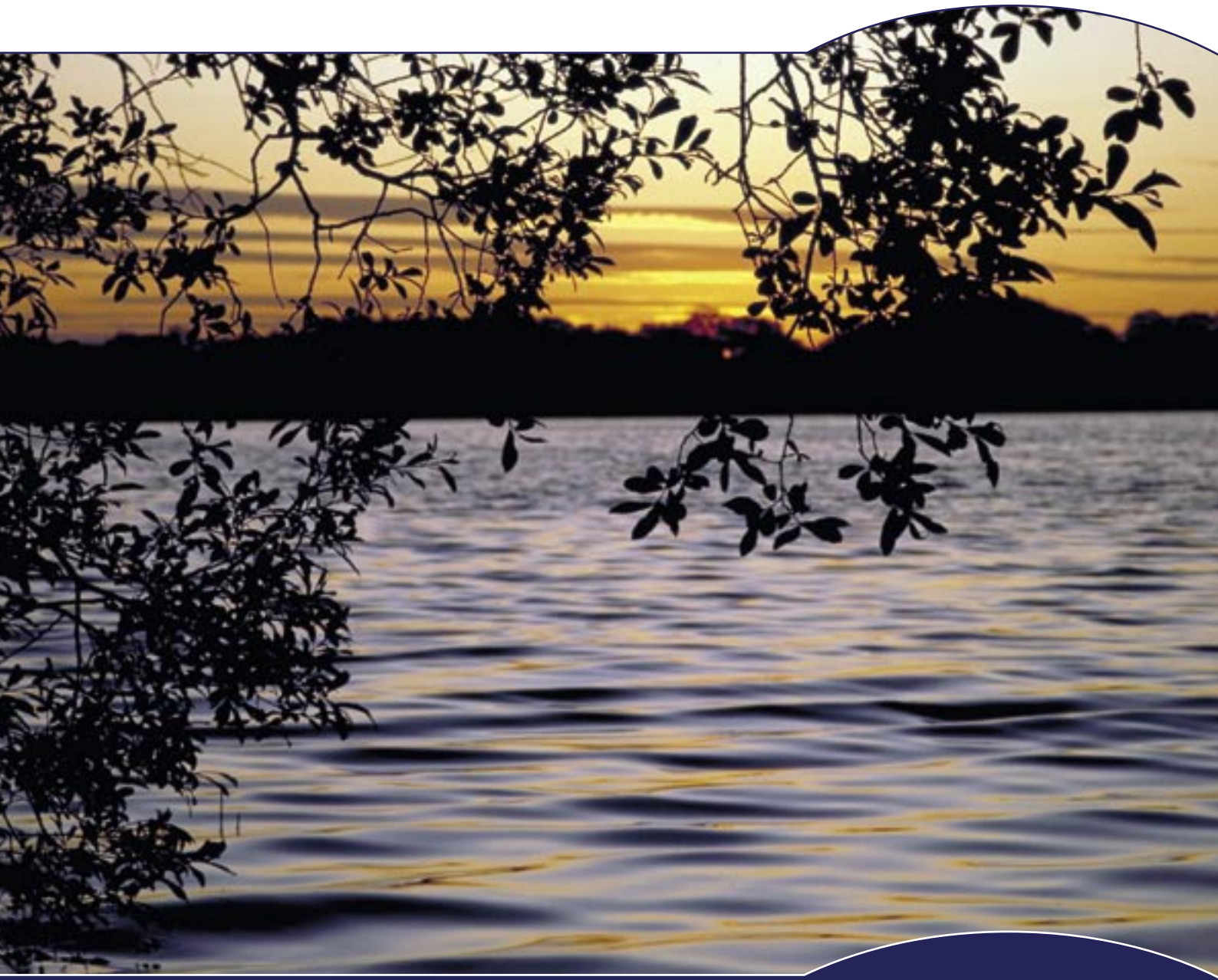
Environment & Heritage Service

Aquatic Monitoring Strategy 2006-07 and Water Framework Directive Monitoring Plans

March 2006



Environment & Heritage Service
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1. Introduction and Aims

Monitoring of the aquatic environment in Northern Ireland has steadily evolved over the last 30 years into a comprehensive network of freshwater, groundwater, estuarine and marine monitoring programmes. A good general background is provided in *Managing the Water Environment in Northern Ireland 2000* [1].

Environment and Heritage Service (EHS) has published documents on monitoring strategies in the past, in particular:

- River Quality Monitoring Strategy for Northern Ireland (2001) [2];
- Groundwater Monitoring Strategy for Northern Ireland (2000) [3];
- Policy for Setting and Delivering Water Quality Targets (2001) [4].

This document is intended to provide an overarching framework and to outline the general approach that will be adopted to monitoring Northern Ireland's aquatic environment for the years 2006 to 2007 and beyond, highlighting the drivers for the work, the main one being the obligation to meet the monitoring requirements of the EC Water Framework Directive (WFD) (2000/60/EC) [5]. It covers surface water, groundwater and hydrological monitoring proposals and draws in particular on the UK WFD Technical Advisory Group (UKTAG)[6] document' Guidance on the selection of monitoring sites and building monitoring networks for surface and groundwater'[7].

[1] *Managing the Water Environment in Northern Ireland 2000,* Environment and Heritage Service, 2002

[2] *A River Water Quality Monitoring Strategy for Northern Ireland,* Environment and Heritage Service, 2001

[3] *A Groundwater Monitoring Strategy for Northern Ireland,* Environment and Heritage Service, 2000

[4] *Policy for Setting and Delivering Water Quality Targets,* Environment and Heritage Service, 2001

[5] Directive 2000/60/EC, *Establishing a Framework for Community Action in the Field of Water Policy,* European Parliament and Council, 2000

[6] UKTAG is a partnership of the UK environment and conservation agencies established in 2001 to provide coordinated advice on technical aspects of the implementation of the Water Framework Directive.

[7] *Guidance on the selection of monitoring sites and building monitoring networks for surface and groundwater,* UK Technical Advisory Group on the Water Framework Directive, 2005

It is not within the scope of this document to provide exact details of planned monitoring stations, networks or parameters monitored. However, where this information is available, it is given, though it should be treated as indicative, as further detailed work will continue through 2006 and beyond, as envisaged under the WFD. The detailed monitoring programmes will be designed and finalised by the end of 2006, in accordance with the Directive requirements. In addition, the programmes will meet the monitoring commitments of a number of other water-related directives and national/international commitments, as set out in Appendix 1.

The assumption is made in this document that the reader has a basic knowledge of the WFD implementation process and of the aquatic monitoring currently undertaken by EHS.

Further information about the WFD can be found on the EHS website at http://www.ehsni.gov.uk/environment/waterManage/wfd/wfd.shtml

Detailed information about aquatic monitoring can be found at http://www.ehsni.gov.uk/environment/waterManage/quality/quality.shtml

Chemical river sampling

2. The Duties of Environment and Heritage Service (EHS) to Protect and Monitor the Aquatic Environment

Article 4 of the Water (Northern Ireland) Order 1999 [8] places a duty on the Department of Environment to *'promote the cleanliness of water in waterways and underground strata.'* Article 5 allows for the prescription of *'a system of classifying the quality of those waters according to criteria specified…'*. Article 6 states that *'the Department may establish the water quality objectives for any waters…'* that have been classified under Article 5. EHS has the lead responsibility within the Department for taking this work forward.

The Water Framework Directive (WFD) takes a much broader view of aquatic management than has been taken previously and its implementation will involve management by means of river basin management plans, taking account of the aquatic environment from source to sea. Essentially, its requirements will shape future aquatic monitoring plans. It subdivides monitoring into three categories: surveillance, operational and investigative. Full details of WFD monitoring requirements are provided in the UKTAG Monitoring Guidance document.

The WFD arose out of the recognised need for an integrated European Union (EU) policy on water. Its purpose is to *'establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater…'* in order to:

- prevent further deterioration and protect and enhance the status of aquatic ecosystems;
- promote sustainable water use;
- protect and improve the aquatic environment;
- ensure the progressive reduction of pollution of groundwater and prevent further pollution; and
- contribute to mitigating the effects of floods and droughts.

The overall objective is that all surface waters should achieve either 'good ecological status' or 'good ecological potential' by 2015. Formulation of the actual scientific definition of good ecological status is part of detailed preparatory work currently under way throughout the EU. The rationale is an inherent shift from chemical to ecological indices for water quality classification. For groundwater, good quantitative and chemical status should be met.

[8] *The Water (Northern Ireland) Order 1999,* Statutory Instrument 1999 No. 662 (N.I.6)

Article 9 of the Water Environment (Water Framework Directive) Regulations (Northern Ireland) 2003 [9], which transposed the Directive into Northern Ireland law, sets out in detail EHS's responsibilities for monitoring under the WFD. For surface waters *'ecological and chemical status and ecological potential…'* and *'the volume and level or rate of flow to the extent relevant to ecological and chemical status and ecological potential…'* are to be monitored, while for groundwater *'chemical and quantitative status'* is the requirement. For protected areas the programmes shall be ' *supplemented by those specifications contained in Community legislation under which …* [the] *areas have been established'.* The monitoring programmes *'are to be made operational by 22nd December 2006.'*

The drivers for EHS to monitor the aquatic environment can be summarised as follows:

1. Statutory Drivers – from European, primary and secondary legislation where EHS has been identified as the competent authority;

2. Policy and Business requirements – to meet EHS business aims and targets as defined by Policy Documents and the Corporate and Business Plan;

3. Commitments under International Conventions such as OSPAR;

4. Sponsorship of, and/or participation in, schemes such as the Environmental Change Network and the National Marine Monitoring Progamme.

The WFD will repeal a number of existing Directives, such as the Dangerous Substances Directive (76/464/EEC), the Groundwater Directive (80/68/EEC), the Freshwater Fish Directive (78/659/EEC) and the Shellfish Waters Directive (79/923/EEC), and absorb their requirements, while retaining others such as the Urban Waste Water Treatment Directive (91/271/EEC). The 'water directives' containing monitoring requirements that will be repealed are listed in Appendix 2.

[9] *The Water Environment (Water Framework Directive) Regulations (Northern Ireland) 2003*, S.R. 2003 No. 544

3. Water Framework Directive Monitoring

3.1. Requirements

The Directive requires the establishment of monitoring programmes for surface waters and groundwater by the end of 2006. Some of the key issues to be addressed are:

- types, methods and frequency of monitoring required; and
- the development of monitoring networks.

We currently undertake a considerable amount of environmental monitoring to meet existing national and international obligations. In developing the WFD monitoring programmes we will adapt and build on our existing programmes to ensure that they are designed to meet:

- the monitoring, classification and reporting requirements of the WFD; and
- national and international monitoring obligations.

Estuarine sampling

3.2. Types of Monitoring

The Directive specifies three types of monitoring:

- surveillance;
- operational; and
- investigative.

It also sets out the monitoring requirements in protected areas.

3.3. Surveillance Monitoring

The main aim of surveillance monitoring is to supplement and validate risk assessments and to identify long-term environmental changes.

