GUIDANCE ON MONITORING FOR SURFACE WATER EUROPEAN WATER FRAMEWORK DIRECTIVE

by the MIR monitoring project group and discipline groups

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1. INTRODUCTION

Why these guidelines

The EU Water Framework Directive (WFD – Council Directive 2000/60/EU) sets explicit requirements for biological, physico-chemical and hydromorphological monitoring. The water managers are responsible for the implementation of the WFD and for ensuring that the existing monitoring networks satisfy the WFD. The monitoring requirements from the WFD are not unequivocal, however, and this can result in considerable differences in interpretation and choice between water managers. To come to an agreement in respect of WFD monitoring, various guides and documents have been published in recent years (e.g. Guidance Monitoring, and Monitoring of Surface waters for the European Water Framework Directive (Breukel, 2003)). Unfortunately, these instructions have not led to a single unequivocal, harmonised approach to WFD monitoring, which has resulted in effects differing per river basin. This is undesirable.

Status and planning of these guidelines

This version of the guidelines was provisionally approved by the MRE (Monitoring, Reporting and Evaluation) management cluster on 6 July 2005. The guidelines were compiled with contributions from the surface water managers in the Netherlands. They must therefore be considered a directive, and must be used when planning the WFD monitoring programmes.
Advancing ideas, resulting from practical experience in the Netherlands or abroad and from consultations with the European Commission, could nonetheless lead to adjustments in the future. As a consequence, an updated version of the monitoring guidelines will be endorsed by the MRE cluster by the end of 2005 or in 2006.

Important milestones in the planning include:

- 18 July 2005 start compiling monitoring programmes in the river basins;
- 31 August 2005 hand in comments on the current guidelines (version 15 July ’05);
- 28 September 2005 adopt monitoring guidelines (version 28 September ’05);
- December 2005 draft monitoring programmes are ready;
- spring 2006 start of the regional policy-making process;
- 22 December 2006 the WFD monitoring programmes are operational;
- March 2007 the Dutch monitoring programme is presented to the EC.

Objective

In summarised form, the national WFD monitoring guidelines' **objective** is:

- the unequivocal interpretation of the monitoring obligations ensuing from the WFD;
- the harmonisation of WFD monitoring by water managers in the Netherlands for the purposes of an unequivocal assessment and report to Brussels;
- the adoption of an initial package for WFD monitoring necessary for the 2009 report to Brussels.

Guide

This document basically includes:

1. Principles underlying WFD monitoring;
2. Surveillance monitoring guidelines;
3. Operational monitoring guidelines;
4. Appendices with background information and methods.

PLEASE NOTE:

WFD texts (from Council Directive 2000/60/EC or CIS Guidance on Monitoring) are highlighted in green.

2. EXPLANATORY NOTES IN RESPECT OF WFD MONITORING

2.1 Types of WFD monitoring

The WFD gives instructions for the three different types of monitoring: surveillance, operational and investigative monitoring. In addition to these instructions, a monitoring programme will be determined by, for example, the limits of the water bodies (monitoring unit), the assessment instruments (assessment tools) and the manner in which reporting will take place. Diagram 1 shows how the various aspects of the WFD are related and how they influence each other from a monitoring perspective.

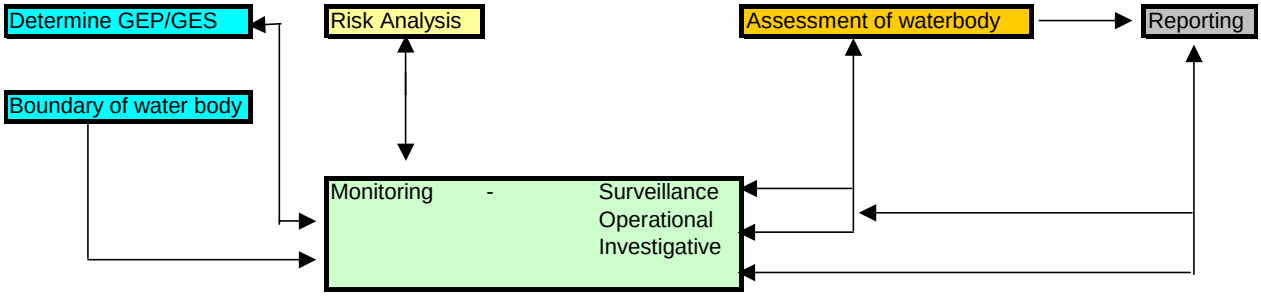


Diagram 1: Diagram 1: Relation between WFD processes from a monitoring perspective.

The three types of monitoring each serve their own purpose. Surveillance monitoring (chapter 5) intends to provide an outline of the status of the water bodies. With the information obtained from this type of monitoring, the status can be described and assessed, and long-term (50 years or more) trends can be determined. For this purpose, a wide range of quality elements is being assessed at a low frequency in the most important waters The selected water bodies stand model for a cluster of closely related water bodies. The results of surveillance monitoring is also used to support the assessment of risks.
Operational monitoring (chapter 6) is problem-oriented. This type of monitoring must be used for water bodies that do not have a potentially good status or may be in danger of reaching that status. It focuses on the most important human loads (pressures) that are present in the area, and the locations where measures are being taken or not. This type of monitoring describes and assesses status and determines short-term trends within a planning period.
Investigative monitoring is employed when it is not clear why a water body does not have a potentially good status. It is therefore even more specific and intensive than operational monitoring; it has an investigative approach and it does not generally take long. This section has not been included in this report.
It is suggested that the programmes of the three types of monitoring should be designed in conjunction with each other, and that they use the same sampling and analysis methods and, where possible, corresponding monitoring locations, in order to increase efficiency and coherence.
The objectives and the effects of the first two types of monitoring will be discussed in extenso in chapters 5 and 6.

2.2 Monitoring for the purposes of ecological and chemical status

The WFD distinguishes the chemical and ecological status (potential) in the status of water, which is assessed on the basis of one or more quality elements (see diagram 2).

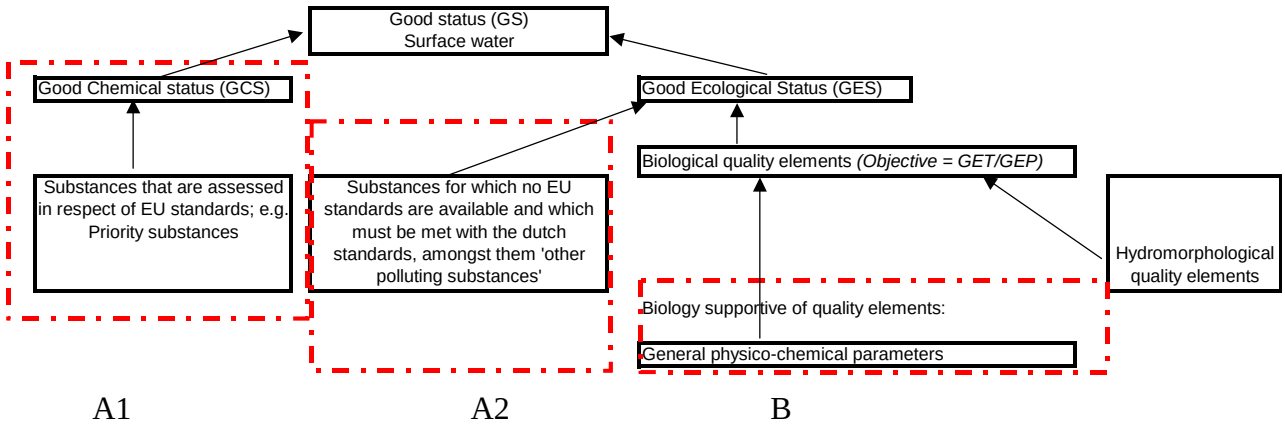


Diagram 2: 'Monitoring blocks' from which a good chemical and ecological status (potential) can be determined.

The **chemical status** (block A1) relates to all substances, including priority substances, for which environmental quality objectives and environmental quality standards have been established at EU level. If the provisional standards for priority substances have not yet been established by the EU by December 2006, the individual Member States must formulate these standards themselves in accordance with a method prescribed in the WFD, and they must adopt these standards. The consequence is, however, that the assessment of priority substances drawn up without the EU standards cannot be made under block A1 but under block A2 (ecological status), because only substances for which standards were set at EU level will fall under the definition of the chemical status.

Chemistry also plays a major role in the assessment of the **ecological status** (blocks A2 and B). Block A2 concerns 'other polluting substances': substances which are discharged in significant quantities but for which no EU standard has been established. National standards must be established for these substances in accordance with a method comparable to that of the FHI system (Frauenhofe Institute). A third and final group of substances (block B) concerns the so-called 'general physico-chemical parameters', which are supportive of biology; these include nutrients and oxygen content.
The ecological status is determined on the basis of biological quality elements, significant quantities of other discharged polluting substances (block A2) the so-called 'biology supportive' elements (general physico-chemical parameters (block B) and hydromorphological quality elements).
Hence, a good ecological status can only be achieved if the other polluting substances also meet the standards.

The importance of the various quality elements in the assessment of the ecological status is included in diagram 3 (Common Implementation Strategy (CIS), 2003).

