TOOLKIT WFD
FROM PRESSURES TO MEASURES

INSTITUNIONAL STRENGHTENING OF THE EAST AEGIAN SEA RBD

FOR THE IMPLEMENTATION OF THE WFD - ARDA PILOT BASIN

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Contents

CHAPTER 1 Introduction

1.1 CONTEXT

One of the tasks according to the European Water Framework Directive (WFD) is to set up a River Basin Management Plan (RBMP). In this RBMP one of the main issues for the surface water quality is a Plan of Measures (PoM). These measures are needed to achieve the environmental objectives. To set up a PoM it is needed to have information about:

- The environmental goals
- The actual status
- The pressures responsible for the gap between the goals and the actual status.

Also information is needed about the ecological effect and costst of measures, so the most cost effective measures can be selected.

In the EVD funded project "Institutional strengthening of the East Aegian Sea RBD for the implementation of the WFD – Arda pilot basin", which is carried out by ARCADIS, technical assistance is given to these tasks. One of the results is a guideline to set up a PoM. The present report is this guideline. In fact it is a toolkit and a description how to use it.

1.2 GOAL

The goal of the guideline / toolkit is to provide information and instruments which can be used to set up a PoM. Because the pressures are the basis of the toolkit, the toolkit is name "From pressures to measures".

1.3 OUTLINE

The guideline starts with some basic principles which are needed to understand the toolkit. In the following two chapters the toolkit is presented for the Chemical Status (Chapter 3) and the Ecological Status (Chapter 4). In the last Chapter some advice is given about public participation.

CHAPTER 2 Basic principles

2.1 CHEMICAL STATUS AND ECOLOGICAL STATUS

According to the WFD the status of surface waters can be split up in the Chemical Status and the Ecological Status[1].

Chemical Status

The Chemical Status is the result of the assessment of all priority and hazardous substances. The standards for these substances are uniform all over Europe. This means there are no differences in goals between regions (river basins) or water types. There are two classes for the Chemical Status: good and bad.

The method to set up a PoM to achieve the Good Chemical Status is quite simple. Search the pollution sources of the substances that do not meet the standard, and take measures to reduce the discharge of these pollution sources. Of course the reality is more complex as described, e.g.

- not all sources are known,
- relative contribution of the source to the total discharge is known,
- which measures are available to reduce the discharge, and
- what are the costs.

Nevertheless, the principle is simpler than the method to set up a PoM for the Ecological Status.

Ecological Status

The Ecological Status consists of three main aspects; each of them has several elements:

- Biological Status. The Biological Quality Elements (BQEs) are: phytoplankton (not in rivers), phytobenthos, macrophytes, macro-invertebrates and fish.
- Hydromorphological Status. There are several hydromorphological elements, related to the hydrological regime, river / lake bed, substrate types and connectivity
- Other chemical substances. These substances can be divided in “Other pollutants” and “Biological supporting substances”.

[1] The Ecological Status is only applicable for Natural water bodies. The ecological quality of Heavily modified and Artificial water bodies is called the Ecological Potential. For reason of readability in this document only the term Ecological status is used.

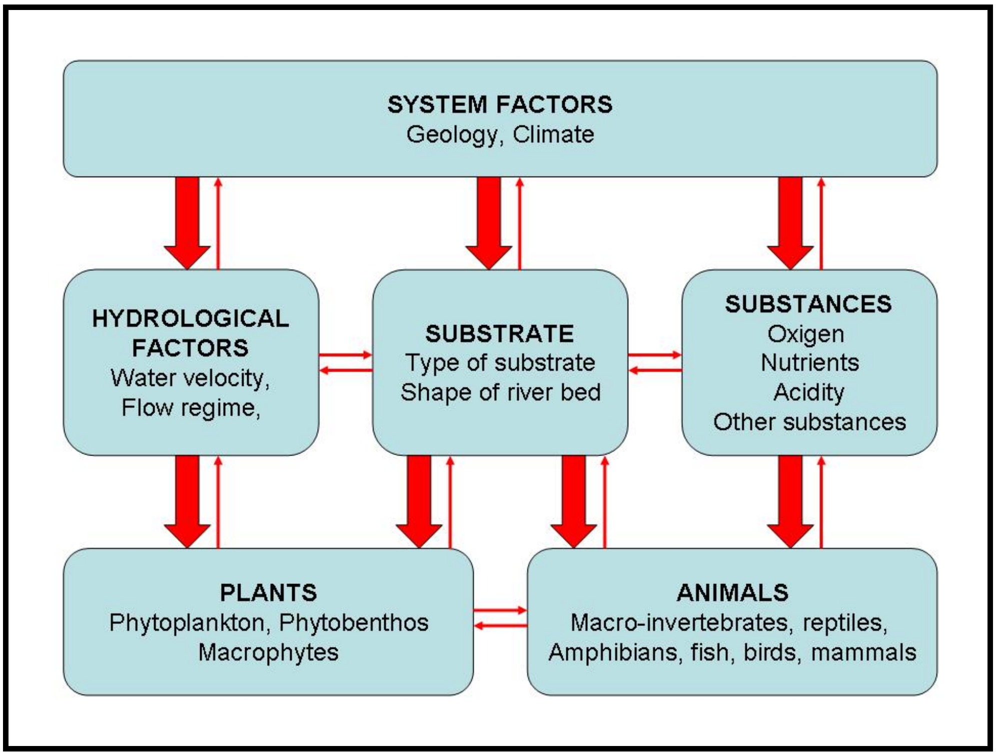
For the Ecological Status there are 5 (for Natural water bodies) or 4 (for Heavy modified and Artificial water bodies) classes. For the Ecological Status the BQEs are the leading elements. This will be explained in the next section.

2.2 ECOLOGICAL CONCEPT

An ecosystem is the complex of animals and plants in relation to each other and in relation to the environment. There exists a hierarchy in relations which is shown in Figure 1. Dominant are the large-scale system factors, like geology and climate. These factors determine local environmental factors like hydrological factors, substrate and substances. Finally these local environmental factors determine the species that occur. The relation vice versa does exist, but the influence is much less important. For example, plants can have influence on phosphorus and nitrogen concentrations. Finally there are relations between all plant and animal species and between the local environmental substances.