The information from the surveillance programmes will be used to:

- refine the assessments of the pressures and impacts on water bodies;
- decide whether operational or investigative monitoring is necessary to establish a water body's status; and
- identify any upward trends in pollutant concentrations in groundwater.

3.4. Operational Monitoring

Operational monitoring programmes will focus on those water bodies that risk assessments indicate could fail to meet their environmental objectives. These programmes will be used to:

- establish the ecological and chemical status of surface water bodies;
- determine the chemical and quantitative status of groundwater bodies;
- identify sustained upward trends in pollutant concentrations;
- demonstrate reversal of any upward trends as a result of management actions; and

- assess changes in the status of water bodies resulting from measures taken to achieve 'good status' in terms of their overall ecological quality.

3.5. Investigative Monitoring

Investigative monitoring will be used to ascertain the causes, sources and effects of problems detected in the operational monitoring programme, to inform the design of appropriate measures and to assess the effects of accidental pollution.

3.6. Protected Area Monitoring

Another requirement of the WFD is additional monitoring of protected areas. If a water body that forms part of a protected area for habitat and species conservation is affected by pressures which could lead to a failure of its objectives, monitoring is required. These water bodies must be monitored through an appropriate surface water or groundwater programme. Water-related conservation objectives or 'good' status under the WFD, whichever is the more stringent, will apply, and monitoring will assess compliance with these.

Surface water and groundwater bodies that provide more than an average of 100 m^3/day of drinking water (public and private supplies) will have to be monitored.

Further details are available in the UKTAG Monitoring Guidance.

3.7. Monitoring Methods

3.7.1. Surface Water

The ecological status of a surface water body is dictated by:

- the deviation from a reference condition of the biological quality element (e.g. plants, invertebrates or fish) most sensitive to the pressures on the water body; and

- the achievement of appropriate values for physico-chemical elements (e.g. nutrient conditions, temperature and dissolved oxygen) for either high or good status.

The chemical status of a water body will be determined by how well it complies with:

- existing environmental quality standards (EQSs) established by current directives; and
- new EQSs that are being developed for the WFD and its Daughter Directives.

In addition, the hydromorphological quality elements of surface waters will have to be monitored and assessed to determine whether they are at high status or support the achievement of good status.

3.7.2. Groundwater

The status of groundwater is dictated by its quantitative status and its chemical status, where:

- 'quantitative status' is an expression of the degree to which a water body (including its dependent ecosystems) is affected by direct and indirect abstractions; and
- 'chemical status' is determined by the concentrations of chemical pollutants due to human activity, and the presence/absence of saline intrusion.

Various approaches will have to be adopted to monitor groundwater bodies. In the case of groundwater level monitoring, the network will have to be designed to provide information on the effects of alterations in the level of groundwater and of changes in groundwater flow supplying surface ecosystems.

4. Water Framework Directive Monitoring Plan Requirements

4.1 Monitoring Plans

The plans must address the following areas:

- freshwater and marine biological quality elements;
- chemistry;
- groundwater;
- hydrology; and
- morphology.

4.1.1. Freshwater and Marine Biological Quality Elements

The biological quality elements to be monitored for rivers and lakes are:

- phytoplankton, macrophytes and phytobenthos, macroinvertebrates and fish.

For estuaries (transitional waters) and coastal waters the biological elements to be monitored are:

- phytoplankton, macroalgae, angiosperms and macroinvertebrates. In addition fish are also to be monitored for estuaries.

The most appropriate indicators are those that are representative of the condition of the biological quality elements most sensitive to particular pressures and which can be monitored easily and reliably. It will sometimes be necessary to use combinations of indicators to produce a reliable estimate of status.

Biological river sampling

4.1.2. Chemistry

Chemical monitoring, analysis and assessment are required under Annex VIII and Annex X of the directive.

A list of 33 Priority Substances has been identified (WFD Annex X) based on their toxicity, persistence and capacity for bio-accumulation. These substances must be monitored and controlled.

The list includes Priority Hazardous Substances, release of which into the aquatic environment must stop within 20 years of the adoption of the Directive. There must be a progressive reduction of pollution by the other Priority Substances.

In addition, monitoring is required for those Specific Pollutants (WFD Annex VIII) that may be present in water bodies as a result of urban and agricultural run-off and the discharge of waste water. The monitoring will assess whether the concentrations of the Specific Pollutants are below environmental quality standards (EQSs). Standards are currently being finalised for an initial list of 16 substances.

4.1.3. Groundwater

Monitoring will be required to assess water quality and quantity across groundwater bodies, as well as at more specific settings

where local pressures require monitoring and investigation. Types of monitoring that can be undertaken for groundwater assessment include water level measurement, chemical analysis, spring flow and river flow gauging, and ecological sampling.

The monitoring will have to meet the requirements of Article 17 of the Directive and the Groundwater Daughter Directive, which is currently being finalised. The Daughter Directive will set criteria for the assessment of good chemical status and for the identification and reversal of significant upward trends in pollutant concentrations. The Daughter Directive will include EU-wide standards and locally set threshold values. The threshold values, if exceeded, will generally trigger more action/ investigation, whereas the standards must be complied with.

4.1.4. Hydrology

For surface waters, monitoring will be required to cover the volume and level or rate of flow to the extent relevant to ecological and chemical status and ecological potential. This will include level monitoring for rivers, lakes and groundwater.

In order to make quantitative assessments, it is necessary to have access to rainfall and river gauging data and hydrological models. Arrangements are in place with the Meteorological Office and the Rivers Agency to obtain these data and to improve on existing hydrological models within EHS.

4.1.5. Morphology

Monitoring will be required for all surface waters. In the case of rivers and lakes this will include parameters such as depth and width variation, bed structure and substrate, river continuity and lake shore structure. For estuaries (transitional waters) and coastal waters, this will include depth variation, bed structure and substrate, and structure of the intertidal zone.


Northern Ireland's coastal waters

4.2 Monitoring Principles

EHS will ensure that monitoring is compatible with:

- EU (Common Implementation Strategy) monitoring guidance;
- UKTAG monitoring guidance; and
- any other specific monitoring protocols.

4.3. Monitoring Issues

The current monitoring networks will be used as much as possible. Meeting all of the WFD requirements will, however, inevitably lead to the opening of some new monitoring stations and the closure of others. EHS will site sampling locations in a scientifically robust manner, taking account of health and safety requirements, accessibility and the existence of other sampling programmes. Monitoring frequencies will be such that scientifically robust conclusions may be drawn from the data obtained.

In many cases, monitoring stations may serve a range of sampling programmes. However, the parameters monitored and the sampling frequency required may vary from programme to programme.

EHS will continue to participate in UKTAG and take account of its monitoring guidance. EHS also supports, and will be guided by,

recommendations arising from the NI/ROI SHARE (SHared Aquatic REsource) project and UKTAG WFD Research and Development projects.

EHS will ensure that all sampling is undertaken by fully trained staff and that analyses carried out meet local and/or national quality requirements.

5. Monitoring Strategy 2006-07

5.1. Key Elements

The 2006 -07 period will see a transition in aquatic monitoring. It will be necessary to start to develop and implement WFD monitoring programmes while at the same time continuing to support existing water quality classification schemes. This is particularly true of the existing chemical and biological General Quality Assessment (GQA) schemes for the classification of rivers. (Further information on GQA schemes can be found in *Managing the Water Environment in Northern Ireland 2000*.) In addition, discharge consent compliance monitoring will continue.

The monitoring done in 2006 will be used to further refine the assessment of pressures and impacts carried out under Article 5 of the Directive and to test some of the classification tools that have been developed. New monitoring methods will be established in 2007 and will contribute to the classification of waters into high/good/moderate status, which is required by 2008/09. The planned approach to monitoring from 2007 onwards is set out later in the WFD Monitoring Plans (see Section 6).

The key elements of the planned strategy are set out below.

5.2. Surface Water Monitoring

- **Operational monitoring to support further characterisation.** This will be targeted at those waterbodies assessed as being in risk category 1b[10] or 2a[11] to confirm presence/absence of pressures identified in the WFD Article 5 Characterisation Report[12]. During 2005, these water bodies were further assessed using data gathered in 2004, investigative field studies and expert judgement. Following this, it was possible to re-categorise some of the water bodies and to draw up a programme of action for 2006. This includes monitoring, impact modelling and further field investigations. However, it is unlikely that it will be possible to re-categorise all of the 1b water bodies before the end of 2006 (for example, it will not be possible to analyse complete 2006 data sets until early 2007). Therefore, for 2007, it is likely that further operational monitoring will be required in the unresolved 1b water bodies and, depending on resources, operational monitoring may also be undertaken in risk category 2a water bodies to support further characterisation.

[10] Water bodies at significant risk of failing their objectives but for which further information is required to ensure that this view is correct.

[11] Water bodies probably not at serious risk of failing to achieve objectives or where limited data are available.

[12] www.ehsni.gov.uk/environment/waterManage/wfd/characterisation/characterisation.shtml

- **Appropriate coverage for ongoing classification and compliance assessment programmes**. Fresh, transitional and coastal waters will continue to be assessed under their current classification and directive compliance programmes. For rivers this means that the current General Quality Assessment (GQA) chemical and biological classification schemes will continue and will overlap with the introduction of WFD classifications. A decision has not yet been made on how long GQA will continue to be used.

- **Appropriate coverage for assessment of compliance with international conventions and other agreements.** This includes, for example, OSPAR, the Environmental Change Network (ECN) and the National Marine Monitoring Programme.

- **Discharge compliance assessment monitoring.** This includes Water Order discharge consent compliance assessment monitoring and check monitoring of Water Service registered standards.

- **WFD implementation monitoring in support of classification tool development and intercalibration**.

- **Additional monitoring in Natura 2000 sites failing to meet their conservation objectives.**

- **Specific investigative projects.** Such projects will include pollution incident investigations and specific targeted projects in catchments or around discharges. For example, EHS is currently sponsoring an investigative project looking at a range of pollution issues in the River Tall in County Armagh which will continue until November 2006.

- **Selection of sites for WFD surveillance monitoring**. These will be based as far as possible on the existing monitoring network. New programmes will need to be designed specifically for lakes.

- **WFD surveillance monitoring.**

- **Appropriate coverage for Protected Areas.** Additional monitoring may be required in Protected Areas, such as Drinking Water Protected Areas (DWPAs) or Natura 2000 locations. Further details are provided in Section 6.1.1.

5.3. Groundwater Monitoring

- **Selection of sites for WFD operational monitoring.** This will be targeted at those waterbodies assessed as 1b or 2a to confirm presence/absence of pressures identified in the WFD Article 5 Characterisation Report.

- **Selection of sites for WFD surveillance monitoring**. These will be chosen to supplement and validate the characterisation and risk assessment procedure with respect to the risks of failing to achieve good groundwater chemical status as well as to provide information for use in the assessment of long-term trends in natural conditions and in pollutant concentrations resulting from human activity.

