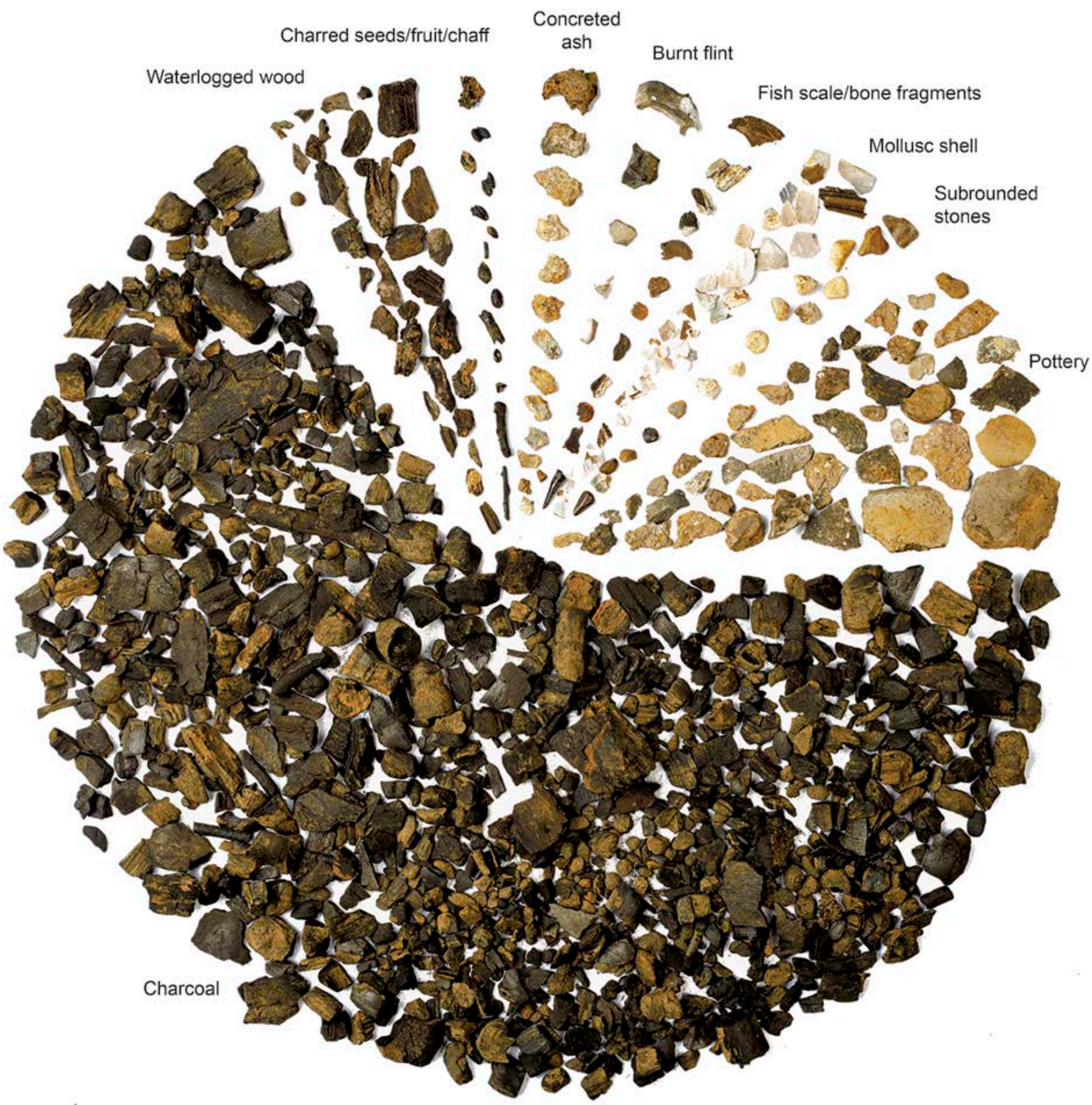
# Environmental Archaeology

A Guide to the Theory and Practice of Methods, from Sampling and Recovery to Post-excavation (third edition)



# Summary

This document, and its associated appendixes (Appendix 1 Case Studies and Appendix 2 Commonly Studied Biological Remains), provides guidance for good practice in environmental archaeology. It gives advice on the applications and methods used in environmental archaeology within archaeological projects, and how to plan those projects. It is a statement of best practice for all project stakeholders and is intended to support the advice given by specialists.

This document provides guidance to:

- those who advise local planning authorities (curators);
- those who write specifications or written schemes of investigation (advisors, curators, project managers, consultants);
- those working on both development-led or research projects, in both fieldwork and post-excavation contexts (practitioners).

The guidelines cover:

- an introduction to environmental archaeology;
- good practice for environmental archaeology within project planning;
- preservation and recovery of environmental evidence;
- processing, reporting and storage of biological remains.

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**Front cover:** Ecofacts and artefacts from a 5 litre sample, sieved to 4mm, taken from a conflagration layer at Must Farm (Knight et al. 2024, 34).

The supporting case studies provide advice on applying environmental archaeology to a range of archaeological projects, with complex or difficult to sample contexts. Appendix 2 provides overviews of a range of biological remains and their applications in archaeological projects. It is further supported by the range of existing guidance produced by Historic England (https://historicengland.org.uk/advice/technical-advice/archaeological-science/).

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# Contents

# 1. Context of this guidance

These guidelines have been produced by Historic England in consultation with archaeologists, curators and environmental specialists. Since 1990 government planning guidance in England, and in many other jurisdictions, has been based around the concept of providing reliable information to inform decision making (Darvill et al. 2019). Although government planning policy changes over time, it is likely that the principles of informed decision making will form the basis of development and planning control for the immediate future (Historic England 2022, 19–20).

Where projects are commissioned to inform the planning process in England, the current National Planning Policy Framework (NPPF) makes it clear that the information sought should be proportionate to the significance of the heritage asset and the impacts of the proposed development on this significance. The NPPF also states that the purpose of studying the historic environment is not merely to record heritage assets, but also to advance knowledge and understanding of them.

This guidance has been tailored for environmental archaeology as practised in temperate climates, such as those found in England. Different climates and burial environments will give rise to different preservation conditions and processes, leading to different specialist considerations. However, the staged, iterative approach to sampling and analysis advocated here is applicable to archaeological projects wherever they are undertaken (*see* Table 1). This approach to project planning adheres to the principles of Management of Research Projects in the Historic Environment (MoRPHE), which offers a framework through project management guides for the planning and implementation of applied research and development projects in the historic environment sector (Lee 2015).

Alterations to heritage assets of all sorts should consider the effect of change on elements of the archaeological record. For buried archaeological remains these alterations relate to any changes in the burial environment that may affect the preservation of the remains (Historic England 2016, 7). In the case of construction activity this can affect remains directly (through physical disturbance) or indirectly (such as altering local water tables in the vicinity of waterlogged remains). These alterations include work undertaken both within and outside the planning system, such as research by academic bodies and community groups or interventions by individuals. Landscape changes such as habitat restoration and forestry should also be considered activities that potentially impact on preserved archaeological remains. In some cases, environmental archaeology projects may need to be devised to mitigate alterations or loss of deposits containing palaeoenvironmental evidence.

Best practice in all of these cases should consider the nature of the buried remains, and the potential of these remains to add to the body of archaeological knowledge and our understanding of the past. It should also consider how alterations to the burial environments will impact their current and future significance, as well as their evidential value (English Heritage 2008; Historic England 2016, 10–16).

Table 1: Stages of project planning for environmental archaeology under MoRPHE with examples of activities at each stage.

| | |
|---|---|
| **Start-up** | • Consider the main purpose and drivers for the project<br>• How will environmental archaeology contribute to the project aims and objectives?<br>• What types of material are likely to survive?<br>• What types of material need to be recovered?<br>• Consult specialists for advice |
| **Initiation** | • Design specifics for the sampling strategy, including sample type, sample size, sample density, general types of context to be sampled<br>• Clearly define how sampling meets the aims and objectives of the project<br>• Clearly state what products will result (e.g. reports, databases, tables, illustrations) |
| **Execution** | • Collect samples, review sampling strategy, adapt sampling strategy in consultation with specialist(s)<br>• Process samples for assessment<br>• Assess samples and report results<br>• Update project design<br>• Undertake analysis<br>• Produce report(s) and any other dissemination products<br>• Deposit material and archive reports, databases, etc., with site archive |
| **Closure** | • Review achievements and lessons learned |

When planning archaeological projects, full use should be made of a range of sources of information on environmental archaeology potential (outlined in section 3, below). Environmental evidence is present in some form on all archaeological sites. Thus, the recovery and study of such material should be an integrated part of the initial project specification. It should not be added on as an unplanned-for contingency or be uncosted.

These guidelines and associated appendices are intended to promote and advocate current best practice in environmental archaeology in England. Carefully considered new approaches are to be encouraged; however, novel methods should achieve a level of consistency with both accepted published methodologies and with the general practice of the specialist community. This consistency is based on the experience of the wider profession, ongoing research and acknowledgement of new research questions. Departures from accepted best practice need to be justified and their impact on the interpretation of results explained in advance of project initiation.

This guidance highlights the importance of specialist input into all stages of archaeological projects, but also encourages all those engaging with the historic environment to consider their own experience and expertise when presenting or processing information. An aim of this guidance is to help archaeologists use their knowledge, and information from a range of sources, to better articulate the significance of the archaeological resource as a whole.

Early engagement between different project stakeholders has significant potential to improve the efficiency and effectiveness of outcomes of archaeological projects. Good-quality discussion as early as possible when planning a project that might impact heritage assets enables better coordination of resources and improved outcomes. These outcomes include the whole project cycle from initiation to archiving. In the case of archiving, it is recommended that this is considered at the point of project initiation and considered within the framework of the Selection Toolkit jointly created by the Chartered Institute for Archaeologists (CIfA) and Historic England (CIfA and Historic England 2022).

Getting specialist advice as early as possible is a key part of the pre-fieldwork preparation process. It is good practice for project managers to be in general contact with specialists for the most commonly encountered biological remains from the projects they undertake. In England this would typically mean specialists in zooarchaeology, archaeobotany and geoarchaeology.

Additionally, advice can be sought from the Historic England Science Advisors. The Science Advisors are available to provide independent advice on environmental archaeology and other aspects of archaeological science to anyone involved in archaeological investigations. They are based in the Historic England offices and contact details can be found on the Historic England web pages.

