Annex 5

UNDP GEF Kura Project "Advancing Integrated Water Resource Management (IWRM) across the Kura river basin through implementation of the transboundary agreed actions and national plans"

Eighteen-month monitoring plan for the ecological assessment in the Kura River basin

March 2018

Abbreviations and acronyms

AWB	Artificial Water Body
EPIRB	Environmental Protection of International River Basins project
RBMP	River Basin Management Plan (of the Water Framework Directive)
QE	Quality Elements (for the classification of water bodies)
WB	Water Body
WFD	Water Framework Directive (Directive 2000/60/EC)

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Executive summary

This document has been developed in order to provide guidance to Georgia and Azerbaijan on the implementation of a river monitoring plan, in three pilot catchments (Aragvi in Georgia, Shamkirchay and Alijanchay in Azerbaijan). The monitoring plan is foreseen to support the classification of river water bodies, based on the project's short-term methodological proposal, and the assessment of the effects of the foreseen pilot implementation of Environmental Flows in the three catchments. For all methodological details not specified in this document, reference has to be made to the previous project deliverable "Updated version of the River Basin classification structure in line with the EU WFD".

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Introduction

The monitoring activity of surface waters in the Kura river basin, both in Georgia and Azerbaijan, is currently still far from sufficient in order to support river basin planning and management, in a framework of WFD approximation. This document is part of a wider effort to support the countries in setting up WFD consistent monitoring and classification of water bodies. It tackles three pilot catchments (Aragvi in Georgia, Shamkirchay and Alijanchay in Azerbaijan). It contains a monitoring plan, to be implemented in the next two years in the pilot catchments. The objective of the proposed monitoring is twofold: primarily it aims to support the classification of water bodies, based on the project's short-term methodological proposal contained in the document "Updated version of the River Basin classification structure in line with the EU WFD"; secondarily it aims to facilitate the assessment of the effects of the foreseen pilot implementation of Environmental Flows in the three catchments. As to the latter, however, it has to be stressed that the specific stretches, timing and flow release changes to be applied have not been defined, yet. Therefore, only general indications can be given at this stage, that can be revised and refined once more information becomes available.

The pilot catchments

Aragvi (Georgia)

The Aragvi river basin is located in the north of Georgia, on the southern slopes of the Caucasus Mountains. The basin has a surface area of approximately 2740 km^2, with elevations ranging from 500 to 3500 m and mostly higher than 1000 m. The main rivers in the basin are:

- Tetri (white) Aragvi;
- Shavi (black) Aragvi (joining the Tetri Aragvi in Pasanauri);
- Pshavis Aragvi (joining the Tetri Aragvi in the Zhinvali reservoir); downstream Zhinvali the river is called simply Aragvi;
- Narekvavi (joining the Aragvi few km upstream Mtskheta, where the Aragvi flows into the Kura).

Figure 1 – The confluence of the Aragvi (right) into the Kura, in Mtskheta

In the Aragvi Pilot River Basin Management Plan drafted in the “Trans-boundary River Management Phase II for the Kura river” TACIS project (Ansbaek et al. 2011) 25 water bodies are delineated (see Figure 2 and Table 1), including 2 reservoirs (Zhinvali and Narekvavi). This can be a starting point for the monitoring and assessment activity, but it has to be considered that this delineation was very preliminary and based on a very limited set of environmental data. Moreover, only 4 water bodies (in addition to the two reservoirs) were identified as at risk of not achieving WFD objectives, in connection to the (mainly) hydromorphological alteration due to the two main reservoirs (rivers Aragvi and Narekvavi), to abstraction for irrigation (rivers Akhatnis-Khevi and Tezami) and to the impact on physico-chemical water quality due to the urban wastewater discharge from the town of Dusheti (river Dushetis-Khevi). However, given the diffuse lack of urban wastewater treatment in the basin, the strong hydrological alteration in other water bodies, the presence of several extraction sites and of other diffuse pressures, it is deemed unlikely that all the remaining water bodies are not at risk. Moreover, very significant additional pressures are foreseen for the next future, such as 10 new hydropower plants and the reactivation of 4 irrigation schemes (G4G, 2017). Therefore, the monitoring activity should cover a wider range of water bodies.

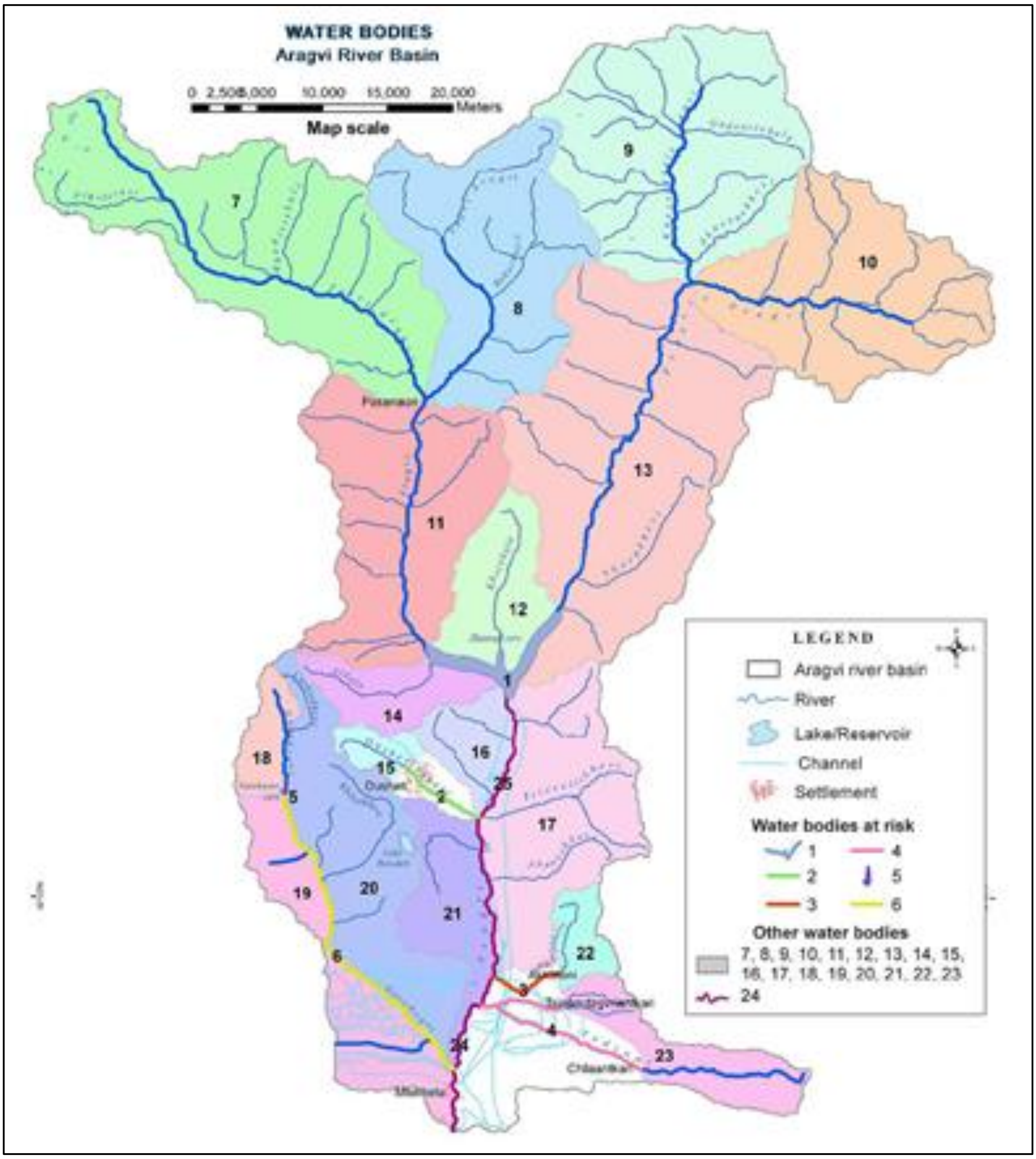

Figure 2 – The water bodies delineated in the Aragvi Pilot RBMP (from Ansbaek et al. 2011).

Numbering in Figure 1	Water Body	Numbering in Figure 1	Water Body
1	*Zhinvali reservoir*	14	Arkala

2	Dushetis-Khevi (downstream Dusheti)	15	(Upper) Dushetis-Khevi
3	Akhatnis-Khevi (downstream Akhatani)	16	Right tributaries of the Aragvi between Zhinvali reservoir and 15
4	Tezami (downstream Chilaantkari))	17	Left tributaries of the Aragvi between Zhinvali reservoir and 3
5	*Narekvavi reservoir*	18	(Upper) Narekvavi (upstream the Narekvavi reservoir)
6	Narekvavi (downstream the Narekvavi reservoir)	19	Right tributaries of the Narekvavi
7	(Upper) Tetri Aragvi	20	Left tributaries of the Narekvavi
8	Shavi Aragvi	21	Right tributaries of the Aragvi (between 2 and 6)
9	Khevsuretis Aragvi	22	(Upper) Akhatnis-Khevi
10	(Upper) Pshavis Aragvi	23	(Upper) Tezami
11	Tetri Aragvi (downstream the confluence with 8)	24	Aragvi (between 2 and confluence with the Kura)
12	Khorshula	25	Aragvi (between 1 and 2)
13	Pshavis Aragvi (downstream the confluence with 9)		

Table 1 – List of water bodies delineated in the Aragvi Pilot RBMP (adapted from Ansbaek et al. 2011).

Shamkirchay (Azerbaijan)

The Shamkirchay basin is located in Western Azerbaijan and has an area of approximately 1170 km^2. The river is called Shamkir starting from the confluence of the Sarisuchay with the Agqayachay, flowing from the north-east of the Shahdagh massive in the Lesser Caucasus. The altitude of the basin ranges from 3220 m, in Hinaldagh, to 158 m, at the confluence in the Shamkir Reservoir, with an average of approximately 1634 m.

A preliminary pressure analysis and WB delineation was carried out in EPIRB (2014a, 2014b), based on field surveys in 2013 and 2014. The Shamkirchay was divided into 6 WBs, while its tributaries accounted for other 6 (see Table 2).

Name	Code	Description	Length (km)
Sarisuchay	211-1-WB025	Sarisuchay from source to confluence in the Agqayachay	23.3

Agqayachay	212-1-WB026	Agqayachay from source to confluence with the Shamkirchay	12.1
Shamkirchay	21-1-WB027	Shamkirchay from the Agqayachay confluence to the Qoshqarchay confluence	8.9
Qoshqar	213-1-WB028	Qoshqar from source to confluence in the Shamkirchay	7.9
Shamkirchay	21-2-WB029	Shamkirchay from the Qoshqar confluence to the Gedebeychay confluence	53.6
Gedebeychay	214-1-WB030	Gedebeychay from source to upstream the city of Gedebey	12.4
Gedebeychay	214-2-WB031R	Gedebeychay from upstream Gedebey to the confluence in the Shamkirchay	6.0
Shamkirchay	21-3-WB032	Shamkirchay from the confluence with the Gedebeychay to the confluence with the Emirvar	2.5
Emirvar	215-1-WB033	Emirvar from source to confluence in the Shamkirchay	6.4
Shamkirchay	21-4-WB034	Shamkirchay from the confluence with the Emirvar to upstream the Mehrli village	35.5
Shamkirchay	21-5-WB035R	Shamkirchay from upstream the Mehrli village to Yeniabad village	31.2
Shamkirchay	21-6-WB036R	Shamkirchay from the Yeniabad village to the confluence in the Shamkir Reservoir	6.6

Table 2 – List of water bodies delineated in the Shamkirchay basin in EPIRB (adapted from EPIRB, 2014a, 2014b)

Untreated waste waters from settlements, dumping of urban solid waste in the river corridor, sand and gravel extraction in the riverbed and water abstraction were indicated as the main pressure factors in the Shamkirchay basin. This led to the a preliminary identification of 3 WBs at risk:

- the Shamkirchay from upstream the Mehrili village to the Yeniabad village (21-5-WB035R);
- the Shamkirchay from the Yeniabad village to the confluence in the Shamkir Reservoir (21-6-WB036R);
- the Gedebeychay from the Gedebay city to the confluence with the Shamkirchay (214-2-WB031R).

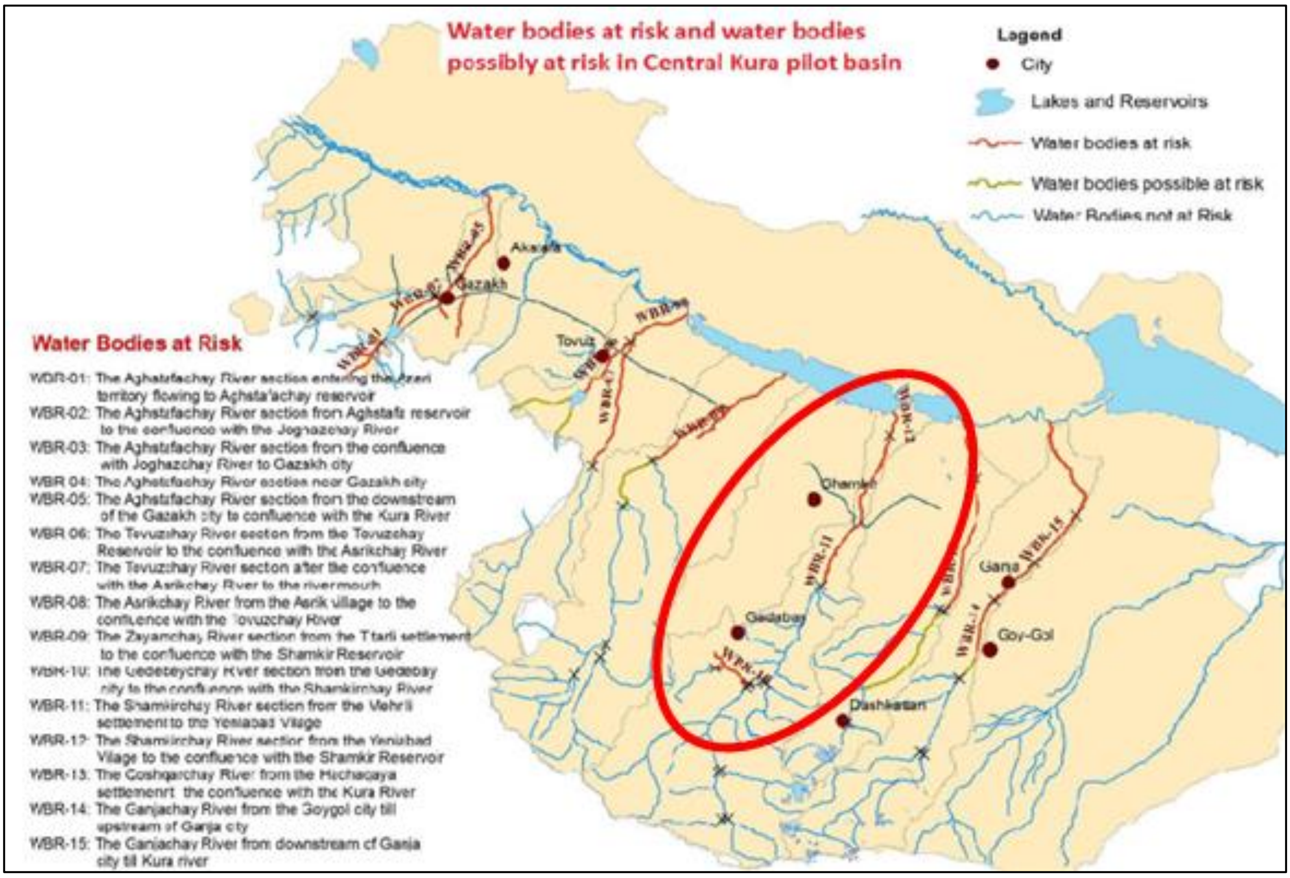

Figure 3 –Water Bodies at risk of not achieving WFD objectives identified in the Shamkirchay catchment in EPIRB (2014a, 2014b)

In EPIRB (2014a, 2014b) two Artifical water bodies have been identified in the catchment: the Dallar canal (21-1-AWB04), 14.5 km long, with an indicative maximum discharge of 0.8 m3/s, constructed in 1928 and serving a 439 ha irrigation area; the Konullu canal (21-2-AWB05), 14.8 km long with an indicative maximum discharge of 2.5 m3/s, constructed in 1916 and serving a 956 ha irrigation area. These strongly affect the instream flow regime downstream, which is now intermittent and are therefore a priority in relation to monitoring activities.

