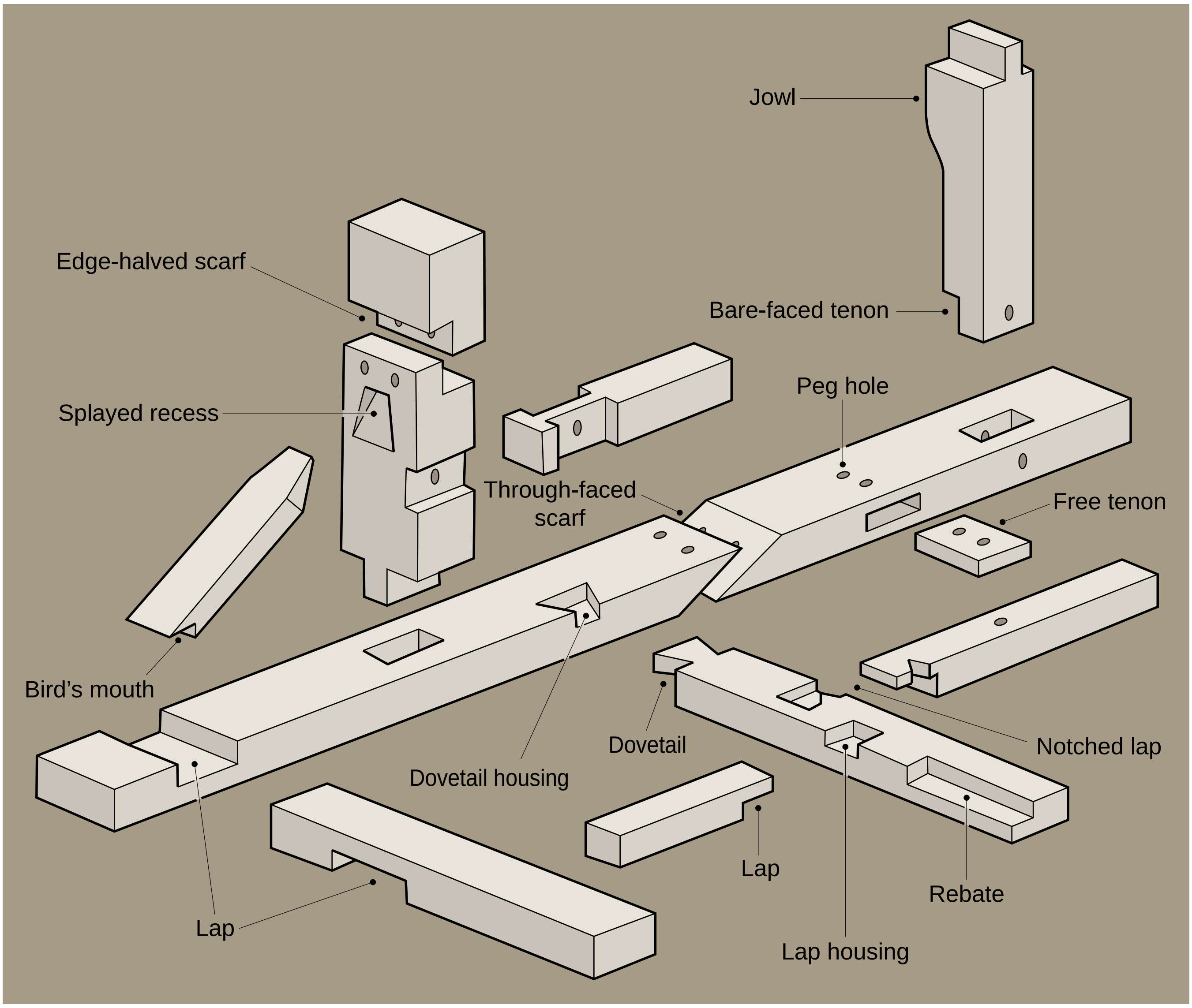


Figure 24b: An exploded image of carpentry joints showing how they fit together.
Illustration: John Vallender after MOLA

5.6 Sampling

Sampling usually happens immediately after wood recording. In general, samples should be taken as soon as is feasible and appropriately stored (*see* Section 6 Temporary storage and timescales). Samples are needed for species identification, woodland management, environmental indicators and scientific dating. The same sample can sometimes be used for multiple analyses. For example, a single section of a complete small diameter branch could be used for both species identification and producing a ring count. Or a tree-ring sample (Figure 14b) could be used for species identification, ring-width dendrochronology, oxygen isotope dendrochronology, blue intensity dendrochronology and radiocarbon wiggle-matching. Measured tree-ring records can also be used for dendroecological and dendroprovenancing studies. Samples are not usually taken at this stage from items/ artefacts selected for later drawing, photography or conservation.

5.6.1 Sampling for species identification

Small samples should be taken for microscopic, laboratory-based species identification (Figure 4c). Sometimes, wood specialists may be able to identify oak (*Quercus* spp.) in the field, from features that are visible macroscopically. In such cases, sampling for identification may not be necessary – although wood samples may still be needed for other scientific purposes.

Samples should be taken from well-preserved knot-free sections of the wood, and, at the very least, a complete annual ring is needed. If the wood is badly preserved, a larger sample should be taken. Samples need to be big enough to thin section and examine the three planes required for secure identifications: the transverse section (TS), radial longitudinal section (RLS) and tangential longitudinal (TLS) section.

Every piece of worked wood should be sampled for identification. However, if the worked group is large with repetitive characteristics, a representative sub-sample may be appropriate. The species identifications should be completed within 48 months of excavation.

5.6.2 Sampling for woodland management

The sampling strategy will be determined by the lead wood specialist. The age and growth rates of the wood can be used alongside species information to reconstruct the character of the woodland from which it came. They can reveal details about coppice cycles, wood harvesting phases, woodland age and tree density, for example. Useful information on woodland management (including ring counts, radial widths/diameters, growth rates and season of felling) can usually be recorded from the same samples as those examined by the wood identification specialist, scientific dating or wood specialist (wood technology and morphology). Ideally, the samples for woodland management should be taken where the largest number of annual growth rings is present, avoiding knot holes and side branches. For roundwood, the sample should be a complete cross-section.

Where coppiced material is suspected (from the presence of long, straight, young stems), the age and size of the roundwood should be determined from samples taken from the widest end of each stem. A minimum of 20 such samples is required for any meaningful analysis from a single wood group or context. For wattle panels, it is advisable to sample every (vertical) sail and at least 20 (horizontal) weavers. Microscopic analysis of woodland management practices should be completed within 48 months of excavation.

5.6.3 Sampling for environmental indicators

Sampling of wood for evidence of fungal, bacterial or beetle attack can help to reconstruct the environment in which the wood was deposited and to determine whether the timber was stored before use.

The choice of sample location is very important and should be decided in consultation with the relevant specialists.

5.6.4 Sampling for scientific dating

At an archaeological site, the scientific dating sampling strategy will be determined by the scientific dating programme, which is based on an understanding of the entire wood assemblage, the site's stratigraphy and any prior scientific dating results associated with the site. This will ensure that the material selected for dating will contribute effectively to the site's chronology and may potentially contribute to developing (regional) master chronologies.

When samples are taken on site under Pathway 1, the scientific dating programme may still be in development. This may require a larger number of samples to be taken (than would be the case under pathway 2), some of which might be deselected later when further stratigraphic and phasing information becomes available.

