

English Version

Conservation of Cultural Heritage - Waterlogged
archaeological wood - Characterization of waterlogged
archaeological wood to support decision-making
processes for its preservation

Conservation du patrimoine culturel - Bois
archéologique gorgé d'eau - Caractérisation du bois
archéologique gorgé d'eau dans le but de soutenir les
processus de prise de décision concernant sa
préservation

Erhaltung des kulturellen Erbes - Archäologisches
Nassholz - Charakterisierung von archäologischem
Nassholz zur Unterstützung von
Entscheidungsprozessen für seine Erhaltung

This European Standard was approved by CEN on 2 March 2025.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Contents

Page

European foreword	
3 Introduction.....	4
1 Scope.....	5
2 Normative references.....	5
3 Terms and definitions.....	5
4 Aim of characterization.....	7
4.1 General	7
4.2 Characterization for preservation by recording.....	8
4.3 Characterization for <i>in situ</i> preservation and reburial	8
4.4 Characterization for remedial conservation.....	9
4.4.1 General.....	9
4.4.2 On-site characterization.....	9
4.4.3 In the laboratory.....	9
5 Sampling plans for characterization.....	9
6 Characterization methods.....	10
6.1 General	10
6.2 Wood species identification.....	10
6.3 Dating and tree ring analyses.....	10
6.4 Degradation profile.....	10
6.4.1 General.....	10
6.4.2 Physical and mechanical properties	10
6.4.3 Morphological alteration.....	12
6.4.4 Chemical properties.....	12
7 Data reporting.....	13
Annex A (informative) Common techniques applied to characterization of chemical properties of waterlogged wood.....	14
Bibliography	15

European foreword

This document (EN 18056:2025) has been prepared by Technical Committee CEN/TC 346 “Conservation of Cultural Heritage”, the secretariat of which is held by UNI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2025, and conflicting national standards shall be withdrawn at the latest by October 2025.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

1 Scope

This document provides guidelines for the characterization of waterlogged archaeological wood to support decision-making processes for its preservation.

This document can be applied for the management of wood discovered in waterlogged environments, including terrestrial and aquatic (marine and freshwater) sites, as a basis for designing conservation strategies (e.g. reburial, *in situ* preservation, post-excavation storage). In the case of composite artefacts made of wood and other materials, this document is applicable only for the wooden components. Methods for conservation, site protection and monitoring for reburial as well as *in situ* preservation are beyond the scope of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 15898, *Conservation of cultural heritage — Main general terms and definitions*

EN 16085, *Conservation of Cultural property — Methodology for sampling from materials of cultural property — General rules*

EN 16682, *Conservation of cultural heritage — Methods of measurement of moisture content, or water content, in materials constituting immovable cultural heritage*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 15898 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at <https://www.iso.org/obp/>

— IEC Electropedia: available at <https://www.electropedia.org/>

3.1

archaeological significance

combination of all the archaeological values and heritage interests to present and future generations, assigned to a find

3.2

basic density

quotient of the mass of the oven dry wood to the water-saturated volume of wood

3.3

collapse

permanent change to the shape of the wood cells due to the uncontrolled evaporation of the free water; this leads to deformation of the find that cannot be recovered upon remoistening of wood

3.4

conservation/preservation

measures and actions aimed at safeguarding tangible cultural heritage while respecting its significance, including its accessibility to present and future generations

Note 1 to entry: Conservation embraces preventive conservation, remedial conservation and restoration. It is important that all measures and actions respect the significance and the physical properties of the cultural heritage item.

3.5
reburial

systematic reburial of finds at the original excavation site (*in situ* reburial) or at another suitable location (*ex situ* reburial) in order to establish the original environmental conditions under which the object was previously well preserved as the base of a further preventive conservation strategy

3.6
degradation

result of the process of wood deterioration through physical, chemical and biological factors

3.7
hardness

material's resistance to penetration or indentation

3.8
in-situ preservation

maintaining finds in their original context whilst monitoring factors influencing degradation

3.9
moisture content

MC %

weight of water contained in the wood, expressed as a ratio to the oven-dry weight of the wood

Note 1 to entry: The maximum water content (MWC %) is a particular value of MC % that is reached when all wood structures (cell walls and cell lumens) are filled with water.

3.10
monitoring

process of collecting and assessing data pertaining to an object, its collection or its environment over time

3.11
pin test

subjective method to assess the penetration resistance (hardness) of an artefact by manually inserting a needle into the wood

3.12
preventive conservation

all measures and actions aimed at avoiding or minimizing future deterioration or loss and, consequently, any invasive intervention

Note 1 to entry: These measures are carried out within the context or on the surroundings of a find, but more often on a group of finds, whatever their age and condition. These measures and actions are indirect – they do not interfere with the materials and structures of the objects. They do not modify their appearance.

