USAID | GEORGIA
FROM THE AMERICAN PEOPLE

Governing for Growth in Georgia

GUIDANCE DOCUMENT

CLASSIFICATION OF ECOLOGICAL STATUS AND ECOLOGICAL POTENTIAL APPLICABLE FOR GEORGIA

USAID GOVERNING FOR GROWTH (G4G) IN GEORGIA

08 August 2017

GUIDANCE DOCUMENT

CLASSIFICATION OF ECOLOGICAL STATUS AND ECOLOGICAL POTENTIAL APPLICABLE FOR GEORGIA

USAID GOVERNING FOR GROWTH (G4G) IN GEORGIA

CONTRACT NUMBER: AID-114-C-14-00007

DELOITTE CONSULTING LLP

USAID | GEORGIA

USAID CONTRACTING OFFICER'S

REPRESENTATIVE: REVAZ ORMOTSADZE

AUTHOR(S): GEORGIA'S ENVIRONMENTAL OUTLOOK (GEO)

WORK PLANNING: WATER RESOURCE MANAGEMENT 5600

LANGUAGE: ENGLISH

8 AUGUST 2017

DATA

Reviewed by:	Giorgi Chikovani, Mariam Bakhtadze, Keti Skhireli, Gvantsa Pochkhua
Project Component:	Water Resource Management
Practice Area:	Water Resource Management
Key Words:	Water Framework Directive, Guidance document, Classification of ecological status and ecological potential for water bodies, common implementation strategy

ACRONYMS

AWB	Artificial Water Body
BBI	Belgian Biotic Index
BEP	Bad Ecological Potential
BES	Bad Ecological Status
BMWP	Biological Monitoring Working Party Score
BOD	Biological Oxygen Demand
CIS	WFD Common Implementation Strategy (Documents)
COAST	Guidance Document No. 5 Transitional and Coastal Waters – Typology, reference conditions and classification systems (2003)
COD	Chemical Oxygen Demand
EPIRB	Environmental Protection of International River Basins, EU Project
EPT	Ephemeroptera, Plecoptera, and Trichoptera (EPT index)
EQR	Ecological Quality Ratio
EQS	Environmental Quality Standard
EU	European Union
GEP	Good Ecological Potential
GES	Good Ecological Status
GIS	Geographic Information System
G4G	Governing for Growth in Georgia
HES	High Ecological Status
HMWB	Heavily Modified Water Body
HMQE	Hydromorhpological Quality Elements
IMPRESS	CIS Guidance for the analysis of Pressures and Impacts In accordance with the Water Framework Directive
MEP	Maximum Ecological Potential
MES	Moderate Ecological Status
PEP	Poor Ecological Potential
PES	Poor Ecological Status
RC	Reference Conditions
RBD	River Basin District
REFCOND	Guidance Document No. 10 River and lakes – Typology, reference conditions and classification systems (2003)
USAID	United States Agency for International Development
WFD	Water Framework Directive

CONTENTS

DEFINITIONS I

EXECUTIVE SUMMARY 4

INTRODUCTION 5

To whom is this guidance Document addressed? 5

What can be found in this Guidance Document? 5

BACKGROUND TO CLASSIFICATION 6

THE NEEDS FOR CLASSIFICATION SCHEMES AND STANDARDS 8

Quality Elements 8

Classification classes 9
Reference Conditions 9
High Ecological Status (HES) and Maximum Ecological Potential (MEP) 10
Good Ecological Status (GES) and Good Ecological Potential (GEP) 11
Moderate ecological status (MES) and potential (MEP) 11
Poor Ecological Status (PES) and Poor Ecological Potential (PEP) 12
Bad Ecological Status (BES) and Bad Ecological Potential (BEP) 12

THE ECOLOGICAL quality Ratios 12

STEPWISE APPROACH OF ECOLOGICAL STATUS CLASSIFCATION SYSTEM IN GEORGIA 15

Establishement of Reference conditions 16

Selection of metrics (biological indices) 17
Effect of sampling season on metrics 17
Variation of selected metrics and redundancy 18

Class boundaries and ecological quality ratios 18
The multimetric index value of the ecological status 19

Class boundaries for physico-chemical parameters 21

Class boundaries for hydromorphological parameters 21

RELATIONSHIPS BETWEEN STRESSORS AND ECOLOGICAL STATUS CLASSES 23

Relation between stressors and macroinvertebrates metrics 23

Relationships between physicochemical parameters and macroinvertebrates metrics 23

NEXT STEPS 25

FURTHER READINGS AND REFERENCES 26

LIST OF FIGURES AND TABLES 27

ANNEX 1. DEFINITIONS FOR HIGH, GOOD AND MODERATE ECOLOGICAL STATUS IN RIVERS AND LAKES (ACCORDING TO ANNEX V WFD) 28

DEFINITIONS

Artificial Water Body (AWB) - Body of surface water created by human activity e.g. a canal.

Biological Quality Elements - Four biological quality elements – phytoplankton, other aquatic flora, benthic invertebrate fauna and fish have been specified by the Water Framework Directive (WFD) for inclusion in the assessment **-**of *ecological status.*

Chemical Status - Chemical Status describes whether waters contain safe levels of certain chemicals that have been identified as of significant risk to or via the aquatic environment at an European Union (EU) level.

Classification System - A technical procedure for assessing the status of a water body in accordance with the requirements of the Water Framework Directive (WFD).

Ecological Potential - Is the status of a heavily modified or artificial waterbody.

Ecological Quality Ratio (EQR) - The relationship between the values of the biological parameters observed for a given body of surface water and the values for those parameters in the reference conditions applicable to that body. The ratio is to be expressed as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero

Ecological Status - An expression of the quality of the structure and functioning of aquatic ecosystems associated with a surface water body. Biological as well as supporting hydromorphological and physico-chemical quality elements are to be used in the assessment of ecological status.

Environmental Quality Standard (EQS) -Specifies the absolute compliance concentration or range for a water quality element in the environment failure of which will be reported to the European Commission.

General physico-chemical components - Pollutants in groups 10-12 of WFD Annex VIII (Substances which contribute to eutrophication (in particular nitrates and phosphates)[1]. Substances which have an unfavourable influence on the oxygen balance and can be measured using parameters as Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), etc.).

Good Ecological Potential - Is the required status of a heavily modified or an artificial water body.

Good Status - The status achieved by a surface waterbody when both its *ecological status* and its *chemical status* are at least 'Good'.

Heavily Modified Water Body (HMWB) - Body of surface water, which is substantially changed in character as a result of human activity.

High Status - The status achieved by a surface water body when there are no, or only very minor, anthropogenic alterations to the values of the physico-chemical and hydromorphological quality elements and the biological quality elements show no or only very minor evidence of distortion.

Hydromorphological Quality Elements - Hydrological regime such as water quantity and hardness and morphology such as altitude, depth and substrate type, river continuity and lake residence time and tidal regime in saline waters.

Intercalibration - A process to ensure consistency and comparability of the classification systems for sampling, measurement and assessment of the biological elements across the EU Member States. It will also establish the boundaries between high and good status and between good and moderate status for these elements.

Invertebrate (macroinvertebrate) communities - Mayflies, Stone Flies, Shrimps, Snails, Bivalves etc. present in the rivers with varying sensitivities to increasing levels of pollution.

[1] Annex VIII of the WFD is incorporated in the "Guidance Document On Analysis of Pressures and Impacts and Assessment of Risks Applicable for Georgia"

Macrophytes – Rooted plants growing in rivers, lakes and tidal waters.

Maximum Ecological Potential (MEP) - The state where "the values of the relevant biological quality elements reflect, as far as possible, those associated with the closest comparable surface water body type, given the physical conditions which result from the artificial or heavily modified characteristics of the water body." For example a part of river stretch with hydro power plants (hydro-peaking) such as the Khrami River, will be compared with a comparable river.

Moderate Status - The values of the biological quality elements for the surface water body deviate moderately, as a result of human activity, from the reference or undisturbed condition.

Normative Definitions - of ecological status classifications – The general definitions of high**,** good and moderate ecological status provided for the various quality elements in Annex V of the Water Framework Directive that together define surface water ecological status. The Directive gives normative definitions of ecological status for each surface water category (Definitions of ecological status classification for river and lakes is given in annex 1. of this document).

Operational Monitoring - One of three types of monitoring specified in the WFD in order to:

- Establish the status of those bodies identified as being at risk of failing to meet their environmental objectives, and
- Assess any changes in the status of such bodies resulting from the programs of measures.

In order to assess the magnitude of the pressure to which bodies of surface water are subject, operational monitoring is to be carried out for the following quality elements which are indicative of the pressures to which the body or bodies are subjected.

- Parameters which are indicative of the biological quality element, or elements, most sensitive to the pressures to which the water bodies are subject;
- All priority substances discharged, and other pollutants discharged in significant quantities;
- Parameters which are indicative of the hydromorphological quality element most sensitive to the pressure identified.

Phytoplankton - microscopic free-floating plants mainly present in lakes and transitional waters.

Priority Substances - Substances identified in accordance with Article 16(2) of the Water Framework Directive and listed in the Annex X[2]

Quality Elements - The WFD specifies the factors, referred to as *quality* elements, that must be used in determining the ecological status or ecological potential and the surface water chemical status of a surface waterbody. The list of quality elements for each surface water category are divided into three groups of elements:

- Biological elements;
- Hydromorphological elements;
- Chemical and physico-chemical elements.

Reference Conditions - The condition established for each biological element in the absence of pollution or disturbance.

River Basin District (RBD) -The area of land and sea, made up of one or more neighboring river basins, together with their associated groundwater and coastal waters, as the main unit for management of river basins.

[2] This list is incorporated in the "Guidance Document On Analysis of Pressures and Impacts and Assessment of Risks Applicable for Georgia"

Specific Relevant Pollutants - These are certain synthetic substances (e.g. biocides and plant protection products) and certain non-synthetic substances (e.g. metals) listed in 1 – 9 of Annex VIII of the WFD[3] that are discharged in significant quantities to surface waters in Georgia and are not identified on the EU priority list.

Surface Water - Means all inland waters, except groundwater, and includes transitional waters and coastal waters; territorial waters are included as surface waters for the purposes of the Directive insofar as chemical status is concerned

Surface Water Status - Is the status of a surface water body, determined by the poorer of the ecological status and the chemical status.

Surveillance Monitoring - One of three types of monitoring specified in the WFD. Its objectives are to information for:

- Supplementing and validating the impact assessment procedure detailed in Annex II (part 1.5) of WFD;
- The efficient and effective design of future monitoring programs;
- The assessment of long-term changes in natural conditions; and
- The assessment of long-term changes resulting from widespread anthropogenic activity.

Surveillance monitoring is to be carried out for each surveillance monitoring site for a period of one year during the period covered by a river basin management plan for:

- Parameters indicative of all *biological quality elements*;
- Parameters indicative of all *hydromorphological quality elements*;
- Parameters indicative of all *general component (physico-chemical) quality elements*;
- Priority pollutants which are discharged into the river basin or sub-basin; and
- Other pollutants discharged in significant quantities in the river basin or sub-basin.

