Ireland

Water Framework Directive Monitoring Programme

Prepared to meet the requirements of the EU Water Framework Directive (2000/60/EC) and National Regulations implementing the Water Framework Directive (S.I. No. 722 of 2003) and National Regulations implementing the Nitrates Directive (S.I. No. 788 of 2005)

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PART I - OVERVIEW OF PROGRAMMES

Glossary of Terms and Abbreviations

Glossary	
Abstraction	The deliberate removal of water from a water body, either surface or groundwater.
Aquifer	water-bearing sand, gravel or rock layer yielding usable water quantities
AWB	Artificial water Body (pAWB indicates provisional AWB)
Benthic Invertebrate Fauna	Invertebrate animals living at least for part of their lifecycles on or in the benthic substrates of rivers, lakes, transitional waters or coastal waters
Coastal waters	Coastal water means surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters.
CSO Point Source	Combined Storm Overflow from a sewer system
Diffuse Pollution	Pollution which originates from various activities, and which cannot be traced to a single source and originates from a spatially extensive land use (e.g. agriculture, settlements, transport, industry).
Discharge	The release of polluting substances from individual or diffuse sources in the installation through effluent directly or indirectly into water bodies as defined under Article 2 (1) of Directive 2000/60/EC.
Eco-region	The geographical areas illustrated in Annex XI of the WFD Maps A (rivers and lakes) and B (transitional waters and coastal waters).
Ecosystem	System in which, by the interaction between the different organisms present and their environment, there is a cyclic interchange of materials and energy, (UN).
EPA	Environmental Protection Agency
Groundwater	Groundwater means all water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil.
HMWB	Heavily Modified Water Body (pHMWB indicates provisional HMWB)
Hydromorphology	The physical characteristics of the shape, the boundaries and the content of a water body. The hydromorphological quality elements for classification of ecological status are listed in Annex V.1.1 and are further defined in Annex V.1.2 of the WFD.
Intercalibration	An exercise facilitated by the Commission to ensure that the high/good and good/moderate class boundaries are consistent with

	the normative definitions in Annex V Section 1.2 of the Directive and are comparable between Member States (see guidance produced by WG 2.5) (Annex V 1.4. (iv)).
IPPC	Integrated Pollution Prevention & Control (Protection of the Environment Act)
Lake	Lake means a body of standing inland surface water.
Macrophyte	Larger plants of fresh water which are easily seen with the naked eye, including all aquatic vascular plants, bryophytes, stoneworts (Characeae) and macro-algal growths.
OSPAR	Commission for the Protection of the Marine Environment of the NE Atlantic
Parameter	Parameters indicative of the quality elements listed in Annex V, Table 1.1 in the Directive that will be used in monitoring and classification of ecological status. Examples on parameters relevant for the biological quality element composition and abundance of benthic invertebrate fauna are: number of species or groups of species, presence of sensitive species or groups of species and proportion of tolerant/intolerant species.
Phytobenthos	All phototrophic algae and cyanobacteria that live on or attached to substrata or other organisms, rather than suspended in the water column.
Phytoplankton	Unicellular algae and cyanobacteria, both solitary and colonial, that live, at least for part of their lifecycle, in the water column of surface water bodies.
Point source pollution	Pollution arising from a discrete source , e.g. the discharge from a sewage treatment works.
POM	Programme of Measures
Q values	Irish EPA index of water quality based on aquatic communities
Quality Element	Annex V, Table 1.1 in the Directive, explicitly defines the quality elements that must be used for the assessment of ecological status (e.g. composition and abundance of benthic invertebrate fauna). Quality elements include biological elements and elements supporting the biological elements. These supporting elements are in two categories: 'hydromorphological' and 'chemical and physicochemical'.
Quantitative status	Expression of the degree to which a body of groundwater is affected by direct and indirect abstraction cf. Art 2(28) of the WFD 'good quantitative status'.
RBMP	River Basin Management Plan
Reference conditions	For any surface water body type reference conditions or high ecological status is a state in the present or in the past where there are no, or only very minor, changes to the values of the hydromorphological, physico-chemical, and biological quality

	elements which would be found in the absence of anthropogenic disturbance. Reference conditions should be represented by values of the biological quality elements in calculation of ecological quality ratios and the subsequent classification of ecological status.
River	River means a body of inland water flowing for the most part on the surface of the land but which may flow underground for part of its course
River Basin District (RBD)	A River Basin District includes coastal/marine waters up to one nautical mile beyond the baseline from which territorial waters are measured. It is an area of land and sea made up of one or more neighboring river basins together with their associated groundwater, and coastal waters
Significant pressure	In the context of the WFD, a pressure that, on its own, or in combination with other pressures, would be liable to cause a failure to achieve the environmental objectives set out under Article 4.
Transitional	Transitional waters are bodies of surface water in the vicinity of river mouths which are partly saline in character as a result of their proximity to coastal waters but which are substantially influenced by freshwater flows.
Water body	the basic compliance reporting and management unit for the Water Framework Directive into which all rivers, lakes, ground, transitional and coastal waters are divided
WFD	Water Framework Directive - Directive 2000/60/EC establishing a framework for Community action in the field of water
WTP	Water Treatment Plant
WWTP	Waste Water Treatment Plant

SUMMARY

Background

The Water Framework Directive (WFD), Directive 2000/60/EC, was adopted in 2000 as a single piece of legislation covering rivers, lakes, groundwater and transitional (estuarine) and coastal waters. Its objectives include the attainment of good status in water bodies that are of lesser status at present and retaining good status or better where such status exists at present. There are provisions also for artificial water bodies such as canals. The Directive requires integrated management and planning based on River Basin Districts (RBDs), which consist of river catchments or groups of catchments. Article 8 (1) of the Directive states "Member States shall ensure the establishment of programmes for the monitoring of water status in order to establish a coherent and comprehensive overview of water status within each river basin district".

Ireland's national regulations implementing the Directive are the European Communities (Water Policy) Regulations 2003 (S.I. No. 722 of 2003). Article 10 (1) of these regulations states that the Environmental Protection Agency (EPA) shall prepare a programme of monitoring of water status in order to provide a coherent and comprehensive overview of water status within each of the seven river basin district in the State in accordance with Articles 7(1) and 8 of the Directive. The EPA shall specify the public authority or authorities by whom the monitoring is to be carried out.

A brief summary is given herein of the national WFD monitoring programme, the development of which involved consultations with the River Basin Districts through their lead local authorities, with local authorities in general, with the relevant State bodies and with others. The programme is set out in detail in the report.

The programme lists the specified authorities to implement the monitoring programme and there is a statutory obligation on the nominated authorities to execute the monitoring assigned to them. The principal rationale determining the assignment of a particular monitoring responsibility to a Public Authority was the established expertise, competency and capacity of the particular Public Authority to perform the task. For the majority of the biological, hydromorphological and physico-chemical parameters, the assigned Public Authorities have been involved in the assessment of these parameters for several decades.

Due to a lack of existing capacity and expertise within the Public Authorities in Ireland, a small amount of the biology and hydromorphology as well as a significant amount of the chemical monitoring may need to be outsourced, at least for an initial period. For practical purposes it is desirable that the outsourcing be as centralised as possible. With this in mind it is proposed that the EPA arrange and manage the outsourcing in freshwaters and the Marine Institute the outsourcing of samples from transitional and coastal waters.

The structure and content of the monitoring programme represents the outcome of a major research and development process involving various sub-groups under the auspices of the National Technical Co-ordination Group for the WFD and the outcome of the consultation process referred to above.

As required by the Regulations, the programme sets out the 'nature, frequency and extent' of the monitoring to be implemented, to be operational 22 December 2006. While the development of the programme has considered monitoring requirements at water body level, the listings of stations as set out in the report on the proposed programme are indicative, and will be subject to amendment periodically based on experience and on new developments, while keeping to the overall nature, frequency and extent of the programme as set out in this report.

Overall Objectives of the Monitoring Programme

The over-riding objective of the monitoring programme is to achieve the objectives of the WFD – i.e. achievement of 'Good Status' generally and to retain 'High' and 'Good Status' where such already exists. Towards this end, the programme:

- covers groundwater and surface waters: rivers, lakes, coastal and transitional waters;
- includes special sub-programmes for the protected areas included in the Register of Protected Areas as defined in Article 6 of the WFD;
- includes artificial and heavily modified water bodies and these, apart from canals monitoring programme, are monitored within the appropriate main monitoring programmes (rivers, lakes or transitional and coastal waters).

The present programme is not intended as an all-embracing monitoring programme for the aquatic environment. It does, however, specify all surface and groundwater monitoring activities required for the purposes of the WFD. For general monitoring this document and associated programme will also replace existing national programmes, for example, the National Rivers and Lakes Monitoring Programmes. While many of the existing legislative requirements are incorporated into the WFD monitoring programmes, some monitoring in relation to other specific directives existing arrangements should continue as appropriate (for example monitoring requirements under Drinking Water Regulations and Bathing Water Regulations). Article 22 of the WFD provides for repeals and transitional provisions for specific directives. The monitoring requirements for these, plus elements of other existing programme are expected to be superseded by later phases of the WFD monitoring programme.

The Three Types of Monitoring

Three types of monitoring are specified and described in the Directive and Common Implementation Strategy (CIS) guidance documents:

- Surveillance Monitoring
- Operational Monitoring
- Investigative Monitoring

The specific objectives and requirements of each type of monitoring are described and an outline is presented of the individual monitoring programmes for rivers, lakes,

transitional and coastal waters, groundwater, and canals. Monitoring for surface waters is more detailed than for groundwater because of the requirement to assess biological and hydro-morphological elements in the former to allow for the assignation of ecological status.

Surveillance Monitoring of Surface Waters

The objectives of Surveillance Monitoring are:

- supplementing and validating the impact assessment procedure detailed in Annex II of the Directive,
- the efficient and effective design of future monitoring programmes,
- the assessment of long-term changes in natural conditions, and
- the assessment of long-term changes resulting from widespread anthropogenic activity.

The selection of sampling points and the design of the Irish Monitoring Programme network is based on key sub-networks ('subnets') each designed to fulfil one or more of the main objectives of Surveillance Monitoring. The subnets of the Surveillance Monitoring Programme for surface waters that are common to the programmes for rivers, lakes and transitional and coastal waters include the following and are set out in Table S.1

Table S.1. Summary of Surveillance Monitoring subnets common to all surface water categories.

Subnet Name	Aim of Subnet
SM Subnet 1	This subnet is designed to be representative of the overall surface water status as per the WFD stated requirement: surface water bodies to provide an assessment of the overall surface water status within each catchment or subcatchments within the River Basin District
SM Subnet 2	Detection of long-term trends as per WFD requirement – the assessment of long-term changes in natural conditions, and the assessment of long-term changes resulting from widespread anthropogenic activity.
SM Subnet 3	Supplementing and validating risk assessments particularly at those sites where the degree of uncertainty is greatest as per WFD requirement: supplementing and validating the impact assessment procedure detailed in Annex II.
SM Subnet 4	Water bodies that are stipulated in the text of the WFD: • the rate of water flow is significant within the river basin district as a whole; including points on large rivers where the catchment area is greater than 2500 km^2, • the volume of water present is significant within the river basin district, including large lakes and reservoirs,

Subnet Name	Aim of Subnet
	• significant bodies of water cross a Member State boundary, • sites are identified under the Information Exchange Decision 77/795/EEC, • at such other sites as are required to estimate the pollutant load which is transferred across Member State boundaries, and which is transferred into the marine environment.

Quality Elements.

Surveillance Monitoring shall be carried out at 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 general physico-chemical quality elements,
- priority list pollutants which are discharged into the river basin or sub-basin, and
- other pollutants discharged in significant quantities in the river basin or sub-basin

Operational Monitoring of Surface Waters

The Operational Monitoring Programme is focussed on supporting measures aimed at achieving the objectives of the WFD. It is designed to provide targeted information on the efficacy of specific measures within catchments. The success of the WFD depends crucially on the implementation of the most appropriate programmes of measures (POM) in the RBDs.

The objectives of Operational Monitoring are to:

- establish the status of those bodies identified as being at risk of failing to meet their environmental objectives.
- assess any changes in the status of such bodies resulting from the programmes of measures.

Because the protection of high and good status from deterioration is required by the WFD, Operational Monitoring must also provide information on whether the POMs, aimed at maintaining such status, are effective. Thus, even waterbodies not be deemed to be at risk in the Characterisation Report prepared under Article 5 of the WFD are included in the Operational Monitoring programme because measures are required to maintain them at their current high or good status regardless of existing

risk category. These latter will be monitored primarily using biological quality elements.

Sampling points for Operational Monitoring are assigned to one or more sub-networks ('subnets') each designed to fulfil one or more of the main objectives of Operational Monitoring. The subnets that are common to the programmes for rivers and lakes are set out in Table S.2. In the case of Transitional and Coastal Waters Subnets 1 and 2 are combined into single subnet.

Table S.2 Summary of Operational Monitoring subnets common to all surface water categories.

Subnet Name	Aim of Subnet
OM Subnet 1	Monitoring to assess whether the measures aimed at improving the impact of individual and combined point sources are successful. This includes assessment of ambient levels of organic pollution, eutrophication impacts and priority substances.
OM Subnet 2	To assess effectiveness of diffuse pollution control measures
OM Subnet 3	To assess effectiveness of measures to reduce hydromorphological pressures and impacts
OM Subnet 4	To monitor high and good status sites currently not deemed to be at risk in order to assess the effectiveness of POMs aimed at maintaining high and good status sites.
OM Subnet 5	To monitor Species and Habitat Protected Areas that are at risk

Quality Elements.

In order to assess the magnitude of the pressure to which bodies of surface water are subject Member States shall monitor for those quality elements that are indicative of the pressures to which the body or bodies are subject. In order to assess the impact of these pressures, Member States shall monitor as relevant:

- parameters indicative of the biological quality element, or elements, most sensitive to the pressures to which the water bodies are subject,
- all priority substances discharged, and other pollutants discharged in significant quantities into the river basin or sub basin.
- parameters indicative of the hydromorphological quality element most sensitive to the pressure identified.

Investigative Monitoring of Surface water

The WFD includes a third type of monitoring called Investigative Monitoring. The approach to Investigative Monitoring proposed in this programme is a radical departure from traditional monitoring practice and it is believed that it will be the key

to achieving the over-riding WFD goal of Good Status in Irish water bodies. The WFD states that this type of monitoring is required for situations:

- "where the reason for any exceedances is unknown;
- where surveillance monitoring indicates that the objectives set under 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;
- and shall inform the establishment of a programme of measures for the achievement of the environmental objectives and specific measures necessary to remedy the effects of accidental pollution."

The Investigative Monitoring Programme contains screening and risk assessment methods that will assist in focussing POMs and in pinpointing pollution sources to more accurately positioning primary monitoring sites for the definition of status.

Investigative subnets include rolling programmes of physico-chemical and biological assessment for waterbodies not covered by the main OM and SM programmes in order to pinpoint sources of pollution that are not well-defined or characterised. This type of snapshot investigative monitoring will be used especially where a main channel river monitoring location is found to be of less than good status and the reason is not immediately obvious. Electronic alert networks are also included in the Investigative Monitoring programme to provide improved temporal and spatial understanding of pollution events and sources within catchments. Similarly, remote sensing will be used in an investigative manner in order to provide improved geographical knowledge of pollution sources and pathways. Aerial photography required for hydromorphological purposes will also be useful for general investigative monitoring purposes.

Frequency of Monitoring

Sample frequency will vary depending on the monitoring programme, the individual subnets of the programme and also on the quality element being assessed. All subnets of the OM and IM Programmes will be required to achieve at least the minimum frequencies required by the WFD for the relevant quality element. The programme sets out minimum requirements for quality elements within each subnet. While the minimum frequencies will be met for all subnets it should be noted that some subnets require more intensive monitoring. Sites in the long-term trend monitoring subnets, for example, will typically require higher frequency sampling than those in the subnet for "supplementing and validating the risk assessment". Monitoring for sites included in the Freshwater Fish Directive monitoring will also require more frequent monitoring as will flux sites measuring inputs of nutrients to lakes.

The frequency of monitoring determines the confidence and precision of the results obtained particularly in the physico-chemical monitoring programmes. Estimates of the confidence and precision likely to be attained by the monitoring programme for individual quality elements are provided in Chapter 4 based on the historically known

statistical variance for individual determinands in rivers and lakes. Estimating the confidence and precision of biological assessments is also dealt with in Chapter 4.

Rivers Monitoring Programmes

The surveillance and operational monitoring network for rivers is designed to represent the range of types and status across all river basin districts (RBDs). Table S.3 gives the breakdown of sites in the SM and OM programmes. More detail is provided in Chapter 7.

Table S.3 Proportional breakdown of river monitoring locations in the SM and OM Programmes by RBD.

RBD	% SM Rivers	% OM Rivers
ERBD	9	19
NBIRBD	2	3
NWIRBD	12	6
SERBD	18	26
SHIRBD	25	19
SWRBD	16	10
WRBD	18	17

Within the surveillance network there are sites specified by the Water Framework Directive (WFD) supplemented by nationally selected networks including programmes for protected areas, long term trend reporting and other WFD cross referencing programmes. The number of SM sites in each subnet is shown in Table S.4.

Table S.4. Breakdown of sites within SM network.

Rivers Surveillance Monitoring Subnet	Number
1 Representative	188
2 Long-term trend monitoring	30
3 Supplementing and validating risk assessment	6% of 1a and 1b risk assessment sites
4 Stipulated Rivers	43

The network for Operational Monitoring targets particular activities identified and prioritised by WFD Article 5 pressures and impact assessments (Table S.5). The networks are activity driven rather than geographically distributed and consequently the sites are more concentrated in some river basin districts than in others.

Table S.5 Breakdown of OM sites by subnet

River Operational Monitoring Subnet	Percent of OM Network Sites
1 Effectiveness of point Source measures	50%
2 Effectiveness of diffuse Pollution measures	55%
3 Effectiveness of measures to reduce Hydromorphological Pressures	10%
4 Effectiveness of measures aimed at retaining high and good status	35%
5 Species and habitats protection areas	10%

The criteria along with the degree of risk and expert knowledge of the point source network were used to select the individual point source discharge sites to be monitored are shown in Table S.6.

Table S.6. Proportion of individual point sources to be included in OM Programme for rivers.

Activity	Target Coverage % of Sources
Wastewater Treatment Plants & IPPC Licensed Industries	75-100%
Local Authority Licensed Industries	50%
Combined Storm Overflows	30%
Mines, Quarries & Landfills	25%
Water Treatment Plants	20%

The operational network designed to represent diffuse source pressures was also driven by the Article 5 risk assessment analyses. A formal aggregation process was followed to ensure that the monitoring sites selected were as representative as possible for particular pressures or combination of pressures. Sites were identified to assess the effectiveness of measures aimed at pressures such as agriculture, urbanisation, forestry and rural populations pressures. Where possible the sites were selected downstream of areas predominantly affected by only one type of activity. The extent and degree of risk coupled with expert knowledge of the diffuse pressures and basin districts were used to select the individual diffuse source sites to be monitored within the operational programme. In many cases operational sites will be supplemented by investigative monitoring to assist in separating the effects of mixed pressures where they exist or may possibly exist and to ensure that the

monitoring results do in fact represent the pressures being assessed and the effectiveness or otherwise of the measures being implemented to either restore waters to Good status or to retain High or Good status where it currently exists.

Lakes Monitoring Programmes

In excess of 12,000 lakes have been identified in Ireland; however, the great majority of these are very small (<1 ha). The criteria developed for the inclusion of lakes in the WFD implementation process resulted in the selection of 745 lakes that were included in the river basin characterisation and risk assessment procedures reported in the Article 5 characterisation report. The WFD monitoring programme (surveillance and operational) networks is based on these 745 lakes.

Table S.7 The selection of lakes according to RBD is set out below.

RBD	All lakes	Article 5 lakes	SM Lakes	SM Lakes as % of Article 5 lakes	OM Lakes	OM Lakes as % of Article 5 lakes
ERBD	552	26	5	19	14	54
NBIRBD	364	1	1	100	0	
NWIRBD	1888	181	17	9	60	33
SERBD	1027	12	0	0	6	50
SHIRBD	1689	113	18	16	47	42
SWRBD	1057	90	7	8	30	33
WRBD	5629	322	25	8	65	20
Total	12206	745	73		222	

Table S.8 The selection of lakes for Surveillance Monitoring according to risk assessed for the purpose of the Article 5 characterisation report is as follows:

Risk category	Article 5 lakes	SM Lakes	Percentage
Waterbodies at Significant Risk	133	25	19
Waterbodies probably at Significant Risk	147	17	12
Waterbodies probably not at Significant Risk	99	9	9
Waterbodies not at Risk	366	22	6
Total	745	73	

Table S.9 The selection of Surveillance Monitoring lakes according to the lake subnets

Lake Surveillance Monitoring Subnet	Number
1 Representative	73
2 Long-term trend monitoring	24
3 Supplementing and validating risk assessment	73
4 Stipulated lakes	54
5 Protected Areas	21 water abstraction 57 Protection of habitats and species (Protected areas total = 61

Table S.10 The selection of Operational Monitoring lakes according to the lake subnets

Lake Operational Monitoring Subnet	Number
1 Effectiveness of point Source measures	42
2 Effectiveness of diffuse Pollution measures	72
3 Effectiveness of measures to reduce Hydromorphological Pressures	123
4 Effectiveness of measures aimed at retaining high and good status	23
5 Species and habitats protection areas	182

Transitional Coastal Waters Monitoring Programmes

In total, 309 water bodies were considered for inclusion in the national Coastal and Transitional Waters monitoring programme. These water bodies were identified as a consequence of a typology project that was concluded in 2003. A subset of the waterbodies was selected on the basis of the risk assessment procedure whereby significant pressures were identified in tandem with a series of subnets describing specific conditions warranting monitoring.

Table S.11 Number of Waterbodies assigned to each monitoring category

	Surveillance	Operational
Transitional Waters	26	56
Coastal Waters	12	23

For Surveillance monitoring four subnets were identified while operational monitoring would be carried out in sites fitting into six subnet categories.

Table S.12 The selection of Surveillance Monitoring Coastal and transitional waters according to the subnets

Surveillance Monitoring Subnet	Coastal Waters	Transitional
1 Representative	12	26
2 Long-term trend monitoring	12	26
3 Supplementing and validating risk assessment	12	26
4 Stipulated sites	2	11

Table S.13 The selection of Surveillance Monitoring Coastal and transitional waters according to the six subnets

Surveillance Monitoring Subnet	Coastal Waters	Transitional
1 Status of at-risk WB	13	48
2 Diffuse and point source	5	39
3 Hydromorphology	10	32
4 Measures – good/high	10	8
6 Protected Areas	12	47

Note: there is considerable overlap in the number of sites assigned to each subnet.

Groundwater Monitoring Programme

A conceptual understanding of the hydrogeology and pressures on groundwater formed the basis for calculating the number of monitoring points in the groundwater monitoring programme to confidently meet the objectives of the WFD. Groundwater bodies with similar hydrogeology and pressures were grouped into nine bedrock unit groups and a single gravel aquifer group. These groups were sub-divided based on aquifer type and risk category as set out in the Characterisation Report and networks representative of the hydrogeology and pressures were designed.

Table S.14 Summary of Proposed Groundwater Monitoring Programme

Monitoring Network	Subnet	Number of Monitoring points
Qualitative		
Surveillance	Productive Aquifers	240
	GW-SW Interactions	15
Operational	Diffuse	145
	Point Source	50
	Urban Pressures	36
GW Dependent Ecosystems	At Risk	84
	Not At Risk	42
Quantitative		
	Productive Aquifers	190
	Poorly Productive Aquifers	70

Further characterisation studies are being carried out to determine appropriate monitoring sites for point sources and urban areas. These further characterisation studies will dictate which urban areas will be monitored and appropriate monitoring locations associated with discharge from licensed and unlicensed activities. As this conceptual understanding improves, the monitoring network will be reviewed.

Quality Control and Quality assurance

QA/QC issues are regarded as an integral aspect of the monitoring programme with individual laboratories, for example, required to meet national and international standards. A quality control and quality assurance scheme will be prepared in advance of the commencement of the monitoring programme.

Precision and Confidence of monitoring programmes

Sampling frequencies of 4, 6 and 12 times per year will be used for physico-chemical parameters in the monitoring programme. Tables have been prepared that will enable the confidence and precision for particular physico-chemical parameters to be estimated. In the case of those biological parameters considered in the WFD intercalibration exercises an indication of the confidence in the status classifications is provided. However, the development of many of the biological classification systems is still incomplete and so it is not possible to provide information on their precision. The EU WFD Working Group ECOSTAT will also be dealing with issues of confidence and precision in ecological assessments.

Data Management

To allow the rapid reporting and publication of results, a water data management system will be required to handle the increased data outputs resulting from the WFD and national monitoring programmes. An Environmental Data Exchange Network is being developed by the EPA that will form the basis for the data management system and allow individual agencies to exchange environmental data. This network will provide the framework for GIS based online reporting of the WFD monitoring programme results to the EC Water Information System for Europe (EU WISE).

Roles and Responsibilities

The monitoring programme lists the public authority or authorities to whom the statutory obligation to perform the various elements of the monitoring activity, including the outsourcing, has been assigned.

PART I OVERVIEW OF PROGRAMMES

Chapter 1 Introduction to Monitoring Programmes

1.1 Background

The Water Framework Directive (WFD), Directive 2000/60/EC, was adopted in 2000 as a single piece of legislation covering rivers, lakes, groundwater and transitional (estuarine) and coastal waters. Its objectives include the attainment of good status in water bodies that are of lesser status at present and retaining good status or better where such status exists at present. There are provisions also for artificial water bodies such as canals. The Directive requires integrated management and planning based on River Basin Districts (RBDs), which consist of river catchments or groups of catchments. Article 8 (1) of the Directive states "Member States shall ensure the establishment of programmes for the monitoring of water status in order to establish a coherent and comprehensive overview of water status within each river basin district".

The structure and content of the monitoring programme represents the outcome of a major research and development process involving various sub-groups under the auspices of the National Technical Co-ordination Group for the WFD. The programme includes amendments on the foot of notice from the Minister for the Environment, Heritage and Local Government made on 22 September 2006.

As required by the Regulations, the programme sets out the 'nature, frequency and extent' of the monitoring to be implemented, to be operational 22 December 2006,. While the development of the programme has considered monitoring requirements at water body level, the listings of sampling points in the proposed programme are indicative, and will be subject to amendment periodically based on experience and on new developments, while keeping to the overall nature, frequency and extent of the programme as set out in this report.

1.2 General Scope of the Programme

The intended aim of this monitoring programme is to specify all surface and groundwater monitoring activities required for the purposes of the WFD. For general monitoring this document and associated programme will replace existing national programmes, for example, the National Rivers Monitoring Programme published by the EPA in 2002 and similarly the national lakes monitoring programme. For monitoring in relation to other specific directives existing arrangements should continue as appropriate. Article 22 of the WFD provides for repeals and transitional provisions for specific directives. These requirements plus elements of the existing hydrometric, coastal and estuarine programmes will eventually be superseded by the WFD monitoring programme.

The WFD aims for monitoring are all-encompassing in the sense that all ambient surface water and ground-water monitoring and characterisation activity must relate to the achievement of the WFD objectives and must support ongoing programmes of measures aimed at maintaining or improving water quality. Thus, the monitoring

needed to satisfy the requirements of existing national and international legislation such as the Phosphorus Regulations, Dangerous Substances Directive, Freshwater Fish Directive and others will be included within the overall framework of this monitoring programme even though this may not be explicitly required by the text of the Directive itself.

The WFD requires the establishment of two primary monitoring programmes: the Surveillance Monitoring (SM) and Operational Monitoring (OM) networks. In the case of groundwater monitoring a separate quantitative monitoring programme is also required. The role of Investigative Monitoring is also outlined as appropriate within Part II addressing each water category.

The monitoring programme, set out in this document, will be modified as further data become available. At all times the most up to date version of all the monitoring networks will be available online. The EPA will co-ordinate all additions, removals or other changes found to be necessary by public authorities in the course of the day-to-day operation of the monitoring programme. It is essential that all changes made by public authorities involved in the monitoring programme are notified to the EPA and discussed in advance to ensure that essential elements of the monitoring programme are not compromised, especially where national WFD reporting obligations to Europe are concerned. This applies particularly to Surveillance and Operational Monitoring programmes while the location of investigative monitoring sites is essentially a local matter.

1.3 Structure of Programme

This document comprises 3 parts, which are listed in Table 1.1 below. Part I is the main report and provides an overview of the WFD monitoring programme for all water categories. Part II provides a detailed breakdown of the monitoring programme for each water category. Part II also includes URL links to files detailing the sampling sites in the rivers, lakes, transitional and coastal waters and groundwater monitoring programme. Part III summarises the links to the dynamic electronic appendices to the monitoring programme and instructions for those interested in obtaining updates of the programme.

Table 1.1 Structure of report

Part of Programme	Description
Part I	Main Report and Summary
Part II	River Monitoring Programme
	Lakes Monitoring Programme
	Transitional and Coastal Waters Monitoring Programme
	Groundwater Monitoring Programme
	Canals Monitoring Programme
Part III	Links to Electronic Appendices

1.4 Linkages between Programmes of Measures and Monitoring

Past experience has shown that there is a danger that monitoring programmes may be undertaken somewhat independently of pollution control measures or other programmes of measures and become an end in themselves. The specific WFD objectives of maintaining the status of existing high and good status water bodies and of restoring those waterbodies that are of less than good status to at least good status are extremely demanding objectives. They imply that a highly targeted and efficient programme of measures (WFD Article 11) is required. The monitoring programme described here is designed to support the programme of measures in a number of distinct ways:

- Providing status information and ongoing impact assessments;
- Providing a means of assessing the effectiveness of Programmes of Measures (POMs) aimed at reducing the impact of, for example, individual point sources;
- Providing data to ensure that measures in place to protect existing high and good status water bodies are effective;
- Providing data to ensure that POMs are accurately targeted particularly in cases of diffuse pollution where the precise source may not be immediately obvious (e.g. as per Article 11 (3)(h)) and;
- Alerting River Basin Districts to new or emerging threats to water status which do not currently have measures in place.

Thus, the monitoring programme described in this document takes account of the need for integration of monitoring with programmes of measures, impact assessment, and ongoing further characterisation. WFD Article 11 (5) clearly requires tight linkages between monitoring and programmes of measures with ongoing revision in response to monitoring and other data in order to achieve the objectives of Article 4 of the WFD. Annex II (1.5) also specifically requires further characterisation to optimise the design of both the monitoring programmes required under Article 8, and the programmes of measures required under Article 11. The monitoring programme is regarded as being central to the achievement of the objectives of the WFD throughout this document.

1.5 Development of a WFD compliant monitoring programme

The programme outlined here is designed to meet the stated requirements of the WFD and CIS Guidance Documents in all cases. The monitoring programmes build on significant experience gained from the long-term monitoring programmes undertaken since the early 1970s up to the present. In order to improve links between Article 7 and Article 8 monitoring and Article 11 programmes of measures and ensure that the monitoring programme is effective in supporting measures and not just a separate entity or an end in itself, a number of innovative approaches are included in the programme.

There is an emphasis on ongoing investigative screening and risk assessment within small sub-catchments of river water bodies in particular in order to pinpoint sources of pollution with a high degree of accuracy. Screening and direct risk assessments will include the use of rapid biological and physico-chemical methods such as snapshot surveys of catchments during wet weather episodes or summer low flow periods.

The use of aerial photography will assist in pinpointing pollution sources and in particular hydromorphological problems within catchments. The use of continuous electronic monitoring networks to provide improved temporal resolution not possible using traditional grab-sampling along a fixed-point network of sampling points is also seen as an essential part of the network in the longer term. The inclusion of such optional screening and risk assessment subnets will help to improve the effectiveness of the operational monitoring programme in particular by providing a much-improved spatial and temporal understanding of catchment processes.

The programme also emphasises the importance of integrating the 'end-of-pipe' compliance monitoring with the monitoring of water bodies in order to compare observed and expected impact by direct comparison and use of models. This additional information will also help to ensure that the primary monitoring points are optimally located. The interpretation of the status classifications from the primary monitoring networks will also be greatly assisted by the additional spatial and temporal risk data. As a result the effectiveness of the overall monitoring programme will be enhanced significantly beyond what is possible using fixed-point monitoring alone.

Monitoring programmes for water bodies or sections of water bodies located in Northern Ireland are dealt with in a separate monitoring programme to be submitted by the UK for Northern Ireland. Monitoring programmes are, however, closely co-ordinated in the three cross-border international RBDs through the INTERREG IIIA funded NS-SHARE project and the coordinated activities of Agencies in each jurisdiction.

1.6 Reporting and Data Management

Timely reporting of monitoring results is seen as a key element in the achievement of the aims of the WFD. The direct linking of monitoring results to specific measures within catchments will help to provide ongoing feedback concerning the effectiveness or otherwise of the measures. Rapid online publication of results from the monitoring programmes is seen as a key target and data handling models to support this are required as part of the monitoring programme. Effective data management will be a critical part of the monitoring programme both to meet formal reporting requirements to the European Commission and to ensure that monitoring information is acted upon during the river basin management cycle in a timely manner.

1.7 Assignment of tasks for the implementation of the Water Framework Directive Monitoring Programme

1.7.1 Background

Article 10 (2) (b) of the European Communities (Water Policy) Regulations 2003 (S.I. No. 722 of 2003) states that the Environmental Protection Agency (EPA) shall "specify the public authority or authorities by whom the monitoring is to be carried out" not later than 22 June 2006.

The Agencies being assigned responsibility for the various aspects of the monitoring programme are, with the exception of those for groundwater dependent ecosystems, set out in Tables 1.2 and 1.3. There will be a statutory obligation on the nominated authorities to execute the monitoring assigned to them by the EPA.

The elements listed are those set out in the Water Framework Directive and listed also in the CIS Monitoring Guidance Document.

1.7.2 Assignments

The rationale determining the assignment of a particular monitoring responsibility to a Public Authority, with the exception of the chemical monitoring, was the established expertise, competency and capacity of the particular Public Authority to perform the task. For the majority of the biological, hydromorphological and physico-chemical parameters, the assigned Public Authorities have been involved in the assessment of these parameters for several decades.

The Local Authorities have been assigned the task of carrying out the physico-chemical monitoring of rivers and lakes for operational monitoring. In instances where more than one Public Authority is currently engaged in such monitoring work the relevant Local Authority should liaise with the other Public Authorities involved to ensure that the monitoring is performed in the most efficient manner.

Table 1.2 List of Public Authorities assigned monitoring tasks in the freshwater component of the WFD monitoring programme.

	Phyto-plankton	Macro-phytes	Benthic Algae	Macro-invertebrates	Fish	Hydro-morphology	Physico-Chemical	Relevant Pollutants	Priority Substances
Rivers	**N.A.**	**EPA**	**EPA**	**EPA**	**CFB**	**EPA/OPW/LA**	**LA/EPA**	**EPA**	**EPA**
Lakes	**EPA**	**EPA**	**EPA**	**EPA**	**CFB**	**EPA/OPW/LA**	**LA/EPA**	**EPA**	**EPA**
Groundwater*						**EPA/OPW/LA**	**EPA**	**EPA**	**EPA**
Canals		**WI**		**WI/EPA**	**WI**	**EPA/WI**	**WI**		
Processing data	**EPA**	**EPA**	**EPA**	**EPA**	**CFB**	**EPA/OPW**	**EPA**	**EPA**	**EPA**
Reporting	EPA								

NA = not applicable

* Ecological information for GWDTE will be provided by NPWS

Table 1.3 List of Public Authorities assigned monitoring tasks in the estuarine/coastal component of the WFD monitoring programme.

	Phyto-plankton	Macro-algae	Angio-sperms	Benthic invertebrates	Fish	Hydro-morphology	Physico-Chemical	Relevant Pollutants	Priority Substances
Transitional	**EPA**	**EPA**	**EPA**	**MI**	**CFB**	**EPA/OPW/MI**	**MI/EPA/LA**	**MI**	**MI**
Processing data	**EPA**	**EPA**	**EPA**	**MI**	**CFB**	**EPA**	**MI**	**MI**	**MI**
Reporting	**EPA**								
Coastal	**MI**	**EPA**	**NPWS**	**MI**	**N.A.**	**EPA/OPW/MI**	**MI**	**MI**	**MI**
Processing data	**MI**	**EPA**	**NPWS**	**MI**	**N.A**	**EPA/OPW**	**MI**	**MI**	**MI**
Reporting	**EPA**								

N.A = not applicable

In the case of the monitoring for relevant pollutants (Annex VIII (1-9)) and priority substances (Annex X) the EPA and Marine Institute have been assigned the responsibility. Both the EPA and Marine Institute have limited capacity in this area, but may be able to perform some of the monitoring. It is anticipated that most, if not all, of the work will have to be outsourced at least initially.

1.7.3 Outsourcing

Due to a lack of existing capacity and expertise within the Public Authorities in Ireland, a small amount of the biology and hydromorphology as well as a significant amount of the chemical monitoring will need to be outsourced, at least for an initial period. For practical purposes it is desirable that the outsourcing be as centralised as possible. With this in mind it is proposed that the EPA arrange and manage the outsourcing in freshwaters and the Marine Institute the outsourcing of samples from transitional and coastal waters.

Chapter 2 Overview of the Monitoring Programmes

2.1 Introduction

In this chapter an overview is given of what constitutes surveillance, operational and investigative monitoring. An outline is presented here of the individual programmes for rivers, lakes, transitional and coastal waters, groundwater, and canals, which are further detailed in Part II of this report.

The WFD sets out three types of monitoring programmes: Surveillance, Operational and Investigative. These are explained further in the sections below. Monitoring for surface waters has more requirements than for groundwater because they require additional biological and hydro-morphological elements to allow for the assignation of ecological status. Sections 2.2 – 2.7 provide additional detail on the overall requirements for surface waters. This is followed in Sections 2.8 – 2.13 with an overview of the monitoring programmes for each water category.

2.2 Surveillance Monitoring (SM) of Surface Waters

The overall objectives of the SM (SM) are specified in the text of the WFD (Table 2.1). There are four main objectives for SM and a number of stipulated types of monitoring points that must be included in the SM programme.

Table 2.1 Extract from WFD (Annex 1.3.1) outlining SM

WFD Text concerning design of Surveillance Monitoring
1.3.1. Design of surveillance monitoring Objective Member States shall establish surveillance monitoring programmes 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. The results of such monitoring shall be reviewed and used, in combination with the impact assessment procedure described in Annex II, to determine requirements for monitoring programmes in the current and subsequent river basin management plans. Selection of monitoring points

WFD Text concerning design of Surveillance Monitoring

Surveillance monitoring shall be carried out of sufficient surface water bodies to provide an assessment of the overall surface water status within each catchment or subcatchments within the river basin district. In selecting these bodies Member States shall ensure that, where appropriate, monitoring is carried out at points where:

1. the rate of water flow is significant within the river basin district as a whole; including points on large rivers where the catchment area is greater than 2500 km^2,

2. the volume of water present is significant within the river basin district, including large lakes and reservoirs,

3. significant bodies of water cross a Member State boundary,

4. sites are identified under the Information Exchange Decision 77/795/EEC, and

5. at such other sites as are required to estimate the pollutant load which is transferred across Member State boundaries, and which is transferred into the marine environment.

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:

1. parameters indicative of all biological quality elements,

2. parameters indicative of all hydromorphological quality elements,

3. parameters indicative of all general physico-chemical quality elements,

4. priority list pollutants which are discharged into the river basin or sub-basin, and

5. other pollutants discharged in significant quantities in the river basin or sub-basin,

Unless the previous surveillance monitoring exercise showed that the body concerned reached good status and there is no evidence from the review of impact of human activity in Annex II that the impacts on the body have changed. In these cases, surveillance monitoring shall be carried out once every three river basin management plans.