All sampling for scientific dating should be undertaken by, or in close discussion with, the respective scientific dating specialists (radiocarbon or dendrochronology). When samples are being taken without the direction of a dating specialist, training should be provided on how to take samples with the best potential (e.g. maximum number of growth rings, presence of sapwood and preferably bark edge, absence of knots, rot or damage by wood borers such as *Teredo navalis* – Figure 23). Where samples need to be taken from many substantial oak timbers, those undertaking the work should have appropriate training in the use of chainsaws.

5.6.5 How to bag and label samples

Best practice is to bag each wood sample in its own labelled bag. The sample should be submerged in water, and as much air as possible should be excluded before sealing. This can be done by immersing the bag in water up to the seal before closing. Clear, resealable, grip-lock/grip-seal bags with write-on panels are the most practical and convenient. If multiple samples come from a single overarching group (such as a particular wattle panel), then several sample bags can be grouped together in a larger sample bag, for convenience.

In exceptional situations, if it is not possible to individually bag samples, then multiple samples from the same wood group may be placed in the same bag. Ideally, the samples should be approximately the same size, and no more than 10 in one bag. In this case, the number of pieces should be written on the label. That way, it will be clear if any fragmentation occurs – and it may be possible to refit the fragments.

Each sample bag should be labelled clearly on the outside using a waterproof permanent black marker pen. There should also be a waterproof, tearproof (Tyvek) label in the bag itself. Labels in the bag should not be pinned to the sample (and certainly not to the cross-sectional surface of the sample).

Bags should be labelled with the following information:

- site name and code
- wood number
- structure/context number
- purpose of the sample, such as species identification

Further information on packaging is provided in First Aid for Finds.

5.7 Packaging for transportation

Waterlogged wood may have to be repackaged for transportation. Transporting it submerged in water in a bucket or box may cause damage to the wood itself as the water moves around.

Smaller items or samples can be transported in water in sealable plastic bags (as described above).

Larger pieces of waterlogged wood should be packaged in such a way as to limit the evaporation of water and protect the surface from damage (Figure 25). This can be achieved by wrapping the wood in layers of bubble wrap (bubbles facing away from wood) or polythene sheets. Applying a layer of wet absorbent material (such as foam or capillary matting) next to the wood will help to keep it wet. Labels should be used on the inside and outside of the wrapped piece of wood.

Figure 25: Packaging up Bronze Age Boat 7 for lifting and transport, in the palaeochannel at Must Farm, Cambridgeshire. © Michael Bamforth

The items should be loaded onto the vehicle with care, because even wrapped wood can be damaged. Particular attention should be paid to the order of packing, with larger heavy items at the bottom and lighter small ones at the top, using cushioning in between where required.

Once the material has reached its storage destination, the packaging will need to be assessed and adjusted if necessary.

5.8 Specialisms within woodwork recording

Some wood specialists will have a wide range of experience, but it is important to remember that multiple subdisciplines exist within the specialism of woodwork recording. It is, therefore, crucial that the specialists involved in a particular project have knowledge that is relevant to the material being recovered. They will need to consider age and time periods as well as function and purpose: prehistoric woodwork evidence, for example, is very different to medieval carpentry marks.

The following section describes the specialism of nautical archaeology.

5.8.1 Nautical archaeology

The general approach outlined in this guidance also applies to ship or boat remains encountered on underwater sites or in intertidal zones. However, the working conditions in these environments can be challenging, especially with regards to *in situ* recording. Not all ship remains present as articulated hull structures, and some are discovered partially or largely disassembled. Ship timbers may be found reused in revetments, or in well/pit linings and a wide range of other structures (Figures 26a, 26b). The recording, assessment and analysis of these requires specialist nautical archaeology input.

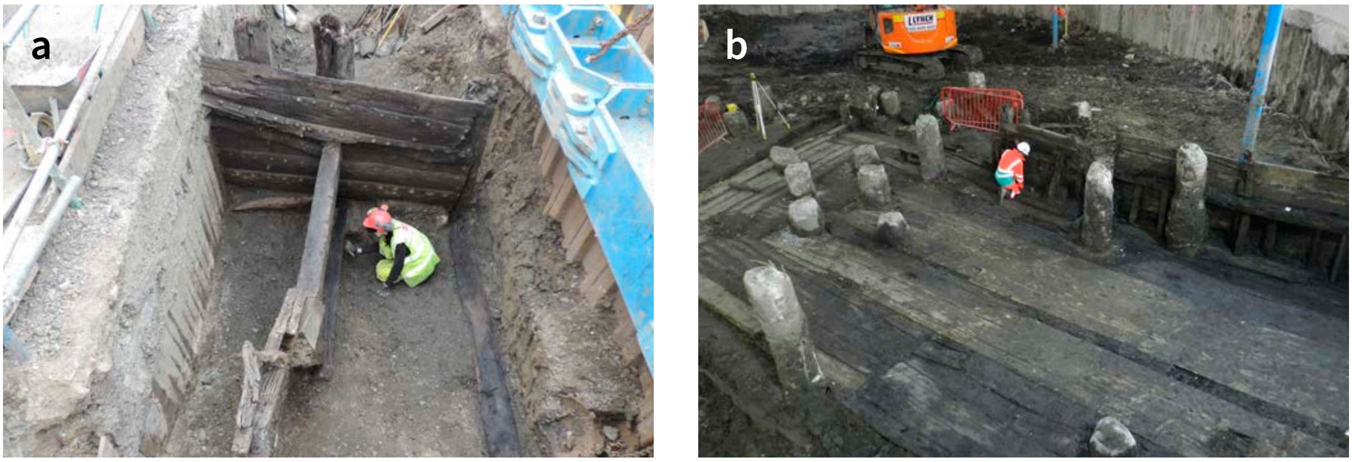


Figure 26: Examples of ship timbers being reused.

26a: A revetment made from reused ship planking (AD 1274), Sugar Quay, London. © MOLA

26b: A 19th century dry dock made from reused barge timbers, Kirtling Street, London. © MOLA

A nautical archaeological specialist (as defined in CIfA's Standard and Guidance for Nautical Archaeological Recording and Reconstruction, 2020) should be engaged in any project where boat and ship remains are found. The nautical archaeologist should be involved in producing the WSI/PD, where ship or boat remains can reasonably be anticipated. They should contribute to excavation and recording methodologies, as well as sampling strategies for species identification and scientific dating from a specialist nautical point of view.

Wood recording sheets that reflect specific shipbuilding technology should be used to capture information on site prior to sampling or recovery. For example, a sheet designed for recording a medieval clinker-built vessel should be used where that type of ship is being excavated.

Sampling strategies should follow current guidance (Domínguez-Delmás et al. 2019), with most sampling being undertaken after the detailed post-excavation timber recording. Careful consideration needs to be given to any sampling of nautical timbers on site – for example, for dendrochronological dating. The full extent of the remains may not yet have been exposed or recorded, and later detailed recording could be jeopardised by the spot sample taken. Ship/boat remains are often excavated and recorded *in situ* without the intention to recover the timbers for post-excavation detailed recording especially in intertidal and underwater contexts. In these situations, an extensive sampling strategy which leads to the recovery of samples for species identification, forest management and scientific dating should be integrated into the WSI/PD. Sufficient samples should be recovered to enable characterisation and dating of the major groups of structural timbers encountered (e.g. ceiling planks, stringers, framing timbers, hull planking, knees and beams).

