River Hydromorphological Assessment and Monitoring Methodologies – FINAL REPORT

Part 1 – Summary of European country questionnaires

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We wish to thank all national experts who completed European country Questionnaire on Hydromorphological Assessment and Monitoring. Their responses to the questionnaire served as the main source of information for this report.

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Key abbreviations

ATG	Adhoc Task Group
BQE	Biological Quality Element
CIS	Common Implementation Strategy
EIA	Environmental Impact Assessment
HMWB	Heavily Modified Water Bodies
HyMo	Hydromorphology
JRC	Joint Research Centre
GEP	Good ecological potential
GES	Good ecological status
PoM	Programme of Measures
RBMPs	River Basin Management Plans
RHS	River Habitat Survey
ToR	Terms of Reference
WB	Water body
WFD	Water Framework Directive

1 Introduction

The experience from implementing the WFD so far shows that there is a need to take hydromorphology better into account, in status assessment, monitoring, characterisation as well as in the design and implementation of measures (ToR ATG on Hydromorphology).[1]

Especially, the assessment of hydromorphological pressures needs to be improved substantially. The pressure analysis should be based on an inventory of pressures at the necessary level of detail as to serve the purpose. The availability of information on hydromorphological pressures for the first RBMPs was scarce in many Member States, as this issue was largely not regulated before the WFD. However, it is expected that Member States will have much better information basis for the update of the pressures and impacts analysis for the 2nd RBMPs (CSWD, 2015).[2]

In general, hydromorphological assessment is crucial for the detection and the knowledge of the hydromorphological conditions and changes, the designation of HMWB, the development of methods to quantify ecological potential, and for the design and monitoring of mitigation measures. It should also be considered that hydromorphological processes occur at different spatial and temporal scales. Hydromorphological assessment methods are needed to account for variations in time and space (multi-scale methods). Until recently, there have been few shared and standardized multi-scale hydromorphological assessment methods. This has been an obstacle for a proper analysis of the linkages with BQEs so far (CIS Workshop "Hydromorphology and WFD classification", 2015).[3]

1.1 Scope of the report

The present report is about methodologies used in European countries for river hydromorphological assessment and monitoring across scales. It has been developed as part of the work programme 2016-2018 of the CIS ATG on Hydromorphology (see activity E.2 in the ToR of the ATG on Hydromorphology).

It is based on an information collection exercise of European countries to get a comprehensive overview of the hydromorphological approaches in use for WFD assessment as well as for Natura 2000, sediment management, monitoring, and EIA, amongst others. The aim of this exercise is also to contribute to more common understanding on how we assess hydromorphological conditions in our national contexts, also as a basis to carry out future relevant CIS activities.

The information collection exercise has been set-up with the support of a new sub-group consisting of MS hydromorphology experts within ECOSTAT. The kick-off meeting of this CIS ECOSTAT hydromorphology group was held on 13 -14 October 2016 at the JRC, in Ispra (Italy). The purpose of the kick-off meeting was to discuss river hydromorphological assessment and monitoring across scales and to prepare an information collection exercise in that respect (see Summary Report).[4] A draft questionnaire to collect information from European countries on river hydromorphological assessment and monitoring was discussed at the kick-off meeting and later revised and circulated for information collection from European countries in December 2016.

The purpose of this report (**Part 1**) is to summarise the key information reported via this questionnaire on hydromorphological assessment methods used in European countries for WFD implementation.

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[1] ToR ATG Hymo, 11 May 2016, https://circabc.europa.eu/w/browse/97972f74-16e6-4ae0-b4ee-d0f84514ddcf.

[2] Commission Staff Working Document, 2015. Report on the progress in implementation of the Water Framework Directive Programmes of Measures.

[3] Summary conclusions workshop "Hydromorphology and WFD classification", 12-13 October 2015, Oslo, Norway.

[4] Kampa, E. 2016. Kickoff workshop of the CIS ECOSTAT hydromorphology group. 13 - 14 October 2016, JRC, Ispra, Italy. Worshop Summary Report.

In addition, a workshop on methods for river hydromorphological assessment and monitoring took place on 20 – 22 November 2017 at Palacio de zurbano, Madrid (hosted by the Spanish Ministry of Agriculture, Fisheries, Food and Environment). **Part 2** of this report summarises the discussions held at the workshop in Madrid and draws key conclusions & recommendations and is made available in a separate document.

2 European country Questionnaire on Hydromorphological Assessment and Monitoring

A questionnaire was circulated in December 2016 to national experts in countries implementing the WFD (EU Member States and EEA countries) to gather information on hydromorphological assessment and monitoring methods in a structured way. The information collection exercise focused only on the surface water category of rivers.

The aim of the questionnaire was not to record every single method available in European countries but to focus on the hydromorphological assessment and monitoring methodologies which are used in the implementation of WFD and the River Basin Management Plans.

In an Excel worksheet, information was requested for each method separately on:

1) General information about the method
2) General characteristics of the method
3) Recorded hydrological features
4) Recorded morphological features
5) Consideration of processes
6) Recorded artificial elements
7) Assessment output
8) Lessons learned

Because of the technical nature of the questionnaire and possible different interpretation of issues and terms across countries, a detailed Guide was circulated together with the questionnaire. This guide explained each entry and reply option of the questionnaire and gave practical examples where possible (see Annexes IV and V).

The specific issues covered in the eight different sections of the questionnaire are outlined in the table below.

1 - General Information	
ID	**Question**
1,1	Components covered by the method
1,2	Use of the method
1,3	Use of the method for the WFD planning process
1,4	Use for other Directives (except WFD)
1,5	Biological considerations (relationship between hydromorphological alterations and habitat quality required by biological quality elements)
1,6	Status of method
1,7	Level of application
1,8	Extent of application
1,9	Inclusion in legislation
1,10	Relevance for specific pressures
1,11	Key reference
1,12	Available supporting material
1,13	Users qualification
1,14	Requirement for accreditation
1,15	Resource intensity
2 - General Characteristics of the method	

ID	Question
2,1	Source of information/data collection
2,2	Longitudinal spatial scale
2,3	Criteria for selection of variable length
2,4	Lateral spatial scale
2,5	Approach used by the method to define reference condition
2,6	Use of hydromorphological types (indicate in the explanatory text if type is intended as "reference type" or as "current morphological type")
2,7	Criteria/parameters for definition of hydromorphological types
2,8	Differentiation of the method for hydromorphological types
2,9	Temporal dimension
2,10	Severity of hydromorphological pressures
3 - Recorded Hydrological Features	
ID	**Question**
3,1	Components of flow regime
3,2	Type of flow year (avg., wet, dry year)
Characteristics of flow regime	
3,3	Magnitude (e.g. average monthly flow)
3,4	Duration (e.g. duration of annual minima and maxima)
3,5	Timing of specific events (e.g. extreme discharge, including Julian date of annual 1-day maximum and minimum)
3,6	Frequency (e.g. number of low pulses)
3,7	Rate of change (e.g. rise and fall rates)
Surface-groundwater interactions	
3,8	Surface-groundwater interactions
Time related information	
3,9	Time resolution
3,10	Minimum length of time series
Pressures on hydrology	
3,11	Pressures causing hydrological alteration
Other related information	
3,12	Reference (natural) flows
3,13	E-flows
4 - Recorded Morphological Features	
ID	**Question**
4,1	Planform pattern (e.g. sinuous, meandering, etc.)
4,2	Longitudinal profile/gradient
4,3	Variability of cross-section by width/depth
4,4	Erosional/depositional features (bars, eroding banks)
4,5	Fluvial landforms in the floodplain
4,6	Bed substrate (substrate composition)
4,7	Bed configuration (e.g. riffle, pool, etc.)
4,8	Flow pattern (e.g. rippled, smooth, etc.)
4,9	Flow velocity
4,10	In-channel large wood

4,11	Macrophytes
4,12	Vegetation lateral/longitudinal extension in the river corridor
4,13	Vegetation type/structure in the river corridor
5 - Consideration of processes	
ID	**Question**
5,1	Consideration of geomorphic processes
5,2	Longitudinal continuity/alteration of channel forming discharge
5,3	Sediment transport
5,4	Longitudinal continuity/alteration in sediment and wood flux
5,5	Lateral continuity of flows
5,6	Connectivity between hillslopes and river corridor
5,7	Occurrence of bank erosion processes
5,8	Presence of a potentially erodible corridor
5,9	Alteration of bed sediment structure/substrate composition/vertical continuity (e.g. armouring, clogging)
5,10	Consideration of temporal changes and dynamics
5,11	Adjustments in channel pattern
5,12	Adjustments in channel width (e.g. narrowing, widening)
5,13	Bed-level adjustments (e.g. incision, aggradation)
6 - Recorded artificial elements	
ID	**Question**
Structures with impacts on longitudinal continuity	
6,1	Dams
6,2	Check dams/abstraction weirs
6,3	Other structures with impacts on flow and/or sediment discharge (retention basins/diversion channels/spillways
6,4	Crossing structures (bridges/fords/culverts)
Structures with impacts on lateral continuity	
6,5	Bank protections
6,6	Artificial levees or embankments
Structures with impacts on channel morphology and/or substrate	
6,7	Artificial changes of river course
6,8	Bed structures (sills, ramps, bed revetments)
Management interventions	
6,9	Sediment management
6,10	Large wood management
6,11	Vegetation management
6,12	Land use in the surrounding area
6,13	Off-site in-channel pressures (e.g. dam upstream or weir downstream the assessed reach)
6,14	Off-site catchment pressures (e.g. land use in the sub-catchment)
7 - Assessment output	
ID	**Question**
7,1	Type of output of the assessment
7,2	Type of scoring

7,3	Scoring information
7,4	Upscaling of the score of a site/reach to the water body (for WFD)
7,5	Degree of confidence
8 - Lessons Learned	
ID	**Question**
8,1	Lessons learned from the application of this method in WFD implementation
8,2	Strengths of the method
8,3	Weaknesses of the method

2.1 Responding countries

A total of 56 questionnaires, corresponding to 56 different assessment methods, from 27 countries have been received. The table below gives an overview of the number of questionnaires received by country.

No filled-in questionnaires were received from 5 Member States (BG, EL, MT, HR, IC).

Iceland (IC) explained that it has not yet completed the implementation of the WFD and no special methods for hydrology, structure or continuity have been set in this respect.

Table 1 Number of questionnaire responses received by European countries

Country	Number of questionnaires
Austria	1
Belgium (Wallonia)	3
Belgium (Flanders)	1
Switzerland	2
Cyprus	1
Czech Republic	1
Germany	5
Denmark	1
Estonia	1
Spain	3
Finland	1
France	6
Hungary	2
Ireland	2
Italy	3
Lithuania	1
Luxembourg	2
Latvia	1
Netherlands	1
Norway	1
Poland	1
Portugal	1
Romania	1

Country	Number of questionnaires
Sweden	1
Slovenia	1
Slovakia	2
Turkey	1
UK England, Wales	5
UK Northern Ireland	2
UK Scotland	1
(UK)	(1)[5]
TOTAL	56

[5] In the UK, one separate questionnaire was filled in by the conservation agencies for the River Habitat Survey (RHS) and its use under the Habitats Directive. As this report focuses only on methods used for WFD implementation, the RHS questionnaire for assessments under the Habitats Directive has not been included into the summary statistics; however, the questionnaire is made available on CIRCABC.

3 Report structure

The purpose of this report is to summarise the key information reported on 55 methods for hydromorphological assessment from 27 European countries.

Chapter 4 gives a first overview of all methods reported, indicating which main components are covered by each method (hydrology, morphology and/or continuity) and whether the method has been already practically applied or not.

Chapter 5 describes the use of the reported methods for different purposes within the WFD planning process as well as beyond the WFD (e.g. to support the implementation of other directives).

Chapter 6 gives information on the status of the method application, the extent to which they are applied, requirements for specific expertise and training as well as some indications on the resource intensity involved.

Chapter 7 summarise the general characteristics of the methods with specific emphasis on the consideration of different scales and the approach followed with respect to reference conditions and typology.

Chapter 8 summarises information on the main hydromorphological features which are recorded by the reported methods (with separate information on hydrology, morphology, processes and artificial elements).

Chapter 9 informs about the kind of assessment output (e.g. scoring) provided by the methods and the upscaling to water body level for the purposes of the WFD.

Chapter 10 summarises the key findings of the report, and draws key conclusions and lessons learned.

IMPORTANT NOTE: Please note that this report is accompanied by Part 2 (see separate document), which presents a summary of the main discussions at the workshop on Methods for River Hydromorphological Assessment and Monitoring (20-22 November 2017, Madrid) and presents key conclusions and recommendations on the basis of the workshop summary, previous relevant conclusions within the CIS process and relevant scientific work.

4 Overview of methods in European countries

59 different methods for hydromorphological assessment and monitoring have been reported.[6]

Each method covers one or more components in terms of hydrology, morphology or continuity:

- The majority of the methods reported (32 out of 59 methods) cover all three components.
- Some methods cover only one component with an emphasis on hydrological methods (9 methods). 2 of the (French) reported methods cover only morphology and 3 methods cover only continuity aspects.
- 12 of the reported methods cover the combination of morphology-continuity but do not address hydrological issues.

Key strengths, weaknesses and remaining challenges for the methods reported by European countries in the context of this survey are outlined in Annex I (as reported by the experts who filled in the questionnaires).

References to relevant publications on the reported methods are given in Annex III.

[6] Detailed questionnaires have been filled in for 56 out of the 60 methods listed in Table 2. For 4 methods, IE (SNIFFER WFD III), IT (Caravaggio) and UK-Scot (MImAS and MImAS2), information has been added to Table 2 but no full questionnaires are available covering all aspects. Therefore these methods are not included in the remaining summary statistics in this report (with the exception of the UK-Scot methods MImAS which have been considered for Figure 2 and Table 3).

Table 2 Reported methods and components covered

Country	Name of method	Method still in development/ not yet applied	Components covered		
			Hydrology	Morphology	Continuity
Austria	Austrian Guidance on hydromorphological assessment of rivers		x	x	x
Belgium (Flanders)	meetnet Hydromorfologie			x	x
Belgium (Wallonia)	Qualphy			x	x
	Walloon method derived from SYRAH (Fr) (National method)		x	x	x
	Riparian Remote Monitoring - RiReMo (future development)		x	x	x
Switzerland	Modul-Stufen-Konzept (MSK) Methode Ökomorphologie Stufe F (Flachdekkend)			x	x
Switzerland	Modul-Stufen-Konzept (MSK) Methode Hydrologie Stufe F (Flachdekkend) Konzept HYDMOD-F		x		
Cyprus	Integrated Pressure Index (IPI)			x	
Czech Republic	HEM 2014 Metodika monitoringu hydromorfologických ukazatelů ekologické kvality vodních toků		x	x	x
Germany	The hydromorphological classification tool Valmorph for large and navigable surface waters		x	x	x
	Klassifizierung des Wasserhaushalts von Einzugsgebieten und Wasserkörpern	x	x		
	LAWA-Verfahrensempfehlung zur Gewässerstrukturkartierung – Verfahren für mittelgroße bis große Fließgewässer			x	x
	evaluation of sediment continuity (Bewertung der Durchgängigkeit von Fließgewässern für Fische und Sedimente, hier: Sedimentdurchgängigkeit)	x			x

Country	Name of method	Method still in development/ not yet applied	Components covered		
			Hydrology	Morphology	Continuity
	LAWA-Verfahrensempfehlung zur Gewässerstrukturkartierung – Verfahren für kleine bis mittelgroße Fließgewässer			x	x
Denmark	Dansk fysisk indeks, DFI (Danish physical Index)		x	x	
Estonia	River HYMO EST		x	x	x
Spain	Protocol for the hydromorphological characterization of water bodies	X	x	x	x
	DRAINAGE[7]	X	x	x	x
	Índice para la evaluación de la calidad hidrogeomorfológica (IHG)			x	x
Finland	HyMo method (Kevomu-menetelmä)		x	x	x
France	AURAHCE (AUdit RApide de l'Hydromorphologie des Cours d'Eau / Hydromorphology auditing)			x	
	CARHYCE (CARactérisation HYdromorphologique des Cours d'Eau / Hydromorphological characterization of rivers)			x	
	ICE project (for "Informations sur la Continuité Ecologique")				x
	RHUM (Référentiel Hydromorphologique Ultra-Marin) SYRAH-CE adapted to the French overseas departments (tropical systems)		x	x	x

[7] DRAINAGE is not yet a consolidated method for the assessment of hydromorphological features in Spain, but an ongoing approach linked to different research projects.

Country	Name of method	Method still in devel-opment/ not yet ap-plied	Components covered		
			Hydrology	Morphology	Continuity
	ROE (Référentiel des Obstacles à l'Ecoulement)[8]		x	x	x
	SYRAH-CE (SYstème Relationnel d'Audit de l'Hydro-morphologie des Cours d'Eau)[9]		x	x	x
Hungary	Planned_HU	X	x	x	x
	HU_RBMP2		x	x	x
Ireland	Abstraction impact screening assessment	x	x		
	River Hydromorphological Assessment Tech-nique/RHAT			x	x
	SNIFFER (WFD III)[10] (is being/to be used in developing Programmes of Measures for Ireland)				x
Italy	MQI Morphological Quality Index		x	x	x
	Indici di hydropeaking	x	x		
	IARI indice di alterazione del regime idrologico		x		
	Caravaggio[11]			x	x
Lithuania	Lithuanian River Hydromorphology Index		x	x	x
Luxembourg	Klassifizierung des Wasserhaushalts von Einzugsge-	x	x		

[8] Nb : It is not a methodology strictly speaking, but a data repository about all man-made barriers used for different evaluations. It is a database with the aim of listing, and localizing and characterizing all man-made barriers. It allows an evaluation of weirs pressure.
[9] Relational, multi-scale system for auditing the hydro-morphology of rivers
[10] No detailed questionnaire was filled in and method is not included in summary statistics in this report.
[11] Nb: it is used for confirming the reference sites for macroinvertebrates. No detailed questionnaire was filled in and method is not included in summary statistics in this report.

Country	Name of method	Method still in devel-opment/ not yet ap-plied	Components covered		
			Hydrology	Morphology	Continuity
	bieten und Wasserkörpern				
	Strukturgütekartierung (LANUV 2012)		x	x	x
Latvia	HAP-LR		x	x	x
Netherlands	Handboek Hydromorfologie 2.0 (Oste et al. 2013)		x	x	x
Norway	Characterization, analysis and risk assessment of water bodies as defined in WFD art. 5		x	x	x
Poland	Hydromorphological Index for Rivers / HIR	x	x	x	x
Portugal	River Habitat Survey (RHS)		x	x	x
Romania	Methodology to determine the hydromorphological indicators for Romanian rivers		x	x	x
Sweden	HVMFS 2013:19 (Agency regulation)		x	x	x
Slovenia	Hydromorphological Monitoring in Slovenia - HIMO.SI	x	x	x	x
Slovakia	Hydromorphology Quality Assessment		x	x	x
	Physical habitat assessment		x	x	x
Turkey	5 Nehir Hidromorfolojisi Değerlendirme İndeksi (NHDI) (Turkish) River Hydromorphology Assessment Index (English)		x	x	x
UK England & Wales	Designation of A/HMWB		x	x	x
UK England (Wales)	Mitigation Measure Assessment		x	x	x
	River habitat Survey (RHS)			x	x
	Morphology Risk Assessment			x	x
UK Northern Ireland	River Hydromorphology Assessment Technique (RHAT)		x	x	x
	Low Flows Enterprise		x		
UK England	Hydrology - Water Resources GIS (WRGIS)		x		

Country	Name of method	Method still in development/ not yet applied	Components covered		
			Hydrology	Morphology	Continuity
UK Scotland	Hydrology water body classification		x		
UK Scotland	Morphological Impact Assessment System (MImAS) [12]			x	x
	Morphological **Im**pact **A**ssessment **S**ystem 2 (MImAS2)	x		x	x

[12] No detailed questionnaires were filled in and MImAS methods are not included in summary statistics in this report except for Figure 2 and Table 3.

6 Use of methods for different purposes

Use for WFD or non-WFD related assessments

The majority of the methods (43) are used to classify hydromorphological status in the context of the WFD.

Many methods are also used to support ecological classification for the WFD, e.g. to confirm high ecological status or risk of deterioration of a water body (40 methods) and as a tool to support the identification and design of measures (38 methods).

Ca. half of the methods reported are used for hydromorphological assessments not specifically (or not only) used for the WFD and for monitoring changes in hydromorphology. Indeed, several of the methods (17 methods) are applied (or can be applied) to support assessments for the Habitats Directive, while some methods are also used for the EIA and the Floods Directives (11 and 10 methods respectively). In other cases, the methods are being used to monitor the evolution of morphological parameters following restoration projects or to support abstraction licensing strategies & decisions.

Only 10 of the methods are used to indirectly assess or replace BQEs.

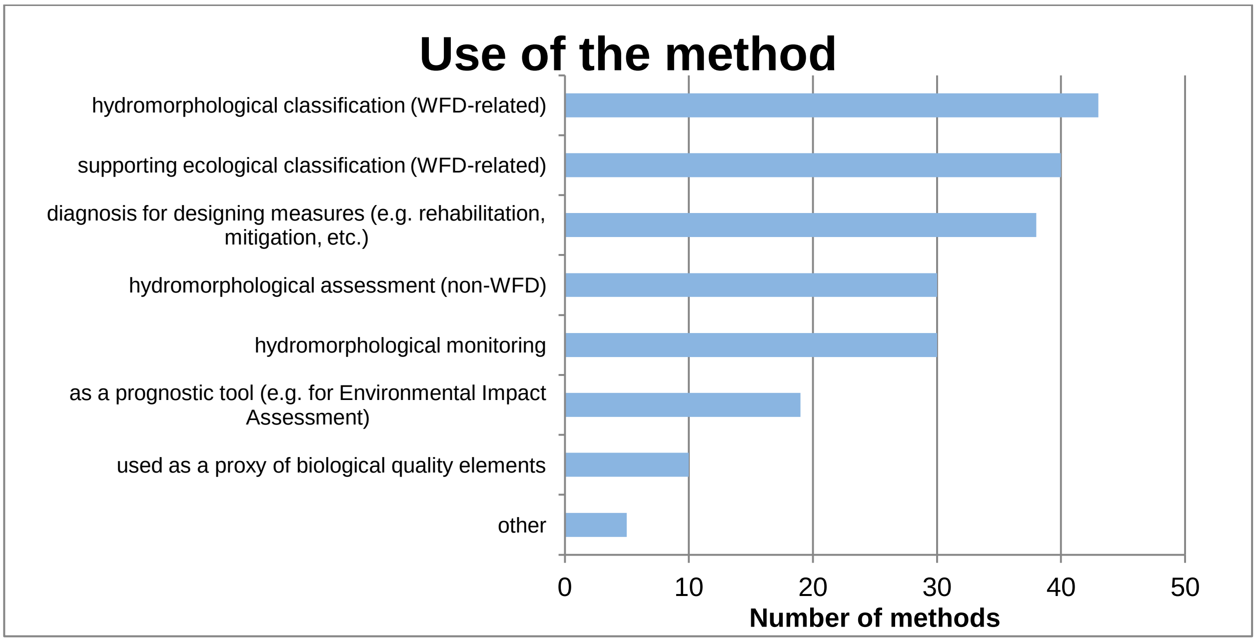


Figure 1 Use of the method for WFD or non-WFD related assessments (n=55)

Use of methods in the WFD planning process

Almost all of the methods reported are used to support at least one or more steps in the WFD planning process.

The following observations on the links between the hydromorphological assessment methods and the WFD planning steps can be made:

- The use of the reported methods in water body delineation and typology is still low (only 11 and 10 methods respectively). A possible explanation is that water body delineation and typologies were often developed before hydromorphological assessment methods for WFD-purposes were introduced. Especially large dams, water abstractions and hydrology in general have been important aspects in water body delineation in certain countries.
- The planning steps which are supported by the highest number of methods are the analysis of pressures and impacts, as well as the design of the programme of measures (44 methods) which should be based on the significant hydromorphological pressures.
- Approximately half of the reported methods support the risk analysis or ecological status classifications or both.

- In the case of status classification, a higher number of current methods are used to support ecological classification at high status only (practised in 15 European countries) than for classification in all 5 ecological status classes (practised in 11 European countries).
  In most countries where hydromorphology is assessed in 5 classes, it is mainly being used as an element supporting ecological classification and hydromorphological status is used directly to downgrade only from high to good ecological status (see Table 3 and Table 4 below for further details on the questionnaire responses).
- In some countries, even though hydromorphological assessment is not used for classification below high status, it is used as proxy for significant hydromorphological pressures and designation of HMWB, i.e. hydromorphologically impacted water bodies which fail to achieve good status because of a key water use.
- In 4 countries, hydromorphological assessment is not used to support ecological assessment, not even for confirming the high status.
- Although HMWB designation is also based on the assessment of severity and significance of hydromorphological modifications, decisions on the designation of HMWB are overall supported only by approximately half of the reported hydromorphological assessment methods.

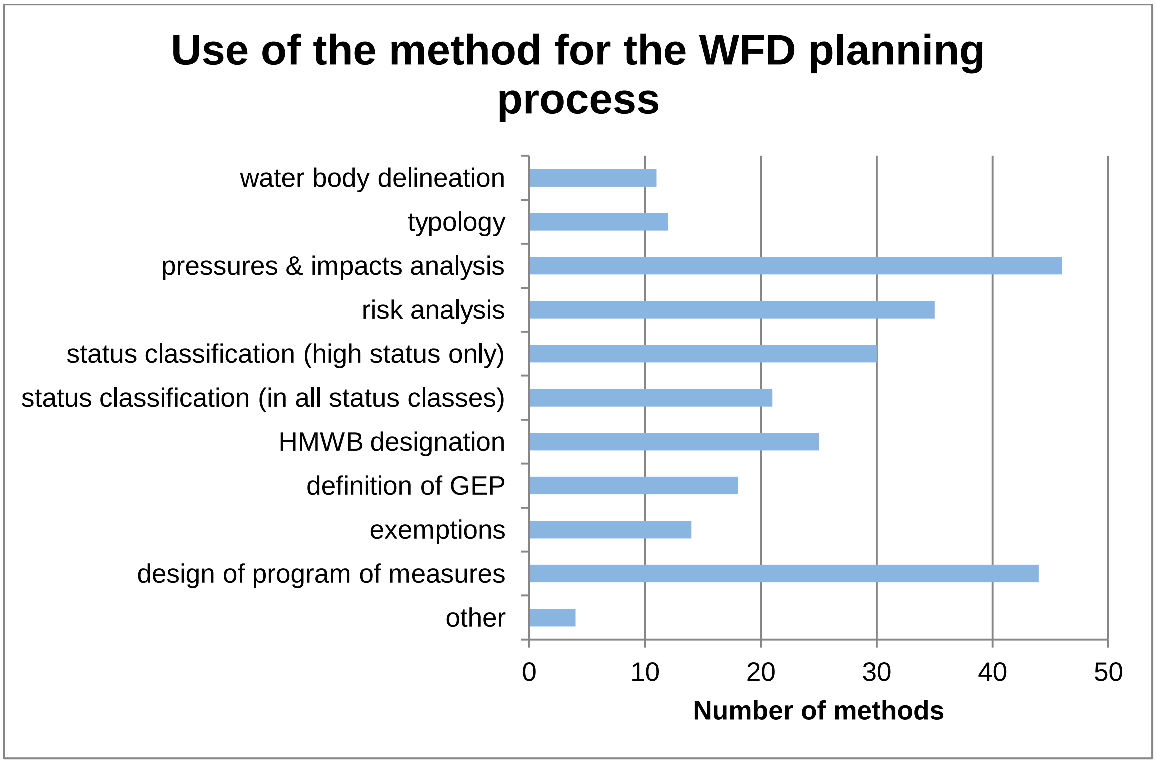


Figure 2 Use of methods in the WFD planning process (n=55)

Table 3 Use of hydromorphological assessment methods for status classification in European countries (green colour indicates that at least one method was reported as relevant to this aspect in the submitted questionnaires)

Country	Number of classes in Hymo classification method	Ecological status classification (for confirming high ecological status only/downgrade to GES)	Ecological Status classification (for classification in all ecological status classes)	Notes
Austria	5			It can be used directly for classification only if no biological assessment is available and in clearcut situations and status is then classified to be of low confidence
Belgium Flanders	5			
Belgium Wallonia	5			
Switzerland	5			
Cyprus	?			Not used for ecological classification
Czech Republic	5			Not used for ecological classification
Germany	5/7			3 different methods; all
Denmark				Not used for ecological classification
Estonia	?			It can be used directly for fish biological assessment in case of significant barriers
Spain	3			
Finland	5			Used as a proxy for significant HyMo pressures; rarely used for ecological classification in classes lower than good
France	5			
Hungary	5			
Ireland	5			New method in development
Italy	5			Also used for identification of HMWB

Lithuania	3			Boundaries for moderate/poor and poor/bad status class are not determined
Luxembourg	5			
Latvia	2			
Netherlands	5			not used for ecological classification
Norway				Norway has no hymo assessment measure but pressures analysis sensu WFD art. 5.
Poland	5			
Portugal	5			
Romania	5			
Sweden	5			Legislation requires assessing hydromorphology in all status classes. A consistency and uncertainty analysis is required in all WB to check if hydromorphological and physico-chemical status is consistent with the ecological status set by BQE. If not consistent and hydromorphological assessment is assumed correct, the BQE can be ruled out. The BQE should then be assessed on expert judgement based on pressure-state knowledge.
Slovenia	5			In development
Slovakia	5			
Turkey	5			
UK-England Wales	5			
UK-Northern Ireland	5			
UK-Scotland	5			Hydrological method supports only the high ecological status classification

Table 4 Use of methods in the WFD planning process

Country	Method	water body delineation	typology	pressures & impacts analy-sis	Ecological status classification (for high status only)	status classification (for classification in all ecological status classes)	risk analysis	HMWB desig-nation	definition of good ecological potential	design of program of measures	exemptions
Austria	Austrian Guidance on hydromorphological assessment of rivers	x	x	x	x	x	x	x	x	x	x
Flanders (Belgium)	meetnet Hydromorfologie					x				x	
BE (Wallonia)	Qualphy										
Belgium Wallonia	Walloon method derived from SYRAH (Fr) (National method)			x	x		x	x	x	x	x
Belgium / Wallonia	Riparian Remote Monitoring - RiReMo (future development)			x						x	
Switzerland	Modul-Stufen-Konzept (MSK) Methode Ökomorpho-logie Stufe F (Flachdekkend)			x		x				x	
Switzerland	Modul-Stufen-Konzept (MSK), Methode Hydrologie Stufe F (Flachdekkend), Kon-zept HYDMOD-F			x		x	x				
Cyprus	Integrated Pressure Index (IPI)										
Czech Republic	HEM 2014 Metodika monitoringu hydromorfologických ukazatelů ekologické kvality vodních toků		x							x	
Germany	The hydromorphological classification tool Valmorph for large and navigable surface waters		x	x			x			x	

Country	Method	water body delineation	typology	pressures & impacts analysis	Ecological status classification (for high status only)	status classification (for classification in all ecological status classes)	risk analysis	HMWB designation	definition of good ecological potential	design of program of measures	exemptions
Germany	Klassifizierung des Wasserhaushalts von Einzugsgebieten und Wasserkörpern			x	x						
Germany	LAWA-Verfahrensempfehlung zur Gewässerstruktur-kartierung – Verfahren für mittelgroße bis große Fließgewässer	x		x	x		x	x	x	x	
Germany	evaluation of sediment continuity (Bewertung der Durchgängigkeit von Fließgewässern für Fische und Sedimente, hier: Sedimentdurch-gängigkeit)			x							
Germany	LAWA-Verfahrensempfehlung zur Gewässerstruktur-kartierung – Verfahren für kleine bis mittel-große Fließgewässer	x		x	x		x	x	x	x	
Denmark	Dansk fysisk indeks, DFI (Danish physical Index)	x					x			x	
Estonia	River HYMO EST	x		x	x		x	x		x	
Spain	Protocol for the hydromorphological characterization of water bodies	x	x	x	x		x	x	x	x	
Spain	DRAINAGE			x						x	
Spain	Índice para la evalua-ción de la calidad hidrogeomorfológica (IHG)			x		x				x	

Country	Method	water body delineation	typology	pressures & impacts analysis	Ecological status classification (for high status only)	status classification (for classification in all ecological status classes)	risk analysis	HMWB designation	definition of good ecological potential	design of program of measures	exemptions
Finland	HyMo method (Kevomu-menetelmä)			x			x	x	x	x	
France	AURAHCE (AUdit RApide de l'Hydromorphologie des Cours d'Eau / Hydromorphology auditing)			x							
France	CARHYCE (CARactérisation HYdromorphologique des Cours d'Eau / Hydromorphological characterization of rivers)			x			x			x	
France	ICE project (for “Informations sur la Continuité Ecologique”)			x			x			x	
France	RHUM (Référentiel Hydromorphologique Ultra-Marin), SYRAH-CE adapted to the French overseas departments (tropical systems)			x	x		x			x	
France	ROE (Référentiel des Obstacles à l'Ecoulement)			x	x		x			x	
France	SYRAH-CE (SYstème Relationnel d'Audit de l'Hydromorphologie des Cours d'Eau)			x	x		x			x	
Hungary	Planned_HU	x	x	x	x	x	x	x		x	
Hungary	HU_RBMP2	x	x	x		x	x	x		x	x

Country	Method	water body delineation	typology	pressures & impacts analy-sis	Ecological status classification (for high status only)	status classification (for classification in all ecological status classes)	risk analysis	HMWB desig-nation	definition of good ecological potential	design of program of measures	exemptions
Ireland	Abstraction impact screening assessment			x			x			x	x
Ireland	River Hydromorphological Assessment Tech-nique/RHAT				x						
Italy	MQI Morphological Quality Index	x	x	x	x		x	x		x	x
Italy	Indici di hydropeaking			x	x		x	x	x	x	x
Italy	IARI indice di altera-zione del regime idrologico			x	x		x	x	x	x	x
Lithuania	Lithuanian River Hydromorphology Index			x		x					
Luxembourg	Klassifizierung des Wasserhaushalts von Einzugsgebieten und Wasserkörpern			x	x			x		x	
Luxembourg	Strukturgütekartierung (LANUV 2012)	x		x	x		x	x	x	x	
Latvia	HAP-LR		x	x	x		x	x		x	x
Netherlands	Handboek Hydromorfologie 2.0 (Oste et al. 2013)			x			x	x	x	x	x
Norway	Characterization, analysis and risk assessment of water bodies	x		x			x	x	x	x	x
Poland	Hydromorphological Index for Rivers / HIR	x	x	x	x	x	x	x	x	x	x
Portugal	River Habitat Survey (RHS)				x					x	

Country	Method	water body delineation	typology	pressures & impacts analy-sis	Ecological status classification (for high status only)	status classification (for classification in all ecological status classes)	risk analysis	HMWB desig-nation	definition of good ecological potential	design of program of measures	exemptions
Romania	Methodology to determine the hydromorphological indicators			x	x	x	x	x		x	x
Sweden	HVMFS 2013:19 (Agency regulation)			x	x	x	x	x		x	x
Slovenia	Hydromorphological Monitoring in Slovenia - HIMO.SI				x						
Slovakia	Hydromorphology Quality Assessment			x		x	x		x	x	
Slovakia	Physical habitat assessment					x				x	
Turkey	Nehir Hidromorfolojisi Değerlendirme İndeksi (NHDI) (Turkish), River Hidromorphology Assessment Index (English)			x	x		x			x	
England & Wales	Designation of A/HMWB			x				x			
England (Wales) - UK	Mitigation Measure Assessment					x			x	x	
England - UK	Hydrology - Water Resources GIS (WRGIS)			x	x		x			x	
England (Wales) - UK	Morphology Risk Assessment			x	x	x	x	x		x	x
Northern Ireland - UK	River Hydromorphology Assessment Technique (RHAT)			x	x			x	x	x	
Northern Ireland	Low Flows Enterprise			x	x	x	x	x	x	x	

Country	Method	water body delineation	typology	pressures & impacts analy-sis	Ecological status classification (for high status only)	status classification (for classification in all ecological status classes)	risk analysis	HMWB desig-nation	definition of good ecological potential	design of program of measures	exemptions
England (Wales) - UK	River habitat Survey (RHS)		x	x	x		x	x		x	
Scotland - UK	Hydrology water body classification			x	x		x			x	
Scotland - UK	**M**orphological **Im**pact **A**ssessment **S**ystem (MImAS)		x	x		x	x			x	
Scotland - UK	**M**orphological **Im**pact **A**ssessment **S**ystem 2 (MImAS2)		x	x		x	x		x	x	

Relevance of methods for specific pressures

Some methods can be particularly suitable to assess the effects of specific pressures, whereas other methods can be applied to assess the effects of all types of hydromorphological pressures.