2.2.1 Sub-networks for SM of Surface Waters

The design of the Irish SM network is based on key sub-networks (or 'subnets') each designed to fulfil one or more of the main objectives of SM. (see Table 2.2) The subnets for surface water categories described in detail in the accompanying volumes to this report along with the lists of monitoring sites. The subnets of the SMSM programme for surface waters that are common to the programmes for rivers, lakes and transitional and coastal waters include those listed below in Table 2.2:

Table 2.2 Summary of SM subnets common to all surface water categories.

Subnet Name	Aim of Subnet
SM Subnet 1	This subnet is designed to be representative of the overall surface water status as per the WFD stated requirement: surface water bodies to provide an assessment of the overall surface water status within each catchment or subcatchments within the River Basin District
SM Subnet 2	Detection of long-term trends as per WFD requirement – the assessment of long-term changes in natural conditions, and the assessment of long-term changes resulting from widespread anthropogenic activity.
SM Subnet 3	Supplementing and validating risk assessments particularly at those sites where the degree of uncertainty is greatest as per WFD requirement: supplementing and validating the impact assessment procedure detailed in Annex II.
SM Subnet 4	Water bodies that are stipulated in the text of the WFD: the rate of water flow is significant within the river basin district as a whole; including points on large rivers where the catchment area is greater than 2500 km2 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 identified under the Information Exchange Decision 77/795/EEC, and at such other sites as are required to estimate the pollutant load which is transferred across Member State boundaries, and which is transferred into the marine environment.

2.2.2 Priority Substances

Priority substances are of particular important in Surveillance Monitoring. In 2003 and 2004 Ireland's National Dangerous Substances Expert Group developed lists of priority action, candidate relevant pollutant and candidate general component substances for surface waters in Ireland and designed a substances screening monitoring programme as part of the implementation of the Water Framework Directive (WFD). A discussion document (May 2004) seeking public input to the lists and programme was presented at the DEHLG Water Framework Directive Information/Consultation Seminar in June 2004.

Following consultation, a national substances screening monitoring programme contract was procured by Carlow County Council via the European Journal, analysing to detect the presence of over 200 substances in water, sediment and biota. A commercial laboratory was awarded the analysis contract and monthly

sample collection was undertaken by the South Eastern River Basin District Monitoring Team at over 30 sites spread across Ireland. Sampling and analysis started in May 2005 with the final phase of samples collected in October 2006.

The purpose of the screening monitoring programme was to help inform the design of the WFD dangerous substances monitoring programme which covered priority substances and relevant pollutants. The Dangerous Substances Expert Group considered the results available from the screening programme to refine the candidate lists and to identify the WFD Monitoring Programme for the first River Basin Management Plan (2007 – 2009).

The following recommendations were made:

- 41 priority action substances identified at European level should be included in the programme with sampling in surface waters at a monthly frequency for one year during the plan cycle, supplementary sediment and biota samples should also be taken to supplement this monitoring information;

- All priority action substances should be monitored at each identified dangerous substances monitoring site;

- Standards for priority action substances are being progressed by the European Union;

- 43 relevant pollutant and general component substances comprising all 25 substances detected in significant concentrations during the screening programme should be included in the programme with sampling in water at a minimum quarterly frequency for one year during the plan cycle. (Separate tables for surface waters parameters and groundwater parameters are provided in Appendix 2.1 [1]);

- Selected relevant pollutant and general component substances should be sampled at dangerous substances monitoring sites on the basis of the site's upstream activities. A Programme of Measures and Standards Study on Dangerous Substance Usage will support the site-specific tailoring of these monitoring lists; pending the results of this study, the initial monitoring will include all listed compounds;

- Standards for relevant pollutant and general component substances in Irish Waters are being progressed by the EPA supported by a Programme of Measures and Standards Study on Environmental Standards, the first list of draft standards will be produced for consultation by early 2007. Target values will be used in the design and specification of the initial monitoring programme;

- The analysis of Dangerous Substances is challenging and costly and capacity to undertake the required programme is not yet available in Ireland. The sampling programme will initially have to be organised by the EPA and Marine Institute with much of the analysis outsourced;

- The first cycle WFD Dangerous Substances Monitoring Programme will incorporate all 188 river surveillance network sites and all 25 transitional and

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

12 coastal surveillance network sites. This network covers the range of geographical areas, types and status. Furthermore the river surveillance network represents the interaction in the water cycle between groundwater, and the inflows to receiving lakes, transitional and coastal waters and therefore provides information for all water categories. In addition complementary dangerous substance monitoring in marine waters will be continued and strengthened under the CEMP programme and Shellfish Directive. In groundwater all surveillance sites will include analysis of core groundwater determinands and operational sites will include analysis of selected additional groundwater determinands as detailed in Appendix 2.1 [1];

- The dangerous substances monitoring network for the second WFD cycle will be further developed based on the locations where and concentrations at which parameters were found during the first programme.

2.3 Operational Monitoring of Surface Waters

The WFD requires Operational Monitoring (OM) primarily in support of measures aimed at achieving the main objectives of the WFD – attainment of at least good status in water bodies that are less than good at present and also to retain high and good status where it exists at present. The success of the WFD depends crucially on the Programmes of Measures (POM) implemented in the RBDs. The l OM Programme outlined here is focussed on support of POM – it is designed to provide highly targeted information on the success or otherwise of particular measures within catchments.

OM is obviously required where pollution or other impacts on ecological status are apparent. Crucially, however, because the protection of high and good status are such high level objectives of the WFD, OM must also provide information on whether the POMs aimed at maintaining high and good status are effective. Thus, even waterbodies which may not be deemed to be at risk in the Characterisation Report prepared under Article 5 of the WFD are included in the OM programme because measures are required to maintain them at their current high or good status regardless of existing risk status.

2.3.1 OM subnets

The subnets of the OM programmes for rivers and lakes have similar aims as follows:

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

Table 2.3 Summary of operational monitoring subnets common to all surface water categories.

Subnet Name	Aim of Subnet
OM Subnet 1	Monitoring to assess whether the measures aimed at improving the impact of individual and combined point sources are successful. This includes assessment of ambient levels of organic pollution, eutrophication impacts and priority substances.
OM Subnet 2	To assess effectiveness of diffuse pollution control measures
OM Subnet 3	To assess effectiveness of measures to reduce hydromorphological pressures and impacts
OM Subnet 4	To monitor high and good status sites currently not deemed to be at risk in order to assess the effectiveness of POMs aimed at maintaining high and good status sites.
OM Subnet 5	To monitor Species and Habitat Protected Areas that are at risk

Note: In the case of Transitional and Coastal Waters Subnets 1 and 2 are combined into single subnet.

2.4 Investigative Monitoring

The WFD includes a third type of monitoring called Investigative Monitoring (IM). The WFD states that this type of monitoring is required for situations:

- "where the reason for any exceedances is unknown;
- where surveillance monitoring indicates that the objectives set under 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;
- and shall inform the establishment of a programme of measures for the achievement of the environmental objectives and specific measures necessary to remedy the effects of accidental pollution."

The Investigative Monitoring Programme will include rolling programmes of snapshot monitoring for water bodies not included for example in the main OM or SM programmes. In the case of rivers it is proposed that one quarter of the effort/resources applied to physico-chemical monitoring generally should be devoted to snapshot monitoring of smaller streams in order to provide a wider geographical assessment of water bodies than is possible with main-stem river monitoring only. Biological screening of river water body risk will assist in pinpointing in a very specific manner the causes of water bodies failing to achieve the required environmental objectives under the WFD. Such programmes will also inform the POM helping it to be more specific and targeted at than would otherwise be possible. Also included in

the IM programme are electronic alert networks aimed at providing greater temporal resolution to help in ascertaining the causes and likely sources of pollution and informing the POM. A remote sensing subnet is also included under IM in which aerial and satellite imagery will be routinely used to inform POM and investigate potential pollution sources and other impacts on ecological status.

2.5 Frequency of Monitoring

Sample frequency will vary depending on the monitoring programme, the requirements of the classification systems and the individual subnets and the quality element. The frequency of monitoring will be reviewed and adjusted where necessary in the future to take account of the outputs from research projects. Minimum requirements for quality elements are specified for SM in the WFD (Table 2.4). For phytoplankton and physico-chemical monitoring the sampling frequencies will be higher than indicated below for SM. Long-term trend monitoring sites will require higher frequency sampling than for example, those required for supplementing and validating the risk assessment or for general representative monitoring. Frequency of monitoring will determine the confidence and precision of the results obtained particularly in the physico-chemical monitoring programmes.

Table 2.4 Quality elements and *minimum* required frequency of SM for individual quality elements in surface waters monitoring as per WFD text.

Quality Element		**Rivers**	**Lakes**	**Transitional**	**Coastal**
Biological	Phytoplankton	6 months	6 months	6 months	6 months
	Other aquatic flora	3 years	3 years	3 year	3 year
	Macro invertebrates	3 years	3 years	3 years	3 years
	Fish	3 years	3 years	3 years	NA
Hydro-morpho-logical	Continuity	6 years	NA	NA	NA
	Hydrology	continuous	1 month	NA	NA
	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	NA
	Nutrient Status	3 months	3 months	3 months	3 months
	Acidification Status	3 months	3 months	NA	NA
Other Pollutants		3 months	3 months	3 months	3 months
Priority Substances		1 month	1 month	1 month	1 month

NA – Not Appropriate

The text of the WFD in Annex 1.3.4 outlines the requirements for frequency of monitoring by making the following points:

- For the surveillance monitoring period, the frequencies for monitoring parameters indicative of physico-chemical quality elements given below should be applied unless greater intervals would be justified on the basis of technical knowledge and expert judgment. For biological or hydromorphological quality elements, monitoring shall be carried out at least once during the surveillance monitoring period.

- For operational monitoring, the frequency of monitoring required for any parameter shall be determined by Member States so as to provide sufficient data for a reliable assessment of the status of the relevant quality element. As a guideline, monitoring should take place at intervals not exceeding those shown in the table below unless greater intervals would be justified on the basis of technical knowledge and expert judgment.

- Frequencies shall be chosen so as to achieve an acceptable level of confidence and precision. Estimates of the confidence and precision attained by the monitoring system used shall be stated in the River Basin Management Plan."

- Monitoring frequencies shall be selected which take account of the variability in parameters resulting from both natural and anthropogenic conditions. The times at which monitoring is undertaken shall be selected so as to minimise the impact of seasonal variation on the results, and thus ensure that the results reflect changes in the water body as a result of changes due to anthropogenic pressure. Additional monitoring during different seasons of the same year shall be carried out, where necessary, to achieve this objective.

The proposed sampling frequency for the physico-chemical quality elements for SM is monthly.

The proposed sampling frequency for the physico-chemical quality elements for OM is set out in a minimum of four times per annum.

2.6 Water Framework Directive Classification Systems

Due to the comprehensive list of ecological quality elements that are required to be monitored under the WFD and that many of the current extant Classification systems are not WFD compliant, new ecological classification systems are required.

The task of developing these classification systems which conform to ISO and CEN standards, for the ecological elements is shared between the UK and Ireland. Thus, where possible, common systems of classification of the biological status of surface waters will be used in UK and Ireland enabling a similar approach to be adopted in Ireland and Northern Ireland.

The environmental quality standards that will allow the classification of the supporting physico-chemical status of surface waters are being developed in close cooperation with the UK.

The classification of the biological status of heavily modified and artificial waterbodies will be made using the systems applied for similar natural waterbodies.

2.6.1 Phytoplankton.

Rivers

Phytoplankton sampling will be carried out on a small number of larger rivers only, using the classification systems developed for lakes.

Lakes

Parameter	Metrics
Phytoplankton biomass:	• chlorophyll measurement
Phytoplankton abundance:	• cell enumeration
Species composition:	• relative percentage of Cyanobacteria in the total phytoplankton

Transitional and Coastal Waters

Metrics are based on assessing phytoplankton biomass (as measured using chlorophyll) and frequency, composition and intensity of phytoplankton blooms. The biomass metric works by quantifying the level of chlorophyll present in a water body over a 5-year period. This is achieved by comparing the value of the 90th percentile and median over a 5-year period against reference based classification boundaries. The second metric works by recording the number of events, defined as occasions when values based on individual phytoplankton species cell numbers, exceed a predefined threshold over the period of the monitoring programme.

Parameter	Metrics
Phytoplankton biomass:	• chlorophyll measurement
Frequency, composition and intensity of phytoplankton blooms	• recording the number of events, defined as occasions when values based on individual phytoplankton species cell numbers, exceed a predefined threshold over the period of the monitoring programme

2.6.2 Macrophytes and other aquatic flora

Rivers and Lakes

“CBAS” model or Free Index. In the case of rivers the NSSHARE “CBAS” Index which is a metric of taxonomic composition will be supplemented by a metric which measures the average macrophytic and phytobenthic abundance.

Diatoms

It is recommended that the DALES systems from the UK be considered for the assessment of the diatom component in lakes and a modified TDI (DARES) for rivers in Ireland.

Macroalgae

A simple classification scheme based on an estimate of macroalgal biomass that is largely independent of the species composition will be used. Macroalgal taxonomic structure is accounted for in the CBAS and Free indexes.

Transitional and Coastal Waters

A series of systems have been developed for the monitoring and classification of macrophytes, including the macroalgal and angiosperm communities, in coastal and transitional waters:

MACROALGAE

The classification system includes a measure of the number of species present on a shore and the ecological status of these species. Changes in the numbers of species present or a shift to more opportunistic algae will indicate changes in the ecological status of the area.

Opportunistic Algae

A classification system has been developed to monitor the spatial extent and biomass of these opportunistic algal blooms in transitional and coastal waters

Fucoid Extent

A classification system based on changes in the upstream extent for Fucoid algae has been proposed. This biological element responds slowly to environmental pressures and so only requires monitoring one year in the RBD cycle.

ANGIOSPERMS

Seagrass

A classification system based on the taxonomic composition, spatial extent and bed density has been developed. Due to a paucity of baseline data, initial surveys will be on an annual basis, with surveys undertaken on a three-year cycle once background data has been accumulated.

Saltmarsh

Methods for assessing habitat extent for purposes of the WFD have been based on a simplified version of habitat mapping techniques. An EQR based on changes in habitat extent and biodiversity of beds has been developed. Depending on the size of the saltmarsh habitat in each water body monitoring will be undertaken at 1-3 locations on a three-year cycle.

2.6.3 Macroinvertebrates

Rivers

The macroinvertebrate component of the EPA Quality Rating System or Q-Value System (the Irish National assessment system) will be used, disaggregated from the overall Q-Value, and expressed as an EQR ranging from 0 to 1. This will be used to assess macroinvertebrate taxonomic composition and abundance, the ratio of disturbance sensitive to insensitive taxa and the diversity of the community. This component of the Q-Value has been intercalibrated in the Northern Geographic Intercalibration Group (NGIG) of the WFD intercalibration exercise and also in the Central Baltic Geographic Intercalibration Group. A separate index for acidification pressure may also be used arising from the NGIG intercalibration group on acidification.

Lakes

Four ecological classification systems are being tested and validated using littoral macroinvertebrate data collected in 2006 from a wide range of lakes. The individual metrics will be combined into a multimetric system.

A separate classification system is being developed to assess the impact of acidification on surface waters is being developed for use in UK and Ireland. Ireland has been using the Norwegian Raddum classification system for the past 20 years and this system is also being considered for use in Ireland.

Transitional and coastal waters

The marine benthic macroinvertebrate biological quality element will be evaluated by the Infaunal Quality Index (IQI) multimetric developed by the UK-Ireland Benthic Invertebrate subgroup of the UK-Ireland Marine Task Team. The required criteria listed in the normative definition of the directive for this ecological quality element are all covered by this metric.

2.6.4 Fish

A classification system for assessing ecological status of lakes, using fish, is been developed as part of the NS SHARE project. During 2005 fish stock surveys were completed in 33 lakes in RoI and 6 lakes in NI. The information collected is currently being processed. A range of river metrics for fish are also being assessed. Ireland is participating in the fish intercalibration exercise at a European level

The classification systems developed for transitional waters are based on examination of species composition in relation to the status of known pressures. Metrics include those based on such attributes as absolute and relative composition; on proportion of specific species; on contribution of specific functional groups.

2.7 Rivers Monitoring Programmes

2.7.1 Surveillance Monitoring (SM) of Rivers

In total the SM network will include approximately 189 sites on Irish rivers. The aims of the four common SM subnets are set out in Table 2.2. The details of subnets are described in Chapter 7 and the actual sampling locations are presented in Appendix 7.1[1] as an electronic file. The most up to date version of the monitoring programme will always be available on the EPA website.

2.7.2 Other Overlapping Subnets

Within the structure of the above subnets the SM programme also includes the following overlapping subnets – overlapping in the sense that they will also be contained in one or more of the four principal subnets above.

- Eurowaternet (EIONET) sites,
- Surface water / groundwater interaction sites,
- River Lake interaction sites - Lake flux sites to measure nutrient loading to some major lakes on e.g. Conn, Derg, Ree, Sheelin, Leane
- Selected reference condition (e.g. RivType Project) sites to ensure that a sufficient number of the highest status RWBs are included (important for detection of long-term natural trends as per CIS Monitoring Guidance)
- WFD Intercalibration register sites
- Selected NPWS Protected Area sites – see also OM programme. NPWS nominated certain high quality sites based on distribution of the fresh water pearl mussel (*Margaritifera margaritifera*) which were included in the SM network SMN.

Priority was also given to sites currently monitored under the Salmonid Regulations in the site selection process. Individual monitoring points may be included in one or more of the main subnets. The OM Programme may also include some sites belonging to these overlapping subnets.

2.7.3 Biological elements for River SM

The quality elements for SM are clearly designated in Annex V of the WFD. Some aspects are presented in greater detail in Chapter 7.

The macroinvertebrate component of the Irish Quality Rating System has been intercalibrated with biological indices from a wide range of other European countries as part of the Northern Intercalibration Group and the Central/Baltic Intercalibration Group. The Quality Rating system is based primarily on macroinvertebrates but also incorporates phytobenthos and macrophytes in the overall Q-Value. Individual metrics will be applied to each biological quality element before recombining and classifying river sites into one of five status categories. As indicated above, new classification systems for other biological elements (e.g. fish) are under development

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

and these will also be intercalibrated as part of the official WFD intercalibration process.

2.7.4 Operational Monitoring (OM) for Rivers

The OM programme for rivers will have from 1100-1500 joint physico-chemical/ecological monitoring points on Irish RWBs and approximately 1500 monitoring points for ecological monitoring only (See Chapter 7). The programme includes all accessible rivers depicted on the Ordnance Survey River Basin map of Ireland in order to provide continuity with previous national programmes. This programme is designed to be flexible in order to respond to changes within catchments that impact on water status. Thus, individual sites may change over time but under a strict version control and notification procedure such that at all times the current OM programme is available as an electronic file from the EPA's website.

The OM programme for rivers incorporates all of the 189 sites contained in the SM programme - the SM network is a subset of the OM network.

As noted earlier, the Irish rivers OM has a number of separate subnets aimed at monitoring particular aspects of POMs and providing feedback for the national EMS system within RBMPs. Details, including the locations are given in Chapter 7 and in electronic files on the EPA website (Appendix 7.1[1]).

2.7.5 Quality Elements for OM Programme

Details of the quality elements for OM monitoring are set out in the Chapter 7. Quality elements appropriate to the pressure being assessed and the effectiveness of particular programmes of measures are chosen for individual subnets.

2.7.6 Monitoring of Drinking Water Abstraction Points

Additional monitoring is required for drinking water sources as per the text of Article 7 and Annex V (1.3.5) of the WFD independently of the SM. Larger sources require more frequent monitoring than smaller sources and the appropriate frequency is listed for individual sites.

2.7.7 Investigative Monitoring (IM) for Rivers

There are four subnets in the rivers investigative monitoring programme. These subnets and their primary aims are presented in Table 2.5. As indicated it is envisaged that one quarter of physico-chemical resources for river monitoring should be devoted to rolling programmes of snapshot catchment monitoring (IM Subnet 2) aimed at informing the POM in a highly precise, targeted manner within individual river water bodies. Such programmes undertaken in conjunction with biological

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

screening of risk status will assist in ascertaining the causes of a water body or water bodies failing to achieve the environmental objectives.

Table 2.5 Summary of rivers investigative monitoring subnet.

Subnet Name	Aim of Subnet
R IM Subnet 1	Monitoring to understand the reasons for any unexplained exceedances and to ascertain the magnitude and impacts of accidental pollution
R IM Subnet 2	Monitoring to provide a more detailed geographical picture of catchments by means of rolling programme of snapshot catchment monitoring. This will help to inform the establishment of the programme of measures by enabling POMs to be aimed at the precise location of pollution problems within catchments.
R IM Subnet 3	Monitoring to identify episodic pollution sources not identified by other subnets.
R IM Subnet 4	In addition to the temporal and geographical coverage provided by the snapshot and electronic alert networks, aerial photography used for hydromorphological assessments can provide additional screening for small point sources of pollution and visual verification of a wide range of catchment pressures. Satellite imagery can provide similar coverage albeit at lower resolution.

2.8 Lakes Monitoring Programme

There are some 12,000 lakes in Ireland ranging in surface area from less than 1 ha to over 50 ha (Figure 2.1). The great majority of these are very small (<1 ha). The criteria developed for the inclusion of lakes under the WFD resulted in the definition of 745 lakes that were included in the river basin characterisation and risk assessment procedures reported in the Article 5 characterisation report.

The total population of lakes from which the WFD monitoring programme (surveillance and operational) networks are drawn is therefore 745, all of which have a surface area greater than 1ha.

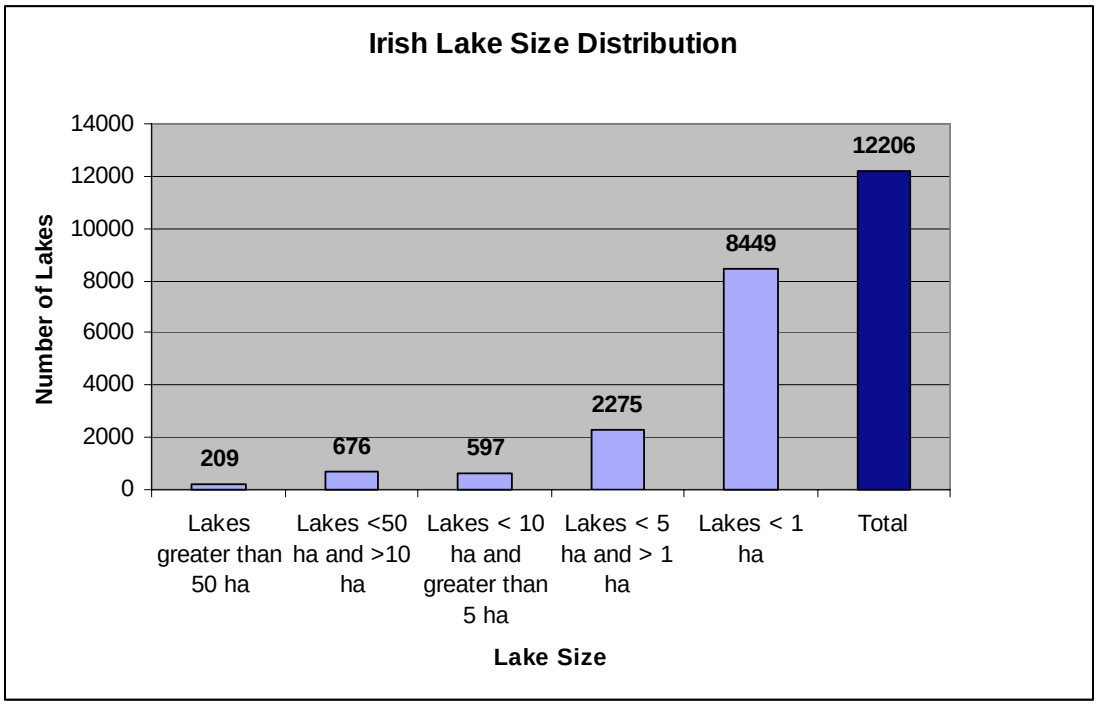

Figure 2.1 Distribution of Irish lakes by surface area (ha).

2.8.1 Surveillance Monitoring (SM) of Lakes

The overall objectives of the SM (SM) are specified in the text of the WFD (Table 2.1). There are four main objectives for SM and a number of stipulated types of monitoring points that must be included in the SM programme. The four subnets and their aims are as outlined earlier in this chapter.

The SM programme comprises 73 lakes.

2.8.2 Other Overlapping Subnets for Lakes

Within the structure of the above subnets the SM programme will also include the following overlapping subnets – overlapping in the sense that they will also be contained in one or more of the five principal subnets above.

- Acidification Monitoring Programme
- Eionet Water (Eurowaternet) sites,
- High Status Waterbodies
- River Lake interaction sites - Lake flux sites to measure nutrient loading to some major lakes five to 10 sites on eg Conn, Derg, Ree, Sheelin, Leane
- Selected reference condition sites to ensure that sufficient of the highest status LWBs are included

- WFD Intercalibration register sites

Individual monitoring points may be included in one or more of the main subnets.

2.8.3 Quality Elements for the Lakes SM Programme

The quality elements for SM are clearly designated in Annex V of the WFD. Some aspects are presented in greater detail in Chapter 8.

2.8.4 Operational Monitoring (OM) for Lakes

The OM programme for lakes comprises 233 lakes (Chapter 8). The distribution of these lakes by RBD is presented in Figures 8.2 to 8.5. This programme is designed to be flexible in order to respond to changes within catchments that impact on water status.

As outlined earlier in this chapter, the OM has five separate subnets aimed at monitoring particular aspects of POMs and providing feedback for the national EMS system within RBMPs. There is considerable overlap of lakes between the subnets because very few lakes are influenced by single types of pressure (i.e. point sources, diffuse sources or hydromorphological pressure). The majority of lakes are influenced by a combination of the main pressure types and in many cases these pressures are exerted in the lake catchment rather than on the lake itself. Further details of the subnets are presented in Chapter 8.

2.8.5 Quality Elements for the Lakes OM Programme

For a discussion on the quality elements for the lakes OM programme, see Chapter 8.

2.8.6 Monitoring of Drinking Water Abstraction Points on Lakes

Additional monitoring is required for drinking water sources as per the text of Article 7 and Annex V (1.3.5) of the WFD independently of the SM or OM programmes outlined above.

2.8.7 Investigative Monitoring (IM) of Lakes

The details of the design and extent of the investigative monitoring programme cannot be fully developed until the results of the surveillance and/or OM are known and any exceedances for which the cause is unknown can be identified.

2.9 Coastal and Transitional Waters Monitoring Programme

2.9.1 Introduction

A total of 309 transitional and coastal water bodies were considered for inclusion in the national Coastal and Transitional Waters monitoring programme (the number of water bodies within each River Basin District and each typology is shown in Table 2.6). This represents 196 transitional water bodies and 113 coastal water bodies.

In accordance with the Water Framework Directive and guidance provided by the Common Implementation Strategy, a representative number of water bodies were selected that were considered to provide an assessment of the overall status of Ireland's transitional and coastal waters and to meet the other specific requirements of the WFD.

Table 2.6 Number of Transitional and Coastal water bodies by type in Ireland.

River Basin District	Typology						
	TW 2	TW 6	CW 2	CW 5	CW 6	CW 8	CW 10
Eastern RBD	10	3	0	6	1	1	0
South Eastern RBD	16	5	2	4	0	3	0
South Western RBD	29	14	9	9	0	3	6
Shannon IRBD	14	6	4	4	0	1	2
Western RBD	21	47	5	15	0	5	5
North Western IRBD	14	8	4	12	0	6	1
Neagh Bann IRBD	6	3	1	3	0	1	0
Total by Type	110	86	25	53	1	20	14

2.9.2 Coastal and Transitional SM Network

A selection or 'subnet' of SM water bodies was chosen to represent the range of significant pressures and typology scenarios present in Ireland's coastal and transitional waters. This selection of representative water bodies was grouped into 3 additional subnets to fulfill the specific SM requirements of the Directive.

2.9.3 Principal Subnets

The subnets of this monitoring programme are the same as those for rivers and lakes and have been listed along with their aim earlier in this Volume. Further details are presented in Chapter 9.

2.9.4 Other Overlapping Subnets

Within the structure of the above subnets the SM programme will also include the following overlapping subnets – overlapping in the sense that they will also be contained in one or more of the four principal subnets above.

- Eurowaternet (EIONET) sites,
- Surface water / groundwater interaction site,
- Selected reference condition sites
- WFD Intercalibration register sites
- Selected NPWS Protected Area sites – see also OM programme

Individual monitoring points may be included in one or more of the main subnets.

2.9.5 Quality Element, Site Selection and Sampling Frequency for SM Programme

As previously stated the quality elements for SM are clearly designated in Annex V of the WFD (see Table 2.4 in this Chapter).

In addition to selecting water bodies that are representative of types and dominant pressures and fulfill specific requirements of the Directive, consideration was given to the selection of quality elements and sufficient monitoring points to assess the status of individual water bodies.

The site selection process within designated water bodies was informed by the United Kingdom – Republic of Ireland Marine Task Team guidelines on site density and coverage required to implement the relevant classification tools. Sites with existing historical monitoring data were also chosen to facilitate the assessment of long-term trends. Expert knowledge on individual biological elements and habitat variation was also used. In addition consideration was also given to clustering sites within adjacent water bodies to improve the overall logistical efficiency of the biological and chemical monitoring programmes. This is extremely important in the marine area given the large size and broad spatial distribution of the water bodies that have to be monitored.

2.9.6 Coastal and Transitional Waters OM Network

For the OM programme a selection or subnet was made of representative water bodies from those identified as being ‘at risk’ or ‘probably at risk’ of failing to meet

their environmental objectives. This selection was further divided into 3 additional subnets for the purposes of assessing the effectiveness of measures to address impacts arising from point, diffuse and hydromorphological pressures, as well as measures to maintain good and high status sites.

These are described in greater detail in Chapter 9 and summarised below in Table 2.7. Lists of water bodies and number of monitoring sites are given in Chapter 9. The operational programme for transitional and coastal waters has 6 subnets consisting of 80 water bodies.

Table 2.7 Summary of coastal and transitional waters OM subnets.

Subnet Name	Aim of Subnet
CT OM Subnet 1	Monitoring to establish the status of those bodies identified as being at risk of failing to meet their environmental objectives.
CT OM Subnet 2	To assess effectiveness of diffuse and point source pollution control measures.
CT OM Subnet 3	To assess effectiveness of measures to reduce hydromorphological pressures and impacts.
CT OM Subnet 4	To monitor high and good status sites currently not deemed to be 'at risk' in order to assess the effectiveness of measures aimed at maintaining high and good status sites.
CT OM Subnet 5	To identify episodic pollution sources and associated impacts not captured by other subnets.
CT OM Subnet 6	To monitor Species and Habitat Protected Areas that are at risk of failing to meet their specific environmental objectives.

2.9.7 Quality Element, Site Selection and Sampling Frequency for the OM Programme

The selection of the most appropriate quality elements for the operational programme was based on expert knowledge, the outcome of classification tool development, and guidance provided by the United Kingdom-Republic of Ireland Marine Task Team. This exercise has helped to identify the elements most sensitive to the relevant pressures (see Chapter 9).

Expert judgment was also used to supplement the risk assessment approach in the selection of site numbers particularly for transitional and coastal lagoons.

It was decided to include most of the biological quality elements in water bodies requiring measures for the protection of high/good status (see subnet 4 above).

2.9.8 Summary of the operational and SM programmes.

A summary of the operational and SM programmes for coastal and transitional waters is shown in Chapter 9. A total of 117 water bodies are included. Of these, 82

are transitional and 35 coastal. Of the transitional water bodies, 57 are included in the operational programme and 25 in the surveillance programme, for coastal water bodies, 23 are operational and 12 are surveillance. The number of monitoring sites and sampling frequency for each quality element in both programmes and water categories is also shown in Chapter 9.

2.10 Groundwater Monitoring Programme

2.10.1 Introduction

Article 8 of the Water Framework Directive (WFD) requires the establishment of programmes of monitoring for groundwater. The groundwater monitoring programmes primarily focus on providing information that can be used to assess the environmental status of groundwater bodies. Additionally, the groundwater monitoring programmes will provide information to assess whether the environmental objectives of Article 4 of the Water Framework Directive (WFD) are being met, thereby supporting the overall environmental and management objectives within a River Basin District (RBD). The groundwater monitoring programmes must include:

- A quantitative monitoring network;
- A surveillance water quality monitoring network;
- An operational water quality monitoring network;
- Appropriate monitoring to support the achievement of Protected Area objectives e.g. Drinking Water or Habitats Protected Areas.

The RBD consultants and the EPA are currently undertaking further characterisation studies to improve upon the anthropogenic pressures data used for the Annex II risk assessment. The further characterisation studies include the study of point source pressures, the study of diffuse mobile organic pressures e.g. pesticides and the study of pressures associated with urban areas.

The selection/location of appropriate sampling sites is based on the conceptual understanding of the hydrogeology and anthropogenic pressures within each groundwater body or group of bodies and will be reviewed as this understanding improves.

Existing groundwater monitoring locations from the current EPA National Groundwater Quality and Level Monitoring Programmes have been reviewed to determine their suitability for WFD monitoring and where appropriate, these monitoring locations have been integrated into the WFD monitoring programmes. Where groundwater bodies have been identified as being “at risk” from point source pressures in the Annex II risk assessment, monitoring data from existing compliance monitoring e.g. from IPPC licensed activities, will be utilised for the assessment of point source pressures. Where necessary, the compliance monitoring may be supplemented by additional monitoring e.g. where the monitoring is deemed to be inadequate for WFD purposes or for currently unlicensed point source pressures.

As in the case of surface waters, the design of the groundwater monitoring network in Ireland is based on key sub-networks (or ‘subnets’); each designed to fulfill one or

more of the main objectives of the groundwater monitoring programme. These are outlined below and are described in greater detail in Chapter 10.

The UK-Ireland Groundwater Task Team has developed draft UKTAG guidance for the assessment of groundwater quantitative and chemical status. It is proposed that groundwater classification systems in Ireland will largely adhere to the principles of this guidance.

The location of monitoring sites will be finalised when the official WFD monitoring programme commences in the Republic of Ireland.

2.10.2 Quantitative Groundwater Monitoring

A quantitative monitoring network is required to:

- Supplement and validate the Annex II risk assessment procedure;
- Determine the quantitative status of groundwater bodies;
- Support the chemical status assessment and trend analysis; and
- Support the design and evaluation of Programmes of Measures (POMs).

The quantitative monitoring network design is based on the conceptual understanding of the groundwater system and abstraction pressures, thereby enabling a water balance assessment. The basis for its development is outlined in Chapter 10.

The overall objectives of the quantitative monitoring are specified in the text of Annex V of the WFD. In summary they include supplementing and validating risk assessments, investigation of long-term water level trends and an assessment of saline or other intrusions caused by groundwater abstraction.

Monitoring will be located across a groundwater body or group of bodies to achieve a good spatial spread of data, with monitoring in groundwater body recharge and discharge areas and areas where there are known future planned abstractions, with monitoring used to determine the abstraction impacts on nearby surface water receptors. In the poorly productive aquifers, monitoring will be focus on the use of multi-level piezometers in ten poorly productive type settings and major fault zones (where abstractions are known to have an impact on water level). Quantitative monitoring will also be required at Groundwater Dependent Terrestrial Ecosystems (GWDTE) to improve conceptualisation and determine impacts from abstractions and/or discharges.

The frequency of monitoring will be determined by the data needed to determine risk and status, and where necessary to support the design and assessment of a POMs. The installation of data loggers is proposed at all quantitative monitoring locations because continuous (e.g. hourly or sub-hourly) data recording provides an opportunity to achieve a greater understanding of the aquifer response and behaviour to precipitation events. The quantitative monitoring frequency is indicated in Chapter 10 and indicates the recommended frequency of site visits to download data and carry out site maintenance.

In addition to monitoring water levels, the WFD specifies that conductivity should be measured as an indicator of saline or other intrusions that are caused by

groundwater abstraction. Probes will be used to continuously monitor conductivity, where groundwater bodies were defined as being at risk from saline or other intrusions in the Annex II risk assessment, and this was attributed to groundwater abstraction. These probes will also provide information on temperature, pH and dissolved oxygen, which will aid conceptualisation, particularly in the more dynamic systems such as karst.

2.10.3 Groundwater Quality Monitoring

A groundwater quality monitoring programme is required to:

- Supplement and validate the Annex II risk assessment procedure;
- Determine the chemical status of groundwater bodies;
- Establish the presence of any significant upward trends in pollutant concentrations in groundwater bodies and the reversal of such trends;
- Support the design and evaluation of POMs.

The design of the groundwater quality monitoring network is based on a conceptual understanding of the hydrogeological system and anthropogenic pressures, with monitoring data used to test or validate this understanding.

Monitoring locations are determined by the requirements for achieving a monitoring network that is representative of the variations in hydrogeology and pressure across a groundwater body or group of bodies. A representative monitoring network for diffuse pollution pressures is achieved when the hydrogeology and pressure variations impacting upon a combined network of monitoring points is proportionally similar to the combined hydrogeology and pressure variations over the whole groundwater body or group of bodies in which the monitoring points are located.

Since groundwater contributions from poorly productive rocks to surface water receptors are limited, and the impacts on groundwater mainly relate to local pressures; the development of a regional monitoring network of sufficient size to record all these variations in the poorly productive aquifers is not practical. Therefore, monitoring water quality in poorly productive areas is limited to monitoring points that have abstractions greater than 100 m^3/d and quantitative status monitoring points.

Groundwater quality samples are currently taken for certain IPPC and waste licensed activities, and also where the conditions of planning regulations stipulate groundwater monitoring. Data gathered at some of these monitoring sites will be utilised for the operational monitoring programme, although supplemental monitoring may also be required, if only to demonstrate the effectiveness of POMs.

A core suite of determinands is clearly designated in Annex V of the WFD (see Chapter 10). At springs, high precision, high frequency discharge monitoring is an essential element when considering the water quality data from the monitoring networks. Estimates of river flow and the percentage contribution from groundwater to surface water receptors is also required where groundwater is thought to be significantly contributing to the associated surface water receptor being at risk.

2.10.4 Surveillance Monitoring of Groundwater

The overall objectives of the surveillance monitoring (SM) programme include validation of the Annex II risk assessments and the assessment of significant long-term water quality trends, both as a result of changes in natural conditions and through anthropogenic activity.

SM is required in groundwater bodies or groups of groundwater bodies that are both at risk and not at risk of failing the WFD objectives. In order to achieve sufficient confidence in the assessment, spatial and temporal variation in aquifer type and pressure are accounted for in the design of the SM programme. Three principal SM subnets are outlined below in Table 2.8.

Table 2.8 Summary of groundwater surveillance monitoring subnets.

Subnet Name	Aim of Subnet
GW SM Subnet 1	Supplementing and validating risk assessments, particularly at those sites where the degree of uncertainty is greatest.
GW SM Subnet 2	Detection of long-term trends in water quality
GW SM Subnet 3	To provide detailed information on the interaction between groundwater and associated surface water receptors.

The results from the SM network will be used to revise the network at the end of each River Basin Management Plan (RBMP) cycle.

2.10.5 Groundwater surveillance monitoring frequency

The appropriate monitoring frequency is based on the conceptual understanding of the flow paths and pressures (see Table 2.9). In less dynamic systems, monitoring may only require two samples per year, with quarterly or even monthly samples initially taken in the more dynamic systems, such as the karst.

Table 2.9 Proposed minimum monitoring frequencies for groundwater surveillance monitoring.

		Aquifer Flow Type				
			Unconfined			
		Confined	Intergranular flow significant			
			Significant deep flows common	Shallow flow	Fracture flow only	Karst flow
Initial frequency – core & additional parameters		Twice per year	Quarterly	Quarterly	Quarterly	Quarterly
Long term frequency – core parameters	Generally high-moderate 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 (on-going validation)		Every 6 years	Every 6 years	Every 6 years	Every 6 years	-

2.10.6 Operational Monitoring of Groundwater

The success of the WFD depends crucially on the POMs implemented in the RBDs. The operational monitoring (OM) programme is focused on assessing at risk groundwater bodies, establishing the presence of any long-term anthropogenically induced upward trend in the concentration of any pollutant, supporting the design of POMs and assessing the effectiveness of such measures within groundwater bodies. This programme is designed to be flexible in order to respond to changes within catchments that impact on groundwater status. The operational groundwater monitoring programme has three separate subnets aimed at monitoring particular water quality pressures and they are designed to advise and provide feedback on the design and effectiveness of POMs developed as part of the RBMPs (Table 2.10).