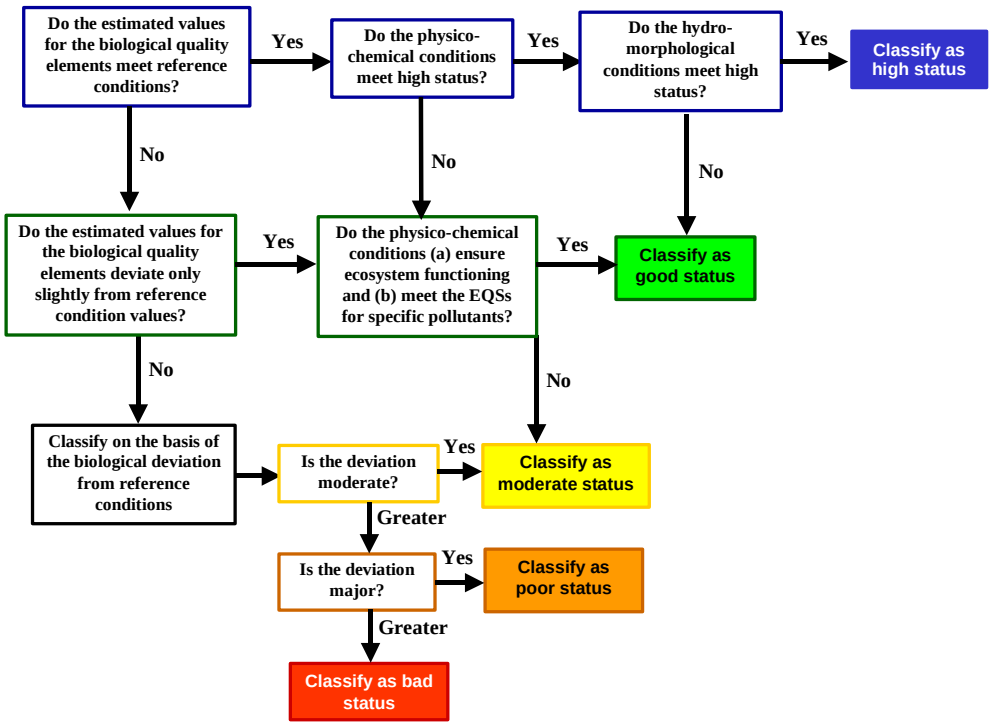


Diagram 3: use of monitoring data for assessment

The consequences of this model are not further discussed in these guidelines; the diagram has been included to provide insight into the relation between monitoring and assessment.
The importance for monitoring always is that all quality elements (also the general physico-chemical and the hydromorphological) must be monitored in spite of the fact that not all monitoring data is used for the assessment of status (WFD appendix V).

3. ESTIMATION OF NUMBER OF MONITORING LOCATIONS

Surveillance Monitoring
In respect of the number of water bodies (around 800 in 40 types) and in compliance with the median method referred to in chapter 5, it is estimated that between 30 and 108 water bodies will be included in the surveillance monitoring. These figures are estimated for biological and hydromorfological monitoring. For chemical monitoring fewer water bodies (approx. 30) will be included, mostly the main waters like big rivers and lakes, coastal and transitional waters.

Operational Monitoring
Because a majority of the 800 water bodies is thought to be at risk for some reason or other, operational monitoring will be carried out in many more water bodies. By clustering water bodies with comparable problems, it is estimated that between 170 and 268 water bodies will be included in operational monitoring, partly overlapping the surveillance monitoring sites.

4. PRINCIPLES UNDERLYING THE NATIONAL GUIDELINES

The starting points are as follows:

- the guidelines only focus on monitoring for the purposes of the WFD, appendix V; guidelines are mostly taken from the WFD and Guidance on Monitoring (see memorandum on decision-making starting points, items 2 and 11);
- as far as possible, WFD monitoring follows the current monitoring practices of the water managers (see memorandum on decision-making starting points, item 5);
- the WFD gives instructions in respect of the monitoring network design (in frequency or number of monitoring locations, for example); downward deviations are allowed; this needs to be substantiated in Brussels, however;
- the monitoring network design takes place at river basin level, from a European and not a local perspective (see memorandum on decision-making starting points, item 1);
- the monitoring network setup always uses representative monitoring points; not all the water bodies need to be sampled;
- the monitoring programmes recommend the use of a rotating monitoring network (distribution of locations over the years with a fixed, uniform frequency of monitoring); it is of great importance that the monitoring disciplines and the water managers work closely with each other;
- WFD monitoring requires comparability of results for the purposes of explicit reporting to Brussels;
- the choice of the location for monitoring points on boundaries will be made in consultation with the neighbouring Member States;
- tenability of data: 6 years; monitoring data from 2003, for example, may only be used for reports until 2009, older data may not be used;
- if different parameters can be selected for operational monitoring, the cheapest will be chosen

5. SURVEILLANCE MONITORING

Surveillance objective

1. The purpose of surveillance monitoring is to establish and assess long-term trends for both human activities and changes in natural conditions. Relevant to hydromorphology, for example, are possibly changes in the discharge patterns of rivers as a result of a change in climate or land use, but also slow changes in sedimentation zones in transitional waters, for example, as a result of natural processes. The presented indicators should be able to detect such changes.

2. Surveillance monitoring also aims to assess to what extent the risk analysis based on human pressure is being properly implemented. Because many risk assessments for the initial planning period have been carried out on the basis of information obtained from already available monitoring data, this current objective is hardly relevant (as of 30 June 2005), at least not for the Netherlands.

3. The results of surveillance monitoring can also be used to plan other monitoring programmes more efficiently and more effectively. The effect is rather limited as far as this objective is concerned; thanks to a long history of water quality monitoring in the Netherlands a great deal of information is already available.

4. The collected surveillance data must ultimately lead to an overall assessment of the waters within a river basin district.

5. Surveillance monitoring must also prove that the planned results/objective have/has indeed been achieved (result obligation).

Finally, it can be established that surveillance monitoring is not intended for:

-mapping and analysing water quality problems;

-testing the effectiveness of the programme of measures;

-obtaining a detailed or complete overview of the quality of all types of water.

WFD investigative monitoring or WFD operational monitoring, and also existing non-WFD monitoring are all of importance for these information objectives.

5.1 Choice of location for surveillance monitoring

What does WFD require and which locations are selected?

One or more water bodies that are considered representative of a cluster of water bodies may be selected. The EU further indicates (source: Guidance on Monitoring) that aggregation is possible if the water bodies can be compared in respect of geography, hydrology, geomorphology, trophic level and extent of human pressure. In the Netherlands, we have established that clustering for the purposes of the surveillance monitoring is only possible if the water bodies are of the same type and status but, strictly speaking, that is not what the EU requires. The Guidance also specifies that it must be possible to rationalise the clustering of water bodies, i.e. make it plausible that the water body where monitoring is carried out, is indeed representative of the group of water bodies. The Framework Directive employs a number of criteria for the selection of surveillance locations. A location must therefore be considered a water body, whether or not representative of a group of water bodies.

A quality element within that water body will be monitored at one or more monitoring points. In the case of cross-boundary waters, consultations about the proposed water body selection should be held with the other Member States involved.

A Member State must always select a surveillance location/water body if one of the following general starting points as regards choice of location are fulfilled with a view to surveillance monitoring (paragraph 1.3.1, appendix V, WFD):

1 where the water discharge flow is significant within the entire river basin district, the locations in large rivers with a river basin exceeding 2,500 km^2 included;
2 where the present volume of water is significant within the river basin district, large lakes included;
3 where significant water bodies cross the boundary of a Member State;
4 that are designated pursuant to Decree 77/795/EEC*;
5 points that are necessary to estimate the pollution pressure at Member States' boundaries ** and on the transitions to the marine environment.

*European Directive 77/795/EEC includes a number of set locations, see list in appendix 2.
**It is expected that existing OSPAR monitoring points will suffice here.

5.1.1 Biology

Regulations for choice of location per river basin:

1. selection of water bodies
Water bodies can be considered for surveillance monitoring if one of the following questions can be answered in the affirmative. Such water bodies are then added to a list.

a. Is it an important water within the river basin in respect of size and function in the entire river basin?
b. Is it a significant cross-boundary water body?
c. Does the water type belong to one of the dominant or important water types?

The purpose of item c. is to ensure that insignificant waters in European terms are not over-represented in the surveillance monitoring network

2. Median Method Within a group of water bodies of the same type and status that meet the above criteria, the Median method is applied. This means that a ranking of the water bodies takes place on ecological status (from bad to high) and on size (from small to bigger surface area). This ranking takes place first on ecological status and secondly on size; this means that in the case of an equal ecological status, size determines ranking. The median water body will be designated as a surveillance location. In the case of an even number (where there is no median) the water body with the better ecological status is selected. If these are also equal the biggest water body is selected. The ecological status is based on the more formal risk assessment.

Example Median method

No.	Name of water body	(Estimated) Ecological status	Surface (ha)
1	Koningsdiep	Good	3
2	Lauwers	Poor	4.5
3	Tjonger	Moderate	4.5
4	Linde	Poor	6.2
5	Eelderdiep and Peizerdiep	Bad	7
		Ranking on status and then on size	
		↓	
	Eelderdiep & Peizerdiep	Bad	7
	Lauwers	Poor	4.5
	Linde	Poor	6.2
	Tjonger	Moderate	4.5
	Koningsdiep	Good	3

No.	Name of water body	(Estimated) Ecological status	Surface area (ha)
1	Koningsdiep	Moderate	3
2	Lauwers	Poor	4.5
3	Tjonger	Moderate	4.5
4	Linde	Poor	6.2
5	Eelderdiep & Peizerdiep	Poor	7
		Ranking on status and then on size	
		↓	
	Eelderdiep and Peizerdiep	Bad	7
	Lauwers	Poor	4.5
	Linde	Poor	6.2
	Tjonger	Moderate	4.5
	Koningsdiep	Good	3

In the above example (left), all type R5 waters (slowly flowing middle reach/lower reach on sand) in the Rhine-North sub-basin have been itemised. All water bodies appear to have been Heavily Modified.
An assessment of the current ecological status (partly filled out fictitiously here!!) has been made from the risk analysis.
The waters score moderate and poor. In the first classification the worst water bodies are high on the list and the best low. The water surface area is added. If the ecological status is identical, the size will determine the ranking (from small to large). The median element (gray) of the new list is now designated as the type 5 surveillance water body in Rhine-North.
Both the Eelderdiep and Peizerdiep were selected to be included in surveillance monitoring for biology.

In the second example (right) the Koningsdiep and the Eelderdiep/Peizerdiep are given a different status, as a result of which the small river Linde comes out as a surveillance water body.

3. common sense
Test whether the surveillance locations are properly distributed within the river basin after having applied the above criteria; in other words does this give an impression of the most important and common water types in the Netherlands. The first important thing to mark is that highly relevant water bodies are not omitted by the median method. An extra water body can be added in exceptional and well-motivated cases.

Application of the above criteria produces a number of choices that result in a variable number of water bodies:

- The number of water types that are considered important or dominant in a sub-basin (this needs to be considered).

The number of artificial waters can be limited, because these are not relevant locations for detecting autonomous changes and they are not usually important in view of their volume. Many main waters can be selected as a surveillance water body on the basis of relative importance in respect of their volume, cross-boundary character, and the transition from freshwater to saline water. This means that smaller, frequently occurring water types, can also be included in surveillance monitoring.

Because the Dutch section of the Eems (shared with Germany) and Scheldt (shared with Belgium) river basins is relatively small, it seems logical that they also have fewer locations than in the Rhine and Meuse river basins.