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Figures 1a-1f (below): the landscapes of England can show great variation across relatively short distances. This variation can include differences in topography, preservation conditions, and evidence for different geological periods of landscape formation and change. Within these landscapes the evidence for human activity and human interaction with the environment can be preserved. Devising an effective sampling strategy relies on understanding what biological remains can tell us about human activity, where such evidence is preserved, and how it can be effectively recovered.

**Figure 1a:** Hornsea Mere, a freshwater lake in the low lying, coastal plain of the East Riding of Yorkshire, the last of the post-glacial lakes on the Holderness peninsula to remain waterfilled. The Scheduled Monuments of Southorpe medieval settlement and a medieval moated site at Hall Garth Park are situated on its shores.

**Figure 1b:** The prehistoric mounds of Thornborough Henge, Yorkshire surrounded by multiple palaeochannels visible as crop marks. In many areas archaeological monuments can be in close association with natural features, which may preserve evidence of human activity.

**Figure 1c:** The glacial landscape of pingos at Stow Bedon Common, Norfolk. Though Pleistocene evidence can be deeply buried, in many areas evidence for older geological periods than the Holocene may be near or on the current ground surface.

**Figure 1d:** Peat cutting on Glastonbury Heath, Somerset. Deposits of high archaeological potential can also be the focus for extractive industries, leading to direct and indirect impacts on archaeological significance.

**Figure 1e:** Birdoswald Roman Fort with peatlands to the north and the River Irthing to the south. Here the landforms act both as a means of preserving archaeological evidence in the peat, and a threat to the archaeological evidence via river erosion.

**Figure 1f:** Windturbines in the Tees Estuary, North East England. Developments in the off-shore environment, such as energy infrastructure, come with considerable complexity for the historic environment but also great potential for understanding off-shore environments which were previously the sites of human settlement (see Case Study 7).

# 2. Key concepts

Environmental archaeology is the study of the relationship between people and their environment through time. It is a fundamental part of archaeological study, which uses the natural and physical sciences to investigate biological remains and the deposits in which they are found (Bell and Walker 2004; Campbell 2018; Dincauze 2000). It also encompasses such emerging disciplines as ecological history, biocultural heritage and the environmental humanities, as well as more traditional subject areas such as palaeoecology and geomorphology. Everything we consume or have made ultimately comes from nature. Human societies do not operate outside the natural world but rather both impact and are impacted by the world in which they live (Albarella 2018). Through its study we gain insights into ecological, climatic and cultural change. The themes covered by environmental archaeology have been addressed in a number of general publications (O'Connor and Evans 2005; Reitz and Shackley 2012; Richards and Britton 2020; Wilkinson and Stevens 2003).

Archaeological sites and their surrounding areas can include deposits or features that preserve evidence of past environments, land use, landscape and climate change. Examples of such assets include buried soils, peats (including offshore, intertidal, lowland and upland peatlands), bogs, lakes, palaeochannels, alluvial deposits and colluvial deposits (Figure 1). The way human societies have altered the natural landscape through time means many deposits that appear natural in origin are in fact the product of, and evidence for, human activity in the past, including human niche construction (the process of altering their own environment and the environment of other organisms, which in turn impacts the development of human and non-human organisms; see Bishop et al. 2015; Laland and O'Brien 2010) and ecosystem engineering (the process of altering and impacting on ecosystems at a range of scales, see Boivin et al. 2016).

In the context of heritage management, an environmental archaeology approach can provide a wider suite of information on buried archaeological remains and their sensitivity to change. Understanding the range of material likely to be preserved in an area of archaeological interest, and the nature of the burial environment, is key to understanding the significance of the remains and their future management.

Like all archaeologists, environmental archaeologists seek to answer questions about people and how they lived in the past. Some typical questions include the following:

- How did the environment change over time?
- How did people manage and use natural resources?
- How did people procure and prepare food?
- What did they throw away and where?
- What did people exchange and trade?
- Is it possible to identify social status?
- How were plants and animals used in ritual activity?
- How did people interact with, and impact, their environment?
- Was this site occupied seasonally or all year round?

There are also a range of questions of wider relevance to the planning of an archaeological project that can be asked. This information should be incorporated into documents such as desk-based assessments (DBAs), project designs (PDs), and updated project designs (UPDs) produced after the assessment stage.

Examples of questions an environmental archaeological approach can help answer, which are directly relevant to development planning, include the following:

- What sorts of burial environments are present across the impacted area?
- How deep is the topsoil, subsoil and bedrock? Are the surface/superficial deposits acidic or basic, and how will this help or hinder preservation of different types of material? Are there deposits present that represent evidence for the development of the topography, such as alluvium, colluvium or aeolian deposits? How does the local hydrology influence preservation?
- What sorts of materials are likely to be preserved within the development area?
- If there are known heritage assets within the development area, what sorts of materials have been encountered on comparable sites, both regionally and nationally? In what ways are these materials vulnerable to change?

- Are any materials vulnerable to activities that might alter the burial environment, and introduce oxygen, water or temperature changes to buried deposits? What are the potential costs associated with excavation, conservation, post-excavation analysis and archiving? Based on experience and regional/national comparisons, what sorts of materials might be anticipated?
- Is any external archaeological expertise required before commencing fieldwork?
- Has the project manager considered whether external advice is needed? How typical is the site for the region, or to other projects they have worked on?
- Have relevant specialists been contacted so all stakeholders understand what time constraints or costs need to be considered?
- Are there design considerations that could minimise the impact of the development on the archaeological remains?
- Would discussions between the developer, archaeological consultant and local authority archaeologist be beneficial as a means of understanding where design changes could be used to incorporate protection of buried archaeological remains as part of a long-term strategy alongside or in place of excavation, or enhance them as a heritage asset?

Answering these questions is not solely the preserve of environmental archaeologists, however. Using experience, local knowledge, and an understanding of different types of archaeological remains, all archaeologists should consider how they already incorporate aspects of environmental archaeology into their daily practice. For example, this can be as simple as knowing that a site on free-draining, acid, sandy soils may be particularly poorly suited for the preservation of animal bone and molluscs. Equally, when working in an area where previously excavated sites have produced delicate biological remains and organic materials such as leather and bone, the assumption should be that these remains are also likely to be present in unexcavated areas.

All those planning an archaeological project should consider these questions and decide what specialist advice they might require when developing an iterative programme for investigating the archaeological remains.

It is also the responsibility of the environmental archaeologists to understand the needs of the project they are advising on. This includes the overall aims and objectives, the context of the project, and the research questions being proposed with reference to the Regional Research Frameworks. The production of specialist work should not be isolated from the project as a whole. Equally, specialists must ensure that other project members understand why certain approaches are being advocated, and what the outputs of their work will be. Clarity of timescales, costs and the suitability of proposed specialist work to answer project aims and objectives should be made clear at the outset.

**Figure 2:** Reconstruction drawing of a medieval urban fringe. Biological remains can be preserved at a range of scales, reflecting human interactions with the local and regional environment. This includes patterns in the production, processing and consumption of foods, evidence for craft activities, and modification of the environment in and around settlements. The role of the environmental specialist is to identify the likely survival of different classes of biological remains, how they may relate to past human activities, and how these may be recovered from sites of archaeological interest. Image: Judith Dobie © Historic England

# 3. Project planning

Consideration of environmental archaeology is applicable to all archaeological projects. This includes desk-based research, the excavation and examination of buried archaeological remains and their curation/archiving, and the long-term management of buried archaeological deposits. The principles provided in these guidelines can be incorporated into decision making by a range of project stakeholders, not only environmental specialists. For these guidelines, the regulations, standards and guidance developed by the Chartered Institute for Archaeologists (CIfA) for archaeological fieldwork are treated as the generally accepted framework for best practice: the full range of their resources can be found on CIfA's webpage.

## 3.1 Desk-based assessment

Consideration of environmental archaeology during the writing of a desk-based assessment (DBA) is important to highlight the potential remains that may be present within the development/study area, and how these remains may be impacted by later fieldwork or ground disturbance activities. Much of the information of relevance to environmental archaeology planning is already collected as a standard part of the DBA process, therefore what is being advocated here is the consideration of this information within an environmental archaeology framework rather than the collection of additional information. Further details of this approach can be found in Historic England's *Preserving Archaeological Remains* guidance (Historic England 2016, 5–19).

The following information in a desk-based assessment (DBA) can be relevant to environmental archaeology, and all those writing such documents should check if this information is available:

- topography;
- solid geology;
- superficial deposits (also known as drift geology);
- aerial photographs;
- lidar survey;
- geophysical survey;

- borehole surveys and geotechnical test pits;
- hydrogeological and geochemical information;
- current land use and surface conditions;
- the nature of any previous ground disturbances;
- nearby archaeology remains/heritage assets;
- the nature and extent of the proposed ground disturbance activities.

Once information from the desk-based study is available, the potential for the survival of a range of biological remains and deposits can be discussed with suitable experts. As a statement of good practice, those who organise and tender for archaeological work should be in general contact with an environmental archaeologist to help in planning and decision-making processes. Someone with experience specific to the region or site types being investigated is best placed to provide this advice. It is crucial to recognise that different sites or regions may produce different types of material and challenges for analysis. Experienced expert advice is essential at this stage to avoid a wasteful or misdirected outlay of resources, reduce project risks, as well as to avoid missed opportunities to advance understanding of the archaeological resource and other heritage assets. This includes the challenge of a lack of understanding of the complexity of likely archaeological remains, or alternatively believing remains are unique and unexpected when they are common-place and well-studied in a particular region.

Questions addressed in a DBA should include the following.

- What is the potential nature of preservation within the area being investigated?
- Are there likely to be variations in preservation across the site vertically and horizontally?
- What sort of material is typically preserved in the superficial deposits present in the area?
- Are there local comparisons that allow inferences to be made regarding preservation of different materials?
- What is the date and type of archaeological deposits likely to be encountered, and how might these affect the types of biological remains likely to be recovered?

## 3.2 Deposit modelling

It is good practice to consider a deposit model when planning a fieldwork project (Historic England 2020). Deposit models can be complex or simple in their construction, depending on the number of inputs to the model. These inputs can include existing information (such as British Geological Survey records), as well as specially collected and analysed material from commissioned investigations such as borehole studies (Fig 3). In determining what sort of deposit model is appropriate, archaeologists should focus on the outputs they need, and then determine what inputs are required to achieve these results. Deposit models can be complex, particularly in urban areas with deeply stratified archaeology that can be several metres deep. Deposit models of this nature may require specialist input from multiple individuals in planning for and constructing the model. Deposit models can also be comparatively simple, such as outlining various deposits in plan across a particular area.