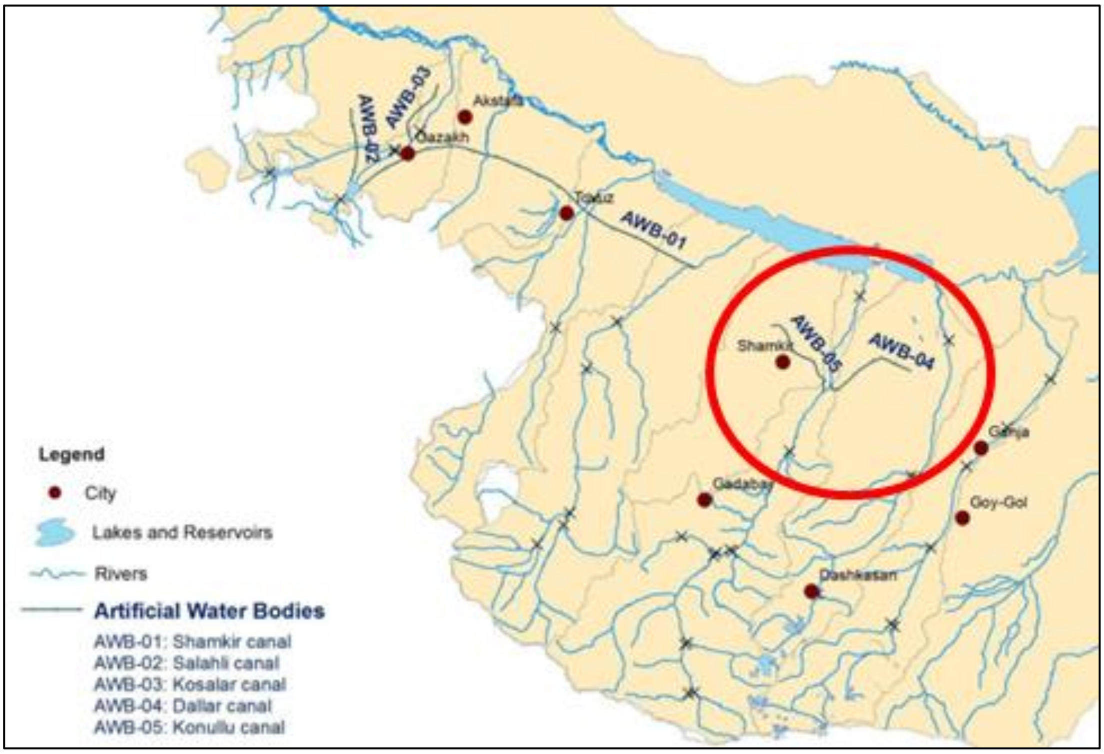

Figure 4 – Artificial Water Bodies identified in the Shamkirchay catchment in EPIRB (2014a, 2014b)

Approximately 45 km upstream from the confluence in the Shamkir reservoir, a recently constructed dam (not completed when the EPIRB assessment was carried out) creates a reservoir along the Shamkirchay, for irrigation, drinking water and hydropower production.

Figure 5 – Shamkirchay reservoir (left) and the Shamkirchay river downstream the dam (right) in November 2017

Field observations in November 2017 showed that due to the main pressure factors mentioned above, the river is split into 4 main sections: upstream of the dam, where the main impact is related to diffuse pollution sources and where the quality of different reaches and tributaries may vary widely; downstream the dam, until the main water abstractions for irrigation, where the flow regime is strongly altered and other pressures coexist; downstream the main water abstractions for irrigation, where the river quality and the instream flow are drastically reduced; further downstream, where no more surface flow is left and the Shamkirchay becomes an ephemeral stream, strongly altered by large sediment extraction and by waste disposal sites.

Figure 6 – The severely impacted reach of the Shamkirchay, upstream (left) and downstream (right) of the bridge between Chinarly and Yeni Hayat, in November 2017.

Figure 7 – The dry riverbed of the Shamkirchay near Mukhtariyyat, approximately 4 km downstream Chinarli, in November 2017

Alijanchay (Azerbaijan)

The Alijanchay is a left tributary of the Kura, with its sources in the South-Western slopes of the Greater Caucasus Range and flowing across the Oghuz, Shaki, and Yevlakh districts. The confluence with the Kura is located approximately 25 km downstream the Mingacevir Reservoir.

Currently, no preliminary assessments of the ecological status of surface waters or water bodies delineation is available to the project. A very preliminary monitoring proposal is thus included in the following, to be revised when more data become available.

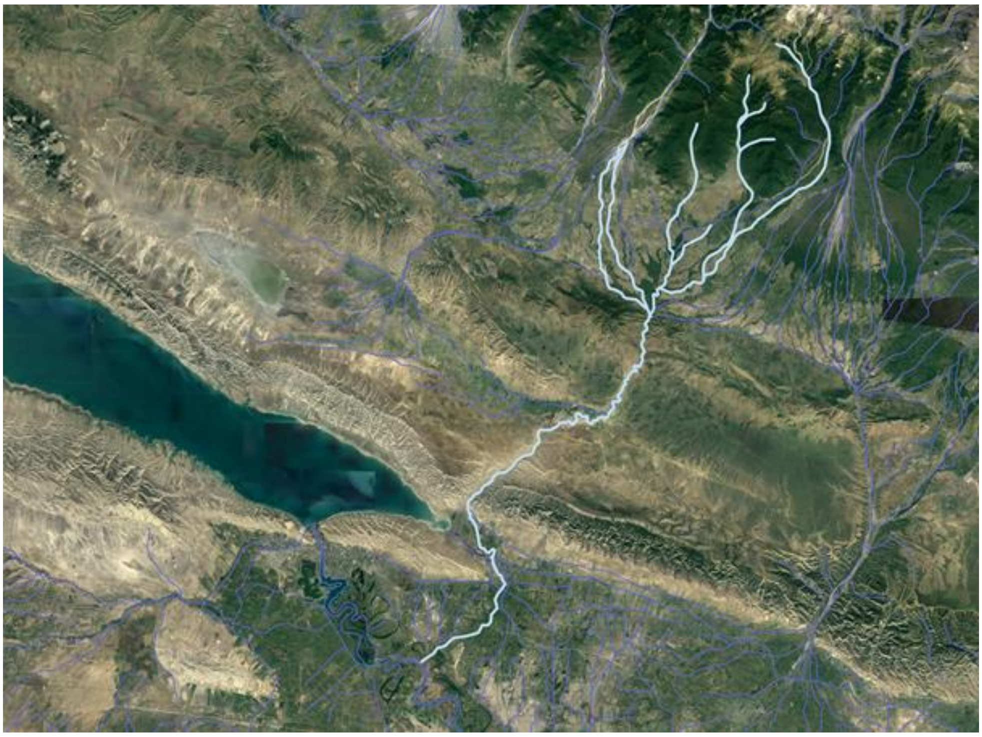

Figure 8 – The course of the Alijanchay and its main tributaries; on the left, the Mingacevir Reservoir

The project field survey carried out in November 2017, despite covering only a limited fraction of the catchment, highlighted some issues that should be taken into account in the implementation of monitoring and assessment activities:

- although the hydrological alteration of the river is relatively limited in comparison to other catchment in Azerbaijan, at least one very relevant abstraction is located near Sarica (Figure 9), while other, probably smaller ones have been identified in other sections; the effects of the main ones should be monitored and evaluated;
- limited vegetation cover in the river corridor in several sections (see e.g. Figure 10); the evolution in time of the riparian forest cover in relation to overgrazing and other land use practices should be established, distinguishing natural dynamics from human impacts;
- extensive signs of morphological alteration of the riverbed were spotted (see e.g. Figure 11), probably due to gravel extraction activities; this pressure factor should be carefully analysed and mapped;
- given the comparatively low level pressure of some parts of the upper catchment, the monitoring activities should aim at identifying reaches of particular high ecological value, where conservation has a higher priority.

Figure 9 – Water abstraction from the Alijanchay , near Sarica (Google Earth image 2015 (left) and 2013 (detail, right))

Figure 10 –The Alijanchay upstream Sarica, in November 2017, showing a relevant alteration of vegetation cover

Figure 11 –Sign of mechanical alteration of the riverbed in the Alijanchay upstream Turan, in November 2017

Monitoring plan for the Aragvi

Hydrological alteration

The hydrological monitoring and assessment should be focused on the water bodies that are significantly altered hydrologically, i.e. the bypassed reaches below hydropower abstractions, and the reaches below relevant abstraction without release, such as in dams for irrigation purposes.

Based on the information available in Ansbaek et al. 2011, the main focus should then be on the Aragvi below Zhinvali, on the Narekvavi below the reservoir (near Petriani), on the Akhatnis-Khevi (downstream Akhatani), and on the Tezami (downstream Chilaantkari), although for the two latter rivers the main abstraction sections are not clearly identified and this needs to be clarified preliminary to the identification of the monitoring sites. In G4G (2017c) the Lami Misaktsieli irrigation system is indicated as the most important active operational one in the basin, therefore its effect on the downstream stretch should be assessed.

Operational flow rate gauging stations (according to Ansbaek et al. 2011 and to information available to date) are only 4 in the Aragvi basin:

1. near Pasanauri on the Tetri Aragvi;
2. near Pasanauri on the Shavi Aragvi;
3. in Magharoskari on the Phsavis Aragvi;
4. in Chinti on the Aragvi below the Zhinvali reservoir.

In summary, the available stations, complemented if necessary with production and release data from the Zhinvali power plant, and with point measurements upstream the Zhinvali reservoir to validate a water flow balance, allow to assess the hydrological alteration in Water Body (WB) 25, applying the full methodology with daily average data.

For WBs 3, 4, 6, and 24 (that should be further partitioned to take into account hydrologically homogeneous stretches), in order to define the operational approach to be followed the availability of abstraction and release data needs to be verified. If no flow rate data is available, monthly point measurements upstream and downstream the main abstractions can be used to apply a simplified hydrological assessment at monthly scale.

For WBs not subject to relevant abstraction, the hydrological alteration can be assumed as negligible.

The morphological assessment described in the next paragraph is expected to locate all water abstraction works, therefore it could provide more detailed information as to additional relevant water regime alterations and support the identification of further reaches where the hydrological alteration should be assessed.

Morphological quality

The proposed morphological assessment approach, contrarily to other methods based on “representative reaches”, foresees an evaluation of the whole river, implying an understanding of processes and pressures at catchment scale. Given the extension of the surface water network in the Aragvi basin, a reasonable compromise is assumed to be the assessment of the morphological quality of the Aragvi itself and of just the main tributaries. Making reference to preliminary WB delineation presented in Par. 0, the WBs to be assessed are those listed in Table 1, with the exception of the reservoirs and of the smaller tributaries not individually identified as WBs, i.e. the whole length of the Tetri Aragvi, Shavi Aragvi, Khevsuretis Aragvi, Pshavis Aragvi, Khorshula, Aragvi, Dushetis-Khevi, Akhatnis-Khevi, Tezami, Narekvavi, Arkala.

The method is strongly based on the analysis of remote-sensing data, but depending on the quality and coverage available, it requires validation and integration through field assessment (e.g. for the mapping of anthropic elements not clearly visible from maps and aerial photographs, or for the identification of evidence of specific morphological processes). However, the assessment should be done only once in the 18-month period foreseen and not necessarily the whole river course need to be entirely travelled.

It has to be stressed that the assessment foresees the identification of morphologically homogeneous reaches, each of them classified with the same scoring method, that can be then spatially aggregated to WBs. The analysis will also allow to better identify differences in hydromorphological characteristics and pressure factors, thus to refine the preliminary WB delineation, with a potential impact on the monitoring activities related to other QEs and the overall classification procedure.

Phyisico-chemical elements

Based on the very preliminary identification of water bodies at risk mentioned above, the monitoring should be focused, as for hydrological alteration, on the Aragvi below Zhinvali, on the Narekvavi below the reservoir, on the Akhatnis-Khevi (downstream Akhatani), and on the Tezami (downstream Chilaantkari); in addition, in the Dushetis-Khevi (downstream Dusheti), where urban untreated wastewater is identified as a main pressure factor.

Currently, physico-chemical quality in the Aragvi basin is monitored (indicatively monthly) only in 4 sites:

1. Tsikhisdziri, on the Tetri Aragvi, upstream the Zhinvali reservoir;
2. Tvalivi, on the Phsavis Aragvi, upstream the Zhinvali reservoir;
3. Chinti, on the Aragvi, below the Zhinvali reservoir;
4. Bulachauri on the Aragvi, downstream the confluence with the Dushetis-Khevi.

Therefore, with the exception of the Aragvi below Zhinvali, for the other 4 WBs preliminary identified as at risk, additional sampling sites are needed. It is suggested to establish for each of them at least one sampling site downstream the abstraction work (or main source of pollution) and one upstream. Moreover, additional sampling sites are suggested in the Upper Tetri Aragvi, in the Shavi Aragvi, in the Khevsuretis Aragvi and in the Upper Pshavis Aragvi, in order to cover reaches with more limited pressures, mainly related to untreated wastewater discharge from small communities. 12 sampling points would thus be added to the current network. In order to reduce the analytical burden for the additional sites, the sampling frequency can be every 3 months, possibly at the same time and location of benthic invertebrates sampling, when this is foreseen.

Benthic invertebrates

Benthic invertebrates is the only biological Quality Element (QE) included in the proposed short-term classification proposal. Therefore a sufficiently wide application should be ensured, in order to:

- support the establishment of proper knowledge on sampling practice;
- enlarge the data set necessary to define reference conditions and class boundaries for classification (for this also sites subject to very limited pressure in the monitored rivers should be included, possibly for different river types);
- to allow correlation analyses between physico-chemical and benthic invertebrates data, to help reducing redundancy in the extension of the monitoring network (for this, timing and sampling sites for benthic invertebrates should be the same used for physico-chemical quality).

As a preliminary proposal, it is suggested to carry out the sampling in 16 sections corresponding to the physico-chemical sampling points defined above. If the list needs to be reduced for budget limitations, priority should be given to wadeable rivers, where the application of well-established protocols is easier.

The timing and frequency should follow the methodological indications detailed in the classification methodology, depending on the river type and context.

The benthic invertebrates monitoring should be carried out during the period of the monitoring plan.

Additional monitoring to support the assessment of Environmental flows implementation

The same QEs described above, foreseen to be monitored for classification purposes, can also be used to assess the impact of existing water abstractions and, conversely, the effects of the establishment of Environmental flows. However, the spatial and temporal scales, location, and/or level of detail may be only partly suited to the evaluation of the effects on the stretches affected by water release changes and a specific monitoring procedure may be necessary.

