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Revision of the EUNIS inland surface water habitat group: finalisation of level 3 and outlook to level 4

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Summary

The EUNIS habitat classification is a comprehensive and extensive pan-European reference system to harmonize and facilitate the description and collection of data across Europe through the use of criteria for habitat identification. It was developed by EEA and ETC/BD and its predecessors in 1995, with the version in use until 2011 little changed since the publication of Davies et al. (2004). Following a workshop held at the EEA in 2011 it was agreed to revise the classification to take into account both experience with using the classification and new information and knowledge. The revision of EUNIS started with terrestrial and marine habitats, the revision of inland waters only started in 2016 and was elaborated since. This elaboration of the inland water habitat group classification has established these habitats at level 3.

Several steps have been undertaken to elaborate the EUNIS inland water habitat group classification and a wide audience of experts was engaged at appropriate intervals during the revision process. The process started with a scoping study in 2016 that was followed by a 1st expert workshop in Paris in 2018. An EIONET consultation was organized in 2019 which generated comments and an outlook for further steps to be taken. This EIONET consultation was followed up by an EIONET webinar in 2020 and a 2nd expert workshop in 2021. A team consisting of EEA, ETC/BD and ETC/ICM had the lead in the whole process and prepared all the next steps to be taken as well as interim reports from all the meetings.

From the start of the process it was decided that an alignment with the existing broad types derived from the Water Framework Directive intercalibration types would be followed with information on biological communities coming from a variety of sources but mainly the intercalibration reports and the WISER database. However, also from the beginning, it was apparent that the large Water Framework Directive lakes and rivers were not sufficiently covering the smaller lakes and rivers representing a large part of the aquatic biodiversity in Europe. Therefore the final list of EUNIS level 3 running and standing waters includes – besides modified Broad Type running and standing waters – also smaller and rare aquatic habitats which considerably contribute to biodiversity in Europe. The current report includes the final list of level 3 standing waters (22 types) and the final list of level 3 running waters (26 types).

Although a floristic approach was considered appropriate for the revision of EUNIS terrestrial habitats, which are largely defined by their vegetation, a different approach was needed for EUNIS inland waters. These habitats are characterized by more groups of organisms, like e.g. macroinvertebrates, fish and algae and therefore required a new methodology to link the biological data to the EUNIS inland waters. This report describes the methodology and the sources for extracting biological information to be linked to the level 3 standing and running waters, but not the biological information as yet. This is ongoing work and needs further elaboration in 2023.

1 Introduction

1.1 Background to the EUNIS habitats classification and its revision

The EUNIS habitat classification is a comprehensive and extensive pan-European reference system to harmonize and facilitate the description and collection of data across Europe through the use of criteria for habitat identification (Davies and Moss 1999; Davies et al. 2004; Moss 2008, Rodwell et al. 2018). It is hierarchical, as shown below (Fig. 1), and covers all types of habitats from natural to artificial, from terrestrial to freshwater and marine. Levels 1 to 3 are highly aggregated types usually occurring across a wide geographical area, often all of Europe, while levels 4 and lower are usually more narrowly defined and occur at regional scales. This hierarchical structure is currently not achieved in the classification of inland surface waters of 2012. EUNIS Habitat types are crosslinked with habitats from other typologies like the Annex I habitats of the Habitats Directive, the European Red List of habitats and the Corine Land Cover classes. Unlike the EUNIS system, the Annex I habitat and Red List of habitats are lists of habitats forming a flat typology rather than being hierarchical in nature. The Red List is a modified EUNIS with the habitats assessed all from level 3 (freshwater & terrestrial) or 4 (marine). The EUNIS system aims to allow for any habitat to be appropriately placed at some level within the system; though some habitats could fit under more than one habitat groups, they are placed in the group that is deemed more appropriate.

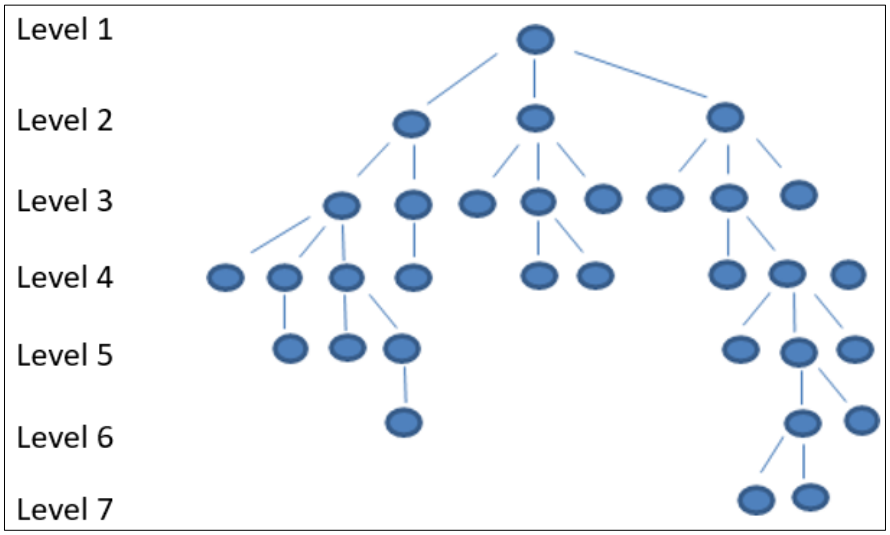

Figure 1: Indicative example of hierarchical structure of EUNIS habitat classification

Since its creation, the EUNIS system has had only minor changes from 2004 to 2011. Support to policy was a motivation for the initial work (1995 onwards), rationale for the full revision was more an awareness that the classification could be improved and this led to an initiation of this revision with a meeting held at the EEA in 2011. The 2004 terrestrial section was already linked to syntaxa so link to in situ data was already possible. An advantage was that an extensive review of the EUNIS habitat classification could be used to support European policy on nature conservation with harmonised habitat descriptions ideally underpinned by field data. For the approaches used to revise EUNIS habitats for different habitat groups see Box 1. The various habitat groups (11 in total), have been addressed one by one through consultations with EIONET (European Environment Information and Observation Network) and external experts. Some revised groups have been published in Chytrý et al. (2020) and to some extent all groups are dependent on revision of the others. Whereas a floristic approach was considered appropriate

for terrestrial EUNIS habitats, which are largely defined by their vegetation, it was agreed that a different approach was required for the marine and freshwater habitats (Box 1).

Box 1: Approaches used to revise EUNIS habitat classification

The EUNIS classification has been revised down to level 3 (level 4 for marine habitats) through three different approaches:

1) **Floristic approach** (main approach for terrestrial habitat types but also used in some marine and inland water types)
2) **Abiotic approach** – **substrate/depth zone/marine region** (the main approach for marine benthic types)
3) **Abiotic approach** – **altitude/catchment size/geology/depth/flow** (main approach for inland water types)

Most of the habitats can be separated and identified by biological features (characteristic species or species groups for habitats following approach 1) at level 3 or 4.

In an entire ecosystem, such as a river system, a coastal area or a wetland, the relevant component habitat types may have been revised through one, two or all approaches. It is necessary to look at many elements in order to have the full systemic perspective. For example:

- For a river ecosystem, it would be necessary to select river type, from *inland water* group, flood plains from the *habitat complexes* group, gravel bars from the *sparsely vegetated habitat* group and, depending on the extent to which the ecosystem is being looked at, estuaries also from the *habitat complexes* group. A floodplain habitat might also include grassland habitats in the floodplain from the *grassland habitat* group and the alder forests from the *forest habitat* group.

- For a delta ecosystem, it may be necessary to select bog habitat (e.g. calcareous fens) types from the *wetland habitat* group, forest types (e.g. *Salix alba* and *Populus alba* galleries) from the *forest habitat* group, grasslands from the *grassland habitat group* and ponds, pools and very small lakes and lowland rivers and streams from the *inland water habitat* group.

1.2 Background to the EUNIS revision of inland waters

The revision of terrestrial habitats made extensive use of phytosociological data, which are available from initiatives such as the European Vegetation Archive (EVA, Chytrý et al. 2016, http://euroveg.org/eva-database). Such data can be also useful for inland water types as can be seen below (Figure 2). Relevés for standing (18 170) and running (8 847) waters, as well as helophyte vegetation (46 328) from the littoral zone are included and available in the EVA database (maps generated based on data points from November 30th 2020). However, as most typologies of rivers and lakes in Europe do not use floristics as the main discriminating factor, it was decided to look into other existing European typologies that could be used as the starting point, such as the Water Frame Directive types, which are based on a limited number of abiotic discriminating factors (Lyche Solheim et al. 2019). As a broad typology derived from the WFD common intercalibration types for lakes and rivers was also being developed (ETC/ICM 2015,

Lyche Solheim et al. 2019), it was decided to investigate the potential for aligning those Broad types with the EUNIS revision.

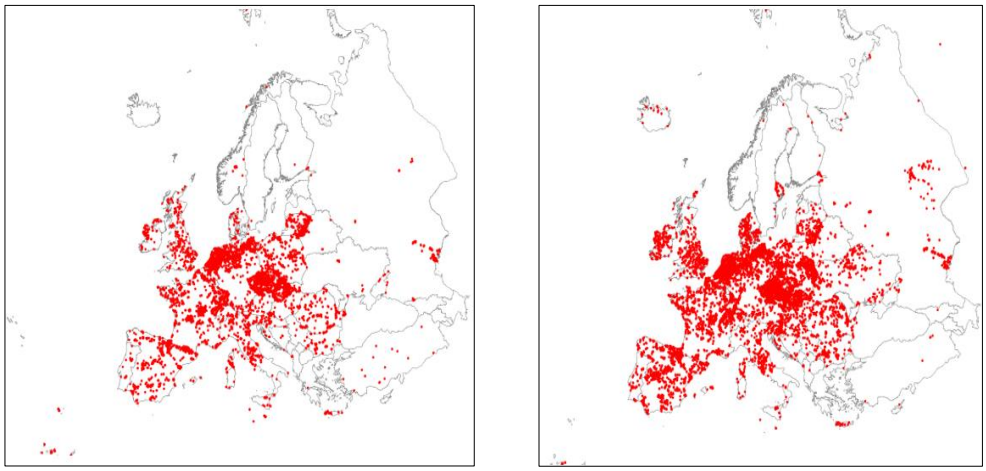

Figure 2: **Relevés for standing and running waters (left) and helophytes (right), extracted from the EVA November 30th 2020. 18,170 for standing and 8,847 for running waters, as well as 46,328 relevés for helophyte vegetation in the littoral zone. Maps generated based on data points from November 30th 2020**

Various additional data sources are available to describe the biological communities of each habitat e.g. the EVA database for vegetation, WISER database for species level information (phytoplankton, macrophytes, benthic invertebrates, fish), and the numerous Intercalibration Technical Reports under the Water Framework Directive with biological information based on a specific water body type e.g. a highland, deep, calcareous lakes in the Alpine region. Many intercalibration reports describe other water body types, including (but not exclusively limited to): Solimini et al. 2014, Gassner et al. 2014, Pall et al. 2014, Wolfram et al. 2014, Portielje et al. 2014 Böhmer et al. 2014, Sandin et al. 2014, Hellsten et al. 2014, Olin et al. 2014, Lyche Solheim et al. 2014, Kelly et al. 2014, Birk et al. 2018, Borics et al. 2018.

Using the discriminating factors from the broad types allows links to be made with Habitat Directive Annex I habitat types (i.e. through the relationship between alkalinity and trophic state referred to in the Annex I descriptions). To further describe lower level inland water habitats, the European Red List descriptions can be used as a basis. There is already a strong relationship between the Red List and EUNIS, and the Red List types will be linked to the broad types via EUNIS. These linkages in typologies further connect EU nature and water policies.

It is important to note that while the proposed EUNIS structure at level 3 is based on the broad types, the broad types do not cover all water body types. As all habitat types need to be acknowledged in the EUNIS system, the proposed level 3 is a combination of the broad types, previous EUNIS types not included in the broad types and additional types as a result of discussions in a webinar (ETC/BD et al. 2021a) and workshop (ETC/BD 2021b). An important component of the inland water habitat revision was recognising the 'complex' nature of this habitat group and how habitats normally considered as part of the wider inland waters ecosystem are actually classified under other habitat groups (further described in other sections below).