Even on sites with shallow stratigraphy a deposit model is a useful way to visualise areas of differing archaeological potential, to consider the nature of preserved material, and where evaluation or excavation work can be most effectively focused. Whatever level of complexity is required a deposit model is also an effective means of communicating to project stakeholders the nature and type of remains present in the area being investigated, and how to plan for the collection of this material. Guidance on deposit modelling and archaeology is available from Historic England (2015 b), Historic England (2020) and Yendell et al. (2022). Case studies relating to deposit modelling in a variety of contexts are also available as a free download from the University of Brighton (Carey et al. 2018).

**Figure 3:** Coring at Rutland Roman villa. Augering or coring (either by hand or using power assisted equipment) can add significant information for evaluations where deep archaeological deposits are anticipated.

## 3.3 Archaeological monitoring and recording/watching briefs

Archaeological monitoring and recording are a form of archaeological fieldwork, and therefore consideration should be given to environmental archaeology. This includes observations of relevance to environmental archaeology and also provision for samplng deposits for biological remains.

Good practice allows for the possibility of sampling archaeological deposits during archaeological monitoring, and their publication (*see* Case Study 1). If sampling takes place it should be done to address a specific question posed in the project design. Even if no samples are taken during the project, the resultant report should include a note on the preservation potential of the deposits/stratigraphy encountered.

The report should include:

- observations regarding the nature of the deposits encountered;
- observations on the presence of organic and inorganic materials;
- evidence for the presence and extent of anoxic/waterlogged deposits;
- a statement of significance to inform future work in the area.

Observations made during archaeological monitoring and recording can significantly aid future, nearby fieldwork by highlighting preservation conditions. At a landscape- or city-wide level these observations can feed into larger projects, such as urban deposit models, as at Berwick-on-Tweed, Northumberland (Derham 2013), Bristol (Wilkinson et al. 2013), Carlisle, Cumbria (Zant et al. 2013), Boston, Lincolnshire (Cope-Faulkner et al. 2017), and Droitwich, Worcestershire (Hurst et al. 2017).

## 3.4 Field evaluation

Field evaluation seeks to understand the nature and extent of the archaeological resource. This information will inform decisions in relation to planning and future archaeological mitigation, which may include archaeological excavation or a preservation strategy. Recovery of environmental archaeology evidence is essential to inform this decision making. In some cases, a field evaluation might be the only intrusive archaeological intervention undertaken for a specific planning application. For this reason, the conclusions of any archaeological evaluation work must be robust, reported on and archived appropriately, as specified in the CIfA standard for archaeological field evaluation (CIfA 2023b). In some cases, this may include full publication of the results.

Evaluation (typically involving the use of linear trenching, often testing the results of geophysical, landscape and aerial survey, but also in some areas utilising geoarchaeological coring) will provide a much more reliable indication of the potential of the environmental archaeology resource than a DBA alone. Therefore, the desk-based predictions and assumptions should be refined in an iterative process. Sampling during an evaluation should inform the understanding of the potential and significance of the archaeological resource. This will then become an important part of future mitigation plans.

The sampling strategy, with its aims and objectives, should form part of the project design and consider:

- the nature of the range of biological remains present;
- possible variations in preservation;
- differential distribution across the site (vertically and horizontally);
- the significance of these remains in a local, regional and national context.

If required, provision should be made for specialists to make site visits to support sampling of deposits and/or environmental material.

Assessment of biological remains from evaluations should be done to the same standards as for excavation. Assessments should clearly set out the significance of the studied material, the limitations of the evaluation process, and the potential of the evaluation work to alter previous assessments of significance.

## 3.5 Excavation

The strategies for recovering biological remains of all types should be designed to meet the aims and objectives as stated in the project design (CIfA 2023a). The project design should be agreed by the project team, which includes the different specialists, and should build upon the results of any evaluation or deposit modelling work. Within the planning system, once a site has been proposed for excavation it has been deemed of sufficient significance to warrant detailed examination. It should also be borne in mind that the site will be either ultimately destroyed by the development process or placed out of access for the foreseeable future in the event that the archaeological remains are secured beneath the development. Decisions made at the project planning stage must ensure suitable attention is given to the range of archaeological evidence present and ensure elements of their significance are fully investigated through effective fieldwork planning. In the case of archaeological deposits being preserved within the overall development, the input of the environmental archaeology team and archaeological conservators may be a determining factor in deciding if the proposed preservation plans are fit for purpose, given the likely wide range of archaeological materials present (Historic England 2016).

It is the project manager's responsibility to ensure that all project members are kept informed during the progress of the excavation, including the discovery of important finds and factors that affect the environmental archaeology elements of the project. Significant changes or alterations in strategy should be agreed by the whole project team and recorded in the project documentation, with justification. Site visits by specialists should form part of the communications plan. Some specialists may need, or prefer, to take their own samples, or be present on site to advise on the recovery of certain materials. It is essential on larger excavations to have a team member whose role it is to coordinate and monitor the sampling and recovery strategy, to identify when there is a need to call in other specialists, and to integrate different or non-standard sampling and recovery methodologies. This person needs to be experienced in excavation and recording methods and to understand the research potential of a wide range of biological remains. It is also desirable for this person to have a broad understanding of the range of scientific techniques applied to both the biological remains and other finds in the widest sense. It is crucial that samples that might require specialist processing methods are distinguished via clear labelling at this stage, for example ensuring samples from waterlogged deposits or potentially waterlogged deposits are not mixed with samples that will be put through the standard flotation process for dry-land samples.

Fieldwork should not be deemed complete until all the materials recovered are in a stable and archival state (see Kerr and Stabler 2008, 13). The level of preservation of all recovered archaeological materials will never be better than at the moment of their excavation. Sediment samples should have an agreed timescale for their processing and assessment by specialists, or for any planned discard. Keeping biological remains, including delicate organic artefacts, for long periods in an unprocessed state will only lead to further degradation and loss of significance. Although the timetabling and budgeting for this activity might come under the 'post-excavation' phase, best practice dictates that unprocessed material (material that has not been washed or processed to extract biological remains and finds) will remain part of the excavation phase of work until they have been stabilised and archived. The only exception to this is where samples have been taken expressly for the purpose of future research. Where this is the case, it should form part of the project design or written scheme of investigation (WSI), with a clear outline for the storage or archiving of this material and its long-term maintenance.

Before the initiation of fieldwork, during fieldwork, and at its conclusion, it is essential to have discussions with environmental archaeology specialists to inform them of the site's progress, and to keep the project management team updated on the post-excavation implications for on-site sampling and recovery.

# 4. Sampling and recovery

This section covers:

- what a good sampling and recovery strategy should include;
- asking the right questions;
- examples of possible methodologies;
- which types of samples to take;
- what to consider when taking samples;
- how to store samples.

In common archaeological parlance ‘sampling’ is often used as a short-hand term for the recovery of sediment/soil from an archaeological layer/context for specialist analysis. In this document sampling is taken to mean both the strategy for planning the recovery of biological remains, as well as the physical recovery of these remains.

A coordinated approach to the sampling and recovery of different environmental archaeology materials allowing for multiproxy analyses will provide a more enhanced interpretation than relying on a single line of evidence (*see* Case Study 6 and Appendix 2). Environmental sampling can also be integrated with sampling of various types of artefactual and technological evidence (Fig. 4). For example, industrial working or production waste such as hammerscale can be recovered using a hand-magnet from the same heavy residue sediment samples taken for charcoal remains for the purpose of studying fuel use (Collard et al. 2006, 370; Historic England 2015a, 11).

In environmental archaeology a sample is a fraction of the totality (population) of remains present in a context or feature. By further inference the totality of remains recovered is seen as representative in some form of past conditions or activity. The scale of environmental archaeology sampling (through the recovery of sediment, hand collection or sieving) is determined by the questions being asked, and the material being investigated. The intensity of sampling (the numbers of samples, their volumes, and the number/types of biological remains being targeted by this activity across the area of investigation) must also be proportionate to the overall project and its associated research questions/aims and objectives. The most important element in developing a sampling and recovery strategy is to understand how the information gained from the archaeological work (fieldwork and post-excavation analysis) will enhance knowledge of the period or site under investigation.

**Figure 4:** Stainton West, part of the Carlisle Northern Development Route (Brown 2023). Archaeological sites may present consistent preservation levels across large areas, but can more often be a complex palimpsest representing different archaeological periods and different preservation environments. The area in this image includes dryland and waterlogged remains, with archaeological remains from the Mesolithic, Neolithic and Bronze Age. Samples were collected for a range of biological and artefactual evidence. © Oxford Archaeology Ltd

The aims and objectives of a project must be clear so that it is possible to work out how to recover environmental archaeology evidence in the most effective way, how best to deploy resources, and how to modify the approach in response to newly arising issues or discoveries. Flexibility in response to new information or changing circumstances is an important part of project planning and management. This makes it possible to modify the aims and objectives as a project progresses and new information comes to light.

The need for sampling and a consideration of what types of samples and collection procedures will best address project aims should be considered at project initiation (*see* Case Studies 2, 4 and 6). Advice should be sought from appropriate specialists to ensure that the sampling, and recovery strategies, will meet the project's needs and use resources most effectively (*see* Appendix 1). The project design must demonstrate that the sampling and recovery strategies address the project aims and objectives.

A well-constructed and documented sampling and recovery strategy therefore addresses the aims and objectives of the project and how these fit into research questions identified in regional and national research frameworks. It is the aims and objectives that will determine:

- what remains may be present and how they can be recovered;
- which archaeological deposits should be targeted to recover these remains;
- the sampling intensity that should be employed;
- the methods of recovery, e.g. flotation samples, hand collection, Kubiena or monolith tins, specialist sampling.

Logistical inconvenience should not be the driving force of how many samples to take, or determine the size of each sample, or what is collected. It is good practice to consider processing samples and other collected materials during the course of a fieldwork project. This can inform on the effectiveness of the sampling strategy and feed back into the ongoing collection strategy, as well as reducing the logistical burden of transporting and storing large volumes of unprocessed sediment.

