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A GUIDANCE STANDARD FOR ASSESSING THE HYDROMORPHOLOGICAL FEATURES OF RIVERS

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0. Introduction

Historically, many countries in Europe have assessed river 'quality' simply in terms of the chemical or pollution status of the water flowing in river channels. A more comprehensive view of river habitats is needed, however, to answer pressing ecological questions such as those arising from the EC Water Framework Directive (WFD) (Commission of the European Communities, 2000) and the EC Habitats Directive, to underpin the International Convention on Biodiversity, or to assess proposed river engineering schemes and other catchment developments. In most European countries there are now pressures from statutory and voluntary environment and conservation agencies to see rivers returned to a more natural condition. This implies a need to evaluate areas deserving protection and those requiring rehabilitation, and to encourage better management of river systems throughout Europe.

1. Scope

This standard provides guidance on the features to be recorded when characterising and assessing the hydromorphology of rivers. It is based on methods developed, tested, and compared in Europe. Its main aim is to improve the comparability of hydromorphological survey methods, data processing, interpretation and presentation of results. Whilst it has particular importance in relation to the reporting requirements of the WFD, it also has considerably wider scope for other applications. Although hydromorphology is dependent on hydrology and underlying geology, this standard is focused on the structural features of rivers and on river continuity. In addition, whilst recognising the important influence of hydromorphology on plant and animal ecology and, conversely, the influence of plants and animals on hydromorphology, no attempt is made to provide guidance in this area.

2. Normative References

EN 14184: Water quality – Guidance standard for the surveying of aquatic macrophytes in running waters.

PrEN 14393: Water quality – Guidance on quality assurance aspects of aquatic macrophytes surveying and analysis in running waters.

PrEN 14011: Water analysis – Sampling of fish with electricity.

3. Definitions

For the purpose of this European Standard, the following terms and definitions apply:

3.1
aquatic macrophytes
plants (mostly vascular plants and bryophytes) which are easily seen with the naked eye and are associated with open water or wetlands with shallow water.

3.2
attribute
a specific recorded element of a hydromorphological feature (e.g. ‘boulders’ and ‘silt’ are substrate attributes; ‘sheet piling’ and ‘gabions’ are attributes of engineered banks).

3.3
backwater
area of low velocity or static water under dry-weather flows, most commonly former river channels or flood channels within the alluvial floodplain and physically separated from the river channel.

3.4
bank
permanent side of river, the top marked by first major break in slope, above which cultivation or development is possible.

3.5
bankfull
maximum point on banks at which floods are held within the channel before spilling over onto the floodplain.

3.6
berm
natural or artificial shelf within a river that is exposed above water level during low flows, but is submerged during high flows.

3.7
bog
a wetland, fed by atmospheric precipitation, in which the vegetation communities (usually dominated by *Sphagnum* mosses) form peat over long periods of time.

3.8
braiding
naturally divided course of a river, characterised by at least two channels which often change their course regularly.

3.9
bryophytes
a collective term for liverworts and mosses – plants which are often abundant on exposed boulders and bedrock of upland streams.

3.10
compaction
consolidation of the river bed through physical, chemical or biological processes.

3.11
contiguous survey
survey carried out along entire river reaches, with data collected from adjoining survey units.

3.12
ecological status
as defined in the Water Framework Directive, an expression of the quality of the structure and functioning of aquatic ecosystems.

3.13
embankment (levee)
artificial bank built to raise the natural bank level thereby reducing the frequency of flooding of adjacent land.

3.14
floodplain
the valley floor adjacent to a river that is (or was historically) inundated periodically by flood waters.

3.15
fluvial features
features shaped by sedimentation and erosion.

3.16
gabion
wire basket containing stones, used for river-bed or bank protection.

3.17
glide
moderately-flowing water with undisturbed surface other than occasional swirls or eddies (*cf.* 'run').

3.18
hydromorphology
the hydrological characteristics of rivers together with the physical structure that they create.

3.19
lateral connectivity
the freedom for water to move between the channel and the floodplain.

3.20
lateral movement
the freedom for a river channel to migrate across a floodplain.