Water body - is a coherent sub-unit (delineated water body) in the river basin (district) to which the environmental objectives of the directive must apply. Hence, the main purpose of identifying “water bodies” is to enable the status to be accurately described and compared to environmental objectives.

[3] Annex VIII of the WFD is incorporated in the “Guidance Document On Analysis of Pressures and Impacts and Assessment of Risks Applicable for Georgia”

EXECUTIVE SUMMARY

EU Member States developed a common strategy for supporting the implementation of the Directive 2000/60/EC, “establishing a framework for Community action in the field of water policy” the Water Framework Directive (WFD). Focus is on methodological questions related to a common understanding of the technical and scientific implications of the WFD.

This “Guidance Document on the Classification of Ecological Status and Ecological Potential applicable for Georgia” is based on the overall ecological classification rules provided by “*Guidance Document Overall Approach to the Classification of Ecological Status and Ecological Potential”, “Guidance Document on River and Lakes Typology, Reference Conditions and Classification Systems (REFCOND) and Monitoring Guidance Documents* (WFD CIS Guidance Documents No. 13, 10 and 7, respectively).

Separate part of the document is related to the ecological status classification system, taking into account the specific (current) conditions in Georgia, mainly data and information availability and expertise. It is also proposed to find the relationships between stressors, physico-chemical parameters and biological metrics (macroinvertebrates). Regression models for such relationships can be used for preliminary assessment of the ecological status of the surface water bodies in Georgia, for the water bodies where data of biological quality elements do not exist.

INTRODUCTION

This document sets out the classification methodology for classifying surface water bodies under the EU Water Framework Directive 2000/60/EC establishing a framework for Community action in the field of water policy. Additionally, this document tries to add general guidance on the assessment of ecological status leading to the overall ecological classification of the surface water bodies for the purposes of the WFD. The document also provides specific guidance on the role of the general physico-chemical and hydromorphological quality elements in ecological classification and relationships between stressors and ecological status. These relationships can be used for preliminary classification of the water bodies of the given type where biological elements are not monitored, only physico-chemical parameters are available.

TO WHOM IS THIS GUIDANCE DOCUMENT ADDRESSED?

This document aims at guiding experts and stakeholders in the implementation of the WFD. It focuses on the implementation of the Annexes II and V of the WFD, with special emphasis on inland surface waters, methods and principles for the establishment of reference conditions and class boundaries between high, good, moderate, poor and bad ecological status. This guidance will help experts to conduct the activities in the field:

- Undertaking the ecological status analysis;
- Policy making process by using the results of the ecological status analysis in the process of development the River Basin Management Plans;
- Reporting on the ecological status analysis on national and EU level as required by the WFD.

WHAT CAN BE FOUND IN THIS GUIDANCE DOCUMENT?

The content of this document is focussing on:

- Common understanding of concepts and terms in the field of ecological status classification as part of the River Basin Management Plans;
- Principles and methods for establishing reference conditions and ecological status class boundaries;
- Description of the ecological classification system applicable in Georgia (macroinvertebrates), based on the existing data, technical conditions and present expertise;
- Better understanding of the relationships between stressors, physico-chemical parameters and ecological state;
- Next steps to be conducted to complete the classification systems for all surface water categories and biological quality elements.

BACKGROUND TO CLASSIFICATION

The WFD was published and entered into force in December 2000 to provide a legislative framework to protect and improve the quality of waters, specifically:

- Rivers;
- Lakes;
- Transitional (estuarine) and coastal waters;
- Ground waters.

(Note: ground waters are not included in this Guidance Document)

The WFD requires the establishment of classification schemes to reflect the ecological status or potential of delineated surface water bodies as measured by the condition of specific biological, hydromorphological and chemical and physico-chemical quality elements. It is understood that classification of the water bodies is part of the "end point" of the WFD implementation that is "River Basin Management Plan" for the established River Basin Districts. The main steps in the planning cycle of the WFD (see Fig.1), which has to be repeated (every 6 years) according the WFD and where classification of water bodies is included, are as follows:

Step 1: Characterisation of the basin and identification of the water quality problems (Water Bodies at Risk) to be addressed in the River Basin Management Plan.

Step 2: Design a WFD compliant monitoring programme based on the characterisation.

Step 3: Implement the monitoring according the WFD compliant monitoring programme in at least 2 years when starting development of the River Basin Management Plan.

Step 4: A. Classify water bodies to high, good, moderate, poor or bad status based on biological monitoring data supported by chemical and hydromorphological monitoring data.

B. Revise the characterisation based upon the information from the data collected during the monitoring in line with the WFD compliant monitoring programme.

Step 5: Define objectives for Water Bodies.

Step 6: Identification of priority measures and design the programme measures. Calculate the cost of implementing the measures. If the costs of realising the objectives are considered disproportionate, it can be considered to revise the objectives. The setting of objectives and the design of the measures plus the costing of them should be implemented in an iterative way.

Step 7: Prioritise and implement the measures.

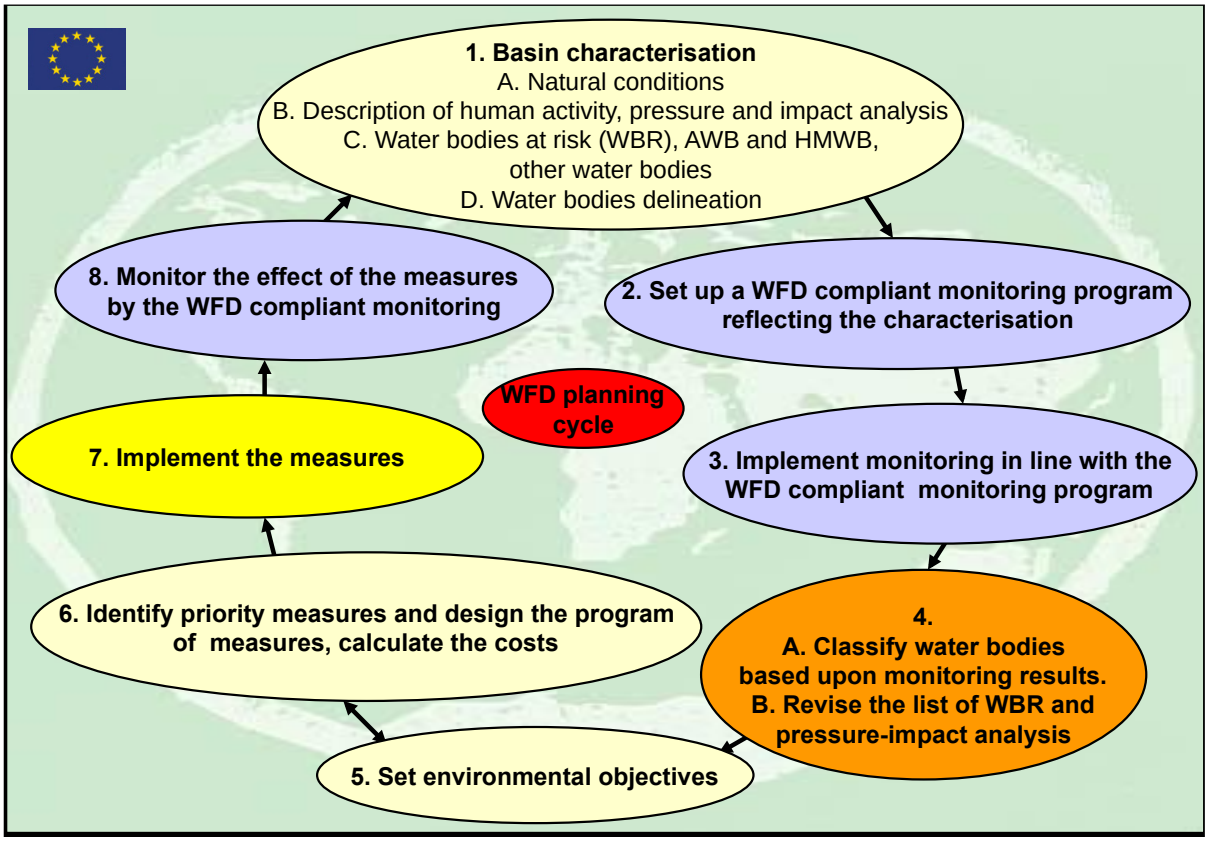
Step 8: Monitor the effect of the measures by the WFD monitoring programme to answer the question: are the measures sufficient to achieve the objectives for the water bodies?

In each River Basin Planning cycle, ***the objectives will be defined for each water body using the classification systems***, considering social, environmental and economic factors. These objectives will be expressed in terms of status, for example the objective may be to „achieve good status", or to "achieve moderate status from poor status" in the first planning cycle.

The Guidance Document take into account information and knowledge from the existing guidance documents: Classification of Ecological Status and Potential, REFCOND, Transitional and Coastal Waters - Typology, Reference Conditions and Classification Systems (COAST), MONITORING and Identification and Designation of Heavily Modified and Artificial Water Bodies (WFD CIS Guidance Documents No's 13, 10, 5, 7 and 4, respectively).

In the next chapters, attention will be paid to the Step 4, to guide process of the development of the Ecological Status Classification System applicable in Georgia.

Figure 1: The EU WFD planning cycle



THE NEEDS FOR CLASSIFICATION SCHEMES AND STANDARDS

The Water Framework Directive defines, both in general and in very detailed terms, ecological status in the high, good and moderate classes for each of the biological quality elements for each of the surface water categories. It indicates that the biological, hydromorphological parameters and the physico-chemical and specific relevant pollutants are required in the overall ecological assessment, as well.

QUALITY ELEMENTS

The quality elements for the classification of ecological status are as follows (WFD, Annex V 1.1.1.):

Biological elements:

- Composition and abundance of aquatic flora;
- Composition and abundance of benthic invertebrate fauna;
- Composition, abundance and age structure of fish fauna;

Chemical and physico-chemical elements supporting the biological elements:

- General;
- Thermal conditions;
- Oxygenation conditions;
- Salinity;
- Acidification status;
- Nutrient conditions;
- Specific pollutants.

Hydro-morphological elements supporting the biological elements:

- Hydrological regime;
- Quantity and dynamics of water flow;
- Connection to groundwater bodies;
- River continuity;
- Morphological conditions;
- River depth and width variation;
- Structure and substrate of the river bed;
- Structure of the riparian zone.

To enable the assessment of water body status that will determine the environmental objectives to apply, the WFD stipulates the establishment of the classification schemes for biological, hydromorphological, chemical and physico-chemical quality elements, including establishing chemical and physico-chemical standards. This will require the development of new biological classification schemes and the derivation of new chemical standards, or the review of existing standards, if they exist. Methods for assessing hydromorphological changes are also required.

Biological assessment

Methods for biological assessment do not exist in Georgia to cover the biological quality elements and parameters required by the WFD. Thus, a major effort for developing new biological assessment methods is required, for the biological elements as presented in Tab. 1.

Table 1: The biological quality elements required to be examined for the assessment of ecological status/potential (WFD Annex V, Annex 1. of this document). The parameters for each element are set out.