Making reference to methodological guidelines for Environmental flows and assessment of hydropower impacts already proposed/applied in the project context (G4G, 2017a, 2017b; GIZ, 2016), the main area not covered by the previously described monitoring is fish fauna. In order to apply most context-specific approaches based on habitat modelling, to assess the effects on longitudinal connectivity, etc. a sufficient knowledge on current and reference fish population in the affected reaches is needed. The eighteen-month monitoring period covered by this document is deemed sufficient only to gather preliminary information and understanding on the fish fauna in some water bodies, and to carry out qualitative and expert-based evaluations on current conditions and impacts; these data that can then be integrated and used for the application of more quantitative and complex assessments in the next future.

In summary, it is suggested to:

- carry out one fish sampling in the bypassed reaches foreseen to be subject to Environmental flows, and in the corresponding upstream reaches, not affected by the water abstraction; information on fish species composition, abundance and age structure should be recorded;
- gather historical information, older sampling data and literature on the concerned rivers and catchments, in order to support the definition of reference conditions.

In addition to fish fauna, in the case reservoir hydropower plants are concerned, and hydropeaking is expected to take place below the flow release section, flow rate measurements at sub-hourly frequency should be foreseen in the affected reaches, at increasing distance from the plant outlet, in periods of the year with different natural average flow, in order to start collecting data to describe the hydropeaking characteristic values

Monitoring plan for the Shamkirchay

Hydrological alteration

The proposed hydrological monitoring, taking into account current limitations in previous data availability and resources, includes 3 components.

1. Identification of the reaches where the flow regime is currently ephemeral due to water abstraction. This can be done through simple visual inspection and, when relevant, point measurements, in different periods of the year (e.g. monthly). This activity can support a more detailed delineation of water body and the selection of monitoring sites for other QEs.
2. Collection of daily average flow rate data downstream the Shamkirchay reservoir, and measurement or reconstruction (through production, abstraction and reservoir level data) of the corresponding unaltered data series of the river upstream the reservoir. This will allow to assess the hydrological alteration in the water body below the dam, applying the full methodology detailed in the deliverable "Updated version of the River Basin classification structure in line with the EU WFD".
3. Collection of daily average flow rate data downstream the Konullu and Dallar abstraction sections. The detailed planning of this component requires to verify whether abstracted flow data are actually available. In case daily average data are not available and at least monthly average flows can be estimated, a simplified hydrological assessment at monthly scale can be applied.

Morphological quality

The proposed morphological assessment methodology was developed for perennial rivers, therefore it should be applied only to the reaches identified as such in the beginning of the hydrological monitoring activity. The evaluation should be applied to the whole Shamkirchay and possibly to all the main perennial tributaries. At least the Sarisuchay, the Agqayachay, the Qoshqarchay, the Gedebeychay, and the Emirvar should be included. The level of detail of the field surveys, complementing remote, GIS-based analyses, can be adapted to the resources available.

The assessment should be done once in the 18-month period.

The morphological assessment and underlying analyses will allow to better identify differences in hydromorphological characteristics (such as level of confinement, morphological configuration, etc.) and pressure factors, thus to refine the preliminary WB delineation, with a potential impact on the monitoring activities related to other QEs and the overall classification procedure.

Phyisico-chemical elements

Currently, a single monitoring site is indicated as active, in EPIRB (2014a), but as in November 2017 the river was completely dry in the reach where this point should be located, updated information is needed on this.

Based on the preliminary pressure analysis, physico-chemical quality should be monitored at least in 2 reaches downstream the Shamkirchay reservoir, indicatively one near the dam and one near Chinarli, and in the Gedebaychay, both upstream and downstream Gedebay. In order to validate the preliminary, mainly expert based, assessment done in EPIRB, and to support the definition of classification class boundaries, one sampling site should be foreseen also in each of the other 8 WBs delineated in EPIRB.

The suggested sampling frequency is every 3 months, possibly at the same time and location of benthic invertebrates sampling. For the WBs indicated as not at risk in EPIRB (2014a, 2014b), in case the first samplings confirm a high physico-chemical status, the following ones can be skipped or their frequency reduced.

Benthic invertebrates

For the same reasons highlighted in Par. 0, it is suggested to carry out the benthic invertebrates sampling in at least 12 sections corresponding to the physico-chemical sampling points defined above. The timing and frequency should follow the methodological indications detailed in the classification methodology, depending on the river type and context.

The benthic invertebrates monitoring should be carried out in the period of the monitoring plan. However, as for the physico-chemical elements, in case some water bodies show negligible levels of impacts in the first samplings, the second year monitoring can be skipped to optimise resources allocation. It is in any case important to ensure at least some samplings in reaches with very limited pressures, in order to support the definition of type-specific reference conditions and class boundaries for classification purposes.

Additional monitoring to support the assessment of Environmental flows implementation

As for the other pilot basins, the 18-month monitoring period can be employed to gather preliminary information on fish fauna in the water bodies downstream and upstream of the main water abstractions; these data that can then be integrated and used for the application of more quantitative and complex assessments in the next future (see G4G, 2017a), most of which imply an extensive knowledge on the current and reference fish communities.

It is suggested to:

- carry out one fish sampling upstream the Shamkirchay reservoir, one downstream the reservoir, between the dam and the main abstractions for irrigation; information on fish species composition, abundance and age structure should be recorded;
- gather historical information (possibly including the periods before the construction of the Shamkir reservoir, in 1982 and of the Mingacevir reservoir in 1953), older sampling data and literature on the concerned catchment, in order to support the definition of reference conditions.

In addition to fish fauna, if hydropeaking is expected to take place below the flow release section of the hydropower plant, flow rate measurements at sub-hourly frequency should be foreseen in the downstream reach, at increasing distance from the plant outlet, in periods of the year with different natural average flow, in order to start collecting data to describe the hydropeaking characteristic values.

Monitoring plan for the Alijanchay

Hydrological alteration

The hydrological monitoring should allow at least to assess the hydrological alteration below the main water abstractions. The level of detail of the assessment depends on the availability of daily average, or lower frequency, data of abstracted and released flows at the abstraction works.

Moreover, the preliminary monitoring, based on point measurements in different periods of the year, or on the availability of older data series, should allow to identify the main, permanent flow, tributaries, also in order to optimize the sampling sites for physico-chemical and biological monitoring.

Morphological quality

The evaluation should be applied to the whole Alijanchay and possibly to all the main perennial tributaries, identified thanks to the preliminary hydrological assessment. The level of detail of the field surveys, complementing remote, GIS-based analyses, can be adapted to the resources available.

The assessment should be done once in the 18-month period.

The morphological assessment and underlying analyses should be focused also on identifying main differences in hydromorphological characteristics (such as level of confinement, morphological configuration, etc.) and pressure factors, in order to support WB delineation.

Phyisico-chemical elements

Currently, no information is available on previous monitoring activities. A very preliminary partitioning of the Alijanchay, that could be used to identify corresponding sampling sections, is the following:

- 1-2 WBs for each of the main tributaries in the upper part of the catchment, to be identified based on the preliminary hydrological (and, if already available, morphological) assessment;
- Alijanchay between the confluence of the main tributaries and the main water abstraction near Sarica;
- the meandering section of the Alijanchay between the water abstraction near Sarica and Turan;
- the Alijanchay between Turan and Xanabad;
- the Alijanchay downstream Xanabad until Yukhari Bujag;
- the most urbanised reach of the Alijanchay, from Yukhari Bujag until downstream Ajami;
- the last reach of the Alijanchay downstream Ajami, until the confluence with the Kura.

The suggested sampling frequency is every 3 months, possibly at the same time and location of benthic invertebrates sampling. In case the first samplings confirm a high physico-chemical status, the following ones can be skipped or their frequency reduced.

Benthic invertebrates

For the same reasons highlighted in Par. 0, it is suggested to carry out the benthic invertebrates sampling in all the sections corresponding to the physico-chemical sampling points defined above. The timing and frequency should follow the methodological indications detailed in the classification methodology, depending on the river type and context.

The benthic invertebrates monitoring should be carried out in the period of the monitoring plan. However, as for the physico-chemical elements, in case some water bodies show negligible levels of impacts in the first samplings, the second year monitoring can be skipped to optimise resources allocation. It is in any case important to ensure at least some samplings in reaches with very limited pressures, in order to support the definition of type-specific reference conditions and class boundaries for classification purposes.

If resources limitations require a reduction of the amount of sampling sites, wadeable reaches can be prioritized.

Additional monitoring to support the assessment of Environmental flows implementation

As for the other pilot basins, the 18-month monitoring period can be employed to gather preliminary information on fish fauna. The focus of the monitoring should be adjusted depending on already available data (including informal knowledge on fish presence and captures) and on updated information on foreseen new water abstractions and potentially impacted reaches. Based upon the information currently available, it is suggested to:

- carry out one fish sampling in each of the following reaches/streams, collecting data on fish species composition, abundance and age structure:
  - permanent flow upper catchment tributaries;
  - Alijanchay between the confluence of the main tributaries and the main water abstraction near Sarica;
  - meandering section of the Alijanchay between the water abstraction near Sarica and Turan, and/or in the Alijanchay between Turan and Xanabad;
  - the Alijanchay between Xanabad until downstream Ajami;
  - the last reach of the Alijanchay downstream Ajami, until the confluence with the Kura;
- gather historical information, older sampling data and literature on the concerned catchment, in order to support the definition of reference conditions.

Literature references

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Annex 6

UNDP GEF Kura Project "Advancing Integrated Water Resource Management (IWRM) across the Kura river basin through implementation of the transboundary agreed actions and national plans"

Updated version of the River Basin classification structure in line with the EU WFD

March 2018

Abbreviations and acronyms

AWB	Artificial Water Body
BOD_5	Biological Oxygen Demand in 5 days
CIS	Common Implementation Strategy (of the Water Framework Directive)
COD	Chemical Oxygen Demand
EIA	Environmental Impact Assessment
EPIRB	Environmental Protection of International River Basins project
EPT	Ephemeroptera, Plecoptera, and Trichoptera
EQR	Ecological Quality Ratio
EQS	Environmental Quality Standards
HMWB	Heavily Modified Water Body
NH_4	Ammonium
NO_3	Nitrate
O_2	(Dissolved) oxygen
PoM	Programme of Measures (of the Water Framework Directive)
PO_4	Phosphate
RBMP	River Basin Management Plan (of the Water Framework Directive)
QE	Quality Elements (for the classification of water bodies)
UNECE	United Nations Economic Commission for Europe
WB	Water Body
WFD	Water Framework Directive (Directive 2000/60/EC)

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Executive summary

This document has been developed in order to provide guidance to Georgia and Azerbaijan to carry out the "classification of water bodies" activity, in the implementation of the Water Framework Directive. It suggests a step-wise approach towards a full implementation of the WFD requirements. It is focused on the classification of "river" water bodies, therefore the methods proposed are not suitable for the classification of lakes, transitional and coastal waters, and groundwater. It does not specifically tackle the designation of Artificial Water Bodies (AWB) and of Heavily Modified Water Bodies (HMWB). It builds upon previous guidelines, suggesting solutions to overcome highlighted limitations and takes into account the current data availability in the countries, proposing how to prioritize the monitoring and assessment efforts to effectively support river basin planning and management.

Introduction

The EU and Georgia have recently adopted a revised EU-Georgia Association Agenda for the period 2017-2020. This includes the commitment to "Continue approximation of legislation of Georgia to EU acquis and implement the provisions of EU Directives and Regulations". Both Georgia and Azerbaijan are working on the implementation of the UNECE Water Convention, foreseeing the finalization of an agreement on the management of transboundary water courses shared by both countries. In this context, the Water Framework Directive is the key piece of legislation that Georgia and Azerbaijan are in the process of adopting, in relation to river basin planning and management.

The **classification of the status of water bodies** (WBs) is one of the key steps in the implementation cycle of the Water Framework Directive (WFD). It is necessary in order to verify the attainment of environmental objectives (the main aim of the WFD is that all WBs reach at least a "good status", although exemptions are foreseen) and, where needed, to identify the measures to be applied for the mitigation and compensation of existing pressures. The approach introduced by the WFD to classify the status of water bodies, especially surface waters, can be considered very innovative, as it fostered a major shift from the previous way of assessing rivers, based only on physico-chemical conditions. The introduction of the obligation to assess the quality of water bodies based on biological quality elements, as well as hydromorphological ones, supports a much more integrated view of the complex interactions between physical variables and ecological processes. It is also one of the cornerstones of the "systemic" approach promoted by the WFD, looking for a more holistic understanding of the relationships between environmental impacts, their causes and measures to be taken to reduce these negative impacts. The practical implementation of such approach is however very challenging, therefore a sufficient time and resources and a proper integration of available know-how in different fields need to be ensured.

Several previous projects have provided technical support for the implementation of the different steps of the WFD in Georgia and Azerbaijan, including classification of WBs. However, only part of the criteria that the WFD foresees to take into account have been applied, and the monitoring and assessment approaches used are only partly compliant with the requirements of the Directive. This document aims at providing methods that the Countries can use to fill these gaps. In doing so, as the path to full compliance is long and resource intensive, it suggests a step-wise approach, starting with the activities that are deemed more urgent and useful to support river basin planning and management. Moreover, it takes into account the feedback from EU-wide discussions on key implementation problems encountered by EU Member States, so that relevant countermeasures can be integrated in an earlier stage by Georgia and Azerbaijan.

Among the main challenges to be faced in relation to the implementation of WFD classification approaches and to their use to define river management measures, the definition of proper reference conditions for all classification quality elements (QEs) and the identification of cause-effect relationships between pressure factors (especially hydromorphological ones) and affected QEs are particularly critical. The present document suggests methods to address these challenges.

It has also to be underlined that the implementation of WFD-compliant classification of WBs can be carried out with several different methods equally valid under a scientific point of view, as it is happening in different EU Member States. However, in order to ensure a homogeneous interpretation of classification results, a long and complex "intercalibration" activity has been necessary (see e.g. van de Bund, 2009), only partly carried out so far and providing only partially satisfactory results. Therefore, for a harmonized classification in the Kura basin, the application of the same monitoring and classification methods by concerned countries is strongly advisable, instead of a future trans-national intercalibration exercise.

The contribution of previous projects on water bodies classification in GE and AZ and remaining gaps and challenges

The full array of steps necessary for WFD implementation, including those related to classification of WBs, has been tackled by previous projects, both for Georgia and for Azerbaijan. In particular, the KURA-II (Transboundary river management for the Kura River, phase II, 2008-2011) and KURA-III (Transboundary river management for the Kura River, phase III) have supported the field implementation of some of the required monitoring activities, while the more recent projects G4G (USAID Governing For Growth in Georgia) and EPIRB (Environmental Protection of International River Basins Project) have provided an extensive summary of "WFD-consistent" activities to be carried out, as well as technical guidance on specific implementation steps, mainly based on the synthesis of the Common Implementation Strategy (CIS)

Guidance Documents[1]. Moreover, a pilot implementation of these steps has been carried out in some catchments, including: delineation of water bodies, provisional definition of river types, pressure and impact analysis, identification of WB at risk of failing to meet the Directive's environmental objectives, of Artificial Water Bodies (AWB) and Heavily Modified Water Bodies (HMWB), monitoring and assessment in the identified WBs of some of the QEs required by the WFD.

For the **classification** of rivers, the WFD foresees the assessment of the following QEs:

Biological quality elements:

- benthic invertebrates (also called "macrozoobenthos");
- fish fauna;
- macrophytes and phytobenthos (or "benthic algae", or "periphyton", often referred simply as "diatoms", which are the most common type of phytobenthos)[2];
- phytoplankton[3].