3.21
levee
See 'embankment'.

3.22
planform
view of river pattern from above (e.g. sinuous, straight).

3.23
point bar
bar of river sediment formed on the inside of a bend in a river (cf. *side bar*).

3.24
pool
a distinct feature of deeper water that does not exceed three channel widths in length, where depth is sustained through fluvial scour and where river flow may be imperceptible in dry-weather conditions.

3.25
reach
a major sub-division of a river, defined by physical, hydrological, and chemical character that distinguishes it from other parts of the river system upstream and downstream.

3.26
reference conditions
conditions reflecting a totally undisturbed state, lacking human impact, or near-natural with only minor evidence of distortion (for waters not designated as heavily modified or artificial, synonymous with 'high ecological status' in the Water Framework Directive).

3.27
revetment
facing built to support a bank.

3.28
riffle
fast-flowing shallow water with distinctly broken or disturbed surface over gravel/pebble or cobble substrate.

3.29
riparian zone
for small rivers, this comprises the bank face and a strip of land on the bank top capable of exerting physical, hydrological and ecological impacts on the aquatic ecosystem (e.g. shading, leaf litter input). For large rivers, the riparian zone usually ends at the bankfull level. In this standard, the term 'riparian zone' does not include the wider floodplain.

3.30
riparian zone vegetation structure
physical character of the vegetation that creates habitat on the banks and land immediately adjacent to the river; e.g. 'complex' – mixture of shrubs, herbaceous vegetation, etc. or 'simple' – only herbaceous vegetation.

3.31
river rehabilitation
partial return of a river to a pre-disturbance condition (e.g. by dredging backwaters that have filled with sediment, changing the planform of channelised reaches, or planting riparian vegetation).

3.32
river type
a group of rivers that can be broadly differentiated from other groups on the basis of their physical and chemical characteristics (e.g. lowland chalk streams; upland ultra-oligotrophic rivers).

3.33
run
fast-flowing water with a disturbed, but not broken, surface (*cf.* 'glide').

3.34
sheet piling
corrugated metal sheets used for vertical bank protection.

3.35
side bar
discrete sediment deposit made by the river along the sides of relatively straight reaches (cf. *point bar*).

3.36
sinuosity
degree of deviation from a straight line, usually defined as channel length/valley length.

3.37
stream ordering
methods for classifying rivers and streams related to the complexity of the drainage basin, with progressively higher order numbers usually assigned to streams with greater discharge lower down the catchment.

3.38
survey unit
length of river from which data are collected during field survey; this may be a fixed length (e.g. 500 m) or variable, according to the method used, but must always be defined and recorded.

3.39
submerged vegetation
plants rooted to the bed and either completely submerged or with only part of their shoots floating or emergent.

3.40
substrate/substratum
material making up the bed of a river.

3.41
weir
a device to control flows above a pre-determined level.

3.42
wetlands
habitats (e.g. marsh, fen, shallow temporary water) occupying the transitional zone between permanently inundated, and generally dry, environments.

4. Principle

A standard assessment protocol is described for recording the physical features of river channels, banks, riparian zones and floodplains. The range of features surveyed, and the methods used for survey, may vary according to river character and the objectives of the study. Guidance is given on data analysis and interpretation so that the hydromorphological characteristics of river reaches can be assessed through comparison with reference conditions.

5. Survey Requirements

5. 1 River 'types'

Describing and identifying river 'types' enables the results of hydromorphological surveys from similar types to be compared. In addition, defining 'high status', type-specific, 'reference conditions' in rivers is a requirement of the WFD, allowing the quality of rivers to be compared in an equitable and ecologically meaningful way.

Some hydromorphological assessment methods are not linked to river types but can still provide useful information for better river management; this standard therefore includes consideration of such methods.

The core information required to define river types can usually be derived from maps or catchment-wide databases. Types may be refined by using information gathered during field surveys, or through input from expert opinion.