Element	Parameters	River	Lake	Trans. water	Coastal water
Phytoplankton	Composition, abundance and biomass		x	x	x
Macrophytes	Composition and abundance of aquatic flora	x	x	x	x
Macroinvertebrates	Composition and abundance of benthic fauna	x	x	x	x
Fish	Composition, abundance and age structure	x	x	x	

Hydromorphological assessment

New assessment systems for assessing hydromorphology in surface waters have to be developed. On the other hand, there is a certain experience with link between hydromorphology and ecology in Georgia, when field trials were conducted in pilot river basins (the Khrami River, the Adjaritskali/Chorokhi River), during the EU projects (Environmental Protection of International River Basins (EPIRB), KURA II and III).

Chemical and physico-chemical assessment

The two element groupings for which environmental quality objectives would be proposed in this document follow requirements set out in WFD Annexes to the directive as follows:

a) General physico-chemical quality elements are as specified in WFD Annex VIII (10 – 12), e.g. dissolved oxygen, nutrients and temperature;
b) Specific relevant pollutants are those identified by country as being discharged in significant quantities; this is also specified in WFD Annex VIII (1 - 9), e.g. metals, synthetic organic substances (List of specific pollutants will be developed during the Pressure Impact Analysis as part of the River Basin Management Plans development process).

For the *general components (physico-chemical)* the WFD requires, for the purpose of classification, the setting of Environmental Quality Standards (EQS) values for the high/good and good/moderate boundaries. For *the specific relevant pollutants* the WFD requires the setting of a single EQS for each pollutant. Failure to achieve one of these standards for either of these two groupings of elements will mean failure to achieve good ecological status.

CLASSIFICATION CLASSES

The WFD sets out also the definitions – the so called “normative definitions” – which form the basis for the classification of surface waters for ecological status. Based on this fact, it is required to develop classification systems capable of distinguishing between the five status classes – high, good, moderate, poor and bad - for each of the biological quality elements (see Table 2). Of particular importance is being able to distinguish between high, good and moderate status.

Table 2: Description of the ecological status classes

High status	Little or no sign of anthropogenic disturbance. [No loss of species, small density changes may occur]
Good Status (WFD)	Slight changes compared to the natural condition: The values of the biological quality elements for the surface water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions. [Some replacement of sensitive/rare species; ecosystem functions fully maintained]
Moderate status	Moderate changes compared to the natural condition. [Many sensitive species disappeared; ecosystem functions largely maintained]
Poor status	Biological communities deviate substantially from those normally associated with the surface water type under undisturbed conditions. [Tolerant species dominate; sensitive species are rare; ecosystem functions altered]
Bad status	Large portions of biological communities normally associated with the surface water type under undisturbed conditions are absent. [Severe alteration of structure and function of the ecosystem]

In the text below, general requirements on the five status classes are described.

REFERENCE CONDITIONS

The status of each of the biological elements for natural water bodies is determined by measuring the extent of the deviation, if any, of the observed condition from ***the reference condition*** established for that water body. Reference conditions are the conditions established for the biological elements in the absence of pollution or disturbance. For HMWBs and AWB the value corresponding to reference condition are referred to as *the maximum ecological potential* and reflect as far as possible, considering the hydromorphological and associated physico-chemical conditions, the reference conditions of the closest comparable normal surface water body type.

WFD Annex II : 1.3 (i-vi) Establishment of type-specific reference conditions for surface water body types:

For each surface water body type type-specific hydromorphological and physico-chemical conditions shall be established representing the values of the hydro-morphological and physicochemical quality elements specified for that surface water body type at high ecological status. Type-specific biological reference conditions shall be established, representing the values of the biological quality elements for that surface water body type at high ecological status.

Type-specific biological reference conditions may be either spatially based (existing maps, monitoring data and subsequently filed reconnaissance will be conducted or based on modelling, or may be derived using a combination of these methods. Where it is not possible to use these methods, Member States may use expert judgement to establish such conditions.

Type-specific biological reference conditions based on modelling may be derived using either predictive models or hindcasting methods. The methods shall use historical, palaeological and other available data.

Following can be summarized for the reference conditions:

- Reference conditions (RC) do not equate necessarily to totally undisturbed, pristine conditions. They include very minor disturbance which means that human pressure is allowed as long as there are no or only very minor ecological effects;
- RC equal high ecological status, i.e. No or only very minor evidence of disturbance for each of the general physico-chemical, hydromorphological and biological quality elements;
- RC shall be represented by values of the relevant biological quality elements in classification of ecological status;
- RC can be a state in the present or in the past;
- RC shall be established for each water body type;
- RC require that specific synthetic pollutants have concentrations close to zero or at least below the limits of detection of the most advanced analytical techniques in general use1;
- RC require that specific non-synthetic pollutants have concentrations remaining within the range normally associated with undisturbed conditions (background concentrations).

HIGH ECOLOGICAL STATUS (HES) AND MAXIMUM ECOLOGICAL POTENTIAL (MEP)

WFD Annex II 1.3 requires Member States to establish type-specific biological, hydromorphological and physico-chemical conditions representing the values of elements defined in Tables 1.2.1 – 1.2.2 of Annex V for High Ecological Status or Maximum Ecological Potential. These Tables are enclosed as Annex 1 of this Guidance Document.

Only if the values for all the **biological, hydromorphological and physico-chemical quality elements** reflect their type-specific conditions can the resulting class be high ecological status or MEP.

For natural water bodies, the values of **the relevant biological quality elements** at high status reflect those normally associated with that type under undisturbed conditions, and show no, or only very minor, evidence of disturbance (HES). For heavily modified water bodies and artificial water bodies, the values of the relevant biological quality elements at MEP, reflect, as far as possible given the MEP values for the hydromorphological and associated physicochemical conditions, those of the closest comparable surface water body type.

For natural water bodies, the values for **the general physico-chemical quality elements** at high ecological status correspond totally or nearly totally to undisturbed conditions. For HMWBs and AWBs, the MEP values for the general physico-chemical quality elements are derived from the ”undisturbed conditions” for the surface water body type most closely comparable to the HMWB or AWB concerned, given the MEP values for the hydromorphological conditions.

The specific pollutant quality elements are subdivided into **specific synthetic pollutants and specific non-synthetic pollutants.** For HES/MEP to be achieved the concentrations of the specific synthetic pollutants must be close to zero and at least below the limits of detection of the most advanced analytical techniques in general use. The concentrations of the specific non-synthetic pollutants must be within the range normally associated with undisturbed conditions (**natural background concentrations**).

For HES, the values for **the hydromorphological quality elements** correspond totally or nearly totally to undisturbed conditions. For MEP, the hydromorphological conditions are consistent with the only impacts on the surface water body being those resulting from the characteristics of the HMWB or AWB once all

mitigation measures have been taken to ensure the best approximation to ecological conditions, in particular with respect to migration of fauna and appropriate spawning and breeding sites.

GOOD ECOLOGICAL STATUS (GES) AND GOOD ECOLOGICAL POTENTIAL (GEP)

Only if the values for the biological, chemical (specific pollutants) and physico-chemical quality elements reflect, the values defined for GES or GEP in that case water body can be classified as GES or GEP.

For natural water bodies, the values of the relevant **biological quality elements** for the surface water body show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions (HES). For an HMWB or AWB to be classified as being at GEP there must be no more than slight changes in the values of the relevant biological quality elements as compared to their values at MEP.

For a water body to be classified as being at GES/GEP, the values for **the general physico-chemical quality elements** must comply with the ranges or levels established so as to ensure:

- The functioning of the type specific ecosystem;
- The achievement of the values specified for the relevant biological quality elements.

GES/GEP also requires that the concentrations of **the specific pollutant quality elements** are not in excess of the EQS set at country (in this document Georgia) level in accordance with the procedure laid down in WFD Annex V, Section 1.2.6 , Please see this section in annex 1,Table 3 of this document.

The conditions of **the hydromorphological quality elements** at GES and GEP must be consistent with the achievement of the values specified for the relevant biological quality elements at GES/GEP level.

For any surface water body type in good ecological status the following criteria should be met:

- The values of the biological quality elements show slight deviation from reference conditions (low levels of impact resulting from human activity);
- The levels of the general physico-chemical quality elements do not exceed the range ensuring ecosystem functioning and the achievement of the values associated to biological quality elements at good status;
- Concentrations of specific synthetic and non-synthetic pollutants are not in excess of environmental quality standards established in accordance with Annex V 1.2.6 (see Annex 1 of this Guidance Document), or under relevant Community legislation.

MODERATE ECOLOGICAL STATUS (MES) AND MODERATE ECOLOGICAL POTENTIAL

A water body will be classified as moderate status/potential where:

- The values for the biological quality elements differ moderately from the type specific communities;
- The values for the biological quality elements differ moderately and the physico-chemical quality element values are less than good or;
- The values for the biological quality elements are better than moderate but the physico-chemical quality element values are less than good.

If the biological quality elements are at moderate status or potential, the conditions of the physico-chemical and hydromorphological quality elements must, by definition, be consistent with the achievement of those biological values.

For any surface water body type in moderate ecological status the following criteria should be met:

- The values of the biological quality elements show moderate deviation from reference conditions (moderate signs of distortion resulting from human activity);
- Conditions consistent with the achievement of values for the biological quality elements and significantly more disturbed than under conditions of good status.

POOR ECOLOGICAL STATUS (PES) AND POOR ECOLOGICAL POTENTIAL (PEP)

In accordance with WFD Annex V, Section 1.2, if the values for the relevant biological quality elements show evidence of major alteration from their type specific values (i.e. the relevant biological communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions), the water body must be classified as ”poor”. The decision on whether a water body is at PES/PEP or not is dictated by the condition of the biological quality elements. The condition of the physico-chemical and hydromorphological quality elements only affects that decision indirectly through their influence on the condition of the biological elements.

BAD ECOLOGICAL STATUS (BES) AND BAD ECOLOGICAL POTENTIAL (BEP)

In accordance with WFD Annex V, Section 1.2, if the values for the relevant biological quality elements show evidence of severe alteration from their type specific values (i.e. large portions of the relevant biological communities normally associated with the type are absent), the water body must be classified as bad”. The decision on whether a water body is at BES/BEP or not is dictated by the condition of the biological quality elements. The condition of the physico-chemical and hydromorphological quality elements only affects that decision indirectly through their influence on the condition of the biological elements.

THE ECOLOGICAL QUALITY RATIOS

The biological quality elements’ grouping comprises four specific elements as follows:

- Phytoplankton;
- Macrophytes;
- Macroinvertebrates;
- Fish.

For each of these elements the WFD prescribes a number of parameters to be examined to assess the condition of that element (e.g. composition and abundance of benthic fauna for macro-invertebrates). An EQR will be calculated for each parameter. Where more than one parameter for an element is monitored, the EQR value for each parameter may be combined, such as by averaging or weighting, to estimate the overall EQR value for the element. In the case where the parameters examined are sensitive to different pressures the condition of the element should be estimated by the results for the worst affected parameter, or group of parameters, indicative of the effects of different pressures on the element. The results of the biological monitoring systems will be expressed numerically as ecological quality ratios (EQR) in the range between 1 (high status) and 0 (bad status). The EQR scale for the monitoring system for each surface water category is divided into the five classes by assigning a numerical value to each of the boundaries between the classes. Scheme of ecological status classification based on EQR is presented on Fig. 2.