Physico-chemical quality elements:

- general conditions;
- specific pollutants;

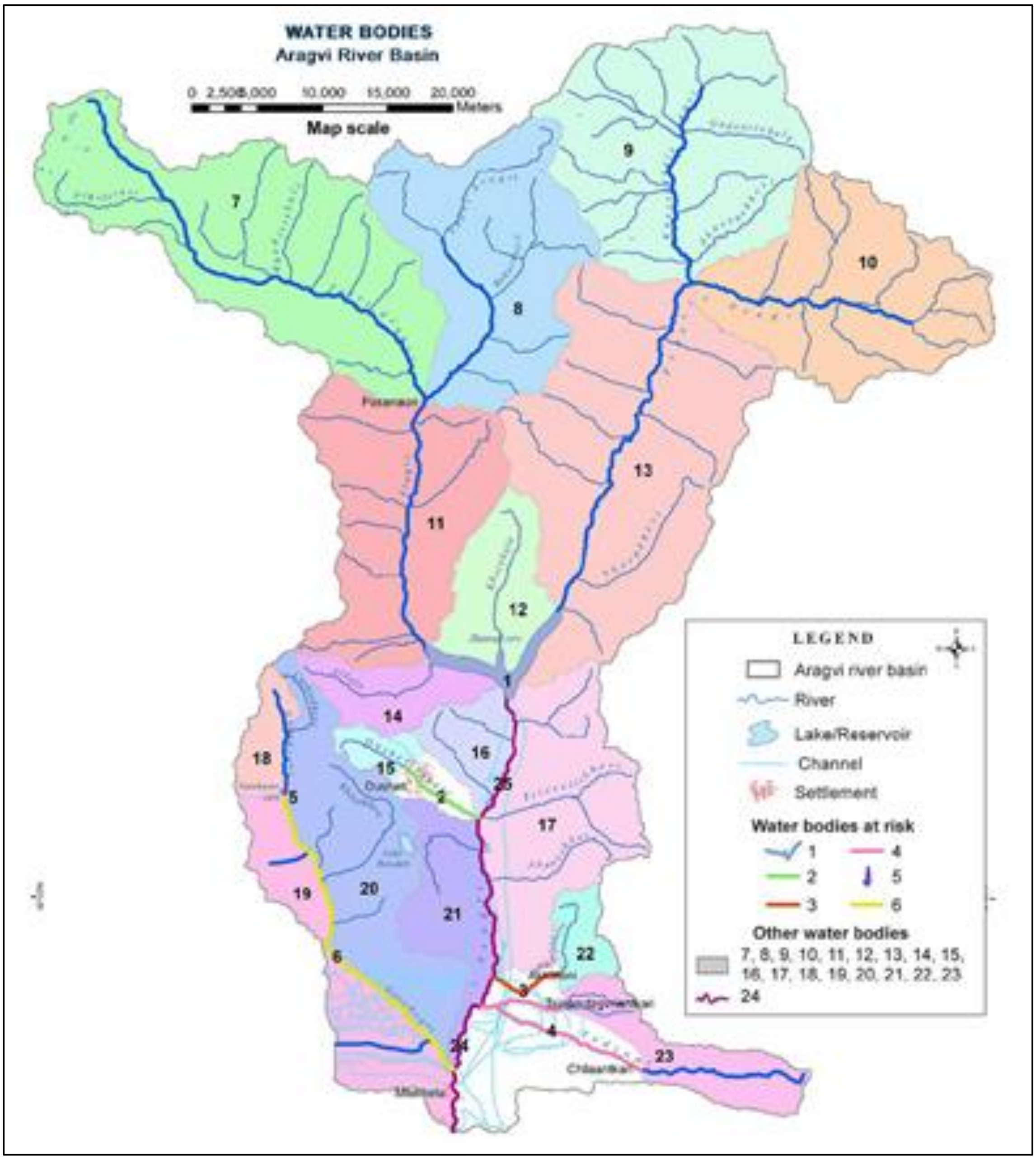
Hydromorphological quality elements:

- hydrological regime;
- morphological conditions;
- river continuity.

These three groups of quality elements concur in the definition of the **ecological status** of water bodies.

[1] For the complete list of CIS guidance documents, see http://ec.europa.eu/environment/water/water-framework/facts_figures/guidance_docs_en.htm
[2] According to the WFD macrophytes and phytobenthos are a single QE (corresponding to aquatic flora); however, most EU Member States have separate assessment methods for macrophytes and phytobenthos.
[3] Most EU Member States do not use phytoplankton to classify rivers, but only for lakes, transitional and coastal waters (see Kelly et al., 2016).

In addition, the WFD foresees the assessment of the **chemical status** (relative to the presence and concentration of priority substances)[4]. The combination of the ecological and the chemical status determine the overall status of a water



body (see Figure 2).

[4] The directive 2008/105/EC (the Environmental Quality Standards Directive – EQSD) set the quality standards required by Article 16(8) of the Water Framework Directive and Annex II to the EQSD replaced Annex X of the Water Framework Directive. The Directive has been later amended by Directive 2013/39/EU.

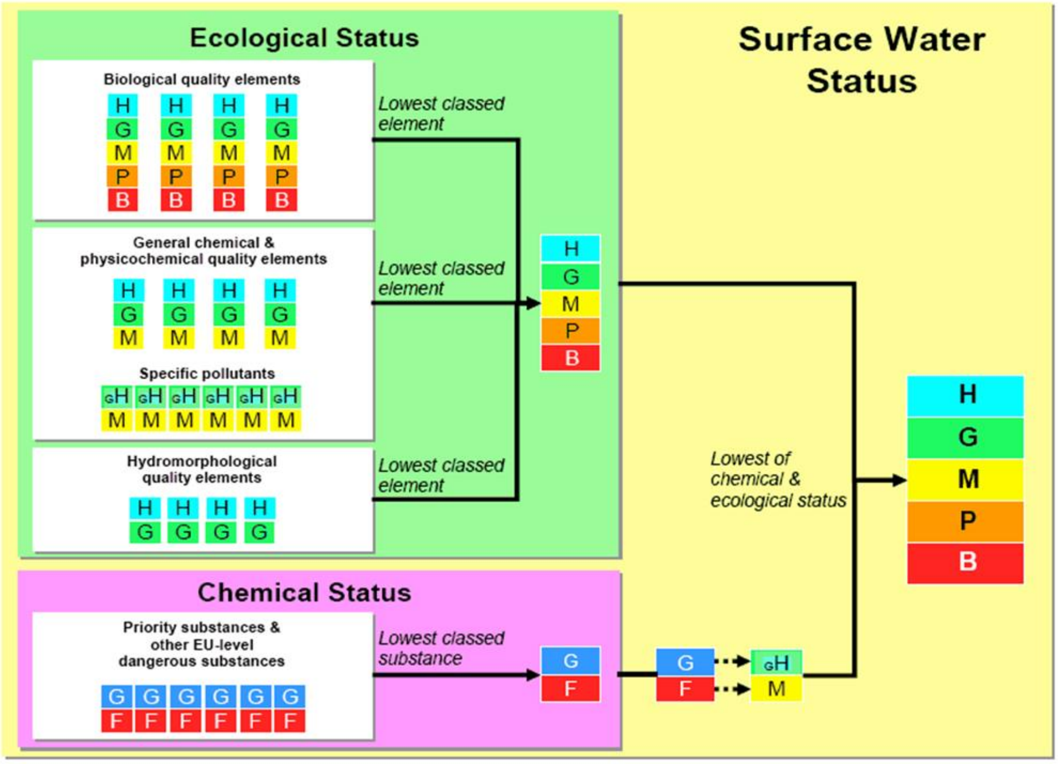


Figure 12 – the one-out-all-out aggregation approach of the WFD to determine the ecological and overall surface water status (UK Environment Agency)

A summary of what has been developed and implemented by previous projects and of the main remaining gaps is provided below.

Physico-chemical elements: the monitoring of general parameters and specific pollutants is foreseen, and adaptation of legislation in order to ensure coherence with the WFD is ongoing. So far the status class boundaries have been defined only for general parameters and for some river types. Moreover, the list of relevant specific pollutants needs to be updated after a more comprehensive pressures and impacts analysis.

Benthic invertebrates: the Rapid Bioassessment method proposed in EPIRB (see EPIRB, 2013 for more details) is a simplified version of the AQEM/STAR multi-habitat sampling method, including also elements of different EN standards. The approach, although in general terms coherent with WFD classification needs, cannot be considered fully WFD-compliant. In particular, it is based on a semi-quantitative sampling approach (kick-sampling) and on a selection of the sites to be sampled that is not coherent with the required EN 16150:2012 standard on pro-rata multi-habitat sampling and that does not ensure a statistically sound representativeness of all microhabitats in the sampling site. Although the kind of indications provided, especially in case of significant pollution, are similar, it has to be underlined, that, as shown among others by Everall et al. (2017), data derived using kick-sampling are not fully comparable for biomonitoring purposes to data derived from quantitative samples. Therefore a quantitative, WFD-compliant sampling method should be applied.

As to the assessment approach, 5 different classification metrics have been applied, and class boundaries have been defined only for some river types; however, no specific choice has been made among the 5 metrics, which provided different results in terms of status class, although among them there are metrics (e.g. IBE – Extended Biotic Index) that are not WFD-compliant.

Moreover, as previously mentioned, reference sites and reference conditions need to be verified, and revised if needed, based upon a more comprehensive analysis of physical characteristics and pressure factors.

Fish: monitoring methods and classification metrics are currently not available; historical information to support the identification of reference conditions is probably available but needs to be systematically gathered.

Macrophytes and phytobenthos: both monitoring methods and classification metrics are currently not available and were not applied in previous projects.

Phytoplankton: both monitoring methods and classification metrics are currently not available and were not applied in previous projects. Coherently with the choice of most EU Member States, the use of this QE for rivers is not assumed as necessary.

Morphological conditions: assessment methods proposed by previous projects are deemed mainly descriptive, but insufficiently process-based; morphological assessment methods that only assess features (e.g. riffles, pools, refuge areas), with no or too limited consideration of processes (e.g. longitudinal continuity of sediment fluxes, lateral connectivity and riverbed mobility) provide limited information on river quality, as deviation from un-impacted conditions are not assessed; surveying features is useful if these are put in the context of processes, but in order to assess the status of a river reach, interpretation of the significance and meaning of the features is key. For instance, a local reduction in the heterogeneity of morphological features in a given stretch not necessarily corresponds to a reduction in its ecological status (as a low heterogeneity can be natural for a given morphological typology of river) and vice-versa. The consideration of adequate temporal and spatial scales in the analyses also needs improvement.

Hydrological regime: methods to assess hydrological alteration are mentioned in the methodology proposed by G4G for assessment of environmental flows for the rivers and streams of Georgia (see G4G, 2017), but not specifically for classification purposes; a simple index based on 4 indicators was proposed by EPIRB, but it appears to insufficiently account for the main ecologically relevant alterations of the hydrological regime. Therefore a complete classification approach needs to be developed.:

River continuity: specific assessment methods are currently not available and were not applied in previous projects.

Chemical status: the adaptation of legislation in order to ensure coherence with the WFD and with Directive 2013/39/EU, in particular to establish Environmental Quality Standards (EQS) and to set the basis for the regular monitoring of priority substances, is ongoing. Detailed guidelines for monitoring the chemical status of surface water bodies have been produced by the EPIRB project (EPIRB, 2015). No specific constraints related to classification methods (which in this case is straightforward, as the chemical status can be good, if all EQS are respected, or failing to be good, otherwise) are highlighted.

Cross-cutting challenges

In addition to gaps related to incomplete implementation of the classification methods themselves, it has to be reminded that the classification is closely linked to other WFD steps, therefore its coherence depends on how accurately these steps have been implemented. In particular, the classification depends on the delineation of water bodies, as the WB is the basic unit for the definition of WFD quality objectives, and on the definition of river types and of related reference conditions, as the status, in particular for biological and physico-chemical QEs, is assessed in relation to type-specific reference conditions.

If one or more of the underlying steps are not properly developed, the result of the classification can be misleading and thus fail one of its main goals, i.e. to support the identification of necessary management and/or restoration measures (i.e. the Programmes of Measures - PoMs required together with the River Basin Management Plans - RBMPs).

In the Kura basin, only a preliminary **delineation of water bodies** has been implemented, based on a partial analyses of pressures and impacts and on a limited consideration of hydromorphological features. In particular, channel morphology (i.e. especially morphological typologies, see WFD CIS Guidance Document No. 2 and Rinaldi et al., 2016, for further guidance on this) should be sufficiently homogeneous within a WB, in order to avoid inconsistencies and insufficient representativeness of the classification. The **size of WBs** is also a critical element, both for their classification and in order to ensure their restoration and protection, as excessively long WBs (e.g. several tens of km) make more difficult to take into account e.g. new pressures and impacts and to react against them making use of WFD tools.

The **definition of water body types** has been carried out so far using the so called “system A”, the simplest approach foreseen in the WFD, based on a limited set of rather general variables: ecoregion and broad categories related to altitude, catchment area and geology. However, the definition of types should be strongly based on the understanding of hydrological and morphological processes, as these support habitat maintenance and thus ecological processes and biotic communities. A sufficient understanding of the river physical long-term trajectories at sufficiently large spatial scale is also crucial for a correct framing and interpretation of the outputs of biological monitoring[5]. The reliability of reference conditions, in particular of biological QEs, is thus strongly linked to the fulfilment of this condition.

[5] For more exhaustive information on hydromorphological issues and open challenges in the EU related to WFD implementation, see the Summary report on Methods for River Hydromorphological Assessment and Monitoring issued by the WFD CIS ECOSTAT technical subgroup on Hydromorphology (https://circabc.europa.eu)

Similar considerations apply to the **identification of reference sites** and to the definition of **reference conditions**. If sites are wrongly identified as reference due to an insufficiently comprehensive analysis of pressures, the actual status of water bodies of the corresponding type risks to be significantly overestimated. Moreover, for an accurate definition of reference conditions, the **natural variability** of the specific QE should be accounted for, with sufficiently extensive monitoring activities.

In summary, in parallel to the implementation of the WFD-compliant classification methods described in the next sections, it is strongly advisable to carry out an overall revision of the previously identified water bodies and types. In particular, the implementation of the assessment procedure for the calculation of the proposed morphological quality index provides relevant information to better characterize the physical features of the river and to support this revision.

River water bodies classification proposal in the short term

Approach and main criteria

The definition of the proposed water body classification approach includes the following main components:

1. the identification of the quality elements to be included in the assessment;
2. the method to aggregate the values of the single elements into the WB status class;
3. the metrics to be used for the evaluation of each quality element;
4. the assessment/sampling methodologies to be adopted, coherently with the metrics.

As previously mentioned, a step-wise approach is proposed for the approximation of WFD-compliant classification of WBs in Georgia and Azerbaijan. The criteria adopted in order to prioritize the methodological revision efforts and to foster cost efficiency can be briefly summarized as follows.

The WB classification approach and related monitoring and assessment methods should be able to support in the short term the identification of:

- existing pressure factors that have the highest potential to negatively affect the ecological status of water bodies at large spatial and temporal scales, as well as habitats and related ecosystem services;
- suitable mitigation measures, also developing synergies with licensing procedures (e.g. of new hydropower plants, sediment extraction sites), EIAs, etc.;
- sites/river stretches/water bodies of particularly high ecological value, that need to be preserved with highest priority.