Table 2.10 Summary of groundwater operational monitoring subnets.

Subnet Name	Aim of Subnet
GW OM Subnet 1	To establish groundwater status for groundwater bodies at risk from diffuse pollution and assess long-term anthropogenic trends and the effectiveness of any POMs within these groundwater bodies.
GW OM Subnet 2	To establish groundwater status for groundwater bodies at risk from point source pollution and assess long-term anthropogenic trends and the effectiveness of any POMs within these groundwater bodies.
GW OM Subnet 3	To establish groundwater status for groundwater bodies at risk from urban pressures and assess long-term anthropogenic trends and the effectiveness of any POMs within these groundwater bodies.

2.10.7 Groundwater operational monitoring frequency

OM will be carried out between periods of SM and samples will be taken, as a minimum, at least once a year (Table 1.11). Higher frequencies are proposed where the potential concentration of a monitoring parameter fluctuates significantly; where there are uncertainties surrounding the Annex II risk assessment; or sites where there had been a lack of previously gathered data.

Table 2.11 Proposed minimum frequencies for groundwater operational monitoring

		Aquifer Flow Type				
			Unconfined			
		Confined	Intergranular flow significant		Fracture flow only	Karst flow
			Significant deep flows common	Shallow flow		
Higher vulnerability groundwater	Continuous pressures	-	Twice per year	Twice per year	Quarterly	Quarterly
	Seasonal / intermittent pressures	-	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	-

In addition to the monitoring requirements of the SM programme, the WFD specifies that additional determinands should be analysed on a case-by-case basis for OM and the selection of these determinands should be influenced by the Annex II risk assessment. OM determinand suites are included in Chapter 10.

2.10.8 Monitoring of Drinking Water Protected Areas (DWPAs)

Article 7 of the WFD requires monitoring programmes to assess the achievement of Drinking Water Protected Areas (DWPA) objectives. The Article 7 DWPA objectives indicate that any groundwater monitoring within DWPA should be used to support DWPA management and assessment.

The Article 7(3) objective of aiming to prevent deterioration in the water quality of DWPA (through a reduction in purification/treatment) implies that there are background quality data for DWPA at the date of implementation of monitoring programmes, against which any subsequent deterioration can be assessed.

Article 7(1) indicates that monitoring to assess the achievement of DWPA objectives should be carried out for groundwater bodies that provide more than 100 m^3/d as an average. Although Article 7(1) indicates that groundwater monitoring at all DWPA is not specifically required; Annex II of the WFD indicates that the chemical composition of groundwater will have to be analysed for all DWPA that are categorised as being significant potable groundwater abstractions and that are located in groundwater bodies defined as being at risk in the Annex II risk assessment.

Water quality samples will be taken at all significant potable groundwater abstractions associated with DWPA in groundwater bodies that are at risk from diffuse or point source pollutants. Water quality samples may also be taken at DWPA that were categorised as being not at risk in the Annex II risk assessment.

Monitoring guidance indicates that water quality samples should be taken at least once in each RBMP cycle.

It will be necessary to monitor for all determinands that are directly related to (untreated) drinking water quality, i.e. those required under the Drinking Water Directive.

2.10.9 Species and Habitat Protected Areas

Chemical and quantitative monitoring in groundwater bodies associated with Species and Habitat Protected Areas is required to determine the impacts of groundwater on these ecosystems.

Monitoring is proposed in groundwater bodies that were identified as being at risk, in the Annex II risk assessments, because of associated GWDTE. Monitoring is also proposed in groundwater bodies associated with GWDTE that are considered to be high status ecosystems.

The proposed GWDTE monitoring will be phased over three years, with approximately one third of the sites monitored in the first year, and a similar proportion of sites monitored in years 2 and 3. Information gathered during the first three years of monitoring will provide the basis for future GWDTE monitoring. Ecological monitoring associated with the Habitats Directive will be required in conjunction with chemical and quantitative groundwater monitoring. The National Parks and Wildlife Service (NPWS) are currently assessing the ecosystems to prioritise locations for monitoring.

2.10.10 Prevent or Limit Monitoring

In accordance with Articles 4, 11 and 17 of the WFD, Member States should assess the effectiveness of POMs introduced to prevent or limit the inputs of pollutants and/or the deterioration of the status of groundwater. Although the surveillance and OM programmes will contribute significantly to this, there may be need for additional

monitoring programmes for particular point sources e.g. ensuring compliance with licensed activities such as landfill or for site specific clean-up after an accidental spill i.e. investigative monitoring.

Therefore, information from certain prevent or limit monitoring may be incorporated into WFD monitoring programmes and additional monitoring points may be required upgradient and/or downgradient of potential point sources to groundwater to monitor any potential impacts on the overall groundwater body.

2.11 Canals Monitoring Programme

2.11.1 Introduction

Artificial Water Bodies (AWBs) are defined in Article 1 of the WFD as "a body of water created by human activity". The WFD also states in Article 4.3(a) that "Member States may designate a body of surface water as artificial or heavily modified when the changes to the hydromorphological characteristics of that body which would be necessary for achieving good ecological status would have significant adverse effects" on a list of activities including navigation and recreation. For these reasons canals were identified as AWBs under the WFD.

Canals are to be included in the OM programme recognising their artificial nature and specific monitoring requirements to ensure their continued beneficial uses. Canals play an important role in Ireland's River Basin Districts for many integrated purposes including for navigation, angling, water sports, water quality, environmental and amenity value. Canal monitoring is currently carried out by the Central Fisheries Board (CFB) on behalf of Waterways Ireland (WI), the owners of most of Ireland's canals, for their maintenance programme. The EPA reports on the water quality of canals in Ireland based on CFB monitoring data.

Chapter 11 outlines the current monitoring undertaken for canals and sets out the anticipated additional work required to make the programme WFD compliant based on initial discussions between WI, EPA and CFB. The exact roles and responsibilities of this programme have yet to be defined between these organisations.

2.11.2 Aim of canals monitoring programme

The Canals Monitoring Programme for WFD reflects the varied beneficial uses of canals. The monitoring programme should allow for the ecological potential of each canal to be identified and support the measures in the River Basin Management Plans aimed at achieving Good Ecological Potential for AWBs.

Good Ecological Potential (GEP) and Maximum Ecological Potential (MEP as reference condition) have yet to be defined for AWBs or Heavily Modified Water Bodies (HMWBs). However, while it is anticipated that the ecological quality associated with GEP and MEP will require mitigation measures in some cases, it is understood that those mitigation measures should not have a significant adverse impact on the use of beneficial uses of canals listed above. Specific management

practices will be required to maintain these beneficial uses, e.g. dredging to ensure safe boat movement and aquatic plant management practices.

This programme should link with the monitoring of feeder streams and associated river water bodies, as in many cases the measures applied to the catchments of feeder streams will play a key role in improving Canal water quality. Given the beneficial uses of canals outlined above, macrophytes, benthic invertebrates, physico-chemical parameters, hydromorphological parameters and fish are deemed the most appropriate elements for inclusion.

2.11.3 Canal monitoring programme outline

It is in anticipated that for the WFD purposes of assigning Ecological Potential to canals and monitoring the influence of measures approximately 40 canal monitoring points are required throughout the ten canal-AWBs identified in Chapter 11. There are currently some 200 monitoring points for physico-chemical parameters sampled by CFB (roughly one site every 3km) used to maintain the canals' beneficial uses. A subset of these sites can accommodate the 40 WFD canal monitoring. The locations of the monitoring points are discussed in Chapter 11.

2.12 Commencement of Monitoring Programme

The monitoring programme will be operational on 22 December 2006. Sampling and analysis will commence according to the schedules developed for each quality element and monitoring type.

Chapter 3 Quality Control and Quality Assurance

3.1 Purpose

To ensure that data generated by WFD physico-chemical and biological monitoring programs is reliable, representative, and facilitates robust assessment of the impacts of Programs of Measures each facility engaged in sampling, or where samples are analysed, is required to put in place a documented Quality Assurance program covering their operations.

3.2 Definitions

A Quality Assurance (QA) programme is a documented system of operating guidelines which, if followed during sample collection, transportation and analysis, will produce reliable data.

Quality Control (QC) is an integral aspect of QA and focuses on ensuring that analytical data are both accurate and precise. The QC programme should encompass all techniques to be used to measure and assess data quality, determination of analytical performance criteria including Limits of Detection / Practical Reporting Limits / Measurement Uncertainty, and remedial actions to be taken when quality criteria are not met.

3.3 Quality Assurance Plan

In preparing their QA programs laboratories are required to develop systems capable of meeting the requirements of the current version of I.S. EN ISO 17025 "General requirements for the competence of testing and calibration laboratories".

The Irish National Accreditation Board (INAB) undertakes assessment to this standard

Laboratories are encouraged to seek accreditation for relevant parameters and matrices tested however those not seeking accreditation are still required to put in place appropriate QA/QC systems in place covering such elements as:

- Sampling, sample transportation, receipt, storage and preservation
- Documented analytical procedures based on recognised National, European or International standards
- In-house Quality Control procedures and participation in relevant external performance testing schemes
- Validation of test methods response, limits of detection, and measurement uncertainty

- Staff training and competency
- Reporting procedures, information storage and data security

Guidance on sampling procedures can be found in the following sources:

Irish Standards:

- I.S. EN 25667-1: 1994 “Water Quality – Sampling – Part 1: Guidance on the design of sampling programmes”.
- I.S. EN 25667-2: 1994 “Water Quality – Sampling – Part 2: Guidance on Sampling Techniques”

International Standards Organisation:

- “Water Quality – Sampling – Part 1 “Guidance on the design of sampling programmes and sampling techniques” is currently under revision (Draft ISO/FDIS 5667-1:2006) is expected to be available from ISO in early 2007.
- IS0 5667-3 “Water Quality – Sampling – Part 3: Guidance on the preservation and handling of samples”
- BS 6068 series of publications relating to water quality. These standards cover sampling of a range of aqueous matrices. Some sections are identical to ISO 5667 publications however not all sections have been adopted by Ireland to date.

In developing their QA / QC procedures laboratories are strongly advised to consult the following document:

- ENV / ISO 13530 “Water Quality - Guide to Analytical Quality Control for Water Analysis (ISO/TR 13530:1997)”.

The EPA operates an inter-calibration programme for several natural water parameters however a number of commercial performance testing (PT) schemes are available. Further information may be obtained at:

http://www.epa.ie/PublicAuthorityServices/LaboratoryIntercalibrationProgramme

and also at www.eptis.bam.de

The use of Certified Reference Materials (CRMs) is encouraged where appropriate to the parameters monitored. These are offered by several commercial companies and can prove useful in validating analytical performance

3.4 Analytical Performance Requirements

The choice of analytical methods available is extensive. It is acknowledged that laboratory facilities will generally utilise in-house documented procedures. These should preferably be based on the following hierarchy of reference sources.

- Irish Standard methods (I.S. EN),
- European Standard Methods (EN),
- International Standard Methods (ISO),

Internationally accepted and documented reference procedures such as those contained in the current edition of APHA / AWWA “Standard Methods for the Examination of Water and Wastewater”

UK Standing Committee of Analysts “Methods for Examination of Waters and Related Materials” (MEWAM) or similar publications.

As a minimum, analytical procedures used should be capable of achieving at least 10% of the concentration of interest (e.g. EQS or other water quality standard) or the lowest measurable value that can be reported with a known statistical confidence. A total error threshold of ± 20% is considered to be the maximum allowable and would be assigned equally to bias and to random variation (standard deviation). For further guidance on method performance refer to Section 6.5 of ISO 13530.

It is recommended that in-house test procedures be set out in keeping with the ISO 78-2:1999 “Chemistry -- Layouts for standards -- Part 2: Methods of chemical analysis”.

Specific performance criteria and prescription of required analytical approaches may require to be defined for some parameters to ensure data comparability both within Ireland, and across the EU, particularly for empirical procedures such as those used for Chlorophyll or for trace metals / organics analysis.

3.4.1 Sub-contracting of analyses

Where sampling / analyses is sub-contracted, the contracting body shall ensure that any contract documentation makes full reference to all aspects of the monitoring process including (where relevant) choice of sample location, sampling technique (e.g. groundwater purging), sample pre-treatment (e.g. filtration), preservation, storage, transport, reporting criteria and analysis turnaround. This can be especially important for some parameters such as those for microbiology, metals, and trace organics. Reputable companies will generally apply the principles set out above however it is important that all bodies subcontracting work satisfy themselves as to the technical and analytical competence of any third parties engaged by them

Price is an important factor however quality of service and reporting limits can vary markedly between service providers, particularly in the case of organic analysis, where lower reporting concentrations necessitate complex sample pre-concentration and analytical procedures. The contracting body must ensure that its quality objectives are met when sub-contracting such analyses.

3.5 Guidance on reporting and interpretation of data

ISO 13530:1997 provides a robust framework for the evaluation of the performance of analytical measurement systems. The following sections provide guidance on preferred approaches for treatment and reporting of analytical data.

3.5.1 Rounding

It is common practice to truncate (or round) instrumental measured values. Consideration must be given to rounding such data in a manner that does not diminish its usefulness for evaluation of process change. In general rounding should provide a result where the uncertainty exists only in the last significant figure, e.g. 8.05(3) would be rounded to 8.05. Where summed values are reported these should be reported to the significance figures applied to the least accurate measurement. The use of 3 significant figures is generally sufficient for most analytical work.

3.5.2 Limit of Detection / Practical Reporting Limit

The “Limit of Detection” of an analytical system can be defined as the lowest concentration for which a response is measurable above background noise with a defined (typically 95%) statistical confidence. It is desirable that the LoD is based on examination of a series of batches of analyses over time by different analysts and not solely on the evaluation of the best possible performance or lowest detectable signal alone within a single batch of analysis. This approach ensures the most holistic estimate of variability likely to be obtained in routine use.

While the LoD provides a measure lowest signal detectable at the defined confidence it is common for laboratories to apply a somewhat higher value as a “Practical Reporting Limit (PRL)” or “Lower Limit of Quantification (LoQ)”. This is generally a multiple of the LoD (e.g. 2xLoD) and is used as an additional safeguard to ensure that responses to the detection of substances at low concentrations are merited based on a higher confidence of its detection.

3.5.3 Reporting and Interpretation of Low concentrations

A major difficulty with measurement at very low concentrations is that analytical systems can yield responses (sometimes negative) falling below the calculated LoD or LoQ above. Such data is often seen reported in one of the following ways:

- as Not detected (ND)
- as Less than the LoD (<LoD or <Value)
- as zero (0)
- as an arbitrary fraction of the LoD (e.g. LoD/2)
- as the measured value + its measurement uncertainty

The terms “Not Detected” and “Zero” should never be used as they convey no quantitative or qualitative information and are wholly dependent on the characteristics of the measurement system used. In many aqueous matrices it will not be possible to determine, with absolute confidence, the complete absence of a particular substance.

Reporting values as “<LoD” is the most commonly accepted practice however incorporating such values into statistical calculations requires their transposition to a replacement value C_R e.g. LoD/2. These values may facilitate calculations but the calculated statistic may be biased and should always be referenced back to the original LoD.

Recording the actual measured values (including negative responses), plus their estimated measurement uncertainty provides the greatest information however few laboratory data handling systems will store information in this manner. It is important that laboratories determine the measurement uncertainty of their analytical procedures such that this information is available to assist in the evaluation of the significance of any analytical data (see Section 3.5.5 below).

In all cases it is essential that a clear distinction is made between recorded (measured) values and any subsequently reported results.

Reference:

Royal Society of Chemistry (Analytical Methods Committee), AMC Technical Brief No.5, April 2001

3.5.4 Estimation and Use of Recovery Factors

Use of recovery factors to correct analytical results is a contentious issue. It is very relevant to trace organic analysis where liquid / liquid or solid phase extraction is used to pre-concentrate samples. It also applies however to inorganic parameters defined as “totals” e.g. Total Phosphorus, Total Cyanide etc. In such cases the recovery should be confirmed from complexed forms of the analyte.

The International Union of Pure & Applied Chemistry (IUPAC), International Standards Organisation (ISO) and AOAC International recommend the following approach.

Quantitative results should be corrected for recovery unless there are specific reasons for not doing so. These may include situations where: (a) the analytical method is regarded as empirical, (b) a contractual or statutory limit has been established using uncorrected data, or (c) recoveries are known to be close to unity.

It is of over-riding importance that all data, when reported, should be clearly identified as to whether or not a recovery correction has been applied and if a recovery correction has been applied, the amount of the correction and the method by which it was derived should be included with the report.

Recovery values should be established as part of method validation. When the use of a recovery factor is justified, the method of its estimation should be specified in the method protocol.

QC charts for recovery should be established during method validation and used in all routine analysis. Runs giving recovery values outside the control range should be considered for re-analysis in the context of acceptable variation, or the results reported as semi-quantitative.

Reference:

Pure Appl. Chem., 1999, 71, 337-348

3.5.5 Measurement Uncertainty

All analytical measurements have an associated uncertainty arising from sampling and analysis. For environmental samples the overall uncertainty arising from sampling variability is less able to be accurately estimated than that for analytical measurements however it has the potential to be a more significant component, particularly if the matrix sampled is not homogenous, e.g. downstream of a mixing zone of two waters, in a stratified water body etc. or where phyisco-chemical parameters are influenced by biological activity e.g. Chlorophyll measurement.

The use of replicate randomised sampling and/or the use of auto-samplers can provide more representative samples however where these approaches are employed it is essential to consider the selection of sites and their potential impact on the measurement achieved. This may require the use of preservatives for auto-sampler bottles and should be taken into account in designing monitoring programs

Analytical measurement uncertainty may be calculated from an evaluation of all contributory factors in a “bottom-up” approach however this can be a complex and lengthy process. It may be appropriate in some circumstances but does not lend itself to use as a routine tool.

A more practical approach to estimation of the analytical uncertainty is to use a “top-down” approach in which the performance of routine control standards is used to assess overall variability. This utilises the standard deviation of controls expressed as a relative standard deviation. A coverage factor of 2 (95%) is commonly applied. It is much simpler to apply but may require additional validation across the range of concentrations to be measured.

References:

“Quantifying uncertainty in Analytical Measurement” 2nd Ed. 2000 Eurachem/Citac Guide CG4.

“Estimation and Expression of Uncertainty of Measurement in Chemical Analysis”, Nordic Committee on Food Analysis, NMKL Procedure No. 5 (1997)

“The Expression of Uncertainty and Confidence in Measurement” (Dec 1997), United Kingdom Accreditation Service (UKAS), Document M3003.

3.5.6 Plausibility Checks / Data Validation

Data should always be checked prior to reporting for overall plausibility and comparability with previous samples. The use of comparative ratios such as BOD:COD, Na:K, Ionic Balances etc., is recommended.

Plotting of trends in such ratios can be of assistance in the early detection of trends in natural variations or step changes due to analytical factors. This may be particularly relevant when assessing parameters which are naturally low e.g. as trace metals concentrations. In addition such checks may also serve to highlight differences in reporting units e.g. Nitrate as NO_3 or as N, Phosphate as P or as PO_4 etc. especially where data from a range of sources is being aggregated.

Chapter 4 Precision and Confidence of Monitoring Programmes

4.1 Confidence and Precision of Physico-Chemical Results:

The inherent natural variability together with the frequency of monitoring determines the confidence and precision of results for physico-chemical parameters. Table 4.1 and 4.2 illustrates typical coefficients of variation for a range of physico-chemical parameters in Irish rivers and lakes respectively. The Coefficient of Variation (CV), or relative dispersion, is a standard statistical measure of the scatter in datasets. It is calculated as the ratio of the standard deviation to the mean of a set of results. Thus a CV of 0.4 implies that the standard deviation is 40% of the mean of a set of values – the higher the value the greater the scatter about the mean.

For a CV of 0.4 the confidence for a mean of 12 results is plus or minus 25% (90% confidence). Thus, to be 90% sure that a water body is of good status, the mean must be less than 75% of the environmental quality standard (EQS) value, assuming that higher values imply poorer status for the parameter in question. To be 90% sure that a water body is of lower than good status, the mean must be more than 125% of EQS. For four results, these threshold values are 50% and 150%, respectively.

Fig 4.1 illustrates the precision of the estimate of an annual mean value in relation to the coefficient of variation for the determinand and the frequency of sampling. Fig. 4.2 illustrates the expected precision at 90% confidence for any parameter over a range of coefficients of variation. Thus, a monitoring programme that measures nitrate which has an average CV of 0.51 would be expected to be able to detect a change in the real mean nitrate value of 100% with 90% confidence if sampled 12 times but if sampled 6 times the precision is reduced with a change of over 140% in the true mean value would be required before it could be detected reliably at the 90% confidence level.

The precise coefficient of variation for an individual water body may vary considerably even for the same parameter. The table above provides a general idea of the likely range of coefficients of variation for the main physico-chemical parameters. It is expected that those for priority substances will be much higher in many cases but it is not yet possible to determine CVs. When publishing results, however, the monitoring programme will provide estimates of the confidence and precision attached to individual sets of results for particular water bodies or water categories generally.

Table 4.1 Coefficients of Variation (CV) for selected physico-chemical determinands in Rivers. CVs were calculated for individual whole-river datasets (i.e. multiple stations) and averaged across a number of rivers (based on over 28,000 individual measurements).

		Coefficient of Variation			
Parameter	**Mean**	**No. of Rivers**	**Q25**	**Median**	**Q75**
Alkalinity	0.39	4	0.3	0.4	0.5
Ammonia	1.58	13	0.7	1.5	2.1
BOD	0.54	17	0.5	0.5	0.6
Chloride	0.89	14	0.1	0.2	0.4
Colour	0.59	12	0.4	0.6	0.8
Conductivity	0.44	14	0.2	0.2	0.4
Copper	8.12	8	2.1	2.7	5.1
DO	0.26	18	0.1	0.1	0.4
Hardness	0.31	8	0.2	0.3	0.5
Nitrate	0.51	11	0.3	0.4	0.7
Nitrite	0.99	13	0.6	0.9	1.3
Phosphate	1.26	18	0.7	0.8	1.1
pH	0.04	18	0.0	0.0	0.1
Suspended Solids	2.33	4	1.6	2.4	3.1
Temperature	0.36	18	0.3	0.4	0.4
Zinc	1.85	7	0.8	0.9	2.4

Table 4.2 Coefficients of Variation (CV) for selected physico-chemical determinands in Lakes. CVs were calculated for individual whole-lake datasets (i.e. multiple years) and averaged across a number of lakes.

		Coefficient of Variation			
Parameter	**Mean**	**No. of Lakes**	**Q25**	**Median**	**Q75**
Alkalinity	0.2	10	0.1	0.2	0.3
Chloride	0.4	3	0.2	0.3	0.5
Colour	0.5	10	0.3	0.4	0.6
Conductivity	0.1	10	0.1	0.1	0.1
M.R.P.	1.2	10	0.8	1.0	1.4
NO2 &NO3	1.1	10	0.9	1.0	1.1
pH	0.7	2	0.4	0.7	1.0
Secchi	0.3	5	0.2	0.4	0.4
Silica	0.4	4	0.2	0.4	0.6
SRP	1.1	6	0.9	1.0	1.2
TFA	1.0	1	1.0	1.0	1.0
TKN	0.2	8	0.2	0.2	0.3
TN	0.6	7	0.6	0.6	0.6
Total Hardness	0.1	10	0.1	0.1	0.2
Total P	0.8	10	0.4	0.7	0.8
Turbidity	0.6	10	0.5	0.5	0.7

In general monitoring frequencies of 4, 6 and 12 times per year will be used for many subnets and for many parameters in the Irish monitoring programme. The tables above and the graphs below enable the confidence and precision for particular parameters and particular subnets to be estimated. While frequency of monitoring is specified for individual subnets, it is nonetheless important that individual laboratories operating the monitoring programmes choose frequencies that are adequate for the purposes of the particular monitoring bearing in mind that a site may belong to a number of different subnets and taking into account the actual variance measured for quality elements in a particular water body. It is not required that all sites are monitored at the same frequency.

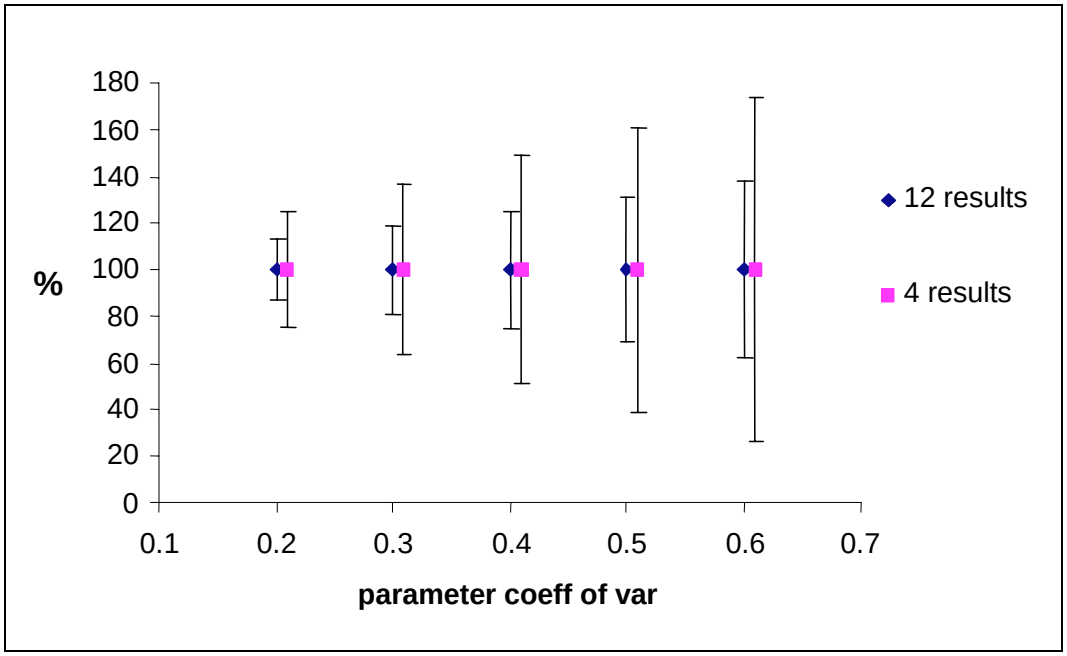

Figure 4.1 The confidence of the estimate (*P*=0.1) of an annual mean value of 100 is shown in relation to the coefficient of variation for the determinand and the frequency of sampling (4 times per year and 12 times per year).

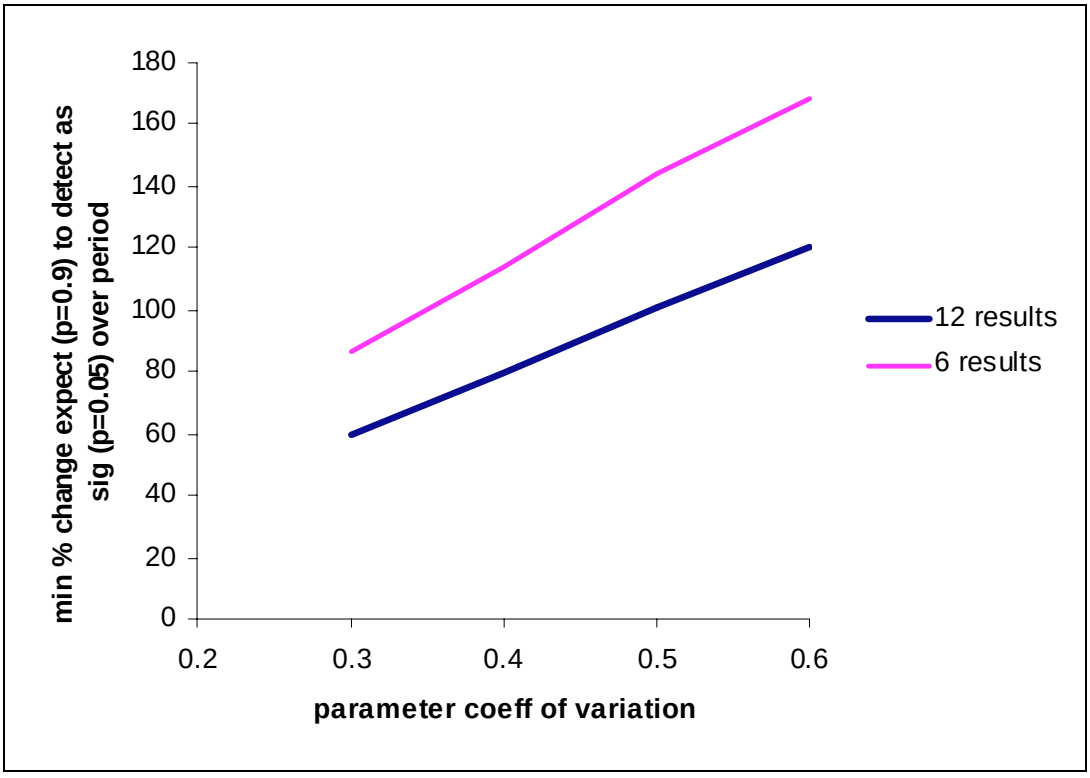

Figure 4.2 Trend detection - Relationship between coefficient of variation and precision of expected results for 6 and 12 individual samples taken within the year.

Confidence in the overall assessment of the status of a water body does not, however, depend simply on the confidence and precision of a single parameter nor will it usually depend solely on a single quality element even allowing for the one out all out principle of the WFD and CIS Guidance. The status will be assigned typically based on a wide range of quality elements both biological and physico-chemical. Where large uncertainties exist in the estimate for a particular determinand or quality element this uncertainty will be incorporated into the overall assessment of metrics used to assign status. Thus, a mean value for ammonia or copper, for example, with a very wide confidence limit attached to it should not be allowed to outweigh a biological metric based on a full biological community of macroinvertebrates which indicates that the ecological status is of a very high status. The statistical approach outlined above for deciding whether a given element is above the EQS threshold must be taken. The combining of chemical and biological results is discussed further below (4.3).

4.2 Confidence and Precision of Biological Results:

The precision and reliability of biological or ecological assessments depends on the accuracy of sampling and taxonomic expertise applied. This is similar to the need for water chemistry methods to be accurate and reliable. The final assessment of status, however, also depends heavily on the reliability of the index or metric used to interpret the raw data – taxonomic, abundance, age class, etc. To this end intercalibration with other independent measures of ecological pressure, related physico-chemical state, other biological elements may be used to indicate the overall reliability and precision of the method and hence the assignment of status class.

Ireland has participated in the official intercalibration process for the WFD participating in a range of Geographical Intercalibration Groups – Northern and Central/Baltic for rivers and lakes and additionally the Atlantic GIG for lakes. The marine intercalibration group have worked on North Atlantic inter-comparisons. In the case of the rivers intercalibration groups, the intercalibration process has resulted in a set of statistical comparisons between the member state biological metrics. This provides a degree of confidence in the status classifications produced by the biological metrics being compared. In Ireland's case a modified Q-Value for macroinvertebrates is being used in the initial intercalibration. This allows a statement that with a confidence level of 95% or 90% the status classes assigned by the Irish Q-Value system are not statistically different from the same classes assigned by other countries participating in the intercalibration process. This process has also allowed coefficients of variation to be developed for biological metrics and the likelihood of misclassification to be expressed statistically. The coefficient of variation for some 1800 biological assessments using the Intercalibration common metric (Buffagni and Furse, 2006) as related to the Irish Q-Value for the Northern Intercalibration Group was 0.12 which indicates, as expected, a higher degree of precision than is possible with individual physico-chemical parameters. (Table 4.3).

Table 4.3 Intercalibration Common Metric (ICMi) values comparing status based on Q-Value with ICMi value and its coefficient of variation within each status class.

Status	CV	Mean	N	StDev
Poor	0.02	0.420	4	0.0071
Bad	0.10	0.627	82	0.0599
Moderate	0.09	0.764	156	0.0687
Good	0.09	0.853	709	0.0791
High	0.09	0.920	866	0.0809

Q-values are based primarily on macroinvertebrates but they also take into account two other biological elements listed in Annex V of the WFD, namely phytobenthos and macrophytes. Q-values are also statistically related to water quality measures such as BOD, ammonia, nitrate and phosphate. Similarly Q-Value is linked to land use pressures in a statistical manner – urban cover, tillage and grassland cover within catchments are linked to Q-Value on a national basis (O'Donohue et al 2005). Recent research has also shown that Q-Value is statistically linked to fish populations in Irish rivers – high Q-Values have fish populations comprised almost entirely of salmon and trout whereas heavily polluted rivers may have no fish or a small population of tolerant sticklebacks (Champ et al. in press.). As indicated above, the WFD intercalibration process has also entailed statistical comparisons between the five principal status categories in different Member States using different ecological assessment systems. A 'bootstrapping' method will be used to combine the known statistical relationships as indicated above in order to provide an overall estimate of the confidence and precision of an EQR based on a modified Q-Value assessment for rivers and likewise for new metrics and classification systems under development.

Many of the biological metrics for classification of status are, however, still under development and it is too early yet to provide information on errors of misclassification.

The issue of new ecological assessment methods for biological elements such as macrophytes or diatoms, for example, with as of yet uncertain variance and reliability must also be dealt with under the heading of confidence and precision and particularly in applying the one out all out rule in order to amalgamate the overall results from different biological elements into a final ecological status assessment. The ECOSTAT working group is also addressing this issue on a European wide scale.

4.3 Combining of Chemical Status and Ecological Status Assessments

While many of the subnets of the operational monitoring programme for rivers, for example, will recommend the WFD-required minimum frequency of four times per year individual laboratories may sample more frequently if greater precision is needed for a particular purpose. (Some subnets will require 12-times per annum sampling – Freshwater Fish Directive water bodies and surveillance monitoring

subnets will also be sampled 12 times per year.) The perceived need for greater precision and confidence in the operational programmes must be viewed in the light of the overall reporting of status for water bodies, which requires the combination of ecological status and chemical status. It is essential to direct scarce laboratory and field sampling resources to where they can maximise returns in terms of achieving the aims of the WFD – i.e. bringing less than 'Good' status water bodies back up to at least Good Status. This may not always coincide with simply increasing monitoring frequency.

In the WFD reporting cycle, the final status of a water body to be reported officially as an output of the Irish WFD monitoring programme will be the poorer of its ecological status and ecological status. (WFD Article 2, 17). The supporting hydromorphological condition is also taken into account at the High/Good boundary in assessing ecological status.

Ecological Status Classification	Colour Code
High	Blue
Good	Green
Moderate	Yellow
Poor	Orange
Bad	Red

The ecological status for natural water bodies will be mapped according to a five category scheme above: High, Good, Moderate, Poor and Bad which are to be colour-coded on maps as: blue, green, yellow, orange, red respectively. Chemical status is a simple binary condition – either 'Good' or 'Failing to Achieve Good' mapped as blue and red respectively as in the table below also taken from Annex V of the WFD.

Chemical Status Classification	Colour Code
Good	Blue
Failing to Achieve Good	Red

The Environmental Quality Standards for individual chemical parameters, established under, for example, Annex IX Article 16, will define the threshold for achieving 'Good' chemical status. Irish EQS values are to be published as a separate document. Based on long-standing experience with biological and chemical assessments of Irish rivers especially, it can be expected that, typically, there will be reasonably good

agreement between the biological status and chemical status results obtained during the course of the WFD monitoring programme. At locations where there is divergence or where borderline conditions exist it may be necessary to take more samples; increasing the frequency in order to reduce the uncertainty of the status assessment.

Where less than good biological status exists with a high degree of confidence and precision, however, and minimum-frequency chemical sampling also produces less than good status there is no particular advantage in increasing the frequency of chemical sampling, as the outcome will be the same regardless of the increased frequency. It is much preferable in such situations to put the resources that would have gone into increased chemical sampling frequency into more detailed investigative work aimed at pinpointing the source of the problem if it is not known.

Where poor or bad status exists and the cause of the problem is well characterised and measures are in train to correct the problem – such as the construction of a new sewage treatment plant to replace an old facility, for example, - there is little additional benefit in increasing the frequency of sampling. Increased frequency may be required if it is necessary to obtain a more precise estimate of nutrient loading to a lake emanating from the plant, for example, or to assess the impact of costly interim measures being taken to improve the operation of the old treatment plant. Generally speaking in such a situation increased frequency will not improve the status and thus the monitoring resources would be better applied elsewhere.

At the minimum sampling frequency of four times per year, using the criteria discussed above in Section 4.1, failure to reach good chemical status will occur when the mean value for the four samples is at least 50% above the EQS threshold for good chemical status – assuming that the parameter has a Coefficient of Variation of 0.4 (but obviously selecting the limits appropriate to the Coefficient of Variation of the particular parameter being assessed). For the same parameter a failure to achieve good chemical status will occur if over a 3-year period the mean of the 12 samples obtained (at the minimum sampling frequency of four times per year) is 25% greater than the EQS for the particular determinand in question. Typically each monitoring point will be subjected to one biological assessment in any 3-year cycle of the monitoring programme and thus overall status is likely to be defined and reported on basis of a 3-year reporting cycle.

The programme published here lists minimum sampling frequencies for different water categories and for individual subnets within the various monitoring programmes. Within local authorities or other public authority bodies involved in sampling and analysis and programmes of measures, the individual teams monitoring and programme of measures teams must decide on a case by case basis what the optimum sampling frequency requirements should be based on the overall balance between physico-chemical uncertainty, biological uncertainty and the over-riding aim of achieving good status in a waterbody. In many cases, for example, snapshot investigative monitoring undertaken in order to pinpoint less well characterised sources of pollution within catchments may be a better use of sampling and analytical results than simply increasing the precision and confidence of sampling for a water body that is quite clearly falling into the moderate, poor or bad status classes (whether due to biological assessment and/or physico-chemical assessments). In cases where it is necessary to prioritise investment in wastewater treatment plants at a range of locations improved physico-chemical precision may be beneficial.

4.4 References

Donohue, I., McGarrigle, M. & Mills, P. Linking catchment characteristics and water chemistry with the ecological status of Irish rivers. *Water Research* 40: 91-98

Buffagni, A. and Furse, M. 2006. Intercalibration and comparison – major results and conclusions from the STAR project. Hydrobiologia, **566**, 357-364.

Chapter 5 Data Management and Reporting

5.1 Data Management

5.1.1 Building and Environmental Data Exchange Network

There is a wide range of environmental datasets, applications, and IT systems in place within the many organisations involved in work related to the Water Framework Directive. Many of these are standalone systems and there is little interaction between them. As such the sharing and exchange of water related data is difficult and time consuming, the complexity of which is acting as a barrier in providing information to analysts and decision makers in an consumable and timely manner.

In order to maximise the use of data generated by the WFD Monitoring Programme it needs to be collected, managed, analysed and reported in a systematic, efficient and timely manner, providing the information to those who need it when they need it.

The Environmental Protection Agency in conjunction with the Local Government Computer Services Board and the River Basin Districts are currently developing an environmental data exchange network (EDEN) aimed at eliminating the difficulties encountered in the sharing and reporting of environmental data.

This system aims to apply the technologies and approaches that have transformed data exchange on the Internet to facilitate the exchange of data between environmental agencies and specifically the exchange of monitoring data arising from this WFD monitoring programme. A system based on standardised Internet languages allows individual agencies to use an Internal storage system of their own choice whilst also supporting easier exchange of environmental data. In time it is intended that EDEN will be a fully distributed data-sharing network allowing all stakeholders to easily share environmental data, see Fig. 5.1 below.

