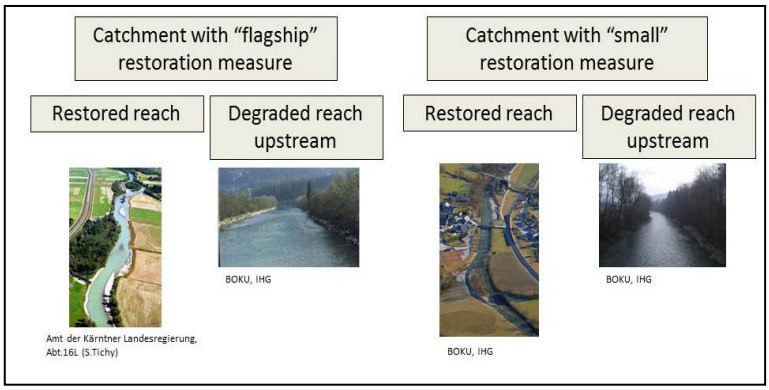
THEME: Environment (including climate change)
TOPIC: ENV.2011.2.1.2-1 Hydromorphology and ecological objectives of WFD
Collaborative project (large-scale integrating project)
Grant Agreement 282656
Duration: November 1, 2011 – October 31, 2015

REstoring rivers FOR effective catchment Management



Deliverable D4.1

Title Field protocols and associated database

Author(s) Michaela Poppe, Michael Stelzhammer, Martin Seebacher, Susanne Muhar (BOKU)

Kathrin Januschke, Armin Lorenz, Benjamin Kupilas, Daniel Hering (UDE)

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Dissemination Level

PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Summary

WP4 evaluates effects of river restoration by analysing existing data as well as performing field studies on paired catchments. The field studies will use examples of restored sites in which either one large scale measure (flagship restoration site) or smaller restoration measures (small restoration site) have been implemented. These restoration sites will be compared to "control sites" that are situated upstream and are still degraded (nested design).

Deliverable 4.1. documents the abiotic and biotic parameters to be recorded at the case study sites and provides a description of the methods for field investigations in 2012 and 2013 including manuals, field forms and protocols. In detail the hydromorphological and stable-isotope investigations as well as sampling of fish, macroinvertebrates, macrophytes, riparian arthropods and riparian/floodplain vegetation are presented.

Additionally the procedure of the selection and final determination of the parameters and field methods are described as well as the general sampling design and techniques.

The site-specific record sets will be complemented by data at catchment scale. To manage the gathered data, a database was created. The final section of this report provides an overview of the structure and organisation of the database and a compilation of tables showing the set of variables to be recorded and their detailed description.

Acknowledgements

The work leading to this report has received funding for the EU's 7th FP under Grant Agreement No. 282656 (REFORM).

Table of Contents

1. Introduction

WP4 evaluates effects of river restoration by analysing existing data as well as performing field studies on paired catchments. The field studies will use examples of restored sites in which either one large scale measure (flagship restoration site) or smaller restoration measures (small restoration site) have been implemented. These restoration sites will be compared to "control sites" that are situated upstream and are still degraded (nested design).

This report includes sampling manuals, field forms, protocols and database structure for the abiotic and biotic assessment to ensure comparable datasets for all case studies. At site scale hydromorphological parameters are recorded while biotic core parameters are fish, macroinvertebrates, macrophytes, riparian arthropods as well as riparian and floodplain vegetation. Additionally stable-isotope analyses are carried out. The integration of existing data is intended (1) as a substitute for data to be collected in the field (if current data on fish and invertebrates are available) and (2) as a data source to address additional questions, e.g. temporal developments.
These site-specific data sets will be complemented by data at catchment scale.

To manage the gathered records, a database was created in two steps. To collect the data from all case study partners a Microsoft Excel file with 33 sheets was created. In this file 10 key subjects are required - 5 abiotic and 5 biotic topics (Site information, Hydromorphology, Pressure types, Restoration measure types, Physico-chemical data; Fish, Invertebrates, Macrophytes, Riparian arthropods, Floodplain Vegetation). In a later stage, the received datasets will be merged in a Microsoft Access database.

1.1 Task 4.2

During the first year of the REFORM project the hydromorphological conditions of restored and degraded sites will be assessed by two different methods:

- CEN compliant **hydromorphological survey** method (adapted Austrian HyMo-survey method)
- Measurement of **meso- and microhabitat composition** (hydromorphological transect method - modified after Jähnig et al. 2008, Januschke et al. 2009)

Functional parameters will be identified by **stable isotope** analysis that supports the investigation of effects of river restoration on aquatic terrestrial linkages and on the complexity of food webs.

1.2 Task 4.3

Data on ecological status and functions in restored and non-restored reaches in the case study sites will be collected and evaluated. Biotic core parameters and sampling methods are:

- Fish will be recorded using electrofishing according to the most recent CEN standard
- Benthic Invertebrates, will be sampled with a multi-habitat approach
- Macrophytes, riparian and floodplain vegetation will be recorded with a transect-based approach

The three parameters fish, invertebrates and macrophytes are chosen as representatives for the biological quality elements corresponding to the Water Framework Directive (EU-WFD 2000). As further biotic indicator riparian arthropods are selected to detect effects of restoration measures (Günther and Assmann 2005, Lambeets et al. 2008, Januschke et al. 2011).
Riparian and floodplain vegetation is an additional important indicator to address the river – floodplain system as a functional unit (Hughes et al. 2001, Muhar et al. 2005).

1.3 Selection and determination of field methods

All methodological approaches and the data collection procedures have first been identified and described by the core team of WP4 based on standard methods applied in many EU member states in a highly comparable way. Then, these descriptions including field protocols have been circulated among the WP4-group. All methods have been presented, discussed and commonly agreed at the field training workshop at Silkeborg in May 2012. A final version of the detailed field methods has been circulated again. This manual provides the basis for the field work at all case study sites.

In the following chapters all methods for field mapping and sampling of the hydromorphological and biological parameters are described in detail.

1.4 Overview of sampling design and procedures

Each case study site comprises a restored and a degraded reach; the latter is located upstream from the restored reach with a sufficient distance to prevent mutual interferences.
Hydromorphological survey method will be done on **4 survey sections** per reach (Figure 1, Figure 2).

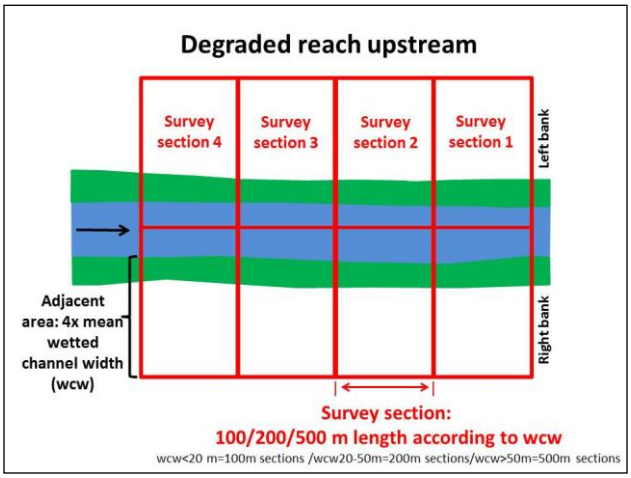


Figure 1: Survey sections - degraded reach

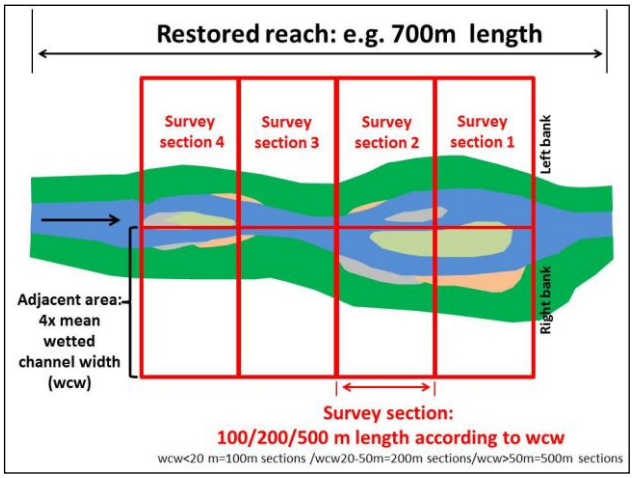


Figure 2: Survey sections - restored reach

Hydromorphological transect method, **stable isotopes** and **biotic sampling** will be done on a representative sample section selected within each degraded and restored reach; the restored sample section should be located in the downstream part of the restored reach (Figure 3, Figure 4).

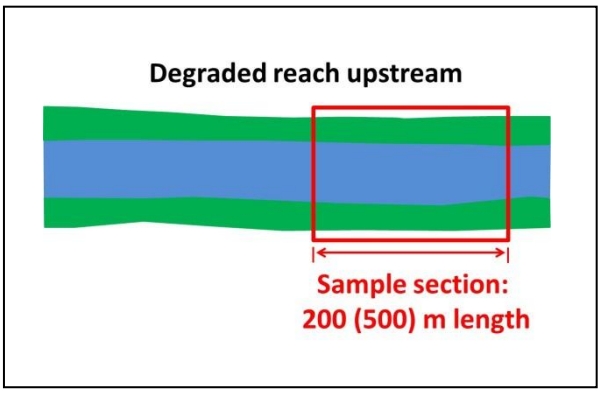


Figure 3: Sample section - degraded reach

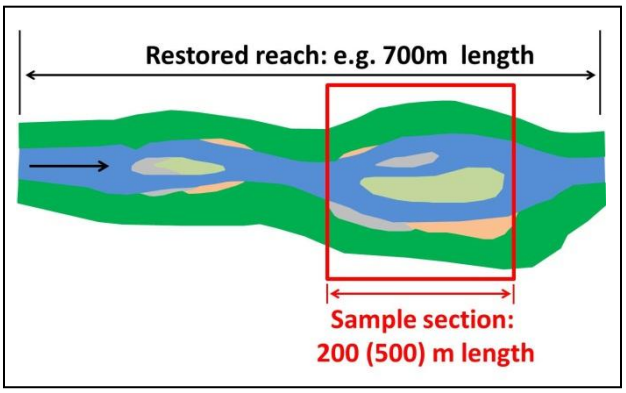


Figure 4: Sample section - restored reach

The lengths of sample sections depend on the wetted channel width and the survey target (Table 1). Sampling sections for recording hydromorphological transects and sampling of riparian arthropods, floodplain vegetation and stable isotopes will have a length of 200 or 500m. For macroinvertebrates and macrophytes, the length of sample sections is 200m independent of the wetted channel width.

For fish sampling the river segment is defined as:

1 km for small rivers (catchment<100km^2)
5 km for medium-sized rivers (100-1000 km^2)
10 km for large rivers (>1000km^2)

according to EFI+ manual (see 4.4.1).

Table 1: Length of sample sections [m] (wcw = wetted channel width)

	wcw < 50m	wcw > 50m
Hymo - survey	4x100(200)*	4x500
Hymo - transect method	200	500
Macroinvertebrates	200	200
Macrophytes	200	200
Fish	10-20 times wcw, with a minimum length of 100 m	
Riparian arthropods	200	500
Stable isotopes	200	500
Floodplain vegetation	200	500

*wcw<20m – length of sampling section is 100m; wcw=20-50m – length of sampling section is 200m

The lateral boundaries of sampling areas and sampling seasons differ between the survey targets (Table 2).

Table 2: Sampling area (lateral boundaries)

	Recording/Sampling area	Recording/Sampling season
Hymo - survey	4x wetted channel width	Low flow in summer
Hymo - transect method: Channel features	The whole flood-prone area including aquatic, transient and terrestrial parts; in restored sections terrestrial area comprises the bankfull discharge area, in degraded sections the area of high-water level ('flood marks'); maximum width of 200m	Low flow in summer
Hymo - transect method: Microhabitats	Aquatic area	Low flow in summer
Macroinvertebrates	Aquatic area without oxbow lakes	Low flow in early summer (June to July)
Macrophytes	Aquatic area	Maximum growth in low flow conditions (mid summer)
Fish	Aquatic area (wadable and <15m width: whole channel surface; wadable and >15m width or boat fishing: partial sampling method)	Late summer/early autumn except non-permanent Mediterranean rivers in spring

Riparian arthropods	10m-stripe of riparian areas	Late June (Mediterranean sites) to early August (Scandinavian sites)
Floodplain vegetation	The whole flood-prone area including aquatic, transient and terrestrial parts; in restored sections terrestrial area comprises the bankfull discharge area, in degraded sections the area of high-water level ('flood marks'); maximum width of 200m	Maximum growth in low flow conditions
Stable isotopes	Aquatic, transient and terrestrial area; terrestrial area comprises the whole flood-prone area + a stripe across the edges of embankment for sampling of non-riparian beetles	Maximum of biomass

Table 3 gives an estimation of time needed for the individual investigations of one study site (degraded + restored sample section). This estimation is based on experiences of recording and sampling of sample sections with a length of 200m.

Table 3: Estimated expenditure of time for investigations per study site (degraded + restored).

	Estimated time [hours]	
	Field work	Lab and pc work
Hymo - survey	6	12*
Hymo - transect method	6-8	3
Macroinvertebrates	2	10
Macrophytes	2-3	1-2
Fish	8-12 (estimated for first run)	16
Riparian arthropods	7-8 (installation of traps and handcollections) + 2 (collection of traps after 1 week)	3
Stable isotopes	6-8	8-10

*include preparation time for defining reference conditions and hydrological impacts

2. Hydromorphological assessment methods

2.1 CEN compliant hydromorphological survey method

2.1.1 Introduction

In Task 1.1 all relevant hydromorphological assessment methods were listed (see FTP Server REFORM/WP1 --> Literature on HYMO methods). For the first period of field surveys in 2012 an Austrian survey method (NOEMORPH) has been selected for REFORM and will be applied in all case study sites.
The NOEMORPH method (Hydromorphological Mapping of Selected Running Waters in Lower Austria - Gewässerzustandskartierung Niederösterreich WAW – Wasser und Abfallwirtschaft NÖ) is based on a structural assessment method (Werth 1987) and has been further developed and extended by an expert team (Freiland Umweltconsulting 2001). The method is CEN compliant (CEN 2002) and applied in Lower Austria. More or less the same survey methods are used per default throughout Austria. Very similar approaches can be found e.g. in Germany (LAWA 2000). The results of these field assessments and evaluations are directly integrated in the National River Basin Plans of Austria respectively Germany.

According to the experiences of the BOKU team and being aware of pros and cons of this method (Steindl 2011) we slightly adapted the NOEMORPH survey assessment for the aims of REFORM. Additionally we integrated some aspects of the German LAWA method (LAWA 2000, Pottgiesser & Sommerhäuser 2004).

Basically, the method analyzes the deviation of the current status of the river from the "type-specific status" - the target state that is represented by "reference conditions".

The river is divided into single river sections - for each section pre-defined attributes are assigned to 5 main parameters which are assessed and evaluated.

1. **Channel Geometry and Flow Characteristics**
2. **Riverbed**
3. **Water - land transition zone**
4. **River bank / Riparian Zone**
5. **Vegetation of the adjacent area**

Each of these five main parameters will be assessed according to a 7-tier scale:

class 1:	undisturbed
class 1-2:	little disturbed
class 2:	moderately disturbed
class 2-3:	clearly disturbed
class 3:	heavily disturbed
class 3-4:	very heavily disturbed
class 4:	totally disturbed

The total evaluation for the survey section is the mean of all 5 main parameters.

Comment:
The results from the hydromorphological survey served as a first step towards the implementation of the WFD. For this purpose the seven classes are reduced to five classes (Kamp et al. 2007):

class 1:	undisturbed	WFD-class 1
class 1-2:	little disturbed	WFD-class 2
class 2:	moderately disturbed	WFD-class 2
class 2-3:	clearly disturbed	WFD-class 3
class 3:	heavily disturbed	WFD-class 4
class 3-4:	very heavily disturbed	WFD-class 5
class 4:	totally disturbed	WFD-class 5

Reference Conditions

The assessment is based on the recording and evaluation of morphological / structural parameters in and around water bodies that are determinant for the role of water bodies as a habitat.
The method assumes that the best biological conditions exist in anthropogenic undisturbed habitats (equals to condition class 1). The reference conditions are defined with the help of the "River Type Region" and the "Morphological River Type" (cf. freiland Umweltconsulting 2001).

Every partner should use the adequate river type descriptions.
The German stream typology comprises a total of twenty-four „biocoenotically relevant stream types": four from the Ecoregion Alps and Alpine foothills, eight from the Central highlands, eight from the Northern German lowlands, and four "Ecoregion independent" types, which can be found in various ecoregions (http://forecaster.deltares.nl/index.php?title=River_Typology).

Lippe (North Rhine-Westphalia). Photograph: T. Ehlert

Sinuate to meandering streams in shallow troughs or wide u-shaped valleys. Besides the dominant sand and loam fractions, gravel is an important substrate, which can form gravel banks; clay and marl are common and can aggregate into flat slabs. Important habitat structures include natural secondary substrates like woody debris, alder roots, macrophytes and fallen leaves.
The channel profile is flat with pronounced slip-offs and stable bank cliffs. In the floodplain numerous drainage channels, detached side arms and backwaters of varying age are common. Valley bogs and fens can form.
Streams with higher amounts of loam are naturally incised well below the floodplain level and have a trench-like profile. Disconnected side channels are rare.

Size class:	100 - 10.000 km² catchment area
Slope of the valley floor:	0,2 - 2 ‰
Flow category:	predominantly calm current flow
Channel substrates:	dominated by sands of varying grain size, or loam; often supplemented by gravel, in parts by clay and marl.

Figure 5: German River Type 15: sand dominated lowland river (mid-sized); (Pottgiesser & Sommerhäuser 2004)

The reference conditions have to be determined **prior to the field work** because the surveyor has to be familiar with them to comparatively evaluate the hydromorphological status.

2.1.2 Mapping approach

The predefined mapping scale is at least 1:25,000 (1:10,000 is recommended). The sites to be investigated (reach with the flagship restoration / degraded reach; smaller restoration – degraded reach) are already determined by the partners. Each reach will be divided into sections (see Figure 1; Figure 2).
The length of a section is 100 m (mean wetted channel width < 20 m); 200 m if mean wetted channel width is between 20-50m; 500 m (mean wetted width > 50m).
The assessment results will be filled in survey protocols. Protocols are numbered following the mapping procedure **upstream** - **left and right banks are assessed and numbered separately**. Accordingly, the sections have to be recorded on the map.
The assessment should be carried out during mean or low flow conditions.

Documents / Preparations for field work

1. topographical map of case study sites (scale 1:10,000 – 1:25,000)
2. definition of hydromorphological river type and reference conditions (quantitative – descriptive data)
3. identification of hydrological impacts (e.g., water abstraction) upstream and/or downstream that affect the hydrological condition of the case study site and influence the evaluation of the survey sections – this information should be indicated in the comment fields of the forms
4. definition of section length (see Figure 1; Figure 2)

5. definition of lateral boundaries of the adjacent area (see Table 2)
6. recording of sections and boundaries on the map (see Figure 6 – R1 right bank of section 1; L1 left bank of section 1,etc.)

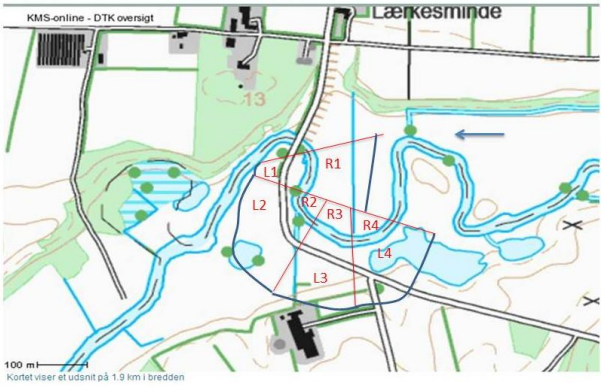


Figure 6: Example of recording sections and boundaries on a topographical map (please avoid the overlapping of adjacent areas at meandering river sites)

Impoundments, residual water stretches, continuum interruptions or backwaters are only recorded if they are **situated within** the survey sections. In case of continuum interruptions and backwaters you have to use additional forms.

Impoundments and Residual Water Stretches

Impoundments are surveyed from the head of the reservoir to the impoundment structure but not evaluated.

The evaluation of residual water stretches is performed with the help of an imaginary mean-water level. It is reported as "water abstraction stretch" but the procedure of the allocation to a condition class is the same as for free flowing stretches.

Structures interrupting the longitudinal River Continuum

Natural and artificial structures that interrupt the river continuum are reported with an ID number on an additional form (see Figure 7) and marked as point information on the map.

Hydromorphological survey method → → → → WP 4.2 REFORM
(based on Gewässer-Zustandskartierung Niederösterreich, WAW – Wasser- und Abfallwirtschaft NÖ)

Structures interrupting the river continuum

River name	Consecutive no.	ID structure	Natural interruption	Type of interruption	Fish ladder	Width (m)	Height (m)	Comments

Figure 7: Additional Form for Structures interrupting the river continuum (Appendix 7.1.2)

ID structure: will be defined for the Access Database after fieldwork
Natural interruption: yes/no (please specify in the comments)
Type of interruption: drop structure/river bottom ramp/sill/weir (see Figure 8)
Fish ladder: yes/no
Width: Width of continuum structure in m
Height: Height of continuum structure in m

Artificial structures are divided into 4 categories:

- drop structure
- river bottom ramp
- sill
- weir

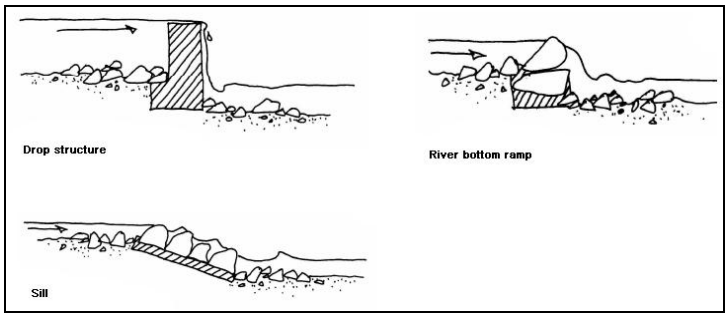


Figure 8: Examples for structures interrupting the river continuum (freiland Umweltconsulting 2001)

Backwaters

Backwaters (e.g., oxbows) are assigned to the corresponding river reach and reported as point information on an additional form (see Figure 9).

Hydromorphological·survey·method····· → WP·4.2¶ REFORM
(based·on·Gewässer-Zustandskartierung· Niederösterreich,·↵
WAW·–·Wasser-·und·Abfallwirtschaft·NÖ¶

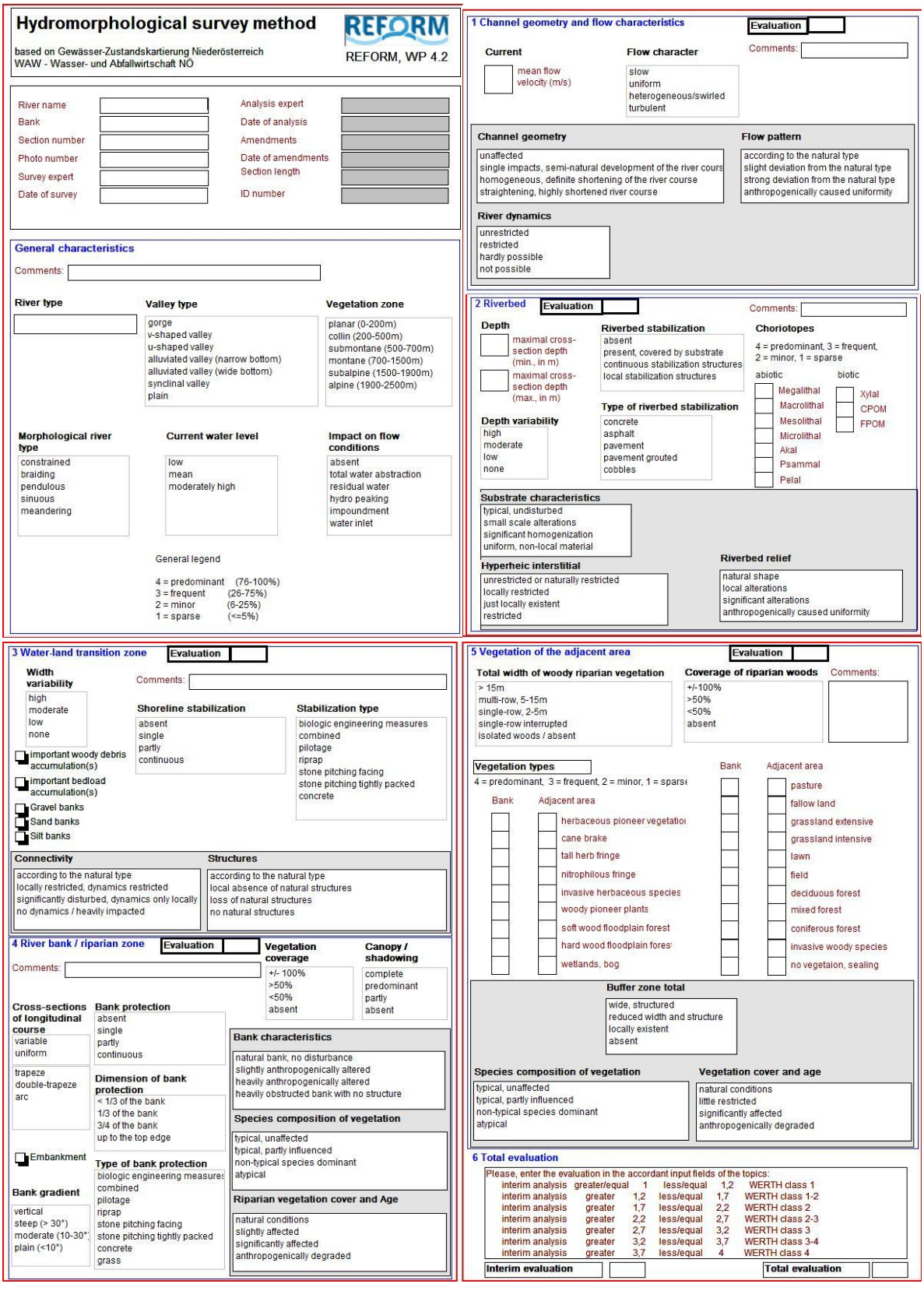
Backwaters¶

Waterbody· name¤	Consecutive· no.¤	ID· backwater¤	Connection¤	Flow·conditions¤
¤	¤	¤	¤	¤
¤	¤	¤	¤	¤
¤	¤	¤	¤	¤
¤	¤	¤	¤	¤
¤	¤	¤	¤	¤
¤	¤	¤	¤	¤
¤	¤	¤	¤	¤
¤	¤	¤	¤	¤
¤	¤	¤	¤	¤
¤	¤	¤	¤	¤
¤	¤	¤	¤	¤
¤	¤	¤	¤	¤

Figure 9: Additional Form for Backwaters (Appendix 7.1.3)

ID backwater: will be defined for the Access Database after fieldwork
Connection: yes/no
Flow conditions: stagnant/slow

2.1.1 Main form



Main Form in Appendix 7.1.1

The first part of the field survey form includes information on river section and the survey/data analysis experts:

- Name of the river; bank (left or right), section number, photo number, name of surveyor, date of survey

- Name of data analysis expert, date of analysis, amendments and date of changing, length of the section (all these data in the grey field will be filled in during the data input in the Access Database; NOT during field work)

General characteristics

The second part of the field survey form generates basic information of the river section and its hydrological impacts.