It is recommended that as a minimum the following factors should be used in the definition of river types:

Size – e.g. stream order, catchment size, distance from source
Gradient – channel slope
Geology – a minimum of three categories, preferably more – e.g. siliceous, calcareous, mixed, organic
Geographical location – latitude and longitude
Altitude – altitude of source within the catchment, altitude of the reach being assessed
Hydrological regime – e.g. mean annual discharge, minimum and maximum discharge, seasonality of flow variations (if intermittent),

Table 1 provides an example of the way in which physical and chemical features are used to derive river types in the legislative context of the WFD. In this example, rivers are 'typed' either according to geographic location (ecoregions) together with a set of obligatory

'descriptors' (System A), or using an equivalent approach based on 'obligatory and optional factors' (System B).

Table 1 – The two systems used in the Water Framework Directive to type rivers

System A	
Key Factors	Descriptors
Altitude	high - >800m mid-altitude – 200-800m lowland - <200m
Size (based on catchment area)	small – 10-100km^2 medium – >100-1,000km^2 large – >1,000 -10,000km^2 very large – >10,000km^2
Geology	calcareous siliceous organic
Ecoregion	ecoregions shown on map in Annex XI of WFD
System B	
Obligatory factors	altitude latitude longitude geology size
Optional factors	distance from source energy of flow (function of flow and slope) mean water width mean water depth mean water slope form and shape of main river bed river discharge (flow) category valley shape transport of solids acid neutralising capacity mean substratum composition chloride air temperature range mean air temperature precipitation

5.2 Dividing rivers into reaches

The relationship between river type, river reach and survey unit is fundamental to survey strategy and assessment. An individual catchment needs first to be divided into river type(s) and then component reaches (Figure 1) based on the factors listed in Table 2.

Table 2 – Factors determining reach boundaries

Significant change in:
▪ geology ▪ valley form ▪ slope ▪ discharge (input of significant tributary/change in stream order) ▪ land use ▪ sediment transport (lake, reservoir, dam, major weirs)

5.3 Survey strategy

The reach provides the primary framework for survey. Reaches can be characterised hydromorphologically using various survey strategies (Figure 1).

Survey of the whole reach

- Single survey: the entire reach is assessed in a single survey unit.
- Contiguous survey: the reach is split into a series of contiguous survey units.

