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Transposition and Implementation of the EU Water Framework Directive in Latvia

Technical Report No. 2

Monitoring programmes for surface and groundwater

Final

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List of Abbreviations

BOD	Biologicla Oxygen Demand
CM	Cabinet of Ministers
CIS	Common Strategy on the Implementation of the Water Framework Directive
DANCEE	Danish Co-operation for the Environment in Eastern Europe
DEPA	Danish Environmental Protection Agency
DSD	Dangerous Substances Directive
EC	European Commission
ELV	Emission Limit Value
EIA	Environmental Impact Assessment
EPD	Environmental Protection Department
EU	European Union
FFD	Fresh Water for Fish Directive
LEA	Latvian Environmental Agency
LHMA	Latvian Hydrometeorological Agency
LWM	Latvian Law on Water Management
MoE	Ministry of Environment
RB	River Basin
RBD	River Basin District
RBM	River Basin Management
RBMA	River Basin Management Authorities
RBMP	River Basin Management Plan
REB	Regional Environmental Board
SEI	State Environmental Inspectorate
SGS	State Geological Survey
ToR	Terms of reference
TR	Technical Report
UWWTP	Urban Waste Water Treatment Plant
WB	Water Body
WFD	Water Framework Directive (2000/60/EC)
WG	Working Group
WRUP	Water Resource Use Permit
WQS	Water Qality Standard
WQO	Water Quality Objectives

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1 Introduction

The present report is part of the reporting for the project financed by the Danish Environmental Protection Agency (DEPA):

Transposition and implementation of the EU Water Framework Directive in Latvia.

The report describes the WFD requirements in Annex V on monitoring programmes for surface and groundwater and the links to the Latvian Water law.

The report provides analysis of the monitoring requirements in other water sector directives, evaluates the degree of overlap and discusses possibilities to integrate them into a single monitoring programme.

The report further makes an overall identification of gaps in the present monitoring compared with the monitoring requirements in the WFD, and identifies elements in the present monitoring that can be considered to phase out considering also national needs and monitoring requirements in other directives.

The report is No. 2 in the following list of reports developed by the project:

Technical reports:

- TR 1A: Typology of waters and procedure for characterisation of waters
- TR 1B: Classification and presentation of status of waters
- TR 2: Recommendations for the monitoring programs for surface, coastal and groundwater and CM Regulations on requirements for establishment of monitoring programs
- TR 3: Draft Action Plan on how to define ecological status of fresh and coastal water
- TR 4: Revision of the draft Regulation on WRUP
- TR 5: Elaboration of a specification of requirements and ToR for a data management/information system

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Outputs:

A: Draft legal acts for the transposition of Annexes II and V of the WFD
B: Assistance to MoE in preparation of information material on the WFD
C: Specification of requirements and ToR for a data management/information system

The main basis for the report is the Annex V of the WFD:
Monitoring and presentation of status of surface water and groundwater

The input to the Regulation based on the structure of Annex V in the WFD (sections in italic are covered by the regulation):

1. SURFACE WATER STATUS
1.1. Quality elements for the classification of ecological status
1.2. Normative definitions of ecological status classifications
1.3. Monitoring of ecological status and chemical status for surface waters
1.4. Classification and presentation of ecological status
2. GROUNDWATER
2.1. Groundwater quantitative status
2.2. Monitoring of groundwater quantitative status
2.3. Groundwater chemical status

2.4. Monitoring of groundwater chemical status
2.5. Presentation of groundwater status

Quality elements for the classification of ecological status, normative definitions of ecological status classifications, classification and presentation of ecological status, groundwater quantitative status, groundwater chemical status and presentation of groundwater status will be covered by a new CM regulation on classification of water (see TR1B).

2 The Law on Water Management

The Latvian **Law on Water Management** states the following of relevance to surface and the groundwater characterisation:

Article 22 Monitoring of status of surface and groundwater and protected areas
(1) The Minister of Environmental Protection and Regional Development shall approve programmes for the monitoring of water status within each river basin district, which shall include monitoring of surface water, groundwater and protected areas.
(2) For surface water, the monitoring programme shall cover:
1) the volume and rate of flow to the extent relevant to evaluate ecological and chemical status and ecological potential;
2) the ecological and chemical status and ecological potential.
(3) For groundwater, the monitoring programme shall cover monitoring of the chemical status and quantitative status.
(4) For protected areas, the monitoring programme shall cover the measures taken in addition to the monitoring of protected areas required by the legislation.
(5) The Cabinet of Ministers determines monitoring requirements and requirements for the establishment of the monitoring programmes referred to in this Article, as well as requirements for monitoring of bathing waters and bathing sites.

3 Quality elements and monitoring types for surface water according to the WFD

The requirements to monitoring for surface water of the WFD can be seen as a combination of three sets of factors:

1. Quality elements
2. Categories of surface water
3. Monitoring types

3.1 Quality elements and categories of surface water

The WFD groups the parameters to be monitored into three groups:

- Biological quality elements
- Hydromorphological quality elements
- Chemical and physicochemical quality elements

The focus of monitoring in the WFD is on the biological elements while hydromorphological elements, chemical and physicochemical elements are considered as supportive.

Supportive means that the values of the physicochemical and hydromorphological quality elements are such as to support a biological community of a certain ecological status, as this recognises the fact that biological communities are products of their physical and chemical environment. The latter two aspects fundamentally determine the type of water body and habitat, and hence the type specific biological community. It is not intended that these supporting elements can be used as surrogates for the biological elements in surveillance and operational monitoring. The monitoring or assessment of the physical and physicochemical quality elements will support the interpretation assessment and classification of the results arising from the monitoring of the biological quality elements (CIS Guidance on Monitoring).

The WFD distinguishes between the following categories of surface water

- Rivers
- Lakes
- Transitional waters
- Coastal waters

In the WFD the quality elements and categories of surface water are linked in the following way:

WFD requirements for monitoring of biological quality elements:

Quality element	Rivers	Lakes	Transitional waters	Coastal waters
Biological elements				
Composition, abundance and biomass of phytoplankton		✓	✓	✓
Composition and abundance of aquatic flora	✓	✓	✓	✓
Composition and abundance of benthic invertebrate fauna	✓	✓	✓	✓
Composition and abundance of fish fauna	✓	✓	✓	

Age structure of fish fauna	✓	✓		

WFD requirements for monitoring of hydromorphological quality elements supporting the biological elements:

Quality element	Rivers	Lakes	Transitional waters	Coastal waters
Hydromorphological elements supporting the biological elements				
Hydrological regime				
- quantity and dynamics of water flow	✓	✓		
- residence time		✓		
- connection to groundwater bodies	✓	✓		
River continuity				
- river continuity	✓			
Morphological conditions				
- depth variation	✓	✓	✓	✓
- width variation	✓			
- structure and substrate of the bed	✓	✓	✓	✓
- quantity of the bed		✓	✓	
- structure of the riparian zone	✓			
- structure of the shore		✓		
- structure of the intertidal zone			✓	✓
Tidal regime				
- freshwater flow			✓	
- direction of dominant currents				✓
- wave exposure			✓	✓

WFD requirements for monitoring of Chemical and physico-chemical elements supporting the biological elements:

Quality element	Rivers	Lakes	Transitional waters	Coastal waters
Chemical and physico-chemical elements supporting the biological elements				
General				
1. Transparency		✓	✓	✓
2. Thermal conditions	✓	✓	✓	✓
3. Oxygenation conditions	✓	✓	✓	✓
4. Salinity	✓	✓	✓	✓
5. Acidification status	✓	✓		
6. Nutrient conditions	✓	✓	✓	✓
Specific pollutants				
7. Pollution by all priority substances identified as being discharged into the body of water	✓	✓	✓	✓
8. Pollution by other substances identified as being discharged in significant quantities into the body of water	✓	✓	✓	✓

For further discussion see chapter 9: Future monitoring system for surface water.

3.2 Monitoring types

The EC Water Framework Directive distinguishes the following monitoring types for the surface waters:

1. Surveillance monitoring
2. Operational monitoring
3. Investigative monitoring

Below the requirements for the monitoring types for surface water are outlined. Further discussion on the implementation of these requirements in Latvia, are provided in chapter 9: Future monitoring system.

WFD sets some additional requirements for monitoring for areas regarded as "protected areas". In fact these include drinking water abstraction points and habitats and species areas (Annex V, 1.3.5). These requirements are outlined section 9.5.

3.2.1 Surveillance monitoring

Surveillance monitoring is carried out to provide an assessment of the overall status of water bodies. The objectives of surveillance monitoring of surface waters are to provide information for:

1. Supplementing and validating the impact assessment procedure detailed in Annex II;
2. The efficient and effective design of future monitoring programmes;
3. The assessment of long-term changes in natural conditions; and
4. The assessment of long-term changes resulting from widespread anthropogenic activity.

3.2.2 Operational monitoring

Operational monitoring is focusing on water bodies identified as being at risk of failing to meet their environmental objectives. It is undertaken in order to:

1. establish the status of those bodies identified as being at risk of failing to meet their environmental objectives, and
2. assess any change in the status of such bodies resulting from the programmes of measures.

3.2.3 Investigative monitoring

Investigative monitoring shall be carried out:

1. where the reason for any exceedances is unknown,
2. where surveillance monitoring indicates that the objective for a water body is not likely to be achieved and operational monitoring has not already been established, in order to ascertain the causes of a water body or water bodies failing to achieve the environmental objectives; or
3. to ascertain the magnitude and impacts of accidental pollution.

The main purpose of the monitoring programme established under the directive is to accurately to describe the status of water bodies and compare with environmental objectives. If the output of this evaluation is that the water body is at risk, measures have to be set up to secure that the water body will not fail to achieve its environmental objectives.

On the other hand, operational monitoring concentrates on water affected by pressures so that they are at risk of not meeting the good status. Thus results of the operational monitoring will be used to determine pressures to be covered by the programme of measures and assess effectiveness of the programme. In other words operational monitoring will determine where

and how much money shall be spent for environmental improvements. Hence operational monitoring is the central monitoring type, and surveillance is supporting the operational monitoring (supporting identification of WBs at risk and the evaluation of long term changes in natural conditions will help in the accuracy of the description of the status of WBs at risk).

Investigative monitoring is supportive for operational monitoring as it addresses WBs at risk that are not included in operational monitoring.

4 Quality elements and monitoring types for groundwater according to the WFD

The requirements to monitoring for groundwater of the WFD can be seen as a combination of three sets of factors:

1. Quantity parameters
2. Chemical parameters
3. Monitoring types

As described in the following it is the decision of each country on what, where and when must be monitored.

4.1 Quantity parameters

The WFD operates with the following quantity parameter to be monitored:

- Groundwater level

This parameter is obviously closely related to abstractions of groundwater. However, although abstractions are assumed to be monitored, they are not considered as part of the monitoring program, but as part of the pressures, and as such the abstractions and the water balance in general are evaluated **as part of the characterisation**.

4.2 Chemical Parameters

For chemical monitoring only five core parameters are required by WFD, but other parameters should be included as necessary. The five core parameters are:

- oxygen
- conductivity
- pH
- Nitrate
- Ammonium

The Project recommends that the existing Latvian monitoring program continue, i.e. that the general composition is also analysed: Calcium, Magnesium, Sodium, Potassium, Bicarbonate, Chloride and Sulphate. It is also advised to include TOC (Total Organic Carbon).

Among these chloride and sulphate are the most useful indicators of intrusions from natural anomalies, and they should therefore be monitored in conjunction with electrical conductivity

in those GW bodies where there is an abstraction-related risk of extending the areas with such natural contamination, or a risk of increasing the concentrations in the water used for drinking water.

4.2.1 Core Parameters

The concentration of **oxygen** (also called DO for Direct Oxygen) in groundwater is not an indicator of pollution, but it illustrates the vulnerability and it shows whether the aquifer is aerobic or anaerobic, which is important for evaluation of the fate of other compounds in the groundwater. In well-protected and deep aquifers the oxygen concentration will be zero, and in shallow, sandy aquifers the value may reach a few milligrams per litre. Oxygen is not commonly measured in groundwater, and it sets strict requirements to the sampling procedure in order to obtain reliable results. It is important that such procedures are elaborated; otherwise the results will not be useful.

EC or **Electrical Conductivity** is an indicator of changes in concentrations of electrically charged compounds. It is an indirect parameter in the sense that it reflects the sum of main ions in the water, and thus the conductivity will increase if a main ion increases in concentration. However, it does not tell *which* ion is increasing. The rate of increase will in some degree depend on the ion, as each main ion has a different electrical charge and therefore a different impact on the conductivity, and furthermore the absolute concentrations of ions are very different.

As an example, an increase of ammonium (in the range normally found, i.e. around 1 mg/l) will most likely be hidden in the variations between measurements, but an increase in chloride (in the range normally found) will show a clear increase in the conductivity.

The conductivity will be mostly affected by the following ions:

- Kat ions: Calcium, Magnesium, Sodium and Potassium
- Anions: Bicarbonate, Chloride, Sulphate, Nitrate

If a significant increase in conductivity is detected, it is necessary to follow up with specific analyses for the main ions in order to detect the reason for the increasing conductivity.

pH should always be measured in the field, as changes in the water quality due to aeration may change the value before the sample reaches the laboratory. Changes in pH should be followed up by specific analyses.

Nitrate is an indicator of excessive use of natural or artificial fertiliser on agricultural areas. In well-protected and deep aquifers the background value will be zero.

Ammonium is an indicator of pollution, but it also occurs naturally in anaerobic aquifers, i.e. mostly in deep aquifers. Changes must therefore be analysed in detail in order to detect if they are caused by human activities.

4.2.2 Other parameters

For groundwater bodies at risk the monitoring programs shall also include the chemical compounds, which are causing this risk.

As an example monitoring for **specific pesticides** is relevant in areas where they are used, but as such analyses are relatively costly, they should initially be focused in areas where they are most likely to be found, based on the assessment of pressures (e.g. in very vulnerable areas

with sandy soils). If they are not found in the most vulnerable areas, then they are probably also not found in better protected areas.

The parameters and the points to analyse should be selected on basis of a ranking procedure, which should be carried out as a result of the initial characterisation of the groundwater bodies.

4.3 Monitoring Types

The WFD distinguishes between the following chemical monitoring types for groundwater:

1. Quantitative monitoring
2. Chemical surveillance monitoring
3. Chemical operational monitoring

As opposed to surface water *investigative monitoring* is not specified, but it is evident that a similar monitoring program may be relevant also for groundwater, on a case-by-case basis.

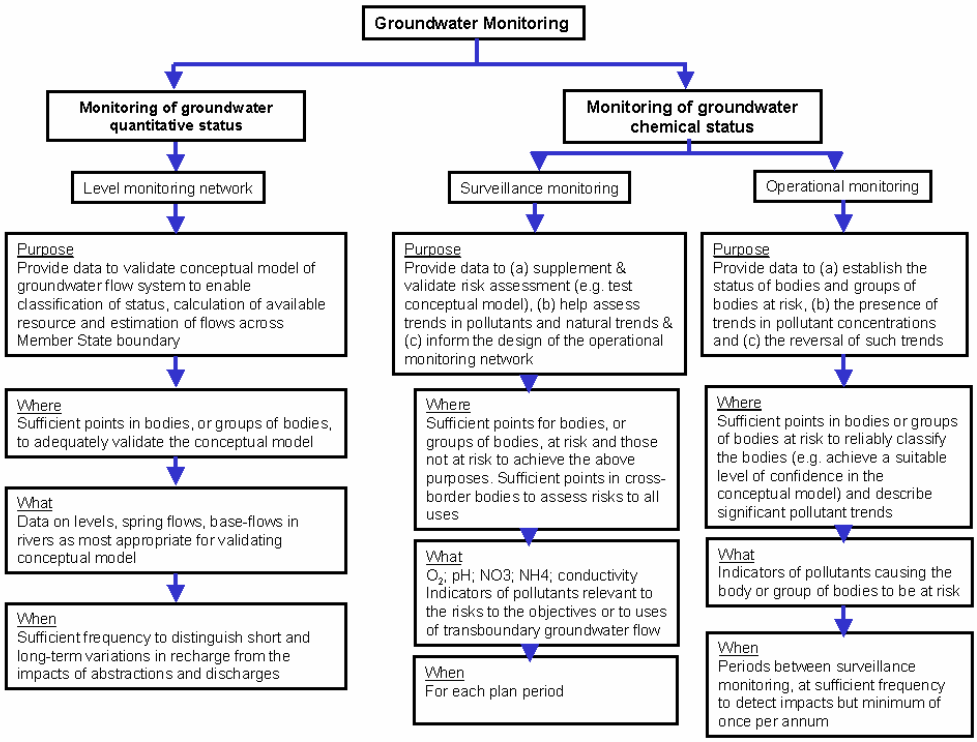
The WFD requires that maps showing the groundwater monitoring network shall be included in the river basin management plan.

The initial and further characterisation described in Annex II should provide the basic information for designing targeted and cost-effective monitoring programmes. To do this, the Annex II procedure must produce a conceptual model / understanding for each body of groundwater, or group of bodies, that include:

(a) information about location and boundaries for body of groundwater, or group of bodies;
(b) information about water flows, directions of water flows, transboundary water flows;
(c) information relevant to assessing how the identified pressures could affect the objectives for the body, or group of bodies;
(d) information proportionate in terms of its detail and complexity to the likely risks to the objectives for that body, or group of bodies;
(e) information about available water resources in the body of groundwater, or group of bodies.

The assessments in the characterisation may need further development to help design the monitoring programmes for implementation at the end of 2006.

The proposed groundwater bodies are 3-dimensional and consist of parts of aquifers and multi aquifer systems. This means that monitoring information from different layers in a body of groundwater is necessary in order to enable appropriate measures to be designed and targeted and in order to document the effects of the measures.



Below the requirements for the monitoring types for groundwater are outlined. Further discussion on the implementation of these requirements in Latvia is provided in chapter 9: Future monitoring system.

4.3.1 Quantitative Monitoring

The requirement to quantitative monitoring is that the monitoring network and the frequency of observations shall be such that a reliable assessment of the quantitative status of all groundwater bodies can be made, including the available resource.

The density of monitoring points and the frequency of observations shall be such that the impacts of abstractions and discharges can be assessed, and since also recharge areas shall be identified, the monitoring points must show both horizontal and vertical variations of the groundwater level. Although it is not specified by the WFD, the distribution of monitoring points should be chosen such that it includes

- at least 3 monitoring points in each groundwater body
- at least 1 monitoring point in each sub-body
- points far from abstractions
- points in shallow aquifers
- points in deep aquifers
- points near rivers

Determination of groundwater flow direction requires a minimum of 3 points, and therefore this number of points is seen as necessary for a description of flow in each groundwater body.

Appointment of a sub-body may be relevant in order to narrow the size of a groundwater body with poor status. For example it could be relevant to define a regional depression cone

from a big well field as a sub-body, but only if it is necessary in relation to the classification of status.

Location of shallow points and points near rivers are essential for the description of interaction between surface water and groundwater, including the impact of abstraction on surface water and terrestrial ecosystems.

For groundwater bodies at risk the frequency may be higher in order to enable a better assessment of the impact of the abstractions leading to this risk.

For transboundary groundwater bodies the WFD requires that sufficient monitoring points are provided to estimate the direction and rate of groundwater flow across the State boundary.

The Project considers a frequency of 1 observation per year as a minimum for the required evaluations, but at selected monitoring points representative for the individual groundwater bodies, including bodies at risk of not fulfilling the quantitative objective, the frequency should be 4 times per year (or continuous, using automatic loggers) in order to describe the seasonal variations.

Well field monitoring

In well fields which abstract more than 100 m^3/day, the water level shall be observed in observations wells with a frequency determined by the Geological Survey. This could be 4 times per year or more in well fields which causes the groundwater body to be at risk, or 1-2 times per year in other well fields. The observations shall be reported to the Geological Survey on an annual basis. This type of monitoring is not included in other Latvian regulations, and therefore it is included here, although it is part of the well field management rather than groundwater body management.