- *River type:* lowland river / mountain river (or national river typology)
- *valley type:* (see Figure 10),
- *vegetation zone*: planar 0-200m, collin 200-500m, submontane 500-700m, montane 700-1500m, subalpine 1500-1900m, alpine 1900-2500m
- *morphological river type* (see Figure 11),
- *current water level*: low, mean, moderately high
- *impact on flow conditions*: absent, total water abstraction, residual water, hydro peaking, impoundment, water inlet

Four parameters can be assessed in frequency classes (abiotic and biotic choriotopes, vegetation types of banks and adjacent areas).

Legend 1:

4 = predominant (76-100%)
3 = frequent (26-75%)
2 = minor (6-25%
1 = sparse (≤ 5%)

Comments can be filled in each section of the main form.

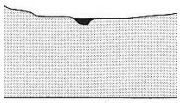
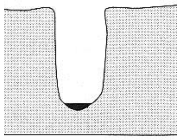
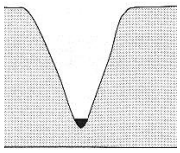
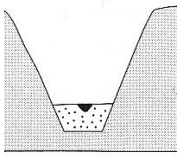
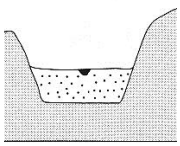
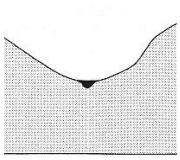
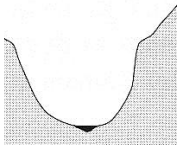
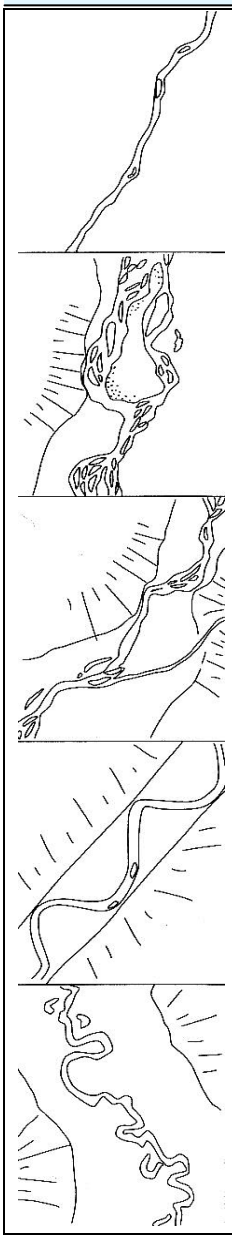
Plain		- channel is running through its own alluvion
Gorge		- profile is represented by vertical slopes and the river bottom - river captures the whole valley bottom
V-shaped valley		- valley formed by water erosion, v-shaped profile - no real valley bottom or rather only local and narrow - combined forms possible, e.g., v-shaped valley incised in u-shaped valley
Alluviated valley with narrow bottom		- slopes show clear characteristics of v-shaped valley - valley bottom present (Alluvion or glacial material)
Alluviated valley with wide bottom		- definite differentiated wider valley bottom - slopes less steep - emerged from other valley form because of lateral erosion or accumulation
Synclinal valley		- smooth transition from flat slopes to valley bottom - soft rock; areal washout plays an important role - often asymmetric valley profile - large alluvion not necessarily existent
U-shaped valley		- u-shaped profile form - soft rounded transition between valley bottom and slopes; upper slopes get steeper again - glacial erosion form

Figure 10: Valley types (Muhar et al. 2000, Jungwirth et al. 2003 based on Mangelsdorf et al. 1990)

Morphological River Type

The morphological river type allows the characterization of a river stretch concerning the dynamic reshaping processes of the riverbed and its environment (potential floodplain). It is formed by the interaction of various abiotic parameters like geology of the watershed, bed load, substrate ratios and runoff, among others.



constrained

- steep slope, mostly narrow valley form
- often sharp changes of direction
- the stream can oscillate locally by what alternating sedimentations occur

braiding

- high bedload transport and a mean to steep slope lead to numerous side channels
- no clearly defined banks
- often the whole valley bottom is influenced
- several subforms (e.g., anastomosing)

sinous

- transitional type between braiding and meandering
- the channel already creates meander curves but is still locally braiding creating islands

pendulous

- the valley bottom is wide enough for the stream to form inner banks and outer banks
- the change of direction are mostly caused by valley sides, alluvial fans, or terrace systems
- normally relative low bedload transport, slope too steep for creation of meanders

meandering

- free meander develops in its own alluvion

Figure 11: Morphological River Types (Muhar et al. 2000, Jungwirth et al. 2003)

The third part of the field survey form includes the characterization and evaluation of five main parameters. It is divided into a describing part (characterization of parameters –white field) and an evaluative part (evaluation of the parameters – grey field).

Within the survey section the main parameter 1-3 ("Channel Geometry and Flow Characteristics" / "Riverbed" / "Water – land transition zone") are related to the active channel whereas parameter 4 ("bank and riparian structures") and 5 ("vegetation of the adjacent area") identify structures and vegetation types on the orographical left (L) and right (R) riverside separately (see Figure 12 and Figure 13).

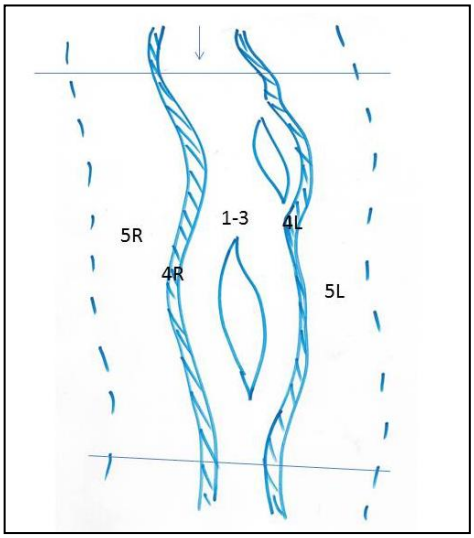


Figure 12: Scheme of spatial relation of 5 main parameters – braided section 1-3: Channel Geometry and Flow Characteristics / Riverbed / Water – land transition zone; 4: bank and riparian structures (L/R: left/right bank); 5: vegetation of the adjacent area (L/R: left/right riverside)

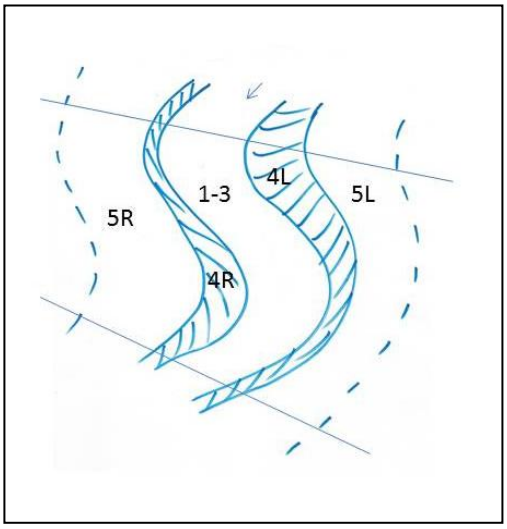


Figure 13: Scheme of spatial relation of the 5 main parameter – meandering section

Parameter 1: Channel Geometry and Flow Characteristics

Parameter characterization:

Current: mean flow velocity in m/s

The required information is the mean flow velocity in the channel. The following procedure can be used in rivers where a measured segment of the reach is uniform and deep enough to float a neutrally buoyant object freely. Examples of suitable objects include small sponge rubber balls or small sticks.
The time that the object needs to pass through a defined segment is measured three times to calculate the mean value.

flow character: slow, uniform (homogenous anthropogenically caused), swirled/heterogeneous, turbulent

Parameter evaluation:

Channel Geometry	- unaffected - single impacts, semi-natural development of the river course - homogeneous, definite shortening of the river course - straightening, highly shortened river course

Flow Pattern	- according to the natural type - slight deviation from the natural type - strong deviation from the natural type - anthropogenically caused uniformity
River Dynamics	- unrestricted - restricted - hardly possible - not possible

Parameter 2: Riverbed

Parameter characterization:

Depth:

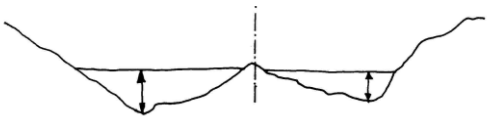


Figure 14: Maximal cross-section depth (maximum, in m; freiland Umweltconsulting 2001)

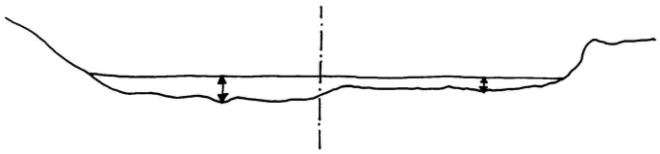


Figure 15: Maximal cross-section depth (minimum, in m, freiland Umweltconsulting 2001)

At the sample section you have to define two cross-sections: one with the maximal depths and one with minimal depths. At these two cross-sections the maximum depth of each will be measured.

Depth variability: high, moderate, low, none

Riverbed stabilization: absent, present covered by substrate, continuous stabilization structures, local stabilization measures

Type of riverbed stabilization: concrete, asphalt, pavement, pavement grouted, cobbles

Choriotopes

Choriotopes are assessed in four frequency classes (see page 17 ; Table 4 and Table 5).

Table 4: Choriotopes – Abiotic (ÖNORM 1997)

Substrate name	Grain Size (mm)	Description
Megalithal	>400	Large boulders, bedrock
Macrolithal	200 to 400	Coarse boulders, mainly head-sized, variable fractions of cobble, gravel and sand
Mesolithal	63 to 200	Fist to hand-sized cobbles with variable fractions of gravel and sand
Microlithal	20 to 63	Coarse gravel (size of a pigeon egg to child's fist) with variable fractions of gravel and sand
Akal	2 to 20	Fine to medium-sized gravel
Psammal	0.063 to 2	Sand
Pelal	<0.063	Silt, loam, clay and mud

Table 5: Choriotopes – Biotic

Substrate name	
Xylal	Woody debris, roots, branches etc.
CPOM	Deposits of coarse particulate organic matter, e.g., fallen leaves
FPOM	Deposits of fine particulate organic material, organic sludge

Parameter Evaluation

Substrate characteristics	- typical, undisturbed - small scale alterations - significant homogenization - uniform, non-local material
Riverbed relief	- natural shape - local alterations - significant alterations - anthropogenically caused uniformity
Hyporheic interstitial	- unrestricted or naturally restricted

	- locally restricted - just locally existent - restricted

Parameter 3: Water – land transition zone

Parameter characterization:

Width variability: high, moderate, low, none

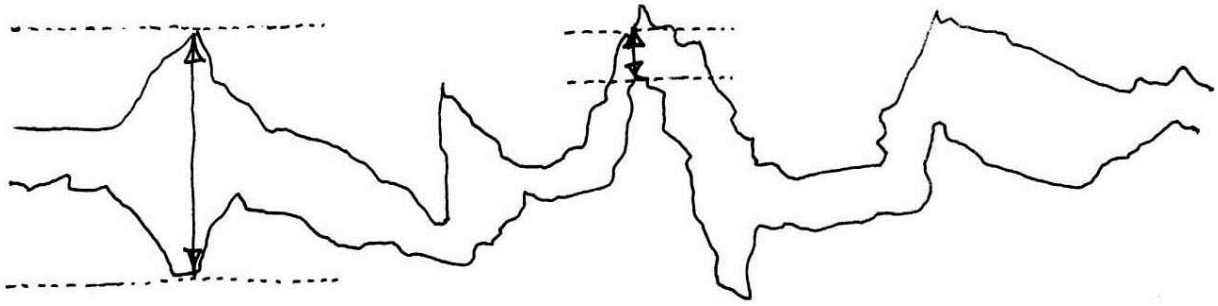


Figure 16: **width variability** (freiland Umweltconsulting 2001)

Shoreline Stabilization: absent, single, partly, continuous

Stabilization type: biological engineering measures (see examples Figure 17), combined (Figure 18), pilotage (Figure 19), riprap (Figure 20), stone pitching facing (Figure 21), stone pitching tightly packed (Figure 22), concrete (Figure 23)

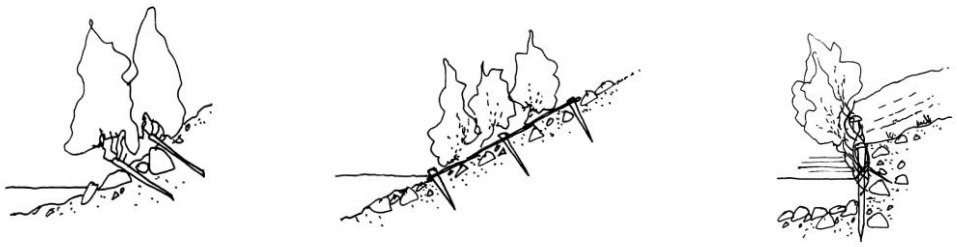


Figure 17: Examples for biological engineering measures (freiland Umweltconsulting 2001)

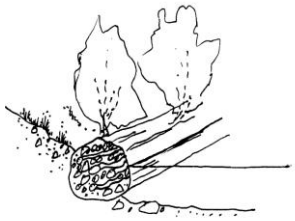


Figure 18: Examples for combined measures (freiland Umweltconsulting 2001)

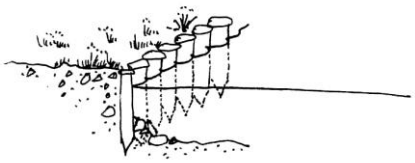


Figure 19: Pilotages (freiland Umweltconsulting 2001)

Figure 20: riprap (BOKU, IHG)

Figure 21: **stone pitching facing** (BOKU, IHG)

Figure 22: stone pitching tightly packed

Figure 23:concrete (BOKU, IHG)

Structures:

Important woody debris accumulation(s): if present – tick the box

Important bedload accumulation(s): if present – tick the box
gravel banks, sand banks, silt banks (if present – tick the box)

Parameter evaluation:

Connectivity	- according to the natural type - locally restricted, dynamics restricted - significantly disturbed, dynamics only locally - no dynamics, heavily impacted
Structures	- according to the natural type - local absence of natural structures - loss of natural structures due to stabilization - no natural structures

Parameter 4: River bank / riparian zone

Parameter characterization:

Cross-sections of longitudinal course: variable, uniform; trapeze, double-trapeze, arc

Embankment: if present – tick the box

Bank gradient: vertical, steep (>30° - 1:1,6 and steeper), moderate (10-30° - 1:5 to 1:1,6), plain (<10° - 1:5 and less) – see Figure 24

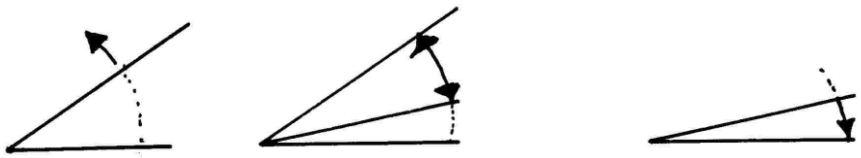


Figure 24: Examples for different bank gradients (freiland Umweltconsulting 2001)

Bank protection: absent, single, partly, continuous

Dimension of the bank protection: < 1/3 of the bank, 1/3 of the bank, 3/4 of the bank, up to top edge of the bank

Type of bank protection: biological engineering measures (see examples Figure 17), combined (Figure 18), pilotage (Figure 19), riprap (Figure 20), stone pitching facing (Figure 21), stone pitching tightly packed (Figure 22), concrete (Figure 23), grass (Figure 25)

Figure 25: grass bank (BOKU, IHG)

Vegetation coverage ***of the river bank***: +/- 100%, >50%, <50%, absent

Canopy / Shadowing ***of the water body***: complete, predominant, partly, absent

Vegetation Types

The frequency of each of the following vegetation types is assigned to (see legend – page 17) one of four frequency classes **for banks** (can be filled in parallel with parameter 5):

Herbaceous pioneer vegetation, cane brake, tall herb fringe, nitrophilous fringe, invasive herbaceous species, woody pioneer plants, soft wood floodplain forest, hard wood floodplain forest, wetlands/bogs

pasture, fallow land, grassland extensive, grassland intensive, lawn, field, deciduous forest, mixed forest, coniferous forest, invasive woody species, no vegetation/ sealing

Parameter evaluation:

Bank characteristics	- natural bank, no disturbance - slightly anthropogenically altered - heavily anthropogenically altered - heavily obstructed bank with no structure
Species composition of vegetation	- typical, unaffected - typical, partly influenced - non-typical species dominant - atypical
Riparian vegetation cover and age	- natural conditions - slightly affected

	- significantly affected - anthropogenically degraded

Parameter 5: Vegetation of the adjacent area

Parameter characterization:

Total width of woody riparian vegetation zone: >15m, multi-row 5-15m, single-row 2-5m, single-row interrupted, isolated woods/absent

Coverage of riparian woods: +/- 100%, >50%, <50%, absent

Vegetation Types

The frequency of each of the following vegetation types is assigned to one (see legend - page 17) of four frequency classes **for the adjacent area** (can be filled in parallel with parameter 4):

Herbaceous pioneer vegetation, cane brake, tall herb fringe, nitrophilous fringe, invasive herbaceous species, woody pioneer plants, soft wood floodplain forest, hard wood floodplain forest, wetlands/bogs

pasture, fallow land, grassland extensive, grassland intensive, lawn, field, deciduous forest, mixed forest, coniferous forest, invasive woody species, no vegetation/ sealing

Parameter evaluation:

Buffer zone total	- wide, structured - reduced width and structure - locally existent - absent
Species composition of vegetation of surroundings	- typical, unaffected - typical, partly influenced - non-typical species dominant - atypical
Vegetation cover and age of surroundings	- natural conditions - little restricted - significantly affected - anthropogenically degraded

2.1.2 Evaluation process

Based on these 5 main parameters the hydromorphological status of a river section is assessed with regard to the reference conditions.

Table 6: Example for the evaluation of a main parameter

PARAMETER	DESCRIPTION	EVALUATION class
Substrate characteristics	typical, undisturbed	1
	small scale alterations	**2**
	significant homogenization	3
	uniform, non-local material	4
Riverbed relief	natural shape	**1**
	local alterations	2
	significant alterations	3
	anthropogenically caused uniformity	4
Hyporheic interstitial	unrestricted or naturally restricted	**1**
	small scale restricted	2
	existent just locally	3
	restricted or rudimentary	4

Example: parameter Riverbed; Evaluation for single parameters in orange/bold letters (2-1-1); **Mean 1,33**; Result for **parameter riverbed: class 1-2**

Greater/equal 1 and less/equal 1,2 - Class 1: undisturbed
Greater 1,2 and less/equal 1,7 - Class 1-2: little disturbed
Greater 1,7 and less/equal 2,2 - Class 2: moderately disturbed
Greater 2,2 and less/equal 2,7 - Class 2-3: clearly disturbed
Greater 2,7 and less/equal 3,2 - Class 3: heavily disturbed
Greater 3,2 and less/equal 3,7 - Class 3-4: very heavily disturbed
Greater 3,7 and less/equal 4,0 - Class 4: totally disturbed

The value for the total evaluation is the mean of all 5 main parameters. The interim evaluation and the total evaluation will be calculated automatically in Access.

2.2 Assessment of hydromorphological micro-/mesohabitats (transect method)

Within the restored and the degraded reach upstream, we select a sample section with 200 (or 500 m) length (compare 1.4 according to the length of recording sections). Each section is divided into 10 transects spanning the flood-prone area from one site to the other; transects will be consecutively numbered from 1 to 10 towards flow direction. The transect method for recording hydromorphology at meso- and microscale comprises two steps: 1. recording of channel features in the flood-prone area, 2. recording of aquatic microhabitats (Figure 26+Figure 27).

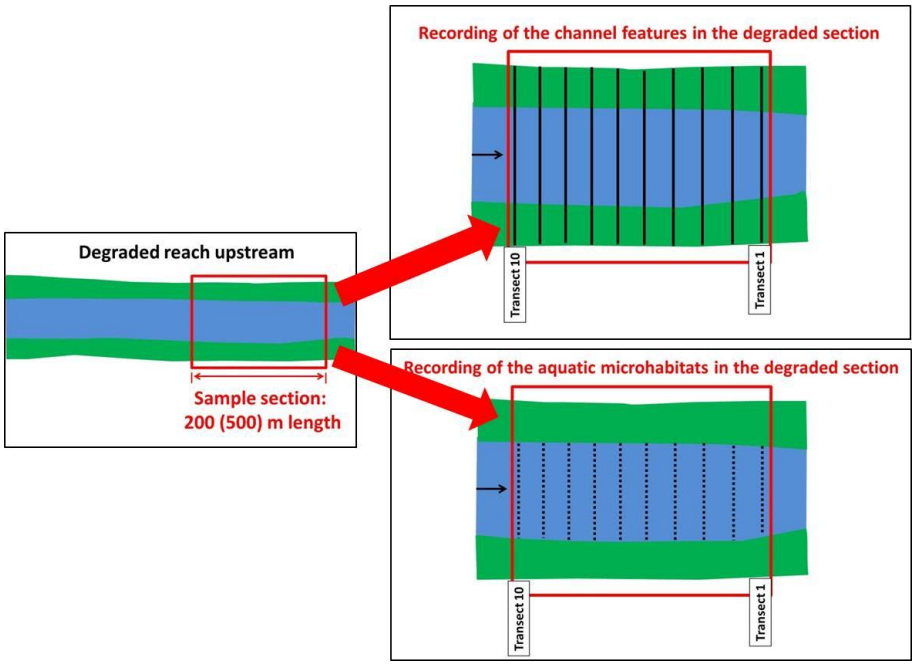


Figure 26: Recording of channel features/aquatic microhabitats along ten transects in the degraded section (continuous black lines: transects for recording channel features; dotted black lines: transect segments for recording aquatic microhabitats)

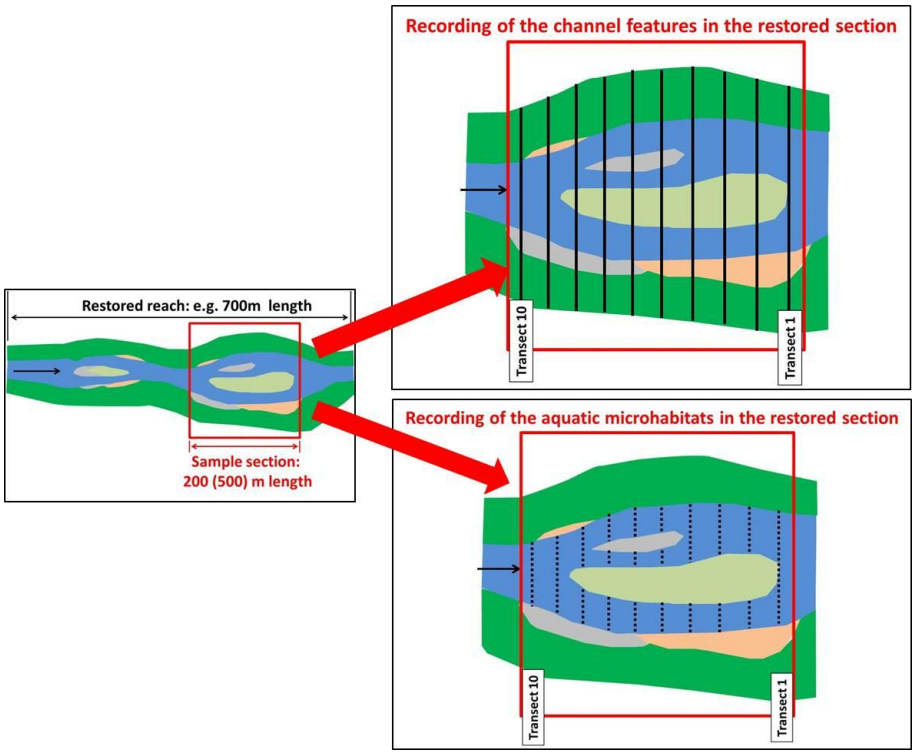


Figure 27: Recording scheme for the channel features /aquatic microhabitats in the restored section (continuous black lines: transects for recording channel features; dotted black lines: transect segments for recording aquatic microhabitats)

Recording of channel features

Each sample section will be investigated according to Jähnig et al. (2008) and Januschke et al. (2009). Channel features are categorized according to their position within the floodplain and their hydrological connectivity to the main river (Table 7). Along ten equidistant transects spanning the flood-prone area (Figure 28) the length of channel features will be measured and the dominant substrate (Table 8) of the channel feature will be recorded. Sampling area comprises the aquatic, transient and terrestrial area; in restored sections it is the bankfull discharge area, in degraded sections the area of high-water level. In case of a spatially extended floodplain, transects will span an area of max. 200m. We will mark the transects in an aerial picture; if it is georeferenced, the lengths of channel features can be measured before recording them in the field and adjusted easily in the field. Geographic coordinates (longitude, latitude, WGS84) of transect 1 and 10 will be recorded in each sample section. We will take pictures of at least of transect 1, 5 and 10.