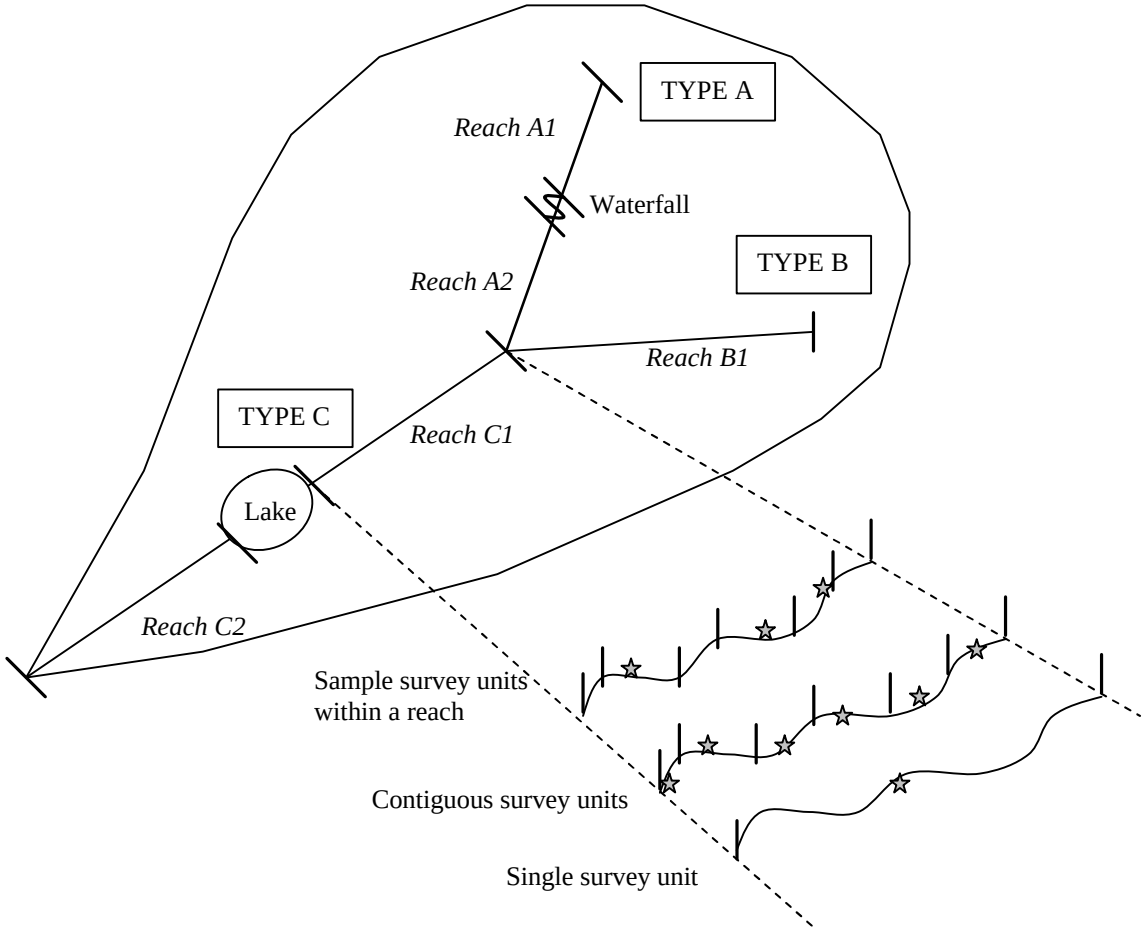
Sampling within a reach

- Survey units are located at random along the reach, or using any other statistically valid approaches.

Survey design should take account of the objectives of the work and the reporting requirements. Where the primary objective is an overall assessment of a river reach, this can be obtained by combining the results from smaller survey units. Individual reaches can also be combined – for example, to assist in reporting the status of 'water bodies' under the WFD. In these cases the overall assessment should take account of the relative length of the constituent reaches. Where the sampling protocol option is used, care must be taken to ensure that the density of the site network is adequate for representing the overall character of the length of river assessed. If the survey is designed to characterise the hydromorphology of rivers over a wide area (rather than targeted on particular areas of impact) a stratified random sampling procedure may be used to survey only a proportion of sites (e.g. 10%) within a type.

In contrast, where the purpose of a survey is to determine the impact of specific environmental pressures on hydromorphology (an aspect of 'investigative monitoring' in the WFD), a more focused survey strategy will be required.

Figure 1: A hypothetical catchment showing the main types of approach to hydromorphological survey, set within the context of river scale ('type', 'reach', 'survey unit') (☆ = survey unit)



5.4 Scale of surveys and evaluations

The length of a survey unit is dependent on the purpose of the assessment and the size of the river. If contiguous survey is used, survey units should be 100 m, 500 m, 1 km, or variable lengths according to the degree of morphological uniformity. If the sampling option is chosen, it is recommended that the length of survey sites should be 100 m, 500 m, or 1 km. Where the main purpose of survey is to assist in operational river management, more detailed collection of data on river features may be required.

Lateral survey boundaries need to encompass all floodplain features that may be present. For large, active, rivers in their lower reaches these features could extend several kilometres from the channel. Where the river valley is less than 100 m wide, it is possible for surveys to include the river and its floodplain. A standard distance of 50 m on either side is recommended for all other watercourses. A category of 'special features' should be used to ensure that any features of ecological or conservation importance but beyond the 50 m boundary are included as well. Where embankments are present, hydromorphological field survey should not extend beyond them. However, notes should be made to allow a description of the *potential* floodplain area and features that could be present if embankments were absent. Hydromorphological information should be gathered for the left and right banks, enabling assessments to be made for each bank separately or both banks together.

5.5 Timing and frequency of field surveys

Assessments should be carried out during periods of the year when all features can be described with confidence. This will often be during periods of low flow (but not when flows have ceased) and where the vegetation type or structure within the channel, bank and riparian zone can be recorded accurately.