More generally and wherever possible, samples should be taken from areas that do not include fasteners or other technological information. Shaped timbers, whose curvature will be crucial to future reconstruction efforts, should not be sampled until recording has been completed. Dendrochronologists should be made aware of the potential need to return the samples for conservation alongside their parent timbers. They should be discouraged from freezing samples for surface preparation.

Where substantial boat or ship remains are not going to be preserved in their original location, plans should be made to recover the remains for detailed off-site recording in controlled conditions. Prior to that, a 3D record of the *in situ* remains should be produced. This needs to be of sufficient accuracy and resolution to show the spatial relationship between articulated timbers (or fragments thereof), and to identify each of them (through annotation).

6. Temporary storage and timescales

Temporary storage refers to storing unconserved waterlogged wood for a limited period – between the time it is recovered or removed from a site and the time it is conserved or deselected. Waterlogged wood should be analysed and submitted for conservation (or deselected) within 36 months, and sooner where possible.

Storage arrangements should be a key part of the project planning stage, agreed upon by the relevant conservator and lead wood specialist. A temporary storage plan should consider timescales for specialist work, continued monitoring and future purpose. If the wood is stored for too long, even in wet conditions, it will continue to degrade. Extended storage times will also increase storage costs. Figure 5 suggests the maximum timeframes for various tasks to be completed.

Waterlogged wood needs to be protected from extremes of temperature, so temporary storage facilities should be located within a suitable building. Freezing will damage the wood structure, while warm conditions will accelerate bacterial and fungal growth. The ideal storage conditions are those that keep the wood wet, dark and cold (cool).

Identification information should always be clearly visible, whatever the storage method, and it is essential to keep a precise and up-to-date record of where individual pieces are stored.

Standard methods of temporary storage:

- Wet storage: Fully submerged in water, in a tank, bucket or box, for example (Figures 27a, 27b).
- Cold storage: Placed in a cold storage unit at a temperature of 5 to 8°C to reduce decay by micro-organisms. Small items can be submerged in water and large items wrapped (wet packed).
- Wet-packed storage: If it is not possible to fully submerge items or place them in cold storage, they should be wrapped in well-soaked, absorbent material and polythene and then sealed (Figure 27c). They should be stored inside and kept as cool and dark as possible.

Figure 27: Storage examples.
27a: Temporary water tank, Must Farm, Cambridgeshire.
Image: Zoë Hazell © Historic England
27b: A piece of wood inside a box, fully submerged in water, with a floating piece of polythene on top to stop water evaporating or debris falling in (note that the plastic cover has been partially folded back for the photograph).
Image: Angela Middleton © Historic England
27c: A long barrel stave being wrapped in wet capillary matting first (left) and then in clear polythene (middle) to prevent evaporation of water. The parcel is then secured and held together with tape (right).
Image: Angela Middleton © Historic England

Wet storage is preferable to cold storage. Continued use of a cold store will increase costs due to high demands on electricity, plus it will not prevent the wood from drying out. Wet storage tanks should be kept dark to reduce algal growth; containers or tanks made of opaque materials with lids are recommended. Using such containers reduces the need for biocides, which can be a health hazard and may interfere with future analysis and conservation processes. Covering these containers will also reduce evaporation.

Sometimes, the size of a find will determine the storage option. For example, particularly large timbers may be too big, if kept whole, to be fully submerged in a tank, or placed in cold storage.

Whichever option is used, waterlogged wood in storage needs to be monitored to ensure that it stays wet and that the water is free of contaminants (debris, algae, microbiological activity). The potential for the development of Legionella needs to be recognised and a risk assessment should be prepared in advance, along with a regular programme of monitoring.

Water within containers and tanks may need to be changed regularly to minimise the build-up of fungi, bacteria and algae, or topped up to maintain the water level. Access to a water supply and a drain is, therefore, essential (bearing in mind relevant environmental legislation around the disposal of wastewater).

Timbers should be periodically checked for degradation during storage, to assess their potential for conservation or study. The time and costs associated with unwrapping and rewrapping timbers will need to be taken into account.

Timbers from a marine environment can be stored directly in fresh water. This will need to be changed frequently on the advice of the conservator, with chloride levels checked before the wood goes into conservation. The conservator may also recommend using corrosion inhibitors, which can be added to the storage tank for wood containing iron. These prevent the iron from deteriorating during storage, which otherwise may cause accelerated damage to the timbers.

Figure 28 (a to c) shows some examples of what can happen when wood is stored incorrectly.

Figure 28: Examples of poorly stored wood.

28a: The bubbles were facing the wood and air trapped between the bubbles has caused partial drying and superficial mould development on the wooden surface.
Image: Angela Middleton © Historic England

28b: Close up of mould and a mushroom fruit body growing on archaeological wood.
Image: Angela Middleton © Historic England

28c: Air trapped under the wrapping caused partial drying and development of mould (white/ grey deposit).
Image: Angela Middleton © Historic England

7. Post-excavation assessment and analysis

The post-excavation assessment is essential to ensure that a properly costed and timetabled programme of analysis and reporting is developed, typically as part of an updated project design (UPD).

7.1 Post-excavation assessment

This stage involves assessing the wood's state of preservation and significance to inform analysis, and the quality and character of the record generated during excavation.

All recorded wood should be quantified at the post-excavation assessment stage (which can't be completed until all the wood selected for assessment has been recorded).
The post-excavation assessment report should include:

- size of the assemblage (for example, number of items, approximate volume)
- methods used to record the wood remains
- state of preservation
- character and context of the assemblage
- a statement of potential
- recommendations of work needed for analysis and/or publication
- a conservation assessment (identifying possible conservation strategies)
- costings for the recommended work
- a proposed timetable of works

The report should highlight any variation in levels of recording or sampling that may affect subsequent analysis tasks.

7.1.1 State of preservation

At the post-excavation stage, the main reason for assessing the state of preservation is to inform recommendations for the analysis programme (*see* 7.2 Analysis). In most cases, a wood specialist will carry out a physical inspection and compile a report using an appropriate recording system (*see* 4.2 State of preservation, and Table 1 and Table 2). In addition, assessing the state of preservation of the wood (especially cellulose content) can help establish the potential for scientific dating.

The other reason for assessing the state of preservation at the post-excavation stage is to inform conservation decisions. For example, determining the cellulose content and identifying the presence of any inorganic salts are both critical for conservation strategies. It is also important to understand the internal condition of the wood, whether the wood is degraded uniformly throughout, or if the degradation is limited to the outer surfaces.

7.1.2 Statement of potential

The statement of potential should address the suitability of the assemblage for analysis of:

- woodworking evidence (the raw material selection, tools and techniques used in modifying wood)
- wood technology (the character and function of wooden products)
- woodland reconstruction, tree-ring studies and human–woodland relationships

7.1.3 Recommendations for work

Recommendations for work should clearly list how many items require illustrating, photographing or 3D modelling, and which samples should be selected for identification and/or tree-ring studies. Selection for the latter may depend on the project's research questions and the wider environmental sampling strategy.