4.3.2 Chemical Surveillance Monitoring

Surveillance monitoring is carried out to provide an assessment of the overall status of water bodies. The objectives of surveillance monitoring of surface waters are to provide information for:

1. Supplementing and validating the impact assessment procedure detailed in Annex II, including identification of GW bodies at risk;
2. The efficient and effective design of future monitoring programmes;
3. The assessment of long-term changes in natural conditions; and
4. The assessment of long-term changes resulting from widespread anthropogenic activity.

Surveillance monitoring is specified in the Directive for bodies at risk or which cross a boundary between Member States. However, to adequately supplement and validate the Annex II risk assessment procedure, validation monitoring will also be needed for bodies, or groups of bodies, **not** identified as being at risk. The amount and frequency of monitoring undertaken for these bodies, or groups of bodies, must be sufficient to enable to be adequately confident that the bodies are at good status and that there are no significant and sustained upward trends.

The Directive says **surveillance monitoring** must be undertaken during each planning cycle, and operational monitoring must be carried out during periods not covered by surveillance monitoring. **Operational monitoring** must be carried out at least once a year during periods between surveillance monitoring.

The WFD does not specify how often the Chemical Surveillance monitoring should be carried out, but it seems that a frequency of one time per each management plan period, i.e. once per 6 years would fulfil the directive. Although changes in the groundwater do occur slowly, it is recommended that a frequency of 2 times per 6 years be applied rather than one.

The network for chemical monitoring shall be designed so as to "establish a coherent and comprehensive overview of groundwater chemical status within each river basin" (Article 8 in WFD) and to detect the presence of long-term anthropogenically induced upward trends in pollutants.

Coherent and comprehensive means that not only the horizontal, but also the vertical distribution of chemical compounds can be described, and that the density of the monitoring network reflects the presence of both natural anomalies and anthropogenic pressures.

4.3.3 Chemical Operational Monitoring

Chemical operational monitoring shall be focused on those groundwater bodies, which have been identified as being at risk on basis of the results of the surveillance monitoring.

The information provided by operational monitoring may establish that some bodies, or groups of bodies, considered likely to fail to achieve environmental objectives on the basis of the Annex II risk assessment and the surveillance monitoring programme are at **good** status.

According to the WFD the frequency of operational monitoring is at least one time per year, and it shall take place in the periods between the surveillance monitoring.

The operational monitoring is carried out in order to:

1. establish the status of those bodies identified as being at risk of failing to meet their environmental objectives, and
2. assess any change in the status of such bodies resulting from the programmes of measures.

Since changes in groundwater occur slowly there is no reason in general to carry out operational monitoring several times per year. However, in areas where rapid changes is expected, operational monitoring should be carried out more often in order to detect these changes.

The options for surveillance and operational groundwater monitoring is shown in table 4.1 Other options are possible. If the surveillance monitoring is increased to a frequency of 1/year, there would be no difference in the surveillance and the operational monitoring, unless the operational monitoring were carried out several times per year, and this is not advised in general, as mentioned above.

Table 4.1 Options for surveillance and operational monitoring cycles

Management plan period	Year	**Option 1**		**Option 2**	
		GW bodies not at risk	GW bodies at risk	GW bodies not at risk	GW bodies at risk
	1	S	S	S	S
	2	-	Op	-	Op
	3	-	Op	-	Op
	4	-	Op	S	S
	5	-	Op	-	Op

	6	-	Op	-	Op

As a basic rule, monitoring should be carried out around the same time each year, in order to avoid influence from seasonal variations, which could be misinterpreted and make conclusions unclear.

Where seasonal variations are known or expected to be significant, it is advised that a period of frequent monitoring, e.g. 4 times/year for at least 2 years is used for documentation of such variations at selected and representative locations.

5 Monitoring requirements of other directives

Monitoring requirements of the existing EU water sector directives are to a large extent predetermined by the objectives of the directive in question. The monitoring requirements can be differentiated by:

- water type (i.e. groundwater, rivers, lakes/reservoirs, estuaries and coastal waters);
- matrix (i.e. water column (including suspended sediments), settled sediment and biota); and,
- determinant type (both quantity and quality determinants).

Table 1 summarises the monitoring requirements in EU legislation according to these criteria. It should be noted that the Water Framework Directive will take over requirements of a number of water sector directives. Three directives[1] will be repealed from 2007-12-22 and four directives[2] – from 2013-12-22.

Table 1. Summary of monitoring requirements of directives according to water type and matrix.

EU DIRECTIVES	**WATER TYPE**												
	GW	**RIVERS**			**LAKES AND RESERVOIRS**			**TRANSITIONAL WATERS**			**COASTAL WATERS**		
	W	**W**	**S**	**B**	**W**	**S**	**B**	**W**	**S**	**B**	**W**	**S**	**B**
Surface Water (75/440/EEC) and (79/869/EEC)		X			X								
Bathing Water (76/160/EEC)		X			X			X			X		
Dangerous Substances (76/464/EEC) [a]		X			X			X					
- Mercury from Chlor-alkali (82/176/EEC)		X	X	X	X	X	X	X	X	X	X	X	X
- Mercury from Other Sectors (84/156/EEC)		X	X	X	X	X	X	X	X	X	X	X	X
- Cadmium (83/513/EEC)		X	X	X	X	X	X	X	X	X	X	X	X
- Carbon Tetrachloride (86/280/EEC)		X	X[b]	X[b]	X	X[b]	X[b]	X	X[b]	X[b]	X	X[b]	X[b]
- Hexachlorocyclohexane (84/491/EEC)		X	X	X	X	X	X	X	X	X	X	X	X
- Aldrin, .etc. (88/347/EEC)		X	X[c]	X[c]	X	X[c]	X[c]	X	X[c]	X[c]	X	X[c]	X[c]
- Dichloroethane, etc. (90/415/EEC)		X	X[d]	X[d]	X	X[d]	X[d]	X	X[d]	X[d]	X	X[d]	X[d]
Freshwater Fish (78/659/EEC)		X			X								
Shellfish (79/923/EEC)								X		X[e]	X		X[e]
Groundwater (80/68/EEC)[f]	X												
UWWT (91/271/EEC) [h]		X			X			X			X		
Nitrates (91/676/EEC) [i]	X	X			X			X			X		
Exchange of Information (77/795/EEC) (86/574/EEC)		X			X								

Notes: Water types GW Groundwater
Matrix B Biota
S Sediment
W Water column

a The provisions of this directive relating to groundwater are superseded by Directive 80/68/EEC.
b Only for DDT and pentachlorophenol (PCP).
c Only for aldrin, dieldrin, endrin and isodrin, hexachlorobenzene (HCB), hexachlorobutadiene (HCBD)

[1] 75/440/EEC Surface Water Directive
79/869/EEC Methods of Measurement and the Frequencies of Sampling and Analysis of Surface Water Intended for the Abstraction of Drinking Waters
77/795/EEC The Decision on Exchange of Information on the quality of surface freshwater

[2] 78/659/EEC The Freshwater fish directive
79/923/EEC The Shellfish Water Directive
80/68/EEC The Groundwater Directive
76/464/EEC The Dangerous Substances Directive

d Only for trichlorobenzene (TCB).

e For metals and organohalogenated compounds only. The requirement for faecal coliforms superseded by Directive 91/492/EEC.

f For prior investigation before granting an authorisation. The prior investigation include examination of the hydrogeological conditions of the area concerning and possible purifying powers of the soil and subsoil and the risk of pollution and alteration of the quality of groundwater form the discharge and shall establish whether the discharge of substances into groundwater is a satisfactory solution from the point of view of the environment.

g An initial analysis to be carried out before exploitation of the source. The parameters listed above plus various toxic or undesirable substances presumed present.

h For identifying sensitive areas. Member States must also monitor waters subject to discharges from STW and direct discharges from industrial sectors in cases where the receiving environment may be significantly affected. For discharges to less sensitive areas and for disposal of sludge, Member States must monitor and carry out any relevant studies to verify that the discharge or disposal does not adversely affect the environment.

i For designating vulnerable zones, Member States must monitor the nitrate concentration in fresh surface and groundwater and review the eutrophic state of fresh water, estuaries and coastal waters. In addition, the nitrate content of waters must be monitored (surface and groundwater) to assess the effects of action programmes.

Requirements for monitoring of groundwater are determined in two EU water sector directives. Main requirements of these directives are summarised in Table 2.

Table 2. Summary of basic monitoring requirements in EU directives for groundwater monitoring.

DIRECTIVE	Sampling location/timing	Parameters/Determinands
Groundwater (80/68/EEC)	Once prior to authorising discharges	Not specified
Nitrates (91/676/EEC)	Within two years of notification of directive over a period of a year. Then every four years period to revise identification of vulnerable zones and asses action programmes. If concentration below 25 mg NO_3/l then repeat only every 8 years.	Nitrate

Requirements for monitoring of surface waters can be differentiated based on type of surface water. Several directives set forth requirements for i) freshwaters only; ii) freshwater, estuaries and coastal waters or iii) estuaries and coastal waters only. Basic requirements of these directives are summarised in Table 3.

Table 3. Summary of basic monitoring requirements made in EU directives for surface water.

Directive	Sampling location/timing	Determinands
FRESHWATER ONLY		
Surface Water (75/440/EEC) and (79/869/EEC)	Designated sites 4-12 times per year	pH, Turbidity, Colour, Temperature, Total Suspended solids, Conductivity, Odour, DO[2], BOD5[2], COD,[2] substances extractable with chloroform[2], Total Organic Carbon[1], Residual Organic Carbon[1], Ammonium[2,] Nitrogen Kjeldahl[2], Nitrates, Fluorides, Total extractable organic chlorine, Dissolved Fe, Mn, Cu, Zn, B[2], Be[1],

		Co[1], Ni[1] V[1] , As, Cd, Total Cr, Hg, Se, Pb, Ba, CN, Sulphates, Chlorides[2] , Surfactants[2] , Phosphates[2], Phenols, Dissolved/emulsified Hydrocarbons, PAHs, Total Pesticides, Total Coliforms[2,] Faecal Coliforms[2,] Faecal streptococci[2], Salmonella[2]
Freshwater Fish (78/659/EEC)	Agreed sites in designated areas Weekly-Monthly	Temperature, DO, pH, Suspended Solids[2], BOD_5[2], Total Phosphor-us[1], Nitrites[2], Phenolic compounds, Petroleum Hydrocarbons, Non-ionised ammonia,· Total ammonium, Total Zn, Dissolved Cu[2], Total residual Chlorine
Exchange of Information (77/795/EEC) as amended by (86/574/EEC)	Selected sites	Flow, Temperature[3], pH, Conductivity Chlorides Nitrates, Ammonia, DO, BOD_5, COD, Total Phosphorous, Surfactants, Total Cd, Hg, Faecal Coliforms, Total Coliforms, Faecal Streptococci, Salmonella, Biological Quality
FRESH WATER, ESTUARIES (transitional waters) AND COASTAL WATERS		
Bathing water directive (76/160/EEC)	Designated sites, Fortnightly in bathing season	Total Coliforms, Faecal Coliforms, Faecal Streptococci[4], Salmonella[4], Enteroviruses[4], pH[5], Colour, Mineral Oils[2],, Surfactants, Phenols, Transparency, DO[4], Tarry residues and floating materials, Ammonia[6],, Nitrogen Kjeldahl[6], Pesticides[6], As[6], Cd[6], CrVI[6], Pb[6], Hg[6], CN[6], Nitrates[6], Phosphates[6],
Dangerous substances (76/464/EEC) and daughter directives	Areas affected by discharges Monthly for water, annually for sediments	Cd, Hg, HCCH, HCBD, PCP, Chloroform, DCE, Drins, DDT, HCB, Carbon tetrachloride, TCE, PCE, TCB
Urban waste water treatment directive(91/271/ EEC)	Areas affected by discharges	Not specified
Nitrates directive (91/676/EEC)	Initially regularly or 12 times per year- repeated for every four year period. Monitoring need greatest when separate vulnerable zones designated.	NO_3
ESTUARIES (transitional waters) AND COASTAL WATERS ONLY		
Shellfish (79/923/EEC)	Designated waters 2-12 times per year	pH, Temperature[2], Colour, Suspended Solids, Salinity[2], Dissolved Oxygen[2], Petroleum Hydrocarbons, Faecal Coliforms[2], Organohalogenated substances, Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Zn, Substances affecting taste, Saxitoxin

Notes:
1 No values specified
2 Guide parameter
3 Weekly
4 Guide value and only to be checked if substance suspected
5 To be checked only if substance suspected
6 No value and to be checked only if substance suspected

Monitoring requirements pursuant to individual directives are briefly discussed in the sections below.

5.1 EU directives that are repealed by the WFD from 2007-12-22

5.1.1 Surface Water Directive (75/440/EEC) and Methods of Measurements Directive (79/869/EEC)

The directive 75/440/EEC concerning the quality required of surface water intended for the abstraction of drinking water will be repealed by the EU Water Framework Directive from the end of 2007. However, during the transitional period its requirements have to be implemented.

The directive 75/440/EEC defines requirements for quality of surface waters used or intended for use in the abstraction of drinking water. Groundwater, brackish water and water intended to replenish water-bearing beds are not subject to this Directive. Therefore, requirements of the directive are applicable only to these surface water bodies if they are designated by competent authorities for current or future use in abstraction of drinking water.

Directive 75/440/EEC requires carrying out of monitoring of water quality at the designated water bodies and prior to supply to the distribution network apply appropriate treatment based on the quality of water (category A1, A2 or A3). Parameters to be monitored in the designated water bodies are provided in Annex II of the directive.

As stated in Article 5 of the directive, the frequency of sampling and the analysis of each parameter, together with the methods of measurement shall be defined by the competent national authorities, which shall take into account the volume of water abstracted, the extent of the abstraction, the population served, the degree of risk engendered by the quality of the water and seasonal variations in the quality.

This article was amended by the by adoption of the Council directive 79/869/EEC concerning the methods of measurement and frequencies of sampling and analysis of surface water intended for the abstraction of drinking water in the Member States, which specifies the reference methods of measurement and frequencies of sampling and analysis for the parameters listed in Annex II to Directive 75/440/EEC.

The Surface water directive 75/440/EEC is applicable to very limited number of water bodies in Latvia and has very precise and specific requirements for monitoring (see summary in Table 3). The project team recommends continuing monitoring of water bodies designated for abstraction of drinking water as a separate task during the transitional period until the end of 2007.

5.1.2 Exchange of Information Decision (77/795/EEC)

The Council Decision 77/795/EEC establishing a common procedure for the exchange of information on the quality of surface freshwater in the Community as amended by 86/574/EEC demands member countries to set up monitoring programmes in freshwater with an annual reporting of a suite of parameters. The decision will be repealed seven years after the entry in force of the Water Framework Directive (December 2007).

Until then Latvia needs to fulfil the requirements of the Decision. LEA has to select a number of river monitoring stations to be included under the Directive and to be monitored for the parameters stated in 86/574/EEC (see summary in Table 3). Monitoring frequency – monthly.

Some criteria for selection of monitoring stations are provided in Article 5 of the Decision 77/795/EEC:

- the stations are at points which are representative of water conditions in the area around and not directly and immediately influenced by a source of pollution,
- they are as a general rule not more than 100 kilometres apart on main rivers, not including tributaries,
- they are upstream of any confluence and not on tidal stretches of water.

4 stations are designated for the purposes of the Exchange of information decision 77/795/EEC in the Latvian Environmental Monitoring programme. These are :

- Daugava upstream Jekabpils
- Lielupe upstream Jelgava
- Gauja upstream Valmiera
- Venta upstream Kuldiga

(data are already sent to Commission)

These stations enable overall assessment of the state (all river basins, representative sites for impact assessment)

In comparison, in Denmark 4 major river monitoring stations are selected for this 'Decision' and annual data are exchanged with the Commission. The river stations have been selected as to represent the Danish conditions in freshwater. Thus, one river monitoring station is selected in each landscape and climate region of Denmark. Denmark has no significant cross-border stations.

For the purposes of implementing the Council Decision 77/795/EEC the project suggests the Latvian EPA to select 4-6 river monitoring stations based on following criteria:

- River monitoring stations that enable an assessment of the state, impact and trend in water quality parameters from inflow of water and substances from countries outside the European Union.
- River monitoring stations that enable an overall assessment of the state, impact and trend in water quality parameters within different regions (different River Basin Districts) of Latvia.

5.2 EU directives that are repealed by the WFD from 2013-12-22

5.2.1 Water for Freshwater Fish Directive (78/659/EEC)

The Council Directive 78/659/EEC on the quality of freshwaters needing protection or improvement in order to support fish life requires the Member states to designate water bodies (salmonid and cyprinid waters) needing protection or improvement in order to support fish life. The Directive will be repealed by the EU Water Framework Directive from 2013-12-22.

The requirements of the Directive on monitoring are applicable only to waters designated by competent authorities as salmonid or cyprinid waters. The directive requires the Member states to carry out monthly monitoring of traditional parameters (monitoring requirements of the Directive are summarised in Table 3). Frequency of sampling may be reduced if the quality of designated waters is appreciably higher than imperative and guidance values provided in the directive.

It is recommended to include monitoring for the Freshwater Fish Directive in the WFD monitoring programme.

LEA has prepared the monitoring program of a prioritised list of fish waters (not included in Surface water monitoring program yet).

5.2.2 Shellfish Waters Directive (79/923/EEC)

The Directive 79/923/EEC on the quality required of shellfish waters applies to those coastal and brackish waters designated by the member states as needing protection or improvement in order to support shellfish (bivalve and gastropod molluscs) life and growth and thus to contribute to the high quality of shellfish products directly edible by man. The directive will be repealed by the WFD.

The Annex to the Directive establishes list of parameters to be monitored in the designated shellfish waters, defines sampling frequency and provides reference to methods of analysis. Short overview of the monitoring requirements of the directive is shortly presented in Table 3.

Due to low salinity and wave activity Baltic Sea is not suitable for growth of sea molluscs directly edible by man. Therefore, this directive is not applicable for Latvia. It is proposed that no monitoring is carried out for the purpose of implementation of the Shellfish waters directive.

5.2.3 Dangerous Substances Directive (76/464/EEC)

The Dangerous Substances Directive (DSD) 76/464/EEC and daughter directives (86/280,88/347 and 90/415) will be repealed by the Water Framework Directive (WFD) from December 2013. In the transition period until the WFD is fully implemented the DSD is still in force.

Article 13 in DSD states that “member states shall supply the Commission with the results of monitoring by the national network”. Moreover, 86/280 made it clear that member states are obliged to perform monitoring if the aquatic environment is affected by discharges of dangerous substances. Consequently, a member state is required to monitor list I substances if they are used in the industrial production in Latvia and/or emitted to the aquatic environment.

The monitoring requirements of the DSD are not very specific and clearly outdated by the requirements of the WFD, which also includes requirements related to dangerous substances. Monitoring of dangerous substances in Latvian surface waters has traditionally been limited to heavy metals and few pesticides. Therefore, collection of information from enterprises, point sources and monitoring of the environment should be regarded as first step in developing the National Dangerous substances reduction programme. It is therefore recommended to base the monitoring requirements in surface water on the demands under the WFD.

The Impact and Pressures working group (IMPRESS) under the Common Implementation Strategy for the Water Framework Directive (CIS) has developed a guidance document for Analysis of Pressures and Impacts in Accordance with WFD. The Guidelines include recommendations on how to select relevant dangerous substances on river basin level (see text box).

Text Box: Recommendations from the IMPRESS guidelines on selecting relevant pollutants on river basin level.

The WFD (Article 5) demands a pressure/impact analysis to be conducted before 2005 to select relevant pollutants on river basin level (IMPRESS-Guideline). The pressure/impact analysis shall help to identify the pressure/impact of priority substances as identified by the EU in the List-A substances and other specific pollutants used and discharged to the aquatic environment within river basins. The requirements of the WFD will demand a three (or more) stage approach in order to take account of the different scales of pollution problems in the aquatic environment:

1. European level: The DSD List I substances (18 substances) and WFD priority substances (32 substances from the Annex X of the WFD) must be considered in the pressure/impact analysis for all water bodies.
2. River basin (district) level: a list of relevant pollutants may be established which are likely to "risk of failing objectives" in a large number of water bodies within that river basin and where downstream effects (including marine environment) may need to be considered. Such substances may be called relevant pollutants for a river basin.
3. Sub-river basin and water body level: pollutants which cause an impact through a significant regional and local pressure, i.e. in one or few water bodies, may need to be considered in addition to the above mentioned levels.