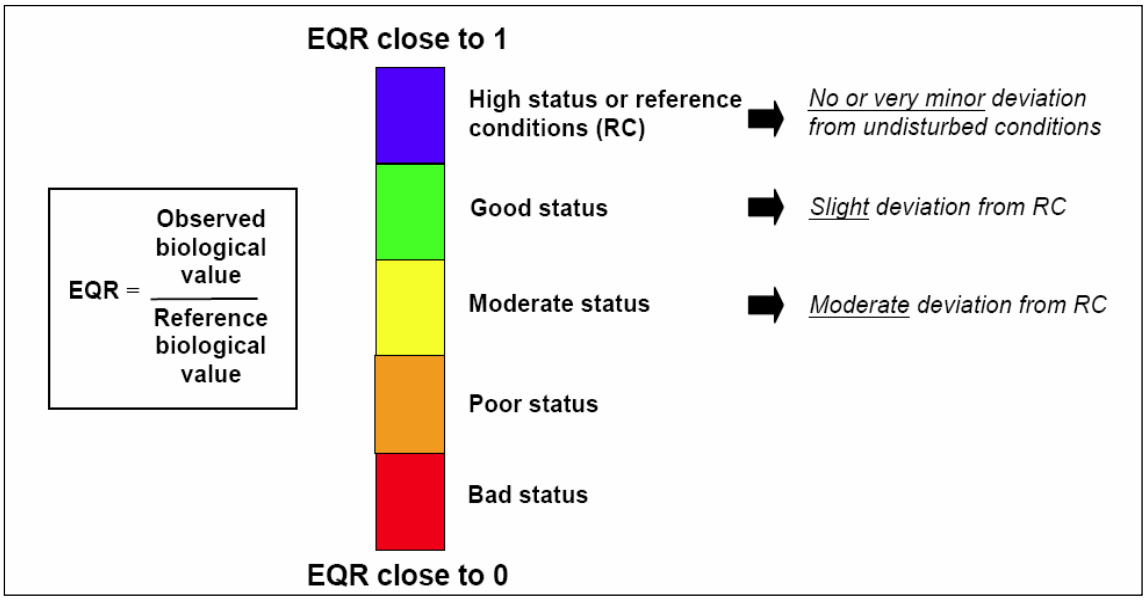


Figure 2: Classification of ecological status based on EQR (Guidelines document No. 10, EC 2003)

The Use of General Physico-chemical and Chemical Quality Elements

An assessment of the of the general physico-chemical quality elements and specific pollutants must be taken into account, when assigning water bodies to the high and good ecological status classes and to the maximum and good ecological potential classes (i.e. when distinguishing between high status/maximum ecological potential and good ecological status/potential as well as between good and moderate ecological status/potential) (see Fig. 3 and 4). For the other status/potential classes the physico-chemical elements are required to have **"conditions consistent with the achievement of the values specified for the biological quality elements." The Use of Hydromorphological Quality Elements**

An assessment of the hydromorphological quality elements must be considered only when assigning water bodies to the high ecological status class and the maximum ecological potential class (Fig. 3 and 4) (i.e. for distinguishing between high ecological status or maximum ecological potential and good ecological status/potential). For the other status/potential classes, the hydromorphological elements are required to have **"conditions consistent with the achievement of the values specified for the biological quality elements."**

When EQRs are calculated for biological quality elements, monitoring data on chemical, physico-chemical and hydromorphological quality elements as supporting elements are used to assign the ecological status classes to natural water bodies as it is presented in Fig. 3.

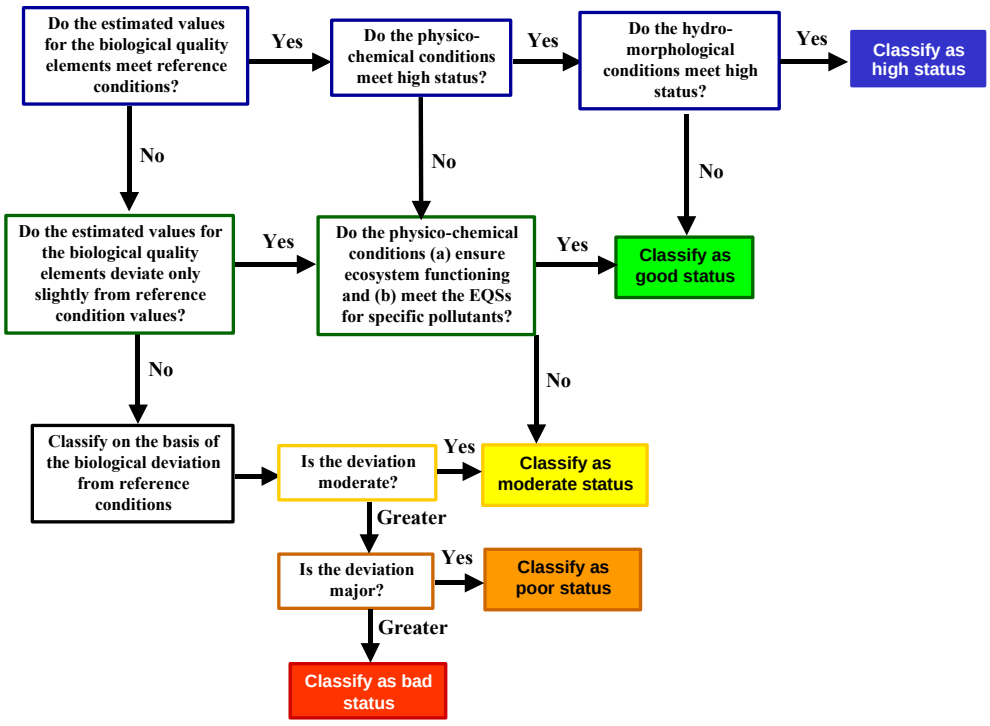


Figure 3: The procedure for assigning ecological status to a natural surface waterbody according to the definitions of high, good, moderate, poor and bad status in the WFD.

A similar approach, as for natural water bodies, is recommended for the classification of the ecological potential of artificial water bodies and heavily modified water bodies (Fig. 4).

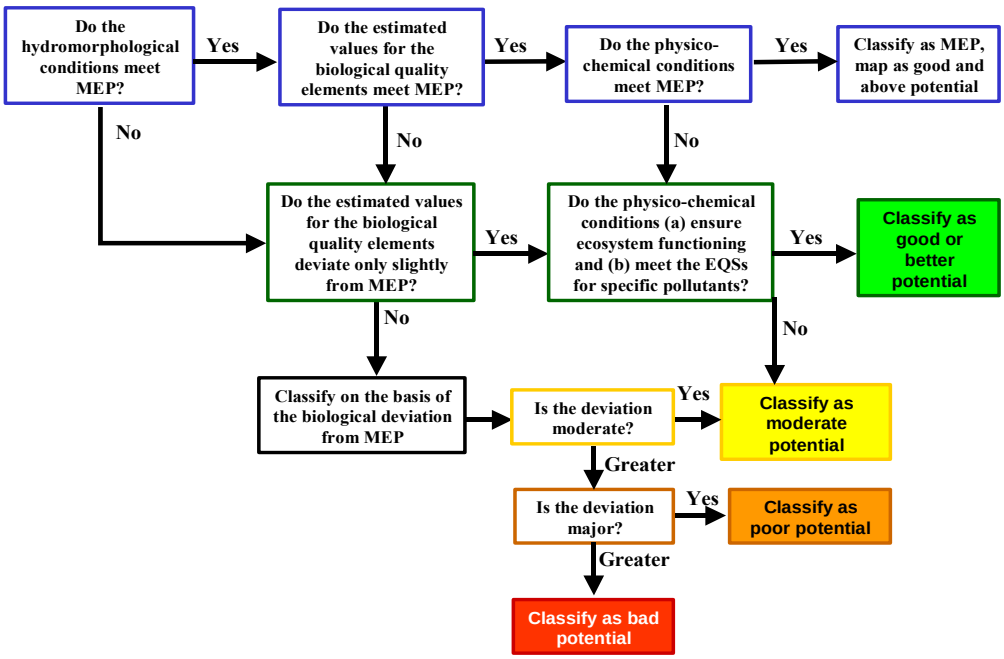


Figure 4: The procedure for assigning ecological status to an Artificial or Heavily Modified Water Body according to the definitions of good and above potential, moderate, poor and bad potential in the WFD.

The "One Out All Out" Principle

In the classification of the ecological status/potential for surface waters, the WFD requires that the lowest status assigned either to the biological quality element, general physico-chemical and hydromorphological elements, or failure to achieve the standards set for the specific relevant pollutant will determine the ecological status that can be assigned to the water body. Thus, the status of a water body is determined by the condition of the quality element most impacted by the pressure to which the waterbody is subject.

In order to achieve the objectives of the WFD a water body must achieve good ecological and chemical status. Failure to achieve good status for the ecological status test, or failure to achieve the EQS for any of the chemical substances results in failure to achieve the objective of the directive.

STEPWISE APPROACH OF ECOLOGICAL STATUS CLASSIFCATION SYSTEM IN GEORGIA

In previous part of the document, legal framework, requirements and principles related to ecological status classification systems of surface water were described. This chapter will pay attention to the current situation and condition in data and expertise availability in Georgia to develop and implement classification system.

The following limitations have been observed:

- In Georgia, National Environmental Agency (Department of Environmental Pollution Monitoring) has started with sampling and identification of the macro-invertebrates for the selected sampling sites in the rivers on the regular basis. However, such programme is not sufficient yet to allow the full ecological classification of the surface water bodies (only rivers);
- There is only limited monitoring of the hydromorphological quality elements focussing just on the hydrological regime. Hydrological gauging stations do not coincide with surface water quality sampling sites;
- A set of general physico-chemical quality elements is monitored in compliance with EU WFD requirements, except N_{total}, P_{total};
- Other specific pollutants discharged in significant quantities in the river basin, which are site specific were not yet identified. When such specific pollutants are identified they should be added into the list of monitoring programme. Nowadays, some heavy metals and group parameters as phenol index, oil substances and surfactants are already monitored, which is not enough for this assessment;
- Despite the huge effort of the NEA laboratory still there are uncertainties in the monitored data;
- Monitoring network of the surface water bodies has to be evaluated and restructured taking into consideration typology of the water bodies;
- Reference conditions locations were selected only preliminary by using spatially based approach in three pilot river basin (EU Kura III project and EU EPIRB project) taking into account only conditions for macroinvertebrates. Thus, it will be necessary to update the reference conditions sites for all biological quality elements.