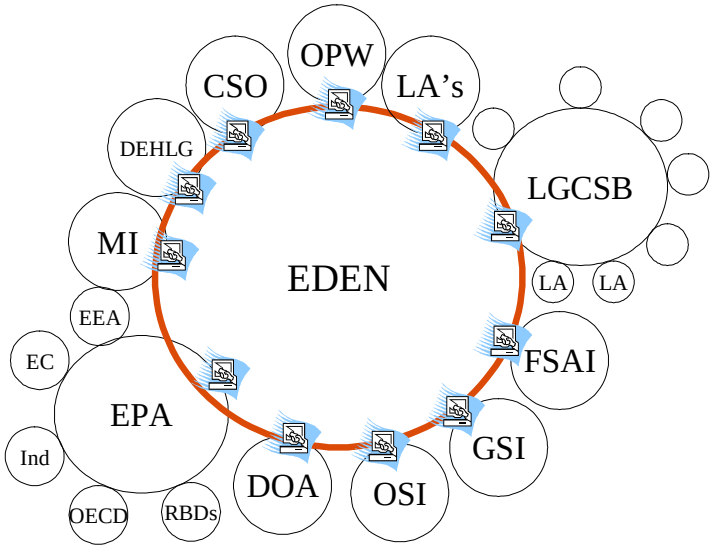

Figure 5.1 Data linkages between organisations

5.1.2 Establishing Data Standardisation

In addition to physically building a data exchange infrastructure much work is ongoing in the area of data standardisation.

Data standards establish a common language across organisations and can facilitate easier and more accurate information exchange among, private organisations, Local Authorities and public authorities including the EPA. Data Standards are documented agreements on formats and definitions of common data. Key elements of a data standard consist of data element names, definitions, data type and formatting prescriptions. A data standard may also include some guidance for usage to facilitate and promote its widespread use.

Establishing data standards for data to be exchanged as part of the national monitoring programmes is currently under way.

5.1.3 Interested Organisations

Table 5.1 indicates the envisaged contributors and users of and environmental data exchange network. Initially the scope will be limited primarily to Local Authorities, RBDs, the EPA and DEHLG, however, it is envisaged that this will expand quite rapidly with other data contributors and users being added as soon as possible.

Table 5.1 Example of Potential Contributors and Users

Contributors & Users
Local Authorities
River Basin Districts
Environmental Protection Agency
Department of Environment (DEHLG)
Marine Institute
Central Fisheries Board
Private Laboratories
Health Boards (Laboratories)
Geological Survey of Ireland
Department of Agriculture
Forest Service
Coillte Research Institutes
Universities
Ordnance Survey of Ireland
Office of Public Works
Electricity Supply Board

This is not considered an exhaustive list and it is envisaged that any organization with water data to contribute or a water data need, will be given some level of access to the system in due course.

5.2 Reporting

The success of any monitoring programme depends ultimately on providing feedback on water status to the general public, policy makers and particularly to stakeholders involved in implementing POMs. The reporting element of the WFD Monitoring programme includes a strong element of online reporting, through an environmental data exchange network as described above, such that results are disseminated as quickly and as widely as possible. Rapid reporting of Operational Monitoring (OM) and Investigative Monitoring (IM) results is particularly important.

As part of its remit and in co-operation with the EDEN project the EPA will define electronic reporting criteria (data schemas) for data to be reported through EDEN. These electronic reports will replace the existing data collection templates already in existence. This new reporting format will allow for validation of the data being uploaded into the system and will check if the data conforms with the data standards which have been agreed for that reporting stream. This will insure that the data contained in the EDEN central data repository is of the highest quality possible.

The EPA is working with the LGCSB and Eastern River Basin District (ERBD) under the EDEN to develop IT solutions to export the data in the defined reporting format from Laboratory Information Management Systems (LIMS) in operation within the Local Authorities. It is therefore most strongly recommended that Local Authorities and other reporting bodies maintain their data within LIMS, or other appropriate database systems, capable of exporting the data in the format specified by the EPA for upload into the EDEN system.

The data collected will continue to be used in National level reporting such as State of Environment reporting, Water Indicator Reports, Water Quality in Ireland reports etc, and will also form the basis for onward reporting of data to European and other institutions such as the European Environment Agency, European Commission, Eurostat, OECD etc.

The collection and management of data is also being harmonised at a European level through and initiative called WISE (Water Information System for Europe). This initiative aims to collect and report the data collected to meet the requirements of all water related directives such as the Water Framework Directive, Urban Waste Water Directive, Bathing Water Directive, Drinking Water Directive etc.

Establishing EDEN places Ireland in an improved position to meet the needs of the WISE system and development is being undertaken in consultation with the WISE development team to ensure data standards and data exchange mechanisms are as harmonised as possible in order to ensure streamlined reporting of data in future.

Chapter 6 Integration of Sub-programmes

6.1 Integration between water categories

The design of the programme has involved a number of meetings aimed at ensuring that there is good integration between the different surface water categories – rivers, lakes, transitional and coastal waters and also between surface waters and ground waters. This entailed, inter alia, expert examination of the geographical layout of the various programmes and the interaction between the water body monitoring points chosen. The inclusion of a range of substance flux stations – to measure loads from rivers to lakes and rivers to sea (OSPAR sites) is an example of the approach to integration. Groundwater/ surface water interactions are also seen as important in order to understand the impact of groundwater on surface and vice versa. During periods of low flows many rivers are largely fed by groundwater aquifers and this has implications for the setting of standards for groundwater which will adequately protect the ecology of the receiving river. Good integration between ecological assessments, physico-chemical assessments, priority substance assessments and hydromorphological and hydrometric assessments is also required.

6.2 Integration with 'end-of-pipe' compliance monitoring

A number of Directives require monitoring of effluent discharges to waterbodies (e.g. UWWD requiring measurements of discharges from municipal wastewater treatment plants and IPPC licences typically require end of pipe compliance monitoring). It is important that the 'ambient' monitoring required by the WFD – where samples are taken from natural waterbodies – is tightly integrated with end of pipe monitoring especially in relation to assessing the effectiveness of POMs.

Modelling of discharges using mass-balance techniques to predict concentrations of pollutants in receiving waters and comparing these with measured values should also be used to help integrate compliance monitoring with ambient monitoring.

Good communications between the compliance monitoring and enforcement authorities and the ambient monitoring programme is required.[1] In reporting the results of monitoring this need for integration of programmes must be born in mind.

1 In cases where, for example, a municipal WWT plant is 'under-performing' so badly that the POM requires it to be completely replaced with a new plant, a small number of samples may allow an assessment of the plant's poor performance to be made. Excessively frequent monitoring is probably not useful when it is known and accepted that a replacement treatment plant is required and in the planning process or perhaps even under construction. (See also Section 4.3)

6.3 Integration with Programme of Measures

There is a danger that monitoring programmes can become isolated from programmes of measures and that full value is not obtained from the monitoring programme. Rapid and targeted reporting is a key issue as discussed above in Chapter 5. The programmes described in the chapters dealing with rivers in particular aims to address some of the inadequacies of historical monitoring programmes. In particular it attempts to place the primary monitoring sites in a wider context through extensive geographical risk assessment, using rapid biological methods and snapshot physico-chemical sampling campaigns as part of a continuous investigative programme. This rolling programme is aimed at screening for risk and helping to pinpoint where measures can be best applied. The use of remote sensing to provide a wider geographical context is also advocated to help pinpoint small point sources of pollution for example. Electronic sensors providing continuous monitoring helps to provide a finer temporal resolution to the monitoring programme, helping to identify occasional or accidental sources of pollution. By integrating this type of risk assessment and spatial and temporal screening with the primary monitoring network it is hoped that measures will be more accurately focussed at particular sources of episodic or diffuse pollution.

6.4 Integration of Existing Monitoring Programmes

The monitoring programme set out in this document while covers all the requirements of the WFD for monitoring surface and groundwater it is not all encompassing. The National Rivers, Lakes and Estuarine and Groundwater Monitoring Programmes will be replaced by this programme, with most of the existing monitoring sites in these national programmes also included in this new programme.

While many related water directives will be brought into the WFD monitoring programme there will be a limited need to continue with existing monitoring in order to comply with specific directives and regulations (for example monitoring requirements such as end-of-pipe monitoring for Urban Wastewater Treatment Regulations, Drinking Water Regulations and Bathing Water Regulations). Article 22 of the WFD provides for repeals and transitional provisions for specific directives. The monitoring requirements for these, plus elements of other existing programme are expected to be superseded by later phases of the WFD monitoring programme.

A number of points are also relevant to ensuring integration between existing programmes and the new WFD programmes:

- The EPA's biological monitoring network will continue to operate, covering all the rivers depicted on the Ordnance Survey river basin map of Ireland. This will ensure continuity with the triennial river water quality maps published by the EPA for many years now. It will still be possible to compare the overall percentage of river channel that is satisfactory, slightly, moderately or seriously polluted with the historical record and to accurately assess long-term trends.

- The continuing biological programme will provide a 'safety net' where physico-chemical monitoring sites are dropped from the programme.

- Where local authorities feel that it is necessary to continue physico-chemical monitoring of river sites that are not listed in the SM or OM programme they may consider including them as investigative monitoring sites. This allows more flexibility in terms of frequency of monitoring and the list of determinands that must be analysed.

- In cases where long-term datasets exist and it is felt that it is valuable to continue monitoring at a site that is not listed in the main OM Programme consideration should be given to swapping such sites in and out of the OM programme on a 3-year cycle. Thus, for example, taking two long-term river locations 6km apart with no significant difference between them in terms of point source or diffuse pressures by including first one and then the other on a 3-year rotation. In this way a long-term record can be maintained albeit with 3-year gap every three years.

- A significant difference between the existing programmes and the new WFD programmes for rivers in particular is the introduction of rolling programmes of snapshot monitoring. These are aimed at building up a better understanding of water bodies that do not have main-stem river stations. Currently two-thirds of water bodies do not have main monitoring locations. This combined physico-chemical and biological risk assessment investigative monitoring will provide an additional back-up where main-stem monitoring sites are dropped in order to either increase the frequency of monitoring or to allow for snapshot sampling aimed in particular at less well characterised often diffuse pollution sources

- Increased use of electronic networks and remote sensing to give improved temporal and spatial understanding of catchments will also compensate for the 'loss' of some main-stem monitoring sites.

PART II - INDIVIDUAL MONITORING PROGRAMMES

Chapter 7 Rivers Monitoring Programme

7.1 Introduction – River Monitoring Programme

This chapter describes the WFD River Monitoring programme for Irish rivers. The structure of the Surveillance, Operational and Investigative Monitoring programmes is described. The subnets targeted at particular requirements of the WFD are outlined with the rationale and indicative size. Locations and details of the monitoring points are listed in separate tables in appendices to the river monitoring programme in Appendix 7.1[1] as dynamic online tables. Monitoring frequency and the associated precision and confidence for quality elements are described (Chapter 4). This chapter describes the structure of the programme in terms of overall numbers of monitoring points assigned to each WFD objective, the quality elements to be monitored and frequency of monitoring. The monitoring programmes, in particular the operational and investigative programmes, require a certain degree of flexibility for change in order to respond rapidly to events and in the light of results obtained. The findings of a number of Programmes of Measures and Standards (POMS) studies to resolve areas of the Article V Characterisation where uncertainty exists may influence the choice of particular sites for particular pressures. Thus, the operational monitoring network has to be somewhat dynamic and subject to change when new information becomes available in order to provide optimal support for programmes of measures. At all times the most up to date version of all the monitoring networks will be available online. The EPA will co-ordinate all additions, removals or other changes found to be necessary by public authorities in the course of the day-to-day operation of the monitoring programme. It is essential that all changes made by public authorities involved in the monitoring programme are notified to the EPA and discussed in advance to ensure that essential elements of the monitoring programme are not compromised, especially where national WFD reporting obligations to Europe are concerned. This applies particularly to Surveillance and Operational Monitoring while the location of investigative monitoring sites is essentially a local matter. The SM network will be a more static network, unlikely to change in the short term, particularly where objectives of long term trend monitoring are concerned. The Investigative Monitoring programme is by nature flexible and does not require a definitive list of monitoring points although it is important that all investigative monitoring results should be reported upon.

At present, a number of existing monitoring programmes are carried out on rivers by various agencies, tasked with meeting existing EU and national legislative requirements. Examples of this monitoring include OSPAR, Eurowaternet, Dangerous Substances, Freshwater Fish Directive, Phosphorus Regulations, hydrometric monitoring and national river water quality monitoring. Currently, around 3200 sites are surveyed for biological quality (Q-value) and 2500 sites for physico-chemical quality.

The WFD programme has between 2500 and 3000 biological sites covering all the rivers depicted on the Ordnance survey catchment map of Ireland. The ecological monitoring will include a full suite of biological quality elements at all the SM sites and a reduced suite in the operational monitoring programme sites. In addition there are 1000-1500 main-stem channel physico-chemical monitoring sites in the SM and OM

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

programmes that overlap with the ecological assessment sites. Thus, not all operational monitoring sites will require physico-chemical monitoring – this will apply particularly at those sites that are included in order to monitor the effectiveness of measures aimed at retaining High and Good status where it currently exists. The third part of the programme is a rolling programme of catchment investigative monitoring aimed at pinpointing sources of pollution in river water bodies that do not have main-stem monitoring locations. Such water bodies nonetheless feed into the main river channels and may have an impact on the status of the main channels. The status of main channel sites will be reported to Europe as one of the major outputs from the WFD monitoring programme. Where the reason for less than good status or for declining status is known and measures have been implemented main-stem monitoring will generally be sufficient. In cases where the source of the problem is not obvious, however, rolling programmes of catchment coverage will be essential in order to pinpoint the source of the problem and enable targeted measures to be put in place. The Article 5 Characterisation report identified a large number of river water bodies that were gauged to be at risk from diffuse pollution. Such waterbodies will be targeted as part of this investigative programme.

The WFD network for rivers emphasises the need for monitoring to support measures aimed at preventing pollution and other threats to the ecological status of rivers. Thus as well as a set of fixed monitoring points belonging to the Surveillance and Operational Monitoring networks the programme places a considerable degree of emphasis on the need for rolling programmes of catchment investigative monitoring in order to support the interpretation of results of the main channel monitoring.

Insofar as is possible all existing statutory monitoring is incorporated into the WFD network and all existing statutory monitoring will continue as part of the WFD monitoring. Thus a river monitoring location in either the Surveillance or Operational Monitoring Programme may belong to a number of different subnets – those specific to the aims and needs of the WFD itself but also fulfilling the requirements of other statutory monitoring programmes. The dynamic tables detailing the individual monitoring locations make this approach clear and they enable anyone viewing the tables to see exactly what monitoring is undertaken at any particular location listed in the programme. The suite of quality elements, biological and chemical together with the required analytical determinands and frequency of monitoring is provided in the tables. As indicated these will be kept up to date on a continual basis in response to the changing needs of programmes of measures and in response to, for example, individual pollution events and changing status of river water bodies.

7.2 River Surveillance Monitoring (SM) Network

The overall objectives of the Surveillance Monitoring are specified in the text of the WFD (Chapter 2, Table 2.1). There are four main objectives for SM and a number of stipulated types of monitoring points that must be included in the SM programme.

The design of the Irish Surveillance Monitoring network is based on key sub-networks (or 'subnets') each designed to fulfil one or more of the main objectives of SM. These are described in greater detail below and lists of monitoring sites are given in the online appendices to this programme (Appendix 7.1)[1].

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

Four principal sub-networks or 'subnets' are outlined here together with a number of overlapping minor subnets designed to match other national and international monitoring requirements:

7.2.1 River SM Subnet 1 - 'Representative' Subnet for Status

Aim of subnet: This subnet is designed to be representative of the overall surface water status as per the WFD stated requirement: 'surface water bodies to provide an assessment of the overall surface water status within each catchment or subcatchments within the river basin district'.

Subnet Size: This network has 188 sites nationally (Appendix 7.1)[1] for the most up to date details of monitoring points and breakdown within RBDs and).

Location of Monitoring Points: Representative sites are distributed evenly within the RBDs and selected to be representative of status within RBD. They also give a good representation of different river types and pressures within catchments. The overall proportional breakdown for the status of sites within this subnet is intended to match the overall water status within Irish RBDs.

Quality Elements: All the biological elements are monitored and supporting elements: physico-chemical, hydromorphological, priority substances and other pollutants appropriate to the individual water bodies are monitored in this Surveillance Network subnet. The precise list of quality elements is indicated in Appendix 7.1 [1]

7.2.2 River SM Subnet 2 - Long-Term Trend Monitoring

Aim of subnet: This subnet is designed for detection of long-term trends as per WFD requirement **-** 'the assessment of long-term changes in natural conditions, and the assessment of long-term changes resulting from widespread anthropogenic activity.'

Subnet Size: This subnet includes a reduced set of 30 monitoring points that are sampled at higher frequency than other SM sites in order to provide reliable and sensitive detection of long-term trends.

Location of Monitoring Points: This subnet includes 10 high status sites of different types aimed particularly at providing early warning of long-term anthropogenically influenced trends and of natural variation over time. It also includes 5 Flux stations or load monitoring stations located on major riverine tributaries to lakes. It also includes a set of marine flux stations - OSPARCOM sites. It also includes sites aimed at assessing long-term trends in diffuse pollution. It will also include a small number of groundwater surface water flux sites aimed specifically at monitoring interactions between surface and groundwater.

Quality Elements: All the biological elements are monitored and supporting elements: physico-chemical, hydromorphological, priority substances and other pollutants appropriate to the individual water bodies are monitored in this Surveillance Network subnet. The detailed list of quality elements for this subnet is indicated in Appendix 7.1 [1]. Frequency of monitoring is also listed

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

7.2.3 River SM Subnet 3 - Supplementing and Validating the Risk Assessments

Aim of Subnet: Supplementing and validating risk assessments particularly at those sites where the degree of uncertainty is greatest as per the WFD requirement - "supplementing and validating the impact assessment procedure detailed in Annex II".

Size of Subnet: This subnet includes a fixed percentage of RWBs in the four major risk categories as identified in the Article 5 Characterisation Report. The number of monitoring points is weighted towards the less certain risk categories i.e. the 'probably at risk' (1b) and 'probably not at risk' (2a). Thus, the subnet includes approximately 6% of RWBs that are 'probably at risk' (1b) and 6% of those that are 'probably not at risk' (2a) - i.e. just over 1 in 20 of these where the risk assessment is less certain will be validated. In addition a smaller number of 1a and 2b sites will be included. As risk assessments are improved, however, with further characterisation and ongoing monitoring, the size of this subnet will decrease.

Location of Monitoring Points: Sites within this subnet are distributed throughout RBDs in proportion to risk categories especially representing the RWBs where the risk category requires to be further validated. The monitoring points also represent the range of pressures identified in the Article 5 report.

Quality Elements: All the biological elements are monitored and supporting elements: physico-chemical, hydromorphological, priority substances and other pollutants appropriate to the individual water bodies are monitored in this Surveillance Network subnet. The precise list of quality elements is indicated in Appendix 7.1[1]

7.2.4 River SM Subnet 4 - Stipulated Rivers

Aim of Subnet: To explicitly include those categories of RWB that are specifically stipulated in the text of the WFD. This includes rivers mentioned in the main text of the WFD as follows for surface waters generally (Table 7.1)

Table 7.1 WFD Stipulated Sites

WFD text stipulating certain river types and locations
1. the rate of water flow is significant within the river basin district as a whole; including points on large rivers where the catchment area is greater than 2500 km^2,
2. the volume of water present is significant within the river basin district, including large lakes and reservoirs,
3. significant bodies of water cross a Member State boundary,
4. sites are identified under the Information Exchange Decision 77/795/EEC, and
5. at such other sites as are required to estimate the pollutant load which is transferred across Member State boundaries, and which is transferred into the marine environment.

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

Size of Subnet: The RWB SM programme includes river sites under the following headings:

4 x Large rivers with catchments over 2500km^2 in area

10 x sites representing the large rivers within each RBD

5 x sites for the significant cross border rivers

4 x existing Exchange of Information Sites

20 x sites representing the major OSPARCOM marine flux sites

Location of Monitoring Points: The locations as described above are shown in detail in Appendix 7.1[1]

Quality Elements: All the biological elements are monitored and supporting elements: physico-chemical, hydromorphological, priority substances and other pollutants appropriate to the individual water bodies are monitored in this Surveillance Network subnet. The precise list of quality elements is indicated in Appendix 7.1

7.2.5 Other Overlapping Subnets

Within the structure of the above subnets the SM programme also includes the following overlapping subnets - overlapping in the sense that they will also be contained in one or more of the four principal subnets above.

Eurowaternet (EIONET) sites,

Surface water / groundwater interaction sites,

River Lake interaction sites - Lake flux sites to measure nutrient loading to some major lakes e.g. Conn, Derg, Ree, Sheelin, Leane

Selected reference condition (e.g. RivType Project) sites to ensure that sufficient of the highest status RWBs are included (important for detection of long-term natural trends as per CIS Monitoring Guidance)

The 23 Irish river sites listed in the official WFD Intercalibration Register, published as a decision of the EU Commission on 19 September 2005. (Note that future revisions of this register may include many hundreds of new sites and not all of these will be automatically included in the Surveillance Monitoring Programme.)

Selected NPWS Protected Area sites - see also OM programme. NPWS nominated certain high quality sites based on distribution of the fresh water pearl mussel (*Margaritifera margaritifera*) which were included in the SMN.

Priority was also given to sites currently monitored under the Salmonid Regulations in the site selection process. Individual monitoring points may be included in one or more of the main subnets.

7.2.6 Design of Future River Monitoring Networks

This is an important objective of the SM programme. It does not require a specific set of sites or subnet, as in the case of other objectives of SM, but is taken here to refer to the network as a whole. As the SM programme proceeds and status is assigned to river water bodies, those which are shown to be of less than good status at any point in the programme may be added to the operational monitoring programme if they are not already included there. This does not necessarily mean that they have to be dropped from the SM programme, as it is essential to maintain continuity in, for example, the long-term trend monitoring subnet. It is obvious too that it is necessary to maintain a representative selection of sites, which mirror the overall surface water status in each RBD. It is envisaged that the detailed results from monthly sampling of priority substances will also inform the design of future monitoring.

The results from the SM network will be used at the end of each RBMP cycle to revise the overall network. The document entitled "Reporting Sheets for Reporting Monitoring Requirements" (DGENV and Littlejohn, 2005) states "The Directive allows for monitoring programmes to be amended during the period of the river basin management plan, and between RBMP cycles." Thus, it is not essential to wait until the end of a River Basin Management Plan (RBMP) cycle to change the location of sites or to increase or decrease the number of monitoring points. It is envisaged that, for example, the subnet for supplementing and validating the risk assessment will be reduced as time goes by as the risk factors affecting the status of RWBs becomes clearer on foot of the monitoring results. If a site is found to be unsuitable for the purpose intended following initial monitoring, it is proposed to replace such a site with a new one, ideally within the same RWB. Similarly, alterations in the range of quality elements or changes to the frequency of monitoring are possible where such a course is dictated by emerging data from the core monitoring programme and in response to other related sources of information such as ongoing risk assessments. All such requests for changes to the Surveillance Monitoring network must, be referred to the EPA for approval and in order that the central online database of WFD monitoring sites can be updated (Appendix 7.1[1]).

The long-term trend subnet is likely to point up potential new threats to water status - e.g. climate change or other as yet unforeseen pressures or impacts and this may suggest revision of the overall network for future RBMP cycles. Similarly, the WFD allows revision of the SM where the monitoring shows that a water body has reached good status.

7.2.7 Quality Elements for Rivers SM Programme

The quality elements for SM are clearly designated in Annex V of the WFD - see Table 7.2 below.

Table 7.2 WFD Quality Elements

WFD text concerning the selection of quality elements for monitoring
"Selection of quality elements Surveillance monitoring shall be carried out for each

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

WFD text concerning the selection of quality elements for monitoring
monitoring site for a period of one year during the period covered by a River Basin Management Plan for: - parameters indicative of all biological quality elements - parameters indicative of all hydromorphological quality elements - parameters indicative of all general physico-chemical quality elements priority list pollutants which are discharged into the river basin or sub-basin and - other pollutants discharged in significant quantities in the river basin or sub-basin Unless the previous surveillance monitoring exercise showed that the body concerned reached good status and there is no evidence from the review of impact of human activity under Annex II that the impacts on the body have changed. In these cases, surveillance monitoring shall be carried out once every three River Basin Management Plans."

7.2.8 Biological elements for SM River Monitoring

The macroinvertebrate component of the Irish Quality Rating System has been intercalibrated with biological indexes from a wide range of other European countries as part of the Northern Intercalibration Group in particular but also with the Central/Baltic Intercalibration Group. The Quality Rating system is based primarily on macroinvertebrates but also incorporates phytobenthos and macrophytes in the overall Q-Value. Individual metrics will be applied to each biological quality element before recombining and classifying river sites into one of five status categories.

Macroinvertebrates

The macroinvertebrate component of the Quality Rating System or Q-Value system (the Irish National assessment system), disaggregated from the overall Q-Value, and expressed as an EQR ranging from 0 to 1 will be used to assess macroinvertebrate taxonomic composition and abundance, the ratio of disturbance sensitive to insensitive taxa and the diversity of the community. This component of the Q-Value has been intercalibrated in the Northern Geographic Intercalibration Group of the WFD intercalibration exercise and also in the Central Baltic Geographic Intercalibration Group.

Macrophytes and Phytobenthos

The NSSHARE CBAS Index (Dodkins, 2005) which is a metric of taxonomic composition will be supplemented by a metric which measures the average macrophytic and phytobenthic abundance. This latter is was previously included in

the overall Q-Value Index TDI, DARES and French diatom index will be trialled and assessed for suitability in Irish rivers and as part of the ongoing WFD intercalibration exercise.

Fish

Fish populations vary temporally and spatially, on a river water body basis due to the mobility of fish. Community composition is determined to a large degree by hydromorphological factors (physical features of the river channel, depth and flow rate etc.) but stock viability and community structure are also influenced by environmental conditions. Consequently representative reaches for assessing fish communities in river water bodies as a whole may not always be precisely the same as the sites selected for the purposes of physicochemical, hydrometric or other biological element monitoring. They will, however, be linked to the nearest appropriate site on the river of similar type and affected by similar pressures.

A range of potential metrics for assessment of fish populations in rivers have been devised based on a large-scale research project that examined the relationship between fish and water quality in some 500 river sites. Ireland is also involved in the European intercalibration effort for fish assessment. Fish assessment metrics may also include Ecoregion 17 variations of e.g. Fame II and modelled relationship between fish populations and water quality in Irish rivers and other systems under development as part of a European intercalibration. The low number of native fish species in Ireland requires special care when extrapolating assessment schemes from continental Europe to Irish waters.

Phytoplankton

Because most Irish rivers have a residence time too short to allow for a true phytoplankton population to develop, phytoplankton sampling will only be carried out on a small number of larger rivers where the residence time is judged to be sufficiently long. (Phytoplankton populations in rivers downstream of lakes with will be inferred from the lake monitoring programme)

7.2.9 Physico-chemical elements for River Monitoring

Standard grab-sampling will continue to be the mainstay of the physico-chemical monitoring network.

Automatic samplers will be used at the major flux sites and some core long-term trend sites in order to provide detailed initial understanding of nutrient and sediment loading patterns. Daily sampling may be required - time weighted or in certain cases flow-triggered sampling for flow-weighted sampling to account for high flow periods that yield large sediment or nutrient loads for example.

Continuous electronic monitoring of parameters such as conductivity, turbidity, temperature, and dissolved oxygen with telemetry to public websites will supplement the SM monitoring (although this will be more important in the OM programme). Results to be judged against EQSs set for the individual determinands.

Guidance on determinands and analytical methods will be developed by the National Monitoring Group and others

7.2.10 Priority Substances to be Monitored in Rivers

Annex X substances monthly for one year during the cycle. Other PS identified within the catchments of SM sites will also be included. Future monitoring will depend on the outcome of the initial phase. (The daughter directive on dangerous substances will also influence the ongoing monitoring for PS perhaps requiring revisions in the medium term). See Appendix 2.1[1] for the list of priority substances to be monitored.

Priority Substances discharge in the river basin or sub basin upstream of water body (initially all Annex X substances will be analysed for at Surveillance Monitoring Sites). As monitoring data and screening data become available it may be possible to determine that certain substances listed in Annex X are not discharged in a particular river basin or sub-basin.

7.2.11 Other Pollutants to be Monitored in Rivers

Other pollutants listed in Annex VIII. Guidance on precise lists within individual catchments and water bodies will be developed in line with international best practice and the results of current screening programmes. (Appendix 2.1[1])

7.2.12 Hydromorphological Monitoring in Rivers

Hydrometric Programme

The Hydrometric Programme is made up of hydrometric stations operated, inter alia, by the Office of Public Works (OPW), Electricity Supply Board (ESB) and the Local Authorities/Environmental Protection Agency. In this programme, there are two categories of station:

> (1) rated and unrated staff gauge locations. Flow data can be provided at rated staff gauge locations if it is read at the time of water quality sampling. Unrated staff gauges are intended for reading at times of flooding and normally flow data cannot be provided at unrated staff gauge locations.
>
> (2) rated and unrated data logger stations. Daily mean flows and flow data for the remainder of the year at the rated stations can be provided based on the processing of the data logger values. Unrated data logger stations can provide data on water levels (generally flood levels) only.

The locations in the National Hydrometric Programme represents a good network for selecting stations for the Surveillance Monitoring Programme, in accordance with the requirements of Article 7 and 8 of the WFD (Fig. 7.1). Also in accordance with the requirements of Article 7, a number of additional stations may be erected on bodies of water intended for future abstraction.

At the power stations operated by the ESB on the major rivers in the country (Rivers Erne, Lee, Liffey and Shannon), the ESB will be able to supply daily mean flow data on the day of sampling and flow data for the remainder of the year. At the other locations where sampling will be carried out, it is proposed that the nearest rated staff gauge be read at the time of water quality sampling. The EPA will draw up rating curves for these locations and will provide flow data at the time of water quality sampling. Flow data throughout the remainder of the year will be provided at the nearby rated recorder station.

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

At a number of data logger stations, the current rating curves are unsatisfactory for the estimation of flow and channel controls will have to be erected in order to (1) stabilise river channel conditions or (2) overcome weed growth. This will allow a good rating curve to be developed. The stations at which channel controls are to be erected will be constructed on a phased basis, with the priority being decided based on the loading on a particular river.

Phone links to data loggers have been erected at a number of priority sites by a number of local authorities (Cork County Council, Dublin City Council and Kildare County Council) and by the ESB. It is hoped that these phone links can be developed further so that stations furthest from the EPA regional offices can be interrogated, and current flow conditions ascertained, prior to the dispatch of staff to a particular site to take a calibration measurement.

The EPA has commissioned a computer model based on flow duration curves (FDC) of hydrometric stations. The EPA will prepare (1) a set unitised FDC's for a number of geographical regions and (2) a GIS protocol that will allow the user to estimate the catchment area and the long-term average rainfall at a particular point in a catchment.

If a person wishes to get an FDC for a particular location in a catchment, using the rainfall and catchment area ascertained in the previous stage and multiply the relevant unitised FDC for this region by the area and rainfall to this point. This will give you a flow duration curve for the ungauged location.

The EPA has also purchased a computer package called WISKI WEB PUBLIC that will allow anyone to download selected flow data from the EPA web site. It is proposed that this will be rolled out in 2006.

Hydromorphology and Continuity

Hydromorphology will be monitored on a 6-year cycle combining remote sensing, GIS analysis and field measurements.

A range of research projects have developed metrics to describe the hydromorphological characteristics of rivers and lakes. A National Expert Committee is tasked with devising an assessment system based on a range of such metrics for judging the hydromorphological condition of rivers particularly as they support ecological status.

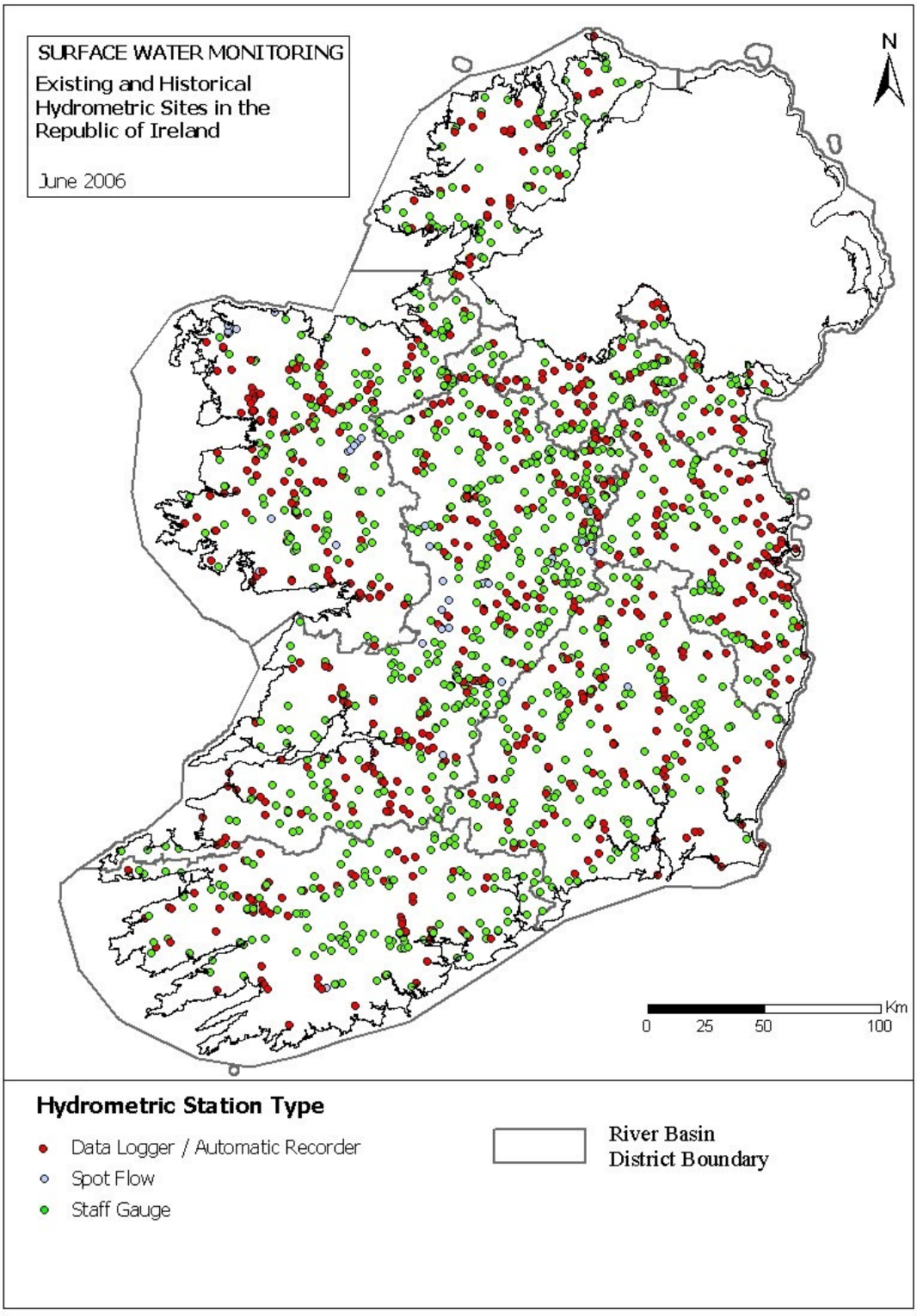

Figure 7.1 Location of hydrometric stations in Republic of Ireland.

7.3 Rivers Operational Monitoring (OM) Network

7.3.1 Introduction to the Rivers OM Programme

The WFD requires Operational Monitoring (OM) primarily in support of measures aimed at achieving the main objectives of the WFD - attainment of at least good status in water bodies that are less than good at present and also to retain high and good status where it exists at present. The success of the WFD depends crucially on the Programmes of Measures (POM) implemented in the RBDs. The Operational Monitoring (OM) Programme outlined here is focussed on support of POM - it is designed to provide highly targeted information on the success or otherwise of particular measures within catchments.

OM is obviously required where pollution or other impacts on ecological status are apparent. Crucially, however, because the protection of high and good status are such high level objectives of the WFD, OM must also provide information on whether the POMs aimed at maintaining high and good status are effective. Thus, even waterbodies which may not be deemed to be at risk in the Characterisation Report prepared under Article 5 of the WFD may be included in the OM programme because measures are required to maintain them at their current high or good status regardless of existing risk status.

The OM programme for rivers has over 1100 joint physico-chemical/ecological monitoring points on Irish RWBs. In addition a further 1600 sites are included for ecological monitoring alone (OM Subnet 4). This programme is designed to be flexible in order to respond to changes within catchments that impact on water status.

The OM programme for rivers incorporates all of the 188 sites contained in the SM programme - the SM network is a subset of the OM network.

The Irish OM has six separate subnets aimed at monitoring particular aspects of POMs and providing feedback for the national EMS system within RBMPs.

7.3.2 Rivers OM Subnet 1: Monitoring of the Effectiveness of Point Source Measures

Aim of Subnet: Monitoring to assess whether the measures aimed at improving the impact of individual and combined point sources are successful. This includes assessment of ambient levels of organic pollution, eutrophication impacts and priority substances.

Subnet Size: Over 600 river water bodies were placed at risk due to point source pressures. Some 800 monitoring points were initially allocated for this purpose, with 671 being selected.

Location of Monitoring Points: The aim of the POMs for point sources is to achieve good status in rivers downstream of discharges. Thus, in theory at least, one sample point downstream of a point source may be sufficient to tell whether a RWB downstream of a point source is at good status or not and thus, whether measures being implemented are effective. If, however, other impacts either diffuse or point

source, located upstream of a point source of interest are also affecting status in the river then control monitoring sites upstream of the original point source may be needed to disentangle the impact of different pressures and the effectiveness of the POMs.

With regard to multiple point sources, for example, in towns or cities, the text of the WFD states clearly that in designing OM programmes representative monitoring points may be used to assess the combined impact of a number of point sources.

7.3.3 Rivers OM Subnet 2: Monitoring of Effectiveness of Diffuse Pollution Measures

Aim of Subnet: To assess effectiveness of diffuse pollution control measures.

Subnet Size: Diffuse pollution risk was the predominant risk to water status identified in the Article 5 Characterisation Report published in December 2004. Some 565 monitoring sites are designated for assessment of diffuse pollution control measures within this subnet. The subnet is further subdivided based on the pressures outlined in the National WFD Article 5 Characterisation Report.

Location of Monitoring Points: The location of monitoring points within this subnet are shown in Appendix 7.1[1]. Currently not all Irish RWBs identified in the Article 5 report are monitored and some aggregation is required in order to provide effective monitoring. Aggregation of water bodies by type and pressure is undertaken to gauge the effectiveness of measures that are implemented on a wide scale.

7.3.4 Rivers OM Subnet 3: Monitoring of Effectiveness of Measures to reduce Hydromorphological pressures-

Aim of Subnet: To assess effectiveness of measures to reduce hydromorphological pressures and impacts

Subnet Size: Hydromorphological risk was an important source of risk to water status identified in the Article 5 Characterisation Report published in December 2004. Some **200** [to be confirmed] RWBs are designated for assessment of measures to reduce hydromorphological risk.

Location of Monitoring Points: As hydromorphology monitoring is a new component of the national monitoring programme, the locations of these sites will be identified in early 2007 by a POM study that is addressing hydromorphological pressures and survey techniques.

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

7.3.5 Rivers OM Subnet 4: Monitoring of the Effectiveness of Measures aimed at retaining High and Good status RWBs

Aim of Subnet: To monitor high and good status sites currently not deemed to be at risk in order to assess the effectiveness of POMs aimed at maintaining high and good status sites.

Subnet Size: Approximately 1600 monitoring points for biological assessment. High status water bodies will require additional hydromorphological and physico-chemical quality elements to confirm high status. These elements will be defined following completion of the intercalibration exercise and POMS studies on Water Quality Standards.

Location of Monitoring Points: This subnet will include representative sites of high and good status rivers located on all major RWBs included in the OS River Basin of Ireland map. It is likely that Q5 and Q4/5 will represent high status sites, and Q4 good status sites, but this may change depending on the final outcome of the WFD intercalibration exercise.