The questionnaire responses indicate that the majority of the reported methods (33 methods) are applied to assess the effects of all hydromorphological pressures. Some methods (14 methods) are relevant only for specific types of hydromorphological pressures. The specific types of hydromorphological pressures addressed have been explained for 10 of these 14 methods, as illustrated in the table below.

Country	Method	Specific types of hydromorphological pressures for which method is relevant
Belgium / Wallonia	Riparian Remote Monitoring - RiReMo (future development)	n/a
Germany	Klassifizierung des Wasserhaushalts von Einzugsgebieten und Wasserkörpern	All flow/hydrology related pressures
Denmark	Dansk fysisk indeks, DFI (Danish physical Index)	n/a (but link is provided where information is available[13])
Estonia	River HYMO EST	Natural seasonal flow regime, ecological minimum flow, water abstraction, water transfer, dicharge, impoundment, indirectly ameloration network in cathment, connection to floodplain, meandering and reparian zone alteration, weirs/dams and beaver dams
Spain	DRAINAGE	Hydromorphological pressures derived for highly regulated rivers
France	RHUM (Référentiel Hydromorphologique Ultra-Marin) SYRAH-CE adapted to the French overseas departments (tropical systems)	n/a
France	SYRAH-CE (SYstème Relationnel d'Audit de l'Hydromorphologie des Cours d'Eau) Relational, multi-scale system for auditing the hydromorphology of rivers	n/a
Ireland	Abstraction impact screening assessment	n/a
Italy	Indici di hydropeaking	Rapid and short term fluctuation in flow due to hydropower production (hydropeaking)
Luxembourg	Klassifizierung des Wasserhaushalts von Einzugsgebieten und Wasserkörpern	Hydrologically relevant land use; drainage areas; water withdrawal and irrigation; discharge in surface water bodies; groundwater recharge; hydraulically relevant channel alterations, connectivity to groundwater; artificial backwaters and associated colmation effects; loss of floodplains and their functions; water flow regulations, engineering activites, river management, other morphological alterations, other pressures.
Sweden	HVMFS 2013:19 (Agency regulation)	n/a (but there are supporting documents on the relationship between certain pressures and alteration of specific hymo parameters available on Water information system in Sweden (https://viss.lansstyrelsen.se/)
England (Wales) - UK	Mitigation Measure Assessment	Other human sustainable development, Wider environment, Recreation, Navigation including ports, Water regulation (i. ii.), Drinking water supply, Irrigation, Power generation, Flood protection, Land Drainage, Urbanisation, Navigation, ports and harbours use, Flood protection use, Coast protection use, Marine aggregate extraction use, Marine shell and fin fisheries use
England - UK	Hydrology - Water Resources GIS (WRGIS)	Abstractions
Northern Ireland	Low Flows Enterprise	Abstractions
Scotland - UK	Hydrology water body classification	Abstractions, discharges and flow regulation pressures

13 http://bios.au.dk/fileadmin/bioscience/Fagdatacentre/Ferskvand/V05_fysisk_indeks_version_2.3_20160520.pdf.

Biological considerations

Some hydromorphological assessment methods also include biological considerations, i.e. they address the relationship between hydromorphological alterations and habitat quality elements required by type-specific biological quality elements.

The majority of methods (31 methods or 56%) contain biological considerations, directly or indirectly:

- 11 methods address fish continuity indirectly, e.g. when the barrier passability is evaluated by the height of the structure, while 6 methods address this directly, e.g. they assess whether a barrier is passable for fish.
- 10 methods also consider other biological elements in addition to fish continuity.
- Only few methods (3) consider other biological elements without including fish continuity.
- Many methods (13) do not include any biological considerations (7) or these aspects were reported as not applicable (6).
- For 7 methods, another type of response was provided either because an evaluation of fish continuity is still being developed or because the method includes biological considerations in another way.
- For 5 methods, no relevant information was provided.

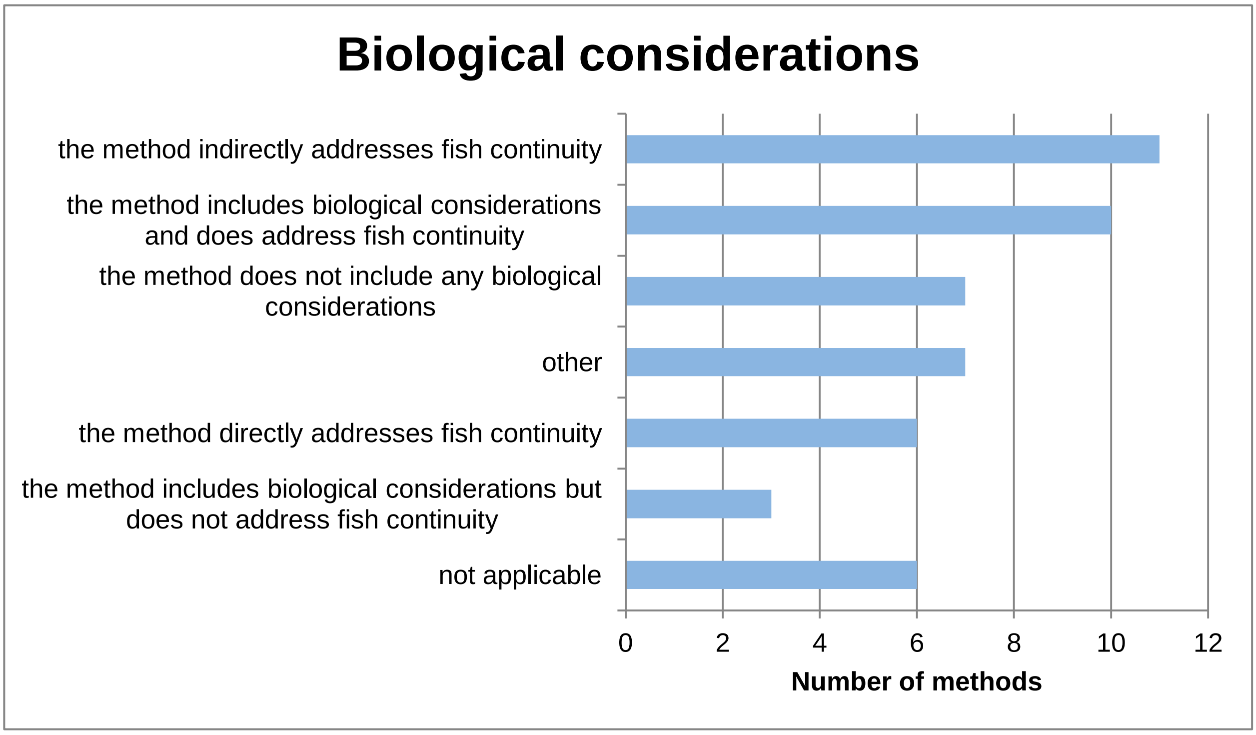


Figure 3 Biological considerations (n=55)

7 Application of methods

Status of method application

The majority of the currently applied methods (42) are the official methods for hydromorphology (or for a component of hydromorphology) in the respective countries.

There are also some methods (11) which are in development or recently developed and not yet used in practice. Such methods are reported from DE, FR, ES, HU, IE, IT, LUX, PL and TK. In Table 2, details are available on which methods are still in development and not yet practically applied.

The number of methods applied has increased from the 1st to the 2nd RBMPs (from 22 to 36 methods), which shows significant progress in the development of methods for hydromorphological assessments since the 1st planning cycle. All of the methods which were applied in the 1st RBMPs (with the exception of 2) are also being applied in the 2nd cycle.

It should also be noted that the majority of methods (34) are included in national guidelines while only some are part of national legislation (17 methods). 10 of the reported methods are both included in national legislation and in guidelines.

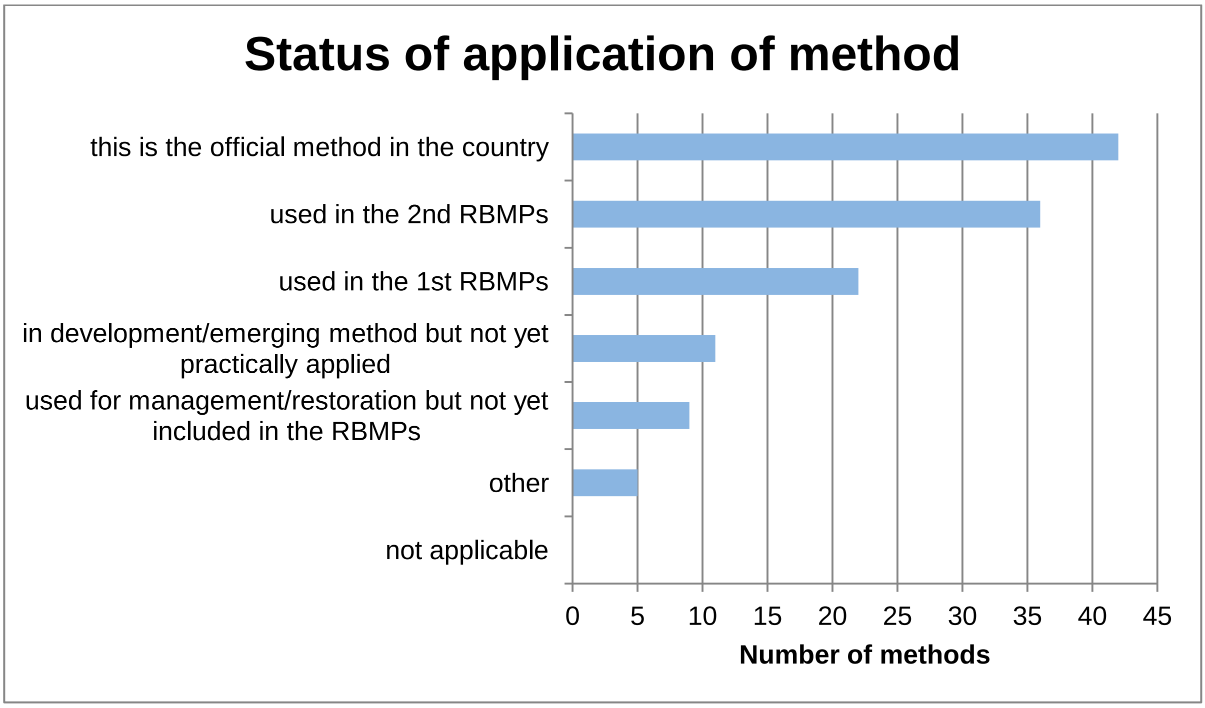


Figure 4 Status of application of method (n=55)

Level of application

Concerning the spatial extent of application of the methods, most of them are applied on the national level, compared to only few that are applied in only part of the country (regional/basin level).

For almost half of the reported methods, the results of the assessment are extended to larger river portions (e.g. water bodies). More details on upscaling the score to water bodies are given in section 10 of this report.

A significant number of methods (23) aim to assess the whole river network (i.e. every km). Slightly less methods aim to assess only specific sites in the network (18).

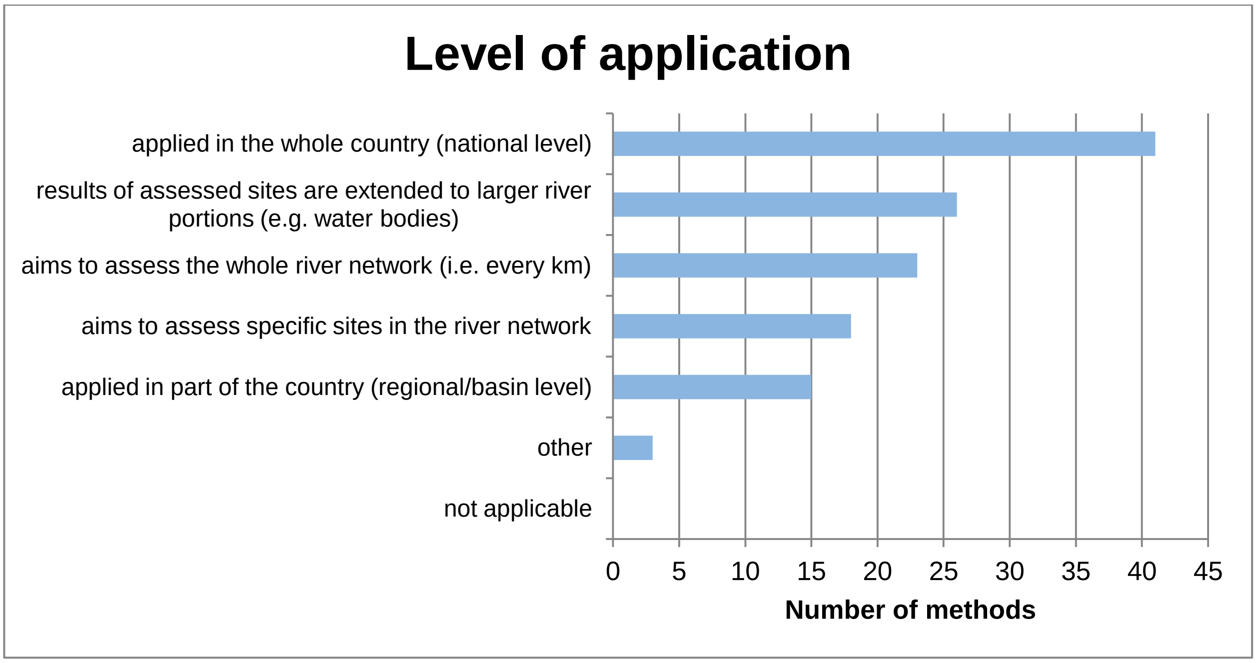


Figure 5 Level of application (n=55)

Extent of application

For 33 of the reported methods, information was provided on the percentage of water bodies (WFD) to which the method has been applied.

- In approximately half of these cases (19 methods from AT, BE, DE, FI, HU, IE, LU, NO, PL, RO, SE, UK – E, W, Scot), the method has been applied for all or almost all water bodies (close to 100%). In some cases (e.g. for the Swedish method HVMFS 2013:19), it has been explained that although the method is applied to all water bodies, not all morphological parameters have been assessed in all bodies due to lack of data.
- Few of the methods (ca. 4 methods from CY, EE, ES, NI-UK) have been applied to approximately half of the water bodies in the country.
- Some of the methods (ca. 7 methods from CZ, DE, IE, NL, PT, SK) have only been applied to a small portion of between 10% and 40% of the relevant water bodies.

User's qualification and accreditation requirements

Hydromorphological assessments require training in order to have comparable and standardised results and each method requires some specific expertise. The survey shows that:

- For 40 of the reported methods, specific expertise is required to apply the method. For at least half of these methods, the specific expertise required includes expertise in fluvial geomorphology and/or hydromorphology. Only for 5 methods, it is explicitly indicated that no specific expertise or qualification is required or specified.
- However, only few methods (17) require a specific certificate or specific training programme to release the accreditation for its use. For the majority of methods, there is no accreditation requirement.

Resource intensity

One important aspect influencing the use of a method is how resource intensive is its application. Estimating the resource intensity in terms of monetary costs has not been required as part of this European questionnaire survey, but an approximate evaluation was based on the working time required (e.g. hours needed to apply the method per km or per reach). The time required should include the field work and the other phases (for example, preparatory work, remote sensing, GIS analysis, etc.).

- Most methods (31) were evaluated to be of medium resource-intensity, which for the purpose of this questionnaire is interpreted as between 1 and 4 hours needed to complete the assessment for 1 km.
- Few methods (11) were evaluated to be of low resource intensity, i.e. needing on average less than 1 hour to complete per km, and even less methods (8) to be highly resource intensive.

8 General characteristics of the methods

8.1 Source of information / data collection

The sources and approaches to obtain the necessary information and/or to measure some parameters needed for the methods reported are summarised in the table below. The most common ones are field surveys, existing GIS data and databases.

The use of more modern technologies such as LiDAR data and drone images are less widespread.

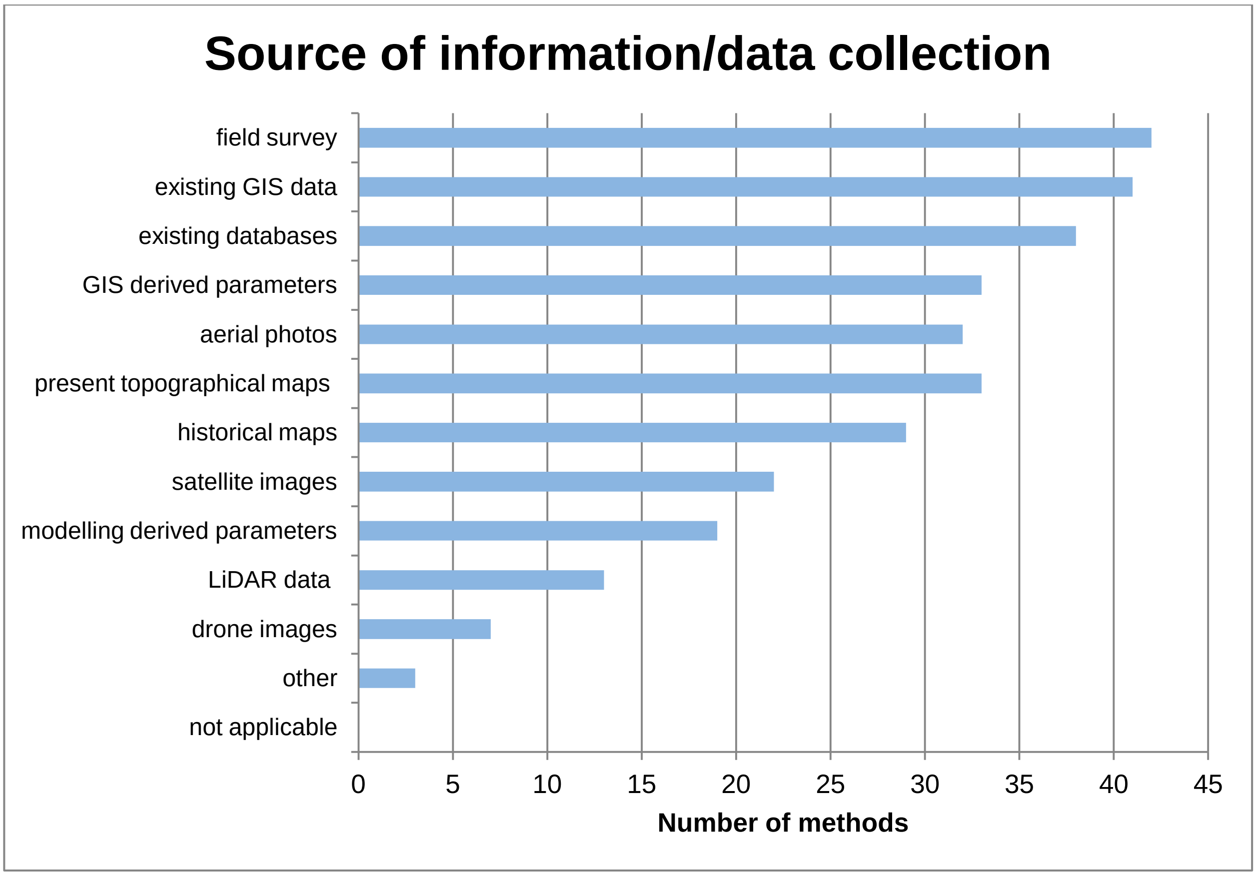


Figure 6 Source of information / data collection (n=55)

8.2 Longitudinal and lateral spatial scales

The longitudinal spatial scale can be considered in different ways in hydromorphological assessments.

- The majority of the reported methods (25) require the assessment of stretches to be performed on a variable length. The criteria most frequently used for the variable length are morphological segmentation (e.g. linked to the degree of alteration, homogeneous geomorphologic reaches, landscape units) and the homogeneity of specific characteristics (e.g. of the river or channel width, flow regime, riparian zone).
- Some methods require the assessment to be carried out on a site of fixed length (usually transects vary between 100 and 500m) (13 methods) or for a length that is scaled to the channel size, for example the channel width (referring to bankfull or low-flow channel) (13 methods).
- A few methods (10) require the assessment to be applied to an exact place, e.g. location of migration barriers.

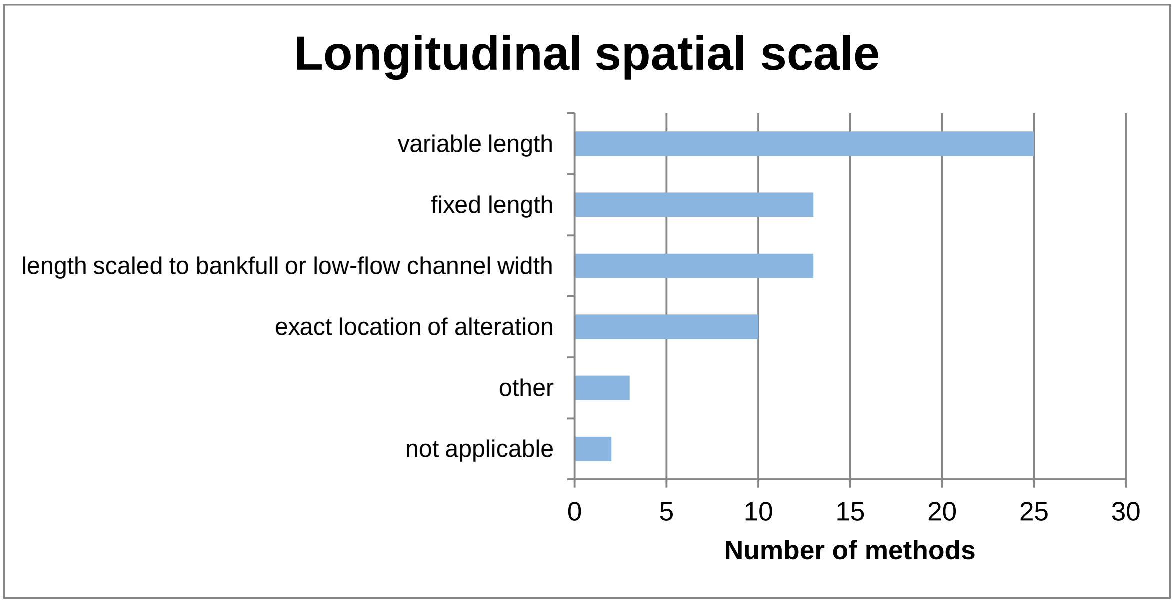


Figure 7 Longitudinal spatial scale (n=55)

In terms of the lateral spatial scale, i.e. the width to which the assessment refers, the most frequent parameters included in the assessment are:

- Floodplain: all the floodplain may be included, but for large alluvial plains only a portion of it could be assessed (33 methods).
- Riparian zone, i.e. the strip immediately adjacent to the banks (32 methods).
- Banks (31 methods).
- Stream channel, i.e. the assessment is carried out only within the channel (31 methods).

In unconfined or semi-confined streams the connection with floodplain is crucial for ensuring good hydromorphological and ecological processes. In naturally confined streams, the connection with hillslopes serves the same functions (e.g. the provision of sediment and organic matter). Nevertheless, few methods consider hillslopes in determining the lateral spatial scale.

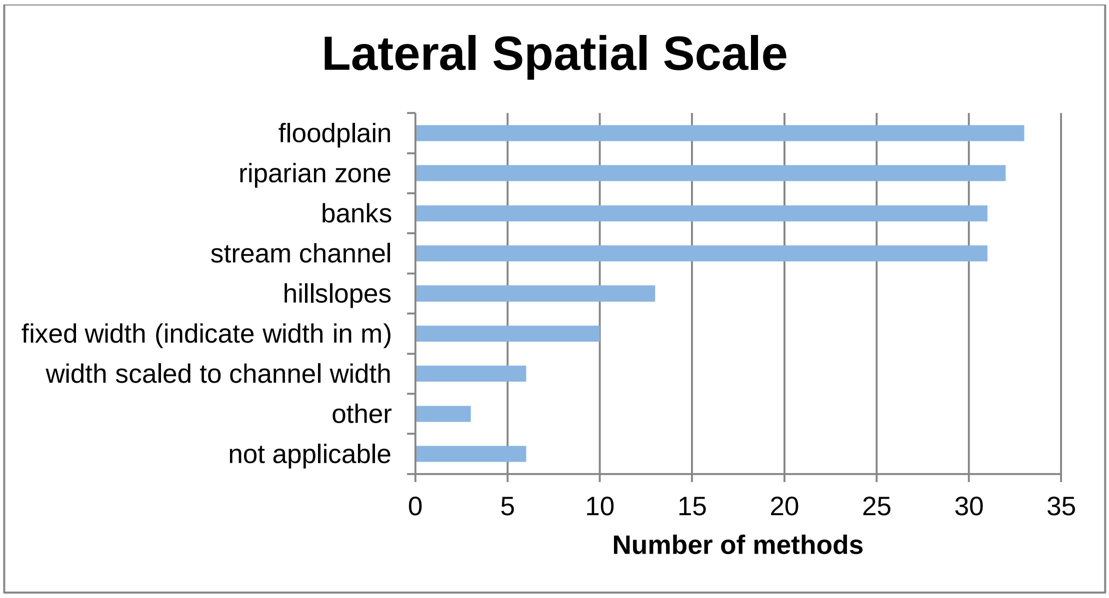


Figure 8 Lateral spatial scale (n=55)

8.3 Defining reference conditions

Each hydromorphological assessment method can define reference conditions in different ways. The main approaches used by most of the reported methods were:

- Theoretical, meaning that the reference conditions have been based on some theoretical assumption and/or some expert judgement of the authors of the method.
- Empirical/statistical, when a range of expected values (generally for each indicator) has been defined by the authors of the method based on the range of data measured (or calculated) for a sufficient number of reference sites of the same river type.
- For some methods, also a historical approach is used, i.e. assuming the channel morphology and other river conditions in the past as the reference condition.

In practice, many methods use a combination of these approaches, e.g.:

- In the Austrian Guidance on hydromorphological assessment of rivers, hydromorphological reference conditions are defined by combination of the three approaches using a hierarchy: 1^{st} historical (before ~ 1850), 2^{nd} empirical and 3^{rd} theoretical approach.
- In Luxembourg, hydromorphological types are based on historical near-natural reference status and empirical/statistical identification of reference conditions.