While the survival of different types of environmental evidence can be predicted to some extent, it also relies on a number of assumptions that may change as the project develops (Figure 5). Archaeological sites can be simple or complex in terms of their features, the deposits available for sampling, chronology, the properties of the deposits, and the site formation processes. These factors will influence the survival of different types of biological remains (Figure 6). Therefore, overall preservation will partly determine the extent and scope of the aims and objectives that can be set. This is due to the complex interplay between numerous variables, with different categories of material having different taphonomic pathways (*see* Case Studies 2 and 3).

Figure 5: The early medieval well from Burlscombe, Devon. Based on available information the initial DBA and geophysical survey of this site considered the palaeoenvironmental potential of the site to be low, however, during the fieldwork phase areas of restricted waterlogging revealed preserved 7th century AD remains, with structural and artefactual evidence preserved. When these remains were identified the project design changed to ensure these remains were properly sampled and recorded. The prior information provided a framework for approaching the site, but was sufficiently flexible to allow for unexpected remains (Best and Gent 2007). © V Straker

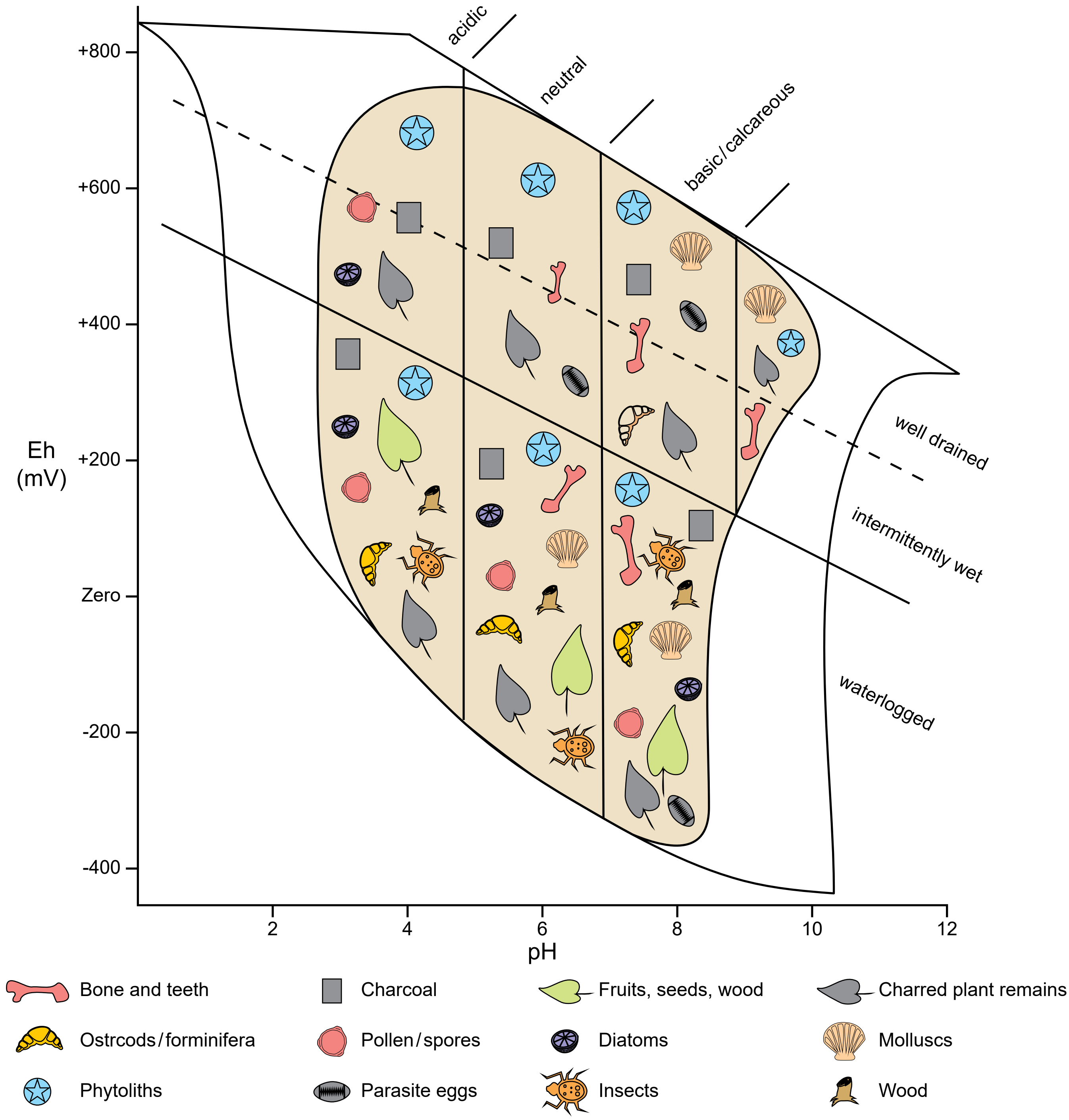
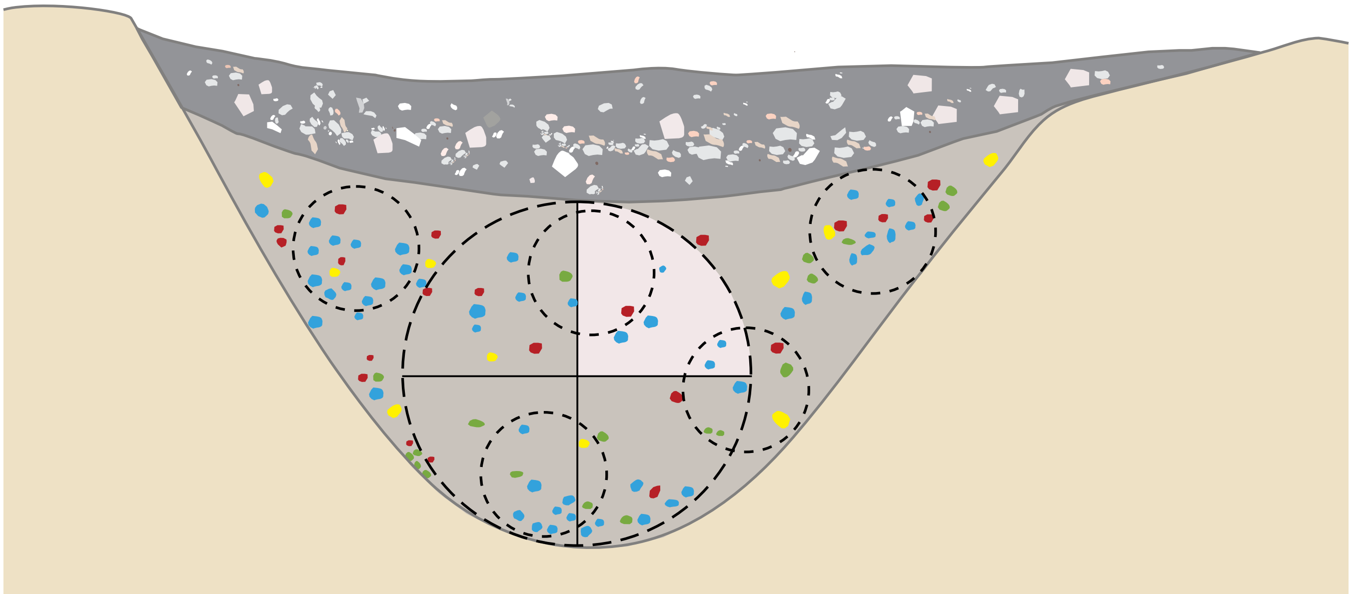



**Figure 6:** Schematic representation indicating under which depositional environments specific categories of environmental remains can expect to survive and hence be recovered using appropriate techniques (modified from Retallack 1984). This has been simplified as a representation of pH and the redox potential of deposits (see also Historic England 2016).

The shaded area represents the envelope into which most naturally derived sediments fit. Outside of these limits human activity can create environments that can also preserve a range of biological remains. One of the key aims of an archaeological evaluation exercise is to understand the range of materials which might be preserved on an archaeological site, and the significance of these remains for answering archaeological research questions. This will then allow the formulation of research questions, and a suitable environmental sampling strategy to answer these questions.



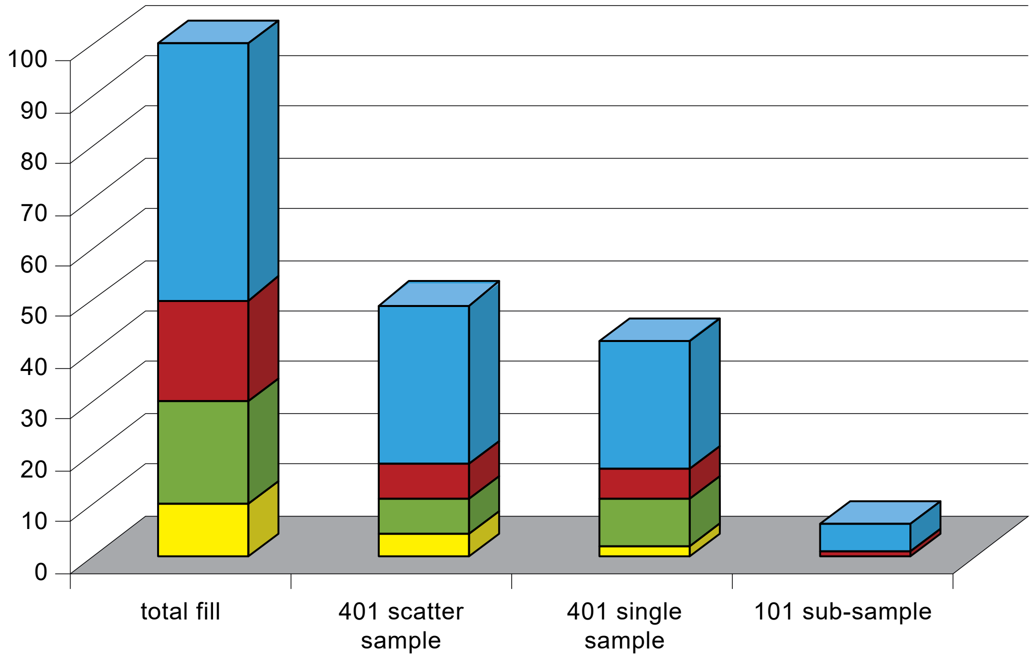



**Figure 7:** Sampling the fill of a pit to recover biological remains.
The figure shows a hypothetical pit fill, which appears to the naked eye to be a homogenous fill showing no differentiation. However, within the fill are biological remains, not visible to the naked eye, which are unevenly distributed. This is a common occurrence. The small circles represent a 40 litre sample (scatter sample, section 3) taken from different areas within the pit and with a bit from each circle put into each sample tub. The large circle represents a 40 litre sample taken out of a single area of the pit, each quarter of the circle representing one sample tub. The light-coloured quarter represents a 10 litre sub-sample of this sample.
There are 10 yellow items. The 40 litre single sample recovers 2 of these, whereas the 10 litre sub-sample of this sample recovers none. The 40 litre scatter sample recovers 4 yellow items.
There are 20 green items. The 40 litre single sample recovers 9 of these, whereas the 10 litre sub-sample of this sample recovers none. The 40 litre scatter sample recovers 7 green items.
There are 20 red items. The 40 litre single sample recovers 6 of these, whereas the 10 litre sub-sample of this sample recovers only 1. The 40 litre scatter sample recovers 7 red items.