Based on this knowledge, several stages are proposed in the development of the Ecological status classification system:

Stage 1: According to fact that only benthic macroinvertebrates are monitored in selected sampling location on the rivers, it is proposed to start with macroinvertebrates as biological quality element for types of water bodies where data are available. In this case, it is proposed to select small mountainous, middle mountainous and large mountainous rivers (*lowland rivers will be included in Stage 3, when more data is available*). Identification of the macroinvertebrates is done to the family (in some cases genera) level. This fact has effect on the selection of appropriate metrics (some of them need to have identification of the macroinvertebrates community to species level).

Revision of existing reference conditions locations will be necessary, if necessary locations are shifted. Furthermore, reference conditions locations will be selected for all surface water types.

Inclusion of list of general physico-chemical parameters (T, Conductivity, pH, BOD_5, COD, O_2, NH_4, NO_3, PO_4) and selected heavy metals (depending on the type of mining) (e.g. As, Cu and Zn) in the physical-chemical assessment is based on the pressure and impact analysis.

In this stage hydromorphological assessment can be done based on the preliminary Hydromophological Quality Score method after field surveys conducted at least in the monitoring location expected to have high or good ecological status.

Stage 2: Calculation of the relationships between EQRs of individual biological indices (metrics) for the macroinvertebrates and physico-chemical parameters (as example see chapter 5). Such relationships can be applied for the assessment of the water bodies without biological monitoring data. For calculations, existing macroinvertebrates data can be used.

Stage 3: In this stage ecological status classification system that has been prepared in the stage 1 for mountainous rivers will be updated for lowland rivers classifications systems after additional data are available from national monitoring programme of surface water and also classification systems for AWB and HMWB will be developed.

Stage 4: Other biological quality elements will be added into the monitoring programme of surface water bodies and subsequently classification system developed for each biological quality elements, as it was used in Stage 1 and 2.

In this part of Guidance Document, only Stage 1 and 2 are described into more details. Stage 3 and 4 will be shortly described as next steps.

STAGE 1

ESTABLISHEMENT OF REFERENCE CONDITIONS

Type specific biological reference conditions represent the values of the biological quality elements at high ecological status for each surface water body type. Those values are normally associated with that type under undisturbed conditions and show no or only very minor, evidence of distortion.

There are several methods to establish water body type specific reference conditions as the spatially based method, predictive models, palaeo reconstruction and expert judgments.

In the Guidance Document it is proposed to use the spatially based method along with expert judgments. Several steps will be conducted to select the potential locations with reference conditions using spatially based method, as follows:

- Starting with search on maps and historical literature for the first identification of suitable (potential) reference condition locations;
- Pressure – impact analysis of the locations (natural conditions without human activities impact);
- After desk work locations reconnaissance by team of experts will be done (hydrology, hydrobiology, chemistry);
- Final step will be sampling for macro-invertebrates (or other biological quality elements), hydro-morphological quality elements and physico-chemical parameters.

For illustration, photograph from one sampling location expected to be reference conditions location is presented on Figure 5.

Figure 5: Potential reference conditions location (The Khrami – upstream Khramhesi)

SELECTION OF METRICS (BIOLOGICAL INDICES)

The normative definitions of ecological status classes of WFD include five characters of river benthic invertebrate assemblages to be considered:

(i) Composition; and
(ii) Abundance of taxa;
(iii) The ratio of disturbance sensitive taxa to insensitive taxa;
(iv) The level of diversity; and
(v) Occurrence of major taxonomic groups.

If the normative definitions are to be taken strictly, all these features of macroinvertebrate community structure should be measured for the purpose of ecological classification. In practice, all these community descriptors can be interpreted in many ways and a large number of metrics (parameters, variables or indices) commonly used in biological assessment can be regarded to portray many of them.

Due to fact that identification of the macroinvertebrates community is done only to family (or genera) level, number of selected of metrics will be limited (some of the metrics required that identification is conducted to the species level such as Saprobic Index). It is recommended that data on the macroinvertebrates will be exported into the AQEM (Asterics) software (river assessment program, based on macroinvertebrate taxa list) and candidate metrics will be calculated.

274 macro-invertebrate metrics were calculated with AQEM (ASTERICS) software by the Slovak experts and these were used in initial testing of candidate metrics, to the extent feasible with the available limited data. Finally, five metrics were selected to calculate EQR for macro-invertebrates as biological quality element (selection was based on the correlation analysis).

A good metric should have a small within-type variation in reference condition, hence allowing for detection of human impact.

For example, in the EU EPIRB project following 5 metrics were selected for the classification of the Khrami, the Alazani and the Adjaritskali/Chorokhi River basins: **Biological Monitoring Working Party Score** (**BMWP), Belgian Biotic Index (BBI), Indice Biotico Esteso (IBE)- Biotic Index**, **EPT (an**

The Biological Monitoring Working Party Score (BMWP) is a procedure for measuring water quality using macroinvertebrates as biological indicators. The method is based on the principle that different aquatic invertebrates have different tolerances to pollutants. In the case of BMWP, this is based on the sensitivity/tolerance to organic pollution (i.e. nutrient enrichment that can affect the availability of dissolved oxygen). In the case of BMWP, the presence of mayflies or stoneflies, for instance indicate the cleanest river and are given a tolerance score of 10. The lowest scoring invertebrates are worms (Oligochaeta) which score 1. The number of different macroinvertebrates is also an important factor, because the better quality water is assumed to contain fewer pollutants that would exclude "sensitive" species resulting in a higher diversity.

BBI, The Belgian Biological Index is an index that is based on the presence or absence of aquatic macro-invertebrates. It is used in the evaluation of the biological water quality. Macro-invertebrates are defined as larger invertebrates that can be seen with the naked eye such as insects (larvae), molluscs, crustaceans, worms, etc. The Belgian Biotic Index is defined by the relative sensitivity of specific indicator species to pollution and the diversity of species. The index value varies from 0 (extremely bad quality) to 10 (extremely good quality). The BBI-scores obtained may be divided into quality classes.

BBI is the most organisms have only to be identified at family or genus level and not on species level.

IBE: The IBE. method derives from the Trent Biotic Index (Woodiwiss 1964). It is based on two evaluation parameters: taxonomic richness and the presence of pollution-sensitive taxa. This method offers synthetic information about the general conditions of river ecosystems, underlining potential alterations.

The ETP Taxa (ETP) displays the richness within the insects groups (Ephemeroptera, Trichoptera and Plecoptera), which are considered to be sensitive to pollution and will increase with increasing water quality. The ETP Index is equal to the total number of families represented within these three orders of in the sample.

Margalef Diversity Index (Clifford and Stephenson, 1975) is a simple index mainly quantifying the range of diameter classes. The index is intuitively easy to interpret, and calculated as the ratio between the number of diameter classes and the natural logarithm of basal area summarized over all diameter classes. The index has a theoretical minimum value of zero when all trees belong to the same diameter class, and the index value increases when the number of diameter classes increases, and/ or when the basal area decreases.

acronym for Ephemeroptera, Plecoptera, and Trichoptera) Taxa and Margalef Diversity Index.

EFFECT OF SAMPLING SEASON ON METRICS

Generally, macroinvertebrate fauna data has differed between spring and autumn. Therefore, the analysis of the data for the monitored locations for the selected metrics have to be done. Different statistical methods (e.g. Student´s t-test) are used for this purpose to find seasonal sampling effect.

VARIATION OF SELECTED METRICS AND REDUNDANCY

Selected metrics should have low within type variation (Generally, it is used than coefficient of variation should be less than 0.3). On the other hand, variations of the metrics values in the monitoring locations (impacted sites) should be higher to leave a scope for values of impact locations to predominantly deviate from those in reference locations in given water body type.

When metrics are selected, it is also necessary to test on the redundancy (many of the metrics can be strongly correlated with each other) among them. It is recommended to use Pearson correlations between selected metrics. Such testing will result into a set of best candidate metrics to cover pressures on surface water.

CLASS BOUNDARIES AND ECOLOGICAL QUALITY RATIOS

The status of each of the biological elements is determined by measuring the extent of the deviation, if any, of the sample taken of that element from the condition established for that element in the absence of pollution or disturbance, known as the reference conditions (see Figure 2). For example, a sample of the macro-invertebrates community taken in a river will be judged against the macro-invertebrates community that would be present in that river in the absence of any pollution or morphological disturbance.

The EQR is expressed numerically as in the range between 1 (high status) and 0 (bad status). The EQR scale for the monitoring system for each surface water category was divided into the five classes by assigning a numerical value to each of the boundaries between the classes.

Type-specific reference conditions are the anchor point of EQR based classifications. Class boundaries are defined as a certain level of deviation from the reference conditions – and changing the anchor point directly affects those class boundaries.

Although simple enough in theory, the EQR concept is rather difficult to put into practice in the practical implementation of the WFD. It requires that several key issues are addressed, including the **choice of appropriate parameters, typology, reference conditions, and agreement on common principles for setting quality class boundaries**.

For example, if there is no agreement on the principles and criteria for setting reference conditions, the value “1” does not represent the same of ecological quality, and the EQR scale is not comparable across countries and cannot fulfil its main purpose of ensuring comparability across countries.

When establishing the class boundaries, a key point is to define the value for the reference condition (high status) and for the bad status as “Lower Anchor Value”. In most cases the reference sites have, unavoidably, some degree of human influence, and thus do not fully represent true reference conditions. This is often taken into account by setting the High/Good – boundary (see Fig. 6) to some percentile (e.g. 25th % or 50th percentile (median)) of the distribution of metric values among the reference sites within a type of surface water bodies.

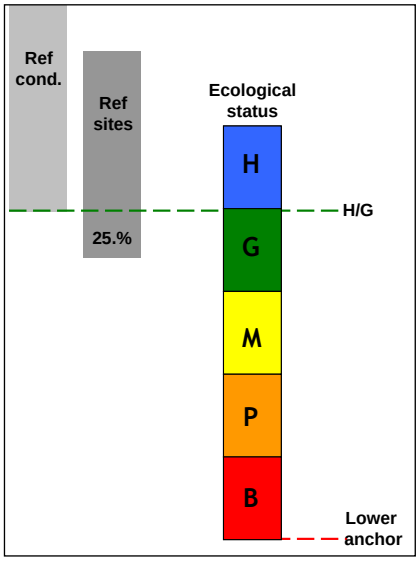


Figure 6: A schematic presentation of the class boundary setting for biological parameters (H = High, G = Good, M = Moderate, P = Poor and B = Bad ecological status)

The remaining class boundaries (G/M, M/P and P/B) can be established, e.g. at the beginning by dividing the range between the "Lower Anchor" and H/G boundary evenly into four bands as it is presented on Figure 7, but there are other options allowing to define more precise boundaries, which can be used later when relevant data on the biological quality elements are available. For example, as you can see in Table 3 boundaries for EQRs and 5 metrics for mountainous middle rivers. In this case, H/G class boundary was calculated as 25th % from reference conditions values for 5 metrics and other boundaries were divided evenly.