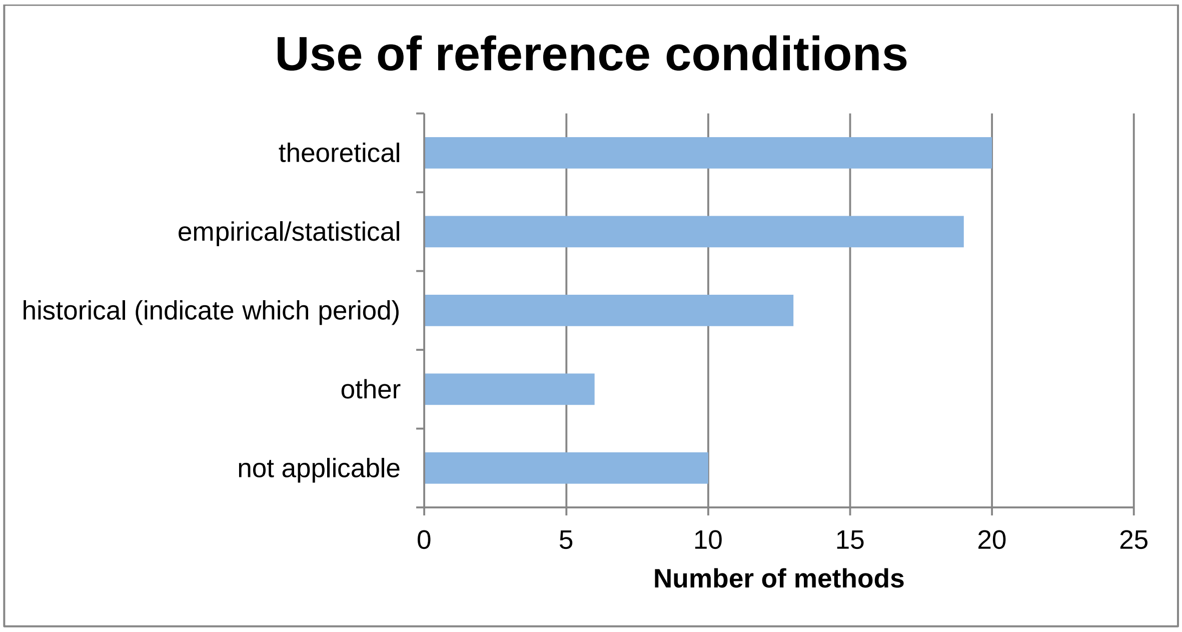


Figure 9 Use of reference conditions (n=55)

The table below outlines how reference conditions are generally defined for the different methods for which relevant information has been provided:

Table 5 Definition of reference conditions for the different methods reported

Country	Method	Empirical/statistical	Historical	Theoretical	Other	No reference
Austria	Austrian Guidance on hydromorphological assessment of rivers	definition of hydromorphological reference conditions defined by combination of the three approaches using a hierachy: 1. historical (before ~ 1850), 2. empirical, 3. theorethical				
Flanders (Belgium)	meetnet Hydromorfologie	Yes		Yes		
BE (Wallonia)	Qualphy					data provided by "Syrah"method
Belgium Wallonia	Walloon method derived from SYRAH (Fr) (National method)		Yes	Yes		
Belgium / Wallonia	Riparian Remote Monitoring - RiReMo (future development)	Yes				
Switzerland	Modul-Stufen-Konzept (MSK) Methode Ökomorphologie Stufe F (Flachdekkend)					In Switzerland for the classification no reference is used. The method dates from 1998. Only in 2013 a Typology was made.
Switzerland	Modul-Stufen-Konzept (MSK), Methode Hydrologie Stufe F (Flachdekkend), Konzept HYDMOD-F				the non-influenced status of the flow regime is derived (any adequate approach) to get the flow characteristics without impact	
Cyprus	Integrated Pressure Index (IPI)	The High/Good boundary was set by calculating the 5th percentile of the index value in (biological) reference sites				

Country	Method	Empirical/statistical	Historical	Theoretical	Other	No reference
Czech Republic	HEM 2014 Metodika monitoringu hydromorfologických ukazatelů ekologické kvality vodních toků	Yes	Present status compared to II. Military Survey (1836 - 1852).	Yes		
Germany	The hydromorphological classification tool Valmorph for large and navigable surface waters	Yes	Yes			
Germany	LAWA-Verfahrensempfehlung zur Gewässerstrukturkartierung – Verfahren für mittelgroße bis große Fließgewässer			deviation from potentially natural conditions		
Germany	evaluation of sediment continuity (Bewertung der Durchgängigkeit von Fließ-gewässern für Fische und Sedimente, hier: Sediment-durchgängigkeit)				WFD definitions	
Germany	LAWA-Verfahrensempfehlung zur Gewässerstrukturkartierung – Verfahren für kleine bis mittelgroße Fließgewässer			deviation from potentially natural conditions		
Denmark	Dansk fysisk indeks, DFI (Danish physical Index)					The method is not used to define refer-ence condition
Estonia	River HYDROMORPHOLOGICAL EST		Maps from 1930s were used to compare the characteristics (historical shape of river bed, before large ameloration works)			

Country	Method	Empirical/statistical	Historical	Theoretical	Other	No reference
Spain	Protocol for the hydromorphological characterization of water bodies			Reference conditions correspond to conditions in absence of significant pressures.		
Spain	DRAINAGE	frequency analysis of flow time series	From 1946 to present			
Spain	Índice para la evaluación de la calidad hidrogeomorfológica (IHG)		Sometimes, we've used 1956 aerial photos to define reference condition	Yes		
Finland	HyMo method (Kevomumenetelmä)				Time before significant human intervention	
France	AURAHCE (AUdit RApide de l'Hydromorphologie des Cours d'Eau / Hydromorphology auditing)	Yes				
France	CARHYCE (CARactérisation HYdromorphologique des Cours d'Eau / Hydromorphological characterization of rivers)	Yes		Yes		
France	RHUM (Référentiel Hydromorphologique Ultra-Marin), SYRAH-CE adapted to the French overseas departments (tropical systems)					It could support the definition of several states (such as reference conditions). To be developed
France	SYRAH-CE (SYstème Relationnel d'Audit de l'Hydromorphologie des Cours d'Eau)					It could support the definition of several states (such as reference conditions). To be developed
Hungary	Planned_HU			Yes		
Hungary	HU_RBMP2			Mainly taking into account EN 15843:2010		

Country	Method	Empirical/statistical	Historical	Theoretical	Other	No reference
Ireland	Abstraction impact scree-ning assessment	Reference conditions were estab-lished by accounting for known abstractions and discharges	Yes			
Ireland	River Hydromorphological Assessment Tech-nique/RHAT			Eight attributes are scored based on departure from naturalness - depending on the RHAT river type		
Italy	MQI Morphological Quality Index			Yes. Reference conditions are those in which function-ality is maximum, artificiality is null and no channel ad-justments occurred.		
Lithuania	Lithuanian River Hydromorphology Index	Yes				
Luxembourg	Klassifizierung des Wasser-haushalts von Einzugsgebie-ten und Wasserkörpern					Focus of method is pressure-based. No type-specific hydro-logical reference conditions are de-fined.
Luxembourg	Strukturgütekartierung (LANUV 2012)	Yes	Yes	Deviation from hydromorphological, type-specific reference conditions		
Latvia	HAP-LR	Yes				
Netherlands	Handboek Hydromorfologie 2.0 (Oste et al. 2013)			Yes		
Poland	Hydromorphological Index for Rivers / HIR	Yes				

Country	Method	Empirical/statistical	Historical	Theoretical	Other	No reference
Portugal	River Habitat Survey (RHS)				PT used the pressures analysis to identify reference sites	
Romania	Methodology to determine the hydromorphological indicators		the period before the construction of hydro-technical works or slight deviation from this status, namely, the natural hydrological regime and the natural riverbed morphology	Yes	expert judgement	0
Sweden	HVMFS 2013:19 (Agency regulation)	Based on time series, aerial photographs from different time periods	Depends on river hydromorphological type. Most swedish rivers has a low dynamics. Most cases old maps back to 1780 need to be assessed	used for expert judgement in addition to the other methods	Modelling of reference condition by artificially remove the hydromorphological pressure	
Slovenia	Hydromorphological Monitoring in Slovenia - HIMO.SI		Yes			
Slovakia	Hydromorphology Quality Assessment		Period before the major human impacts occurred in the river system, usually end of 19. and the beginning of 20. Century			
Slovakia	Physical habitat assessment	Yes				
Turkey	Nehir Hidromorfolojisi Değerlendirme İndeksi (NHDI) (Turkish), River Hydromorphology Assessment Index (English)			Index has class boundary value. According to this boundary value hydromorphological status of waterbodies is determined. The reference conditions for waterbodies are the scores that pass the boundary value between high and good status.		

Country	Method	Empirical/statistical	Historical	Theoretical	Other	No reference
England (Wales) - UK	Mitigation Measure Assessment			Yes		
England - UK	Hydrology - Water Resources GIS (WRGIS)	Define Naturalised flows for Q95, Q70, Q50 & Q30 based on rainfall over the period of 1990-2007				
England (Wales) - UK	Morphology Risk Assessment			based on broad UKTAG ecological status class criteria		
Northern Ireland - UK	River Hydromorphology Assessment Technique (RHAT)			Yes		
Scotland - UK	Hydrology water body classification	Define naturalised flows based on rainfall over the period of 1961-1990				

8.4 Use of hydromorphological types

For the majority of hydromorphological assessment methods (22 methods), a hydromorphological type is assigned at some stage of the assessment to each investigated site/reach. For some methods, the term “type” is used as reference conditions / “reference types” (methods applied in AT, ES (method “Drainage”), LU, SK) and for some methods, the term “type” is used to characterise present conditions (methods applied in CH, ES (Protocol for the hydromorphological characterization of water bodies), IT).

The criteria or parameters used to define the types are specified in the following figure according to the frequency by which they are used in the reported methods:

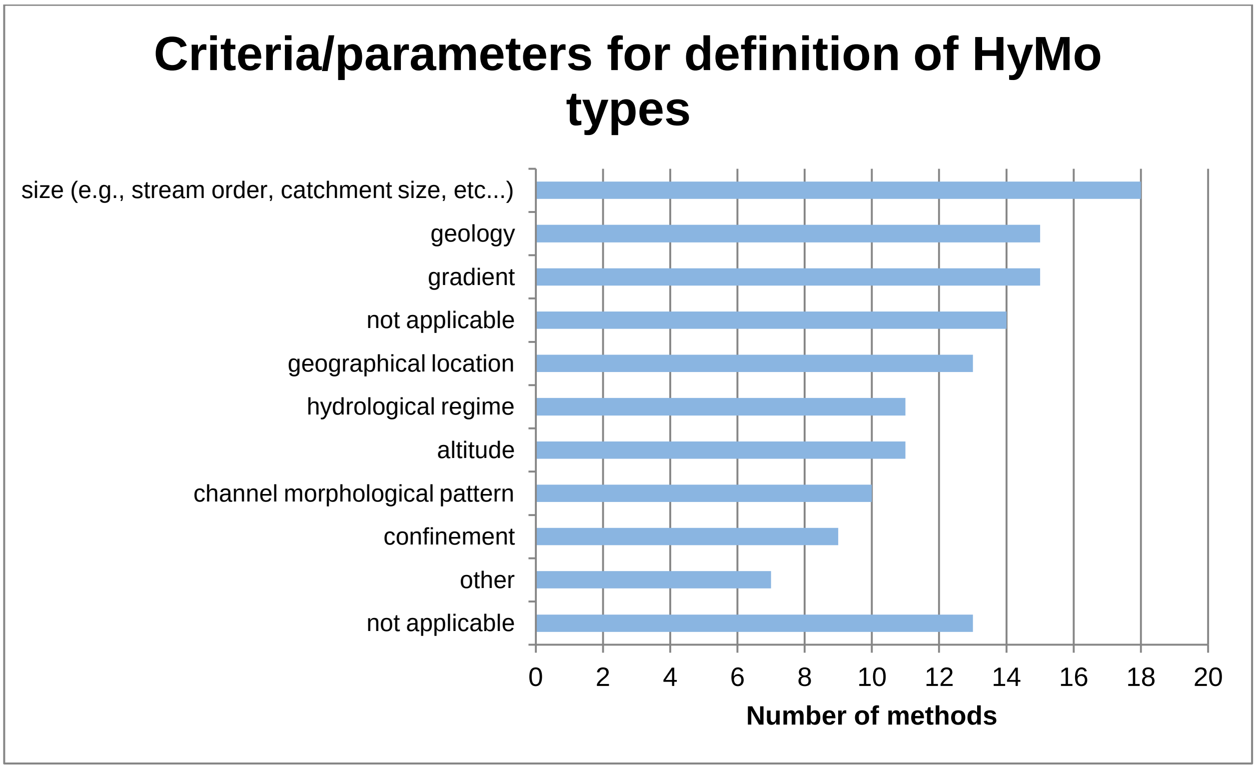


Figure 10 Criteria for defining hydromorphological types (n=55)

Note: “other” indicates responses that could not be placed into the available categories

The majority of methods (27) are applied in the same way for all (hydromorphological) types[14], i.e. they are completely independent in all their parts of assessment from the hydromorphological type. Nevertheless, for certain methods, it is noted that although the same indicators are recorded for all types, the evaluation of the indicators can be type - specific.

For 9 of the reported methods, all or some of the indicators are applied in a different way dependent on the hydromorphological type. For example, in the Spanish protocol for the hydromorphological characterization of water bodies, specificities are included in order to determine the Hydromorphological status for temporary rivers.

For 12 methods, it was reported that there is no consideration of hydromorphological types. E.g. in Portugal, hydromorphological types are not considered, but only WFD types defined according Annex 2.

[14] Note that for a few of these methods, hydromorphological types are not directly used.

8.5 Temporal dimension

22 of the reported methods give some consideration to past morphology or other river conditions (e.g. riparian vegetation, channel straightening or other past artificial modifications, etc.) in the assessment. More details on the temporal dynamics and the consideration of processes are provided in section 9.3 of this report.

For 16 methods, it is reported that they do not consider past channel morphology/condition.

8.6 Severity of hydromorphological pressures

The majority of methods (27 methods) attempt to account for or evaluate the severity of hydromorphological pressures.

This is particularly relevant for the process of identifying HMWBs whereby the water body must be “substantially changed in character”, which usually entails hydromorphological change which is extensive/widespread or profound as well as permanent (see CIS Guidance no.4 on HMWB designation).

Only 10 methods attempt to account for the ecological significance of hydromorphological pressures. For example, in the Austrian Guidance on hydromorphological assessment of rivers, the assessment of the severity of the pressure has to be combined with effects on biology for HMWB-designation (as failing of GES is prerequisite for HMWB-designation). In the Estonian River HYMO EST, dams with fish passage are considered to have less impact.

Very few methods (only 4) do not attempt to evaluate the severity of hydromorphological pressure at all.

9 Recording of hydromorphological features

9.1 Recording of hydrological features

This section mainly addresses features that are normally accounted by methods specifically used for hydrology, i.e. to assess the deviation of the hydrological regime from unaltered or previous conditions. The methods can be based directly on flow data (measured and/or modelled) or indirectly on pressures by using hydrological regime as a proxy for the lack of data.

In the first case, methods are usually based on the Indicators of Hydrologic Alteration (IHA, Richter et al., 1996; Poff et al., 1997) and/or successive Range of Variability Approach (RVA, Richter et al., 1997). According to the IHA, the flow regime is described by five main flow characteristics (magnitude, duration, timing of specific events, frequency and rate of change), to derive a suite of parameters / indicators of the flow regime.

There have been in total 40 responses to this part of the questionnaire. No information on hydrological features has been provided for 2 methods (FR-ROE, HU- Planned_HU). The questionnaire section on hydrological features has not been filled in for 14 methods which do not deal with hydrological features (according to the instructions given).

Components of flow regime

Alterations are assessed for the following components of the flow regime:

- Average flows (in 23 methods)
- Low flows (in 20 methods)
- High flows (e.g. small and large floods) (in 15 methods)
- Other components (in 10 methods)

Type of flow year

The questionnaire aimed to specify if the methods account for the fact that the year in consideration could be anomalous with respect to the long term average (normal, wet or dry year) and so needs normalization for getting unbiased alteration assessment.

Only 9 of the reported methods consider the type of flow year, while for 17 methods, there is no such consideration.

Characteristics of flow regime

Out of the five main flow characteristics which are used to describe the flow regime, **magnitude** and **duration** are those recorded and used to evaluate river conditions by the highest number of methods.

The **timing of specific events**, **frequency and rate of change** are also recorded in several methods (12), but they are not considered in another 7 to 10 methods.

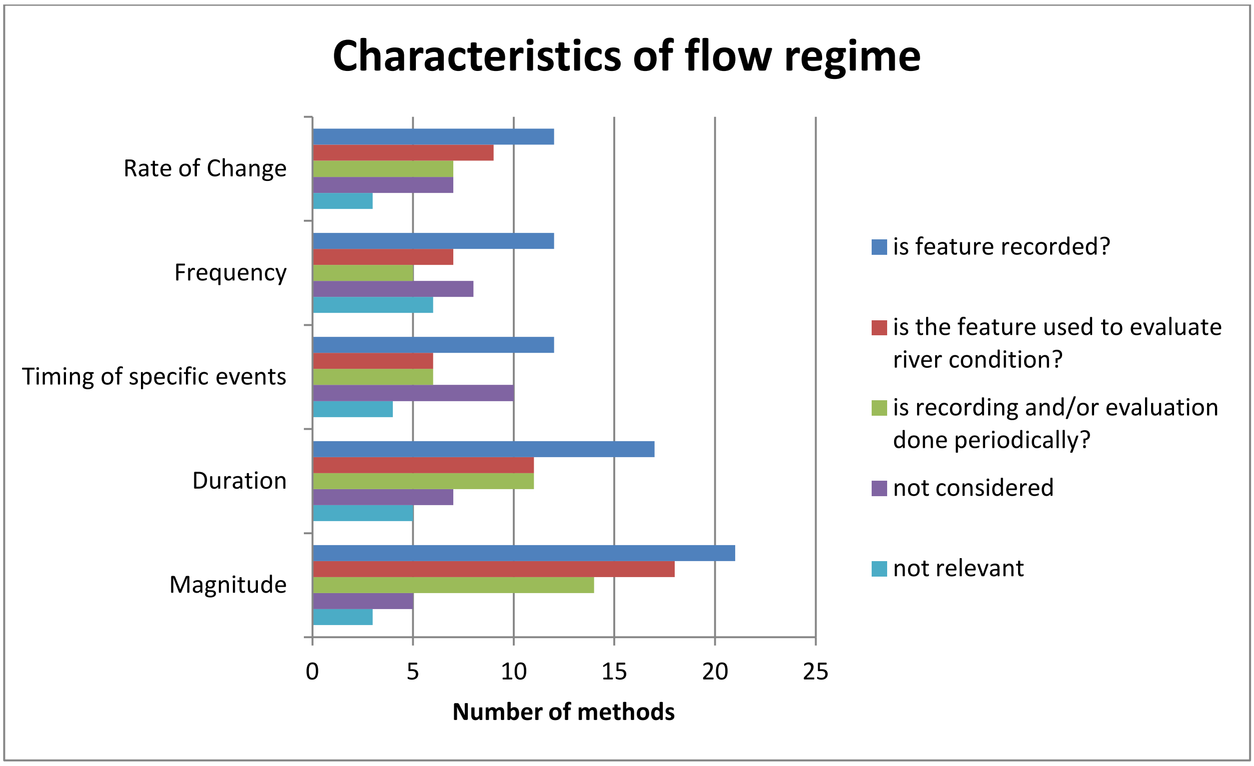


Figure 11 Characteristics of flow regime (n= 40)

Surface – groundwater interactions

In 19 methods, there is consideration of the groundwater – surface water interaction (for example, no interaction, limited or extensive interactions), e.g. through consideration of alterations of base-flow.

However, for 10 methods, it was indicated that this aspect is not considered.

Time related information

In terms of the specific time resolution of hydrological data used to assess the flow regime characteristics, 18 methods use a daily resolution, 12 use an hourly resolution and 10 use a sub-hourly resolution.

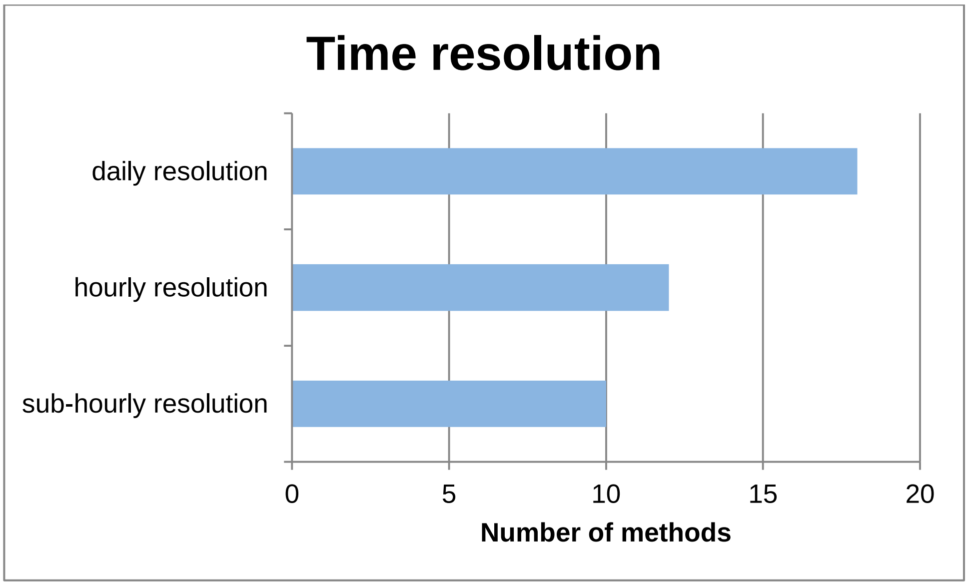


Figure 12 Time resolution (n= 40)

Concerning the required minimum length in years of the time series of hydrological data used to calculate the previous indicators, the following table summarises the country responses:

Table 6 Minimum length of time series

Country	Name of method	Minimum length of time series
Switzerland	Modul-Stufen-Konzept (MSK) Methode Hydrologie Stufe F (Flachdekkend) Konzept HYDMOD-F	5 -10 year
Germany	The hydromorphological classification tool Valmorph for large and navigable surface waters	Time series range between approx. 15 years to a hundred years and longer, depending on the available data (for large and navigable rivers the data has often been measured and documented since around 1820)
Germany	Klassifizierung des Wasserhaushalts von Einzugsgebieten und Wasserkörpern	1 year
Spain	Protocol for the hydromorphological characterization of water bodies	15 years
Spain	DRAINAGE	20 years
Finland	HyMo method (Kevomu-menetelmä)	10 years
Hungary	HU_RBMP2	10 years
Ireland	Abstraction impact screening assessment	10 years
Italy	Indici di hydropeaking	1 year
Italy	IARI indice di alterazione del regime idrologico	15 years

Country	Name of method	Minimum length of time series
Latvia	HAP-LR	30 years
Slovenia	Hydromorphological Monitoring in Slovenia - HIMO.SI	30 years
Turkey	Nehir Hidromorfolojisi Değerlendirme İndeksi (NHDI) (Turkish) River Hidromorphology Assessment Index (English)	15 years
Northern Ireland	Low Flows Enterprise	6 years (can vary)
Scotland - UK	Hydrology water body classification	30 years

Reference (natural) flows

In the case of 11 methods, the natural conditions used as a reference for assessing the hydrological alterations are the current ones in absence of pressures (as derived from modelling the current context of the catchment removing the pressures).

For 7 methods, the natural conditions used as a reference are the past ones (pre-impact).

For an even higher number of methods (16 in total), both aspects are combined, i.e. current and past natural conditions (depending on hydrological data availability).

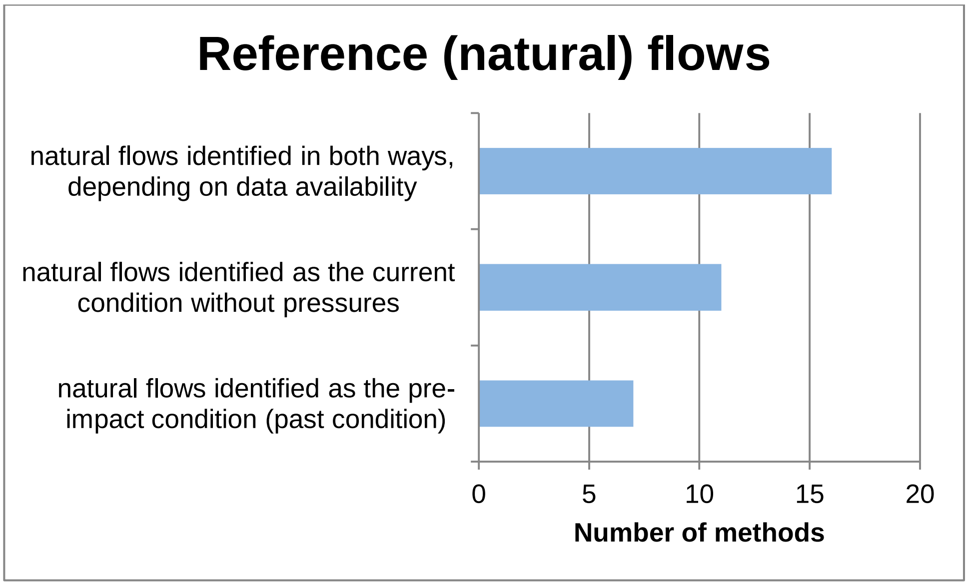


Figure 13 Reference (natural) flows (n= 40)

E-flows

In the questionnaire, Member States were asked to indicate whether a method to define ecological flow requirements is available or not. The intention was to update information on whether or not eflow methods have been developed. Therefore, no further information has been collected on the specific links of eflow requirements to hydromorphological assessments and the result of the responses are summarised in Annex II to this report.

9.2 Recording of morphological features

This section addresses the survey responses on the morphological features which are considered in the hydromorphological assessment methods of different European countries.

There were 46 responses to this part of the questionnaire (as well as on the following sections dealing with the recording of processes and artificial elements). These sections have not been filled in for 9 methods which do not deal with morphological features but only address hydrology.

The morphological characteristics which are recorded by more than 30 of the reported methods are:

- Planform pattern.
- Variability of cross-section by width / depth.
- Vegetation lateral / longitudinal extension in the river corridor
- Vegetation type / structure in the river corridor
- Erosional/depositional features.
- Bed substrate and bed configuration.

The same morphological characteristics are also used to evaluate river conditions in the majority of reported methods.

Between ca. 20-25 methods record or evaluate most morphological characteristics periodically, except for macrophytes, long profile/gradient, fluvial landforms and flow velocity and pattern, which are recorded/evaluated periodically in less than 20 methods.

Flow velocity is actually the feature which is recorded and evaluated in the lowest number of methods, possibly because this part of the survey concentrates on methods which mainly addressing morphology-continuity issues rather than hydrological ones.

Certain morphological features are not considered at all in ca. 6-11 of the reported methods. These are macrophytes, in-channel large wood, flow velocity and flow pattern, fluvial landforms and long profile/gradient.

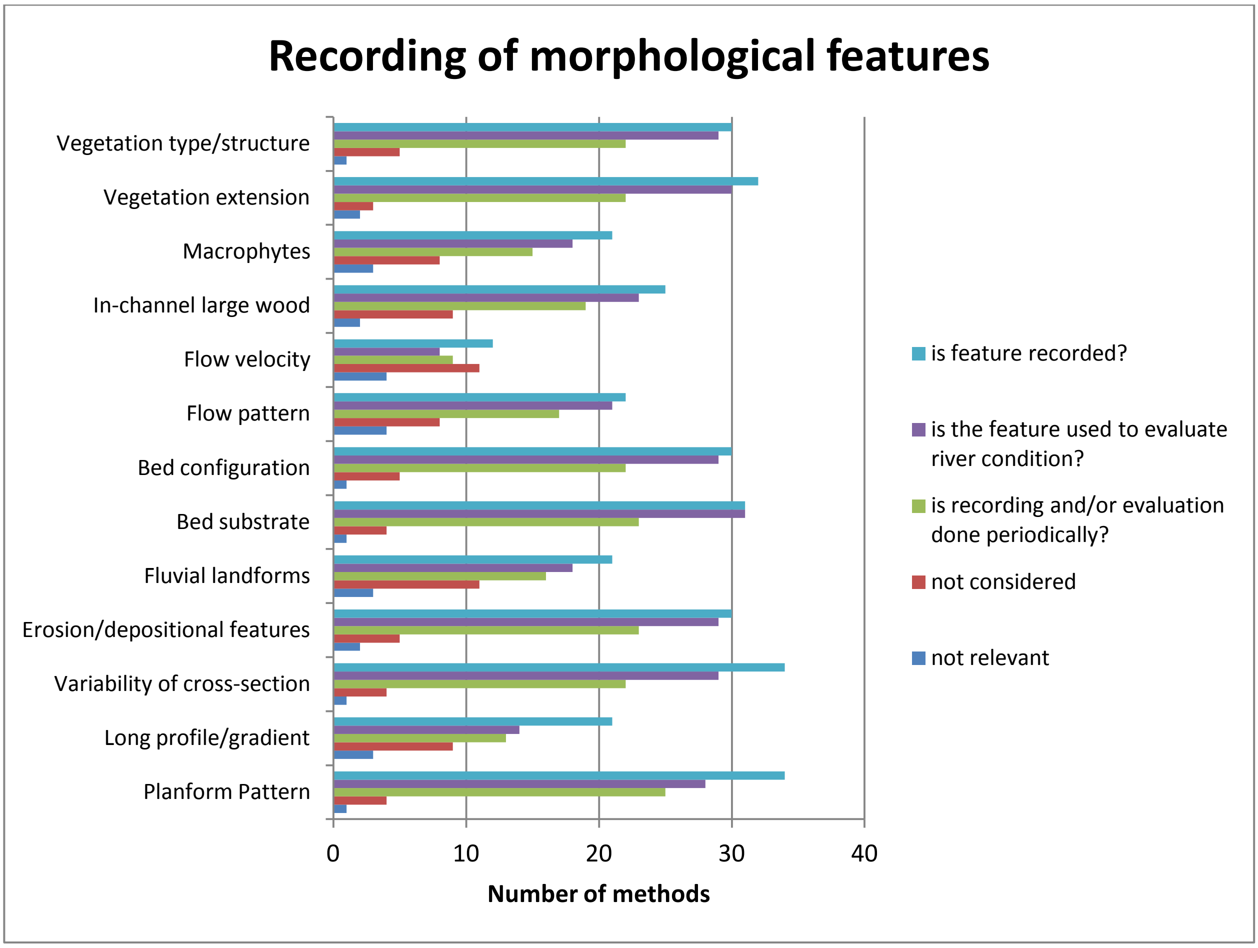


Figure 14 Recording of morphological features (n= 46)

9.3 Recording of continuity features

Three out of the 60 reported hydromorphological assessment methods exclusively address continuity aspects. These are the following methodological protocols:

- Germany: Evaluation of sediment continuity (still in development, a practical test started in the beginning of 2018). This method supports the WFD pressures & impacts analysis and status classification.
- France: ICE project (for “Informations sur la Continuité Ecologique”). This method is used for WFD pressures & impacts analysis, risk analysis and to design the programme of measures (PoM).
- Ireland: SNIFFER (WFD III). This method is being/will be used in the development of the programmes of measures. In Ireland, continuity and barrier assessment/mitigation is seen as a potential area for significant management progress with the PoM.

At the same time, continuity aspects are addressed in combination with morphology aspects or hydrology and morphology aspects in a large number of methods. This has been outlined in section 4 which gave an overview of the hydromorphology components assessed by the different reported methods.

In the European questionnaire on hydromorphological assessment and monitoring, specific information on the assessment of continuity has been collected as part of the recording of artificial elements (structures with impact on longitudinal and lateral continuity).

Recording structures with impact on longitudinal continuity

The structures recorded / considered by the majority of methods (42) are dams. In general, however, all artificial elements with impacts on longitudinal continuity are recorded / considered by at least 2/3 of the reported methods.

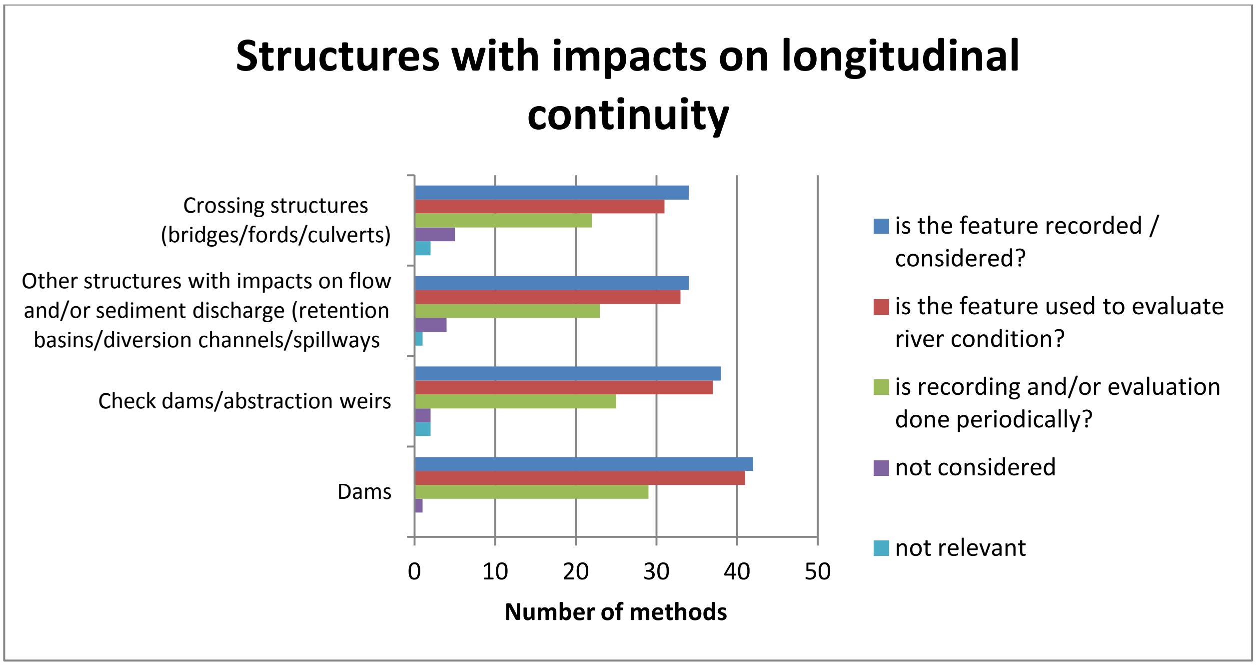


Figure 15 Structures with impacts on longitudinal continuity (n= 46)

Recording structures with impact on lateral continuity

Both bank protections and artificial levees (or embankments) are recorded / considered by a similarly high number of methods (40 and 36 methods respectively).