It is essential that samples are collected from all types of deposit that are relevant to the aims of the sampling strategy. Many classes of biological remains are not visible to the naked eye. In this respect appearances can also be deceptive. Dark deposits, for example, might be rich in organic silt, but this does not mean they are rich in charred plant remains; conversely, archaeological deposits that appear clean with no inclusions can be rich in charred plant remains, such as chaff, cereal grains and weed seeds (*see* Case Study 4).

Sediment sampling on excavations can be achieved using several different methodologies. The choice is primarily between random, judgement and systematic sampling (*see* Table 2). Further detail on the effectiveness of random and judgement sampling can be found in Veen and Fieller (1982). Common practice uses a combination of judgement and systematic sampling.

Table 2: Sampling methodologies.

| Sampling method | Description | Advantages | Disadvantages |
| --- | --- | --- | --- |
| Random | Contexts to be sampled are selected in a statistically random manner | Mathematically rigorous | Could miss all important deposits if used on its own |
| Judgement | Samples are taken from obviously 'rich' deposits | Cost-effective because only the 'good' contexts are targeted | Highly subjective; 'good' contexts are not always apparent to the excavator |
| Systematic | Samples are taken to an agreed strategy | Ensures that the whole site is considered; can be easily re-evaluated during excavation | Can miss the unusual contexts, or sample inappropriate contexts if poorly planned |

Environmental archaeology evidence may not be homogenously distributed through an archaeological feature, and this needs to be considered when taking samples (Fig 7). The most appropriate way of obtaining a representative sample of material within a context is to recover the sediment being sampled from different areas within the context (scatter sampling). If the objective is to explore overall variation within a context, then multiple, separately identifiable sediment samples from different locations within the context will be required (*see* Case Study 4). For example, a grid can be used to sample an occupation layer. These separate samples can always be combined later, if appropriate. To explore variation within a context, a single sediment sample cannot be divided meaningfully once taken, and will be less representative of the context as a whole (Lennstrom and Hastorf 1992; Orton 2000, 153–4).

This process also follows through to the processing stage, where subsampling risks only recovering some of the material in the whole sample (e.g. if only processing 10 litres of a 40-litre sample). Subsampling the totality of the remains recovered on site should never be undertaken without a clearly articulated argument to justify this (*see* Case Studies 4 and 5). It must be remembered that the original sample volume recovered is itself only a partial representative of the living population, therefore further subsampling this will likely lead to a biased record and a reduction in the material available for study.

Recovery of sediment samples should not concentrate solely on features that can be dated or phased in the field. Recovery must also consider features that are undated at the time of excavation. Recovered biological remains can provide the material needed to date these features and, by ignoring them, some types of activity (or periods of activity) might be entirely overlooked (*see* Case Study 1).

Samples should be taken from individual contexts, unless they are column samples where they intentionally cross stratigraphic boundaries in a vertical sequence. Sometimes it is appropriate to sample thick contexts in spits, for example of 50–100mm. Each sample must come from a cleaned surface, be collected with clean tools, and be placed in clean containers.

The following should be included in a sample register:

- sample type, e.g. flotation, coarse sieved, specialist;
- feature type;
- reason for sampling;
- size of the sample in litres (also noting the number of bags/buckets used);
- context and sample numbers;
- spatial location;
- date of sampling;
- context description and interpretation;
- the approximate percentage of the context sampled, where known/relevant.

This information should be shared with the specialists working on the different classes of biological remains.

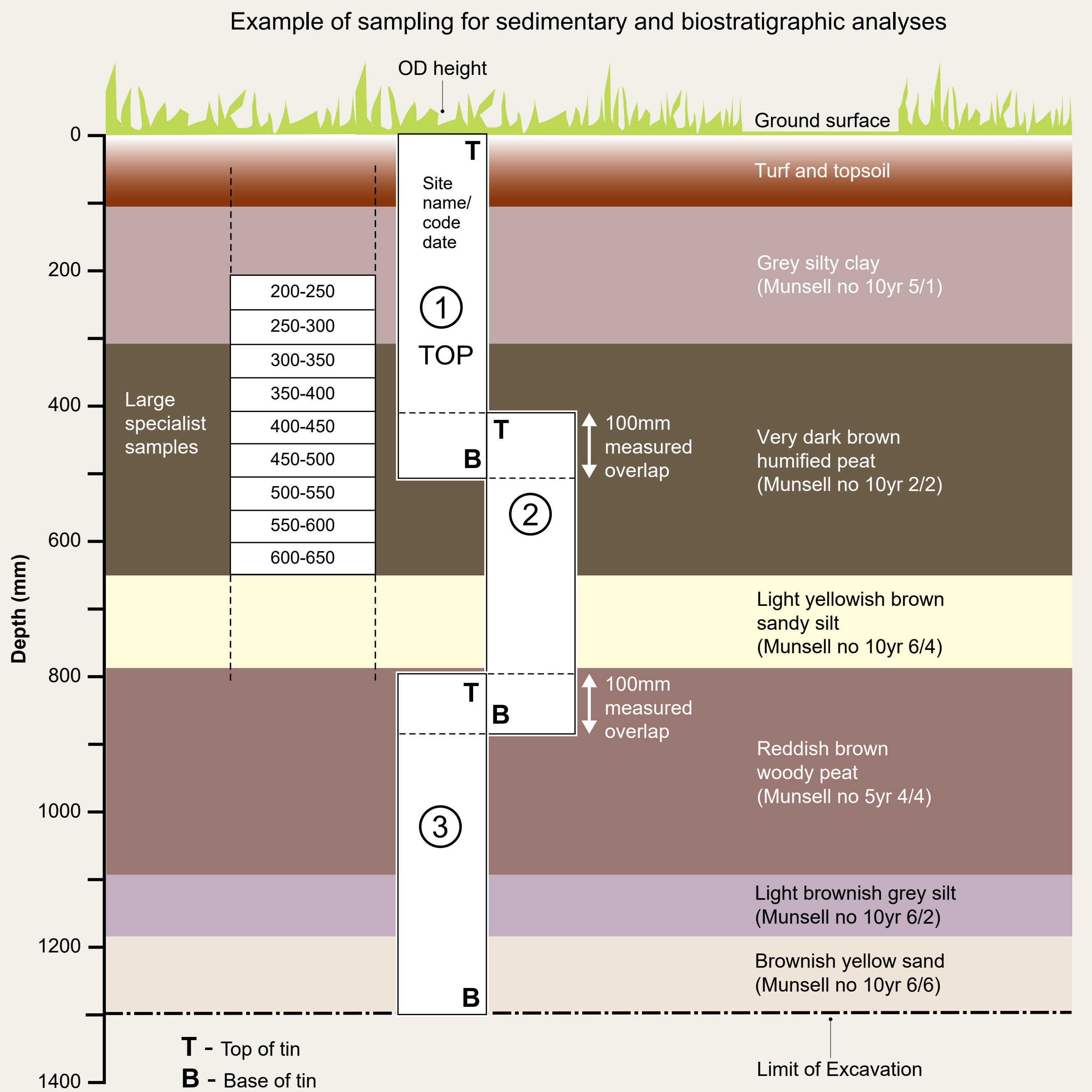
Labelling must be legible, consistent and permanent. It is best to use plastic or plasticised labels and permanent markers. It is essential that all samples are adequately recorded and labelled. Samples without labels or in damaged or unsuitable containers result in information loss, and avoidable harm to the project archive and heritage asset. This can occur for a variety of reasons, but there is a greater risk of containers being damaged or labels becoming illegible or lost if there is an unplanned delay between when the sample is taken and when it is processed. Project planning should consider whether more durable, reusable plastic tubs should be used rather than less durable packing materials (see Fig 4, and further discussion of this in Brown et al. 2023, 19-22).

Samples in plastic tubs should be labelled both on the inside and outside. Samples in polythene bags should be double-bagged, with labels placed inside both bags and on the outside of the outer bags, and the bags securely tied/sealed. Specialist samples with a sample orientation (such as cores, columns and Kubiena tins) need to have the top and bottom marked, and the depth within the sequence of the deposit, and the height above and below Ordnance Datum (OD), recorded. Overlapping samples must have their physical relationship to each other noted. The position of samples should be marked on all relevant site plans and section drawings and provided to the specialists working on those samples (Fig 8).

Like all human activities, archaeological fieldwork generates a carbon footprint, as well as potential waste materials. Projects need to consider how we can improve our behaviours to minimise impact. This could be through preventing waste in the first place, as well as encouraging the re-use and recycling of materials, and following this guidance will support the reduction of potential waste. For example, processing samples and avoiding storage of sample tubs for long periods in direct sunlight will prolong the life of the sample tubs and reduce breakage as the plastic becomes brittle. On larger schemes careful consideration should be given to whether samples are processed on-site or transported to a separate facility (see Fig 10).

In development-led schemes consideration of the role of archaeology in the carbon cycle must also take into account the sum total of the carbon output of the development scheme as a whole, not merely the role of archaeological fieldwork and post-excavation activities.

Specialists might also wish to make sketches and take separate notes. Photographic records of the sampling as it took place can be extremely useful in providing a complete record of sample position and orientation. It should be borne in mind that these records also form part of the final project archive and should be included in the data management plan for the project.




Radiocarbon samples - no thicker than 10mm. Samples for dating can also be taken from vertical monolith or monolith tin placed horizontally. these are sub-sampled in the laboratory as required. Tins in drawing are 500x100x100mm.

Specialists will carry out more detailed sediment description in the lab when sub-sampling for analysis.

Position of samples should be marked on site drawings.

Large specialist samples - for waterlogged macroscopic plant remains, foraminifera, molluscs and insects.

Number of samples, sample size and sample intervals should be advised by specialists.