Moreover, it has to be taken into account that the diagnostic value of currently available classification methods is not the same for all QEs. In order to translate the information on water body status into indications on suitable measures, a critical step to be carried out is the identification of cause-effect relationships between pressure factors (the main types of pressures identified by the WFD are: point source pollution, diffuse source pollution, morphological alterations, hydrological alteration) and the status of affected quality elements. If this in some cases can be relatively straightforward, e.g. linking point pollution sources to physico-chemical conditions downstream, interpreting the effects of several cumulative pressures (and, conversely, of their mitigation measures), often at different scales, on biological and ecological processes, can be a very demanding exercise (see for instance the example in Figure 13).

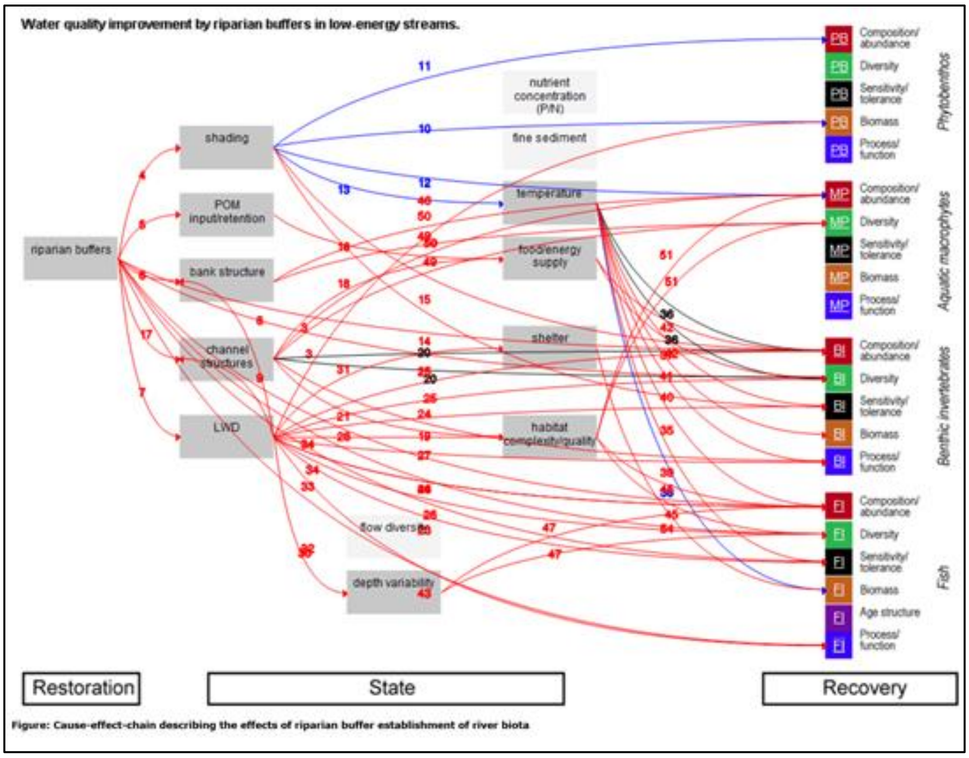


Figure 13 – Example of an attempt to establish cause-effect relationships between management/restoration measures and biological quality elements, through state and function variables, based on scientific literature: the case of riparian buffers (from the WISER project – www.wiser.eu)

In addition to this, it has to be highlighted that the main classification metrics currently used in the EU for macrophytes, diatoms and phytoplankton derive from older bio-indicators that were developed mainly to inform on water pollution and especially on trophic and saprobic conditions. This is to a large extent applicable also to benthic invertebrates. Although the monitored communities may be sensitive to other pressure factors, such as hydromorphological alterations, the available metrics are often unable to properly reflect this. Several studies (see for instance Friberg et al., 2009; Göthe et al., 2017; Golfieri et al., 2018) reported only relatively weak relationships between various measures of hydromorphological stress and commonly used macroinvertebrate assessment tools; this is particularly evident where water physico-chemical quality is good, i.e. where hydromorphological alteration does not entail significant worsening of physico-chemical quality. This means that the contemporary use for classification purposes of benthic invertebrates, macrophytes and diatoms (phytoplankton as said is usually not applied to rivers) may very well reflect physico-chemical pressure, but fail to provide sufficient information on hydromorphological pressures, which is critical for instance in all those contexts where most of the impacts on freshwater biological communities are due to ordinary “management measures” such as riverbed dredging, water withdrawals and other hydrological or morphological alterations.

The issue of **redundancy** of some biological metrics for WFD classification is often raised by EU national and regional environmental agencies (on this, see for instance Schneider et al., 2012 and Kelly et al., 2016) and needs to be seriously taken into account by countries that have just started their WFD implementation process.

To the contrary, the use of **fish fauna** in the classification of WB usually has a strong overall diagnostic value, as fish are known to react in a holistic way to a wide range of pressure factors (see for instance Karr et al., 1987; Fausch et al., 1990; Schmutz et al., 2007).

In order to account for hydromorphological pressures, and given the insufficiently reliable response or current applicability of most biological QEs, the inclusion of a hydromorphological assessment, especially if it incorporates an analysis of pressures and the analysis of evolutionary trajectories of rivers (i.e. their changes at sufficiently large temporal and spatial scales), is deemed to significantly improve the diagnostic value in comparison to a classification only or mainly based on biological QEs. Moreover, the assessment of river hydromorphological aspects is needed not only for the implementation of the WFD, but also or for the Habitats and Floods Directives (more in general for biodiversity conservation and flood risk management) and for the implementation of climate change adaptation strategies. Therefore, methods able to support synergies and to provide the different information needed for these strategies are to be favoured.

Lastly, the WFD foresees to aggregate hydromorphological QEs in the classification only for high status, but it is suggested here to aggregate them for the whole range of status values, in order to fully exploit their sensitivity to hydromorphological pressures and to compensate for current gaps in available biological metrics.

Quality elements to be included in the short term assessment

In order to support the conditions and priorities exposed in the previous sections, in the short term it is proposed to classify river water bodies using the following QEs:

- **Physico-chemical elements**
- **Benthic invertebrates**
- **Hydromorphological elements** (combination, based on the one-out-all-out principle, of a **Morphological quality index** and a **Hydrological alteration index**)

As already mentioned, the use of **fish fauna** as additional biological QE would be very beneficial, However, the data sets presently available are deemed insufficient to support the identification of reference conditions and the identification of a suitable index. In the short term, it is suggested to start filling the knowledge gaps, both in relation to existing historical data (collection of historical records of occurrence of fish species in the river basin and creation of a single database), and to current fish populations through monitoring in relevant catchments, focusing with higher priority on high status WBs, but possibly covering all status classes (based on the proposed assessment below) and river types. This phase should allow to define reference conditions (for which a key step is the identification of expected fish communities in un-impacted conditions in all river types). In the meantime a suitable fish index should be identified. Proposals on this are described in chapter 4.

The use of the remaining components of WFD-compliant biological monitoring for rivers, i.e. diatoms and macrophytes (having discarded phytoplankton), and the development of adequate metrics for the project context seem too ambitious taking into account the present knowledge and data available, as this would imply dedicated, resource intensive efforts, but, as explained earlier, with limited added value in diagnostic terms. A long term proposal is described in chapter 5.

Method to aggregate the single QE metrics into the overall ecological status class

It is proposed to combine the values of the corresponding 3 metrics using the one-out-all-out principle for all status classes (see Figure 14).

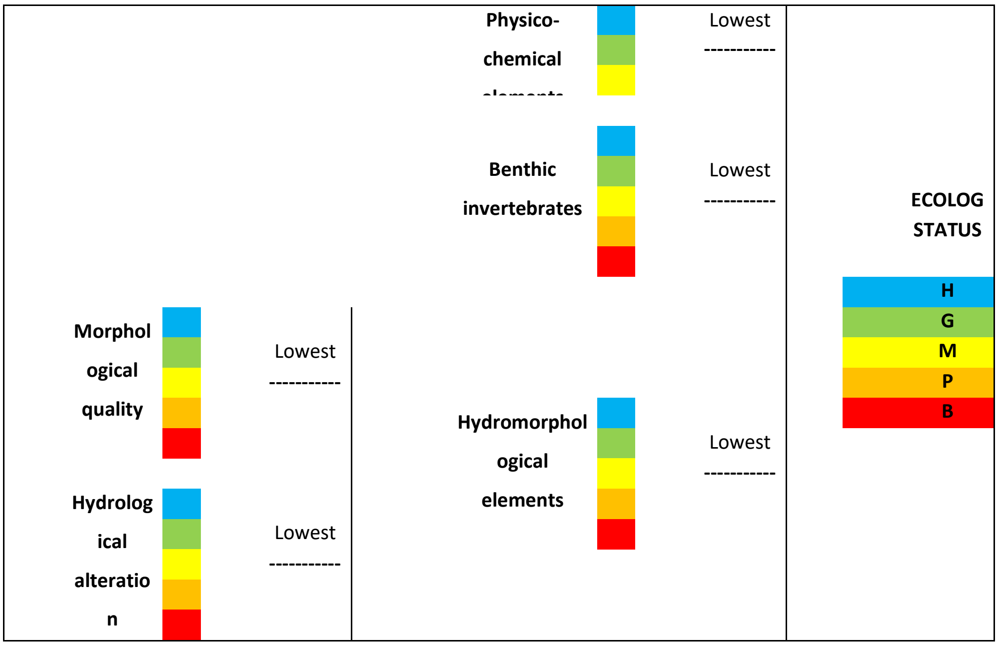


Figure 14 – Proposed short-term approach to aggregate the values of single QEs into the ecological status class

Proposed assessment methods and metrics

Physico-chemical elements

The list of general physico-chemical elements adopted in previous EPIRB applications (Temperature, Conductivity, pH, BOD_5, COD, O_2, NH_4, NO_3, PO_4) should be confirmed, while the list of relevant specific pollutants needs to be updated based on a revised pressures and impacts analysis for all river types. For both the general elements and the specific pollutants discharged in significant quantity in the rivers, status class boundaries (implying the definition of natural background) need to be defined for all river types.

According to the WFD, physico-chemical elements are considered in the classification of moderate to high status classes, as for lower than moderate classes the ecological status value is based only upon the biological QEs. Therefore, class boundaries between moderate and poor and between poor and bad are theoretically not required. It is suggested here to use the WFD approach for classification purposes, but to identify anyway the two lower class boundaries, as for management purposes a 5 class classification of physico-chemical elements can be particularly useful, in order to evaluate improvements or degradation of water bodies.

The suggested sampling frequency is every 3 months, possibly at the same time of benthic invertebrates sampling. The classification should be based on the sampling of at least 3 consecutive years for each planning cycle.

Benthic invertebrates

Sampling method for wadeable rivers

The sampling method adopted needs to be coherent with the standards EN 16150:2012 - Water quality - Guidance on pro-rata Multi-Habitat sampling of benthic macro-invertebrates from wadeable rivers and EN ISO 10870: 2012 - Water quality - Guidelines for the selection of sampling methods and devices for benthic macroinvertebrates in fresh waters.

The main characteristics of the method in case of wadeable rivers are summarized in the following (description based on ISPRA, 2014b).

- Use of a quantitative sampler, typically a Surber net, with a square or rectangular sampling surface of 0.05 or 0,1 m^2 and mesh size of 500 µm (in case of water depth higher than 50 cm, but still allowing to wade, a standard hand net can be adopted).
- In order to minimize disturbance, the sampling should be carried from downstream to upstream.
- Physico-chemical and general characteristics of the site (riparian vegetation, substrates, shading, land use in the floodplain, etc.), need to be assessed and recorded prior to sampling.
- The established sampling period and frequency should be adapted to the river type and to the corresponding ecology (i.e. of the seasonal life cycles) of benthic invertebrates and, if pertinent, to seasonality of pressures. 2 to 4 samplings per year may be appropriate, depending on local specificities. The sampling should be avoided just after floods (at least 2 weeks, indicatively, should be allowed for recolonization) and after extreme droughts (few weeks should be allowed after the re-establishment of the ordinary flow regime).

- The sampling site should be representative of a wider reach of the stream, and possibly of the whole water body. Its length can be variable, depending on the average riverbed width, 10 times the width is often an appropriate size.
- The main concept of a pro-rata multi-habitat sampling in a given monitoring site is to collect samples in defined units, which area is proportional to the microhabitat composition of the monitored site (see Figure 15). Operationally (unless more detailed information needs to be gathered for specific investigations) usually the sampling is carried out only within a single mesohabitat type, typically riffle or pool depending on the river type, therefore the riffle/pool sequence needs to be identified before starting the sampling. Where a clear riffle/pool sequence is not present (e.g. in steep mountain streams), the distribution of microhabitats is assessed in the whole site. The minimum amount of sampling units should be 10, located in different microhabitats proportionally to their extension (e.g. if sand correspond to 10% of the sampled mesohabitat, 1 unit will be placed in sand; if 30% is macrolithal, 3 units will have to be placed on macrolithal areas); microhabitat present with an extension lower than 10% are recorded, but not sampled. The surface area of each unit should be either 0.05 or 0,1 m^2, depending on the river type (and relative abundance of benthic invertebrates).
- The samples collected in the different units are merged into a single homogeneous sample, unless more accurate investigations need to be carried out in relation to specific microhabitats.
- Sorting and identification of taxa need to be performed on site. The abundance of each taxa needs to be assessed based on direct counting of individuals, with the exception of very abundant taxa, that can be estimated through the direct counting of just sub-samples. Specimens that cannot be identified on site, and possibly a sub-sample for further validation of field work, need to be fixed with ethanol and taken to the laboratory for further analyses.

	Microhabitat	Size (mineral microhab.)*	Code (IT)	Description
Mineral microhabitats	Silt / Clay	<6 µ	ARG	Silty substrates, also with prominent organic component part, and/or clay substrates with very fine granulometry, sticky particles and compact sediment, sometimes creating a solid surface.
	Sand	6 µ - 2 mm	SAB	Fine and coarse sand.
	Akal	0.2 - 2 cm	GHI	Gravel / akal and coarse sand with predominace of gravel.
	Microlithal	2 - 6 cm	MIC	Small stones.
	Mesolithal	6 - 20 cm	MES	Medium sized stones.
	Macrolithal	20 - 40 cm	MAC	Coarse stones, the size of a rugby ball as maximum.
	Megalithal	>40 cm	MGL	Large stones, blocks, rocky substrates, sampled on the surface only.
	Artificial	(e.g. concrete)	ART	Concrete and all substrates artificially placed in the channel.
	Hygropetric		IGR	Thin water layer flowing over a solid substrate, generally covered with mosses.
	*(sizes refer to intermadiate axis)			
Biotic microhabitats	Algae		AL	Mostly filamentous algae; also diatoms or other algae creating a thick periphytic layer.
	Submerged macrophytes		SO	Submerged aquatic macrophytes. Mosses, Characeae etc. are also included.
	Emergent macrophytes		EM	Emergent macrophytes rooted in the channel (e.g. *Typha, Carex, Phragmites* etc.).
	Living part of terrestrial plants		TP	Floating roots of riparian vegetation (e.g. alder roots).
	Xylal		XY	Coarse woody debris, e.g. branches, dead wood, roots (diameter at least 10 cm).
	CPOM		CP	Coarse particular organic matter (leaves, small branches).
	FPOM		FP	Fine particular organic matter.
	Bacterial		BA	Fungi and sapropel (e.g. *Sphaerotilus* , *Leptomitus*), solfobacteria (e.g. *Beggiatoa* , *Thiotrix*).