- **Selection of sites for WFD quantitative monitoring**. These will be chosen to supplement and validate the characterisation and risk assessment procedure with respect to risks of failing to achieve good groundwater quantitative status in all groundwater bodies or groups of bodies.

- **Ongoing operation of existing groundwater monitoring network.** The current network will be maintained in 2006 until migration to the WFD-compliant network.

- **Ensuring appropriate coverage for assessing compliance with Drinking Water Protected Area (DWPA) objectives** . The network will be designed to ensure appropriate monitoring of designated DWPAs.

- **Ensuring appropriate coverage for assessing compliance with other groundwater-relevant directives**. The existing network will be maintained for reporting under existing directive compliance programmes, such as the Nitrates Directive.

- **Additional monitoring in Natura 2000 and ASSI designated sites failing to meet their conservation objectives.**

- **Specific investigative projects.** Such projects will include pollution incident investigations and specific targeted projects in catchments or around discharges.

- **WFD surveillance monitoring.**

- **Operational monitoring to support further characterisation.**

- **Quantitative monitoring to confirm status assessment.**

- **Appropriate coverage for Protected Areas.** Additional monitoring may be required in Protected Areas such as Drinking Water Protected Areas or Natura 2000 locations.

5.4. Hydrological Monitoring

The hydrological monitoring strategy for 2006–07 sets out to fulfil the hydrological requirements of the WFD through a review of the existing hydrological monitoring network and identification of new sites based on monitoring guidance and the results of the pressures and impacts analysis report. The strategy also sets out plans for improving current hydrological datasets and flow assessment techniques as modelling is considered the most cost-effective way to provide the wider hydrological information needed to support surface water and groundwater status. The development of a new system for assessing water resources based on risk from abstraction and flow regulation is also planned to inform the new WFD classification schemes currently under development.

- **Review of existing hydrological monitoring network.** To review the existing flow monitoring network in Northern Ireland, identify new sites based on the requirements of Annex V of the WFD and, in agreement with Rivers Agency, present a plan for the future design. This may involve the construction and development of new gauging stations to supplement the existing network as well as the decommissioning of old stations considered surplus to requirements. Further details of locations and types for the final monitoring programme are not available at this early stage, but the general approach and methodology set out in this document will form the rationale behind the selection of new sites. The guidance in Annex V on the hydrological needs of surveillance, operational and investigative monitoring, including that of small water bodies and protected areas, will be taken into consideration.

- **Development of hydrological models and estimation techniques**. Drafting of specification and procurement of a new model to update current hydrological models for estimating flow. The model will be based on hydrological data and conditions experienced from river regimes in

Northern Ireland. Completion of the project will require a scientific review to improve on existing techniques and an implementation programme to trial the model and test the techniques on naturalised, gauged catchments within Northern Ireland.

- **Development of a spot gauging programme.** To complement the gauged network and provide improved estimation and knowledge of the variation of flows at ungauged sites.

- **Development of a water resource assessment map for Northern Ireland.** The development of a water resource assessment map based on environmental thresholds will support the hydrological requirements of classification schemes currently under development. This will be based on the amount of deviation a river or lake has experienced from natural conditions due to existing abstraction and flow regulation pressures and the considered impact on the environment.

- **Development of catchment-specific rainfall run-off models.** Flow estimation in the future will be based on the derivation of synthesised daily flow estimates. Catchment-specific models are the next generation to regional models and considerably more accurate. Catchments that require this level of accuracy can be targeted from the monitoring programmes and site-specific models developed and tested as required.

6. Water Framework Directive Monitoring Plans

The monitoring plans, as set out below, describe in general terms the approach and methodologies that will be used to design the monitoring programmes required under Article 8 of the Directive. The detailed monitoring programmes will be completed by December 2006 and a summary report will be submitted to the Commission by March 2007, in accordance with Article 15(2) of the Directive.

6.1. Surface Waters

6.1.1 Types of Freshwater Monitoring and Methods

Surveillance Monitoring

Surveillance monitoring will include all biological, hydromorphological and general physico-chemical quality elements (QEs), priority list pollutants discharged and other pollutants discharged in significant quantities. As stated previously, EHS currently classifies rivers by means of the GQA classification systems. A further range of chemical QEs, including nutrients, metals and trace organics, are reported under the OSPAR and ECN schemes. EHS also has a programme of macrophyte monitoring and in recent years has also included phytoplankton (in this case diatoms). GQA classification does not extend to lakes, but they are assessed against the chemical requirements of the EC Freshwater Fish Directive. In total, the freshwater monitoring network includes some 700 monitoring stations. In summary, EHS currently undertakes an extensive monitoring programme for a wide range of quality elements, but, for surveillance monitoring, the range required is broader still, and this is discussed in the paragraphs below.

A fundamental change for WFD classification is that it will be based on defined water bodies (see Article 5 Report, page 16) as opposed to river length as at present, i.e. a water body, rather than a river length, will be assigned a status class. WFD classification criteria are currently being developed for physico-chemical QEs, invertebrates, macrophytes, phytoplankton and fish. These will all be 5-class status systems to indicate high, good, moderate, poor or bad status.

Physico-chemical QEs

The increase in the range of chemical QEs will be for priority substances. For surveillance monitoring, the Directive requires that 'priority list pollutants which are discharged…' are assessed, and that account is taken of the requirements of Annexes VIII and IX. A screening exercise to identify in particular trace

organics in rivers is planned for 2006. Information provided by this, together with consideration by the NI Expert Group on Priority Substances, will provide guidance on what is required.

New sampling and analytical methodologies will also be developed. While dissolved oxygen (DO) meters have been around for some time, they are not routinely used for GQA DO monitoring, but this will change in the next year or so. For trace organics, spot sampling (i.e. a single sample at an instant in time) may not be an effective method because of the episodic nature of discharges and also because many substances break down within a short period of time. Sampling technology is developing in this field and includes the potential use of passive sampling devices designed to absorb organic pollutants, with it being possible to relate the quantities absorbed over a period of time to concentrations of the pollutants in the river. Investigation of passive sampling devices is included in the specification for the River Tall project in 2006. Further development of analytical methodologies will also be necessary for trace organics.

Biological QEs

River sampling methodologies should be broadly unchanged for invertebrates, macrophytes and diatoms, but further development of lake macrophyte sampling is anticipated. Water quality as indicated by macrophytes and diatoms is currently assessed by means of 3-class status systems, but these will be replaced by the WFD 5-class systems mentioned earlier.

EHS has not previously monitored freshwater fish. However, an ongoing project sponsored by EHS is developing an assessment tool for small, wadeable rivers which should provide fish monitoring of such rivers until the middle of 2008. N/S SHARE and UK projects are developing tools for deeper rivers and lakes, but at this stage it has not been decided how these monitoring needs will be met.

Hydromorphological QEs

The introduction of hydromorphology as a quality element marks progress into a new range of water quality assessment criteria. Hydrology is discussed later in this document.

Morphological assessments were undertaken for the Article 5 Characterisation Report. This was done using available database

information, such as land cover and use, and also River Habitat Survey (RHS) data that had been collated by EHS Natural Heritage.

Subsequently, Water Management Unit staff have been RHS trained and have undertaken surveys during 2005 as part of the further characterisation process. Morphological assessment methodologies are currently under development by a range of SHARE, SNIFFER (Scotland & NI Forum for Environmental Research) and UK projects, and at this stage it has not been decided what field methodology will ultimately be used for morphological surveillance monitoring.

Operational Monitoring

The Quality Elements to be assessed by operational monitoring should be those considered most sensitive to the pressure(s) being investigated. Tables 1 and 2 (from the UKTAG monitoring guidance) show the elements considered sensitive to pressures affecting rivers and lakes.

Expert judgement will be used to decide exactly which elements should be included. Sampling and analytical methodologies will be similar to those used for surveillance monitoring. It is important to note that other assessment methods, such as expert judgement and field studies other than monitoring, will also be used as part of the further characterisation process.

Table 1 Quality elements sensitive to the pressures affecting rivers

SOURCE PRESSURE	CATEGORY OF PRESSURE	EXPOSURE PRESSURE	MACROPHYTES	PHYTOBENTHOS	MACROINVERTEBRATES	FISH	MORPHOLOGY	HYDROLOGY	GENERAL PHYSICO-CHEMICAL	SPECIFIC POLLUTANTS	PRIORITY SUBSTANCES	PRIORITY HAZARDOUS SUBSTANCES
Nutrient enrichment	Primary effect on biology	Change in nutrient concentration in defined water body. Enhanced biomass, changes to other primary producers.	X	X				X	Nutrient suite			
Organic enrichment	Primary effect on biology	Increased organic enrichment; change in biological community structure.			X			X	Organic suite			
Annex VIII & X pollutants	Primary effects on sediment and water quality	Increased concentration of contaminants (water column and sediments).			X			X	General suite	X	X	X
Hydrological	Primary effect on biology	Changed water levels from abstraction; altered flow regime impacting biology.	X	X	X	X	X	X	General suite			
Morphological	Primary effect on biology	Riparian and channel modification. Altered sediment characteristics (e.g. size), smothering and damage to river bed.	X		X	X	X	X				
Acidification	Primary effect on biology	Change in ANC and pH; change in biological community and toxicity synergies.		X	X	X			Acidific-ation suite			

Table 2 Quality elements sensitive to the pressures affecting lakes

SOURCE PRESSURE	CATEGORY OF PRESSURE	EXPOSURE PRESSURE	PHYTOPLANKTON	MACROPHYTES	PHYTOBENTHOS	MACROINVERTEBRATES	FISH	MORPHOLOGY	HYDROLOGY	GENERAL PHYSICO-CHEMICAL	SPECIFIC POLLUTANTS	PRIORITY SUBSTANCES	PRIORITY HAZARDOUS SUBSTANCES
Nutrient (& organic) enrichment	Primary effect on biology	Change in nutrient concentration in defined water body. Enhanced biomass, changes to other primary producers.	X	X	X				X	Nutrient suite			
Annex VIII & X pollutants	Primary effects on sediment and water quality	Increased concentration of contaminants (water column and sediments).				X			X	General suite	X	X	X
Hydrological	Primary effect on biology	Changed water levels from abstraction; altered flow regime impacting biology; concentration of nutrients	X	X		X		X	X				
Morphological	Primary effect on biology	Shoreline and channel modification. Altered sediment characteristics (e.g. size), smothering and damage to river bed.		X		X		X	X				
Acidification	Primary effect on biology	Change in ANC and pH; change in biological community and toxicity synergies.			X	X	X		X	Acidific-ation suite			

Lake sampling

Investigative Monitoring

Investigative monitoring includes investigations of water bodies that do not meet the required standards for reasons that are unclear, and pollution incident investigations. As stated above, the ongoing River Tall project would be considered investigative monitoring. Its initial remit was to examine poor biological quality in the river, but it has widened to investigate possible pesticide pollution and the use of developing sampling technologies.

Protected Area Monitoring

For habitat and species protected areas the Directive requires that '*Bodies of water forming these areas shall be included within the operational monitoring programme*……. [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*….' Any specific operational monitoring directed at such areas during 2006-7 will rely on pressures and impacts analysis and existing monitoring data as detailed results from surveillance monitoring will not be available.