Figure 8: Schematic diagram for sampling.

## 4.1 Sampling in difficult conditions

Sampling of archaeological deposits can also be undertaken from non-terrestrial or atypical contexts, such as a marine environment (see Case Studies 6 and 7), bodies of freshwater (including artificial bodies of water such as ponds and moats; Historic England 2018b), and caves and fissures. All of these contexts present particular challenges and the sampling strategy adopted needs to take these factors into account, with the advice of an experienced practitioner sought.

Samples from deeply buried deposits that are inaccessible to hand excavation are often taken using coring equipment (ranging from hand augers to larger drilling rigs), in order to recover sedimentary sequences that can be used for a variety of different analyses (Historic England 2015b; Historic England 2020). These contexts can include deep wells, where provision needs to be made for recovering material at the base of the feature (such as with coring equipment). Sampling using equipment of this type must ensure sufficiently large volumes of sediment are recovered to constitute a sufficient volume for the recovery of biological remains (*see* Appendix 2).

## 4.2 Which types of samples to take

The archaeological context is important when deciding what types of samples should be collected. The likely presence of particular biological remains will be related to preservation conditions, past human activities and depositional processes.

The terminology applied to different sample types is varied. In part this reflects the wide range of materials for which samples are taken and the different processing methods used for them. These guidelines classify sample types primarily by how they are dealt with on-site or who takes them. The use of the term 'bulk sample' is often used to refer to whole sediment, which is recovered from an archaeological deposit and often sent off-site to be processed and analysed. However, it is important to recognise that this term applies to a range of sample types that need to be processed and treated using specific methodologies. The term bulk sample is not used in these guidelines as it fosters a lack of clarity about the purpose for which the samples were taken. Inappropriate processing of a specialist sample leads to the needless destruction of the material being targeted. This is particularly significant in the case of inappropriate methods being used to process waterlogged samples (such as processing them in a standard flotation tank and drying the resultant material) rather than following accepted best practice (Kenward et al. 1980). In this guidance, samples have been classified into three basic types: flotation, coarse-sieved, and specialist recovery. Specialist recovery samples can be further divided into three categories, general specialist samples, column samples and core samples, depending on the purpose for which the samples are taken and the method of sampling.

Both flotation and coarse-sieved samples should be ‘whole earth’ and representative of the archaeological context deposit as a whole. If it is felt necessary to remove items from the sediment (e.g. intact animal mandibles with teeth that may be important for stable isotope analysis, or delicate artefacts that might require conservation, such as metal artefacts), this should be noted on the sample record. In some circumstances, such as where sediments contain large cobbles, it may be pertinent to remove larger stones from the sample in order to maximise the volume of sediment bearing biological remains. Such practices should be noted on the sample records.

### 4.2.1 Flotation samples

Flotation samples are taken from well-drained deposits principally for the recovery of charred plant remains (Fig 9). However, they are often used to recover multiple strands of archaeological evidence, including small mammal and fish bones, mineral-replaced plant remains, industrial residues such as slag and hammerscale, and smaller finds. They are usually taken as part of the excavation process, and commonly seen on-site being collected in plastic buckets. During excavation consideration should be given to where the samples will be processed and the logistics of their transportation. On large excavations there can be considerable benefits to processing samples on-site where facilities (such as water, adequate drainage and appropriate permissions for discharge, silt disposal and drying space) are available (see Fig 9, and Brown et al. 2023, 19-22 for an example of how this can be achieved at scale). This provides rapid feedback on the effectiveness of the sampling strategy employed and reduces transportation and storage costs.

**Figure 9:** Floation for charred plant remains.

Figure 10: The on-site artefacts processing facility at the Carlisle Northern Development Route, Cumbria. This facility was used to process c.27,000 buckets of sediment and recover almost 300,000 lithics (Brown 2023, 20). © Oxford Archaeology Ltd

A sample size for the recovery of charred plant remains will normally be of the order of 40–60 litres or 100% of smaller features. The washover/flot is usually collected on a geological sieve with a mesh size of 250–300µm (microns). The mesh size might need to vary from site to site according to the practicalities of processing different soil types. For example, where silty deposits are present a mesh size of 400–500µm might be considered to avoid the mesh becoming blocked. Residues are usually collected on a nylon mesh size of 0.5–1mm and are sorted for the recovery of the small items mentioned above. The advice of a specialist with local experience or knowledge should be sought for the most appropriate sample size and mesh sizes for a given site, with this decision documented in the project archive. Specialist advice will be needed particularly for sites on iron-rich clay soils, where charred plant remains are often partly coated or impregnated with iron salts, and where conditions are suitable for mineral-replacement by calcium phosphate or calcium carbonate (Carruthers and Smith 2020; *see* Appendix 2, Section 13). Only a small proportion of this material will float, with most remaining in the residue. In order to ensure full recovery of mineral-replaced remains the residue mesh should be 0.5mm.

It should be noted that flotation machines are not always effective at recovering charred plant remains, and that it is necessary to check residues to determine the quality of recovery. One method of doing this to re-float the dried and sorted residue. The dried and sorted residue can be placed into a bucket of water and the resultant floating material decanted through a 300µm geological sieve.

For the recovery of finds (e.g. beads, flint, glass, pot), residue fractions larger than *c*. 2mm can be sorted by eye by staff under appropriate supervision and with training provided. In practice most finds are recovered from the >4mm residue, so it is worth considering what proportion of the <4mm residues are to be sorted and which materials are picked out as opposed to recorded. Specialist advice, in particular from a zooarchaeologist, should be sought regarding the types of remains that might be present in the fraction finer than 2mm (Baker and Worley 2019, table 3.5). This work will need to be undertaken by someone with suitable training to identify the material. In managing this element of the workflow it must be ensured there is integration between the process of residue sorting and examination of the washover/flot.

### 4.2.2 Coarse-sieved samples

Coarse-sieved samples can be wet or dry sieved depending on the soil conditions and the materials being targeted for recovery. They are collected for the retrieval of small bones, bone fragments, larger molluscs (particularly marine molluscs such as oysters, mussels and limpets) and smaller artefactual finds (Fig 11). They are best taken with the advice of the appropriate material specialist. This process can recover other material incidentally, such as wood charcoal, large plant remains (such as charred, waterlogged and mineral-replaced fruit stones) and waterlogged wood, but coarse-sieved samples are not suitable as the sole means of retrieving these materials.

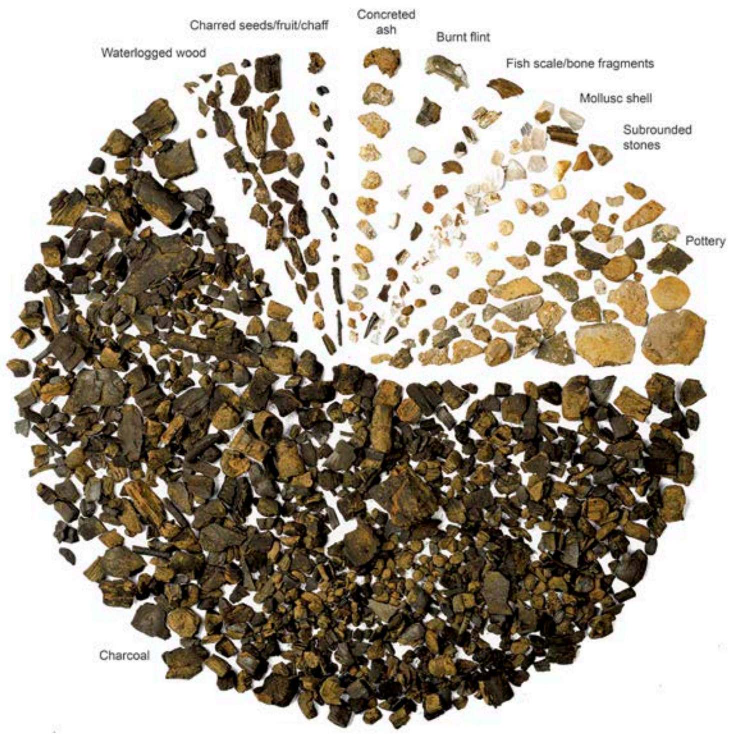



**Figure 11:** Ecofacts and artefacts from a 5 litre sample, sieved to 4mm, taken from a conflagration layer at Must Farm (Knight et al. 2024, 34).
© Cambridge Archaeology Unit

Coarse-sieved samples are usually sieved on a minimum mesh size of 2mm. However, full recovery of fish and small mammal bones requires a 1mm or 0.5mm mesh size depending on the remains being targeted (Baker and Worley 2019, fig. 3.2 ; *see* also Case Study 8). The residues from flotation samples are also often used for this purpose (Barrett et al. 2004).

Hand recovery of animal bones is always biased in favour of larger elements and will tend to over-represent the importance of larger animal bones, for example cattle over sheep, or long bones over foot bones. Specialist advice should be sought on the sample size, mesh size and suitability of the context being targeted (Baker and Worley 2019, fig. 3.2).

### 4.2.3 General specialist samples

General specialist samples can vary greatly in size depending on the levels of preservation, and the required volume should be checked with the relevant project specialist. Larger samples are typically in the order of 10 litres for waterlogged plant, insect and mollusc remains. For biological remains such as ostracods, diatoms, foraminifera, pollen and parasites, samples can be in the order of 50g or less (*see* Appendix 2).

These samples are usually processed by individuals with specialist training, and in some cases the specialists themselves may prefer to take the samples when on-site. The taking of sediment samples for flotation and recovery of charred archaeobotanical material is now a well-established process in England. However, it is felt that other sediment samples need to be distinguished from flotation samples as there has been an increasing trend, particularly for material from deposits with anoxic/waterlogged preservation, for them to be processed inappropriately using the standard flotation method, which is designed for the recovery of charred plant remains.

Other sediment samples are referred to here as specialist recovery samples, as the method of processing is often specific to the nature of the material being sampled, and uses specialist equipment or chemicals. In addition, the material being recovered can be more sensitive to damage or bias if collected or stored improperly. This can include recovery of waterlogged plant remains, insect remains and molluscs, all of which require their own forms of processing and recovery (Davies 2008; Law and Davies 2018; Rousseau 2011). Some of these biological materials can be seen in flotation samples and can provide information on preservation conditions. However, for detailed analysis it is accepted that without appropriate methods of recovery the retrieved remains can be both statistically unusable and damaged beyond the point of useful identification.