Figure 1

Hierarchy in ecological relations

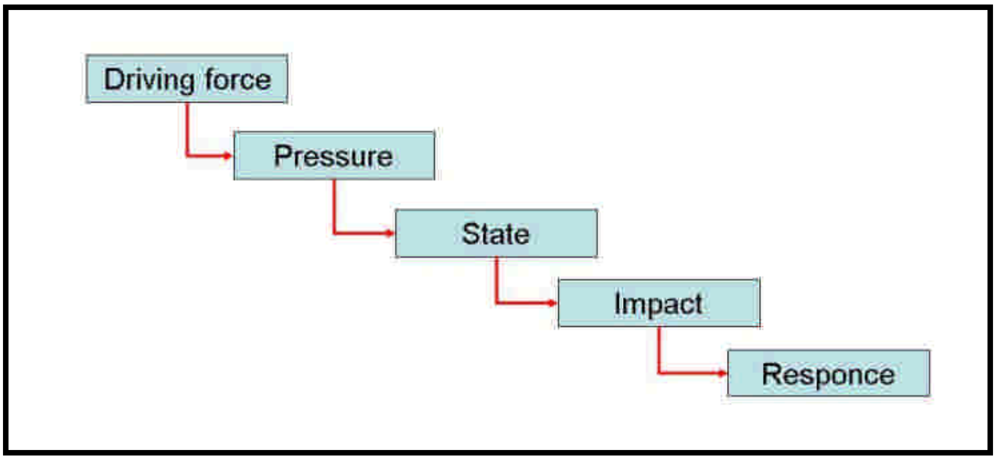


Based on this concept, it is said in the WFD that for the Ecological Status the BQEs (plants and animals) are the final goal. In Annex V of the WFD for example is said that for the Good Ecological Status the hydromorphological conditions are consistent with the achievement of the values for the BQEs. Also the general physico-chemical conditions (temperature, oxygen balance, pH, acidity neutralising capacity, salinity and nutrient concentrations) are not outside the range to ensure the functioning of the type specific ecosystem and the achievement of the values of the biological quality elements.

The problem now is that pressures and measures mostly do not influence directly species and animals. The effect runs via the environmental conditions. For this reason the DPSIR-concept (Driving force – Pressure – State – Impact – Response) is defined (see Figure 2). The driving force (e.g. energy supply, industry, agriculture) can lead to a pressure (discharge, dam, dike, sand abstraction). The result of the pressure is a change in the state of the environmental conditions (e.g. nutrient concentration, water flow velocity, substrate type). Finally the change of the environmental state can have an impact on the biological quality element (plants and animals). The response is a measure to improve the situation.

Figure 2

The DPSIR model



In fact, to select an appropriate measure (response) the same principle should be followed. A measure has influence on the environmental state, and the change of the environmental state has influence on the biological quality elements. The only difference is that now the effects are positive.

So the difference between the methods to set up a PoM to achieve the Good Chemical Status and to set up a PoM to achieve the Good Ecological Status is:

- There is a direct relation between pressures & measures and the Chemical Status
- The relation between pressures & measures and the ecological status (for which the BQEs are leading) is indirect, namely via the environmental factors (hydromorphological elements and the biology supporting chemical elements).

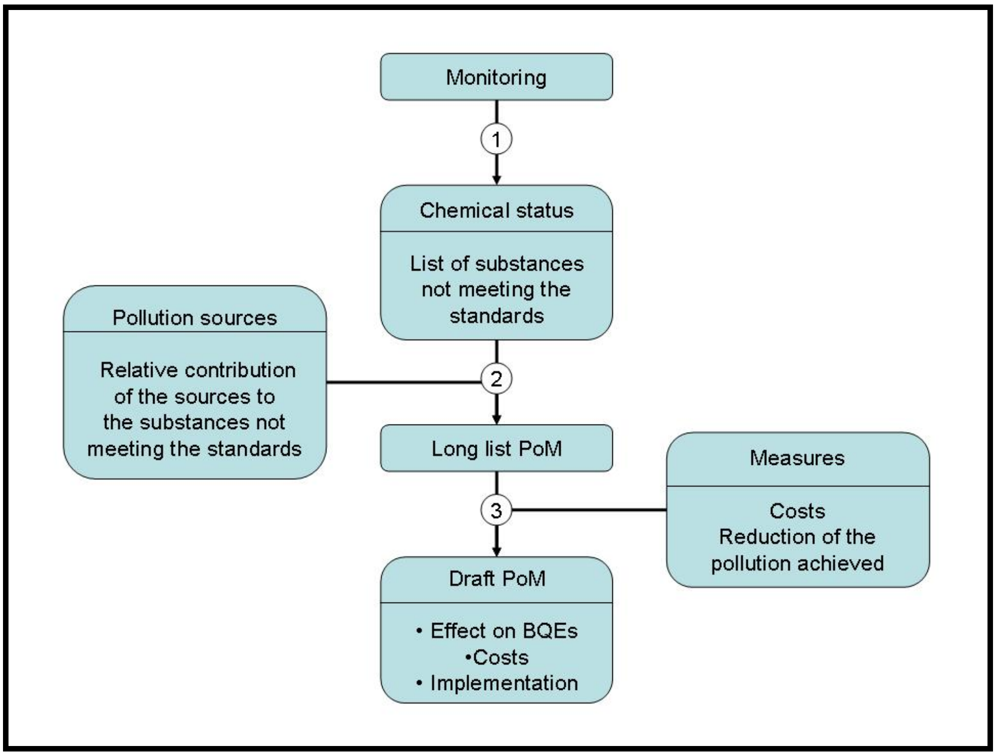
A main issue of the present toolkit is to give information about the relations between pressures & measures and BQEs.

CHAPTER 3 Chemical status

As is explained in Chapter 2, the relation between pressures & measures and the Chemical status is direct. The procedure to set up a PoM to achieve the Good Chemical Status is as follows (see Figure 3):

Figure 3

Steps to set up a PoM to achieve the Good Chemical Status



The following steps should be followed:

1. Based on the results of monitoring program, make a list of substances not meeting the standards. Note that this is the procedure only for priority and hazardous substances. How to handle the biological supporting substances is described in Chapter 4.
2. For each substance not meeting the standards, the pollution sources must be defined. This can be point sources, lake discharge of (purified or non-purified) urban waste water and industrial discharges. But also diffuse sources should be investigated, like traffic, agriculture, air pollution). For each source the relative contribution to the substances should be calculated or estimated. This information is needed in order to know the effectiveness of measures. When the relative contribution of a specific source is very low, it is not effective to take measures to reduce this source. The information about relative contribution of sources might be hard to gather and a lot of date might be needed. On the other hand, sometimes it might be simple. When there is a point source, e.g. an industrial discharge, and the load of this discharge is know, the relative contribution to the

concentration in the surface water can be estimated in combination with the river water discharge. When the outcome is that this industrial discharge is the main source of pollution, measures should be focussed on this discharge.

3. The result of step 2 is a list of (point and diffuse) sources of pollution that should be reduced. For the reduction of these pollution sources, several measures might be possible. In order to select a final (draft) PoM, information about costs and effectiveness of the measures is needed. Because of lack of time, this information is not included in the present toolkit.

CHAPTER 4 Ecological status

The general concept of the impact of pressures and measures on the Ecological status is described in Chapter 2. The steps that should be taken to set up a PoM to achieve the Good Ecological Status (or Good Ecological Potential) are (see also Figure 4).