The frequency of survey should ideally be linked with the rate of hydromorphological change; this may result in surveys being repeated every 5-10 years.

5.6 Reference conditions

The identification of hydromorphological 'reference conditions' is an essential pre-requisite for assessing hydromorphological quality, and is a specific requirement of the WFD to enable classification of other levels of status. Reference conditions should be identified within each river type reflecting totally, or nearly totally, undisturbed conditions, using the following criteria:

A. Bed and bank character
Reference conditions: lacking any artificial instream and bank structures that disrupt natural hydromorphological processes, and/or unaffected by any such structures outside the site; bed and banks composed of natural materials.

B. Planform and river profile
Reference conditions: planform and river profiles unmodified by human activities.

C. Lateral connectivity and freedom of lateral movement
Reference conditions: lacking any structural modifications that hinder the flow of water between the channel and the floodplain, or prevent the migration of a river channel across the floodplain.

D. Free flow of water and sediment in the channel
Reference conditions: lacking any instream structural modifications that affect the natural movement of sediment, water and biota.

E. Vegetation in the riparian zone
Reference conditions: having adjacent natural vegetation appropriate to the type and geographical location of the river.

If reference conditions for any particular type cannot be found, they may be sought in other countries or regions, by modelling, or by using expert judgement. (Note that the reach scale is not necessarily the scale at which reference conditions will be set under the WFD.)

6. Features for Survey and Assessment

6.1 Standard suite of features

Table 3 provides a standard check-list of hydromorphological features for survey and assessment. These are grouped within 10 categories and cover the three broad zones of river environments: (a) channel; (b) river banks/riparian zone; (c) floodplain.

6.2 Feature recording related to purpose and method of data gathering

The following examples show the way that the assessment categories and groups of features (as defined in Table 3) may be selected for survey according to purpose:

- For a comprehensive overview of river hydromorphology, it is recommended that all categories and features should be assessed.

- To identify sites or reaches that should be classified as 'high status' under the WFD, attention should focus on features within categories 1, 2, 5, 6, 7, 8 and aspects of 3, 9 and 10.

- For 'operational monitoring' under the WFD, features should be selected that are likely to be the most sensitive to the prevailing pressures on hydromorphology.

- For survey and monitoring linked to river rehabilitation projects:

  - record the full suite of features for monitoring the success of a project involving re-meandering or restoring connectivity of the river with its floodplain;
  - record only instream and bank features if habitat rehabilitation undertaken within the channel has no effects on the floodplain or flood hydraulics;
  - record floodplain features if developments are likely to affect adjacent land.

Remote sensing methods such as aerial photography, video recording, or satellite imagery are recommended where appropriate as they can yield valuable data on large-scale features (e.g. extent of riparian zones, location of embankments, river planform, artificial structures). Other features that are smaller or those that may be found under water (e.g. substrate types, channel vegetation, organic debris) may not readily be assessed in this way.

Table 3 – Assessment categories, features and attributes comprising a standard hydromorphological assessment.

No	Assessment Categories	Generic Features	Examples of Attributes Assessed
	CHANNEL		
1	Channel geometry	Planform	Braiding, sinuosity Modification to natural planform
		Longitudinal section	Gradient, long section profiles
		Cross-section	Variations in cross-section shown by depth, width, bank profiles, etc.
2	Substrates	Artificial	Concrete, bed-fixing
		Natural substrate types	Embedded (non-movable boulders, bedrock, etc.) Large (boulders and cobbles) Coarse (pebble and gravel) Fine (sand) Binding (silt and clay) Organic (peat, etc.)
		Management/catchment impacts	Degree of siltation, compaction
3	Channel vegetation & Organic debris	Structural form of macrophytes present	Emergent, free-floating, broad-leaved submerged, bryophytes
		Leafy and woody debris	Type and size of feature/material
		Vegetation management	Weed cutting
4	Erosion/deposition character	Features in channel and at base of bank	Point bars, side bars, mid-channel bars and islands (vegetated or bare); Stable or eroding cliffs; slumped or terraced banks
5	Flow	Flow patterns	Free-flow, rippled, smooth Effect of artificial structures (groynes, deflectors)
		Flow features	Pools, riffles, glides, runs
		Discharge regime	Off-takes, augmentation points, water transfers, releases from hydropower dams
6	Longitudinal continuity as affected by artificial structures	Artificial barriers affecting continuity of flow, sediment transport and migration for biota	Weirs, sluices across bed, culverts
	RIVER BANKS/ RIPARIAN ZONE		
7	Bank structure and modifications	Bank materials	Gravel, sand, clay, artificial
		Types of revetment/bank protection	Sheet piling, stone walls, gabions
		Bank profiles	Cliffs, berms, re-graded, trampled, eroding, depositing
8	Vegetation type/ structure on banks and adjacent land	Structure of vegetation	Vegetation types, stratification, continuity
		Vegetation management	Bank mowing, tree felling
		Types of land-use, extent and types of development	Agriculture, urban development