7.3.6 Rivers OM Subnet 5: Species and Habitat Protected Areas

Aim of Subnet: To monitor Species and Habitat Protected Areas that are at risk.

Text from Article 1.3.5 of Annex V
"Habitat and species protection areas Bodies of water forming these areas shall be included within 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 under Article 4. 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 requirements of the legislation under which they are designated and meet their objectives under Article 4."

Size of Subnet: Terms of reference for the selection of the appropriate representative monitoring points within protected areas will be developed and the subnet confirmed later in the year. This will define the size of the subnet as large SAC/SPA areas for example, may require multiple representative monitoring sites. Where possible, sites already being monitored in existing networks will be nominated, with the inclusion of appropriate extra determinands as required.

Location of Monitoring Points: The protected areas requiring monitoring are summarised in the Article V Characterisation Report and consist of SAC's and SPA's with particular sensitivity to water related issues, waters containing significant economic species e.g. salmon and drinking water abstraction catchments. Site locations will be confirmed when the terms of reference are completed. Appropriate POMS studies outputs may inform this process. Drinking water abstractions are referenced in section 1.4.7.

7.3.7 Other Overlapping Subnets

As it is envisaged that the WFD Monitoring Programme should encompass most river monitoring activities other legal requirements governed by other directives or for other national or international agreement purposes should be included in the programme. Significant numbers of such sites are included in the Surveillance Monitoring network but others may be included in the Operational Monitoring Network. Thus, within the structure of the above subnets the OM programme also includes the following overlapping subnets - overlapping in the sense that they may also be contained in one or more of the principal subnets above. Examples include:

- Surface water / groundwater interaction sites,
- River Lake interaction sites - Lake flux sites to measure nutrient loading to some major lakes.
- Selected reference condition (e.g. RivType Project) sites to ensure that sufficient of the highest status RWBs are included (important for detection of long-term natural trends as per CIS Monitoring Guidance)
- Sites listed in the official WFD Intercalibration Register.
- Selected NPWS Protected Area sites
- Sites identified under the Dangerous Substances Directive Regulations, Urban Waste Water Regulations, Phosphorus Regulations

7.3.8 Quality Elements and Determinands for OM Programme

Biological elements

Macroinvertebrates, Phytobenthos, Macrophytes and Fish as described in section 7.2.8.

Physico-chemical elements

The WFD specifies a range of physico-chemical elements that are required to support the biological elements. It is likely that a core range of determinands will be monitored at each site, with an additional selection inserted where appropriate to be representative of the specific dominant pressure at that sample location. The generic list of physico-chemical determinands includes temperature, dissolved oxygen, BOD, salinity, conductivity, hardness, chloride, phosphorus, nitrogen, silicon, pH and alkalinity. It is possible that not all determinands need be monitored at each sample location, and that the selection of determinands will reflect the dominant pressures. Clarification will be sought and provided regarding the status of similar determinands such as alkalinity/hardness and salinity/conductivity for example. This will also apply to the appropriate form of determinands such as phosphorus.

Priority Substances

Some of the sites within the point and diffuse sub-nets may require some priority substances (as listed in Annex X) sampling to be undertaken. These substances will be identified as being specific to activities or pressures identified as being dominant at that sample location. Pressure based sub-net elements that may include some elements of PS monitoring may include pesticides from arable farming, forestry and sheep dip, specific process based substances from IPPC and section 4 activities, as well as those from WWTPs with significant trade effluent inputs. POMS working groups are investigating these factors in more detail and their findings will guide the eventual list of selected determinands. Further screening using biological metrics might also be appropriate in confirming those sites which require further chemical monitoring.

Other Pollutants

A range of other pollutants (as listed in Annex VIII) must be measured if they are discharged in significant quantities within a river basin or sub-basin. It is not always possible to

The range of quality elements that are selected in the OM programme are selected to be those most sensitive to the dominant pressure. For example, for acidification from forestry, biological and physico-chemical quality elements may be selected. Within those quality elements, specific determinands or parameters will also be selected to represent the potential impacts of the pressure. For example, benthic invertebrates (biological Q.E) and pH, alkalinity and aluminium (physico-chemical) may represent appropriate determinands.

Priority substances will be monitored where they are discharged to the catchment in significant quantities. The identification of these substances and assessment as to their presence in significant quantities, will be defined by the outputs of the current National Dangerous Substances Screening programme and the development of suitable environmental quality standards(EQS). This programme was reported to the commission and DEHLG in reporting sheets SWPI8 and GWPI10 concerning Gaps and Uncertainties.

Hydrometric Monitoring

The locations in the National Hydrometric Programme represent a good network for selecting stations for the Operational Monitoring Programme, in accordance with the requirements of Article 7 and 8 of the WFD. Also in accordance with the requirements of Article 7, a number of additional stations may be erected on bodies of water intended for future abstraction.

At the locations where sampling will be carried out, it is proposed that the nearest rated staff gauge be read at the time of water quality sampling. The EPA will draw up rating curves for these locations and will provide flow data at the time of water quality sampling. Flow data throughout the remainder of the year will be provided at the nearby rated recorder station.

Where data loggers have unsatisfactory ratings, channel controls will have to be erected in order to (1) stabilise river channel conditions or (2) overcome weed growth. The stations at which channel controls are to be erected will be constructed on a phased basis, with the priority being decided based on the loading on a particular river.

Hydromorphology

The requirements of the hydromorphological quality elements are being addressed as part of the POMS studies and will be incorporated into the National WFD monitoring network following the recommendations made.

7.4 Investigative Monitoring

The Investigative Monitoring Programme typically is one which does not have a fixed set of monitoring points as is obvious from the nature of its objectives. It is important, however, that when investigative monitoring is undertaken in response to pollution events that the results of such monitoring is reported upon as part of WFD national reporting programmes in order to assist other public authorities in the handling of similar problems or pollution events.

Table 7.3 WFD on Investigative Monitoring

WFD text concerning investigative monitoring
"1.3.3 Design of investigative monitoring Objective Investigative monitoring shall be carried out: - where the reason for any exceedances is unknown; - where surveillance monitoring indicates that the objectives set under 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; and shall inform the establishment of a programme of measures for the achievement of the environmental objectives and specific measures necessary to remedy the effects of accidental pollution."

7.4.1 Rivers IM Subnet 1: Investigation of unexplained exceedances and accidental pollution;

Aims of subnet: To understand the reasons for any unexplained exceedances and to ascertain the magnitude and impacts of accidental pollution;

Subnet size: Dependent on particular events or problems being investigated

Location of Monitoring Points: Not applicable

7.4.2 Rivers IM Subnet 2: Geographical/spatial Screening and Risk Assessment Subnet

Aim of subnet: To provide a more detailed geographical investigation of catchments by means of a rolling programme of snapshot catchment monitoring. This will help to inform the establishment of the programme of measures by enabling POMs to be aimed at the precise location of pollution problems within catchments. Investigative monitoring of this nature allows for ongoing refinement of POMs to ensure that they are targeted effectively. Widespread 'snapshot' sampling within waterbodies will identify the sub-catchments most at risk. Results will also be used to identify new permanent monitoring points within the other subnets of the OM and SM programmes. Wider geographical coverage than is possible with a fixed point monitoring network is essential when it is realised that over 70% of total channel length may not be monitored if first and second order streams are omitted. Omitting smaller streams may reduced the effectiveness of measures particularly for diffuse pollution. The risk of diffuse pollutants entering a river may be seen as proportional to the total length of the riverbank. Thus, additional geographical screening of 1st and 2nd order streams that comprise over 70% of total channel length in Irish rivers can assist in improved location of primary monitoring points and in more effective POMS. Similarly, a significant proportion of the river water bodies identified in the WFD Characterisation Report will not be included in the main SM and OM programmes . This approach to screening will provide at least some data on those RWBs not included in the main-stem programmes.

Subnet Size: This is a nation-wide rolling programme covering up to 25,000 individual monitoring points which covers all the 4000+ waterbodies identified in the WFD Article 5 Characterisation Report.

Location of Monitoring Points: All small streams within all identified waterbodies. Snapshot monitoring will be carried out in a small number of water bodies on any given day with the aim of giving an instantaneous picture of the risk of impact on water status associated with individual subcatchments. This is intended as a rolling programme of snapshot monitoring moving from catchment to catchment over time. This will include a large number of sites within a catchment in order to pinpoint potential sources of pollutants within sub-catchments and to verify that existing risk assessments provide a realistic assessment of the true risk. Local authorities will select the catchment based on similar methodologies used for the Small Streams Risk Score site selection criteria.

This risk programme will include separate physico-chemical **and** biological programmes. The biological programme will use rapid screening techniques such as the 'Small Stream Risk Score' approach developed by the WRBD and EPA for this purpose. This type of investigative screening methods cannot provide true 'status' assessments but rather a risk assessment that can be used to guide the location of main-stem monitoring sites and in the interpretation of the status information provided by the primary monitoring points on the surveillance and operational programmes.

In the case of the snapshot programme it is proposed to allocate 25% of the overall sample collection and physico-chemical analysis effort for water chemistry to this risk assessment subnet. In the case of the biological SSRS programme this will be undertaken mainly in winter and spring in order to maximise the reliability of the

biological risk score in identifying RWBs that are definitely at risk. An appropriate general suite of physico-chemical determinands is provided in Appendix 7.1[2].

7.4.3 Rivers IM Subnet 3: Electronic Alert and Screening Subnet

Aim of Subnet: To identify episodic pollution sources not identified by other subnets. Routine grab sample monitoring does not always coincide with actual pollution events in RWBs. Infrequent discharges of pollutants may be highly damaging to aquatic ecosystems but can be difficult to pinpoint in space and time using standard main channel river monitoring based on standard sample collection routes. Where discharges are constant, grab sampling is effective but many discharges are episodic and unpredictable in nature. Electronic alert networks - providing continuous measurement and telemetry of parameters such as conductivity, turbidity, DO, etc. will be used to provide alerts to potential pollution sources or pollution incidents. These will involve telemetry to a public website. Alerts generated will be used to direct RBD resources to solving problems within catchments through improved operational monitoring and more focussed programmes of measures.

Size of subnet: This subnet will be introduced on a trial basis in a number of catchments in order to assess the effectiveness of the approach. It is envisaged that a major catchment of 500 km^2 would have up to 100 individual low-cost nodes providing continuous data for a range of parameters. Results will be assessed in conjunction with high resolution spatial data emanating from e.g. chemical snapshot sampling of catchments, the biological small stream risk score and from remote sensing.

Location of Monitoring Points: The alert network should be flexible allowing for ongoing relocation of monitoring nodes depending on the results obtained from the network itself. Typically an alert network will start with a small number nodes located on the main river channel plus nodes on all major tributaries (of 3rd order or greater). Nodes can be relocated to provide greater spatial resolution when sufficient data are available to pinpoint tributaries that appear to have anomalous discharges within their catchments. In this manner an initial picture of both the temporal and spatial pattern of potential discharges can be built up. Such networks will help to modify the OM and SM programmes and the relevant POM for the catchments being monitored. Sufficient resources to enable the ongoing maintenance of such a network is a key to the success of this type of approach.

7.4.4 Rivers IM Subnet 3: Remote Sensing Subnet

Aim of Subnet: In addition to the temporal and geographical coverage provided by the snapshot and electronic alert networks, aerial photography used for hydromorphological assessments can provide additional screening for small point sources of pollution and visual verification of a wide range of catchment pressures. Satellite imagery can provide similar coverage albeit at lower resolution.

Size of subnet: The subnet for aerial photography will coincide with that of the hydromorphological network. Satellite imagery is available for complete RBDs at low

[1]Appendix 7.1 is available at: http://www.epa.ie/whatwedo/wfd/monitoring/programme/

resolution and should be used in conjunction with the aerial photography and the snapshot screening subnet.

Location of Monitoring Points: The RWBs surveyed will coincide with those chosen for hydromorphological purposes but additional investigative coverage may be necessary when particular catchments need more detailed surveys to discover the source of a particular problem.

7.5 Frequency of Monitoring

Sample frequency will vary depending on the monitoring programme and the individual subnets and the quality element. Basic requirements for quality elements are specified in the WFD (Table 7.2) and the WFD also outlines the minimum requirements for frequency of monitoring (Table 7.4). Long-term trend monitoring sites will require higher frequency sampling than for example, than those required for supplementing and validating the risk assessment or for general representative monitoring. Full details of the frequency of monitoring required for each of the individual river subnets are given in Appendix 7.1[1].

Table 7.4 WFD - frequency of monitoring

WFD text concerning frequency of monitoring
1.3.4 Frequency of monitoring "For the surveillance monitoring period, the frequencies for monitoring parameters indicative of physico-chemical quality elements given below should be applied unless greater intervals would be justified on the basis of technical knowledge and expert judgement. For biological or hydromorphological quality elements, monitoring shall be carried out at least once during the surveillance monitoring period."
"For operational monitoring, the frequency of monitoring required for any parameter shall be determined by Member States so as to provide sufficient data for a reliable assessment of the status of the relevant quality element. As a guideline, monitoring should take place at intervals not exceeding those shown in the table below unless greater intervals would be justified on the basis of technical knowledge and expert judgment."
"Frequencies shall be chosen so as to achieve an acceptable level of confidence and precision. Estimates of the confidence and precision attained by the monitoring system used shall be stated in the River Basin Management Plan."
"Monitoring frequencies shall be selected which take account of the variability in parameters resulting from both natural and anthropogenic conditions. The times at which monitoring is undertaken shall be selected so as to minimise the impact of seasonal variation on the results, and thus ensure that the results reflect changes in the water body as a result of changes due to anthropogenic pressure. Additional monitoring during different seasons of the same year shall be carried out, where necessary, to achieve this objective."

Quality Element	**Rivers**	**Lakes**	**Transition**	**Coastal**
Biological				
Phyto-Plankton	6 months	6 months	6 months	6 months
Other aquatic flora	3 years	3 years	3 year	3 year

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

WFD text concerning frequency of monitoring				
Macro invertebrates	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

7.6 Maps of River Surveillance and Operational Sites

Maps of river water body surveillance and operational sites on the day of publication are presented in Figures 7.2 and 7.3 below. See Appendix 7.1[1] for the most current version of the Rivers Monitoring Programme.

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

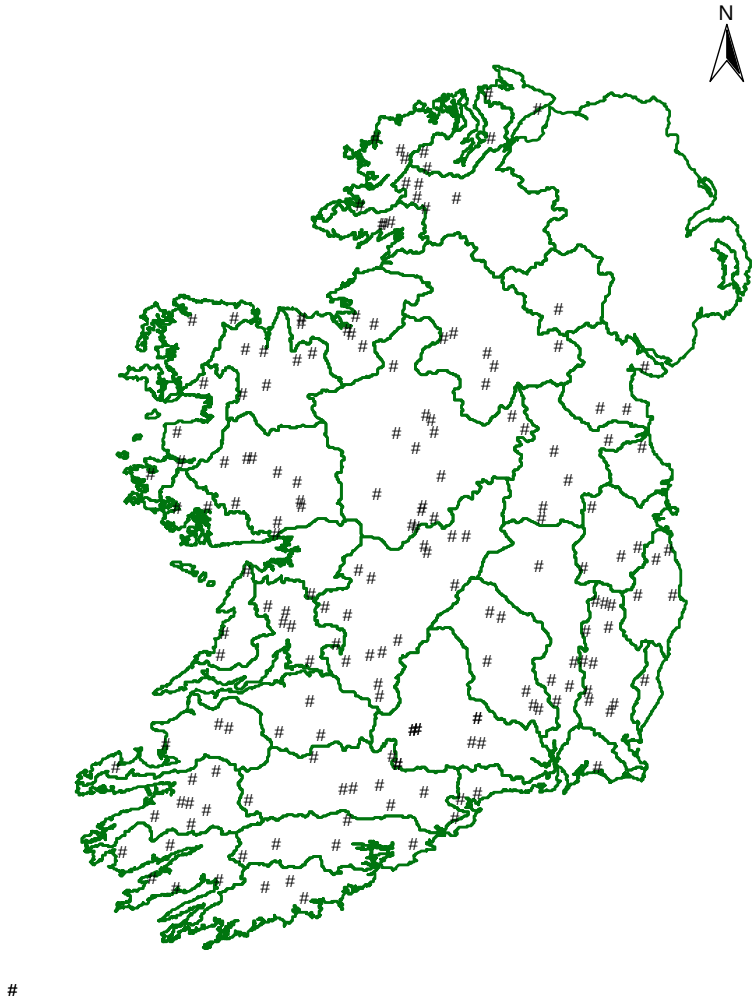

Figure 7.1 Surveillance Monitoring Sites for Rivers in the Republic of Ireland. (See Appendix 7.1[1] for the most current version of the SM Rivers Programme.)

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

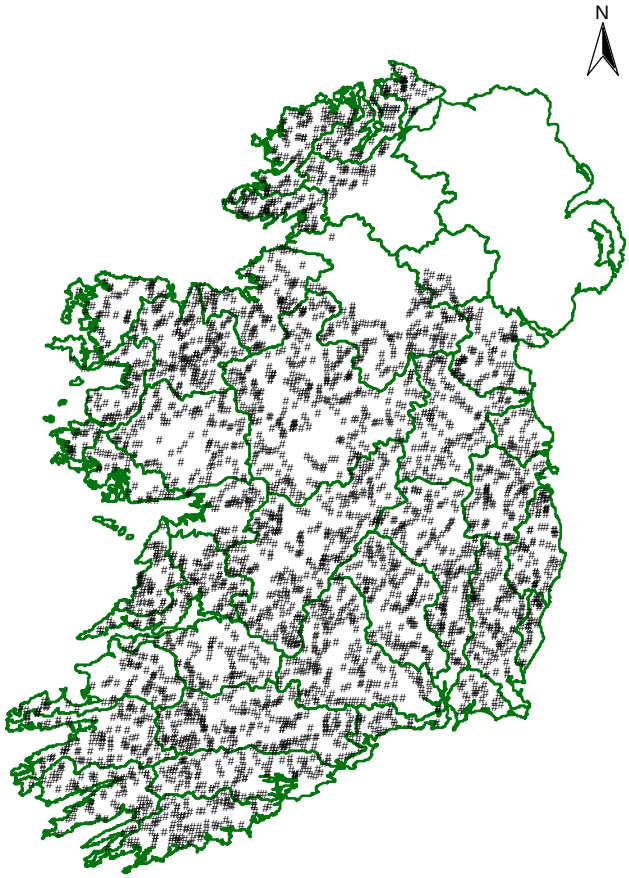

Figure 7.2 Operational Monitoring Sites for Rivers in the Republic of Ireland. (See Appendix 7.1[1] for the most current version of the OM Rivers Programme.)

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

Chapter 8 Lake Monitoring Programme

8.1 Introduction – Lake Monitoring Programme

This chapter describes the Water Framework Directive (WFD) Lake Monitoring Programme - Surveillance, Operational and Investigative Monitoring programmes -for Irish lakes. Lakes designated as potentially Heavily Modified Waterbodies (pHMWB) in the Article 5 characterisation report are included under this programme. . Subnets targeted at particular requirements of the WFD are outlined with their rationale and indicative size. Locations and details of the actual monitoring points are listed in Appendix 8.1[1] to this document. The monitoring frequency of the quality elements are described. The associated precision and confidence for lakes are described in Table 4.2 of Chapter 4.

There are 12,206 lakes in Ireland ranging in surface area from less than 1 ha to over 50 ha (Figure 8.1). The great majority of these are very small (< 1 ha) and many are inaccessible. For the purpose of the WFD monitoring programme (Surveillance and Operational) networks lakes were selected from the 745 lakes for which information was available or and which were used in the WFD Article 5 characterisation report[3] (Figure 8.2).

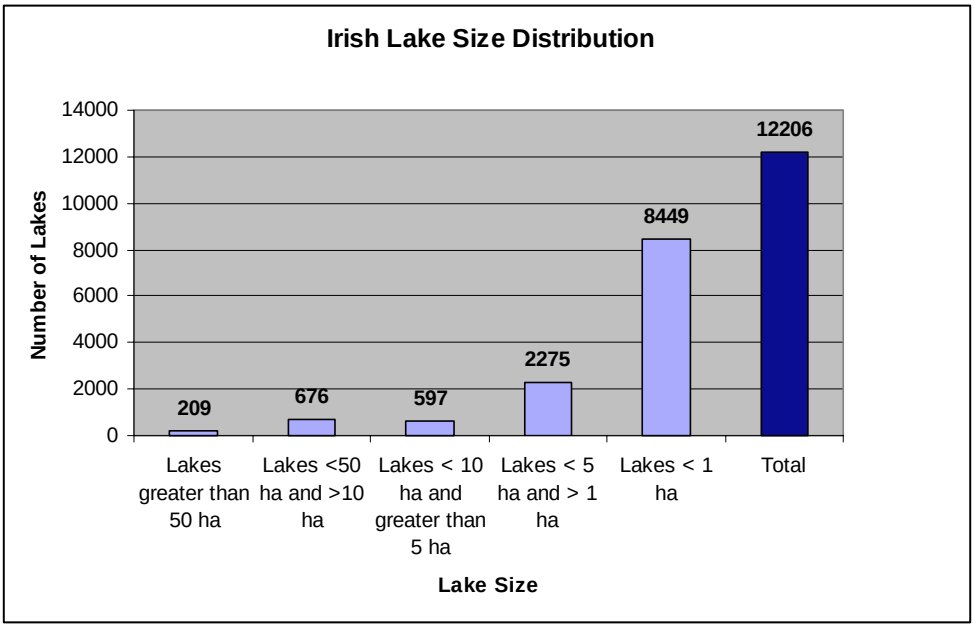

Figure 8.1 The distribution of Irish lakes by surface area.

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

[3] Article 5_The Characterisation and Analysis of Ireland's River Basin Districts, in accordance with Section 7(2 & 3) of the European Communities (Water Policy) Regulations 2003 (SI 722 of 2003), Summary Report on the Characterisation and Analysis of Ireland's River Basins.

Historically, monitoring of Irish lakes has been undertaken to a varying extent on 520 lakes. Such monitoring has been undertaken as part of the National Lakes Monitoring Programme, which commenced in 2000, and as part of investigations carried out under the EPA Environmental Research Technological Development and Innovation (ERTDI) Projects. In the period 2001 – 2003 some 492 lakes were examined[4]. The Monitoring programmes were established to provide the basis for assessment of the quality of Irish lakes and reservoirs and included all of the large and important lakes in the country.

Some remote sensing of Irish lakes was also undertaken by the EPA as part of a programme for largely inaccessible lakes. Although information was less precise than direct sampling the programme did provide some general indication of the quality of such remote lakes based mainly on chlorophyll a calculations.

The existing monitoring programmes were undertaken by the Local Authorities, Environmental Protection Agency and the Central and Regional Fisheries Boards with additional data provided by ERTDI research projects.

The WFD Lake Monitoring Programme is designed to reflect elements of existing monitoring programmes and the WFD's specific requirements. The Surveillance Monitoring (SM) Network comprises five subnets (Table 8.1 below).

The Operational Monitoring Programme is designed to establish the status of those waterbodies identified as being at risk of failing to meet the environmental objectives of the WFD, to monitor the effectiveness of measures for the protection of existing status and the restoration to at least good status for lake water bodies at Moderate or poorer status. It consists of five subnets (Table 8.2 below).

[4] Water Quality in Ireland 2001-2003, Environmental Protection Agency, Toner *et al.*, (2005)

Table 8.1 Surveillance Monitoring Networks.

Subnet	Subnet Type	Relevant Existing Monitoring Programme
Subnet 1	Representative Subnet for Status	Elements of all existing lake monitoring programmes Particular relevance to Dangerous Substances
Subnet 2	Long Term Trend Monitoring	Lakes under the Nitrates Directive (Directive 91/676/EEC) Lakes in Acid Sensitive Areas
Subnet 3	Supplementing and Validating the Risk Assessment	Elements of all existing lake monitoring programmes
Subnet 4	Stipulated lake water bodies	Elements of existing lake monitoring programmes
Subnet 5	Protected Areas	Elements of existing lake monitoring programmes and in particular: Freshwater Fish Directive Lakes (Water Standards for Freshwater Fish Directive 78/659/EEC) Bathing Waters Lakes (76/160/EEC) Surface water abstracted for Drinking Water (under Directive 75/440/EEC)

Table 8.2 Operational Monitoring Networks.

Subnet	Subnet Type	Relevant Existing Monitoring Programme
Subnet 1	Monitoring effectiveness of point source measures	Elements of all existing lake monitoring programmes Particular relevance to Dangerous Substances
Subnet 2	Monitoring of the effectiveness of Diffuse Source measures	Lakes under the Nitrates Directive (Directive 91/676/EEC) Lakes in Acid Sensitive Areas
Subnet 3	Monitoring of the effectiveness of Measures to reduce hydromorphological pressures	Elements of all existing lake monitoring programmes
Subnet 4	Monitoring of the effectiveness of measures for high and good status sites	Elements of existing lake monitoring programmes
Subnet 5	Monitoring of the effectiveness of measures for species and habitat protected areas	Elements of existing lake monitoring programmes and in particular Freshwater Fish Directive Lakes (Water Standards for Freshwater Fish Directive 78/659/EEC) EU Habitats Directive EU Birds Directive

Long term trend monitoring is included in the Surveillance Monitoring (SM) Programme as a specific subnet (2) but is also reflected in the Operational Monitoring (OM) Programme under the Point and Diffuse networks established to determine effectiveness of measures for impacts such as eutrophication.

The thirty lakes presently identified and monitored under the Nitrates Directive are included in the programme, with a representative number in the SM Programme and all in the OM Programme.

A representative subset of acid sensitive areas lakes is included under both the SM and OM Programmes, including Lough Veagh (Donegal), Maumwee (Galway) and Upper Lough (Glendalough, Co. Wicklow).

Lough Corrib, the only designated Freshwater Fish Directive Lake in the country, is included in both the SM and OM Programmes. However, other important salmonid and coarse fish lakes have been included in the overall programme including char,

salmon and trout lakes such as Kindrum, Gartan, Conn, Feeagh, Ballinahinch and Gill (Kerry), the important sea trout lake Currane and the coarse fish lakes Vearty, Monalty and Gowna.

The nine designated freshwater bathing water sites are located on seven lake water bodies. Of these four lake bathing sites are listed in the SM Programme and six in the OM Programme.

A representative subnet of water abstraction lakes are included in both the SM and OM Programmes.

Limited monitoring for Dangerous Substances has been undertaken in the past on lake water bodies. Significantly more intensive monitoring for Priority Action substances discharged into the RBD basins and Relevant Pollutants discharged in significant quantities will be undertaken as part of the SM and OM Programmes.

In addition a programme for monitoring of drinking water sources is also included to fulfil the requirements of the WFD.

The sampling frequency of lakes and range of quality elements monitored for lakes selected under the WFD Programme will be significantly higher than exists under current monitoring programmes.

Supporting quantitative elements, water level and flow, are important for the calculation of loads, for hydromorphology and for impact assessment of abstractions and other activities. The Directive specifically requires quantitative elements to be protected at high-status water bodies. These will continue to be monitored at the existing sites listed in the EPA Hydrometric Register of Hydrometric Stations. They will be used to transfer flow information from representative hydrometric sites to the quality sites listed below, with additional staff gauge measurement of water level at the surveillance quality sites. Some critical sites will be added to the hydrometric network. In addition, a representative set of hydrometric sites will be chosen for monitoring of sediment movement.

8.2 Monitoring Site Selection

The selection of lakes for inclusion in the SM and OM Programmes (Appendix 8.1[1]) was undertaken by an Expert Group from the EPA, National Parks and Wildlife, Central Fisheries Board and the Western RBD Project. The selection was based on the characterisation and risk analysis carried out as part of the Article 5 National Characterisation Report (www.wfdireland.ie). For the SM Programme selection was made on the basis of:

- Adequate representation of different lake typologies
- Adequate representation of different risk categories
- Adequate representation of different pressures

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

- Availability of long term records (from existing monitoring programmes)
- Expert knowledge

For the OM Programme the selection of lake water bodies was based on the risk analysis carried out as part of the Article 5 National Characterisation Report.

A major factor affecting the selection of lakes for the surveillance and operational monitoring networks was suitable access to enable the prescribed monitoring techniques to be undertaken. Many lakes are situated some distance from suitable road access and some are located within difficult terrain (i.e. access via steep slopes) or land type (i.e. deep peat). For these lakes, monitoring is not possible based on health and safety issues in relation to field monitoring operations requiring boat access and sampling.

A further complicating factor in attempting to achieve adequate representation of lake types is the lack of typology for a large number of lakes. Many lakes could not be typed due to lack of data on mean depth or alkalinity.

A total of 73 lakes have been selected for the SM Programme (see Figure 8.4) and 222 lakes have been selected for the OM Programme (see Figure 8.5). There is an overlap between the SM and OM Programmes with 63 lakes common to both. The overall WFD Lake Monitoring Programme includes a total of 232 distinct lakes.

8.3 Lake Surveillance Monitoring Network

The overall objectives of the SM are specified in the text of the WFD (Section 2.2, Chapter 2). There are four main objectives for SM and a number of stipulated types of monitoring points that must be included in the SM programme.

8.3.1 Lake SM Subnet 1 – 'Representative' Subnet for Status

Aim of subnet: This subnet is designed to be representative of the overall surface water status as per the WFD stated requirement: 'surface water bodies to provide an assessment of the overall surface water status within each catchment or sub catchments within the river basin district'.

Subnet Size: This subnet comprises all the 73 lake water bodies in the Surveillance Monitoring Programme.

Location of lakes : Representative sites are not distributed proportionately between RBDs with respect to the number of lakes within their boundary (Table 8.3) but are representative of status within the RBD and where possible giving a good representation of different lake types and pressures within catchments (Table 8.4). The overall proportional breakdown for the status of sites within this subnet should match the overall water status within Irish RBDs. (See Appendix 8.1[1] for details of monitoring points).

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

Table 8.3 The distribution of lakes (All), WFD lakes and SM lakes by River Basin District (RBDs).

RBD	All Lakes	Article 5 (WFD) Lakes Reported	SM	SM lakes as a % of All Lakes	SM lakes as a % of Article 5 (WFD) Lakes Reported
ERBD	552	26	5	0.9	19.2
NBIRBD	364	1	1	0.3	100
NWIRBD	1888	181	17	0.9	9.4
SERBD	1027	12	0	0	0
SHIRBD	1689	113	18	1.0	15.9
SWRBD	1057	90	7	0.7	7.8
WRBD	5629	322	25	0.5	7.8
Total	12206	745	73	0.6	9.8

Table 8.4 The distribution of WFD lakes by typology, and SM lakes by typology and risk category.

Typology*	Article 5 (WFD) Lakes	Number SM lakes	Risk Categories			
			1a	1b	2a	2b
0 - No Typology Available	566	1	0	0	0	1
1 - Low alkalinity, shallow and small	2	6*	0	0	0	6
2 - Low alkalinity, shallow and large	21	8	3	1	1	3
3 - Low alkalinity, deep & small	2	1	1	0	0	0
4 - Low alkalinity, deep & large	41	11	3	4	0	4
5 - Moderate alkalinity, shallow & small	5	3	1	0	0	2
6 - Moderate alkalinity, shallow & large	30	9	5	0	4	0
7 - Moderate alkalinity, deep & small	4	3	0	2	0	1
8 - Moderate alkalinity, deep & large	21	9	5	2	2	0
9 – High Alkalinity Shallow & Small	3	4*	0	2	0	2
10 – High alkalinity, shallow & large	26	9	2	4	2	1
11 – High Alkalinity Deep and Small	1	1	0	0	0	1
12 – High alkalinity, deep & large	23	8	5	2	0	1

(*) Note Lake typology updated since Article 5 National Summary Characterisation Report

Quality Elements: All the biological elements are monitored and supporting elements: physico-chemical, hydromorphological, priority substances and other pollutants appropriate to the individual water bodies are monitored in this SM subnet.

8.3.2 Lakes SM Subnet 2 – Long-Term Trend Monitoring

Aim of subnet: Detection of long-term trends as per WFD requirement – 'the assessment of long-term changes in natural conditions, and the assessment of long-term changes resulting from widespread anthropogenic activity.'

Subnet Size: This subnet includes is comprised of 24 lake water bodies of which 14 are susceptible to acidification pressure from atmospheric sources[5] as an example of

[5] Source – EPA

widespread anthropogenic activity and 21 reference lake water bodies[6] representing potential high status water bodies. It also includes 12 EOINET (EUROWATERNET) lake water bodies for which long-term data are available and which will serve to provide long term trend monitoring. These latter lakes form part of the Nitrates Action Plan Lake Monitoring Programme for sensitive areas.

Location of Monitoring Points: The locations of the sites in this subnet are detailed in Appendix 8.1[*].

Quality Elements: All the biological elements are monitored and supporting elements: physico-chemical, hydromorphological, priority substances and other pollutants appropriate to the individual water bodies are monitored in this SM subnet.

8.3.3 Lake SM Subnet 3 – Supplementing and Validating the Risk Assessments

Aim of Subnet: Supplementing and validating risk assessments particularly at those sites where the degree of uncertainty is greatest as per the WFD requirement – "supplementing and validating the impact assessment procedure detailed in Annex II".

Size of Subnet: This subnet comprises the 73 lake water bodies in the SM Programme drawn from the four risk classes (Table 8.5).

Table 8.5 Distribution of WFD lake sites and SM lakes by risk classes.

Risk Category	WFD (Article 5)	SM	%
At risk(1a)	133	25	19
Probably at risk (1b)	147	17	12
Probably not at risk (2a)	99	9	9
Not at risk (2b)	366	22	6
Total	745	73	10

The selection of lake sites for this subnet was heavily influenced by the accessibility of sites for monitoring.

The greater proportion of lake sites in the 1a (at risk) category reflects an attempt to include the larger lakes. These lakes generally have a good long term record of

[6] EPA ERTDI IN-SIGHT Research Project and EPA Expert opinion
[*] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

monitoring which has contributed more reliable information to the risk assessments and resulted in many cases in the at risk designation.

The lesser proportion of lakes sites in the 2b (not at risk) category was due in part to the inaccessibility of many of these lakes and their exclusion from the monitoring networks on that basis.

The selection of 12% of 1b and 9% of 2a WFD Article 5 lakes adequately covers the supplementing and validating of the risk assessment as they were selected to represent as many pressures as possible.

Location of Monitoring Points: The locations of the sites in this subnet are detailed in Appendix 8.1[1]

Quality Elements: All the biological elements are monitored and supporting elements: physico-chemical, hydromorphological, priority substances and other pollutants appropriate to the individual water bodies are monitored in this SM subnet.

8.3.4 Lake SM Subnet 4 – Stipulated lakes

Aim of Subnet: To explicitly include those categories of lake water bodies that are specifically stipulated in the text of the WFD. This includes lakes mentioned in the main text of the WFD as follows for surface waters generally:

WFD text stipulating certain lake types and locations
1. the rate of water flow is significant within the river basin district as a whole; including points on large rivers where the catchment area is greater than 2500 km^2,
2. the volume of water present is significant within the river basin district, including large lakes and reservoirs,
3. significant bodies of water cross a Member State boundary,
4. sites are identified under the Information Exchange Decision 77/795/EEC, and
5. at such other sites as are required to estimate the pollutant load which is transferred across Member State boundaries, and which is transferred into the marine environment.

Size of Subnet: The Lake SM Programme includes 54 lake water bodies under the following headings:

- 54 lakes (≥ 50 ha) representing the large lakes within each RBD

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

- 2 lakes representing the significant cross border lakes - (Lough Melvin (35_160) and Macnean Upper (36_673)

Location of Monitoring Points: The locations of the sites in this subnet are detailed in Appendix 8.1[1].

Quality Elements: All the biological elements are monitored and supporting elements: physico-chemical, hydromorphological, priority substances and other pollutants appropriate to the individual water bodies are monitored in this SM subnet.

8.3.5 Lake SM Subnet 5 – Protected Areas

Aim of Subnet: To explicitly include those categories of lake that are contained within the two types of Protected Areas listed in Annex IV of the Directive that have associated monitoring requirements: 'Areas designated for the abstraction of water intended for human consumption' and 'Areas designated for the protection of habitats and species where maintenance of the status of water is an important factor in the their protection, including relevant Natura 2000 sites designated under the Birds and Habitats Directives.

Size of Subnet: The Lake SM Programme includes lakes under the following headings:

- Areas designated for the abstraction of water intended for human consumption' - 21 lake water bodies for water abstraction -.

- Areas designated for the protection of habitats and species where maintenance of the status of water is an important factor in their protection, including relevant Natura 2000 sites designated under the Birds and Habitats Directives' - 57 lakes in designated SACs -. (18 < 50 ha, 22 > 50 ha in size and 17 lakes are both SAC and water abstraction).

Location of Monitoring Points: The locations of the sites in this subnet are detailed in Appendix 8.1[1].

Quality Elements: All the biological elements are monitored and supporting elements: physico-chemical, hydromorphological, priority substances and other pollutants appropriate to the individual water bodies are monitored in this SM subnet.

8.3.6 Other Overlapping Subnets

Within the structure of the above subnets the SM Programme will also include the following existing lake monitoring networks–that will be contained in one or more of the five principal subnets above. The existing lake monitoring networks are:

- The Acidification Monitoring Programme

- Eurowaternet (EIONET) sites

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

- High Status Water bodies (lakes determined to be or probably at reference condition based on the EPA ERTDI IN-SIGHT project and on Expert opinion).

- River Lake interaction sites. (River flux sites to measure nutrient loading to some major lakes. The location of the river flux sites are provided in the section on rivers).

- WFD Intercalibration register sites

- Lake water bodies with freshwater designated bathing water sites

Individual monitoring points may be included in one or more of the main subnets.

8.3.7 Design of Future Lake Monitoring Networks

This is an important objective of the SM Programme. It does not require a specific set of sites or subnets, as is the case of other objectives of SM, but is taken here to refer to the network as a whole. As the SM programme proceeds and status is assigned to lakes those that are shown to be of less than good status at any point in the programme may be added to the operational monitoring programme if they are not already included there. This does not mean, however, that they necessarily have to be dropped from the SM programme, as it is essential to maintain continuity in, for example, the long-term trend monitoring subnet. It is obvious too that it is necessary to maintain a representative selection of sites, which mirror the overall surface water status in each RBD.

The results from the SM network will be used at the end of each RBMP cycle to revise the overall network. The document entitled “Reporting Sheets for Reporting Monitoring Requirements” (DGENV and Littlejohn, 2005) states “The Directive allows for monitoring programmes to be amended during the period of the river basin management plan, and between RBMP cycles.” Thus, it is not essential to wait until the end of a River Basin Management Plan (RBMP) cycle to change the location of sites or to increase or decrease the number of monitoring points. It is envisaged that, for example, the subnet for supplementing and validating the risk assessment will be reduced as time goes by as the risk factors affecting the status of lakes becomes clearer on foot of the monitoring results. If a site is found to be unsuitable for the purpose intended following initial monitoring, it is proposed to replace such a site with a new one, ideally within the same lake. Similarly, alterations in the range of quality elements or changes to the frequency of monitoring are possible where such a course is dictated by emerging data from the core monitoring programme and in response to other related sources of information such as ongoing risk assessments. All such changes to the Surveillance Monitoring network should, however, be referred to the EPA in order that the central database of WFD monitoring sites can be updated.

The long-term trend subnet is likely to point up potential new threats to water status – e.g. climate change or other as yet unforeseen pressures or impacts and this may suggest revision of the overall network for future RBMP cycles. Similarly, the WFD allows revision of the SM where the monitoring shows that a water body has reached good status.

8.3.8 Quality Elements for the Lake SM Programme

The WFD requirements for quality elements and minimum frequency for lake water body monitoring are set out in Chapter 2. The monitoring frequencies indicated are to be interpreted as minimum requirements with actual frequencies determined by the required precision of the selected parameters. These can only be confirmed when the classification schemes have been fully developed. For elements such as phytoplankton, nutrients and physico chemistry monthly sampling may be required.