1. Status assessment

Based on the results of monitoring program, the actual Ecological status should be determined. For this an ecological assessment method should be available. When this is not the case, existing indices (e.g. saprobic indices, biological index) should be used, in combination with expert judgement of biologists.

Also information about the hydromorphological quality elements and the biology supporting chemical elements must be gathered and assessed.

When there are no data, an risk assessment of the biological status can be made, using the information of Table 1 (see step 2). When the present pressures are known, this table gives information about the expected effect on the biological quality elements. Also when only information about the hydromorphological elements and the biology supporting substances is available, a risk assessment of the biological quality elements can be made, using Table 1.

2. List of problems

The next step is to set up a list of problems. First the existing pressures should be listed, and the size of the pressure. The information of Table 1 (see Annex 5) can be used to link the pressures to the abiotic elements and the biological quality elements. In other word: for each biological quality element the pressures can be selected which are responsible for not achieving the good status, and the mechanism of the impact of the pressure on the biological quality element (via hydromorphological an chemical elements).

The impact of the pressures on hydromorphological, chemical and biological quality elements is expressed in three classes:

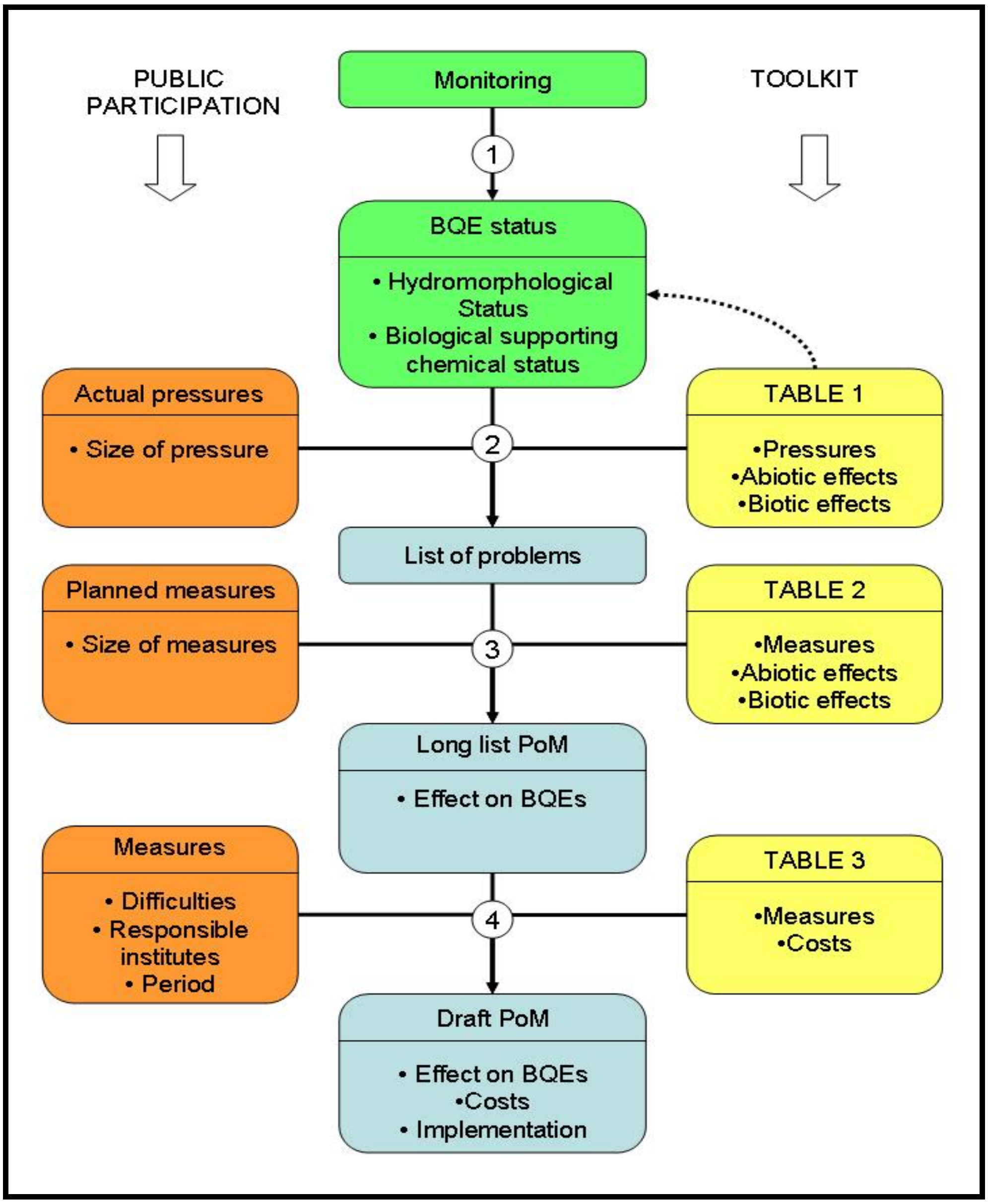
- -1 = small negative impact
- -2 = moderate negative impact
- -3 = large negative impact

When there is no indication in a specific cell, this means there is (almost) no impact.

Figure 4

Steps to set up a PoM to achieve the Good Ecological Status/Potential.

- Green: information form monitoring
- Red: information from Public Participation
- Yellow: information from the Toolkit
- Blue: results of the process



The result of step 2 that it is clear what pressures are responsibly for not achieving the Good Ecological status, and what the relative importances of these pressures are.

3. Long list PoM

Based on the list of problems (step 2) a first selection of measures can be made, using the information of Table 2 (see Annex 6). In this table the effect of measures on hydromorphological, biological supporting chemical, and biological quality elements is given. There are three classes:

§ 1 = small positive effect
§ 2 = moderate positive effect
§ 3 = large positive effect.

When there is no indication in a specific cell, this means there is (almost) no effect.

So this information can be used to make a first selection of measures. Look at the effect of the problems on the abiotic and biotic elements (step 2), and select measures with effect on the same elements. Note that the classes of Table 1 and Table 2 can not be used to calculate effects. You can not add effects of different pressures or effect of different measures, nor can you add or subtracts effects of pressures and measures. The figures are just an indication of the scale of the effect. You can only use it to select the important pressures and to select appropriate measures.

The combination of the information about the effects of pressures and the selected measures can lead to an estimated assessment of the biological quality elements. In other words: are the selected measures capable to achieve the Good Ecological Status or not?

4. Final (draft) PoM

It might happen there are more measures available to salve one problem. In that case the most cost-effective measures can be selected. To do this, information about the effect of measures, and information about costs of measures is needed. Information about the effect of measures is presented in Table 2 (see step 3 and Annex 6). Information about the costs of measures is presented in Table 3 (see Annex 7). In the latest table only an indication of the costs is given in four classes:

- 0 = almost no costs
- 1 = low costs
- 2 = moderate costs
- 3 = high costs

These classes can be combined with the effect of measures. The combination leads to an indication of cost-effectiveness of measures as indicated in Table 1. Because it is important to achieve the goals, measures with large or maybe moderate effect must be selected (third or maybe second row). From these rows the most left measures (lowest costs) are the best. A measure with low cost but small effect, might be moderate cost-effective (in economical terms), but when only this type of measures are taken, the environmental goals might not be achieved.