The aim of the classification is to have a wall-to-wall classification where all inland water habitat types can be placed. The habitats are separated based on abiotic features and identified by biological groups (characteristic species or species groups) at level 3. If information is available,

further discrimination based on additional abiotic factors can take place to lower levels. This document details the revision to level 3.

The level 3 and 4 types were developed with their abiotic descriptions throughout 2021 and 2022. While it was anticipated that the classification would be developed to level 4, as for EUNIS marine habitats, it became clear in 2022 that this was an ambitious undertaking for the time period and resources involved and so a decision was taken in to limit the final classification to level 3 with a view to mobilising additional resources needed to continue the work beyond 2022. As a result of this decision, level 3 was described more extensively.

1.3 Principles of the revision of the EUNIS inland waters classification

The principles on which the EUNIS inland waters classification was based were developed specifically for this group due to the unique nature of the inland waters ecosystem and the relationship between these habitats and other habitat groups within the EUNIS classification system. The starting point of developing a system of classification was to investigate if the Broad Types and their underlying factors could be used as a basis for the revision. There was agreement to use geology (related to alkalinity) as a proxy for trophic state and where trophic status is referred to in the EUNIS system, it is the natural trophic state of the habitat. This proxy was based on the relationship between total phosphorus (natural trophic state) and alkalinity in reference lakes (Lyche-Solheim et al. 2006, 2008, Phillips et al. 2013, Bennion and Simpson 2011; see also Annex 2 of this report). This allows a link between the revised EUNIS habitats and the HD Annex I habitat types. This means that the habitat is described in its natural and unimpacted condition and biological communities describing the habitat type should reflect the reference condition of the habitat. Also, the other discriminating factors, altitude and - for running water bodies catchment size – were initially agreed. A complete alignment with the Broad Types would overlook the smaller water bodies however, which are also important for aquatic biodiversity, as well as a number of other, more specific or rare aquatic habitats of international value. Therefore, temporary and saline lakes, temporary and tidal rivers and ponds, pools and very small lakes were added as separate water body types. The following principles were agreed for the proposed EUNIS inland water revision:

1. To broadly align the EUNIS inland waters at level 3 with the Broad Types developed from Lyche Solheim et al. 2019, which are derived from the intercalibration types of the Water Framework Directive.
2. To cover other inland water habitats by adding further types where the Broad types do not cover water body types identified in the countries.
3. To add smaller water bodies and other rare types that are not covered by the broad types.
4. To refer to the natural trophic status when the term “trophic status” is being used.
5. To use geology (alkalinity) as a proxy for trophic state as a parameter to describe the water bodies’ natural (pristine or unimpacted) state.
6. To capture differences in all biological communities, not just vegetation, where there is a clear difference in at least one part of the taxonomic assemblages (e.g. fish, benthic algae, macrophytes, macroinvertebrates, phytoplankton, zooplankton), this may constitute a different habitat.
7. Where reference is made to trophic status, it is the natural trophic state of unimpacted water bodies.

1.4 How to read this report

This report describes the different steps that were undertaken to develop level 3 of the EUNIS inland waters and will address issues with developing level 4 and how to approach this in the future. Section 2 summarises the stepwise development of the revised EUNIS inland waters including the main workshops (expert and internal), webinars and consultations that were undertaken to develop both levels 3 and 4. Section 3 describes the current state of level 3 of the inland waters. Section 4 describes the limitations and issues encountered. Section 5 presents perspectives for future work. Sections 6 and 7 provide a glossary and list of references for this work. The final list of level 3 habitat types for both standing and running surface waters is shown in Section Final list of level 3 types', a summary of the outcome of the EIONET webinar in Annex 1 Outcome of EIONET Webinar for standing and running waters' and the outcome of the EUNIS aquatic habitats expert workshop is in Annex 2 Outcome of the EUNIS aquatic habitats expert workshop'.

2 Stepwise developing level 3 of EUNIS inland waters

The following section provides an account of the revision of EUNIS inland water from 2016 to present. The main workshops and meetings are described, four of which resulted in a report or technical document (Figure 3).

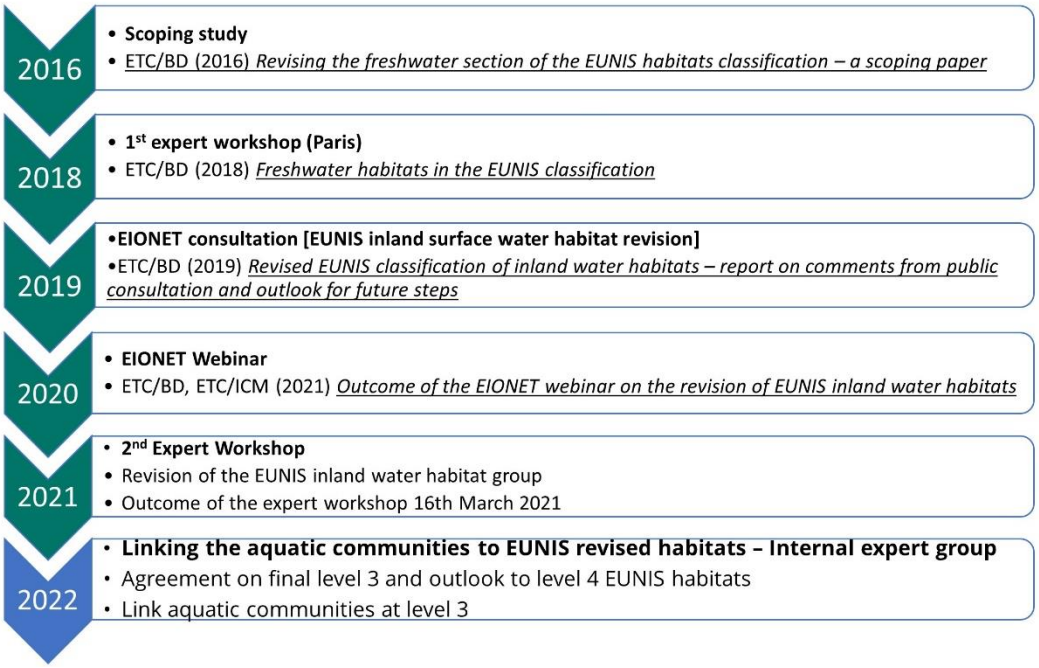

Figure 3: Timeline of revision of EUNIS inland water habitat group

2.1 Scoping paper

The review of the inland waters group began in 2016 with a scoping study to compare the current EUNIS system with other European typologies: European Red List of habitats, Annex I habitats under the EU Habitats Directive and the Broad Types derived from the Water Framework Directive (ETC/BD 2016). The freshwater scoping study (ETC/BD, 2016) describes and discusses several typologies as they are in use for freshwater habitats across the European Union. These include the EUNIS (2012) aquatic habitat classification, the list of habitats on Annex I of the Habitat Directive, the Water Framework Directive typology for freshwater habitats and the EU Red List habitat project typology. The freshwater scoping study (ETC/BD, 2016) also presents a crosswalk between WFD, HD and EUNIS (2012) aquatic habitat types based on the work of the Freshwater Group of the EU Red List habitat project and the EU broad lake and river typology published by ETC/ICM (2015).

The typologies described for freshwater habitats differ in their approach. The EUNIS (2012) freshwater and WFD typologies are both hierarchical systems. However, the abiotic conditions used in both typologies differ from each other. The EUNIS system is focused on trophic status, while the WFD broader typology considers alkalinity and calcium as the most important and determinant factors. In contrast, the Habitat Directive does not apply an abiotic approach but

instead defines habitat types covering a selection of habitats that are of specific conservation value at the European level. Those habitats are mostly taken from the CORINE biotopes typology. The EU Red List habitat project typology integrates modified EUNIS habitats with the Habitat Directive habitat types.

Also, from a floristic and phytosociological point of view, the typologies differ in their approach. EUNIS and the Habitat Directive are based on a phytosociological approach. EUNIS operates at the level of vegetation alliances. Many habitats in the Habitats Directive (ca. 60 % as suggested by Rodwell et al., 2018) are based on phytosociological units as well, mainly at the level of alliances and associations. The WFD is not based on such a phytosociological approach, but floristics are used to characterise units based on abiotic factors. Characteristic macrophyte species (in some countries derived from characteristic plant communities) are deduced for the reference class for each WFD type. These characteristic species are quantified in metrics for the different WFD types. Some countries have chosen the approach of macrophyte metrics including characteristic species as well as species indicating deterioration of the habitat. The EU Red List considers phytosociological alliances.

The broad types of rivers (20) and lakes (15) (Lyche Solheim et al., 2019) were based on data provided under the WFD. They are based on the discriminating factors, altitude, size and geology, as well as mean depth for lakes (Lyche Solheim et al. 2019). The broad type description and how they can be related to both EUNIS and the freshwater habitats of Annex I of the EU Habitats Directive is outlined in ETC/ICM 2015.

The freshwater scoping study concluded with a number of recommendations (not in order of priority):

1. The EUNIS river habitat types need better definitions and it was recommended to refine the classification system and add missing river habitats (e.g. mid-altitude river types); this can be achieved and underpinned by the databases collected and connected. The Red List project did not optimize the EUNIS river habitat types.
2. A second priority was to explore how the EUNIS level 3 habitats could be linked to the EU common intercalibration types. These common intercalibration types are more specific than the broad river and lake types and are more similar to EUNIS level 3 habitat types. However, a first glance at this shows this might work for lakes but not for rivers. Therefore, the EUNIS river habitat types first need more specification and it is recommended to refine the classification system for the rivers.
3. At the European level, it was recommended to explore if the EUNIS types could benefit from floristic and vegetation descriptions and data from WFD and HD typologies. In line with the former work on forests (2013), tundra, heath and shrublands (2014), and grasslands (2015-2016), a project to couple and underpin the EUNIS aquatic habitat types with the European vegetation data at the level of alliances was recommended. Important input for this will be provided by the EC Red List project on habitat types.
4. The EUNIS level 3 river habitat types, that are too broad, were recommended to be divided into more specific river types, e.g. habitat C2.3 could be split up in upper, middle and lower river stretches and described in types at the EUNIS level 3. Here EUNIS can benefit from the WFD typology.
5. The more specific EUNIS level 3 habitats that cover rare and rather unique habitats could be linked to specific habitats of EU Member States, as these habitats are specific and often limited to one or two EU Member States. Therefore, it is expected that these definitions can be improved using information at the national level, e.g. information from the HD.

The scoping paper proposed that a small working group would be the best way forward and this approach was also approved by a joint meeting between the EEA, ETC/ICM & ETC/BD on 24 February 2016 to discuss freshwater biodiversity related issues.

Following the recommendation to organise a workshop with experts, this was held at the ETC/BD in Paris on 3 and 4 May 2018 to discuss the principles to follow for revising the freshwater section of EUNIS (see 2.2 below).

2.2 First expert workshop in Paris

Based on the scoping study above (2.1), a first workshop was held in 2018 to take a further look at how the current EUNIS system could be represented based on the typology factors used for the Broad Types (ETC/BD 2018). This took place at the Museum National d'Histoire Naturelle (MNHN) in Paris and participants representing ETC/BD, ETC/ICM and EEA. Two independent experts were present to give a wider geographical coverage of expertise.

The workshop participants agreed upon the main distinguishing factors to be applied in the EUNIS classification for European lakes and rivers at levels 1 to 3 following the underlying factors for the Broad Types.

- Level 1 to represent 'Inland surface waters'.
- Level 2 to have two classes – lakes and rivers, as for the Broad Types.
- It was agreed that level 3 was the level where the classification becomes aligned with the Broad types. It was proposed that level 3 will be primarily based on combinations of three factors which reflect the national classifications reported under the intercalibration types (see tables 1 and 2 below).
- It was agreed that level 4 was the level where biological information is described in the EUNIS classification.

Level 3 also needed to include temporary and saline/brackish water bodies i.e. types that were not covered under the Broad Type system.
The habitats in the third group at level 3, 'C3 Littoral zone of inland surface waterbodies', were discussed and it was agreed these should be allocated to the relevant place at level 4.