8.3.9 Biological elements for lake monitoring

Macroinvertebrates

The monitoring technique and associated classification scheme is under development. It is proposed that the 73 SM sites will be sampled on a 3-year cycle at the frequency required by the classification system.

Phytoplankton

The monitoring technique and associated classification scheme is under development. It is proposed that the 73 SM sites will be sampled on a 3-year cycle at a frequency of 12 times per year. Phytoplankton populations in rivers downstream of lakes will be inferred from the lake monitoring programme results.

Macrophytes

The monitoring technique and associated classification scheme is under development. It is proposed that the 73 SM sites will be sampled on a 3-year cycle at the frequency required by the classification system.

Phytobenthos

The monitoring technique and associated classification scheme is under development. It is proposed that the 73 SM sites will be sampled on a 3-year cycle at the frequency required by the classification system.

Fish

The monitoring technique and associated classification scheme is under development. It is proposed that the 73 SM sites will be sampled on a 3-year cycle at the frequency required by the classification system.

8.3.10 Hydromorphological elements for lake monitoring

Hydrology

The hydrology of lakes requires knowledge of the inflow and level of each lake. Where we have recorders on lakes (and the rate of outflow of which is calibrated), or the lakes are used by the ESB for power generation, we will have data on the lake

level and rate of outflow from the lake which will enable us make estimates of the rate of inflow to these lakes.

In other cases, it may be possible to estimates of the inflow from rainfall and evapotranspiration data.

Where data is vital for the project and it is practical to obtain the data, additional stations will be erected on lakes.

Morphology

The technique for assessing lake morphology has yet to be developed. It has been proposed that the appropriate morphological monitoring will be undertaken on a 6-year cycle at a frequency of once per year.

8.3.11 Physico-chemical elements for lake monitoring

Standard limnological techniques will be employed to measure the required physico-chemical parameters. It is likely that sampling will be associated with that for other quality elements as far as is practicable. It has been proposed that monitoring of the physico-chemical parameters will be undertaken on a 3 year cycle at a frequency of 12 times per year. Two suites of analysis are proposed, one for acid waters and one for non acid waters:

Acid waters			
	Parameter	**Units**	**Annual Frequency (12 times)**
Field	Temperature	^{O}C	Monthly
Field	Dissolved oxygen	% sat	Monthly
Field	Dissolved oxygen	mg /l	Monthly
Field	Secchi disc	m	Monthly
Laboratory	Calcium	mg /l	Monthly
Laboratory	Sodium	mg /l	Monthly
Laboratory	Magnesium	mg /l	Monthly
Laboratory	Chloride	mg /l	Monthly
Laboratory	Sulphate	mg /l	Monthly
Laboratory	Total phosphorus	mg /l	Monthly
Laboratory	Total Oxidised Nitrogen	mg /l	Monthly
Laboratory	Alkalinity	mg /l	Monthly
Laboratory	pH		Monthly

Acid waters			
	Parameter	**Units**	**Annual Frequency (12 times)**
Laboratory	Conductivity @ 20 ^{O}C	mS/cm	Monthly
Laboratory	Chlorophyll	mg/m^3	Monthly
Laboratory	Ammonium	mg N/l	Monthly
Laboratory	Colour	Hazen	Monthly

Non acid waters			
	Parameter	**Units**	**Annual Frequency (12 times)**
Field	Temperature	^{O}C	Monthly
Field	Dissolved oxygen	% sat	Monthly
Field	Dissolved oxygen	mg /l	Monthly
Field	Secchi disc	m	Monthly
Laboratory	Total phosphorus	mg /l	Monthly
Laboratory	Total Oxidised Nitrogen	mg /l	Monthly
Laboratory	Alkalinity	mg /l	Monthly
Laboratory	pH		Monthly
Laboratory	Conductivity @ 20 ^{O}C	mS/cm	Monthly
Laboratory	Chlorophyll	mg/m^3	Monthly
Laboratory	Ammonium	mg N/l	Monthly
Laboratory	Colour	Hazen	Monthly
Laboratory	Silica	mg /l	Monthly

8.3.12 Other Pollutants and Priority Substances for lake monitoring

Priority substances

Priority substances listed in Annex X of the WFD (Appendix 8.1[1]) will be monitored in the surveillance programme. It is proposed that monitoring for these substances will take place on a 3-year cycle at a frequency of 12 times per year.

Other pollutants

The list of other pollutants Appendix 2.1[1] will be determined from the National Pilot Screening Survey and from knowledge of possible sources of the categories of other pollutants listed in Annex VIII of the WFD in the lakes or their catchments. It is proposed that monitoring for these substances will take place on a 3-year cycle at a frequency of 12 times per year.

8.4 Lakes Operational Monitoring Network

8.4.1 Introduction to the Lakes Operational Monitoring (OM) Programme

The WFD requires Operational Monitoring (OM) primarily in support of measures aimed at achieving the main objectives of the WFD – attainment of at least good status in water bodies that are less than good at present and also to retain high and good status where it exists at present. The success of the WFD depends crucially on the Programme of Measures (POM) implemented in the RBDs. The OM Programme outlined here is focused on supporting the POMs – it is designed to provide highly targeted information on the success or otherwise of particular measures within catchments.

OM is obviously required where pollution or other impacts on ecological status are apparent. Crucially, however, because the protection of high and good status are such high level objectives of the WFD, OM must also provide information on the efficacy of the POMs aimed at maintaining high and good status. Thus, even lakes which may not be deemed to be at risk in the Characterisation Report prepared under Article 5 of the WFD may be included in the OM Programme because measures are required to maintain them at their current high or good status regardless of existing risk status.

The OM Programme for lakes comprises 222 lakes Appendix 8.1[1] (Figure 8.5). This programme is designed to be flexible in order to respond to changes within catchments that impact on water status.

The OM Programme has five separate subnets aimed at monitoring particular aspects of the POMs and providing feedback for the national Environmental Management System (EMS) within River Basin Management Plans. There is

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

considerable overlap of lakes between the subnets because very few lakes are influenced by only one type of pressure (i.e. point sources, diffuse sources or hydromorphological pressure). The majority of lakes are influenced by a combination of the main pressure types and in many cases these pressures are exerted in the lake catchment rather than on the lake itself.

8.4.2 OM Subnet 1: Monitoring of the Effectiveness of Point Source Measures

Aim of Subnet: Monitoring to assess whether the measures aimed at improving the impact of individual and combined point sources are successful. This includes assessment of ambient levels of organic pollution, eutrophication impacts and priority substances.

Subnet Size: 42 lakes were determined to be at risk (1a and 1b) (Ireland Article 5 report) due to point source pressures and all of these Lake water bodies are included in the OM Programme.

Location of Monitoring Points: The aim of the POMs for point sources is to achieve good status in lakes. The location of monitoring points in relation to the discharge is still to be determined on a site-specific basis but there may be a need for more than one monitoring site. The locations of the sites in this subnet are detailed in Appendix 8.1[1].

8.4.3 OM Subnet 2: Monitoring of Effectiveness of Diffuse Pollution Measures

Aim of Subnet: To assess effectiveness of diffuse pollution control measures

Subnet Size: Diffuse pollution risk was the predominant risk to water status identified in the Article 5 Characterisation Report. 142 Lakes were determined to be at risk (1a and 1b) from diffuse pollution pressures (LD1 Risk Assessment) in that report and 62 of these lakes are included in this subnet. An additional 10 lakes have been included in the diffuse pollution network which were selected on the basis of total phosphorous or chlorophyll a monitoring data or expert judgement, but for which no pressure was identified.

Location of Monitoring Points: The locations of the sites in this subnet are detailed in Appendix 8.1[1].

8.4.4 OM Subnet 3: Monitoring of Effectiveness of Measures to reduce Hydromorphological pressures

Aim of Subnet: To assess effectiveness of measures to reduce hydromorphological pressures and impacts

Subnet Size: Hydromorphological risk was an important source of risk to water status identified in the Article 5 Characterisation Report. Some 90 lake water bodies were determined to be at risk (1a and 1b) from hydrological pressure (abstraction) and 135 at risk from morphological pressure. This subnet of the OM Programme contains 90 lake water bodies at risk due to hydrological pressure - abstraction - and

69 water bodies due to hydromorphological pressure - morphology to assess the effectiveness of hydromorphological measures.

Location of Monitoring Points: The locations of the sites in this subnet are detailed in Appendix 8.1[1].

8.4.5 OM Subnet 4: Monitoring of the Effectiveness of Measures aimed at retaining High and Good status Lake Water Bodies

Aim of Subnet: To monitor high and good status sites currently not deemed to be at risk in order to assess the effectiveness of POMs aimed at maintaining high and good status sites.

Subnet Size: 465 lakes were determined to be not at risk (2a and 2b) and these lakes are therefore likely to be either of good or high status, 24 of these lakes are included in the OM programme to assess the effectiveness of measures aimed at retaining high and good status. The selection of these sites was driven primarily by accessibility to the lakes. A further four lakes have been identified by the Central Fisheries Board, which were not included in the National Risk Assessment of Irish Lakes, but which are included on the basis of existing fish populations and which have been assessed as part of the development of classification tools. These are Vearty (Donegal 36_711), FAD (Donegal 40_2), Naglack (Monaghan 06_55) Monalty (Monaghan (06_234). One lake, Salt (Donegal 38_649), has been included at the request of Donegal County Council.

Location of Monitoring Points: The locations of the sites in this subnet are detailed in Appendix 8.1[1].

8.4.6 OM Subnet 5: Species and Habitat Protected Areas

Aim of Subnet: To monitor Species and Habitat Protected Areas that are at risk.

Text from Article 1.3.5 of Annex V
"Habitat and species protection areas Bodies of water forming these areas shall be included within 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 under Article 4. 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 requirements of the legislation under which they are

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

designated and meet their objectives under Article 4."

Size of Subnet: 182 lake water bodies designated as being at least part of a SAC are included in the OM Programme in this subnet.

Location of monitoring points: The locations of the sites in this subnet are detailed in Appendix 8.1[1].

8.5 Quality Elements for OM Programme

8.5.1 Biological elements

Macroinvertebrates

The monitoring technique and associated classification scheme is under development. It is proposed that the 222 OM lake water bodies will be sampled on a 3-year cycle at the frequency required by the classification system.

Phytoplankton

The monitoring technique and associated classification scheme is under development. It is proposed that the 222 OM lake water bodies will be sampled on a 3-year cycle at a frequency of 4 times per year.

Macrophytes

The monitoring technique and associated classification scheme is under development. It is proposed that the 222 OM lake water bodies will be sampled on a 3-year cycle at the frequency required by the classification system.

Phytobenthos

The monitoring technique and associated classification scheme is under development. It is proposed that the 222 OM lake water bodies will be sampled but the phasing and frequency of the sampling has yet to be decided.

Fish

The monitoring technique and associated classification scheme is under development. It is proposed that the 222 OM sites will be sampled on a 3-year cycle (74 sites per year) at a frequency of once per year.

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

8.5.2 Hydromorphology Lake Monitoring

Hydrology

The hydrology of lakes requires knowledge of the inflow and level of each lake. Where we have recorders on lakes (and the rate of outflow of which is calibrated), or the lakes are used by the ESB for power generation, we will have data on the lake level and rate of outflow from the lake that will enable us make estimates of the rate of inflow to these lakes.

In other cases, it may be possible to estimate the inflow from rainfall and evapotranspiration data.

Where data is vital for the Programme and it is practical to obtain the data, additional stations will be erected on lakes.

Morphology

The technique for assessing lake morphology has yet to be developed. It has been proposed that the appropriate morphological monitoring will be undertaken on a 6-year cycle at a frequency of once per year.

8.5.3 Physico-chemical elements

Standard limnological techniques will be employed to measure the required physico-chemical parameters. Communities >30,000 are served by the following waterbodies and shall be sampled at a frequency of 12 times per year.

Vartry Reservoir	Pollaphuca Reservoir	Knockaderry Reservoir
Inniscarra Reservoir	Lough Talt (Sligo)	Lough Gill (Sligo)

Communities of 10,000 - 30,000 are served by the following waterbodies and shall be sampled at a frequency of 8 times per year.

Mayo: Loughs Conn, Mask, Carrowmore and Moher

Donegal: Keel, Reelan and Salt;

Clare: Castle, Doo, Lickeen and Derg (Tipperary)

Loughs Kilsellagh (Sligo), Melvin (Leitrim), Corcaghan (Monaghan)

For the remaining waterbodies it is proposed that the examination of the physico-chemical parameters will be undertaken on an annual cycle at a frequency of 4 times per year for the purpose of OM. Two suites of analysis are proposed, one for acid waters and one for non-acid waters.

Acid waters			
	Parameter	**Units**	**Annual Frequency (4 times)**
Field	Temperature	^{O}C	February, March, summer (1) & November

Acid waters			
	Parameter	**Units**	**Annual Frequency (4 times)**
Field	Dissolved oxygen	% sat	February, March, summer (1) & November
Field	Dissolved oxygen	mg /l	February, March, summer (1) & November
Field	Secchi disc	m	February, March, summer (1) & November
Laboratory	Calcium	mg /l	February, March, summer (1) & November
Laboratory	Sodium	mg /l	February, March, summer (1) & November
Laboratory	Magnesium	mg /l	February, March, summer (1) & November
Laboratory	Chloride	mg /l	February, March, summer (1) & November
Laboratory	Sulphate	mg /l	February, March, summer (1) & November
Laboratory	Total phosphorus	mg /l	February, March, summer (1) & November
Laboratory	Total Oxidised Nitrogen	mg /l	February, March, summer (1) & November
Laboratory	Alkalinity	mg /l	February, March, summer (1) & November
Laboratory	pH		February, March, summer (1) & November
Laboratory	Conductivity @ 20 ^{O}C	mS/cm	February, March, summer (1) & November
Laboratory	Chlorophyll	mg/m^3	February, March, summer (1) & November
Laboratory	Ammonium	mg N/l	February, March, summer (1) & November
Laboratory	Colour	Hazen	February, March, summer (1) & November

Non-acid waters			
	Parameter	**Units**	**Annual Frequency (4 times)**
Field	Temperature	^{O}C	April and 3 times in the period Jul - Oct
Field	Dissolved oxygen	% sat	April and 3 times in the period Jul - Oct
Field	Dissolved oxygen	mg /l	April and 3 times in the period Jul - Oct
Field	Secchi disc	m	April and 3 times in the period Jul - Oct
Laboratory	Total phosphorus	mg /l	April and 3 times in the period Jul - Oct
Laboratory	Total Oxidised Nitrogen	mg /l	April and 3 times in the period Jul - Oct
Laboratory	Alkalinity	mg /l	April and 3 times in the period Jul - Oct

Non-acid waters			
	Parameter	**Units**	**Annual Frequency (4 times)**
Laboratory	pH		April and 3 times in the period Jul - Oct
Laboratory	Conductivity @ 20 ^{O}C	mS/cm	April and 3 times in the period Jul - Oct
Laboratory	Chlorophyll	mg/m^3	April and 3 times in the period Jul - Oct
Laboratory	Ammonium	mg N/l	April and 3 times in the period Jul - Oct
Laboratory	Colour	Hazen	April and 3 times in the period Jul - Oct
Laboratory	Silica	mg /l	April and 3 times in the period Jul - Oct

8.5.4 Other Pollutants and Priority Substances

Priority Substances

Priority substances listed in Annex X of the WFD Appendix 2.1 will be monitored in the surveillance programme. It is proposed that monitoring for these substances will take place on a 3-year cycle at a frequency of 12 times per year.

Other Pollutants

The list of other pollutants Appendix 2.1 will be determined from the National Pilot Screening Survey and from knowledge of possible sources of the categories of other pollutants listed in Annex VIII of the WFD in the lakes or their catchments. It is proposed that monitoring for these substances will take place on a 3-year cycle at a frequency of 12 times per year.

8.5.5 Monitoring of Drinking Water Abstraction Points

Additional monitoring is required for drinking water sources as per the text of Article 1.3.5 of Annex V of the WFD independently of the SM or OM Programmes outlined above:

Bodies of surface water designated under Article 7 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 meet the requirements of that Article. 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 shall be carried out in accordance with the frequencies set out below:

Community served	**Frequency**

< 10 000	4 per year
10 000 to 30 000	8 per year
> 30 000	12 per year.

Size of Programme: Currently the Register of Protected Areas indicates there are 1916 drinking water abstractions. Of these 181 lakes are included in the drinking water quality Programme. Of these lakes, 148 provide a supply greater than $100m^3$ per day and the lake water bodies which contain these sites will be monitored as per Annex V (1.3.5) and Article 7 of the WFD emphasising such sites that are at risk of failing to meet the requirements of Article 7.

Location of Monitoring Points: The locations of monitoring sites for lake water bodies containing drinking water abstraction points supplying greater than $100m^3$ per day are listed in Appendix 8.1[1]. Insofar as is possible such bodies will also be included in the surveillance and operational monitoring programmes for other purposes as well as meeting the drinking water monitoring requirement in order to prevent duplication of effort and maximize use of available resources.

8.6 Investigative Monitoring (IM) of Lakes

WFD text concerning design of investigative monitoring:

"1.3.3 Design of investigative monitoring

Objective

Investigative monitoring shall be carried out:

– where the reason for any exceedances is unknown;

– where surveillance monitoring indicates that the objectives set under 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;

and shall inform the establishment of a programme of measures for the achievement of the environmental objectives and specific measures necessary to remedy the

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

effects of accidental pollution."

The details of the design and extent of the investigative monitoring IM Programme cannot be fully developed until the results of SM and/or OM are known and any exceedance for which the cause is unknown can be identified. Similarly, the details of the response to accidental pollution cannot be fully developed. However, the procedures for monitoring the cause and the impact of accidental pollution should be developed for inclusion in the 2007 report on monitoring to the Commission.

Where an incidence of accidental pollution occurs a system will be in place to allow notification through established hotlines to the Local authorities, Regional Fisheries Boards and the EPA. Where such pollution incidence occurs it will be investigated by the appropriate relevant authority to establish cause and instigate remedial measures.

8.6.1 IM Subnet 1: Investigation of unexplained exceedances and accidental pollution;

Aims of subnet: To understand the reasons for any unexplained exceedances and to ascertain the magnitude and impacts of accidental pollution.

Subnet size: Dependent on particular events or problems being investigated.

Location of Monitoring Points: Not applicable.

8.6.2 IM Subnet 2: Remote Sensing

Consideration will be given to snapshot monitoring of inaccessible lakes using remote sensing techniques to compliment the main monitoring programme. Lakes which are indicated as being subject to excessive algal development will be investigated in more detail to determine if they should be included in the general monitoring programme.

Aims of subnet: To understand the reasons for any unexplained exceedances and to ascertain the magnitude and impacts of accidental pollution.

Subnet size: The use of remote sensing will focus on inaccessible lakes which are largely in the western part of the country and will be dependent on particular events or problems being investigated.

Location of Monitoring Points: Not applicable

8.7 Frequency of Monitoring

8.7.1 Introduction

Sample frequency will vary depending on the monitoring programme and the individual subnets and the quality element. The minimum monitoring frequencies are set out in Chapter 2 of the National Monitoring Programme document. Details of the monitoring frequencies for the quality elements for lakes are set out above for SM and OM.

The text of the WFD below outlines the requirements under frequency of monitoring

WFD text concerning frequency of monitoring:

.3.4 Frequency of monitoring

"For the surveillance monitoring period, the frequencies for monitoring parameters indicative of physico-chemical quality elements given below should be applied unless greater intervals would be justified on the basis of technical knowledge and expert judgement. For biological or hydromorphological quality elements, monitoring shall be carried out at least once during the surveillance monitoring period."

"Frequency of monitoring will determine the confidence and precision of the results obtained particularly in the physico-chemical monitoring programmes"

"Frequencies shall be chosen so as to achieve an acceptable level of confidence and precision. Estimates of the confidence and precision attained by the monitoring system used shall be stated in the River Basin Management Plan."

"Monitoring frequencies shall be selected which take account of the variability in parameters resulting from both natural and anthropogenic conditions. The times at which monitoring is undertaken shall be selected so as to minimise the impact of seasonal variation on the results, and thus ensure that the results reflect changes in the water body as a result of changes due to anthropogenic pressure. Additional monitoring during different seasons of the same year shall be carried out, where necessary, to achieve this objective."

Frequency of monitoring will determine the confidence and precision of the results obtained particularly in the physico-chemical monitoring programmes Monitoring Reporting Sheet Table C2 Surveillance and Operational Monitoring Programmes for Irish lake water bodies.

8.7.2 Quality Elements (QE) for Surveillance Monitoring

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:

Benthic invertebrate fauna, Macrophytes, Phytobenthos, Fish, Phytoplankton, and Chlorophyll.

Parameters indicative of all hydromorphological quality elements:

Hydrology and Morphology.

Parameters indicative of all general physico-chemical quality elements:

Not all parameters will be measured in all subnets of the Lakes SM Programme.

General:Temperature, Dissolved Oxygen, Conductivity, Light penetration, Alkalinity, pH, colour

Nutrients: Phosphorus, Nitrogen, Ammonium Silica

Acidification Status, pH, Alkalinity, Acid Neutralising Capacity

Priority Substances

Priority list pollutants which are discharged into the river basin or sub-basin.

The precise list of compounds will vary from site to site depending on whether the Annex X substance in question is discharged in the river basin or sub-basin in which the SM point is located. The initial approach will be conservative in that it will be assumed that all Annex X compounds are likely to be discharged until evidence to the contrary becomes available. The initial list of compounds are set out in Appendix 2.1[1]

Other pollutants discharged in significant quantities in the river basin or sub-basin

The precise list of substances analysed for at any individual site will vary from site to site depending on whether the pollutant in question is discharged in significant quantities in the river basin or sub-basin in which the SM point is located.

8.7.3 Quality Elements (QE) for Operational Monitoring

In order to assess the magnitude of the pressure to which bodies of surface water are subject Member States shall monitor for those quality elements which are indicative of the pressures to which the body or bodies are subject. In order to assess the impact of these pressures, Member States shall monitor as relevant.

The parameters chosen shall be from the list given above in Section 8.7.2 above.

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

8.8 Electronic Files

Part III of this document summarises the links to the online electronic files containing the principal monitoring locations and other documents related to the WFD monitoring programme:

Lake Water Body Surveillance Monitoring Programme

- A table with the list of lake monitoring points flagged according to their subnets and including GIS co-ordinates (where applicable). Data to be compatible with outlined monitoring reporting sheets.

Lake Water Body Operational Monitoring Programme

- A table with the list of lake monitoring points flagged according to their subnets and including GIS co-ordinates (where applicable). OM sites will also be flagged according to the risk assessment pressures or dominant pollution sources and impacts within the upstream catchment. Data to be compatible with outlined monitoring reporting sheets.

Those involved with the monitoring programme or who wished to be informed of the latest changes to the programme should email wfd.monitoring@epa.ie and request to be placed on the mailing list for this purpose. All subscribers will receive an email whenever changes are made to the main appendices containing the list of monitoring locations – in this case Appendix 8.1[1].

8.9 Maps of Lake Surveillance and Operational Sites

Maps of the total distribution of Irish lakes, lakes reported under Article 5 of WFD and lake water body surveillance and operational sites as currently known are presented in Figures 8.2 to 8.5 below.

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

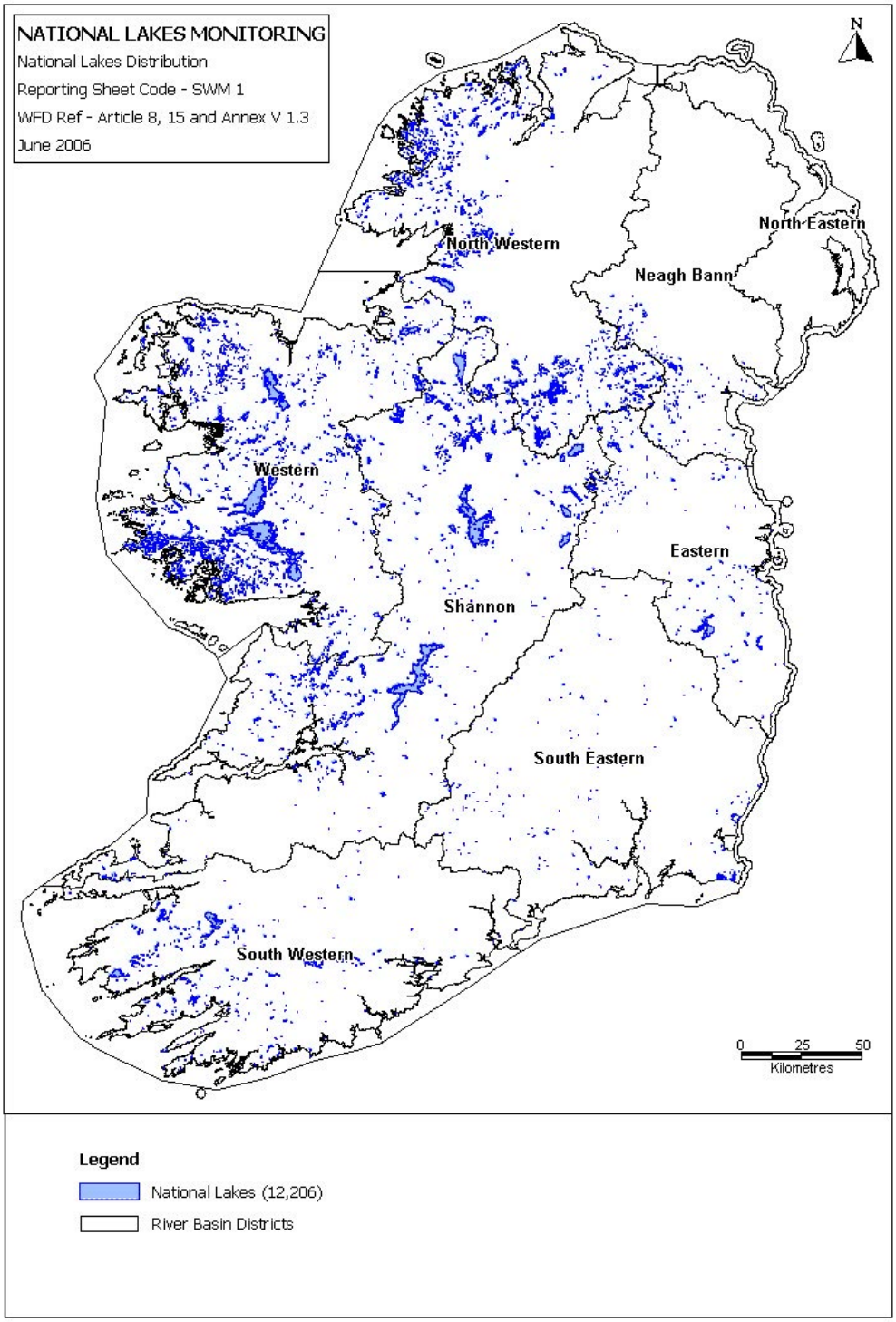

Figure 8.2 The national distribution of Irish lakes.

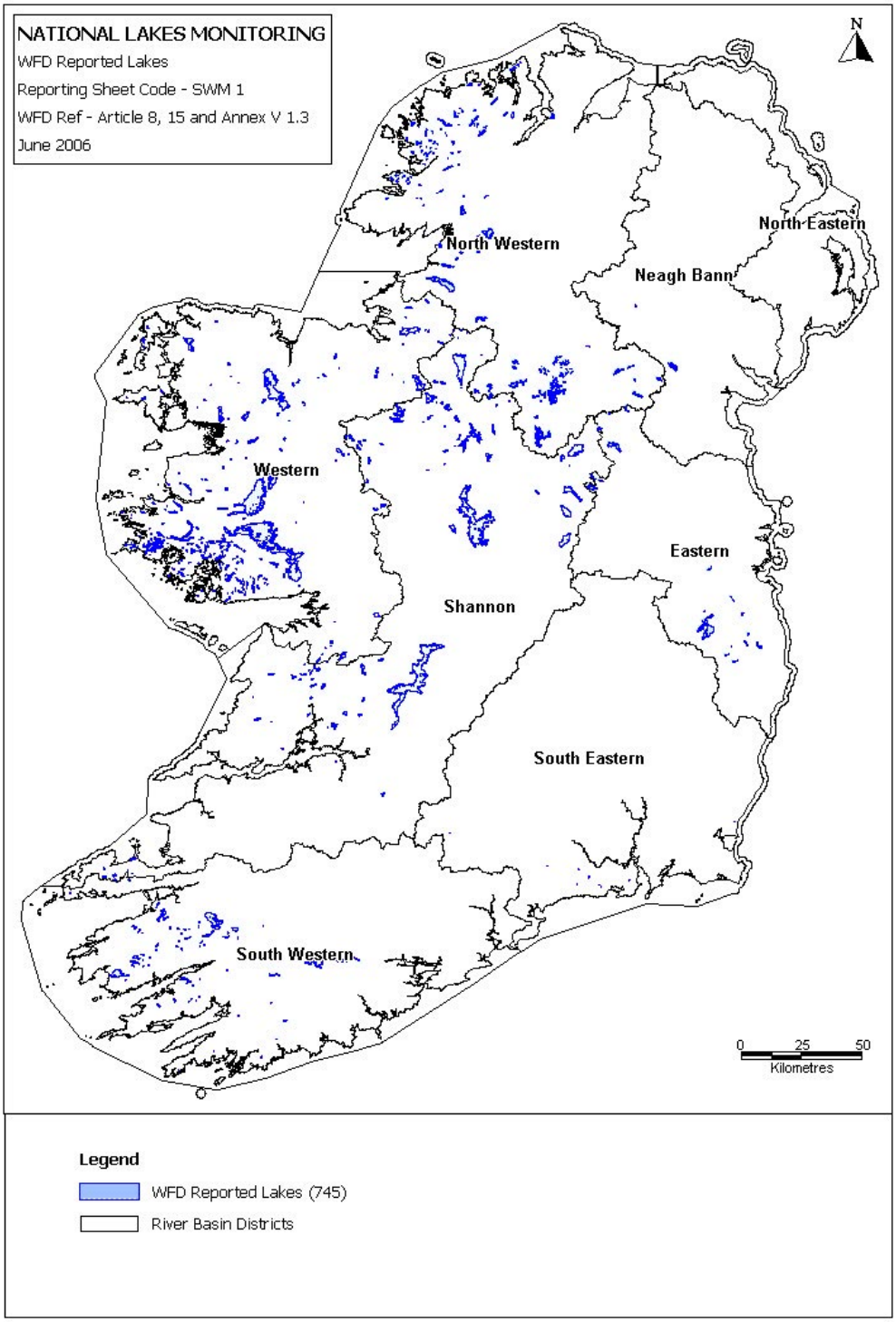

Figure 8.3 Irish Lakes reported under Article 5 of the Water Framework Directive.

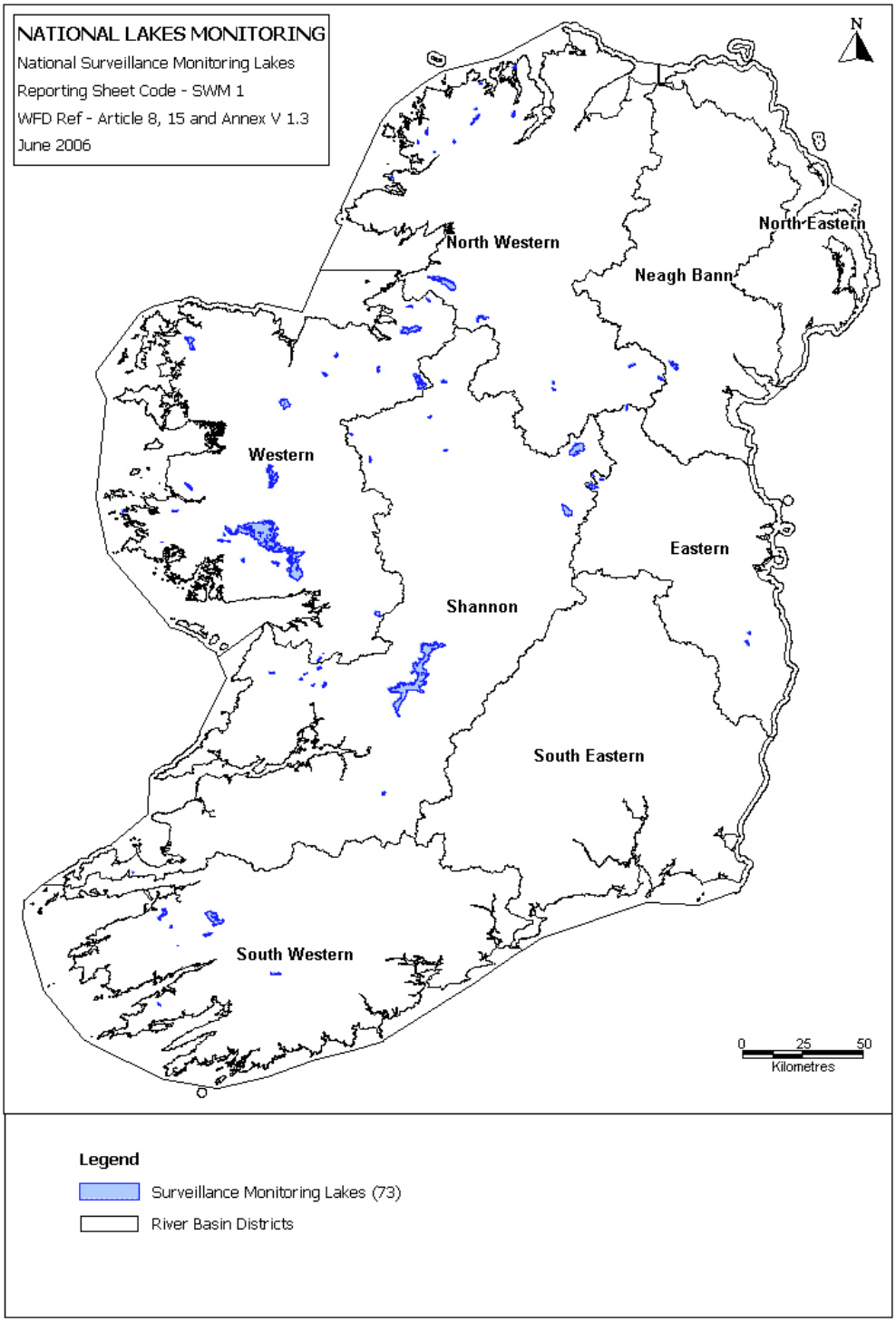

Figure 8.4 National Surveillance Monitoring Lakes.

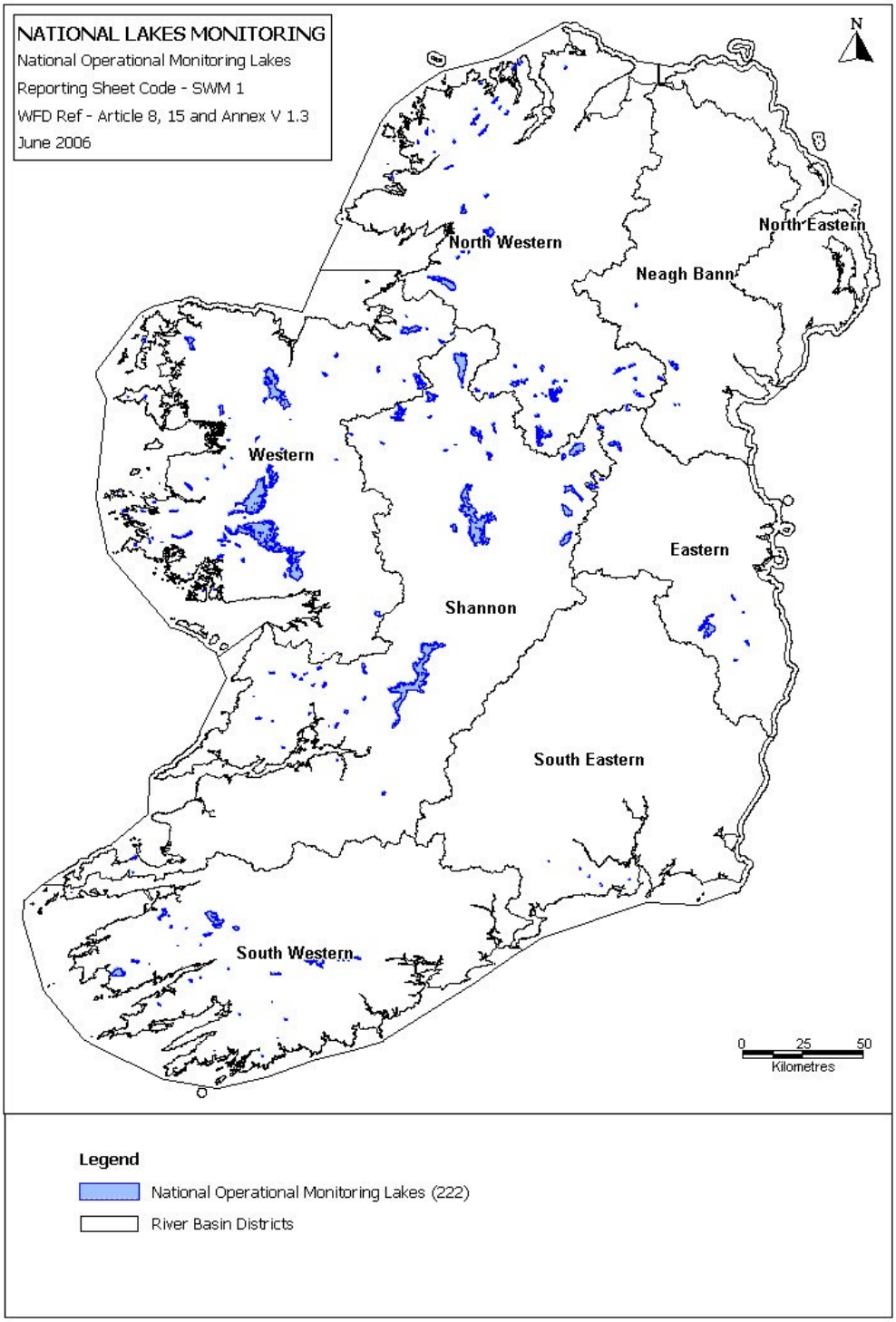

Figure 8.5 National Operational Monitoring Lakes.

Chapter 9 Transitional and Coastal Waters Monitoring Programme

9.1 Introduction

A total of 309 transitional and coastal water bodies were considered for inclusion in the national Coastal and Transitional Waters monitoring programme (the number of water bodies within each River Basin District and each typology is shown in Table 9.1).

In accordance with the Water Framework Directive and guidance provided by the Common Implementation Strategy, a representative number of water bodies were selected that were considered to provide an assessment of the overall status of Ireland's transitional and coastal waters and to meet the other specific monitoring requirements of the Directive. As previously noted the programme described here for transitional and coastal waters builds upon national and local knowledge obtained from previous and existing monitoring programmes in Irish tidal waters undertaken since the early 1970s. A number of innovative approaches are included in order to help in targeting programme of measures at the local sub-catchment scale and to begin to provide real-time alert systems for pollution incidents plus remote sensing capability aimed at ensuring that all potential pollution sources are known.

Two primary monitoring programmes are hereby established – the surveillance monitoring (SM) and operational monitoring (OM) programmes. The role of Investigative Monitoring (IM) is outlined in Chapter 2.