Table 1

Cost-effectiveness of measures, based on costs and effects

	1. Low costs	**2. Moderate costs**	**3. High costs**
1. Small effect	Moderate cost-effective	Cost-effectiveness is low	Cost-effectiveness is very low
2. Moderate effect	Cost-effectiveness is high	Moderate cost-effective	Cost-effectiveness is low
3. Large effect	Cost-effectiveness is very high	Cost-effectiveness is high	Moderate cost-effective

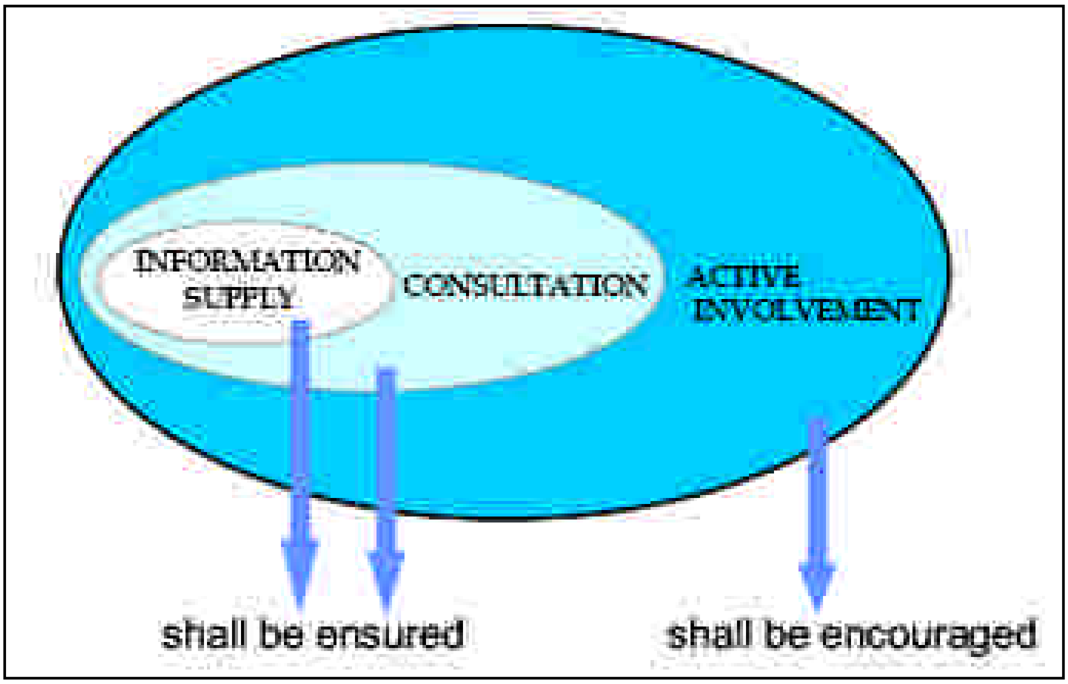
Besides the cost-effectiveness, there might be other reasons not to select measures. There might be difficulties for implementation (legislation, permission, etc) and the costs might be too high for the institute responsible for implementation. All this information must be used to make a final (draft) PoM.

CHAPTER 5 Public Participation

In the WFD public participation is an obligatory aspect. Stakeholders should be involved in the process of setting up a PoM. Stakeholders can play different roles in this process. In Figure 5 these roles are demonstrated: information supply, consultation and active involvement. Stakeholders who have an active involvement are for example land owners and participants who have a responsible task to carry out specific measures (and have budget for those measures). The involvement of these stakeholders is of course very important. Involvement of stakeholders with information may lead to a more comprehensive PoM.

Figure 5

Roles of Stakeholders



In Figure 4 the involvement of stakeholders in the process is indicated. The involvement may be related to:

- The list of pressures
- The existing plans for measures
- The Programme of Measures

The planning of stakeholder meetings and workshops can vary between the River basin districts. However, it should be considered that most stakeholders are not familiar with the

WFD, so at least 2 or three meetings / workshops should be organized. An appropriate schedule could be:

- General introduction about the principles of the WFD. Explanation of the public participation process.
- Workshop on pressures and goals.
- Workshop on PoM.

ANNEX 1 Abbrevations

BQE	Biological Quality Element
DPSIR	Driving force – Pressure – State – Impact - Response
PoM	Program of Measures
RBMP	River Basin Management Plan
WFD	Water Framework Directive
WWTP	Waste Water Treatment Plant

ANNEX 2 Description of biological quality elements

Phytoplankton
Phytoplankton are free-floating microscopic small algae. There are different groups, like green algae, blue algae, diatoms, gold algae, etc.

Phytoplankton strongly reacts to the general chemical conditions of the water. Especially trophic level (phosphorus and nitrogen concentrations) are important, but also transparency and temperature. Phytoplankton is capable to change water chemistry. Due to the assimilation process, oxygen concentration and pH increase. During night time or early morning (when assimilation stops due to lack of light), the dissimilation process results in low oxygen concentration. So, intensive growth of phytoplankton may lead to great changes in oxygen concentration and high pH. Because the algae fix nitrogen and phosphorus, concentrations of nitrate, ammonium and ortho-phosphate reduce strongly.

Besides that, intensive growth of algae leads to low transparency of the water. This can influence macrophytes: when light is not capable to reach the bottom, macrophytes are not capable to germinate.

When algae die (e.g. at the end of the summer), they sink to the bottom and the dissimilation processes start. This lead to low oxygen concentrations, firstly in and near the bottom, but finally the whole water column can be effected.

Phytobenthos
Phytobenthos are algae growing on substrates. In most European countries diatoms are used as representative group of the phytobenthos community. Like phytoplankton, phytobenthos strongly react to water chemistry. Besides nutrients concentration, the impact of acidity, salinity and oxygen balance on diatoms is well known.

Macrophytes
Higher plants often are divided in submerged water plants, water plants with floating leaves, and emergent water plants. Some species of the latest group can also on the banks. In many studies all species growing on the area which is inundated during flood, are considered as water plants.

Macrophytes react to trophic level, but in general less strong than phytoplankton and phytobenthes. The reason is, that many species are rooted and take up nutrients from the sediment and for that reason are not dependent of nutrients in the water. Another important factor is water transparency. When light can not penetrate to the bottom, most water plants are not capable to germinate.

Besides water chemistry, macrophytes also react to hydromorphological conditions. Important factors are shape of the bed (area of shallow water), water flow and changes in water level.

Macro-invertebrates

Macro-invertebrates are animals without an internal skeleton and big enough to see with the naked eye. Important groups are worms, snails, and insects. Especially the group of insects is very big: beetles, water bugs, and larvae of dragonflies, mosquito's, caddish flies, may flies, etc.