Table 7: Channel features (modified after Raven et al. 1997 and Jähnig et al. 2008)

	Channel feature	Abbreviation	Description
Aquatic	Main channel	MC	Hydrological dynamic water body, most important runoff channel
	Secondary channel	SC	Hydrological dynamic water body, connected with the main channel at both ends, less water runoff
	Connected sidearm	CS	Water bodies lacking unidirectional current, connected only at the downstream or upstream end
	Disconnected sidearm	DS	No connectivity with the main channel
	Permanent standing water body	PSW	On the floodplains, fed by high water levels and groundwater, no signs of drying
	Temporally standing water body	TSW	On the floodplains, fed by high water levels, will dry out quite shortly, puddle-like
Transient	Bank with woody vegetation	BW	Woody aquatic-terrestrial transient zone with an inclination <10°
	Bank with herbaceous vegetation	BH	Herbaceous aquatic-terrestrial transient zone with an inclination <10°
	Side bar	SB	Unvegetated bar close-by the shoreline either at the floodplain or at an island
	Midchannel bar	MB	Unvegetated bar in the middle of main or secondary channel
Terrestrial	Island with woody vegetation	IW	Woody areas with higher elevation (→terrestrial), separating main and secondary channel(s) or separating main channel and floodplain
	Island with herbaceous vegetation	IH	Herbaceous areas with higher elevation, , separating main and secondary channel(s) or separating main channel and floodplain
	Artificial embankment	AE	Artificially created area e.g. with trapezoidal or rectangular profile, often built of blocks (technolithal) as bank fixation
	Embankment with woody vegetation	EW	Woody area with an inclination 10-30°, confines bankfull discharge area
	Embankment with herbaceous vegetation	EH	Herbaceous area with an inclination 10-30°, confines bankfull discharge area
	Steep unvegetated embankment	SE	Steep brim at riparian area with an inclination >30°; if inclination is 90°, it will be mapped with length=0
	Floodplain area	FA	Within bankfull discharge area, area prone to flooding

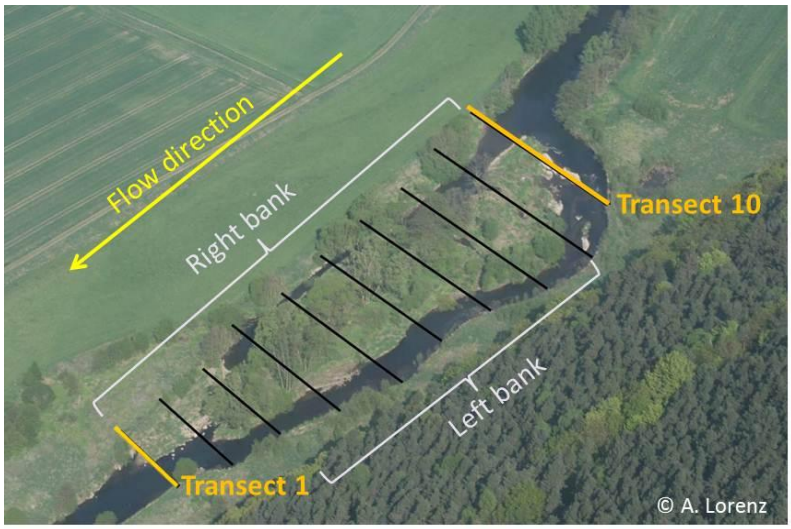


Figure 28: Example of a sample section with ten transects (black lines) for mapping of hydromorphology

Table 8: Substrates for instream microhabitat recording according to multi-habitat sampling protocol (Hering et al. 2003); substrates marked green are also used for recording of channel features

Substrate name for database	Substrate name	Abbreviation	Description	Type	Grain size [mm]
Mega-/ Macrolithal	Blocks	block	Large cobbles, boulders and blocks, bedrock; coarse blocks, head-sized cobbles, with a variable percentages of cobble, gravel and sand	mineral	>200
Mesolithal	Cobbles	cobble	Fist to hand-sized cobbles with a variable percentage of gravel and sand	mineral	>60-200
Microlithal	Coarse gravel	c-gravel	Coarse gravel (size of a pigeon egg to child's fist) with variable percentages of medium to fine gravel	mineral	>20-60
Akal	Fine gravel	f-gravel	Fine to medium-sized gravel	mineral	>2-20
Psammal	Sand	sand	Sand	mineral	>0.006–2
Argyllal	Loam	loam	Silt, loam, clay (inorganic)	mineral	<0.006
Technolithal	Artificial	techno	Artificial blocks often used as	mineral	>200

	mega-/ macrolithal		bank fixation in degraded sections		
Xylal	Large wood	wood	Tree trunks, dead wood, branches, roots	biotic	
CPOM	Coarse particulate organic matter	cpom	Deposits of coarse particulate organic matter, e.g. fallen leaves	biotic	
FPOM	Fine particulate organic matter	fpom	Deposits of fine particulate organic matter, e.g. mud und sludge (organic)	biotic	
Algae	Algae	algae	Filamentous algae, algal tufts	biotic	
Sub_ macrophytes	Submerged macrophytes	subm	Submerged macrophytes, including moss and Characeae	biotic	
Em_ macrophytes	Emergent macrophytes	emm	Emergent macrophytes, e.g. Typha, Carex, Phragmites	biotic	
LPTP	Living parts of terrestrial plants	lptp	Fine roots, floating riparian vegetation	biotic	

Aquatic microhabitats

First, common parameters concerning the whole sample section will be recorded (header of the field protocol). In detail, the parameters are:

- Number of:
  - unvegetated gravel/mud/sand bars
  - herbaceous gravel/mud/sand bars
  - woody gravel/mud/sand bars

  } Will only be recorded, if length/width is > 0,2m
- Number of :
  - unvegetated islands
  - islands with herbaceous vegetation
  - islands with woody vegetation
- Number of :
  - woody debris laying in the water with a volume > 1m³
  - deadwood trunks laying in the water with a diameter > 0,1m (not connected with woody debris)

- Number of:
  - standing water bodies
  - secondary channels
  - connected sidearms
  - disconnected sidearms

  } Will only be recorded, if they are hydrologically connected with the main channels in case of bankfull discharge

- Proportion of:
  - bank fixation left bank
  - bank fixation right bank

Second, for each of the ten transects (the same of channel feature mapping) the bankfull width and height will be measured. The measurement of bankfull width starts and ends at the point bankfull discharge; in non-restored it is the point of high-water level. The bankfull height is the vertical distance between the water surface and the line of bankfull discharge/high-water level (Figure 29).

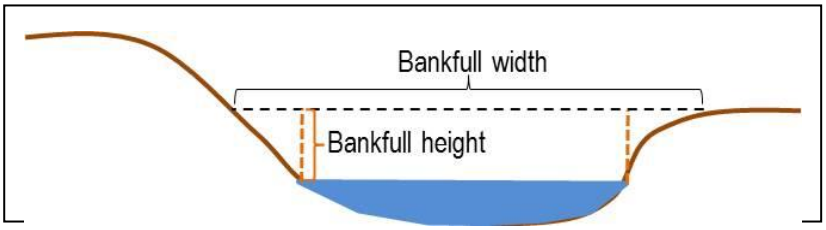


Figure 29: Example for determining bankfull discharge and measuring the height of left/right bank at a transect.

Third, the following parameters within the water body will be recorded at 10 survey points along each transect, whereas:
Distance between the survey points = (width of water surface – 20 cm)/9, resulting from the fact that survey point 1 and 10 have a respective distance of 10 cm from the left/right bank. If secondary channels, connected or disconnected sidearms are present, so that the water body along a transect is divided into two or more areas, survey points will be distributed proportionally to their lengths on the transect.

The following parameters will be mapped at each survey point:

- depth of water body [m]
- dominant substrate (Table 8)
- estimated flow velocity (scale from 0 to 4):

Flow velocity class	Description	Flow velocity [m/s]
0	stagnant	0
1	slow	<0,3
2	rippled	0,3-0,5
3	swirled	0,5-1
4	turbulent	>1

Field forms for the transect method: Appendix 7.2.

3. Stable isotope analysis

3.1 Introduction

This sampling protocol for stable isotopes supports the investigation of effects of river restoration on ecosystem services. It states what and how to sample along the investigated section of a stream and how to treat fresh samples before freeze-drying. Always make sure that there is a sufficient amount of collected samples for further treatment, as it is much easier to discard excess material in the laboratory than collecting new. Always keep the labeling of samples in mind, record the Number (N) of the individuals as each sample will be a composite sample of several individuals and identify individuals to the lowest feasible taxonomic level.
Minimum dry-weight of each sample should be > 50 mg to allow further processing. All samples should be processed as soon as possible. Identical treatment between all partners is important to avoid affecting the isotopic signature and to obtain most comparable results.

3.2 Aims

The sampling procedure and the stable isotope analysis support the investigation of effects of river restoration on ecosystem services (functional parameter). It aims to show the effect of hydromorphological restoration on aquatic terrestrial linkages and on the complexity of food webs by comparing restored and degraded reaches across Europe.

3.3 Sampling

3.3.1 Overview

Figure 30 shows what to sample for the stable isotope analysis along the investigated section of the stream (cf. Appendix 7.3.3). Take samples at time of maximum biomass.

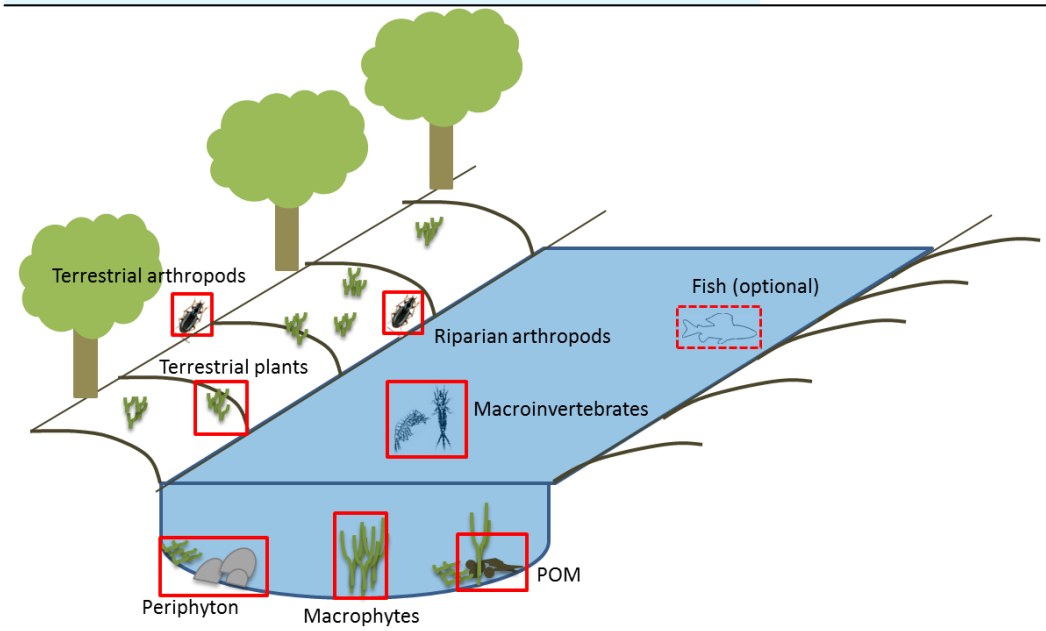


Figure 30: Overview of samples to be taken for stable isotope analysis

3.3.2 Stream bed organic sediment (POM)

Samples of fine (< 1mm) and coarse (> 1mm) particulate organic matter (POM) should be taken with a sediment corer (or s.th. similar). Take these samples at deposition zones of the stream bed (e.g. in macrophyte stands). Transfer the upper 1-2 cm of the sediment core to a sample container/bucket. Repeat this procedure in 10 POM deposition zones within the section and pool the samples in one bucket.

In the laboratory, the sample should be wet sieved through 1 mm to separate fine and coarse POM. The sieving can be simplified by transferring the sample into a larger bucket with added stream water. Stir the bucket and carefully decant the organic matter into the sieves. To avoid clogging an extra sieve can be added. Take a sample from both (fine and coarse) fractions and freeze them (each sample of approx. 100 g fresh weight). Both samples should be inspected visually to remove all inorganic matter, any macroinvertebrates and/or fragments of fresh plants prior to freezing.

3.3.3 Periphyton

Collect periphyton from randomly selected plants and/or stones depending on the dominant substrate types at the section. Take approx. five plant samples (only those covered with periphyton should be selected). Lift the plants by cutting the stem and carefully move them into plastic bags. Stones (approx. 10) should carefully be rinsed in stream water to remove excess organic matter. Then brush the stones over a tray to take off the periphyton. As filtering is time

consuming, use as little water (stream water) as possible. Then store the stone sample (scraped off from the stones) in a container in the field.
In the laboratory, remove the plants from the plastic bags and scrape off the periphyton carefully. This can be done in a white tray with a little stream water using a razor blade or a toothbrush (this can also be done in the field). Avoid damaging the plant tissue. Afterwards the water in the tray should be filtered (using Whatman GF/F filters). The retained periphyton on filters after filtration should be pooled. Likewise, the stone sample is filtered on Whatman GF/F filters to remove excess water. The periphyton samples taken from stones and plants should be pooled and frozen. Before freezing, the sample should be inspected visually to remove all inorganic matter, any macroinvertebrates and/or fragments of fresh plants.

3.3.4 Macrophytes and terrestrial plants

Take samples of the dominant primary producers along the section and identify them to genus level. Therefore one sample of the dominant macrophyte species (submerse or emerse) should be taken and one sample of the dominant terrestrial species of the sand or gravel bars (herbaceous riparian vegetation). Collect from several different plants/stands of the same species (to achieve a representative composite sample) and put them into plastic bags. Use one plastic bag for each species. Do not collect the root and make sure to take sufficient sample (approx. 100 g fresh weight i.e. approx. one plastic bag 25 x 30 cm). Remove invertebrates and loose organic material by rinsing the plants in water prior to freezing. Avoid dead tissue.
If biofilm covers the macrophytes (this should be assessed visually) it should be removed by scraping before freezing. This can be done in a white tray with a little stream water using a razor blade or a toothbrush. Avoid damaging the plant tissue. Afterwards the water in the tray can be filtered and frozen to determine the signal of the biofilm. This can either substitute or complement the periphyton sample.

3.3.5 Macroinvertebrates

Take samples of macroinvertebrates from different habitats along the section using a shovel sampler (mesh size 500µm). The exact area to be sampled is not important, merely that a sufficient amount of macroinvertebrates is collected for further treatment. Late-instar larvae should be sampled, as it reflects its isotopic composition at the time of emergence when it is most prone to predation by riparian arthropods.
Make sure that the collected macroinvertebrates reflect functional feeding groups (FFG). The samples should include the following FFG. Focus on the taxa named below:

- Predators (*Rhyacophila* sp., *Sialis* sp., or equal),

- Grazer (*Baetis* sp., *Rhithrogena* sp., or equal),
- Shredders (*Gammarus* sp., *Asellus* sp., *Nemoura* sp., or equal),
- Collector-gatherers (Oligochaeta, or equal),
- Collector-filterers (*Hydropsyche* sp., *Simuliidae* sp., or equal).

Sample other FFG when present in high density. Sorting of macroinvertebrates should be done directly in the field (use polypropylene bottles). In contrast to the biotic sampling, macroinvertebrates for stable isotope analysis are not treated with alcohol as this might affect the isotopic signature of the sample.
In the laboratory, macroinvertebrates should be identified to genus level and kept individually, i.e. individuals should be separated by species/functional types and allow time for gut clearance (approx. 24 hours). Avoid having to many individuals together and avoid contact between predators and prey. Therefore put each group of individuals in petri dishes with a thin layer of water (filtered stream water). Cover the petri dishes with a lid so that mobile macroinvertebrates cannot escape. Put the dishes in the refrigerator (at approx. 5°C).
For each FFG minimum one composite sample (composed of approx. 15 individuals consisting of one of the taxa named above) should be taken (if present). An adequate sample size usually covers the bottom of a vial (diameter = 2.5 cm). Record the exact amount of individuals (N) within each sample. If case-bearing caddis flies are used as a FFG, remove cases prior to freezing.

3.3.6 Riparian arthropods and terrestrial arthropods

Collect riparian arthropods from the family Carabidae (*Bembidion* sp.) within 1 m of the stream edge at randomly selected locations along the section using aspirators, forceps and/or exhaustors. Separate them by size immediately (use polypropylene bottles). Figure 31 shows *Bembidion decorum* as an example for riparian arthropods.

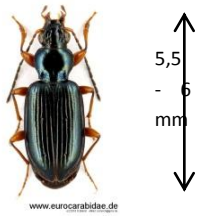


Figure 31: *Bembidion decorum* (www.eurocarabidae.de)

To infer possible terrestrial food sources of riparian arthropods indirectly, samples of predaceous terrestrial arthropods from the ground at randomly selected locations across the top edge of the embankment should be taken, simultaneously with riparian arthropods. Group them by taxon and size class to infer potential terrestrial food sources for the Carabidae more specifically (as taxon-specific foraging behavior and predator size mostly determine the potential

prey). Hence it is necessary to collect terrestrial predators that represent riparian arthropods in size.
In the laboratory, allow time for gut clearance (approx. 24 hours). Always keep riparian and terrestrial arthropods separated from each other! Avoid having to many individuals together and avoid contact between predators and prey. Therefore put each group of individuals in petri dishes, cover the dishes with a lid so that they cannot escape and put the dishes in the refrigerator (at approx. 5°C).
Several individuals (approx. 15) of each taxon and/or size class are needed for one composite sample and minimum one sample has to be taken for riparian and terrestrial arthropods each.

3.3.7 Fish (optional)

As it is necessary to take tissue samples (liver and dorsal muscle) for the stable isotope analysis, getting the license for this procedure might be difficult in some countries. Hence taking fish samples is optional.
In case fish samples are taken, identify them to species level and measure length and weight of each fish. For the stable isotope analysis a fresh weight of about 10 mg of the tissue is needed, i.e. a small piece of tissue (< 1 cm^3). The individual tissue samples should be frozen in plastic vials and labelled as shown in Appendix 7.3.1.

3.4 Treatment of samples/sample processing

3.4.1 Treatment

All samples should be placed in a frost box in the field. Macroinvertebrates and riparian/terrestrial arthropods should be treated as described before for gut evacuation. After gut clearance they should be frozen (at -18°C) until further processing. All other groups should be put in a freezer (at -18°C) as soon as possible if they are not processed immediately.

3.4.2 Processing

All samples should be processed as soon as possible. Therefore each sample should be ground into fine powder to obtain a homogenized composite sample (make sure that the homogenized sample consists only of individuals of the same species, or size class in case of carabidae!). The homogenized samples should be transferred to Eppis 2 ml (Eppendorf-reactor vessel). Then all samples have to be freeze-dried (between -55° and -60°C) until all water has been removed (samples can also be freeze-dried before they are homogenized). Afterwards samples have to be stored dry and dark (Exsiccator) before they are send to the laboratory for stable isotope analysis. Make sure that samples are labeled correctly (see Appendix 7.3.1) and that there is no contamination between

samples.
Identical treatment between all partners is important to avoid affecting the isotopic signature and to obtain most comparable results.
Minimum dry-weight for each sample: > 50 mg

3.4.3 Analysis

For further processing all labeled (see appendix 7.3.1 for right labeling) samples– freeze dried, finely ground to a homogenized composite sample and dry packed– should be send to the laboratory for the analysis.
It is recommended that all partners use the same laboratory to ensure identical treatment and thereby obtain most comparable results.

We offer to send the samples to:
Benjamin Kupilas
University of Duisburg-Essen
Department of Aquatic Ecology
Universitätsstraße 5
D - 45141 Essen

4. Biotic sampling

4.1 Macroinvertebrates

The sampling of benthic invertebrates should follow an EU Water Framework Directive (WFD) compliant sampling protocol (e.g. Haase et al. 2004). We propose the multihabitat sampling standardized in the AQEM and STAR projects, which reflects the proportion of the microhabitat types that are present with > 5% cover. Samples should be taken from a 200m long stream section (Figure 32).

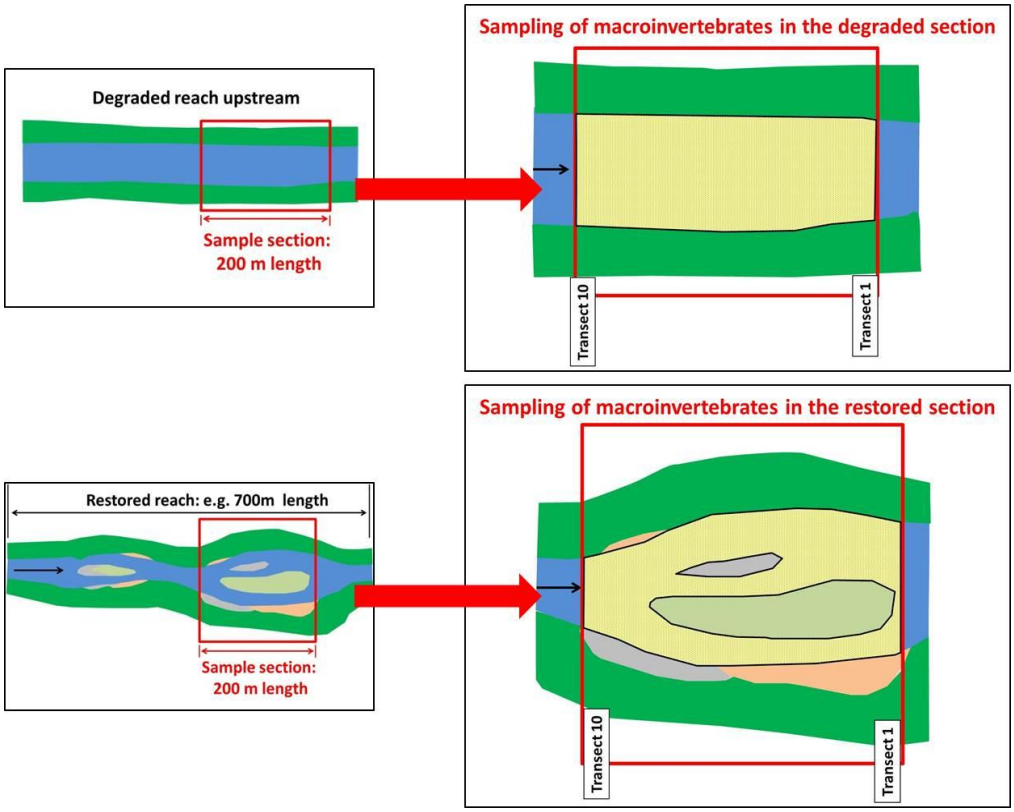


Figure 32: Sampling scheme for macroinvertebrates in the degraded and restored section (sample area is marked in yellow)

At each section, 20 individual samples (sample units) must be taken with a hand-net/shovel sampler or a surber sampler with a mesh size of 500 µm (Figure 33). The recommended area is 25 x 25 cm each, resulting in 1.25 m2 of river bottom being sampled.

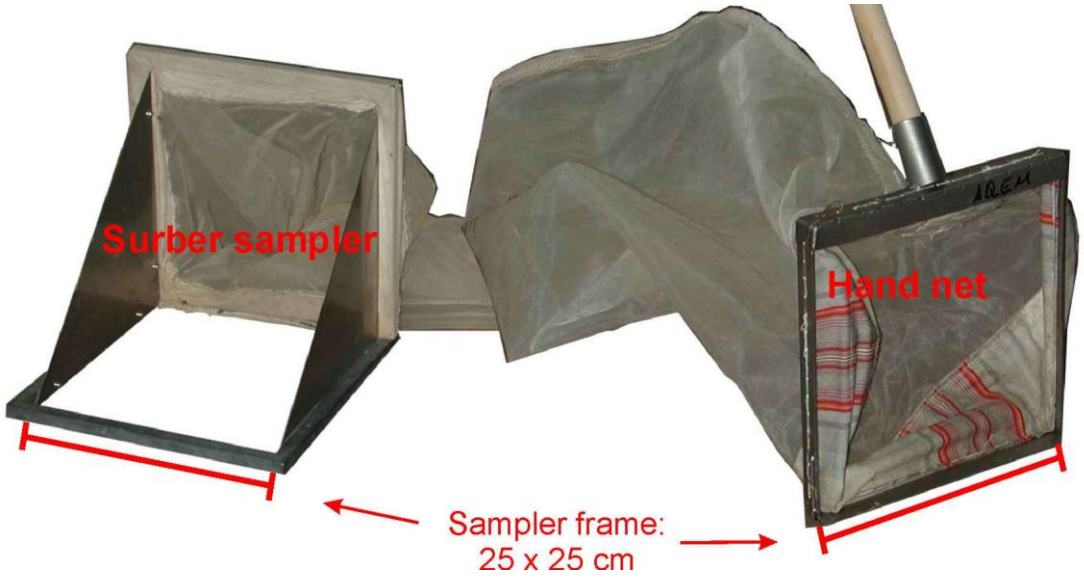


Figure 33: Surber sampler and hand-net

A "sampling unit" is a stationary sampling accomplished by positioning the net and disturbing the substrate for a distance that equals the square of the frame width upstream of the net (0.25 x 0.25 m). The 20 "sampling units" must be distributed according to the share of microhabitats (Figure 34). For example, if the habitat in the sampling section is 50% psammal (sand), then 10 "sampling units" must be taken there. The categories of microhabitat composition are to be taken from the site protocol.

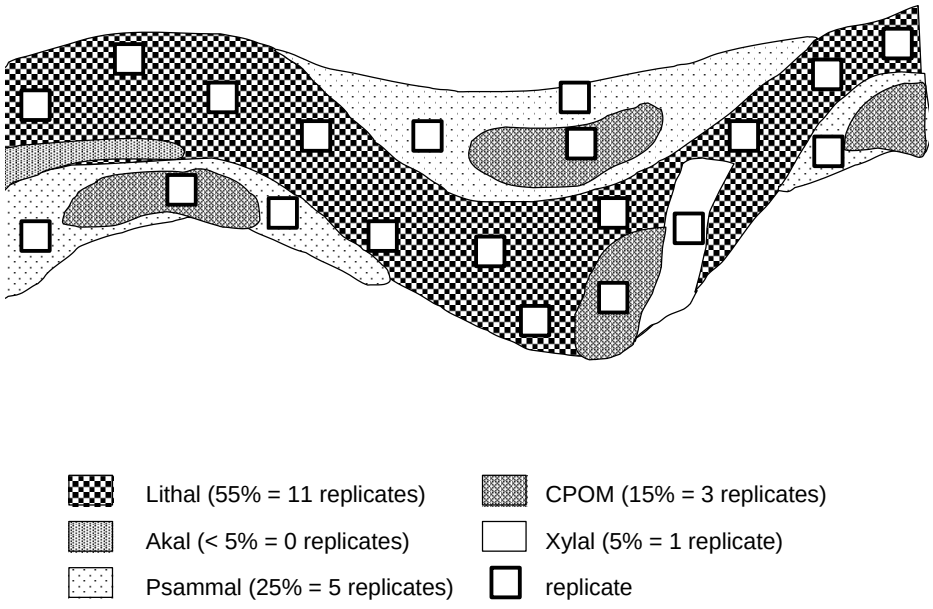


Figure 34: Example of "sampling unit" position in a theoretical sampling section according to the „multi habitat sampling" method applied in the AQEM and STAR project.

More specifically, the "multi-habitat sampling" procedure is performed in the following steps:

4.1.1 Preparation

1. **Select an appropriate sampling section**. The length of the sampling section should be 200 metres. The sampling section must cover the whole width of the stream and be representative for the restored reach; in case of the degraded reach it should be representative for a minimum survey area of 500 meters stream length. Before sampling, the field form should be completed. However, the sampling area should not be disturbed by physical contact, if at all possible. Therefore, after sampling, this information should be reviewed for accuracy and completeness.
2. Based on the microhabitat list given in the field form, the **coverage of all microhabitats** with at least 5% cover is recorded to the nearest 5% interval, the presence of other microhabitats (<5% cover) is only indicated (by "X").

If you have problems to estimate microhabitat composition from the bank, it is allowed to enter the stream (one access point per 20 metre stream length). However, the area accessed must not be sampled. Since especially the proportion of the rare habitats around 5% coverage is difficult to estimate, the estimation of microhabitat cover might be refined during sampling.
The estimation of microhabitat composition comprises the following steps:

- Estimation of the cover of all substrates; the sum of the coverage of all individual microhabitats must be 100% (1st column of the table).
- Based on estimation of microhabitat coverage the number of sampling units in the individual habitats is determined and indicated in the field form (2rd column). For example, if a sampling section consists of 50% mesolithal (pebbles and stones), 25% psammal (sand) and 25% CPOM, then 10 sampling units should be taken in the mesolithal, 5 sampling units in the psammal and 5 sampling units in the CPOM. Every microhabitat covering at least 5% of the s bed must be sampled.

When allocating your sampling units you should take into consideration that microhabitats may be unequally distributed between:

- Lentic and lotic sites; the distribution of sampling units in an individual microhabitat should therefore reflect its proportion in lentic and lotic zones.
- The sampling units in habitats with a very high proportional coverage (e.g. mesolithal in lotic sites) should be distributed between the stream margin and central zones of the stream bed, e.g. in form of a transect.
- The distribution of sampling units in organic microhabitats should consider, which mineral substrates they are covering. E.g., if submerged macrophytes are equally distributed on macrolithal and akal, half of the

macrophyte sampling units should be taken in macrophytes growing on macrolithal, and the other half in macrophytes growing on akal.