Recommendations should state which items have potential for scientific dating (ring-width, oxygen isotope and blue intensity dendrochronology, and radiocarbon dating) and which items should be considered for conservation, based on advice from the relevant specialists. The report recommendations should also make clear where further work is required, for example, which aspects of the dataset need further analysis and reporting. The recommendations should correspond to the points made in the statement of potential about any aspects (or the whole) of the assemblage.

Depending on the project requirements, assessment reports relating to different wood specialisms (*see* 2.6 Specialisms) may also be produced at this stage.

7.1.4 Scientific dating

A review of the dating potential of the assemblage needs to consider how the samples taken during fieldwork and any retained wood assemblage relate to structural groups and stratigraphic phases. Other dating evidence (from ceramic assemblages and coins, for example) should also be considered. There may be spot-dating results available from initial analyses during the evaluation or excavation phases.

Dendrochronology (ring width, oxygen isotope and blue intensity): Usually, the lead wood specialist will assess the material for its dendrochronological dating potential in consultation with the project dendrochronologist. They will consider the wood taxa, approximate ring count and presence of sapwood and/or bark edge (English Heritage 1998). Oak is the most commonly used wood type for dendrochronology. However, the development of oxygen isotope and blue intensity dendrochronology has increased the likelihood of being able to date non-oak timber (Loader et al. 2021; Bridge et al. 2019) (*see* New horizons in scientific dating of waterlogged wood). Where significant amounts of other species occur (for example, conifers, beech, elm and ash), these should also be considered.

Where a timber is destined to be conserved and put on display, and a sample is taken for scientific dating, the dendrochronologist should be encouraged to keep the sample in good condition (e.g. through refrigeration within its sample bag rather than by freezing) and return it as soon as possible. Ideally the sample should be conserved alongside its parent timber (Figure 29).

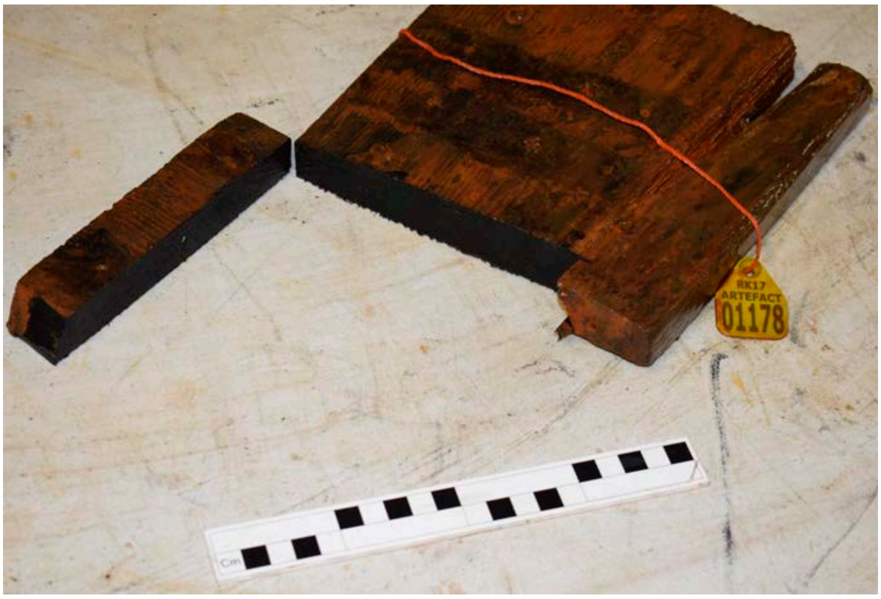


Figure 29: Wooden chest fragment from the Rooswijk wreck (sank in 1740), with the dendro slice next to it. Image: Alex Bliss © Rooswijk1740

Radiocarbon dating: Where limited or no material is suitable for dendrochronological dating or where the dendrochronological analysis has been unsuccessful, radiocarbon dating should be considered. Multiple samples from a piece of wood (in which the time interval between samples from single annual rings and the bark edge is known) can be used for wiggle-match radiocarbon dating. Such sampling should be undertaken by a competent dendrochronologist or wood identification specialist, with advice from the radiocarbon specialist. They will need to identify the most appropriate number of sub-samples and their location in the ring series. Samples from identified species, taken from near the bark edge of immature roundwood, are best for individual radiocarbon dates. Wiggle-matching can, however, be effectively undertaken on roundwood samples where precise dating is required.

It is best to seek advice on sample size directly from the dating laboratory, because sample size depends on the state of preservation of the wood (and its water content). If the wood is in a particularly poor state, it may not contain sufficient celluloses for dating. Weights of 100 to 150 mg of waterlogged wood should be ample for radiocarbon dating by accelerator mass spectrometry (AMS). This means that individual rings, often as a series of rings of known annual spacing, can be sampled and dated.

Information on radiocarbon dating and chronological modelling can be found in Bayliss and Marshall (2022) Radiocarbon Dating and Chronological Modelling: Guidelines and Best Practice (*see* section 5.6 therein for more detail on wiggle-matching).

New horizons in the scientific dating of waterlogged wood

If the outer surface of a tree survives, ring-width dendrochronology can be used to precisely date the felling of that timber to the year, or even season. Usually, several timbers with more than 50 rings are required, and only certain species (principally oak, but other species such as pine) can be dated (English Heritage 1998). Oxygen isotope dendrochronology matches the pattern of stable oxygen isotopes in tree-rings to a known-age master sequence. A wider range of wood species may be datable using this technique, as may trees that have growth patterns that are unsuitable for ring-width analysis. At present, the oxygen isotope reference curve for southern England extends to AD 1200, but research is underway to extend this into the prehistoric period (Loader et al. 2019). Blue intensity dendrochronology measures the relative density of wood using the intensity of light reflectance of a tree-ring as a proxy of mean cell wall thickness in the latewood of conifer species, allowing comparison to known-age reference series. It has been used for dating conifer timbers in the historic period and has the potential for use on a wider range of wood species. However, the method is in the early stages of development and the network of reference data is currently relatively sparse (Wilson *et al.* 2017).

Sequences of tree-rings of known annual separation can be wiggle-matched to the radiocarbon calibration curve, supporting tentative dates provided by dendrochronology or giving independent dating evidence. Single-year radiocarbon calibration means that much shorter sequences of tree-rings can be pattern matched to within a few decades (including, in favourable circumstances, those with only about 10 growth rings). Single-year calibration is currently available for the past thousand years and the late glacial period, although research to extend this is ongoing (Heaton et al. 2024) and it should soon be available for the last ~4000 years. When selecting samples for dating (particularly for Pathway 1), this potential for dating much shorter sequences of tree rings than can be achieved with dendrochronology alone needs to be considered.

The continued development of these techniques will be aided by the retention of wood samples for future research (for suggested methods see 8.1.4 Controlled air-drying).

7.1.5 Conservation recommendations

Selecting wood for conservation should be discussed and agreed by the wood specialist(s), project manager, local authority archaeologist, receiving museum/archive, conservator and project funder. Generally, the wood specialist and conservator will make recommendations within the post-excavation assessment report. The rationale for selecting wood for conservation and archiving should be guided by the principles and values set out in Section 4.1 Significance.

All wood selected should be submitted within 36 months of excavation, with some items (such as fragile wooden artefacts) requiring fast-track submission.