3.13
relative density

(synonymous specific gravity)

ratio of the density of the wood to the density of a given reference material, typically water

3.14**residual basic density**

ratio of the actual basic density of the wood divided by the corresponding reference value for the wood of the same species

3.15**remedial conservation**

actions applied directly to an object to arrest deterioration and/or limit damage

3.16**supporting capacity**

ability of the wooden archaeological find to support its own weight without breaking or crushing during lifting or transportation

Note 1 to entry: In case of reburial, this indicates the ability of the wood to support the weight of the reburial sediments.

4 Aim of characterization**4.1 General**

The aim of characterizing waterlogged archaeological wood is to support the development of a preservation strategy (see Table 1 and the flow chart in Figure 1).

Wood in waterlogged environments is degraded by a range of agents resulting in a loss of wood substance to a varying degree. It is therefore essential to obtain representative information on the state of preservation of the wooden remains, which can be variable. This information is critical in determining the vulnerability of the material and in providing a baseline against which future changes can be reliably measured.

Characterization can provide useful information to support:

- the decision-making process on the assessment of the archaeological or other scientific (e.g. botany, palaeontology, geology, paleobiology) value or significance of the find;
- the decision to be made on whether the wood should be preserved *in situ*, reburied, lifted for conservation, or preserved by recording only.

Characterization shall be developed in accordance with the site environment (e.g. underwater, terrestrial), archaeological context, sampling policies, type and size of finds and available time and resources. Whenever possible, characterization should be carried out soon after the discovery, as delays can reduce either its effectiveness and or its analytical potential. Qualified professionals with relevant expertise shall be involved as early as possible to design the analytical protocol to be carried out, including methods and sampling strategy, and for the subsequent implementation of characterization.