4.1.2 Sampling

1. Sampling starts at the downstream end of the section and proceeds upstream.
2. When sampling the "sampling units" use the hand-net either as a kick net, or for "jabbing", "dipping" or "sweeping" (Figure 35). When kick-sampling, hold the net vertically with the frame at right angles to the current, downstream from your feet, and disturb the stream bed vigorously by kicking or rotating the heel of your boot to dislodge the substratum and the fauna within a depth of at least 10 cm. Disturb the substrate in the 0.25 x 0.25 m area upstream of the net. Hold the net close enough for the invertebrates to flow into the net with the current, but far enough away for most of the sand and gravel to drop before entering the net. Move cobbles and large stones by hand, sweep or brush the surfaces to dislodge clingers and sessile organisms. It is recommended to deposit wood and cobbles in a plastic bucket for a later inspection to remove adhering animals by hand-picking with forceps. To dislodge the animals from the interstices of the sediments, the substrate should be disturbed with a screwdriver or similar device. The surface of soft sediments and fine or organic microhabitats should be sampled by pushing the hand-net gently through the uppermost 2-5 cm of the substratum. In shallow waters with a strong current an open Surber sampler can be used instead of a hand-net (Figure 36). To sample with an open Surber sampler in slow-flowing areas the sediment within the Surber frame can be disturbed using the hands, in the normal fashion, and then a current created by pushing water through the net with the hands to trap the animals. It is possible to use different devices for different microhabitats, as long as the same area is sampled.

Some further comments on sampling selected microhabitats:

- Stones with noticeable algae cover can also be considered as part of mineral substrate. Algae that grow in tufts or bigger fractions are considered as organic habitat.
- Megalithal (boulders): It is recommended to sample different positions (frontal, sideways) for different sampling units.
- Xylal (woody debris): Avoid relatively new deadfall that lacks microbial conditioning. Washing the samples into a bucket is effective. Alternatively: take the woody debris out, spray on a net, lay down in sun and pick the animals. Sweeping followed by vigorous shaking is effective for roots.
- CPOM (leaf litter): wash carefully in field, avoid taking a large amount of leaves to the lab.

- Macrophytes should be searched for pupae and taken to the lab for further examinations, because especially Simuliidae cannot be washed off in the field. The sampling of an adequate area of the macrophyte stand is recommended instead of taking some sweeps with the hand net. For this purpose, macrophytes covering an area of 25 x 25 cm must be cut and transferred into the net. The sediments below the macrophytes must be sampled, too. This procedure is to be applied for both, floating and emergent macrophytes.
- Microlithal/Akal: Care should be taken to minimise the amount of sand in the sample.
- Deep parts of a river which cannot be sampled by moving cobbles and large stones by hand, must be sampled by kicking the substrate. For this purpose, hold the net vertically with the frame at right angles to the current, downstream from your feet, and disturb the stream bed vigorously by kicking or rotating the heel of your boot to dislodge the substratum and the fauna within a depth of at least 10 cm.

3. Rinsing: After every three sampling units (or more frequently if necessary) rinse the collected material by running clean stream water through the net two to three times. If clogging occurs, which may interfere with obtaining an appropriate sample, discard the material in the net and redo the sampling unit in the same habitat type but at a different location.

Figure 35: Using a hand-net for jabbing and sweeping.

Figure 36: Kick-sampling.

4.1.3 Follow-up treatment

1. **Removal of large material and sorting**: Large wood and stones can be removed after being rinsed and inspected for clinging or sessile organisms. Any organisms found have to be placed into the sample container.

Generally, it is recommended not to spend time inspecting small debris in the field; however, large and fragile organisms (e.g. Ephemeroptera) or species that cannot be preserved (e.g. Tricladida, Oligochaeta) should could be picked out of the sample in the field (a maximum of 20 representative organisms in total). These organisms should be stored in a small separate container containing only organisms but no substrate.

2. **Removal of large organisms**: Large and rare organisms, which can easily be determined in the field (such as large mussels or crayfish), should be removed from the sample, recorded and be placed back in the stream.

3. **Storing**: Transfer the sample from the net to sample container(s) and preserve in enough 95% ethanol to cover the sample immediately after collection. This form of fixation is important to prevent carnivores, particularly stoneflies (Setipalpia), beetles (Adephaga), caddis larvae (e.g. Rhyacophilidae), Sialidae and certain Gammaridae, from eating other organisms. The final ethanol concentration should be around 70%. When using ethanol, water in the sample should be decanted before adding the fixation liquid. The sample container should close tightly. The samples should be stored cool. The whole sample should be lumped together and treated as one sample.

4. **Labelling**: Place a label (written in pencil, printed on a laser printer or photocopied) indicating the following information inside the sample container:

   - stream name
   - site name
   - site code (optional)
   - date of sampling
   - investigators name

   The outside of the container should include the same information and the words "preservative: 95% ethanol". If more than one container is needed for a sample, each container should be labelled with all the information on the sample and should be numbered (e.g., 1 of 2, 2 of 2, etc.). If rare taxa (e.g. crayfish, large mussels) have been identified in the field and returned to the river, record their presence and abundance on the label placed in the sample containers as well as on the sample protocol. If possible, label and place the container with the rare and fragile organisms into the main sample container and note its existence in the site protocol.

4.1.4 Sample Processing

Subsampling and sorting

Rationale for subsampling

- reduces the effort required for sorting and identification
- provides an unbiased representation of a large sample
- provides a more accurate estimate of time expenditure
- thus, it reduces costs for the process of macro-invertebrate samples

The following subsampling procedure is based on Caton (1991).

Subsampling devices

The subsampling device comprises (see Figure 37 and Figure 38):

- the (inner) gridded pan with 6 x 5 grids, each 6 x 6 cm, and a 500 µm mesh bottom
- the outer tray (watertight) to facilitate homogenization of the sample
- "cookie cutter" (6 x 6 cm)
- small shovel or a teaspoon to remove the material from the grids
- pair of dices or a random number table

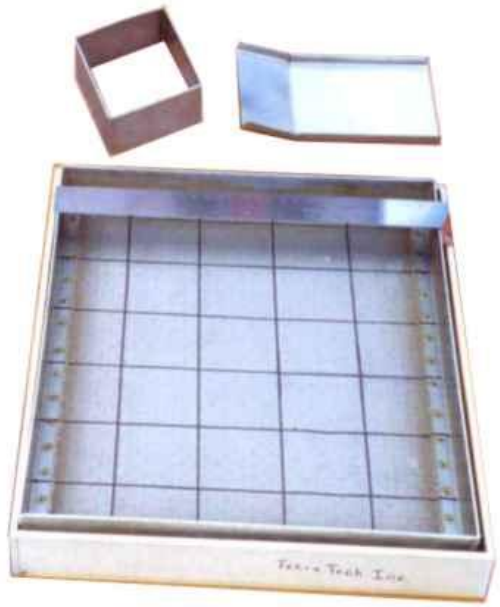


Figure 37: Subsampling gear: pan, grid and devices to remove debris from selected grids

Figure 38: Subsampling procedure.

The following steps of subsampling are to be processed in the lab under controlled conditions:

1. If the sample was stored in more than one container, the contents of all containers for a given sample are combined.
2. The preservative is carefully decanted from the preserved sample through a 500 µm sieve. Inspect the sieve for any organisms and retrieve attached organisms.
3. Thoroughly rinse the sample over a 500 µm sieve to remove preservative and fine sediment. It is particularly recommended to follow this step if the samples are preserved with Formalin. Avoid direct contact with formalin! Do not use too much pressure on the water in order not to force the specimens through the sieve mesh.
4. Transfer the washed material into the gridded pan (inner pan) and homogenise the material. Therefore, place the gridded pan into the outer tray and add a sufficient amount of water to facilitate the procedure. Spread the sample material evenly throughout the gridded pan (Figure 37). Move the material also into the corner. Do not remove large or rare species from the pan.
5. If macrophytes are included into the sample they have to be treated the following way: If no sessile animals are attached the macrophytes have to be rinsed in a bucket by vigorously shaking and need to be controlled for remaining specimen afterwards. If few sessile organisms are attached, they should be removed by hand and treated as above. If many sessile organisms are attached, the macrophytes have to be sub- sampled in the pan.
6. Lift the gridded pan out of the outer tray to drain. Pour the water off the tray, but leave just enough water to keep the bottom of the gridded pan moist when it is returned to the tray.
7. Use dices or a random number table to select a grid to process.

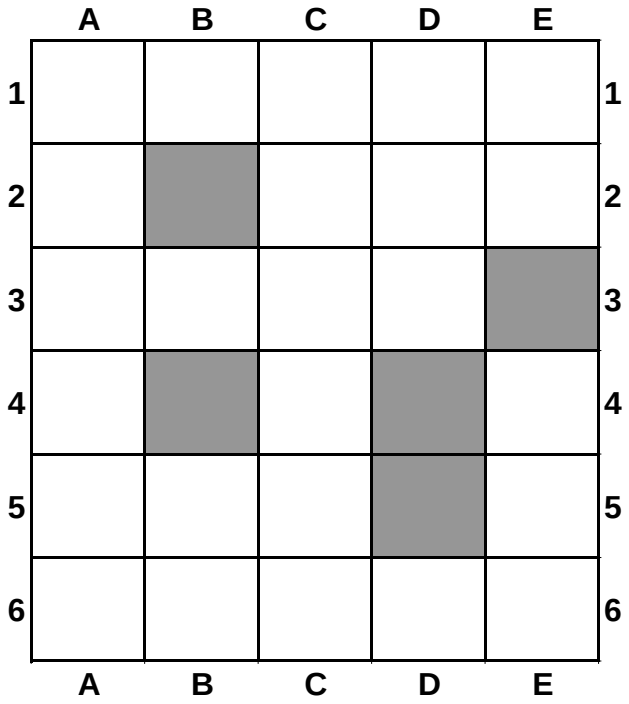


Figure 39: Subsample pan with 5-grids to be subsampled at least (= 1/6th of the whole sample) Grids to be processed: B2, B4, D4, D5 and E3

8. Remove all the material from that grid with a scoop or teaspoon, and place the removed material into a separate white tray. Repeat this process until 5 grids have been processed (5 grids represent a 6th of the total sample material).
9. It might be necessary to cut the material along the outside of the "cookie cutter" with scissors to push the cookie cutter carefully onto the bottom of the gridded pan. Inspect the bottom for any remaining organisms.
10. If there appear to be a number of organisms that equal or exceed the targeted number (350 individuals), then subsampling is finished. Sort out the whole 5-grid composite sample. Place the sorted organisms in vials with sufficient preservative, and label every vial and the sorted material accurately for further processing. The animals sorted should be separated into systematic units.
11. If the 5-grid composite subsample contains less than 350 organisms, then randomly select and process one additional grid. Pick out the specimens from the material. Repeat this process until the targeted number of 350 organisms is achieved. Remember: Each grid once begun has to be sorted out completely, even if the 350th organism is counted halfway.
12. While sorting out the subsampled material, prevent the remainder material in the gridded pan from desiccation. This can be done by covering it with aluminium foil. It is recommended to periodically moisten the sample with water from a spray bottle if necessary.

13. Avoid disturbance of the subsampling device in order not to redistribute the sampling material and containing organisms between two subsampling operations.

Sorting rules

Some rules for the removal of organisms:

- An organism belongs to the grid containing its head.
- If the head is difficult to locate, the organism is considered to be in the grid containing most of its body.
- If the head of an organism lies on the line between two grids, all organisms on the top of a grid and those on the right side of a grid belong to that grid.
- The animals sorted in the lab should be separated into systematic units.
- for Oligochaeta try to remove and count only whole specimens or fragments that include the head.

Note the total number of processed grids and the number of organisms contained in the grids in the laboratory sheet.

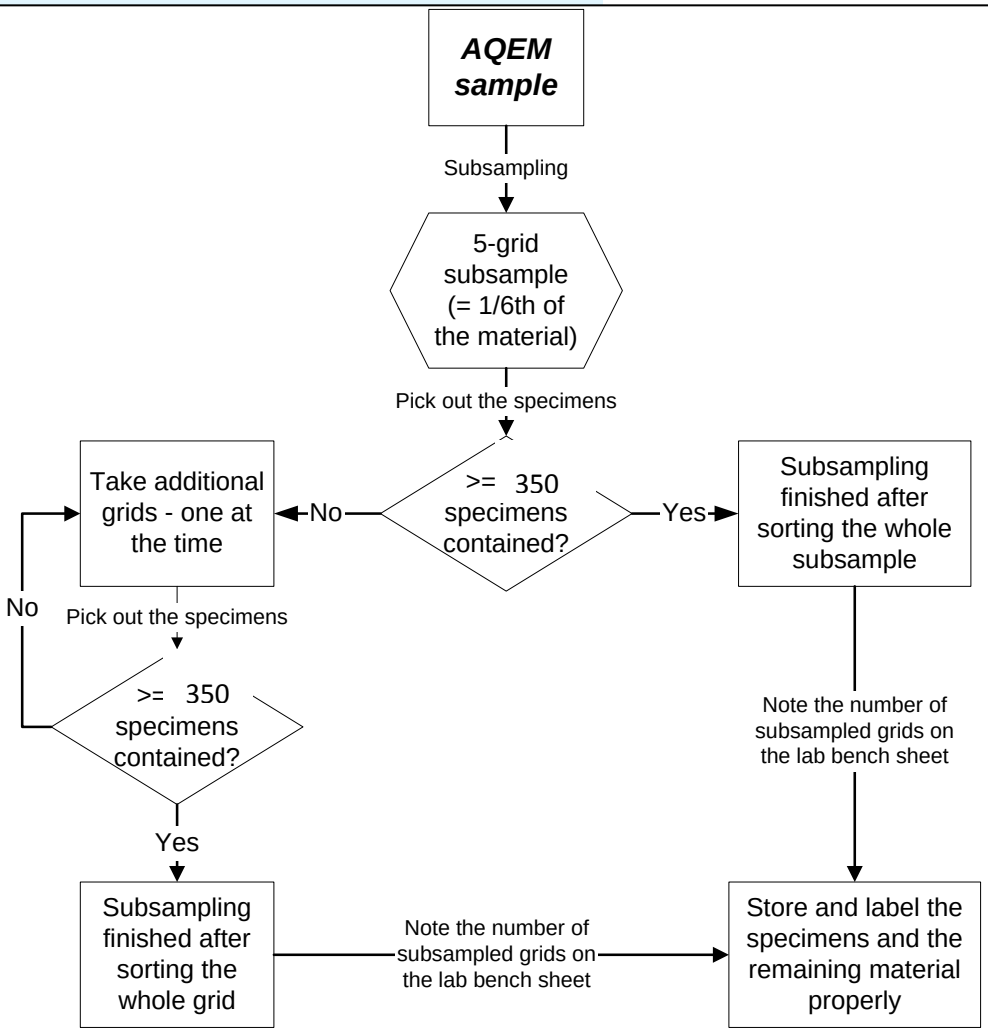


Figure 40: Flowchart of the subsampling procedure. The example is based on the original subsampler after (Caton 1991) with 30 grids, each 6 x 6 cm. A minimum amount of 1/6th of the material has to be subsampled, containing a minimum number of 350 specimens

The recommended sampling season is early summer (June to July) before the emergence period of many Trichoptera and Ephemeroptera species. At each site, sampling of the restored and control sections will be done on the same day by the same person. Taxa will be identified to the lowest possible level. For most taxa, the resolution will be at the genus or species level, but selected families such as Chironomidae, and Oligochaeta will be identified to the tribe, sub-family, or family level.

4.1.5 Additional macroinvertebrate sampling in lentic habitats

In the majority of restoration measures, one of the main differences between restored and morphologically degraded sections is the configuration of the bank structure. Restoration measures create shallow and slow flowing areas at the

river banks. We would like to account for this difference and explore the benthic communities at the river margins/banks.
At every section 5 sample units should be taken with the shovel sampler in the lentic zone.
The lentic zone is characterized by:

- flow velocities between 0 and 30 cm/s
- a water depth between 1 and 30 cm

If there are different microhabitats present in the lentic zone, the 5 samples should be allocated accordingly. The 5 sample units will be pooled and subsequently sorted completely in the lab.
Identification of the organism should be the same level as in the normal composite sample.

Field protocols: Appendix 7.4

4.2 Macrophytes

Macrophyte sampling is conducted in the main growing season (July to mid-September). A 200-m section per reach will be surveyed for macrophytes by wading in a zigzag manner across the channel and walking along the riverbank (Figure 41+Figure 42).

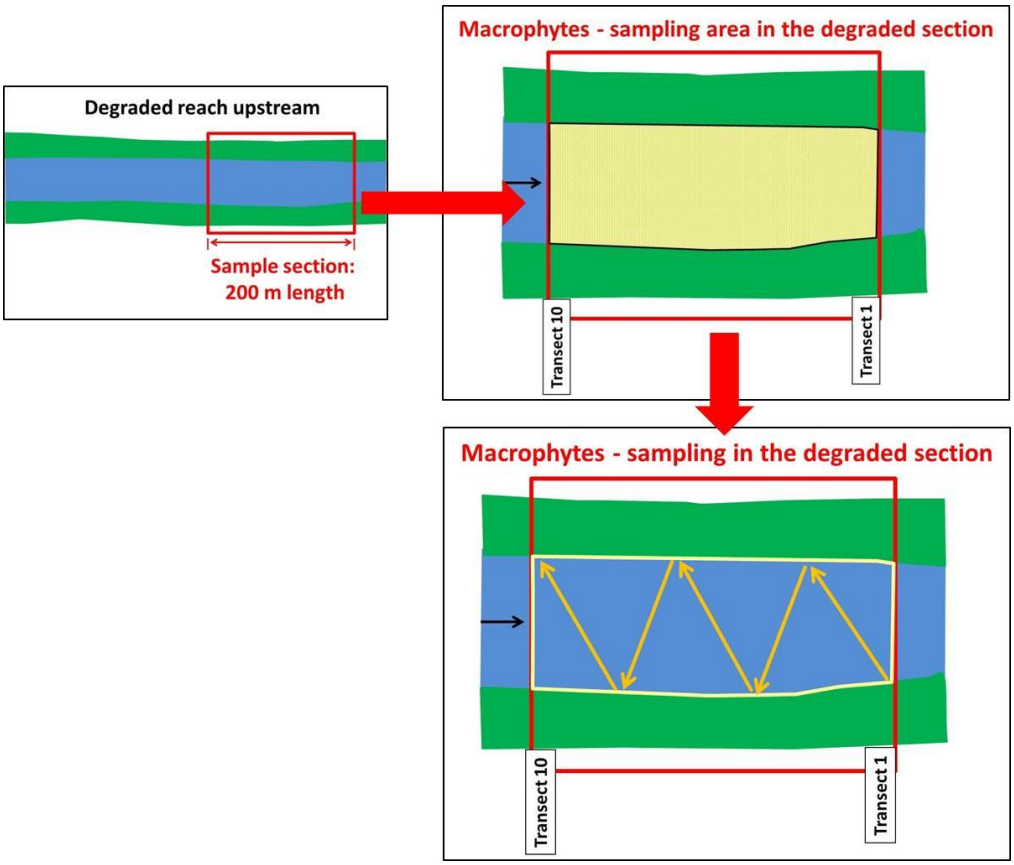


Figure 41: Sampling of macrophytes in the degraded section (sample area is marked in yellow; orange arrows show the way of wading)

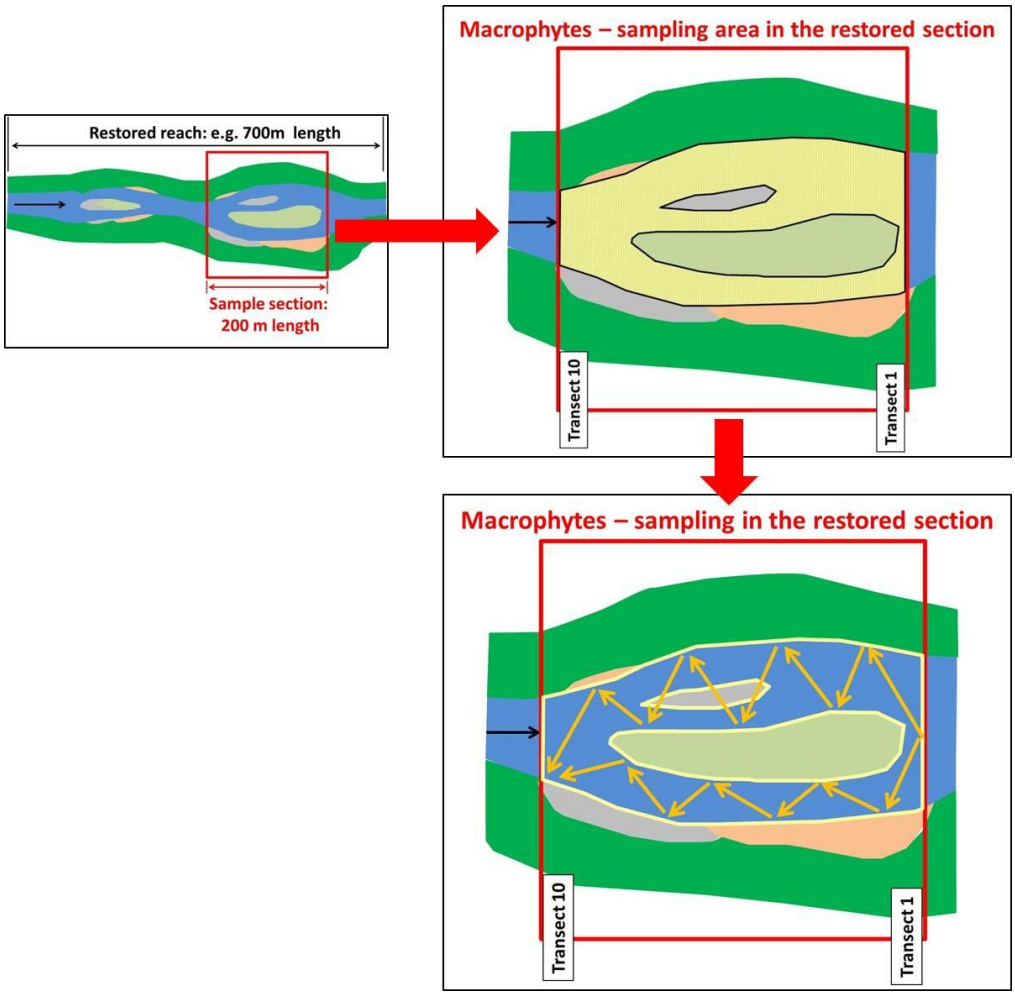


Figure 42: Sampling of maccrophytes in the restored section (sample area is marked in yellow; orange arrows show the way of wading)

In non-wadeable areas, the river bottom will be raked with a rake (on a long pole or at the end of a rope) to reach the macrophytes. All macrophyte species will be recorded and identified to the species level, except for Callitriche stands without fruits, which will be identified to genus level. The survey includes all submerged, free-floating, amphibious and emergent angiosperms, liverworts and mosses. In addition, plants will be recorded which are attached or rooted in parts on the river bank that are likely to be submerged for more than 85% of the year. The abundance of each species should be recorded according to the 5-point NOVANA scale: 1= 1-5%; 2= 5-25%; 3= 25-50%; 4= 50-75%; 5= 75-100%. Additionally, the growth form of each species should be recorded according to Den Hartog & Van der Velde (1988) and Wiegleb (1991). The growth forms comprise different plant species that realized the same or comparable phenotypical adaptations to the aquatic environment.

Field protocol: Appendix 7.5

4.3 Riparian arthropods

Riparian arthropods, especially carabid beetles are good indicators for changing environmental conditions (Kotze et al. 2011). Even if terrestrial organism groups are not included in the WFD, they could be easily and successfully used to detect effects of restoration measures (Günther and Assmann 2005, Lambeets et al. 2008, Januschke et al. 2011). They strongly benefit from the creation of near-natural floodplain habitats including e.g. unvegetated bars or vegetated swamps. Sampling season for riparian arthropods will be late June to early August, in the Scandinavian sites ideally August, in the Mediterranean sites ideally late June. Sampling must be performed at conditions of low discharge. As for most organism groups, the composition of the riparian fauna strongly depends on habitats. Therefore, sampling will be mesohabitat-specific and be done in a max. 10 m wide stripe of the riparian areas of each sample section (Figure 43 + Figure 44). If banks have a shorter width (common in degraded reaches), sampling area only spans the area of high-water level. Sometimes, the banks of degraded sections are made up of riprap so it is impossible to install the traps in the area of high-water level; in this case, we position the traps in the embankment, but preferably in the shortest distances from the area of high-water level.

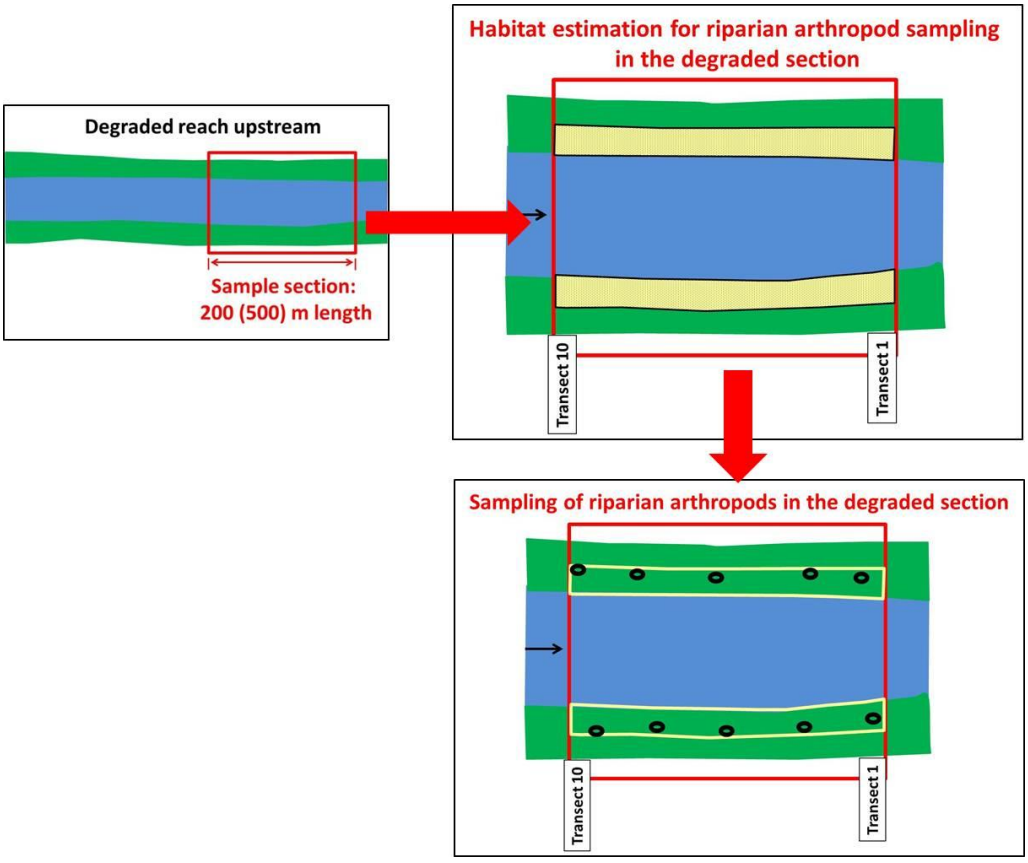


Figure 43: Habitat estimation and sampling of riparian arthropods in the degraded section (sample area is marked in yellow; black rings = pitfall traps).