Water Service currently monitors water treatment works supply zones as part of its obligations under the Surface Water for Abstraction of Drinking Water Directive (SWAD) (75/440/EEC). This Directive is to be repealed at the end of 2007. The monitoring frequencies for DWPAs are shown in Table 3.

Table 3 DWPA WFD monitoring requirements

Size of community served by water treatment works	Monitoring frequency
< 10 000 persons	4 samples per year
10 000 to 30 000	8 per year
> 30 000	12 per year.

DWPA monitoring will be '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.' The priority substances screening exercise will, therefore, be used to inform this work, along with further characterisation. Also, there is the need to detect any upward trends in the concentrations of substances that may ultimately require enhanced treatment at a water treatment works.

In any case, EHS will ascertain during 2006 whether the SWAD monitoring will satisfy the requirements of DWPA monitoring for 2007 and assess the resources required to undertake this monitoring.

Natural Heritage of EHS recently awarded a contract which will include monitoring of particular rivers and lakes in Special Areas of Conservation (SACs) and Areas of Special Scientific Interest (ASSIs) for a range of quality elements. Information from this project will also inform habitat and species protected area monitoring.

Freshwaters designated under the Freshwater Fish Directive and the Nitrates Directive and sensitive areas designated under the Urban Waste Water Treatment Directive are also Protected Areas. As the Freshwater Fish Directive is not to be repealed until 2013, compliance monitoring will continue until then. EHS will be developing proposals for Nitrates Directive Effectiveness monitoring during 2006.

6.1.2. Monitoring Frequencies

The Directive sets out the minimum frequencies at which parameters have to be monitored during a 6-year River Basin Management Plan (RBMP) cycle for surveillance monitoring.

Table 4 shows, for physico-chemical elements, the minimum frequency of monitoring in a one-year surveillance monitoring period during a RBMP cycle. Biological and hydromorphological elements should be monitored at least once during this period.

For operational monitoring, the table shows the maximum intervals between successive monitoring events, unless greater intervals can be justified on the basis of expert judgement.

Table 4 Minimum WFD monitoring frequencies

Quality Element	Rivers	Lakes	Transitional Water	Coastal Water
Biological				
Phytoplankton	6 months	6 months	6 months	6 months
Other aquatic flora	3 years	3 years	3 year	3 year
Macroinvertebrates	3 years	3 years	3 years	3 years
Fish	3 years	3 years	3 years	
Hydromorphological				
Continuity	6 years			
Hydrology	continuous	1 month		
Morphology	6 years	6 years	6 years	6 years
Physico-chemical				
Thermal conditions	3 months	3 months	3 months	3 months
Oxygenation	3 months	3 months	3 months	3 months
Salinity	3 months	3 months	3 months	
Nutrient status	3 months	3 months	3 months	3 months
Acidification status	3 months	3 months		
Other pollutants	3 months	3 months	3 months	3 months
Priority substances	1 month	1 month	1 month	1 month

Currently, monitoring for some quality elements (for example invertebrates and general chemistry elements) is considerably more frequent. For example, GQA chemistry parameters are monitored monthly and GQA biology invertebrates are currently monitored on a 2-season basis. However, UKTAG guidance states that '*Until the detail* [is available] *on how classification schemes for each of the biological and physico-chemical elements perform, it is not possible to provide new guidance about sampling frequency*'.

6.1.3. Freshwater Monitoring Network Design

Surveillance Monitoring

EHS is currently drawing up the proposed freshwater surveillance monitoring network taking into account Directive requirements and UKTAG guidance. The Directive requires the inclusion of stations where:

'*the rate of water flow is significant within the river basin district as a whole, including large rivers where the catchment is greater than 2500 km*^{2}*'* – the largest catchment in Northern Ireland is the Lower Bann. However, the most downstream station on primary river basins will be included.

'the volume of water is significant within the river basin district, including large lakes and reservoirs' – all primary basins will be included and all lakes over 50 hectares.

'*significant bodies cross a Member State boundary'* – an N/S SHARE monitoring project will provide recommendations on the cross-border WFD monitoring. EHS will, however, develop initial proposals in advance of the SHARE project report.

'*sites are identified under the Information Exchange Decision 77/795/EEC* '– this will include OSPAR, EIONET, ECN and Intercalibration rivers and lakes sites.

UKTAG suggests that further stations should be added in proportion to the number of water bodies in each risk category, aiming for around 10% in each category if resources permit. Stations should ideally have existing long-term chemical and biological monitoring records. Also, issues such as the proximity of flow gauging stations, groundwater interaction and suitability for fish monitoring will be taken into account. Further, since Annex V 1.3.2. of the Directive suggests that operational monitoring is applicable only to water bodies at risk, surveillance monitoring is required to classify water bodies categorised as not at risk.

In total, this could lead to around 170 surveillance monitoring stations, although it will be later in 2006 before the number is finalised. It is likely that this will necessitate a 'rolling' approach to the monitoring programme: for example, if there were 150 stations to be sampled once every three years in a 6-year River Basin Management Plan cycle, 50 would be sampled in the first year, 50 more in the second year, and so on.

Another fundamental difference arising from the Directive will be the spatial nature of surveillance monitoring stations due to the differing methodologies for sample collection of the quality elements being monitored. For example, for a current GQA chemical and biological river monitoring station, the chemistry sample is generally taken from a bridge with the biological sample taken nearby where the river conditions are suitable. For macrophytes, fish and hydromorphology, longer stretches (up to 500m for hydromorphological assessments) of river are required with suitable access, so it is clear that surveillance monitoring stations will actually consist of stretches of rivers rather than single locations. Similarly for lakes, differing locations will be required to monitor littoral and profundal invertebrates and fish.

The EHS approach to the selection of surveillance monitoring stations is comparable with that of the rest of the UK and the Republic of Ireland.

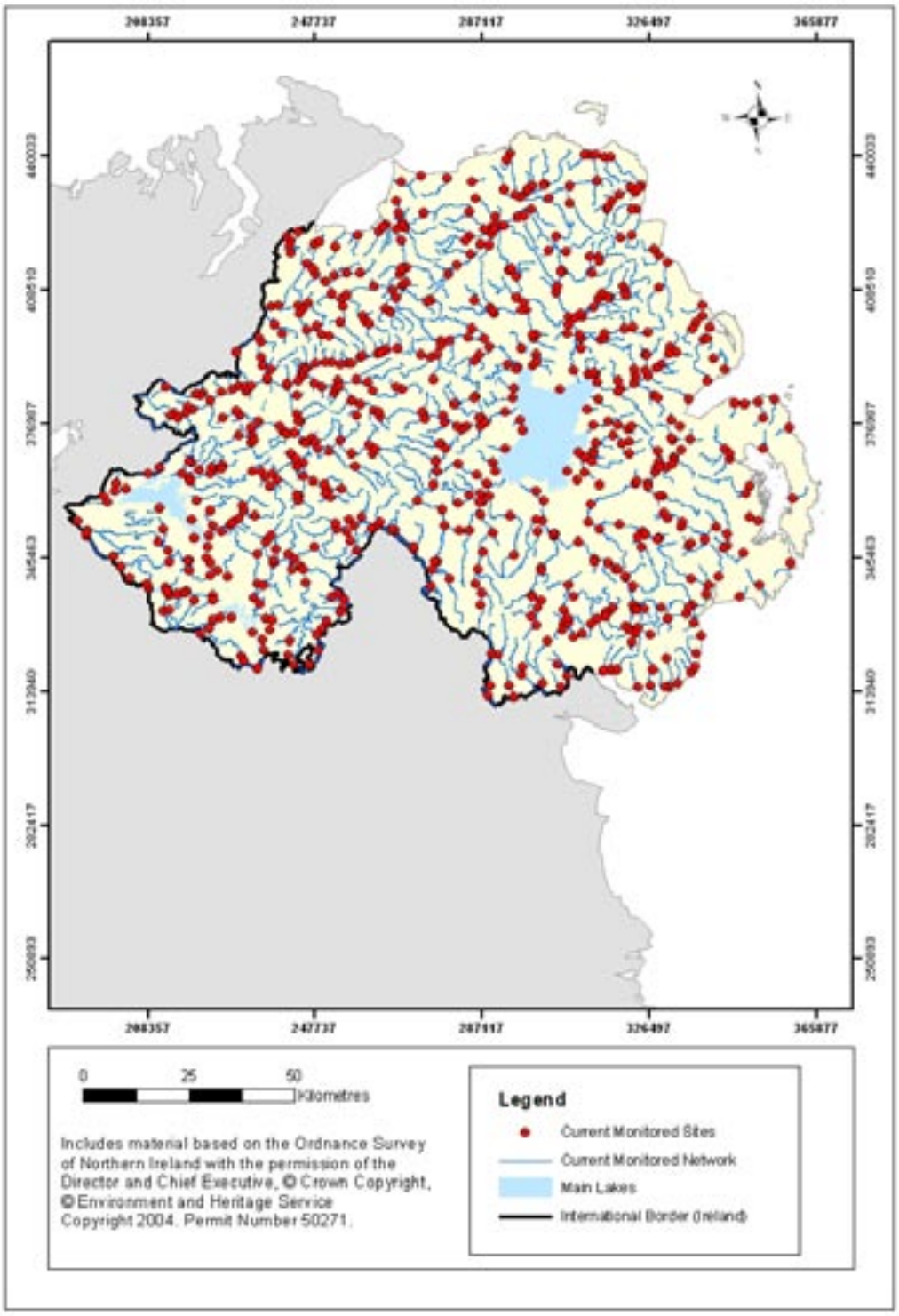
Operational Monitoring

As stated previously, operational monitoring is required to classify those waterbodies considered at risk and, in the future, to assess the outcome of programmes of measures. It will also be used to check for no deterioration in class and to identify water bodies that are near a class boundary and therefore at risk of deteriorating in class. Operational monitoring may therefore also be undertaken at surveillance monitoring sites.

Given that GQA and Freshwater Fish Directive compliance monitoring are to continue, the approach will be to use the existing monitoring network for operational monitoring as far as possible, particularly since issues such as health and safety have been considered for existing sampling locations and sampling staff are familiar with them.

Map 1 shows the existing network of freshwater monitoring stations and illustrates the coverage provided at present.

Map 1 Existing freshwater monitoring network



6.1.4. Types of Marine (Transitional and Coastal Waters) Monitoring and Methods

The current EHS policy is to generally manage estuarine (transitional) and coastal waters so that water quality is at least good under the Northern Ireland Estuarine and Coastal Waters Classification Schemes (NIECWCS) with no downward movement between classes. All surface waters are managed to ensure compliance with the requirements of the relevant EC directives and international agreements.

EHS currently has an Estuarine and Coastal Waters Monitoring Programme made up of a network of 44 sites in the 5 sea loughs and major estuaries. These sites are monitored for water quality, sediment quality, biological effects and fish population studies. Monitoring has been taking place at many of these sites for more than 10 years.

The information collected from this monitoring formed the basis of the pressures and impacts assessment carried out under Article 5.