Macro-invertebrates react to water chemistry. Especially oxygen balance is important. For that reason macro-invertebrates are a good indicator for organic pollution.

Besides water chemistry, hydromorphological conditions are very important. In running water the water velocity and discharge regime is dominant. Besides that, the diversity of substrates (silt, sand, gravel, pebbles, vegetation, tree leaves, wood) is important. A lot is known about the indicator value of macro-invertebrates in running water. Less knowledge is available about macro-invertebrates in lakes.

Fish

A definition of fish is not needed. Fish is fish.

Fish react to water chemistry. Important factors are trophic level, oxygen balance, pH, salinity and temperature. But also almost all hydromorphological conditions are important: water velocity, discharge regime, changes in water level, diversity in substrates, availability of appropriate spawning ground, etc. Last but not least, for some species connectivity is very important. Some species migrate from inland waters to the sea or in the opposite direction for spawning.

ANNEX 3 Description of pressures

1. Water abstraction

Water abstraction is the intake of water. The water can be used for the industry, for drinking water, for hydropower stations or irrigation. In the present toolkit, water abstraction is only valid for rivers. The intake from lakes or reservoirs is treated in this toolkit as “changes in water level”.

Water abstraction leads to a diminishing of the water discharge and water flow velocity. In the first place this influences macro-invertebrates and fish. But changes in river bed and water velocity also can influence macrophytes. When the discharge diminishes strongly, chemical conditions may change and this can influence macrophytes and even phytobenthos.

2. Regulation of water discharge (small reservoirs)

In many rivers the water discharge is regulated by the construction of small reservoirs. During periods with high discharge, the water is stored. During dry periods, the water is released slowly. The pressure is only valid for rivers.

Like water abstraction, changes in discharge and water velocity, strongly influence macro-invertebrates and fish. However, the total annual discharge is not changed, so the impact is less. Because there is no reduction of the total annual discharge, there is no significant effect on water chemistry and hence on macrophytes and phytobenthos. For fish the dams of the reservoirs are important, because they are migrating barriers.

3. Hydropower reservoirs

For hydropower stations dams and built and reservoirs are formed. In some cases the water is abstracted and released downstream. The effect of the latest pressures is described as “water abstraction”. When a reservoir surface is larger than 0.5 km^2, the reservoir is delineated as a separate water body. In that case the effects must be assessed with lake reference conditions, not with river reference conditions.

The effects of a dam in a river are migration barrier, loss of water velocity, changes in substrates, temperature, oxygen balance and other general chemical conditions. In the first place fish and macro-invertebrates are influenced, but also macrophytes and phytobenthos can be influenced.

4. Correction of water flow (straitening, dams)

In rivers the course of the water flow can be corrected. The course can be straitened and the course can be corrected by dams. The pressure is only valid for rivers.

The effect of this pressure is a change in water velocity and especially the diversity of water velocity in the cross-section. The result is a diminishing of the diversity of substrate types. This influences the macro-invertebrate community strongly, but also the fish community.

Because of the morphological changes, the appropriate conditions for macrophytes decrease.

5. Cut of river- and shore bed vegetation

This pressure is valid both for rivers and lakes. Of course the pressure directly influences the macrophytes. But because macrophytes function as substrate for macro-invertebrates and fish, these groups are also influenced.

6. Sand- and gravel abstraction

This pressure is valid both for rivers and lakes. Abstraction of sand and gravel means an huge impact on substrates. Moreover in rivers the water flow velocity may be changed. Macrophytes, macro-invertebrates and fish are influenced.

7. Erosion

Erosion occurs when soil in hilly areas is not consolidated. Main courses are deforestation and (intensive) agricultural use of the land. The result is soil particles are flushed away during rainfall. When these particles land into rivers or lakes, the water transparency can be reduced, which effects grow of phytoplankton, phytobenthos and macrophytes. When organic substances fall into the water, dissimilation can reduce the oxygen concentration, which is negative especially for macro-invertebrates and fish.

One has to keep in mind that the effect only occurs during heavy rainfall. After these periods, the ecosystem can recover. For this reason the ecological effect is limited.

8. Discharge of untreated urban wastewater

Untreated urban wastewater contains a lot of organic substances. When these substances are discharged to surface water, the process of dissimilation starts. During the decomposition oxygen is used. So dependent of the decomposition rate, oxygen concentration can diminish. This has big influence on macro-invertebrates and fish. There are some saprobic indices, which assess the effect discharge of organic substances on biological quality elements.

A secondary effect of decomposition of organic substances is the release of the fixed nutrients (nitrogen and phosphorus). This leads to the process of eutrophication, with effects on especially phytoplankton, phytobenthos and macrophytes.

9. Discharge of treated urban wastewater

It is assumed that the treatment includes a biological step. During this step oxygen is added to the waste water and the process of dissimilation is stimulated. During this process organic substances decompose and the fixed nutrients are released. When this treated waste water is discharged into surface water, there is no saprobic effect, only a eutrophic effect. In the first place this influences phytoplankton, phytobenthos and macrophytes.

A secondary effect of eutrophication is the accumulation of dead algae and plants, which leads to an increase of organic substances. So saprobic phenomenons are secondary effects of eutrophication.

10. Discharge of (industrial) micro-pollutants

There are many micro-pollutants and hence biological effects. In general animals are more sensitive to micro-pollutants because of the phenomenon of bio-accumulation. The higher an organism stands in the food-web, the higher the effect may be.

But this is a very general description of the effect. Of course there are micro-pollutants with specific effect to plants and / or algae, and no or limited effects on animals. So, when a specific micro-pollutant is discharged and this leads to an exceeding of the standards, always check the eco-toxicological effect.

11. Agriculture

From agricultural areas nutrients can wash-out and lead to the process of eutrophication. Primary phytoplankton, phytobenthos and macrophytes are affected.

Another possible impact of agriculture is the diffuse discharge of pesticides. For the ecological effect of that, see “discharge of micro-pollutants.

12. Rubbish dump

Dump of rubbish may occur as a “point source” of pollution but also as a “diffuse source” of pollution. A part of the rubbish will consists of organic substances. So the effect is comparable with discharge of unpolluted waste water. Another effect is the release of micro-pollutants, like heavy metals and synthetic compounds.

However rubbish on banks and drifting on surface waters looks very badly, the ecological effects are limited. Much rubbish will stay very long in the water or the banks and are visible because they “accumulate”. The discharge of organic substances and micro-pollutants is limited compared with other sources of pollution.

13. Changes in water level

This pressure is only valid for lakes and reservoirs. Reference conditions are high water levels during winter and early spring, and low water levels at the end of the summer. When the maximum amplitude is app. 0.5 to 1.5 meter, the most valuable shore vegetation can develop. Any change in this water level regime may have negative influence on the shore vegetation. So, a very small amplitude (or a fixed water level), a very large amplitude (more than 1.5 meter), and frequent changes, hinder an optimal development of the shore vegetation.