Table 1: The discriminating factors for consideration at level 3 for standing waters

Factor	Divisions
Geology (of catchment)	Siliceous (< 1 meq/l alkalinity or < 20 mg Calcium/l)
	Calcareous (> 1 meq/l alkalinity)
	Humic (= dystrophic, organic or peaty waters with colour > 30 mg Pt/l, or natural TOC > 5 mg/l)
Altitude	Lowland (below 200m)
	Mid altitude
	Highland/alpine (above tree line)
Size & depth	Small very shallow < 1km^2 & < 3m average depth (unstratified)

	Medium to large very shallow 1 – 100 km^2 & < 3m average depth (unstratified)
	Small shallow or deep (<1 km^2 & > average 3m depth), stratified in summer
	Medium to large , shallow or deep (1 – 100 km^2 & > 3m average depth) (stratified in summer)
	Very large lakes (>100 km^2), shallow or deep and normally stratified
Saline & brackish	Salinity > 0.5 PSU
Temporary	calcareous
	siliceous
Glacial	Turbid lakes due to inflow of glacial meltwater in summer

Table 2: The discriminating factors for consideration at level 3 for running waters

Factor	Divisions
Altitude	Lowland (< 200 m)
	Mid-altitude
	Highland (above treeline)
Geology (of catchment)	Siliceous
	Calcareous & mixed
	Humic
Catchment size	Very small - small (<100 km²)
	Medium - large (100 – 10 000 km²)
	Very large (>10 000 km²)
Temporary	Added as a general category
Tidal	Added as a general category
Glacial	[Turbid mid-altitude or highland rivers with glacial meltwater in summer]
Clay-influenced	[Turbid lowland rivers draining clayish soils]

2.3 EIONET Consultation

A proposed structure was put to public consultation in 2019, the outcome of which was a clear desire to further look at the proposed structure and the factors used to discriminate at level 3 (ETC/BD 2019). In preparation for an EIONET consultation of the proposed revision of the EUNIS classification for inland waters with experts, the recommendations for discriminating criteria from the Paris workshop were further modified by experts from ETC/BD, ETC/ICM and EEA.

A consultation was organized in the period from 10 May 2019 until 23 June 2019 and extended until 30 June 2019. In total, 14 comments were received for the running surface waters, while 23 comments were received for the standing waters.

As noted in section 2.2, the proposed EUNIS classification of inland water habitats (level 1) included standing and running waters at level 2, while level 3 further divided the standing and running waters into habitats based on physio-chemical parameters such as size, altitude and geology (the latter reflects the natural trophic status). It was planned to base level 4 on parameters such as depth, stratification (lakes) and slope (rivers) with species composition as a discriminating factor included in levels 5 to 6. This proposed revision did not have as starting point the EUNIS (2012) classification of inland water habitats that incorporates parameters such as nutrient status, flow and biological communities at level 3. Therefore, and in most cases, the crosslinks to the EUNIS (2012) inland water habitats were not a 1:1 match and there were cases where there was no crosslink at all. The proposed revision aimed to align with the Broad Types developed to help with the implementation of the Water Framework Directive.

The consultation revealed that experts were missing important information on the proposed discriminating factors intended to be used, both for the standing and the running waters. Therefore, the linkage of the water types to biology and communities, originally not foreseen at level 3, was seen as an omission by the stakeholders who commented. For lakes, the comments were mainly related to these missing factors and to the linkage with biology, but also to size issues, missing types and how to link to shore and helophyte vegetation. For the river classification, many of the commenting experts proposed alternative discriminating factors to consider. In their view, these were (more) meaningful for aquatic communities, instead of the currently used altitude, size and geology. Factors seen as more important for aquatic communities were gradient, stream order and velocity (flow); channel types; ecological relations to the adjacent floodplain; substrates; and flow stability. These suggestions were not small changes and would require a re-consideration of the discriminating factors. It was clear from the comments, that the experts who participated in the consultation did not fully support either the river or lake classification.

Based on the outcome from this consultation, the recommendation was to organize a further workshop but this time including European EUNIS, WFD and HD experts. The intention of the workshop was to be multi-disciplinary and include experts from several fields of expertise (aquatic ecologists, phyto-sociologists, vegetation ecologists, stream and lake specialists). It would also include representatives from different regions of Europe. The overall aim was to discuss and provide recommendations for the factors underlying a classification of lakes and rivers in Europe.

As a precursor to this workshop, an EIONET webinar was organized in 2020 (see section EIONET NRC Webinar) and a workshop for final expert discussions to guide the finalisation of the revision took place in March 2021 (see section Second workshop with EUNIS aquatic habitats experts).

2.4 EIONET NRC Webinar

Due to Covid 19 and travel restrictions, the expert workshop was delayed in the hope of holding an in-person meeting in 2021. An EIONET webinar was held on 8th December 2020 to further explain the proposed structure and to establish if and how EUNIS is used in the EIONET countries (ETC/BD 2021). The aim of this webinar was to discuss the revision of the EUNIS Inland waters on key aspects of the proposed revision and to get further direction in order to conclude on the revision. More specifically, the aim of the webinar was to gather additional comments and

further information to complement those received during the EIONET consultation of May 2019 (ETC/BD, 2019).

Table 3: The countries that were represented through an Eionet NRC or an inland water expert are shown below

Austria (AT)	Netherlands (NL)
Switzerland (CH)	Latvia (LV)
Germany (DE)	Romania (RO)
Spain (ES)	Serbia (RS)
France (FR)	Turkey (TR)
Iceland (IS)	Kosovo (XK)
Italy (IT)	

Also ETC/BD, ETC/ICM and EEA were represented in the webinar participants. The webinar participants discussed the EUNIS (2012) structure of the inland surface water habitats and the proposed new structure of the revised inland water habitats group (Fig. 4). The outcome of the discussions in the EIONET webinar have been summarized for standing and running waters (Annex I). The webinar participants agreed on a number of issues but also a number of topics were touched upon and needed further decisions later on (Annex I).

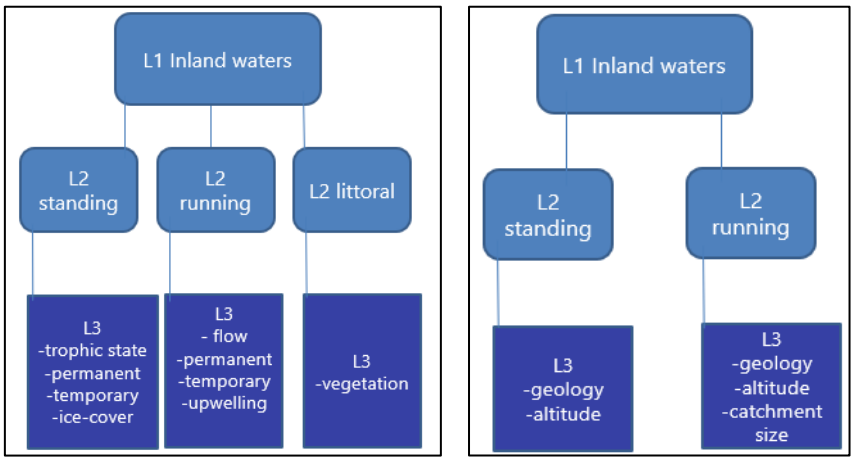

Figure 4: The current (2012; left) and proposed (right) structure of EUNIS level 3 inland waters

The overall response for both standing and surface waters was positive for both level 3 and the approach for level 4 (outlook). Additionally, it appeared that most participating countries already had a typology in place that could be linked or partly linked to the proposed EUNIS classification:

- 40 % of participants said their national typologies were linked to or inspired by the EUNIS classification.
- 77 % of participants thought the Broad type approach is a useful basis for the inland water revision, based on expanding the number of habitat types and adding more abiotic factors.

- 75 % of participants agreed that a revision of EUNIS inland waters was possible based on the proposed structure (abiotic factors at level 3 and additional abiotic factors including biology at level 4).
- 86 % agreed that the proposed typology could be linked to their current national typology (either fully or to a certain extent).

This webinar presented an opportunity to extend the discussion on the proposed revision well beyond the responses received during the 2019 consultation. Additional water body types were recommended for inclusion, workable solutions to the more contentious issues (e.g. the inclusion of biogeographic regions as a discriminating factor) were presented and a broader insight was gained from country specific perspectives.

The outcome of the EIONET webinar was very fruitful and was used as a basis for further discussions in the expert workshop that was held in March 2021.

2.5 Second workshop with EUNIS aquatic habitats experts

A virtual workshop on the revision of the EUNIS inland water habitat group of the EUNIS habitat classification was held on 16 March 2021 and was organised by EEA and ETC/BD with support from ETC/ICM. The aim was to further discuss the proposed revision of level 3, to help clarify the discriminating factors used at level 3 and to discuss further biotic and abiotic discriminating factors to be used at level 4. The conclusion of this discussion was needed in order to proceed with the final revision and based on the outcomes of the workshop the revision was further progressed with. The results of the earlier EIONET consultation and the EIONET webinar served as an input to this aquatic habitat expert workshop.

A range of experts covering areas of inland water expertise were invited to the workshop. These experts covered the expertise in particular for habitats and biological communities, the Habitats Directive and/or the Water Framework Directive or both. Eventually, 18 external experts, apart from the organising team were available to participate in the workshop. These experts were from 12 countries and 16 different universities and national environmental agencies across Europe, spanning most geographical regions.

Annex 2 presents the outcome of the discussions for running and standing waters in more detail. Despite the different approaches and proposals, a consensus was reached among the experts on a number of important topics highlighted below:

- **inland water habitats should be considered as complexes** or can include 'complexes' if these include aquatic habitats (this to distinguish from the group of habitat complexes in EUNIS). Examples are floodplains and braided rivers. For the standing waters this meant they include the surrounding shores. For running waters it meant they include the adjacent floodplains. The shores and floodplains can be described in terms of aquatic habitats and habitats from other habitat groups. E.g. a floodplain might include the oxbow lakes, being aquatic, but also the grasslands in the floodplain from the grassland habitat group and the alder forests from the forest habitat group. Braided rivers will be kept as a part of the inland water habitat group. They will be described at Level 4 or lower. They are part of the floodplain habitat as described above. However, it was to be noted that this would mean somehow incorporating the former C3.3 group of littoral zone habitats that were discarded as a separate group in themselves due to issues with the scale they represent in the wider freshwater ecosystem.

- **pools and ponds were to be kept as a separate group at level 3**: the exact size category for these small water bodies was to be decided later.
- **altitude:** timberline was decided as a more appropriate delineation of high-altitude and high-latitude waterbodies rather than the tree-line. 200m was decided as the most appropriate delineation between low-mid-altitude water bodies.
- **temperature:** would not be used as a separate discriminating factor.
- **geology (i.e. alkalinity)**: to be retained as a discriminating factor at level 3 as the relationship between total phosphorus (natural trophic state) and alkalinity has been shown in reference lakes (Lyche-Solheim et al. 2006, 2008, Phillips et al. 2013, Bennion and Simpson 2011). This relationship allows a link between the revised EUNIS habitats and the Habitat Directive Annex I habitat types. The positive relationship between alkalinity and total phosphorus may not apply to all Mediterranean waterbodies. Therefore, the system should enable these types to also be reflected either as a separate type at Level 3 or a sub-type of calcareous lakes at level 4.
- **additional lake categories:** added to the EUNIS standing waters, namely marl / karstic lakes and volcanic lakes.
- **indicator species:** namely *Isoetids,* these are indicator species that are sensitive to eutrophication and should be kept as aquatic vegetation and described in the inland standing water habitats.
- **helophytes**: to remain in the wetland habitat group. As the aquatic habitats are considered as complexes, a reference can be made to the helophyte habitats when describing these complexes.
- **flow/stream power:** experts acknowledged that stream power or flow should be considered in the running water habitats. Stream power is based on modelling and is not available at the European scale as yet. Flow is foreseen to be included at level 3 in terms of pool, riffles and run habitats. The placement of these very fine scale habitats in the classification system was a point of discussion. Reference was made to Rinaldi et al. (2016) suggesting a system based on basic river typology (BRT) and extended river typology (ERT). It was decided to further analyse this concept in more detail in relation to describing level 4.
- **regions:** it was decided not to include the Mediterranean region separately if temporary and saline aquatic habitats are distinguished at level 3.
- **gravel bars:** were to be moved to the EUNIS group U 'Inland habitats with no or little soil and mostly with sparse vegetation', due to the fact that vegetation occurring on a gravel bar is not aquatic and therefore cannot represent an aquatic habitat. This habitat can, however, be linked to inland water habitats in the habitat descriptions.
- **reservoirs:** were deleted from the standing waters. It was originally planned to distinguish between 'natural' reservoirs and completely constructed ones. While this distinction can be kept, the term 'natural' should not be used and they should just be described as 'lake/waterbody used as a reservoir'.
- **'humic lakes on calcareous bedrock'**: during the webinar this water body type was discussed and it was concluded to merge it into 'Calcareous/mixed including humic', as being calcareous was considered more ecologically important than being humic. Moreover, a calcareous and at the same time humic water body is quite rare in Europe. However, later on in the process, in September 2022, we reversed this decision.