In the ideal case, there may be a clear relationship between a pollutant released to the environment at (a number of) well known point sources or diffuse sources and causing a visible or measurable effect on the biology (fauna or flora) of a water body. However, given the high number of pollutants there is a considerable gap of information and data for many pollutants, in particular:

- In many cases and for a lot of pollutants pressures can hardly be related to status or impact as a result of lack of data;
- Only a limited number of pollutants is continuously or regularly monitored;
- The relation between pollutants and impact covers the whole field of ecotoxicology – coping with problems as acute/chronic or combined effects of substances.

The starting point of a pressure/impact analysis is to include the universe of chemicals and then in an iterative approach narrow this endless list of substances down to a manageable number of pollutants in a pragmatic and targeted step-by-step approach. The final aim is to target the measures and the monitoring of those substances first which are most affecting the aquatic environment. The generic approach put forward by IMPRESS includes the following major steps:

Starting point: List of substances from DSD and WFD and other dangerous substances used in the river basin.
Screening: Collation of all available information on use and emission of substances in river basins being from point sources or diffuse sources.
Test for relevance: Estimate or monitor likely concentrations in water bodies and compare estimated/monitored concentrations with benchmarks (LC50,NOEC,PNEC, EQS, etc.).
Safety net: Assess whether confidence in assessment is adequate or monitoring is required to establish confidence (surveillance and/or operational monitoring).
Final outcome: A list of dangerous substances relevant to the river basin and for which appropriate measures are required.

The project recommends that monitoring of dangerous substances in receiving waters shall be based on following requirements:

- The monitoring programme should cover the whole national territory;
- The number of monitoring stations as well as the frequency of sampling should be adequate, e.g. all water basins should be represented in the programme.
- The programmes should include substances that are regarded as relevant considering the emissions of dangerous substances to the environment;
- Any monitoring value that exceeds the WQS should be recorded and included in the reporting to the Commission.
- The reporting should provide detailed geographic information.

These recommendations are already implemented in the present monitoring programme.

5.2.4 Groundwater Directive (80/68/EEC)

The Groundwater Directive (GD) 80/68/EEC will be repealed by the Water Framework Directive (WFD) from December 2013. In the transition period until the WFD is fully implemented the GD is still in force.

The Directive has been transposed into Latvian legislation by CM Regulation Nr 34 On emissions into water (22.01.2002).

5.3 EU Directives that are not repealed by the WFD

5.3.1 Bathing Water Directive (76/160/EEC)

The directive 76/160/EEC concerning the quality of bathing water establishes requirements for quality of surface waters designated by competent authorities as bathing waters. Monitoring requirements of the 76/160/EEC directive are summarised in Table 3.

Initiatives to revise the Bathing Water Directive started in 1994 with the Commission presenting a proposal for a revision. However, the new Directive is not yet adopted. This directive will repeal the old Bathing water directive 76/160/EEC. The Proposal for a Directive of the European Parliament and of the Council concerning the quality of bathing water (COM(2002) 581 final) changes the requirements for monitoring of bathing waters:

- Scope of the directive is extended and also covers “Other recreational activities”: those activities, where devices are used to move across the water, involving a meaningful risk of swallowing water, such as surfing, windsurfing and kayaking.
- Number of parameters is reduced from 19 to 2 key microbiological parameters in the new Directive, complemented by visual inspection (algae bloom, oil) and pH measurement in fresh waters.
- Frequency of monitoring depends on quality of bathing waters (ranging from 0.5 samples per month for excellent quality to 2 samples per month for poor quality bathing waters).

The Bathing water directive applies to specific designated water bodies and establishes specific requirements for monitoring of water quality (in terms of frequency and parameters), which do not fit into the frame of surveillance/ operational/ investigative monitoring under the WFD. Therefore, the project recommends carrying out monitoring of bathing waters as a separate programme and not integrating it into the proposed monitoring programme for surface waters under the Water Framework Directive.

5.3.2 Nitrates Directive (91/676/EEC)

The Council directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources aims at reducing and preventing further such pollution. The Water Framework Directive will not repeal this directive.

Requirements for monitoring in the Nitrates Directive are outlined in article 5 on action programmes and in article 6 on monitoring for the purpose of designating and revising the designation of vulnerable zones. Monitoring requirements in the Nitrates directive should be differentiated into:

- Waters affected by nitrate pollution (article 3).
- Monitoring for the purposes of designation and revision of nitrate vulnerable zones (Article 6).
- Monitoring for assessment of effectiveness of action programmes (Article 6, para 5).

Monitoring for the purposes of designation and revision of nitrate vulnerable zones (Art 3 and 6) should be carried out within two years of notification of the Directive and repeated at least every four years. To carry out this exercise the Member States shall monitor nitrate concentration in surface waters and groundwaters and review the eutrophic state of fresh, estuarial and coastal waters.

Monitoring for assessment of the effectiveness of action programmes (Article 6, para 5) is not well specified, but it is indicated that monitoring should be carried out at selected measuring points which make it possible to establish the extent of nitrate pollution in the waters from agricultural sources.

Monitoring of waters for the Nitrates Directive is closely linked with the Water Framework Directive. The Surveillance monitoring programme under the WFD aims to assess impacts of widespread human activity on the status of water bodies. Analysis of pressures of agriculture on water bodies is needed for characterisation of river basin districts according to WFD Annex II. The project recommends to integrate monitoring programmes under the Nitrate directive and WFD.

Groundwater
As required by the Nitrate Directive, the variation of the nitrates, nitrites, ammonium shall be observed in the shallow groundwater. Depending on the depth of shallow groundwater occurrence and lithology of the aeration zone and aquifer, water samples are to be taken: once per year or once per two years. In new wells 2 samples per year is recommended the first 2-3 years.

In order to get a better knowledge on the nutrient transport in agriculture within minor watersheds it is recommended to establish a simplified monitoring programme in shallow groundwater pilot watersheds, selected to illustrate the situation under different conditions, preferable in co-operation with the Ministry of Agriculture. Monitoring in such pilot watersheds should be more frequent, for example 4-6 times per year. Selection of areas and monitoring should be coordinated with monitoring at surface water stations.

When separate vulnerable zones are designated monitoring needs are increased.

5.3.3 Urban Waste Water Treatment Directive (91/271/EEC)

The directive 91/271/EEC concerning urban waste water treatment aims to protect the environment from the adverse effects of the waste water discharges. The main focus of the directive is on the discharge of water and it provides only minor requirements for monitoring of receiving water quality.

It should be noted that the Water Framework Directive establishes no requirements for monitoring of emissions. Therefore, in this context only requirements of the UWWTD concerning monitoring of receiving water quality are discussed.

The following requirements for monitoring of receiving water quality are not well defined in the UWWTD:

- Data on eutrophication status of water bodies are needed for designation and revision of designation of sensitive areas under Article 5.
- Article 15 (para 2) states that competent authorities shall monitor waters subject to discharges from urban waste water treatment plants and direct discharges in cases where it can be expected that the receiving environment will be significantly affected.

Format for reporting on implementation of UWWTD is provided in the Commission Decision 93/481/EEC. The Member States are not required to provide any results of the monitoring of receiving water quality.

Requirements of UWWTD on monitoring of receiving waters (Article 15) will be fully covered by the operational monitoring under the WFD. Therefore, the project recommends to integrate surface water quality monitoring programmes under the Urban Waste Water Treatment directive and WFD. Monitoring of emissions from urban waste water plants should still be covered under the monitoring for UWWTD.

5.4 Recommendations for combining monitoring requirements of WFD and other directives

The requirements for monitoring of the status of the environment in the WFD are very broad and shall make it possible to follow the status of waters impacted by pressures plus assess long-term changes resulting from widespread anthropogenic activity.

This project considers that the monitoring programme to fulfil WFD requirements can be designed to also meet the requirements of the other directives with extensive monitoring requirements:

- Freshwater Fish Directive (repealed by the WFD from 2007-12-22).
- Dangerous Substances Directive with daughter directives (repealed by the WFD from 2013-12-22).
- Nitrates Directive.

Also monitoring requirements in the directives and decisions with less comprehensive requirements (e.g. Exchange of Information Decision) can be addressed in the future WFD monitoring programme.

The monitoring programme proposed in chapter 9 and chapter 10 is designed to include the requirements of the directives mentioned above.

An exception is the Bathing Water Directive, which includes so specialised monitoring requirement that the types of monitoring required by the WFD do not cover it. It should also be noted that monitoring of discharges is not required by the WFD. Therefore, specific requirements of the EC Urban Waste Water Treatment Directive and Dangerous Substance Directives related to quantification of discharges shall not be integrated into the WFD monitoring programme.

6 Existing monitoring system, surface water

Monitoring in line with the National Environmental Monitoring Program accepted by the Minister of Environment and Regional Development (prescript Nr.85 of 15.05.2002.) started in 2003. Altogether the programme consists of five divisions of monitoring from which one is monitoring of waters. To implement the programme action plans for each division have been elaborated. The responsible authority for the implementation of National Environmental Monitoring Program is Latvian Environmental Agency.

Water quality standards for priority fish waters, bathing waters surface waters, used for the abstraction of drinking water, are provided in Annexes 3, 4, 6 of the Cabinet Regulation No. 118 On the Quality of Surface Water and Groundwater.

6.1 Types and principles

Monitoring of inland waters is covered by several subprogrammes:

- Surface Water Quality Monitoring Subprogram..
- Wastewater Emission Monitoring Subprogram
- Drinking Water Monitoring Subprogram
- Bathing Water Monitoring Subprogram
- Surface Water Hydrological Monitoring Subprogram
- Agricultural Runoff Monitoring Subprogram

Monitoring of marine waters is covered by Marine monitoring sub programme.

Surface Water Quality Monitoring Subprogram

The principle of designing the monitoring network was to obtain comprehensive characterisation of rivers and lakes of the territory of Latvia, and at the same time linking the information obtained with observations from other monitoring subprograms. Monitoring is carried out in river catchments, starting with the upper reaches and taking into account the following principles for the choice of the stations:

- the location of pollution sources, land use;
- character and amount of pollutant emissions;
- economic importance of the region;
- transboundary pollution (boundary stations).

The water quality network is divided into representative, background, impact, boundary and flux stations.

Reference monitoring stations (B) *characterise water quality in environments with little anthropogenic pressure, and observations at these stations should provide for the interpretation of observations, carried out at representative monitoring stations (identification of pollution) and the emergence of adverse impacts in a relatively undisturbed environment. The purpose of monitoring at these stations is to estimate the values of the*

physicochemical, hydromorphological and biological water quality elements for surface water bodies, in which these values have not changed as a result of human activity or where such changes are insignificant, compared to water bodies of this type which are subject to anthropogenic pressure.
***Impact stations (I)** characterise water quality resulting from a direct impact of pollution from a point source or diffuse source.*
***Representative stations (R)** characterise water quality in the catchment depending on its characterisation and anthropogenic pressure.*
***Boundary and flux stations (F)** are located in the boundary areas (in Latvia – near the border of Lithuania and Byelorussia, and at the sectors of the marine border of Latvia), and the end sectors of river basins, in order to be able to assess transboundary transfer and the impact of surface runoff on the quality of the Baltic Sea.*

The subprogram altogether includes monitoring in 66 rivers (116 stations), 41 lakes (50 stations) and 3 reservoirs (5 stations).
The monitoring network was designed in a way which allows one station to perform several functions. From the established network:

- 57 rivers, 40 lakes and 1 reservoir have been chosen to represent inland water status for EUROWATERNET programme;
- 27 stations have been planned to ensure the implementation of Nitrate Directive (91/676/EEC) – rivers of Bauska, Jelgava, Riga Districts and 1 lake;
- 4 river stations have been selected to provide the requirements of EU Decision 77/795/EEC on Information Exchange;
- 6 stations were selected to implement ICP - Water programme, 5 stations – ICP – Integrated Monitoring Program, 6 stations – Helsinki Convention;
- Radioactive substances are monitored in 5 largest rivers and 7 lakes.

Fish monitoring stations in rivers and lakes may not coincide with hydrochemical, hydrobiological or radioactive parameter monitoring stations, because they have been chosen based on the typical habitats – rapids, coastal vegetation in lakes etc.

Water quality monitoring includes determination of standard hydrochemical indicators (O_2, O_2%, pH, BOD_5, TOC (COD)), nutrients (N/NO^-_2, N/NO^-_3, N/NH_4^+, N_{tot}, P/PO^{3-}_4, P_{tot}), salinity, heavy metals (Pb^{2+}, Cd^{2+}, Cu^{2+}, Zn^{2+}, Hg^{2+}), oil hydrocarbons, surfactants, hydrobiological indicators (phytoplankton saprobiotic index, quantitative and qualitative composition, chlorophyll-a concentration, macrozoobenthos, saprobity index, quantitative and qualitative composition, macrophytes), microbiological indicators.

Sampling frequency for hydrochemical analysis is 6 - 12 times per year, for hydrobiological analysis - 2 – 6 times per year.

Ichtiological monitoring is carried out once a year, determining the composition, abundance and age structure of fish fauna.

Wastewater Emission Monitoring Subprogram

The aim of wastewater emissions monitoring is to obtain information on the quantity and quality of wastewater discharged into surface waters and to assess the character and load of various point sources of pollution in Latvia.

The objective of monitoring is to ensure control of the compliance with the allowed limits of wastewater discharge and the emissions of pollutants into surface waters.

The wastewater emission network is formed by operators (companies) with their direct discharges of wastewater into surface waters (there are also indirect discharges when the company discharges wastewater into sewage system). These operators have received Water Use Permits (WUP) at their respective Regional Environmental Board (REB) in accordance with the Cabinet Regulation No. 155.

The Permit issued by the REB includes requirements to monitoring by the operator and specifies monitoring frequency depending on the character and type of emissions. The WUP is issued for a definite period and it specifies the permitted amount of wastewater discharge, and the allowed concentrations and the annual amounts (limits) of pollutant concentrations for each discharge point. An accredited laboratory must do analyses necessary for the control. (*233 operators are shown on the map of LEA)*
For some companies REB stipulates monitoring "upstream" and "downstream" from the discharge point to make a better assessment of their pollution.

Drinking Water Monitoring Subprogramme

Monitoring of drinking water quality has the following objectives:

- early identification of pollution of drinking water;
- protection of human health from negative consequences that can be caused by water pollution;
- providing information on the quality of drinking water to the community and the relevant authorities.

Within this monitoring program the quality of drinking water is assessed in accordance with the CM regulations No.63. Responsible authority for this monitoring is Public Health Agency.

Only Municipal enterprise "Rigas udens" (Riga`s Water) for the needs of water supply of the Riga City abstracts water from surface waters (Daugava, Riga HPS reservoir) and from Lake M.Baltezers. Regular control of water quality(compared to quality requirements CM regulations No 118 (Annex 5, 6,7) is provided by the laboratory of enterprise and overseen by Public Health Agency.

Bathing Water Monitoring Subprogram

The aim of the monitoring is to assess water quality at bathing sites, to ensure early identification of pollution of bathing sites and provide the public with objective information on the quality of bathing waters, and to prevent further deterioration of the quality of bathing waters.

Sampling of bathing water for the purposes of this monitoring subprogramme (under Cabinet Regulation No. 118) should be carried out at the following sites:
in Daugavpils region (29 sites); Liepajas region (7 sites); Tukums region (17 sites); Gulbene region (72 sites); Jekabpils region (27 sites); Valmieras region (28 sites); Riga and Riga district (28 sites); Ventspils region (19 sites); Zemgale region (25 sites); Rezekne region (31 site). In total 283 sampling sites have to be surveyed.

Surface Water Hydrological Monitoring Subprogram

The aim of hydrological monitoring is to provide systematic observations of hydrological regime in inland surface waters in Latvia. The objectives of hydrological monitoring include regular observations of inland waters and systematisation of these data, which is necessary for ensuring the economic and social development of the country and for environmental protection. That includes aggregation of operational hydrological data, creating long-term

observation data records, calculation of statistical parameters and making hydrological forecasts.

Responsible authorities are Latvian Hydrometeorological Agency (LHMA) and the Ministry of Agriculture. The number of hydrological stations of LHMA was significantly reduced during last decade due to shortage of funding. The current monitoring network is composed of 52 stations in rivers, 12 stations in lakes and reservoirs, and 10 stations in the Baltic Sea.

Agricultural Runoff Monitoring Subprogramme

In general the aim of agricultural runoff monitoring is to determine the load and impact of various agricultural activities and different pollution sources on the quality of waters focusing on losses of nutrients from agricultural lands.

Monitoring of diffuse and point source agricultural pollution is carried out in the small catchments. The number of stations (4) in the diffuse pollution monitoring network, included in the sub programme, is a minimum number for representation of regions with a variety of soils, climates and intensity of agricultural practices.

For determination of agricultural point source pollution monitoring is carried out in specially selected stations that are not equipped with discharge measuring structures. For the implementation of the minimum programme it is necessary to continue the monitoring that started in 1995 on 3 sites. Point pollution load is determined by taking water samples once a month (during the flood period – samples are taken more often) throughout the year, in the specially selected small agricultural catchments. No special measuring facilities are being used to measure discharge, which is determined by modelling.

Marine monitoring subprogram

The Marine monitoring subprogram was designed as integral programme with the aim to cover coastal, transitional and marine waters. The main aim of programme is to establish the ecological status of Latvia's marine waters with respect to natural changes (hydrological events, climatic changes, etc.) and anthropogenic pressure (discharges of nutrients and hazardous substances).
At present state 48 stations (16 transitional, 11 coastal and 21 marine) are monitored. The general principle is that supporting physical and hydro-chemical parameters are monitored more often than biological parameters and used as co-factors in spatial and temporal analyses of data.

6.2 Gaps

Comparison of the current surface water monitoring programme with the requirements of the WFD indicates the following main gaps:

1. The current surface water monitoring programme is focusing on chemical parameters, while main emphasis in the WFD is on biological quality elements (only chemical quality elements that are supporting biological quality elements should be monitored).
2. The division of the water quality network within the Surface Water Quality Monitoring Subprogram into representative, background, impact, boundary and flux stations does not correspond to the types of monitoring required by WFD: Surveillance, operational and investigative monitoring. Therefore, it is

very difficult to assign existing stations to a particular monitoring type of the WFD.

3. No monitoring of emissions is required by the WFD. Monitoring of discharges for the purposes of Urban Waste Water Treatment directive and quantification of the discharge of dangerous substances should be separated from the monitoring programme under the WFD.
4. Monitoring of bathing waters should be carried out as a separate part of the surface water monitoring programme
5. There is a great need for integration of hydrological monitoring with the rest of the surface water monitoring programme. It is recommended to revise and centralise financing of monitoring activities, to ensure that river basin management authorities and EPA can decide where to place the monitoring stations, define frequencies of monitoring and that they have full access to data.
6. More specific requirements on Quality Assurance, confidence and precision of data are needed.
7. Specific requirements on access to data from other institutions and provision of information on status of water bodies to the public is needed.
8. An integrated data management system where access to data in databases are given via one common portal. Access to data should be given to both institutions and the public.

6.3 Elements that can be considered to phase out

It is recommended that the new WFD monitoring programme substitutes as much of the present monitoring programme as possible. The present approach of monitoring of upstream downstream from point sources can be phased out.

The concept extensive/intensive stations can be used to reduce number of intensive monitoring stations.

Targeting the parameters to the type of monitoring and pressure can reduce the number of parameters monitored on each station.

7 Existing monitoring system, groundwater

7.1 Types and principles

PRESENT GROUNDWATER MONITORING IN LATVIA

The present groundwater monitoring system in Latvia consists of

1. a state monitoring network,
2. a municipal monitoring network and
3. monitoring of enterprises.