A bad developed shore vegetation has a negative influence on macro-invertebrates (because vegetation forms a habitat for specific species), and fish (because shore vegetation forms a spawning substrate for specific species).

ANNEX 4 Description of measures

1. Replacement of water abstraction point to a water body (river) with a higher discharge

When the abstraction point can be replaced to a river with a higher discharge, and hence with a smaller effect on water velocity, this is a good measure from an ecological point of view. The negative effect of the original location is solved, and the negative effect on the new location is limited.

There are cases where no alternative locations for water abstraction can be found. The termination of the abstraction can be considered, e.g. the termination of irrigation.

Yet, the costs can be very large. When the water is used for irrigation, new canals must be constructed. When the water is used for drinking water of industrial process water, pipelines must be constructed, or the industry must be replaced.

2. Removal of small dams for water regulation

This measure is not only the removal of small dams, but also the replacement by objects, like rocks. These objects reduce water transport capacity of the stream and hence lead to retention of water. So, the hydrological effect can be the same as the original dam. The advantage is that ther is no migration barrier any more. The negative biological effect is solved completely. The removal of small dams and the replacement by objects is a simple and cheap measure.

3. Removal of big dams

The hydrological effect of bigger (especially higher) dams can not be achieved by objects as described with the previous measure. The removal of a big dam will solve the ecological pressure completely, but the removal will not always be possible. Dams mostly are created for hydro power. The removal of the dam implies the loss of the hydro power. Hydro power is stimulated because it is a clean source of energy. An option is to concentrate hydro power stations in specific rivers, and other rivers are saved as natural rivers and remain free from hydro power stations.

4. Replacement of dikes

The goal of this measure is to solve the impact of water flow correction. The removal of a dike means an increase of natural conditions. Nevertheless, the replaced dike will still have some negative impact, so the problem is not solved completely. The costs are moderate.

5. Creation of flood plains

The goal of this measure is to solve the impact of water flow correction. The creation of flood plains means an increase of natural conditions. Nevertheless, the new flood plains will never be like the reference conditions, so the problem is not solved completely. The costs are moderate.

6. Renaturation of river beds

The goal of this measure is to solve the impact of water flow correction. The rehabilitation of the river beds means an increase of natural conditions. Nevertheless, the new river bed will never be like the reference condition, so the problem is not solved completely. The costs are moderate.

7. Re-meandering

The goal of this measure is to solve the impact of water flow correction. This is the most optimal measure to salve this problem. The negative effect of the water flow correction is almost completely solved. The costs are moderate.

8. Alternative methods for cut of bed vegetation

The alternative methods are e.g. a differentiated cut regime(a part of the vegetation is spared during the first cut; during the second treatment only the spared part is cut) or a selective cut (e.g. only trees). There will always remain a negative effect of the alternative method, so the problem is not solved completely. The costs of this measure are almost nihil.

9. Afforestation

The goal of this measure is to stop the process of erosion and its negative effect. The measure takes a lot of time (tens of years). In the first years the effect is limited. To stop the erosion quickly (e.g. to reach the environmental goals in 2015), the measure must be carried out on a large scale. Only then the negative effect can be solved completely. The costs are moderate.

10. Other measures to prevent erosion

There are some other measures to prevent erosion. One of them is to plough farmland in a direction parallel to height contour lines. Another method is to build small dikes parallel to height contour lines. Because erosion cannot be stopped completely by this kind of measures, the measures should be carried out on a large scale. The costs of these kind of measures are low.

11. Sand catchments

A measure which is not focussed on the prevention of erosion but on the diminishing of the negative effect of erosion is the building of sand catchments in small tributaries. Sand catchments are places in water courses where the water velocity is diminished strongly by broadening the water course. Sand and silt are settled down and because of the accumulation of it, sand catchments should be dredged regularly.

To solve the negative effect of erosion, the measure should be carried out on a large scale. The costs are low.

12. Fish ladders and fish by-passes

To solve the problem of discontinuity near dams, fish ladders or fish by-passes can be built. A fish ladder is an construction in the river bed. A high dam can be replaced by many small cascades. Each cascade must be low enough and the distances between the cascades must be long enough. A fish by-pass is a parallel water course around a dam. The length of the parallel water course depends on the height of the dam. The slope of the parallel water course must be low enough.

The effect of a fish ladder or a fish by-pass depends on the construction and the characteristics, like the height of the cascades, the length between cascades, the slope of the by-pass and the resulting water velocity. So the effectiveness may be small or large, but in general the problem is never solved completely. The costs are low.

13. Waste water treatment plant; only mechanical step

In a mechanical step of a WWTP the largest particles in the waste water are removed. This also includes organic compounds. This measure partly solves the negative effect of untreated waste water discharge. The costs are moderate.

14. Improvement WWTP: biological step

In a biological step organic compounds are decomposed, but nutrients are formed. So the effect of the measure is a shift of the negative effect of the discharge: instead of a saprobic effect, there is an effect of eutrophication. The costs to build a WWTP with a biological step are high.

15. Improvement WWTP: N and P removal step

When nutrients are removed in a WWTP, the problem of eutrophication is also solved. The costs to build a WWTP with N an P removal are high.

16. Reed bed treatment of waste water

An alternative method for purification of urban waste water is a reed bed. The principle of a reed bed purification is settlement of particles and uptake of nutrients by helophytes (like reed). Morover, helphytes are capable to transport oxygen into the roots. In the soil around the roots conditions with high and low oxygen concentrations exist close to each other. This situation is optimal for the processes nitrification and denitrification and hence for a good purification of waste water. The effect of a reed bed is not as good as a biological purification step in a waste water treatment plant. On the other hand, the costs are lower.

17. Purification of industrial waste water

The effect of this measure is that discharged compounds (which may be organic compounds, nutrients and micro-pollutants) are diminished. Depending on the effectiveness of the purification, the negative effect of the discharge can be solved partly or completely. Costs are high.

18. Implementation of clean technology in industry

Another method to reduce the discharge of industrial waste water is the implementation of new, clean technologies in the production process. The measure is focussed on the prevention of pollutants in the waste water. Costs can vary (depending on the type of measures), but in general are moderate.

19. Less use of fertilizes in agriculture

Use of fertilizes in agriculture may lead to eutrophication. Less use of fertilizes can diminish this effect. The process of nutrients wash-out is very slow, so it may take many years before effects occur. Moreover there always will be some nutrients wash-out, because always the application of fertilizers is needed in agriculture practice. The effect of this measure for these reasons is limited. Costs are almost nil. The diminished economical yield is not included.

20. Good agriculture practice

This measure also is focussed on the diminishing of nutrients wash-out. The good agriculture practice focuses on the period and the way of application of fertilizers. For example, fertilizers should not be used before heavy rainfall is expected. Also fertilizers only should be used during grow season, and not during winter.