To determine the surveillance water bodies, the Median method is employed once. The order of these monitoring locations is then fixed and will not be adjusted in a subsequent monitoring and ranking session. Changes can only be made in exceptional cases.
The various quality elements must be monitored in the same water body as much as possible, so that trends can be explained as best as possible.

The locations for monitoring the other polluting substances are not selected in accordance with the above but with the system described in paragraph 5.1.2.

5.1.2 Chemistry

Chemical monitoring comprises three categories of substances / parameters (see diagram 1, chapter 2):
- substances that must be tested against EU standards and fall under the chemical status (diagram 1; block A1);
- substances for which no EU standards are available and must be tested against NL standards and that fall under the ecological status in respect of assessment (diagram 1; block A2);
- general physico-chemical parameters supportive of biology (diagram 1; block B;).

Priority and other polluting substances (diagram 1; blocks A1 and A2)
Chemical monitoring relates to the hydrological drainage units (these can contain more than one water body!). It is therefore logical that monitoring locations at the downstream end of such an area or unit are ideally situated for this purpose.

In accordance with the WFD starting points for a choice of a surveillance location (see above), not all the substances in all the smallest (capillary) waters need to be monitored and reported. The larger waters in the (relativity high) southeast of the Netherlands act as drainage and in the northern and western parts (lower) they supply water. Based on this information it is reasonable to assume that well-selected locations in the main waters, with the addition of a number of regional waters, will be representative of the most important water systems in the Netherlands. The additional regional locations are situated within water systems that, in respect of size, fulfil the earlier mentioned WFD starting points as regards choice of surveillance location, and for which it is clear that they contribute significantly to the discharge into the main waters.

The chemical surveillance WFD monitoring network comprises the estuaries of the larger river basins, boundary-crossings, and representative locations in the most important water systems as well as the larger lakes. Surveillance points that are in the same cluster of water bodies as the 77/795/EEC points can be considered representative of these points.

International harmonisation
The WFD does not mention which country is responsible for implementing monitoring on the Member States' boundaries. Further agreements between the countries concerned are to be expected in the near future. Harmonisation at an international level is necessary before consultations on a regional level can be started (f.i. through the existing international river committees).

Loads
Insofar as loads are relevant to the quality description (country boundaries and transition of inland waters to marine environment), a representative water quantity monitoring point should exist alongside to a quality monitoring point. After all, loading is the product of substance concentration and discharge flow. No current arrangements have been made about the load calculation method for the WFD.

General physico-chemical parameters (diagram 1; block B)
Monitoring the general or biology supportive physico-chemical parameters is in line with the biological monitoring. The general physico-chemical parameters must be monitored in the same water body as where biological monitoring takes place. As far as possible the monitoring should be carried out at the same time and, where possible, at the same location as where the factor biology is monitored. The general physico-chemical parameters, however, need not be monitored at all the biological monitoring points, but they must be representative of the water body in question. A recommended strategy is to monitor these parameters at the same monitoring points and at the same time as the phytoplankton or phytobenthos (in the case of rivers) parameters. For a detailed description of the selection criteria of the biological surveillance monitoring points, see paragraph 5.1.1 and appendix 4B.

5.1.3 Hydromorphology
The hydromorphological parameters are supportive of the biology. It is therefore recommended to also carry out the hydromorphological surveillance monitoring in the same water bodies as those selected for the biological surveillance monitoring. The entire range of hydromorphological parameters in the selected water body must be monitored, this means the parameters that fall under the hydrology quality element, continuity as well as morphology. For a detailed description of the selection criteria of the biological surveillance monitoring points, see paragraph 5.1.1.

Besides the choice of water bodies, the number of monitoring points within the water body for the various hydromorphological parameters must also be determined. This point is discussed in Guidance on Monitoring: "Sampling points are selected within the water body at places that are representative of the general condition of the water body with special attention for the long-term effects by human pressures as well as the establishment of future monitoring programmes." The surveillance monitoring of hydromorphological quality elements is discussed in more detail in appendix 6 and this is further described per parameter under the heading "where".

Paragraph 5.1.2, where the choice of location for chemical surveillance is discussed, also explains that, insofar as loads are relevant to the quality description (country boundaries and transitional waters to marine environment), a representative water quantity monitoring point must exist beside a chemical quality monitoring point. After all, loading is the product of quality and discharge. The discharge must therefore be determined at this water quantity monitoring point.

Protected Areas
For surveillance monitoring of the water quality in Protected Areas (PA), the nearest surveillance monitoring location will meet the requirements. If there is a water quality problem in the area in question, operational monitoring may well have to be carried out. Paragraph 6.3 (operational monitoring) discusses this topic in more detail.

5.1.4 Sampling strategy within a water body (choice of monitoring points)
In addition to the water body choice (location) where the monitoring of the various quality elements takes place, it is important to have a strategy for choosing actual monitoring points within a water

body. The strategy for representative sampling should be extended to the local level and ensure that sufficient samples are taken to be able to come to a reliable conclusion as to the relevant parameter for the water body in question. The strategy for representativeness should include both the number of monitoring points and the frequency; this depends on the parameter group.
The starting points presented here for the three disciplines are for representative sampling at water body level (where this is also applicable to a cluster of water bodies, this is mentioned). For technical details, see appendix 4.

Chemistry
Chemical sampling takes place at one location per water body. Reliability is mainly achieved through a high repetition frequency, as is also prescribed by the WFD. This particularly applies to priority and other polluting substances. General physico-chemical parameters are also monitored at a fixed monitoring point per water body and concur with the monitoring points for phytoplankton (lakes, transitional and coastal waters) and for phytobenthos (rivers).

Biology
General.
To form an idea of the status of a water body, only the habitats (or biotopes) that are present in relevant numbers are sampled. 10% of the water body is taken as the lower limit for the occurrence of a biotope. This minimum is applied for benthic invertebrates, macrophytes and fish.

Phytoplankton
One fixed monitoring point per water body or cluster of water bodies. The monitoring point connects where possible to the chemical monitoring network (cost efficient) and when new monitoring points are selected, they must be as far away as possible from disruptive influences such as tributaries and human activities.

Phytobenthos
In principle, phytobenthos is sampled on reed land or, if not present, on artificially-cultivated reed. Up to now it has been assumed that one monitoring point per water body would suffice.

Angiosperms and Macroalgae
Angiosperms are mapped, i.e. the areas where they are found are plotted.
No information is available for macroalgae.

Macrophytes
More than one monitoring point will be needed per water body. Sampling points in lakes should be well distributed over the potential vegetation areas (very deep zones are therefore excluded from sampling). Stratified Random Sampling is used for this purpose. This means that 20 to 30 locations are sampled per water body and per stratum. Potential strata are deep and shallow waters, and in case of rivers: tributaries, oxbow lakes or pools.
Ribbon-shaped lakes (canals, ditches) usually have only one stratum.
The sub-assessment tool for riparian plants requires a different approach when used for large lakes and rivers. There is only one stratum (the riparian zone). This stratum is random sampled at 20 to 30 monitoring points per water body. In smaller waters, the riparian zone can be sampled as a separate stratum, together with the water plants at the same monitoring points (also 20 to 30 monitoring points).

Benthic invertebrates
Stratified Random Sampling is also used here. Possible strata are: soil (gravel, silt, clay, sand, peat, zebra mussel) and vegetation. The assessment tools determine which strata are used for which particular type. The samples are taken together per stratum for analysis.
In order to get a good idea of the species composition and the numbers, and in response to the need for information from the assessment tools, the monitoring points must be sampled in both the spring and in the autumn. Species groups that are primarily present in one of these two seasons, need not be sampled again in the other season.

Fish
In principle, the same type of sampling on the various habitats or strata applies to fish. The number of random tests for a species in any water body depends on its rarity and subsequently the chance of hitting on that species.
Fish monitoring is carried out in large waters from sailing ships, which means that the monitoring point can not, in fact, be entirely accurate. The same area is located with the aid of GPS. Changing conditions (the absence or presence of large sections of water plants, for example) can, however, influence the choice, and a certain amount of leeway must be allowed. In smaller waters, fishing is usually carried out from the river bank and it is easier to work from fixed points.
At some times of the year, fish do not circulate homogeneously in the water (winter) and some species do not circulate at all (rudd can always be found in vegetation, for example). This explains the decision to sample in September in accordance with the multi-strata approach. This is a compromise between recording a good distribution of the fish in the summer and a greater chance of mortality during sampling in warm water.

Hydromorphology
For the factors involved in the choice of hydromorphological monitoring points, see appendix 6.

5.2 Choice of frequency of surveillance monitoring

For surveillance purposes, monitoring must take place in accordance with the WFD: at least 1 monitoring year during any planning period (= 6 years). The table below shows the minimum frequencies per monitoring year.

Table with minimum monitoring frequencies per monitoring year for the various quality elements.

Discipline	Quality element	Rivers	Lakes	Transitional waters	Coastal waters
Biology	Phytoplankton		2**/monit.yr	6/monit.yr	6/monit.yr
	Phytobenthos	1/monit.yr	1/monit.yr		
	Macrophytes	1/monit.yr	1/monit.yr		
	Macroalgae			1/monit.yr	1/monit.yr
	Angiosperms			1/monit.yr	1/monit.yr
	Benthic invertebrates	1/meetjr[1]	1/meetjr[1]	2/monit.yr	1/monit.yr
	Fish	1/monit.yr	1/monit.yr	1(2)/monit.yr[2]	
Chemistry	Priority substances that are discharged	12/monit.yr	12/monit.yr	12/monit.yr	12/monit.yrs
	Other polluting substances that are discharged	4/monit.yr	4/monit.yr	4/monit.yr	4/monit.yrs
Supportive of biology	General physico-chemical parameters	4/monit.yr	4/monit.yr	4/monit.yr	4/monit.yrs
Hydromorphology	Hydrological regime /Tidal regime		[3] High frequency-within the monit.yr		
Supportive of biology		Continuous		[3] High frequency-within the monit.yr	[3] High frequency within the monit.yr

	River continuity Morphology	1/monit.yr 1/monit.yr	1/monit.yr	1/monit.yr	1/monit.yr

** To be able to use the Assessment tools for ecological assessment, however, a monitoring frequency of 6x a year is required.