7.1.1 Legislative documents, stipulating the need for monitoring

- Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy;
- Council Directive 80/68/EEC of 17 December 1979 on the Protection of Groundwaters Against Pollution Caused by Some Dangerous Substances;
- Council Directive 91/676/EEC of 12 December 1991 Concerning the Protection of Waters Against Pollution Caused by Nitrates from Agricultural Sources;
- Council Directive 98/83/EC of 3 November 1998 on the Quality of Water Intended for Human Consumption;
- EPA recommendation for the implementation of the EUROWATERNET (EWN) programme;
- EURATOM Treaty;
- Regulation 2000/473/EURATOM of 8 July 2000 concerning Article 36 of the EURATOM Treaty with regard to monitoring of the level of radioactivity in the environment to which the public is exposed;
- Law On Environmental Protection;
- Law On Subsoil;
- Law On Pollution;
- Law on Water Management (draft);
- Cabinet Regulation No. 118 On the Quality of Surface Water and Groundwater;
- Cabinet Regulation No. 149 On the Protection Against Ionising Radiation;
- National Groundwater Monitoring Programme, approved by the MEPRD (1999).
- Contract B7/0320/2000/166079/MAR/C2 between the EU and CASSIOPEE Consortium “Long-term safety analysis of the Baldone radioactive waste repository and updating of waste acceptance criteria”.

7.1.2 State monitoring system

The State Monitoring system was approved in 2002 after a revision of the existing monitoring system, designed step by step from 1950. The new monitoring program was based on requirements of existing Latvian legislation, EU Directives and EPA recommendations.

255 observation wells at 43 stations are included in the national basic observation well network.

Within the framework of integrated monitoring groundwater measurements are carried out at the Taurene station (3 wells) and Rucava stations (4 wells). Monitoring of radioactive substances in groundwater should be carried out by the Baldone Radioactive Waste Repository (RWR) in a borehole well and in Daugavpils at the drinking water abstraction sites „Ziemeļi" and „Vingri" .

At the stations of the regional basic network observations of groundwater level and quality are carried out. Groundwater levels in the wells are determined in a discrete way and manually with electric measuring devices (precision – 0.01 m), and in artesian wells with the help of a manometer.

In 2001 groundwater levels were measured in 209 observation wells: at 16 stations from 2 times a week to once in 10 days; at 15 stations – once a month, and samples of groundwater were collected from 90 wells of the basic network.

In recent years, due to insufficient funding, samples from the wells of the basic network are collected during a cycle of 2 – 3 years. This ensures relatively representative data of the whole territory of Latvia, and the sampling frequency is sufficient considering that the long-term monitoring data show that the water quality in artesian aquifers (the main source of water supply in Latvia) is rather stable.

During recent years measurements of groundwater level, apart from Lielriga (Greater Riga) and Liepaja regions, which is in areas of undisturbed regime, continue only at 6 stations. In the rest of the wells groundwater levels are measured only during sample collection, that is, once in 2 – 3 years.

Groundwater quality monitoring includes sampling, testing for physical properties and chemical composition during the process of pumping out from the well and at the laboratory. The programme envisages determination of the following parameters: water level, pH, Eh, oxygen content and conductivity, Fe^{2+}, Fe^{3+} ion content, Na^{+}, K^{+}, Ca^{2+}, Mg^{2+}, Cl^{-}, SO_4^{2-}, total nitrogen and its mineral forms (N/NH_4^{+}, N/NO_2^{-}, N/NO_3), alkalinity, total organic carbon and total organic halogen.

At the integrated monitoring stations, in Taurene and Rucava wells the following parameters are determined in addition to the above-mentioned ones: S/SO^{2-}_4, water hardness and heavy metals (Zn^{2+}, Cd^{2+}, Pb^{2+}, Cu^{2+}, As^{3+}, Mn^{2+}, Ni^{2+}).
Minimum radioactive substances programme includes determination of ^{137}Cs, ^{90}Sr, ^{60}Co, 4 times a year in Daugavpils water abstraction sites „Ziemeli" and „Vingri", to control transboundary pollution of groundwater, and determination of ^{137}Cs, ^{60}Co, ^{3}H, ^{94}Nb and ^{36}Cl twice a year at in the deep well the Baldone RWR to ensure surveillance over a site of ionising radiation of national importance.

For selecting the locations and the design of monitoring stations, the following factors were taken into account:

- The requirement to cover all aquifers of the active water exchange zone (freshwater zone). The main attention should be paid to aquifers which are used for drinking water abstraction, controlling also the neighbouring aquifers and aquifer which serve as indicators of pollution or other adverse hydrochemical processes;
- Regular distribution of the stations across all the territory of Latvia to cover all major hydrogeological structures and catchments, as well groundwater bodies of national importance, identified in the Eurowaternet programme;

- Proportionality in distribution of the selected stations to match technogenic load. The highest density of stations is found in Riga and Liepaja district, characterised by the highest number of potential sources of pollution, formation of regional groundwater depression cones and hydraulic preconditions for infiltration of surface pollution and intrusion of saline waters. In the eastern part of Latvia and northern Kurzeme the density of the stations is the lowest;
- Importance of the stations, i.e., observation records, arrangement costs and the stage of development, and also costs of the station upgrading and the technical condition of the existing wells.

For groundwater monitoring mostly the monitoring stations with several wells are used. The stations, by the design of the well and the specific features are differentiated as follows:

- Balance stations. These stations consist of shallow well profiles perpendicular to the local flow direction. Groundwater level fluctuation data allow to estimate groundwater infiltrative recharge trends;
- Stage stations. These stations consist of a set of wells, close together but equipped with filters at different depths. Observations of water level and quality in all major aquifers are intended at a depth up to 200-400 m;
- Complex stations. These stations have a shallow well profile and also some deep wells.

The existing monitoring network was designed before the requirements of WFD and is not taking into account the newly delineated groundwater bodies. The present state groundwater monitoring design was based on delineation of aquifers and multi-aquifer systems.

7.1.3 Municipal groundwater monitoring

At present the state groundwater monitoring covers the largest urban areas.

Groundwater monitoring at the municipal level has not yet been started, but programs approved by the Geological Survey have been lined out in Riga and Liepaja. The first of these municipal programs is in Riga city that shall carry out groundwater quantitative and chemical monitoring in the city area. In Riga most attention is given to monitoring of water levels. The nature of these programs justifies that they could be called operational monitoring in the terms of the WFD, but today there are no legal requirement to this kind of monitoring.

The monitoring sub-programme, Monitoring of Groundwater in Agglomerated Areas, is intended to cover 61 wells in Riga and 24 wells in Liepaja, because groundwater pollution has been detected there, and the polluted groundwater runoff from these cities reaches the Baltic Sea, as these cities are situated near the sea.

Furthermore, Riga and Liepaja are the centres of regional groundwater depression cones that create preconditions for polluted groundwater infiltration to artesian aquifers.

In the future similar monitoring is also anticipated in Ventspils and Jurmala, and with the newly introduced requirement in the CM, groundwater monitoring in other urban areas (with abstractions greater than 100 m^3/day) should be carried out by the water user, i.e. the municipality.

The aim of the municipal groundwater monitoring is different from the aim of the state monitoring. The municipal groundwater monitoring is focused on solving of the practical tasks (water quality for water consumption, level regime including shallow aquifers, water resources). Therefore some guidance and legislative documents is necessary to increase the

quality and quantity of this monitoring, so the programs can be included in the future operational monitoring.

7.2 Groundwater monitoring in the enterprises

According to the requirements in Latvian legislation, groundwater monitoring is obligatory:

- as pollution control system for polluters (land fields, oil storages, etc.).;
- as groundwater resource and quality control system for enterprises with large abstractions of groundwater (municipal water works, mineral water extraction, extraction of raw materials, etc.).

Mostly monitoring requirements are included in the water use permits and licence on subsoil using. The requirements for water users include water level measurements and water quality control.

The State Geological Survey includes the water users' groundwater monitoring information for calculation of water balance and estimation of the available groundwater reserves at the abstraction sites.

Requirements for groundwater monitoring in polluted, potentially polluted sites and enterprises of risk (oil storages) are included in the law "On pollution". The requirements are included in the category A and B permits. The value of this monitoring information however, is often limited, because many enterprises for economic reasons do not fulfil the requirements (e.g. they do not use accredited laboratories for analyses, the analyses are done with different methods, and the sampling methods may be wrong). This means that information from these sources must be reviewed very carefully and after such a review the largest part of data are assessed as being of unsatisfactory quality.

7.3 Gaps

The aim of the state groundwater monitoring (which could be called surveillance monitoring) is to identify changes of any origin in the groundwater quantity and quality on the regional, sub regional and local level and to assess the compliance of the inland water status with the set groundwater quality standards. Monitoring data enables the making of early forecasts of threats to human health or stability of ecosystems, to mitigate or prevent adverse processes.

This description of the aim is fully in line with the chemical part in the WFD aim of monitoring.

However, apart from this the WFD requires an analysis of the link between groundwater and surface water regarding mutual impact and status. This is not an aim of the present Latvian monitoring program, but it is assessed that the program provides data that makes it possible to describe at least some of these links.

The elements of operational monitoring is not included in the existing program.

7.4 Elements that can be considered to phase out

There are more quality elements included in the present national monitoring program than required by the WFD. However the WFD is not specific as to which quality elements should be included, and for the general purposes of water resource planning the existing program is

needed. For this reason it is not recommended to phase out quality elements from the program.

When in the future the monitoring program is divided into surveillance and operational monitoring, the frequency of surveillance monitoring may be reduced from 1 per year (as today, theoretically) to 1 per 3 years (as today in reality) or 1 per 6 years (1 per management plan period) where historic data shows that this is sufficient.

8 Aim, definitions, responsible authorities and deadlines

8.1 Aim

The aim of the CM regulation on monitoring programmes for surface and groundwater shall be to collect the data needed to establish a coherent and comprehensive overview of water status within each river basin district and to permit the classification of all surface water bodies into one of five classes and groundwater into one of two classes.

The CM regulation on monitoring programmes for surface and groundwater shall regulate:

- Monitoring of ecological status and chemical status for surface waters
- Monitoring of groundwater quantitative status
- Monitoring of groundwater chemical status

8.2 Definitions

Definitions are already sufficiently covered in the Latvian **Law on Water Management**, Art. 1.

8.3 Responsible authorities

According to the Latvian Law on Water Management (Article 9 a) a Co-ordination Committee shall be established for each of the four river basin districts to co-ordinate the management measures within the river basin districts.

There are three institutions in Latvia that are responsible for practical implementation, coordination and supervision of water management related issues defined by Law on Water Management (LWM). Those are:

- State Geological Survey and its regional units;
- The Latvian Environmental Agency;
- The State Environmental Inspection.

The **State Geological Survey** and its regional units (river basin authorities), shall:

1. establish and update drafts of management plans and programmes of measures;
2. carry out an economic analysis of water resources use;
3. ensure participation of the public in preparation and updating of management plans and programmes of measures and inform those municipalities, which administrative territories are covered by these documents about the plans and programmes;
4. co-ordinate the implementation of programmes of measures;
5. develop the budget proposals necessary for the implementation of the programme of measures;
6. facilitate activities of the Co-ordination Committees;
7. co-operate with the competent authorities of the relevant countries to ensure the achievement of the environmental objectives for the whole international river basin district as well as implement joint programmes of measures;
8. participate in the development and implementation of the programmes for monitoring of water status.

Further the State Geology Survey and its regional units (river basin authorities) shall update management plans and programmes of measures and inform the municipalities about the plans and programmes.

The **Latvian Environmental Agency** shall:

1. develop programmes for monitoring of water status within each river basin district;
2. develop budget proposals for the implementation of the monitoring programmes;
3. co-ordinate and arrange implementation of the monitoring programmes;
4. provide the European Commission with the information specified by the Cabinet of Ministers.

The **State Environmental Inspection** shall supervise implementation of the programme of measures.

8.4 Relationship between annex II and annex V of the WFD in the design of surface water monitoring programmes

The CIS guidance on monitoring stresses that monitoring is a cross-cutting activity within the Directive and as such there are important interrelationships with other articles and annexes of the Directive. A key WFD article in relation to monitoring and the design of appropriate programmes for surface waters and groundwater is article 5 with the related annex II on typology and characterisation.

The CIS guidance illustrates the relationship between article 5 (annex II) and article 8 (annex V) in the design of surface water monitoring programmes as shown in Figure 1, and for groundwater as shown in Figure 2. This relationship is the background for the projects proposal for deadline for revision of the monitoring programme. (The WFD specifies deadlines for the revision of the Annex II analysis but not for the revision of the monitoring programme).

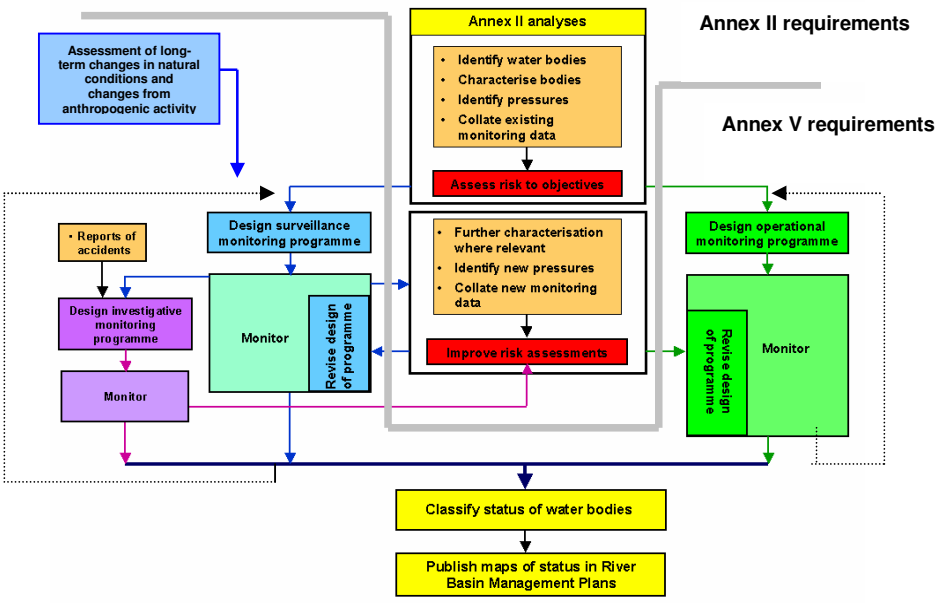


Figure 1. Schematic diagram illustrating the relationship between annex II and annex V of the WFD in the design of surface water monitoring programmes

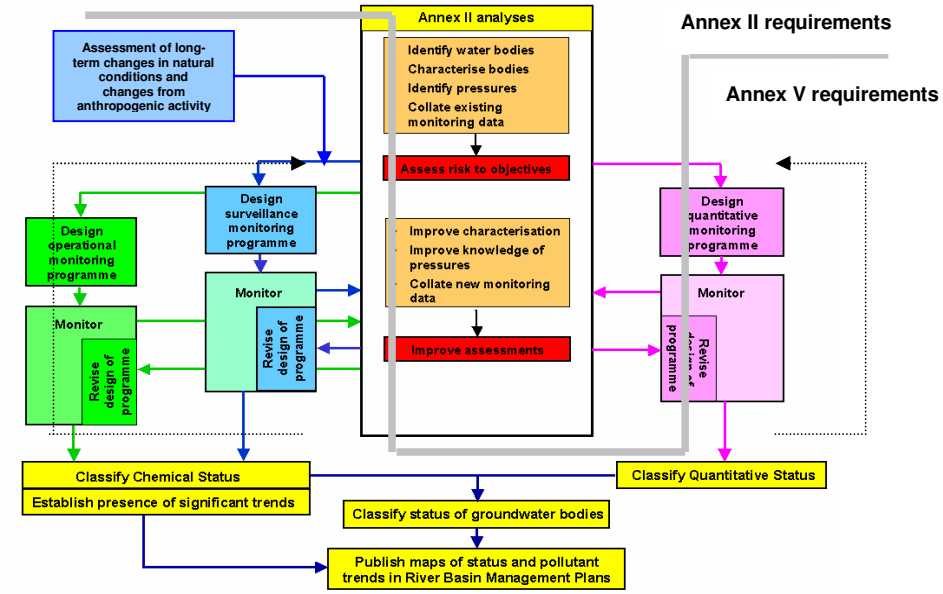


Figure 2. Schematic diagram illustrating the relationship between annex II and annex V of the WFD in the design of groundwater monitoring programmes

The annex II analysis is based on information on the status of the environment and information on pressures. Thus the information on the status of the environment obtained from the monitoring programmes is an important input to the annex II analysis. However, for the first annex II analysis to be completed by the end of 2004, there will not be data available from the annex V monitoring programmes, as they do not have to be operational until the end

of 2006. Therefore, the first annex II analysis has to rely on existing data, and there will be a great need to review it based on data from the WFD monitoring programmes. The deadline in the WFD for the first revision of the annex II analysis is 2013. After 2013 revision of the analysis shall be carried out every 6 years.

On the other hand the annex II risk assessments play a key role in the initial design and subsequent revision of the monitoring programmes as the operational monitoring addresses the water bodies at risk identified by this assessment. The WFD does not specify a deadline for revision of the monitoring programme but this project recommends that the monitoring programme be revised as soon as the revised annex II analysis is available.

8.5 Deadlines

Monitoring programmes shall be established and approved by the 1st January 2005, and shall be fully operational at the latest by the 22nd December 2006 according to the Latvian law on water.

The WFD also requires monitoring programmes to be fully operational at the latest by the 22nd December 2006.

The first data from the new monitoring programme will be available in the middle of 2008, as data from the first year of monitoring has to be collected, quality assured and reported before they can be used.

The Project recommends that the first revision of the monitoring programme be in 2010. This revision shall be based on the experience from monitoring and the elaboration of the first generation of River Basin Management Plans in order to have monitoring data based on a revised monitoring programme available for the elaboration of second generation of River Basin Management Plans (to be ready by the end of 2015). It should be noted that no revised Annex II analysis will be available for this revision.

The project further recommends carrying out the second revision of the monitoring programmes in the end of 2014, based on the revised annex II analysis, and then for every 6 years (see section 8.4).

9 Future monitoring system for surface water

The future monitoring system of the aquatic environment in Latvia should be based on the principles of the EU Water Framework Directive. The monitoring of surface and ground water shall be closely coordinated, however, taking into account Latvian traditions and distribution of responsibilities among institutions, the project proposes to treat surface and groundwater as separate parts in the revised water monitoring programme.

9.1 WFD approach

Monitoring programmes meeting WFD requirements shall be operational 22nd December 2006 (WFD Article 8 and Annex V). The monitoring programme is structured according to Annex V into:

1. Surveillance monitoring
2. Operational monitoring
3. Investigative monitoring

In addition Water Framework Directive requires to establish a reference network *"for spatially based type-specific biological reference conditions, Member States shall develop a reference network for each surface water body type. The network shall contain a sufficient number of sites of high status to provide a sufficient level of confidence about the values for the reference conditions"*.

For surface waters the monitoring shall cover:

1. The volume and level or rate of flow relevant for status of WBs;
2. The ecological and chemical status and ecological potential of WBs.

Protected areas may require further monitoring.

Each type of monitoring (surveillance, operational and investigative) is carried out to meet specific information needs, and this determines principles for selection of monitoring sites, monitoring frequency and parameters to be monitored.

"Water bodies" are the units that will be used for reporting and assessing compliance with the principal environmental objectives of the Directive. A key Article of the Directive in relation to monitoring and the design of appropriate programmes for surface waters and groundwater is Article 5. It requires river basin districts to be characterised, and the environmental impact of human activities to be reviewed in accordance with Annex II.

The risk assessments that are specified in Annex II play a key role in the initial design and subsequent revision of the monitoring programmes required by the Directive.

The key element in the design of surface water monitoring programmes is delineation of water bodies and identification of water bodies at risk. Although the process of identification of water bodies is not a part of monitoring programme, it is very important to have a common understanding of this procedure. Specification of procedures for identification of water bodies, and identification of water bodies at risk of not meeting the environmental objectives, is provided in Annex 1 of this report.