This existing network of sites has changed to meet the requirements of the WFD. The marine monitoring network now consists of 20 coastal waters and 7 transitional waters (excluding saline lagoons).

Previous legislation has been directed at controlling specific discharges or activities in the marine environment whereas the WFD aims to take a holistic view of all the activities in the aquatic environment. The emphasis has now been put on measuring the biological status of organisms rather than physico-chemical parameters in discharges or receiving waters. In marine waters the biological status for the WFD will be assessed by measuring the following elements:

- benthic invertebrate fauna;
- macroalgae and angiosperms;
- phytoplankton; and
- fish fauna (transistional waters only).

Ecological status is determined by the biological elements, the physico-chemical elements and hydromorphology.

Surveillance Monitoring

Surveillance monitoring 'shall be carried out at selected water bodies to provide an assessment of the overall surface water status within each catchment within the river basin district'.

Selection of Quality Elements

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

- parameters indicative of all biological quality elements;
- parameters indicative of all hydromorphological quality elements;
- parameters indicative of all physico-chemical elements;
- priority list pollutants which are discharged into the river basin or sub-basin; and
- other pollutants discharged in significant quantities into the river basin or sub-basin.

Sites were chosen to give a mix of 1a (at risk) and 1b (probably at risk) water bodies across the three River Basin Districts and a range of typologies[13].

Sites considered for operational monitoring are:

- three lagoons, one in each RBD (transitional water),
- Lough Foyle (coastal water),
- Carlingford Lough (coastal water), and
- Strangford Lough North (coastal water).

All water bodies currently monitored for the National Marine Monitoring Programme were automatically assigned as water bodies for surveillance monitoring. This gives a further 3 sites:

- Bann Estuary (transitional water),
- Foyle Estuary (transitional water), and
- Inner Belfast Lough (coastal water).

[13] See Article 5 Report, Section 3.2.

Operational Monitoring

Operational monitoring will be established in response to information on anthropogenic pressures that have the potential to affect ecological status. The network will establish status and assess any changes in status due to the programme of measures. The network will be defined by the risk assessment, using data on pressures and their impact on ecological quality to identify those sites that may be at risk (i.e. characterisation). Monitoring is to be used to support and validate risk assessments.

In Northern Ireland, sites identified as being 1b (probably at risk) for a particular pressure will be monitored for the quality element most sensitive to that pressure. The link between quality elements and associated pressures is shown in Table 5.

A list of sites identified as being probably at risk (1b) for a particular pressure was compiled. Sites sensitive to the same pressure, with the same typology and within the same RBD, were grouped and the most representative site chosen (see Section 6.1.6 for further details). This means that for every individual pressure one site from each typology was selected from each RBD where a risk was identified. This provides a range of sites categorised overall as 1a or 1b.

In Northern Ireland we reported 30 saline lagoons as transitional waters (TW6) in the Article 5 Report. This number has since been reviewed as a result of site visits and now stands at 28. These sites have been identified as 2a (probably not at risk) and 1b (probably at risk). The main risk to these sites is from eutrophication and alien species. We have selected one lagoon from each RBD to be included in the operational monitoring programme. This monitoring will consist of phytoplankton, macroalgae, benthos, general physico-chemical and alien species. A limited number of hazardous substances samples will be collected at these sites.

All water bodies which are designated as sensitive under the Urban Waste Water Treatment Directive are included in the monitoring programme for the element most sensitive to eutrophication.

Table 5 Quality elements sensitive to the pressures affecting transitional and coastal waters

SOURCE PRESSURE	CATEGORY OF EFFECT	EXPOSURE PRESSURE	QUALITY ELEMENT								
			PHYTOPLANKTON	MACROALGAE	ANGIOSPERMS	BENTHIC INVERTEBRATES	FISH (Transitional only)	MORPHOLOGY	HYDROLOGY	GENERAL PHYSICO-CHEMICAL	SPECIFIC POLLUTANTS
NUTRIENT ENRICHMENT	**Primary effects on water quality**	**Change in nutrient concentration in defined water body** [DIN], [DIP], N:P, N:Si (current and changes over time)	✓	✓	✓					✓	
ORGANIC ENRICHMENT	**Primary effects on sediment quality**	**Increased deposition of organic carbon to seabed**				✓				✓	
	Primary effects on water quality	**Increased organic enrichment of water column**				✓				✓	
	Secondary effects on water quality	**Reduced oxygen availability** (reduced dissolved oxygen in water column, and anaerobic sediments)				✓	✓			✓	
POINT HAZARDOUS SUBSTANCES	**Primary effects on sediment and water quality**	**Increased concentrations of contaminants** (water column and sediments)				✓	✓				✓
INDUSTRIAL ABSTRACTION	**Primary effects on ecology**	**Entrainment of fish and invertebrates**					✓		✓		
	Primary effects on water quality	**Altered temperature regime of water column** (mean seasonal temp, spatial temp pattern, degrees above surrounding water)					✓			✓	
	Secondary effects on water quality	**Reduced oxygen availability** (reduced dissolved oxygen in water column, and anaerobic sediments)					✓			✓	
CATCHMENT ABSTRACTION	**Primary effect on hydrology**	**Altered salinity regime of estuary** (salinity of water body)				✓	✓		✓	✓	
	Primary effect on hydrology	**Reduced flushing leading to reduced oxygen availability**				✓	✓			✓	
MORPHOLOGICAL (INCLUDING: SHORELINE REINFORCEMENT, BARRAGES, WEIRS, SLUICES, LAND RECLAMATION, DREDGING AND DREDGED MATERIAL DISPOSAL, AGGREGATE EXTRACTION)	**Primary effects on morphology**	**Removal of intertidal or subtidal area** (area lost), **Increased availability of hard substrate** (area added), **Altered sediment characteristics** (e.g.size), **smothering and damage to seabed structures** (e.g.increased sedimentation)		✓	✓	✓	✓	✓	✓	✓	
	Secondary effects on hydrology	**Barrier to movement of mobile fauna, reduced flushing, altered tidal range, decreased/increased saline intrusion**	✓	✓	✓	✓	✓		✓	✓	
	Secondary effects on water quality	**Reduced oxygen availability** (reduced dissolved oxygen in water column, and anaerobic sediments) **Increased turbity, change in nutrient concentrations**	✓	✓	✓	✓	✓			✓	
COMMERCIAL FISHING	**Primary effect on morphology**	**Altered distribution of sediment & seabed topography**			✓	✓		✓			
	Primary effect on ecology	**Damage to sensitive habitats**			✓	✓		✓			
	Primary effect on ecology	**Removal of target and non-target species**				✓	✓				
AQUACULTURE	**Primary effects on sediment quality**	**Increased deposition of organic carbon to seabed**				✓				✓	
	Primary effects on water quality	**Increased organic enrichment of water column**	✓							✓	
	Primary effects on sediment and water quality	**Increased concentrations of contaminants** (water column and sediments)				✓	✓				✓

Protected Areas

Marine Protected Areas include designated Bathing Waters, Shellfish Waters, Sensitive Areas (Eutrophic) and Nitrate Polluted Waters (Eutrophic), Nitrate Vulnerable Zones and water-dependent Natura 2000 sites (SACs and SPAs).

In Natura 2000 protected areas, *'monitoring shall continue until the areas satisfy the water-related requirements of the legislation under which they are designated and meet their objectives under Article 4'* (Annex V 1.3.5).

It is envisaged that Natural Heritage will assess compliance with conservation objectives and Water Management Unit will monitor the aquatic parameters (water quality and quantity) upon which the conservation objectives depend. Existing EC monitoring programmes (e.g. shellfish waters and dangerous substances) will be maintained until such time as these directives are repealed.

6.1.5. Marine Monitoring Frequencies

Minimum monitoring frequencies are set out in the Directive (see Table 6). Current monitoring for some biological elements is carried out at a higher frequency than that specified. However, as is the case with freshwater monitoring, it will not be possible to specify monitoring frequencies until the detail is available on how the new WFD classification schemes for each of the biological and physico-chemical elements perform.

Table 6 Minimum operational monitoring frequencies

Quality Element	Transitional Water	Coastal Water
Biological		
Phytoplankton	6 months	6 months
Other aquatic flora	3 year	3 year
Macroinvertebrates	3 years	3 years
Fish	3 years	
Hydromorphological		
Morphology	6 years	6 years
Physico-chemical		
Thermal conditions	3 months	3 months
Oxygenation	3 months	3 months
Salinity	3 months	
Nutrient status	3 months	3 months
Other pollutants	3 months	3 months
Priority substances	1 month	1 month

6.1.6. Marine Network Design

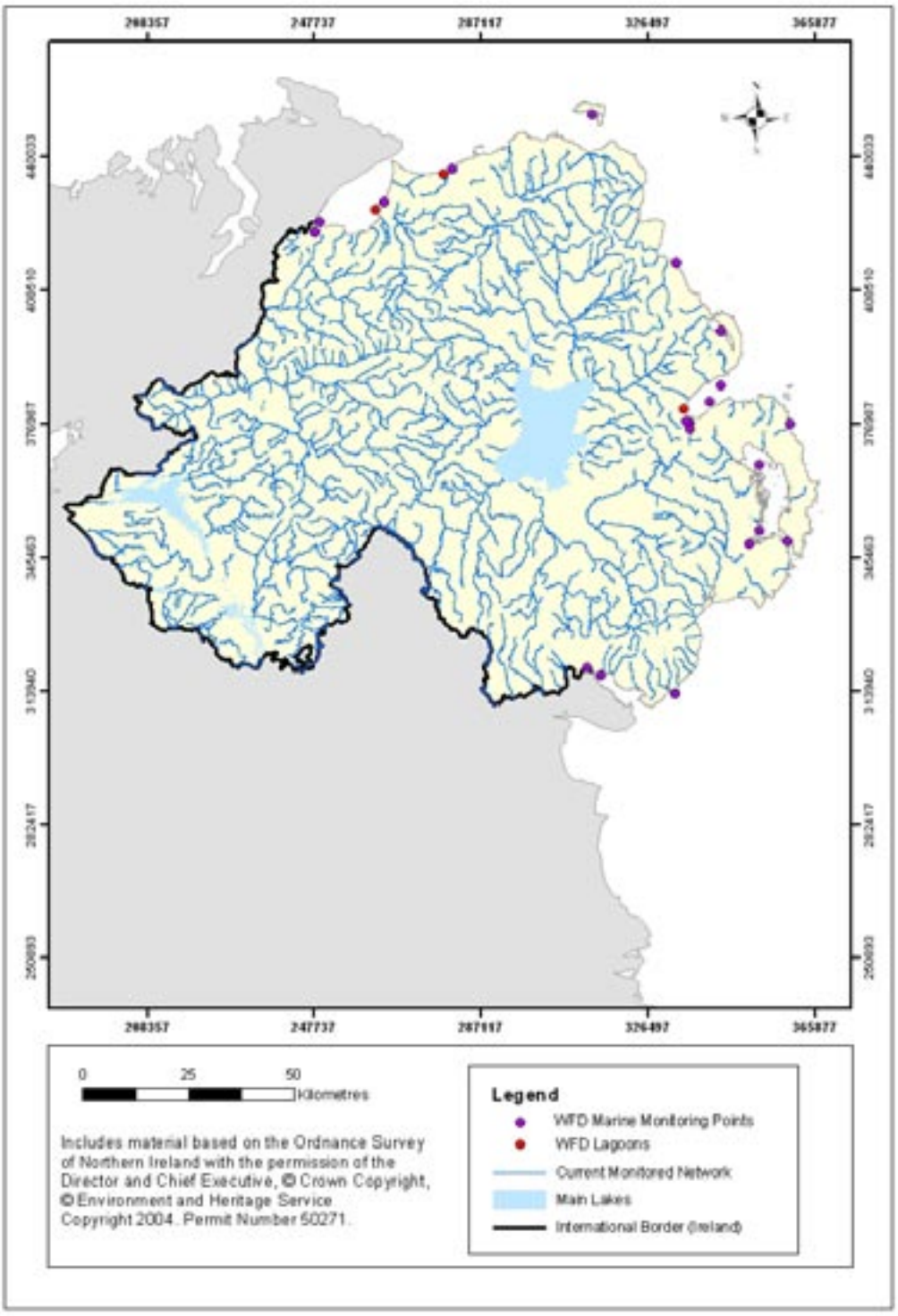
Details of the combined surveillance and operational monitoring networks are given in Table 7. These include those water bodies that will be monitored for each of the different elements indicated. The locations of the monitoring sites are shown in Map 2.