In general, new ideas and concepts were discussed in terms of alternative or additional discriminating factors at both levels 3 and 4 which may be more appropriate or provide added

value. In some cases, it was found that suggested factors (e.g. Environmental Zones) were a combination of discriminating factors already incorporated at level 3, or others (e.g. stream power) were based on localised data and modelling which could not be extrapolated to a European scale within the scope of this revision. However, these factors may be captured at level 4 in the proposed system i.e. region or Environmental Zones can be captured if needed and a current proposed system of describing riffles, runs and pools at level 4 captures elements of flow and stream power. It was acknowledged that these factors could be considered for a future revision of the system.

2.6 Further decisions made in 2022

While decisions arising from the expert workshop (Second workshop with EUNIS aquatic habitats experts) provided the basis for progressing with levels 3 and 4, work continued in parallel to investigate and assign the biological communities information (Section 3.2 Assigning biological communities) to the proposed level 4 types. The discriminating factors proposed at level 4 proved too restrictive in relation to the amount of information available on biological communities for those types, therefore it was necessary to review the approach for defining the structure of levels 3 and 4, and best describing and distinguishing the habitat types based on biological communities' information. Below are described the main changes undertaken by ETC/BD and ETC/ICM experts throughout 2022 to further develop the inland surface water habitats revision and adapt the structure to the best information available on biological communities.

Changes made to the structure:

- **Level 4:** the original proposal to describe inland water habitats at this lower level is put on hold until a later time. Further information is needed on biological communities based on the current discriminating factors, particularly for standing waters. The outlook is better for running waters but a wider literature review and access to additional datasets on biological communities is needed.
- **Level 3:** this is the level that biological communities will be described at instead. Even at this level, there is still a need for a wider literature review and access to further information complementing the work already undertaken. For the rarer water body types, further datasets are needed from different sources to describe the biological communities of these habitats (e.g. volcanic lakes). Some datasets have already been sourced for further work on this (e.g. for brackish waters).
- **Discriminating factors at level 3:** as a result of decisions made as described above, some amendments were made to the level 3 abiotic discriminating factors. This was to make the best use of the biological communities information already available (e.g. incorporating depth for some standing water body types) and to ensure the most ecologically appropriate factors were being represented at level 3 (e.g. flow for running waters)
    - *Standing waters:* the exercise to extract biological communities information for the level 4 types revealed that there was sufficient information on one additional standing water body type based on depth. The level 3 water body type 'lowland lakes on calcareous or mixed bedrock' was further divided into 'lowland very shallow (unstratified), calcareous or mixed lakes non-humic, often turbid' (≤ 3m mean depth) and 'lowland shallow to deep (stratified), calcareous or mixed lakes, non-humic' (mean depth ≥ 3m) at level 3. This is the only standing water body type for which this distinction has been made. From the IC reports information is not sufficiently available for other types.

      It was decided to reverse a decision previously made to merge 2 standing water body types. Now 'lowland humic lakes on calcareous or mixed bedrock' is a separate type to

lowland calcareous or mixed bedrock lakes described above. These types were previously merged as the 'calcareous/mixed including humic lake type' is considered one of the rarer types, however there is enough information available to distinguish it as a separate type. Moreover, this decision was informed by the fact that a water layer being humic or not, has a large impact on the submerged living biological communities. This decision also further aligns the level 3 structure for lowland lakes where 'lowland humic lakes on siliceous bedrock' were already distinguished from their 'lowland siliceous lakes, non-humic' counterparts.

  - *Running waters:* flow was originally included at level 4. It was agreed by experts (ETC/BD 2021b) that flow is a fundamental abiotic factor to include for running waters in distinguishing habitats and describing the biological communities associated with them. It was decided to incorporate this at level 3 in terms of describing the substrate and grain size of the river bed.

- **Underground habitats**: it was decided that underground inland water habitats are covered by the habitats already included in the group of 'Terrestrial underground caves, cave systems, passages and waterbodies' included in the group of 'Inland habitats with no or little soil and mostly with sparse vegetation'. As a result, the EUNIS group of inland water habitats refers to inland surface water habitats.

Confirmation of previous decisions made

Although decided in principle, the decisions made regarding the placement of key inland water related habitat types were reviewed based on finalising the level 3 structure. The following habitat types were addressed:

- **Reservoirs:** those of a more natural origin i.e. natural water bodies used for storing and abstraction of water for domestic/industrial purposes, were confirmed as remaining in the inland surface waters group. These types would be represented either at level 4 or below. This type was proposed in the 2019 consultation as a separate level 3 type and was deleted during the 2021 expert workshop, although with much discussion about the natural versus artificial nature of this water body type. For the final list it is decided to:
  - Place man-made highly artificial reservoirs (e.g. with completely man-made substrate) in the EUNIS group *Y constructed, industrial and man-made habitats*.
  - Retain natural water bodies used as reservoirs for domestic or industrial abstraction in the inland surface waters habitat group. As the biological communities typical of these water body types do not differ from other level 3 types, it was decided that reservoirs would be represented as sub-types of their level 3 parent (e.g. as a sub-type of mid-altitude siliceous lakes).
- **Floodplain habitats:** while an integral part of the wider running waters ecosystem, a floodplain habitat cannot be strictly defined as an inland surface water habitat according to the principles of defining and placing EUNIS habitats (see section Principles of the revision of the EUNIS inland waters classification). Floodplains are placed at level 2 of group *X Habitat complexes*. There are further sub-types of floodplain habitats (e.g. channel patterns) that could be described at lower levels in the future. Links will be made to level 3 of running waters via a crosswalk to floodplains.
- **Gravel bar habitats:** while a key component of the floodplain habitat (EUNIS group *X Habitat complexes*), gravel bars have a well-defined vegetation that falls under the EUNIS habitat group *U Inland habitats with no or little soil and mostly with sparse vegetation*, as opposed to *X Habitat complexes* or *P Inland surface waters*. Additionally, vegetation types that can be supported by gravel bars are not strictly aquatic dependent.

- **Dystrophic lakes:** it was decided that there is no need for a separate category for dystrophic lakes at level 3 as there is now a category for humic lakes both on siliceous and calcareous bedrock. Both of these types cover the pH spectrum typical of dystrophic lakes (up to pH 7 or 8) with a high water colour. Humic lakes on siliceous bedrock can be described as dystrophic lakes (Gray et al. 2022).

To note: at the time of compiling this report, the information on extracting data on and assigning biological communities information to the level 3 types is in progress. A next important step is condensing this information and ensuring uniformity in data and setting in place a process for thresholds to distinguish between 'common' and 'characteristic' species in each habitat type (see Table 8). The characteristic species will then be used to describe the biological communities of the habitat types. See Section 3.2 Assigning biological communities to inland surface water types for more information on this process.

3 Inland waters level 3

Based on discussions and decisions made between 2016 and 2022 and the evolution of discriminating factors for inland waters, the final lists of types at level 3 include 22 standing surface waters types and 26 running surface waters types. These are described below.

3.1 Final list of level 3 types

The level 2 descriptions of EUNIS Group P Inland surface waters are:

- standing aquatic habitats characterized by a natural or semi-natural dynamics and a water and sediment quality that sustains its natural communities. The habitat covers all sizes of water systems and occurs from lowland up to the highlands. The habitat includes lakes on specific bedrock such as volcanic lakes and marl lakes. The systems might run dry during the summer season. Ice cover is possible during part of the year.
- running aquatic habitats include water courses or sections of water courses with natural or semi-natural dynamics and a water and sediment quality that sustains its natural communities. The habitat covers all sizes of water systems and occurs from lowland up to the highlands. The habitat includes the origin of the running water systems, i.e. the springs, as well as lowland parts under the influence of the sea. The systems might run dry during the summer season. Ice cover is possible during part of the year.

The final list of abiotic factors used for standing and running surface water types at level 3 is presented in table 4 below.

Table 4: The final abiotic factors used to distinguish different habitats in standing and running waters at level 3

Standing surface waters	Type categories	Running surface waters
Altitude	highland: above timberline mid-altitude: 200m – timberline lowland: below 200m	Altitude
Geology	Calcareous & non-humic: >20 mg/L calcium or alkalinity >1 mEq/L,))/and mixed (calcium concentration 4-20 mg/L or alkalinity 0.2-1.0 mEq/L, and colour <30 mg Pt/L) Calcareous & humic: >20 mg/L calcium or alkalinity >1 mEq/L,))/and mixed (calcium concentration 4-20 mg/L or alkalinity 0.2-1.0 mEq/L, and colour >30 mg Pt/L) Siliceous & non-humic (< 4 mg/L calcium or alkalinity < 0.2 mEq/L and colour <30 mg Pt/L,) Siliceous & humic (< 4 mg/L calcium or alkalinity < 0.2 mEq/L and colour > 30mg Pt/L)	Geology
Size	ponds, pools & very small lakes: < 0.5 km2 small to large lakes: 0.5-50 km2 very large lakes: > 50 km2	Surface area

Size	Very small - small: 0.5 - 100 km^2 medium to large: 100 - 10,000 km^2 very large: > 10,000 km^2	Catchment area
Depth	<3m very shallow (unstratified) & >3m shallow to deep (stratified) (Only used for one level 3 type: lowland very shallow to shallow calcareous or mixed lakes and lowland shallow to deep calcareous or mixed lakes)	-

The final list of EUNIS inland surface waters habitats at level 3 are presented in tables 5 and 6 below.

Table 5: Final list of level 3 standing waters (22 types)

Code	Title
P11	Lowland, very shallow (unstratified), calcareous or mixed lakes non-humic, often turbid
P12	Lowland, shallow to deep (stratified), calcareous or mixed lakes, non-humic
P13	Lowland, humic lakes on calcareous or mixed bedrock
P14	Lowland siliceous lakes, non-humic
P15	Lowland, humic lakes on siliceous bedrock
P16	Mid-altitude, calcareous or mixed lakes, non-humic
P17	Mid-altitude, humic lakes on calcareous or mixed bedrock
P18	Mid-altitude siliceous lakes, non-humic
P19	Mid-altitude, humic lakes on siliceous bedrock
P1A	Highland, calcareous or mixed lakes, non-humic
P1B	Highland, humic lakes on calcareous or mixed bedrock
P1C	Highland siliceous lakes, non-humic
P1D	Highland, humic lakes on siliceous bedrock
P1E	Temporary calcareous lakes, including non-humic and humic lakes
P1F	Temporary siliceous lakes, including non-humic and humic lakes
P1G	Temporary saline and brackish lakes
P1H	Permanent saline and brackish lakes
P1J	Glacier fed lakes
P1K	Marl/karst lakes
P1L	Volcanic lakes
P1M	Very large lakes
P1N	Ponds, pools & very small lakes

Table 6: Final list of level 3 running waters (26 types)

Code	Title
P21	Lowland rivers and streams draining clay rich catchments, turbid
P22	Lowland, very small to small, calcareous or mixed rivers and streams, non-humic
P23	Lowland, very small to small, humic rivers on calcareous or mixed bedrock
P24	Lowland, very small to small, siliceous rivers and streams, non-humic
P25	Lowland, very small to small, humic rivers and streams on siliceous bedrock
P26	Lowland, medium to large, calcareous or mixed rivers and streams, non-humic
P27	Lowland, medium to large, humic rivers on calcareous or mixed bedrock
P28	Lowland, medium to large, siliceous rivers and streams, non-humic
P29	Lowland, medium to large, humic rivers on siliceous bedrock
P2A	Mid-altitude, very small to small, calcareous or mixed rivers and streams, non-humic
P2B	Mid-altitude, very small to small, humic rivers and streams on calcareous or mixed bedrock
P2C	Mid-altitude, very small to small, siliceous rivers and streams, non-humic
P2D	Mid-altitude, very small to small, humic rivers and streams on siliceous bedrock
P2E	Mid-altitude, medium to large, calcareous or mixed rivers and streams, non-humic
P2F	Mid-altitude, medium to large, humic rivers or streams on calcareous or mixed bedrock
P2G	Mid-altitude, medium to large, siliceous rivers and streams, non-humic
P2H	Mid-altitude, medium to large, humic rivers and streams on siliceous bedrock
P2J	Highland, calcareous or mixed rivers and streams, non-humic
P2K	Highland, humic rivers and streams on calcareous or mixed bedrock
P2L	Highland siliceous rivers and streams, non-humic
P2M	Highland humic rivers and streams on siliceous bedrock
P2N	Springs
P2P	Temporary rivers and streams
P2Q	Tidal rivers and streams
P2R	Glacial rivers and streams
P2S	Very large rivers

3.2 Assigning biological communities to inland surface water types

To distinguish between habitat types at level 3 it is necessary to capture differences in the biological communities using different taxonomic assemblages: fish, benthic algae, macrophytes, macroinvertebrates, phytoplankton and zooplankton. Assigning biological communities to the EUNIS types depends on accessing numerous data sources (databases, literature, expert opinion), with information at European scale. An overview of sources initially considered is shown in Table 7. At the European level the main and available sources of information are the intercalibration reports and the WISER database (Table 7). Any further information extracted from additional data sources should be cross-referenced against these two data sources for accuracy.