Selection criteria include:

- Date of the material: Very few examples of Palaeolithic, Mesolithic or Neolithic worked wood are encountered and, as such, they are likely to be of high significance.
- Rarity and comparators: Is the waterlogged wood a rare example of its kind nationally? Are there only a few conserved examples?
- Complexity and character of the woodworking: Representative examples of artefacts and jointed, decorated or deliberately marked material should be considered for conservation (Figure 30).

Figure 30: Wooden trough preserving toolmarks from manufacture and from the cutting of a hole in the base, Must Farm, Cambridgeshire. © Cambridge Archaeological Unit

The conservation assessment should provide sufficient information about the waterlogged wood to understand the requirements for a conservation treatment and the future purpose (storage and/or display). From the conservation proposal (method statement), the likely timescales and a breakdown of costs can be determined. The assessment should clearly state the aim i.e. result in a stable material suitable for deposition according to the repository's specific deposition guidelines.

More specifically, the assessment should include a quantification, ideally listing the respective identification numbers, measurements, wood identification (if known) and elaborate on other materials present, such as metal components or other materials associated with the waterlogged wood, such as paint or tar for example. The facility undertaking the work, and the personnel involved need to be named.

The state of preservation of the waterlogged wood should be explained, making references to the methodology employed as well as stating whether the assessment was made across the whole or only part of the assemblage/object.

In situations where a decision on selection has not been finalised yet, the conservator may be asked to provide costed options for the conservation of the whole and/or part of the assemblage. They may also be asked to provide quotes to make the archaeological wood fit for display (e.g. mounts, infills, etc.). It should be noted that packaging for larger objects can add to the overall costs and that conservation facilities and repositories are not always close to each other, therefore transport costs need to be considered at this stage.

7.1.6 Timetabling

A proposed timetable of works should be made at this point so the project management team knows what to expect in terms of scheduling specialist work.

7.2 Analysis

A programme of analysis will have been identified, quantified and costed during the post-excavation assessment. Primary tasks relating to waterlogged wood include:

- completing the graphical recording
- analytical tasks, such as tree-ring studies, dendrochronology and species identification
- data analysis
- producing specialist reports

By this point, the site's interpretation and phasing should be more refined. This knowledge should be shared with the specialists to help them contextualise their results.

The following sections set out waterlogged wood analysis activities that are not described in detail in other guidelines or covered by standard post-excavation practices.

7.2.1 Graphical recording (illustration, photography and 3D modelling)

As much graphical recording as possible should take place during the main recording stage of the project (*see* Section 5 Methods of excavation, recording and sampling), when the state of preservation is optimal. Any need for further recording during the analysis phase should be identified in the post-excavation assessment report. Graphical recording can include drawing, photography and 3D modelling. In all cases, annotating the images will help produce a clear visual record.

The level of detail required in drawings will have been determined during the assessment phase (*see* Allen 1994), depending on the character of the woodworking present. Drawings will need to be carried out by an illustrator who has experience of handling and depicting archaeological wood, and who understands tool and raw material use.

Technical drawing (edge and face drawing) is appropriate to record the form of converted timbers and the location of joints or pegs. Technical drawings should:

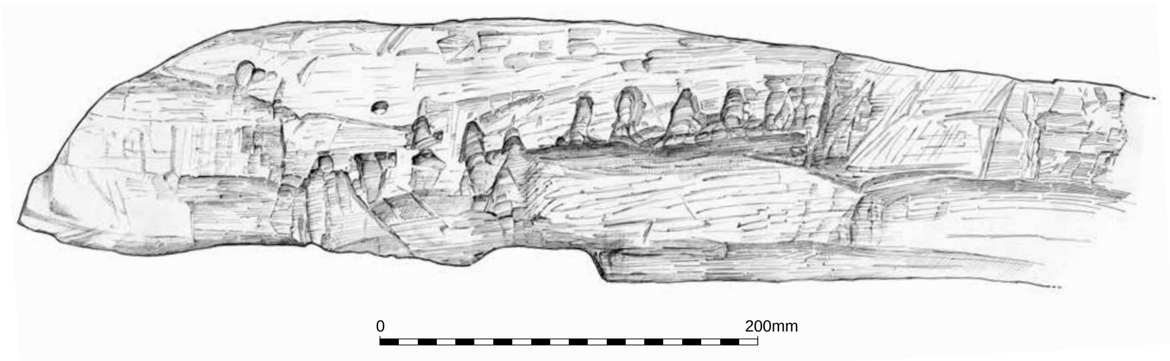
- record the timber's dimensions
- give an indication of the direction of the grain
- include at least one cross-section. Cross-sections should show the pith, sapwood and ray or ring patterns where visible.

Detailed illustration (employing lines or shading to convey 3D shape) is appropriate to record artefacts, complex joinery or unusual morphology (Figures 31a, 31b). Detailed illustrations should record:

- grain and growth features
- areas of bark, sapwood and exposed heartwood
- areas of decay, damage (ancient and modern), wear and compression
- the position and character of joints, holes, nails and toolmarks

The scale of the drawings will vary according to the size of the piece, from 1:1 to 1:20.

Scaled photography can complement drawing in the archival record and provide useful images for publication and dissemination. Additionally, the potential to document use-a



b

Figure 31: Detailed illustration of the Boxford Timber.

31a: Illustration of the Boxford timber by J Dobie. © Historic England

31b: Showing illustrator Judith Dobie at work, drawing the Boxford timber. © Historic England

wear, joints and toolmarks through detailed images is particularly valuable. Waterlogged wood can be a challenging material to photograph, and an experienced photographer will be needed. The use of raking light and/or wet surfaces can help highlight details. In the case of toolmarks, scale bars should be placed parallel to the ‘stop marks’ so that the width of the toolmarks is clearly recorded.

3D modelling is a complementary form of recording. It is not a direct replacement for illustration, because subtle details such as wood grain cannot be represented. Current digital recording methods (*see* 3D recording) include laser scanning, reflectance transformation imaging (RTI) and photogrammetric recording, which can record use-wear or toolmarks in fine detail. These different methods have varying benefits and cost/time implications.

3D recording

3D recording is a very powerful visualisation tool, and it is increasingly used on waterlogged archaeological material for a variety of purposes:

- **Recording *in situ* remains: Provides an enhanced record of remains still in the ground, in addition to standard recording methodologies. It is particularly valuable for complex or jointed structures. For example, see Cotswold Archaeology's Structure from Motion (SfM) model of a medieval bridge near Tewksbury, Gloucestershire, or CAU's work at Must Farm in Cambridgeshire.**

- **Recording individual artefacts: For example, the Tetney axe found at Tetney, Lincolnshire (Figure 32), and the wooden bucket base from Must Farm.**

- **Recording subtle surface detail:** For example, working marks, decoration and inscriptions. See the use-wear analysis of material from Must Farm (Xhauflair *et al*. 2024).

- **Producing digital reconstructions:** To virtually refit remains that may not have been recorded and/or recovered as a whole: for example, the Tetney log coffin (see Bamforth, forthcoming).

- **Creating replicas and/or scale models:** For example, through 3D printing, for dissemination and outreach. These may be used in displays and as part of handling collections: for example, the Newport Ship (Jones 2015, figure 150).

Figure 32: A 2D image taken from the 3D model of the Tetney Axe, Lincolnshire.
Image: Jon Bedford © Historic England

It is important to remember that using 3D recording has implications for the size of the digital archive, and the associated costs. Furthermore, methods and techniques will constantly develop and evolve over time. An overview of some of the methods of 2D and 3D recording techniques for timbers, and an assessment of 3D annotated scans, is provided by Van Damme *et al.* (2020).