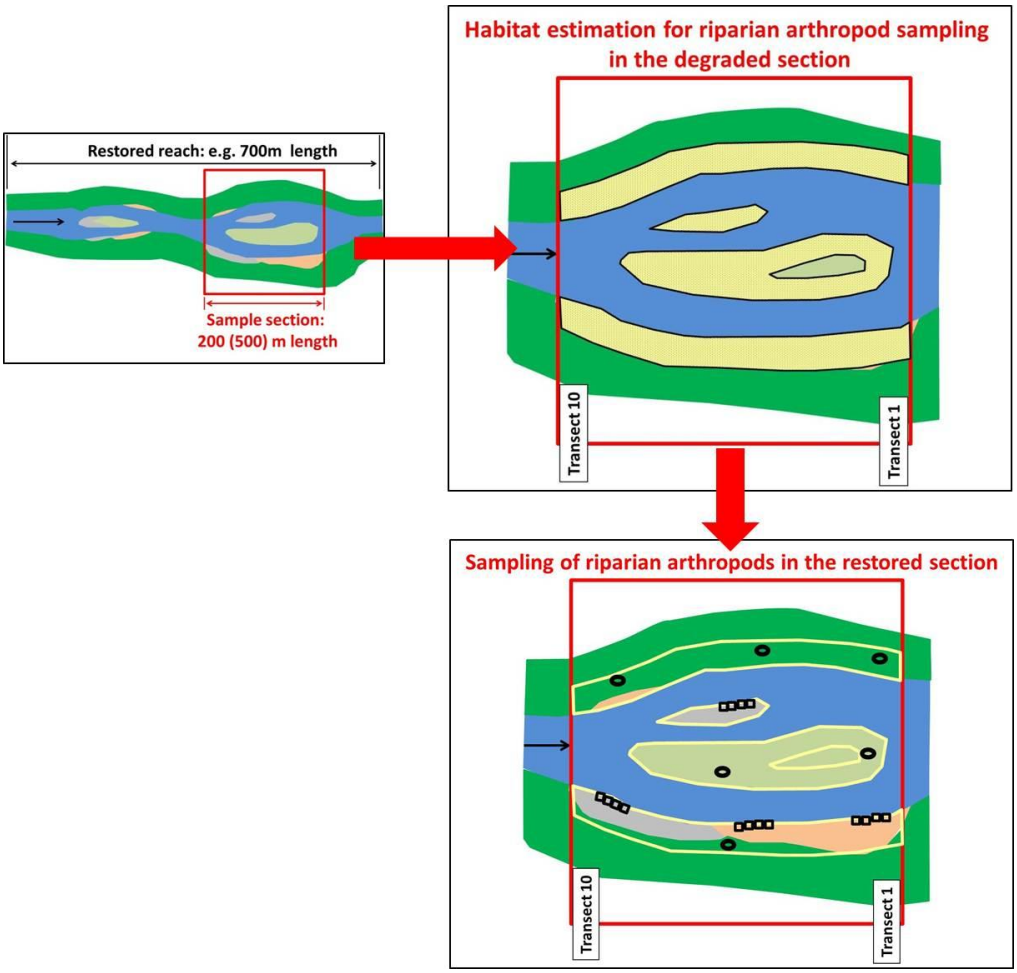


Figure 44: Habitat estimation and sampling of riparian arthropods in the restored section (sample area is marked in yellow; black rings = pitfall traps, row of black quadrats = hand collections)

First step is the estimation of riparian mesohabitat coverage in the max. 10m wide stripe of the riparian areas (Figure 43 + Figure 44). Therefore, aerial pictures could be used additionally; if hydromorphology is already recorded with the transect method, it could also be used additionally. We will estimate the coverage of riparian mesohabitats in 10%-steps; mesohabitats with coverage of < 10% should be marked with an "x". For riparian beetle sampling, only mesohabitats with coverage of at least 10% will be regarded. Each 10% of total habitat coverage will account for one riparian beetle sample; so, according to the composition 10 samples per section will be taken. Example:

- mesohabitat coverage: 50% open sand bars, 30% riparian forest, 20% pasture
- -> 5 samples on open sand bars (hand sampling); 3 samples in riparian forest, 2 samples in pasture (pitfall traps)

Vegetated mesohabitats (> 25% vegetation cover on the mesohabitat) will be sampled by pitfall traps. Open bars (< 25% vegetation coverage on the

mesohabitat) will be sampled by "hand sampling". Pitfall traps (diameter 4 cm, depth 8.5 cm, volume 200ml, Figure 45) will be filled with 100ml Renner-solution made up of 40% ethanol (70-proof), 20% glycerine, 10% acetic acid, 30% water adding a detergent to reduce surface tension. The pitfall traps will be secured from rain and falling leaves by a petri dish (9 cm diameter) as a roof (Figure 46). They should not be installed to close to the shoreline; we always consider that water level could increase, while traps are exposed. Traps will be exposed for one week.

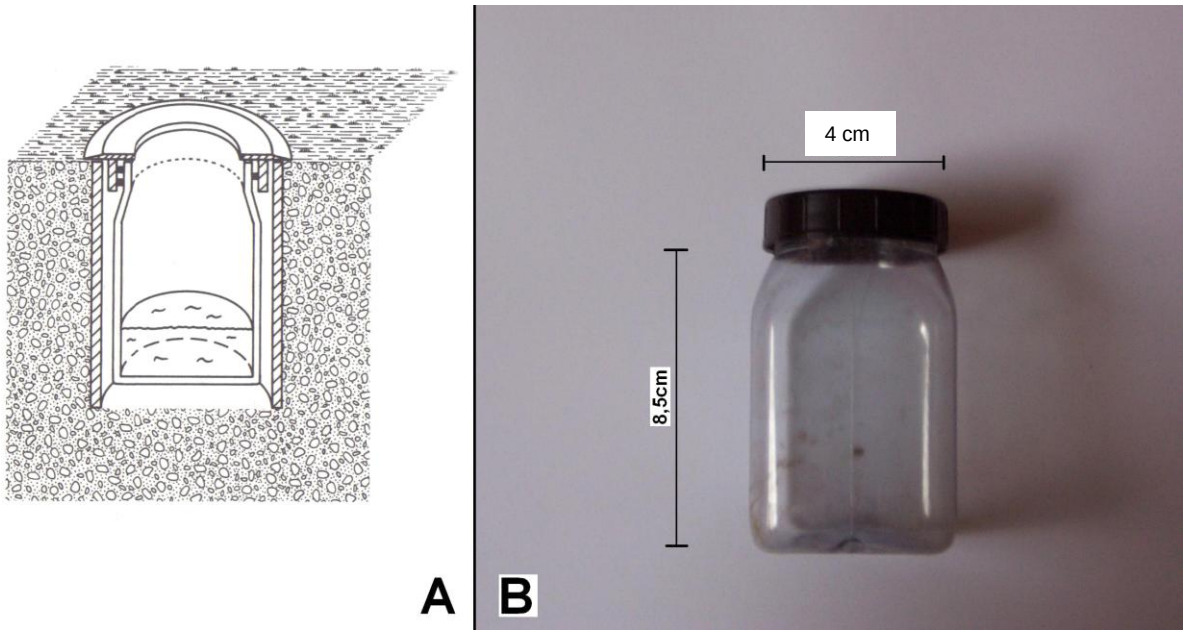


Figure 45: Pitfall trap

After the collection of the traps larger animals that are not part of the epigeic arthropod fauna (e.g. mice and snails which are frequently captured by pitfall traps) will be removed; mice will be preserved separately. All other animals will be placed in vials (1 vial per pitfall trap) and preserved with 96% ethanol.

Figure 46: Petri dish as a „roof" of a pitfall trap.

In the course of the hand sampling, organisms will be collected with an exhaustor (Figure 47). Sampling should be performed at sunny days. One sample covers 1m2. A wooden quadratic frame (50 x 50 cm = 0.25 m2) will be used to delineate the surface area to be sampled. For one sample, four 0.25 m2 areas

will be sampled parallel to and in direction of the shoreline. The area will be scanned for a maximum of 10 minutes by turning over all mineral and organic substrates to collect riparian beetles which hide or live in the underground. Afterwards, water will be poured over the area to drive organism hidden in the interstitial to the surface. All organisms will be sucked in with the exhaustor, killed using some drops of ethylacetate and afterwards preserved with 100% ethanol.
The 10 individual samples must be kept separate. Therefore, the several samples will be numbered consecutively from 1 to 10. For each sample, we will note the sampled mesohabitat and the type of sample in the field protocol. Carabid beetle species will be identified to the species level according to Müller-Motzfeld (2004). All other beetle species will be identified to family level.

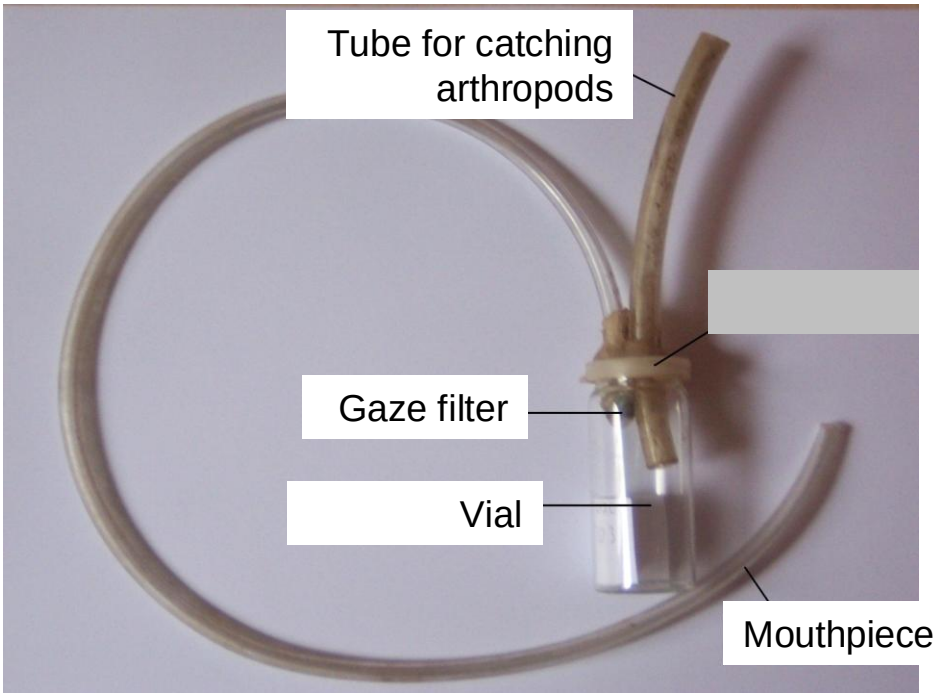


Figure 47: Exhaustor

Field protocol: Appendix 7.6

4.4 Fish

The EFI+ manual is the guiding line for fish sampling (http://efi-plus.boku.ac.at/project_results.htm : EFI+ Software Manual).
The following sampling description is extracted from EFI+ Consortium (2009):

4.4.1 Site selection

The selected site should be representative within the river segment in terms of habitat types and diversity, landscape use and intensity of human pressures.
A river segment is defined as:

- 1 km for small rivers (catchment<100 km²)
- 5 km for medium-sized rivers (100-1000 km²)
- 10 km for large rivers (>1000 km²)

A segment for a small river will thus be 500 m upstream and 500 m downstream of the sampling site.

4.4.2 Environmental variables and sampling methods

To model the reference conditions for the sampled site, the variables from Appendix 7.7 "Reference fields" should be recorded in the data sheet.

4.4.3 Fish sampling

To calculate the index, only fish data obtained by electric fishing can be used. Standardised electric fishing procedures are precisely described in the CEN directive, "Water Analysis – Fishing with Electricity (EN 14011; CEN, 2003) for wadable and non-wadable rivers".

Fishing procedures and equipment differ depending upon the water depth and wetted width of the sampling site. The selection of waveform, DC (Direct Current) or PDC (Pulsed Direct Current) depends on the conductivity of the water, the dimensions of the water body and the fish species to be expected. AC (Alternating Current) is harmful for the fish and should not be used. The fishing procedure is summarised below, separately for wadable and non-wadable rivers. In both cases, fishing equipment must be suitable to sample small individuals (young-of-the-year).

According to the CEN-standard, the main purpose of the standardised sampling procedure is to record information concerning fish composition and abundance; therefore, no sampling period is defined (according to CEN). However, the EFI+ approach recommends a sampling period of late summer/early autumn except for non-permanent Mediterranean rivers where spring samples may be more appropriate.

Electric fishing at a given site must be conducted over a river length of 10 to 20 times the river width, with a minimum length of 100m. This is to ensure sampling covers the variability of habitats and fish communities within rivers sections, and to ensure accurate characterisation of a fish assemblage. However, in large and shallow rivers (width >15m and water depth <70cm) where electric fishing by wading can be used, several sampling areas cumulating in total at least 1000m^2 should be prospected, covering all types of mesohabitats present in a given sampling site (partial sampling method). The length of the sampling site (station) is also calculated as 10 to 20 times the river width. Fishing of longer river sections should be avoided as some metrics referring to the number of species caught (e.g. number of rheophilic species) might be biased due to over sampling.

As a general guide one anode per 5-m of wetted width should be appropriate for sampling in wadable rivers. The operators should fish upstream so that water and sediment disturbed by wading does not affect efficiency. Operators should move slowly, covering the habitat with a sweeping movement of the anodes and attempt to draw fish out of hiding. To aid effective fish capture in fast flowing water the catching nets should be held in the wake of the anode. Each anode is generally followed by one or two hand-netters (hand net: mesh size of 6 mm maximum) and one suitable vessel for transporting fish (Table 9).

In large rivers, the depth (> 0.7 m) and variety of habitats makes prospecting the entire area impossible. Therefore, a partial sampling procedure is applied covering all types of habitats to obtain a representative sample of the site. Qualitative and semi-quantitative information can be obtained by using conventional electric fishing with hand held electrodes in the river margins and delimited areas of habitat. Alternatively, where resources exist capture efficiency can be improved by increasing the size of the effective electric field relative to the area being fished by increasing the number of catching electrodes (electric fishing boats with booms). Arrays comprising many pendant electrodes can be mounted on booms attached to the bows of the fishing boat. The principal array should be entirely anodic with separate provision being made for cathodes. Depending upon water conductivity, the current demands of multiple electrodes can be high and large generators and powerful control boxes may be needed (Table 9 and Table 10). In Table 9 and Table 10, the river width corresponds with wetted width.

Table 9: Fishing method: Rivers < 0.7 m depth = wadable rivers

Waveform selection:	DC or PDC
Number of anodes:	One anode per 5-m wetted width
Number of hand-netters:	Each anode followed by 1 or 2 hand-netters (mesh size of 6 mm maximum) and 1 suitable vessel for holding fish.
Number of runs:	One run – recommended: 2-3 runs
Time of the day:	Daylight hours
Fishing length:	10 - 20 times the wetted width, with a minimum length of 100 m

Fished area:	river width <15 m: The whole site surface river width >15 m: Several separated sampling areas are selected and prospected within a sampling site, with a minimum of 1000 m² (partial sampling method) – recommended: stripe-fishing-method according to Schmutz et al. (2001), BAW (2006)
Fishing direction:	Upstream
Movement:	Slowly, covering the habitat with a sweeping movement of the anodes and attempt to draw fish out of hiding.
Stop nets:	Used if necessary and feasible

Table 10: Fishing method: Rivers > 0.7 m depth = non-wadable rivers (boat fishing)

Waveform selection:	DC or PDC
Number of anodes:	Depending on boat configuration
Number of runs:	One run - recommended: 2-3 runs
Time of the day:	Daylight hours
Fishing length:	10 -20 times the wetted width, with a minimum length of 100 m
Fished area:	Both banks of the river or a number of sub-samples proportional to the diversity of the habitats present with a minimum of 1000 m² (partial sampling method) – recommended: stripe-fishing-method according to Schmutz et al. (2001), BAW (2006)
Fishing direction:	Normal flow: downstream in such a manner as to facilitate good coverage of the habitat, especially where weed beds are present or hiding places of any kind are likely to conceal fish High flow: upstream Low flow: not necessary to match boat movement to water flow, and the boat can be controlled by ropes from the bank side if required
Movement:	Slowly, covering the habitat with a sweeping movement of the anodes or drifting with the boom along selected habitats and attempting to draw fish out of hiding.
Stop net	Used if necessary and feasible

4.4.4 Fish data

To calculate the EFI+, each collected specimen should be identified to species level by external morphological characters and the total number of specimens per species should be recorded on the field protocol data sheet (7.7 fish data). Also, the EFI+ requires the number of fishes larger and smaller than 150 mm to be recorded. Therefore, total length (in mm) of all fish captured should be measured

Field protocols: Appendix 7.7

4.5 Floodplain Vegetation

Floodplain vegetation will be sampled in summer (June-July). In a stream section of 200 m length (in case of a wetted channel width >50m: section of 500m length) we choose three of the transects that were surveyed for hydromorphology (see 2.2 transect method), one at the lower, one at the middle and on at the upper area of the section (Figure 48).

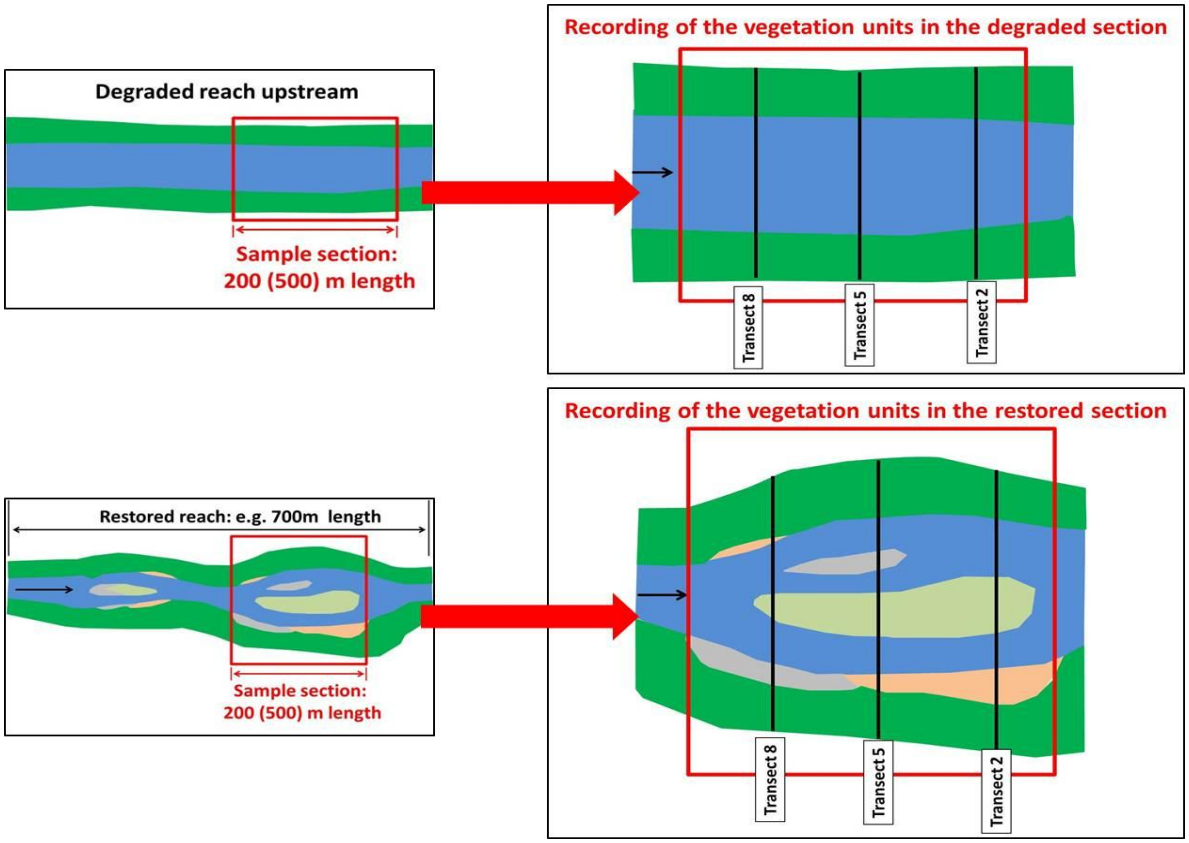


Figure 48: Recording of vegetation units along three transects per section; black lines mark the three chosen transects

First, the lengths of vegetation units, classified according to Oberdorfer (1983, 1992) and Ellenberg (1996) to the order level (Table 11), will be measured along transects to determine the proportion of vegetation units per stream section; this value can be used as a proxy for extension. Each measured section of a single vegetation unit will be numbered resulting in a "Vegetation Unit Code" that consists of the name of the vegetation unit consecutively numbered, e.g. Salicion_1, Salicion_2, Salicion_3, Aegopodion_1, Aegopodion_2. Transect numbers, mapped vegetation units with their lengths and vegetation unit codes must be listed in 'Field form 1 – Vegetation units'.

Table 11: Classification on vegetation units following Oberdorfer and others, adjusted to particular "new" units (e-g. neophytes etc.).

Abbreviation	Name of vegetation unit	Short description
Aeg	Aegopodion	Nitrophilous stands dominated by *Urtica dioica*, *Aegopodium podagraria* or *Galium aparine*
AgRu	Agropyro-Rumicion	Grassland in frequently flooded areas dominated by *Alopecurus geniculatus*
AP	Alno-Padion	Most frequent floodplain-forests in low-mountain regions dominated or characterized by *Alnus glutinosa* (tree layer) and *Stellaria nemorum* in the herb layer
Arr	Arrhenatherion - fragment association	Mown (or grazed) grassland dominated or characterized by *Arrhenatherum elatius* and other meadow-species like *Trifolium pratense*, *T. repens*, *Alopecurus pratensis* or *Leucanthemum vulgare*, as well as species poor and degraded stands composed of *Arrhenatherum elatius* and a few other species (e.g. *Dactylis glomerata*, *Taraxacum officinalis* agg.) frequently abandoned
Bid	Bidention - fragment association	Species poor and not well developed stands dominated or characterized by *Bidens*-species
BPW	Sambuco-Salicion	Wood and shrubland of early successional stages dominated by *Betula pendula*
JefB	Calthion elements	Moist, species poor grassland dominated of or only comprising *Juncus effusus*
Cal	Calthion	Moist, species poor grassland dominated by *Scirpus sylvaticus* (and *Juncus effusus)*
Caly	Calystegion sepi	Nitrophilous stands dominated by *Calystegia sepium, Convolvulus, Galium aparine* (and *Urtica dioica)*
DaM	Dauco-Melilotion	Dry ruderal stands dominated or charcterized by *Daucus carota, Melilotus* ssp. or *Echium vulgare*
Elo	Potamogetonion	Standing water bodies dominated by *Elodea*-species
SpGlyc	Glycerion	Stands of *Sparganium* ssp. in running water bodies with low current
Her	Calystegion sepi - fragment association	Nitrophilous stands dominated by or only comprised of *Heracleum mantegazzianum*
Mcar	Magnocaricion	Stands of tall sedges like *Carex gracilis, C. acutiformis*

MenUS	Calthion-Filipendulion	Embankment edges dominated by *Mentha aquatica* and others
Myr	Nymphaeion	Flooding stands of *Myriophyllum spicatum*
Glyc	Glycerion	Stands dominated by *Glyceria fluitans* or *G. plicata*
OKB	Mixture of Sysimbrion-Chenopodium-Dauco-Melilotion on gravel bars	Sparse vegetation on open gravel banks comprising a species-mixture from many different units, frequently characterized by predominantly dry-ruderals like *Daucus, Melilotus, Sisymbrium, Echium* or other ruderals like *Arctium, Saponaria, Alliaria*
Phal	Phalaridion	Reeds of *Phalaris arundinacea*
Pot	Potamogetonion	Stands of floating species like *Nymphaea, Nuphar, Potamogetum* etc.
Pot	Potamogetonion - mixed associations	Stands of *Potamogetum*-species in pools or in water bodies with low current, frequently mixed with *Glyceria* ssp.
Prun	Rubo-Prunion	Shrub patches dominated or characterized by *Prunus spinosa* or *Crataegus* ssp.
Ran	Ranunculion fluitantis	Flooding stands of *Ranunculus fluitans*
Sal	Salicion albae	Frequently flooded woods and forests dominated by *Salix alba* or *S. fragilis* (and hybrids)
SamS	Sambuco-Salicion	Open woods in early successional stages dominated by *Sambucus ssp., Salix caprea* or *Betula pendula*
Tan	Dauco-Melilotion	Stands dominated by *Tanacetum vulgare*
VbN	Glycerion	Stands dominated by *Veronica beccabunga*
Querc	Quercion	Woods and forest on acidous soils dominated by *Quercus petraea*
CG	Ranunculion / Nymphaeion	Stands in pools or in water bodies with low current dominated or characterized by *Callitriche* ssp.
Carp	Carpinion	Forests characterized by *Carpinus* ssp. and *Quercus robur* in the tree layer, *Stellaria holostea* and *Poa nemoralis* in the herb layer
Fag	Fagion	Forests dominated by *Fagus sylvatica*
Phrag	Phragmition	Stands of *Phragmites australis*
Typh	Phragmition	Stands dominated by *Typha latifolia*
ImpG	Calystegion - fragment association	Nitrophilous stands dominated by *Impatiens glandulifera*
WG	Salicion albae	Floodplain-woods characterized by *Salix viminalis, S. cinerea or S. triandra*

FalG	Calystegion sepi - fragment association	Stands dominated by *Fallopia* ssp.
Lem	Lemnion	Stands of floating *Lemna* ssp.
Rub	Pruno-Rubion-fruticosi / Calystegion sepi - fragment association	Shrub patches dominated or characterized by *Rubus fruticosus* agg. or *R. caesius*
Bar_S		Bare soil
UGP		Embankement afforestations with *Salix-, Alnus* or *Fraxinus*-species (atypical or non-native species)
PA		Afforestation with *Populus*-species

Second, each of the transects will be divided into three subzones on each side of the main channel) with subzone 1 placed nearest to the waterline of the running water body. If for example the total width of the floodplain at one site of the main channel is 100 m, then each sub-zone will be 33 m (Figure 49). A total of 12 sample plots (size 0.5 m x 0.5 m) per transect should be established (six on each side of the main channel) but these will be differently distributed within the subzones following a randomized and stratified sampling approach. At each site of the channel three sample plots per transect should be placed evenly distributed in the first subzone, two sample plots should be placed in the second subzone and finally one sample plot should be placed in the third subzone (Figure 49).