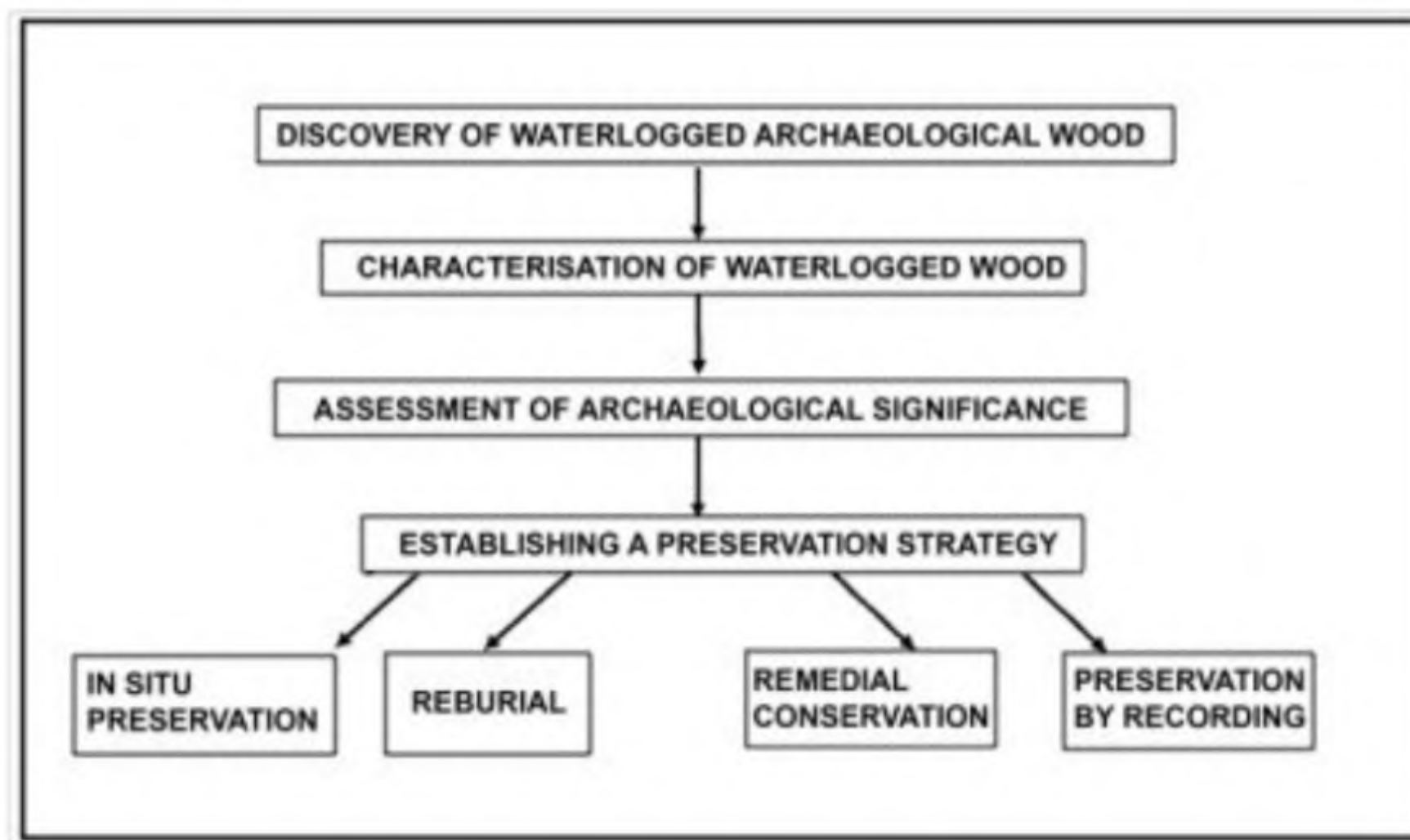


Figure 1 — Steps to a preservation strategy

4.2 Characterization for preservation by recording

Analysis of wooden remains can provide unique and significant information about material culture, economies, industries, buildings, and landscapes of the past. As a minimum the information listed below shall be recorded and archived to provide a permanent record (i.e. preservation by recording), when the condition of the wood allows:

- dating (tree ring analysis, isotope determination);
- documentation of tool marks and any evidence of working, shaping or surface coating;
- wood species identification.

It is recommended that the above documentation is supplemented with any other additional dendroarchaeological information gathered.

If the decision is made to dispose of the wood, considerations should be given to making the wood available for study and research.

4.3 Characterization for *in situ* preservation and reburial

The goal of both *in situ* preservation and reburial is to secure the long-term preservation of finds by monitoring and controlling factors that influence degradation in the burial environment. In these cases, the characterization process shall be focused on assessing the state of preservation and potential for further degradation of the wood during the reburial process and in the burial environment. To ensure the wood can be preserved the following shall be evaluated as a minimum:

- wood species identification;
- morphological alteration;
- moisture content or basic density;

- existing or permanent deformation;
- residual self-supporting capacity of the wood in the case of lifting and reburial;
- chemical characterization;
- burial environment.

4.4 Characterization for remedial conservation

4.4.1 General

When the preservation strategy includes remedial conservation, characterization shall be carried out either on site and or in the laboratory. Characterization on site is undertaken to assess the physical integrity of the wood, required to make decisions on the recovery / lifting method (see list of references). Characterization in the laboratory is undertaken to develop an appropriate conservation treatment. These assessments should be carried out in addition to those in 4.1.

4.4.2 On-site characterization

Waterlogged wood might appear to be in sound condition upon exposure but can be heavily degraded. In order to select the appropriate lifting technique, the physical condition and mechanical strength of the wood shall be assessed non-destructively on site by evaluating the following:

- surface hardness;
- presence of damages that affect structural integrity;
- self-carrying capacity (ability of the wood to support its own weight).

4.4.3 In the laboratory

The aim of characterization in the laboratory is to assess the nature of degradation and its extent and variability on samples taken from the site. In order to select an appropriate conservation treatment, the following shall be evaluated:

- physical properties characterization – (MC % and basic density);
- microbial degradation.

Furthermore, for a more complete understanding of wood degradation and for a better understanding of the potential effectiveness of the treatments and of the long-term stability of the wood, chemical characterization is also recommended.

5 Sampling plans for characterization

Sampling shall be carried out in accordance with EN 16085. The sampling plan shall be agreed on and coordinated between the stakeholders and decision makers. The sampling plan shall be designed taking into account the large variability within sites and find(s) and the needs of the preservation strategy adopted, ensuring the minimum removal of original parts from the find(s). When samples taken to establish archaeological value (e.g. dating) are available, their use for other types of characterizations is recommended.

Samples shall be taken where visual impacts are minimal and from locations which represent the range of preservation conditions of the find. Sampling shall be carried out by a qualified conservator or under their supervision.

During transport the samples shall be kept wet, and movement restricted to prevent mechanical damage. Finds immersed in water should be secured (e.g. by suitable wrapping) in order to avoid loosening or movement.

During storage samples shall be kept wet, at low temperature (optimum 3 °C - 6 °C) to maintain their physical stability in a container properly labelled with an identification code.