Table 7 Marine WFD monitoring network

RBD	Typology	Water Body	Phytoplankton	Macroalgae	Angiosperms	Benthos	Fish	Physico-chem	Hazardous Subs
NW IRBD	TW2	Foyle and Faughan Estuaries				x	x		x
NW IRBD	TW2	Roe Estuary					x		
NW IRBD	TW6	Lagoons	x	x	x	x		x	x
ALL RBDs	CW2	Portstewart Bay	x						
NW IRBD	CW8	Lough Foyle	x	x	x	x		x	x
NB IRBD	TW2	Bann Estuary				x	x		x
NB IRBD	TW2	Newry Estuary					x		x
NB IRBD	TW6	Lagoons	x	x	x	x		x	
ALL RBDs	CW2	Portstewart Bay	x					x	
NB IRBD, NE RBD	CW5	Mourne Coast				x		x	
NB IRBD	CW8	Carlingford Lough	x	x	x	x			x
NE RBD	TW2	Lagan Estuary	x				x		
NE RBD	TW2	Connswater Estuary	x	x				x	
NE RBD	TW2	Quoile Estuary	x				x		x
NE RBD	TW6	Lagoons	x	x	x	x		x	x
NE RBD	CW2	Rathlin Island				x			
NE RBD	CW2	North Coast							
ALL RBDs	CW2	Portstewart Bay	x						
NE RBD	CW5	Maiden Islands							
NE RBD	CW5	North Channel				x			
NE RBD	CW5	Belfast Lough Outer	x	x	x			x	
NE RBD	CW5	Ards Penninsula				x		x	x
NE RBD, NB IRBD	CW5	Mourne Coast				x		x	
NE RBD	CW5	Dundrum Bay Outer							
NE RBD	CW8	Dundrum Bay Inner							
NE RBD	CW8	Strangford Lough North	x	x	x			x	x
NE RBD	CW8	Strangford Lough South				x			
NE RBD	CW8	Strangford Lough Narrows	x						
NE RBD	CW8	Larne Lough North							
NE RBD	CW8	Larne Lough Mid							
NE RBD	CW8	Larne Lough South				x			
NE RBD	CW8	Belfast Lough Inner	x	x	x	x		x	x
NE RBD	CW8	Belfast Harbour	x			x		x	

x= element that will be monitored

Map 2 Marine WFD monitoring network



6.2. Groundwater

6.2.1. Types of Monitoring and Methods

Chemical

Assessment of groundwater chemistry allows the natural (background) quality of groundwater to be established and identifies any anthropogenic (man-made) impacts.

Monitoring of groundwater generally involves obtaining samples from sources such as boreholes, wells or springs. A strict sample collection procedure must be followed to ensure that data obtained are representative of the groundwater body from which the source obtains its water.

The analysis undertaken will comprise a core suite incorporating parameters specified within the proposed Groundwater Daughter Directive along with other parameters which describe the natural chemistry of the groundwater and which can be used to quality assure sample analysis. In addition, analysis for anthropogenic contaminants (e.g. sheep dip, insecticides, hydrocarbons) will be undertaken, with the parameters to be measured at a specific monitoring point based upon Article 5 assessment of pressures and risks for the area.

The core suite will comprise dissolved oxygen (DO), pH, electrical conductivity (EC), nitrate and temperature along with a suite of major and trace ions. Selected metals and radionuclides will also be measured where required for characterisation of natural groundwater quality and trends.

Quantitative

Quantitative impacts on groundwater and dependent ecosystems can occur for a variety of reasons including:

- general over-abstraction across a groundwater body;
- local abstraction (or dewatering) within an area sensitive to water level changes; and
- alteration of recharge to groundwater, for example due to sealing of land surfaces with hard-standing.

Although the Directive identifies groundwater level as the measurement parameter for determining quantitative status,

in practice, the requirements of status assessment mean that additional supporting information will be needed. Parameters that will be considered for incorporation into the quantitative network include:

- groundwater levels in boreholes or wells;
- spring flows;
- flow characteristics and/or stage levels of surface watercourses; and
- stage levels in significant groundwater-dependent wetlands and lakes.

Additional monitoring to support groundwater characterisation and classification may also include:

- chemical monitoring for saline or other intrusions;
- rainfall and the components required to calculate evapotranspiration (to calculate groundwater recharge);
- ecological monitoring of groundwater-dependent terrestrial ecosystems (including ecological indicators); and
- groundwater abstraction (and any artificial recharge).

Measurement of water level within a borehole

Trend

Assessment of trends in both water quality parameters and indicative quantitative parameters will be achieved by regular collection and analysis of data following initiation of monitoring. Trends will be assessed against relevant quality standards, threshold values and/or specific site conditions to determine their significance and the need for further action. Any further action taken, such as more detailed investigative monitoring or implementation/adaptation of programmes of measures, will be informed by the conceptual understanding of the hydrogeological setting being assessed.

Approach to Protected Area Monitoring

With respect to groundwater, Protected Area designations include groundwater-dependent Natura 2000 sites and groundwater bodies used (or planned for future use) for the abstraction of water intended for human consumption ('drinking water').

For groundwater-dependent terrestrial ecosystems, site-specific monitoring of both quantitative and chemical parameters will be considered where a significant impact or risk has been identified. Consideration will also be given to the use of ecological monitoring, where appropriate.

For Drinking Water Protected Areas (DWPAs), only groundwater bodies which provide more than 100 m^3 per day need to be monitored. Generally, the monitoring carried out under the standard surveillance and operational programmes will be applicable to assist with assessment of compliance with specific DWPA objectives. For DWPAs, the main specific objective is to ensure that no increase in the level of purification/treatment is required at abstraction sources. Within DWPAs, the more significant drinking water (potable) sources will be targeted for monitoring and assessment. More intensive monitoring will be undertaken in those groundwater bodies which support DWPAs that are considered to be at risk (1a and 1b) than in those bodies where DWPAs are not considered at risk.

6.2.2. Monitoring Frequencies

Frequency of monitoring will depend on a number of factors such as the hydrogeological setting (including aquifer type) in which the monitoring point is located. Frequency of monitoring

will also depend on the specific parameters being monitored. Guidelines for the frequency of surveillance and operational chemical monitoring have been produced by UKTAG and are shown in Tables 8 and 9. For each site selected to be in the groundwater monitoring network an appropriate monitoring frequency will be assigned.

Table 8 Minimum monitoring frequencies for surveillance monitoring suggested by the UK Technical Advisory Group (UKTAG)

Analysis Suite		Aquifer Flow Type				
		Confined	Unconfined			
			Intergranular flow significant		Fracture flow only	Karst flow
			Significant deep flows common	Shallow flow		
Initial frequency– core & additional parameters		Twice per year	Quarterly	Quarterly	Quarterly	Quarterly
Long term frequency – core parameters	Generally high-mod transmissivity	Every 2 years	Annual	Twice per year	Twice per year	Twice per year
	Generally low transmissivity	Every 6 years	Annual	Annual	Annual	Twice per year
Additional parameters (ongoing validation)		Every 6 years	Every 6 years	Every 6 years	Every 6 years	-

For operational monitoring a higher minimum monitoring frequency was suggested.

Table 9 Minimum monitoring frequencies for operational monitoring suggested by the UK Technical Advisory Group (UKTAG)

Assessment Types and Vulnerability Settings		Aquifer Flow Type				
		Confined	Unconfined			
			Intergranular flow significant		Fracture flow only	Karst flow
			Significant deep flows common	Shallow flow		
Higher vulnerability groundwater	Continuous pressures	Annual	Twice per year	Twice per year	Quarterly	Quarterly
	Seasonal/intermittent pressures	Annual	Annual	As appropriate	As appropriate	As appropriate
Lower vulnerability groundwater	Continuous pressures	Annual	Annual	Twice per year	Twice per year	Quarterly
	Seasonal/ intermittent pressures	Annual	Annual	As appropriate	As appropriate	As appropriate
Trend assessments		Annual	Twice per year	Twice per year	Twice per year	-

For **quantitative monitoring,** groundwater levels should preferably be monitored daily, but at least once a month. It would be preferable to measure levels of surface water bodies (rivers, groundwater-dependent terrestrial ecosystems) and spring discharges daily where possible and where appropriate monitoring equipment is installed. Otherwise monthly would be the minimum required monitoring frequency.

Frequency of monitoring will be determined by the total number of sites incorporated within the network, taking into account available resources.

6.2.3. Monitoring Network Design

The network must, among other things, be representative and suitable to:

- confirm or otherwise the Article 5 risk assessment;
- monitor background chemical concentrations and quantitative levels and future trends; and
- allow classification of groundwater bodies.

Careful site selection is critical to ensure that all the objectives required of the network will be met. There are two main elements to this process to ensure that a representative network is in place:

i) Consideration of the integrity of the sample point itself. This requires knowledge of the physical characteristics of the monitored source as well as an understanding of the local catchment zone and hydrogeological setting which the source 'samples'. Understanding such factors will allow an assessment of whether a useful representative sample can be obtained which is not unduly influenced by very local pressures such as point source pollution or nearby abstraction (except where the monitoring point is selected specifically to monitor such pressures); and

ii) Analysis of the particular pressure-pathway susceptibility[14] setting which a candidate sample point would monitor. Assessing the local landuse pressures and hydrogeological setting around the monitoring point will allow a check to be made of how representative this will be of the different pressures and settings occurring across a groundwater body or group of bodies. Additional monitoring points can then be selected for other types of pressure-pathway susceptibility settings to ensure that the potential impact from the most significant pressures across a body or bodies will be monitored.