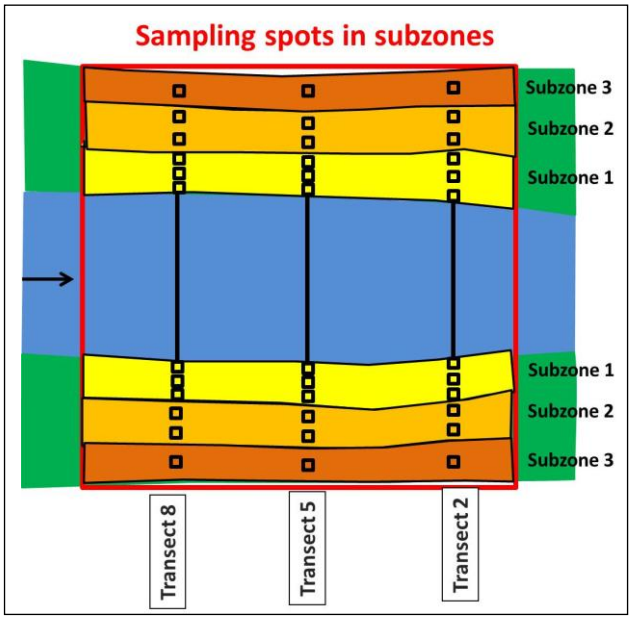


Figure 49: Sample section with sample plots in subzones 1-3 (black quadrats = sample plots).

In cases of a 100 m wide floodplain at one site of the main channel the distance between the plots will be app. 11.1 m in the first subzone and it will be app. 16.5 m in the second subzone. The absolute number of sample plots per section is 18 sample plots in subzone 1, 12 sample plots in subzone 2 and six sample plots in subzone 3. Sample plots will be numbered for each transect separately with additional notes of the subzone number. In case of braided rivers a main channel needs to be defined, and the method will be applied accordingly. If the floodplain is narrow (e.g., just 5 meters of each side of the channel) the same number of sample plots as in broader floodplains must be sampled. However, in these cases the sample plots cannot be distributed along transects. Therefore, at each site of the channel nine sample plots must be placed close to the shoreline, three at the margins of the shoreline and six in between (Figure 50).

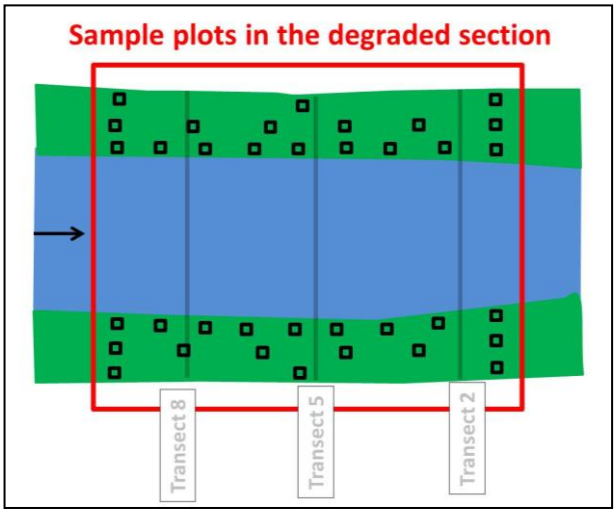


Figure 50: Sample section of floodplain vegetation with sample plots without reference to transects in case of a floodplain with a width of <5m at each site of the main channel (black quadrats = sample plots)

Within the plots, plant species and their abundance will be sampled by estimating their coverage (~ abundance) following the classification of Braun-Blanquet: 0.5: 0 -1%, 1: 1-5%, 2: 5-25%, 3: 25-50%, 4: 50-75%, 5: 75-100%. Sample plot details (mapped taxa and their coverage) will be noted in 'Field form 2 – Sample plots'. So, 'Field form 2 – Sample plots' must be filled once per sampling spot, always noting transect, sampling spot number and the subzone number. The vegetation samples (species coverage in the plots) will be subjected to a species-based statistical classification model (Baattrup-Petersen et al. 2012) which analyze and classify the units along species assemblage and species coverage.

5. Database

Task 4.2 and 4.3 ask for collecting data to assess abiotic and biotic effects of river restoration measures in restored catchments – one "flagship" and one "small" restoration site, each with one degraded site. Therefore all comparable data on hydromorphology, pressures, restoration measures, land use and different biotic key variables, potentially supporting or impeding restoration success are collected. Information on land use in the case study sites will be integrated in the database later on in the project, centrally analysed.

5.1 Methodology

To manage the gathered data, a database was created in two steps. To collect the data from the partners a Microsoft Excel file was created at first. Secondly, the received datasets will be merged in a Microsoft Access database. This procedure makes it easier to merge the gathered data, prove IDs and consistency of data and provides centralized data input in the Access database. This procedure is based on experiences of database experts at BOKU.

Based on existing databases of the WISER project[1], the database of REFORM task 4.1, internal databases on fish and macroinvertebrates of the BOKU Institute of Hydrobiology and Aquatic Ecosystem Management, a list of parameters was compiled by BOKU and UDE.
In this first step a total of 324 parameters were defined. Whereas 248 entries are with regard to the content (biotic and abiotic factors), 76 entries consist of definitions and identifications of sites or samples and contain IDs to link different tables of the later database. Table 12 gives an overview of these sheets and their content. This file was sent to all partners of task 4.2 and 4.3 to fill in all required available data of their case study sites.

In a second step, a Microsoft Access database was built, using the same structure of tables as the Excel file in which the datasets, coming back from the partners can be imported and interrogated (Figure 51).

5.2 Database structure

Considering the final case study database structure in Microsoft Access the composition of the Excel file, created to collect data from the several working task partners, consist of 21 sheets with parameters of the several key subjects, 10 tables with ID and taxa lists as well as an explaining "How to use" sheet and a description of all required variables. In this file altogether 10 key subjects are required, 5 abiotic and 5 biotic topics:

- Site information

[1] http://www.wiser.eu

- Hydromorphology
- Pressure types
- Restoration measure types
- Physico-chemical data
- Fish
- Invertebrates
- Macrophytes
- Riparian arthropods
- Floodplain Vegetation

For each of the abiotic subjects there is one sheet to fill in the data. For the biotic subjects there are several tables necessary to separate different information concerning the site (geographic coordinates, altitude, etc.), the sample (date, area, methods, etc.) and the catch (taxa names, number of individuals, etc.), getting a well-structured database. For a detailed overview of the Excel file's content see Table 12.

Structure of the Excel file

- The first sheet of this file contains the whole list of required parameters and their descriptions, classified in 10 subjects (from site information to vegetation, also marked in different colours).
- The parameters of fish, invertebrates, macrophytes, beetles and vegetation are divided into several tables (marked with different grey shades).
- Hyperlinks (blue font) in the Description sheet either guide to referring code or taxa lists (brown marked sheets) or to referring parameters (just intended to ease the navigation).
- The remaining sheets contain the tables that should be filled with data - in the same order and marked with the same colours as in the Description sheet.
- The last 10 sheets contain code lists and taxa lists, where you can find the required IDs and codes for the parameters.

Structure of the tables

- The 21 sheets (marked in different colours) contain the tables of the different key subjects, where data should be filled in.
- The first row of each table contains the acronym of the parameters. The second row contains the units or the link to the description for those parameters that require a special explanation.
- Hyperlinks (blue font) in the first row either guide to referring code or taxa lists (brown marked sheets) or to referring parameters.

Structure of code or taxa lists

- The last 10 sheets contain code lists and taxa lists, where required IDs and codes for the parameters are listed.

- Requested codes or IDs can be found in the columns marked with ⇩; except the plant taxa list: here the row number is the ID.
- The hyperlinks (top right) either lead you back to the Description sheet or the accordant table.

5.2.1 Tables, variables and relationships

The following tables give an overview of the databases tables' content (Table 12), a description of all requested variables (Table 13 - Table 22) and the relationships of these tables in Microsoft Access (Figure 51).

Table 12: Content overview of the Excel file for the case study database (task 4.2, 4.3).

Table	Content	No. of entries / variables
SiteInfo	General information on case study site	39
Hydromorph	Info on hydromorphology of the site	38
Pressure	Info on pressure types of the site	28
RestorMeasures	Info on restoration measures of the site	69
PhysChem	Info on physic-chemical parameters	21
FishSite	General info on fish sampling point	8
FishSample	Specific info on fish sampling (date, method, etc.)	27
FishCatch	Specific info on fish catches (taxa, etc.)	9
InvSite	General info on invertebrates' sampling point	6
InvSample	Specific info on invertebrates' sampling (date, method, etc.)	8
InvCatch	Specific info on invertebrates' catches (taxa, etc.)	4
MacrophSite	General info on macrophytes' sampling point	5
MacrophSample	Specific info on macrophytes' sampling (date, method, etc.)	7
MacrophCatch	Specific info on macrophytes' catches (taxa, etc.)	6
BeetSite	General info on sampling points of riparian beetles	5
BeetSample	Specific info on sampling of riparian beetles (date, method, etc.)	16
BeetCatch	Specific info on riparian beetles' catches (taxa, etc.)	7
VegSite	General info on vegetation sampling points	5
VegSample	Specific info on vegetation sampling (date, etc.)	6
VegTransUnit	Info on transects, vegetation orders and units	7
VegTaxa	Specific info on vegetation taxa and coverage	4
ListCountryCodes	List of countries of the task 4.1 and 4.2 partners with codes	14
Ecoregions	List of ecoregions (according Water Framework directive)	31
Substrate	List of dominating substrate in the case study site (classified)	8
FishTaxa	List of fish taxa, ordered by taxagroups and families	794
InvertTaxa	List of invertebrates, ordered by group, family, subfamily and genus	13472
MphTaxa	List of European macrophytes taxa, ordered by families	1295
MphGrowth	List of definitions and examples of growth recorded forms of macrophytes	15
BeetlesTaxa	List of European carabid taxa	1107
VegUnit	List of vegetation units, according to Oberdorfer	129
PlantTaxa	List of plant species	5552

Table 13: Variables and descriptions of the table "Site information" for the case study database (task 4.2, 4.3).

Parameter	Description
StationCode	Station code; please enter an unique internal or national code
StationName	Station name [national name of case study reach]
CasestudyType	Type of case study: R1 = "flagship" restoration, R2 = "normal" restoration, D1 = degraded reach corresponding to "flagship" restoration reach, D2 = degraded reach corresponding to "normal" restoration reach [R1, R2, D1, D2]
BeginLongitude	Begin of reach upstream - Longitude [degrees W (-) or E (+), decimal], WGS84
BeginLatitude	Begin of reach upstream - Latitude [degrees N, decimal], WGS84
EndLongitude	End of reach downstream - Longitude [degrees W (-) or E (+), decimal], WGS84
EndLatitude	End of reach downstream - Latitude [degrees N, decimal], WGS84
ReachLength	Length of reach [km]
ReachArea_cat	Floodplain area (the river and valley bottom, that is flooded and shaped by dynamic processes - under natural conditions!); categorised (<1, 1-10, 10-50, 50-100, 100-500, >500) [ha]
ReachArea_exc	Floodplain area (the river and valley bottom, that is flooded and shaped by dynamic processes - under natural conditions!); exact value (if known) [ha]
FloodplainWidth	Average Floodplain width (average of floodplain transects every 100m of the reach)[m]
AltitudeBegin	Altitude at begin of reach (Meters Above Sea Level) [m]
AltitudeEnd	Altitude at end of reach (Meters Above Sea Level) [m]
Elevation	Elevation, according to the WFD categories [lowland = <200 m, mid-altitude = 200-800 m, high = >800 m]
RiverName	National river name
StrOrder	Stream order, according to Strahler
WaterbodyID	Water body code, according to River Basin Management Plan (RBMP)
CountryID	Country code (see country code list)
BQE_Type	Biological Quality Elements (BQE) of original station [1 = fish, 2 = invertebrates, 3 = phytobenthos, 4 = macrophytes (combinations possible)]
MultipleBQE	Are there more than one BQE samples for this site with the specified timeframe? [yes / no / nodata]
EcoregionID	Ecoregion number, according to WFD (see ecoregions list)
GeologicalType	Geological type according to WFD [calcareous / silicious / organic]
Geol_cat	Geology of catchment upstream according to WFD [calcareous / silicious / organic]
CatchmentArea	Catchment size [km²]
CatchmentCat	Catchment categories according to the WFD categories [very small = <10km² / small = 10-100km² / medium = 100-1000km² / large = 1000-10000km² / very large = >10000km²]
CatchmentName	National name of catchment
MainRiverRegion	Name of main river region
RestDate	Year(s) of restoration [yyyy; yyyy-yyyy]
Rest_TimeAfter_exc	Time after restoration [in years]
Rest_TimeAfter_cat	Time after restoration, categorised [1 = 0-1y / 2 = 2-4y / 3 = 5-12y]
Mon_Rest	Repeated monitoring, present or absent [0 = no / 1 = yes]

Mon_Freq	Frequency of monitoring [monthly / semi-annually / annually / only once / other {please describe: e.g. biennial,…} / nodata]
Mon_Time	Time between implementation of project(s) and monitoring [month]
UpstreamLakes	(if the lake upstream affects a site) [yes / no / nodata]
ProjSum	Brief summary of the project location, pressure situation, objectives and implemented measures
Pictures	Include pictures (with description) before and after restoration of this site or pictures of degraded reach
ReporterID_site	Finally established by BOKU; please fill in name and organisation of the person who obtained the data; either you, or the organisation you got it from - so that it is transparent where the data come from
DataSourceID_site	Finally established by BOKU; please fill in the database name, report, etc. of the obtained data - so that it is transparent where the data come from
Comment_site	Any other comment

Table 14: Variables and descriptions of the table "Hydromorphology" for the case study database (task 4.3, 4.3).

Parameter	Description
ID_SC	Enter code of referring site (field "StationCode" of table Site information)
ID_HM	Enter a consecutive number, beginning with 1
SampelDate	[dd.mm.yyyy]
ChanPatt	Natural channel pattern [meandering, braiding, wandering, anastomosing, constrained] classification of channel pattern should be consistent with other WPs!
ChanBankW_cat	Bankfull width of river channel, categorised [<5m / <10m / <20m / <50m />50m]
Slope_exc	Channel slope [in %]
Slope_cat	Channel slope, categorised [<0,1% / 0,1-0,5% / 0,5-1% / 1-3% / >3%]
FlowVel_hm	Mean flow velocity [m/s]
Discharge	Mean discharge [m³/s]
Mean_river_width	Mean width of water body [m]
Mean_river_depth	Mean depth of water body [m]
River_width_min	Minimum width of water body [m]
River_width_max	Maximum width of water body [m]
River_depth_min	Minimum depth of water body [m]
River_depth_max	Maximum depth of water body [m]
FlowDiversity	Type-specific flow diversity [present / slightly reduced / reduced / absent]
DepthVariability	Type-specific depth variability [present / slightly reduced / reduced / absent]
Substrate_dom_ID	Dominating substrate, categorised; according to codelist
Substrate_divers	Type specific substrate diversity [present / slightly reduced / reduced / absent]
BedFixation	Bed-fixation [yes / no / nodata]
InstrHabit	Type specific instream habitats [present / slightly reduced / reduced / absent] (e.g. sediment bars, pools, rapids, cascades)
RiverDynamics	Features indicating type specific river dynamics [present, slightly reduced, reduced, absent] (e.g. woody debris, undercut banks, islands,..)

Barriers_art	Artificial barriers [present / absent] (e.g. dams, weirs)
ChanForm_modified	Channel form modified [no / intermediate / straightened]
CrossSect_modified	Cross section modified [no / intermediate / technical profile]
Artific_Embank	Artificial embankment [no / slight / intermediate / high]
RiparianVeg_modified	Riparian vegetation modified [no / slight / intermediate / high]
FloodplHabitat	Type specific floodplain habitats [present / slightly reduced / reduced / absent]
BufferZone	Nature-like or extensive land use in the adjacent area along the river - riparian buffer strip [present / absent]
FloodplLanduse_cat	Landuse of floodplain; categorised [(near-)natural / extensive agriculture / intensive agriculture / urban / forestry]
HymoStatus	Mean hydromorphological status [1 = very good / 2 = good / 3 = moderate / 4 = poor / 5 = bad]
HymoStat_Method	Name of hydromorphological survey method
Detail_Hymo	Detailed hydromorphological datasets available [yes / no; if yes, please specify]
Detail_Hydrol	Detailed hydrological datasets available [yes, no; if yes, please specify]
HydrolModel	Hydrological model available [yes / no / nodata; if yes, please specify]
ReporterID_hyd	Finally established by BOKU; please fill in name and organisation of the person who obtained the data; either you, or the organisation you got it from - so that it is transparent where the data come from
DataSourceID_hyd	Finally established by BOKU; please fill in the database name, report, etc. of the obtained data - so that it is transparent where the data come from
Comment_hyd	Any other comment

Table 15: Variables and descriptions of the table "Pressure types" for the case study database (task 4.2, 4.3).

Parameter	Description
ID_SC	Enter code of referring site (field "StationCode" of table Site information)
ID_PR	Enter a consecutive number, beginning with 1
Impoundment	Impoundments or stagnation [yes / no / nodata]
Hydropeaking	Height of hydropeaking or puls releases [cm]
WaterAbstraction	Water abstraction [yes / no / nodata]
SurfWaterAbstr	Surface water abstraction [yes / no / nodata]
GroundwAbstr	Groundwater abstraction [yes / no / nodata]
FlowRegulation	Change of hydrological regime [yes / no / nodata]
FlowVelIncrease	Flow velocity increase [yes / no / nodata]
SedimentStor	Sediment storage upstream [yes / no / nodata]
NutrPollution	Nutrient pollution [yes / no / nodata]; if yes, specify: [point / diffuse]
Morph_alter	Alteration of morphology: Channelization [yes / no / nodata]
RipVeg_alter	Alteration of riparian vegetation [yes / no / nodata]
InstrHabit_alter	Alteration of instream habitats [yes / no / nodata]
MorphDike	Presence of embankments, levees or dikes [yes / no / nodata]
Sedim_artif	Artificially induced (increased) sedimentation (deposition) [yes / no / nodata]
Sedim_extrac	Sand and gravel extraction, dredging [yes / no / nodata]
BarriersCatchmUp	Presence of barriers in catchment upstream [yes / no / nodata]
BarriersCatchmDown	Presence of barriers in catchment downstream [yes / no / nodata]
NumberBarrierUp	Number of barriers in catchment upstream

NumberBarrierDown	Number of barriers in catchment downstream
DistNextBarrUp	Distance to next barrier upstream [km]
DistNextBarrDown	Distance to next barrier downstream [km]
WaterUse	Water use [HP= Hydropower / I = Irrigation / DW = Drinking Water / SP = Snow Production /FP = Fishponds / CW = Cooling Water/ IW = Industrial Water]; if there are others, please specify; multiple answers possible
PressCatchmUp	Pressure types catchment upstream [CH = channelization / IP = impoundment /WA = water abstraction / HP = hydropeaking / PO = pollution /FA = flow alteration / SA = sediment alteration]; if there are others, please specify; multiple answers possible
ReporterID_pres	Finally established by BOKU; please fill in name and organisation of the person who obtained the data; either you, or the organisation you got it from - so that it is transparent where the data come from
DataSourceID_pres	Finally established by BOKU; please fill in the database name, report, etc. of the obtained data - so that it is transparent where the data come from
Comment_pres	Any other comment

Table 16: Variables and descriptions of the table "Restoration measure types" for the case study database (task 4.2, 4.3).

Parameter	Description
ID_SC	Enter code of referring site (field "StationCode" of table Site information)
ID_RM	Enter a consecutive number, beginning with 1
MP_PointS	Decrease of point source pollution [yes / no / nodata]
MP_DiffS	Decrease of diffuse nutrient or pollution input (other than buffer strips!) [yes / no / nodata]
MH_Abstr	Reduction of surface water abstraction without return [yes / no / nodata]
MH_Ret	Improvement of water retention (e.g. on floodplain, urban areas, overlaps with MFlow_APeak) [yes / no / nodata]
MH_GW	Reduction of groundwater abstraction [yes / no / nodata]
MH_Stor	Improvement/creation of water storage (e.g. polders) [yes / no / nodata]
MH_Min	Increase of minimum flow (to generally increase discharge in a reach or to improve flow dynamics) [yes / no / nodata]
MH_Div	Improving water quantity by water diversion and transfer [yes / no / nodata]
MH_Cycle	Recycling of used water (off-site measure to reduce water consumption) [yes / no / nodata]
MH_Cons	Reduction of water consumption (other measures than recycling used water) [yes / no / nodata]
MS_Add	Adding/feeding of sediment (e.g. downstream from dam) [yes / no / nodata]
MS_Input	Reduction of undesired sediment input (e.g. from agricultural areas or from bank erosion other than riparian buffer strips!) [yes / no / nodata]
MS_Reser	Prevention of sediment accumulation in reservoirs [yes / no / nodata]
MS_Trans	Improvement of continuity of sediment transport (e.g. manage dams for sediment flow) [yes / no / nodata]
MS_Trap	Trapping of sediments (e.g. building sediment traps to reduce washload) [yes / no / nodata]
MS_Dredg	Reduction of impact of dredging [yes / no / nodata]
MF_EFlow	Establishment of environmental flows / naturalise flow regimes (does focus on discharge variability compared to water quantity of MH_Min) [yes / no / nodata]
MF_HPeak	Modification of hydropeaking [yes / no / nodata]
MF_FPlain	Increase of flood frequency and duration in riparian zones or floodplains [yes / no / nodata]
MF_APeak	Reduction of anthropogenic flow peaks [yes / no / nodata]

MF_Imp	Shortening the length of impounded reaches [yes / no / nodata]
MF_MorphFlow	Favouring morphogenic flows (can also be considered a measure to improve planform or in-channel habitat conditions) [yes / no / nodata]
MC_Up	Installing fish pass, bypass, side channel for upstream migration [yes / no / nodata]
MC_Down	Installing facilities for downstream migration (including fish friendly turbines) [yes / no / nodata]
MC_Manag	Management sluice, weir, and turbine operation for fish migration [yes / no / nodata]
MC_Remov	Removal of barrier (e.g. dam or weir) [yes / no / nodata]
MC_Culv	Modification or removal of culverts, syphons, piped streams [yes / no / nodata]
MIn_FixBed	Removal of bed fixation [yes / no / nodata]
MIn_FixBank	Removal of bank fixation [yes / no / nodata]
MIn_RemSed	Removal of sediment (e.g. mud from groin fields) [yes / no / nodata]
MIn_AddSed	Adding of sediment (e.g. gravel, overlaps with MS_Add) [yes / no / nodata]
MIn_Veg	Management of aquatic vegetation (e.g. mowing) [yes / no / nodata]
MIn_HyStruc	Removal or modification of in-channel hydraulic structures (e.g. groins, bridges) [yes / no / nodata]
MIn_Shall	Creation of shallows near the bank [yes / no / nodata]
MIn_Wood	Recruitment or placement of large wood [yes / no / nodata]
MIn_Bould	Placement of boulders [yes / no / nodata]
MIn_Dynamic	Initiation of natural channel dynamics to promote natural regeneration [yes / no / nodata]
MIn_Riff	Placement of artificial gravel bar or riffle [yes / no / nodata]
MR_NBuff	Development of buffer strips to reduce nutrient input [yes / no / nodata]
MR_SBuff	Development of buffer strips to reduce fine sediment input [yes / no / nodata]
MR_VegBuff	Development of natural vegetation on buffer strips (other reasons than nutrient or sediment input, e.g. shading, organic matter input) [yes / no / nodata]
MP_Meander	Remeandering of water course (actively changing planform) [yes / no / nodata]
MP_Wide	Widening or re-braiding of water course (actively changing planform) [yes / no / nodata]
MP_Shallow	Creation of shallow water course (actively increasing level of channel-bed) [yes / no / nodata]
MP_Narrow	Creation of narrow over-widened water course (actively changing width) [yes / no / nodata]
MP_LowC	Creation of low-flow channels in over-sized channels [yes / no / nodata]
MP_Dynamic	Allowing/initiation of lateral channel migration (e.g. by removing bank fixation and adding large wood) [yes / no / nodata]
MP_2Flod	Creation of secondary floodplain on present low level of channel bed (floodplain compensation) [yes / no / nodata]
MFP_Con	Reconnection of existing backwaters, oxbow-lakes, wetlands [yes / no / nodata]
MFP_Create	Creation of semi-natural / artificial backwaters, oxbow-lakes, wetlands [yes / no / nodata]
MFP_Lower	Lowering embankments, levees or dikes to enlarge inundation and flooding [yes / no / nodata]
MFP_Back	Back-removal of embankments, levees or dikes to enlarge the active floodplain area [yes / no / nodata]
MFP_Remove	Removal of embankments, levees or dikes or other engineering structures that impede lateral connectivity [yes / no / nodata]
MFP_other	Other measures concerning Floodplain and Vegetation [yes / no / nodata]
MFP_other_name	If you anwered the field "MFP_other" with yes, please specify this measure here

RestLimits	Constraints or limiting factors which might have impeded restoration effects (e.g. multiple stressors, key habitats still missing) [yes / no / nodata]
RestCosts_plann	Planning and project design costs before project implementation [EUR]
RestCosts_dike	Construction costs for dike relocation or extension, if relevant [EUR]
RestCosts_transc	Transaction costs such as administrative and legislative costs [EUR]
RestCosts_acqu	Land acquisition costs, if relevant [EUR]
RestCosts_oth	Other construction and investment costs [EUR]
RestCosts_maint	Annual maintenance costs after project implementation [EUR]
RestCosts_monit	Annual monitoring costs after project implementation [EUR]
RestCosts_total	Total consts of restoration [EUR]
ReporterID_res	Finally established by BOKU; please fill in name and organisation of the person who obtained the data; either you, or the organisation you got it from - so that it is transparent where the data come from
DataSourceID_res	Finally established by BOKU; please fill in the database name, report, etc. of the obtained data - so that it is transparent where the data come from
Comment_res	Any other comment

Table 17: Variables and descriptions of the table "Physico-chemical data" for the case study database (task 4.2, 4.3).

Parameter	Description
ID_SC	Enter code of referring site (field "StationCode" of table Site information)
ID_PC	Enter a consecutive number, beginning with 1
SampleMean	Does this data set contain means of more than one sample [yes / no / nodata]; if you have mixed data for the following parameters, please use separate rows for each parameter
SampleDateStart	If you answered the field "SampleMean" with yes, enter the date of your first sample here; if you answered the field "SampleMean" with no, enter the date of your individual sample here [dd.mm.yyyy; hh:mm]
SampleDateEnd	If you answered the field "SampleMean" with yes, enter the date of your last sample here; if you answered the field "SampleMean" with no, leave this field empty [dd.mm.yyyy; hh:mm]
pH	PH 0-14; value at sampling time
WaterTemp	Water temperature, value at sampling time [°C]
Conductivity	Electrical conductivity, value at sampling time [microS/cm];
Oxygen	Oxygen content, value at sampling time [mg/l]
OxygenSaturation	Oxygen saturation [%], if applicable
BOD5	Biological oxygen demand [mg/l]
Nitrite	Nitrite [mg/l] (NOT Nitrit-N!)
Nitrate	Nitrate [mg/l]
Ammonia	Ammonia [mg/l]
Chloride	Chloride [mg/l]
OrthoPhosphate	Ortho-phosphate [microg/l] (NOT PO4-P!)
TotalPhosphate	Total-phosphate [microg/l]
Alkalinity	Alkalinity [mval/l], if applicable
ReporterID_phych	Finally established by BOKU; please fill in name and organisation of the person who obtained the data; either you, or the organisation you got it from - so that it is transparent where the data come from

DataSourceID_phych	Finally established by BOKU; please fill in the database name, report, etc. of the obtained data - so that it is transparent where the data come from
Comment_phych	Any other comment

Table 18: Variables and descriptions of the key subject "Fish", with its three different tables, for the case study database (task 4.2, 4.3).