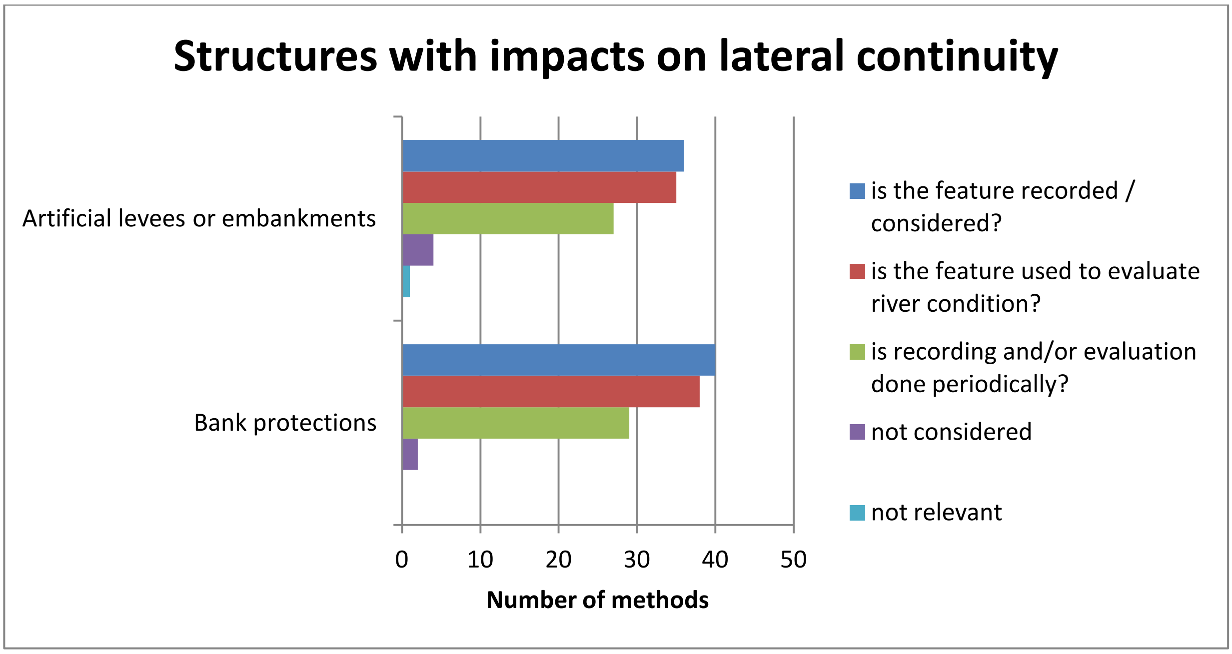


Figure 16 Structures with impacts on lateral continuity (n= 46)

Furthermore, the consideration and recording of continuity-related aspects has been addressed as part of geomorphic processes. For an overview of the relevant responses, please refer to section 9.5.

9.4 Recording of other artificial elements

Structures with impact on channel morphology/substrate

Artificial changes of river course and bed structures (sills, ramps, bed revetments) are recorded / considered by a similar number of methods (33 and 32 methods respectively, which account for ca. 2/3 of the reported methods).

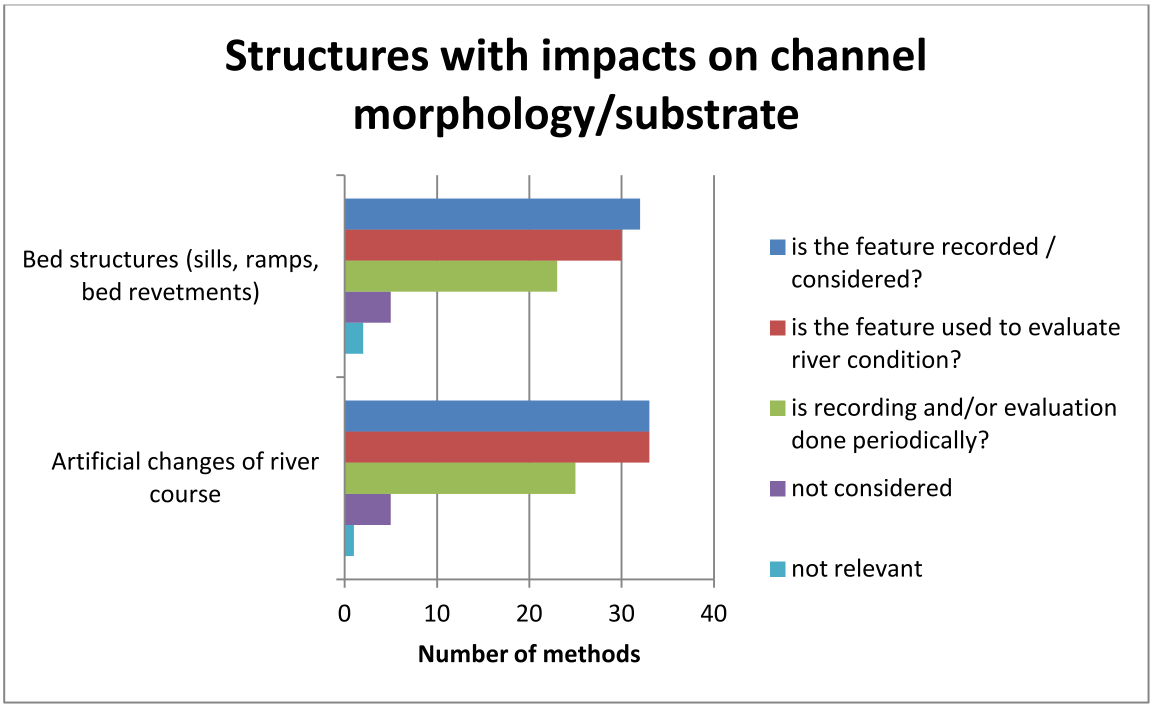
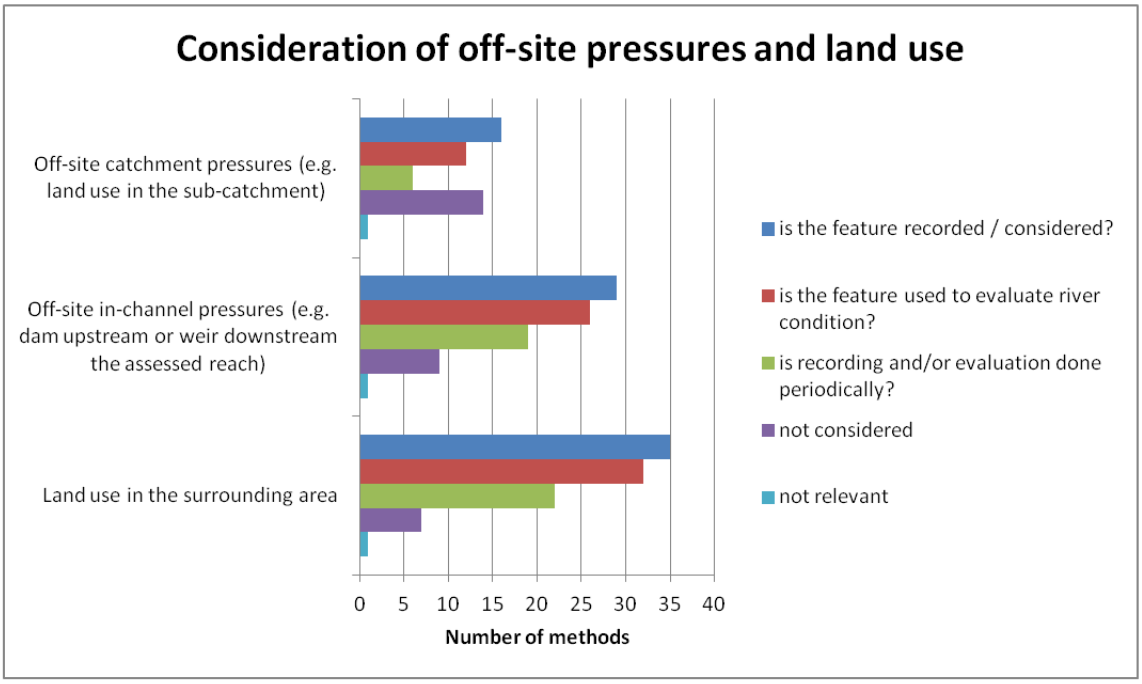


Figure 17 Structures with impacts on channel morphology/substrate (n= 46)

It has to be reminded that WFD Annex V refers to continuity as the function that ensures free movement of sediment and also aquatic organism. Pure hydromorphological methods consider only continuity in sediments, large wood and vegetation (with regard to their interaction with water and sediments in shaping the habitats), as the finer scale for sediments is also consistent with the finer scale for aqutic organism connectivity (e.g. macroinvertebrates). Nevertheless, several methods consider only obstacles for fish continuity, neglecting for example those alteration that disconnect river cannel from its floodplain or/and that interrupt hyporreic exchange.

Land use and off-site pressures

The description of the land use in the surrounding area is envisaged in many methods (35) whereas only half of those (16) consider land use and other pressures off-site (e.g. in the upstream subcatchment). In-channel structures located upstream or downstream that may have caused channel adjustments or other impacts in the assessed reach are only considered in 29 methods.



Management interventions

Management interventions are frequent and often severe pressures on rivers, but sediment management (25), large wood management (17) and vegetation management are considered / recorded only by some methods wherea, at the same time, they are not considered at all in several of the reported methods.

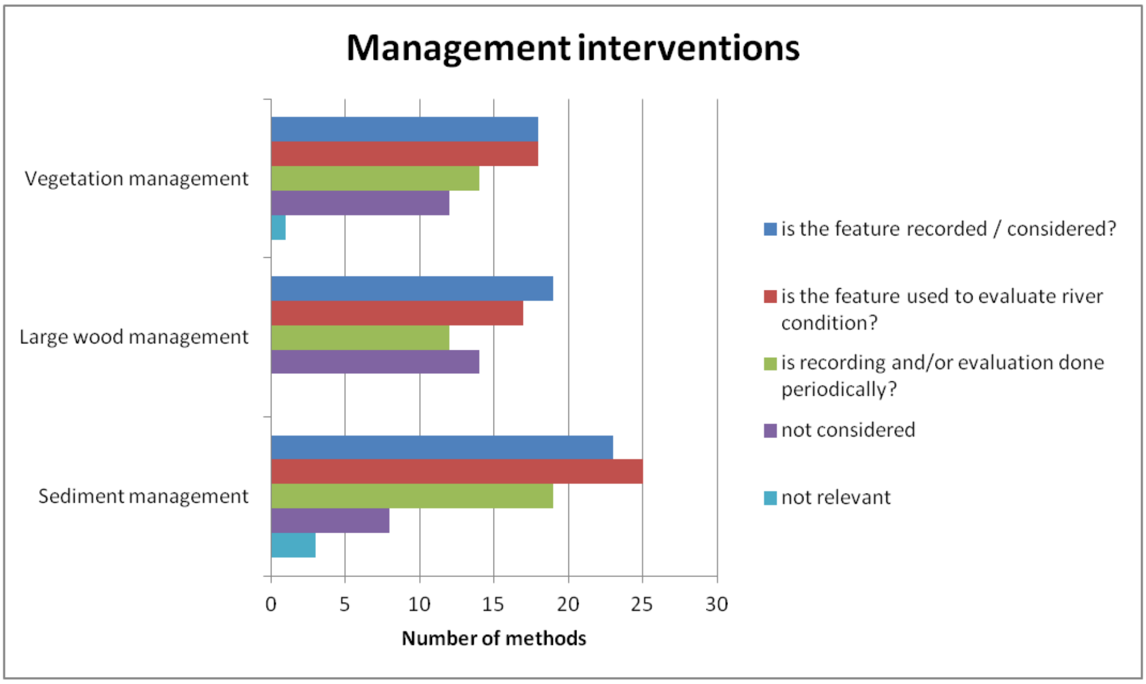


Figure 18 Management interventions (n= 46)

9.5 Consideration of processes

Process-based methods can be defined as those methods that (i) emphasize the consideration of the occurrence of expected geomorphic processes (e.g., the continuity of sediment and wood fluxes, lateral connectivity, bank erosion, and armouring) rather than just classifying physical habitats and channel forms; and (ii) include the explicit consideration of temporal changes and dynamics (Rinaldi, 2016).

International reviews on hydromorphological assessment methods (e.g. Fryirs 2015), including a recent review of hydromorphological assessment methods carried out during the FP7 REFORM project (Rinaldi et al., 2013; Belletti et al., 2015) concluded that many methods have insufficient consideration of physical processes. Therefore, in this survey, we specifically targeted the consideration of physical processes in the methods. The outcomes seem to contradict the former review: in facts, according to the questionnaires received, several methods are declared to include considerations of processes.

Through the survey and inside process-based methods, some of the indicators may appear as partially redundant compared with indicators in other sections, but they more specifically focus on whether or not the processes responsible for the correct functioning of the river are prevented or altered by some type of artificial element or by channel adjustments related to human disturbances. It is important to consider that the same type of pressure may result in different responses for different rivers (depending on their valley setting, energy conditions, channel morphology, and therefore their sensitivity to pressures etc.), so consideration of processes and temporal channel changes can provide information on the response to a given pressure. In other cases, together with morphological and hydrological features, processes and temporal dynamics can provide a full understanding of the response of the river to hydromorphological pressures.

The focus of this section is on the processes occurring along the river channel and in the surrounding areas (floodplain, or adjacent hillslopes in case of a confined or partly confined setting), whereas no attempts are made to consider processes at catchment scale (landslides, soil erosion, etc. in the catchment).

Geomorphic processes

Geomorphic processes are considered by 18 of the reported methods to some extent, while 16 of the methods do not explicitly include consideration of such processes.

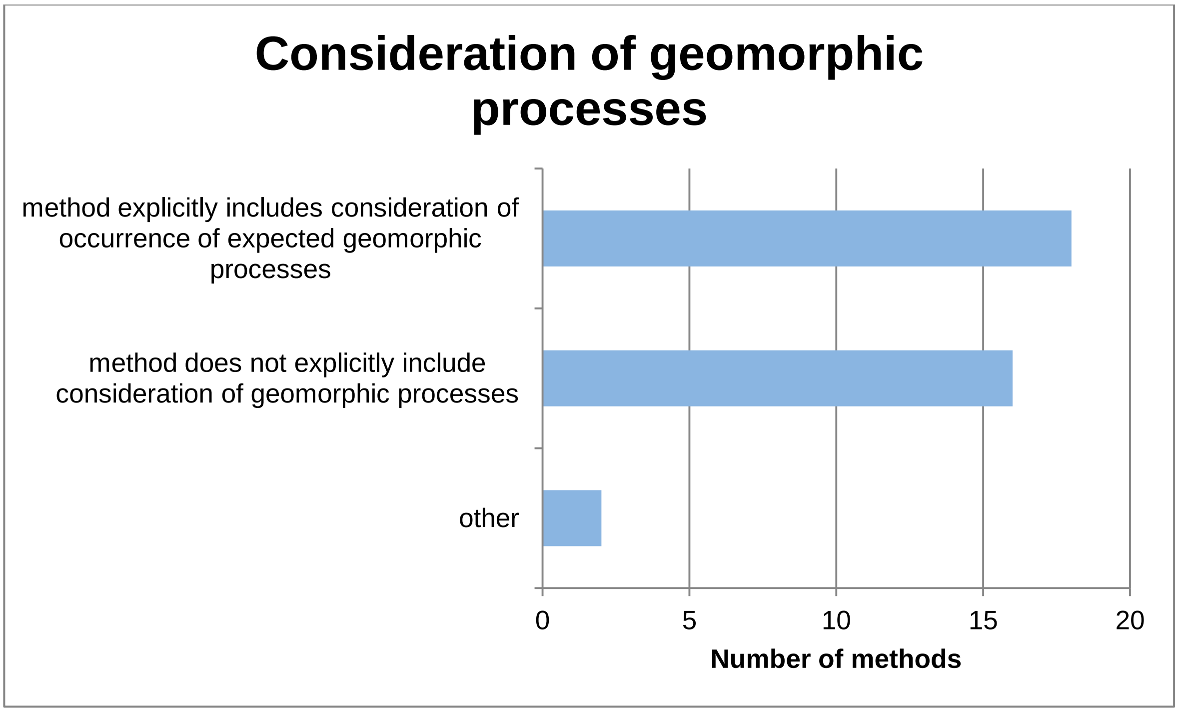


Figure 19 Consideration of geomorphic processes (n= 46, no response=16, not applicable=3)

Notes: “other” indicates responses that could not be placed into the available categories

The following processes are recorded / considered in more than 25 of the reported methods:

- Longitudinal continuity/alteration of channel forming discharge.
- Longitudinal continuity / alteration in sediment and wood flux.
- Lateral continuity of flows.
- Occurrence of bank erosion processes.

Consistently with the outcomes in the preceding chapters regarding consideration of hillslopes, the process which is recorded / considered in less than 20 of the reported methods is the connectivity between hillslopes and river corridor.

The rest of the processes in the survey are recorded / considered in ca. 20 to 25 of the reported methods:

- Sediment transport.
- Presence of a potentially erodible corridor.
- Alteration of bed sediment structure / substrate composition / vertical continuity.

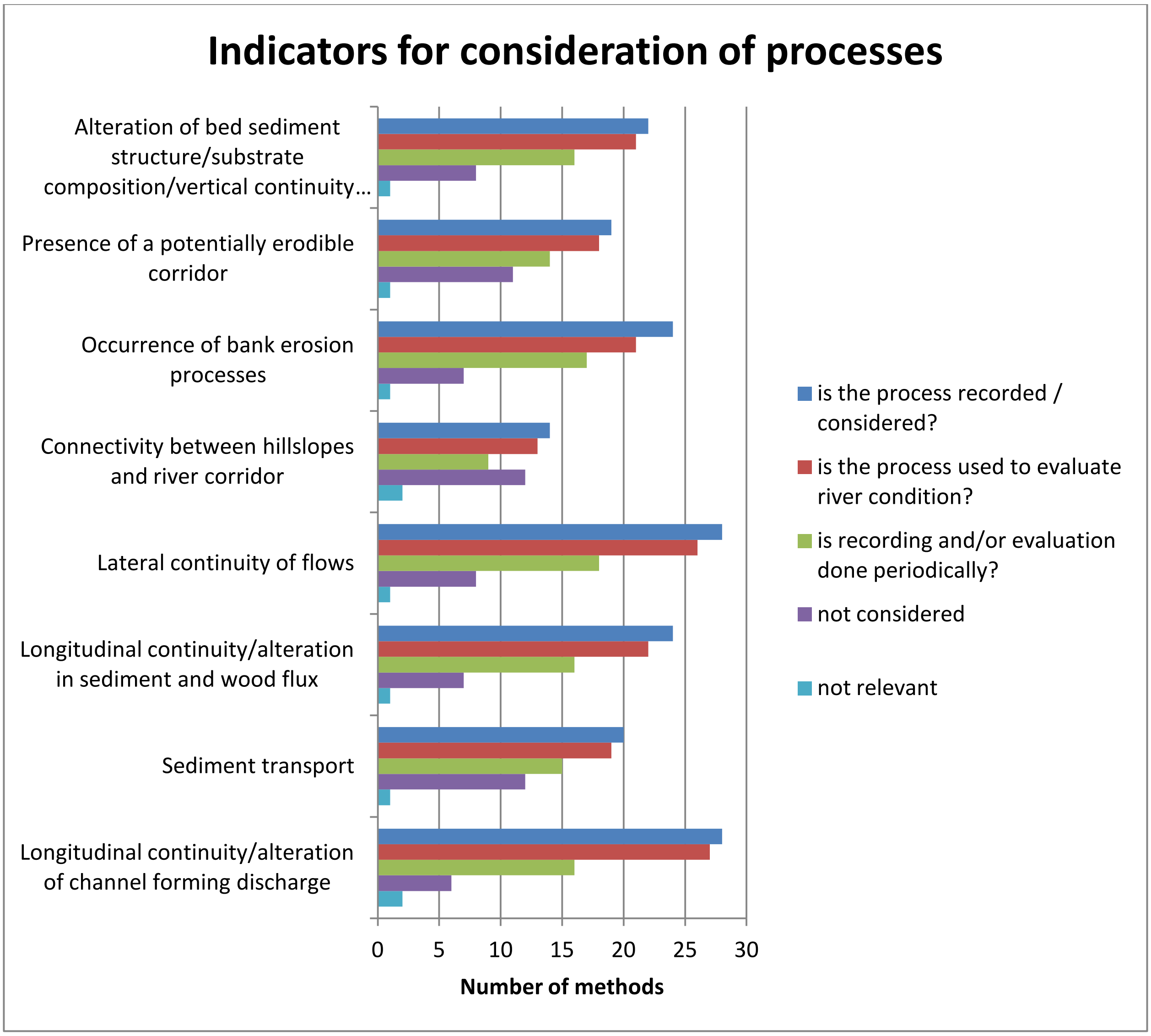


Figure 20 Indicators for consideration of processes (n= 46)

Table 7 Process indicators used

Longitudinal continuity/alteration of channel forming discharge.	This indicator is related to possible alterations of flow conditions which may have significant effect on channel form and processes (channel forming discharge and/or hydraulic conditions, such as river stage and flow velocity, associated to this discharge), for example due to the presence of dams, discharge diversions or water abstractions, spillways, retention basins, etc., located upstream and/or within the investigated reach and/or downstream.
Sediment transport.	This relates to possible measures or evaluations on sediment transport within the reach investigated.
Longitudinal continuity / alteration in sediment and wood flux.	This indicator is related to possible alterations in sediment discharge and wood transport upstream and/or within the investigated reach. For example, an indirect evaluation can be based on the existence of blocking structures intercepting bedload and wood (dams, check dams, weirs), if they are already filled or not by sediment, if measures of sediment release are undertaken, etc.
Lateral continuity of flows.	This indicator concerns the occurrence (or the alteration) of the normal flooding processes of rivers (expected in an unconfined or partly confined valley setting). For example, a typical indicator used to evaluate this process is the presence and lateral extent of an adjacent modern floodplain that is frequently inundated (every 1 – 3 years) with no protection by artificial levées.
Connectivity between hillslopes and river corridor.	This evaluates the linkage between hillslopes and river corridor causing a sediment supply normally expected in a confined valley setting. For example, an indicator of alteration of this connectivity can be represented by the presence of artificial elements of disconnection (e.g. roads, structures for landslide protection) on the hillslopes adjacent to the river
Occurrence of bank erosion processes.	This evaluates the occurrence of bank erosion processes causing sediment supply, vegetation turn-over and habitat diversity, as normally expected in an unconfined or partly confined setting.
Presence of a potentially erodible corridor.	This evaluates the potential for the river to move laterally over the coming decades as normally expected for rivers in an unconfined or partly confined setting.
Alteration of bed sediment structure / substrate composition / vertical continuity.	This evaluates the presence of processes that alter the natural bed sediment structure and potentially affecting vertical continuity. The main processes altering bed structure are: (i) armouring, i.e. presence of a surface layer in which bed material size is significantly coarser than the sub-layer; (ii) clogging, i.e. excess of fine sediments causing interstitial filling of the coarse sediment matrix and potentially smothering the channel bed; (iii) burial or siltation, i.e. where finer sediments (e.g. silt and sand) are deposited in a sufficiently thick layer to bury a coarser (e.g. gravel) river bed; (iv) substrate outcropping in alluvial rivers related to bed incision. Restoration measures involving changes in the natural substrate (e.g. placement of boulders for salmonid habitats) are also considered as an alteration of bed sediment structure.

Temporal changes and dynamics

Temporal channel changes (i.e. channel adjustments) and dynamics are considered as important indicators as they provide an information on how the channel has responded to some type of pressure, including off-site impacts (i.e. not along the reach investigated but upstream or downstream) and disturbances not occurring today but in the past (e.g. an instream sediment mining activity now concluded can still have severe effects on the present river conditions).

Only 10 of the reported methods explicitly consider temporal changes and dynamics of the river channel. Temporal channel changes (such as changes in channel pattern, channel width) may be investigated by comparison of aerial photos, maps, field evidence, amongst other methods. The interval of time of investigation (e.g. 100 years, 50 years, etc.) can be variable.

- In the German hydromorphological classification tool Valmorph for large and navigable surface waters, the investigation interval varies (for natural water bodies 100 years or more, for HMWB approx. 15 years / the year 1999).
- In the Spanish method DRAINAGE, the time scale considered is between 1946 to present.
- In the Italian method MQI, the time scale covers the last 50-100 years.

For the majority of the reported methods (24), it is indicated they do not explicitly include consideration of temporal changes and dynamics.

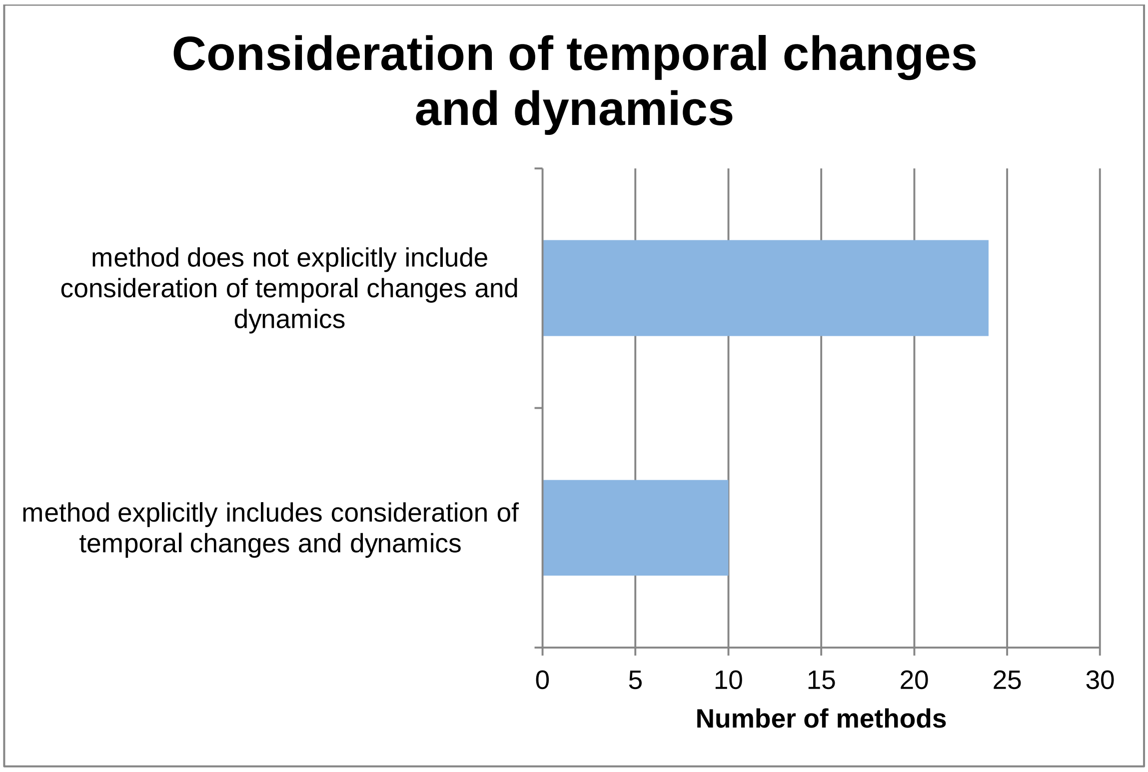


Figure 21 **Temporal changes and dynamics** **(n= 46, no response: 20, not applicable=3)**

Bed-level adjustments and adjustments in the channel width and pattern are indicators of temporal changes and dynamics.

Table 8 Process indicators used

Adjustments in channel pattern.	This indicator concerns the occurrence (and intensity) of adjustments in channel morphological configuration, i.e. the change in channel pattern (e.g. from sinuous to meandering, or from meandering to braided, etc.) that may be caused by changes of some factor controlling channel mor-

	phology. As for the consideration of temporal changes and dynamics, the interval of time of investigation (e.g. 100 years, 50 years, etc.) can be variable.
Adjustments in channel width.	This concerns the occurrence (and amount) of changes in channel width (e.g. channel narrowing or widening) that may be caused by changes of some factor controlling channel morphology. As for the consideration of temporal changes and dynamics, the interval of time of investigation (e.g. 100 years, 50 years, etc.) can be variable.
Bed-level adjustments.	This considers the occurrence (and amount) of changes in bed elevation (e.g. incision or aggradation) that may occur in alluvial channels as a response to possible alterations of flow and/or sediment discharge. As for the consideration of temporal changes and dynamics, the interval of time of investigation (e.g. 100 years, 50 years, etc.) can be variable.

Although the temporal dimension is declared to be explicitly considerd in only 10 of the methods, the above mentioned indicators are recorded / considered and used to evaluate river conditions in more than 10 methods and in a similar number of reported methods (ca. 15-20 methods).

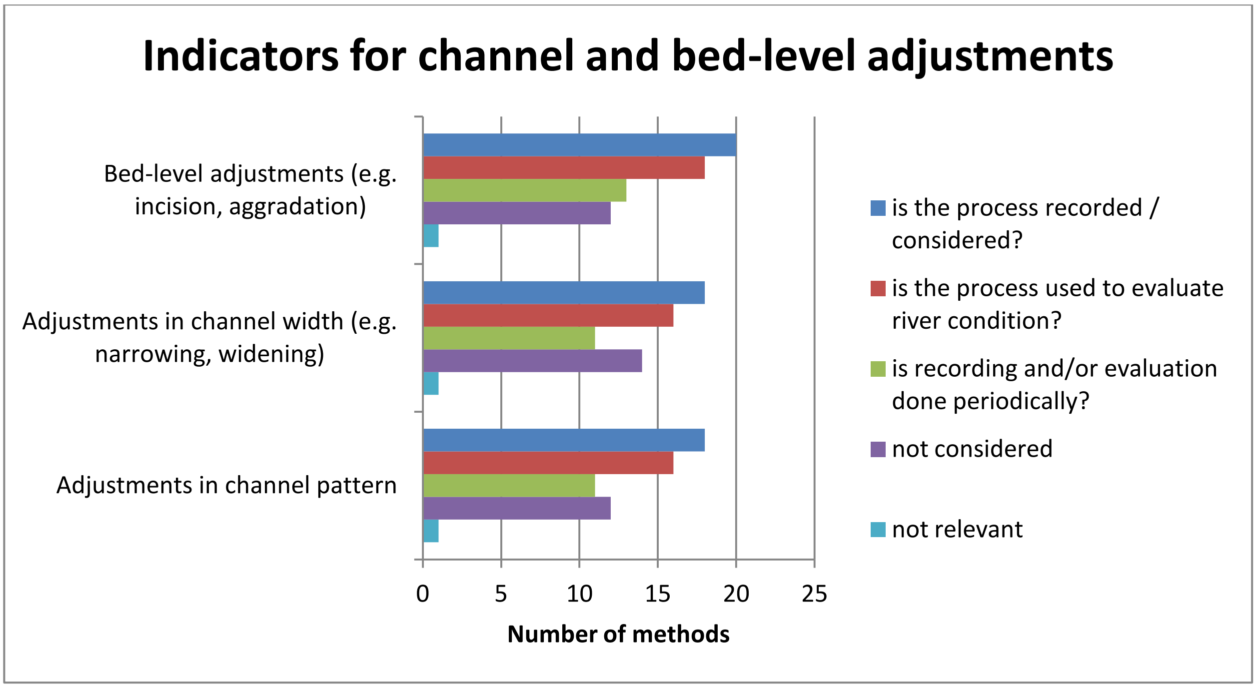


Figure 22 **Indicators for channel and bed-level adjustments (n= 46)**

10 Assessment output of methods

Type of output

The application of the assessment methods can produce a series of outputs, such as scoring, establishing a typology, maps summarising results, report, etc.

The majority of the reported methods (48 of 55) result in a scoring and half of them have maps and reports as additional assessment outputs.