In some cases samples will be subsampled to provide material for a number of different specialists. Following best practice, a specialist should have input as to the nature, volume and context location of the material being sampled. Inappropriate sampling and recovery can materially affect the significance of the evidence being recovered, and thus affect the overall value of the final report as a contribution to the fieldwork project.

### 4.2.4 Column samples

Column samples are collected from suitable vertical sections. They can be collected in monolith tins/Kubiena boxes or blocks of sediment cut from a cleaned vertical section. Samples taken on-site can be subsampled in the laboratory for a range of analyses such as pollen, spores, diatoms and foraminifera, as well as for micromorphology (Historic England 2015b). Kubiena boxes are usually made of aluminium or stainless steel, with lids on the front and back. In order to collect sequences of deposits, a series of overlapping monolith tins may be used. By whatever means they are taken, samples should be of a size suitable for the different types of material being recovered (Fig 12). Multiple subsamples may be taken from each column depending on the range of biological remains being investigated. The vertical sections from which the samples are taken should be drawn, photographed and described. It is important to ensure that there is coordination between the different specialists who might want access to these samples, as some processes may negatively impact on others; for example, excessive removal of sediment for one type of analysis may negatively impact the possibility of sampling for another.

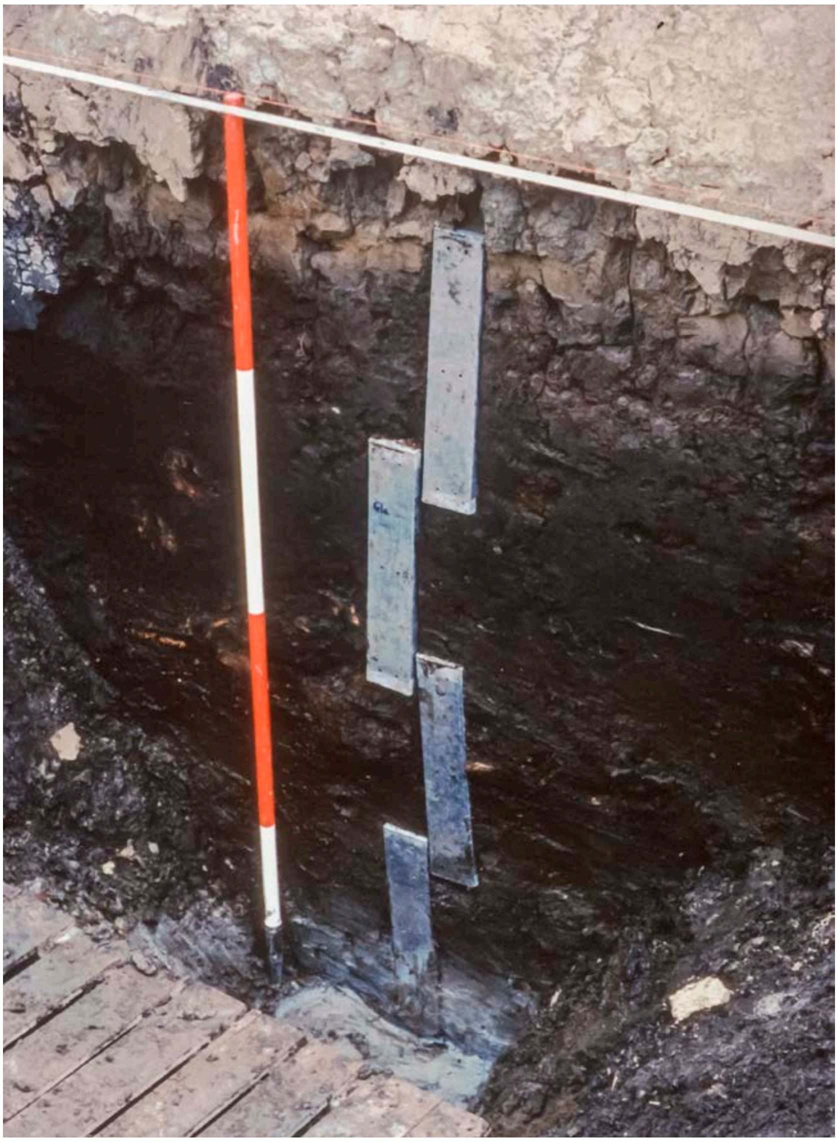


**Figure 12:** Glastonbury Relief Road: monolith tins in peat deposits overlying estuarine silty clays. Note the overlapping tins, which enable researchers to take samples from undisturbed positions throughout the length of the sequence. The monoliths were sampled for pollen and diatoms. Additional specialist samples from the same deposits were analysed for insects, macroscopic plant remains and foraminifera. © V Straker

### 4.2.5 Core samples

Cores can be taken where it is not possible or desirable to collect columns and specialist samples from sections. For further details on coring refer to Historic England's geoarchaeology guidelines (Historic England 2015b). The size, type of core and coring method used should be carefully considered at the project design stage (Historic England 2020). The methodology employed will typically be tailored to the nature of the deposits being explored and the aims and objectives of the project.

Core samples may be recovered from locations with substantial accumulations of sediments, for example river channels, lakes, bogs, mires, glacial depressions, marine contexts (*see* Case Studies 6 and 7) (Figures 1 and 12), ditch sections and ponds. Sampling continuous sedimentary sequences will provide information about both the site and the wider ecological history of the area (Gearey et al. 2016). Multiple samples of the same sequence from distinct but related locations will give a more accurate picture than a single sequence, which may be biased by local factors.

**Figure 13:** Coring with a Russian auger at Dickleburgh Mere, Norfolk.
© Royal Holloway and the Centre for Quaternary Research

## 4.3 Recovery of human remains

The unique status of human remains as the remnants of once living people means that their treatment in archaeology involves legal and ethical considerations over and above those that apply to other classes of remains. The responsibilities of the human osteologist in an archaeological fieldwork project have been outlined in Historic England guidance (Historic England 2018a). Further guidance documents covering various facets of the treatment of human remains is available from the Advisory Panel on the Archaeology of Burials in England (APABE) and the British Association for Biological Anthropology and Osteoarchaeology (BABAO) ; perhaps the most pertinent of these is APABE (2017), particularly the sections on human remains and the law, and the excavation of inhumation burials. Permission, under either secular or ecclesiastical law, is needed to disturb human burials. Excavated human remains should always be treated with respect and decency.

At the project planning stage, careful thought should be given to the type and number of burials likely to be encountered, as this will impact directly upon project costs. This also includes planning for those deposits which are suspected to be grave cuts, but where visible bone and tooth survival may be minimal or completely absent (*see* Case Study 9).

Environmental archaeology factors to consider for human remains include the following.

- Is the material likely to be from cremation-related deposits or inhumations or both?
- Cremated remains (from prehistory to the late 7th century AD) will likely include other burnt material (mainly charcoal) which will require specialist analysis.
- Are grave goods or other grave furnishings likely to be associated with the burials?
- Metal artefacts, such as copper or iron objects, will have associated conservation costs and can also be associated with mineral-preserved organics (MPOs), such as cloth and leather, which survive due to the toxic effects of metal corrosion products (Cronyn 2003). The analysis of MPOs requires specialists to work closely together and needs to be considered when resourcing a project.
- The likely level of skeletal survival in inhumation burials.
- Waterlogging may result in extensive preservation of organic remains of mortuary material culture, occasionally including ephemeral items, for example floral tributes in 19th century burials.
- There may be specific health and safety considerations, for example where there is extensive soft tissue preservation, where lead coffins are present, or when working in enclosed burial spaces, such as crypts or vaults.

On excavation, each inhumation burial should be given a unique context number and excavated by hand. If soil samples are to be taken to investigate the survival of gut parasites or food residues, then these are normally taken, prior to the lifting of the bones, from the abdominal/pelvic area, together with control samples from the grave fill away from the body or inside the skull. After lifting the bones, the soil remaining in the base of the grave should be recovered and sieved to retrieve small bones, bone fragments, loose teeth, and any small artefacts that might be present. Exact procedures differ in detail according to the nature of the site, but it is often useful to recover the soil as three separate subsamples relating to the head, torso and leg/foot regions, to show approximately where, in relation to the body, any recovered items came from. After sample processing, recovered skeletal material should be boxed with the skeleton in separate, labelled bags.

All cremation deposits should be 100% sampled. Generally, cremation deposits should be half sectioned and excavated in spits, with each spit retained as a separate sample. Vessels from urned burials should be block-lifted before being excavated and sampled. Larger crematory deposits, such as pyre sites, should be excavated as multiple discrete samples. Any fragments of charcoal greater than 100mm should be recovered as individual samples and three-dimensionally (3D) recorded. Flotation can be used to recover charcoal and other plant remains associated with the cremation rite. Careful processing is required to minimise fragmentation of any cremated bone. Samples can be gently dry sieved over an 8mm or 4mm mesh to recover larger bone fragments and finds prior to flotation. For further guidance on the sampling of cremation burials and related deposits see McKinley and Roberts (1993).

Best practice for the assessment, analysis, and scientific sampling of human remains is outlined in the documents cited above. The approaches to processing, reporting and storage of environmental samples and biological remains outlined in the following section, Section 5, are not applicable in all cases to human remains. Therefore, the primary guide to the treatment of human remains should be published best practice and the recommendations of an experienced human osteologist. When human remains are recovered it is also advisable to contact the receiving museum to discuss any specific archiving needs.

# 5. Processing, reporting and storage

## 5.1 Processing samples

A prime purpose of archaeological fieldwork is to create a secure, ordered and accessible archive (Brown 2011, 3; CIfA 2020b, 3) that can then be analysed during the post-excavation stage, and whose contents form the basis of an updated project design (UPD). The accepted best practice in the extraction of recovered biological remains includes ensuring material is not carelessly damaged though ill-informed processing. In order to create a secure archive, flotation samples, coarse-sieved samples and hand-collected material that are identified as relevant to the project aims and objectives must be processed, to both stabilise the materials recovered and prepare them for deposition. In some cases material might be archived for future research in an unprocessed state. This retention must be planned, stable, and within a secure facility that has been documented in the paper archive. Merely storing the material in an unprocessed state without justification or documentation would not in this case constitute suitable retention.