Surveillance monitoring

Surveillance monitoring is carried out to provide an assessment of the overall water status in catchments and sub-catchments. The results provide information for the revision of the Annex II impact assessments, for revision of the monitoring programme, on long-term changes in natural conditions and in effects of widespread anthropogenic activity. Generally the monitoring shall be carried out at a surveillance monitoring site during one year within each 6 years planning period.

The Directive stipulates that surveillance monitoring should be carried out at points where:

- The rate of water flow is significant within the river basin district as a whole; including points on large rivers, where the catchment is greater than 2 500 km^2;
- The volume of water present is significant within the river basin district, including large lakes and reservoirs;
- Significant bodies of water cross a Member State boundary;
- Sites are identified under the Information Exchange Decision 77/795/EEC; and,
- Sites that are required to estimate the pollutant load which is transferred across Member States boundaries, and which is transferred into the marine environment.

Operational monitoring

Operational monitoring is carried out to clarify the status of water bodies identified as being at risk of non-compliance with their objectives and to assess changes resulting from the programmes of measures (as an input for establishing and revising the programmes of measures included in the river basin management plans).

For operational monitoring, Member States are required to monitor for those biological, chemical and hydromorphological quality elements most sensitive to the pressures to which the body or bodies are subject and all priority substances discharged and other substances discharged in significant quantities.

Investigative monitoring

Investigative monitoring is carried out where further monitoring is needed to clarify reasons for non-compliance and needed measures and in case of accidental pollution.

Investigative monitoring may also be required in specified cases. These are given as:

- Where the reason for any exceedances (of Environmental Objectives) is unknown;
- Where surveillance monitoring indicates that the objectives set under WFD Article 4 for a body of water are not likely to be achieved and operational monitoring has not already been established, in order to ascertain the causes of a water body or water bodies failing to achieve the environmental objectives; or
- To ascertain the magnitude and impacts of accidental pollution.

Investigative monitoring will thus be designed to address and clarify the specific case or problem identified.

9.2 Proposed approach for development of monitoring programme

The overall approach for the proposed monitoring programme is to:

- address requirements of the EU directives, in particular EU Water Framework Directive, and Latvian needs,
- to get maximum amount of information on the status of the environment and the impact of pressures compared with the resources allocated.

To optimise amount of information compared with the resources allocated the project proposes a concept of intensive and extensive monitoring stations (more explanation will be provided later in this report) and use monitoring data from reference monitoring also for the purpose of surveillance monitoring.

For further saving of resources it can also be considered to reduce or stop monitoring activities at the stations in water bodies, where existing monitoring data show that they definitely do not meet their objective until the measures addressing the improvement of the water body in question are operational (e.g. downstream of untreated water discharges).

Also a stepwise implementation of the monitoring programme can be considered.

Surveillance monitoring

Surveillance monitoring is carried out to provide an assessment of the overall water status in catchments and sub-catchments. Therefore, surveillance monitoring stations should be evenly distributed in different River Basin Districts and represent all categories (rivers, lakes, transitional and coastal waters) and all types of water bodies.

The project recommends:

1. To include reference network as a part of surveillance monitoring.
2. To introduce concept of intensive and extensive monitoring stations in order to extend the coverage of the monitoring programme.

The Water Framework Directive states: "For spatially based type-specific biological reference conditions, Member States shall develop a reference network for each surface water body type. The network shall contain a sufficient number of sites of high status to provide a sufficient level of confidence about the values for the reference conditions". Reference monitoring provides an input to surveillance monitoring. The reason is that the monitoring of reference stations will give information on long-term changes in natural conditions and to some extent on effects of widespread anthropogenic activity, as it will be very difficult to identify reference stations that are not to some degree impacted by widespread anthropogenic activity (e.g. input of pollutants from the atmosphere).

This project recommends including both intensively and extensively sampled monitoring stations in the surveillance monitoring programme for rivers, lakes, transitional and coastal waters. The advantage of this approach is that a large number of water bodies can be covered using the extensive monitoring (e.g. stations are sampled every three years using rotation principle). At the same time the monitoring results from the intensively monitored sites (every year) enable the authorities to avoid misinterpretations in the assessments of the status of the extensive stations. Misinterpretations could be due to e.g. unusual weather conditions. The intensive monitoring stations will also ensure a more safe evaluation of reference conditions and of the more general status of the water bodies within a reasonable short span of years. The approach of intensive/extensive monitoring stations will maximise the information gained compared to the resources used.

Thus stations for the surveillance monitoring could be divided into three main categories:

A. Stations for calculation of river transport and source apportionment
B. Stations for assessment of status of water bodies
C. Reference stations

Stations for calculation of river transport and source apportionment (type A stations) will serve several purposes:

- Calculation of the diffuse agricultural load reflecting different types of agricultural production and soil types (also cover monitoring needs of EU Nitrates Directive).
- Calculation of effects of widespread anthropogenic activity, including dangerous substances.
- Calculation of transport of pollutants from neighbour countries and to the Baltic Sea
- Identification of WBs at risk not identified in the first Annex II analysis.
- Calculation of load to standing waters (e.g. lakes and water reservoirs).

Type A stations should be located on the main transboundary rivers entering Latvia, at the mouth of major Latvian rivers and selected tributaries (e.g. with catchment area larger than 5000 km^2). It should be noted that type A stations are not directly linked to water bodies. Example: transboundary station shall be placed close to the border and enable estimation of pollution transported across the border from the neighbour country or to the Sea. Transboundary station shall not necessarily reflect the status of the particular water body.

Stations for assessment of the status of water bodies (type B stations) will be used for classification of water bodies according to requirements of WFD Annex V. Main focus of monitoring activities in these stations is on biological parameters. To reduce the costs of the monitoring programme it is proposed to run intensive monitoring on a limited number of sites (sampling every year), whereas other stations can be monitored once or twice during the 6 years planning cycle. Intensive monitoring stations are selected to be sufficient to give the baseline reflecting natural variation in the biological community caused by e.g. natural changes in climatic conditions.

It is proposed to divide Latvian territory by a grid with 100 km^2 cells (10x10 km). Each cell in the grid should be represented by at least one monitoring station for rivers. For the cells that do not contain a reference station, operational monitoring station or surveillance monitoring station (type A and B in the table above) it is proposed to include one extensive river surveillance monitoring station. These stations will cover the spatial variation; provide information on long-term changes in natural conditions and to some extent on effects of widespread anthropogenic activity to the extent that the other types of monitoring do not cover this. In addition the approach of extensive monitoring will provide good spatial coverage and sufficient number of stations in each water body to meet the requirements of WFD on precision and confidence. These stations can be visited every 3 or 6 years. Density of stations may be revised after a statistical evaluation of the monitoring data (assessment of confidence).

Reference stations (type C stations) are needed for the establishment of type specific reference conditions (if available). These stations will reflect the state of waters only affected by human activities to a very minor extent. The possibilities for sharing reference stations between the countries in the Baltic Ecoregion are under discussion.

Operational monitoring

The operational monitoring is carried out at water bodies “at risk of not meeting environmental objectives” due to known pressures. Therefore, the operational monitoring programme is very closely linked to the risk assessment procedure according to analysis required by the WFD Annex II. I.e. operational monitoring should be carried out for the water bodies at risk of not meeting the environmental objectives, targeting the significant pressures

for each of these water bodies. Thus the operational monitoring programme can be designed only after the identification of water bodies at risk, and the identification of significant pressures for each WB at risk has been carried out.

The results of the operational monitoring are key input to the river basin management plan that has to be published 22 December 2009. In general operational monitoring shall be undertaken at all WBs at risk. If measures to meet the WB objectives have been decided or if sufficient knowledge is available for establishing the necessary measures to meet the objectives operational monitoring is not needed for the first river basin plan, but needed to follow the development of the status of the WB.

Operational monitoring sites, parameters and frequencies reflect the pressures on each WB at risk. For example if an effluents from an industrial plant includes dangerous substances in such quantities that the receiving river is considered at risk (violation of water quality standards) the water body should be monitored for the dangerous substances in question plus the biological components most vulnerable to those substances.

Investigative monitoring

General monitoring programmes cannot be not elaborated for investigative monitoring. The relevant authority should be prepared for monitoring in cases of accidental pollution.

Examples on investigative monitoring:

- In connection with oil spills.
- Stations where fauna-indices are low while hydromorphological indices are high and there are no point sources in the catchment that can explain the low fauna-index value.

9.2.1 Stepwise design of monitoring programme

The project recommends that the surface water monitoring programme in line with WFD is developed using the following step-wise approach. It is assumed that prior to development of the monitoring programme characterisation of river basins according to the Annex II of the WFD is carried out (including identification of water bodies and water bodies at risk):

Stepwise approach for design of surface water monitoring programme in line with WFD

1. Identification of reference stations (surveillance monitoring, type C stations) representing type-specific biological reference conditions for different types of water bodies (reference network will become a part of surveillance monitoring)
2. Identification of stations for operational monitoring (at water bodies identified as being at risk of not meeting the objectives, based on analysis of pressures)
3. Identification of river transport and source apportionment stations (surveillance monitoring, type A stations);
4. Identification of intensive monitoring stations for assessment of status of water bodies (surveillance monitoring type B stations);
5. Identification of areas not represented by the monitoring under 1 and 2 above (surveillance monitoring type B stations)

(A, B and C stations for surveillance monitoring are defined below)

Identification of monitoring stations in each step should be followed by selection of parameters and definition of monitoring frequency. When developing the monitoring

programme it is recommended to use GIS facilities, as it will make the subsequent use of data from the monitoring programme and reporting easier and more efficient.

9.3 Selection of quality elements, monitoring stations and parameters

The WFD proposes to use the following quality elements for the classification of ecological status, indicating that they should also be included in the relevant parts of the monitoring programme:

- Biological quality elements
- Hydromorphological elements supporting the biological elements
- Chemical and physico-chemical elements supporting the biological elements

Biological quality elements

Summary of the WFD requirements for monitoring of biological quality elements is provided in table below:

Quality element	Rivers	Lakes	Transitional waters	Coastal waters
Biological elements				
Composition, abundance and biomass of phytoplankton		✓	✓	✓
Composition and abundance of aquatic flora	✓	✓	✓	✓
Composition and abundance of benthic invertebrate fauna	✓	✓	✓	✓
Composition and abundance of fish fauna	✓	✓	✓	
Age structure of fish fauna	✓	✓		

Note: this is the same table as in section 3.1

Benthic invertebrate fauna
It is proposed to use Benthic invertebrate fauna as the main element for biological monitoring in streams, transitional and coastal waters. It is recommended not to include it in monitoring of lakes.

Fish fauna
Fish fauna should only be included in *river* monitoring if the size of the river is not to big to allow quantitative electro-fishing (e.g. mean summer flow below 200 l/s and mean summer water depth below 0,3 meter).

For all intensive monitored *lakes* monitoring of fish fauna should be carried out every 12 year.

Fish fauna should be monitored in transitional waters in form of intensive monitoring until compliance with ecological quality objectives is achieved. Furthermore it is recommended to carry out monitoring every 3rd year.

Aquatic flora

The project recommends to carry out monitoring of macrophytes in *rivers, lakes, transitional and coastal waters* (intensive stations only). Parameters such as species composition, coverage, depth limits shall be monitored in lakes and coastal waters.

It is recommended not to include periphyton in the monitoring programme.

Phytoplankton
It is proposed to include phytoplankton (chlorophyll a, algal blooms, species composition and abundance and indicator species) in the intensive biological monitoring of *lakes, transitional and coastal waters* but not in rivers.

Other biological parameters not included in the WFD list of quality elements
Monitoring of other biological parameters such as zooplankton, bacteria etc. may be included in the monitoring programme if the information on environmental status compared with costs justifies this.

Hydromorphological elements

Summary of the WFD requirements for monitoring of hydromorphological quality elements supporting the biological elements is provided in the table below:

Quality element	Rivers	Lakes	Transitional waters	Coastal waters
Hydromorphological elements supporting the biological elements				
Hydrological regime				
Quantity and dynamics of water flow	✓	✓		
residence time		✓		
Connection to groundwater bodies	✓	✓		
River continuity				
River continuity	✓			
Morphological conditions				
Depth variation	✓	✓	✓	✓
Width variation	✓			
Structure and substrate of the bed	✓	✓	✓	✓
Quantity of the bed		✓	✓	
Structure of the riparian zone	✓			
Structure of the shore		✓		
Structure of the intertidal zone			✓	✓
Tidal regime				
Freshwater flow			✓	
Direction of dominant currents				✓
Wave exposure			✓	✓

Note: this is the same table as in section 3.1

Quantity and dynamics of water flow
For all stations for calculation of river transport and source apportionment the quantity and dynamics of water flow shall be monitored.

Residence time
Residence time for lakes shall be calculated based of inflowing water on yearly basis (from the rotational monitoring of 10 new lakes every year).

River continuity
A map and database with information on dams and reservoirs should be established. The database should also contain information on position and effectiveness of fish passes.

Morphological conditions
Depth and width variation plus structure and substrate of the bed of rivers should be part of the benthic invertebrate monitoring in streams and rivers (standardised hydromorphological index). Substrate and structure of the bed should be part of the benthic invertebrate monitoring in transitional and coastal waters. Depth variation and structure of the intertidal zone are proposed to be part of reference monitoring once every 6-year period.

For all lakes included in the monitoring programme a map with the depth variations should be made, and mean depth should be calculated. Structure and substrate of the shore should be included for coastal waters but not in lakes. The same rotational system as for the monitoring of river transport of water and pollution to the lakes is recommended to be used.

Tidal regime
Direction of dominant currents should be calculated from hydrological monitoring. The wave exposure is proposed to be calculated once every 6-year period.

Chemical and physico-chemical elements

Summary of the WFD requirements for monitoring of Chemical and physico-chemical elements supporting the biological elements is provided in the table below:

Quality element	Rivers	Lakes	Transitional waters	Coastal waters
Chemical and physico-chemical elements supporting the biological elements				
General				
Transparency		✓	✓	✓
Thermal conditions	✓	✓	✓	✓
Oxygenation conditions	✓	✓	✓	✓
Salinity	✓	✓	✓	✓
Acidification status	✓	✓		
Nutrient conditions	✓	✓	✓	✓
Specific pollutants				
Pollution by all priority substances identified as being discharged into the body of water	✓	✓	✓	✓
Pollution by other substances identified as being discharged in significant quantities into the body of water	✓	✓	✓	✓

Note: this is the same table as in section 3.1

General
In *lakes* transparency, thermal conditions, oxygenation conditions, pH, alkalinity, content of humic substances and nutrient conditions shall be monitored. Salinity is only monitored for lakes with brackish water intrusion.

In *rivers*, temperature, oxygenation conditions, biological oxygen demand, pH, ammonia, and content of humic substances shall be monitored. Salinity is only monitored for rivers with brackish water intrusion. Nutrient status should be monitored in river stations used for calculation of river transport and source apportionment.

In *transitional and coastal waters* transparency, thermal conditions, pH, oxygenation conditions, nutrient and salinity conditions shall be monitored.

Specific pollutants
In the following categories of intensive surveillance stations for calculation of river transport and source apportionment: river mouth stations, cross-border river stations and baseline sub-basin river stations priority substances (listed in Annex X of the WFD) and other specific pollutants shall be monitored in the water phase and sediment. On the other intensive surveillance stations for calculation of river transport and source apportionment priority substances identified as being discharged into the catchment and other specific pollutants identified as being discharged in significant quantities shall be monitored in the water phase and sediment.

In the intensive surveillance stations of transitional and coastal stations priority substances should be monitored in biota.

One station for monitoring of Radioactivity in water and sediment in the part of the Daugava catchment receiving the cooling water from the Ignalina nuclear power plant is proposed.

9.3.1 Surveillance monitoring

As discussed above, the project recommends dividing the surveillance monitoring stations into three main categories:

Type A: Stations for calculation of river transport and source apportionment
Type B: Stations for assessment of status of water bodies
Type C: Reference stations

Selection of parameters depends on the objectives set for that particular type of monitoring station, thus different quality elements and parameters will be monitored in e.g. reference stations (type C) and stations for calculation of river transport and source apportionment. It should be stressed that a limited number of stations may serve several objectives: e.g. reference station (type A) or station for assessment of status of the water body (type B) could be used for source apportionment.

Stations for calculation of river transport and source apportionment (Type A)

Surveillance monitoring stations for calculation of river transport and source apportionment (Type A) serve several objectives, which are summarised in the table below:

Objective	Estimated number of stations	Explanatory notes
to provide information on the flux of water and substances to transitional and coastal waters	5	stations located at the mouth or largest Latvian rivers
to provide data on the flux of water and substances either entering Latvia from other	15	cross-border river stations

countries or leaving Latvia to other countries		
to serve as a baseline programme giving a complete overview of the state and changes in river hydrology, chemistry, loads and source apportionment	10	Stations located in the mouth of largest tributaries of Latvian rivers (sub-basin rivers)
to calculate the natural background level of area load	10	nature dominated stations (stations with little anthropogenic impact) covering different soil types and regions with different precipitation
to give an overview of the state and changes in river hydrology and chemistry where the main pressures come from diffuse sources	15	Stations located in areas dominated by agriculture
to provide information on the load of pollutants to lakes	10	Stations located in the tributaries of selected lakes
Total estimated number of stations: 65.		

It is important to point out that Type A stations are not connected to water bodies. The location of a monitoring station shall reflect objective set for that particular station type (e.g. cross-border river stations shall be established close to the national border, river mouth stations shall be established close to the sea).

It is recommended that all stations for calculation of river transport and source apportionment (Type A) are monitored intensively: i.e. monitoring is carried out every year. Recommendations for selection of quality elements for the type A stations are outlined in the table below:

Quality element	**Recommendation**
Biological	Biological quality elements should be monitored only if needed for operational monitoring or other purposes
Hydromorphological	Quantity and dynamics of water flow shall be monitored at all stations
Chemical and physico-chemical	General. All stations: BOD, Ntot, Ptot, nitrate, ammonia, pH, temperature. Recommended frequency of sampling – 18 samples per year
	Dangerous substances: hazardous and priority substances (DSD list I and WFD Annex X substances) as well as other substances relevant for Latvia shall be monitored in river mouth stations, cross-border river stations and sub-basin river stations (sampling of water and sediments). Pesticides: only in stations located in areas dominated by agriculture.
	Radioactivity: 1 station (sampling in water and sediment) in the part of the Daugava catchment receiving the cooling water from the Ignalina nuclear power plant

Proposal for identification of stations for calculation of river transport and source apportionment.

1. Stations located at the mouth or largest Latvian rivers. Proposed rivers: Daugava, Lie Lupe, Venta, Gauge, Silica. Stations located in the mouth of these rivers will provide sufficient information for calculation of transport of nutrients from Latvian territory to the Baltic Sea.
   Estimated number of stations: 5

2. Cross-border river stations. These stations should be located on the main rivers entering the Latvian territory or discharging waters to neighbouring countries.
   Estimated number of stations: 15
3. Stations in the mouth of main tributaries (sub basin stations), where pressure comes from both point and diffuse sources. Only tributaries with catchments area above 2000 km^2 should be selected.
   Estimated number of stations: 10
4. Nature dominated stations. Stations should be located in the catchments dominated by natural vegetation: more than 50% of the catchment area covered by natural vegetation e.g. forest, bogs, lakes etc. with no large towns. Selection of the stations should be based on CORINE land cover map. Stations should be distributed in different regions of Latvia to reflect different soil types and differences in precipitation.
   Estimated number of stations: 10
5. Stations located in areas dominated by agriculture. Stations should be located in the catchments dominated by agriculture: more than 50% of the catchment area used for agriculture, no big towns. Selection of the stations should be based on CORINE land cover map.
   Estimated number of stations: 15
6. Stations located in the tributaries of selected lakes, to provide information on the load of nutrients to the lakes. It is proposed to sample in a rotational system, monitoring 10 new lakes every year.

Stations for assessment of water body status (Type B)

Monitoring at Type B stations will provide information needed for classification of water bodies into classes according to the Annex V of the WFD. These stations should be evenly distributed over the Latvian territory, representing the widespread human activities and all water body types. It is proposed to have two types of stations:

- Intensive stations (to be monitored every year).
- Extensive stations (to be monitored once every three years in a rotational programme).