Table	Parameter	Description
FishSite	ID_SC	Enter code of referring site (field "StationCode" of table Site information)
	ID_site_fish	Enter a consecutive number, beginning with 1
	Site_altitude_fish	Altitude [m]
	Site_name_fish	Local or internal name of site
	Site_SectBegLong_fish	Begin of sample section upstream - Longitude [degrees W (-) or E (+), decimal], WGS84
	Site_SectBegLati_fish	Begin of sample section upstream - Latitude [degrees N, decimal], WGS84
	Site_SectEndLong_fish	End of sample section downstream - Longitude [degrees W (-) or E (+), decimal], WGS84
	Site_SectEndLati_fish	End of sample section downstream - Latitude [degrees N, decimal], WGS84
FishSample	ID_site_fish	Enter number of referring fish site (field "ID_site_fish" of table FishSite)
	ID_sample_fish	Enter a consecutive number, beginning with 1
	FishSampleDate	Date of sample [dd.mm.yyyy]
	SamplingMethod	e.g. electrofishing, demersal line, beach seine, gill net
	BoatWade	[boat / wading]
	Anode	[fixed / handheld]
	AnodeNo	Number of handheld anodes
	GenPower	Power of generator [kW]
	Voltage	Voltage, e.g. 300 or 600 [V]
	Amperage	Amperage during sampling [A]
	Barrier	Barrier at upstream end of sample [yes / no / nodata]
	SampStrat_el	Sampling strategy (if electrofishing) [partial habitat / partial strip / serial removal]
	SampStrat_el_No	Sampling strategy (if electrofishing) [number of runs]
	SamplingDuration	Sampling duration / exposure time [hh:mm]
	SampleLength	Length of sample [m]
	SampleWidth	Width of sample [m]
	SampleRiverWidth	River width at sampling site [m]
	SampleRiverDepth_av	Average depth at sampling site [cm]
	SampleRiverDepth_max	Maximum depth at sampling site [cm]
	FlowVel_fish	Flow velocity at sampling site [m/s]
	SampleType	[midstream / riparian zone / whole width]
	SampleHabitat	[main channel / side channel connected / backwater / oxbow]
	SampleHabitatStruct	[rock / boulders / gravel / sand / mud / litter / woody debris / reeds / submersal macrophytes / riparian vegetation]; multiple answers are permitted
	CaptureEfficiency	Capture efficiency; estimated for each species and different age/size classes: 100% is the total of visually detected fish [%]

	ReporterID_fish	Finally established by BOKU; please fill in name and organisation of the person who obtained the data; either you, or the organisation you got it from - so that it is transparent where the data come from
	DataSourceID_fish	Finally established by BOKU; please fill in the database name, report, etc. of the obtained data - so that it is transparent where the data come from
	Comment_fish	Any other comment
FishCatch	ID_sample_fish	Enter number of referring sample (field "ID_sample_fish" of table FishSample)
	ID_catch_fish	Enter a consecutive number, beginning with 1
	FishSpeciesID	ID of scientific name of species (see taxa list)
	FishLength	Length of fish [mm]
	FishWeight	Weight of fish [g]
	Sex	[m/f]
	FishAbundJuv	Abundance data of whole community (juveniles), area-related [absolute no. of individuals in sample]
	FishAbundAdu	Abundance data of whole community (adults), area-related [absolute no. of individuals in sample]
	AddInfo	Additional information

Table 19: Variables and descriptions of the key subject "Invertebrates", with its three different tables, for the case study database (task 4.2, 4.3).

Table	Parameter	Description
InvSite	ID_SC	Enter code of referring site (field "StationCode" of table Site information)
	ID_site_inv	Enter a consecutive number, beginning with 1
	Site_Long_inv	Longitude at midpoint of sample reach [degrees W (-) or E (+), decimal], WGS84
	Site_Lati_inv	Latitude at midpoint of sample reach [degrees N, decimal], WGS84
	Site_altitude_inv	Altitude [m]
	Site_name_inv	Local or internal name of site
InvSample	ID_site_inv	Enter number of referring site (field "ID_site_inv" of table InvSite)
	ID_sample_inv	Enter a consecutive number, beginning with 1
	InvSampleDate	Date of sample [dd.mm.yyyy]
	InvSampleMeth	Sampling methode
	Sample_area_inv	Sampling area [m²]
	ReporterID_inv	Finally established by BOKU; please fill in name and organisation of the person who obtained the data; either you, or the organisation you got it from - so that it is transparent where the data come from
	DataSourceID_inv	Finally established by BOKU; please fill in the database name, report, etc. of the obtained data - so that it is transparent where the data come from
	Comment_inv	Any other comment
InvCatch	ID_sample_inv	Enter number of referring sample (field "ID_sample_inv" of table InvSample)
	ID_catch_inv	Enter a consecutive number, beginning with 1
	Inv_spec_ID	Species ID of invertebrates (according to codelist)
	InvSpecAbund	Abundance of species

Table 20: Variables and descriptions of the key subject "Macrophytes", with its three different tables, for the case study database (task 4.2, 4.3).

Table	Parameter	Description
MacrophSite	ID_SC	Enter code of referring site (field "StationCode" of table Site information)
	ID_site_mph	Enter a consecutive number, beginning with 1
	MPhSiteLong	Longitude of sample site [degrees W (-) or E (+), decimal], WGS84; midpoint of sample reach
	MPhSiteLati	Latitude of sample site [degrees N, decimal], WGS84; midpoint of sample reach
	MPhSite_name	Local or internal name of site
MacrophSample	ID_site_mph	Enter number of referring sample (field "ID_site_mph" of table MacrophSite)
	ID_sample_mph	Enter a consecutive number, beginning with 1
	MPhSampleDate	Date of sample [dd.mm.yyyy]
	MPhSampleMeth	Sampling methode
	ReporterID_mph	Finally established by BOKU; please fill in name and organisation of the person who obtained the data; either you, or the organisation you got it from - so that it is transparent where the data come from
	DataSourceID_mph	Finally established by BOKU; please fill in the database name, report, etc. of the obtained data - so that it is transparent where the data come from
	Comment_mph	Any other comment
MacrophCatch	ID_sample_mph	Enter number of referring sample (field "ID_sample_mph" of table MacrophSample)
	ID_catch_mph	Enter a consecutive number, beginning with 1
	MPhTaxonID	Macrophytes Taxon ID (according to codelist)
	MPhEmSub	[emergent / submerged]
	MPhGrowthForm	Enter ID of growth form, according to Den Hartog & Van der Velde 1988 and Wiegleb 1991 (see codelist)
	MPhAbundance	Abundance of Species; 5-point scale, according to Kohler (1978) [1 = very rare, 2 = rare, 3 = common, 4 = frequent, 5 = abundant, predominant]

Table 21: Variables and descriptions of the key subject "Riparian Beetles", with its three different tables, for the case study database (task 4.2, 4.3).

Table	Parameter	Description
BeetSite	ID_SC	Enter code of referring site (field "StationCode" of table Site information)
	ID_site_beet	Enter a consecutive number, beginning with 1
	BeetSiteLong	Longitude of sample site [degrees W (-) or E (+), decimal], WGS84; midpoint of sample reach
	BeetSiteLati	Latitude of sample site [degrees N, decimal], WGS84; midpoint of sample reach
	BeetSite_name	Local or internal name of site
BeetSample	ID_site_beet	Enter number of referring sample (field "ID_site_beet" of table BeetSite)
	ID_sample_beet	Enter a consecutive number, beginning with 1
	BeetSampleDate	Date of sample; for pitfall traps date of installing traps [dd.mm.yyyy]

	BeetMH_RipFor	Coverage of mesohabitat 'Riparian forest' [%]: > 25% coverage of woody riparian vegetation; trees cover the area
	BeetMH_Past	Coverage of mesohabitat 'Pasture' [%]: Gras land (no tree cover)
	BeetMH_Ohv	Coverage of mesohabitat 'Other herbaceous vegetation' [%]: Riparian herbaceous vegetation (no tree cover)
	BeetMH_VegS	Coverage of mesohabitat 'Vegetated swamp' [%]: very moist (muddy) vegetated patches
	BeetMH_Ogbr	Coverage of mesohabitat 'Open gravel bank/bar' [%]: < 25% vegetation coverage
	BeetMH_Osbr	Coverage of mesohabitat 'Open sand bank/bar' [%]: < 25% vegetation coverage
	BeetMH_Ombr	Coverage of mesohabitat 'Open mud bank/bar' [%]: < 25% vegetation coverage
	BeetMH_Sue	Coverage of mesohabitat 'Steep unvegetated embankment' [%]: < 25% vegetation coverage
	BeetMH_othName	If mesohabitat is present, that does not fit to the classification of mesohabitats above, please specify
	BeetMH_Oth	Coverage of other mesohabitat, if it doesn't fit to defined mesohabitats [%]
	ReporterID_beet	Finally established by BOKU; please fill in name and organisation of the person who obtained the data; either you, or the organisation you got it from - so that it is transparent where the data come from
	DataSourceID_beet	Finally established by BOKU; please fill in the database name, report, etc. of the obtained data - so that it is transparent where the data come from
	Comment_beet	Any other comment
BeetCatch	ID_sample_beet	Enter number of referring sample (field "ID_sample_beet" of table BeetSample)
	ID_catch_beet	Enter a consecutive number, beginning with 1
	BeetSampleMeth	Sampling methode [hand collection / pitfall trap]
	BeetSampleNo	Enter consecutively from 1 within a sample; each subsample (each trap and handcollection get a unique number)
	BeetMesohab	Name of mesohabitat that was sampled
	BeetTaxonID	Beetles Taxon ID (according to codelist)
	BeetAbundance	Abundance of species absolute

Table 22: Variables and descriptions of the key subject "Vegetation", with its four different tables, for the case study database (task 4.2, 4.3).

Table	Parameter	Description
VegSite	ID_SC	Enter code of referring site (field "StationCode" of table Site information)
	ID_site_veg	Enter a consecutive number, beginning with 1
	VegSiteLong	Longitude of sample site [degrees W (-) or E (+), decimal], WGS84; midpoint of sample reach
	VegSiteLati	Latitude of sample site [degrees N, decimal], WGS84; midpoint of sample reach
	VegSite_name	Local or internal name of site
VegSample	ID_site_veg	Enter number of referring sample (field "ID_site_veg" of table VegSite)
	ID_sample_veg	Enter a consecutive number, beginning with 1
	VegSampleDate	Date of sample [dd.mm.yyyy]
	ReporterID_veg	Finally established by BOKU; please fill in name and organisation of the person who obtained the data; either you, or the organisation you

		got it from - so that it is transparent where the data come from
	DataSourceID_veg	Finally established by BOKU; please fill in the database name, report, etc. of the obtained data - so that it is transparent where the data come from
	Comment_veg	Any other comment
VegTransUnit	ID_sample_veg	Enter number of referring sample (field "ID_sample_veg" of table VegSample)
	ID_transect_veg	Transect number (1, 2 or 3) at which the (length of) vegetation order/unit was mapped
	ID_VegCode	Each order or unit can appear more than once per transect or site, so each one is counted separately. Please, enter the ID of the order or unit with an underscore and the consecutive number (beginning with 1) here, e.g. U34_1, U34_2
	ID_vegorder	ID of vegetation order of community (according to codelist)
	ID_vegunit	ID of vegetation unit of community (according to codelist)
	Veg_othName	If there is a vegetation order or unit that you don't find in the list, please specify here
	VegUnitLength	Length of vegetation orders/units at transect number x for all vegetation orders/units present in a sample site [m]
VegTaxa	ID_transect_veg	Enter number of referring transect (field "ID_transect_veg" of table VegTransUnit)
	ID_VegCode	Enter number of referring field "ID_VegCode" of table VegTransUnit
	VegTaxonID	Taxon ID of plants (according to codelist)
	VegTaxonCoverage	Coverage of the taxon within a vegetation unit at an area of 2x3 meters [abundance classes: 1%, 5%, 10%, 15%, 20% and continuing in 10%-steps up to 100%]; only for 3 mapped areas per vegetation unit within a sample site

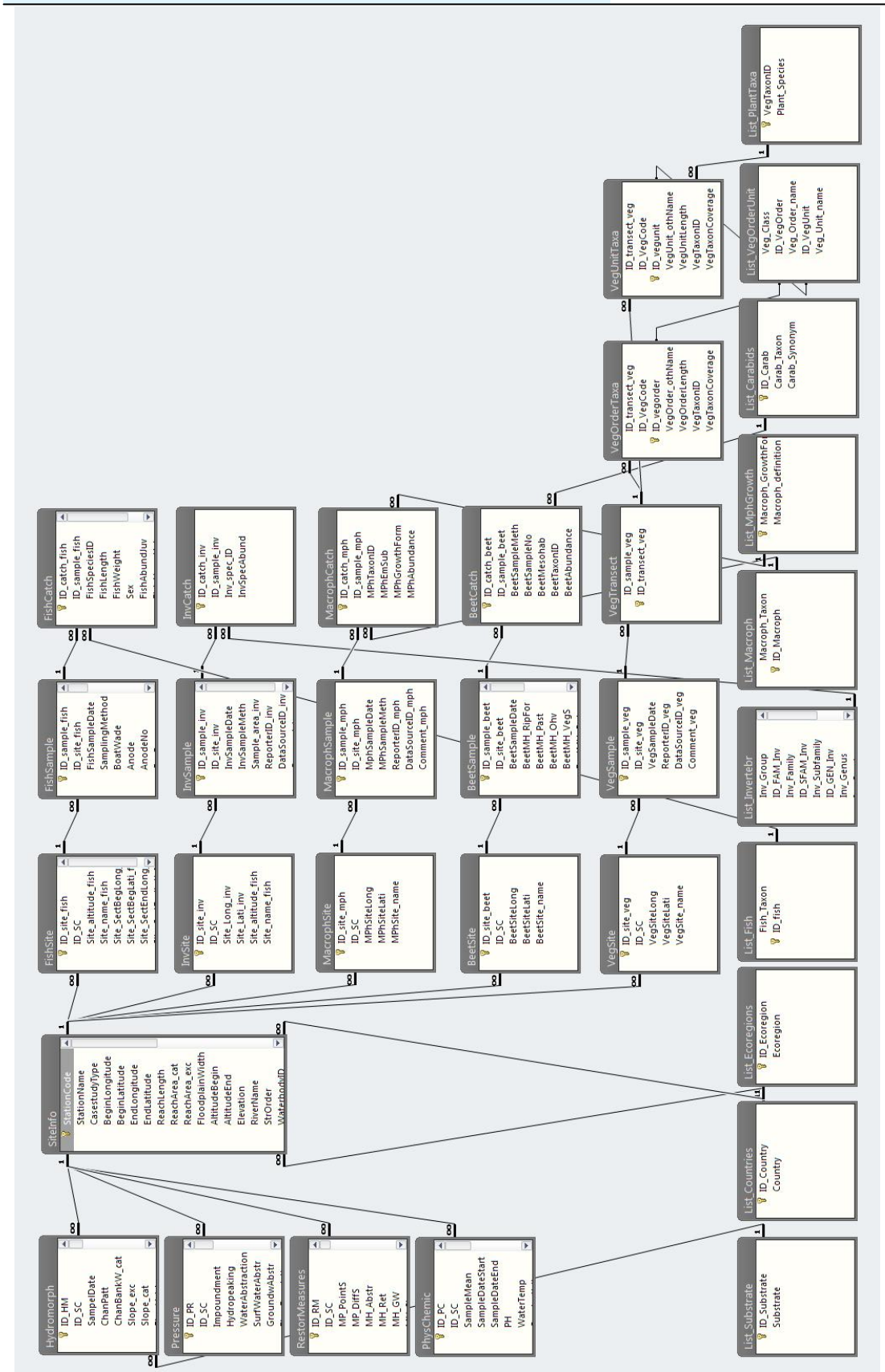


Figure 51: Screenshot of the relationships of the several tables for the case study database in Microsoft Access.

6. References

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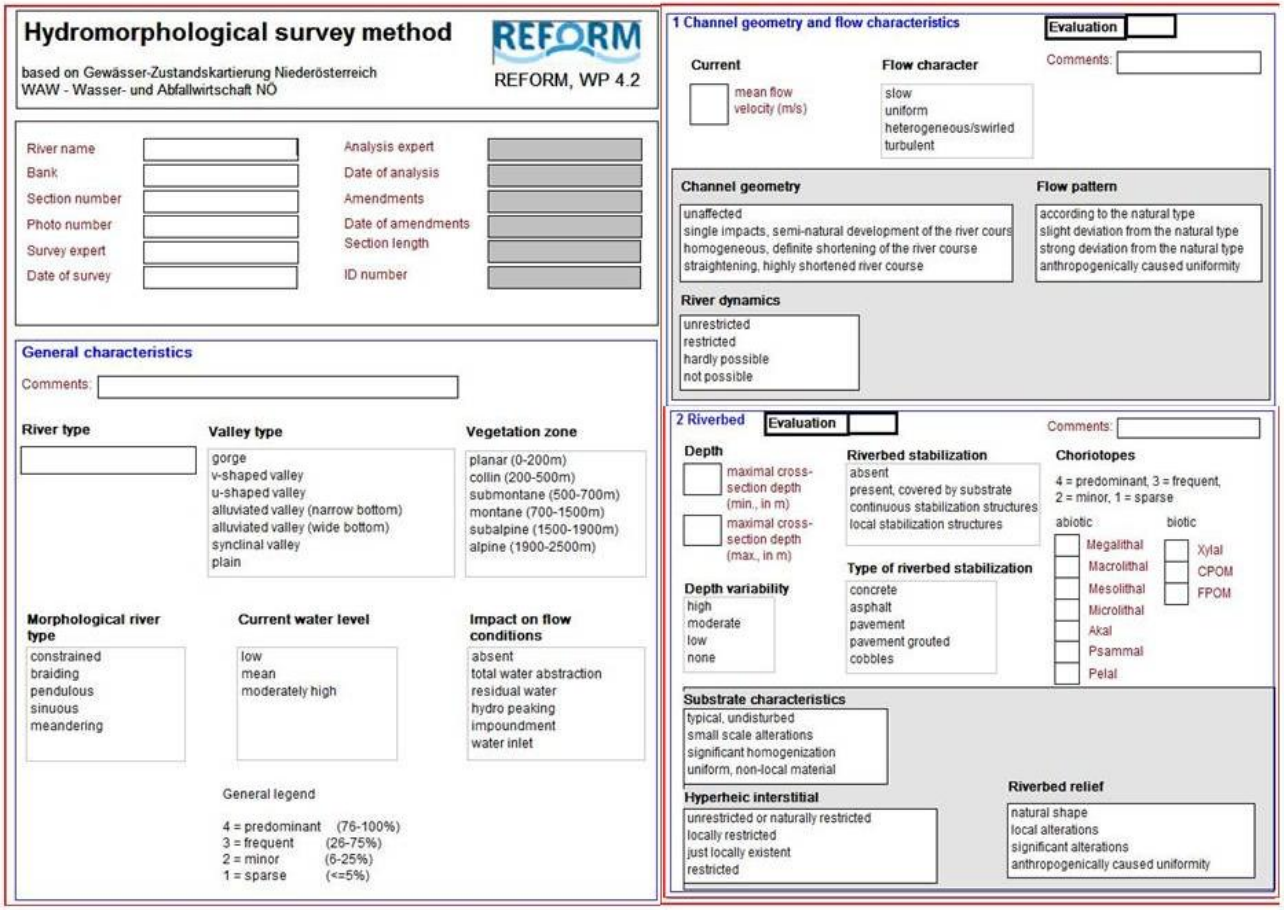
7. Appendix

7.1 Protocols for the hydromorphological survey method

7.1.1 Main form



Hydromorphological survey method

based on Gewässer-Zustandskartierung Niederösterreich
WAW - Wasser- und Abfallwirtschaft NÖ

REFORM, WP 4.2

River name | Analysis expert
Bank | Date of analysis
Section number | Amendments
Photo number | Date of amendments
Survey expert | Section length
Date of survey | ID number

General characteristics

Comments:

River type

Valley type
gorge
v-shaped valley
u-shaped valley
alluviated valley (narrow bottom)
alluviated valley (wide bottom)
synclinal valley
plain

Vegetation zone
planar (0-200m)
collin (200-500m)
submontane (500-700m)
montane (700-1500m)
subalpine (1500-1900m)
alpine (1900-2500m)

Morphological river type
constrained
braiding
pendulous
sinuous
meandering

Current water level
low
mean
moderately high

Impact on flow conditions
absent
total water abstraction
residual water
hydro peaking
impoundment
water inlet

General legend

4 = predominant (76-100%)
3 = frequent (26-75%)
2 = minor (6-25%)
1 = sparse (<=5%)

1 Channel geometry and flow characteristics Evaluation

Comments:

Current
mean flow velocity (m/s)

Flow character
slow
uniform
heterogeneous/swirled
turbulent

Channel geometry
unaffected
single impacts, semi-natural development of the river cours
homogeneous, definite shortening of the river course
straightening, highly shortened river course

Flow pattern
according to the natural type
slight deviation from the natural type
strong deviation from the natural type
anthropogenically caused uniformity

River dynamics
unrestricted
restricted
hardly possible
not possible

2 Riverbed Evaluation

Comments:

Depth
maximal cross-section depth (min., in m)
maximal cross-section depth (max., in m)

Riverbed stabilization
absent
present, covered by substrate
continuous stabilization structures
local stabilization structures

Choriotopes
4 = predominant, 3 = frequent, 2 = minor, 1 = sparse

abiotic: Megalithal, Macrolithal, Mesolithal, Microlithal, Akal, Psammal, Pelal
biotic: Xylal, CPOM, FPOM

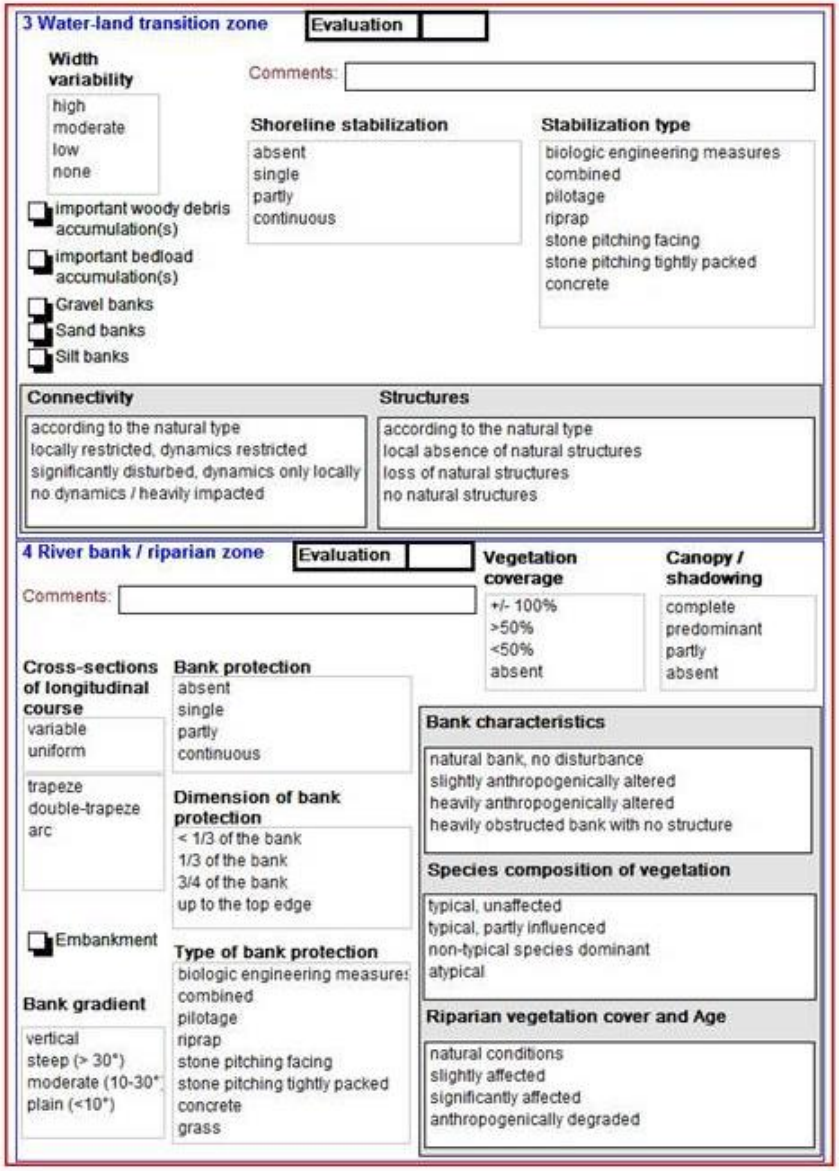
Depth variability
high
moderate
low
none

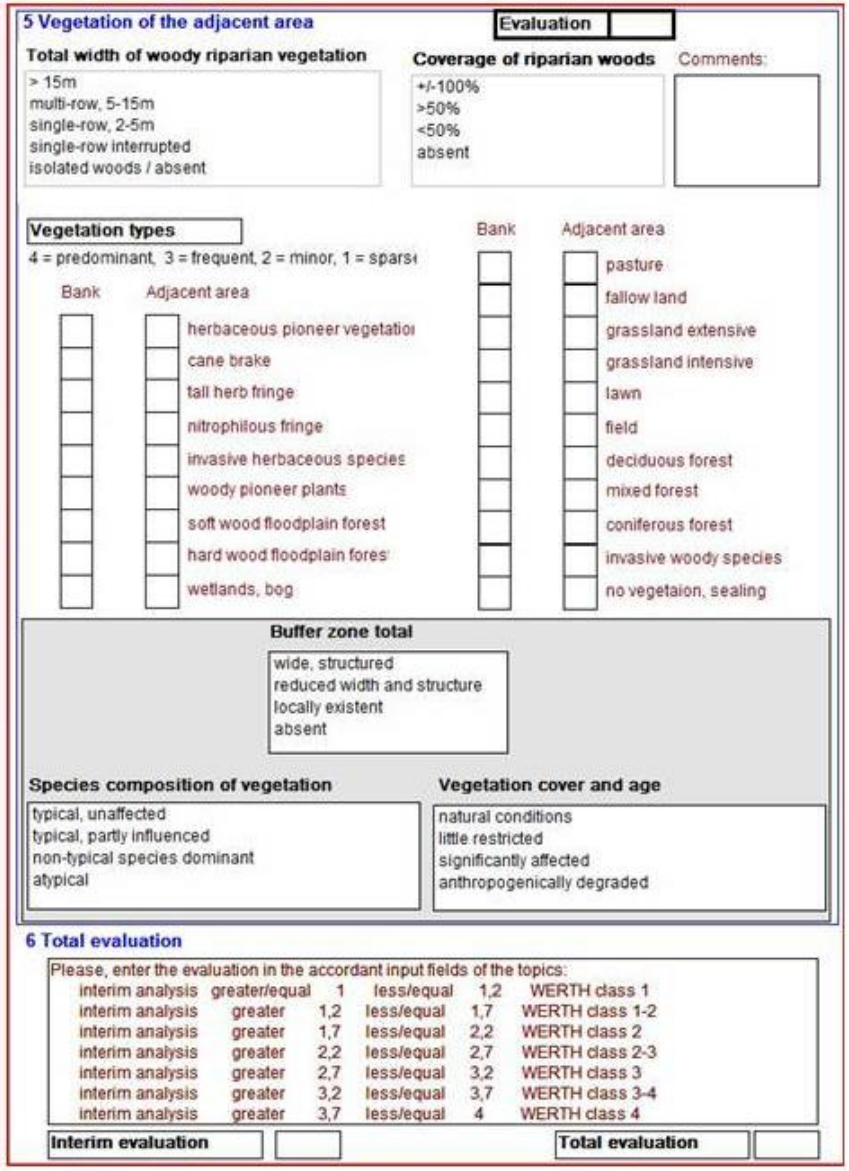
Type of riverbed stabilization
concrete
asphalt
pavement
pavement grouted
cobbles