Synthesizing data sources, preferably at the level of alliances for vegetation, could contribute to a revised and improved EUNIS typology for freshwater, building upon the revised EUNIS level 3 typology. It should be noted that other sources of information (e.g. Red list of habitats) contain information on the rarer level 3 types i.e. volcanic lakes, saline and brackish waters, but might not be complete. The European Red List of Habitats reviews the current status of all natural and semi-natural terrestrial, freshwater and marine habitats and highlights the pressures they face. It uses a modified version of the IUCN Red List of Ecosystems categories and criteria. Over 230 terrestrial and freshwater habitats were assessed. The European Red List of Habitats provides descriptions, indicators of good quality, characteristic species, classification among different systems and descriptions of rare habitats (Janssen et al., 2016). It also provides a link to the EuroVegChecklist of alliances. It also includes or gives links to the Annex I habitats.

The European Vegetation Archive (EVA) database is a single data repository of vegetation-plot observations (i.e. records of plant taxon co-occurrence at particular sites, also called phytosociological relevés) from Europe and adjacent areas (http://euroveg.org/eva-database; Chytrý et al., 2016). The EVA database was used to extract diagnostic species, constant species and dominant species for aquatic plant communities that can be used to characterise the revised EUNIS inland surface water habitat group (Schaminee et al, 2022). A set of eight types of purely aquatic habitats and two types for spring communities were identified and linked to EuroVegChecklist 2016 syntaxa.

A list of 'typical species' is submitted (or updated) by Member States as part of their 6-year Habitats Directive report. The species information can be useful for the EUNIS project by assigning the typical species based on the Annex I cross-linked habitat (92/43/EEC; https://www.eionet.europa.eu/etcs/etc-bd/activities/reporting/article-17. Habitats Directive Article 17 reports can provide descriptions and species lists. Similar to the EU Red List of habitats Annex I can especially be used for the descriptions of rare habitats within the EUNIS inland freshwater habitats.

3.2.1 Approach to extracting information

A first step to determining and assigning the biological communities to the level 3 types was to finalise the list of level 3 types. As the level 3 structure is largely, but not only, based on the Broad Type approach, the main sources of data are those under the Water Framework Directive process i.e. the intercalibration reports and the WISER database. At the point of compiling this report, Table 7 gives an outline of the data sources that have been explored and used to extract data so far.

Table 7: Summary of the data sources used for biological communities data extraction to be included in the descriptions of EUNIS inland surface water types

Data source	Description	Information explored and obtained	Limitations for this work
Intercalibration Reports	Individual reports under the Water Framework Directive with biological information based on specific water body types. wfd - Library (europa.eu) There are many sources for these intercalibration reports, inluding 13 river reports and 13 lake reports from 2013 and several smaller reports. These include but are not limited to the following references: Birk et al. 2018, Böhmer et al. 2014, Borics et al. 2018, Gassner et al. 2014, Hellsten et al. 2014, Kelly et al. 2014, Lyche Solheim et al. 2014, Olin et al. 2014, Pall et al. 2014, Portielje et al. 2014, Sandin et al. 2014, Solimini et al. 2014, Wolfram et al. 2014.	List of species normally found under reference conditions for the different biological quality elements in the most common intercalibration types shared by the countries collaborating in the Geographical Intercalibration Groups (GIGs). More than 13 reports for lakes and more than 13 reports for rivers: one report for each biological quality element (= taxonomic assemblage) and each geographic region. The geographic intercalibration groups (GIGs) are Northern, Central & Baltic, Alpine, Easter Continental and Mediterranean. The biological quality elements for lakes are: phytoplankton, macrophytes, benthic invertebrates and fish. The biological quality elements for rivers are phytobenthos, benthic invertebrates and fish. Each report was searched to find the section describing reference communities. These are only described for a few common	The data within these reports had to be extracted manually. Such lists are provided as text paragraphs mainly in the lake reports and more rarely in the river reports. There are several of the common intercalibration types not represented in the lists of typical reference taxa.

		intercalibration types (which can be cross-walked to the revised EUNIS types).	
WISER database	In the project Waterbodies in Europe, an Integrative System approach was used to assess Ecological status and Recovery (WISER), biological and environmental data from rivers, lakes, transitional and coastal waters in 26 European countries were collated. More than one million records of biological observations were stored in the project's central database, representing phytoplankton, macrophytes, phytobenthos, invertebrates and fish. See Moe et al (2013): https://rdcu.be/c1sCw	Data at species or genus level has been extracted and grouped into the different EUNIS habitats at level 3 to provide: 1. Proportion of occurrence of single species (or genera or higher taxonomic level) in each group of lake water bodies corresponding to one EUNIS habitat. This has been done for most of the revised EUNIS habitats for lakes (but little data is available for highland types and very large lakes). 2. Average relative abundance of single phytoplankton taxa in a group of lakes belonging to a type corresponding to a EUNIS habitat. This is not possible for other taxonomic groups due to lack of abundance data (but will be double-checked for fish in 2023). 3. Identification of characteristic (diagnostic) species or genera in each habitat type will be done in 2023 (see below).	Limited data is available for running waters (to be further explored and extracted).

3.2.2 Proposal for assigning biological communities

While there is a well-established methodology for assigning vegetation communities to habitat types in the terrestrial system based on a system of diagnostic, dominant and constant species (Chytrý et al., 2020), a methodology was needed for inland waters to accommodate wider biological communities that define these habitats. It was proposed to describe the 'common' and the 'characteristic' species associated with each water body type, to be in line with the assignment of alliances and their species to EUNIS habitats.

The principles for distinguishing between inland surface water habitats using information on biological communities are the following:

1. A species would be categorised as 'constant' and 'characteristic' according to its importance to a surface water body type (see below for further detail). The characteristic species are those used to determine the different habitat types. This approach of distinguishing 'constant' and 'characteristic' species mutatis mutandis follows the approach for the terrestrial habitats.
2. There should be a difference in the species composition (characteristic species) in at least one of the biological communities in order for the habitat type to be considered different to the other ones at level 3. While the same 'characteristic' species from each group may be present in a habitat type, as long as there is a difference in at least one of these groups (i.e. different macrophyte community but the same species for all other groups) this constitutes a different habitat.
3. Where no difference can be found in species composition between 2 habitat types, these are candidate habitats to be merged, or, if not enough biological data is available to conclude on this, further assessment is needed (see 3 below).
4. Habitats with no difference in biological communities should undergo an expert evaluation to establish if this conclusion is a result of a gap in data e.g. if phytoplankton information in a lake type(s) is missing, and if phytoplankton could realistically be used to distinguish between two habitats. A more in-depth assessment (i.e. based on expert opinion) may be needed.

Identification of characteristic (diagnostic) species or genera in each habitat type will be performed in 2023 based on comparison of proportion of occurrence of single taxa between the different EUNIS habitats where it occurs. (e.g. histogram with percentage of occurrence on the y-axis and each of the habitats along the x-axis). Such histograms will be made for each taxon (after deciding on a cut-off for taxa with very low proportion of occurrence across all the habitats). The histograms will reveal whether a taxon has a narrow niche (mainly occurring in one or a few habitats) or a wide niche occurring with almost the same proportion in many habitats. Those with a narrow niche will be the characteristic species (or diagnostic species), while those with a wide niche will be the "constant" species.

For the rivers, the reference rivers are not identified in the WISER database. Therefore there is a need to find a different way to do this. The most likely method which will be tested in 2023 is to use GIS techniques to link the WISER river water bodies to the WFD water bodies reported to be in high status (= reference sites). Once this has been done, we can go back to the WISER database and add a new field called reference site (yes or no) and then select the taxa occurring only in those river water bodies. This would allow the same calculations as done for the lakes to calculate the proportion of occurrence in each of the revised EUNIS river habitats. This can then

be followed by an analysis of the characteristic (diagnostic) species or genera in the same way as suggested for lakes.

3.2.3 Next steps for biological communities data compilation

As the preliminary stage described in section 3.2 is underway, several next steps have been identified for each of the species groups with a view to continuing this work in the future. These are summarised in Table 8.

Table 8: State of play (December 2022) with the biological communities information per group of interest and a view to further developing the list of biological communities in the future

	Status of information available 2022	Next steps
General	Comprehensive lists of biological communities have been developed for both standing and running waters for the EUNIS level 3 types that align with the Broad Types. The main source of information collected is via the WISER database and the intercalibration reports (see Table 7). For rivers, the reference sites have not been identified in the WISER database, so there is a need for a next step (see right column). This exercise has been valuable for identifying gaps to be addressed and further data sources to be explored post-2022.	To identify reference sites for rivers in the WISER database through GIS links to the WFD high status rivers (see above). To consolidate data collected in 2022 and develop a common approach to 'frequency of occurrence' for all biological groups (except phytoplankton). To develop thresholds for delineating 'common' and 'characteristic' species. This will be done by comparing the proportion of occurrence for each taxon across the different habitats. To develop a crosslink with the delineation as used for the terrestrial communities (i.e. diagnostic, dominant, constant) in terms of the macrophyte information from EVA database. To further investigate datasets for rare water body types.
Fish	No data available on fish communities in the intercalibration reports (but to be checked again in 2023, as new reports have been published). Fish data have been found in the WISER database from 184 lakes (+ 202 which could not be allocated to any EUNIS habitat type).	The WISER data for fish will be further explored in 2023. An expert review of the level 3 habitat types might suffice for assigning the broad fish communities indicative of each type.

Macrophytes	Information available from the EVA database (see report Schaminée et al., 2022) Macrophytes data from 928 lakes in the WISER database have been extracted and the average proportion of occurrence of single species have been calculated for the different EUNIS lake habitats, using in all the reference lakes in each habitat.	To review and crosscheck the information on macrophytes between the EEA/WENR framework contract (Schaminée et al., 2022) with data from WISER and intercalibration reports. The characteristic species and the constant species will be identified from the proportion of occurrence across the different habitats.
Phytobenthos	Good information available for surface water bodies in Norway. The WISER data has been checked, but further work is needed to identify reference rivers (see the right column under General above). Most countries mainly use diatoms and not the other algal groups. This will restrict the descriptions of the biological communities not belonging to the diatoms. However, in Norway other algal groups are used, so can be used to estimate the proportion of occurrence for those other taxa.	To be investigated if this information is available for other countries. See the right column under General above for plans of identifying the reference rivers and then extract the data from WISER. In addition the Norwegian database can be explored to get data for non-diatom taxa.
Macroinvertebrates	The WISER data has been checked, but further work is needed to identify reference rivers (see the right column under General above).	See the right column under General above for plans of identifying the reference rivers and then extract the data from WISER.
Phytoplankton	Good data available for phytoplankton, i.e. data on abundance of algae taxa. A lot of work already done in 2022 on proportion of occurrence and average relative biomass for each taxon in each EUNIS habitat.	Further work needed to distinguish characteristic versus constant species, as described above.
Zooplankton	Nothing done so far. There is no information in the intercalibration reports, nor in the WISER database.	Other data sources can be explored if funding allows, using Norwegian data of data from other Member States (The Netherlands ?).

		Otherwise, expert judgement can be used based on experience from lakes in Norway.