Table 3: Possible methods for producing 3D models of waterlogged deposits and artefacts.

Technique	Brief description, notes	Possible applications		Example
		In situ	Artefacts	
Structure from Motion (SfM)	Series of overlapping photographs	✓	✓	Cotswold Archaeology 2018
Reflectance transformation imaging (RTI)	For low relief traces		✓	Kipling and Beamish 2018
Structured light scanning (SLS)	Projecting patterned light onto a surface		✓	
Laser scanning	Using lasers to record surface form	✓	✓	Lobb *et al*. 2010, 2020
FaroArm®	Portable coordinate measuring machine (CMM)		✓	Jones 2015
Light detection and ranging (lidar)	Using light beams to determine surface topographies. Capability available on some smart phones and tablets	✓	✓	
Micro Computed Tomography (µ-CT) scanning	High resolution X-rays, taken as a series of multiple 'slices'. For use post-conservation.		✓	Rankin *et al*. 2021

Advice and guidance can be found here:

- Surveying and Recording Heritage (Historic England 2021)
- Photogrammetric Applications for Cultural Heritage: Guidance for Good Practice (Historic England 2017)
- Multi-light Imaging: Highlight-Reflectance Transformation Imaging (H-RTI) for Cultural Heritage (Historic England 2018)
- 3D Laser Scanning for Heritage: Advice and guidance on the use of laser scanning in archaeology and architecture (Historic England 2018)

7.2.2 Woodworking and wood technology

Woodworking is a reductive technology, with wood removed from the raw material to produce the desired finished object. In the broadest sense, worked wood consists of finished products (artefacts, structural timbers, stakes) and woodworking waste (woodchips, shavings, off-cuts). Marks left on the surface of the wood are analysed to determine the tools, techniques and technologies used.

Recording often includes, but is not limited to:

- primary conversion (whether the item is in the round – largely unmodified – or its cross-section has been reduced or modified)
- tools used in conversion (such as wedges for splitting, axes for hewing, and saws)
- working to the ends (tool faceting from axes or flat surfaces from sawing)
- cutting of joints
- surface modifications or decoration (such as incised marks or paint)

Ship and boat timbers may retain surface treatments, such as tars and paints, which can be examined analytically. Waterproofing between timbers (caulking/luting) often comprises a matrix (such as tar) and a component filler (such as animal hair, moss, plant remains, textiles), and analysis will require an appropriate range of specialist input. Pollen analysis of caulking material can provide supplementary evidence of plant types used and vegetation sources.

Analytical techniques specific to waterlogged organic artefacts are described in Historic England's Waterlogged Organic Artefacts: Guidelines on their Recovery, Analysis and Conservation (2018).

7.2.3 Wood studies

Microscopic/laboratory-based analysis for species identification, ring-width studies and dendrochronology should be interpreted alongside the data on the gross morphology of the wood and the presence of natural features (such as side branches) collected during the main recording stage. This information can provide valuable insights into the woodland environment, the resources being exploited or managed, and the wood selection strategies employed.

Ideally, every piece of worked wood should undergo a species identification, but for particularly large assemblages this may not be necessary or practicable. Discussions should be held with the wood specialist(s), who will consider the contextual information available and the potential of the remains to provide insight into specific use/selection/woodland practices. For grouped deposits of woodworking waste or small roundwood, a more selective sample can be taken. This should be done on a random basis to avoid over-representation of the larger or better preserved pieces.

7.2.4 Timetabling

For some types of analyses, there are clear sequences to the work that need to be respected. Lead times will need to be factored into the project's programming, in discussion with the specialists and according to their availability (*see* Figure 5).

7.2.5 Final reporting and publication

The final project report, also known as the archive report, should include:

- quantification of the wood assemblage (as set out in the post-excavation assessment report)
- methodologies undertaken throughout the project (recording, assessment and analysis)
- results of analysis tasks
- discussion section, integrating results of analysis tasks with phasing and site interpretation
- selection and retention strategy, and record of decisions taken for the archaeological archive

Guidelines on producing specialist reports are available. For general guidance, see CIfA's (2020b) Standard and Guidance for the Collection, Documentation, Conservation and Research of Archaeological Materials and the CIfA Toolkit for Specialist Reporting. For subject-specific guidance, see, for example Dendrochronology: Guidelines on Producing and Interpreting Dendrochronological Dates for guidance on producing a dendrochronology report.

It is likely that other publications (such as monographs and journal articles) will also be produced as part of the project. These should include details of the excavation, wood sampling strategy, investigative/analytical/conservation methods and specialist results.

7.3 Options for disposal

Depending on the size and importance of the site and its assemblage, not all of the waterlogged wood that formed part of the working project archive will (or should) be selected for inclusion in the preserved archive. Throughout the project, the ongoing selection strategy process will have considered and documented what is to be kept and what is to be deselected – based on discussions with the project stakeholders and specialists and informed by relevant guidance (e.g. EAC 2021 Guidance on Selection in Archaeological Archiving).

There are several options for dispersing the unconserved waterlogged wood that is not selected as part of the preserved archive, which will probably include:

- donation/reuse, where the wood can be used for research or for training/teaching as experimental/practice material

- discarding, where the material is suitably disposed of, usually as part of routine waste collection procedures

For waterlogged wood that has been recorded using Pathway 1 (*in situ*) and never recovered from site, the reburial and maintenance of that material in its initial location is, by default, a form of disposal. This is because without specific mechanisms for management and monitoring to ensure the long-term preservation of the wood (as set out in Historic England's (2016) Preserving Archaeological Remains: Decision-taking for Sites Under Development) it is likely to degrade and result in the loss of any remaining information.

8. Conservation

The aim of any conservation treatment is to preserve waterlogged wood in a stable condition that allows it to be curated, studied or displayed. This involves replacing water with a chemical and drying in a controlled manner, so that the overall shape and dimensions are retained. The methods used will influence the appearance of the wood after treatment.

A suitably experienced and accredited conservator is needed to select and implement wood conservation treatments. The Institute of Conservation (Icon) accredits and regulates conservators who meet defined standards of professional practice in the UK. The Conservation Register is a register of privately practising Accredited conservators.

The choice of treatment will be determined by the size of the wood, availability of equipment, budget and timescale. The immediate future use (storage or display with realistic environmental conditions) may also influence the conservation treatment.

Before conservation is initiated, all recording, sampling (for example, for species identification) and analysis should have been completed. Any wood selected for conservation should be submitted within 36 months of excavation, with items of high significance (such as artefacts) considered for fast-track submission.

Sometimes, extra evidence may be revealed during the conservation processes themselves, such as surviving small areas of pigments that are not visible on wet wood surfaces. Any such new information should be shared with the post-excavation team.

8.1 Conservation techniques

8.1.1 Cleaning and pre-treatment

Further surface cleaning may be necessary before the conservation treatment can begin (Figures 33a, 33b). Just like on site, care must be taken not to damage the soft wood surface. Any new observations of toolmarks, decoration or construction need to be shared with the relevant specialist. Timbers from marine environments should go through desalination by changing the water regularly. Removing soluble salts will reduce the potential for salt efflorescence damage post-drying, such as surface spalling, and allow for improved impregnation (*see* 8.1.2 Impregnation).