During 2006, candidate groundwater monitoring sources will be identified from known existing private and public abstractions, disused wells and springs, following a desktop screening process to eliminate obviously unsuitable sites. Sites within the existing monitoring network will be included within this process. Where further assessment, including site visits, indicates that a source may be suitable and access can be agreed, the location of the site will be considered with respect to its general representativeness of pressures and pathway susceptibility. It is expected that this process will involve a number of iterations prior to finalising the network. Due to the specific hydrogeological settings found in Northern Ireland and the

[14] pressure-pathway susceptibility - an assessment of the relationship between a pressure and a receptor considering such factors as the nature of intervening soils and sub-soils and aquifer type

relatively limited degree of exploitation of groundwater, locating suitable sites in some areas will be problematic. Gaps in the network will be identified and the need for installation of new groundwater monitoring points determined.

For groundwater bodies which cross the border with the Republic of Ireland, EHS will liaise with the Department of the Environment, Heritage and Local Government to ensure that adequate monitoring is in place to meet the objectives of the Directive.

6.2.4. Number and Distribution of Stations

Monitoring will be required at two different scales to meet the various requirements of the Directive's Article 4 objectives. Firstly, 'regional' monitoring to assess the general quantitative and chemical 'health' of groundwater bodies is required. Secondly, there may be a need for more focused 'local' monitoring of selected parameters that relate to identified risk areas, such as point source pollution or local groundwater-supported receptors (i.e. groundwater-dependent terrestrial ecosystems) impacted by over-abstraction.

To ensure an efficient and cost-effective monitoring network, UK TAG suggests the grouping of groundwater bodies under certain conditions. One of the conditions is that the data gained from monitoring give reliable information on water quality, levels and trends, especially possible increases in pollutant concentrations, across all the component bodies. In addition, grouped groundwater bodies must have similar aquifer characteristics and pathway susceptibilities, and similar pressures acting upon them.

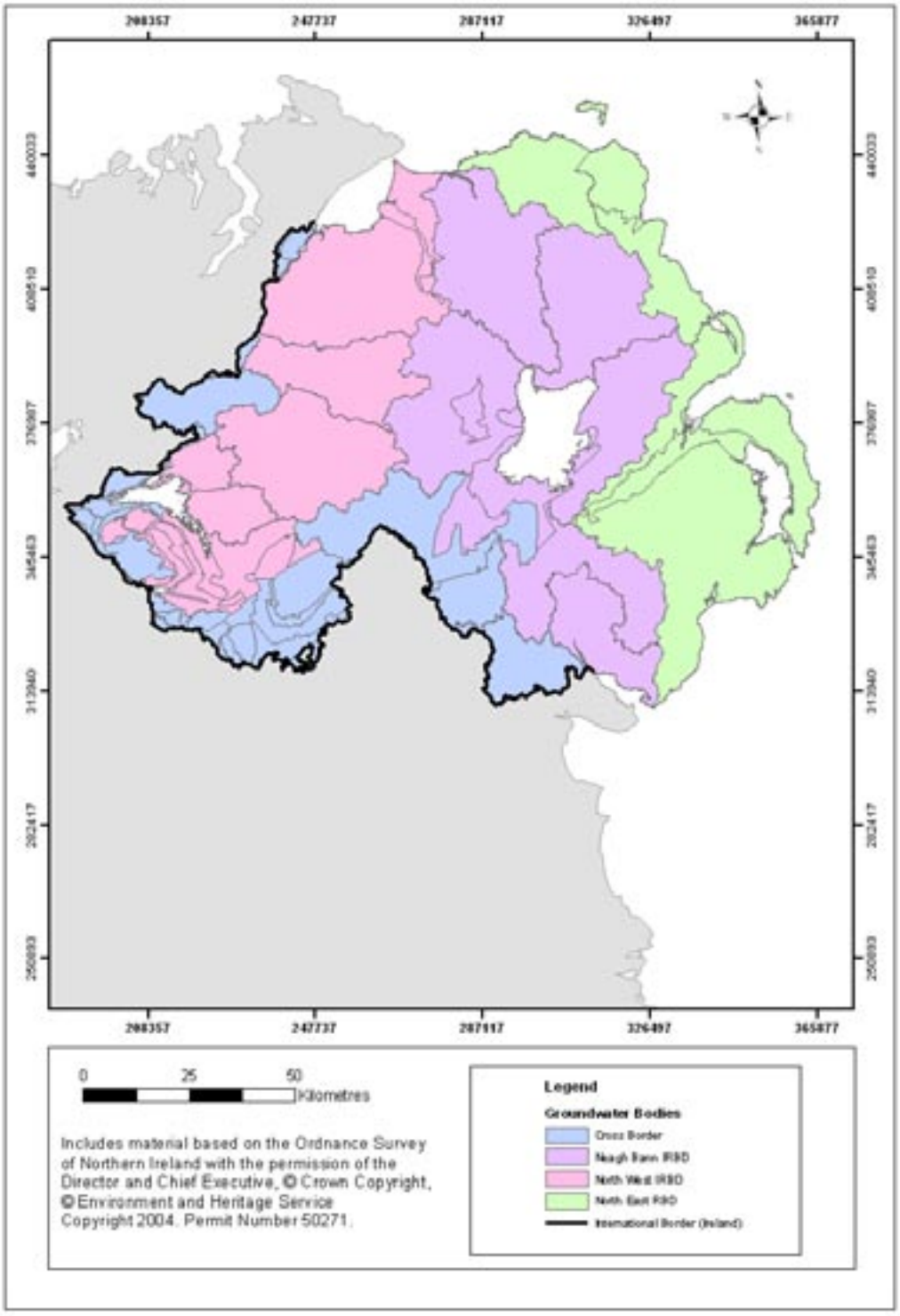
In groundwater bodies or groups of groundwater bodies assessed as being not at risk, the monitoring can be minimised. Indeed, monitoring points need not be located in each body within a group, provided that the groups are hydrogeologically comparable.

In groundwater bodies or groups of groundwater bodies assessed as being at risk, the distribution of monitoring points will reflect the need to understand the hydrogeological conditions that relate to the receptors identified as being at risk and their perceived importance. At least one monitoring point will be needed in any body assessed as at risk.

The distribution of groundwater bodies across Northern Ireland

is shown in Map 3.

Map 3 Distribution of groundwater bodies



At this stage it is not possible to specify the distribution and number of groundwater monitoring points required. This will be established during 2006 and reported on by March 2007. Where appropriate, integration with the surface water monitoring network will be undertaken.

6.3. Hydrology

6.3.1. Types of Monitoring and Methods

The type of flow monitoring and techniques used will depend on the level of accuracy required to ensure an adequate assessment of water status.

Accurate hydrological monitoring could be considered for all the sites within the monitoring programme, but this would be impractical considering the resources required for access routes, construction, instrumentation costs and the general maintenance of a large network of flow and level monitoring stations. A combination of continuous flow measurement, spot gauge measurement, modelling and flow estimation techniques will be used to address the hydrological requirements of the monitoring programme.

Annex V of the WFD defines the hydromorphological elements required to assess the biology of inland, transitional and coastal waters which is needed to classify ecological status. For inland waters this is the quantity and dynamics of flow, including the connection to groundwater, as well as residence time for lakes and freshwater flow for transitional waters.

In Northern Ireland a surface water hydrometric network currently exists consisting of some 113 monitoring stations, 70 of which are fully or partially rated for flow measurement, with many located at the lower end of river catchments. It is acknowledged that continuous monitoring of flow is not economically viable at the water body or reach scale. It will be necessary therefore to rely on estimation techniques that will use data from the existing network supported by hydrological models (with known uncertainties in the estimates) to provide the hydrological information required to support ecological classification.

Flow Estimation Techniques

The hydromorphological quality elements required for the classification of ecological status are described in Annex V of the Directive. High status requires a hydrological regime that reflects totally or nearly totally undisturbed conditions. Good and moderate status require hydrological regimes that support the values specified for the biological elements. It will be necessary therefore to provide an assessment of the natural hydrological regime and to estimate by how much the regime has deviated due to anthropogenic activities. The hydrological regime for rivers includes the quantity and dynamics of flow and groundwater connection. For lakes, the hydrological regime also includes residence time, and for transitional waters the total freshwater flow is required. The latest methodology to derive low flow duration curves (probability exceedence curves that provide an indication of the frequency and range of flows expected) will be necessary to provide the estimated variation in flow. A methodology to describe the contribution to surface flow from groundwater sources (another requirement of the hydromorphological elements) will also be needed. For lakes, the use of residence time for hydromorphology requires the estimation of average volume and average discharge. Average discharge and bathymetric surveys will be necessary, therefore, for lakes. The above flow parameters can be generated by using continuous daily flow data from existing or new gauging stations with software analysis programs or can be estimated from hydrological models including site-specific rainfall run-off models.

Other flow estimation techniques that will be employed are the use of local data for improving estimates derived from models, including the transposition of observed data from suitable analogous catchments, and the development of spot gauging programmes to support the estimation of flow duration curves at ungauged locations.

Gauging Stations

Continuous Level Monitoring Stations

Collection of river and lake level data at identified existing sites within the network and at proposed new sites will be the most widely used method for future WFD hydrological monitoring. New level monitoring sites will involve the construction of river flow gauging stations. These may range from a weir and cableway design for gauging low and high flows accurately, including stilling well and brick/concrete housing for the

protection of instrumentation, to a simpler velocity-area design for continuous level monitoring and calibration. A number of new lake level monitoring sites will also be required to improve information on lake level range and the effect of abstractions as well as to monitor lake outfalls.

River flow gauging station (Courtesy of Rivers Agency)

Gauging Data Programmes
Additional gauging programmes will be required to develop and maintain stable stage (level)/discharge relationships at new, strategically identified river sites. This will enable the collection of accurate discharge data in areas currently under-representative in flow measurement information.

Staff Gauge Installations
This will also involve the installation of new, strategically placed staff gauges at proposed spot gauging sites. If resources and accessibility permit, automatic data loggers could also be planned for these spot gauging sites to upgrade them to continuous monitoring sites if daily data are needed and the measuring sections are suitable for long-term monitoring.

Modelling

The use of hydrological models will form the wider basis of support needed for estimating the quantity and dynamics (volume and variability) of flow and connection to groundwater. This will be required to support surveillance, operational and investigative monitoring, including, for example, in protected areas, and to enable further characterisation work to be carried out. The development of any new hydrological models will consider recent scoping studies carried out on existing models

within Northern Ireland and ensure, where possible, consistency with techniques adopted by other agencies.

Further improvements to flow estimation from site-specific rainfall run-off models are planned in areas where the uncertainty attached to regional models is too great. The output from these models will be linked to the existing rainfall network and data synthetically derived to produce the required flow information.

6.3.2. Monitoring Frequencies

The WFD states that the frequency of monitoring shall be chosen so as to achieve an acceptable level of confidence and precision. Estimates of the confidence and precision attained by the monitoring shall be stated in the River Basin Management Plan.