3.3 Links to habitats in other EUNIS groups

One of the challenges of revising the inland surface water classification within the rules governing the placement of habitats in the EUNIS system, was that the inland surface water ecosystem is a complex in itself which is comprised of habitat types belonging to other habitat groups in EUNIS. This is described in Box 1. In practice, this means that many habitats that form part of the wider inland surface water ecosystem are placed in other habitat groups. Where this occurs, these habitats will be referred to in the level 3 descriptions. A good example of this is the floodplain habitat types. These are an integral component of the running waters ecosystem, however a floodplain can contain other habitats as well, e.g. from the sparsely vegetated habitats group (e.g. gravel bars) and the forest habitat group (e.g. Alder forests). Moreover, each floodplain type can be linked to many inland water types and this is why we decided to place floodplains in the habitat complex groups with linkages to the inland waters. Below is described the collection of habitat types from other EUNIS habitat groups which can be associated to the EUNIS inland water habitats (Table 9).

Table 9: Habitat types from other EUNIS groups associated with the EUNIS group 'P Inland surface water' (the habitats are at level 3 apart from the ones from the group of 'Complexes')

Habitat name and code	Habitat group	Comment
U11 Caves	U Inland waters with little or no soil and mostly with sparse vegetation	Underground water bodies (standing and running waters) are placed in the sparsely vegetated habitat group.
U12 Disused underground mines and tunnels	U Inland waters with little or no soil and mostly with sparse vegetation	Underground water bodies (standing and running waters) are placed in the sparsely vegetated habitat group.
U71 Unvegetated or sparsely vegetated gravel bars in montane and alpine regions	U Inland waters with little or no soil and mostly with sparse vegetation	Linked to all running surface water types (P2) where there is a link to floodplains (group X habitat complexes)
U72 Unvegetated or sparsely vegetated gravel bars in the Mediterranean region	U Inland waters with little or no soil and mostly with sparse vegetation	Linked to all running surface water types (P2) where there is a link to floodplains (group X habitat complexes)
Q24 Intermediate fen and soft-water spring mire	Q Wetlands	Springs are represented at level 3 in P2 running surface waters (P2N springs).
Q41 Alkaline, calcareous, carbonate-rich small-sedge spring fen	Q Wetlands	Springs are represented at level 3 in P2 running surface waters (P2N springs).

Q42 Extremely rich moss-sedge fen	Q Wetlands	
Q43 Tall-sedge base-rich fen	Q Wetlands	
Q44 Calcareous quaking mire	Q Wetlands	Fed by calcareous, nutrient poor water.
Q45 Arctic-alpine rich fen	Q Wetlands	
Q46 Carpathian travertine fen with halophytes	Q Wetlands	Associated with saline water bodies. Level 3 types include P2Q Tidal rivers and streams, P1G Temporary saline and brackish lakes and P1H Permanent saline and brackish lakes.
Q51 Tall-helophyte bed	Q Wetlands	Forms part of the wider riparian and water fringing vegetation in inland surface water ecosystems, but can also occur independently from inland water habitats.
Q52 Small-helophyte bed	Q Wetlands	Forms part of the wider riparian and water fringing vegetation in inland surface water ecosystems but can also occur independently from inland water habitats..
Q53 Tall-sedge bed	Q Wetlands	Forms part of the wider riparian and water fringing vegetation in inland surface water ecosystems but can also occur independently from inland water habitats..
Q54 Inland saline or brackish helophyte bed	Q Wetlands	Forms part of the wider riparian and water fringing vegetation in inland surface water ecosystems but can also occur independently from inland water habitats..
Q61 Periodically exposed shore with stable, eutrophic sediments with pioneer or ephemeral vegetation	Q Wetlands	Forms part of the wider riparian and water fringing vegetation in inland surface water ecosystems.
Q62 Periodically exposed shore with stable, mesotrophic sediments with pioneer or ephemeral vegetation	Q Wetlands	Forms part of the wider riparian and water fringing vegetation in inland surface water ecosystems.
Q63 Periodically exposed saline shore with pioneer or ephemeral vegetation	Q Wetlands	Forms part of the wider riparian and water fringing vegetation in inland surface water ecosystems.
*X01 Estuaries	X Habitat complexes	Both P2Q Tidal rivers and streams and P2S Very large rivers are represented at level 3 in P2 running surface waters.

*X02 Saline coastal lagoons	X Habitat complexes	Associated with saline and brackish waters (P1G Temporary saline and brackish lakes, P1H Permanent saline and brackish lakes, P2Q Tidal rivers and streams).
*X03 Brackish coastal lagoons	X Habitat complexes	Associated with saline and brackish waters (P1G Temporary saline and brackish lakes, P1H Permanent saline and brackish lakes, P2Q Tidal rivers and streams).
*X29 Salt lake islands	X Habitat complexes	Features associated with inland saline water bodies (P1G Temporary saline and brackish lakes and P1H Permanent saline and brackish lakes).
*X34 Anchialine caves	X Habitat complexes	Underground water bodies (standing and running waters) are placed in the sparsely vegetated habitat group.
*X36 Depressions (pody) of the Steppe zone	X Habitat complexes	Temporary water bodies are represented at level 3 in inland surface waters (PIE Temporary calcareous lakes, including humic lakes and P1F Temporary siliceous lakes, including humic lakes).
*XX Floodplains	X Habitat complexes	Related to all running water types where floodplains are described/linked.
*J5.2 Highly artificial saline and brackish running waters	Y Constructed, industrial and other artificial habitats	Natural saline and brackish standing and running waters are represented at level 3 (P1G Temporary saline and brackish lakes, P1H Permanent saline and brackish lakes, P2Q Tidal rivers and streams)
*J5.3 Highly artificial non-saline standing waters	Y Constructed, industrial and other artificial habitats	Related to natural water bodies used as reservoirs, which can be represented at lower levels of standing waters.
*J5.4 Highly artificial non-saline running waters	Y Constructed, industrial and other artificial habitats	
*J5.5 Highly artificial non-saline fountains and cascades *[this is not a final habitat code]*	Y Constructed, industrial and other artificial habitats	Waterfalls and cascades are placed at lower levels in group P2 running surface waters.
*C3.8 Inland spray- and steam-dependent habitats *[this is not a final habitat code]*	The final habitat group is to be decided	Waterfalls and cascades are placed at lower levels in group P2 running surface waters.

* The EUNIS habitat groups X Habitat complexes and Y Constructed, industrial and other artificial habitats have not yet been revised and the codes in Table 9 are from the 2012 classification (apart from floodplains where the code is yet to be assigned).

The habitats above are referred to in the level 3 descriptions of inland waters, by code and the habitat title, where appropriate without appearing as a separate level 3 type in inland waters.

3.4 Uses of EUNIS inland waters level 3 habitats

The EUNIS habitat classification is used in several ways. For the revised EUNIS terrestrial habitats the level that is mostly used at European scale is level 3 for which lists of characteristic species have been developed, it is crosslinked with several other habitat typologies and EuroVegChecklist 2016 syntaxa and for which, based on vegetation plots, distribution, suitability and probability maps have been developed and produced. For the marine habitats the level 3 of the terrestrial habitats corresponds broadly to level 4 but work still needs to be done to see how the classifications can be further used. For the inland waters, the current level 3 structure provides broad coverage of most European inland water habitat types. It needs to be further investigated if level 3 of the revised inland water habitats can serve the needs of the users of EUNIS habitat classification or if further developments at level 4 are necessary. In any case, EUNIS inland waters at level 3 could be possibly used for the following:

Linking typologies: The EUNIS system of habitat classification aims to crosslink typologies; national typologies, policy-oriented typologies (e.g. Annex I habitats under the Habitats Directive, European Red List of habitats, Broad Types developed under the Water Framework Directive) and broader ecosystem typologies (Corine Land Cover, IUCN, MAES). Some of these are not structured in the sense of EUNIS (i.e. being flat typologies without lower levels) but are nonetheless much used at national level for different purposes. Under EUNIS, the habitats in these typologies are cross-linked with the aid of qualifiers to denote the direction of the link (e.g. if a EUNIS type is broader in definition than an Annex I type). This serves as a comprehensive system housing multiple habitat typology in one place. EUNIS inland waters at level 3 will be crosslinked to the older version of EUNIS (2012), to the Broad Types, to the European Red List of habitats, to Annex I habitats, to MAES ecosystems typology, IUCN global ecosystem typology and Corine Land Cover types. Crosslinks might need to be improved and updated once further work on the revision is done.

Basis for national typologies: The EUNIS habitat classification system can be used as a basis, either wholly or partially, to develop a national system. An EIONET webinar held in December 2020 (see EIONET NRC Webinar) revealed that some participants already had a national classification system in place linked to EUNIS 2012. The majority of participants thought that the proposed system at the time (i.e. level 4) was a good way to proceed with revising the EUNIS inland waters classification. The use of level 3 as a basis or national typologies needs to be scrutinised.

Habitat mapping

The EUNIS habitats can be used for habitat mapping. Habitat mapping usually refers to mapping the habitats on a given site or across a region.

4 Challenges and limitations of the revision of EUNIS inland waters

It was clear from the outset that the development in EUNIS inland waters was unlike other habitat groups in the EUNIS system (marine and terrestrial). This was mainly due to the challenges with the previous classification at level 3; in this classification trophic state independent of human interventions was used to describe the habitat types, and moreover, the level 3 structure included a wide scale of habitats that are not set in a hierarchical structure. Such a structure is a feature of the EUNIS classification and allows habitats to be progressively described at a finer level of detail at lower levels in the classification.

The fact that the development in EUNIS inland waters was unlike other habitat groups in the EUNIS system (marine and terrestrial), is also caused by the fact that unlike terrestrial habitats, aquatic habitats are not primarily characterized by plants (vegetation) only, but by a wide range of groups of organisms that constitute the aquatic community: macrophytes (plants), macro-invertebrates, phytoplankton (algae), phytobenthos (diatoms) and fish. To capture this biodiversity in the EUNIS level 3 descriptions was a huge challenge and could not be finalised within the project.

From the start of the process it was decided that an alignment with the existing broad types derived from the Water Framework Directive intercalibration types would be followed with information on biological communities coming from a variety of sources but mainly the intercalibration reports and the WISER datasets. However, also from the beginning, it was apparent that the large Water Framework Directive lakes and rivers were not sufficiently covering the smaller lakes and rivers representing a large part of the aquatic biodiversity in Europe (ETC/BD, 2016; 2021b). Therefore the final list of EUNIS level 3 running and standing waters includes – besides the broad WFD intercalibration type running and standing waters – also smaller and rare aquatic habitats which considerably contribute to biodiversity in Europe.

The main issue encountered from the start of the process was a lack of time and resources to fully realise the task from start to finish. Below are described some of the challenges encountered with a view to informing on further work to be undertaken to finalise the classification beyond 2022.

4.1 Definition of inland waters

The inland water group in itself was difficult to define at level 1. As work progressed on the levels 3 and 4 structure it became clear that many habitats normally considered as a part of the wider inland waters ecosystem, were better placed in other EUNIS groups. There was not unanimous agreement among experts about which habitats should be placed in the inland waters groups e.g. strong opinions were expressed in the expert workshop that floodplains and gravel bars could not be decoupled from the inland waters habitat definitions.

In the end, it was decided to refer to inland waters at level 1 as a habitat complex in itself. However, there is another EUNIS habitat group under the title of 'habitat complexes', which will not be finalised in 2022. It remained to be addressed how these two groups can be best defined and distinguished at level 1, keeping in mind that the 'habitat complex' group also contains other aquatic 'complex' habitats related to other groups (e.g. estuaries related to the coastal habitat group).

A further issue that needed to be addressed was how level 3 was presented in the former classification. While the EUNIS 2012 C1 and C2 groups described habitats of standing and running surface waters, respectively, previous C3 group (littoral zone of inland surface water habitats) described habitats associated with both C1 and C2, and therefore the system was not hierarchical at level 3. This was addressed by distributing the C3 littoral habitats to either their appropriate habitat group (e.g. helophyte habitats were moved to Group Q Wetlands) or by replacing C3 habitats to the descriptions of the revised habitats. Some EUNIS 2012 habitats could not be linked at the revised level 3 (e.g. C3.8 Inland spray and steam dependent habitats are to be linked with waterfalls in the revised EUNIS system, which will be described at lower levels). The wetlands with helophytes (Group Q Wetlands) will be referred in the inland water habitat descriptions.

4.2 Expert approach

A wide audience of experts was engaged at appropriate intervals during the revision process. This was necessary as the system was undergoing a vast change from the original version of the 2012 EUNIS inland surface waters classification. Expertise was needed in relation to the relevant directives (Water Framework Directive and the Habitats Directive), inland waters specific species and habitats, catchment systems and geomorphology, inland water habitats in different biogeographical regions.