Some timbers, especially those from marine environments, may be contaminated with iron salts from iron fittings or nearby artefacts and ship structures (Figures 34a, 34b). This may accelerate the rate of decay. Anaerobic bacteria contribute to the presence of iron sulphides within wood structures by breaking down abundant iron minerals in the soil and utilising sulphur from decaying vegetation. The resultant compounds in archaeological wood are unstable in the presence of oxygen and release sulphuric acid, which breaks down wood.

Removing or neutralising these compounds involves various chemical treatments, which are used to limit post-conservation degradation.

Figure 33: Examples of cleaning during conservation.
33a: A conservator carefully cleaning the surface of a Mary Rose timber using a soft brush and water.
© Mary Rose Trust
33b: Using an air cleaner to gently clean the surface of a section of linstock.
Image: Zoë Hazell © Historic England

Figure 34: Examples of mineral deposits on waterlogged artefacts.
34a: Iron sulphides formed around a former iron fixing hole within a timber from the Mary Rose. Formed by the presence of iron ions from corroding fixings and sulphur from the sea. © Mary Rose Trust
34b: A wooden chest panel, recovered from the Rooswijk wreck (sank in 1740), showing iron contamination and two empty holes where an iron handle would have been attached. Image: Nicole Schoute © Rooswijk1740

8.1.2 Impregnation

Currently, impregnation is the favoured method of conservation. Water within the weakened wood cells is replaced with a chemical to provide structural support for when the wood is dry. Polyethylene glycol (PEG), both a bulking and impregnation agent, is the most commonly used material. It can be applied either by immersing the wood in a tank or by spraying (Figures 35a to 35c). Depending on the application method, treatments can take months (immersion) to years (spraying).

Recently, the high prices and poor availability of PEG have not only increased overall conservation costs and prolonged treatment schedules but also raised the need to develop alternative methods of conservation.

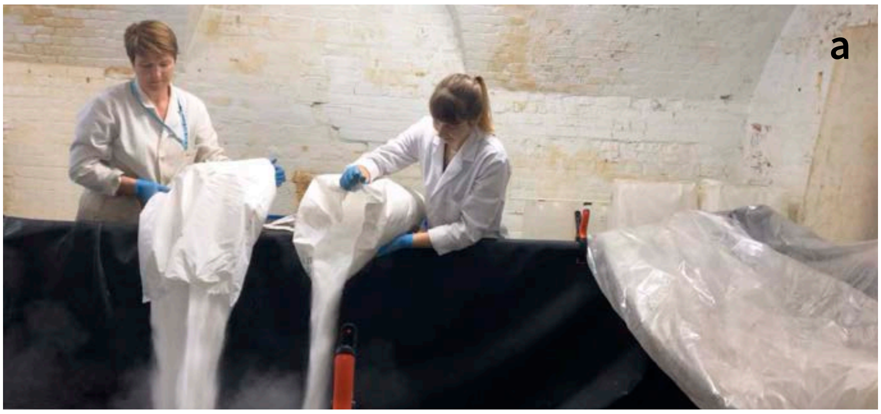


Figure 35: Stages of the PEG application and impregnation process.

35a: Two conservators adding high molecular PEG to a tank for impregnation.
Image: Angela Middleton
© Historic England

35b: Mixing PEG 4000 flakes within a PEG:water solution to increase the concentration.
© Mary Rose Trust

35c: Mary Rose timbers placed on shelving within a tank of water ready for the addition of PEG.
© Mary Rose Trust

8.1.3 Vacuum freeze-drying

Vacuum freeze-drying (Figures 36a, 36b) is the preferred method of drying waterlogged wood that has been treated by impregnation. It is a controlled process that works by the sublimation of water (when its physical state changes directly from a solid (ice) to a gas (water vapour)). It avoids drying by evaporation and the surface tension issues caused by this method. Wood that has been vacuum freeze-dried will usually retain its natural colour and surface details, with reduced shrinkage and surface cracking.

The main limitations of vacuum freeze-drying relate to the size of wood that can fit in a chamber. Larger structures may need to be dismantled or cut into sections. There are only a few conservation facilities in the UK with freeze-dryers capable of drying large timbers. Freeze-drying equipment uses a lot of energy, and costs for long drying processes will rise as energy prices increase.

Figure 36: Stages of the freeze-drying process.

36a: Large freeze dryer with Mary Rose timbers that have been dried post PEG treatment.
© Mary Rose Trust

36b: Timbers from the Newport ship at the end of the freeze drying process.
© Newport Ship and Mary Rose

8.1.4 Controlled air-drying

This method is usually only considered for timbers or structures that are too large for a vacuum freeze-dryer and cannot be dismantled (Figure 37). Controlled air-drying is a high-risk approach for large material. It can result in significant warping, shrinkage and cracking of timbers.

Controlled air-drying methods generally use dehumidifiers to control the drying rate. To fully control the drying environment, treatment tents can be sized according to the specific wooden structure, as seen with the Mary Rose.

Drying by this method can take several years, and it requires careful monitoring throughout. Tell-tale crack monitoring gauges and 'total stations' can be used to track structural movements and crack development.

Wood samples selected for long-term archiving for scientific purposes (for example, to extend oxygen isotope dendrochronology beyond the reach of existing reference data) may be slowly air-dried without prior impregnation. Valuable sapwood is likely to be lost through this process, and poorly preserved samples may disintegrate. Therefore, the ring-width series of any surviving sapwood and the presence of bark need to be recorded prior to drying. Alternatively, smaller specimens may be vacuum-packed to enable a representative selection of material to be retained.