Substrate characteristics
typical, undisturbed
small scale alterations
significant homogenization
uniform, non-local material

Hyperheic interstitial
unrestricted or naturally restricted
locally restricted
just locally existent
restricted

Riverbed relief
natural shape
local alterations
significant alterations
anthropogenically caused uniformity


3 Water-land transition zone
Evaluation
Width variability
high
moderate
low
none
Comments:
Shoreline stabilization
absent
single
partly
continuous
Stabilization type
biologic engineering measures
combined
pilotage
riprap
stone pitching facing
stone pitching tightly packed
concrete
important woody debris accumulation(s)
important bedload accumulation(s)
Gravel banks
Sand banks
Silt banks
Connectivity
according to the natural type
locally restricted, dynamics restricted
significantly disturbed, dynamics only locally
no dynamics / heavily impacted
Structures
according to the natural type
local absence of natural structures
loss of natural structures
no natural structures
4 River bank / riparian zone
Evaluation
Comments:
Vegetation coverage
+/- 100%
>50%
<50%
absent
Canopy / shadowing
complete
predominant
partly
absent
Cross-sections of longitudinal course
variable
uniform
trapeze
double-trapeze
arc
Bank protection
absent
single
partly
continuous
Dimension of bank protection
< 1/3 of the bank
1/3 of the bank
3/4 of the bank
up to the top edge
Embankment
Type of bank protection
biologic engineering measures
combined
pilotage
riprap
stone pitching facing
stone pitching tightly packed
concrete
grass
Bank gradient
vertical
steep (> 30°)
moderate (10-30°)
plain (<10°)
Bank characteristics
natural bank, no disturbance
slightly anthropogenically altered
heavily anthropogenically altered
heavily obstructed bank with no structure
Species composition of vegetation
typical, unaffected
typical, partly influenced
non-typical species dominant
atypical
Riparian vegetation cover and Age
natural conditions
slightly affected
significantly affected
anthropogenically degraded


5 Vegetation of the adjacent area
Evaluation
Total width of woody riparian vegetation
> 15m
multi-row, 5-15m
single-row, 2-5m
single-row interrupted
isolated woods / absent
Coverage of riparian woods
+/-100%
>50%
<50%
absent
Comments:
Vegetation types
4 = predominant, 3 = frequent, 2 = minor, 1 = sparse
Bank
Adjacent area
herbaceous pioneer vegetation
cane brake
tall herb fringe
nitrophilous fringe
invasive herbaceous species
woody pioneer plants
soft wood floodplain forest
hard wood floodplain forest
wetlands, bog
pasture
fallow land
grassland extensive
grassland intensive
lawn
field
deciduous forest
mixed forest
coniferous forest
invasive woody species
no vegetaion, sealing
Buffer zone total
wide, structured
reduced width and structure
locally existent
absent
Species composition of vegetation
typical, unaffected
typical, partly influenced
non-typical species dominant
atypical
Vegetation cover and age
natural conditions
little restricted
significantly affected
anthropogenically degraded
6 Total evaluation
Please, enter the evaluation in the accordant input fields of the topics:
interim analysis greater/equal 1 less/equal 1,2 WERTH class 1
interim analysis greater 1,2 less/equal 1,7 WERTH class 1-2
interim analysis greater 1,7 less/equal 2,2 WERTH class 2
interim analysis greater 2,2 less/equal 2,7 WERTH class 2-3
interim analysis greater 2,7 less/equal 3,2 WERTH class 3
interim analysis greater 3,2 less/equal 3,7 WERTH class 3-4
interim analysis greater 3,7 less/equal 4 WERTH class 4
Interim evaluation
Total evaluation

7.1.2 Additional form – continuum interruptions

Hydromorphological survey method
(based on Gewässer-Zustandskartierung Niederösterreich, WAW –Wasser- und Abfallwirtschaft NÖ

WP 4.2

Structures interrupting the river continuum

River name	Consecutive no.	ID structure	Natural interruption	Type of interruption	Fish ladder	Width (m)	Height (m)	Comments

7.1.3 Additional form - backwaters

Hydromorphological survey method
(based on Gewässer-Zustandskartierung Niederösterreich,
WAW – Wasser- und Abfallwirtschaft NÖ

WP 4.2

REFORM

Backwaters

Waterbody name	Consecutive no.	ID backwater	Connection	Flow conditions

7.2 Field forms for transect method

7.2.1 Field forms for channel features

Page 1

Field form for recording hydromorphology within REFORM WP4.2 – Channel features

Investigator: ..... Country: .....

Stream name: ..... Site name: .....

Site (please mark):

Catchment with large restoration measure(s)
O Restored section
O Degraded section upstream

Catchment with short restoration measure(s)
O Restored section
O Degraded section upstream

Length of sample section: .....

Transects should be numbered TOWARDS flow direction (transect 1 at the downstream end and transect 10 at the upstream end of section)

Sampling date: .....

Transect 1	Channel feature	Dominant substrate	Length [m]	Comments (e.g.on location of transect)
Direction of recording (left → right or right → left)				

Transect 2	Channel feature	Dominant substrate	Length [m]	Comments (e.g.on location of transect)
Direction of recording (left → right or right → left)				

Page 2

Field protocol for recording hydromorphology within REFORM WP4.2 – Channel features

Transect 3	Channel feature	Dominant substrate	Length [m]	Comments (e.g.on location of transect)
Direction of recording (left → right or right → left)				

Transect 4	Channel feature	Dominant substrate	Length [m]	Comments (e.g.on location of transect)
Direction of recording (left → right or right → left)				

Transect 5	Channel feature	Dominant substrate	Length [m]	Comments (e.g.on location of transect)
Direction of recording (left → right or right → left)				

Field protocol for recording hydromorphology within REFORM WP4.2 – Channel features

Transect 6	Channel feature	Dominant substrate	Length [m]	Comments (e.g.on location of transect)
Direction of recording (left → right or right → left)				

Transect 7	Channel feature	Dominant substrate	Length [m]	Comments (e.g.on location of transect)
Direction of recording (left → right or right → left)				

Transect 8	Channel feature	Dominant substrate	Length [m]	Comments (e.g.on location of transect)
Direction of recording (left → right or right → left)				

Field protocol for recording hydromorphology within REFORM WP4.2 – Channel features

Transect 9	Channel feature	Dominant substrate	Length [m]	Comments (e.g.on location of transect)
Direction of recording (left → right or right → left)				

Transect 10	Channel feature	Dominant substrate	Length [m]	Comments (e.g.on location of transect)
Direction of recording (left → right or right → left)				

Please record the coordinates ([degrees W (-) or E (+), decimal], WGS84) of transect 1 and transect 10!

	Longitude	**Latitude**
Transect 1		
Transect 10		

7.2.2 Field forms for microhabitat measurement

Field form for recording hydromorphology within REFORM WP4.2 – Aquatic microhabitats

Investigator: ..... Country: .....

Stream name: ..... Site name: .....

Site (please mark):

Catchment with large restoration measure(s)	O Restored section O Degraded section upstream
Catchment with short restoration measure(s)	O Restored section O Degraded section upstream

Length of sample section: .....

Transects should be numbered TOWARDS flow direction (transect 1 at the downstream end and transect 10 at the upstream end of section)

Sampling date: .....

Number of bars		Number of secondary channels/sidearms		Number of islands		Number of...	
Unvegetated		Secondary channels		Unvegetated		Standing water bodies	
Herbaceous		Connected sidearms		With herbaceous vegetation		Woody debris	
Woody		Disconnected sidearms		With woody vegetation		Deadwood trunks	

Transect 1			Direction of recording	Survey point	Depth [m]	Substrate	Height of vegetation [% of total water column]*	Flow velocity
Bankfull width [m]	left			**1**				
	right			**2**				
Bankfull height [m]	left			**3**				
	right			**4**				
Comments:				**5**				
				6				
				7				
				8				
				9				
				10				

Transect 2			Direction of recording	Survey point	Depth [m]	Substrate	Height of vegetation [% of total water column]*	Flow velocity
Bankfull width [m]	left			**1**				
	right			**2**				
Bankfull height [m]	left			**3**				
	right			**4**				
Comments:				**5**				
				6				
				7				
				8				
				9				
				10				

Classification of flow velocity (0 = stagnant, 1 = slow, 2 = rippled, 3 = swirled, 4 = turbulent);
*: if macrophytes are present at survey point; if identification is possible, note species in comments

Field form for recording hydromorphology within REFORM WP4.2 – Aquatic microhabitats

Transect 3			Direction of recording	Survey point	Depth [m]	Substrate	Height of vegetation [% of total water column]*	Flow velocity
Bankfull width [m]	left			**1**				
	right			**2**				
Bankfull height [m]	left			**3**				
	right			**4**				
Comments:				**5**				
				6				
				7				
				8				
				9				
				10				

Transect 4			Direction of recording	Survey point	Depth [m]	Substrate	Height of vegetation [% of total water column]*	Flow velocity
Bankfull width [m]	left			**1**				
	right			**2**				
Bankfull height [m]	left			**3**				
	right			**4**				
Comments:				**5**				
				6				
				7				
				8				
				9				
				10				

Transect 5			Direction of recording	Survey point	Depth [m]	Substrate	Height of vegetation [% of total water column]*	Flow velocity
Bankfull width [m]	left			**1**				
	right			**2**				
Bankfull height [m]	left			**3**				
	right			**4**				
Comments:				**5**				
				6				
				7				
				8				
				9				
				10				

Classification of flow velocity (0 = stagnant, 1 = slow, 2 = rippled, 3 = swirled, 4 = turbulent);
*: if macrophytes are present at survey point; if identification is possible, note species in comments

Field form for recording hydromorphology within REFORM WP4.2 – Aquatic microhabitats

Transect 6			Direction of recording	Survey point	Depth [m]	Substrate	Height of vegetation [% of total water column]*	Flow velocity
Bankfull width [m]	left			**1**				
	right			**2**				
Bankfull height [m]	left			**3**				
	right			**4**				
Comments:				**5**				
				6				
				7				
				8				
				9				
				10				

Transect 7			Direction of recording	Survey point	Depth [m]	Substrate	Height of vegetation [% of total water column]*	Flow velocity
Bankfull width [m]	left			**1**				
	right			**2**				
Bankfull height [m]	left			**3**				
	right			**4**				
Comments:				**5**				
				6				
				7				
				8				
				9				
				10				

Transect 8			Direction of recording	Survey point	Depth [m]	Substrate	Height of vegetation [% of total water column]*	Flow velocity
Bankfull width [m]	left			**1**				
	right			**2**				
Bankfull height [m]	left			**3**				
	right			**4**				
Comments:				**5**				
				6				
				7				
				8				
				9				
				10				

Classification of flow velocity (0 = stagnant, 1 = slow, 2 = rippled, 3 = swirled, 4 = turbulent);
*: if macrophytes are present at survey point; if identification is possible, note species in comments

Field form for recording hydromorphology within REFORM WP4.2 – Aquatic microhabitats

Transect 9			Direction of recording	Survey point	Depth [m]	Substrate	Height of vegetation [% of total water column]*	Flow velocity
Bankfull width [m]	left			**1**				
	right			**2**				
Bankfull height [m]	left			**3**				
	right			**4**				
Comments:				**5**				
				6				
				7				
				8				
				9				
				10				

Transect 10			Direction of recording	Survey point	Depth [m]	Substrate	Height of vegetation [% of total water column]*	Flow velocity
Bankfull width [m]	left			**1**				
	right			**2**				
Bankfull height [m]	left			**3**				
	right			**4**				
Comments:				**5**				
				6				
				7				
				8				
				9				
				10				

Classification of flow velocity (0 = stagnant, 1 = slow, 2 = rippled, 3 = swirled, 4 = turbulent);
*: if macrophytes are present at survey point; if identification is possible, note species in comments

7.3 Protocols for stable isotope analysis

7.3.1 Labeling of samples

Every sample should be labeled with an acronym that is composed of three parts:

(1) a representative letter for the stream the particular sample originates from,
(2) a second letter that is either **R** (for **R**estored reach) or **D** (for **D**egraded reach),
(3) a number that is continued consecutively (start with 1,2,3 for FPOM, continue with 4,5,6 for CPOM…)

For example, the label acronym "RR1" has the following meaning:

(1) The first letter represents the stream the sample originates from. In this case the "R" is an acronym for the river Ruhr. (2) The second letter is either "R" (for restored reach) or "D" (for degraded reach. In this case the sample was taken at the restored reach of river Ruhr. And (3) the number that is continued consecutively starting with 1 for POM. So the sample labeled as RR1 contains FPOM from the restored reach of river Ruhr.

Furthermore an additional description should always be added so that people in the laboratory can reconstruct the labeling. The description should look like the following:

Investigator: …… Country: Germany

Stream name: Ruhr (flagship). Site name: ……

Site (please mark):

Catchment with large restoration measure		Catchment with short restoration measure	
☒	Restored section	○	Restored section
○	Degraded section upstream	○	Degraded section upstream

Label-Acronym	content (type of sample and subtype)	Species name/size class	number of Individuals within the composite sample (N)	date of sampling
RR1	FPOM	-	-	15.06.2012
RR2	CPOM	-	-	15.06.2012
RR3	Periphyton	-	-	15.06.2012
RR4	macrophyte	Carex aquatilis	103 g fresh weight	15.06.2012
RR5	terrestrial plant	Alnus glutinosa	105 g fresh weight	15.06.2012
RR6	Macroinvertebrate (Shredders)	Gammarus pulex	15	15.06.2012
RR7	riparian arthropod	Bembidion sp.	15	15.06.2012
RR8	terrestrial arthropod	…	…	15.06.2012
…	…	…	…	…

The species name is not necessary for POM and periphyton and ground beetles but for all other components as terrestrial and aquatic plants and macroinvertebrates (if possible).

7.3.2 Overview of material

POM

- Sediment corer (or s.th. similar)
- Sample container/bucket (to pool samples)
- Sieve (1mm)
- Vessels/bottles to store samples before they are further processed (Polypropylene)

Periphyton

- Knife/cutter
- Plastic bags (approx. 25 x 30 cm)
- Brush
- Whitetray
- Razorblade/toothbrush
- Sample container (= bottle)
- Filter (Whatman GF/F)
- Vessels/bottles to store samples before they are further processed (Polypropylene)

Plants

- Knife/cutter
- Plastic bags (approx. 25 x 30 cm)
- White tray, Razorblade/toothbrush, Filter (Whatman GF/F), bottles (all in cases of macrophytes covered with periphyton)

Macroinvertebrates

- Shovelsampler (0,5 mm), mesh
- Forceps
- White tray
- Vessels/bottles to separate individuals in the field (Polypropylene)
- Petri dishes and lid

Arthropods

- Aspirator, forceps, exhaustors
- Vessels/bottles to separate individuals in the field (Polypropylene)
- Petri dishes and lid

Other

- Waders/gloves
- Frost box and thermal packs
- Sampling manual/notebook
- Edding/pencil
- Aqua dest.
- GPS/maps
- Additional vessels/bottles (Polypropylene)
- Eppendorf reaction vessels (2 ml)

7.3.3 Overview of samples and expected number of samples for each section

Type of sample	Subtype	Minimum number of samples	Sample size	Minimum dry-weight
POM	FPOM	1 composite sample	100 g fresh weight	> 50 mg
	CPOM	1 composite sample	100 g fresh weight	> 50 mg
Periphyton	-	1 composite sample	several samples taken from plants and/or stones	> 50 mg
Plants	terrestrial (herbaceous riparian vegetation)	1 composite sample of the major dominant species	100 g fresh weight or one plastic bag of approx. 25x30 cm	> 50 mg
	aquatical (submerse or emerse macrophytes)	1 composite sample of the major dominant species	100 g fresh weight or one plastic bag of approx. 25x30 cm	> 50 mg
Macroinvertebrates	Predators	1 composite sample (consisting of individuals of the same species)	15 individuals	> 50 mg
	Grazer	1 composite sample (consisting of individuals of the same species)	15 individuals	> 50 mg
	Shredders	1 composite sample (consisting of individuals of the same species)	15 individuals	> 50 mg
	Collector-gatherers	1 composite sample (consisting of individuals of the same species)	15 individuals	> 50 mg
	Collector-filterers	1 composite sample (consisting of individuals of the same species)	15 individuals	> 50 mg
Arthropods	riparian	1 composite sample for each taxon/size class	15 individuals	> 50 mg
	terrestrial	1 composite sample for each taxon/size class	15 individuals	> 50 mg
Fish (optional)				

⇨ **minimum 12 samples per section**

7.4 Field protocols for Macroinvertebrate sampling

Field protocol for macroinvertebrate sampling within REFORM WP4.3

Investigator: ..... Country: .....

Stream name: ..... Site name: .....

Site (please mark):

Catchment with large restoration measure(s)	O Restored section O Degraded section upstream	Catchment with short restoration measure(s)	O Restored section O Degraded section upstream

Sampling date: .....

Mineralic substrates	% of coverage (5%-classes); x = present but <5%	Number of replicates	Remarks
megalithal (> 40 cm) upper sides of large cobbles, boulders and blocks, bedrock			
macrolithal (> 20 cm – 40 cm) coarse blocks, head-sized cobbles, with a variable percentages of cobble, gravel and sand			
mesolithal (> 6 cm – 20 cm) fist to hand-sized cobbles with a variable percentage of gravel and sand			
microlithal (> 2 cm – 6 cm) coarse gravel, (size of a pigeon egg to child's fist) with variable percentages of medium to fine gravel			
akal (> 0,2 cm – 2 cm) fine to medium-sized gravel			
psammal/psammopelal (> 6 µm – 2 mm) sand and mud			
argylall (< 6 µm) silt, loam, clay (inorganic)			
technolithal 1 riprap			
technolithal 2 concrete walls			
Organic substrates			
algae filamentous algae, algal tufts			
submerged macrophytes macrophytes, including moss and Characeae			
emergent macrophytes e.g. Typha, Carex, Phragmites			
living parts of terrestrial plants fine roots, floating riparian vegetation			
xylal (wood) tree trunks, dead wood, branches, roots			
CPOM deposits of coarse particular organic matter, e.g. fallen leaves			
FPOM deposits of fine particular organic matter			
sewage bacteria and –fungi and saprobel/organic mud e.g. Sphaerotilus, Leptomitus/organic slud and mudge			
debris organic and inorganic matter deposited within the splash zone area by wave motion and changing water levels, e.g. mussel shells			
	Sum	**100%**	**20**

7.5 Field Protocol for Macrophyte sampling

Field protocol for macrophyte sampling within REFORM WP4.3

Investigator: ..... Country: .....

Stream name: ..... Site name: .....

Site (please mark):

Catchment with large restoration measure(s)	O Restored section O Degraded section upstream
Catchment with short restoration measure(s)	O Restored section O Degraded section upstream

Sampling date: .....

Scientific name of taxon	Emergent/ submerged	Growth form	Abundance (NOVANA scale: 1= 1-5% 2= 5-25% 3= 25-50% 4= 50-75% 5= 75-100%)

Macrophyte sampling within REFORM WP4.3 - Definitions and examples for the growth forms according to Den Hartog & Van der Velde (1988) and Wiegleb (1991)

Growth form	Definition	Example
Ceratophyllids	Free-floating plants with large, finely devided submerged leaves	*Ceratophyllum* spec., *Utricularia* spec.
Elodeids	Submerged plants with whorled stems	*Elodea* spec., *Hippuris vulgaris*
Equisetids	Horse tails	*Equisetum* spec.
Haptophyts	Mosses, red and green algae, lichen	*Fontinalis* spec.
Helodids (Helophytes)	Emergent plants	*Typha* spec., *Phalaris arundinacea*
Hydrocharids	Free-floating plants with rosettes of specialised floating leaves	*Hydrocharis morsus-ranae*
Isoetids	Submerged plants (and filamentous algae) with short shoots/stems and a rosette of stiff radical leaves	*Isoëtes* spec., *Littorella uniflora, Cladophora spec.*
Juncids	Submerged plants with simple, narrow, margin entire, with septate leafs (rush)	*Juncus* spec.
Lemnids	Free-floating plants with small leaf-like thalli	*Spirodela polyrhiza, Lemna* spec.
Magnopotamids	Submerged plants with oblong to lanceolate submerged leaves	*Potamogeton polygonifolius, Potamogeton crispus*
Myriophyllids	Submerged plants with leafs at stem, feather-like leafs	*Myriophyllum* spec., *Ranunculus* spec.
Nymphaeids	Plants with longly petiolated floating leaves	*Nuphar lutea, Persicaria amphibia*
Parvopotamids	Entirely submerged plants with linear to oblong leaves	*Zannichellia pallustris, Potamogeton berchtoldii*
Peplids	Plants with oblong and spatulate leaves, the upper ones forming floating rosettes	*Callitriche* spec.
Vallisnerids	Submerged plants with a short stem and a rosette or bundle of long, linear, floating leaves, rooted in the soil	*Sparganium* spec., *Vallisneria spiralis*

7.6 Field protocols for riparian arthropod sampling

Field protocol for riparian arthropod sampling within REFORM WP4.3

Investigator: ..... Country: .....

River name: ..... Site name: .....

Site (please mark):

Catchment with large restoration measure(s)	O Restored section O Degraded section upstream
Catchment with short restoration measure(s)	O Restored section O Degraded section upstream

Length of sample section: .....

Sampling date for habitat cover estimation and hand samples: .....

Sampling date for pitfall traps (1 week):

- from: ..... to: .....

Mesohabitat cover (riparian area on a max. 10m wide stripe):

Mesohabitat	Description	% Coverage	Number of samples
Riparian forest	> 25% coverage of woody riparian vegetation; trees cover the area		
Pasture	Gras land (no tree cover)		
Other herbaceous vegetation	Riparian herbaceous vegetation (no tree cover)		
Vegetated swamp	Very moist (muddy) vegetated patches		
Steep unvegetated embankment			
Open gravel bar	< 25% vegetation coverage		
Open sand bar	< 25% vegetation coverage		
Open mud bar	< 25% vegetation coverage		
Others (please specify)			

Sample number (1-10)	Mesohabitat	Pitfall trap or hand sampling	Comments

7.7 Field protocols for fish sampling

Fish data

Fish data			
Date (dd/mm/yyyy)			
Site code		Sampling method	
Site name		Sampling location	
Name of watercourse		Main river region	
XY co-ordinates		GPS co-ordinates	
Longitude		Transect length [m]	
Latitude		Fished area [m2]	
Altitude[m]		Wetted width [m]	

	Fish data		
	Fish species	number of specimen length ≤150 mm	number of specimen length >150 mm
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
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25			
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27			
28			
29			
30			
31			
32			
33			
34			
35			

Abiotic and method data

Reference fields	
Site code	
Date	dd/mm/yyyy
Site name	
Name of watercourse or River name	
River region	
XY co-ordinates or longitude, latitude	
GPS co-ordinates	
Altitude	m
Sampling location	Main channel/Backwaters/Mixed
Sampling method	Boat/Wading
Fished area	m^2
Wetted width	m
Abiotic variables	
Altitude	m
Lakes upstream affecting the site	Yes / No
Distance from source	km
Flow regime	Permanent / Summer dry/Winter dry/Intermittent
Geomophology	Naturally constrained no modification/ Braided/Sinuous/Meand regular/Meand tortuous
Former floodplain	No/Small/Medium/Large/Some waterbodies remaining/
Water source type	Glacial/Nival/Pluvial/Groundwater
Former sediment size	Organic/Silt/Sand/ Gravel-Pebble-Cobble/Boulder-Rock
Upstream drainage area	km^2
Distance from source	km
River slope	m/km (‰)
Mean air temperature	Celsius (C)

Human impact data (optional)

Site code		**Chemical data**	
Name watercourse		Oxygen (mg/l or % saturation)	
XYZ co-ordinates or longitude latitude altitude	X:……(N) Y:……(E) Z :……m	Conductivity (mS/cm)	
Site name		pH	
Main river region		Phosphate (mg/l)	
Field responsible		Nitrite (mg/l)	
GPS co-ordinates		Nitrate (mg/l)	
Sampling hour		Turbidity (NTU)	
		Secchi depth (cm)	
Site characteristics			
Water level	low / normal / high		
Natural shelters	natural / poorly developed / absent		
Pools in transect	number:		
Riffles in transect	number:		
Meanders in transect	number:		
Bank	natural / partly artificial / overall reinforced		
Morphological condition	Minor / slight / moderate / strong / severe / disturbance		
Agricultural activities	range: 50 m from stream: none / along one bank / along both sides		
Prairies	range: 50 m from stream: none / along one bank / along both sides		
Trees	range: 20 m from stream: none / < 10 / >10 & < 50 / > 50 or forest		
Urbanisation (constructions)	range: 100 m from stream: none / < 5 / >5 & <10 / >10		
Industrial activities	Yes: describe……/ none		
Water flow	Minor / slight / moderate / strong / severe / disturbance		
Impact of agriculture in river basin upstream	> 40% cultivated land, severe impact: class 5; > 40% cultivated land, strong impact: class 4; < 40% cultivated land, moderate impact: class 3; < 40% cultivated land, low impact: class 2; < 10% cultivated land: class 1;		
Urbanisation in river basin upstream	>15% urban land severe impact: class 5 >15% urban land strong impact: class 4 <15% urban land moderate impact: class 3 <15% urban land low impact: class 2 <1% urban land: class 1		
Migration barriers (transect)	Yes: describe……/ none		
Dam present upstream	Yes / No		
Migration barriers in the river (total river)	Barriers present: no passage for fish possible: class 5 passage for 1 single species occasionally: class 4 passage for certain species or certain years: class 3 passage for most species most years: class 2 No barriers (or functional bypass): class 1		

7.8 Field protocols for floodplain vegetation sampling

Field form 1 for floodplain vegetation sampling within REFORM WP4.3 - Vegetation units

Investigator: ..... Country: .....

Stream name: ..... Site name: .....

Site (please mark):

Catchment with large restoration measure(s)	O Restored section O Degraded section upstream	Catchment with short restoration measure(s)	O Restored section O Degraded section upstream

Sampling date: ..... Length of sample section: .....

Transect number	Vegetation unit	Vegetation unit code	Length [m]

Field form 2 for floodplain vegetation sampling within REFORM WP4.3 – Sample plots

Investigator: ..... Country: .....

Stream name: ..... Site name: .....

Site (please mark):

Catchment with large restoration measure(s)	O Restored section O Degraded section upstream	Catchment with short restoration measure(s)	O Restored section O Degraded section upstream

Sampling date: .....

Transect number: ..... Subzone number : ..... Sample plot number: .....

Scientific name of plant taxon	Coverage according to Braun-Blanquet (0.5: 0 – 1%, 1: 1-5%, 2: 5-25%, 3: 25-50%, 4: 50-75%, 5: 75-100%)