[1] After studying the monitoring need from the perspective of the assessment tools, it has become clear that benthic invertebrates must be sampled in both the spring and in the autumn.
[2] From the assessment tools for fish in the transitional waters it became clear that it is necessary to sample in the spring and in the autumn.
[3] In appendix V of the WFD, the frequency is not filled out for the hydromorpholical quality element seasonal regime in transitional and coastal waters. The processes that are monitored are, however, comparable to the processes under the hydrological regime in rivers. Within the monitoring year the tidal regime must be monitored continuously as applies to the hydrological regime in rivers. For lakes the WFD prescribes a minimum frequency of 12x per monitoring year for the hydrological regime. Here, too, the processes to be monitored in the Netherlands are comparable to the hydrological regime in rivers and the tidal regime in coastal and transitional waters. The hydrological regime for lakes must therefore be continuously monitored throughout the monitoring year
In practice, continuous monitoring is often translated into a 10 or 15 minute average, an hourly or a daily average. The choice depends on the variation in the process to be monitored. Normally, the water level of a river without tidal influence will fluctuate less than a river with tidal influence. On a tidal river, a 10-minute average value for the water level is therefore recorded every 10 minutes; on a non-tidal river a 10-minute average value is recorded every hour.
The continuous monitoring of a quality element often needs the construction of a robust assessment apparatus. It is not realistic to use this monitoring apparatus for only 1 monitoring year within the planning period of 6 years. It is much more sensible and probably desirable from the point of view of statistical reliability to monitor continuously during the entire planning period.

In many European countries surveillance monitoring is carried out in rotation; measurements are taken annually. The efficiency and effectiveness of keeping the monitoring methods operational would benefit greatly from regularly recurring monitoring efforts such as in a rotating monitoring programme; the quality of implementation is enhanced with routine use.
If a rotating monitoring network is used, it is recommended to monitor all the chemical, biological and hydromorphological quality elements within one representative water body (read: at one monitoring location) in the same year. This is compulsory for the biological and general physico-chemical parameters.

The WFD requires that surveillance monitoring monitors all general physico-chemical parameters, priority and other polluting substances for one year during the period of the river basin management plan (= 6 years). For priority and other polluting substances applies that if a good status was shown for a substance in the last surveillance monitoring and this substance is not discharged, surveillance monitoring is carried out once per three river basin management plans or once in 18 years.

5.3 Quality elements and surveillance parameters

Which parameters are monitored?
For surveillance monitoring all the quality elements must be monitored that are available in the assessment tools. At this moment only the assessment tools for natural waters have been fully developed. When validating these assessment tools, the sub-assessment tools for a certain type of waters can be modified or dropped. When drawing up MEPs/GEPs for artificial and significantly changed waters, the sub-assessment tools can also be dropped. This means that in most Dutch waters - because they are mostly artificial or significantly changed – deviations/reductions will be found in the biological parameters to be monitored (read: fewer sub-assessment tools) as compared to the natural waters. However, each biological quality element must be measured at a surveillance location. This means that sub-assessment tools may be dropped from the MEP/GEP, but quality elements as a whole may not.

5.3.1 Biology

Main characteristics of the biological quality parameters according to Dutch assessment tools:

Phytoplankton:

- M (lakes), O (transitional) and K (coastal) types: chlorophyll (biomass), species composition and abundance. Determination down to species level. In fresh water the assessment tool uses positive and negative indicators in the form of desmidian algae and algal bloom; in saline waters *Phaeocystis* are a negative indicator.
- PLEASE NOTE: The sampling of desmidian algae can best be combined with the phytobenthos monitoring network.

Phytobenthos (diatom algae):

- R and M types: species composition and abundance. Determination down to species level. Assessment tool uses positive and negative indicators. Limited to benthic diatom algae.

Macrophytes (water plants):

- R and M types: species composition and abundance. Determination down to species level. Abundance per growth form (submerged, floating, emerged water plants, flab, duckweed and riparian plants).

Angiosperms (water plants):

- O and K types: species composition and abundance. Determination down to species level (especially the sea grass vegetation).

Macroalgae (seaweeds):

- O and K types: species composition and abundance. Determination down to species level.

Benthic invertebrates:

- R, M, O and K types: species composition and abundance. Determination down to species level. Assessment tool uses dominant negative, dominant positive and characterising taxa.

Fish:

- R, M, and O types: species composition, abundance and age structure (transitional waters excepted). Assessment tool uses 5 ecological groups (limnophyles, oxygen tolerance, perch/roach, part benthivores, part piscivores).

5.3.2 Chemistry

At this moment (30 June 2005) environmental quality objectives and environmental quality standards have been established at EU level for 18 substances from earlier guidelines (see WFD appendix IX), 9 of which are priority substances. The other 24 priority substances cannot yet be added to that list, as the EU standards have not yet been established. These are expected in the autumn of 2005. The 'other polluting substances' are substances which are discharged in significant quantities but for which no EU standard has yet been established. The third and last group of substances concerns the so-called 'general physico-chemical parameters' that are supportive of biology, such as nutrients and oxygen content. As long as no water type-differentiated standards have been derived for these substances, the numerical values from the NW4 must be used.

The following selection criteria are based on the above-mentioned substance groups (source: Manual Water Framework Directive):

- The explicit appearance on an EU substance list (in the order of degree of seriousness: priority dangerous > priority > others);
- Exceedance of the emission limit values in g/ton production mentioned in EU directives (76/464/EEC daughter directives) (WFD appendix IX);
- Evident exceedance of the water quality objectives (environmental quality requirements adopted in the Regulation Environmental Quality Requirements, otherwise the MTR and VR values will be provisionally employed for this purpose);
- A clearly increasing trend for concentrations found in the water body;
- An uncertain situation, hence the substance is included as a precautionary measure (because the detection limit > standard, for instance);
- Discharged into a water body in significant quantities.

Priority substance (diagram 2; block A1)

These substances are described in the WFD. Substances in this list need not be monitored if it can be explained that they are not present in the river basin (on the basis of monitoring or discharge data, for example).

Other polluting substances (diagram 2; block A2)

There is still a lack of clarity about the definition of 'other polluting substances'
The black list given in Council Directive 76/464/EEC is used as a guideline for the other polluting substances in the main waters. The Supreme Court's Scheldt Ruling makes it clear that the other water systems in the Netherlands must also be monitored in respect of these substances.
For each river basin, the international committees will establish a list of the relevant substances that also determine the choice of substances in the river basin if they are discharged (see appendix 3A for an overview of the substances relevant for the river basins.).

In all cases one list ultimately remains of priority substances that must be monitored 12x per monitoring year, and one shorter list of other substances that must be monitored 4x per monitoring year.

General physico-chemical parameters (*supportive of biology*; diagram 2; block B).

The compulsory physico-chemical parameters set by the WFD concern temperature, oxygen, salinity, pH value, nutrients (total P, total N, diluted inorganic P and diluted inorganic N) and transparency. These WFD parameters are compulsory for the M, O, K en R types, with the exception of transparency which is not compulsory for the R types and the pH parameter, which is not compulsory for the O and K types (see also appendix 3A).

Compulsory general physico-chemical parameters	Lakes	Rivers	Transitional waters	Coastal waters
Oxygen content and/or saturation	yes	yes	yes	yes
Temperature	yes	yes	yes	yes
Salinity	yes	yes	yes	yes
Concentration of total phosphorus	yes	yes	yes	yes
Concentration total of nitrogen	yes	yes	yes	yes
Concentration of diluted inorganic phosphorus (DIP)	yes	yes	yes	yes
Concentration of diluted inorganic nitrogen(DIN)	yes	yes	yes	yes
Transparency	yes	no	yes	yes

pH value	yes	yes	no	no

According to Guidance Monitoring, physico-chemical parameters that are deemed not to be useful may be monitored less often, provided that this is well founded.

5.3.3 Hydromorphology

The tables below represent the parameters for monitoring in respect of surveillance monitoring hydromorphology in flowing waters, lakes, coastal and transitional waters respectively.
The compulsory quality elements from the Water Framework Directive are taken as a starting point for the tables. One or more indicators are given for each quality element and these are compared with other systems or regulations (CEN documents, e.g. CEN guidance standard for assessing the hydromorphological features of rivers (CEN TC 230/WG 2/TG 5: N32) and the draft CEN Guidance on Assessing River Quality based on hydromorphological features (CEN TC 230/WG 2/TG 5: N48), RWSR, EU Guidance on Monitoring). The values and indicators for hydromorphological quality elements mentioned in References and Draft Assessment tools for Natural waters are also included, and where possible directly adopted. There are two types of indicators. On the one hand there are indicators that basically represent the hydromorpholical functioning (such as depth division, water balance). On the other there are a number of indicators that are strongly linked to human intervention (such as % length of artificial embankment).

The approach is to do as little as possible, but what is done must be in accordance with all the available guidelines, so as to obtain a proper picture of the hydromorphological situation. That is why a qualitative estimate suffices for a large number of parameters. In many cases, only one overall inventory will be necessary, after which only the changes will be registered. Finally, it can be remarked that the information necessary to determine the parameters is already available, particularly for the main waters. The designated parameters therefore correspond well with current monitoring practices.

Streams, rivers and tidal rivers

Table Quality elements and parameters surveillance monitoring hydromorphology for streams, rivers and tidal freshwater rivers.

Quality element	**Sub-elements**	**Parameter**
Continuity		1. Number, location and possibility to cross barriers 2. Accessibility/connectivity for fish
Hydrological regime	Quantity and dynamics of the water flow	3. Water level 4. Discharge, current velocity 5. Degree of free run-off 6. Degree of natural discharge pattern 7. Tidal features: (tidal rivers) a. Slack tide b. Tidal amplitude c. ratio of horizontal tide
	Connection with groundwater bodies	8. Groundwater level
Morphological conditions	Variation of depth and width of the river	9. River course 10. Cross section and degree of naturalness
	Structure and substrate of the river bed	11. Presence of artificial river bed 12. Degree of naturalness in substrate composition of the river bed 13. Erosion/sedimentation structures
	Structure of the riparian zone	14. Presence of embankment zone 15. Land use of embankments 16. Land use of flood plain/river valley 17. Possibility for entirely natural inundation 18. Possibility for entirely natural meandering

Lakes

Table Quality elements and parameters surveillance monitoring hydromorphology for lakes.*

Quality element	**Sub-elements**	**Parameter**
Hydrology	Quantity and dynamics of the water (water balance) Residence time, connection with groundwater	1 Downward seepage 2 Seepage 3 Precipitation 4 Evaporation 5 Supply (per significant source) 6 Discharge (per significant object) (all in m3y-1 per post)
	Water dynamics	7 Mean summer level with 10 and 90 percentile (m with respect to Amsterdam Ordnance Level (NAP) 8 Mean spring level with 10 and 90 percentile (m with respect to Amsterdam Ordnance Level (NAP)
Morphology	Depth variation	9 Depth division in Frequency division (in steps of 0.25 m)
	Quantity, structure and substrate of bed	10 Soil type (in % of the WB surface with dominant stone, gravel, clay, sand, and organic substances, water content)
	Bank structure	11 Contribution to Bank length (% unnatural) 12 Gradient bank

* In principle, the indicators can also be used for saline lakes. It should be borne in mind that most saline lakes do not have a natural origin and are initially from another classification, viz. a coastal or transitional water. It is quite possible that indicators will also be suitable for lakes. It is, however, important to also check the list of indicators for coastal or transitional waters in the case of such lakes.