This approach, of course, comes with many different views and ways of approaching the reclassification. This was particularly true when it came to deciding the appropriate discriminating factors to use and which level to use them at. While each approach had pros and cons, some topics remained without an unanimous agreement among experts but it was necessary to decide on a system in order to finalise the revision.

4.3 Level 4 running waters: scale of system

Another issue of scale arose during the expert engagement that was the subject of much debate. The running waters habitat types aim to incorporate 'flow' to distinguish between habitat types. Capturing flow through a river system proved complex at lower levels. The channel system of pools, riffles and runs was proposed but proved difficult to quantify flow as a metric as such a parameter is often influenced by human activities (dams, weirs etc) and the system needs to describe reference conditions. Additionally, it was complicated to adapt the concept of flow to the scale of a whole river system and and the level 3 discriminating factor of altitude.

For the moment, level 4 is not being progressed with. However, level 3 is too broad a structure without incorporating some element of 'flow', therefore it was decided to describe the system of pools, riffles and runs (originally intended to be described at level 4) at level 3 and incorporate a description of substrate and grain size for these areas in the river channel.

4.4 Level 4 standing waters: area and depth

Level 4 was originally developed for standing waters based on abiotic distinguishing factors: surface area and depth. While this system of abiotic factors worked well for standing waters, issues were encountered when extracting biological communities based on this division. Although every effort was made to reduce the number of types at level 4, there was not enough information on biological communities to fully describe different habitat types at this level,

particularly when taking surface area as a discriminating factor. While surface area might be a factor for some biological communities (e.g. macro-invertebrates), it is much less a discriminating factor for plant communities. For the time being, biological communities will be described at level 3 and one adaptation has been made to incorporate depth into the level 3 description (i.e. lowland calcareous lakes).

4.5 Information on biological communities

Much work was undertaken into investigating and extracting the biological information for the level 4 types throughout 2022. However, it became evident that while the most important datasets for this information were being used (the intercalibration reports, WISER datasets), the task included a lot of manual work and, therefore, was time-consuming despite additional resources being made available. Also, a wider literature review is needed to fill in the gaps particularly for the rarer types (such as volcanic lakes).

5 Future perspectives

For future work to further develop EUNIS inland waters, the recommendations below should be taken into consideration.

Develop a specific project with dedicated resources to address the next steps for compiling information on the biological communities. This comprises further work on the WFD databases and reports complemented with other sources of information (see Table 8). Although partly covered by the Red list of habitats descriptions, further research should be undertaken to source information for the rare water body types.
There is also much information referred to in the literature that could be accessed if time and resources allow. The data on macrophyte communities extracted from the intercalibration reports and WISER database need to be compared / completed with the vegetation alliances and species information that comes from Schaminée et al. (2022).

As new information becomes available, work needs to be continued on crosslinking habitats with other typologies.

Once the biological information has been extracted at level 3, it needs to be investigated how level 4 can be developed based on appropriate abiotic factors and appropriate biological information to be linked to the abiotic factors at this level. This needs quite some detailed data and specific ecological knowledge for different groups of organisms.

An extensive data compilation exercise as executed for level 3 may be able to inform whether further lower level habitat can be described with biological information.

A methodology needs to be developed to continuously update the EUNIS inland water information with information on biological communities.

Also, a methodology is needed to map EUNIS inland water habitats.

6 Glossary

Amphibious vegetation: Vegetation in the littoral zone of lakes/rivers adapted to both the aquatic and terrestrial environments. These macrophytes have submerged growth forms and can adapt to a period of the year when this zone is running dry by producing emergent growth forms e.g. leaves with stomata. They form part of the ecosystems of aquatic and terrestrial habitats. The littoral zone changes throughout the year for temporary surface water systems.

Aquatic vegetation: macrophyte vegetation that can complete their whole life cycle in water either submerged-rooted, submerged or floating e.g. Charids, some Isoëtids, Elodeids, Nymphaeids, Lemnids.

Broad types: 'Broad Types' is a generic typology of European water body types whose basis lies in the national types of the Water Framework Directive. Through reflecting the natural variability in the most commonly used environmental type descriptors i.e. altitude, geology and size the Broad types capture 60 to 70 % of all national Water Framework Directive types and almost 80 % of all European river and lake bodies in almost all European countries. The environmental type descriptors reflect most of the natural variability in reference conditions for the biological quality elements. The broad types are linked to the Intercalibration types (see below).

Floodplain: a complex of habitats prone to complete or partly flooding and bordering a river or a number of river arms. It stretches from the river banks to the outer edges of the river valley.

Helophyte: emergent plants typical of marshy or lake-edge environments and shores of slow-flowing rivers, in which the perennating organ lies in soil or mud below the water table but the aerial shoots and flowers protrude above the water (e.g. *Phragmites australis*, the common reed, *Carex* and *Typha* species). They can grow on muddy land or in water.

Intercalibration types: common types for a regional group of countries based on high similarity of national types defined for the Water Framework Directive. For each common intercalibration type, the class boundaries between high and good, as well as between good and moderate ecological status for national indicators of different biological quality elements were intercalibrated between the countries sharing the intercalibration type. The aim was to ensure that the good status class boundaries were consistent with the normative definitions in the WFD Annex V for each of the biological quality elements and that they were harmonized between the countries (i.e. showing the same deviation from reference conditions).

Riparian and water fringing vegetation: the zone along the lake shores and river banks which is subject to water level fluctuations and wave action, and where the sediments have sufficient light available for plants. The littoral zone contains typical habitats for both submerged and truly aquatic vegetation (*Charids, Isoëtids, Elodeids, Nymphaeids, Lemnids*) and amphibious vegetation adapted to aquatic and terrestrial environments.

Ponds, pools and very small lakes: small and shallow aquatic habitats with a limited surface area (< 0.5 km^2) and a photic zone comprising the full water body, meaning they are shallow enough to allow sunlight to reach the sediment surface.

Riparian zone: the zone along the river bank which can be subject to flooding and contains vegetation adapted to both aquatic and terrestrial environments (e.g. Salix and Alnus species, Phragmites and Typha).

Shore: zone bordering a river or lake marked by the upper level of the surface water.

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Annex 1 Outcome of EIONET Webinar for standing and running waters (8 December 2020)

Outcome for standing waters

Topics agreed upon	Topics for further discussion
Typology factors at level 3	
Altitude/latitude: The treeline will be used instead of a precise altitude to specify the mid-altitude from the high altitude types. Treeline will also reflect latitude and both will be described at level 3.	To be decided whether 200 meters above sea level is acceptable to distinguish lowland from mid-altitude types.
Size: very small water bodies like ponds will be included in the definition of standing waters at level 3. Other size differences will be dealt with at level 4. The proposed size categories are <1km^2 (very small to small) and 1 – 100 km^2 (small to medium). If further subdivision is needed to distinguish ponds from very small lakes, this can be done at level 5.	
The current structure at level 3 is appropriate as additional types that are not distinguished by geology or altitude e.g. temporary and saline water bodies are included.	
Missing types and Mediterranean region	
Regions: Not necessary to divide level 3 based on regions, except the Mediterranean region, which should be kept separate at level 3 due to very different climate from the rest of Europe.	It was noted that it may not be necessary to include the Mediterranean region at level 3 as long as saline/temporary water bodies are included as a separate types (the main types distinguishing Mediterranean water bodies). This is to be further looked at.
Missing types: To include volcanic lakes as an additional type at level 3. To include marl (incl karstic) lakes, oxbow lakes and beaver pools at level 4.	To be decided if volcanic lakes should be further distinguished at level 4, as those in Iceland are very different from those in Southern Europe.
Level 4 additional abiotic factors and biological communities	
Agreed that the inclusion of mean depth at level 4 is appropriate.	
The differences in species composition based on regional climatic differences (e.g. oceanic	

versus continental) will be captured in further detail at level 4 through the further break-up based on regions.	
Retention time will be included at level 4, this is particularly important for distinguishing phytoplankton communities.	
Littoral habitats	
Helophyte habitats are better placed in the wetlands group, these can then be linked in terms of description to level 4 inland waters if needed.	Other amphibious habitats in the littoral zone will be placed into other habitat groups, the appropriate groups are yet to be decided.
True aquatic species will be described in the level 4 descriptions of the inland waters types.	

Outcome for running waters

Topics agreed upon	Topics for further discussion
Typology at level 3	
For areas where it is difficult to assign a river as having completely siliceous or totally calcareous bedrock (because the river runs through areas with shifting geology), these types are included under 'calcareous/mixed'.	
Replace the term 'unstable' with 'dynamic' when describing the riverine system in general.	
The current structure at level 3 is appropriate in terms of including as separate groups those types that are not distinguished by geology, altitude or catchment size e.g. temporary water bodies.	It is to be investigated whether flow, proposed at level 4, should be included at level 3 instead. This is discussed as perhaps a more important factor than geology in highland rivers.
The riparian habitats described in the 'littoral' section of the level 3 current EUNIS will be moved to other appropriate habitats groups (e.g. wetlands or habitat complexes). These can be referred to in the level 3 inland waters habitat descriptions.	Need a common system to handle the 'riparian' habitats.
Missing types and division into the Mediterranean region	
Include 'Ephemeral' river types at level 4 where appropriate, they are a subtype of temporary rivers, primarily in the Mediterranean region.	As with standing waters, it was noted that the distinction of Mediterranean region at level 3 may not be needed as saline/temporary water bodies, the main types distinguishing Mediterranean water

	bodies are already represented as their own groups there. This is to be further looked at.
Gravel bars are a part of the floodplain habitat.	
Floodplains and braided rivers, which are difficult to distinguish from each other, will not form a part of the inland water habitats group (perhaps the habitat complex group).	
Level 4 additional abiotic factors and biological communities	
The current system of level 3 to level 4 covers most biotic and abiotic factors and follows the broad type system. It also incorporated a level of 'dynamism' (e.g. flow).	To be seen if the current placement of flow is appropriate (i.e. at level 4 as pools, riffles, runs) or if it should replace a factor at level 3. If placed at level 3 this would mean the proposed system would no longer follow the broad type approach.
The multi-taxon approach to describing biological communities is appropriate for running waters. This is due to different communities reacting at different rates to the proposed factors e.g. phytoplankton are more sensitive to flow than other communities.	To be decided how to address river dynamics at level 5, level 4 currently describes a static system, however some river types e.g. high-altitude rivers, are not a static system which would allow some biological groups to reach equilibrium. In general, rivers will 'reorganise' themselves after storm events.
Littoral habitats, gradient and stream order, data sources	
The riparian zone will be included in the other habitat groups, EUNIS inland waters addresses only truly aquatic vegetation types. For example, the floodplains will be placed in the wetland group, wetland habitats to be moved to the wetland habitats group and forest fringe habitats in the forest habitat group.	Placement of braided rivers and gravel bars (habitat complexes, sparsely vegetated). Request to have a longer discussion about flood plains in particular in light of describing the riparian zone that is temporarily flooded
A further data source to investigate for freshwater species 'BioFresh' (https://data.freshwaterbiodiversity.eu/).	

Annex 2 Outcome of the EUNIS aquatic habitats expert workshop (16 March 2021)

This annex presents an overview of topics discussed for standing and running inland water habitats during the expert workshop. While some conclusions were reached on some topics, topics that needed further discussion are listed in the column 'General outputs from workshop'.

Summary of the main topics discussed during the workshop for the standing water bodies.

Main abiotic factors at Level 3		
Topic discussed	Details	General outputs from workshop
Ponds/pools to be included as a separate group at L3 Upper size limit <1ha or <5ha	Ponds are a very different habitat to lakes (e.g. they can be represented more by invertebrates as the top predators in the absence of fish, used more by amphibians) Ponds also have smaller catchments and are easier to conserve and incorporating them at L3 is a good way to protect biodiversity at landscape level. This also ensures they are kept visible in the proposed structure. It is proposed to further divide these based on size and depth at L4. The appropriate cut-off size for ponds/pools was discussed i.e. whether 5ha or 1ha could be an appropriate cut-off size. Many fish ponds can be over 100ha. It is important to avoid including those which are artificial fish ponds. Area is currently a defining factor at L4 so this water body type will be further divided. Small dystrophic pools in bogs are considered as inland waters based on their biological communities. These are totally separated from other water bodies, can be as small as 2x2m area. Water bodies with small surface areas may also have a wide range of depth e.g. Annex I habitats 3190 Lakes of gypsum karst. Depth is already considered as a discriminating factor at L4.	Ponds will be kept as a separate group at L3. Also, to include 'pools' in the title as this will capture the smallest inland standing water bodies The exact surface area increments are to be decided however 1ha or 5ha was discussed. It will be investigated to define further size limits at L4 (e.g. 1ha, 0.1ha, 0.01 – 0.1ha etc), however it depends on biological communities being distinguished further based on size classes.
Delineation of the boundary for high-altitude water bodies	As the climate clearly gets harsher above the timberline it was suggested to use this as the delineation of high-altitude waterbodies rather than the treeline.	Timberline is more appropriate and this will be used instead of treeline.