	FLOODPLAIN		
9	Adjacent land-use and associated features	Types of land-use, extent and types of development Types of open water/wetland features	Floodplain forest, agriculture, urban development Ancient fluvial/floodplain features (cut-off meanders, remnant channels, bog) Artificial water features (irrigation channels, fish ponds, gravel pits)
10	Degree of (a) lateral connectivity of river and floodplain; (b) lateral movement of river channel	Degree of constraint to potential mobility of river channel and water flow across floodplain Continuity of floodplain	Embankments and levees (integrated with banks or set back from river), flood walls and other constraining features Any major artificial structures partitioning the floodplain

7. Field Survey Procedure

Depending on the purpose of the assessment, field survey should be preceded or followed by exhaustive use and interpretation of all available data, such as from historical or recent maps. or from remote sensing.

Field survey should be carried out by walking along the river bank. In wide rivers (i.e. >100m), recording the features of the floodplain on the opposite side of the river will normally require access to that bank too. Using a boat can help in seeing channel and bank features in places not easily accessible from the banks. Under certain conditions it may be impossible to gain access to the channel to record features such as river substrates. These may sometimes be obvious from the bank, but entering the channel to check is recommended wherever possible.

Field recorders require a good understanding of the survey method, and familiarity with the features recorded. Surveys should characterise the river by recording the presence and relative abundance of hydromorphological features and attributes, whether natural or artificial, rather than producing detailed descriptions. Completed survey forms should be accompanied by photographs of the site with details of the location carefully recorded; these are important for reporting purposes as well as providing a record for future comparisons. Locations of sites (e.g. upstream and downstream limits, positions of photographs) may be accurately determined using GPS equipment.

Safety issues are paramount when surveying rivers. Surveyors should conform to EU and national Health and Safety legislation, and any additional guidelines appropriate for working in or near rivers.

8. Classification and Reporting Based on Hydromorphological Assessment

The procedure for assessing hydromorphological survey data will vary according to the purpose of assessment (e.g. assisting with local river management, guiding the rehabilitation of degraded stretches of rivers, or identifying sites or reaches in reference condition under the WFD).

This standard takes account of the present level of sophistication of national hydromorphological assessment methods and provides guidance to enable a basic assessment of the extent of deviation from reference conditions. It is intended that further development of national methods and inter-comparison of the results that they produce will lead to harmonised assessments based on type-specific predictions of the occurrence of physical features within a river.

The extent of deviation from reference condition is used to place a site or reach in one of five classes according to its degree of modification. This is achieved by assessing data from field survey and other sources (e.g. maps, remote sensing) to determine how far the four criteria described in section 5.6 are met. The following are examples from Table 3 of attributes and features (together with the category number) that contribute to this assessment:

A. Bed and bank character
Artificial substrates (2); Artificial bank material (7); Re-graded or trampled banks (7);
Any revetments or bank protection measures (7)

B. Planform and river profile
Modifications to planform (1); Modifications to long section and cross-sectional profiles (1)

C. Lateral connectivity and freedom of lateral movement
Embankments, levees and other constraining features (10)

D. Free flow of water and sediment in the channel
Vegetation management (3); Modifications to flow (5); Artificial barriers (6) (10)

E. Vegetation in the riparian zone
Types of adjacent land-use (e.g. urban development) (8);Vegetation management (8)

Whilst an overall assessment of quality should be determined, it is essential that individual quality assessments for the channel, banks and floodplain are kept separate and can be used as three distinct outputs (as shown in Annex I).