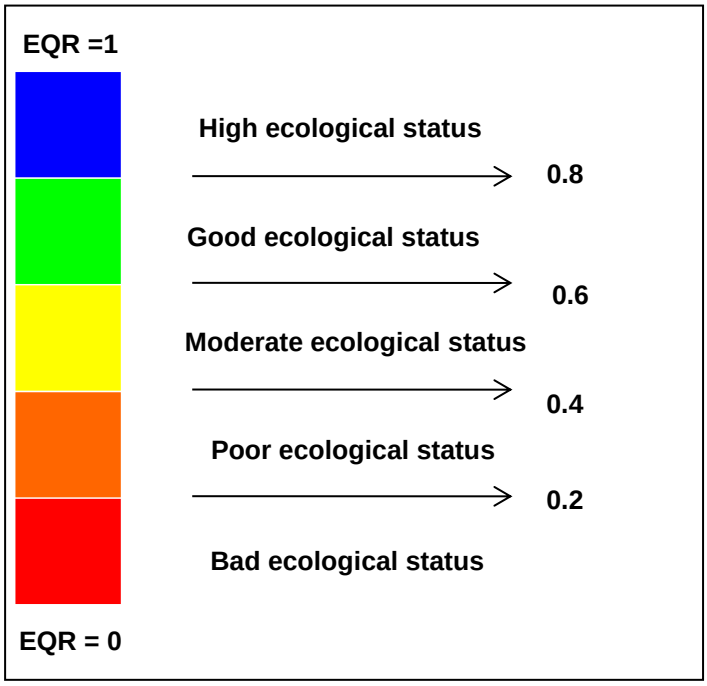


Figure 7: Boundaries among ecological status classes for macro-invertebrates expressed as EQR

Table 3: Classification scheme for the middle gravel mountainous river type in the Khrami River basin (EU EPIRB project, 2016)

	Middle gravel mountainous type				
Class	I	II	III	IV	V
EQR	>0.83	>0.6	>0.4	>0.2	≤0.2
BMWP Score	>120	>90	>62	>31	≤31
EQR	>0.9	>0.6	>0.4	>0.2	≤0.2
BBI	>9	>6	>4	>2	≤2
EQR	>0.9	>0.6	>0.4	>0.2	≤0.2
IBE	>10	>6.6	>4.4	>2.2	≤2.2
EQR	>0.88	>0.6	>0.4	>0.2	≤0.2
EPT	>16	>11	>7	>4	≤4
EQR	>0.78	>0.6	>0.4	>0.2	≤0.2
Margalef's Diversity Index	>3.68	>3.06	>2.04	>1.02	≤1.02
Multimetric Index EQR	>0.86	>0.6	>0.4	>0.2	≤0.2

THE MULTIMETRIC INDEX VALUE OF THE ECOLOGICAL STATUS

When for each of the selected metrics, Ecological Quality Ratios (EQR) are calculated, based on procedure described in previous subchapter, corresponding ecological status will be determined as it is shown on Fig. 8.

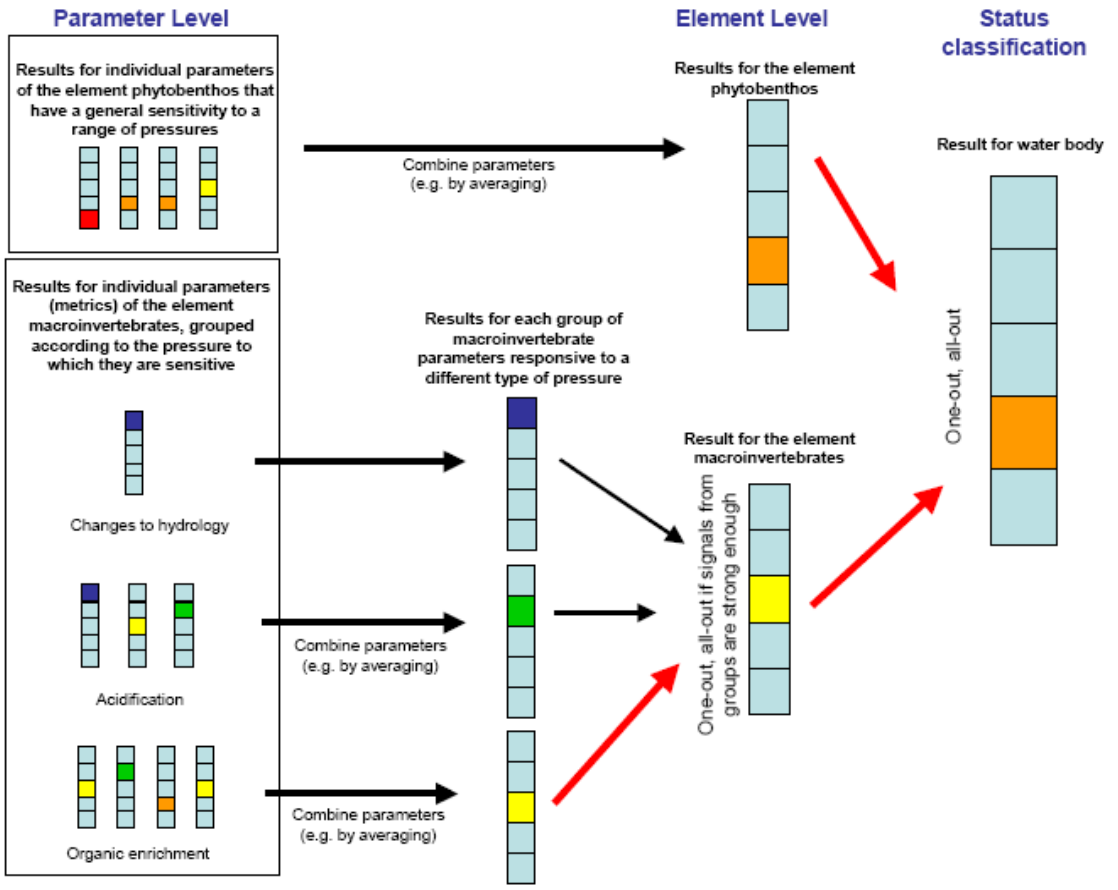


Figure 8: Combining parameters to indicate the status of a biological quality element and applying the "one out all out" principle to overall ecological classification

However, due to the metrics variability responding to different environmental gradients and specific geographical conditions, so called "Multimetric Index" is calculated from selected metrics.

Note: In the case where the parameters examined are sensitive to different pressures the condition of the element should be estimated by the results for the worst affected parameter, or group of parameters, indicative of the effects of different pressures on the element. Therefore, combining of the metrics to calculate Multimetric Index will need knowledge on sensitivity to pressures.

There are several methods to be used for such calculation. One of them is based on weighting individual EQR of the metrics, according their importance for the macroinvertebrates community (see box below).

Adopted from "Assessment of the ecological status using different quality elements in the Prut River basin", 2012
Saprobic index (SI): 30%
EPT index (EPT): 10%
Shannon-Wiener diversity index (DI): 20%
Number of family index (NF): 10%
OCH/O index (OCH): 10%
Functional groups index (FG): 10%
Preference flow index (REO/LIM): 10%.
The Multimetric Index value is given by the following equation:
MI = 0.3 * EQRSI+0.1*EQREPT +0.2*EQRDI +0.1*EQRNF +0.1*EQROCH +0.1 *EQRFG +0.1*EQRREO/LIM

Another alternative is to calculate the mean value of the Multimetric Index as it is shown in Tab. 3 of this document.

Finally, the Multimetric Index value will give the ecological status of the classified water body.

CLASS BOUNDARIES FOR PHYSICO-CHEMICAL PARAMETERS

An assessment of the general component (physico-chemical) quality elements must be taken into account when assigning water bodies to the high and good ecological status (i.e. when distinguishing between high status and good ecological status as well as between good and moderate ecological status). For the other status classes the physico-chemical elements are required to have “conditions consistent with the achievement of the values specified for the biological quality elements.” Hence, the assignment of water bodies to moderate, poor or bad ecological status may be made on the basis of the monitoring results for the biological quality elements.

The so called Environmental Quality Standards (EQS) for the general component (physico-chemical) parameters and specific relevant pollutants i.e. those chemical substances listed in points 1 to 9 of Annex VIII of the Water Framework Directive have to be derived from an examination of existing surface water monitoring databases collected at sites considered to be of high and good biological status. The development of the proposed EQSs is dependent on the availability of both biological and physico-chemical data. It is recommended to use at least three years of data for each site.

Knowledge is needed about the stressors, related to the specific human activity and the nature of the impact of the stressors identified in the basin, to evaluate the impact of the human activities in the basin on the surface water bodies. However, more specific definitions and functional relationships between biological and chemical status needs to be established in order to develop operational tools for setting the quality targets in the practical management of water bodies. This requires expertise and availability of comparable biological monitoring data where functional relationships can be established across pressure gradients.

Based on the pressure and impact analysis organic pollution from untreated waste waters, nutrients from agricultural activities and heavy metals from mining industry are the main stress factors in Georgia. Therefore, general physico-chemical parameters (T, Conductivity, pH, BOD_5, COD, O_2, NH_4, NO_3, PO_4) and selected heavy metals depending on the type of mining (e.g. As, Cu and Zn). It is necessary to note, that the list of relevant specific pollutants will be updated after pressure impact analysis.

Summary statistics, such as annual median values and percentiles, is recommended to be used to develop the EQSs for the relevant physico-chemical parameters.

In Tab. 4 classification scheme for general physico-chemical parameters for **Middle mountainous river type** is presented. Boundaries were derived based on the results from the correlation analysis of the metrics of macroinvertebrates community and physico-chemical parameters.

Table 4: Classification scheme for general physico-chemical parameters for Middle mountainous and river types (EU EPIRB project, 2016)

Parameter		unit	I	II	III
Temperature	Mean	°C	<20	<23	≥23
Conductivity		µS/cm			
pH		-	(7.0; 8.5)	(6.0; 7.0> or <8.5; 9)	≤ 6.0 or ≥ 9.0
Dissolved oxygen	Min	mg/l	>7.0	>6.0	≤6.0
BOD_5	Mean	mg/l	<3.0	<5.0	≥5.0
COD-Cr	Mean	mg/l	<7.0	<15.0	≥15.0
N-NH_4	Mean	mg/l	<0.2	<0.5	≥0.5
N-NO_3	Mean	mg/l	<2.0	<3.0	≥3.0
P-PO_4	Mean	mg/l	<0.04	<0.08	≥0.08

CLASS BOUNDARIES FOR HYDROMORPHOLOGICAL PARAMETERS

Hydromorphological quality elements (HMQE) must be taken into account when assigning water bodies to the high ecological status class. For the other status classes, the HMQE are required to have conditions which are consistent with the biological values set for the biological class for each water body type.

The HMQE assessment system for the classification of the ecological status, developed in EU EPIRB project, can be used (see Tab. 5). This preliminary Hydromorphological Quality Score system was used in Slovakia to classify the water bodies (SHMI, 2004) as well. To use such classification scheme, field surveys will be needed to conduct at least in location expected to have high and good status.

Table 5: Preliminary boundaries of the hydromorphological quality classes (SHMI, 2004)

Hydromorphological quality class		Limit values	Colour
1	High	1.0 – 1.7	
2	Good	1.8 – 2.5	
3	Moderate	2.6 – 3.4	
4	Poor	3.5 – 4.2	
5	Bad	4.3 – 5.0	

Another option can be to use results and findings from the pressure impact analysis. The category “Not At Risk” can be assigned to the High Status Class.