Table 9.1 Number of water bodies in each type in each RBD

	Typology						
River Basin District	**TW 2**	**TW 6**	**CW 2**	**CW 5**	**CW 6**	**CW 8**	**CW 10**
Eastern RBD	10	3	0	6	1	1	0
South Eastern RBD	16	5	2	4	0	3	0
South Western RBD	29	14	9	9	0	3	6
Shannon IRBD	14	6	4	4	0	1	2
Western RBD	21	47	5	15	0	5	5
North Western IRBD	14	8	4	12	0	6	1
Neagh Bann IRBD	6	3	1	3	0	1	0
Total by Type	110	86	25	53	1	20	14
Total by Category		196					113
Overall Total							309

9.2 Coastal and Transitional Surveillance Monitoring Network

A selection or 'subnet' of surveillance monitoring water bodies was chosen to represent the range of significant pressures and typology scenarios present in Ireland's coastal and transitional waters. Three additional subnets were selected from this 'representative' subnet, to fulfil the specific surveillance monitoring requirements of the Directive. These subnets included sites required for assessing long-term anthropogenic and natural change; sites required to supplement and validate the risk assessment process (Annex II); stipulated sites such as significant bodies of water that cross a Member State boundary and sites that are used to assess pollutant loading to the marine environment (e.g., OSPAR Riverine and Direct Discharges Programme).

These are described in detail in the section below and presented in Figure 9.1. Lists of the monitored water bodies are given in Tables 9.4 and 9.5

Four principal subnets are outlined here together with a number of overlapping minor subnets designed to match other national and international monitoring requirements.

9.2.1 SM Subnet 1 – 'Representative' Subnet for Status

Aim of subnet: This subnet is designed to be representative of the overall surface water status as per the WFD stated requirement: 'surface water bodies to provide an assessment of the overall surface water status within each catchment or subcatchments within the river basin district'.

Subnet Size: This network comprises 37 water bodies of which 26 are transitional and 12 coastal. (See Table 9.4 for breakdown within RBDs)

Location of Monitoring Points: Representative sites are distributed evenly within the RBDs and selected to be representative of status within RBD and where possible were selected to give a good representation of different tidal water types, habitats and pressures within catchments. As a result of the outcome of the risk assessment process and given the relatively small number of typologies represented by these two water categories it was not possible to represent all types and risks for each RBD. It was decided, therefore to adopt a regional and national approach to ensure a full representation of types and risk categories.

The overall proportional breakdown for the status of sites within this subnet should match the overall water status within Irish RBDs.

9.2.2 SM Subnet 2 – Long-Term Trend Monitoring

Aim of subnet: Detection of long-term trends as per WFD requirement – 'the assessment of long-term changes in natural conditions, and the assessment of long-term changes resulting from widespread anthropogenic activity.'

Subnet Size: This subnet includes all the water bodies in subnet 1 above.

Location of Monitoring Points: This subnet includes 12 water bodies of high status (4 transitional and 8 coastal) and 26 water bodies of lower status (22 transitional and 4 coastal) and is designed to provide early indication of long-term anthropogenically influenced trends and of natural variation over time. The majority of sites included in this subnet possess historical monitoring data hence facilitating the detection of long-term trends. It includes 11 OSPAR marine flux stations located on major riverine tributaries flowing into transitional water bodies. It also includes sites aimed at assessing long-term trends in diffuse and point source pollution. (See Table 9.4). Groundwater surface water interaction in the marine environment is also represented by the inclusion of a single water body (e.g. Kinvara Bay).

9.2.3 SM Subnet 3 – Supplementing and Validating the Risk Assessments

Aim of Subnet: Supplementing and validating risk assessments particularly at those sites where the degree of uncertainty is greatest as per the WFD requirement – "supplementing and validating the impact assessment procedure detailed in Annex II".

Size of Subnet: The approach taken to selecting surveillance monitoring sites for this subnet was to represent where possible each of the 4 major risk categories within individual RBDs. The number of sites selected is proportional to the number of water bodies in each risk category. For example, for transitional waters in the Eastern – RBD, the number of sites selected in the 1a risk category is twice the number of sites selected in the 1b category based on the relative proportion of water bodies in that category. Typically, 1 in 5 or 20 % of water bodies were considered for further validation. This initial selection was further reduced by aggregation and resulted in the final selection of 26 transitional water bodies and 12 coastal water bodies.

Location of Monitoring Points: Sites within this subnet will be distributed throughout RBDs in proportion to risk categories (see Table 9.4).

9.2.4 SM Subnet 4 – Stipulated Sites

Aim of Subnet: To explicitly include those categories of transitional and coastal waters that are specifically stipulated in the text of the WFD. This includes tidal waters that cross a Member State boundary and other sites, in or upstream of specific water bodies, that are required to estimate the pollutant load which is transferred across Member State boundaries, and which is transferred into the marine environment.

Size of Subnet: This subnet includes 3 transitional and 2 coastal water bodies that cross a Member State boundary and 11 OSPAR marine flux stations. It should be noted that the remaining OSPAR flux stations are included in the operational programme.

Location of Monitoring Points: The locations as described above are shown in detail in Table 9.4.

9.2.5 Other Overlapping Subnets

Within the structure of the above subnets the SM programme will also include the following overlapping subnets – overlapping in the sense that they will also be contained in one or more of the four principal subnets above.

- Surface water / groundwater interaction sites,
- Selected reference condition sites
- WFD Intercalibration register sites
- Selected NPWS Protected Area sites – see also OM programme

9.2.6 Design of Future Monitoring Networks

As the surveillance programme proceeds and status is assigned to transitional and coastal water bodies, those that are shown to be of less than good status will automatically be transferred to the operational monitoring programme. (This does not necessarily mean, however, that they will be dropped from the surveillance programme as it is essential to maintain continuity in, for example, the long-term trend monitoring subnet. It is also necessary to maintain a representative selection of sites that reflect the overall surface water status in each RBD.

As monitoring progresses it is also likely that investigative monitoring will be required to answer questions raised by the results from the surveillance or operational programme, e.g., regarding sources of any priority substances found. Similarly, if a site is found to be unsuitable for the purpose intended following initial monitoring it is proposed to replace such a site with a new one, ideally within the same water body.

The results from the surveillance network will be used at the end of each RBMP cycle to revise the overall network. It is envisaged that, for example, the subnet for supplementing and validating the risk assessment will be reduced as time goes by and the actual risk factors affecting the status of individual coastal and transitional water bodies becomes clear.

The long-term trend subnet is likely to point up potential new threats to water status – e.g. climate change or other as yet unforeseen pressures or impacts and this may suggest revision of the network for future RBMP cycles. Similarly, the WFD allows revision of the SM where the monitoring shows that a water body has reached good status.

9.3 Quality Element, Site Selection and Sampling Frequency for Surveillance Monitoring Programme

As previously stated the quality elements for surveillance monitoring are clearly designated in Annex V of the WFD – see Chapter 2.

In addition to selecting water bodies that are representative of types and dominant pressures and fulfil specific requirements of the Directive, consideration was given to

the selection of quality elements and sufficient monitoring points to assess the status of individual water bodies.

The site selection process within designated water bodies was informed by the United Kingdom – Republic of Ireland Marine Task Team guidelines on site density and coverage required to implement the relevant classification tools.Sites with existing historical monitoring data were also chosen to facilitate the assessment of long-term trends. Expert knowledge on individual biological elements and habitat and water body spatial variation was also used, particularly when considering the number of sites to be monitored for each biological element. In addition, consideration was also given to clustering sites within adjacent water bodies to provide a mechanism to determine downstream effects of pressures and to improve the overall logistical efficiency of the biological and chemical monitoring programmes. This is extremely important in the marine area given the large size and broad spatial distribution of the water bodies that have to be monitored.

9.3.1 Biological elements for Coastal and Transitional Waters

An overview of each biological element, the particular feature or aspect that is being considered for classification tool development and the required sampling and cycle frequency is given in the sections below.

9.3.2 Benthic Macroinvertebrates

The marine benthic macroinvertebrate biological quality element will be evaluated by the Infaunal Quality Index (IQI) multimetric. This multimetric has been developed by the UK-Ireland Benthic Invertebrate subgroup of the UK-Ireland Marine Task Team. The IQI describes ecological status based on the composition and abundance of soft sediment infaunal communities.

The IQI operates over a range from zero (bad status (azoic)) to one (high status (reference)). Each metric is normalised to a maximum value expected for that metric. Max parameters relate to the reference condition for that metric for a specific habitat.

Class boundaries are defined using the behaviour of the benthic invertebrate communities over a quantifiable organic enrichment gradient. Deviation from reference condition for each WFD ecological status class, was established by comparing the proportions of the AMBI taxa groups (Group I (sensitive) through to Group V (first order opportunistic taxa)) with the expected proportions of the groups defined in the expanded normative definitions.

Single samples will be collected once per year on a three –year cycle from matched habitats throughout the water body. (Sufficient samples must be taken to ensure the required degree of confidence in WFD status assessment). All samples must be outside any Allowable Zone of Effect (AZE's) that exists for licenced impact areas in the water body. Where possible, it is recommended that samples are taken from stable, depositional sediments within the water body as we currently have the most information regarding these habitats for both the setting of max values for the metrics and defining the inherent variability of the systems.

9.3.3 Macrophytes (Macroalgae and Angiosperms)

In coastal and transitional waters the macrophyte biological quality elements include the macroalgal and angiosperm communities. A series of tools have been developed for the monitoring and classification of these elements.

Macroalgae

(1) Reduced Species List

Species richness has been shown to respond to changes in environmental conditions including nutrient enrichment and hydromorphological changes. The tool will include measures of the number of species present on a shore and the ecological status of these species. Changes in the numbers of species present or a shift to more opportunistic algae will indicate changes in the ecological status of the area. Due to the taxonomic complexity of macroalgal communities, a reduced list of taxa has been complied for shore classification. Three to five sites in each water body will be monitored once every 3 years.

(2) Opportunistic Algae

Certain species of algae respond to changes in the nutrient condition of a water body by producing large mats of algae overlying soft intertidal sediments. As well as being indicators of change in the nutrient dynamics of a water body, these macroalgal blooms are a source of ecological disturbance themselves.

A tool has been developed to monitor the spatial extent and biomass of these opportunistic algal blooms in transitional and coastal waters, although such events are generally confined to soft-sediment filled transitional water bodies. In areas where such events occur, or where suitable conditions for potential blooms exist, the biomass and spatial cover will be assessed annually.

(3) Fucoid Extent

The distribution upstream of low-salinity tolerant marine algae has been shown to respond to certain environmental pressures, in particular stresses from toxic compounds. The geographical limit of Fucoid species towards the freshwater boundary in transitional waters will be used as a measure of ecological status in estuarine water bodies. An EQR based on changes in the upstream extent for Fucoid algae has been proposed. This biological element will respond slowly to environmental pressures and as such only requires monitoring one year in the RBD cycle.

Angiosperms

(1) Seagrass

Seagrass communities occur as intertidal and subtidal communities around the Irish coast. For practical purposes only the intertidal beds will be assessed. Seagrass communities are known to respond to environmental pressures such as increased nutrient loading and physical disturbance.

Responses are likely to include a reduction in species diversity and habitat extent. An EQR based on the taxonomic composition, spatial extent and bed density has been developed. Due to a paucity of baseline data, initial surveys will be on an annual basis, with surveys undertaken on a three-year cycle once background data has been accumulated.

(2) Saltmarsh

Saltmarshes are a common element of transitional water bodies and coastal lagoons. This biological element is particularly susceptible to habitat loss through erosion. Erosion occurs under natural conditions but can be exacerbated by anthropogenic impacts arising from morphological pressures. Consequently, habitat extent has become a popular means of assessing saltmarsh health. Methods for assessing habitat extent for purposes of the WFD have been based on a simplified version of habitat mapping techniques. An EQR based on changes in habitat extent and biodiversity of beds has been developed. Depending on the size of the saltmarsh habitat in each water body monitoring will be undertaken at 1-3 locations on a three-year cycle.

9.3.4 Fish

Under the Water Framework Directive monitoring of fish communities is only required in transitional waters. The directive requires an assessment of species composition and abundance as well as an indication of the presence of sensitive species.

Development of analysis tools is based on examination of species composition in relation to the status of known pressures. Metrics include those based on such attributes as absolute and relative composition; on the proportion of specific species andon the contribution of specific functional groups.

In terms of sampling, the rationale will be to assess species composition over as wide a range of habitats and niches as possible. Sampling for fish is based on the multi-method approach developed by the UK's Environment Agency in pilot studies on the Thames estuary. The procedure involves use of a series of netting techniques to develop an appraisal of the fish community over a range of habitats, including littoral and open-water areas.

The mobility of fish, in comparison with the fixed nature of benthic invertebrates and of fucoids and angiosperms, produces additional difficulties in sampling for status assessment. It may be necessary to sample a greater number of stations within a transitional water-body. It may also be necessary to sample across a broad range of niches in order to more fully establish the community composition. This may create difficulties in developing a 'consistent' site selection procedure.

Sampling frequency will be once per year in autumn and for most water bodies this will take place on a 3-year cycle.

9.3.5 Phytoplankton

The Water Framework Directive states that for phytoplankton the composition, abundance and biomass of phytoplankton taxa and the frequency and intensity of phytoplankton blooms needs to be considered when assessing status.

Metrics are based on assessing phytoplankton biomass (as measured using chlorophyll) and frequency, composition and intensity of phytoplankton blooms. The biomass metric works by quantifying the level of chlorophyll present in a water body over a 5-year period. This is achieved by comparing the value of the 90th percentile and median over a 5-year period against reference based classification boundaries. The second metric works by recording the number of events, defined as occasions when values based on individual phytoplankton species cell numbers, exceed a predefined threshold over the period of the monitoring programme.

For transitional waters sampling frequency is monthly and restricted to the summer growth period (June-September) for both operational and surveillance monitoring. For coastal waters sampling is monthly over the entire year for both operational and surveillance monitoring. Given the high level of inter-annual variability of phytoplankton assemblages, monitoring in transitional and coastal waters should take place on an annual basis.

9.3.6 Physico-chemical elements

Standard bottle-sampling supplemented by vertical profiling CTD (conductivity, temperature, depth) instruments will continue to be the mainstay of the physico-chemical monitoring network. CTD minisondes will be used to measure salinity, temperature, dissolved oxygen, turbidity and depth. Discrete samples will be analysed for ammonia, total oxidized nitrogen, phosphate, silica, pH, chlorophyll and BOD.

It is anticipated that automatic samplers will be used at the major flux sites and core long-term trend sites in order to provide detailed initial understanding of nutrient and sediment loading patterns (automatic water samplers may also be used for high frequency (e.g., weekly or monthly phytoplankton sampling). Daily sampling may be required - time weighted or in certain cases flow-triggered sampling for flow-weighted sampling to account for high flow periods that yield large sediment or nutrient loads to transitional waters.

Continuous electronic monitoring of parameters such as salinity, turbidity, temperature, chlorophyll fluorescence and dissolved oxygen with telemetry to public websites will supplement the surveillance monitoring programme (although this will be more important in the operational monitoring programme).

9.3.7 Priority Substances

Priority substances (PS) (Annex X) to be sampled monthly for one year during the cycle. Other PS identified within the catchments of SM sites will also be included. Future monitoring will depend on the outcome of the initial phase. (The daughter directive on dangerous substances will also influence the ongoing monitoring for PS

perhaps requiring revisions in the medium term). See Appendix 2.1 for details of PS to be monitored for surface waters.

9.3.8 Hydromorphology

The hydromorphology quality element for transitional and coastal waters comprises three components, tidal regime, river flow and morphological conditions.

Tidal regime can be monitored on a national basis by a series of tide gauges located around the coast and overseen by the Marine Institute. Criteria for evaluating status have yet to be determined.

High precision, high frequency river flow monitoring will be required for the long-term trend and flux sites (OSPAR and lakes). Automatic gauges will be essential for these subnets. Lower precision measurements may be sufficient for other subnets – e.g. well-calibrated staff gauges with good ratings to enable flows to be determined on the day of sampling if the staff gauge is read accurately.

Morphological conditions are described in the directive as the depth variation, structure and substrate of the seabed and condition of the intertidal zones. In light of these assessment criteria, a research project, under the auspices of the Programmes of Measures Working Group, is currently underway in order to establish which morphological indicators might best describe the conditions in coastal and transitional monitoring programmes and respond to the pressures that might act specifically on the morphology of a water body, e.g., dredging (fishing, channelisation), or coastal defenses. In addition, the project will define the relationship between morphology characteristics and biological status and develop a decision support tool for regulators to assess the potential impact of future developments on individual water bodies (i.e. to prioritise activities and establish a tiered assessment system).

9.4 Coastal and Transitional Waters Operational Monitoring Network

For the operational monitoring programme a selection or subnet was made of representative water bodies from those identified as being ‘at risk’ or ‘probably at risk’ of failing to meet their environmental objectives. This selection was further divided into 3 additional subnets for the purposes of assessing the effectiveness of measures to address impacts arising from point, diffuse and hydromorphological pressures, as well as measures to maintain good and high status sites. A further 2 subnets to accommodate alert and remote sensing and protected areas were also included.

These are described in greater detail below and lists of water bodies and number of monitoring sites are given in the appendices to this programme.

The operational programme for transitional and coastal waters has 6 subnets consisting of 8079 water bodies. This total is comprised of 56 transitional and 23 coastal water bodies.

9.4.1 OM Subnet 1: Monitoring to establish status of at risk water bodies

Aim of Subnet: Monitoring to establish the status of those bodies identified as being at risk of failing to meet their environmental objectives.

Subnet Size: This subnet includes 61 water bodies selected for operational monitoring and is considered to be representative in terms of type and pressures of all the water bodies that have been identified as being 'at risk' or 'probably at risk'. This total is comprised of 48 transitional and 13 coastal water bodies (see Table 9.5).

Location of Monitoring Points: The location of these water bodies is given in Table 9.5.

9.4.2 OM Subnet 2: Monitoring of Effectiveness of Diffuse and Point Source Pollution Measures

Aim of Subnet: To assess effectiveness of diffuse and point source pollution control measures.

While the measures needed to reduce diffuse and point source pollution are likely to be different they are combined in this subnet because in most cases the approach in terms of monitoring and assessment will be similar. This is particularly the case in urbanised transitional waters where tidal movement and the presence of multiple point sources such as industrial and waste water treatment plant discharges can make it difficult to identify the most relevant pressures. In this situation multiple representative sites located less specifically will be used to assess the overall status of the water body.

In some cases, particularly where the source of the pressure/impact is well defined, the approach will be different and will involve monitoring in the vicinity of the pressure but outside the identifiable zone of impact. This approach should be appropriate for activities such as aquaculture, dredging and spoil disposal

Subnet Size: This subnet has 44 water bodies with 39 of those being transitional and the remaining 5 coastal.

Location of Monitoring Points: The location of water bodies within this subnet are shown in Table 9.5. Currently not all Irish tidal water bodies identified in the Article 5 report are monitored and some aggregation is required in order to provide effective monitoring. Aggregation of water bodies by type and pressure is undertaken to gauge the effectiveness of measures that are implemented on a wide scale.

9.4.3 OM Subnet 3: Monitoring of Effectiveness of Measures to reduce Hydromorphological pressures

Aim of Subnet: To assess effectiveness of measures to reduce hydromorphological pressures and impacts

Subnet Size: Hydromorphological risk was the most important source of risk to transitional and coastal water status identified in the Article 5 Characterisation Report published in December 2004. Approximately 1 in 3 transitional water bodies and 1 in

5 coastal water bodies were placed 'at risk' or 'probably at risk'. In total 42 water bodies are included in this subnet, with 32 being transitional and 10 being coastal. This represents over 50% of the total number of water bodies in the operational monitoring network, reflecting the importance of hydromorpholigal pressures as a source of risk.

Location of Monitoring Points: The location of monitoring points within this subnet are shown in Table 9.5. As with the diffuse pollution monitoring some aggregation is required in order to provide effective monitoring of measures for hydromorphological pressure.

9.4.4 OM Subnet 4: Monitoring of the Effectiveness of Measures aimed at retaining High and Good status

Aim of Subnet: To monitor high and good status sites currently not deemed to be 'at risk' in order to assess the effectiveness of measures aimed at maintaining high and good status sites.

Subnet Size: This subnet includes 8 transitional and 10 coastal water bodies.

Location of Monitoring Points: This subnet will include representative water bodies of high and good status transitional and coastal waters. Water bodies in this subnet are given in Table 9.5.

9.4.5 OM Subnet 5: Electronic Alert and Remote Sensing Subnet

Aim of Subnet: To identify episodic pollution sources and associated impacts not captured by other subnets. Routine spot sampling does not always coincide and therefore capture pollution events that occur over short time-scales. Infrequent discharges of pollutants may be highly damaging to aquatic ecosystems but can be difficult to pinpoint in space and time using traditional spot sampling techniques. Where discharges are constant spot sampling is effective but many discharges are episodic and unpredictable in nature. Electronic alert networks of in-situ monitoring instruments – providing continuous measurement and telemetry of parameters such as salinity, turbidity, DO, etc. will be used to provide alerts to potential pollution sources or pollution incidents.

Size of subnet: This subnet will be introduced on a pilot basis and will link in with what has been suggested for the rivers and lake monitoring programmes.

Location of Monitoring Points: The most obvious advantage of using in situ monitoring devices over traditional methods is their ability to collect high frequency information that can be used to resolve the temporal variability of the parameter(s) being measured. However, it will also be necessary to assess the number of single point locations that will be required to resolve the spatial resolution of the water body or area being monitored. In areas that display high temporal variation but low spatial variation, a single point location may be sufficient, whereas in areas that display both high temporal and spatial variability, a number of sites may be required. For example, a small to medium sized shallow lake that remains vertically mixed throughout the year, displaying relatively little spatial variation, may only require a single point location. In an estuary, however, where the level of spatial variation

along the salinity gradient is high a number of sites may be needed, whereas in the adjacent coastal water, where the level of spatial variability is low, a single site may be adequate. This is one of the fundamental questions that should be addressed in any pilot programme.

As stated previously sufficient resources to enable the ongoing maintenance of such a network is a key to the success of this type of approach.

9.4.6 OM Subnet 6: Species and Habitat Protected Areas

Aim of Subnet: To monitor Species and Habitat Protected Areas that are at risk of failing to meet their specific environmental objectives.

Size of Subnet: A total of 59 water bodies, or just over 70% of all water bodies in the operational network are included in this subnet. This includes 12 coastal water bodies and 47 transitional water bodies. See Table 9.3 for initial coastal and transitional water bodies included in this subnet.

Location of Monitoring Points: See Table 9.5 for location of monitoring points.

9.5 Quality Element, Site Selection and Sampling Frequency for the Operational Monitoring Programme

The selection of the most appropriate quality elements for the operational programme was based on expert knowledge, the outcome of classification tool development, and guidance provided by the United Kingdom-Republic of Ireland Marine Task Team. This exercise has helped to identify the elements most sensitive to the relevant pressures (see Table 9.2).

Expert judgement was also used to supplement the risk assessment approach in the selection of site numbers particularly for transitional and coastal lagoons.

It was decided to include most of the biological quality elements in water bodies requiring measures for the protection of high/good status (see subnet 4 above).

9.5.1 Biological elements for Coastal and Transitional Waters

A comprehensive overview of each biological element has been given in section 9.3 above.

9.5.2 Summary of the Operational and Surveillance Monitoring programmes.

A summary of the operational and surveillance monitoring programmes for coastal and transitional waters is shown in Table 9.3. A total of 117 water bodies are included. Of these, 82 are transitional and 35 coastal. Of the transitional water bodies, 56 are included in the operational programme and 26 in the surveillance

programme, for coastal water bodies, 23 are operational and 12 are surveillance. The number of monitoring sites and sampling frequency for each quality element in both programmes and water categories is also shown in Table 9.3

The combined operational and surveillance monitoring programmes, which includes 117 water bodies, represents approximately 40% of the total number of water bodies that were originally considered for inclusion.

Table 9.2 Sensitivity of quality elements (and associated metrics) to pressures

Biological Element	Pressure biological element responds to:
BENTHIC MACROINVERTEBRATES	
Soft sediment multi-metric	Hazardous substances, TBT, organic enrichment, dredging, aggregates extraction, spoil disposal
Sensitive species/megafauna tool (To be Developed)	Commercial fishing & shellfish
Hard substrate tool	TBT, disposal
MACROALGAE	
Opportunistic species tool	Nutrient enrichment
Reduced species list	Nutrient enrichment, disposal, hydromorphological change
Fucoid extent (TW only)	Hazardous substances
SEAGRASS	
Intertidal spatial extent, density and diversity	Hydromorphology and nutrient enrichment
SALTMARSH	
Spatial extent	Hydromorphology
PHYTOPLANKTON	
Bloom frequency, composition and biomass	Nutrient enrichment
FISH	
Transitional multi-metric	Ammonia, hazardous substances, catchment abstraction, fishing, shellfish, landclaim, shoreline, barrages (TBD), weirs/sluices (TBD)
Transitional multi-metric with increased summer sampling	Organic enrichment, catchment abstraction

Biological Element	Pressure biological element responds to:
PHYSICO-CHEMICAL	
Nutrients	Nutrient enrichment, Industrial abstraction, catchment abstraction
Dissolved oxygen	Nutrient and organic enrichment
Temperature	Industrial abstraction/discharges
Transparency/Turbidity	Nutrient enrichment
Salinity (monitored with DO & temp)	Catchment abstraction and hydromorphological change
HYDROMORPHOLOGICAL	
Exposure	Landclaim, shoreline
Freshwater flow	Industrial abstraction, catchment abstraction, barrages, weirs/sluices
Currents	Landclaim, shoreline
Depth, substrate, structure & condition of intertidal	Landclaim, shoreline, dredging, aggregate, disposal, barrages, weirs/sluices, fishing, shellfish, alien species (chinese mitten crab only)
Depth, substrate, structure of coastal bed	Landclaim, shoreline, dredging, aggregate, disposal, weirs/sluices, fishing, shellfish
DANGEROUS SUBSTANCES	
Priority Substances	Industrial discharges, agricultural, landfill sites, domestic, transport, run-off,
Relevant Pollutants	Industrial discharges, agricultural, landfill sites, domestic, transport, run-off,

Table 9.3 Summary of Coastal and Transitional Waters Monitoring programme

a) Transitional Waters									
Quality Element	**Phytoplankton**	**Macroalgae**	**Angiosperms**	**Benthic Invertebrates**	**Hydromorphology**	**Physio-chemical**	**Relevant Pollutants**	**Priority Substances**	**Fish**
56 Operational Water Bodies									
Total number of Operational Sites	53	42	30	74	38	191	13	13	96
Number of sites required:									
On an annual cycle	53 (4)	-	-	-	-	191 (4)	13 (4)	13 (12)	-
On a 3-year cycle	-	14 (1)	10 (1)	25 (1)	-	-	4 (4)	4 (12)	32 (1)
On a 6-year cycle	-	-	-	-	6	-	-	-	-
26 Surveillance Water Bodies									
Total number of Surveillance Sites	27	28	45	36	22	61	23	23	54
Number of sites required:									
On an annual cycle	27 (4)	-	-	-	-	61 (4)	-	-	-
On a 3-year cycle	9 (4)	9 (1)	15 (1)	12 (1)	-	-	-	-	18 (1)
On a 6-year cycle	-	-	-	-	4	-	4 (4)	4 (12)	-

Table 9.3 (contd) Summary of Coastal and Transitional Waters Monitoring programme

b) Coastal Waters

Quality Element	Phytoplankton	Macroalgae	Angiosperms	Benthic Invertebrates	Hydromorphology	Physio-chemical	Relevant Pollutants	Priority Substances	Fish
23 Operational Water Bodies									
Total number of Operational Sites	16	41	26	96	10	92	1	0	NR
Number of sites required:									
On an annual cycle	16 (12)	-	-	-	-	92 (4)	1 (4)	-	NR
On a 3-year cycle	-	14 (1)	9 (1)	32 (1)	-	-	-	-	NR
On a 6-year cycle	-	-	-	-	2	-	-	-	NR
12 Surveillance Water Bodies									
Total number of Surveillance Sites	21	44	23	53	12	48	12	12	NR
Number of sites required:									
On an annual cycle	21 (12)	-	-	-	-	48 (4)	-	-	NR
On a 3-year cycle	7 (12)	15 (1)	8 (1)	18 (1)	-	-	-	-	NR
On a 6-year cycle	-	-	-	-	2	-	2 (4)	2 (12)	NR

(parenthesis denotes sample frequency per year; NR = not required)

Table 9.4 Location and number of water bodies in each of the surveillance monitoring subnets. (Subnet 1; representative, Subnet 2; long-term trend analysis (a) natural, (b) anthropogenic, Subnet 3; validating and supplemented the risk assessment, and Subnet 4; stipulated sites)

(i) Transitional Water Bodies								
Water body **a = Reference** **b = Intercalibration** **c = OSPAR** **d = Crosses MS Boundary**	**RBD**	**TYPE**	**Overall 'Risk' Status**	**Subnet 1**	**Subnet 2 (a)**	**Subnet 2 (b)**	**Subnet 3**	**Subnet 4**
Boyne Estuary[c]	EARBD	TW2	1a					
Avoca Estuary[c]	EARBD	TW2	1a					
Newry Estuary[cd]	NBIRBD	TW2	1a					
Erne Estuary[cd]	NWIRBD	TW2	1b					
Gweebarra Estuary[a]	NWIRBD	TW2	2b					
Foyle and Faughan Estuaries[cd]	NWIRBD	TW2	1a					
Barrow Nore Estuary Upper	SERBD	TW2	1a					
Upper Barrow Estuary[c]	SERBD	TW2	1a					
Nore Estuary[c]	SERBD	TW2	1b					
Lower Suir Estuary[b]	SERBD	TW2	1a					
New Ross Port	SERBD	TW2	1a					
Barrow Suir Nore Estuary	SERBD	TW2	1b					
Lough Gill	SHIRBD	TW6	2a					
Limerick Dock[c]	SHIRBD	TW2	1a					
Upper Shannon Estuary[c]	SHIRBD	TW2	1a					
Fergus Estuary[c]	SHIRBD	TW2	1a					
Lower Shannon Estuary	SHIRBD	TW2	1a					
Drongawn Lough, Sneem[a]	SWRBD	TW6	1b					
Castlemaine Harbour	SWRBD	TW2	1b					
Cromane	SWRBD	TW2	1b					
Loch an tSaile, Mannin Bay	WERBD	TW6	2b					
Murree Lough	WERBD	TW6	2b					
L. an Aibhinn, Camus Bay[a]	WERBD	TW6	2b					

(i) Transitional Water Bodies								
Water body **a = Reference** **b = Intercalibration** **c = OSPAR** **d = Crosses MS Boundary**	**RBD**	**TYPE**	**Overall 'Risk' Status**	**Subnet 1**	**Subnet 2 (a)**	**Subnet 2 (b)**	**Subnet 3**	**Subnet 4**
Kinvarra Bay	WERBD	TW2	1b					
Ballysadare Estuary[c]	WERBD	TW2	1b					
Camus Bay[a]	WERBD	TW2	2a					
Total in each subnet				26	4	22	26	11
(ii) Coastal Water Bodies								
Water body a = Reference b = Intercalibration c = OSPAR d = Crosses MS Boundary	RBD	Type	Overall 'Risk' Status	Subnet 1	Subnet 2 (a)	Subnet 2 (b)	Subnet 3	Subnet 4
Dublin Bay[b]	EARBD	CW5	1a					
Carlingford Lough[d]	NBIRBD	CW8	1b					
Gweebarra Bay[a]	NWIRBD	CW5	2b					
Lough Foyle[bd]	NWIRBD	CW8	1b					
NW Atlantic (HAs 37;38) [a]	NWIRBD	CW2	2b					
Waterford Harbour[a]	SERBD	CW2	2a					
Cork Harbour[b]	SWRBD	CW8	1a					
Outer Kenmare River[a]	SWRBD	CW2	1b					
Roaring Water Bay[a]	SWRBD	CW2	2b					
Ballysadare Bay[a]	WERBD	CW8	2b					
Sligo Bay[b]	WERBD	CW5	2a					
Kilkieran Bay[a]	WERBD	CW5	2a					
Total in each subnet				12	8	4	12	2

Table 9.5 Location and number of water bodies in each of the operational monitoring subnets. (Subnet 1; at risk or probably at risk, Subnet 2; point and diffuse measures, Subnet 3; hydromorphological measures, Subnet 4; high and good status, Subnet 5; alert and remote sensing (To be decided), and Subnet 6; protected areas.

(i) Transitional Water Bodies									
Water body **a = Reference** **b = Intercalibration** **c = OSPAR** **d = Crosses MS Boundary**	**RBD**	**TYPE**	**Overall 'Risk' Status**	**Subnet 1**	**Subnet 2**	**Subnet 3**	**Subnet 4**	**Subnet 5**	**Subnet 6**
Rogerstown Estuary	EARBD	TW2	1b	■	■	■			■
Broadmeadow Water	EARBD	TW6	1a	■	■	■			■
Broad Lough	EARBD	TW2	1a	■	■	■			■
Liffey Estuary Lower	EARBD	TW2	1a	■	■	■			
Liffey Estuary Upper[c]	EARBD	TW2	1a	■	■	■			■
Tolka Estuary[c]	EARBD	TW2	1a	■	■	■			■
Castletown Estuary	NBIRBD	TW2	1a	■	■	■			■
Inner Dundalk Bay	NBIRBD	TW2	1a	■	■	■			■
Inch Lough	NWIRBD	TW6	1b	■		■			■
Swilly Estuary	NWIRBD	TW2	1b	■		■			■
Durnesh Lough	NWIRBD	TW6	2b				■		■
Inner Donegal Bay	NWIRBD	TW2	2a				■		■
North Slob Channels	SERBD	TW6	1b	■		■			■
Tacumshin Lake	SERBD	TW6	1b	■		■			■
Bridgetown Estuary	SERBD	TW2	1b	■		■			■
Lower Slaney Estuary	SERBD	TW2	1a	■	■	■			■
Middle Suir Estuary	SERBD	TW2	1a	■	■	■			■
Lady's Island Lake	SERBD	TW6	1b	■	■				■
Colligan Estuary	SERBD	TW2	1b	■	■				■
Upper Slaney Estuary[c]	SERBD	TW2	1a	■	■				■
Upper Suir Estuary[c]	SERBD	TW2	1a	■	■				■
Lee Estuary Tralee	SHIRBD	TW2	1a	■	■	■			■

(i) Transitional Water Bodies									
Water body **a = Reference** **b = Intercalibration** **c = OSPAR** **d = Crosses MS Boundary**	**RBD**	**TYPE**	**Overall 'Risk' Status**	**Subnet 1**	**Subnet 2**	**Subnet 3**	**Subnet 4**	**Subnet 5**	**Subnet 6**
Shannon Airport Lagoon	SHIRBD	TW6	1a						
Cashen	SHIRBD	TW2	1a						
Maigue Estuary[c]	SHIRBD	TW2	1a						
Upper Feale Estuary	SHIRBD	TW2	1a						
Lough Donnell	SHIRBD	TW6	1a						
Deel Estuary[c]	SHIRBD	TW2	1a						
Glashaboy Estuary	SWRBD	TW2	1a						
Lough Mahon	SWRBD	TW2	1a						
(Harper's Is.), L. Mahon	SWRBD	TW2	1a						
Owenacurra Estuary	SWRBD	TW2	1a						
Lee (Cork) Estuary Lower	SWRBD	TW2	1a						
Lee (Cork) Estuary Upper[c]	SWRBD	TW2	1a						
Lower Bandon Estuary	SWRBD	TW2	1a						
Lower Blackwater Estuary	SWRBD	TW2	1a						
Inner Kenmare River[a]	SWRBD	TW2	2b						
Kilkeran Lake	SWRBD	TW6	2a						
Kilmakilloge Harbour	SWRBD	TW2	2a						
Argideen Estuary	SWRBD	TW2	1b						
Ilen Estuary	SWRBD	TW2	1b						
Nrth. Channel Great Island	SWRBD	TW2	1a						

Table 9.5 (continued)

(i) Transitional Water Bodies									
Water body a = Reference b = Intercalibration c = OSPAR d = Crosses MS Boundary	RBD	TYPE	Overall 'Risk' Status	Subnet 1	Subnet 2	Subnet 3	Subnet 4	Subnet 5	Subnet 6
Upper Bandon Estuary[c]	SWRBD	TW2	1a						
Upper Blackwater Estuary[c]	SWRBD	TW2	1a						
Sruwaddacon Bay	WERBD	TW2	1b						
Tullaghan Bay	WERBD	TW2	1b						
Corrib Estuary[c]	WERBD	TW2	1a						
Garavoge Estuary[bc]	WERBD	TW2	1a						
Bridge L., Knockakilleen	WERBD	TW6	2b						
Loch Tanai	WERBD	TW6	2b						
Loch an tSaile	WERBD	TW6	2a						
Furnace Lough	WERBD	TW6	1b						
Newport Bay[b]	WERBD	TW2	1b						
Westport Bay[b]	WERBD	TW2	1b						
Erriff Estuary	WERBD	TW2	1a						
Moy Estuary[c]	WERBD	TW2	1a						
Total in each subnet				48	39	32	8		47
(ii) Coastal Water Bodies									
Water body	RBD	TYPE	Overall 'Risk' Status	Subnet 1	Subnet 2	Subnet 3	Subnet 4	Subnet 5	Subnet 6
Boyne Est. Plume Zone	EARBD	CW5	1a						
Irish Sea - Killiney Bay	EARBD	CW5	1a						
Northwestern Irish Sea	EARBD	CW5	2a						
Malahide Bay[b]	EARBD	CW8	1a						
Outer Dundalk Bay[b]	NBIRBD	CW5	1b						

Table 9.5 (contd)

(ii) Coastal Water Bodies									
Water body	RBD	TYPE	Overall 'Risk' Status	Subnet 1	Subnet 2	Subnet 3	Subnet 4	Subnet 5	Subnet 6
Killybegs Harbour	NWIRBD	CW8	1a						
Mulroy Bay Broadwater	NWIRBD	CW8	1b						
Lough Swilly	NWIRBD	CW5	1b						
Southwestern Irish Sea	SERBD	CW5	1b						
Wexford Harbour[b]	SERBD	CW8	1b						
Tramore Back Strand	SERBD	CW8	1b						
Dungarvan Harbour	SERBD	CW5	1b						
Inner Tralee Bay	SHIRBD	CW8	1a						
Mouth of Shannon	SHIRBD	CW2	2a						
Youghal Bay	SWRBD	CW5	2b						
Outer Cork Harbour	SWRBD	CW5	2b						
Kinsale Harbour[a]	SWRBD	CW5	2b						
Berehaven	SWRBD	CW5	2b						
Portmagee Channel	SWRBD	CW8	2b						
Sligo Harbour	WERBD	CW8	1a						
Inner Galway Bay North	WERBD	CW5	2a						
Killary Harbour	WERBD	CW5	2a						
Inner Clew Bay[b]	WERBD	CW5	2a						
Total in each subnet				13	5	10	10		12

9.6 Summary Map of Surveillance and Operational Monitoring for Transitional and Coastal Waters

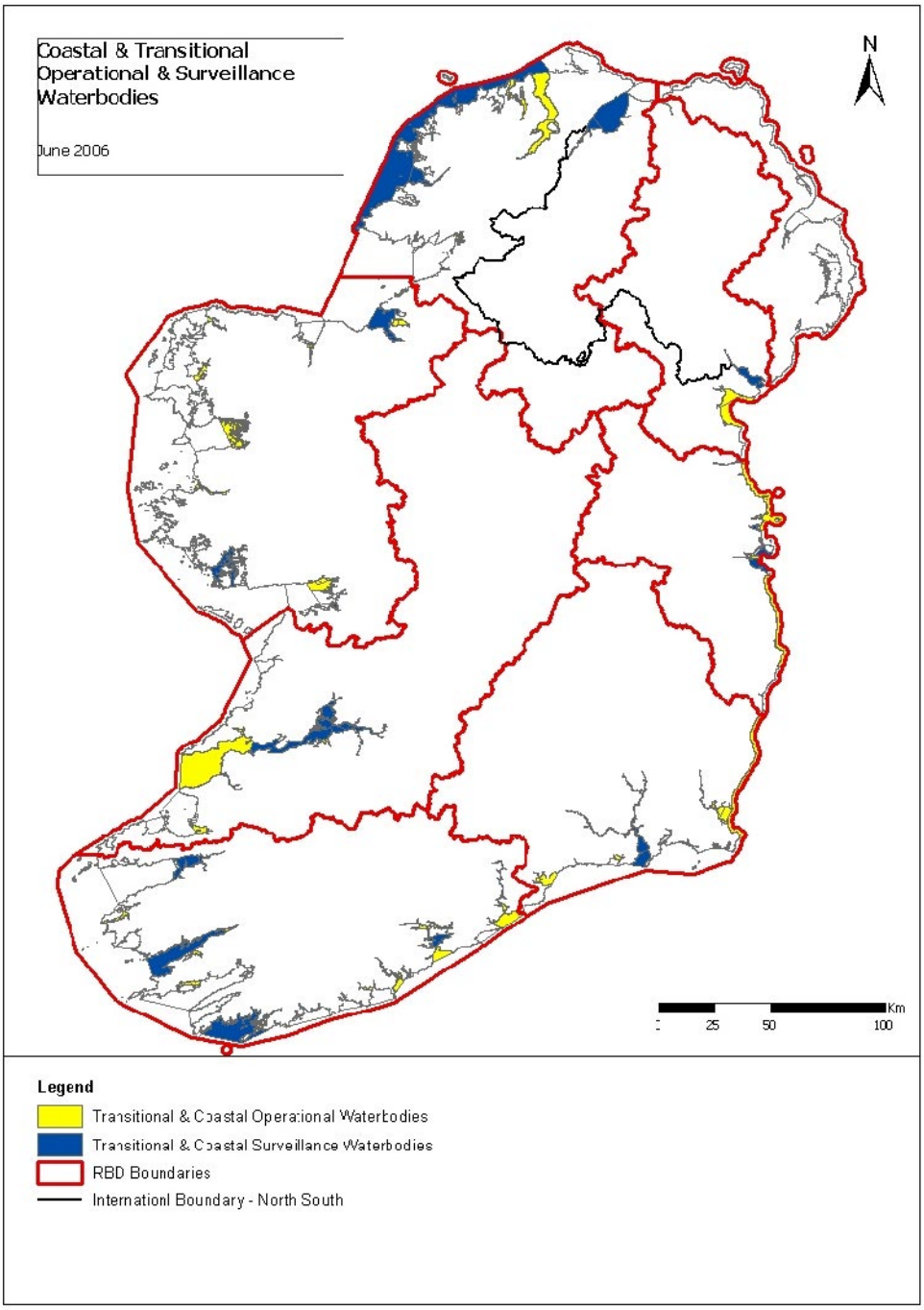

Figure 9.1 Summary Map of Surveillance and Operational Monitoring for Transitional and Coastal Waters.