Intensive monitoring stations are needed for the assessment of long-term changes in natural conditions and long-term changes resulting from widespread anthropogenic activity. These stations will allow interpreting the variation in results obtained from the extensive monitoring stations. Estimated number of stations: 10 stations in lakes, 15 in rivers, 6 in transitional waters and 18 in coastal waters. To reduce the costs of the monitoring programme some reference stations could be used as intensive stations, too.

Extensive monitoring stations will provide information on state and trend of ecosystems. The stations will be monitored once every third year in a rotational programme.

<u>Rivers</u>

The same quality elements and parameters shall be monitored in intensive and extensive river monitoring stations:

Quality element	Recommended parameters
Biological	• Benthic invertebrate fauna (proposal to use benthic fauna index) • Fish fauna: all intensive stations and 20% of extensive stations • Macrophytes (species composition, coverage)
Hydromorphological	• Standardised hydromorphological index shall be monitored at all stations. • River continuity monitoring (database on dams and fish passes) should cover all rivers.
Chemical and physico-chemical	• General: temperature, oxygenation conditions, biological oxygen demand, pH, ammonia, and content of humic substances shall be monitored in all stations • No monitoring of dangerous substances and radioactivity

Proposal for identification of stations for assessment of water body status. Rivers

It is proposed to divide the territory of Latvia into a grid of 100 km^2 (10x10 km cells). In each cell one station is identified, unless on operational or reference station in the rivers already exists, or the station could be pooled with another station, e.g. in areas with little human impact. When selecting the stations care should be taken to represent all water body types. Stations for intensive monitoring should represent all water body types and should be evenly distributed throughout the Latvian territory. Stations for extensive monitoring to be visited each year should be selected using a random selection procedure.

Estimated number of stations for intensive monitoring (assessment of long term changes in the biological community): 15
Estimated number of stations for extensive monitoring: 300.

Lakes

The same quality elements and parameters shall be monitored in lakes covered by both intensive and extensive monitoring programme.

Quality element	Recommended parameters
Biological	• Phytoplankton (chlorophyll a, algal blooms, species composition and indicator species) • Fish fauna: all intensive stations, monitoring every 12 years • Macrophytes (species composition, coverage, depth limits)
Hydromorphological	• Residence time (based of inflowing water on yearly basis. Rotational monitoring of 10 new lakes every year) • Depth variation (map with the depth variations, and mean depth)
Chemical and physico-chemical	• General: transparency, thermal conditions, oxygenation conditions, pH, alkalinity, content of humic substances and nutrient conditions • No monitoring of dangerous substances and radioactivity

Proposal for identification of stations for assessment of water body status. Lakes

It is proposed to make list (or GIS map) of lakes indicating the type of the lake. All types should be equality represented in the monitoring programme.

Estimated number of stations for intensive monitoring (assessment of long term changes in the biological community): 10
Estimated number of stations for extensive monitoring: 50.

Transitional and coastal waters

Quality element	Recommended parameters
Biological	• Phytoplankton (chlorophyll a, algal blooms, species composition and abundance, and indicator species[3]) • Benthic invertebrate fauna (species composition, abundance and biomass) • Fish fauna. One station only, monitoring every 3 years • Macrophytes – intensive stations only (species composition, coverage, depth limits)
Hydromorphological	• Structure and substrate of the shore
Chemical and physico-chemical	• Transparency, thermal conditions, pH, oxygenation conditions, nutrient and salinity conditions

Proposal for identification of stations for assessment of water body status. Transitional and coastal waters

It is proposed to make a GIS map indicating the type of coastal waters and transitional waters, indicating bed substrate composition and structure.

Estimated number of stations for intensive monitoring (assessment of long term changes in the biological community): chlorophyll a 24, phytoplankton 5, fish fauna 1, benthic invertebrates 24, macrophytes 3 transects.
Estimated number of stations for extensive monitoring: 60

Reference stations (type C)

The Reference network should be designed to provide information on type specific reference conditions – i.e. areas only to minor extent affected by human activity. The same parameters should be monitored at reference stations as at stations for assessment of water body status (Type B). However, in coastal, transitional and marine waters of Latvia no areas can be identified to correspond the status of reference areas and therefore, it is not possible to establish reference network.

9.3.2 Operational monitoring

Operational monitoring shall be carried out in water bodies that are at risk of not meeting the environmental objectives. This means that stations for operational monitoring can be identified only after completion of the characterisation procedure according to the WFD Annex II. The EU working group on Identification of pressures and impacts (IMPRESS) under the Common Implementation Strategy for WFD has issued a guidance document "Guidance for the analysis of Pressures and Impacts in accordance with the Water Framework Directive". Summary of the guidance document is provided in Annex 2 of this report.

The first characterisation of river basin districts (including identification of water bodies at risk) shall be carried out by the end of 2004 and should be based on existing data. Taking into account the limited time and limited data, the project proposes to concentrate on few main pressures:

- Discharge of hazardous and priority substances
- Waste water discharges
- Dams
- Agricultural inputs (for lakes only)

Data from existing monitoring (especially biological monitoring) should be used as far as possible to identify possible pressures and assess impacts. If other available monitoring results indicate that the ecological status is less than good the water body is identified as being at risk of not meeting good status. A water body is not classified as being at risk, if monitoring results indicate that good status is achieved.

The textboxes below present a pragmatic approach for identification of water bodies at risk for the purpose of the first characterisation of river basins.

Discharge of hazardous and priority substances

The water body should be identified as being at risk, if it is expected that the concentration of hazardous and/or priority substances exceeds the water quality standards. Assessment shall be made based on:

- Existing monitoring data (monitoring of both effluent and receiving waters)
- Inventory of industrial activities and discharges (simple dilution models should be applied to assess compliance with WQS downstream from discharges)
- Inventory of polluted territories (e.g. former military sites)

Pesticides should be monitored at selected sites situated in intensive agricultural areas.

Waste water discharges

1. River reaches downstream wastewater discharges are considered to be at risk for non-compliance with good status or good potential if the specific waste water discharge is estimated to increase the annual average BOD concentration in the river by >0.2 mg/l.

Assumptions used:
The average annual river flow is assumed to correspond to 200 mm/year from the catchment corresponding to 200,000 m^3/km^2 year. A BOD increase of 0.2 mg/l corresponds to 40 kg/year. If sufficient wastewater discharge monitoring results are not available the BOD from 1 person is assumed to be 20 kg BOD/year (untreated or mechanically treated). For biologically treated wastewater the load from 1 person is assumed to be 4 kg BOD/year. It is generally assumed that degradable organic matter from one discharge point is mineralised before reaching the next downstream wastewater discharge point. Dry weather discharges from one town to the same river are summarised and considered as one wastewater outlet.
BOD from wastewater, calculated criteria:
An annual discharge of *above 40 kg BOD/km^2 year* will lead to an identification of the reach downstream the discharge point to be at risk. This corresponds approximately to a discharge of untreated wastewater from 2 persons/km^2 catchment at the discharge point or biologically treated wastewater from 10 persons/km^2.

2. A lake is considered to be at risk because of wastewater discharges in its catchment if the estimated increase in annual average total P concentration of inflowing water is

above 10 mg P/m^3.

Assumptions used:
The average annual river flow is assumed to correspond to 200 mm/year from the catchment corresponding to 200,000 m^3/km^2 year. An increase of 10 mg P/m^3 corresponds to 2 kg P/km^2 year. If sufficient wastewater discharge monitoring results are not available the total P from 1 person is assumed to be 2 kg/year from untreated, mechanically, or biologically treated wastewater. For wastewater with P removal the contribution is assumed to be 0.5 kg P/year.
Phosphorus from wastewater, calculated criteria:
An annual discharge of *above 2 kg total P/km^2 year* in a lake catchment will lead to an identification of the lake to be at risk. This corresponds approximately to a discharge of wastewater from 1 person/km^2 catchment area of the lake (with treatment plants with P removal from 5 persons). All discharges from the entire lake catchment are summarised.

Dams

Dams prevent the natural migration and spreading of the freshwater fauna, especially the migratory fish. Further, the river ecosystem is changed upstream a dam, if the damming of a river creates a significant reservoir. Such reservoirs can not meet the requirements for a good status, but possibly the requirements for a good potential. The water bodies in the entire catchment upstream an artificial dam should be designated as water bodies at risk of not meeting good status unless well functioning passage possibilities are established at the dam for upstream and downstream migration.

However, the character of the impact of a dam on upstream water bodies differs widely from the impacts from a discharge of pollutants and local physical modifications of a water body. Some water bodies upstream dams and otherwise unpolluted can in fact in most aspects have a high status if not otherwise impacted. Therefore, the identification of water bodies at risk because of damming is in practice made by a separate identification of the sites of dams on a GIS map. This identification of the upstream water bodies at risk will in most cases not require a further operational monitoring to be able to decide upon the measures needed to establish the needed passage possibilities.

Nutrients form agriculture

Cultivation of land leads to increases in nutrient losses. Especially increased P loadings from the catchment will contribute to a eutrophication of lakes. The relations between agricultural activities and P losses are insufficiently known and widely different from field to field.
Criteria for agricultural impact
Agricultural activities in a catchment to a lake are considered to lead to a risk of non-compliance if more than 50% of the catchment is classified in the CORINE land use maps as agricultural areas (cultivated, pastures, gardens etc.). If more than 25% of the lake catchment can be identified as intensively cultivated (e.g. though agricultural statistics) the lake is also considered being at risk.

9.3.3 Investigative monitoring

The monitoring programme shall identify problems. The general approach is that the authority that is responsible for monitoring shall allocate some resources (e.g. 5% of the total budget for operational and surveillance monitoring) for more detailed investigations of causes for water bodies not meeting the good status, where causes are not known at present. It is recommended to carry out the investigative monitoring as separate projects.

Investigative monitoring also covers the effects of accidents.

Transitional and coastal waters
All stations designated in transitional waters as type (B) stations are from the present monitoring programme. Most of coastal stations are either operational or should be designated by pilot projects within the frame of "Implementation plan of National monitoring program".

9.4 Additional monitoring requirements (protected areas)

The WFD specifies that surveillance and operational monitoring programmes need to be supplemented in order to fulfil the following requirements:

1. drinking water abstraction points
2. habitat and species protection areas

Re. 1: The WFD states that surface water bodies used for abstraction of drinking water which provide more than 100 m^3 a day as an average shall be designated as monitoring sites and shall be subject to such additional monitoring as may be necessary to assess the level of purification treatment required in the production of drinking water. Such bodies shall be monitored for all priority substances discharged and all other substances discharged in significant quantities which could affect the status of the body of water, and which are controlled under the provisions of the Drinking Water Directive. Monitoring frequencies are set out in Annex V (para 1.3.5) of the WFD.

Re. 2: Bodies of water bodies that are habitat and species protection areas shall be included in the operational monitoring programme referred to above where, on the basis of the impact assessment and the surveillance monitoring, they are identified as being at risk of failing to meet their environmental objectives. Monitoring shall be carried out to assess the magnitude and impact of all relevant significant pressures on these bodies and, where necessary, to assess changes in the status of such bodies resulting from the programmes of measures. Monitoring shall continue until the areas satisfy the water-related need for habitat and species protection and meet their objectives.

9.5 Assessment of costs of the new monitoring programme

As the design of the new monitoring programme is very tightly linked with the available resources, the project has elaborated a Decision Support Tool for assessment of costs of the monitoring programme in line with WFD. The tool shall make it possible:

1. To get a rough estimate of the overall costs of the programme.
2. To see the influence of a change in number of stations or parameters.
3. To see the influence of a change in approach (e.g. an increase in intensive and decrease in extensive surveillance monitoring stations)

The Decision Support Tool is based on interlinked Excel worksheets. All calculations are based on unit costs. The tool will assist to estimate the following operational and maintenance (running) costs:

- Sampling costs - includes assessment of time needed to collect the samples (therefore expressed in man-hours). Note, that average time needed to collect the sample should also include travel time
- Travel costs includes travelling expenses related to collection of the samples - expressed in LVL
- Costs for analysis of samples - includes two types of costs: time needed to carry out the analysis (expressed in man-hours) and costs for consumables, depreciation of equipment, accommodation etc. expressed in LVL.

The calculation sheets DO NOT include investment costs e.g. investments needed to upgrade the laboratories, purchase of additional vehicles, boats or sampling equipment. Furthermore, the estimated costs of the monitoring programme do neither include costs related to data processing and storage nor the reporting costs.

The Decision Support Tool enables the user to manipulate the unit costs (e.g. number of sampling stations, number of samples per year, costs per analysis, average travel distance, time needs for sampling etc.) and immediately see the implications on the overall budget of the monitoring programme. The Decision Support Tool should be seen as a planning tool and not as a final estimate of the costs of the new monitoring programme.

With the specifications of the contents of the three monitoring types mentioned above it is proposed to budget the monitoring costs at 35% for surveillance monitoring, 60% for operational monitoring and 5% for investigative monitoring.

10 Future groundwater monitoring

10.1 Monitoring Network Design

According to the requirements of WFD groundwater monitoring network must be designed after delineation of groundwater bodies, distributed vertically and horizontally on the basis of the initial characterisation. The distribution should also be based on an analysis of the existing monitoring network within the groundwater body including the existing monitoring results.

In the following the state groundwater monitoring system is analysed and compared with the newly delineated groundwater bodies and the requirement of the WFD to monitoring of those bodies.

In all state groundwater monitoring wells both water level and water quality monitoring are carried out.

Table 10.1 Existing monitoring program and the new groundwater bodies

No.	Proposed Ground-water body*	Aquifers and multi-aquifer systems, integrated into the groundwater body	River basin district	Number of existing monitoring stations
1	Q-1	Quaternary water-table aquifer	Daugava, Gauja	6
2	Q-2		Venta	-
3	Q-3		Venta	-
4	D_3-1	Quaternary aquifers, Famenian – Permian multi-aquifers system, Plavinas – Amula multi-aquifer system	Venta	4
5	D_3-2		Venta	2
6	D_3-3		Lielupe, Daugava	13
7	D_3-4	Quaternary aquifers, Plavinas – Amula multi-aquifer system	Gauja	2
8	D_3-5		Daugava	6
9	D_3-6		Daugava	-
10	D_{2-3}-1	Quaternary aquifers, Arukila – Amata multi-aquifer system	Venta	3
11	D_{2-3}-2		Venta, Lielupe, Daugava, Gauja	25
12	D_{2-3}-3		Venta	1
13	D_{2-3}-4		Gauja	1
14	D_1	Lower- Middle Devonian multi-aquifer system	Gauja	2
Total	14		4	63

*Note: The Groundwater bodies are described in TR1A, including maps.

The table shows that some groundwater bodies are not covered by monitoring stations, while others already have many stations.

The distribution of existing groundwater monitoring stations is shown in Annex 3 on 4 maps:

1. monitoring stations in Quaternary GW bodies (Q)
2. monitoring stations in GW bodies D_3
3. monitoring stations in GW bodies D_{2-3}
4. monitoring stations in GW bodies D_{1-2}

10.2 Water Level monitoring

Information on groundwater levels should be used in conjunction with estimates of recharge and an appropriate conceptual model/understanding of the groundwater flow system when assessing the quantitative status of bodies of groundwater, or groups of bodies.

The aims of groundwater level monitoring is:

- to validate conceptual model of groundwater flow;
- to enable classification of status;
- to calculate available resources;
- to estimate the flows across borders.

In principle, the more spatially variable the groundwater flow system or the pressures on it, the greater the density of monitoring points that will be required to provide the data needed to make suitably confident assessments of the status of a groundwater body.

Groundwater level monitoring shall comprise:

- Measurements of groundwater level in undisturbed areas (control of natural long-term fluctuations of the level) in all groundwater bodies;
- Control of regional groundwater depression cones (Liepaja, greater Riga, groundwater bodies D_3 –1, D_{2-3}-1, D_3 –3, D_{2-3}-2, Q-1;
- Monitoring to estimate the direction and rate of groundwater flow across the State Boundary.

The present state monitoring system does not cover all these issues. It is necessary to develop the monitoring system in the following fields:

- New monitoring wells must be installed in the newly delineated groundwater bodies without present monitoring network stations – Q-2, Q-3, D_3-6.
- Additional monitoring wells on all aquifers must be installed in the groundwater bodies D_3-4; D_{2-3}-3; $D_{1;}$
- There are no monitoring stations and points for estimation of transboundary flow. Such monitoring stations must be installed in groundwater bodies D_1; D_3-1; D_3-2; D_3-3; D_{2-3}-2; D_3-6; D_{2-3} -4

It should be noted that some of this information may be possible to obtain by using water abstraction wells and networks of observation wells of local importance. This, however, requires a thorough an analyses of all information on water use and existing monitoring in well fields.

10.3 Surveillance monitoring of chemical status and pollutant trends

Groundwater quality monitoring carried out in accordance with the WFD should be designed to answer specific questions and support the achievement of the environmental objectives. The principal purposes of groundwater quality monitoring are to:

(a) Provide information for use in classifying the chemical status of groundwater bodies or groups of bodies.
(b) Establish the presence of any **significant** upward trend in pollutant concentrations in groundwater bodies and the reversal of such trends.

In the Surveillance Groundwater Monitoring System it is necessary to have monitoring stations in all groundwater bodies. In the present program the majority of the stations cover more than one groundwater body. Annex 4 shows the suggestion for a future monitoring program for groundwater.

The following parameters are recommended for the monitoring program:

water level, pH, Eh, oxygen content and conductivity, Fe^{2+}, Fe^{3+} ion content, Na^{+}, K^{+}, Ca^{2+}, Mg^{2+}, Cl^{-}, SO_4^{2-}, total nitrogen and its mineral forms (N/NH_4^{+}, N/NO_2^{-}, N/NO_3), phosphor, alkalinity, total organic carbon and total organic halogen.

Due to the location of the nuclear power station Ignalina in Lithuania, near the Latvian border, it is necessary to control the risk of transboundary groundwater pollution by means of a special monitoring program. It is suggested to continue the already established monitoring of the GW body D_3-3 in the vicinity of Daugavpils, for content of radioactive substances including ^{137}Cs, ^{90}Sr, ^{60}Co. The existing monitoring wells at the „Ziemeli" and „Vingri" well fields may be used for this purpose.

10.4 Operational monitoring

Operational monitoring must provide the monitoring data needed to achieve an appropriate level of confidence to classify bodies at risk as either poor or good status or to establish the presence of significant upward trends in pollutants.

Operational monitoring must be established for each groundwater body after the initial characterization. It is envisaged that operational monitoring should be carried out for the following areas:

- Water quantity and quality control in the territories of regional groundwater depression cones (Liepaja, Greater Riga, the groundwater bodies D_3 –1, $D_{2\text{-}3}$-1, D_3 –3, $D_{2\text{-}3}$-2, Q-1);
- Additional water quantity and quality control in the groundwater bodies with large and concentrated well fields;
- Water quality control in water resources artificial recharging schemes;
- Groundwater monitoring in the most dangerous polluted sites (Inčukalns, Olaine, old Soviet Army bases and the like) based on a ranking of known sites.
- Areas which are identified as being vulnerable on basis of the on-going co-joint project for shallow groundwater, which is carried by the Danish and the Latvian Geological Surveys.

10.5 Investigative monitoring

Unlike surface water, the WFD does not describe investigative monitoring for groundwater. It should be noted that investigative monitoring for *surface water* is not a requirement, but an option that may be used when and where needed.

The reason this term is not included in the WFD may be that it is directed towards rapidly spreading problems which is relevant for surface water, but not for groundwater. For groundwater, operational monitoring will fulfil the same purpose due to the slow changes that occur in groundwater, also related to polluted sites.

However, the groundwater Working Group in this project decided that the CM regulation should include investigative monitoring it for groundwater in a similar way as for surface water.

It means, following the definitions for surface water, that groundwater investigative monitoring may be carried out:

1. where the reason for any exceedances is unknown,

2. where surveillance monitoring indicates that the objective for a water body is not likely to be achieved and operational monitoring has not already been established, in order to ascertain the causes of a water body or water bodies failing to achieve the environmental objectives; or
3. to ascertain the magnitude and impacts of accidental pollution.