Reference conditions (WFD ‘high status’) for hydromorphology take into account the natural range of variation but form a narrow quality band. The boundaries between the other hydromorphological quality bands should reflect deviation from reference conditions. Adjustment of the boundaries to ensure an even spread of sites across the full quality spectrum in any particular country should not be made, as this will give a misleading impression of hydromorphological quality.

9. Data Presentation

Guidance in this document is given only for presenting data for strategic reporting purposes, rather than for local, site-specific, outputs.

For strategic reporting purposes, a single composite assessment for a river or river reach is likely to be a necessity. However, for operational or monitoring purposes it will be essential to keep elements of the assessment (i.e. channel, banks/riparian zone, and floodplain)

separate. An ability to map these separate components will be important, both for a fuller understanding of the outputs and to encourage managers to make better use of the information. With the use of GIS 'layering' technology, it is possible to present information at different scales and levels of integration, including the relationship between hydromorphological features and artificial modifications.

Whilst the WFD does not require hydromorphology to be reported in five classes, this standard recommends the use of an equivalent 5-band classification system in which reference conditions (high status) are defined as Class 1, and the remaining classes as 2-5. For the purposes of this standard, use of the WFD terms such as 'good status' and 'moderate status' should be avoided as they are linked entirely to WFD assessments of biological conditions. Where maps of hydromorphological quality are produced, it is recommended that the following colours are used:

Blue	Class 1 (reference conditions)
Green	Class 2
Yellow	Class 3
Orange	Class 4
Red	Class 5

It should be stressed that guidance on an integrated quality classification of the features in Table 3, or on ways of classifying the quality of individual features, has yet to be developed. However, as an example of one form of colour-coded output, Annex I shows a map derived from the SEQ method of assessment in France.

10. Quality Assurance

10.1 Training and Quality Assurance for survey and assessment

Surveyor training is essential to ensure consistency in recording river features. Surveyors should have a background in environmental science, but they should not normally be expected to have specialist knowledge of plant identification or fluvial geomorphology.

Training should be structured to cover aspects such as:

- safety issues;
- planning surveys, including issues of access and permission;
- recognising features;
- determining boundaries for field surveys;
- accurate completion of recording forms;
- how to compile a series of reference photographs;
- how to collect and interpret non-survey data – historical maps, aerial photos

Training should:

- incorporate a certification system;
- include regular refresher courses;

- be carried out over a wide range of river types (in the absence of this, certification is only valid for the range of river types experienced during the training);
- be fully supported by manuals and other teaching aids (e.g. videos).

Procedures should be put in place to test the results obtained by different surveyors on the same stretches of river. If a surveyor consistently records results which vary from those recorded by others, the problem should be rectified by additional training.

10.2 Training manuals

Manuals should present general background on the development of the method, and unambiguous information on how to carry out the survey, with accurate descriptions of the features to be recorded. Text should be supported by illustrative material (e.g. photographs, videos, DVDs, CDs) to illustrate what features look like (not just the typical, but extreme forms as well).

Manuals should include guidance on:

- how to transfer information from field sheets to databases
- how to obtain and interpret information from maps
- how to apply the results to assessments of hydromorphological quality
- how to apply quality assurance protocols
- Issues of Health and Safety
- matters relating to access to rivers

10.3 Data entry and validation

It is important that no errors occur when transferring data from field sheets to databases. Suitable quality assurance methods should be used, such as double entry of data onto databases by two different operators, followed by tests to ensure the results are identical. Random testing should also be carried out on hydromorphological quality assessments and other applications to ensure that consistent results are obtained from the same data. Data corruption can occur when systems are up-dated or during information transfer; some form of checking procedure is required following such changes.

11. Bibliography

Agences de l'Eau and Ministère de l'Environnement 1998. *SEQ-Physique: a System for the Evaluation of the Physical Quality of Watercourses*, 15 pp.