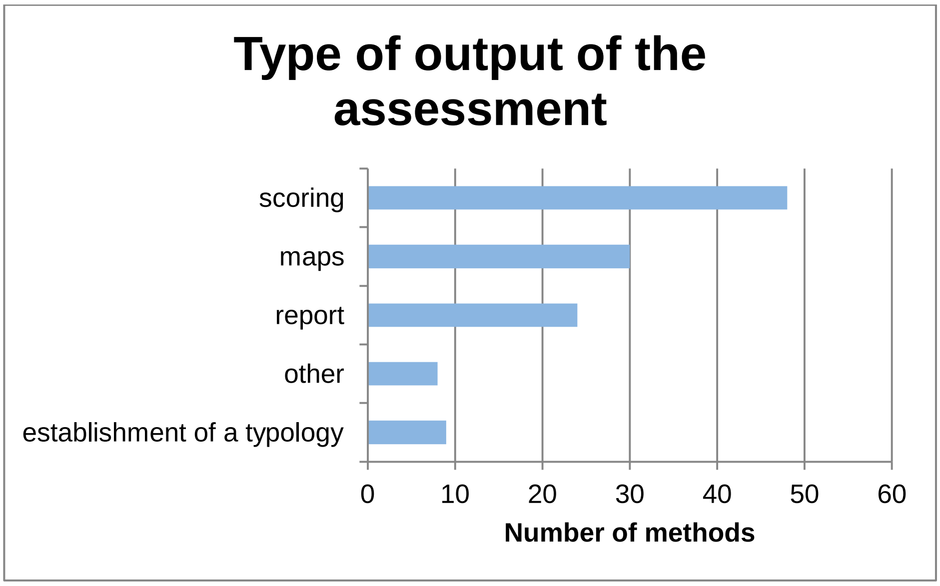


Figure 23 Output of assessment (n=55)

Type of scoring and scoring information

The type of scoring which is used is:

- qualitative, i.e. the final product is a qualitative class (e.g. good, poor, etc.) in 41 of the reported methods and
- quantitative, e.g. one or more quantitative indices, in 32 methods.

In 21 cases, methods are both quantitative methods and qualitative (e.g. the quantitative score is equivalent to a certatin status class).

For the majority of the methods (40) the scores and algorithms are transparent, i.e. the entire process producing the final result (e.g., scores assigned to single indicators, weights, procedure or equations used to calculate the final result) is clearly specified and can be reproduced by the user of the method.

In the case of 7 methods only, the scores and algorithms are not transparent, which means that the calculation of the result cannot be done independently by the user of the method, for example when a software is used to calculate the result.

Upscaling of the score of a site/reach to water body (for WFD)

The issue of upscaling is relevant to how the score assigned to the reach or site investigated is extended to the whole water body and made applicable to the WFD.

- For 23 reported methods, the method needs to be applied to all reaches included in the water body and an average or the minimum of the scores (or qualitative classes) is assigned to the water body.
- For 16 reported methods, the method is applied to only one portion of the water body (i.e. one or more sites/reaches) and the score is then extended to the whole water body.

- For 7 of the reported methods, another approach is used, indicating that for some of them, the methodology can be applied to the whole water body or the approach may be mixed, i.e. some indicators are evaluated at the water body level, some at the site and upscaled to water body level.

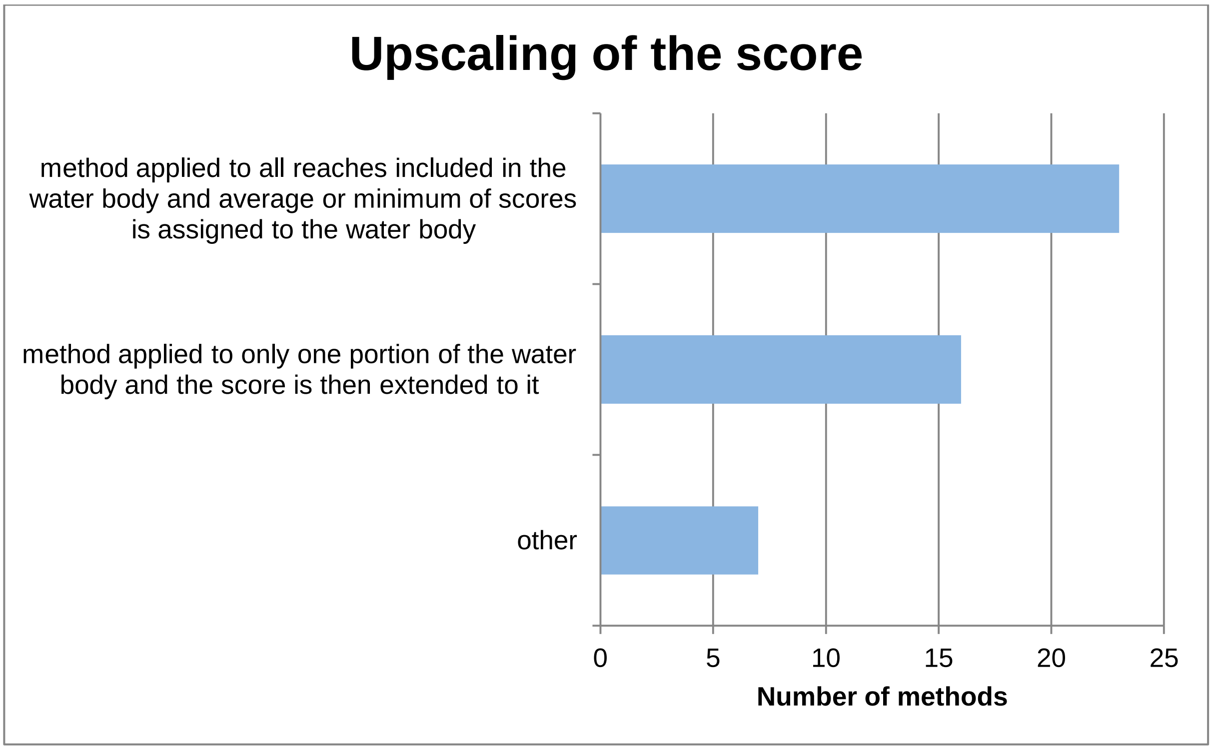


Figure 24 Upscaling of score (n=55, no response=4, not applicable=5)

Degree of confidence

Some uncertainties are possible in various phases of application of a method, for example the assignment to a class of one or more indicators can be uncertain because of various reasons (e.g. difficulties in measurement of a feature or in interpretation of a process, data not available on existing pressures, etc.). Thisi is particularly relevant if no specific qualification of expertise of the user in fluvial geomorphology or river hydromorphology is required (see section 6)

For 20 of the reported methods, some indication about the degree of confidence (uncertainties) is included.

For 21 methods, it is explicitly indicated that they provide no information on the degree of confidence.

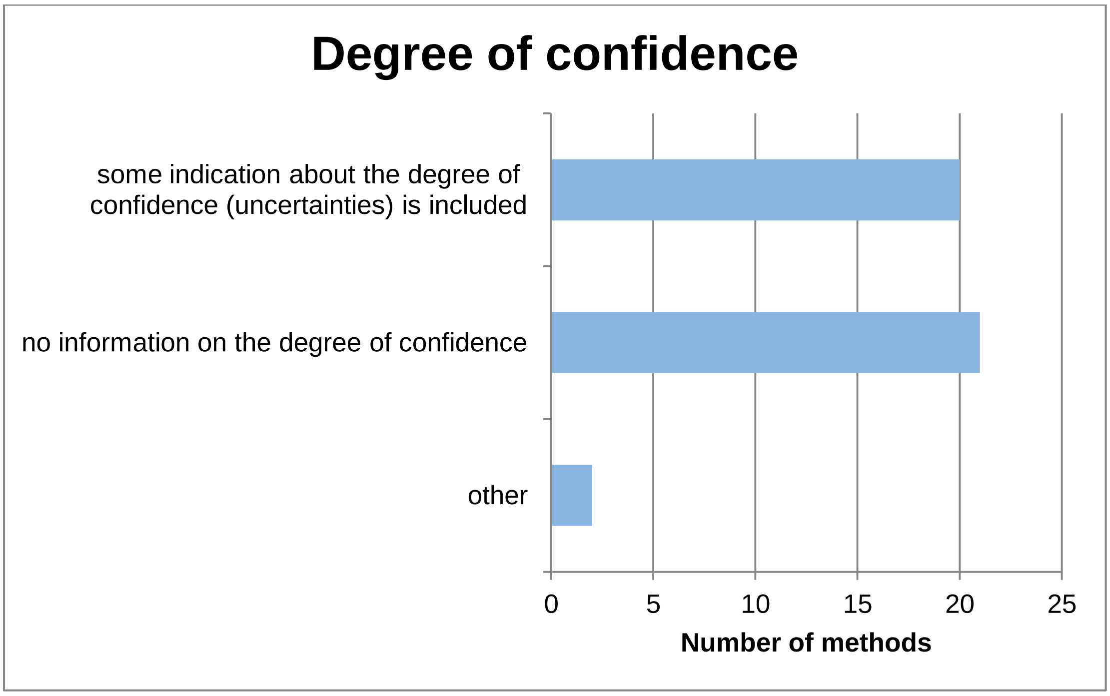


Figure 25 **Degree of confidence (n=55, no response=7, not applicable=5)**

11 Key strengths and weaknesses of methods

Strengths, weaknesses and remaining challenges for the methods reported by European countries in the context of this survey are outlined in Annex I (as reported by the experts who filled in the questionnaires). It is not straightforward to identify common strengths and weakness across all methods, because the same issue which might be strength of one method may still be a weakness for another method. Some general observations can be made, but the reader should refer to Annex I for more detailed comments per method.

Some of the most frequent advantages (**strengths**) indicated for several of the reported methods include:

1. the easiness of method application,
2. the applicability to all river types and size categories,
3. repeatability and small degree of subjectivity (which makes methods fit for monitoring purposes),
4. rapid indication of the degree of river alteration,
5. low cost and labour efficient,
6. the provision of standardised knowledge (e.g. via standardised field protocols),
7. support of methods for ecological assessments,
8. support in designing effective restoration measures and evaluating their impact in the future.

Main **weaknesses and challenges** for some of the methods reported are:

1. the need for intensive field work (for field-based surveys) and measured data,
2. the lack of data for using the method,
3. the need to develop detailed field work guides (to reduce dependency on surveyors' judgement),
4. the lack of historical information on morphological changes (thus relying on expert judgement),
5. the need to develop further parameters for the hydrological regime,
6. the lack of providing a fluvial geomorphological picture and the need to better consider processes at larger scales.

12 Lessons learned

Preliminary lessons learned from the development and application of the hydromorphological assessment methods included in this report as well as from previous discussions in relevant CIS workshops (such as the workshop "Hydromorphology and WFD classification", 2015) are the following:

1. The development of methodologies for the hydromorphological assessment of rivers has been an important step for implementing the WFD and for an integrated ecological status assessment of rivers.
2. The number of hydromorphological assessment methods applied for WFD purposes has increased significantly from the 1st to the 2nd RBMPs.
3. Some countries have made considerable efforts in terms of developing different methods. These practices can help other Member States to develop their methods.
4. Ca. half of the methods reported are used for hydromorphological assessments not specifically (or not only) used for the WFD, e.g. some methods are used to support assessments for the Habitats Directive, the EIA and/or the Floods Directives.
5. For WFD implementation, a pragmatic approach for hydromorphological assessments is needed to ensure on the one hand the assessment of the whole river network within a reasonable timeframe and, on the other hand, to link the hydromorphological alterations to biological impacts (cause-effect-relationship), keeping into account the difficulty in disentangling the effects of multiple pressures.
6. The steps of the WFD planning process which are supported by the highest number of methods are the analysis of pressures and impacts, as well as the design of the programme of measures. In the same time, the use of hydromorphological assessment methods in water body delineation and typology is still low, and the implication of this needs further discussion.
7. A higher number of methods currently in use are applied to support ecological classification at high status only than for classification in all 5 ecological status classes. In most countries where hydromorphology is assessed in 5 classes, it is mainly being used as an element supporting ecological classification and hydromorphological status is used directly to downgrade only from high to good ecological status. In some countries, even though hydromorphological assessment is not used for classification below high status, it is used as proxy for significant hydromorphological pressures and designation of HMWB, i.e. hydromorphologically impacted water bodies which fail to achieve good status because of a key water use.
8. According to the WFD, high ecological status occurs when supporting elements are in high status, i.e. when no pressures insist on river processes. This is why hydromorphology has to be assessed *per se* only for high status classification, which explains why most hydromorphological assessment methods have so far been mainly developed to distinguish between high and good status of river reaches and only comprise two classes. It also accounts for the simplicity of some methods that only assess pressures.
9. At the same time, there is an interaction between water, sediments and vegetation which creates habitats, which in their turn are biologically colonized depending on the particular river type. For this reason, hydromorphology is considered as a key "supporting element" and hydromorphological conditions related to good or less than good ecological status should be consistent with the ecological status itself (WFD, Annex V). In order to ensure this, hydromorphology should be assessed according to five classes. This is particularly relevant when defining significant alterations in order to identify HMWBs.
10. Hydromorphological assessments require training in order to have comparable and standardised results. Experience shows that most experts using the methods have no or limited training in hydrology and geomorphology. In fact, for the majority of methods, there is no relevant accreditation requirement.
11. The interactions of processes in the river, on the banks and catchment, which can be preliminarly studied analysing the different information available, can only be fully understood in the field. However, field surveys are often insufficient in this respect. Especially in those cases,

information from local owner/operator/inhabitants can be of added value. Overall, a more open process to get additional information from local actors and hydromorphology experts should be encouraged.

12. Remote sensing has a large potential to support hydromorphological assessments but have so far not been used extensively as source of data for this kind of assessments.
13. The links between pressures on hydromorphology and diagnostic tools in biology (sensitivity of biological indicators to pressures) need to be improved.
14. In order to establish the relationship between biological data and hydromorphological features and understand the response of biological elements to hydromorphological changes, it is important to use the hydromorphological assessment methods in reaches inclusive of the biological monitoring points. These issues are dealt with in a specific ECOSTAT activity starting with an ad-hoc workshop in May 2018.

13 References

Commission Staff Working Document, 2015. Report on the progress in implementation of the Water Framework Directive Programmes of Measures.

Belletti, B., Rinaldi, M., Gurnell, A.M., Buijse, A.D., Mosselman, E., 2015. A review of assessment methods for river hydromorphology. Environmental Earth Sciences 73, 2079-2100. http://link.springer.com/article/10.1007/s12665-014-3558-1.

Fryirs, K. Developing and using geomorphic condition assessments for river rehabilitation planning, implementation and monitoring. Wires Water, Volume 2, Issue 6, November/December 2015 , Pages 649–667. http://onlinelibrary.wiley.com/doi/10.1002/wat2.1100/pdf

Kampa, E. 2016. Kickoff workshop of the CIS ECOSTAT hydromorphology group. 13 - 14 October 2016, JRC, Ispra, Italy. Worshop Summary Report.

Poff, N.L., David Allan, J., Bain, M.B., Karr, J.R., Prestegaard, K.L., Richter, B.D., Sparks, R.E., Stromberg, J., 1997. The Natural Flow Regime, A paradigm for river conservation and restoration, Bioscience, 47, 769–784. http://rydberg.biology.colostate.edu/poff/Public/poffpubs/Poff1997(BioScience_NFR).pdf

Richter, B.D., Baumgartner, J.V., Powell, J., Braun, D.P., 1996. A method for assessing hydrologic alteration within ecosystems, Conservation Biology, 10, 1163–1174. https://www.conservationgateway.org/Documents/1996.pdf.

Richter, B.D, Baumgartner, J.V., Wigington, R., Braun, D.P., 1997. *How much water does a river need?* Freshwater Biology 37, 231-249.

Rinaldi, M., Belletti, B., Van de Bund, W., Bertoldi, W., Gurnell, A., Buijse, T., Mosselman, E., 2013. Review on eco-hydromorphological methods. Deliverable 1.1, REFORM (REstoring rivers FOR effective catchment Management), a collaborative project (large-scale integrating project) funded by the European commission within the 7th framework programme under grant agreement 282656. http://www.reformrivers.eu/results/deliverables.

Rinaldi, M., Gurnell, A.M., Belletti, B., Berga Cano, M.I., Bizzi, S., Bussettini, M., González Del Tánago, M., Grabowski, R., Habersack, H., Klösch, M., Magdaleno Mas, F., Mosselman, E., Toro Velasco, M., Vezza, P., 2015. Final report on methods, models, tools to assess the hydromorphology of rivers, Deliverable 6.2, Part 1, of REFORM (REstoring rivers FOR effective catchment Management), a Collaborative project (large-scale integrating project) funded by the European Commission within the 7th Framework Programme under Grant Agreement 282656, 113 pp. http://www.reformrivers.eu/results/deliverables.

Rinaldi, M., et al., New tools for the hydromorphological assessment and monitoring of European streams, Journal of Environmental Management (2016), http://dx.doi.org/10.1016/j.jenvman.2016.11.036

Summary conclusions workshop “Hydromorphology and WFD classification”, 12-13 October 2015, Oslo, Norway.

ToR ATG Hymo, 11 May 2016, https://circabc.europa.eu/w/browse/97972f74-16e6-4ae0-b4ee-d0f84514ddcf

Annex I: Strengths, weaknesses and challenges of methods

Name of the method	Country	Strengths of method	Weaknesses & challenges of method
Austrian Guidance on hydromorphological assessment of rivers	Austria	* cost efficient pragmatic approach; whole rivernet can be assessed within time and resource constraints * detailed information on hydromorphological alterations allows the development of pressure sensitive biological assessment methods * method is easy to apply and data is easy to be continously updated * output of method is applicable for use in all hydromorphological-relevant steps of WFD-implementation * transparent way of assessment; high reproducability of classification results	pragmatic approach: for designing detailed restoration measures at a specific site the method is not detailed enough and has to be supplemented by additional data/information
meetnet Hydromorfologie	Flanders (Belgium)	Detailed view on a large scale of hydromorphological parameters.	Requires a lot of field work. Qualitative method does not allow to make a link with certain species ecological requirements.
Riparian Remote Monitoring - RiReMo (future development)	Belgium / Wallonia	Repeatable, objective, rely on public remote sensing data	Rely on public remote sensing data … and associated acquisition plan
Modul-Stufen-Konzept (MSK) Methode Ökomorphologie Stufe F (Flachdekkend)	Switzerland	With the method an overview of the Swiss rivers can easily be reached. A comparison can be made.	* determination of the section is not always easily done, when changes occur gradually. * the data were collected by various persons. They can have interpreted data differently * the method can only be used for smaller streams (<15 m) * the width of the floodplain is in some cases taken too narrow. For example when a dirtroad crosses the floodplain, the width was taken until the dirtroad. But in these cases a broader width might have been taken in account. * some artificial measures (Belebungssteinen) actually improve the riverflow, but are negatively qualified, while they are artificial structures * by removal of barriers, this is difficult to take into account by new classifications. Actually the section length should change, which increases the workload. A practical solution has been introduced by one of the kantons.
Modul-Stufen-Konzept (MSK)	Switzerland	HYDMOD-F is designed as an intervention-related approach. The causes of hydrological disturbances are mostly punctual and direct	

Name of the method	Country	Strengths of method	Weaknesses & challenges of method
Methode Hydrologie Stufe F (Flachdekkend) Konzept HYDMOD-F		water management interventions, which can be clearly identified. This has the advantage that the enquiries can specifically focus on the interventions and the water sections concerned.	
Integrated Pressure Index (IPI)	Cyprus	Takes into account both morphological and ecological (habitat) features.	Covers only a part of the WB surveyed of 500m length.
HEM 2014 Metodika monitoringu hydromorfologických ukazatelů ekologické kvality vodních toků	Czech Republic	The method is relatively well suited to the demands of the WFD and standards for assessing the hydromorphological state, particularly in the field of morphological parameters.	Until now the method was applied to only small percentage of water bodies. Method less reflects the monitoring and evaluation of the hydrological regime. Although an instruction manual is provided, field survey is subjective, especially in the estimate of the areal characteristics. Method is suggested for monitoring of the whole core stream of the water body. It seems to be very time (and monetary) demanding.
The hydromorphological classification tool Valmorph for large and navigable surface waters	Germany	quantitative method; indicator specific; for derivation of measures; applicable for any river type, for any water body, for NWB/HMWB/AWB; implies a spatial and temporal watercourse development; close relationship to the DPSIR-concept; supports decision-making processes, e.g. in regard to environmental impact studies or sediment management; forecasting tool; for efficiency controls and monitoring; the method covers the total area of navigable surface waters in Germany	the method needs a good data base (quantitative data). This normally exists for large and navigable rivers. But for smaller rivers, in particular without navigation, there is often a lack of data for using the method. A transferability of the method is guaranteed (approved in case studies), but in these cases, firstly, a detection of quantitative data would be necessary. Consequently, the method does not consider all of the rivers in Germany
Klassifizierung des Wasserhaushalts von Einzugsgebieten und Wasserkörpern	Germany	easy way to score the water balance	simple calculation contradicts the technical validity, no inclusion of the seasonal variablility of the water balance (low tide etc.), insufficient databasis (e.g. "Wasserbuch")
LAWA-Verfahrensempfehlung zur Gewässerstrukturkartierung – Verfahren für mittelgroße bis große Fließgewässer	Germany	The method covers medium and large rivers in Germany, The method covers most of the river types and defines their reference conditions. The method is an appropriate approach for the assessment in the context of Natura 2000. It serves as a basis for the planning and monitoring of renaturalisation of rivers. Furthermore, the parameters can be used for the description of habitat conditions for maximum and good ecological potential.	The method presents the reference conditions and, consequently, also evaluates hydromorphology of HMWB and AWB in comparison with natural reference conditions. Hence, evaluation results (classes) for these waterbodies do not indicate the structural deviation from good structural potential (Germany measures the ecological potential by applying a modified PERLODES evaluation). However, the single parameters and indices can be used to describe structural targets for HWMB/AWB and evaluate deviation of these targets on parameter level.
evaluation of sediment	Germany	applicable for every river type, for every size category, draft of a	scientifically ambitious; there is often a lack of data for the

Name of the method	Country	Strengths of method	Weaknesses & challenges of method
continuity (Bewertung der Durchgängigkeit von Fließgewässern für Fische und Sedimente, hier: Sedimentdurchgängigkeit)		standardised method for WFD reporting	application of the method; consequently, only a limited and reduced extent of the procedure will be feasible in practice (as a rule, only cross structures based); no application until today (method is being developed)
LAWA-Verfahrensempfehlung zur Gewässerstrukturkartierung – Verfahren für kleine bis mittelgroße Fließgewässer	Germany	The information detail and reliability gained by assessing every stretch of a river in the field. Grouping parameters into 6 categories allows for easy design of different maps. Detailed parameters and parameter values allow for detailed monitoring of restoration measures.	Data are recorded for 100-m sections of small rivers and streams, hence hydraulic and transportation processes in the catchment are not included in the individual data set. For this reason, a separate methodology for evaluating longitudinal continuity (sediment/fish) is currently being developed. The method does not provide a classified deviation from structural potential in case of HMWB, however the single parameters and their indices can be used to assess distance to target.
Dansk fysisk indeks, DFI (Danish physical Index)	Denmark	The method is Water Framework compliant and describes the physical (hydromorphological) conditions in rivers.	
River HYMO EST	Estonia	inexpensive and practical, easily applicable in all waterbodies, Used for fish status, high status definition, developing measures, monitoring risk assessment, weighting and development of status indicators	Hydrological alteration method could be further developed, density of artificial water network as proxy to water regime alteration (we see it promising, further measurement is needed)
Protocol for the hydromorphological characterization of water bodies	Spain	Quantitative scoring allows a more sensitive assessment, and will facilitate the definition of specific thresholds and other adaptations for different river types. The method is very sensitive (the indicators react very clearly) to managerial decisions/actions to be taken in order to improve the different aspects of the river.	Outputs of field work required for the collection and/or evaluation of some of the variables considered by the protocol might be much dependent on the observer´s judgement. With the aim of mitigation this source of uncertainty, a detailed field work guide is currently under development.
DRAINAGE	Spain	The method is robust as it considers hydrology, geomorphology and impact of artificial elements	The method is very costly in terms of implementation time which difficulty its application in the whole fluvial system
Índice para la evaluación de la calidad hidrogeomorfológica (IHG)	Spain	It is possible to identify clearly the elements that reduce the valuation of the section and that it allows to propose concrete actions of restoration, mitigation … The versatility: the index can be applied to a punctual section, to a complete WB ... The possibility of modeling and weighing the scores. The results usually come out consistent with reality. It is a useful methodology for teaching and for social awareness.	It is difficult to obtain data in some rivers and in some parameters. It is necessary to simplify the index (there is a reduced version in tests). It is also necessary to make a version for ephemeral rivers (there is a version that is being applied in Aragon and the Júcar Basin)

Name of the method	Country	Strengths of method	Weaknesses & challenges of method
		Not dependent on the presence of water (although help)	
HyMo method (Kevomu-menetelmä)	Finland	14 Relatively easy to understand and available in centralized database open for every citizen.	Waterbodies are quite large Sometimes difficult to find historical information of morphological changes and thus, the assessment is sometimes based on expert judgment that may vary or be subject to criticism
AURAHCE (AUdit RApide de l'Hydromorphologie des Cours d'Eau / Hydromorphology auditing)	France	Standardized protocol which permit to develop knowledge about links between pressures and impacts at the reach scale.	Not enforce at the national scale. Currently we only have regional data, so we cannot illustrate all river types. Lack of quatitative data
CARHYCE (CARactérisation HYdromorphologique des Cours d'Eau / Hydromorphological characterization of rivers)	France	A single, centralized database based on standardized knowledge and evaluation. The DB is regularly actualised and implemented (new stations or new iteration on an existing station). Outputs can rapidly indicate the degree of alteration of studied river section.	A transposition to the water body remains difficult because the CARHYCE protocol is only applied at the station scale. Moreover, temporal evolution is difficult to apprehend beacause the protocol is not regularly realised upon each station.
ICE project (for “Informations sur la Continuité Ecologique”)	France	A single, centralized database based on standardized knowledge and evaluation. A transparent approach with a methodology and a standardized field protocol.	A transposition to the water body remains difficult because of temporality of hydrological system and migratory needs of fishes. This approach may also be applied to assessments of downstream migration. However, as noted in the section on the protocol objectives and limits, given the complexity of downstream-migration parameters and situations, it was decided not to establish assessment criteria for the passability of structures during downstream migration. A specific study carried out by highly specialised technicians remains indispensable.
RHUM (Référentiel Hydromorphologique Ultra-Marin) a specific method for the French overseas departments (tropical systems)	France	Info collected by the method can be combined with data required for management, programming, decision-making and assessment of restoration actions (objectives of WFD) It uses a National database on barriers to flow continuity It’s a precious system for a first hydromorphological approach, to complete by other spatial scales. A better potential to become a	No temporal approach

Name of the method	Country	Strengths of method	Weaknesses & challenges of method
		tool than SYRAH-CE We can still improve by creating a system focused on physical processes and features. It could support the definition of several states (such as reference conditions). To be developed	
ROE (Référentiel des Obstacles à l'Ecoulement)	France	A single, centralized database based on standardized knowledges	A database still incomplete because of the large number of barriers to be identified
SYRAH-CE (SYstème Relationnel d'Audit de l'Hydromorphologie des Cours d'Eau)	France	It has been applied to all the French metropolitan territory It’s a precious system for a first hydromorphological approach, to complete by other spatial scales We can still improve by creating a system focused on physical processes and features. It could support the definition of several states (such as reference conditions). To be developed Info collected by the method can be combined with data required for management, programming, decision-making and assessment of restoration actions (objectives of WFD) It uses a National database on barriers to flow continuity	No temporal approach Not automatically method, it’s not a tool Difficulty in recalculating Bayesian treatments
Planned_HU	Hungary	The main elements of the method are already clear. It will fill the gaps of the previous method. The main added value against the previous method is the morphological field work which will be built on a guidebook, field survey sheets and training courses.	The method is under planning. A project will be responsible to evaluate it in the next 2 years.
HU_RBMP2	Hungary	The method is a step forward compared to the method of the first RBMP. It enables clear data management and assessment, and is unified for the whole country. It involved all data types that are available with desk study or the knowledge of regional directorates was present.	The WFD method's most important weakness was the lack of morphological field survey.
Abstraction impact screening assessment	Ireland	Transparency, repeatability.	Reliance on detailed, up to date, mapped data sets of abstractions and discharges. Does not take local site specific hydrological requirements into account. Difficult to clearly link flow regime with ecological status in Ireland. A more comprehensive abstraction database is required to complete this work and abstraction and discharge points

Name of the method	Country	Strengths of method	Weaknesses & challenges of method
			need to be accurately mapped
River Hydromorphological Assessment Technique/RHAT	Ireland	Rapid assessment (i.e. avoids detailed quantitative measurements); low cost; provides insight into physical habitat quality/condition; and therefore, complements ecological monitoring as carried out at a site scale. If the existing method was implemented in full, as originally envisaged, it would likely highlight the most significant and urgent hydromorphological pressures contributing to failure to meet objectives in both cycles.	Relies heavily on field surveys (therefore time consuming); restricted to four RHAT river types (i.e. not wandering, braided or anastomosing types - however, these types are not common in Ireland so the assessment with the four RHAT river types is currently fit for purpose); survey (whether site scale or spot check) will not provide the full fluvial geomorphological picture of a water body (in terms of morphological processes, presence of pressures throughout the entire water body and river behaviour in response to those pressures) – need to consider processes at a much larger scale.
MQI Morphological Quality Index	Italy	The method support a wide understanding of river conditions and a good support for ecological assessment It can be applied in all river types, it provides a sound diagnosis of river health and can also be used in provisional mode; the evaluation is guided by selection of fixed responses and the consideration of uncertainties allows to understand the reliability of the assessment	It requires a background in river sciences. Some indicators require good degree of geomorphic interpretation because alteration of physical processes is often difficult to assess, therefore a background of fluvial geomorphology is required for them.
Indici di hydropeaking	Italy	It is easy to be applied and requires low resources	It needs measured data The method works only if at least 1 year of sub-hourly data of discharge are available
IARI indice di alterazione del regime idrologico	Italy	It is easy to be applied and requires low resources	It needs measured data (even to calibrate models) The method works only if long time series of discharge are available.
Caravaggio	Italy	Significant correlation with macroinvertebrates response; comprises a standardised approach based on a strict field protocol	It assesses river continuity but only within 500m; some morphological process are not explicitly recorded.
Lithuanian River Hydromorphology Index	Lithuania	Easy to use, requires low resource-intensity. Method was developed based on assessment of significance of impact of various hydromorphological modifications on fish and benthic invertebrates. A good correlation with national fish index (R>0.7; n=185), satisfactory correlation with benthic invertebrate index (R>0.3; n=183).	Assesses only country-specific disturbances, mainly impact of weirs, HPP functioning and river straightening. Scores are not transparent, therefore differences in evaluation may occur. River continuity is almost not covered.
Klassifizierung des Wasserhaushalts von Einzugsgebie-	Luxembourg	Realistic assumptions of data availability, pragmatic assessment approach (pressure based),	not yet identified

Name of the method	Country	Strengths of method	Weaknesses & challenges of method
ten und Wasserkörpern		synergy with morphological monitoring.	
Strukturgütekartierung (LANUV 2012)	Luxembourg	Detailed (26 single parameters) and standardized (pre-defined section lenghts). High potential for identifying hydromorphological hotspots and deficits/pressures. High cost-efficiency. Good potential for monitoring of restoration projects (though alterations on micro-habitat level not detectable).	No consideration of the WFD hydromorphological category "hydrological regime" (i.e. flow discharge, connectivity to groundwater) Additional process-based assessment on watershed level would be helpful to get entire picture of Hydromorphological alterations and their causes.
HAP-LR	Latvia	There is the possibility to assess conditions of river morphology and hydrological regime as well as river banks and riparian zone. All scores ar transparent	Presence of barriers in streams is given in the "overview" of Protocol, and assessment of river continuity is not scored. It means that final hydromorphological assessment should be done out of Protocol taking into account expert judgment about dams impact.
Handboek Hydromorfologie 2.0 (Oste et al. 2013)	Netherlands	Covers hydrology, morphology and continuity	Does not cover vegetation for its features related to hydrology and morphology
Characterization, analysis and risk assessment of water bodies as defined in WFD art. 5	Norway	Pragmatic, low intensity, based on existing databases and knowledge. Simple enough to ensure similar practice and understanding among the people using it.	Factors that can be important/relevant for ecological status and identification of adequate mitigation measures is not systematically considered. Finding a method that is applicable throughout the whole country with our extensive river system, simple enough for all the people involved in the characterization work to apply it in practical work, yet giving relevant and useful information, is challenging.
Hydromorphological Index for Rivers / HIR	Poland	Labour efficient (less than 2 hours of the work per site), Repitable (good for monitoring), Statistically robust	
River Habitat Survey (RHS)	Portugal	The decision to adopt RHS in PT was supported on several reasons: i) RHS methodology was a major contributor to the CEN guidance standards EN 14614 and EN 15843; ii) experience in RHS application and validation in the UK dates back to 1994 (Raven et al., 2009); iii) the method has been successfully used across most of Europe, showing that it can be adapted for general use outside the UK (Raven et al., 2009); iv) RHS is partially compliant with some WFD normative definitions for hydromorphological quality elements; v) RHS comprises a standardised approach based on a strict field protocol, clearly defined quality control procedures, and surveyors are required to be fully trained and accredited (Raven et al.,	RHS present some gaps concerning WFD implementation (Ferreira et al. 2011): Hydrological regime - RHS only assesses dynamics of river flow: River continuity- RHS assesses river continuity but only within 500m. For a broader scale (e.g. waterbody) it has to be complemented by other sources of information (e.g. GIS) or by carrying out several continuous surveys. Morphological conditions – RHS does not assess river depth and width variation and do not fully assess the structure of the riparian zone.