Figure 15 – List of microhabitats related to benthic invertebrates sampling (from www.life-inhabit.it)

Sampling method for non-wadeable rivers

Sampling approaches for non-wadeable rivers are not widely agreed and standardized, yet. Therefore it is suggested to select a locally feasible method based upon existing methodological reviews and proposals and of availability of necessary instruments and staff.

Recent reviews of alternative methods can be found for instance in Johns and Bowker (2014), and Hauer and Resh (2017). Several researchers and environmental agencies have been testing different methods recently. E.g. Bowker et al (2014), for river sections with a mean depth > 80 cm suggest the adoption of a long-handled pond net (reaching out as far as safely possible from the channel or bank) where the width of the watercourse is <15m and an airlift deployed from a boat if the width is >15 m. In both cases it is required to sample all habitats in proportion to their cover. Di Sabatino et al. (2016) proposed a leaf-net method, using Phragmites australis leaves as substrate, and comparing it to the widely used Hester–Dendy multiplates method. Advantages and disadvantages of the use of artificial substrates for sampling have been analysed in the INHABIT project[6].

Proposed assessment metrics

In different EU Member States different benthic invertebrates multi-metric indexes have been adopted to fulfil WFD classification requirements. The WFD foresees the assessment of at least the taxonomic composition and abundance, the ratio of disturbance sensitive taxa to insensitive taxa, the level of diversity of taxa. The choice of a suitable metrics for Georgia and Azerbaijan should be based on a regional process including the relevant technical and scientific community and taking into account available alternatives and locally consolidated approaches. However, as several metrics adopted by EU Member States have undergone an intercalibration exercise (see van de Bund, 2009, for a summary of the results of the intercalibration for rivers), in order to ensure that respective classifications would provide comparable results, these could be a reasonable starting point. Nevertheless, it has to be stressed that research institutions and environmental agencies are working towards the revision of some of the current metrics, in order to tackle their limitations, e.g. the limited sensitivity to hydromorphological pressures. See for instance Mondy et al., 2012 (suggesting an index aggregating (i) Shannon diversity index, (ii) original ASPT score, (iii) the relative abundance of polyvoltine taxa, (iv) the relative abundance of ovoviviparous taxa and (v) taxonomic richness).

Among the several possible alternatives, it is suggested here to adopt the STAR_ICMi index (Buffagni et al., 2006, ISPRA, 2014b), that was used as tool for the previously mentioned intercalibration related to benthic invertebrates in rivers. As

[6] www.life-inhabit.it/cnr-irsa-activities/en/cnr-irsa-activities-related-inhabit/sampling-methods/non-wadable-rivers/artificial-substrates

for other methods, however, it has to be taken into account that limitations have been highlighted recently (see Spitale, 2017).

The STAR_ICMi is a multi-metric index that includes 6 normalized and weighted metrics: ASPT, Log10(sel_EPTD+1), 1-GOLD, Number of EPT families, Total number of families and Shannon-Weiner diversity index, as detailed in Table 3. The taxonomic level requested in the identification is the family. Some of the metrics require information about abundance of collected taxa.

Information type	Metric name	Taxa considered	Literature references	Weight
Tolerance	ASPT (Average Score Per	Whole community (Family level)	e.g. Armitage et al., 1983	0.333
Abundance/ habitat	Log_{10} (Sel_EPTD +1)	Log_{10} (sum of Heptageniidae, Ephemeridae, Leptophlebiidae, Brachycentridae, Goeridae, Polycentropodidae	Buffagni et al., 2004	0.266
	1-GOLD	1 - (relative abundance of Gastropoda, Oligochaeta and	Pinto et al., 2004	0.067
Richness and diversity	Total number of	Sum of all Families present at the site	e.g. Ofenböck et al., 2004	0.167
	Number of EPT Families	Sum of Ephemeroptera, Plecoptera and	e.g. Ofenböck et al., 2004	0.083
	Shannon-Wiener diversity	Whole community	e.g. Hering et al., 2004	0.083

Table 3 - The 6 metrics included in the STAR_ICMi benthic invertebrates index

The calculation of the STAR_ICMi is performed in 4 steps:

1. calculation of the raw value for each of the 6 metrics;
2. calculation of the Ecological Quality Ratio (EQR) value for each of the 6 metrics by dividing the observed value by the median value of the metric calculated on the reference samples for the relevant river type (the current application of the method foresees that for ASPT the value of 2 must be subtracted from the observed value before EQR conversion);

3. calculation of the weighted average of the EQR considering the weight assigned to each metric;
4. normalization of the obtained value by dividing the value of the considered sample by the STAR_ICMi expected in reference samples.

The calculation of the metrics can be performed with the dedicated free software MacrOper.ICM.[7]

Similar free software have been made available to apply other indexes, often including at least part of the same individual metrics included in the STAR_ICMi. E.g. ASTERICS is the software linked to the German Assessment System PERLODES[8].

It has to be highlighted that in order to apply this and other similar methods in Georgia and Azerbaijan reference conditions and status class boundaries in terms of EQR (see Figure 16) **need to be established for all river types to be monitored.**

STAR_ICMi RQE values	Status class
$RQE \geq RQE_{g-h}$	very good or high
$RQE_{m-g} \leq RQE < RQE_{g-h}$	good
$RQE_{p-m} \leq RQE < RQE_{m-g}$	moderate
$RQE_{b-p} \leq RQE < RQE_{p-m}$	poor
$RQE < RQE_{b-p}$	very poor or bad

Figure 16 – Required class boudaries for the calculation of the status class for benthic invertebrates

Key expertise needed: at least one operator specifically trained in field sampling techniques and in the identification of benthic invertebrate taxa at the taxonomic level required by the classification metrics used (usually genus or family).

Morphological quality

In order to fulfil the criteria previously described, it is suggested to apply the Morphological Quality Index (MQI) and the corresponding assessment protocol (Rinaldi et al., 2013, 2016). The MQI is framed within a comprehensive hydromorphological assessment, useful not only to support water body classification purposes, but also for the identification of key pressure factors at river basin scale and to support decisions on management/mitigation/restoration

[7] www.life-inhabit.it/cnr-irsa-activities/it/download/software/macropericmsoft/macropericm-software-download
[8] www.fliessgewaesser-bewertung.de/en/download/berechnung/

measures (Belletti et al., 2017) related both to ecological and to flood risk goals, as well as licensing procedures and EIAs where hydromorphological pressures are relevant.

The main characteristics of the method can be summarized as follows (Rinaldi et al., 2013; 2015):

- it is relatively simple, but its application should be carried out by technicians with sufficient background in fluvial geomorphology, as it makes use of expert judgement;
- it is a process-based method, therefore the consideration of channel forms is in relation to river processes, such as continuity in sediment and wood flux, bank erosion, lateral mobility, and channel adjustments;
- its main aim is to assess morphological quality, not to provide a precise quantification of processes or an in-depth understanding and forecast of channel evolution;
- the temporal component is explicitly accounted for, considering that an historical analysis of channel adjustments provides insight into the causes and time of alterations and expected future geomorphic changes;
- the multiscale, hierarchical approach developed by Gurnell et al. (2015) is adopted, where the “reach” (i.e., a section of river along which present boundary conditions are sufficiently uniform, commonly few kilometres in length) is the basic spatial unit for the application of the evaluation procedure;
- reference conditions for the MQI entail a river reach in dynamic equilibrium, where the river is performing those morphological functions that are expected for a specific morphological typology, and where artificiality is absent or does not significantly affect the river dynamics at the catchment and reach scale. It has to be underlined that unlike biological QEs, the morphological one does not foresee the identification of type-specific reference and class boundary conditions, as the former are part of the assessment analyses, while the latter are predefined by the method.

The aspects considered for the assessment of the morphological quality of river reaches, are: i) continuity of river processes, including longitudinal and lateral continuity; ii) channel morphological conditions, including channel pattern, cross section configuration, and bed substrate; iii) vegetation (exclusively in relation to its effects on geomorphological processes). These aspects are analysed in terms of three components: 1) the geomorphological functionality of river processes and forms; 2) artificiality; and 3) channel adjustments.

Indicators of geomorphic **functionality** evaluate whether or not the processes and related forms responsible for the correct functioning of the river can take place.

Indicators of **artificiality** assess the presence and frequency of artificial elements or Interventions.

Indicators of **channel adjustments** focus on relatively recent morphological changes (i.e., less than 1 century) that are indicative of a systemic instability related to human factors. Channel changes that are not clearly related to human disturbances but that occurred during this time frame (e.g., changes related to large floods) may also be recognised but are not considered as an alteration.

In summary, indicators of geomorphic functionality and channel adjustments can be considered as ‘response indicators’, whereas indicators of artificiality are ‘pressure indicators’.

Slightly different lists of indicators are used for confined or partly confined/unconfined stretches.

The final result of the assessment is a MQI value, corresponding to morphological quality classes defined as in Figure 17.

MQI value	Morphological quality
0.85 ≤ IQM ≤ 1.0	very good or high
0.7 ≤ IQM < 0.85	good
0.5 ≤ IQM < 0.7	moderate
0.3 ≤ IQM < 0.5	poor
0.0 ≤ IQM < 0.3	very poor or bad

Figure 17 – Class boundaries for the MQI

The assessment should be carried out at least once per planning cycle, but increased frequencies (e.g. once every 3 years) can be foreseen if significant changes occur. The revision of the assessment would in any case be less resource-intensive than the first one, and faster if the necessary information (e.g. updated satellite images, digital elevation models, or the location of new infrastructure) is systematically updated and stored.

Key expertise needed:

- technicians specifically trained in fluvial geomorphology, as some of the evaluation are expert-based and imply the capacity to understand fluvial processes;
- basic GIS data representation and analysis capacity, as the calculation of some indicators should be supported by measures best carried out in a GIS environment; moreover the data collected in the field, if included in a GIS can provide very useful information beyond the classification exercise, for planning and management purposes.

For a comprehensive description of the MQI application, see the full MQI manual (Rinaldi et al., 2016)[9].

[9] The MQI manual in English can be freely downloaded from www.isprambiente.gov.it/pre_meteo/idro/idromorfologia/MQI_final_Aug16_revOct16.pdf
MQI evaluation forms in English can be downloaded from www.isprambiente.gov.it/pre_meteo/idro/idro.html

Hydrological alteration

It is suggested to adopt a method based on the consolidated and widely applied IHA (Indicators of Hydrologic Alteration, Richter et al., 1996, 1997)[10] approach, i.e. assessing the alteration of all the main water flow regime characteristics that are known to affect ecological processes and biotic communities. In particular, 5 different aspects of the flow regime are taken into account:

- magnitude in different periods of the year;
- timing of specific flow events (such as main floods and low flow periods);
- duration of specific flow events;
- frequency of specific flow events;
- rate of change of flow rates.

A series of indicators (33 in the full IHA assessment) are measured, comparing the values in altered with unaltered conditions (measured or reconstructed). Data series of average daily flow rate are needed for a full assessment. WFD-compliant methods based upon the IHA principles are for instance the IAHRIS (Martínez Santa-María and Fernández Yuste, 2010)[11], where indicators covering the 5 IHA criteria are included, and the IARI (ISPRA, 2011), using the whole set of IHA indicators (when data availability allows it).

Minimum required data availability and whether to use the same time interval or different ones for the natural and altered series are critical issues for this kind of methods. The full version of the IARI requires minimum 20 years of non-altered and minimum 5 years of altered daily average flow data, while the standard IAHRIS application requires 15 years of impacted and corresponding (reconstructed) non-impacted daily average flow data. The comparison of different periods allows to account for hydrological impacts related e.g. to land use changes at catchment scale; however, the value of the index is affected by hydrological changes due to climate change. Therefore in order to assess the impact of a specific pressure factor, such as a water withdrawal, and where the hydrology of the catchment is known to have changed significantly, using the same period is probably advisable.

For detailed calculations of the IAHRIS reference is made to the available manual (Martínez Santa-María and Fernández Yuste, 2010), while the IARI procedure is summarized in the following (as the manual is currently available only in Italian). It has to be noted that the IAHRIS, in order to take into account the ecologically important inter-annual variations of the flow regime, that would be lost working with average values calculated from all of the available years, yearly data series are classified into 3 types: “wet year” (if its annual volume in natural regime is greater than the volume corresponding to 25% exceedance percentile), “normal year” (if its annual volume in natural regime lies between the volume

[10] Reference literature and software on the IHA are freely available on https://www.conservationgateway.org/ConservationPractices/Freshwater/EnvironmentalFlows/MethodsandTools/IndicatorsofHydrologicAlteration/Pages/indicators-hydrologic-alt.aspx

[11] For more details and software manual see http://www.ecogesfor.org/IAHRIS_es.html and http://www.ecogesfor.org/pdf/User_manual_IAHRIS_v2_2.pdf

corresponding to 25% and 75% exceedance percentile) and "dry year" (if its annual volume in a natural regime is less than the input corresponding to 75% exceedance percentile). This generates three series of natural regimes (series of wet, normal and dry years), which are then used as a basis for the assessment.

For the calculation of the IARI in its "complete" version, for each of the 33 IHA indicators the 25th and 75th percentiles (indicated as $XN_{0.25,i}$ and $XN_{0.75,i}$ respectively) of the available non-altered series are computed. Then the 33 characteristic values of the altered series (e.g. median values) $X_{i,k}$ are compared with these thresholds; the corresponding alteration indicator $p_{i,k}$ is computed as follows:

$p_{i,k} = 0$ if $XN_{0.25,i} \leq X_{i,k} \leq XN_{0.75,i}$

$$p_{i,k} = \min\left(\left|\frac{X_{i,k} - XN_{0.25,i}}{XN_{0.75,i} - XN_{0.25,i}}\right|, \left|\frac{X_{i,k} - XN_{0.75,i}}{XN_{0.75,i} - XN_{0.25,i}}\right|\right) \quad \text{if } X_{i,k} < XN_{0.25,i} \text{ or } X_{i,k} > XN_{0.75,i}$$

where:

i indicates the i-th IHA indicator

k indicates the year taken into account

which corresponds to assuming no impact whenever a value remains within a band of natural variation, between the 25th and 75th percentiles; these boundaries could be reduced for a more stringent assessment.

The overall value of the index, where 0 corresponds to no alteration and 1 to maximum alteration, is computed as average of the single indicators:

$$IARI_k = \frac{1}{33}\sum_{j=1}^{5} n_j \left(\frac{1}{n_j}\sum_{i=1}^{n_j} p_{i,k}\right) = \frac{1}{33}\sum_{i=1}^{33} p_{i,k}$$

The current class boundaries are currently set at 0,05 for high-good and 0,15 for good-lower than good. Coherently with the other metrics and with the proposal to use hydromorphology for all status classes, it is suggested here to use as metrics "1-IARI", so that the highest score corresponds to the best conditions; moreover, it is suggested to define class boundaries for all classes, as detailed in Figure 18.

Index value	**Hydrological quality**
0.95 < 1-IARI ≤ 1.0	very good or high
0.85 < 1-IARI ≤ 0.95	good
0.6 < 1-IARI ≤ 0.85	moderate

$0.3 < 1\text{-IARI} \leq 0.6$	poor
$0.0 < 1\text{-IARI} \leq 0.3$	very poor or bad

Figure 18 – Proposed class boundaries for a hydrological alteration metrics based on the IARI

A different and somehow simpler approach, based again on the IHA indicators, but adopting a year by year comparison (therefore applicable even with a flow rate series corresponding to a single year), with a scoring system taking into account all deviations between the altered and non-altered series (i.e. not adopting the "variation coefficient" approach used in the IARI) is the indicator of alteration proposed in the CH_2OICE hydropower certification procedure (Goltara et al., 2011).