	The difference being that treeline means the upper limit of single individual trees, while the timberline is the upper limit of forests.	
Threshold between low and mid-altitude waterbodies - 200m	There was general agreement that this an acceptable limit (also from a Central European perspective)	200m is appropriate for delineation between low-mid-altitude water bodies.
Temperature as an independent discriminating factor	Temperature by itself will not be included as a separate factor as it is often difficult to obtain this information (i.e. should be water temperature and not air temperature) and it varies a lot in space (at a scale of a few km2 depending on local topography and size/depth of the lake) and time (at a scale of hours) and it is too difficult to get access to the data. Altitude/latitude is a good proxy for temperature so it is not needed as a discriminating factor.	Temperature by itself will not be included as a separate factor.
Alkalinity (i.e. geology) as a discriminating factor	It was discussed whether the relationship between alkalinity and nutrient concentration was statistical rather than there being a fundamental reason for this relationship. This relationship (i.e. between low/high alkalinity and low/high phosphorus) was shown in reference lakes (REBECCA and WISER projects, as well as from paleolimnology), but does not apply to marl-lakes, karstic lakes where the alkalinity is extremely high (because the phosphorus is naturally low due to co-precipitation with CaCO3). It has been shown, in Scandinavia, where the majority of European lakes are found, the reason for this relationship is that the bedrock is often siliceous and the natural P-concentration is very low (< 5 µg/l), while in areas in the lowlands where there are marine deposits (after the last glaciation), the soils have higher P-concentration and provide naturally more fertile areas, and lakes with higher natural P-concentration (the	Geology (i.e. alkalinity) is retained as a discriminating factor at L3 as a relationship between total phosphorus (natural trophic state) and alkalinity has been shown in reference lakes (Lyche-Solheim et al. 2006, 2008, Phillips et al. 2013, Bennion and Simpson 2011). This allows a link between the revised EUNIS habitats and the HD Annex I habitat types. The positive relationship between alkalinity and total phosphorus may not apply to all Mediterranean waterbodies. Therefore, the system should enable these types to also be reflected either as a separate type at L3 or a sub-type of calcareous lakes at level 4.

	marine deposit-line is ca. 200 m altitude in Eastern Norway and Southern Sweden and Southern Finland). Marl-lakes and karstic lakes are proposed as separate types at L3. Separately, it was discussed that this relationship may not apply to some Mediterranean water bodies e.g. calcareous lakes with low phosphorus concentrations. A system whereby alkalinity ranges are referred to in level 4 rather than at level 3 may be a way to ensure this current system is retailed while allowing these specific lake types to be included in the system.	
Additional abiotic factors at Level 4		
Topic discussed	Details	General outputs from workshop
Area as a discriminating factor	Water body size (surface area) is important for biodiversity and is appropriate to be included at L4. Ponds/pools are captured as a separate group at L3. Very large lakes (> 100 km^2) are also identified as a separate type at L3 due to their huge water volume and very long retention time.	Further discussion is needed concerning finer divisions of size at L4 for ponds/pools (see the first row on 'Main abiotic factors at level 3'). This subdivision depends on whether differences in biological communities can be identified at further size classes.
Depth as a discriminating factor	It was agreed that depth was an important factor for discriminating between standing water body types due to stratification and mixing patterns influencing the functioning of the lake and its biological communities. Its placement at L4 is appropriate. Depth was previously included at L3 in an earlier version of the structure. However, based on the multiple depth classes to be considered this resulted in a large number of types at L3, therefore depth was moved to L4. Water retention time is also described alongside depth at L4.	Depth and water retention time to be included at L4. Depth increments were suggested but not decided upon. Ponds will also be further divided by depth at L4.
Distinction of Mediterranean region		
Topic discussed	Details	General outputs from workshop

Inclusion of the Mediterranean region at L3.	Saline and temporary lakes are represented at L3, which is sufficient to distinguish the Mediterranean region water bodies. Regions can be included at lower levels if needed. The Metzger (2012) 'Environmental Zones' (i.e. climatic zones) is another factor which could be included at lower levels instead of region (if needed).	Region is not to be included at L3, but may be considered at L4.
Missing types to incorporate		
Topic discussed	Details	General outputs from workshop
Marl/karstic lakes to be included as a separate group at L3	To be included as a separate group at L3 (see the L3 row on alkalinity above).	To be included as a separate group at L3.
Volcanic lakes to be included as a separate group at L3	These lakes have a different water chemistry to other standing water bodies in the proposed structure. There are also regional differences i.e. between Icelandic, Macaronesian and Italian volcanic lakes. These will be distinguished further at L4.	To be included as a separate group at L3.
Placement of ditches	It was not decided if ditched should be kept in standing or running waters. It was suggested to include these in the title of 'ponds' at L3 if kept in the standing water group. There was opposition to including then in the EUNIS system at all as it was noted that the system needs to describe natural habitats which would not include ditches.	No decision has been made on the placement of ditches.
Placement of littoral habitats		
Topic discussed	Details	General outputs from workshop
Isoetids species to describe aquatic communities	It is noted that in the Mediterranean, *Isoetes histrix* is found on wet outcrops in spring and live in dry soil for most of the year. Isoetids in both the Atlantic and Mediterranean regions can be amphibious in very small lakes, ponds and pools. However, in other lake types, the isoetids are more submerged.	Isoetids are indicator species that are sensitive to eutrophication and should be kept as aquatic vegetation and described in the inland standing water habitats.
Helophytes to be included in wetlands	This proposal is based on reed beds often occurring separately from water bodies i.e. wetland depressions in the landscape. If these are included only in the inland waters, it will result in many	Helophytes to stay in the wetland habitat group

	non-aquatic habitat types. Finland and Poland use these as part of WFD ecological status assessment for macrophytes in lakes and would prefer to keep them in inland waters. It was suggested to move the helophytes to the wetland habitat group and refer to it in the inland water habitats descriptions.	
Placement of amphibious habitats	This is still an ongoing discussion in relation to the revision of the EUNIS wetland habitats group.	This is to be further investigated in conjunction with the discussion on helophyte habitat placement.

Summary of the main topics discussed during the workshop for the running water bodies.

Main abiotic factors at Level 3		
Topic discussed	Details	General outputs from workshop
'Environmental Zones' (Metzger et al. 2012) and the possible inclusion as an alternative discriminating factor at L3 (not to replace a factor)	Climatic factors have a direct relationship with flow (which is too difficult to characterise/measure). These are missing at L3. Environmental Zones are based on the factors used at L3 and some climatic factors (e.g. temperature). Additionally, the AMBER project used this (and other variables) and found a good relationship with fish communities. L3 needs to incorporate factors independent of human influence, Environmental Zones meets this criterion. It was proposed that this would not replace the current criterion, but complement them. Environmental Zones could be seen as a proxy for regions at L4.	The Environmental Zones were derived from the same or similar factors that are already included at L3. This would cause redundancy in the current factors. There was a discussion to include 'regions' at L4 if needed. However, this was mainly in relation to the distinct hydrology of the Mediterranean region, which is being resolved in another way (please see below).
An indicator of form or shape is needed at L3 or L4.	One view was to include form/shape at L3 and include water chemistry at L4. Catchment area was described as an appropriate factor of form, and is already incorporated. An opposite view was that L3 should be coarser, with geology, altitude, catchment size (and possibly Environmental Zones). Shape and form should then be included at more detailed, lower levels.	The factors that are incorporated in the current system (altitude, catchment size and geology) are clear and simple and represent a coarse system, anything more than this is too fine in detail.
Inclusion of flow at Level 4		
Topic discussed	Details	General outputs from workshop
Inclusion of flow in the system, including its placement in the structure (i.e. at L3 or L4)	It was discussed that a measurement describing the 'function' of a river system should be incorporated at L3 with flow being an obvious factor. However, it is difficult to measure/subject to human influences and therefore too difficult to incorporate at this level	Stream power, while an appropriate measurement to capture flow, velocity and hydraulic energy, cannot be included in this revision of EUNIS. The reason being that it is based on modelling that has not yet been applied on a European scale. This can be considered in the future. However, stream power is strongly

	'Stream power' captures the 'energy' of the system i.e. the hydraulic energy. It's an indication of river size, velocity is something that organisms experience. This drives the 'shape' of the habitat and nature/dynamics of substrates. Flow is currently captured at L4 through pools, riffles and runs.	modified by man in a large number of rivers and is highly variable with time (sometimes from hour to hour due to flash floods or hydropeaking). Flow in general is an issue in terms of how to characterising it/measuring it. It changes with location and time and is subject to human influence. The proposed system includes the system of riffles, pools, runs at L4, which encapsulates flow to a degree.
Current L4 discriminating factors: Riffles, pools, runs.	It was discussed that these are very fine scale habitats and would be more appropriate to include at levels lower than 4 (e.g. L7 or 8). Further divisions are needed before describing pools, riffles, rapids and runs.	Further investigation needed for L4 factors. It was suggested to place these at levels lower than 4 (e.g. L7 or 8). It was questioned what to include at the levels in between, but there was not a clear view on this by the workshop participants. Rinaldi et al. 2016 suggests a system based on basic river typology (BRT) and extended river typology (ERT), this will be analysed in more detail in relation to describing L4.
Distinction of Mediterranean region		
Topic discussed	Details	General outputs from workshop
Inclusion of the Mediterranean region at L3.	Originally proposed as a factor due to water bodies in the Mediterranean having a more specific hydrological regime to the rest of Europe.	Not to be included as a separate discriminating factor. The inclusion of temporary, ephemeral and saline water bodies at L3 is sufficient to represent the distinction of Mediterranean water bodies from the rest of Europe.
Incorporation of floodplains and braided rivers		
Topic discussed	Details	General outputs from workshop
Placement of gravel bars in the EUNIS system.	It is logical to include gravel bars in the Sparsely vegetated habitat group based on its vegetation i.e. *Epilobium fleischeri*.	Gravel bars to be moved to the EUNIS Sparsely vegetated habitat group. Vegetation that occurs on a gravel bar is not aquatic and therefore

	However, there was opposition to this as it was felt that anything occurring 'in-channel' should be a part of the river, it was described as a retrograde step to take gravel bars out of the inland water habitat group.	cannot represent an aquatic habitat. This habitat can, however, be linked to inland water habitats in the habitat descriptions.
Placement of braided rivers in the EUNIS system.	Braided rivers (and floodplains) are habitat complexes due to the different stages of vegetation succession and were originally considered to be a part of the EUNIS habitat complexes group. However, as a braided river is itself a channel form, it should be included in the inland waters group, at lower levels which will describe more the form of a river.	Braided rivers to be kept as a part of the inland water habitat group. They will be described at L4 or lower. They are part of the floodplain habitat (see Placement of floodplains below)
Placement of floodplains in the EUNIS system.	This was originally considered for placement in the habitat complex group (i.e. along with braided rivers). The rationale behind this is the different stages of succession of vegetation (i.e. initial, advanced etc). However, it was discussed that floodplains, braided rivers and the extended riparian zone should be a part of the inland water habitat group as they are a functional part of the whole river ecosystem, even if they are more characteristic of a habitat complex in terms of vegetation present. From a conservation and habitat restoration perspective, the whole ecosystem is considered in terms of restoring that ecosystem to its natural structure and function and keeping floodplains as a part of the inland water habitat group ensures the conservation rationale for floodplain and riparian habitats remains linked to the conservation rationale for the whole river system. In terms of linking to other habitat groups in EUNIS system, this can be done through the habitat descriptions at lower levels.	Floodplains will remain with the inland water habitat group. The inland water habitat group can include complexes if the complex includes aquatic habitats. Examples are floodplains and braided rivers.