Investigative monitoring is supportive for operational monitoring as it addresses WBs at risk that are not included in operational monitoring.

For groundwater, it could be considered that investigative monitoring is limited in time (months to a few years) and place (point sources), in order to distinguish it from operational monitoring. One purpose could be to establish a basis for operational monitoring, or a basis for very localised actions to be taken (e.g. remediation of a limited pollution from an old spill).

Annex 1 Procedure for identification of surface water bodies

The EU Member States shall generally achieve a good status of their water bodies by 2015, and identify water bodies before 2005 (22-12-2004).

The WFD definition of a surface Water Body is outlined below (Art 2.10):

"Body of surface water" means a **discrete and significant element** of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal, transitional water or a stretch of coastal water.

Water body is a unit to which the environmental objectives of the directive must apply ("compliance checking unit").

Annex II of the WFD requires:

Member States shall identify the location and boundaries of bodies of surface water and shall carry out an initial characterisation of all such bodies

The Directive requires Member States to identify "water bodies" as part of the analysis of the characteristics of the river basin districts (under Art. 5 and Annex II). The first such analysis must be completed by 22 December 2004. The analysis must be reviewed, and where necessary, updated by 22 December 2013 and then every six years.

However, identification of water bodies will require information from the Article 5 analyses and reviews, and the Article 8 monitoring programmes. Some of the necessary information will not be available before 2004. The information that is available is likely to be updated and improved in the period prior to the publication of each river basin management plan.

EU working group on identification of water bodies under the Common Implementation Strategy of WFD has developed a document CIS Horizontal Guidance on the Application of the Term "Water Body" in the Context of the Water Framework Directive. The purpose of the guidance document is to develop a common understanding of the definition of water bodies and specific practical suggestions for the identification of water bodies under the Water Framework Directive. The text below is based on the guidance.

The Water Framework Directive covers **all** waters, including inland waters (surface water and groundwater) and transitional and coastal waters up to one sea mile (and for the chemical status also territorial waters which may extend up to 12 sea miles) from the territorial baseline of a Member State, independent of the size and the characteristics.

This totality of waters is, for the purpose of the implementation of the directive, attributed to geographical or administrative units, in particular the **river basin**, the **river basin district**, and the "**water body**". In addition, groundwaters and stretches of coastal waters must be associated with a river basin (district).

The success of the Directive in achieving this purpose and its related objectives will be mainly measured by the status of "water bodies". Therefore "water bodies" are the units that will be used for reporting and assessing of compliance with the principal environmental objectives of the Directive. However, it should be emphasised that the identification of a "water body" is a tool not an objective in itself.

It is evident that for the first RBMP, all waters must be assigned to water bodies and their status must be described. However, practical approaches may be required in particular for large numbers of pristine waters in remote areas, where it can be demonstrated that no significant pressure exist.

"Water bodies" are the units that will be used for reporting and assessing of compliance with the Directive's principal environmental objectives. However, it should be emphasised that the identification of a "water body" is a tool not an objective in itself.

The "water body" should be a coherent sub-unit in the river basin (district) to which the environmental objectives of the directive must apply. Hence, the main purpose of identifying "water bodies" is to enable the status to be accurately described and compared to environmental objectives[4].

The **main criteria** for delineation of water bodies are outlined below:

1. A surface water body must belong to only one category: river, lake, transitional waters and coastal waters. The boundary of a water body may be established where two different category "meet" (Figure 3).

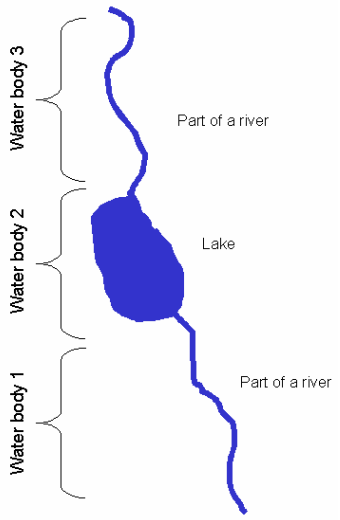


Figure 3. Example of delineation of surface water bodies in river-lake-river system

2. Water bodies must not overlap with each other or be composed of elements of surface water that are not contiguous.

3. A surface water body must not cross the boundaries between surface water body

[4] *An estimate of the status of water bodies will be required to assess the likelihood that they will fail to meet the environmental quality objectives set for them under Article 4 [Article 5; Annex II 1.5 & 2]. The status of water bodies must be classified using information from the monitoring programmes [Article 8, Annex V 1.3, 2.2 & 2.4]. The status of water bodies must be reported in the river basin management plans [Article 13, Annex VII] and, where necessary, measures must be prepared [Article 11, Annex VI].*

types. It must be of one type or another since one purpose of characterising surface water bodies is to differentiate them into types.

4. Physical features (geographical or hydromorphological) that are likely to be significant in relation to the objectives of the Directive should be used to identify discrete elements of surface water. For example, the confluence of one part of a river with another could clearly demarcate a geographically and hydromorphologically distinct boundary to a water body (Figure 4).

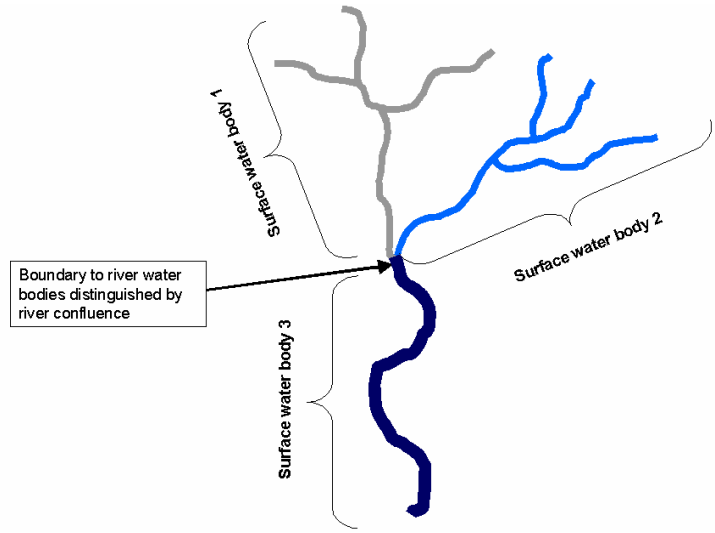


Figure 4. Example of delineation of water bodies based on physical features (confluence of rivers)

5. Heavily modified water bodies may be identified and designated, where good ecological status is not being achieved because of impacts on the hydromorphological characteristics of a surface water resulting from physical alterations.

Other criteria for delineation of surface "water bodies"

6. A discrete element of surface water should not contain significant elements of different status. A "water body" must be capable of being assigned to a single ecological status class with sufficient confidence and precision through the Directive's monitoring programmes (Figure 5).

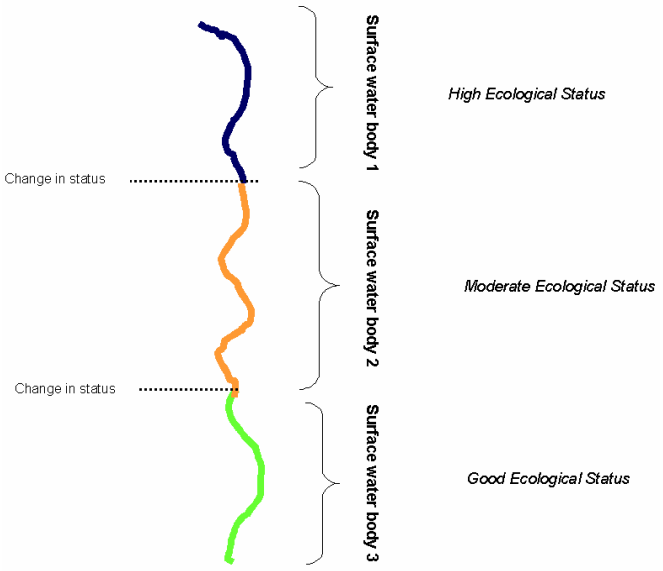


Figure 5. Example of delineation of water bodies based on status.

It may be appropriate to use the analysis on pressures and impacts as a surrogate for status. As understanding of status improves, the boundaries of water bodies can be adjusted. Contiguous elements of surface water within a type that are of the same status may be recombined to avoid unnecessary sub-division of surface waters.

NOTE: It will be necessary to balance the requirement to adequately describe water status with the need to avoid the fragmentation of surface waters into unmanageable numbers of water bodies. In addition, the aggregation of water bodies may be appropriate, under certain circumstances, to reduce meaningless administrative burden

The CIS Horizontal guidance propose the following approach for small elements of surface water (Figure 6):

- Include small elements of surface water as part of a contiguous larger water body of the same surface water category and of the same type, where possible.
- Where this is not possible, screen small elements of surface water for identification as water bodies according to their significance in the context of the Directive's purposes and provisions (e.g. ecological importance; importance to the objectives of a Protected Area, significant adverse impacts on other surface waters in the river basin district). In such a case, small elements:

  (1) belonging to the same category and type,

  (2) influenced by the same pressure category and level and

  (3) having an influence on another well-delimited water body, may be grouped for assessment and reporting purposes.
- For those small elements of surface water not identified as surface water bodies, protect, and where necessary improve them to the extent needed to achieve the Directive's objectives for water bodies to which they are directly or indirectly connected (i.e. apply the necessary basic control measures under Article 11).

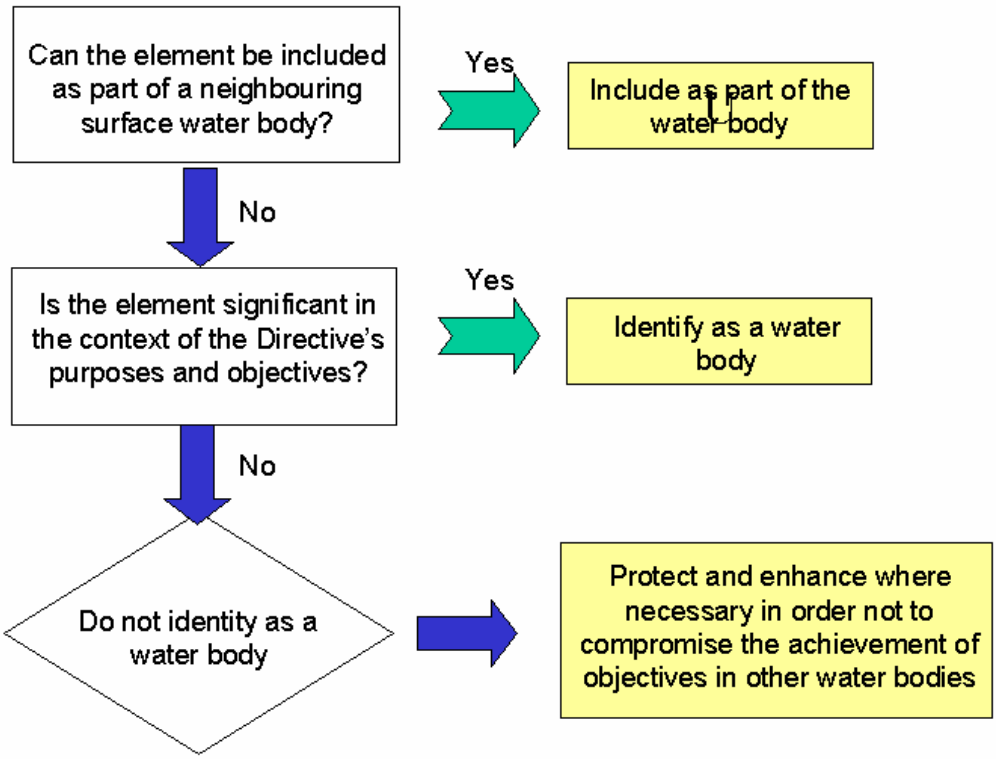


Figure 6: Approach for delineation of water bodies to ensure appropriate protection of smallest surface water units

Procedure for identification of surface water bodies proposed by the project is described in the text boxes below.

Rivers:

1. Rivers belonging to the same type are regarded as one water body if there are no significant changes in pressures.
2. Rivers are subdivided into several water bodies when:
    a. River changes type (e.g. change from small river upstream to medium size);
    b. River passes large lake (> 0.5 km^2);
    c. Significant change in status of the river due to pressures (e.g. dam, discharge from UWWTP).
3. Ditches and small streams (streams without names) are not taken into account when identifying water bodies (assigned to nearest or most appropriate water body).
4. Rivers passing through small lakes (<0.5 km^2) are regarded as continuous water body (not segmented to river-lake-river stretches)
5. Small streams (<100 km^2) are not cut to smaller units for the purpose of identification of water bodies, unless it is feasible to address changes in land use or other pressures
6. Small streams (<100 km^2) of similar status (based on pressures) within the same sub basin are mapped but clustered together and described as one water body.
7. Pressures that can be expected to change the status of the WB (e.g. sewage outlet of a size which compared to the summer water flow can be expected to influence the flora and fauna of the stream, damming)

Lakes:

1. Large lakes (>0.5 km^2) are identified as individual water bodies
2. Small lakes (< 0.5 km^2) are mapped but not identified as individual water bodies (clustered together and described as one water body in area/areas with similar pressures, e.g. land use)
3. Outstanding examples of small lakes of different status as compared to general status of lakes in the catchment can be identified as separate water body (e.g. few small lakes of high status in an agriculture dominated catchment)

Annex 2 Summary of "Guidance for the analysis of Pressures and Impacts in accordance with the Water Framework Directive".

1. WFD REQUIREMENTS IN RELATION TO PRESSURE AND IMPACT ANALYSIS

The necessity to analyse pressures and impacts is stated in Article 5 of the WFD

WFD Art.5:

1. Each Member State shall ensure that for each River Basin District or for the portion of an international River Basin District falling within its territory:

- an analysis of its characteristics,
- a review of the impact of human activity on the status of surface waters and on groundwater, and
- an economic analysis of water use

is undertaken according to the technical specifications set out in Annexes II and III and that it is completed at the latest four years after the date of entry into force of this Directive.

The WFD requires the tasks specified under Article 5 to be completed by 2004. They will then be reviewed by 2013, and subsequently every 6 years (2019, 2025…). Given the overall purpose of the WFD, the analysis undertaken in 2004 must consider both the current condition for each water body, and a prognosis for the period to 2015. A specification for the impact review is contained in WFD Annex II Section 1 for surface waters, and Annex II Section 2 for groundwaters.

The most important goal of the first review, required in 2004, is to understand the significant water management issues within each river basin and how they affect each individual water body. This may be considered a screening step prior to additional description and analysis at a later stage. This screening should identify issues to be addressed in the drawing up of the river basin management plan (RBMP), and it may also reveal a number of gaps in data or knowledge that should be filled during the process of drawing up the RBMP and the monitoring programme.

Accordingly, the analyses of pressures and impacts must not only present a snapshot on present situation but also consider, how pressures would be likely to develop prior to 2015 in ways that would place water bodies at risk of failing to achieve good status, if appropriate programmes of measures were not designed and implemented. The pressure and impact analyses will also need to identify which of the risks to the WFD's objectives are expected to be addressed by the implementation of measures specified under other Community legislation.

The review process is described in five parts corresponding to the sub-sections within Annex II Section 1, i.e.
1. Identification of surface water body types,
2. Establishment of type-specific reference conditions for surface water body types,
3. **Identification of Pressures**, and
4. **Assessment of Impacts**.

The WFD requires information to be collected and maintained on the type andmagnitude of significant anthropogenic pressures, and indicates a broad categorisation of the pressures into:

- point sources of pollution,
- diffuse sources of pollution,
- effects of modifying the flow regime through abstraction or regulation, and
- morphological alterations.

Any other pressures, i.e. those not falling within these categories, must also beidentified. In addition there is a requirement to consider land use patterns (e.g. urban, industrial, agricultural, forest) as these may be useful to indicate areas in which specific pressures are located.

The impact assessment should use both information from the review of pressures, and any other information, for example environmental monitoring data, to determine the likelihood that the surface water body will fail to meet its environmental quality objectives. For bodies at risk of failing their specified objectives, it will be necessary to consider the implementation of additional monitoring and a programme of measures.

Ideally, a pressure and impact assessment will be a four-step process (according to the CIS guidance on Impacts and Pressures):

1. describing the "driving forces", especially land use, urban development, industry, agriculture and other activities which lead to pressures, without regard to their actual impacts,
2. identifying pressures with possible impacts on the water body and on water uses, by considering the magnitude of the pressures and the susceptibility of the water body,
3. assessing the impacts resulting from the pressure, and
4. evaluating the likelihood of failing to meet the objective.

In the first instance (i.e. for 2004) the list of pressures and the assessment of impacts on a water body, and possibly on up- or downstream-situated water bodies, shall ensure the identification of all of the potentially important problems. At this stage, (i.e. for 2004) a screening approach is likely to simplify the task, as it means focusing on the search for pressures on those areas and pressure types that are likely to prevent the meeting of the objectives. The identification of significant pressures could involve a combined approach of assessing monitoring data, model usage and expert judgement.

1.1 Key terms

While it is clear from the WFD that the impacts are the result of pressures, neither term is explicitly defined. The IMPRESS guidance uses DPSIR (Driver, Pressure, State, Impact, Response) analytical framework and some of the terms are described in the Table 4 below.

Table 4. The DPSIR framework used in the pressure and impact analysis

Term	Definition
Pressure	the direct effect of the driver (for example, an effect that causes a change in flow or a change in the water chemistry.
State	the condition of the water body resulting from both natural and anthropogenic factors (i.e. physical, chemical and biological characteristics)
Impact	the environmental effect of the pressure (e.g. fish killed, ecosystem modified)
Response	the measures taken to improve the state of the water body (e.g. restricting abstraction, limiting point source discharges, developing best practice guidance for agriculture)

It is clear from these definitions that in the analysis of *pressures* and *impacts,* it is necessary to include information about changes in the *state*, but that *responses* need not be considered.

If a water body fails to meet its objective, or is at risk of failing to meet its objective, then the cause of this failure (i.e. the pressure or combination of pressures) must be investigated. Thus, *when the Directive states that significant pressures must be identified, this can be taken to mean any pressure that on its own, or in combination with other pressures, may lead to a failure to achieve the specified objective.*

1.2 Relevant considerations

The timetable for completing the first pressure and impact analyses and reporting their results is very short. Therefore, the first analyses will rely heavily on existing information on pressures and impacts and existing assessment methods. The pressure and impact analyses should be focused in such a way that the effort involved in assessing whether any body, or group of bodies, is at risk of failing to achieve its environmental objectives is proportionate to the difficulties involved in making that judgement.

The WFD defines four types of objectives; ecological status, ecological potential, chemical status and quantitative status, but these are not all applicable to all water bodies (see Table 5).

Ecological status and ecological potential both contain three elements; these are biological, chemical - physical (or physico-chemical), and hydromorphological elements. The lower of the biological and chemical components determines the overall ecological status. Note that the objective for surface waters is not just that good status is achieved, but also that no deterioration of quality occurs. Thus, if ecological status of a water body is currently assessed as “high”, it must not deteriorate to “good” in the future.

Table 5. Objectives applicable to different water body types

	River	Lake	Transitional water	Coastal water	HMWB or AWB	Groundwater
Ecological status	✓	✓	✓	✓	×	×
Ecological potential	×	×	×	×	✓	×
Surface water chemical status	✓	✓	✓	✓	✓	✓
Ground water chemical status	×	×	×	×	×	✓
Groundwater quantitative status	×	×	×	×	×	✓

In addition to the objectives in Table 5, it is required that objectives for protected areas established under Community legislation should also be met. Specific Community legislation designating protected areas is listed in Table 6.

Table 6. Existing community legislation designating protected areas

Directive	Reason for protection of waters
2000/60/EC (Water Framework Directive)	Drinking water protected areas.
76/160/EEC (Bathing water Directive)	Bathing waters
78/659/EEC (Freshwater fish Directive)	Fresh waters needing protection in order to support fish life.