With this method each of the 5 different aspects of the flow regime mentioned above is described by a synthetic index for each year t and aspect A ($I_{t,A,j}$), computed as the average of the IHA alteration indicators $a_{,I}$ pertaining to the A-th group and calculated as the relative difference, in absolute value, between the value in non-altered and altered conditions:

$I_{t,A,j} = 1- |a_{non\text{-}alt,j}-a_{alt,j}| / a_{anon\text{-}alt,j}$ if $1- |a_{non\text{-}alt,j}-a_{alt,j}| / a_{anon\text{-}alt,j} > 0$

$I_{t,A,j} = 0$ otherwise

for all indicators, with the following exceptions:

- the indicator on the amount of days with zero flow, which value is 0, if zero flow days are present only in the altered series, 1 otherwise;
- the two indicators related to the date of occurrence of extreme events, which value varies continuously from 1 (if the date is the same) to 0 if the date is shifted by 6 months or more.

For each of the 5 aspects:

$I_{t,A}= 1/n \sum_i^n I_{t,A,j}$ (with n = number of indicators in the A-th group)

The overall alteration index for each year t is again the average of each of the 5 sub-indices above:

$I_t = 1/5 * \sum I_{t,A}$

The class boundaries are defined homogeneously (0,2; 0,4; 0,6; 0,8), with 1 corresponding to no alteration and 0 to maximum alteration.

Where daily average series are not available, a simpler (though much less representative) assessment can be applied, if at least monthly average data (altered and non-altered, usually reconstructed through modelling approaches) are available. In this case either the IARI or the approach proposed by Goltara et al., 2011 can be applied, limiting the calculation to the 12 monthly average IHA indicators.

Whatever is the method applied, the assessment needs to be carried out in reaches that are hydrologically homogeneous, therefore a WB is usually segmented in several shorter stretches whenever confluences, discharges, or abstractions determine significant changes in instream flow.

The metrics value for the whole WB is computed averaging the values of the single reaches.

As it is based on data collected continuously, the index can be updated yearly.

Additionally, if sub-hourly flow rate data is available, one or more indicators accounting for **hydropeaking** could be included in the classification. However, in general, indicators measuring the simple peak to base flow rate (i.e. the "magnitude" of hydropeaking) are weakly correlated with the actual impact on biota, and more complex assessments are necessary, taking into account additional hydropeaking descriptors (e.g. frequency, ramping rate and timing, see e.g. Schmutz et al., 2015) and involving site-specific habitat modelling (see e.g. Weber et al., 2015).

Key expertise needed: variable depending on the specific approach, but at least one trained hydrologist.

River water bodies classification proposal in the medium term

Once the short term classification (and corresponding monitoring) approach is regularly implemented and the proposed integrative data collection activity has been finalized, a more comprehensive WB classification approach can be applied, integrating fish fauna, river continuity in relation to fish fauna and chemical status. The time necessary to shift to this second phase will depend on the resources allocated in the first phase, but indicatively it can be assumed to be between 3 and 5 years.

The additional metrics would be combined with a one-out-all-out principle for all status classes as in the short-term proposal (see Figure 19).

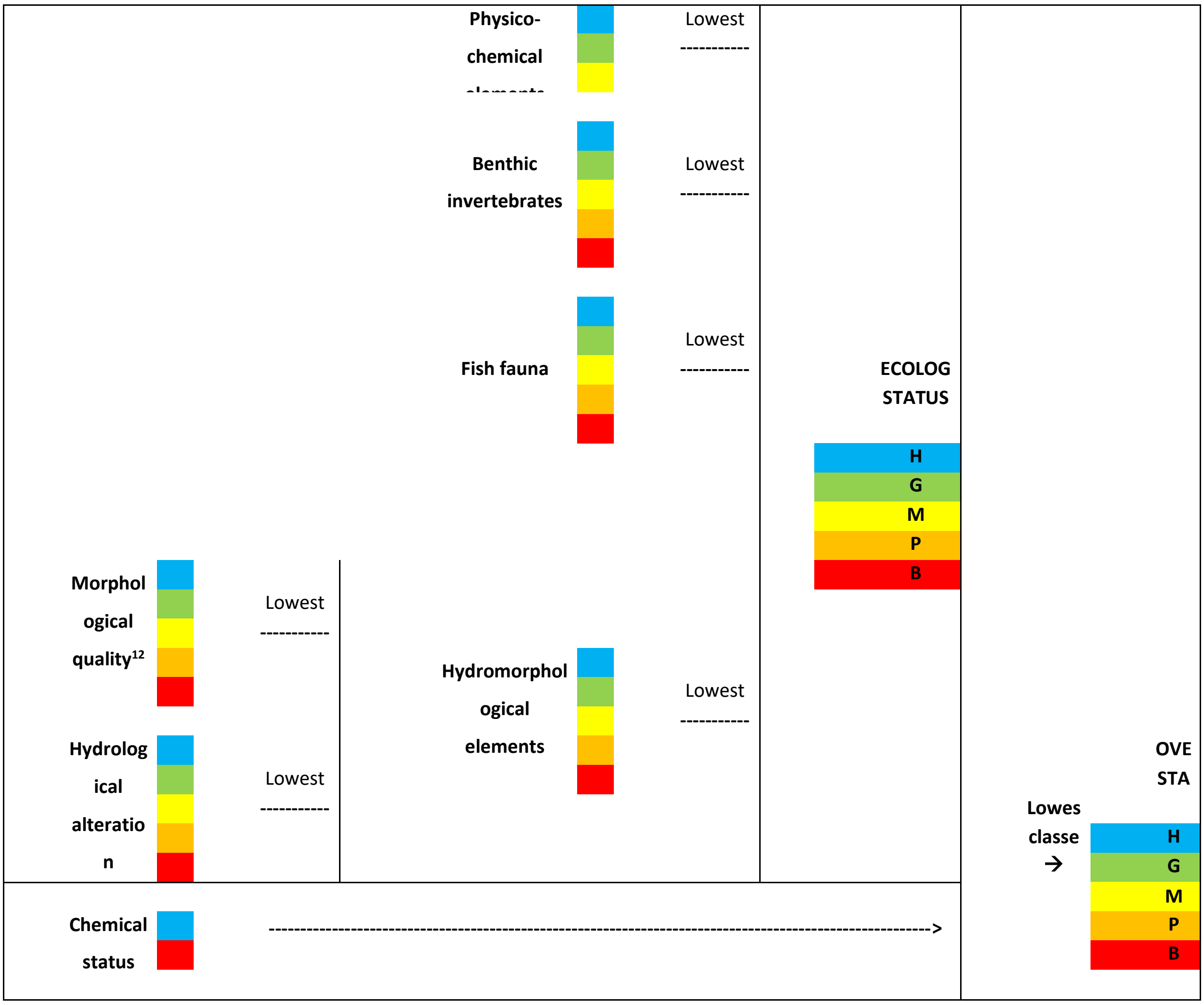


Figure 19 – Proposed medium-term approach to aggregate the values of single QEs into the WB ecological status and the overall WB status classes

[12] Including continuity for fish fauna; the aggregation approach will depend on the specific metrics adopted.

Fish fauna

Sampling method for wadeable rivers

The usual method for fish sampling in wadeable rivers is electrofishing. Electrofishing procedures are described in the specific CEN standard EN 14011 (CEN, 2013). A specific field protocol based on this standard needs to be developed according to national regulations and to the final choice on the fish fauna metrics to be used. A **detailed sampling protocol** coherent with the widely applied EFI+ index can be found in EFI+ Consortium, 2009 and could be used as reference. In the following, the main characteristics of a method coherent with the requirements of the WFD, i.e. able to provide quantitative data on fish species composition, abundance and age structure, are summarized (mainly based on EFI+ Consortium, 2009 and ISPRA, 2014b).

- The sampling period needs to be adapted to the specific hydrological and ecological conditions, as it should correspond to hydrological conditions allowing a safe in-stream activity and a sufficiently low flow in order to facilitate capture. The transparency of water should also be as high as possible. Interference with critical biological periods such as spawning (which varies greatly between different species and especially between salmonids and cyprinids) should be avoided. The CEN standard does not define any specific sampling period, while the EFI+ approach recommends summer/early autumn low flow periods except for temporary Mediterranean rivers where spring samples should be considered.
- Where restocking activities or other direct alteration of fish communities has taken place, sampling should be avoided for at least one year.
- Within each WB one or more sampling sites (stretches) should be identified, that should adequately represent the variability of habitats of the whole WB, as well as land use and anthropogenic pressures. According to the EFI+ protocol, each site should represent segments of the following lengths: 1 km for small rivers (catchment area <100 km²), 5 km for medium-sized rivers (catchment 100-1000 km²); 10 km for large rivers (catchment >1000 km²).
- The sampled river length should be indicatively 10 to 20 times the river width, with an indicative minimum length of 100 m, ensuring to sample all mesohabitats.
- In order to minimize harm to fish, the electrofishing device should be used at the lowest effective dosage, possibly with Direct Current (with Pulsed Direct Current only if necessary, and never with Alternate Current), depending on water conductivity, river size and expected fish species; voltage, pulse duration, amplitude and frequency can be raised incrementally to fit the specific local conditions.
- The operators should fish upstream, in order to avoid affecting the sampled stretch with turbidity. They should move slowly and cover the whole mesohabitat with a sweeping movement. The operators should move forward alternating downstream to upstream and bank to bank directions. Usually the operator handling the anode is followed at a short distance by two operators with hand-netters, and one operator handling a bucket where the fish are temporarily stored. The same operator is responsible for transferring the fish to the collection point at

the end of the sampling stretch and to ensure that thermal and oxygenation conditions remain suitable until the end of the operations.

- The use of stop-nets, hindering the movement of fish into or out of the sampled stretch can be foreseen, but it is not strictly required.

Figure 20 – Electrofishing in a wadeable river (from EFI+ Consortium, 2009)

- According to the EFI+ protocol, a single electrofishing run is carried out and for a river width <15 m the whole site surface is sampled, while for a river width >15 m several separated sampling areas are selected within a sampling site (partial sampling method), corresponding overall to a minimum of 1000 m². In other protocols, to the contrary, in order to ensure a more quantitative sampling, multiple runs are foreseen. E.g. in ISPRA, 2014b, a second run is carried out and the number of specimens caught is compared to those of the first run. If the amount is not at least 50% lower, a further run is foreseen, up to a maximum of 4 electrofishing runs. A discussion on advantages and disadvantages of single vs. "multi-pass" sampling can be found for instance in Lake, 2013.
- Collected fish need to be identified in the field to the species level by the analysis of external morphological characters, measured (total length and weight), and inspected for evident morphological anomalies and signs of pathologies. Pictures should be taken for further validation of field identification. After identification and measures, the fish are carefully released in the reach where they were previously caught.
- The sampling frequency can be limited to once per monitoring year. The sampling should be repeated every 3 years, but depending on the monitoring site and on the nature of existing pressures it can be decided to monitor fish fauna at shorter or longer intervals.
- Safety issues are particularly relevant when carrying out electrofishing, therefore a specific field safety protocol, adapted to the electrofishing devices used and to the kind of rivers monitored, needs to be put in place and proper safety equipment needs to be available.

Sampling method for non-wadeable rivers

For non-wadeable rivers (indicatively with an average water level > 70 cm) the sampling methods is similar to the wadeable rivers, but the electrofishing takes place from a boat. As to areas covered, the EFI+ methodology suggest to sample both banks of the river or a number of sub-samples proportional to the diversity of the habitats present (partial sampling method), corresponding overall to a minimum of 1000 m². The catching efficiency can be increased by increasing the number of electrodes, but quantitative sampling is usually not realistic. The use of nets can also be foreseen, when feasible.

Figure 21 – Electrofishing from a boat in a non wadeable river (from EFI+ Consortium, 2009)

Proposed assessment metrics

Among the several metrics applied in different EU Member States, the EFI+ index (EFI+ Consortium, 2009) can be considered of particular interest, given its wide application and the intense research activity that has supported its development since its first version (EFI, FAME Consortium, 2004).

The EFI+ is based on the assumption that the fish assemblage structure responds to human alterations of aquatic ecosystems in a predictable and quantifiable manner (see e.g. Karr, 1981), thus it makes use of environmental descriptors to predict biological reference conditions and then quantifies the deviation of the fish community structure from these reference conditions on a statistical basis. The development of the EFI+ was based on a large database of about 30,000 fish assemblage surveys covering more than 14,000 sites from 2,700 rivers in 15 European eco-regions. For each of these, information about the fish assemblage, environmental characteristics and human pressures was collected. These data supported the development of a predictive model, that derives reference conditions from abiotic environmental characteristics of individual sites and quantifies the deviation between the predicted fish assemblage (in the "quasi absence" of any human disturbance) and the observed fish assemblage.

The EFI+ (as detailed in EFI+ Consortium, 2009) includes two sub-indices, each composed of two different metrics:

- **Salmonid Dominated Fish Assemblage Index** (Salm.Fish.Index), for sites classified as Salmonid Dominated Fish Assemblage River Type (Salmonid river type)
  Salm.Fish.Index = (Ni.Hab.150 + Ni.O2.Intol) / 2
- **Cyprinid Dominated Fish Assemblage Index** (Cypr.Fish.Index) for sites classified as Cyprinid Dominated Fish Assemblage River Type (Cyprinid river type)
  Cypr.Fish.Index = (Ric.RH.Par + Ni.LITHO) / 2

where:

Ni.O2.Intol = Density (number of individuals per $100m^2$ in one run of a sample site) of species intolerant to oxygen depletion, always more than 6 mg/l O2 in water;

Ni.Hab.Intol.150 = Density (number of individuals per $100m^2$ in one run of a sample site) in the size class ≤150 mm (total length) of species intolerant to habitat degradation;

Ric.RH.Par = Richness (number of species in one run of a sample site) of rheopar species (requiring a rheophilic reproduction habitat, i.e. preference to spawn in running waters);

Ni.LITHO = Density (number of individuals per $100m^2$ in one run of a sample site) of species requiring lithophilic reproduction habitat (species which spawn exclusively on gravel, rocks, stones, cobble or pebbles; their hatchlings are photophobic).

The species to be classified in the different categories are indicated in the method.

The distinction between the two river types is based on the proportion (relative abundance of individuals) of typical species belonging to salmonid dominated fish assemblage - which are oxygen depletion intolerant, habitat alteration intolerant, stenothermic, lithophilic or speleophilic reproduction type species and with a rheophilic reproductive habitat. This classification, based on abiotic environmental parameters, is one of the most critical steps in the application of the method.

The value of the index is computed as the standardised distance between the expected value in the absence of any significant human disturbance (estimated with the statistical approach described above) and the observed value (computed from the sampled fish assemblage), then expressed as EQR to provide a value between 0 and 1. Class boundaries are defined in EFI+ Consortium, 2009, separately for the salmonid index and for the cyprinid index and, for the latter, different boundaries are defined depending on the sampling technique (wading or boating).

A free dedicated software is available for the calculation of the index.[13]

[13] For details on the EFI+ methodology and the related software for calculating the index, see http://efi-plus.boku.ac.at/software/index.php

However, the EFI+ predictive models underpinning the index calculation were derived only for 17 Ecoregions, not including the Caucasus Ecoregion, and the index cannot be applied in areas with a fish fauna deviating from those of the tested ecoregions. Therefore, in order to allow the application of the EFI+ in Georgia and Azerbaijan, an extension of the statistical models for the Caucasus, covering all relevant river types, should be previously foreseen. This implies, among other conditions, to identify a sufficiently large set of reference sites, where the fish assemblages can be considered sufficiently undisturbed.