Guidance is given in Annex V of the Directive on the frequency of monitoring required for the hydromorphological elements (see Table 4). For operational monitoring, the 'parameters indicative of the hydromorphological quality element most sensitive to the pressure identified' shall be monitored, and for all surveillance monitoring sites 'parameters indicative of all hydromorphological quality elements' shall be monitored at least once in a one-year surveillance monitoring period during the River Basin Management Plan cycle.

Sites will therefore be identified for continuous monitoring based to a large extent on the risk to the water body from significant hydromorphological pressure and where hydrological data coverage is poor. Lake monitoring is required only monthly, but daily level and outfall discharge data would be preferable as the main source of hydrological pressure in NI is concentrated in lake water bodies. Spot gauging and modelling data would support the hydrological needs for those monitoring sites not identified for continuous monitoring. Spot gauging would be carried out at a frequency based on climatic factors rather than at regular intervals as extreme weather conditions are important times for measurement to quickly define the flow duration curve at new sites.

6.3.3 Monitoring Network Design

The design of the monitoring network will be based on the existing network of gauging stations which monitor river flow and lake levels in Northern Ireland. The WFD requires

surveillance monitoring points where water flow is significant, including points where the catchment area is greater than 2500 km^2, where large lakes and reservoirs are present, where significant bodies of water cross a Member State boundary, and including those sites identified under the Information Exchange Decision and other sites required to estimate pollutant load.

The current river flow gauging network covers all primary river basins in NI, including level monitoring of the largest lakes, and will be used to supply the hydrological needs within this monitoring type. Additional lake level monitoring at sites identified as having a surface area greater than 0.5km^2 will be required as, historically, only Northern Ireland's largest lakes have been monitored for this parameter. For operational monitoring, there is clearly a need to monitor hydrology accurately in those areas that are identified as at risk from hydrological pressures and to ensure appropriate representation for 'at risk' sites of different typologies. This is required to validate the results of the original risk assessment and to monitor the effects of any programme of measures needed to achieve environmental objectives.

It is also important to monitor at sites in different types of water bodies found to be not at risk from hydrological pressures to provide an indication of the natural flow regime these river types can display. This is important because the degree of impact from hydrological pressure is determined by the deviation measured from what would be expected under natural conditions. Monitoring the flow from catchments of different physical types that are 'hydrologically natural' (artificial influences from abstractions or discharges are considered negligible) will therefore be important in the design of the network, as improving the accuracy and measurement of uncertainty when assessing risk from hydrological pressures and the accuracy of future flow estimation models are key areas of the hydrological strategy.

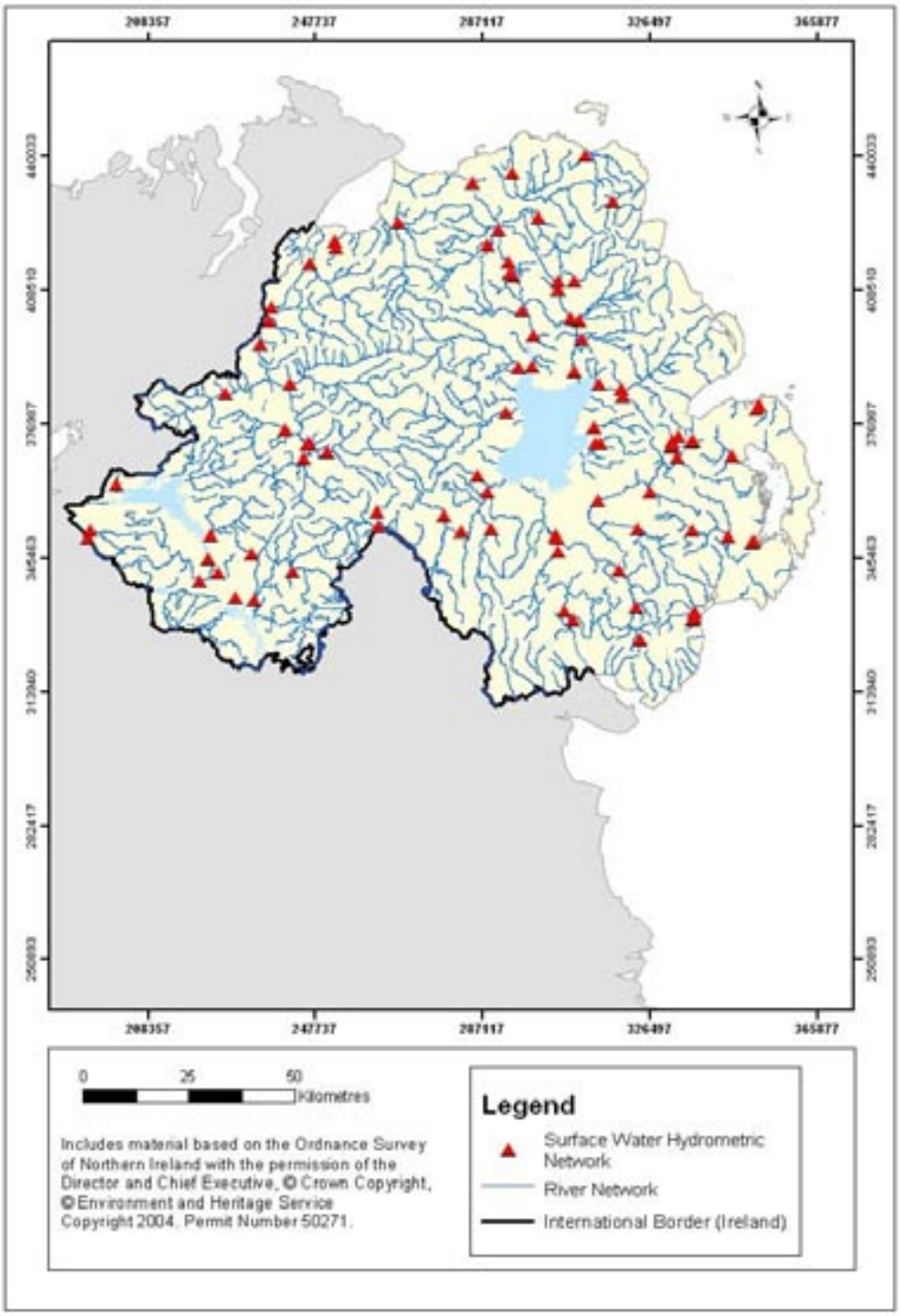
The design of the hydrological network will also consider important 'at risk' sites that are water-dependent (such as habitat and species protected areas), rivers or lakes that transfer pollutant load across a Member State's border or into the marine environment, and those areas considered necessary to cover geographical deficiencies in flow data. The use of spot gauging sites is considered important to provide further coverage where gaps are seen within existing and future gauged catchments and will form an integral part of the design. Data from these sites can be transferred with reasonable accuracy to provide the flow parameters needed for validation and assessment purposes

without the need for a continuous monitoring station.

6.3.4 Number and Distribution of Stations

The number and distribution of stations will depend on the identification of surveillance sites and operational sites requiring hydrological data within each River Basin District, and on the coverage of unimpacted sites of similar type and areas where catchments are ungauged. The current network (see Map 4) evolved to monitor the major river basins and larger sub-basins and provides an ideal base network for WFD purposes. Further proposed hydrological monitoring will be needed for smaller catchments in lowland and upland areas that represent the majority of catchment types in Northern Ireland. It will also be necessary to group water bodies for cost-effectiveness where water bodies of a similar risk and type can be found nested within a larger catchment. Given the small number of lake water bodies identified, it is proposed to monitor lake levels continuously at all sites that are not already monitored. Resources required to operate any proposed enhancement of the network will be a limiting factor in the number and distribution of stations established. The review of the existing network will have to consider the need to maintain historical sites where the quantity and dynamics of flow have been established, and further monitoring will need to be justified outside WFD requirements. It will be important for flow information from any proposed new stations to serve the needs of as many users as possible and to feed into future flow estimation models to improve the accuracy of existing models.

Map 4 Existing surface water hydrometric network



6.4. Data Storage and Reporting

All data collected will be held on EHS databases designed to allow reporting to Europe and general data interrogation. In addition to storage of analytical results, the database will hold details of each monitoring point, such as location, associated groundwater body and physical characteristics. Databases will be required to store both water level/flow data and water quality data. All databases will be compatible with GIS to facilitate display and analysis of data. Results of monitoring will be made available through reports and via the EHS website.

Sample collection and analysis will follow rigorous quality control and quality assurance procedures to ensure that data held on the database are valid and representative.

Appendix 1 Principal Monitoring Drivers

Drivers	Start	End	Data collected
EU Directives			
Birds Directive	1979	Ongoing	Biology and chemistry as appropriate
Bathing Waters Directive	1975	Ongoing	Chemistry, microbiology, water resources for abnormal weather
Dangerous Substances Directive	1976	2013	Chemistry
Dangerous Substances Daughter Directives	1976	2006	Chemistry
Freshwater Fish Directive	1978	2013	Chemistry, microbiology, biology
Groundwater Directive	1979	2013	Chemistry, water resources
Habitats Directive	1992	Ongoing	Biology and chemistry as appropriate
Integrated Pollution Prevention and Control	1999	Ongoing	Chemistry
Nitrates Directive	1991	Ongoing	Chemistry, biology
Shellfish Hygiene Directive	1991	Ongoing	Chemistry, microbiology
Shellfish Waters Directive	1979	2013	Chemistry, microbiology
Surface Waters for Drinking Directive	1975	2007	Chemistry, microbiology
Urban Waste Water Treatment Directive	1991	Ongoing	Chemistry, microbiology, biology
Water Framework Directive; and Daughter Directives: Groundwater Priority Substances	2003 2 years from agree-ment	Ongoing TBC TBC	All metrics included Chemistry and water quantity Chemistry
Other legislation and drivers			
Acid Waters	1988	Ongoing	Biology, chemistry
Biodiversity Strategies	-	Ongoing	Biology, chemistry as appropriate
Environmental Change Network (ECN)	1995	Ongoing	Biology, chemistry, water resources
Food and Environmental Protection Act	1985	Ongoing	Biology, chemistry
General Quality Assessment	1973	2006	Biology, chemistry
National Marine Monitoring Plans	-	2006	Biology, chemistry
OSPAR	1998	Ongoing	Chemistry, water resources for loadings, discharges
Silage, Slurry and Agricultural Fuel Oil Regs	2004	Ongoing	Biology, chemistry
Water Order	1999	Ongoing	Biology, chemistry, water resources for Q_{95}

Appendix 2 Directives to be Repealed

Title (commonly used)	Number	Repeal date
Surface Water Abstraction Directive	75/440/EEC	December 2007
Freshwater Fish Directive	78/659/EEC	December 2013
Shellfish Waters Directive	79/923/EEC	December 2013
Groundwater Directive	80/68/EEC	December 2013
Dangerous Substances Directive (except Article 6)	76/464/EEC	December 2013 (December 2000)

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Our aim is to protect and conserve the natural and built environment and to promote its appreciation for the benefit of present and future generations.

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