Name of the method	Country	Strengths of method	Weaknesses & challenges of method
		2009); vi) RHS follows rapid and simple sampling procedures (Raven et al., 2009); vii) RHS is effective for detecting hydromorphological degradation on Portuguese rivers (Hughes et al, 2008); viii) RHS outputs are easily understood by managers, scientists and community groups; ix) RHS has many applications beyond the scope of WFD.	
Methodology to determine the hydromorphological indicators for Romanian rivers	Romania	The method is based on 11 indicators belonging to the three groups of elements required by WFD as follows: hydrological regime (quantity and dynamics of water flow, connection to groundwater bodies), river continuity (longitudinal and lateral continuity / connectivity) and morphological condition (river depth and width variation, structure and substrate of the riverbed and the riparian zone). The hydromorphological characteristics of the Romanian rivers are assessed at the water body level. An interesting approach should be highlighted for the riparian zone assessment. The delineation of the riparian zone (type-specific width), is based both on valley geomorphology and water bodies' typology, accepting that the riparian zone width under natural conditions is different, increasing from upstream to downstream. The classification system is in five classes (class I - is the most natural condition and class V - the highest anthropogenic impact).	Indicators given consideration to river processes should be further developed
HVMFS 2013:19 (Agency regulation)	Sweden	Scientifically based parameters to assess hydrological and geomorphological functions and structures. In line with projects like REFORM. Strong scientific base on setting reference condition using hydrological modelling. In 2017, much stronger link between hydromorphological assessment method, habitat survey and description of locality in biological monitoring	Parameters in hydrological regime need to be developed further. A daily average is too coarse time step. Links between characterisation - setting reference condition - hydromorphological assassment - measures needs to be developed further. Biological methods are in many cases insensitive for hydromorphological alteration. Fish status usually works well (report available). Setting proper reference condition for hydromorphological is one of the most difficult part for people working with hydromorphological assessment or in licensing.
Hydromorphological Monitoring in Slovenia - HIMO.SI	Slovenia	1. The method includes conditions of all reaches of water body. 2. The method concern hydrology, biology, morphology change and continuity conditions for every reach of the river according to type-specific conditions from 19th century.	The method should include river type specific conditions for scoring.

Name of the method	Country	Strengths of method	Weaknesses & challenges of method
Hydromorphology Quality Assessment	Slovakia	Process based method allows to diagnose hydromorphological deficits, assessment of the river modification and identification of the causes; results provide the basis for designation of effective restoration measures to support more natural functioning; created databases (including results of field measurements) enable to evaluate the impact of restoration measures in the future;	Spatial and temporal scales for method application (river basin approach) need to be improved and harmonized in association with biological assessment (included in method update); Integration of morphological classification - typology into the existing delineation of the water bodies (for WFD)– included in method update
Physical habitat assessment	Slovakia	The method is repeatable with small degree of subjectivity. In case of more survivors on the same monitoring place the final results are same.	
Nehir Hidromorfolojisi Değerlendirme İndeksi (NHDI) (Turkish) River Hidromorphology Assessment Index (English)	Turkey	*Method can use at different waterbodies that have different characteristics/features (WFD: typology), *Application of method is easy, but the data collected and result obtained are effective and at sufficient level to ensure the requirements of the WFD.	
Designation of A/HMWB	England & Wales	Fairly easy to carry out (if not time consuming), produces good map of spatial distribution of A/HMWB waters and where the different uses (pressures) are within England and Wales	Does not give you the exact location of individual modifications. The method is very data hungry and you need up to date accurate data. Border line cases that fall very close to the bounds for designation need expert judgement. Whether a water body could reach GES with the physical modification is very hard to identify and has to be done by expert judgement.
Mitigation Measure Assessment	England (Wales) - UK	Easy to process the classification once the mitigation measures have been assessed. Allows tracking towards better status.	It is highly qualitative. Very difficult to assess how much of a mitigation measure is 'enough'. No biological component.
Hydrology - Water Resources GIS (WRGIS)	England - UK	National Consistent approach. Output provides national datasets at water body scal. GIS format enables visualisation and mapping.	Generic definition of EFI may not be considered appropriate for all water bodies. Output of the tool needs QA to give confidence. Tool doesn't work for reservoirs or rivers with heavily modified flow regime. There will be a review of the Environmental Flow Indicators prior to 3rd planning cycle
Morphology Risk Assessment	England (Wales) - UK	based on available information at the time, transparent, high level, has multiple uses for characterisation purposes (article V), augmented by other evidence including expert opinion	Input data need updating, does not account for different typologies, links to ecology and ecological status based on expert opinion
River Hydromorphology Assessment Technique	Northern Ireland - UK	The RHAT method was written specifically for WFD assessment and developed with ecological considerations for WFD. It is compliant	It needs staff resources.

Name of the method	Country	Strengths of method	Weaknesses & challenges of method
(RHAT)		with the CEN Hydromorphological standard. The RHAT method breaks the channel into sections for assessment (In channel, banks, riparian). Using all available GIS layers enables a score to be assigned without extensive field work. The use of field work allows scores to be confirmed and elements such as fine sediment and barriers to be assessed.	
River habitat Survey (RHS)	England (Wales) - UK	Standardised approach, application on any river environment, wealth of data generated to use Many elements of RHS can now be identified using other techniques (e.g. remote sensing), huge amount of data available since survey began is helping develop other tools, maps and secondary data.	Some morphological process are not explicitly recorded - only during further analysis of data (often in combination with other evidence), site replication is difficult (precision of location), surveyor variance
Hydrology water body classification	Scotland - UK	Nationally consistent approach. Output provides national datasets at water body and sub water body scale. The sub-water body scale helps identify the sources of degradation	The assumptions in the links between hydrology and ecological status are pragmatic but , consequently, over-simplified. The method does not take into account the temporal nature of flow impacts i.e. temporary failures of environmental standards are not distinguishable from permanent ones There will be a review of the environmental standards and typology prior to 3rd planning cycle
Morphological **Im**pact **A**ssessment **S**ystem (MImAS)	Scotland - UK	Transparent, replicable and auditable. Applicable with or without field data - full national assessment of all water bodies are made annually using combination of field and remotely sensed data. Allows seamless integration of WFD classification, regulation of river engineering activites & scoping of river restoration mitigation measures. Allows cumulative impacts of multiple pressures to be assessed. The use of impact ratings (expert judgment assessments of damage caused by pressures in different river types) allows estimates of the total amount of water bodydamage to be made in the absence of empirical observation of damage. There is a rudimentary linkage between the degree of mor-	The accuracy of assessments is lower if only remotely sensed data are being used. There is some double-counting of pressure impacts. Derivation of the impact ratings is based on expert judgment, as opposed to direct empirical observation (although the latter does inform the former). The expert judgment assessments could be improved in some cases to more accurately reflect likely levels of damage.This linkage is very, very simplistic. Not all pressures or impacts that should be assessed are being assessed, e.g. sediment discontinuity downstream from dams, livestock poaching.Some types are inappropriately grouped together for the purposes of scoring and assessment.

Name of the method	Country	Strengths of method	Weaknesses & challenges of method
		phological damage and the degree of biotic damage. Use of a typology allows the sensitivity of different river types to morpholgical modifications to be taken into account.	Assessments are based on the lengths of water bodies and pressures, as opposed to the area of water bodies and channels impacted by pressures, so assessments do not reflect the amount of habitat that has been damaged as accurately as they could. The upstream- and downstream-migrating impacts of pressures are not dealt with as appropriately as they could be.
Morphological **Im**pact **A**ssessment **S**ystem 2c(MImAS 2)	Scotland - UK	Transparent, replicable and auditable.A full national assessment of all water bodies will be made annually using a combination of field and remotely sensed data. The proportion of field-derived data has recently increased substantially, with about 20% of the total baseline river network in Scotland having been surveyed. These surveys were also focussed in the parts of the country most likely to be the subject of regulatory and restoration management interventions.Allows seamless integration of WFD classification, regulation of river engineering activites & scoping of river restoration mitigation measures.Allows cumulative impacts of multiple pressures to be assessed. The factors causing the double counting of pressure impacts in MImAS have been removed.The impact ratings (expert judgment assessments of damage caused by pressures in different river types) allows estimates of the total amount of water body damage to be made in the absence of empirical observation of damage. The ratings have been substantially revised to more accurately reflect the likely level of damage.There is a rudimentary linkage between the degree of morphological damage and the degree of biotic damage. Additional pressures (sediment discontinuity, livestock poaching of river banks, channel resectioning) are now considered, while other pressures such	The accuracy of assessments is lower if only remotely sensed data are being used, though fewer water bodies are now subject to this problem. Derivation of the impact ratings is based on expert judgment, as opposed to direct empirical observation (although the latter does inform the former). This linkage is very, very simplistic, but has been revised slightly in MImAS2.

Name of the method	Country	Strengths of method	Weaknesses & challenges of method
		as channel straightening, flood embankments and bank protection are dealt with in a more flexible fashion, to more accurately reflect the wide range of impacts they can have. The area of river channel estimated to have been lost as a result of channel straightening is also explicitly accounted for.The underlying typology has been improved through the use of more field data. Also, all channel types are considered separately, to allow for more accurate assessment of damage. Assessments are based on the areas of water bodies and the areas of pressure impacts, thus more accurately reflecting the amount of habitat that has been damaged or lost. The upstream- and downstream-migrating impacts of pressures are now assessed in the zones of the river in which they actually occur.	

Annex II: Questionnaire responses on e-flows

In the questionnaire, Member States were asked to indicate whether a method to define ecological flow requirements is available or not. The intention was to update information on whether or not eflow methods have been developed. Therefore, no further information has been collected on the specific links of eflow requirements to hydromorphological assessments and the result of the responses are summarised below.

For 13 countries, it was reported that a method to define ecological flow requirements is used. Another 13 countries reported that there is no method available to define ecological flow requirements.

However, it should be noted that methods for setting or assessing environmental flow are not included here because e-flow methods are used to assess flow requirements of the many interacting components of aquatic systems. Hydrological alteration methods reviewed in this section of the questionnaire are specifically focussed on the assessment of the flow regime alterations.

Table 9 Methods to define ecological flow requirements

	Countries
A method to define ecological flow requirements is used	Austria Switzerland Czech Republic Spain Hungary Ireland Italy Latvia Norway Portugal Romania Slovenia UK (England & Wales, Northern Ireland, Scotland)
No method available to define ecological flow requirements* *(*linked to the hydrological alteration methods reviewed in this section of the questionnaire)*	Belgium Wallonia Germany Denmark Spain Finland France Lithuania Luxembourg Netherlands Poland Sweden Slovakia Turkey

Notes: Finland: Some studies and testing exist, but not applied so far in the WFD implementation; Sweden: Is developing guidance document on Eflow; Slovakia: There is a method to estimate min. flow (SHMU) but it doesn't correspond to ecological flow requirements; France: Has a national hydrological database (Banque Hydro). Hydrological time series can be long (more 30 years). A method exists for determining flows on ungauged rivers.

Annex III: Key references for the reported methods

Country	Name of the method, or acronym/abbreviation	Key reference
Austria	Austrian Guidance on hydromorphological assessment of rivers	"Leitfaden zur hydromorphologischen Zustandserhebung von Fliessgewässern"
Flanders (Belgium)	meetnet Hydromorfologie	http://www.integraalwaterbeleid.be/nl/stroomgebiedbeheerplannen/stroomgebiedbeheerplannen-2016-2021/stroomgebiedbeheerplannen-voor-schelde-en-maas-2016-2021
BE (Wallonia)	Qualphy	-
Belgium Wallonia	Walloon method derived from SYRAH (Fr) (National method)	Développement et application d'une méthode d'évaluation globale de la qualité hydromorphologique des masses d'eau de surface définies en Région wallonne ULG Guyon, Cogels & Vanderborgt (2006)
Belgium / Wallonia	Riparian Remote Monitoring - RiReMo (future development)	Scientific paper: http://hdl.handle.net/2268/153872 - Rapport: http://hdl.handle.net/2268/199917
Switzerland	Modul-Stufen-Konzept (MSK) Methode Ökomorphologie Stufe F (Flachdekkend)	www.modul-stufen-konzept.ch
Switzerland	Modul-Stufen-Konzept (MSK) Methode Hydrologie Stufe F (Flachdekkend) Konzept HYDMOD-F	http://www.modul-stufen-konzept.ch/fg/module/hydro/index
Cyprus	Integrated Pressure Index (IPI)	ENVECO S.A. and I.A.CO Ltd. (2013). REVIEW AND UPDATE OF ARTICLE 5 OF DIRECTIVE 2000/60/EC (WATER RESERVOIRS) & CLASSIFICATION OF WATER STATUS (RIVERS, NATURAL LAKES AND WATER RESERVOIRS), THAT WILL ESTABLISH BASELINE INFORMATION AND DATA FOR THE 2ND CYPRUS RIVER BASIN MANAGEMENT PLAN. REPORT ON THE CLASSIFICATION OF WATER STATUS (RIVERS, NATURAL LAKES, WATER RESERVOIRS). Contract No.: YY 02/2013. Final Report. Nicosia-Cyprus: Water Development Department, Ministry of Agriculture, Natural Resources and Environment. [online]. Available from: http://www.moa.gov.cy/moa/wdd/wdd.nsf/all/AAA019E372936A76C2257E6500271FB4/$file/Ekthesi_art5_Tax_river_dams.pdf [Accessed September 27, 2015].
Czech Republic	HEM 2014 Metodika monitoringu hydromorfologických ukazatelů ekologické kvality vodních toků	http://www.mzp.cz/C1257458002F0DC7/cz/prehled_akceptovanych_metodik_tekoucich_vod/$FILE/OOV-HEM%20_2014_Metodika_monitoringu-15092015.pdf http://www.mzp.cz/C1257458002F0DC7/cz/prehled_akceptovanych_metodik_tekoucich_vod/$FILE/OOV-HEM_2014_Metodika_typove_specifickeho_hodnoceni-

Country	Name of the method, or acronym/abbreviation	Key reference
		15092015.pdf
Germany	The hydromorphological classification tool Valmorph for large and navigable surface waters	Quick, I.; König, F.; Baulig, Y.; Borgsmüller, C.; Schriever, S. (2017): The hydromorphological classification tool Valmorph 2 for large and navigable surface waters. BfG-Report No. 1910. Federal Institute of Hydrology. Koblenz. http://doi.bafg.de/BfG/2017/BfG-1910-ENG.pdf
Germany	Klassifizierung des Wasserhaushalts von Einzugsgebie-ten und Wasserkörpern	Laenderarbeitsgemeinschaft Wasser (LAWA), 2014: Klassifizierung des Wasserhaus-halts von Einzugsgebieten und Wasserkoerpern
Germany	LAWA-Verfahrensempfehlung zur Gewässerstruktur-kartierung – Verfahren für mittelgroße bis große Fließ-gewässer	Laenderarbeitsgemeinschaft Wasser (LAWA) (ed.) (2014): LAWA-Verfahrensempfehlung Gewaesserstrukturkartierung. Verfahren fuer mittelgrosse bis grosse Fliessgewaesser
Germany	evaluation of sediment continuity (Bewertung der Durchgängigkeit von Fließgewässern für Fische und Sedimente, hier: Sedimentdurchgängigkeit)	not yet publicly available
Germany	LAWA-Verfahrensempfehlung zur Gewässerstruktur-kartierung – Verfahren für kleine bis mittelgroße Fließ-gewässer	Laenderarbeitsgemeinschaft Wasser (LAWA) (ed.) (2000): Gewaessersturkturguetekartierung in der Bundesrepublik Deutschland. Verfahren für kleine bis mittelgroße Fließgewaesser.
Denmark	Dansk fysisk indeks, DFI (Danish physical Index)	-
Estonia	River HYMO EST	Developement of methodology in Estonian;"Oluliste looduslike ning inimtegevuse tulemusena rikutud (tugevasti muudetud või tehislike) vooluveekogude hüdromorfoloogilise seisundi uurimine ning hüdromorfoloogilise seisundi hindamise metoodika väljatöötamine" 2014, http://www.envir.ee/et/eesmargid-tegevused/vesi/uuringud-ja-aruanded#2014
Spain	Protocol for the hydromorphological characterization of water bodies	Document: Protocolo de caracterización hidromorfológica de masas de agua de la categoría río (*.doc). Doc_code: M-R-HMF-2016
Spain	DRAINAGE	Scientific paper
Spain	Índice para la evaluación de la calidad hidrogeomor-fológica (IHG)	http://www.chebro.es/contenido.visualizar.do?idContenido=28577
Finland	HyMo method (Kevomu-menetelmä)	In Rivers: Vuori, K-M. & Hellsten, S. 2002. A three-step HCMo-model for identifica-tion of heavily modified rivers in Finland. In Ruoppa, M. & Karttunen, K. Typology and ecological classification of lakes and rivers. TemaNord 2002:566: 109-110. Preliminary idea presented here.

Country	Name of the method, or acronym/abbreviation	Key reference
France	AURAHCE (AUdit RApide de l'Hydromorphologie des Cours d'Eau / Hydromorphology auditing)	Valette L., Chandesris A., Souchon Y. (2013) Protocole AURAH-CE (AUdit RApide de l'Hydromorphologie des Cours d'Eau - Méthode de recueil d'informations complé-mentaires à SYRAH-CE sur le terrain v,2.0, Pôle Onema/Irstea Hydroécologie des cours d'eau.
France	CARHYCE (CARactérisation HYdromorphologique des Cours d'Eau / Hydromorphological characterization of rivers)	Gob F., Bilodeau C., Thommeret N., Tamisier V., Albert M.-B., Beliard J. (2015) - Vers la construction d'indicateurs hydromorphologiques soutenant la biologie à partir de la base de données nationale CARHY_CE. Livrable Convention Onema -CNRS Gob F., Bilodeau C., Thommeret N., Tamisier V., Baudouin J.-M., Kreutzenberger K. (2014). A tool for the characterisation of the hydromorphology of rivers in line with the application of the European Water Framework Directive in France (CARHYCE). Géomorphologie : relief, processus, envi-ronnement, 2014, n° 1, p. 57-72. http://lgp.cnrs.fr/carhyce
France	ICE project (for "Informations sur la Continuité Ecolo-gique")	Methodology and assessment protocol (EN) : Baudoin J.M., Burgun V., Chanseau M., Larinier M., Ovidio M., Sremski W., Steinbach P. and Voegtle B., 2014. Assessing the passage of obstacles by fish. Concepts, design and application. Onema. 200 pages. Field protocol (FR) : Burgun V., Chanseau M., Kreutzenberger K., Marty M., Penil C., Tual M. and Voegtle B., 2016. ICE Informations sur la continuité écologique. Proto-cole de terrain pour l'acquisition des données. Onema. 84p.
France	RHUM (Référentiel Hydromorphologique Ultra-Marin) a specific method for the French overseas departments (tropical systems)	Asconit consultants, Dynamique Hydro, Laboratoire Hydreco (2014). Mise en œuvre du Référentiel hydromorphologique ultra-marin (RHUM) - Adaptation du système relationnel d'audit hydromorphologique (SYRAH) dans les Départe-ments d'outremer (DOM). Rapport méthodologique pour l'Agence française pour la biodiversité (AFB), les Offices de l'eau et les Directions régionales de l'envi-ronnement, de l'aménagement et du logement (DEAL), 79 p.
France	ROE (Référentiel des Obstacles à l'Ecoulement) Nb : It is not a methodology strictly speaking, but a data repository about all man-made barriers used for different evaluations. It is a database with the aim of listing, and localizing and characterizing all man-made barriers. It allows an evaluation of weirs pressure.	SANDRE, 2015. Description des ouvrages faisant obstacle à l'écoulement, Dic-tionnaire de données, 128p. SANDRE, 2015. Obstacles à l'écoulement, Présentation des données, 80p. SANDRE, 2016. Diffusion du référentiel des obstacles à l'écoulement des obs-tacles à l'écoulement aux formats simplifiés, 32p.

Country	Name of the method, or acronym/abbreviation	Key reference
		Data: http://www.data.eaufrance.fr/jdd/070df464-73d3-4c00-be2f-93f2a97ef8f5
France	SYRAH-CE (SYstème Relationnel d'Audit de l'Hydromorphologie des Cours d'Eau) Relational, multi-scale system for auditing the hydromorphology of rivers	Valette, L., Piffady, J., Chandesris, A., Souchon, Y., 2012. SYRAH-CE : Description des données et modélisation du risque d'altération de l'hydromorphologie des cours d'eau pour l'Etat des lieux DCE, rapport final, 104 p. Chandesris, A., Mengin, N., Malavoi, J.R., Wasson, J.G., Souchon, Y., 2008. SYRAH-CE: A relational, multi-scale system for auditing the hydro-morphology of running waters: diagnostic tool to help the WFD implementation in France. 4th international conference on river restoration, Venice, ITA, 16-21 June 2008, 4 p. Data: http://www.data.eaufrance.fr/jdd/9c86a5da-88f4-4819-a84e-c09a69394a34
Hungary	Planned_HU	-
Hungary	HU_RBMP2	https://www.vizugy.hu/vizstrategia/documents/988BF7DB-B869-46C6-9463-E9E4BFC81D2A/6_4_hatteranyag_hidromorfologiai_allapotertekeles.pdf
Ireland	Abstraction impact screening assessment	Link to draft River Basin Management plan: http://www.housing.gov.ie/water/water-quality/river-basin-management-plans/public-consultation-draft-river-basin-management To be updated when final plan is published (i.e. Q2 2018)
Ireland	River Hydromorphological Assessment Technique/RHAT	Murphy, M. and Toland, M., 2014. River Hydromorphology Assessment Technique (RHAT). Training guide. Version 2. Northern Ireland Environment Agency (NIEA), Department of the Environment: 42 pp.
Iceland	Not relevant	-
Italy	MQI Morphological Quality Index	http://www.isprambiente.gov.it/it/pubblicazioni/manuali-e-linee-guida/idraim-sistema-di-valutazione-idromorfologica-analisi-e-monitoraggio-dei-corsi-dacqua http://www.isprambiente.gov.it/pre_meteo/idro/idromorfologia/MQI_final_Aug16.pdf
Italy	Indici di hydropeaking	http://www.isprambiente.gov.it/files/pubblicazioni/manuali-lineeguida/Metodo_Hydropeaking_CAROLLI_ET_AL2014.pdf
Italy	IARI indice di alterazione del regime idrologico	http://www.isprambiente.gov.it/it/pubblicazioni/manuali-e-linee-guida/analisi-e-valutazione-degli-aspetti

Country	Name of the method, or acronym/abbreviation	Key reference
Italy	Caravaggio	http://www.life-inhabit.it/it/download/tutti-file/doc_download/123-manuale-caravaggio
Lithuania	Lithuanian River Hydromorphology Index	-
Luxembourg	Klassifizierung des Wasserhaushalts von Einzugsgebie-ten und Wasserkörpern	LAWA (2014): Wasserhaushalt Verfahrensempfehlung Mehl et al. (2015): Zusammenfassung der Verfahrensempfehlung
Luxembourg	Strukturgütekartierung (LANUV 2012)	LANUV-NRW (2012). Gewässerstruktur in Nordrhein-Westfalen: Kartieranleitung für die kleinen bis großen Fließgewässer – LANUV Arbeitsblatt 18, Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen, Recklinghausen.
Latvia	HAP-LR	http://www.shmu.sk/File/implementacia_rsv/twinning/a1_Protocol_final.pdf; http://wiki.reformrivers.eu/images/3/33/SlovakHAP.pdf
Netherlands	Handboek Hydromorfologie 2.0 (Oste et al. 2013)	Osté, A.J., B. de Groot & O. van Dam (2013) Handboek hydromorfologie 2.0 - Afleiding en beoordeling hydromorfologische parameters Kaderrichtlijn Water. Rijkswaterstaat. 174 p.
Norway	Characterization, analysis and risk assessment of water bodies as defined in WFD art. 5	"Veileder 01:2011a - Karakterisering og analyse. Metodikk for karakterisering og risikovurdering av vannforekomster etter vannforskriften § 15 "; Veileder 02:2013: Klassifisering og Veileder 01:2014 - SMVF
Poland	Hydromorphological Index for Rivers / HIR	Ocena wód płynących w oparciu o Hydromorfologiczny Indeks Rzeczny (HIR) - Wstępna wersja metodyki obserwacji hydromorfologicznych elementów oceny stanu ekologicznego wód płynących zgodnej z normą PN-EN 14614: Poznań 2016. http://www.gios.gov.pl/images/dokumenty/pms/monitoring_wod/zadanie_6a_raport.pdf
Portugal	River Habitat Survey (RHS)	Raven, P., Holmes, N., Pádua, J., Ferreira, J. Hughes, S., Baker, L., Taylor, L. Seager, K. 2009. River Habitat Survey in Southern Portugal: Results from 2009. Environment Agency, Bristol. 29pp. Ferreira, J., Pádua, J., Hughes, S.J., Cortes, R.M.V., Varandas, S., Holmes, N., Raven, P. 2011. Adapting and adopting river habitat survey: Problems and solutions for fluvial hydromorphological assessment in Portugal. Limnetica, 30(2): 263-272. http://www.apambiente.pt/dqa/hidromorfologia.html

Country	Name of the method, or acronym/abbreviation	Key reference
Romania	Methodology to determine the hydromorphological indicators for Romanian rivers	The Romanian methodology has been developed by the National Institute of Hydrology and Water Management - Romania within a research study
Sweden	HVMFS 2013:19 (Agency regulation)	-
Slovenia	Hydromorphological Monitoring in Slovenia - HIMO.SI	
Slovakia	Hydromorphology Quality Assessment	Applied Fluvial Geomorphology for River Engineering and Managmenet (Ed) Thorne, Hey, Newson and other relevant references on river processes; channel types and morphological classification Methodology for Testing and Designation of Heavily Modified Water Bodies in Slovakia (VUVH/2007)
Slovakia	Physical habitat assessment	-
Turkey	Nehir Hidromorfolojisi Değerlendirme İndeksi (NHDI) (Turkish) River Hidromorphology Assessment Index (English)	methods based on Expertise Thesis (Azlak, 2015) of Ministry of Forestry and Water Affairs.
England & Wales	Designation of A/HMWB	UK Technical Advisory Group on the Water Framework Directive - 'Criteria and Guidance Principles for the designation of heavily modified water bodies'
England (Wales) - UK	Mitigation Measure Assessment	https://circabc.europa.eu/sd/a/06480e87-27a6-41e6-b165-0581c2b046ad/Guidance%20No%2013%20-%20Classification%20of%20Ecological%20Status%20(WG%20A).pdf
England - UK	Hydrology - Water Resources GIS (WRGIS)	
England (Wales) - UK	Morphology Risk Assessment	Technical Method Physical or morphological pressures on rivers: https://ea.sharefile.com/share?#/view/s907bd03e9e74b74a
Northern Ireland - UK	River Hydromorphology Assessment Technique (RHAT)	-
Northern Ireland	Low Flows Enterprise	-
England (Wales) - UK	River habitat Survey (RHS)	River Habitat Survey Manual 2003
Scotland - UK	Hydrology water body classification	http://www.gov.scot/Resource/0045/00458328.pdf

Country	Name of the method, or acronym/abbreviation	Key reference
Scotland - UK	**M**orphological **Im**pact **A**ssessment **S**ystem (MImAS)	Greig, S.M., Richardson, R. and Gibson, J. (2006a). A new impact assessment tool to support river engineering regulatory decisions. SNIFFER Technical Report. Project No. WFD49. 48 pp. Greig, S.M., Richardson, R. and Gibson, J. (2006b). A new impact assessment tool to support river engineering regulatory decisions. Appendix to te-chnical report. SNIFFER Technical Report. Project No. WFD49. 12 pp.
Scotland - UK	**M**orphological **Im**pact **A**ssessment **S**ystem 2 (MImAS2)	Not yet written

Annex IV: European country questionnaire on hydromorphological assessment and monitoring

CIS ECOSTAT hydromorphology group

European country Questionnaire on Hydromorphological Assessment and Monitoring

0,0	Name of the method, or acronym/abbreviation	
0,1	Country	
0,2	Contact Person	

1 - General Information

neral Infor-

ID	Question	Options	Answer	Explanation
1,1	Components covered by the method	hydrology		
		morphology		
		continuity		
1,2	Use of the method	hydromorphological classification (WFD-related)		

			supporting ecological classification (WFD-related)		
			used as a proxy of biological quality elements		
			hydromorphological monitoring		
			hydromorphological assessment (non-WFD)		
			diagnosis for designing measures (e.g. rehabilitation, mitigation, etc.)		
			as a prognostic tool (e.g. for Environmental Impact Assessment)		
			other		
	1,3	Use of the method for the WFD planning process	water body delineation		
			typology		
			pressures & impacts analysis		
			status classification (for high status only)		
			status classification (for classification in all status classes)		
			risk analysis		
			HMWB designation		
			definition of good ecological potential		
			design of program of measures		
			exemptions		
			other		
			not applicable		
	1,4	Use for other Directives (except WFD)	Habitats Directive		
			Floods Directive		
			Environmental Impact Assessment Directive		
			other		
			not applicable		

	1,5	Biological considerations (relationship between hydromorphological alterations and habitat quality required by biological quality elements)	*select one answer from the options on the right*		
	1,6	Status of method	this is the official method in the country		
			used in the 1st RBMPs		
			used in the 2nd RBMPs		
			used for management/restoration but not yet included in the RBMPs		
			in development/emerging method but not yet practically applied		
			other		
			not applicable		
	1,7	Level of application	applied in the whole country (national level)		
			applied in part of the country (regional/basin level)		
			aims to assess the whole river network (i.e. every km)		
			aims to assess specific sites in the river network		
			results of assessed sites are extended to larger river portions (e.g. water bodies)		
			other		
			not applicable		
	1,8	Extent of application	indicate the percentage of water bodies (WFD) to which the method has been applied		
			information not available		
			not applicable		
	1,9	Inclusion in legislation	the method is included in national legislation		
			the method is included in regional legislation		
			the method is included in national guidelines		
			the method is included in regional guidelines		

			other		
			not applicable		
	1,10	Relevance for specific pressures	*select one answer from the options on the right*		
	1,11	Key reference	Indicate reference (available report, scientific paper, web page, etc.) and explain if needed		
	1,12	Available supporting material	guidebook		
			field sheet forms		
			compilation sheet forms		
			databases		
			software		
			other		
			not applicable		
	1,13	Users qualification	Describe the specific expertise required to apply the method (e.g. expertise in fluvial geomorphology, specific level of education, etc)		
	1,14	Requirement for accreditation	*select one answer from the options on the right*		
	1,15	Resource intensity	*select one answer from the options on the right*		
	1,16	Feedback on this section	If you were not able to fill in this section or part of this section of the questionnaire, please explain briefly why		

2 - General Characteristics of the method

cte rist	**ID**	**Question**	**Options**	**Answer**	**Explanation**
	2,1	Source of information/data collection	historical maps		

			present topographical maps		
			aerial photos		
			satellite images		
			drone images (including low flights with Unmanned Aerial Systems)		
			LiDAR data		
			field survey		
			existing GIS data		
			GIS derived parameters		
			existing databases		
			modelling derived parameters		
			other		
			not applicable		
	2,2	Longitudinal spatial scale	fixed length (indicate length in m)		
			length scaled to bankfull or low-flow channel width		
			variable length (not including the previous case)		
			exact location of alteration		
			other		
			not applicable		
	2,3	Criteria for selection of variable length	morphological segmentation		
			homogeneity of some specific characteristics (indicate which one in the explanation text box)		
			accessibility		
			random		
			other		
			not applicable		
	2,4	Lateral spatial scale	stream channel		
			banks		

			riparian zone		
			floodplain		
			hillslopes		
			fixed width (indicate width in m)		
			width scaled to channel width		
			other		
			not applicable		
	2,5	Approach used by the method to define reference condition	empirical/statistical		
			historical (indicate which period)		
			theoretical		
			other		
			not applicable		
	2,6	Use of HyMo types (indicate in the explanatory text if type is intended as "reference type" or as "current morphological type")	*select one answer from the options on the right*		
	2,7	Criteria/parameters for definition of HyMo types	size (e.g., stream order, catchment size, distance from source)		
			gradient		
			geology		
			geographical location		
			altitude		
			hydrological regime		
			confinement		
			channel morphological pattern (based on sinuosity, braiding, anabranching)		
			other		
			not applicable		

	ID	Question	Options	Answer	Explanation
	2,8	Differentiation of the method for HyMo types	*select one answer from the options on the right*		
	2,9	Temporal dimension	*select one answer from the options on the right*		
	2,10	Severity of hydromorphological pressures	*select one answer from the options on the right*		
	2,11	Feedback on this section	If you were not able to fill in this section or part of this section of the questionnaire, please explain briefly why		

3 - Recorded Hydrological Features

3 - Recorded Hydrologi-cal Features

ID	Question	Options	Answer	Explanation
3,1	Components of flow regime	low flows		
		average flows		
		high flows (e.g. small floods, large floods, etc)		
		other		
3,2	Type of flow year (avg., wet, dry year)	the method considers the type of flow year		
		the method does not consider the type of flow year		
		not applicable		
Characteristics of flow regime				
3,3	Magnitude (e.g. average monthly flow)	is feature recorded?		
		is the feature used to evaluate river condition?		
		is recording and/or evaluation done periodically?		
		not considered		
		not relevant		
3,4	Duration (e.g. duration of annual minima and maxima)	is feature recorded?		
		is the feature used to evaluate river condition?		