Due to this relevant limitation, an alternative classification approach can be considered, at least in the medium term, **based on expert judgement for the definition of reference fish assemblages**. A simpler metrics could also be adopted, reflecting the basic criteria required by the WFD, i.e. including a comparison between sampled and reference fish species composition, abundance and age structure. One possible metrics is suggested here as a starting point for a Fish Index for Georgia and Azerbaijan, a simplification of the proposal by Zerunian et al. (2009), where class boundaries are also expert based and predefined. The proposed index includes three sub-indices:

f_1 = presence of reference species;

f_2 = biological conditions of reference species;

f_3 = presence of alien species.

f_1 is computed as the ratio between the number of native species observed and the number of (native) species in the reference fish assemblage; this sub-index can potentially be split in two components, aggregated with different weights, related to species with higher and lower ecological or functional importance.

f_2 is computed as average of the values f_{2i} for each reference species i; f_{2i} is computed based on two expert based indicators, accounting for the age structure and abundance in the observed community for each reference species; $f_{2i} = 0{,}6 * f_{2i1} + 0{,}4 * f_{2i2}$ where:

$f_{2i1} = 1$ if the population is well structured;

$f_{2i1} = 0{,}5$ if the age structure is moderately altered;

$f_{2i1} = 0$ if the age structure is strongly altered;

$f_{2i2} = 1$ if the abundance is equal or very close to reference;

$f_{2i2} = 0{,}5$ if the abundance is intermediate in comparison to reference;

$f_{2i2} = 0$ if the abundance is low in comparison to reference.

If species i is not observed, both values are set to 0.

f_3 is computed based on 3 lists of alien species (to be defined for the local context), depending on their expected impact on native species: high, intermediate and low impact; the suggested values (that can be adapted according to the local knowledge on the presence and impact of alien fish species) are the following:

$f_3 = 1$ if no alien species are present;

$f_3 = 0,85$ if only alien species in list 3 are present, but none in lists 1 and 2;

$f_3 = 0,50$ if at least 1 species in list 2 is present;

$f_3 = 0,25$ if at least one species in list 1 is present with a population which is not well-structured;

$f_3 = 0$ if at least one species in list 1 is present with a well-structured population.

In case $f_1 = 0$, f_3 is also set to 0.

When aggregating the values of the sub-indices into the overall Fish Index, the suggested weights for f_1 , f_2 , and f_3 are 0,5, 0, 3, and 0,2, respectively. Thus $FI = 0,5 * f_1 + 0,3 * f_2 + 0,2 * f_3$.

Given its definition, the resulting Fish Index is already expressed as EQR between 0 and 1. The class boundaries can be assumed homogeneous, between 0 and 1 (0,2, 0,4, 0,6, 0,8).

Key expertise needed:

- at least 2 operators with appropriate training in hydrobiology, fish identification, and fish handling minimising unnecessary harm;
- at least 2 operators with appropriate training in the safe use of electrofishing devices;
- at least one expert in fish ecology for the assessment of the selected metrics.

River continuity for fish fauna

Once sufficient information is gathered about current and reference fish communities (through monitoring and data collection suggested in chapter 0) and on the presence of anthropogenic obstacles (through the application of the MQI assessment), it should be possible to include in the classification a full assessment of river (longitudinal) continuity, as foreseen in the WFD. Longitudinal continuity has two main components: one is related to the effect of transversal barriers (dams, check-dams, weirs, etc.) on sediment (especially bedload) transport; the other is related to the effect on the free movement of fish. The first component is already included in the MQI assessment (as in other morphological assessment methods), the second needs to be defined separately.[14]

[14] According to Annex V of the WFD, river continuity is part of hydromorphological quality elements and requires an assessment of the extent to which "the continuity of the river is not disturbed by anthropogenic activities and allows undisturbed migration of aquatic

The actual metrics used will strongly depend on the feasible level of detail in the assessment of continuity, but it should possibly include the following components:

- assess separately upstream and downstream migration;
- assess separately the effect on different species or groups of species, taking into account the respective ability to pass obstacles;
- weigh the single assessments taking into account the importance of migration for different species or groups of species (e.g. anadromous and catadromous species requiring to migrate respectively upstream and downstream in order to reproduce);
- for an assessment at water body scale, and for classification purposes, take into account the cumulative effect of single barriers on the overall connectivity.

Detailed methodological approaches for the quantitative assessment of (physical) passability of obstacles by fish have recently been developed. For a comprehensive guideline, see e.g. Baudoin et al., 2014. Novel approaches are under development for instance in the AMBER[15] project.

It has to be underlined that applicable methods are limited by the current scientific knowledge on the issue. For instance physical barriers are not the only limitation to fish migration: chemical (e.g. stretches with very low oxygen concentration), thermal (e.g. when discharge of water turbined at much higher altitude determines the so-called “thermopeaking”), hydrological (e.g. the behavioural effects on fish in stretches subject to hydropeaking) hindrances can also have strong effects on fish mobility. The approach to be applied in the medium and long term will therefore need to take into account the scientific knowledge that will become available.

Chemical status

In the medium term it is assumed realistic to have a regular monitoring of priority substances in place, therefore also the **chemical status** can be included in the classification.

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organisms and sediment transport”. However, only some EU Member States have assessed it, and, when assessed, the way this element was included in the classification differs from State to State.

[15] https://amber.international

River water bodies classification proposal in the long term

In the longer term, indicatively between 5 to 10 years, a full implementation of the WFD classification approach can be foreseen. In such a time framework, it has to be considered that after the current "fitness-check" phase[16], the WFD may undergo a revision phase in the next couple of years, therefore also the classification approach may be modified.

Making reference to the current classification scheme, the QEs neglected in the previously described short and medium term classification proposals for rivers are **macrophytes and phytobenthos**. Therefore it may be relevant to foresee their integration in WB classification. However, as previously commented, the metrics currently adopted in operational management for these QEs (in some Member States a single metrics including both, but in most cases two separate metrics) are essentially trophic/saprobic ones (see for instance the widely applied Macrophyte Biological Index for Rivers – IBMR, Haury et al., 2006 or the Biological Diatom Index – IBD, Coste et al., 2009), raising issues of redundancy and cost-efficiency of monitoring programmes.

Various studies are showing that macrophytes and diatoms communities actually do react to different pressures, such as fine sediments concentration or alteration of water velocity patterns (see e.g. Francoeur and Biggs, 2006; Bona et al., 2011; Rimet and Bouchez, 2012). However, metrics able to translate these community changes into a usable assessment tool are still at research level. The same applies to sampling approaches, that need to fit the requirement of the applied metrics. New sampling methods, based e.g. on quantitative estimation of abundance, are under development, but no consolidated monitoring and assessment procedures can be considered appropriate for operational application in Georgia and Azerbaijan at this stage.

Therefore, it is suggested to follow the outputs of relevant research projects and testing procedures by EU Member States in the following years, to verify whether proper metrics are developed and validated. In the meantime, the use of indices based on macrophytes and diatoms can be applied to specific "investigative monitoring" activities (i.e. to better identify cause-effect relationships in specific contexts), or for the monitoring and assessment of mitigation/restoration measures, when deemed pertinent and feasible. Appropriate metrics will have to be selected according to the specific objective of each investigation.

Coordination at Kura basin level

One of the main challenges in the EU-wide application of the WFD is the comparability of classification results in different Member States, especially within transboundary basins. In order to ensure comparability in the definition of status and target objectives, and as every Member State had different monitoring and assessment methods, a series

[16] For more details on this process, see https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2017-5128184_en

of “intercalibration” exercises, for different QEs, WB categories, typologies and ecoregions has started, and after more than one decade it is still on its way, far for being successfully concluded.

Georgia and Azerbaijan, being in the initial phase of WFD implementation, have now the opportunity to strongly facilitate a harmonized classification in the Kura basin, by agreeing since the beginning on common approaches. The application of the same monitoring and classification methods (including carrying out a common definition of reference and boundary conditions for relevant QEs) by concerned countries is strongly advisable, instead of a future trans-national intercalibration activities.

The organisation of inter-comparison exercises both at national level (e.g. between different regional offices) and involving both countries on all classification QEs is also deemed very useful. These would consist in the application of the monitoring and classification methodologies on test stretches/sites in order to compare results and validate the application of a common approach.

It has also to be highlighted that a correct assessment and classification of a given WB, especially, but not exclusively, in relation to hydromorphological elements, requires to take into account the effects linked to status and identified impacts on processes of upstream stretches and catchments. At the same time, the monitoring and classification results of downstream WBs can help to better interpret the pressure-impact paths in upstream ones. Therefore, the access not only to aggregated data, but also to the main elaborations used for classification by neighbouring countries should be ensured (e.g. a georeferenced database of collected data, available to responsible agencies of both Georgia and Azerbaijan). This kind of data sharing is clearly useful also independently from WFD implementation, but more in general for integrated planning and management of river basins. Trans-national data sharing agreements in this respect should be possibly signed at an early stage of the WB classification activity, i.e. during the short term phase proposed in this document.

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Annex 7

The NEA protocols presently in use within the national monitoring programme for the surface waters of Georgia. (a) Site protocol for macroinvertebrates. (b) Hydromorphology assessment form – structural features and hydrological features. (c) Sampling protocol for chemistry.

(a). Site protocol for macroinvertebrates.

1. SITE NAME:			
Site type:		Waterbody name:	
GPS coordinates	accurate/approximate	N:	E:
Municipality:		Watershed :	
Habitat type:		Substratum:	
General description:			
2. SAMPLING		Date and time:	Agency:
Monitoring/project name:		Number of samples to be taken at site:	
Sampling device:		Area covered by device/sample [cm^2] :	
Dimensions of device (LxWxH):		Sampling time [s]:	Mesh size [mm]:
3. FIELD OBSERVATIONS			
Surveyor name:			
GPS coordinates	**N:**	**E:**	**Altitude (m.a.s.l.):**
Additional information: Visibility: Number of photographs:			

Substrate (0-3*)		**Plant cover (0-3*)**		**Environmental and chemical parameters**		**Riparian zone (0-3*)**	
Bedrock [> 4 m]				Maximum depth[m]		length[m]: width[m]:	
Large boulder [256 mm - 4 m]		Emergent plants		Width[m]		Shading [%]	
Boulder [64-256 mm]		Floating leaf plants		Current velocity*[m/s]		Evergreen trees	
Cobble [16-64 mm]		Submergent plants		Water level[cm]		Deciduous	
Pebble [2-16 mm]		Isoetids		Discharge (m3/s)		Mixed forest	
Sand [0,06-2 mm]		Free floating plants		Oxygen (mg/l)		Clearcut	
Silt		Mosses		pH		Field/pasture	
Clay		Macroalgae		T (^{o}C)		Swamp	
Mud		Algae				Shrubs/bushes	
Peat		No vegetation					

Fine detritus		**Sewage fungus (0-4*)**		Conductivity (mS/cm)		Road/settlement	
Coarse detritus				Colour		Forest drainage/other drainage	
Tree branches and stems						Else, what?	
Artificial							

4. THE SAMPLE		
Number of containers:	**Code:**	

5. SAMPLE INFORMATION :

6. SITE LOCATION (description of how to arrive to the site and the):

7. HABITATS SAMPLED (photo of the sampling area):

* Scores are defined in Table 1, 2 and 3 in the instructions.

(b). Hydromorphology assessment form – structural features.

Stream / River name: Site name: Date:

Surveyor:

Category	Parameter	SSU1		SSU2		SSU3		SSU4		SSU5		SU
		L	R	L	R	L	R	L	R	L	R	Score
1 Channel	1.1 Channel sinuosity											
	1.2 Channel type											
	1.3 Channel shortening											
	Channel planform score, CPS: (1.1+1.2+1.3)/3											
2 In-stream	2.1 Bed elements[1)]	BA/IS/RI/RA/RO/SP		BA/IS/RI/RA/RO/SP		BA/IS/RI/RA/RO/SP		BA/IS/RI/RA/RO/SP		BA/IS/RI/RA/RO/SP		
	2.2 Substrate[2)]	BE/BO/CO/GR/SA/CD		BE/BO/CO/GR/SA/CD		BE/BO/CO/GR/SA/CD		BE/BO/CO/GR/SA/CD		BE/BO/CO/GR/SA/CD		
		MD/CL/PE		MD/CL/PE		MD/CL/PE		MD/CL/PE		MD/CL/PE		
	2.3 Variation in width[3)]	W:	S:	W:	S:	W:	S:	W:	S:	W:	S:	
	2.4 Flow types[4)]	FF/CH/CA/BS/US/RP/UP		FF/CH/CA/BS/US/RP/UP		FF/CH/CA/BS/US/RP/UP		FF/CH/CA/BS/US/RP/UP		FF/CH/CA/BS/US/RP/UP		
		SM/NO		SM/NO		SM/NO		SM/NO		SM/NO		
	2.5 Large woody debris[5)]	Number:		Number:		Number:		Number:		Number:		
	2.6 Artificial bed features											
	Instream feature score, IFS: (2.1+2.2+2.3+2.4+2.5+2.6)/6											
3 Bank and riparian	3.1 Riparian vegetation											
	3.2 Bank stabilisation											
	3.3 Bank profile											
	Bank and riparian score, BRS: (3.1+3.2+3.3)/3											
4 Floodplain	4.1 Flooded area											
	4.2 Natural vegetation											
	Floodplain score, FPS: (4.1+4.2)/2											
Hydromorphological Quality Score (CPS+IFS+BRS+FPS)/4												

1) BA: Bars, IS: Islands, RI: Riffles, RA: Rapids, RO: Rocks, SP: Step/pools

2) BE: Bedrock, BO: Boulders, CO: Cobble, GR: Gravel, SA: Sand, CD: Coarse debris, MD: Mud/silt, CL: Clay, PE: Peat

3) Measure widest and smallest width in each SSU. Calculate variation in width overall smallest and widest width

4) FF: Freefall, CH: Chute, CA: Chaotic, BS: Broken standing waves, US: Unbroken standing waves, RP: Rippled, UP: Upwelling, SM: Smooth, NO: No perceptible flow

5) Count number of woody debris in all SSU and scale total number for the whole SU to numbers per km

(b) Continued. Hydromorphology assessment form – hydrological features.

Stream / River name: Site name:

Date:

Surveyor:

Category	Parameter	SU Score
5. hydrological regime	5.1 Mean flow	
	5.2 Low flow	
	5.3 Water level range	
	5.4 Frequent flow fluctuations	
	Hydrological regime score, HRS: (5.1 + 5.2 + 5.3 + 5.4)/4	

(c). Sampling protocol for chemistry.

Purpose of the sampling: Joint Field Surveys

Institution: ____

Collected by: ___________________________, **Completed by:** __________________________

Date:_______________________(day/month/year**),** **Local time:** _______________,

Location: City____________________ State__________________________

Watershed: ___________________, **Stream:** ___________________, **River km:** ______ **,**

SITE DESCRIPTION

Weather: Sunny Cloudy Partly Cloudy Raining Foggy

Longitude _______________, **Latitude** ________________, **Elevation** _________________

Land Use: Urban Suburban Agricultural Grazing Forest

Channelized: Yes No

River bottom substrate: Boulders Rubble Gravel Sand Silt Clay

Air Temperature: __________________(C) (at site)

WATER QUALITY PARAMETERS (in situ measurements)

Water Temperature: _________(C**), pH: ______** , **Conductivity:__________**

O2 concentration:_______mg/l, O2 saturation:_______%, Turbidity:____________

Mineralization: ____________

Surface Oils: None Some Lots

Water Odours: Normal Sewage Petroleum Chemical Other__________

Additional Notes: Document below any information or observations you made that are not included on this form: ____

____