Coastal and transitional waters

Table Quality elements and parameters surveillance monitoring hydromorphology for coastal waters.

Quality element	**Sub-elements**	**Parameter**
Tidal regime	General	1. Tidal amplitude 2. Discharge flow of freshwater
	Velocity wave	3. Wave climate category
	Dominant direction of flow	4. Dominant direction of flow and current velocity
Continuity		
Morphology	General	
	Depth variation	5. Water depth variation 6. Hypsometric curve or depth division
	Structure and substrate of bed	7. Type of soil (natural, artificial) 8. Composition of substrate
	Structure of the tidal zone	9. Type of inter tidal area (banks, tidal flats, dry shoal) 10. Type of bank (natural, artificial) 11. Coast and embankment zone 12. Land use of tidal zone

Table Quality elements and parameters surveillance monitoring hydromorphology for transitional waters.

Quality element	**Sub-elements**	**Parameter**
Tidal re-gime	General	1. Tidal amplitude
	Freshwater flow	2. Discharge flow of freshwater 3. Ratio of horizontal tide
	Velocity wave	4. Wave climate category
Morphology	General	
	Depth variation	6. Water depth variation 7. Hypsometric curve or depth division
	Quantity, structure and substrate of the soil	8. Type of soil (natural, artificial) 9. Composition of substrate
	Structure of the tidal zone	10. Type of inter tidal area (banks, tidal flats, dry shoal) 11. Type of bank (natural, artificial) 12. Coast and embankment zone 13. Land use of tidal zone

5.4 Sampling and analysis methods

5.4.1 Biology

Strategy in respect of sampling and analysis methods
The WFD requires representative samples of biotopes that occur over significant surface areas. The species composition and abundance is therefore determined with the help of a representative random sample. The aim is not to spell out the complete species diversity. Rules of thumb for representative sampling are given in the text of paragraph 5.1.4 .

There are not yet many European (CEN) standards available for hydrobiological monitoring. Standards that are available include, for example, a Guidance for Electric Fishing and two Guidances for Sampling Benthic Invertebrates. In addition, a Guidance on the Scope and Selection on Fish Sampling Methods and a Guidance for Phytoplankton Analyses are currently being drawn up.

5.4.2 Chemistry

Strategy in respect of analysis methods
Analysis methods need not be carried out in accordance with any particular standard regulations. The quality of the applied analysis methods is guaranteed by monitoring the performance features (in particular, determination limit, monitoring defect, selectivity) of the applied methods. This is how the laboratories have some leeway to apply innovative techniques that are able to supply more reliable results than is currently possible with the standardised methods.

Choice of compartment
A draft EU Directive is being prepared for priority and other polluting substances (status was not yet clear in June 2005). This proposal (which has been distributed to and commented on as a non-paper by groups of experts) comprises standards for metals (and their components) in water (diluted) and for organic micro-pollutants in total water. An operational definition has been formulated for dilution that connects with monitoring practice (filter through 0.45 µm filter). Organic micro-pollutants must be monitored in unfiltered water.
Note: This may lead to insufficient information if the analysis detection limit in water is too high to allow comparison with the standard or even to make the substance visible.

5.5 Summary biological monitoring programme

Quality element	Minimum WFD frequency within monitoring year (1 monitoring year per 6 years (= planning period))	freq. (per monitoring year) as a result of assessment tools	What to monitor? *)
Lakes			
Phytoplankton	2 x between 1 April and 30 Sept.	6 x	S,A,B
Desmidian algae	1 x	1 x	S, A
Phytobenthos	1 x between 1 April and 1 June	1 x	S, A
Macrophytes (riparian plants included)	1 x between June and August	1 x	S, A
Benthic invertebrates	1 x in the spring	2 x (spring and autumn)	S, A
Fish	1 x	1 x	S,A,L,(B)
Rivers			
Phytoplankton			B
Phytobenthos	1 x between 1 April and 1 June	1 x	S, A
Macrophytes (riparian plants included)	1 x between June and August	1 x	S, A
Benthic invertebrates	1 x in the spring	2 x	S, A
Fish	1 x	1 x	S,A,L
Transitional waters			
Phytoplankton	2 x	6 x	S,A,B

Benthic invertebrates	1 x in the spring	2 x	S, A
Angiosperms	1 x	1 x	S, A
Macroalgae	1 x	1 x	S, A
Fish	1 x	2 x	S,A,L
Coastal waters			
Phytoplankton	2 x	6 x	S,A,B
Benthic invertebrates	1 x in the spring	1 x	S, A
Angiosperms	1 x	1 x	S, A
Macroalgae	1 x	1 x	S, A

*)S = Species composition, A = Abundance, L = Age structure, B = Biomass

6. OPERATIONAL MONITORING

6.1 Introduction

Objective

Operational monitoring has two objectives (Guidance on Monitoring):

1. to monitor the condition of the water bodies that are considered at risk (read: have a poor or moderate status and may therefore not achieve their 2015 objective);
2. to establish the effect (and not the extent!) of the measures taken to improve the status.

A distinction must be made between the good chemical and the good ecological status.

Differentiation

Operational monitoring does not aim to assess the effect of each measure separately, but the effect of the combination of measures in respect of the condition of the water body. Monitoring does not consider the extent of the measure taken.

Operational monitoring is carried out in water bodies:

- for which it is known that they are in danger of not reaching the environmental objectives in accordance with the significant antropogenous loads (risk assessment in 2004) and/or
- for which there are indications from surveillance monitoring that they are in danger of not achieving the environmental objectives and/or
- in which substances included in the priorities list are discharged.

Operational monitoring only focuses on the parameters, which can best indicate the changes in a poor status. They can be chemical, hydromorphological and biological parameters. To assess a good ecological status/potential, at least one biological parameter must be included (guidance).

This chapter includes a step-by-step plan by which a water manager can check whether, how and where operational monitoring should be carried out. With the help of this step-by-step plan, an analysis can be made of a river basin on the basis of which a specific, problem-oriented operational monitoring programme can be drawn up. The 2004 risk assessment is used for this analysis and an overview is drawn up of the most important pressures and measures to be taken. This also establishes which biological parameters are related to which pressures. The paragraphs below explain the various stages of the step-by-step plan. To clarify the effect of these guidelines, five cases have been schematically elaborated as to how a certain water bodies or group of water bodies are selected for monitoring. One of these cases has been included in the main text.

6.2 Step 1 Operational monitoring: Yes / No?

This concerns the decision whether or not operational monitoring must be carried out in a water body. For this purpose it must be known whether a water body is at risk, or is in danger of not achieving the 2015 objective. To carry out an 'at risk' assessment or risk analysis, information is needed about the type of water and status of the water body; information is also needed about the pressures, the objectives and the chemical and ecological test results.

The 'at risk' assessment is an estimate, as it concerns the expected status in 2015 and is therefore dependent on the estimate of the realisation and the effect of the measures. In accordance with the Guidance Monitoring, the starting point for the operational monitoring is, however, the actual status at this moment in time. In other words: as long as the chemical and ecological quality elements do not comply with the necessary standards or objectives, a water body is at risk and operational monitoring is required. The programme for operational monitoring can, however, be modified during the planning period (6 years) if there is reason to do so from the viewpoint of monitoring results. The monitoring frequency can be reduced, for example, when an effect is no longer deemed to be sig-

nificant or the load in question has been eliminated. This applies when at least a good ecological status has been achieved. As soon as the 'Good Status' has actually been achieved, the operational monitoring can be completely stopped (Guidance on Monitoring) and surveillance monitoring will suffice. Diagram 3 in paragraph 2.2 gives insight into the assessment of human pressure.

6.3 Step 2 Clustering of water bodies

6.3.1 Ecological status (biology, chemistry, hydromorphology)

Biology, general physico-chemical and hydromorphology

The WFD and the Guidance on Monitoring clearly indicate that not all water bodies that are at risk need to be monitored, but clustering can take place on a basis of similarity in the river basin, pressure and ecological, morphological and hydromorphological functioning. This means that monitoring can take place in one water body or a cluster of water bodies; this cluster can sometimes contain various types of water. Clustering occurs mainly in respect of pressure. The effect of the pressure, or the measures taken, on the cluster is monitored in a selected water body (monitoring location). Assessment is carried out with the assessment and sub-assessment tools for the relevant type of water. Water bodies can be clustered if the problems in respect of pressure correspond or almost correspond. Special attention must be given to the pressures that should be dealt with as a priority and that are the most problematic in respect of achieving the objectives of the water bodies and the clusters of water bodies.

Clustering must fit in with the scale level at which measures have effect. Thus if the most important pressures are at a regional level (such as pre-contamination with substances) the effect of the measures must be noticeable at a regional level and water bodies in that particular river basin must be combined (if they share ecological features, hydrological coherence, etc.). If, however, the most important limiting pressures are local, then the measures will have to have local effect; consequently they must be monitored at a local level, in which case clustering will most probably not be possible.

Clustering of water bodies can not cross boundaries (Rhine, Meuse, etc.) and generally speaking they do not cross the limits of hydrological units; unless there is some hydrological coherence between the water bodies. The water bodies must influence each other at least in one direction. In this context, hydrological units are, for example, the Dommel, Overijsselse Vecht, Dinkel, but also drainage units such as the Amsterdam or Frisian catchment basins. Exceptions are possible in the latter case, if various hydrological units are subject to the same generic pressures (and measures). This can, for example, be the case in agricultural areas where the manure and fertiliser policy plays an important role. One water body can in such cases be made representative of a cluster of hydrological drainage units.

In essence, the clustering in surveillance monitoring (biology) works differently, because no attention is paid to the pressures that are present or to the division of the monitoring operations over the major types of water.