The effect of the measure either is limited, because some of the applied fertilizers will wash-out anyway. Costs are almost nil.

21. Removal of rubbish

This measure is easy to carry out when rubbish is accumulated. When accumulation does not take place in a natural way, the construction of grids can be useful. When rubbish is removed, the problem is solved almost completely. However, the negative impact of rubbish is not very large and hence the positive effect of the measure is limited. Costs are low.

22. Natural water level regime

This measure is only applicable to lakes and reservoirs. As is explained below pressure 13 (changes in water level), the optimum water level regime is high in winter and spring and low in summer and autumn, with a maximum amplitude of 1.5 m. When the regime is different, the measure is focussed on the establishment of the optimum water level regime. When this is achieved, the negative effects are solved completely. Costs are almost nil.

22. Dredging

In reservoirs particles from the river can precipitate. This may lead to accumulation of silt with negative effects on oxygen balance. The best way to solve this problem is regular removal of the silt by dredging. The ecological effect of this measure is large. The measure is quite expensive.

ANNEX 5 Table 1. Effects of pressures

A. Rivers

			Effect on hydro-morpho-logical state			Effect on biological supporting chemical state			Impact on biological quality elements				
Nr.	Pressure	Size of presure	Hydrology	River bed, substrates	Connectivity	Organic pollution / oxigen	Nutrients	Others (pH, temp, ...)	Phytoplankton	Phytobenthos	Macrophytes	Macro-invertebrates	Fish
1	Water abstraction	< 10% of water flow reduction	-1						n.a.				
		10-50% of water flow reduction	-2	-1					n.a.			-1	-2
		> 50% of water flow reduction	-3	-2	-1	-1		-1	n.a.	-1	-2	-3	-3
2	Regulation of water discharge (small reservoirs)	<10% of water flow reduction	-1		-2				n.a.			-1	-2
		> 10% of water flow reduction	-2		-3				n.a.			-2	-3
3	Hydropower reservoirs	Each reservoir	-2	-2	-3	-1		-1	n.a.	-1	-1	-3	-3
4	Correction of water flow (straithening, dams)	< 10% of river length		-1					n.a.			-1	
		10-50% of river length	-1	-2					n.a.		-1	-2	-1
		> 50% of river length	-2	-3					n.a.		-2	-3	-2
5	Cut of river bed vegetation	<10% of river length							n.a.		-1		
		10-50% of river length		-1					n.a.		-2	-1	-1
		>50% of river length	-1	-2					n.a.		-3	-2	-2
6	Sand and gravel abstraction	< 10% of river length		-1					n.a.		-1	-1	-1
		10-50% of river length	-1	-3					n.a.		-3	-2	-2
7	Erosion	< 10% of the catchement area							n.a.				
		> 10% of the catchement area		-1				-1	n.a.	-1	-1	-1	-1
8	Discharge of untreated urban wastewater	Some small villages				-1			n.a.	-1		-1	-1
		Many small villages or 1 city				-2	-1		n.a.	-2	-1	-2	-2
		Many cities				-3	-2	-1	n.a.	-3	-2	-3	-3
9	Discharge of treated urban wastewater	Some small villages					-1		n.a.	-1			
		Many small villages or 1 city				-1	-2		n.a.	-2	-1	-1	-1
		Many cities				-2	-3	-1	n.a.	-3	-2	-2	-2
10	Discharge of (industrial) micro-pollutants	Some small discharges						-2	n.a.			-1	-1
		Many small discharges and/or large discharges						-3	n.a.	-1	-1	-3	-3
11	Agriculture	< 10% of catchment area							n.a.				
		10-50% of catchment area					-1	-1	n.a.	-1			
		> 50% of catchment area					-2	-2	n.a.	-2	-1		
12	Rubbish dump	Small scale							n.a.				
		Large scale		-1		-1		-1	n.a.			-1	-1

B. Lakes

Nr	Pressure	Size of presure	Effect on hydro-morpho-logical state			Effect on biological supporting chemical state			Impact on biological quality elements				
			Hydrology	Shore bed, substrates	Connectivity	Organic pollution / oxigen	Nutrients	Others (pH, temp, ...)	Phytoplankton	Phytobenthos	Macrophytes	Macro-invertebrates	Fish
5	Cut of bed vegetation	<10% of shore length									-1		
		10-50% of shore length		-1							-2	-1	-1
		>50% of shore length	-1	-2					-1		-3	-2	-2
6	Sand and gravel abstraction	< 10% of shore length		-1							-1	-1	-1
		10-50% of shore length		-3							-3	-2	-2
7	Erosion	< 10% of the catchement area							-1				
		> 10% of the catchement area		-1				-2	-2	-2	-1	-1	-1
8	Discharge of untreated urban waste	Some small villages				-1						-1	-1
		Many small villages or 1 city				-2	-1		-1	-1	-1	-2	-2
		Many cities				-3	-2	-1	-2	-2	-2	-3	-3
9	Discharge of treated urban wastewa	Some small villages					-1		-1	-1	-1		
		Many small villages or 1 city				-1	-2		-2	-2	-2	-1	-1
		Many cities				-2	-3	-1	-3	-3	-3	-2	-2
10	Indistrial discharge of micro-pollutar	Some small discharges						-2				-1	-1
		Many small discharges and/or large discharges						-3	-1	-1	-1	-3	-3
11	Agriculture	< 10% of catchment area							-1				
		10-50% of catchment area					-1	-1	-2	-1			
		> 50% of catchment area					-2	-2	-3	-2	-1		
12	Rubbish dump	Small scale											
		Large scale		-1		-1		-1				-1	-1
13	Changes in water level	<50 cm	-1								-1		-1
		50-150 cm. High in winter, low in summer											
		>150 cm and/or unnatural regime	-2	-1						-1	-3	-1	-2