			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	3,5	Timing of specific events (e.g. extreme discharge, including Julian date of annual 1-day maximum and minimum)	is feature recorded?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	3,6	Frequency (e.g. number of low pulses)	is feature recorded?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	3,7	Rate of change (e.g. rise and fall rates)	is feature recorded?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	Surface-groundwater interactions				
	3,8	Surface-groundwater interactions	*select one answer from the options on the right*		
	Time related information				
	3,9	Time resolution	daily resolution		
			hourly resolution		
			sub-hourly resolution		
	3,10	Minimum length of time series	*Please respond to the right and explain if needed*		
	Pressures on hydrology				

	3,11	Pressures causing hydrological alteration	hydropeaking		
			abstraction		
			flood mitigation		
			water level change (e.g. artificial waves from naviga-tion)		
			urbanization		
			agriculture		
			other		
	Other related information				
	3,12	Reference (natural) flows	are the natural flows identified as the pre-impact con-dition (past condition) to assess the hydrological alter-ation?		
			are the natural flows identified as the current condition without pressures (modelled current catchment condi-tion where the pressures are removed) to assess the hydrological alteration?		
			are the natural flows identified in both ways, depend-ing on data availability?		
	3,13	E-flows	*select one answer from the options on the right*		
	3,14	Feedback on this section	If you were not able to fill in this section or part of this section of the questionnaire, please explain briefly why		

4 - Recorded Morphological Features

Morp hologi	ID	Question	Options	Answer	Explanation
	4,1	Planform patter (e.g. sinuous, meandering, etc.)	is feature recorded?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		

			not considered		
			not relevant		
	4,2	Longitudinal profile/gradient	is feature recorded?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	4,3	Variability of cross-section by width/depth	is feature recorded?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	4,4	Erosional/depositional features (bars, eroding banks)	is feature recorded?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	4,5	Fluvial landforms in the floodplain	is feature recorded?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	4,6	Bed substrate (substrate composition)	is feature recorded?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		

			not relevant		
	4,7	Bed configuration (e.g. riffle, pool, etc.)	is feature recorded?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	4,8	Flow pattern (e.g. rippled, smooth, etc.)	is feature recorded?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	4,9	Flow velocity	is feature recorded?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	4,10	In-channel large wood	is feature recorded?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	4,11	Macrophytes	is feature recorded?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	4,12	Vegetation lateral/longitudinal extension in the river corridor	is feature recorded?		

			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	4,13	Vegetation type/structure in the river corridor	is feature recorded?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	4,14	Feedback on this section	If you were not able to fill in this section or part of this section of the questionnaire, please explain briefly why		

5 - Consideration of processes

5 - Consideration of processes	ID	Question	Options	Answer	Explanation
	5,1	Consideration of geomorphic processes	*select one answer from the options on the right*		
	5,2	Longitudinal continuity/alteration of channel forming discharge	is the process recorded / considered?		
			is the process used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	5,3	Sediment transport	is the process recorded / considered?		
			is the process used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		

	5,4	Longitudinal continuity/alteration in sediment and wood flux	is the process recorded / considered?		
			is the process used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	5,5	Lateral continuity of flows	is the process recorded / considered?		
			is the process used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	5,6	Connectivity between hillslopes and river corridor	is the process recorded / considered?		
			is the process used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	5,7	Occurrence of bank erosion processes	is the process recorded / considered?		
			is the process used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	5,8	Presence of a potentially erodible corridor	is the process recorded / considered?		
			is the process used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		

	5,9	Alteration of bed sediment structure/substrate composition/vertical continuity (e.g. armour-ing, clogging)	is the process recorded / considered?		
			is the process used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	5,10	Consideration of temporal changes and dy-namics	*select one answer from the options on the right*		
	5,11	Adjustments in channel pattern	is the process recorded / considered?		
			is the process used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	5,12	Adjustments in channel width (e.g. narrowing, widening)	is the process recorded / considered?		
			is the process used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	5,13	Bed-level adjustments (e.g. incision, aggrada-tion)	is the process recorded / considered?		
			is the process used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	5,14	Feedback on this section	If you were not able to fill in this section or part of this section of the questionnaire, please explain briefly why		

6 - Recorded artificial elements

6 - Recorded artificial elements

ID	Question	Options	Answer	Explanation
Structures with impacts on longitudinal continuity				
6,1	Dams	is the feature recorded / considered?		
		is the feature used to evaluate river condition?		
		is recording and/or evaluation done periodically?		
		not considered		
		not relevant		
6,2	Check dams/abstraction weirs	is the feature recorded / considered?		
		is the feature used to evaluate river condition?		
		is recording and/or evaluation done periodically?		
		not considered		
		not relevant		
6,3	Other structures with impacts on flow and/or sediment discharge (retention basins/diversion channels/spillways	is the feature recorded / considered?		
		is the feature used to evaluate river condition?		
		is recording and/or evaluation done periodically?		
		not considered		
		not relevant		
6,4	Crossing structures (bridges/fords/culverts)	is the feature recorded / considered?		
		is the feature used to evaluate river condition?		
		is recording and/or evaluation done periodically?		
		not considered		
		not relevant		
Structures with impacts on lateral continuity				

	6,5	Bank protections	is the feature recorded / considered?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	6,6	Artificial levees or embankments	is the feature recorded / considered?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	Structures with impacts on channel morphology and/or substrate				
	6,7	Artificial changes of river course	is the feature recorded / considered?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	6,8	Bed structures (sills, ramps, bed revetments)	is the feature recorded / considered?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	Management interventions				
	6,9	Sediment management	is the feature recorded / considered?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		

			not relevant		
	6,10	Large wood management	is the feature recorded / considered?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	6,11	Vegetation management	is the feature recorded / considered?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	6,12	Land use in the surrounding area	is the feature recorded / considered?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	6,13	Off-site in-channel pressures (e.g. dam up-stream or weir downstream the assessed reach)	is the feature recorded / considered?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		
	6,14	Off-site catchment pressures (e.g. land use in the sub-catchment)	is the feature recorded / considered?		
			is the feature used to evaluate river condition?		
			is recording and/or evaluation done periodically?		
			not considered		
			not relevant		

	6,15	Feedback on this section	If you were not able to fill in this section or part of this section of the questionnaire, please explain briefly why		

7 - Assessment output

7 - Assessment output	ID	Question	Options	Answer	Explanation
	7,1	Type of output of the assessment	scoring		
			establishment of a typology		
			maps		
			report		
			other		
			not applicable		
	7,2	Type of scoring	qualitative evaluation (e.g. qualitative class)		
			quantitative scoring (e.g. one or more quantitative index)		
			other		
			not applicable		
	7,3	Scoring information	*select one answer from the options on the right*		
	7,4	Upscaling of the score of a site/reach to the water body (for WFD)	*select one answer from the options on the right*		
	7,5	Degree of confidence	*select one answer from the options on the right*		
	7,6	Feedback on this section	If you were not able to fill in this section or part of this section of the questionnaire, please explain briefly why		

8 - Lessons Learned

n s	ID	Question	Options	Answer	Explanation

	8,1	Lessons learned from the application of this method in WFD implementation		
	8,2	Strengths of the method		
	8,3	Weaknesses of the method		

Annex V: Guide to the entries of the Questionnaire

The aim of this Guide is to explain each entry and reply option of the questionnaire and give practical examples where possible.

Key terms used in the Questionnaire

The following key terms used in the Questionnaire are defined as follows (according to Rinaldi et al., 2015; Mosselman et al., 2015):

- **Delineation** (or **Segmentation**): delimitation of the boundaries of the spatial units of a catchment and its river system.

- **Characterization**: description of the river system or part of it (answering to the question 'How does my river work?').

- **Evaluation** or **Assessment**: evaluation of the conditions and functioning of the river system or part of it (answering to the question 'What's wrong?').

- **Classification**: for the WFD, the term is commonly used to classify the status of the water body, i.e. assigning the water body to a class resulting from the evaluation (e.g., good, poor, etc.). In a more general sense, classification is intended as assigning the river or part of it to a class of any given characteristics or parameter.

- **Monitoring**: commonly, it is intended as a periodic measurement (or evaluation) of parameters or indicators to assess the changes that are occurring in the river system or part of it (answering to the question 'How is changing?').

1 General information

0,0 Name of the method / acronym or abbreviation of method. Provide the complete name and/or an acronym or abbreviation of the method.

0,1 Country. Specify the Country where this method is applied.

0,2 Contact person. Specify the contact person who has filled (or supervised) the questionnaire (name, organisation).

1,1 Components covered by the method. This entry is aimed at specifying the components that are covered by the method. The assessment method may cover only one or more components. Whereas sections 1, 2, 7 and 8 are common to all methods, sections 3, 4, 5 and 6 are related to the covered components as follows: (i) if the answer is hydrology, only section 3 needs to be completed (sections 4, 5 and 6 will be omitted); (ii) if the answer is morphology, sections 4, 5 and 6 need to be completed (section 3 will be omitted); (iii) if the answer is continuity* (e.g. longitudinal continuity including fish continuity), only specific questions included in sections 6 should be answered (sections 3, 4 and 5 will be omitted, and for the not relevant questions in section 6 the option "not applicable" should be used).

If the method only concentrates on the assessment of pressures, only some relevant parts of the questionnaire should be completed (see especially section 6) and the option "not applicable" should be used in the non-relevant parts.

Some methods may combine or group together different aspects. In such a case, a multiple answer should be provided and all corresponding sections will be completed (example: if a method covers both hydrology and morphology, all sections from 3 to 6 need to be completed).

*** Please note:** Methods that exclusively assess fish continuity are not addressed by this questionnaire, whereas in the case of methods that include fish continuity together with other hydromorphological aspects, this can be specified in the entry "Biological considerations".

1,2 Use of the method. This entry relates to the overall use of the method for different purposes (a more detailed entry on its specific use for the WFD planning will follow). The following options are included:

- hydromorphological classification (WFD-related): used to classify the hydromorphological status (i.e. High, Good, Moderate, Poor, Bad) of a water body;

- supporting ecological classification (WFD-related): used to support the ecological classification, for example to confirm or not the high ecological status or the risk of deterioration of a water body;

- used as a proxy of biological quality elements: used to indirectly assess or replace biological quality elements;

- hydromorphological monitoring: used to assess whether changes through time in hydromorphology are occurring (e.g. deterioration or enhancement), for example for each RBMP;

- hydromorphological assessment (non-WFD): the method is not specifically (or not only) used for the WFD but (also) for other purposes and/or Directives (e.g. Floods Directive, Habitats Directive, Directive on the assessment of the effects of certain public and private projects on the environment (Environmental Impact Assessment Directive), sediment management plans, etc.);

- diagnosis for designing measures (e.g. rehabilitation, mitigation, etc.): the method is used as a tool to support the identification and design of possible measures (for the WFD but possibly also for other purposes e.g. mitigation of flood risk);

- as a prognostic tool (e.g. used for Environmental Impact Assessment): used to achieve a prognosis of the problem, for example for an Environmental Impact Assessment or other similar types of evaluation;

1,3 Use of the method for the WFD planning process. This entry relates more in detail with the use of the method for the various steps of the WFD planning process. Indicate for which steps of the WFD planning process the method is used from the list below:

- water body delineation: e.g. for supporting the definition of the boundaries of water bodies;

- typology: e.g. for characterising the river types (depending on the method, type may be intended as “reference type” or as used for characterising present conditions);

- pressures & impacts analysis: the method is used to evaluate pressures and impacts;

- status classification (for high status only): hydromorphology is used only to confirm or not the high ecological status;

- status classification (for classification in all status classes): hydromorphology is used for all ecological status classes;

- risk analysis: the method is used to identify water bodies at risk of not achieving the good status;

- HMWB designation: the method is used for the designation of HMWB;

- definition of good ecological potential: the method is used to support the definition of the GEP;

- design of programme of measures: the method is used to support the identification and design of rehabilitation measures;

- exemptions: hydromorphology is used to support the identification of exemptions;

- other

- not applicable

Please note: If your method only concentrates on the assessment of pressures, you should only complete the relevant parts of the questionnaire (see especially section 6) and indicate “not applicable” in the non-relevant parts.

1,4 Use for other Directives (except WFD). The question concerns whether the method is applied (or can be applied) for other European Directives, besides the WFD, for example for the Habitats Directive, the Floods Directive. and/or the Environmental Impact Assessment Directive.

1,5 Biological considerations. This entry investigates on whether the method, further than assessing hydromorphological elements, is also used for biological considerations, i.e. for addressing the relationship between hydromorphological alterations and habitat quality elements required by type-specific biological quality elements (with the main focus on fish continuity). The following options are possible:

- the method directly addresses fish continuity: for example, it assesses whether a barrier is passable for fishes;

- the method indirectly addresses fish continuity: for example, when the barrier passability is evaluated by the height of the structure;

- the method includes biological considerations but does not address fish continuity: when fish continuity is not included but other biological elements are considered;

- the method includes biological considerations and does address fish continuity: when fish continuity is included together and additional biological elements are considered;

- the method does not include any biological considerations

- other

- not applicable

1,6 Status of method. This question deals with the status of application of the method, whether it is (or not) the official method in the country for hydromorphology (or for a component of hydromorphology), whether the method has already been applied during the 1st RBMPs and/or is currently applied for the 2nd RBMP, or the method is fully developed and used for management / restoration but not yet included in the RBMPs, or is in development / recently developed but not yet used.

1,7 Level of application. The first two options are related to the spatial extent of application in the country (whether at national or regional/basin level), whereas the following two options concern whether the method is applied in continuum along the whole river network, or only to specific sites. The fifth option concerns whether the results of the assessment are extended to larger river portions (e.g. WFD water bodies): in such a case, more details on how the information is upscaled will be addressed in section 7 (Upscaling of the score of a site/reach to the water body).

1,8 Extent of application. Important information, when available, is to know the percentage of water bodies (WFD) to which the method has been applied (independently whether the assessment is carried out on the whole river network or on specific sites).

1,9 Inclusion in legislation. This entry informs about the inclusion or not of the method in the legislation of the country (national or regional) and/or in guidelines.

1,10 Relevance for specific pressures. Some methods can be particularly suitable to assess the effects of specific pressures (e.g. hydropeaking), whereas other methods can be applied to assess the effects of all types of hydromorphological pressures.

1,11 Key reference. One or more key references of the method should be indicated, consisting of a technical report, a scientific paper, a web page, etc.

1,12 Available supporting material. You are asked to indicate the supporting material that is available for the application of the method. This can be a guidebook, field sheet forms (for example, sheet forms that need to be compiled during the field survey), compilation sheet forms (for example sheet forms that are compiled in the office after the field work), databases (for example, hydrological data, data layer of interventions, etc.), software (for example, to calculate an index), etc.

1,13 User's qualification. Normally each method requires some specific expertise. In this entry you are asked to describe the type of qualification that is required (e.g. expertise in fluvial geomorphology, hydrology, natural science, environmental engineering, forestry, etc.) and whether some specific level of education is required (for example bachelor or master degree).

1,14 Requirement for accreditation. Some methods require a specific certificate or specific training programme to release the accreditation for its use. This question is about this aspect.

1,15 Resource intensity. One important aspect influencing the use of a method is how resource intensive is its application. Estimating the resource intensity in terms of monetary costs is not required, but an evaluation can be based on the working time required (e.g. hours needed to apply the method per km or per reach). The time required should include the field work and the other phases (for example, preparatory work, remote sensing, GIS analysis, etc.). For the scope of this questionnaire, the following qualitative options are considered:

- high resource-intensity: where more than 4 hours are needed to complete 1 km (in case the investigated reach length is less than 1 km, the time required will be upscaled to 1 km).

- medium resource-intensity: where between 1 and 4 hours are needed to complete 1 km.

- low resource-intensity: where less than 1 hour is needed in average to complete 1 km.

- other

- not applicable

1,16 Feedback on this part of the questionnaire. At the end of each section, a specific box is reserved for general feedback, in particular if you were not able to fill in this section or part of it of the questionnaire, please explain briefly why.

2 General characteristics of the method

2,1 Source of information / data collection. This entry concerns possible types of sources and approaches to obtain the necessary information and/or to measure some parameters needed for the method. A variety of data sources can be used, including: historical maps, for example to assess past channel morphology or human interventions; present topographical maps; aerial photos; satellite images (including Google imagery); drone images (including low flights with Unmanned Aerial Systems); LiDAR data (including terrestrial laser scanner); field survey, including topographic surveys and all other types of measurements carried out in the field; existing GIS data; GIS derived parameters, for example channel width, width of vegetation in the fluvial corridor, etc.; existing databases, for example data-layer of interventions; modelling derived parameters, for example hydrological parameters, flow velocity, etc.; other; not applicable.

2,2 Longitudinal spatial scale. This question concerns the longitudinal scale of investigation, i.e. the length of a reach (or site) to which the assessment refers. Note that, if different methods are used for the various components (hydrology, morphology, continuity), only one reply is possible for each method, but if a method covering all the different components is used, more than one reply is possible (in such a case, this should be explained in the explanatory free text). The following options are included:

- fixed length (indicate length in m): some methods require the assessment to be carried out on a site of fixed length, independently of the river size or other factors;

- length scaled to bankfull or low-flow channel width: some methods require the assessment to be carried out for a length that is scaled to the channel size, for example the channel width (referring to the bankfull channel or the low-flow channel) (e.g. 20 times the channel width);

- variable length (not including the previous case): other methods require the assessment to be performed on a variable length but not scaled to the channel width: for such cases, the following entry ("Criteria for selection of variable length") will specify the criteria used;

- exact location of alteration: some methods (for example for fish continuity) require the assessment to apply to an exact place (e.g. to the location of a barrier for fish passage);

- other

- not applicable

2,3 Criteria for selection of variable length. Where the assessment is carried out on a variable length (see previous entry), the criteria for defining this length are indicated here. The following options are considered:

- morphological segmentation: this term refers to the delineation of a river reach following a multiscale hierarchical approach. This consists of delineating regional landscapes into nested spatial units at catchment, landscape unit, segment, reach, geomorphic unit and finer scales (for more details, see Gurnell et al., 2014, 2016; Rinaldi et al., 2015), where the reach is a relatively homogeneous portion of the river with a length of several kilometers.

- homogeneity of some specific characteristics (indicate which one): if the length is not based on the application of a morphological segmentation (previous point) but is defined with a criterion of homogeneity of some specific characteristic (for example, homogeneous channel width, or flow discharge, etc.).

- accessibility: in some cases, the portion of the river investigated can be defined only according to its accessibility;

- random: in other cases, the investigated length is not related to some particular criteria;

- other

- not applicable

2,4 Lateral spatial scale. This refers to the lateral scale, i.e. width to which the assessment refers. The following options are included: stream channel, i.e. the assessment is carried out only within the channel; banks, i.e. the banks are included in the assessment; riparian zone, i.e. the strip immediately adjacent to the banks; floodplain: in general, all the floodplain may be included, but for large alluvial plains only a portion of it could be assessed; hillslopes: in a confined valley setting where the floodplain is absent (or limited), the assessment may include a portion of hillslopes directly adjacent to the river that may influence river processes (e.g. by sediment supply, effects of bank vegetation, wood recruitment, etc.); fixed width (indicate width in m): some methods may require the assessment to be made for a given width; width scaled to channel width: some methods may require the assessment to be carried out for a width scaled to the river size (usually this is done in terms of channel width); other; not applicable.

2,5 Approach used by the method to define reference conditions. This question concerns the definition of reference conditions and therefore refers to methods used for the WFD. Each hydromorphological assessment method can define reference conditions in different ways. Three main categories are indicated here:

- empirical / statistical: when a range of expected values (generally for each indicator) has been defined by the authors of the method based on the range of data measured (or calculated) for a sufficient number of reference sites of the same river type.

- historical (indicate which period): some methods assume the channel morphology and other river conditions in the past as the reference condition (e.g. the “natural” river morphology before some interventions of channelization);

- theoretical: reference conditions (i.e. the maximum value that each indicator may assume) have been based on some theoretical assumption and/or some expert judgement of the authors of the method (for example, the maximum score corresponds to undisturbed or nearly undisturbed conditions of each indicator);

- other

- not applicable

2,6 Use of hymo types. Depending on the method, “type” may apply either to “reference type” or used for characterising present conditions (independently of reference conditions) (which one of these two cases will be indicated in the explanatory free text). The question is whether some kind of hydromorphological classification is used to characterize and classify the site or reach investigated (for example, river type: medium-large calcareous lowland river, or confined bedrock stream, or unconfined fine-grained meandering, or third Horton Strahler order, etc.). The following options are considered: attribution of a hymo type to the assessment site/reach, i.e. a type is assigned at some stage of the assessment to each investigated reach (in such a case, the possible criteria are defined in the next entry); no consideration of hymo types; other; not applicable.

2,7 Criteria/parameters for definition of hymo types. Where a hymo type is assigned to the reach of investigation (previous entry), the criteria or parameters used to define the typology are specified in this entry. The following options are possible: size: this can be defined in different ways, for example in terms of stream order, catchment size, distance from source; gradient: the bed gradient is often used to classify different types of streams (e.g. steep, low gradient, etc.); geology, i.e. dominant rock type in the catchment, e.g. calcareous, siliceous, mixed, etc.; geographical location, e.g. highland, lowland, etc.; altitude, e.g. high, medium or low altitude; hydrological regime, e.g. perennial, ephemeral, etc.; confinement: this parameter is generally used to characterize the lateral valley setting, and three classes are usually differentiated: (1) confined (i.e., more than 90 % of the river banks are directly in contact with hillslopes or ancient terraces); (2) partly confined (i.e., river banks are in contact with the alluvial plain for between 10 and 90 % of their total length); and (3) laterally unconfined channels (i.e., less than 10 % of the river bank length is in contact with hillslopes or ancient terraces); channel morphological pattern, that is usually based on sinuosity, braiding and anabranching (e.g. straight, sinuous, meandering, braided, wandering, anabranching, etc.); other; not applicable.

2,8 Differentiation of the method for hymo types. The question relates to whether the method is completely independent in all its parts of assessment from the hymo type or whether there are differences in terms of its application dependent on the hymo type. For example, one of the indicators may be specific to some particular river type and not applied to some other type (e.g. the fluvial landforms in the floodplain may not be applied to confined streams), or the entire method may not be applicable to some specific type (for example, some method may not be applicable to non-wadeable rivers).

2,9 Temporal dimension. This question is about whether or not the method makes any attempt to include past morphology or other river conditions (e.g. riparian vegetation, channel straightening or other past artificial modifications, etc.) in the assessment (more detailed questions about the temporal dynamics are included later in section 5).

2,10 Severity of hydromorphological pressures. This entry relates to whether the severity of hydromorphological pressures is accounted for; this is particularly relevant for the process of identifying HMWBs whereby the water body must be “substantially changed in character”, which usually entails hydromorphological change which is extensive/widespread or profound as well as permanent(see CIS Guidance no.4 on HMWB designation).

2,11 Feedback on this part of the questionnaire. At the end of each section, a specific box is reserved for general feedback, in particular if you were not able to fill in this section or part of it of the questionnaire, please explain briefly why.

3 Recorded hydrological features

This section mainly includes features that are normally accounted by methods specifically used for hydrology, i.e. to assess the deviation of the hydrological regime from unaltered or previous conditions. The methods can be based directly on flow data (measured and/or modelled) or indirectly on pressures by using hydrological regime as a proxy for the lack of data.

In the first case, methods are usually based on the Indicators of Hydrologic Alteration (IHA, Richter et al., 1996; Poff et al., 1997) and/or successive Range of Variability Approach (RVA, Richter et al., 1997). According to the IHA, the flow regime is described by five main flow characteristics (corresponding to five entries of this section), to derive a suite of parameters / indicators of the flow regime. The following entries concern additional information that should be known about hydrological methods.

3,1 Components of flow regime. This entry specifies for which components of the flow regime alterations (sensu Environmental flow components, Richter 1997) are assessed, i.e. low flows (including extreme low flows – i.e. droughts), average flows and/or high flows (e.g. small and large floods)

3,2 Type of flow year: this entry specifies if the method accounts for the fact that the year in consideration could be anomalous with respect to the long term average (normal, wet or dry year) and so needs normalization for getting unbiased alteration assessment.

Characteristics of flow regime

For each entry, various replies are possible:

(i) the first option “is feature recorded?” (Y or N) refers to whether the feature is measured or recorded in some way in the method;

(ii) “is the feature used to evaluate river conditions?” (Y or N) refers to whether that indicator or parameter is actually used to assess the degree of deviation of the investigated portion of river from some reference condition (i.e. to evaluate river conditions), or (where the answer is not) is just used for characterization;

(iii) the third option "is recording and/or evaluation done periodically?" (Y or N) specifies whether the feature is used for monitoring (i.e. periodic measurement or evaluation);

(iv) "not considered" means that the feature is not included in the procedure;

(v) "not relevant" means that this indicator is not relevant for the scope of the assessment (e.g. planform pattern is not relevant for a hydrological assessment).

(vi) "Explanation (free text)" is optional and can be used (1) to give information on the temporal /spatial scale for recording specific features; and (2) whether only a visual assessment or a measurement is carried out to record the feature.

3,3 Magnitude. This corresponds to the first component of IHA, answering to the question 'how much?', and includes average flows, such as the 12 monthly flows, average weekly flow, etc.

3,4 Duration. This corresponds to the second component of IHA answering to the question 'how often?'), and includes the duration of annual minima and maxima (1-day, 3-day, 7-day, 30-day, 90-day means), number of zero-flow days, the base flow index.

3,5 Timing of specific events (e.g. annual extreme discharge). This corresponds to the third component of IHA answering the question 'when?', and includes the Julian date of annual 1-day maximum and minimum.

3,6 Frequency. This corresponds to the fourth component of IHA answering to the question 'how often?', and includes, among other things, the number of low and high pulses within each water year, and the mean or median duration of low and high pulses.

3,7 Rate of change. This corresponds to the fifth component of IHA answering to the question 'how fast?', and includes rise rate (mean or median of all positive differences between consecutive daily values), fall rates (mean or median of all negative differences between consecutive daily values), and number of hydrologic reversals.

Surface – groundwater interactions

3,8 Surface – groundwater interactions. This question concerns whether the method includes consideration of the groundwater – surface water interaction (for example, no interaction, limited or extensive interactions), e.g. through consideration of alterations of base-flow.

Time related information

3,9 Time resolution. This question concerns the time resolution of hydrological data used to assess the previous indicators. Three main options are considered: (1) daily; (2) hourly; (3) sub-hourly. The last of these can be necessary to assess some specific type of alteration such as hydropeaking.

3,10 Minimum length of time series. This information concerns the required minimum length in years of the time series of hydrological data used to calculate of the previous indicators (e.g. 15 years, which is considered as the minimum length for a time series to have statistical integrity and reliable analysis, Kennard et al., 2010)

Pressures on hydrology

3,11 Pressures causing hydrological alteration. In some cases, specifically when sufficiently long time series of flow data are not available, the assessment can be carried out by considering the pressures causing hydrological alteration as a proxy. Various options are considered, i.e. hydropeaking related to hydropower production, water abstraction (for irrigation and water supply), flood mitigation (e.g., dams, spillways, or water retention structures reducing peak flows) , water level change (e.g. artificial waves from navigation), urbanization, agriculture, other.

Other related information

3,12 Reference (Natural) Flows The question of this entry is whether the natural conditions used as a reference for assessing the hydrological alterations are the past ones (pre-impact), the current ones in absence of pressures (as derived from modelling the current context of the catchment removing the pressures), or both (depending on hydrological data availability).

3,13 E-flows. The question for this entry is whether a method to define ecological flow requirements is used in the country. Note that methods for setting or assessing environmental flow are not included here because e-flow methods are used to assess flow requirements of the many interacting components of aquatic systems, whereas hydrological alteration methods reviewed in this section are specifically focussed on the assessment of the flow regime alterations.

3,14 Feedback on this part of the questionnaire. At the end of each section, a specific box is reserved for general feedback, in particular if you were not able to fill in this section or part of it of the questionnaire, please explain briefly why.

4 Recorded morphological features

This section concerns the morphological characteristics that are considered in the assessment. For each entry, various replies are possible:

(i) the first option "is feature recorded?" (Y or N) refers to whether the feature is measured or recorded in some way in the method;

(ii) "is the feature used to evaluate river condition?" (Y or N) refers to whether that indicator or parameter is actually used to assess the degree of deviation of the investigated portion of river from some reference conditions (i.e. to evaluate river condition and determine WFD hydromorphological status), or (where the answer is not) is just used for characterization;

(iii) the third option "is recording and/or evaluation done periodically?" (Y or N) specifies whether the feature is used for monitoring (i.e. periodic measurement or evaluation; in the case of WFD, this may occur per RBMP cycle or within a single RBMP cycle);

(iv) "not considered" means that the feature is not included in the procedure;

(v) "not relevant" means that this indicator is not relevant for the scope of the assessment.

(vi) "Explanation (free text)" is optional and can be used (1) to give information on the temporal /spatial scale for recording specific features; and (2) whether only a visual assessment or a measurement is carried out to record the feature.

4,1 Planform pattern. Planform pattern refers to the 2D planimetric characterization of the channel morphology. Definition of planform pattern (e.g., straight, sinuous, meandering, wandering, braided, anabranching) is usually based on measurement of sinuosity (sinuosity index), number of channels separated by bars (braiding index) or separated by islands (anabranching index).

4,2 Longitudinal profile / gradient. Longitudinal profile refers to the 2D representation of bed topography, where bed elevation is plotted against longitudinal distances downstream along the channel. From the longitudinal profile, bed gradient (or slope) is the feature most often used for channel characterization and classification.

4,3 Variability of cross-section by width / depth. Cross-section refers to the 2D representation of channel morphology perpendicular to the flow. The parameters used most frequently to characterize a cross section are width, depth, and their ratio. To calculate these parameters, it is necessary to refer to a given flow stage (the bankfull stage is generally used as the reference elevation).

4,4 Erosional/depositional features. Erosional (e.g. eroding banks, bed scour, etc.) and depositional (e.g. bars, islands, etc.) are often used to characterise channel morphology and habitat diversity and, at some extent, to infer dominant processes responsible for these features.

4,5 Fluvial landforms in the floodplain. This entry deals with the fluvial landforms (such as abandoned meanders, oxbow lakes, secondary channels, abandoned anabranches, natural levées, ridges and swales, wetlands and swamps etc.) that are normally expected to exist in the floodplain of unconfined (or partly confined) alluvial rivers.

4,6 Bed substrate. This deals with the type (alluvial, colluvial, bedrock) and texture or size (boulders, cobbles, gravel, sand, etc.) of the sediment composing the channel bed.

4,7 Bed configuration. This refers to the instream geomorphic units characterizing the channel bed (cascade, steps, rapids, riffles, pools, glides or runs, etc.). It also includes natural barriers such as near vertical steps with significant height or water falls, landslide dams, etc.