Boon, P. J., Wilkinson, J. and Martin, J. 1998. The application of SERCON (System for Evaluating Rivers for Conservation) to a selection of rivers in Britain. *Aquatic Consrevation: Marine and Freshwater Ecosystems*, **8**: 597-616.

Buhmann, D. and Hutter, G. 1996. *Fließgewässer in Vorarlberg. Gewässerstrukturen Erfassen - Bewerten - Darstellen. Ein Konzept*.Schriftenreihe Lebensraum Vorarlberg, Band 33, Bregenz.

Commission of the European Communities (2000). *Directive 2000/60/EC Establishing a Framework for Community Action in the Field of Water Policy*. Official Journal of the European Communities, L327, 1-71.

Fox, P. J. A., Naura, M. and Scarlett, P. 1998. An account of the derivation and testing of a standard field method, River Habitat Survey. *Aquatic Conservation: Marine and Freshwater Ecosystems*, **8**: 455-475.

Indrist, M. *et al*., 1996. *Fließgewässer Tirol – Bezirk Kufstein. Bachmorphologische und nutzungsorientierte Inventarisierung*. Amt der Tiroler Landesregierung, Abt. VI h Wasserwirtschaft, Innsbruck.

Jeffers, J. N. R. 1998. Characterization of river habitat and prediction of habitat features using ordination techniques. *Aquatic Consrevation: Marine and Freshwater Ecosystems*, **8**: 529-540.

Länderarbeitsgemeinschaft Wasser (LAWA) (Hrsg.) 2000. *Gewässerstrukturgütekartierung in der Bundesrepublik Deutschland – Verfahren für kleine bis mittelgroße Fließgewässer*, Berlin.

Muhar, S., Muhar, A., Schmutz, S., Wimmer, R., Wiesbauer, H., Hozang, B., Imhof, G. and Tschemernig, P. 1993. *Ausweisung naturnaher Fließgewässerabschnitte in Österreich – Methodik-Vorstudie*. Blaue Reihe des BMUJF, Bd. 1, Wien, 175 pp.

Muhar, S., Kainz, M., Kaufmann M., and Schwarz, M. 1996. *Ausweisung flußtypspezifisch erhaltener Fließgewässerabschnitte in Österreich - Österreichische Bundesgewässer*, BMLF, Wasserwirtschaftskataster. Wien, 176 pp.

Muhar, S., Kainz, M. and Schwarz, M. 1998. *Ausweisung flußtypspezifisch erhaltener Fließgewässerabschnitte in Österreich – Fließgewässer mit einem Einzugsgebiet >500km^2 ohne Bundesflüsse*, BMLF, BMUJF, Wasserwirtschaftskataster. Wien, 177 pp.

Muhar, S., Schwarz, M., Schmutz, S. and Jungwirth, M. (2000). Identification of rivers with high and good habitat quality: methodological approach and applications in Austria. *Hydrobiologia* 422/423, 343-358.

Raven, P. J., Fox, P. J. A., Everard, M., Holmes, N. T. H. and Dawson, F. D. 1997. River Habitat Survey: a new system for classifying rivers according to their habitat quality. In: Boon, P. J. and Howell, D. L. (Eds.), *Freshwater Quality: Defining the Indefinable?* The Stationery Office, Edinburgh, 215-234.

Raven, P. J., Holmes, N. T. H., Dawson, F. D., Fox, P. J. A., Everard, M., Fozzard, I. R. and Rouen, K. J. 1998. *River Habitat Quality: the Physical Character of Rivers and Streams in the UK and Isle of Man.* Environment Agency, Bristol.

Zumbroich, Th., Müller, A., Friedrich, G. (Hrsg.) 1999. *Strukturgüte von Fließgewässen. Grundlagen und Bewertung*. Springer, Heidelberg.

Annex I: An example of a colour-coded map of hydromorphological quality (Verdon catchment, southern France, produced using the SEQ method of river survey). The colours represent classes of hydromorphological quality, as described in section 9 of the text.