Sampling of wood shall be carried out before any kind of manipulation or the addition of substances, to avoid contamination that can influence the results of analysis. Similarly, particular attention shall be given to the constituent materials of instruments and containers used in the above-mentioned sampling operations.

6 Characterization methods

6.1 General

Characterization shall be carried out according to the sampling strategy and by relevant specialists. Sometimes more than one technique is available and selection shall be made to satisfy primarily the preservation requirements of the find. The characterization process shall consider the importance of wood variability (natural and degradation-induced inhomogeneity). Priority shall be given to quantitative information, taking cost-effectiveness of the process into account.

A summary of the characterization required according to the established preservation strategy is given in Table 1.

6.2 Wood species identification

The determination of the wood species of the find provides valuable information for assessing the archaeological and paleoenvironmental value and enables development of a preservation strategy. Identification is dependent upon the integrity and condition of the wood. It can be performed in successive stages from the macroscopic to the microscopic level, on site or in the laboratory.

Determination shall be made at the level of wood species or at the closest taxon possible. The identification report shall state the anatomical features used for identification.

6.3 Dating and tree ring analyses

Dating techniques and tree ring analyses are beyond the scope of this document.

Sampling for scientific dating usually involves a degree of intrusive damage, but this should be kept to a minimum, and the multipurpose use of samples is strongly recommended. The development of an appropriate sampling plan (EN 16085) will help balance the integrity of the object with the desirability of scientific dating.

6.4 Degradation profile

6.4.1 General

The degradation profile of waterlogged wood can be very heterogeneous between different finds at the same site or within the same object in the case of large finds.

6.4.2 Physical and mechanical properties

6.4.2.1 General

For this document the physical characterization is the assessment of the moisture content (MC) and density of the wood. Both density and MC have direct relevance in the development of preservation and conservation strategies, in particular, to prevent irreversible collapse or anomalous deformation of the wood find during uncontrolled or controlled drying.

6.4.2.2 Density

In waterlogged archaeological wood density is directly correlated with the degree of degradation and is reflected in material strength and maximum water content. A representative number of measurements is necessary to adequately map the variability in the state of preservation within each find.

With waterlogged wood basic density (dry weight / waterlogged volume) is the most common density measurement used. Basic density determination is a destructive test that requires sampling.

Basic density is expressed in terms of g/cm³ or Kg/m³ and shall be compared with the corresponding reference value for wood of the same species.

On samples or on small objects relative density (R) can be estimated non-destructively by measuring the wet weight in water (Ww) and the wet weight in air (Wa) assuming a standard density for water of 1 g/cm³ and a standard density for the wood cell wall of 1,5 g/cm³, based on the following formula:

$$R = 3 Ww / (Wa - Ww)$$

For an initial assessment of the state of preservation of finds in the field or in the laboratory, density can be estimated indirectly through the measurement of material resistance to penetration. Techniques include simple pin tests or instruments designed to measure wood hardness profiles.

For large objects, density values shall be plotted in a density map that provides a spatial visualization of the density variation throughout the object.

6.4.2.3 Moisture content (MC)

The moisture content (MC) of waterlogged wood at complete saturation reflects its state of preservation and is expressed as a percentage (MC % or MWC % (maximum water content)). The higher the percentage the greater the loss of wood substance and the potential for shrinkage and collapse.

The MC shall be established on a representative number of saturated samples. It can be measured by means of destructive or non-destructive techniques. The destructive gravimetric technique, using wet weight vs oven-dried weight, shall be carried out according to EN 16682. The MC can be measured non-destructively by determining the wet weight in water (Ww) and the wet weight in air (Wa) as follows:

$$MC_{max} = 100((Wa - 3 Ww) / 3 Ww)$$

If density values (R) are known MC_{max} can be calculated according to the following formula:

$$MC_{max} = 100(1,5 - R) / 1,5 R$$

In the case of destructive gravimetric determination, samples can be used also for measuring wood shrinkage and or collapse (6.4.2.4).

6.4.2.4 Shrinkage and collapse

Moisture removal in waterlogged wood can lead to a volume reduction, caused by collapse and shrinkage. Collapse occurs as the consequence of the uncontrolled removal of water from the cell lumens of wood where the degraded cell walls cannot withstand the surface tension of the water as it is removed from the cell lumens. Shrinkage is the normal behaviour of wood when moisture is removed from the cell walls and can show different intensity and behaviour in waterlogged wood.