Small water bodies

As these guidelines have pointed out above, small water bodies (<0.5 km^2 (lakes) or <10 km^2 river basin (rivers) need not be included in the monitoring. There are, however, 2 exceptions. One exception is dealt with under step 2a. The other exception is when the water body in question is of considerable importance to the river basin, so that pressures will also effect a major part of the river basin as a whole. An example is the spawning grounds of fish.

Other polluting substances (chemistry)
For this part see the clustering of water bodies for the purpose of the chemical monitoring of priority substances described below. A distinction can be made in load caused by point sources and diffuse sources.

In the case of a significant load of substances from **point sources**, sufficient locations must be found to assess the effect of these point sources. If multiple point sources are present, a location must be selected that is representative of the load on the entire water body or cluster of water bodies.
For more detailed information about the load from point sources, it should be noted that the information from sewage studies is of a better quality than the monitoring data of surface water.
In the case of a significant load from **diffuse sources**, a location must also be selected that is representative of the load of the entire water body or cluster of water bodies.

6.3.2 Chemical status (chemistry)
Operational chemical monitoring must be carried out in all the water bodies in which priority substances are discharged in significant quantities. The nearest surveillance chemical locations are deemed sufficient to give a reasonably representative and average picture for these substances (see also paragraph 5.1.2). The significant discharged priority substances in these surveillance locations must be monitored with an operational frequency (6 years of monitoring with a frequency of 12x a year instead of 12x monitoring in 1 monitoring year of a 6 years period).

Step 2a. Operational monitoring: WFD and Protected Areas

What needs additional monitoring if one or more Protected Areas (PA) are in or near[1] a water body?

The text of the Water Framework Directive has the following to say about monitoring in protected areas:
"The Member States are responsible for the drawing up of programmes for the monitoring of the water status, in order to obtain a coherent total picture of the water status within each river basin district. For protected areas, programmes are supplemented by the specifications in the Community legislation pursuant to which the individual protected areas have been established (Article8)."
With respect to supplementary monitoring requirements for protected areas, there are explicit supplementary requirements regarding drinking water and the areas under the EU Bird and Habitat Directives. About the latter the following is stated: "If water bodies constitute such areas, they will be included in the programme for operational monitoring if there is the chance, pursuant to the effect assessment and the monitoring with a view to monitoring, that the environmental objectives as stipulated in article 4 are not achieved. Monitoring is carried out in order to assess the extent and the effect of each relevant load of those bodies and, if necessary, the changes resulting from the programme of measures in the status of those bodies. The monitoring will be continued until the areas comply with the regulations in respect of water of the regulation of which they are part and the objectives of article 4 have been achieved (Appendix V, 1.3.5)."

In spite of the fact that the text is not very explicit, it can be assumed that supplementary requirements will also be set for monitoring in other types of protected areas. Reports must be submitted, whether or not the objectives have been achieved. The Guidance on monitoring for the WFD specifies that the WFD monitoring must be supplemented by the monitoring (and reporting) that is a requirement for the protected areas.

[1] It concerns water bodies where protected areas are situated in the water body, overlap, or directly depend on the water body in question.

Protected Areas (PA) are the areas that are protected under the:
- Fishing water directive (78/659/EEC)
- Birds Directive (79/409/EEC)
- Habitat Directive (92/43/EEC)
- Drinking Water Directive (80/778/EEC), as amended by (98/83/EU)
- Bathing Water Directive (76/160/EEC)
- Shellfish waters Directive (79/923/EEC)
- Urban Waste-water Treatment Directive (91/271/EEC)
- Nitrates Directive (91/676/EEC)

The Protected Areas Register holds small bodies of groundwater that have been designated as protected drinking water areas (approx. 350). As far as surface waters are concerned, only the drinking water intakes (approx. 45) have been mapped out. Within the framework of the Birds and Habitat Directives protected areas have been designated and registered. About 640 locations have been designated as bathing water. The Shellfish waters Directive applies to the following areas: Westerschelde (west of Hulst), Oosterschelde, Grevelingen, Voordelta and Wadden Sea.

(NB. The Netherlands has not designated any protected areas for the Nitrates and Urban Waste-water Treatment Directive, because it has undertaken to apply the requirements of these Directives to all its areas. For these Directives applies that the relevant monitoring requirements must be immediately implemented in the WFD monitoring programme; for these Directives apply for all areas.)

In relation to the protected areas, the above means that the following steps must be completed by the water manager (from a WFD perspective):

1. Are there one or more protected areas in the water body or cluster of water bodies? Or are there one or more protected areas directly dependent on the water body or cluster of water bodies? If not, supplementary monitoring is not necessary.
2. If yes, is there a chance that the PA objectives will not be achieved, and are the most important causes for not achieving the objective water or groundwater related? Go to 3.
   If not, surveillance monitoring will be sufficient. (This is often difficult to determine in practice. When in doubt assume 'yes'.)
3. If yes, operational monitoring is required. It is possible that supplementary monitoring will be necessary for the protected area.

Size of the water body

The WFD argues that water bodies that are smaller dan 0.5 km^2 (lakes) or 10 km^2 river basin (rivers) do not need to be monitored (and assessed). If there is, however, a protected area that also depends on the quality of a water body, this rule lapses and the quality of the small water body must also be guaranteed. After all, this is important for achieving the objectives of the protected area. The Guidance argues that such a small water body must also be included in the monitoring programme.

6.4 Step 3 What to monitor? (quality elements and parameters)

In this step it is decided which quality elements or parameters are to be included in the operational monitoring programme. This depends, *inter alia*, on whether the ecological status/potential is at risk, the chemical status is at risk or both are at risk.

6.4.1 Ecological status (biology, chemistry, hydromorphology)

If the ecological status is at risk, biological operational monitoring must always be carried out and in many cases also chemical or hydromorphological operational monitoring. In accordance with the Guidance on Monitoring: "the use of non-biological indicators for estimating the status of a biological quality element may complement the use of biological indicators but cannot replace it."

Biology
Steps 1 and 2 will already have shown why the water body is at risk or which pressures are present and which quality elements do not comply with the standards or objectives. Verification is needed whether more instances of pressures or exceedances of objectives exist. If this is the case, the water manager will have to decide what is most important, and reverse / limit pressures with 'no regret' measures (see box). Other pressures, the solution of which is not so simple or is less relevant, will not therefore be included in the initial setup of the operational monitoring; these pressures can be more relevant in the monitoring programme at a later stage (once the 'important' pressures have been eliminated).

'No regret' measures
There is no list with 'no regret' measures at this moment that apply to all the river basins. However, more often it will concern measures that have an impact on a large section of the river basin, which means that it has a strong effect. Possibilities are the introduction of water level measures in lakes or polder areas, the removal of migration barriers in previously freely connecting rivers or streams, the restoration of significant hydromorphological damage such as streams in concrete, the reduction of substantial disturbance such as intensive fishing, the cleaning-up of significant point sources, and the removal of contaminations that cause substances to exceed the standards. Local measures or measures of which the effect is uncertain will not be included, but they may be relevant in the future.

The monitoring must give an impression of the quality of the water body or cluster of water bodies where a certain pressure exists and of the effect of the measures that were implemented. To achieve this it should be determined which biological quality elements / parameters can give the best indication of a poor status or changes in a poor status.
To assist this process the following three tables are included in the document with the step-by-step plan:

- table with classification of types of pressures / loads on the Dutch surface waters (source: area characterisation, scorecards of sub-river basins) including:
    - chemical pressures
        - load with chemical substances (distinction in point and diffuse discharge);
        - load with nutrients and organic substances (distinction in point and diffuse discharge);
    - physical pressures
        - hydromorphological pressures;
        - thermal pressures;
        - other physical pressures
    - (direct) biological pressures.
- table in which the most indicative (read: sensitive / suitable) biological quality element is given per type of pressure for:
    - coastal waters;
    - transitional waters;
    - lakes (distinction between 'real' lakes, canals / ditches / brackish / saline lakes);
    - rivers (distinction between large rivers R7, large rivers R8, small rivers);
- table in which the most indicative (read: sensitive / suitable) hydromorphological parameter(s) is(are) given per type of hydromorphological pressure and per group of water types.

The table with biological quality elements should perhaps be partly split up into parameters or sub-assessment tools (for vegetation, phytoplankton and possibly fish). It is possible that it will be relevant to provide further details in respect of certain pressures.

Chemistry

If a significant chemical pressure of the other polluting substances (A2 substances; see diagram and chapter 5.1.2) or general physical chemical parameters (B substances; see diagram 2 and chapter 5.1.2) is also present within the water body or clusters of water bodies, a chemical operational monitoring of the substances must also be carried out. For the determination of the general physico-chemical parameters reference is made to the tables in 6.4.1. Of the other polluting substances that are discharged, the substances that exceed or threaten to exceed the standard must be monitored.

Hydromorphology
If a significant hydromorphological pressure is also present within the water body and the cluster of water bodies, hydromorphological operational monitoring must also be carried out in addition to the biological operational monitoring, (WFD Appendix V. p. L327/54-55). For this purpose the above-mentioned tables serve to determine which hydromorphological quality element(s) is(are) the most sensitive to the relevant hydromorphological pressure.

Selection of the most sensitive biological quality elements for operational monitoring
The sensitivity of a quality element / indicator for a pressure has different aspects An assessment tool, which only reacts if the human pressure is very low, can be considered 'highly sensitive'. However, other aspects can also play a role in the selection of indicators, and determine how 'sensitive' an assessment tool is. It is recommended to consider a number of aspects that are determinant for 'the most sensitive indicator':
-the degree to which an indicator reacts;
-the degree of precision with which an indicator reacts;
-the degree to which the indicator is the most critical;
-the time scale by which an indicator reacts.
On the basis of these criteria, a rough estimate can be made of which indicators are most useful to start using for operational monitoring of the various human pressures. It must ultimately also remain possible, however, to select a certain parameter from a biological quality element on the basis of sensitivity. This explanation will show that specialised interventions will be necessary and that regional knowledge is also needed to select the best indicators. The validation of the assessment tools must further underpin and justify the choice of indicators before they are used in operational monitoring. It is our hypothesis that in view of the Dutch input in monitoring waters, the current monitoring programme will be more than adequate for the organisation of the operational monitoring programme.