ANNEX 6 Table 2. Effects of measures

A. Rivers

Nr	Measure	Size of measure	Effect on hydromorpho-logical state			Effect on biological supporting chemical state			Impact on biological quality elements				
			Hydrology	River bed, substrates	Connectivity	Organic pollution / oxigen	Nutrients	Others (pH, temp, ...)	Phytoplankton	Phytobenthos	Macrophytes	Macro-invertebrates	Fish
1	Replacement of water abstraction point to a water body (river) with a higher discharge	< 10% of water flow rehabilitation	1						n.a.				
		10-50% of water flow rehabilitation	2	1					n.a.			1	2
		> 50% of water flow rehabilitation	3	2	1			1	n.a.	1	2	3	3
2	Removal of small dams for water regulation	<10% of water flow rehabilitation	1		2				n.a.			1	2
		> 10% of water flow rehabilitation	2		3				n.a.			2	3
3	Removal of big dams		1	1	3				n.a.			1	3
4	Replacement of dikes	<10% of river length							n.a.				
		10-50% of river length		1					n.a.				1
		> 50% of river length	1	2					n.a.		1	1	2
5	Creation of flood plains	<10% of river length							n.a.				1
		10-50% of river length		1					n.a.			1	2
		> 50% of river length	1	2					n.a.		1	2	3
6	Renaturation of river beds	<10% of river length							n.a.				
		10-50% of river length		1					n.a.		1	1	1
		> 50% of river length	1	2					n.a.		2	2	2
7	Re-meandering	<10% of river length		1					n.a.			1	
		10-50% of river length	1	2					n.a.		1	2	1
		> 50% of river length	2	3					n.a.		2	3	2
8	Altenative methods for cutting river bed vegetation	<10% of river length							n.a.				
		10-50% of river length		1					n.a.		1		
		>50% of river length		2					n.a.		2	1	1
9	Afforestation	< 25% of the catchement area							n.a.				
		> 25% of the catchement area		1				1	n.a.	1	1	1	1
10	Other measures to prevent erosion	< 25% of the catchement area							n.a.				
		> 25% of the catchement area		1				1	n.a.	1	1	1	1
11	Sand catchments	A few, small ones											
		Many, large ones		1				1		1	1	1	1
12	Fish ladders and fish by-passes				2							1	2
13	Waste water treatment plants, only mechanical step	<10% of waste water treated							n.a.				
		10-50% of waste water treated						1	n.a.				
		> 50% of waste water treated				1		1	n.a.	1		1	1
14	Improvement WWTP: biological step	<10% of waste water treated				1						1	1
		10-50% of waste water treated				2						1	1
		> 50% of waste water treated				3		1		1	1	2	2
15	Improvement WWTP: N and P removal step	<10% of waste water treated					1			1			
		10-50% of waste water treated					2			1	1		
		> 50% of waste water treated					3	1		2	2	1	1
16	Reed bed treatment of waste water	<10% of waste water treated											
		10-50% of waste water treated											
		> 50% of waste water treated											
17	Purification of industrical waste water	<25% of waste water treated						2	n.a.			1	1
		> 25% of waste water treated						3	n.a.	1	1	3	3
18	Implementation of clean technology in industry	<25% of waste water improved						2	n.a.			1	1
		> 25% of waste water improved						3	n.a.	1	1	3	3
19	Less use of fertilizers in agriculture						1			1	1		
20	Good agriculture practice						1			1	1		
21	Removal of rubbish			1		1		1				1	1

B. Lakes

Nr	Measure	Size of measure	Effect on hydro-morpho-logical state			Effect on biological supporting chemical state			Impact on biological quality elements				
			Hydrology	Shore bed, substrates	Connectivity	Organic pollution / oxigen	Nutrients	Others (pH, temp, ...)	Phytoplankton	Phytobenthos	Macrophytes	Macro-invertebrates	Fish
6	Renaturation of shore beds	<10% of shore length											
		10-50% of shore length		1							1	1	1
		> 50% of shore length	1	2							2	2	2
8	Altenative methods for cutting shore bed vegetation	<10% of shore length											
		10-50% of shore length		1							1		
		>50% of shore length		2							2	1	1
9	Afforestation	< 25% of the catchement area							1				
		> 25% of the catchement area		1				1	2	1	1	1	1
10	Other measures to prevent erosion	< 25% of the catchement area							1				
		> 25% of the catchement area		1				1	2	1	1	1	1
13	Waste water treatment plants, only mechanical step	<10% of waste water treated											
		10-50% of waste water treated						1					
		> 50% of waste water treated				1		1		1		1	1
14	Improvement WWTP: biological step	<10% of waste water treated				1						1	1
		10-50% of waste water treated				2						1	1
		> 50% of waste water treated				3		1	1	1	1	2	2
15	Improvement WWTP: N and P removal step	<10% of waste water treated					1			1			
		10-50% of waste water treated					2			1	1		
		> 50% of waste water treated					3	1	2	2	2	1	1
16	Reed bed treatment of waste water												
17	Purification of industrical waste water	<25% of waste water treated						2				1	1
		> 25% of waste water treated						3	1	1	1	3	3
18	Implementation of clean technology in industry	<25% of waste water improved						2				1	1
		> 25% of waste water improved						3	1	1	1	3	3
19	Less use of fertilizers in agriculture						1		1	1	1		
20	Good agriculture practice						1		1	1	1		
21	Removal of rubbish			1		1		1				1	1
22	Natural water level regime		2	1						1	3	1	2
23	Dredging	<80% of accumulated sediment				1	1	1	1	1		1	1
		>80% of accumulated sediment				3	2	2	3	2	1	2	2

ANNEX 7 Table 3. Costs

Nr	Measure	Size of measure	Costs
1	Replacement of water abstraction point to a water body (river) with a higher discharge	< 10% of water flow rehabilitation	3
		10-50% of water flow rehabilitation	3
		> 50% of water flow rehabilitation	3
2	Removal of small dams for water regulation	<10% of water flow rehabilitation	1
		> 10% of water flow rehabilitation	1
3	Removal of big dams		2
4	Replacement of dikes	<10% of river length	1
		10-50% of river length	2
		> 50% of river length	3
5	Creation of flood plains	<10% of river length	1
		10-50% of river length	2
		> 50% of river length	2
6	Renaturation of river beds	<10% of river length	1
		10-50% of river length	2
		> 50% of river length	2
7	Re-meandering	<10% of river length	2
		10-50% of river length	3
		> 50% of river length	3
8	Altenative methods for cutting river bed vegetation	<10% of river length	0
		10-50% of river length	0
		>50% of river length	0
9	Afforestation	< 25% of the catchement area	1
		> 25% of the catchement area	1
10	Other measures to prevent erosion	< 25% of the catchement area	1
		> 25% of the catchement area	1
11	Sand catchments	A few, small ones	2
		Many, large ones	3
12	Fish ladders and fish by-passes		1
13	Waste water treatment plants, only mechanical step	<10% of waste water treated	1
		10-50% of waste water treated	1
		> 50% of waste water treated	2
14	Improval WWTP: biological step	<10% of waste water treated	2
		10-50% of waste water treated	3
		> 50% of waste water treated	3
15	Improval WWTP: N and P removal step	<10% of waste water treated	2
		10-50% of waste water treated	2
		> 50% of waste water treated	2
16	Reed bed treatment of waste water	<10% of waste water treated	1
		10-50% of waste water treated	2
		> 50% of waste water treated	2
17	Purification of industrical waste water	<25% of waste water treated	*
		> 25% of waste water treated	*
18	Implementation of clean technology in industry	<25% of waste water improved	*
		> 25% of waste water improved	*
19	Less use of fertilizers in agriculture		*
20	Good agriculture practice		*
21	Removal of rubbish		1
22	Natural water level regime		0
23	Dredging	<80% of accumulated sediment	3
		>80% of accumulated sediment	3

* = Costs for industry or agriculture