4,8 Flow pattern. This refers to above-water spatial unit formed by the interaction between local hydraulic and sediment conditions which produces a series of distinct flow patterns at the flow surface. The following flow types are normally distinguished: free fall, chute, broken standing waves, unbroken standing waves, rippled, upwelling, smooth, no perceptible flow.

4,9 Flow velocity. Flow velocity is in some cases included in the morphological features recorded. It can be measured in the field during the survey or calculated (from the cross-section, slope and flow elevation).

4,10 In-channel large wood. Large wood includes trees, trunks, branches, and root wads having a length > 1 m and diameter > 10 cm. It is a distinctive feature having several effects on geomorphic-hydraulic and ecological processes.

4,11 Macrophytes. This entry concerns aquatic macrophytes in terms of their potential effect on morphology and in creating river habitat, and not in terms of species. In fact, some macrophytes (aquatic linear-leaved emergent macrophytes, in particular rushes and reeds) may have important morphological effects in some specific contexts (i.e. low-energy straight, sinuous, meandering and anabranching channels), by creating flow resistance, sediment trapping, and consequent creation of instream morphological features such as benches.

4,12 Vegetation lateral / longitudinal extension in the river corridor. This feature concerns the vegetation existing in the river corridor, including not only the riparian zone adjacent to the riverbanks, but potentially all the area extending from the channel to the hillslopes. The vegetation is considered as contributing functionally to the normal geomorphic processes (flow resistance, bank stabilization, wood recruitment, sediment trapping, etc.), whereas determination or consideration of species are not included. Functional vegetation in terms of geomorphic processes is mainly woody and shrub, but herbaceous vegetation can also be included as it can be relevant in some contexts (e.g. low-energy systems).

4,13 Vegetation type / structure in the river corridor. This entry represents a further detail of the previous aspect, concerning the type (e.g. herbaceous, shrubs, trees) and the spatial structure, e.g. vegetation patches or stands that may be associated with functional zones indicative of hydromorphological processes and vegetation interactions.

4,14 Feedback on this part of the questionnaire. At the end of each section, a specific box is reserved for general feedback, in particular if you were not able to fill in this section or part of it of the questionnaire, please explain briefly why.

5 Consideration of processes

A recent review of hydromorphological assessment methods carried out during the REFORM project (Rinaldi et al., 2013; Belletti et al., 2015) concluded that many methods have insufficient consideration of physical processes. Therefore, in this questionnaire a specific section on consideration of physical processes has been included.

Although some of the indicators included in this section may appear as partially redundant compared with indicators in other sections, they more specifically focus on whether or not the processes responsible for the correct functioning of the river are prevented or altered by some type of artificial element or by channel adjustments related to human disturbances. It is important to consider that the same type of pressure may result in different responses for different rivers (depending on their valley setting, energy conditions, channel morphology, and therefore their sensitivity to pressures etc.), so consideration of processes and temporal channel changes can provide information on the response to a given pressure. In other cases, together with morphological and hydrological features, processes and temporal dynamics can provide a full understanding of the response of the river to hydromorphological pressures.

The focus of this section is on the processes occurring along the river channel and in the surrounding areas (floodplain, or adjacent hillslopes in case of a confined or partly confined setting), whereas no attempts are made to consider processes at catchment scale (landslides, soil erosion, etc. in the catchment).

For each entry, various replies are possible:

(i) the first option "is the process recorded / considered?" (Y or N) refers to whether the process is recorded or considered in some way in the method;

(ii) "is the process used to evaluate river condition?" (Y or N) refers to whether that indicator or parameter is actually used to assess the degree of deviation of the investigated portion of river from some reference condition (i.e. to evaluate river conditions), or (where the answer is not) is just used for characterization;

(iii) the third option "is recording and/or evaluation done periodically?" (Y or N) specifies whether the feature is used for monitoring (i.e. periodic measurement or evaluation);

(iv) "not considered" means that the feature is not included in the procedure;

(v) "not relevant" means that this indicator is not relevant for the scope of the assessment.

(vi) "Explanation (free text)" is optional and can be used (1) to give information on the temporal /spatial scale for recording specific processes; and (2) whether only a visual assessment or a measurement is carried out to record the process.

5,1 Consideration of geomorphic processes. The first entry of this section is a general question on whether geomorphic processes are considered by the method to some extent. The possible options are the following:

- the method explicitly includes consideration of the occurrence of expected geomorphic processes: if yes, the type of processes that are considered will be detailed in the next entries;

- the method does not explicitly include consideration of geomorphic processes: if this is the case, the answer to all the following entries will be 'not considered' (or 'not relevant').

- other;

- not applicable.

5,2 Longitudinal continuity/alteration of channel forming discharge. This indicator is related to possible alterations of flow conditions which may have significant effect on channel form and processes (channel forming discharge and/or hydraulic conditions, such as river stage and flow velocity, associated to this discharge), for example due to the presence of dams, discharge diversions or water abstractions, spillways, retention basins, etc., located upstream and/or within the investigated reach and/or downstream. In the case of a specific method for the assessment of hydrologic alteration, this aspect is covered in section 3, whereas methods for assessing morphology are covered in this section.

5,3 Sediment transport. This entry relates to possible measures or evaluations on sediment transport within the reach investigated.

5,4 Longitudinal continuity / alteration in sediment and wood flux. This indicator is related to possible alterations in sediment discharge and wood transport upstream and/or within the investigated reach. For example, an indirect evaluation can be based on the existence of blocking structures intercepting bedload and wood (dams, check dams, weirs), if they are already filled or not by sediment, if measures of sediment release are undertaken, etc.

5,5 Lateral continuity of flows. This indicator concerns the occurrence (or the alteration) of the normal flooding processes of rivers (expected in an unconfined or partly confined valley setting). For example, a typical indicator used to evaluate this process is the presence and lateral extent of an adjacent modern floodplain that is frequently inundated (every 1 – 3 years) with no protection by artificial levées.

5,6 Connectivity between hillslopes and river corridor. This entry evaluates the linkage between hillslopes and river corridor causing a sediment supply normally expected in a confined valley setting. For example, an indicator of alteration of this connectivity can be represented by the presence of artificial elements of disconnection (e.g. roads, structures for landslide protection) on the hillslopes adjacent to the river.

5,7 Occurrence of bank erosion processes. The entry evaluates the occurrence of bank erosion processes causing sediment supply, vegetation turn-over and habitat diversity, as normally expected in an unconfined or partly confined setting.

5,8 Presence of a potentially erodible corridor. This evaluates the potential for the river to move laterally over the coming decades as normally expected for rivers in an unconfined or partly confined setting.

5,9 Alteration of bed sediment structure / substrate composition / vertical continuity. This evaluates the presence of processes that alter the natural bed sediment structure and potentially affecting vertical continuity. The main processes altering bed structure are: (i) armouring, i.e. presence of a surface layer in which bed material size is significantly coarser than the sub-layer; (ii) clogging, i.e. excess of fine sediments causing interstitial filling of the coarse sediment matrix and potentially smothering the channel bed; (iii) burial or siltation, i.e. where finer sediments (e.g. silt and sand) are deposited in a sufficiently thick layer to bury a coarser (e.g. gravel) river bed; (iv) substrate outcropping in alluvial rivers related to bed incision. Restoration measures involving changes in the natural substrate (e.g. placement of boulders for salmonid habitats) are also considered as an alteration of bed sediment structure.

5,10 Consideration of temporal changes and dynamics. This entry is a general question on whether temporal changes and dynamics of the river channel are explicitly considered by the method. For example, temporal channel changes (such as changes in channel pattern, channel width) may be investigated by comparison of aerial photos, maps, or field evidence. The interval of time of investigation (e.g. 100 years, 50 years, etc.) can be variable and can be indicated in the explanation (free text).

Temporal channel changes (i.e. channel adjustments) and dynamics are considered as important indicators as they provide an information on how the channel has responded to some type of pressure, including off-site impacts (i.e. not along the reach investigated but upstream or downstream) and disturbances not occurring today but in the past (e.g. an instream sediment mining activity now concluded can still have severe effects on the present river conditions).

The possible options are the following:

- <u>the method explicitly includes consideration of temporal changes and dynamics</u>: if yes, the main types of channel adjustments that can occur in dynamic (unstable) systems will be detailed in the next entries;

- <u>the method does not explicitly include consideration of temporal changes and dynamics</u>: if this is the case, the answer to all the following entries will be ‘not considered’ (or ‘not relevant’).

- <u>other</u>;

- <u>not applicable.</u>

5,11 Adjustments in channel pattern. This indicator concerns the occurrence (and intensity) of adjustments in channel morphological configuration, i.e. the change in channel pattern (e.g. from sinuous to meandering, or from meandering to braided, etc.) that may be caused by changes of some factor controlling channel morphology. As for the consideration of temporal changes and dynamics, the interval of time of investigation (e.g. 100 years, 50 years, etc.) can be variable and can be indicated in the explanation (free text).

5,12 Adjustments in channel width. This entry concerns the occurrence (and amount) of changes in channel width (e.g. channel narrowing or widening) that may be caused by changes of some factor controlling channel morphology. As for the consideration of temporal changes and dynamics, the interval of time of investigation (e.g. 100 years, 50 years, etc.) can be variable and can be indicated in the explanation (free text).

5,13 Bed-level adjustments. This entry considers the occurrence (and amount) of changes in bed elevation (e.g. incision or aggradation) that may occur in alluvial channels as a response to possible alterations of flow and/or sediment discharge. As for the consideration of temporal changes and dynamics, the interval of time of investigation (e.g. 100 years, 50 years, etc.) can be variable and can be indicated in the explanation (free text).

5,14 Feedback on this part of the questionnaire. At the end of each section, a specific box is reserved for general feedback, in particular if you were not able to fill in this section or part of it of the questionnaire, please explain briefly why.

6 Recorded artificial elements

For each entry, various replies are possible:

(i) the first option "is feature recorded?" (Y or N) refers to whether the feature is measured or recorded in some way in the method;

(ii) "is the feature used to evaluate river condition?" (Y or N) refers to whether that indicator or parameter is actually used to assess the degree of deviation of the investigated portion of river from some reference conditions (i.e. to evaluate river condition), or (where the answer is not) is just used for characterization;

(iii) the third option "is recording and/or evaluation done periodically?" (Y or N) specifies whether the feature is used for monitoring (i.e. periodic measurement or evaluation);

(iv) "not considered" means that the feature is not included in the procedure;

(v) "not relevant" means that this indicator is not relevant for the scope of the assessment.

(vi) "Explanation (free text)" is optional and can be used (1) to give information on the temporal /spatial scale for recording specific features; and (2) whether only a visual assessment or a measurement is carried out to record the feature.

Structures with impacts on longitudinal continuity

6,1 Dams. Structure that creates a reservoir and induces a significant alteration of flow and sediment discharges with complete (and permanent) interception of bedload.

6,2 Check dams / Abstraction weirs. In mountain areas, two types of check dams are distinguished: (a) *retention check dam*, usually of great size (> 5-6 m height), aiming at intercepting the bedload; (b) *consolidation check dam*, of smaller size and aiming at stabilizing the channel bed by reducing the channel slope. Abstraction weirs are structures for water diversion purposes (e.g. for agriculture), but having significant effect on the bedload. Run-of-the-river structures used for hydropower generation where little or no water storage is provided are also included in this category.

6,3 Other structures with impacts on flow and/or sediment discharge. This category includes a series of other structures (retention basins, diversion channels, spillways) having a potential impact on flow and/or sediment discharge, in most cases used for flood mitigation purposes.

Two types of retention basins are distinguished: (1) *lateral retention basin* (located outside of the channel, delimited by artificial levées and periodically flooded; (2) *instream retention basin* (transversal structure within the bankfull channel that causes a partial storage of peak discharges). A diversion channel is an in and out-flow channel which conveys water flow from other watercourses at all flow discharges. A spillway is a specific diversion channel for flood protection purposes.

6,4 Crossing structures. Crossing structures include bridges, fords, and culverts which may interfere with water flow and reduce or intercept sediment and wood transport.

Bridge: Above-ground structure allowing the river channel to be crossed (road, railway, crosswalk). It can have piles within the channel.

Ford: structure allowing the baseflow channel to be crossed that can be submerged at high flow conditions. It can be associated with culverts to allow the water flow at low-flow condition.

Culvert: structure allowing the river to be crossed and located below other structures (e.g. a road, a town).

Structures with impacts on lateral continuity

6,5 Bank protection. Structure aiming at preventing bank erosion and/or bank mass movement. Various types of bank protection exist, including both hard bank reinforcement (walls, rip-raps gabions, groynes), and soft reinforcement (bioengineering).

6,6 Artificial levée or embankment (or dyke). Longitudinal structure located above ground, aimed at protecting adjacent areas against floods for discharges higher than bankfull discharge.

Structures with impacts on channel morphology and/or substrate

6,7 Artificial change of river course. Artificial past change in the river course (recent or in historical periods) (e.g. meander cutting, change of position of river mouth, etc.). It includes overall channelization interventions modifying channel pattern (e.g., straightening) and land reclamation schemes (e.g., excavating a new channel).

6,8 Bed structures. This entry includes other crossing structures (such as sills, ramps, and bed revetments) which, in general, cause increases in the rigidity of the bed, paving or reinforcement, but without significantly altering the sediment transport.

Sill: transverse structure with low height (< 1-2 m), aimed at stabilizing the channel bed and at reducing bed erosion.

Ramp: transverse structure with low height (< 1-2 m), aimed at stabilizing the channel bed and at reducing bed erosion, generally made with boulders arranged longitudinally along the water channel.

Bed revetment: Revetment of the channel bed (in the case of river banks) by concrete or unconsolidated coarse material.

Management interventions

6,9 Sediment management. This includes alluvial sediment mining (commercial purposes), sediment removal for channel maintenance or reducing flood risk, or sediment addition.

6,10 Large wood management. This includes large wood removal from the channel or riparian zones (periodically carried out by various public agencies in charge of river management and maintenance for safety reasons), or addition.

6,11 Vegetation management. Selective cutting or total removal of living vegetation in the channel and riparian zones, including cutting and/or dredging aquatic vegetation.

6,12 Land use in the surrounding area. Description of land use in the area surrounding the channel (floodplain, or adjacent hillslopes in case of a confined or partly confined setting).

6,13 Off-site in-channel pressure. In-channel structures located upstream or downstream (e.g., dams, weirs, mining sites, etc.) that may have caused channel adjustments or other impacts in the assessed reach.

6,14 Off-site catchment pressure. Pressure that is located out of the channel (in the floodplain or in the sub-catchment) upstream or downstream of the assessed reach (e.g., land use in the sub-catchment).

6,15 Feedback on this part of the questionnaire. At the end of each section, a specific box is reserved for general feedback, in particular if you were not able to fill in this section or part of it of the questionnaire, please explain briefly why.

7 Assessment Output

This section is reserved for some basic information about the approach used to provide the final result of the method.

7,1 Type of output of the assessment. The application of the assessment method can produce a series of outputs, such as scoring, establishing a typology, maps summarising results, report, etc.

7,2 Type of scoring. This entry relates to the type of scoring that is used, i.e. whether the final product is a qualitative class (e.g. good, poor, etc.) and/or a quantitative output (i.e. any final output in the form of a number).

7,3 Scoring information. This information concerns the type of data processing that the method uses to deliver the final result (a class or a number). The following options are considered:

- scores and algorithms are transparent: when the entire process producing the final result (e.g., scores assigned to single indicators, weights, procedure or equations used to calculate the final result) is clearly specified and can be reproduced by the user of the method;

- scores and algorithms are not transparent: when some parts or the entire process are not explicitly defined and the calculation of the result cannot be done independently by the user of the method, for example when a software is used to calculate the result (with no transparent algorithms and scores).

- other

- not applicable

Details on the number of classes, weighting of parameters, etc. can be optionally added in the Explanation.

7,4 Upscaling of the score of a site/reach to water body (for WFD). The question posed by this entry is how the score assigned to the reach or site investigated is then extended to the whole water body and made applicable to the WFD. In some cases (first option), the method needs to be applied to all the sites/reaches included in a water body, and then the score (or qualitative class) assigned to the whole water body derives from some type of average (arithmetic or weighted) or from the minimum score or class (worst case) obtained within the water body. In other cases (second option) the method is applied to only some parts of the water body (i.e. one or more sites or reaches), and the score for a single reach (or the average or minimum value of more reaches) is then extended to the whole water body. If no upscaling to the water body is done as part of your method, please choose the reply option “other” or “not applicable” and explain your approach of upscaling in the free text entry.

7,5 Degree of confidence. Some uncertainties are possible in various phases of application of a method, for example the assignment to a class of one or more indicators can be uncertain because of various reasons (e.g. difficulties in measurement of a feature or in interpretation of a process, data not available on existing pressures, etc.). This entry asks whether or not some attempts to consider these uncertainties are included in the method.

7,6 Feedback on this part of the questionnaire. At the end of each section, a specific box is reserved for general feedback, in particular if you were not able to fill in this section or part of it of the questionnaire, please explain briefly why.

8 Lessons learned

The last section of the questionnaire includes three questions where you have the opportunity to report some general considerations and comments on the lessons learned, strengths and weaknesses of the method (free text).

References

Belletti, B., Rinaldi, M., Gurnell, A.M., Buijse, A.D., Mosselman, E., 2015. A review of assessment methods for river hydromorphology. Environmental Earth Sciences 73, 2079-2100. http://link.springer.com/article/10.1007/s12665-014-3558-1.

Gurnell, A.M., Belletti, B., Bizzi, S., Blamauer, B., Braca, G., Buijse, T., Bussettini, M., Camenen, B., Comiti, F., Demarchi, L., García de Jalón, D., González del Tánago, M., Grabowski, R.C., Gunn, I.D.M., Habersack, H., Hendriks, D., Henshaw, A., Klösch, M., Lastoria, B., Latapie, A., Marcinkowski, P., Martínez-Fernández, V., Mosselman, E., Mountford, J.O., Nardi, L., Okruszko, T., O'Hare, M.T., Palma, M., Percopo, C., Rinaldi, M., Surian, N., Weissteiner, C., Ziliani, L., 2014. A hierarchical multi-scale framework and indicators of hydro- morphological processes and forms. Deliverable 2.1, a report in four parts of REFORM (REstoring rivers FOR effective catchment management), a collaborative project (large-scale integrating project) funded by the European commission within the 7th framework programme under grant agreement 282656. http://www.reformrivers.eu/results/deliverables.

Gurnell, A.M., Belletti, B., Bizzi, S., Blamauer, B., Braca, G., Buijse, A.D., Bussettini, M., Camenen, B., Comiti, F., Demarchi, L., García De Jalón, D., González Del Tánago, M., Grabowski, R.C., Gunn, I.D.M., Habersack, H., Hendriks, D., Henshaw, A., Klösch, M., Lastoria, B., Latapie, A., Marcinkowski, P., Martínez-Fernández, V., Mosselman, E ., Mountford, J.O., Nardi, L., Okruszko, T., O'Hare, M.T., Palma, M., Percopo, C., Rinaldi, M., Surian, N., Weissteiner, C., Ziliani, L., 2016. A multi-scale hierarchical framework for developing understanding of river behaviour. Aquatic Sciences, 78, 1-16. http://link.springer.com/article/10.1007/s00027-015-0424-5.

Kennard, M.J., Mackay, S.J., Pusey, B.J., Olden, J.D. & Marsh, N., 2010. Quantifying uncertainty in estimation of hydrologic metrics for ecohydrological studies. River Research and Applications 26, 137-156. http://onlinelibrary.wiley.com/doi/10.1002/rra.1249/full.

Mosselman, E., Angelopoulos, N., Belletti, B., Brouwer, R., Gurnell, A.M., Friberg, N., Kail, J., Reichert, P., Geerling, G., 2015. Guidance and decision support for cost-effective river and floodplain restoration and its benefits. Deliverable 6.3, REFORM (REstoring rivers FOR effective catchment management), a collaborative project (large-scale integrating project) funded by the European commission within the 7th framework programme under grant agreement 282656. http://www.reformrivers.eu/results/deliverables.

Poff, N.L., David Allan, J., Bain, M.B., Karr, J.R., Prestegaard, K.L., Richter, B.D., Sparks, R.E., Stromberg, J., 1997. The Natural Flow Regime, A paradigm for river conservation and restoration, Bioscience, 47, 769–784. http://rydberg.biology.colostate.edu/poff/Public/poffpubs/Poff1997(BioScience_NFR).pdf

Richter, B.D., Baumgartner, J.V., Powell, J., Braun, D.P., 1996. A method for assessing hydrologic alteration within ecosystems, Conservation Biology, 10, 1163–1174. https://www.conservationgateway.org/Documents/1996.pdf.

Richter, B.D, Baumgartner, J.V., Wigington, R., Braun, D.P., 1997. *How much water does a river need?* Freshwater Biology 37, 231-249.

Rinaldi, M., Belletti, B., Van de Bund, W., Bertoldi, W., Gurnell, A., Buijse, T., Mosselman, E., 2013. Review on eco-hydromorphological methods. Deliverable 1.1, REFORM (REstoring rivers FOR effective catchment Management), a collaborative project (large-scale integrating project) funded by the European commission within the 7th framework programme under grant agreement 282656. http://www.reformrivers.eu/results/deliverables.

Rinaldi, M., Gurnell, A.M., Belletti, B., Berga Cano, M.I., Bizzi, S., Bussettini, M., González Del Tánago, M., Grabowski, R., Habersack, H., Klösch, M., Magdaleno Mas, F., Mosselman, E., Toro Velasco, M., Vezza, P., 2015. Final report on methods, models, tools to assess the hydromorphology of rivers, Deliverable 6.2, Part 1, of REFORM (REstoring rivers FOR effective catchment Management), a Collaborative project (large-scale integrating project) funded by the European Commission within the 7th Framework Programme under Grant Agreement 282656, 113 pp. http://www.reformrivers.eu/results/deliverables.

Annex VI: List of national experts responding to the Questionnaire

Country	Name of the method, or acronym/abbreviation	Contact Person
Austria	Austrian Guidance on hydromorphological assessment of rivers	Helena Muehlmann, Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management helena.muehlmann(at)bmlfuw.gv.at
Flanders (Belgium)	meetnet Hydromorfologie	Maarten Van Aert m.vanaert(at)vmm.be Bart Vervaeke b.vervaeke(at)vmm.be
Belgium (Wallonia)	Riparian Remote Monitoring - RiReMo (future development)	Christine Keulen christine.keulen(at)spw.wallonie.be
Belgium (Wallonia)	Qualphy	Christine Keulen christine.keulen(at)spw.wallonie.be
Belgium Wallonia	Walloon method derived from SYRAH (Fr) (National method)	Christine Keulen christine.keulen(at)spw.wallonie.be
Switzerland	Modul-Stufen-Konzept (MSK) Methode Hydrologie Stufe F (Flachdekkend) Konzept HYDMOD-F	Katharina Edmaier, Bundesamt für Umwelt Katharina.Edmaier(at)bafu.admin.ch
Switzerland	Modul-Stufen-Konzept (MSK) Methode Ökomorphologie Stufe F (Flachdekkend)	Katharina Edmaier, Bundesamt für Umwelt Katharina.Edmaier(at)bafu.admin.ch
Cyprus	Integrated Pressure Index (IPI)	Gerald Dörflinger
Czech Republic	HEM 2014 Metodika monitoringu hydromorfologických ukazatelů ekologické kvality vodních toků	Pavel Kožený, T.G. Masaryk Water Research Institute pavel_kozeny(at)vuv.cz
Germany	The hydromorphological classification tool Valmorph for large and navigable surface waters	Dr. Ina Quick, Federal Institute of Hydrology, Germany quick(at)bafg.de
Germany	Klassifizierung des Wasserhaushalts von Einzugsgebieten und Wasserkörpern	Adrienne Weber, HMUKLV
Germany	LAWA-Verfahrensempfehlung zur Gewässerstrukturkartierung – Verfahren für mittelgroße bis große Fließgewässer	Daniela Bleck, for LAWA daniela.bleck(at)mulnv.nrw.de
Germany	evaluation of sediment continuity (Bewertung der Durchgängigkeit von Fließgewässern für Fische und Sedimente, hier: Sedimentdurchgängigkeit)	Dr. Ina Quick, Federal Institute of Hydrology, Germany quick(at)bafg.de
Germany	LAWA-Verfahrensempfehlung zur Gewässerstrukturkartierung – Verfahren für kleine bis mittelgroße Fließgewässer	Daniela Bleck, for LAWA daniela.bleck(at)mulnv.nrw.de
Denmark	Dansk fysisk indeks, DFI (Danish physical Index)	Ivan Karottki, Ministry of Environment and Food, Environmental Protection Agency ibk(at)svana.dk
Estonia	River HYMO EST	Irja Truumaa Agne Aruväli
Spain	DRAINAGE	José María Bodoque del Pozo JoseMaria.Bodoque(at)uclm.es
Spain	Protocol for the hydromorphological characterization of water bodies	Francisco Javier Sánchez Martínez, Ministry of Agriculture and Fisheries, Food and Environment fsmartinez(at)mapama.es
Spain	Índice para la evaluación de la calidad hidrogeomorfológica (IHG)	Daniel Ballarín Ferrer, University of Zaragoza

Finland	HyMo method (Kevomu-menetelmä)	Seppo Hellsten, Syke Seppo.Hellsten(at)ymparisto.fi Teemu Ulvi Teemu.Ulvi(at)ymparisto.fi
France	AURAHCE (AUdit RApide de l'Hydromorphologie des Cours d'Eau / Hydromorphology auditing)	Laurent Valette, National Research Institute of Science and Technology for Environment and Agriculture laurent.valette(at)irstea.fr Karl Kreutzenberger, National agency for water and aquatic environments karl.kreutzenberger(at)afbiodiversite.fr Gabriel Melun, National agency for water and aquatic environments gabriel.melun(at)afbiodiversite.fr Stephane Grivel, French ministry of environment stephane.grivel(at)developpement-durable.fr
France	CARHYCE (CARactérisation HYdromorphologique des Cours d'Eau / Hydromorphological characterization of rivers)	Karl Kreutzenberger, National agency for water and aquatic environments karl.kreutzenberger(at)afbiodiversite.fr Gabriel Melun, National agency for water and aquatic environments gabriel.melun(at)afbiodiversite.fr Stephane Grivel, French ministry of environment stephane.grivel(at)developpement-durable.fr
France	ICE project (for “Informations sur la Continuité Ecologique”)	Karl Kreutzenberger, National agency for water and aquatic environments karl.kreutzenberger(at)afbiodiversite.fr Stephane Grivel, French ministry of environment stephane.grivel(at)developpement-durable.fr
France	RHUM (Référentiel Hydromorphologique Ultra-Marin) SYRAH-CE adapted to the French overseas departments (tropical systems)	Karl Kreutzenberger, National agency for water and aquatic environments karl.kreutzenberger(at)afbiodiversite.fr Gabriel Melun, National agency for water and aquatic environments gabriel.melun(at)afbiodiversite.fr Stephane Grivel, French ministry of environment stephane.grivel(at)developpement-durable.fr
France	ROE (Référentiel des Obstacles à l'Ecoulement) Nb : It is not a methodology strictly speaking, but a data repository about all man-made barriers used for different evaluations. It is a database with the aim of listing, and localizing and characterizing all man-made barriers. It allows an evaluation of weirs pressure.	Karl Kreutzenberger, National agency for water and aquatic environments karl.kreutzenberger(at)afbiodiversite.fr Gabriel Melun, National agency for water and aquatic environments gabriel.melun(at)afbiodiversite.fr Stephane Grivel, French ministry of environment stephane.grivel(at)developpement-durable.fr
France	SYRAH-CE (SYstème Relationnel d'Audit de l'Hydromorphologie des Cours d'Eau) Relational, multi-scale system for auditing the hydro-morphology of rivers	Laurent Valette, National Research Institute of Science and Technology for Environment and Agriculture laurent.valette(at)irstea.fr Karl Kreutzenberger, National agency for water and aquatic environments karl.kreutzenberger(at)afbiodiversite.fr Gabriel Melun, National agency for water and aquatic environments gabriel.melun(at)afbiodiversite.fr Stephane Grivel, French ministry of environment stephane.grivel(at)developpement-durable.fr
Hungary	Planned_HU	Szilvia David, General Directorate of Water Management david.szilvia(at)ovf.hu Miklos Szalay

Hungary	HU_RBMP2	Szilvia David, General Directorate of Water Management david.szilvia(at)ovf.hu Miklos Szalay
Ireland	Abstraction impact screening assessment	Conor Quinlan, EPA (ECOSTAT HYMO WG Representative for EPA: Emma Quinlan (e.quinlan(at)epa.ie))
Ireland	River Hydromorphological Assessment Technique/RHAT	Emma Quinlan, Environmental Protection Agency e.quinlan(at)epa.ie
Italy	Indici di hydropeaking	Martina Bussettini, ISPRA martina.bussettini(at)isprambiente.it Guido Zolezzi, UNITN
Italy	IARI indice di alterazione del regime idrologico	Martina Bussettini, ISPRA martina.bussettini(at)isprambiente.it
Italy	MQI Morphological Quality Index	Martina Bussettini, ISPRA martina.bussettini(at)isprambiente.it
Lithuania	Lithuanian River Hydromorphology Index	Martynas Pankauskas martynas.pankauskas(at)aaa.am.lt
Luxembourg	Klassifizierung des Wasserhaushalts von Einzugsgebieten und Wasserkörpern	Martine Bastian, Ministry of Sustainable Development and Infrastructure martine.bastian(at)eau.etat.lu Nora Welschbillig, Ministry of Sustainable Development and Infrastructure nora.welschbillig(at)eau.etat.lu
Luxembourg	Strukturgütekartierung (LANUV 2012)	Martine Bastian, Ministry of Sustainable Development and Infrastructure martine.bastian(at)eau.etat.lu Nora Welschbillig, Ministry of Sustainable Development and Infrastructure nora.welschbillig(at)eau.etat.lu
Latvia	HAP-LR	Tatjana Kolcova, Latvian Environment, Geology and Meteorology Centre tatjana.kolcova(at)lvgmc.lv
Netherlands	Handboek Hydromorfologie 2.0 (Oste et al. 2013)	Tom Buijse, Deltares Tom.Buijse(at)deltares.nl Jappe Beekman JBeekman(at)aaenmaas.nl
Norway	Characterization, analysis and risk assessment of water bodies as defined in WFD art. 5	Ragnhild Stokker, Norwegian Water Resources and Energy Directorate rast(at)nve.no
Poland	Hydromorphological Index for Rivers / HIR	Krzysztof Szoszkiewicz, Poznan University of Life Sciences
Portugal	River Habitat Survey (RHS)	Maria Helena Alves helena.alves(at)apambiente.pt
Romania	Methodology to determine the hydromorphological indicators for Romanian rivers	Rusu Cristian cristian.rusu(at)rowater.ro Andreea Galie andreea.galie(at)hidro.ro
Sweden	HVMFS 2013:19 (Agency regulation)	Katarina Vartia, Swedish Agency for Marine and Water Management katarina.vartia(at)havochvatten.se
Slovenia	Hydromorphological Monitoring in Slovenia - HIMO.SI	Florjana Ulaga, Slovenian Environment Agency florjana.ulaga(at)gov.si
Slovakia	Hydromorphology Quality Assessment	Katarina Holubova, Water Research Institute holubova(at)vuvh.sk
Slovakia	Physical habitat assessment	Mgr.Katarina Melová PhD Katarina.Melova(at)shmu.sk
Turkey	Nehir Hidromorfolojisi Değerlendirme İndeksi (NHDI) (Turkish) River Hidromorphology Assessment Index (English)	Muhammet Azlak mazlak(at)ormansu.gov.tr Ersin Yildirim eyildirim(at)ormansu.gov.tr R.T. Ministry of Forestry and Water Affairs / Directorate General of Water Management
England (Wales) - UK	Mitigation Measure Assessment	Amanda Veal, Environment Agency amanda.veal(at)environment-agency.gov.uk
England - UK	Hydrology - Water Resources GIS (WRGIS)	Anna Hawksley, Environment Agency Anna.hawksley(at) environment-agency.gov.uk

England (Wa-les) - UK	River habitat Survey (RHS)	Glenn Maas, Environment Agency glenn.maas(at)environment-agency.gov.uk
England & Wales	Designation of A/HMWB	Kevin Hall
England - UK	Hydrology - Water Resources GIS (WRGIS)	Anna Hawksley, Environment Agency Anna.hawksley(at) environment-agency.gov.uk
Northern Ireland	Low Flows Enterprise	Wendy McKinley
Northern Ireland - UK	River Hydromorphology Assessment Technique (RHAT)	Wendy McKinley
Scotland - UK	Hydrology water body classification	Richard Gosling, SEPA richard.gosling(at)sepa.org.uk