79/923/EEC (Shellfish waters Directive)	Shellfish waters
79/409/EEC (Birds Directive)	To protect birdlife
92/43/EEC (Habitats Directive)	Natural habitats of wild fauna and flora
91/271/EEC (Urban Waste Water Treatment Directive)	Nutrient sensitive areas
91/676/EEC (Nitrates Directive)	Prevent nitrate pollution

2. GENERAL APPROACH FOR THE ANALYSIS OF IMPACTS AND PRESSURES

The key stages of the general approach as laid down in the WFD are:

- Identifying driving forces and pressures
- Identifying the significant pressures
- Assessing the impacts, and
- Evaluating the risk of failing to meet the objectives

There will be many instances in which these key stages need not be undertaken as a linear sequence. An example of such a case would be where monitored data from the water body, which define an impact, can be used to refine the identification of significant pressures. While it may be appropriate to adopt a different sequence for the analysis, it is required that all key stages are addressed.

2.1 Identifying driving forces and pressures

In addition to a general description of the water body, it is essential to identify the driving forces that may be exerting pressures on the water body. A broad categorisation of driving forces is contained in Table 7. This is expanded into a more complete list of driving forces and pressures, which can be used as a check-list to inventory the relevant pressures. In using this check-list it may be helpful and straightforward to note all pressures without concern for their significance.

Table 7. Broad categorisation by driving force of pressures to be considered

DIFFUSE SOURCE	urban drainage (including runoff), agriculture diffuse, forestry, other diffuse
POINT SOURCE	waste water, industry, mining, contaminated land, agriculture point, waste management, aquaculture
ACTIVITIES USING SPECIFIC SUBSTANCES	manufacture, use and emissions from all industrial/agricultural sectors
ABSTRACTION	reduction in flow
ARTIFICIAL RECHARGE	groundwater recharge
MORPHOLOGICAL (Refer also to HMWB working group guidance)	flow regulation, river management, transitional and coastal management, other morphological
OTHER ANTHROPOGENIC	miscellaneous

Driving forces are sectors of activities that may produce a series of pressures, either as point and non-point sources. When screening data, DF are quantified by aggregated data, simple to obtain, for example: number of ha of arable land, population density, etc., for a certain area. Comparing this DF data with appropriate aggregated monitoring information quickly allows assessment of the likelihood that the considered DF is related to environmental pressures. In that case, only the expected pressures should be investigated in greater details.

Clearly the use of a GIS will facilitate the process of screening for driving forces.

2.2 Identifying the significant pressures

The inventory of pressures is likely to contain many that have no, or little, impact on a specific water body. In the case of surface waters, the WFD recognises this by only requiring significant pressures to be identified, and within the IMPRESS guidance significant is interpreted as meaning that the pressure contributes to an impact that may result in failure to meet an objective.

The assessment of whether a pressure on a water body is significant must be based on a knowledge of the pressures within the catchment area, together with some form of conceptual understanding of water flow, chemical transfers, and biological functioning of the water body within the catchment system. In other words there must be some knowledge that a pressure may cause an impact because of the way the catchment system functions. This understanding coupled to the list of all pressures and the particular characteristics of the catchment makes it possible to identify the significant pressures. However, this approach often requires two stages. In the first one, correlation assessment can be carried out.

An alternative is that the conceptual understanding is embodied in a set of simple rules that indicate directly if a pressure is significant. One approach of this type is to compare the magnitude of the pressure with a criterion, or threshold, relevant to the water body type.

Pollution pressures from diffuse and point sources

A pollution pressure results from an activity that may directly cause deterioration in the status of a water body. In most cases, such a pressure relates to the addition, or release, of substances into the environment. This can be the discharge of a waste product, but may also be the side-effect or by-product of some other activity, such as the leaching of nutrients from agricultural land.

The most usual categorisation of pollution pressures is to distinguish between diffuse and point sources (Table 8, Table 9).

Table 8. Examples of diffuse source pressures and their impacts.

Activity	Pathway causing Pressure	Possible change in state or impact

Agriculture	Nutrient loss from agriculture by • surface runoff • ·soil erosion • ·artificial drainage flow • ·leaching (*i.e.* interflow, spring water and groundwater) (includes excess fertilisers and manures and mineralization of residues).	Nutrients modify ecosystem.
	Pesticide loss by pathways mentioned above	Toxicity, contamination of potable water supplies.
	Sediment loss by soil, bank and riverbed erosion	Smothering of bed, alteration of invertebrate assemblage, loss of spawning grounds.
Industry discharges to the atmosphere.	Deposition of compounds of nitrogen and sulphur.	Acidification of surface and groundwater bodies. Eutrophication.
Transportation	Pollutant spillages	Gross pollution of water bodies.
	Use of salt as de-icer.	Elevated chloride concentration.
	Use of herbicides	
	Engine exhausts	Increase in acidifying chemicals in atmosphere and hence deposition

Table 9. Example point source pressures and their impacts.

Activity	**Pressure**	**Possible change in state or impact**
Industrial (IPPC and non-IPPC)	Effluent disposal to surface and groundwaters.	Toxic substances have direct effect, increased suspended solids, organic matter alters oxygen regime, nutrients modify ecosystem.
Urban activity	Effluent disposal to surface and groundwaters	As above.
Landfill	Chemical fluxes in leachate	As above.
Animal burial pits (e.g. following epidemic)	Contaminated leachate	As above.
Former land use	Contaminated land	Various
Thermal power generation	Return of cooling waters cause alteration to thermal regime.	Elevated temperatures, reduced dissolved oxygen, changes in biogeochemical process rates.
	Biocides in cooling water	Direct toxic effect on aquatic fauna.
Dredging	Sediment disposal	Smothering of bed, alteration of invertebrate assemblage
	Removal of substrate	Loss of habitat

Quantitative resource pressures

Quantitative status is only referred to specifically within the WFD for groundwater bodies, but **quantitative pressures must be assessed for all water bodies**. For surface waters these pressures are used to assess hydromorphological status. In all water bodies quantitative pressures are also important as they have an effect on dilution, residence time, and storage.

Table 10. Example quantitative pressures and their impacts

Activity	**Pressure**	**Possible change in state or impact**
Agriculture and land use change	Modified water use by vegetation. Land sealing	Altered recharge of groundwater body
Abstraction for irrigation, public & private supply	Reduction in flow or aquifer storage.	Reduced dilution of chemical fluxes. Reduced storage. Modified flow and ecological regimes. Saline intrusion. Modified dependent

		terrestrial ecosystem.
Artificial recharge	Increased storage Increased outflow.	Contamination of groundwater.
Water transfer	Increased flow in receiving water.	Modified thermal, flow and ecological regimes

Hydromorphological pressures

Table 11. Example hydromorphological pressures and their impacts

Activity	Pressure	Possible change in state or impact
Dredging	Sediment disposal	Smothering of bed, alteration of invertebrate assemblage
	Removal of substrate	Loss of habitat
	Change in water level	Change in water table, loss of wetlands, loss of spawning areas.
Physical barriers (dams, weirs etc.)	Variation in flow characteristics (e.g. volume, velocity, depth) both up and downstream of barrier.	Altered flow regime and habitat.
Channel modification (e.g. straightening)	Variation in flow characteristics (e.g. volume, velocity, depth)	Altered flow regime and habitat.

Biological pressures

Table 12. Example biological pressures and their impacts.

Activity or Driving force	Pressure	Possible change in state or impact
Fisheries	Fishing	Reduced fish fauna, especially on migratory and amphibiotic fish
	Fish stocking	Genetic contamination of wild populations.
Introduction of alien species	Competition with indigenous species	Substitution of populations, destruction of habitats, food competition.

2.3 Assessing the impacts

Assessing the impacts on a water body requires some quantitative information to describe the state of the water body itself, and/or the pressures acting on it. The type of analysis will dependend on the available data . Regardless of the particular process to be adopted, and similar to the identification of significant pressures, the assessment requires a conceptual understanding of the cause of the impacts. In many situations a simple approach may be completely suitable to assess the impact of a pressure.

The information required to adopt the modelling approach will rarely be available at present and generally not in the foreseeable future. By implication, the initial analysis will be based on less demanding methods for which the required data are available, e.g. pressure screening tools.

In situations where data are available for the water body itself, it may be possible to make a direct assessment of the impact. Data may be of different types (Table 13). Data themselves are not enough to assess possible impact. A correct indicator of the expected impact must be constructed. Moreover, it must be kept in mind that most pressures do not create a clear-cut impact, but substantially change the probability of adverse conditions.

Table 13. Possible impacts or changes in state that can be identified from monitoring data

BIOLOGICAL QUALITY ELEMENTS	
macrophytes	composition, abundance
phytoplankton	composition, abundance, biomass
planktonic blooms	frequency, intensity
benthic invertebrates	composition, abundance
fish	composition, abundance, age structure
eutrophication	chlorophyll concentration
HYDROMORPHOLOGICAL QUALITY ELEMENTS	
hydrological regime	quantity and dynamics of water flow, connection to groundwater bodies, residence time
tidal regime	freshwater flow, direction of dominant currents, wave exposure
river continuity	
morphology	depth and width variation, quantity, structure and substrate of the bed, structure of the riparian zone, lake shore or intertidal zone
CHEMICAL AND PHYSICO-CHEMICAL QUALITY ELEMENTS	
transparency	concentration of total suspended solids, turbidity, Secchi disc transparency (m)
thermal conditions	temperature (^{o}C)
oxygenation conditions	concentration
conductivity	conductance, converted to concentration of total dissolved solids,
salinity	concentration
nutrient status	concentration of nitrogen and phosphorus, loads in, view of sea protection
acidification status	pH, alkalinity, acid neutralising capacity (ANC)
priority substances	concentration
other pollutants	concentration

Monitoring data may indicate that there are no current impacts. This information itself reveals that none of the pressures identified in the initial screening process is significant, or that the time lag required for a pressure to give rise to an impact has not yet passed.

The HMWB guidance offers some assistance in relating biological indicators to different types of hydromorphological pressure (Table 14).

Table 14 Biological indicators of morphological pressures (adapted from HMWB guidance)

Indicator	**Pressure**
Benthic invertebrate fauna and fish	Hydropower generation impacts in freshwater systems
Long distance migrating fish species	Disruption in river continuity inducing lag in migratory process.
Macrophytes	Flow from reservoirs, Regulated lakes (change in flow regime)
Benthic invertebrates and macrophytes/phytobenthos	Linear physical alterations, such as flood works.

Impacts of specific pollutants

The WFD provides rather complex approach for dealing with chemical pollutants within the concept of the "good ecological status" and "good chemical status" of the WFD. Whereas the "priority substances" are clearly identified in Annex X, one key question in the context of the analysis of pressures and impacts is the selection of **specific pollutants** (other than priority substances) for which data on pressures must be collected in order to assess whether there are impacts for the different water bodies in a river basin (district).

Hence, the issue on how to select a list of relevant pollutants is related to significant pressures or impacts.

Given the potential number of pollutants, there is a considerable gap of information and data for many pollutants, in particular:

- in many cases and for a lot of pollutants pressures can hardly be related to status or impact as a result of a lack of data;
- only a limited number of pollutants is continuously or regularly monitored;
- the relation between pollutants and impact covers the whole field of ecotoxicology; reporting may cope with problems as acute/chronic or combined effects.

First, a list of pollutants needs to be established for which the pressure and impact analysis is carried out (completed by 2004). Only if a defined "list of candidate substances" is established, it is possible to collect data on significant pressures and impacts. For this first analysis, it may not be possible to derive EQS for all candidate substances. In this case, alternative screening benchmarks are acceptable.

Second, selection is required of those pollutants for which additional information is to be gathered through "surveillance monitoring" (by 2006). These substances may be a sub-list of pollutants for which the level of certainty in the pressure and impact analysis may not be sufficient. Finally, the list of relevant pollutants must be identified for which measures are prepared (by 2007/2008).

SUMMARY OF KEY TASKS FOR SURFACE WATERS

Data collection for river basin (prerequisite to the pressures and impacts analysis):

- · Access or establish database and data management systems on activities within the river basin district, and existing monitoring data.

Basic information specific to water body:

- · Abstract information on driving forces in the catchment area of the water body.
- · Identify pressures caused by the driving forces taking particular regard to those pressures listed under Annex II 1.4.
- · Abstract data specific to the water body, including quantitative, hydromorphological, physical, chemical and biological data.
- · Identify dependent water bodies and water bodies on which the water body under consideration is dependent as well as their basins.
- · If relevant, ensure links with data managers of upstream and downstream water bodies, including foreign organisations

Additional existing information and analyses:

- · Review existing analyses of water monitoring, status, management plans etc.

- · Information collected under existing European Community legislation (use register of protected areas, Article 6) and national legislation.
- · Review whether available methods are capable of producing the required assessments.

Objectives (Article 4):

- · Determine objectives pertinent to water body.
- · Assess the existing monitoring data (biological, physico-chemical and hydromorphological),against the environmental objectives, or assumed equivalent objectives.
- · Consider if analogous catchment approach helpful.

Pressures and impacts analysis, to be complete by 2004:

- · Develop appropriate conceptual understanding considering characteristic of water body, catchment area, activities, driving forces, pressures, and objectives.
- · Select appropriate tools based on conceptual understanding and data availability.
- · Assess vulnerability of water body and dependent water bodies to impact from the identified pressures, to assess whether the water body is at risk of failing to achieve objectives.
- · Explore the variability of pressures and impacts within the catchment of the water body – variability may indicate that it would be helpful to subdivide the water body for the purpose of developing a practical programme of measures.
- · Ensure variability is not caused by uncertainty in source data or methods.
- · Take forward the analysis by exploring changes and trends in activities and pressure anticipated in the period to 2015 and beyond.
- · If failure is likely, review exemptions that may be applicable (provisional identification as heavily modified Article 4.3, temporary deterioration Article 4.6).
- · Review all steps above as (i) more, or better, data become available, (ii) new assessment tools become available, and (iii) as experience and expertise develop.

Outputs:

- · Report on pressures and impacts analysis within 3 months of completion (Article 15, Chapter 3.10).
- · First list of water bodies “at risk”
- · Use the results of the analysis to inform development of monitoring programme (Article 8) and programme of measures (Article 11).

Pressure checklist based on IMPRESS guidance

The pressure checklist contains an uncompleted list of pressures considered as part of the WFD pressures and impacts assessment. The pressure checklist is presented in two stages. First, in Table 15 the pressures are grouped into four main classes of driving forces that may impact the different water body categories and prevent them from meeting the objectives. A tentative indicator of these likely-to-be relationships is provided in Table 15.

Table 15 Pressures to be considered.

		Water body category					**OBJECTIVES**				
	Driving forces	Rivers	Lakes	Coastal/transitional	groundwater		WFD(biota)	Tap water, NO3	Bathing	Habitats, birds	Shellfish farming
	Pollution										
	Household	x	x	x	x		x	x	x		
	Industry (operating, historical)	x	x	x	x		x	x			
	Agriculture	x	x	x	x		x	x	x	x	

	Aquiculture /fish farming	x		x			x				
	Forestry	x	x	x	x						
	Impervious areas	x	x	x			x		x		
	Mines, quarries	x			x		x				
	Dump, storage sites	x		x	x		x			x	
	Transports	x		x						x	
	Alteration of hydrological regime										
	Abstraction (agri, indus, househ)	x	x		x		x	x			x
	Flow regulation works	x		x			x			x	
	Hydropower works	x		x			x			x	
	Fish farming	x					x				
	Cooling	x									x
	Flow enhancement (transfers)	x			x		x			x	
	Morphology (changes in)										
	Agricultural activities	x	x	x			x			x	x
	Urban settlements	x	x	x			x	x		x	
	Industrial areas	x	x	x			x			x	
	Flood protection	x		x			x				
	Operation, maintenance	x		x			x				
	Navigation	x		x						x	
	Biology										
	Fishing/angling	x	x	x			x				
	Fish/shellfish farming	x	x	x			x				x
	Emptying ponds	x	x							x	x

Annex 3: Location of the existing groundwater monitoring points

Annex 4 Surveillance monitoring program for proposed Groundwater GWB's

Suggestion for groundwater monitoring programme

For planning purposes it is advisable to divide the monitoring programme into sub-elements as described in Table A4.1. Note, that an 'x' only indicates the relevance, not the frequency. The term "nitrate watersheds" is a option which can be used, if study areas are established under the Nitrate monitoring program as described in chapter 5.3.2 . Such study areas should be equipped with shallow monitoring wells. Experiences from Lithuania can be used, as such a programme is planned there. In Denmark such programmes have been in operation for some years.

Apart from the elements mentioned in the table below, also a reduced "limited" programme could be introduced, with a selection of main ions and the field measurements. This might include the WFD core parameters [pH, Cond., DO, NO_3, NH_4] and for example chloride and sulphate. The limited programme would be relevant for wells in the optional nitrate watersheds. Another limited programme could be introduced for deep wells with stable quality. As an option the limited programme can interchange with the full programme.

In the basic Surveillance Groundwater Monitoring System the following parameters are recommended for the limited monitoring program for deep wells:

> water level, pH, Eh, oxygen content and conductivity, Fe^{2+}, Fe^{3+} ion content, Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, total nitrogen and its mineral forms (N/NH_4^+, N/NO_2^-, N/NO_3), phosphor, alkalinity, total organic carbon and total organic halogen.

In the main program also the remaining main ions should be included in order to complete the chemical ion balance.

Water levels should always be measured at times of sampling.

Elements in the GW monitoring program

Table A4.1 Suggested elements in the GW monitoring program

Element	National monitoring wells				Well Fields
	Shallow GW	Deep GW	New wells	Nitrate Watersheds(3)	
Abstraction	-	-	-	-	x
Water level	x	x	x	x	x
Main program	x	x	x	x	x
Limited program		(x)			
Microelements	x	x	x	-	x
Organic comp.	(1)	x	x	-	x
Pesticides	x	-	x	x	x
Age dating	(2)	(2)	(2)	-	-

(1) In those production wells which are included in the programme.
(2) Age dating is not routine, but could be carried out as research projects, possibly joint international.
(3) Optional, but recommendable

Microelements in old groundwater are not essential to include, where they are found in low concentrations not exceeding the drinking water limits. Only where high values have been found previously, these locations should be included in the programme. In table A4.2 it has been assumed that no deep wells are included. In new wells (not yet drilled) knowledge is needed, and in young groundwater microelements may reflect human activities and should therefore be included. Refer also to **WFD Annex VIII**, where metals and arsenic are specifically mentioned as part of the pollutants to control.

The organic compounds are generally more relevant for the well fields near towns than for monitoring wells placed far from industrial activities. Therefore these analyses should be focused firstly on those production wells that have been included in the national programme, but should also be required to be performed at drinking water production wells at all major water works.

Pesticides are expensive to analyse and for this reason it is not possible to include all wells; it is suggested to include 1/5 of the shallow wells. The wells should be selected through talks with the municipalities and the landowners where the wells are situated, in order to ensure that the analysis programme corresponds to the pesticides used.

Until the age has been determined, the *young* (less than 50 years using the CFC method) and *old* GW can be divided as *shallow* and *deep*, taking also the cover into consideration (sandy or clayey).

Frequency of sampling

Table A4.2 shows the suggested frequencies of sampling in the surveillance monitoring programme. 1/6 means once per 6 years. 4 means 4 times per year. Where wells are found to be situated in groundwater bodies at risk, the frequency should be minimum once per year.

Table A4.2 Suggestion for frequencies in a 6 year monitoring programme

Element	National monitoring wells				Well Fields
	Young GW	Deep GW	New wells	(Nitrate Watersheds)	
Abstraction	-	-	-	-	4
Water Level	4	4	4	6	a.p.
Main programme	1	(1/6)[a]	2		a.p.
Limited progr.		(1/6)[a]		6	
Microelements	1/3	1/6	1/6		
Organic comp	1/6	1/6			1/6*
Pesticides	1/6		1/6	1	1/6
Age dating **	once	once	once	once	

Note: Frequency is stated in times per year. 1/5 means one time in 5 years.
Division between young and old groundwater is based on shallow and deeper.
a.p.: According to requirements in Permission
All individual wells at a WF should be analysed in rotation through a 6 year period.
** Age determination is optional, and it is not necessary to repeat in later plan periods
[a]: main programme could be interchanging with limited program.