When remedial conservation is being considered, shrinkage and collapse quantification shall be carried out in order to assess material behaviour and or treatment efficacy. Volume reduction is determined by measuring the difference between the waterlogged and the dried dimensions of the sample. Shrinkage and collapse quantification can be carried out by destructive testing that can require sampling or by using digital modelling.

6.4.2.5 Hardness

Material resistance to penetration (hardness) in waterlogged wood is an estimation of the degree of degradation, which is normally higher in the outermost layers. Determination of hardness depth profiles and or surface mappings lead to the assessment of the state of preservation of the wooden find. The large variability of degradation requires an appropriate number of measurements according to the dimension and complexity of the object.

Techniques are locally destructive and include the pin test or other instruments suitable to assess the hardness or density profiles in waterlogged wood.

6.4.3 Morphological alteration

The morphology of waterlogged archaeological wood is affected by abiotic and biotic processes. The morphological characterization provides information about the nature and extent of the alterations throughout the wood and shall be studied on both the macroscopic and microscopic level.

Macro-morphological characterization is carried out by means of visual observation of the wood. It provides information about the nature and extent of alterations by insects, molluscs, crustaceans, plants, etc., or changes caused by abiotic processes (e.g. presence of inorganic compounds, mechanical damages, incrustations).

Micro-morphological characterization is carried out at the microscopic level (including light and electron microscopy) and it requires sampling. It provides information about the nature of the alteration caused by microorganisms at cellular level (e.g. bacteria, fungi).

The morphological characterization shall provide information on the spatial distribution of the alterations and causative agents.

6.4.4 Chemical properties

Chemical analysis provides important information to establish the properties of the archaeological waterlogged wood, which in turn can help determine the nature and distribution of alterations, which can vary considerably. Chemical characterization covers organic polymers (e.g. cellulose, hemicelluloses, lignin, extractives) and both inorganic wood constituents (e.g. mineral, ash) and contaminants (iron and sulphur inclusion in particular).

The determination of organic components characterizes the state of preservation of the wood and provides information about the burial environment.

The contaminants shall be considered for their reactive effect on the preservation of the wood because such inclusions can cause further chemical degradation.

Chemical characterization is needed prior to the choice of remedial conservation treatment and post-conservation environments and for documenting the baseline condition for future characterization.

Characterization is used to identify alterations, qualitatively and quantitatively, to the chemical composition of wood. Qualitative results provide information on the presence and modification of the wood constituents. Quantitative results provide information on the amount of these constituents present. Each evaluation is carried out on the basis of comparison with analytical results obtained from fresh wood of the same species.

A list of the most common analytical techniques is given in Annex A, Table A.1.

Table 1 — Summary of the characterization required according to the established preservation strategy

Characteristics	Remedial Conservation (4.4)	<i>In situ</i> preservation (4.3)	Reburial (4.3)	Preservation by recording (4.2)	Archaeological significance (4.1)
Determination of wood species	Needed	Needed	Needed	Needed	Needed
Basic density /moisture content (6.4.2)	Needed	Needed	Needed	-	-
Morphological alteration (6.4.3)	Recommended	Needed	Needed	Recommended	-
Mechanical properties (hardness/pin test) (6.4.2.5)	Needed	Needed	Needed	-	-
Chemical characterization (6.4.4)	Recommended	Recommended	Recommended	-	-
Iron, sulphur and inorganic inclusions (6.4.4)	Needed	Recommended	Recommended	-	-

7 Data reporting

The report on each characterization shall contain the following information on:

- sampling procedure and samples according to EN 16085;
- the name of the institution(s) and of the person(s) who undertake the work;
- description of the method(s) applied.

Annex A (informative)

Common techniques applied to characterization of chemical properties of waterlogged wood

**Table A.1— List of the common techniques applied to characterization of chemical properties of
waterlogged wood**

Method	Cellulose	Hemicellulose	Lignin	Inorganic
FTIR (Fourier-transform infrared spectroscopy)	*	*	*	*
Raman spectroscopy	*	*	*	*
TAPPI STANDARD (Quantitative only)	*	*	*	*
¹³ C NMR (Nuclear magnetic resonance)	*	*	*	N/A
XAS (X-ray absorption spectroscopy)	N/A	N/A	N/A	*
EDX (Energy Dispersive X-ray Spectroscopy)	N/A	N/A	N/A	*
XRD (X-ray diffraction)	*	N/A	N/A	*
Key N/A – not applicable * – applicable				

Bibliography

- [1] EN 16873:2016, *Conservation of cultural heritage — Guidelines for the management of waterlogged wood on archaeological terrestrial sites*
- [2] EN 17652:2022, *Cultural heritage — Assessment and monitoring of archaeological deposits for preservation in situ*