RELATIONSHIPS BETWEEN STRESSORS AND ECOLOGICAL STATUS CLASSES

STAGE 2

Traditionally, in the past majority of the surface water quality monitoring programmes was oriented on the physico-chemical parameters. Therefore, there is long data series covering different periods (seasons) and also different locations from undisturbed conditions to heavily impacted by human activities. Such data sets exist in Georgia as well and can be used for the purpose of the preliminary classification of the ecological status, after analysis of uncertainties and knowledge of the relations with aquatic environment and calculating relationships with biological metrics (EQRs).

One of the crucial point in classification system is to find critical threshold or class boundary values for variables indicative of human induced stress (water quality should support biotic elements (Annex 1. of this document). One of the ways to ensure to find such threshold values is correlation of stressor data, physico-chemical parameters with the estimated biological EQRs of the biological metrics. In this part of the Guidance Document, several examples of using technics are shortly described to find relationships between stressors and biological metrics.

RELATION BETWEEN STRESSORS AND MACROINVERTEBRATES METRICS

Under EU 6th Framework Programme, Project REBECCA (Relationships between ecological and chemical status of surface waters) large regression and correlation analysis was conducted for the macroinvertebrates metrics and stressors. Simple regression models (formulas) were derived.

As example, relationships between macroinvertebrate metrics (ASPT - Average Score per Taxon; Number of EPT families) and explanatory environmental variables (P_{Tot} = Total phosphorus concentration, mg/l; BOD_5 = 5 day biological oxygen demand in mg/l; MD =morphological degradation (0 equals zero physical stress and 1 maximum physical stress); ARABLE = percentage agricultural land use in the catchment) are presented. General model is derived from data received from all 6 project countries and also specific models were derived for each country separately. Value R^2 is so called "R-squared value" and represent the significance of the relations or better said statistical measure of how close the data are to the fitted regression line.

General model: ASPT (Family level) =5.26 – 3.33*PTOT – 0.014*ARABLE +2.32*MD; (R^2 = 0.61);

Slovak model: ASPT (Family level) = 5.14 – 1.58*PTOT – 0.018*ARABLE + 1.97*MD; (R^2 = 0.61);

General model: Number of EPT families = 4.91 – 0.52*BOD5 – 0.026*ARABLE + 7.73*MD (R^2 = 0.44);

Slovak model: Number of EPT families = 2.67 – 0.22*BOD5 + 0.003*ARABLE + 9.26*MD (R^2 = 0.44).

RELATIONSHIPS BETWEEN PHYSICOCHEMICAL PARAMETERS AND MACROINVERTEBRATES METRICS

Different combinations of physicochemical parameters can be used for estimating metrics (biotic indices). One of the method to use for such purpose is Principal Component Analysis (PCA) method. PCA is a multivariate statistical analysis technique, which has been widely used in the water quality related studies.

As example of using such approach, the results of the correlation analysis to estimate Margalef Diversity Index (macroinvertebrates metric) for the Aboulabbas River (Iran).

The equation generated in regression analysis is below and results are presented in Tab. 6:

$MI=DO*(T+2*DO)*(T+EC+BOD_5)$

Where:

MI: Margalef diversity index;

DO: dissolved oxygen (mg/l);

T: water temperature (°C);

EC: Electrical Conductivity of the water (µmohs/cm); and

BOD_5: 5 days Biological oxygen demand (mg/l).

Table 6: Comparison of the results for observed and calculated Margalef Diversity Index for Aboulabbas River (Iran)

Margalef index	Observed	Calculated	Error (%)
Mean	1.19	1.13	5.1
Std. deviation	0.43	0.48	11.6
R^2		0.738	

Other example of relationships between physico-chemical parameters and ecological status can be regression analysis directly between EQRs of Multimetric Index for large river types of water bodies and BOD_5, in Slovakia (see Fig. 9). Such studies are used also in the intercalibration exercises that are defined by WFD (to establish boundaries between High and Good ecological status).

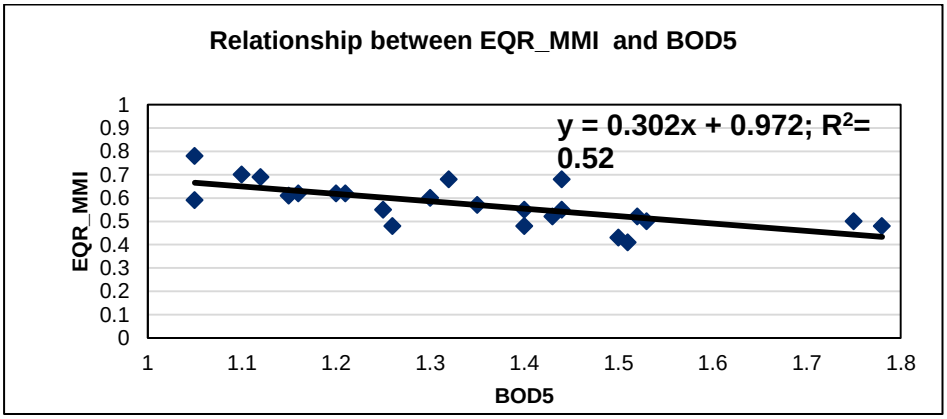


Figure 9: Relationship between EQR of Multimetric Index and BOD_t for large river water body types in Slovakia

NEXT STEPS

To implement the WFD in the part of the ecological classification of surface water categories, it is necessary in the future:

- To include all biological quality elements as macrophytes, fish fauna, phytobethos and phytoplankton in the monitoring programmes;
- To cover the whole vegetative cycle for biological quality elements;
- To complete the surface water monitoring for specific pollutants and hydromorphological parameters;
- All surface water categories (lowland rivers, lakes, transition and coastal waters) should be involved in the monitoring programmes;
- Based on data from the surface water monitoring compliant with WFD requirements, the classification systems will be developed for all categories and biological quality elements;
- When List of specific pollutants is developed in Georgia, so called EQSs have to be established for each pollutant, if such EQS does not exist;
- Furthermore, the schemes for artificial water bodies and heavily modified water bodies, should be derived as well.

The next steps will need technical, personal and financial support from state authorities and monitoring institutions.

FURTHER READINGS AND REFERENCES

EU Directive 2000/60/EC establishing a framework for Community action in the field of water policy (Water Framework Directive).

The Common Implementation Strategy (C.I.S.) "Guidance Document No. 13 – Overall Approach to the Classification of Ecological Status and Ecological Potential ".

REFCOND Guidance Document No. 10 River and lakes – Typology, reference conditions and classification systems (2003).

EU EPIRB, 2016. Review of the initial development of the ecological status classification of water framework directive river waterbody typologies.

EU 6th Framework Programme, Project REBECCA (Relationships between ecological and chemical status of surface waters), Deliverable D 14: Report on relations linking pressures, chemistry and biology in rivers and tools assessing these linkages, National Environmental Research Institute, Denmark, 2005.

LIST OF FIGURES AND TABLES

Figure 1 The EU WFD planning cycle

Figure 2 Classification of ecological status based on EQR (Guidelines document No. 10, EC 2003)

Figure 3 The procedure for assigning ecological status to a natural surface waterbody according to the definitions of high, good, moderate, poor and bad status in the WFD.

Figure 4 The procedure for assigning ecological status to an Artificial or Heavily Modified Water Body according to the definitions of good and above potential, moderate, poor and bad potential in the WFD.

Figure 5 Potential reference conditions location (The Khrami – Khramhesi)

Figure 6 A schematic presentation of the class boundary setting for biological parameters (H = High, G = Good, M = Moderate, P = Poor and B = Bad ecological status)

Figure 7 Boundaries among ecological status classes for macro-invertebrates expressed as EQR

Figure 8 Combining parameters to indicate the status of a biological quality element and applying the “one out all out” principle to overall ecological classification

Figure 9 Relationship between EQR of Multimetric Index and BODť for large river water body types in Slovakia

Table 1 The biological quality elements required to be examined for the assessment of ecological status/potential (WFD Annex V). The parameters for each element are set out

Table 2 Description of the ecological status classes

Table 3 Classification scheme for the middle gravel mountainous river type in the Khrami River basin (EU EPIRB project, 2016)

Table 4 Classification scheme for general physico-chemical parameters for Middle gravel mountainous and braided river types (EU EPIRB project, 2016).

Table 5 Preliminary boundaries of the hydromorphological quality classes (SHMI, 2004)

Table 6 Comparison of the results for observed and calculated Margalef Diversity Index for Aboulabbas River (Iran)

ANNEX 1. DEFINITIONS FOR HIGH, GOOD AND MODERATE ECOLOGICAL STATUS IN RIVERS AND LAKES (ACCORDING TO ANNEX V WFD)

Table 1. For Rivers (Table 1.2.1.)

Biological quality elements

Element	High status	Good status	Moderate status
Phytoplankton	The taxonomic composition of phytoplankton corresponds totally or nearly totally to undisturbed conditions. The average phytoplankton abundance is wholly consistent with the type-specific physico-chemical conditions and is not such as to significantly alter the type-specific transparency conditions. Planktonic blooms occur at a frequency and intensity which is consistent with the type-specific physicochemical conditions.	There are slight changes in the composition and abundance of planktonic taxa compared to the type-specific communities. Such changes do not indicate any accelerated growth of algae resulting in undesirable disturbances to the balance of organisms present in the water body or to the physico-chemical quality of the water or sediment. A slight increase in the frequency and intensity of the type-specific planktonic blooms may occur.	The composition of planktonic taxa differs moderately from the type-specific communities. Abundance is moderately disturbed and may be such as to produce a significant undesirable disturbance in the values of other biological and physico-chemical quality elements. A moderate increase in the frequency and intensity of planktonic blooms may occur. Persistent blooms may occur during summer months.
Macrophytes and phytobenthos	The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. There are no detectable changes in the average macrophytic and the average phytobenthic abundance.	There are slight changes in the composition and abundance of macrophytic and phytobenthic taxa compared to the type-specific communities. Such changes do not indicate any accelerated growth of phytobenthos or higher forms of plant life resulting in undesirable disturbances to the balance of organisms present in the water body or to the physico-chemical quality of the water or sediment. The phytobenthic community is not adversely affected by bacterial tufts and coats present due to anthropogenic activity.	The composition of macrophytic and phytobenthic taxa differs moderately from the type-specific community and is significantly more distorted than at good status. Moderate changes in the average macrophytic and the average phytobenthic abundance are evident. The phytobenthic community may be interfered with and, in some areas, displaced by bacterial tufts and coats present as a result of anthropogenic activities.
Benthic invertebrate fauna	The taxonomic composition and abundance correspond totally or nearly totally to undisturbed conditions. The ratio of disturbance sensitive taxa to insensitive taxa shows no signs of alteration from undisturbed levels. The level of diversity of invertebrate taxa shows no sign of alteration from undisturbed levels.	There are slight changes in the composition and abundance of invertebrate taxa from the type-specific communities. The ratio of disturbance-sensitive taxa to insensitive taxa shows slight alteration from type-specific levels. The level of diversity of invertebrate taxa shows slight signs of alteration from type-specific levels.	The composition and abundance of invertebrate taxa differ moderately from the type-specific communities. Major taxonomic groups of the type-specific community are absent. The ratio of disturbance-sensitive taxa to insensitive taxa, and the level of diversity, are substantially lower than the type-specific level and significantly lower than for good status.
Fish fauna	Species composition and abundance correspond totally or nearly totally to undisturbed conditions. All the type-specific disturbance-sensitive species are present. The age structures of the fish communities show little sign of anthropogenic disturbance and are not indicative of a failure in the reproduction or development of any particular species.	There are slight changes in species composition and abundance from the type-specific communities attributable to anthropogenic impacts on physicochemical and hydromorphological quality elements. The age structures of the fish communities show signs of disturbance attributable to anthropogenic impacts on physico-chemical or hydromorphological quality elements, and, in a few instances, are indicative of a failure in the reproduction or development of a particular species, to the extent that some age classes may be missing.	The composition and abundance of fish species differ moderately from the type-specific communities attributable to anthropogenic impacts on physico-chemical or hydromorphological quality elements. The age structure of the fish communities shows major signs of anthropogenic disturbance, to the extent that a moderate proportion of the type specific species are absent or of very low abundance.