To show the degree of the reaction and the precision of an indicator, a fictive example has been elaborated in *figure 1*. The example shows that the response of an indicator covers the entire quality range but, in the case of random pressure, a great many variations are possible in the biological quality. This variation can be the result of all kinds of causes and need not always be caused by a shortcoming in the indicator. Another possibility is that the indicator value does not reveal a great deal of variation in the case of a particular human pressure, but that not all quality categories are being covered. The sensitivity is then in fact not so great, because the extent of the indicator change is insignificant in great changes in particular human pressure. In that case the indicator is also responsive to other human pressures. Ideally both characteristics would be combined in one indicator and the best indicator is the one that is most accurate with the greatest change to human pressure.

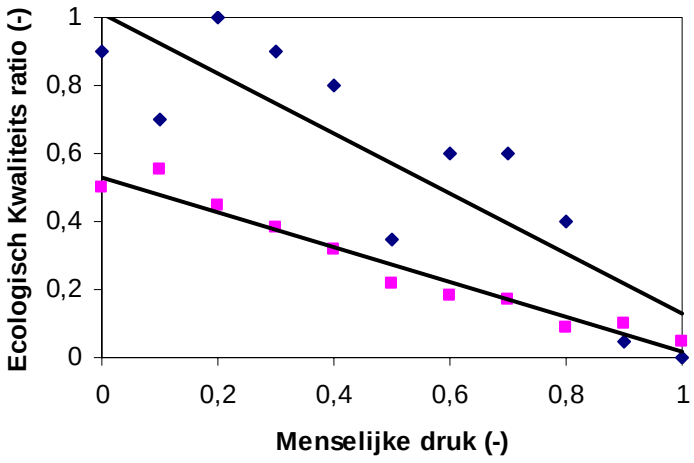


Figure 1. Fictive example response of the two quality elements to specific human pressure. The response is strong, but shows a low precision (blue). The response is weak, but shows a high precision (red).

A third aspect of being most sensitive, is whether the indicator is the most critical one. This will be abundantly clear in some of the cases. A river dam will mainly form a barrier for migrating fish, for example, but it will not create a barrier for plants or benthic invertebrates. Fish will therefore be the most critical quality element. It becomes more complicated if the dam also affects the natural discharge pattern and/or current velocity. These changes can, in fact, be considered another aspect of the human pressure, so that, if necessary, additional parameters must still be monitored. This could be fish again, but it is more probable that macrophytes or benthic invertebrates are more sensitive to changes in current velocities than fish. Another aspect that can be considered is that for some normative descriptions, such as phytoplankton, the quality is being compared to the quality of other biological quality elements. The phytoplankton status indirectly gives an indication for some other quality elements. This may play a role in the selection.
In most cases the lowest scoring quality element will also be the most critical. It is obvious that a different indicator must be selected if it can be reasoned that another indicator is more critical after all, because - for example - the relation between indicator and pressure is not always linear.

The fourth sensitivity aspect explains the differences in the speed at which indicators react to changes in human pressure. The speed with which an indicator reacts will in general be closely connected to the generation time of the organisms used for calculating indicator values. But dispersion speed also can influence the reaction speed of an indicator. The differences in generation times between the four biological elements are substantial. Phytoplankton has a generation time of a few hours, whilst fish may take several years. Macrophytes (angiosperms and macroalgae) and benthic invertebrates lie somewhere in between. This wide difference in generation time has a profound effect on the speed with which the quality elements will react to human pressure. Phytoplankton can in fact vary from day to day, while the abundance of macrophytes will hardly change in the course of a year, with the exclusion of the natural summer peak. Different quality elements not only express different matters, but also the different periods that precede sampling.

6.4.2 Chemical status (chemistry)

If the chemical status is at risk, chemical operational monitoring must be carried out (this has nothing to do with the ecological status).
For chemical operational monitoring the following parameters from the earlier mentioned two monitoring objectives (see paragraph 6.1) must be monitored.
Objective 1 – status:

- all priority substances (with EU standard) that are discharged;
- all other polluting substances (with EU standard) that are discharged in significant quantities or do not comply with the environmental quality requirements (see paragraph 6.1).

Objective 2 – effects of measures:

- priority substance (with EU standard) at which measures are aimed.
- other priority substance(s) (with EU standard) at which measures are aimed.

6.5 Step 4 Monitoring: where? (choice of monitoring points within the water body (cluster))

6.5.1 Ecological status (biology, chemistry, hydromorphology)

Biology
The choice of monitoring points within the cluster of water bodies has been specified in paragraph 5.1.4 and appendix 4B. The general physico-chemical parameters are linked to the locations for phytoplankton or phytobenthos. To some extent the sampling strategy depends on the field techniques to be used.

Chemistry
General physico-chemical parameters (supportive of biology)
Monitoring the general or biology supportive physico-chemical parameters supplements the biological monitoring. The general physico-chemical parameters must be monitored in the water body where the biological monitoring also takes place. The monitoring must be carried out as much as possible in the same year and where possible at the same location, as where biology is monitored (at any rate it must be representative of the monitoring points where biological monitoring takes place). A recommended strategy is to monitor these parameters from the same monitoring points and at the same time as the phytoplankton or phytobenthos parameters.

Other polluting substances (chemistry)
See paragraph 6.3.1.

Hydromorphology
p.m.

6.5.2 Chemical status (chemistry)

See paragraph 6.3.2.

6.6 Step 5 Frequency of monitoring (choice of frequency)

"For operational monitoring the Member States themselves establish the required frequency of monitoring for each parameter with a view to sufficient data for a reliable assessment of the status of the quality element involved." The table below gives the minimum frequencies for the planning period of six years. The frequency can be lowered if it can be proved that an effect is not significant or the load involved has been eliminated. (WFD Appendix V, par. 1.3.4 monitoring frequency)

*Table showing the minimum total number of monitoring **per planning period of 6 years** for the different quality elements. The green columns show the minimum number according to the WFD; the adjoining white column shows the minimum number, possibly increased as a result of the assessment tools.*

Qual. Elem.	**Rivers WFD**	**Rivers Assessment tool**	**Lakes WFD**	**Lakes Assessment tool**	**Transit. w. WFD**	**Transit. w. Assessment tool**	**Coastal w. WFD**	**Coastal w. Assessment tool**
Ecological status								
Biology								
Phytoplankton:	12*	36 #	12	36	12	36	12	36
Phytobenthos	2****	2	2	2				
Macrophytes/angiosperms/macroalgae	2	2	2	2	2	2	2	2
Benthic invertebrates	2	4 ##	2	4 ##	2	4 ##	2	2
Fish	2	2	2	2	2	4 ###		
Chemistry								
General Physico-chemical								
Thermal conditions	24**	24	24	24	24	24	24	24
Oxygen supply	24	24	24	24	24	24	24	24
Salinity	24	24	24	24	24	24	24	24
Nutrients	24	24	24	24	24	24	24	24
Acidification status	24	24	24	24	24	24	24	24
Other polluting substances	24	24	24	24	24	24	24	24
Hydromorphology								
Continuity	1*****	1						
Hydrology	Continuous	Continuous	72***	72				
Morphology	1	1	1	1	1	1	1	1
Chemical status								
Priority substances	72***	72	72	72	72	72	72	72

* = each half year (2/yr x 6 years=12);
** = each quarter (4/yr x 6 years= 24);
*** = monthly (12/yr x 6 years= 72);
**** = once per 3 years (=2)
**** = once per 6 years (=1)
# u/i ### these numbers are based on the assessment tools used to assess the status of the water (version Dec. '04). # phytoplankton 6 times in the year (summer half year) yearly (= 36)
benthic invertebrates twice a year (spring and autumn) every 3 years (except for coastal waters) (= 4)
fish in transitional waters twice a year every 3 years (= 4)

Explanation of the table of monitoring frequencies.

These frequencies will generally suffice to monitor the status of the water body and cluster of water bodies at risk. This frequency will most certainly not suffice, however, for detecting trends as a re-

sult of measures intended or already taken. To be able to make statistically relevant statements about the changes (trend) as a result of the measures taken, a higher frequency will generally be needed. A statistical test can be useful to establish which frequency is required for which exact situation. The aim of this test must be that the critical limit between the categories good and moderate is statistically significant.
The table includes the monitoring frequencies for a number of elements that are prescribed by the assessment tools. It is recommended to use these monitoring frequencies, because no correct assessment can be carried out on the basis of a lower frequency.

6.7 Step 6 How to monitor? (sampling and analysis methods)

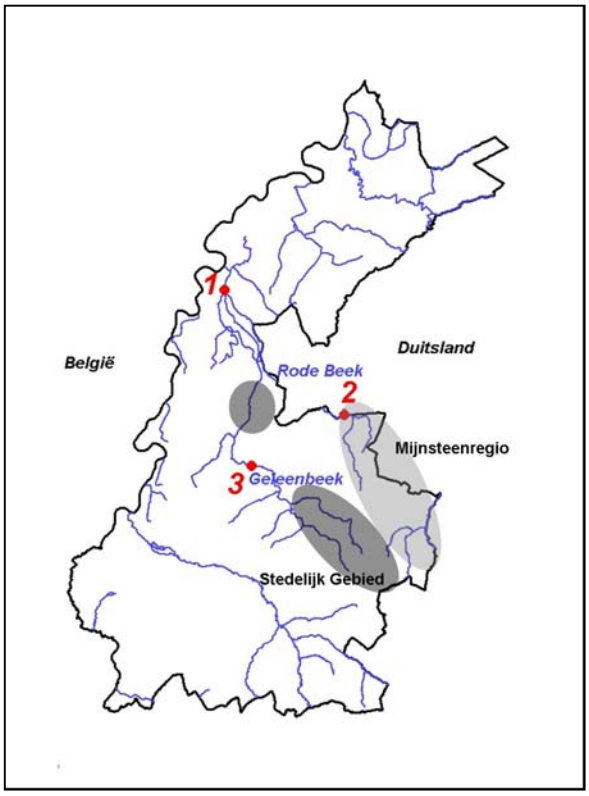
Biology
See: under surveillance monitoring (§ 5.1.4)

Chemistry
All WFD monitoring must take place in total water, as long as there are no standards for suspended matter at an EU level.

6.8 Example of elaboration of step-by-step plan. Rivers: Case Geleenbeek

An other case (Afgedamde Maas) is te be found in the annex.

The area:
The Geleenbeek in the province of Limburg rises from a few springs and a pond south of the town of Heerlen. The Geleenbeek takes its water from a large number of small tributaries such as the Retersbeek, Hulsbergerbeek, Caumerbeek, Platsbeek, Middelsgraaf and the larger Rodebeek. The Vloedgraaf is a water course that takes some of the flows from the Geleenbeek and the Rodebeek.