The effects of any delay between sampling and processing will vary widely depending on the material, its original burial environment, and the duration of the delay. Well-preserved mammal bone may be relatively robust, but deposits containing fish bones can be vulnerable to fluctuations in moisture and temperature. Likewise, waterlogged deposits containing delicate plant remains, insect remains or animal fibres can rapidly degrade if stored in conditions with fluctuations in temperature, light and moisture. In the case of charred plant remains the nature of the material means it is resistant to biological and chemical changes; however, when removed from its burial medium it is vulnerable to the physical damage that can result from being compressed during inappropriate storage (particularly an issue when stored in bags) or through cycles of wetting/drying.

All sample processing should be recorded on sample records the format of which is agreed upon by the project manager, the specialists and the on-site environmental supervisor. Processing records should include sample volume (for coarse-sieved samples and flotation samples), context and sample number, mesh sizes used, the date processed, the volume of any retained unprocessed sediment (and the reason for its retention), and any other comments or observations that will inform assessment and analysis.

## 5.2 Storing samples

Key points for storage are:

- keep samples cool;
- exclude light and air;
- all relevant records need to be secure and accessible;
- avoid long-term storage without a processing or archiving plan.

Samples for laboratory processing should be collected by, or sent to, specialists as soon as possible (ideally within 3–6 months of the material being excavated). Once excavated, organic remains become more vulnerable to decay by micro-organisms such as bacteria, algae and fungi. It is not possible to prevent this process completely, but the rate of deterioration can be minimised. The general rule is to maintain samples in conditions as close as possible to those in the ground in which they were found. They should be protected from fluctuations in temperature, kept out of direct sunlight, and, as far as possible, stored in airtight containers. This will slow bacterial and algal growth. Organic-rich samples should be monitored for fungal growth, which can also occur in dark conditions. Waterlogged samples should be well sealed to prevent drying out. If a waterlogged sample does accidentally dry out it should not be re-wetted but left dry and a note put in the sample record stating what has happened during storage.

As well as damaging the preserved biological remains, inappropriate storage can also impact on suitability for radiocarbon dating, through growth of fungal hyphae, or through plant germination and photosynthesis in a sample, which leads to the redistribution of carbon (Bayliss and Marshall 2022, 47). With long-term and inappropriate storage these biological processes can also cause substantial damage to preserved biological materials. Therefore, samples should be processed as soon as possible to stabilise the archive.

Longer term storage of waterlogged material normally involves storage in a mixture of ethanol and water; however, material intended for radiocarbon dating, biochemical analysis or aDNA analysis should be stored in distilled water. Guidance on the curation of waterlogged plant macrofossils and invertebrate remains is given in Robinson (2008). Waterlogged wood should only be stored for short periods of time before it is recorded or sent for conservation, as the longer it is kept in storage the worse its condition will become (Historic England 2025 Waterlogged wood: guidance on the excavation, recording, sampling and conservation of waterlogged archaeological wood).

## 5.3 Assessing significance in reports on biological remains

The purpose of an assessment is to:

- establish the potential significance of the material;
- assess its potential to address project aims and objectives;
- assess its potential to enhance understanding of the past;
- advise on the resources needed to complete a full analysis.

The Historic England-funded CIfA Toolkit for Reporting Archaeological Materials can be used at this stage.

An assessment should take account of the results of previous interventions and make recommendations for the type and scope of further analysis. These recommendations should feed into the UPD. To be effective (for both time and costings) these decisions should reflect the best current knowledge and understanding, and therefore need to be carried out by specialist staff who are experienced in studying the type of material being assessed. For example, specialists need to be able to recognise the significance of interesting or unusual taxa, which may not always be found in all samples.

An understanding of heritage significance needs to take into account the value and importance of the heritage asset, both to the current and future research community (Historic England 2015c; Historic England 2019 , 8–9). A contemporary consideration of current significance must include:

- examination of material to a high professional standard;
- ensuring archaeological material is not needlessly or carelessly destroyed;
- ensuring there is repeatability of results by protecting non-excavated remains where possible;
- ensuring excavated material is studied and archived in a manner that allows future researchers to interrogate the resulting material archive and datasets in line with findable, accessible, interoperable, reusable (FAIR) data principles (Wilkinson et al. 2016).

Assessment methodologies will vary according to the type of remains being studied and the research questions posed within the project design. The distribution and occurrence of biological remains and artefacts cannot be determined without examining what is present in the samples. As these samples will have been collected according to a strategy designed to meet project aims, this will normally mean that all material recovered should be assessed (*see* Case Study 5), unless there is a compelling reason why this should not take place, such as where multiple samples have been taken from the sample context (e.g. across a floor area), or where a number of column samples have been taken through a sequence of deposits. In these cases, it can be appropriate to assess only a subset of the samples taken. However, the sample selection process and the reasons for it should be articulated within the assessment report. Unprocessed samples should be retained to allow further assessment/analysis as part of an iterative process of assessment.

Useful information that should be provided to specialists to facilitate an assessment includes:

- a brief account of the character and history of the site;
- the aims and objectives of the project;
- a summary of the archaeological results;
- context types and stratigraphic relationships;
- a list of samples;
- phasing and dating information;
- sample locations;
- preservation conditions;
- evidence of residuality/contamination;
- other relevant contextual information;
- some indication of quantity (number of boxes, flots, etc.);
- contact details of other project team members.

Although not all of these elements may be fully prepared at the time the material is sent for assessment, providing as much detail as possible will improve the quality of the information produced by the assessment report to address the aims and objectives of the project.

The assessment report should include:

- aims and objectives relevant to the project;
- a summary description of soil, sediments and stratigraphy, where relevant;
- sampling and processing methods (including mesh sizes for sieved materials);
- the assessment methodology;
- any known biases in recovery;
- any known problems of contamination or residuality;
- the quantity/volume of material (e.g. the number of samples, sample sizes and, in the case of zooarchaeological material, the total number of standard archive boxes of bone, and the number of these which have been assessed;
- a statement on the abundance, diversity and form of preservation;
- an assessment of the state of preservation of the material (condition assessment);
- a statement of the potential of the material to contribute to the project aims;
- a statement of potential to contribute to research topics of wider significance;
- comparisons with analogous sites of the same type or period, both regionally and nationally;
- recommendations of material suitable for scientific dating;
- recommendations for future work (analysis and publication);
- resources required for further work;
- recommendations for sampling and recovery in case of further excavation;
- recommendations for retention and discard, including details of temporary storage arrangements at the time of report writing.

## 5.4 Analysis and reporting on biological remains

The type and level of analysis required should be clear from the assessment report and UPD, as agreed by the project team. The report should state the aims in relation to the project design, methods, results and conclusions. Reports need to include clear statements of methodology, with the results of scientific analyses clearly distinguished from their interpretation. Non-technical summaries of results should be included, and the full data from the analysis presented. Access to data from other elements of the project will allow the production of an integrated report.

Analysis reports should include as a minimum the following sections:

- Summary of results (to assist with future signposting);
- Introduction;
- Aims and objectives;
- Methods;
- Results (including the full dataset, which can be included as supplementary data made available online and ideally in recognised data depositories);
- Discussion;
- Conclusion.

Each field of study will have its own reporting standards and accepted best practice, which should be considered by specialists when preparing reports.

Overviews and syntheses of the environmental results will generally be written by one of the environmental specialists involved in the project, in collaboration with other members of the project team. To avoid misinterpretation or technical inaccuracy, any integrated discussion incorporating specialists' results should be seen by the specialists who undertook the work. Contributions of this nature should be considered when estimating project costs.

## 5.5 Publication

It is essential that a report on any archaeological intervention should be lodged with the local Historic Environment Record as promptly as possible. This is necessary to inform future interventions and guide the local planning authority on future decision making. Environmental archaeology information should form part of this report, including any information on deposits and the preservation of biological remains.

The presentation of the full datasets in association with their interpretation should be in the main body of reports or provided as supplementary data. As a minimum, a publication needs to include the aims and objectives of the study, a basic description of the material, methods of analysis, interpretation of results, and sufficient data to support the conclusions drawn. Information of interest to specialists within a particular field of study, including illustrations of unusual or important material, should also be published, or, where this is not practical, full details of the location of the project archive and the biological remains (including museum accession numbers and digital object identifiers, DOI) must be included in the publication. The location of the archive should also be included, as should the scope and limitations of the study, its relevance to other research, and any recommendations for future work. Non-standard methodologies should be described and justified.

## 5.6 Archiving and data management

Biological remains, associated data and related documentation should all be incorporated into the overall preserved project archive, which will be deposited with the appropriate repository. The receiving museum should be contacted at the point of project initiation to discuss project archiving. All archive material should be stable and accessible, in line with published guidelines (Brown 2011; CIfA 2020; Perrin et al. 2014). The digital archive should contain original digital material, and digitised material selected from the working project archive, as well as further documentation (metadata) required to understand both the data and methodologies. Selection should distil the information, research and utility values of an archive into a manageable and cost-efficient archive, without compromising its scientific integrity (Oniszczuk et al. 2021), and be fully documented and indexed (Archaeology Data Service and Digital Antiquity n.d. 2020; Brown 2011, 18).

Data management strategies should be in place to ensure the integrity and trustworthiness of the data. CIfA guidance on data management and selection requires the utilisation of a project data management plan (see Dig Digital). Signposting, such as OASIS V, should be used to ensure data is findable. Use of standardised vocabularies enhances interoperability and reusability. To ensure data is FAIR, preservation files formats should be appropriate to the type of data and future-proof.

Archives of human remains are used intensively by researchers, so the retention of human remains for future research is key to mitigating the impact of development on ancient cemetery sites. Secular law is permissive towards retention of human remains in museums and other accredited archaeological stores, and public opinion is generally supportive of this. Storage should conform to existing standards (DCMS 2005). Ecclesiastical Law generally stipulates reburial.

No decision on the disposal of archaeological material generated by a project should be taken until an agreement is reached with relevant stakeholders. In such cases full details of the disposed material should be documented. The archiving of environmental material allows for the possible application of analytical techniques by future researchers, such as different forms of isotope analysis or ancient DNA analysis. As well as current research, it also allows for future improvement and refinement of these techniques.

In preparing the archive, specific material may be chosen for deselection and discard. Decisions on selection should be set out in the selection strategy and be reached as a result of consultation with relevant stakeholders. These processes should be fully documented. A summary of the archived data should include sufficient descriptions of what is in the archive as well as the fate of non-archived material (such as material that is retained in reference collections or disposed of), in order to enable future researchers to understand the completeness of the archive and decide whether or not the data is relevant to their investigation. Retainment in alternative locations to the main archive should be signposted with information on access provided. In England this may be particularly pertinent to material that requires specialist storage conditions, as the regional repository may not be able to provide these.

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