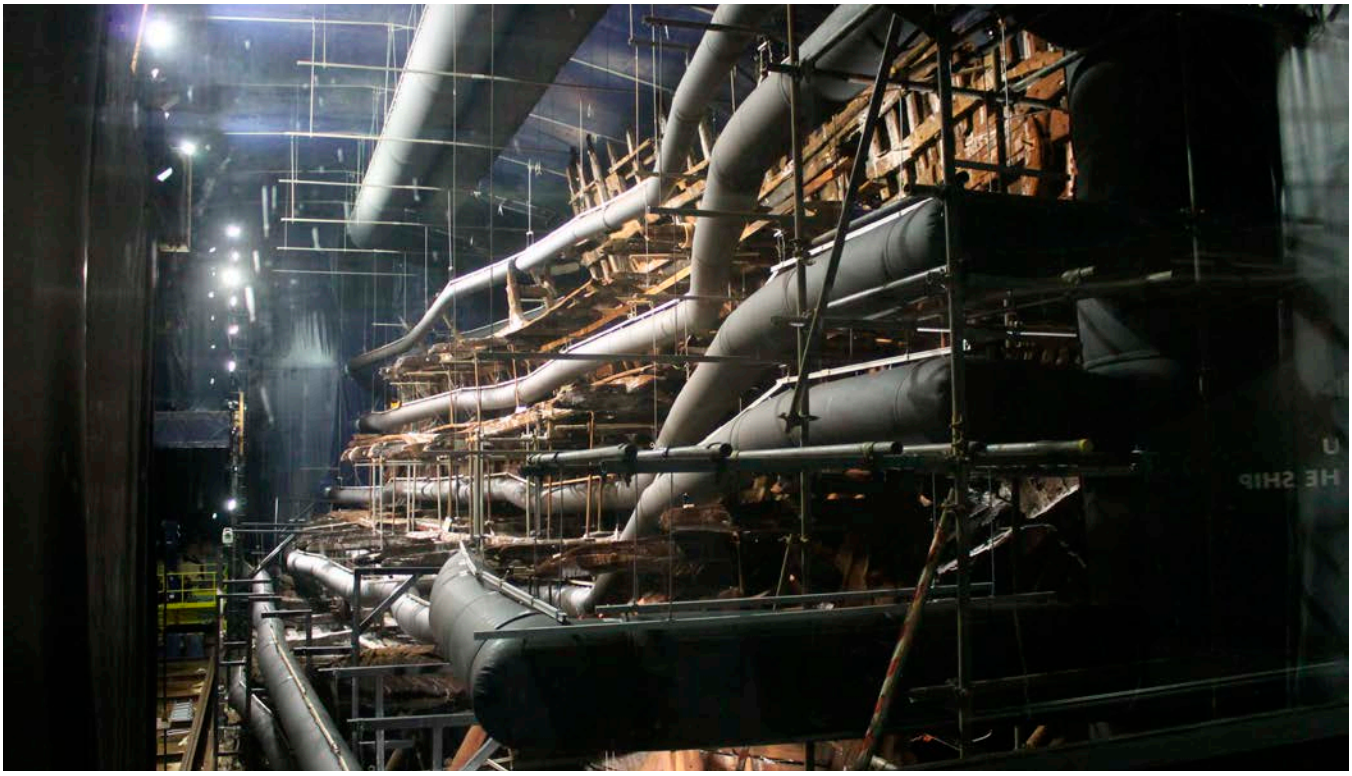


Figure 37. Ducting suppling conditioned air to all parts of the remains of the hull of the Mary Rose during the air drying process. © Mary Rose Trust

9. Archiving and curation

It is essential that the conservator and collecting institution are involved at the earliest opportunity in projects that may generate collections of archaeological wood that merit conservation, display or archiving. This ensures that time and money can be anticipated and made available. Early conversations and planning will help reduce temporary storage requirements.

The conservator will be able to advise on conservation options, storage and display requirements depending on the size and state of preservation of the assemblage.

The wood itself is an obvious element of the preserved archive, but it is important to remember that all drawings/illustrations, original recording sheets, photographs and data (for example, specialist data in spreadsheets and associated metadata) also form part of the archive. The DMP's selection and preservation section should be used to effectively plan the creation of the preserved archive, which will need to be quantified and costed for deposition.

There may be multiple reports produced throughout the project, and they will need to be considered as part of the selection strategy – with a view to being deposited in the project archive. Such documents may include the post-excavation assessment report, wood specialist reports, conservation report and final project report. The project's digital archaeological archive should be deposited with a trusted digital repository. In England, this is usually with the Archaeology Data Service (ADS), which has CoreTrustSeal status.

Signposting: As part of the online process of registering and recording the excavation through OASISV, the location of where the physical archive will be deposited is stated. Once the excavation entry is created, the local Historic Environment Records will automatically be notified.

9.1 Storage and display

Continued care needs to be taken when handling and moving conserved archaeological wood, as some timbers remain fragile and heavy.

Once conserved, archaeological wood needs to be kept in stable conditions (for example, as set out in BS EN 16893:2018 Conservation of Cultural Heritage. Specifications for Location, Construction and Modification of Buildings or Rooms Intended for the Storage or Use of Heritage Collections), so that it is not exposed to extremes or fluctuations of temperature and humidity.

In general, large environmental fluctuations over a short period (day–night cycles) should be avoided, and the aim should be to maintain a consistent environment. Environmental conditions should factor in the conservation treatment used and the effects of temperature and relative humidity on it. Stable values in the range of 40 to 60 per cent relative humidity and 16 to 23°C, with fluctuations of no more than ±10 per cent relative humidity per 24 hours, are recommended for display and storage (British Standards Institution 2017, Bizot Group 2023). Relative humidity greater than 65 per cent should be avoided, as this will encourage mould development and efflorescence of soluble salts.

Wood is classed as being ‘moderately sensitive’ to light, and 200 lux values are recommended (with an annual light exposure maximum of 450,000 lux hours) (Museums Galleries Scotland 2009).

For long-term storage, depending on the size of the timber, the wood can either be packaged using materials that allow for air exchange or be covered over in open storage (*see* Figures 38a to 38d). A framework can be built around the timber (Figures 38c, 38d), over which the covering material is hung. Either way, functional textiles (such as spunbonded high-density polyethylene (HDPE) or a polyester-polyether membrane) should be used. These will protect against water ingress while allowing the timber to breath. Cotton or linen fabric covers should be avoided because these materials are hygroscopic and can hold moisture on or next to the object. They are also susceptible to mould and insect infestations.

Cushioning materials are recommended to protect vulnerable wood surfaces, support fragile pieces and minimise the effects of a fluctuating environment.

Figure 38: Examples of packing objects, large and small.

38a: Plastazote® (low-density polyethylene foam) has been cut out using a thermal cutter.
Image: Angela Middleton © Historic England

38b: The Plastazote® support has been lined with soft Japanese tissue to accept small wooden artefacts, which have been individually labelled with archival tape and Tyvek® (flashspun high-density polyethylene fibres).
Image: Angela Middleton © Historic England

38c: A custom-built, foam lined box for a wooden gun carriage, with support feet enabling transport by pallet truck.
Image: Angela Middleton © Historic England

38d: A wooden gun carriage inside its custom-built box, with foam supports and padding as well as wooden cross bars.
Image: Angela Middleton © Historic England

10. Where to get advice

- Historic England science advisors offer independent, non-commercial advice. Based in the Historic England local offices, they are often able to provide a list of specialists/organisations with appropriate expertise and skills. For contact details, see historicengland.org.uk/scienceadvice
- Local authority planning archaeologists can be contacted via the ALGAO website algao.org.uk/algao-uk/orgs
- Local finds liaison officers (part of the Portable Antiquities Scheme) can be contacted via finds.org.uk/contacts

Historic England guidance

- Preserving Archaeological Remains Decision-taking for Sites under Development (2016)
- Waterlogged Organic Artefacts: Guidelines on their Recovery, Analysis and Conservation (2018)
- Water Features in Historic Settings: A Guide to Archaeological and Palaeoenvironmental Investigations (2018)
- Peatlands and the Historic Environment: An Introduction to their Cultural and Heritage Value (2024)

The Charcoal and Wood Workgroup collates useful publications and information on recording archaeological wood and understanding its uses. Details can be found at historicengland.org.uk/research/current/heritage-science/charcoal-wood-work-group/

CIfA standards and guidance can be found at archaeologists.net/codes/cifa. Relevant documents include:

- Standard for archaeological field evaluation
- Universal guidance for archaeological field evaluation
- Standard for archaeological excavation
- Universal guidance for archaeological excavation
- Standard and guidance for the collection, documentation, conservation and research of archaeological materials
- Standard and guidance for the creation, compilation, transfer and deposition of archaeological archives

For more advice on dealing with waterlogged remains – including lifting, labelling, sampling and packing – see First Aid for Finds.

The Institute of Conservation (Icon) maintains a directory of privately practising accredited conservators who are required to work to the professional standards set out by Icon. The directory is free to use and it is possible to search for a conservator by services, specialism and location – see the Find a Conservator directory.

11. References

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