The Geleenbeek is largely regulated and tiled and covered or roofed in places. A great deal of discharge overflow occurs into the Geleenbeek. In addition, the effluent from three Sewage Treatment Plants (STP) is discharged into the Geleenbeek. This largely determines the discharge flow of the Geleenbeek. The Rodebeek forms a separate sub-flow area of the Geleenbeek. The Geleenbeek is further affected by various pit stone dumpings, resulting in seepage with a high sulphate content and heavy metals. Downstream from Millen the water quality of the Rode Beek is predominantly determined by the water from the Saeffelerbeek. The nutrient issue is also important here, as it is in the rest of higher situated Holland. More specific for the Geleenbeek and to a lesser extent for the Rodebeek are the problems as a result of their historic use as drains for the mining industry, and the current urbanisation, resulting in stream regulation (morphology), sewage overflows and discharges from STPs.

Figure. River basin of the Geleenbeek in the province of Limburg and the location of the urban areas (dark-grey) and the pit stone areas (light-grey). The large stream at the bottom of the figure is the river Geul which is not included in this case. This also applies to the streams at the top of the figure (on the right above the red '1'). Points 1, 2 and 3 are explained in the text.

STEP 1. OPERATIONAL MONITORING: YES / NO?

The problems of the water bodies in the area are mapped out at this stage, and the risk analysis is used as source.

The 2004 risk assessment shows that nearly all water bodies are at risk. This is caused by:
- Chemical loads; sulphate and heavy metals from the former mining industry (diffuse), agriculture
- Hydromorphological loads; regulation, covering or roofing, peak discharges, no connectivity for fish
- Nutrient loads and organic load; STP (point), sewage overflows and agriculture (diffuse)

Is operational monitoring in this water body or system of water bodies necessary?
Yes

STEP 2. CLUSTERING

The Geleenbeek (see figure) is a water with ecological, agricultural and recreational (angling) functions. It is part of the Provincial Network of Important Ecosystems. There are also other streams in the figure, but this is only relevant to the river basin in which 'Geleenbeek' is shown in blue. The table shows which water bodies are situated in this river basin.
Considerations around this clustering are that all water bodies are affected by the same pressures outlined in step 1 above: they are connected, are similar in respect of ecological functioning, and are situated in the same hydrological unit (and river basin).

STEP 3. WHAT IS MONITORED?

In this step we focus on the 'no regret' measures. Only the pressures related to the 'no regret' measures are taken into account. Table 3 tells which biological quality elements are most sensitive to this pressure. This calls for consultation of the table in step 3. In addition, the relevant chemical and hydromorphological parameters must be selected on the basis of the same table.

What does not comply with the objective / standard?

Chemistry : general physico-chemistry, heavy metals, pesticides, relevant priority substances.
Biology : it is probable that no single biological quality element complies with the objective.
Hydromorphology : probably does not comply with the objective.

This is a matter of multiple significant pressures. The most important chemical pressures are the leaching of slag heaps, pollution from urban areas and agriculture. The most important biological pressures are caused by regulation and nutrient loads / organic loads.

Biology
Possible 'no regret' measures are in this case restoration and a reversal of the loads from the STPs, overflows and agriculture. Restoration of the area (re-meandering and construction of fish corridors) has already been planned. The table shows that benthic invertebrates and fish are most closely related to the most important pressures and the most logical and priority 'no regret' measures.

Chemistry
Problem substances must be monitored. These include heavy metals, pesticides, and priority substances that exceed the standard. In addition, the general physical chemical parameters must be monitored. Sulphate must be regarded as an 'other pollutant that is discharged' and as such must also be monitored.

Hydromorphology
Description of location and profile of the stream by map and some cross-sections (morphology). Further hydrology.

STEP 4. MONITORING: WHERE?

(see figure for location of monitoring points)

This step serves to designate the most logical monitoring points for the cluster of water bodies is designated. For chemistry this will indeed concern points, for biology a point is often a larger section of the cluster, or a water body. The dots on the map indicate the presumed centre of the water

body. Some measurements for hydromorphology are restricted to a particular area (cross-sections), but others relate to the entire cluster (map with location and profile).

Chemistry : Monitoring points 1 (physico-chemistry, heavy metals, pesticides, priority substances) and 2 (physico-chemistry, heavy metals) (see figure). Monitoring point 1 is also a surveillance monitoring point and will be extended for operational monitoring. This location gives a good impression of the chemical loads throughout the entire stream system. Monitoring point 2 provides an insight into the chemical leaching from the slag heaps.

Biology : Fish and benthic invertebrates are monitored at monitoring points 2 and 3. The biological quality at these locations is the result of the various influences/pressures, with the emphasis at monitoring point 2 on the pit stone problems and at monitoring point 3 on the urban loads.

Hydromorphology : Description of location and profile of the stream by map and some cross-sections (morphology). Further hydrology.

STEP 5. FREQUENCY OF MONITORING

See § 6.5 (choice of frequency).

STEP 6. HOW TO MONITOR?

See § 6.6 (sampling and analysis methods).

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Annex I
Case Afgedamde Maas (Meuse)for Operational Monitoring

STEP 1. MONITORING YES / NO?

The functions of the Afgedamde Maas are: recreational boating, water supply, agriculture, upstream functions, other leisure activities and inland shipping. Classified as WFD R8 freshwater tidal river.

Is at risk because of:

Diffuse sources: ship-yards and pig farming; Copper (MTR); Tributyltin (FHI) from shipping;

Further, there is **pre-contamination** (upstream supply from Meuse water) for the parameters Zinc (MTR), Nickel (FHI), Benzo(k)fluoranthene, Chlorpyrifos and Diuron (the last two substances can also result from polder discharges (**contamination via neighbouring waters**) from pesticides used in the Bommelerwaard). Diuron levels exceed the drinking water standard, as do Isoproturon and Atrazin.

Nutrient loads via polder water discharges and the supply of Meuse water (**contamination via neighbouring waters and pre-contamination).**

The parameter groups PAHs and PCBs referred to in the risk analysis are only monitored in respect of suspended matter and **are currently not applicable** to the WFD.

Hydromorphological load (weirs and locks/sluices, canalisation, regulation, diking and the connecting and disconnecting of river basins, water-level control).
Dredging operations are carried out regularly in view of de-phosphation for the provision and management of drinking-water supplies.

Is operational monitoring in this water body or system of water bodies necessary?

Yes

STEP 2. CLUSTERING NOT APPLICABLE

STEP 3. monitoring: why and what?

What fails to comply with the standard?

Chemistry : PS (BkF, CpyrP, DIURN, Ni, TBySn).
Ecology: Other polluting substances (Zn, Cu); gen. physico-chemical (P and N and others).
Biology : No parameters currently comply with the requirements, but testing was done on the basis of the assessment tools for natural waters. In view of the construction of fish ladders in the Meuse and the opening of the Haringvliet locks (2008), the fish stocks in the large rivers will comply with WFD requirements in the future. Construction work is still necessary, however, to allow fish in from main to regional waters.
Restoration is a possible measure. In view of the pressures, benthic invertebrates and macrophytes will react best to this type of rehabilitation. Phytobenthos might be a good parameter for monitoring the effects of organic pollution (P and N).
Hydromorphology : No standards have been developed, but this aspect is of vital importance for biological functioning.

STEP 4. MONITORING: WHERE?

Chemistry : Keizersveer (surveillance monitoring point is also usable for operational monitoring).
Biology : 2 locations Getijde Maas (surveillance monitoring for fish) and Afgedamde Maas (operational monitoring, effects and loads phytobenthos, macrophytes and benthic invertebrates).
Hydromorphology :
This section concerns the Afgedamde Maas (south of the Wilhelmina lock at Andel), the Dode Maas tributary and the Heusdensch Kanaal. The Afgedamde Maas (south) has a mean depth of approximately -4.50 m below Amsterdam Ordnance Level (NAP), the Heusdensch Kanaal approximately -3.20 m NAP and the Dode Maas tributary approximately -4.20 m NAP. All three sections seem to have a tendency to become shallow. Some dredging operations are being carried out in the Afgedamde Maas (south) and the Heusdensch Kanaal.

The hydrological situation in this section of the Afgedamde Maas (and the Dode Maas tributary and the Heusdensch Kanaal) are determined by the changes in the water level in the Bergsche Maas. Because of the presence of the Wilhelmina lock the Afgedamde Maas (south) fills up and empties under the influence of tidal fluctuations. If high water levels are expected, the flood defences in the Heusdensch Kanaal are closed so that the water levels will not endanger the dikes.

Description of location and profile of the stream by map and some cross-sections (morphology). Further hydrology.

STEP 5. MONITORING: FREQUENCY?

According to EU regulations/Directives the following monitoring actions are to be carried out:

Biology: Phytobenthos, annually, 6x during the period 1 April – 30 September (WFD 1x in 6 months);
Macrophytes, annually, during the period June – August (WFD 1x in 3 years);
Benthic invertebrates 1x in 3 years during autumn and spring;

Chemistry: relevant priority substances with EU standard; monthly, 12x a year for a period of 6 years;
Ecology: other polluting substances, no EU standard; 1x in 3 months for a period of 6 years;
General physico-chemical parameters; 1x in 3 months for a period of 6 years;

Hydromorphology :
Morphology: Once in 6 years;
Hydrology: concerns the water level at Heesbeen on the Bergsche Maas. Heesbeen is a Main Monitoring Station, hence monitoring takes place non-stop.

STEP 6. MONITORING: HOW?

See the Guidelines

Biology*:*
Phytobenthos; one location per water body is sufficient, multiple (10 to 30 reed stems) natural/artificial substrates are collected from that location.
Macrophytes; the mean high and low water lines in the zone are included (riparian zones and parts shallower than 3 metres). It concerns the intake of plants with floating leaves, submerged water plants, emerged water plants, duckweed, flab and possibly moss. The low-flow sections that are in open connection should also be monitored (secondary channels). The distribution of points is between 20 to 25 km. Line transects are parallel to the river bank.
Benthic invertebrates; standard sampling length of 5 metres, sampling takes place in the spring (?) and the autumn (September and October). All biotopes present are sampled as long as they occur in significant quantities (minimum of 10% of the water body). Samples are taken from the biotope (vegetation, silt/sand, gravel/stones, dead trees) present in each water body. Number of locations?

Chemistry:
In accordance with the Surveillance Directive. All WFD monitoring is required to take place in total water, as long as no standards exist for suspended matter at EU level.

Hydromorphology
In accordance with the Guidelines.