Hydromorphological quality elements

Element	High status	Good status	Moderate status
Hydrological regime	The quantity and dynamics of flow, and the resultant connection to groundwaters, reflect totally, or nearly totally, undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
River continuity	The continuity of the river is not disturbed by anthropogenic activities and allows undisturbed migration of aquatic organisms and sediment transport.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Morphological conditions	Channel patterns, width and depth variations, flow velocities, substrate conditions and both the structure and condition of the riparian zones correspond totally or nearly totally to undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.

Physico-chemical quality elements

Element	High status	Good status	Moderate status
General conditions	The values of the physico-chemical elements correspond totally or nearly totally to undisturbed conditions. Nutrient concentrations remain within the range normally associated with undisturbed conditions. Levels of salinity, pH, oxygen balance, acid neutralising capacity and temperature do not show signs of anthropogenic disturbance and remain within the range normally associated with undisturbed conditions.	Temperature, oxygen balance, pH, acid neutralising capacity and salinity do not reach levels outside the range established so as to ensure the functioning of the type specific ecosystem and the achievement of the values specified above for the biological quality elements. Nutrient concentrations do not exceed the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific synthetic pollutants	Concentrations close to zero and at least below the limits of detection of the most advanced analytical techniques in general use.	Concentrations not in excess of the standards set in accordance with the procedure detailed in table 3 (section 1.2.6 annex V WFD) without prejudice to Directive 91/414/EC and Directive 98/8/EC. (<EQS)	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific non-synthetic pollutants	Concentrations remain within the range normally associated with undisturbed conditions (background levels = bgl).	Concentrations not in excess of the standards set in accordance with the procedure detailed in table 3 (section 1.2.6 (2) annex V WFD) without prejudice to Directive 91/414/EC and Directive 98/8/EC. (<EQS)	Conditions consistent with the achievement of the values specified above for the biological quality elements.

(1) The following abbreviations are used: bgl = background level, EQS = environmental quality standard.

(2) Application of the standards derived under this protocol shall not require reduction of pollutant concentrations below background levels: (EQS >bgl).

Table 2. For Lakes (Table 1.2.2.WFD)

Biological quality elements

Element	High status	Good status	Moderate status
Phytoplankton	The taxonomic composition and abundance of phytoplankton correspond totally or nearly totally to undisturbed conditions. The average phytoplankton biomass is consistent with the type-specific physico-chemical conditions and is not such as to significantly alter the type-specific transparency conditions. Planktonic blooms occur at a frequency and intensity which is consistent with the type specific physicochemical conditions.	There are slight changes in the composition and abundance of planktonic taxa compared to the type-specific communities. Such changes do not indicate any accelerated growth of algae resulting in undesirable disturbance to the balance of organisms present in the water body or to the physico-chemical quality of the water or sediment. A slight increase in the frequency and intensity of the type specific planktonic blooms may occur.	The composition and abundance of planktonic taxa differ moderately from the type-specific communities. Biomass is moderately disturbed and may be such as to produce a significant undesirable disturbance in the condition of other biological quality elements and the physico-chemical quality of the water or sediment. A moderate increase in the frequency and intensity of planktonic blooms may occur. Persistent blooms may occur during summer months.
Macrophytes and phytobenthos	The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. There are no detectable changes in the average macrophytic and the average phytobenthic abundance.	There are slight changes in the composition and abundance of macrophytic and phytobenthic taxa compared to the type-specific communities. Such changes do not indicate any accelerated growth of phytobenthos or higher forms of plant life resulting in undesirable disturbance to the balance of organisms present in the water body or to the physico-chemical quality of the water. The phytobenthic community is not adversely affected by bacterial tufts and coats present due to anthropogenic activity.	The composition of macrophytic and phytobenthic taxa differ moderately from the type-specific communities and are significantly more distorted than those observed at good quality. Moderate changes in the average macrophytic and the average phytobenthic abundance are evident. The phytobenthic community may be interfered with, and, in some areas, displaced by bacterial tufts and coats present as a result of anthropogenic activities.
Benthic invertebrate fauna	The taxonomic composition and abundance correspond totally or nearly totally to the undisturbed conditions. The ratio of disturbance sensitive taxa to insensitive taxa shows no signs of alteration from undisturbed levels. The level of diversity of invertebrate taxa shows no sign of alteration from undisturbed levels.	There are slight changes in the composition and abundance of invertebrate taxa compared to the type-specific communities. The ratio of disturbance sensitive taxa to insensitive taxa shows slight signs of alteration from type-specific levels. The level of diversity of invertebrate taxa shows slight signs of alteration from type-specific levels.	The composition and abundance of invertebrate taxa differ moderately from the type-specific conditions. Major taxonomic groups of the type-specific community are absent. The ratio of disturbance sensitive to insensitive taxa, and the level of diversity, are substantially lower than the type-specific level and significantly lower than for good status.
Fish fauna	Species composition and abundance correspond totally or nearly totally to undisturbed conditions. All the type-specific sensitive species are present. The age structures of the fish communities show little sign of anthropogenic disturbance and are not indicative of a failure in the reproduction or development of a particular species.	There are slight changes in species composition and abundance from the type-specific communities attributable to anthropogenic impacts on physicochemical or hydromorphological quality elements. The age structures of the fish communities show signs of disturbance attributable to anthropogenic impacts on physico-chemical or hydromorphological quality elements, and, in a few instances, are indicative of a failure in the reproduction or development of a particular species, to the extent that some age classes may be missing.	The composition and abundance of fish species differ moderately from the type-specific communities attributable to anthropogenic impacts on physico-chemical or hydromorphological quality elements. The age structure of the fish communities shows major signs of disturbance, attributable to anthropogenic impacts on physico-chemical or hydromorphological quality elements, to the extent that a moderate proportion of the type specific species are absent or of very low abundance.

Hydromorphological quality elements

Element	High status	Good status	Moderate status
Hydrological regime	The quantity and dynamics of flow, level, residence time, and the resultant connection to groundwaters, reflect totally or nearly totally undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Morphological conditions	Lake depth variation, quantity and structure of the substrate, and both the structure and condition of the lake shore zone correspond totally or nearly totally to undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.

Physico-chemical quality elements (!)

Element	High status	Good status	Moderate status
General conditions	The values of physico-chemical elements correspond totally or nearly totally to undisturbed conditions. Nutrient concentrations remain within the range normally associated with undisturbed conditions. Levels of salinity, pH, oxygen balance, acid neutralising capacity, transparency and temperature do not show signs of anthropogenic disturbance and remain within the range normally associated with undisturbed conditions.	Temperature, oxygen balance, pH, acid neutralising capacity, transparency and salinity do not reach levels outside the range established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements. Nutrient concentrations do not exceed the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific synthetic pollutants	Concentrations close to zero and at least below the limits of detection of the most advanced analytical techniques in general use.	Concentrations not in excess of the standards set in accordance with the procedure detailed in table 3 (section 1.2.6 annex V WFD) without prejudice to Directive 91/414/EC and Directive 98/8/EC. (<EQS)	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific non-synthetic pollutants	Concentrations remain within the range normally associated with undisturbed conditions (background levels = bgl).	Concentrations not in excess of the standards set in accordance with the procedure detailed in table 3 (section 1.2.6 (2) annex V WFD) without prejudice to Directive 91/414/EC and Directive 98/8/EC. (<EQS)	Conditions consistent with the achievement of the values specified above for the biological quality elements.

(1) The following abbreviations are used: bgl = background level, EQS = environmental quality standard.

(2) Application of the standards derived under this protocol shall not require reduction of pollutant concentrations below background levels: (EQS >bgl).

Table 3. Procedure for the setting of chemical quality standards by Member States (Table WFD)

In deriving environmental quality standards for pollutants listed in points 1 to 9 of Annex VIII for the protection of aquatic biota, Member States shall act in accordance with the following provisions. Standards may be set for water, sediment or biota.

Where possible, both acute and chronic data shall be obtained for the taxa set out below which are relevant for the water body type concerned as well as any other aquatic taxa for which data are available. The 'base set' of taxa are:

- Algae and/or macrophytes;
- Daphnia or representative organisms for saline waters;
- Fish.

Setting the environmental quality standard

The following procedure applies to the setting of a maximum annual average concentration:

(i) Member States shall set appropriate safety factors in each case consistent with the nature and quality of the available data and the guidance given in section 3.3.1 of Part II of "Technical guidance document in support of Commission Directive 93/67/EEC on risk assessment for new notified substances and Commission Regulation (EC) No 1488/94 on risk assessment for existing substances' and the safety factors set out in the table below:

	Safety factor
At least one acute L(E)C_{50} from each of three trophic levels of the base set	1 000
One chronic NOEC (either fish or daphnia or a representative organism for saline waters)	100
Two chronic NOECs from species representing two trophic levels (fish and/or daphnia or a representative organism for saline waters and/or algae)	50
Chronic NOECs from at least three species (normally fish, daphnia or a representative organism for saline waters and algae) representing three trophic levels	10
Other cases, including field data or model ecosystems, which allow more precise safety factors to be calculated and applied	Case-by-case assessment

(ii) where data on persistence and bioaccumulation are available, these shall be taken into account in deriving the final value of the environmental quality standard;

(iii) the standard thus derived should be compared with any evidence from field studies. Where anomalies appear, the derivation shall be reviewed to allow a more precise safety factor to be calculated;

(iv) the standard derived shall be subject to peer review and public consultation including to allow a more precise safety factor to be calculated.

USAID Governing for Growth (G4G) in Georgia
Deloitte Consulting Overseas Projects LLP
Address: 5 L. Mikeladze Street, Tbilisi
Phone: +995 322 240115 / 16
E-mail: info@g4g.ge