Chapter 10 Groundwater Monitoring Programme

10.1 Introduction

Article 8 of the Water Framework Directive (2000/60/EC) requires the establishment of programmes of monitoring for groundwater. The groundwater monitoring programmes primarily focus on providing information that can be used to assess the environmental status of groundwater bodies. Additionally, the groundwater monitoring programmes will provide information to assess whether the environmental objectives of Article 4 of the Water Framework Directive (WFD) are being met, thereby supporting the overall environmental and management objectives within a River Basin District (RBD).

This chapter was compiled by the EPA and is based on discussions with the WFD National Groundwater Working Group in Ireland.

Article 8 of the WFD and CIS monitoring guidance (CIS Guidance Document No. 7, 2003) indicate that monitoring is required to assess groundwater status and groundwater monitoring programmes must include:

- A quantitative monitoring network;
- A surveillance water quality monitoring network;
- An operational water quality monitoring network;
- Appropriate monitoring to support the achievement of Protected Area objectives e.g. Drinking Water or Habitats Protected Areas.

The RBD consultants and the EPA are currently undertaking further characterisation studies to improve upon the anthropogenic pressures data used for the Annex II risk assessment in 2005. The further characterisation studies include the study of point source pressures (landfill, contaminated land, quarries and mines); the study of diffuse mobile organic pressures e.g. pesticides; and the study of pressures associated with urban areas.

The initial recommendations from a number of these studies are fundamental to the selection of appropriate groundwater monitoring locations for the groundwater monitoring programmes. Hereafter, the application of the further characterisation methodologies, in conjunction with monitoring data, will be used to verify the Annex II risk assessment and support the groundwater status assessment.

Therefore, the exact location of groundwater monitoring points in the Republic of Ireland will not be finalised until November 2006, with monitoring programmes becoming operational on 22nd December 2006. Once the exact monitoring point locations have been finalised, their locations will be circulated to relevant stakeholders. There will be ongoing liaison between representatives from the National Groundwater Working Group in Ireland and relevant stakeholders to discuss the installation of monitoring infrastructure for the monitoring programmes, e.g. new wells, piezometers, weirs and data loggers.

10.1.1 Background for Selecting Sites

Annex V of the WFD and the CIS monitoring guidance indicate that conceptual understanding of the hydrogeological system and the impact assessment of anthropogenic pressures, used to prepare the WFD Annex II risk assessment, should be used to help target and prioritise the selection/location of appropriate monitoring points and the monitoring network should be reviewed as this understanding improves. To avoid the unnecessary expenditure and resources required to install new monitoring points, the WFD permits grouping of groundwater bodies if the hydrogeology and pressures are similar. The National Groundwater Working Group in Ireland decided upon nine bedrock unit groups and a single gravel aquifer group in the Republic of Ireland. Broadly, the groups are as follows:

- Permo-Triassic Sandstones & Mudstones;
- Silesian Sandstones & Shales;
- Dinantian Impure Limestones;
- Dinantian Pure Limestones & Precambrian Marbles;
- Devonian / Dinantian Sandstones;
- Old Red Sandstone & Dinantian Sandstones & Mudstones (Cork Group);
- Lower Paleozoic Volcanics & Metasediments;
- Basalts;
- Granites;
- Gravels.

These groups were sub-divided using the groundwater bodies defined in the Annex II Characterisation and Risk Assessment Report, i.e. it is based on aquifer type (Figure 10.1) and risk category (Figure 10.2). The CIS monitoring guidance indicates that a monitoring network should be developed to reflect variation in hydrogeology and pressure within each groundwater body or group of bodies. The selection of groundwater monitoring locations that reflect this conceptual understanding is paramount when designing a representative groundwater monitoring network because of the resources and costs associated with relocating groundwater monitoring sites.

Existing groundwater monitoring locations from the current EPA National Groundwater Quality and Level Monitoring Programmes have been reviewed to determine their suitability for WFD monitoring and where appropriate, these monitoring locations have been integrated into the WFD monitoring programmes. Where groundwater bodies have been identified as being “at risk” from point source pressures in the Annex II risk assessment, monitoring data from existing compliance monitoring e.g. from IPPC licensed activities, will be utilised for the assessment of point source pressures. Where necessary, the compliance monitoring may be supplemented by additional monitoring e.g. where the monitoring is deemed to be inadequate for WFD purposes or for currently unlicensed point source pressures.

The monitoring programmes are being designed to coincide with monitoring in Northern Ireland, so an assessment can be made of the rate and direction of flow across Member State boundaries. Monitoring locations in groundwater bodies or groups of bodies that cross Member State boundaries are determined by the need to develop a representative monitoring network and, where appropriate, include monitoring in both Northern Ireland and the Republic of Ireland.

The design of the groundwater monitoring network in the Republic of Ireland is based on key sub-networks (or 'subnets'); each designed to fulfil one or more of the main objectives of the groundwater monitoring programme. These are described in greater detail in the subsequent sections of this chapter.

10.1.2 Sampling

Monitoring data can be inadvertently impacted upon by borehole construction and sampling procedures. The RBD consultants have screened all potential monitoring sites to ensure they are suitable WFD monitoring sites and are not subject to localised anthropogenic influences. Any new monitoring sites will also be subject to this screening exercise. Sampling methods and protocols are outlined in the CIS monitoring guidance and these will be used in conjunction with other internal and external sampling guidance e.g. those mentioned in Chapter 3 of this report.

Sampling will begin on December 22nd 2006 at all monitoring sites that currently exist, with monitoring beginning at new sites once they are installed in 2007. The current shortfall of monitoring sites is mainly associated with point source pressures, Groundwater Dependent Terrestrial Ecosystems (GWDTE) and poorly productive aquifers. Monitoring locations for point sources will not be determined until further characterisation study methodologies are applied, although monitoring data currently gathered for licensed point sources will be utilised for this monitoring network. Ecosystem monitoring will be phased in between 2007-2009, initially focusing on the ecosystems that are known to be "at risk" and where groundwater is potentially contributing to the ecosystem being damaged. Rather than monitoring existing sites in the poorly productive aquifers, the National Groundwater Working Group in Ireland decided that new monitoring points should be installed in these aquifers because the hydrogeological knowledge gained during installation is fundamental to understanding what is being monitored.

Generally, sampling depth is not considered to be a critical factor when monitoring groundwater in the Republic of Ireland because most of the bedrock aquifers are unconfined and have fissure permeability only. The only aquifers in the Republic of Ireland with an intergranular permeability are the sand and gravels. Consequently, groundwater velocities in most Irish bedrock aquifers are relatively fast (a few metres/day) and mixing of groundwater in the top ~60m readily occurs. The proposed monitoring network uses points with relatively large groundwater abstractions and these are considered to give representative samples because they are not usually affected by nearby point source pollution.

In the case of springs, the sampling depth is at the ground surface. In boreholes, pumps are usually located towards the bottom of the boreholes; therefore the sampling depths are determined by borehole depth. In some instances, screens are installed at the main water entry zones. In the remaining monitoring points, the boreholes are 'open hole', i.e. a liner or screen is not needed due to the competent nature of the bedrock. Water can usually be drawn from all bedrock fractures in the borehole, i.e. from the total bedrock length. Therefore, the water sample is generally

a composite of water from all fractures and/or conduits through out the total length of bedrock in the borehole.

In the poorly productive bedrock aquifers, groundwater flow is considered to flow in three pathways: in fault zones; in fractured and weathered zones at the top of the bedrock; and at depth in widely dispersed, poorly interconnected fissures. There are a number of monitoring points currently installed in the fault zones and multi-level piezometers will be installed to monitor the latter two pathways.

10.1.3 Data Handling

An assessment of confidence in the status assessment is key in the justification of corrective action. When assessing confidence in groundwater data, the UKTAG monitoring guidance (UKTAG Guidance 12a, 2004) indicates that a combination of hydrogeological knowledge and statistics is important. Hydrogeological knowledge will be provided through the selection of appropriate monitoring frequencies. Once appropriate monitoring points and sampling frequencies have been selected, confidence will be assessed using standard statistical tests on the available data to identify upper and lower confidence limits associated with the data. Thresholds for trends and means can then be assessed against these limits. Exceedence of a threshold at the 95% confidence limit will generally be the key driver for initiating corrective action. Lower levels of confidence should generally drive further investigation, rather than corrective action. Given the hydrogeological variability and frequency of groundwater sampling, it is recommended that the statistical tests should be based on at least six years of data.

It is recommended that the WFD requirements for precision in the monitoring data be addressed through:

- The use of a minimum six years of data and appropriate minimum sampling frequencies in carrying out status assessments;
- The use of accredited laboratories;
- The implementation of appropriate Quality Assurance and Quality Control procedures (Chapter 3).

10.1.4 Groundwater Classification Systems

The UK-Ireland Groundwater Task Team has developed draft UKTAG guidance for the assessment of groundwater quantitative and chemical status[7]. It is proposed that groundwater classification systems in Ireland will largely adhere to the principles of this guidance, although it is recognised that the guidance has been developed to cover scenarios in both Member States and there are scenarios in the UK that would not exist in Ireland and vice versa.

[7] Currently the draft UKTAG guidance is going through a formal process of sign off within the UKTAG group.

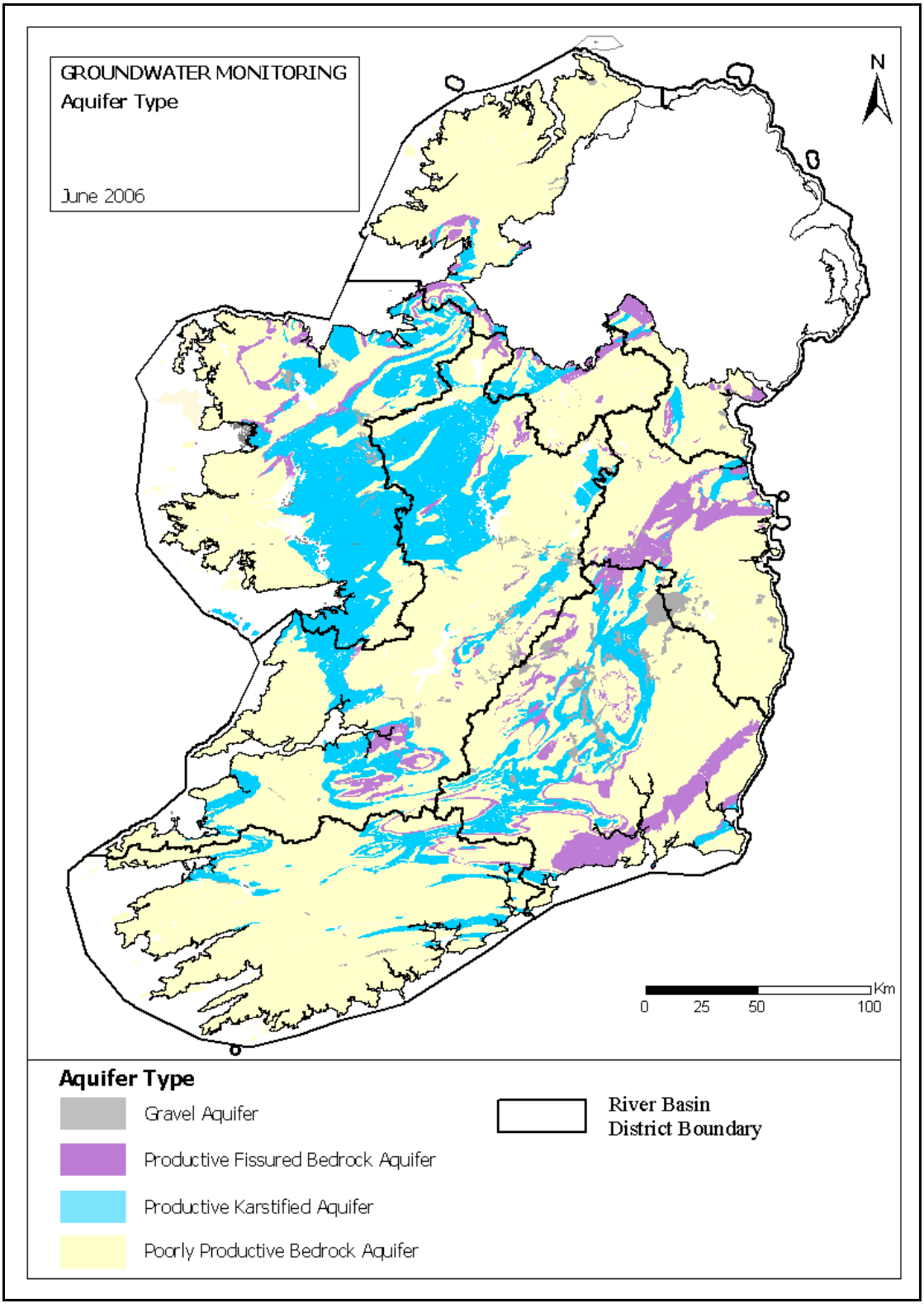
GROUNDWATER MONITORING
Aquifer Type
June 2006
N
Km
0
25
50
100
Aquifer Type
Gravel Aquifer
Productive Fissured Bedrock Aquifer
Productive Karstified Aquifer
Poorly Productive Bedrock Aquifer
River Basin
District Boundary

Figure 10.1 Conceptual Aquifer Flow Regime in the Republic of Ireland

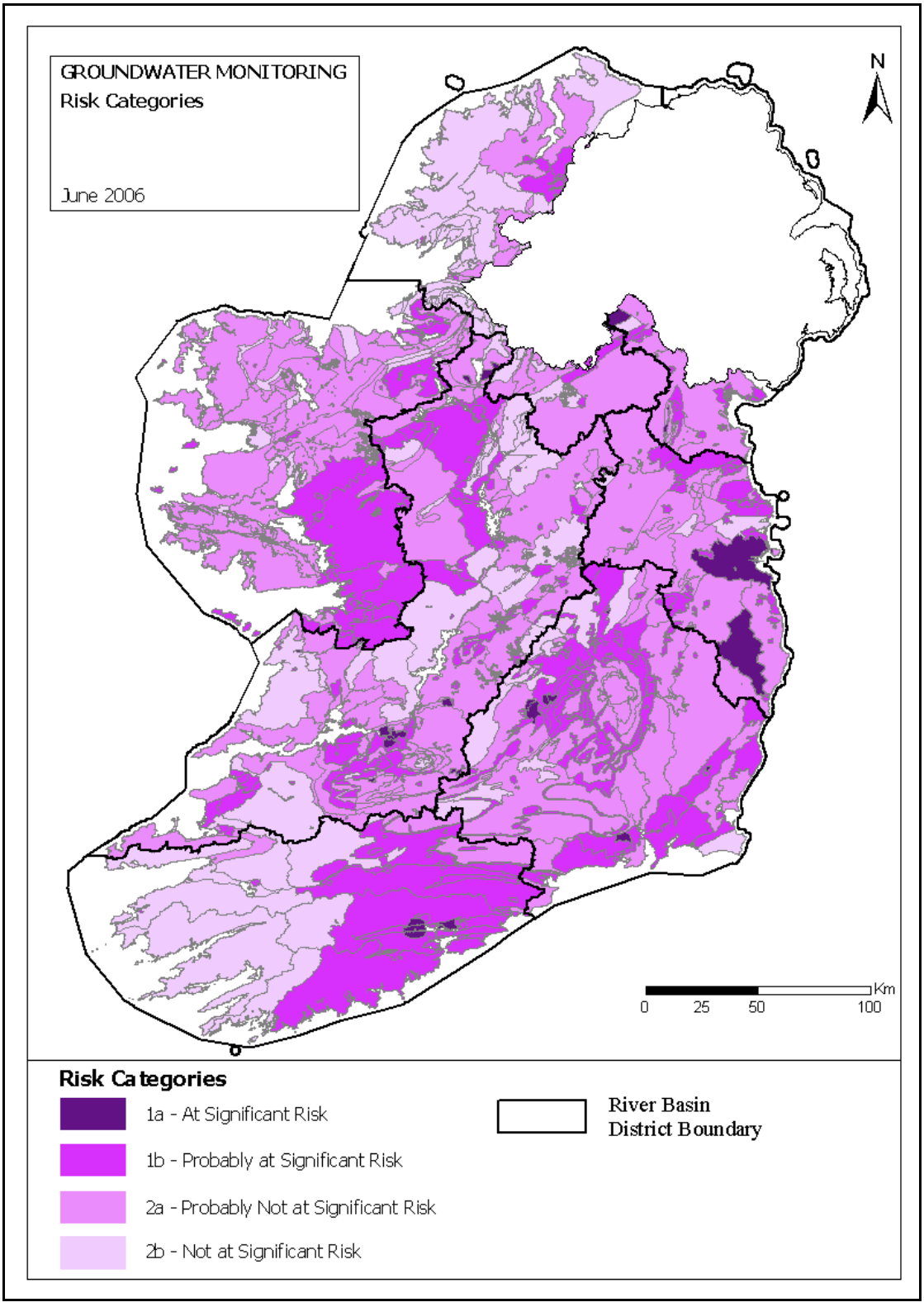

Figure 10.2 Groundwater Body Annex II Risk Assessment in the Republic of Ireland

10.2 Quantitative Groundwater Monitoring

The quantitative groundwater monitoring programme is required to:

- Supplement and validate the Annex II risk assessment procedure;
- Determine the quantitative status of groundwater bodies;
- Support the chemical status assessment and trend analysis; and
- Support the design and evaluation of Programmes of Measures (POMs).

Annex V of the WFD indicates that the network shall include sufficient representative monitoring points to estimate the groundwater level in each groundwater body or group of bodies, taking into account short and long-term variations in recharge and the impacts of abstractions and discharges on groundwater levels.

The quantitative monitoring network design is based on the conceptual understanding of the groundwater system and abstraction pressures, thereby enabling a water balance assessment for the overall groundwater body or group of bodies. Consideration has also been given to 'local' monitoring of levels and flows that relate to relevant local groundwater supported receptors, i.e. surface water bodies (rivers, lakes, estuaries) and GWDTE.

The quantitative monitoring network has been developed after assessing:

- Recharge and the water balance;
- Existing groundwater level and/or discharge data and relevant information on the risks for groundwater dependent surface waters and GWDTE;
- The degree of interaction between groundwater and related surface water receptors.

10.2.1 Site Selection in Productive Aquifers

The monitoring network in groundwater bodies or groups of bodies defined as being "at risk" in the Annex II Characterisation and Risk Assessment Report reflects the need to understand the hydrogeological conditions associated with "at risk" receptors. In these groundwater bodies, the monitoring network is designed to help assess anthropogenic impacts on the flow of water across the groundwater body from recharge to discharge areas and on the flow from groundwater bodies to associated receptors defined as being "at risk". The monitoring network is also designed to improve knowledge of the hydrogeology.

Monitoring in groundwater bodies or groups of bodies defined as being "not at risk" in the Annex II Characterisation and Risk Assessment Report, has been optimised by grouping bodies where the hydrogeology and pressures are similar. The distribution of monitoring points for quantitative monitoring in the productive aquifers is designed to improve knowledge of the hydrogeology and improve understanding of the flow of water across the groundwater body from recharge to discharge areas.

10.2.2 Site Selection in Poorly Productive Aquifers

As poorly productive aquifers, by their nature, are generally unable to yield significant quantities of groundwater for abstraction, their quantitative status is unlikely to be impacted upon by abstractions, except where sensitive receptors are affected by localised pumping. In addition, groundwater flow paths are generally short in these aquifers, and consequently water level monitoring is probably only representative of a small area in the vicinity of the monitoring point. Consequently, the National Groundwater Working Group in Ireland decided that a dispersed network of monitoring in the poorly productive aquifers would not be beneficial and the proposed monitoring network would focus on monitoring three scenarios:

- Groundwater bodies where there are sensitive receptors considered to be "at risk" from abstraction;
- Major fault zones;
- Ten poorly productive typology settings that take account of many of the different poorly productive aquifer types in the Republic of Ireland.

Monitoring in the ten poorly productive typology settings will require the installation of piezometers, with pumping tests used to provide information on the hydrogeology. These settings and the River Basin Districts where monitoring will take place are indicated in Table 10.1.

Table 10.1 Quantitative monitoring in poorly productive aquifers in the Republic of Ireland

Hydrogeological setting	River Basin District
Carboniferous (Upper Impure Limestone – 'Calp')	ERBD
Carboniferous (Lower Impure Limestone – 'Ballysteen')	ERBD
Namurian (Upper Carboniferous) Sandstone	ShRBD
Westphalian / Namurian (Upper Carboniferous) – mudstone / shale	ShRBD
Weakly metamorphosed (Ordovician/Silurian) – sandstone	SERBD / ERBD
Weakly metamorphosed (Ordovician/Silurian) – siltstone / mudstone	SERBD / ERBD
Highly metamorphosed (Pre-Cambrian)	WRBD
Granites	WRBD
Granites with overlying weathered granite gravels	SERBD
Old Red Sandstone	SWRBD

Groundwater quality samples will also be taken at the monitoring locations in the poorly productive aquifers to support the conceptual understanding of the hydrogeology and pressures at these locations. These samples will be taken during site visits e.g. when downloading data loggers or carrying out site maintenance. Water quality samples will be analysed for the surveillance monitoring determinands indicated in Appendix 10.1.

Where appropriate, supporting information from ecological monitoring (as evidence of impact on ecosystems from groundwater abstractions) may also be required.

10.2.3 Quantitative Monitoring Subnet

Aim of subnet: Supplement and validate the Annex II risk assessments and provide information to support the quantitative status assessment e.g. through long-term water level trends.

Subnet size: Quantitative monitoring of the "at risk" and "not at risk" productive aquifers will involve the installation of data loggers at approximately 190 monitoring points in the Republic of Ireland.

Quantitative monitoring in the poorly productive aquifers will be limited to the installation of data loggers at an additional 70 monitoring points nationally.

Location of monitoring points: Monitoring in the groundwater bodies, defined as being "at risk" in the Annex II Characterisation and Risk Assessment Report, must be sufficient to ensure proper assessment of impacts on groundwater level caused by abstractions and discharges. Therefore monitoring will focus on the groundwater body recharge and discharge areas, with monitoring used to determine the abstraction impacts on nearby surface water receptors. Monitoring will be used to confirm the Annex II risk assessment and improve hydrogeological understanding of the groundwater flow in "not at risk" productive aquifers. Therefore, monitoring sites will be located across a groundwater body or group of bodies to achieve a good spatial spread of data, with monitoring in groundwater body recharge and discharge areas and areas where there are known future planned abstractions.

In the poorly productive aquifers, monitoring in the ten poorly productive typology settings will comprise of pairs of (newly installed) piezometers, installed at 30 separate locations nationally, with monitoring points divided equally amongst the ten poorly productive aquifer hydrogeological groups identified in Table 10.1. Monitoring will also take place at known major fault zones, where abstractions are known to have an impact on water level, and in groundwater bodies where there are sensitive receptors considered to be "at risk" from abstraction.

10.2.4 Quantitative Monitoring Summary

The RBD breakdown of the quantitative monitoring locations is given in Appendix 10.3. There will be a number of monitoring locations in Northern Ireland to accommodate the assessment of quantitative status in groundwater bodies that cross Member State boundaries. Once the final location of all monitoring points has been decided upon, the location details will be provided in Appendix 10.4.

In total, approximately 260 monitoring points are proposed for the quantitative monitoring programme in the Republic of Ireland. Infrastructure shortfalls for the quantitative monitoring programme, including numbers of new piezometers and data loggers required within each RBD are identified in Appendix 10.3.

10.2.5 Monitoring frequency

Annex V of the WFD and CIS monitoring guidance indicate that the frequency of monitoring should be influenced by the data requirements to confidently determine risk and status, and where necessary to support the design and assessment of

POMs. Therefore, monitoring points with significant annual variability should be monitored more frequently than points with only minor variability.

The installation of data loggers is proposed at all quantitative monitoring locations because continuous (e.g. hourly or sub-hourly) data recording provides an opportunity to achieve a greater understanding of the aquifer response and behaviour to precipitation events. Continuous data recording also provides the opportunity to investigate groundwater-surface water interactions in greater detail and reduces the need for site visits.

The quantitative monitoring frequency in Appendix 10.2 indicates the recommended frequency of site visits to download data and carry out site maintenance. Higher site visit frequencies are recommended in the first year because checks are essential to assess the reliability of the equipment and therefore verify the accuracy of the data. The frequency of sites visits can be reduced once it has been verified that the equipment is working correctly, although quarterly visits are recommended to ensure data are not lost e.g. through equipment malfunction or vandalism. The frequency of data recordings taken by the data logger may be revised as knowledge of the aquifer response and behaviour improves, or if there are significant changes in pressures on the groundwater body.

10.2.6 Water quality determinands for the quantitative monitoring programme

In addition to monitoring water levels, information on groundwater abstraction and discharge rates is also required to determine the quantitative status of groundwater bodies and conductivity should be measured as an indicator of saline or other intrusions that are caused by groundwater abstraction. Where groundwater bodies were defined as being “at risk” from saline or other intrusions in the Annex II risk assessment and this was attributed to groundwater abstraction, probes will be used to continuously monitor conductivity. These probes will also provide information on temperature, pH and dissolved oxygen, which will aid conceptualisation, particularly in the more dynamic systems such as karst.

10.3 Groundwater Quality Monitoring

The groundwater quality monitoring programme is required to:

- Supplement and validate the Annex II risk assessment procedure;
- Determine the chemical status of groundwater bodies;
- Establish the presence of any significant upward trends in pollutant concentrations in groundwater bodies and the reversal of such trends;
- Support the design and evaluation of POMs.

The chemical monitoring network design is based on the conceptual understanding of the groundwater system and anthropogenic pressures, thereby enabling an assessment of the pollutants impacting on the overall groundwater body or group of bodies. Water quality data are then used to test or validate this understanding. A good conceptual understanding of the hydrogeological system and pressures is of paramount importance when designing a monitoring network that is representative of the variations in hydrogeology and pressure between, and within, groundwater bodies or groups of bodies.

Conceptual models of the hydrogeological system and the impact of pressures were used to prepare the Annex II Characterisation and Risk Assessment Report in 2005 and additional information has subsequently been gathered, e.g. on well design and water quality, to further improve the conceptual understanding.

10.3.1 Monitoring Site Selection

Monitoring locations are determined by the requirements for achieving a monitoring network that is representative of the variations in hydrogeology and pressure across a groundwater body or group of bodies. The distribution of groundwater quality monitoring points in the productive aquifers takes account of different hydrogeological settings in the Republic of Ireland and focuses on areas where there are perceived pressures on groundwater and associated surface water receptors.

The National Groundwater Working Group in Ireland decided that a representative monitoring network for diffuse pollution pressures is achieved when the hydrogeology and pressure variations impacting upon a combined network of monitoring points is proportionally similar to the combined hydrogeology and pressure variations over the whole groundwater body or group of bodies in which the monitoring points are located i.e. the average concentrations of diffuse pollutants from a representative network of monitoring points should reflect the average concentrations for those pollutants across the whole groundwater body or group of bodies.

Since groundwater contributions from poorly productive rocks to surface water receptors are limited, and the impacts on groundwater mainly relate to local pressures, the development of a regional monitoring network of sufficient size to record all these variations in the poorly productive aquifers is not practical. The National Groundwater Working Group in Ireland decided that monitoring water quality in poorly productive areas should be limited to monitoring points that have abstractions greater than 100 m^3/d and quantitative status monitoring points in poorly productive aquifers (Section 10.2.2).

Groundwater quality samples are currently taken for certain IPPC and waste licensed activities, and also where the conditions of planning regulations stipulate groundwater monitoring. Data gathered at some of these monitoring sites will be utilised for the operational monitoring programme, although supplemental monitoring may also be required, if only to demonstrate the effectiveness of POMs.

10.3.2 Surveillance Monitoring of Groundwater

The overall objectives of the surveillance monitoring programme are specified in the text of Annex V of the WFD and include validation of the Annex II risk assessments and the assessment of significant long-term water quality trends, both as a result of changes in natural conditions and through anthropogenic activity.

Surveillance monitoring is required in groundwater bodies or groups of bodies that are both “at risk” and “not at risk” of failing the WFD objectives. In order to achieve sufficient confidence in the assessment, spatial and temporal variation in aquifer type and pressure are accounted for in the design of the surveillance monitoring programme. Three principal surveillance monitoring subnets are outlined below.

Surveillance Monitoring Subnet 1: Supplementing and validating the risk assessment

Aim of subnet: Supplementing and validating the risk assessment, particularly at those locations where the degree of uncertainty is greatest.

Size of subnet: The number of monitoring points in this subnet is determined by the development of a representative monitoring network for the productive groundwater bodies or groups of bodies. A small number of monitoring points in the poorly productive groundwater bodies, where the abstractions are greater than 100 m^3/d (associated with fault zones), have been included in this subnet. As confidence in the Annex II risk assessment improves through further characterisation and ongoing monitoring, the size of this subnet may change.

This subnet will include approximately 240 monitoring points in the Republic of Ireland.

Location of monitoring points: The monitoring locations are comprised of a selection of existing groundwater and spring abstractions greater than 100 m^3/d and a small number of new wells that will be installed to achieve a representative monitoring network.

The RBD breakdown of these monitoring locations is given in Appendix 10.3. Once the final location of these monitoring points has been decided upon, the location details will be provided in Appendix 10.4.

Surveillance Monitoring Subnet 2: Long-term trend monitoring

Aim of subnet: Detection of long-term trends in water quality.

Subnet size: Long-term water quality trend monitoring is proposed at all 240 monitoring points proposed for Surveillance Monitoring Subnet 1. Of the 240 proposed monitoring points, 36 monitoring points have been identified as locations for trend monitoring of natural background water quality conditions i.e. ‘clean sites’.

Location of monitoring points: Long-term trends will be assessed at each monitoring location proposed for supplementing and validating the risk assessments, i.e. monitoring locations are the same as Surveillance Monitoring Subnet 1.

Surveillance Monitoring Subnet 3: Groundwater-surface water interaction monitoring

Aim of subnet: To provide detailed information on the interaction between groundwater and associated surface water receptors.

The groundwater and surface water monitoring locations have been selected to help explain three main scenarios:

- The interaction between groundwater and surface waters at locations where there is likely to be significant impact from diffuse pollution on surface waters, with the view to explaining if groundwater is a significant pathway for this pollution;
- The interaction between groundwater and surface water at GWDTE e.g. turloughs;
- The interaction between groundwater and surface waters where the groundwater is thought to be unpolluted.

Subnet size: This subnet will include approximately 15 groundwater-surface water monitoring flux sites[8]. The groundwater monitoring points that make up the groundwater element of the groundwater-surface water interaction scenarios are additional monitoring points to the monitoring points proposed in Surveillance Monitoring Subnet 1. Groundwater and surface water monitoring will be carried out for each of the flux sites. Water quality, levels and flows will be gathered for both groundwater and surface water at these flux sites.

Location of monitoring points: The groundwater-surface water monitoring flux sites are located in areas where there is uncertainty surrounding the interaction between groundwater and surface water and monitoring may improve the understanding of one or more of the three main scenarios identified above. The RBD breakdown of these monitoring locations is given in Appendix 10.3. Once the final location of these monitoring points has been decided upon, the location details will be provided in Appendix 10.4.

Surveillance Monitoring Summary

In total, approximately 255 monitoring points are proposed for the surveillance monitoring programme in the Republic of Ireland. There will be a number of monitoring locations in Northern Ireland to accommodate the assessment of chemical status in groundwater bodies that cross Member State boundaries. Infrastructure shortfalls for the surveillance monitoring programme, including numbers of new wells, piezometers and data loggers required within each RBD are identified in Appendix 10.3.

10.3.3 Operational Monitoring of Groundwater

Annex V of the WFD indicates that the operational monitoring programme should focus on assessing the chemical status of "at risk" groundwater bodies or groups of bodies and establish the presence of any long-term anthropogenically induced upward trend in the concentration of any pollutant. Therefore, the operational monitoring programme will focus on monitoring groundwater bodies or groups of bodies which are defined as being "at risk" on the basis of both the Annex II risk assessment and data gathered from surveillance monitoring. The monitoring programme will also be used to support the design of POMs, with monitoring data used to help assess the effectiveness of such measures within groundwater bodies.

This programme is designed to be flexible in order to respond to changes within groundwater bodies that impact on groundwater status.

The operational groundwater monitoring programme has three separate subnets aimed at monitoring particular water quality pressures. They are designed to advise and provide feedback on the design and effectiveness of POMs developed as part of the River Basin Management Plans (RBMPs).

Operational Monitoring Subnet 1: Monitoring diffuse pollution pressures

Aim of subnet: To establish groundwater status for groundwater bodies or groups of bodies "at risk" from diffuse pollution; to provide an assessment of long-term

8 Note that the selected surface water monitoring is part of the surveillance monitoring network for surface waters. Therefore the groundwater monitoring points have initially been included in the surveillance monitoring network for groundwater.

anthropogenic trends; and to assess the effectiveness of any POMs implemented within these groundwater bodies or groups of bodies.

Monitoring for this subnet will be carried out for all groundwater bodies or groups of bodies identified as being "at risk" from diffuse pollution in the Annex II risk assessment.

Subnet size: Diffuse pollution was identified as the predominant risk to groundwater status in the Annex II risk assessment.

As with the surveillance monitoring network, operational monitoring locations are determined by the requirements for achieving a monitoring network that is representative of the variations in hydrogeology and pressure across a groundwater body or group of bodies. A small number of monitoring points in poorly productive groundwater bodies, where the abstractions are greater than 100 m^3/d (associated with fault zones), have been included in this subnet.

This subnet will include approximately 145 monitoring points in the Republic of Ireland.

Location of monitoring points: The actual monitoring locations are comprised of a selection of existing groundwater and spring abstractions greater than 100 m^3/d and a small number of new wells that will be developed to achieve a representative monitoring network.

The RBD breakdown of these monitoring locations is given in Appendix 10.3. Once the final location of these monitoring points has been decided upon, the location details will be provided in Appendix 10.4.

Operational Monitoring Subnet 2: Monitoring point source pressures

Aim of subnet: To establish groundwater status for groundwater bodies or groups of bodies "at risk" from point source pressures; to provide an assessment of long-term anthropogenic trends; and to assess the effectiveness of any POMs implemented within these groundwater bodies or groups of bodies.

Subnet size: Point source pollution was also identified as a significant risk to groundwater status in the Annex II risk assessment.

Monitoring data from existing compliance monitoring e.g. from IPPC licensed activities, will be utilised for the assessment of point source pressures within these groundwater bodies. The compliance monitoring data may be supplemented by additional monitoring e.g. where the monitoring is deemed to be inadequate for WFD purposes or for currently unlicensed point source pressures.

Approximately 50 additional monitoring points are proposed for this subnet to supplement the compliance monitoring network and monitor any significant unlicensed point sources that have been identified in the Republic of Ireland[9].

[9] The RBD consultants and the EPA are undertaking further characterisation studies to determine pressures from unlicensed activities e.g. unlicensed or decommissioned landfills, mines and gasworks. Information from these studies will be used to determine the exact number and locations of monitoring points for point sources. The assessment methodologies developed from these studies are scheduled for completion at the end of September 2006.

Location of monitoring points: Groundwater monitoring data from existing compliance monitoring locations will be utilised for this subnet. The findings of the point source further characterisation studies will be used to select appropriate compliance monitoring locations.

The findings of the point source further characterisation studies will also be used to determine the monitoring locations for any significant unlicensed point sources and the compliance monitoring locations that require additional monitoring.

Once the final location of these monitoring points has been decided upon, the location details will be provided in Appendix 10.4.

Operational Monitoring Subnet 3: Monitoring urban pressures

Aim of subnet: To establish groundwater status for groundwater bodies "at risk" from urban pressures; to provide an assessment of long-term anthropogenic trends; and to assess the effectiveness of any POMs implemented within these groundwater bodies or groups of bodies.

Subnet size: In total the urban pressures monitoring subnet will include 36 monitoring points in the Republic of Ireland.

Location of monitoring points: There will be 36 monitoring points nationally, situated in urban areas that have a population greater than 10,000. The findings from the urban pressures further characterisation study, being undertaken by the RBD consultants, will be used to determine appropriate urban areas and monitoring locations for this subnet[10]. Monitoring locations within the appropriate urban areas will be determined through a receptor risk assessment e.g. the impact on the water quality of drinking water abstractions or ecological receptors. Monitoring data from this subnet will be used, in part, to assess status for all urban area groundwater bodies in the Republic of Ireland.

Once the final location of these monitoring points has been decided upon, the location details will be provided in Appendix 10.4.

Operational Monitoring Summary

In total, approximately 230 monitoring points are proposed for the operational monitoring programme in the Republic of Ireland. Infrastructure shortfalls for the operational monitoring programme, including numbers of new wells, piezometers and data loggers required within each RBD are identified in Appendix 10.3.

10.3.4 Monitoring frequency

CIS monitoring guidance indicates appropriate surveillance and operational monitoring frequencies for certain hydrogeological settings (Tables 10.2 and 10.3). Operational monitoring will be carried out between periods of surveillance monitoring and will be undertaken, as a minimum, at least once a year. Where there is inadequate knowledge of the groundwater system and historical data are unavailable, monitoring frequencies are higher until such a time has been reached when a satisfactory understanding has been achieved. In less dynamic systems, monitoring may only require two samples per year, with quarterly or even monthly samples initially taken in the more dynamic systems, such as the karst.

[10] The urban pressures further characterisation study is scheduled for competition at the end of 2007.

Table 10.2 - Proposed monitoring frequencies for surveillance monitoring (UKTAG Guidance 12a, 2004)

		Aquifer Flow Type				
			Unconfined			
		Confined	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-moderate 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 (on-going validation)		Every 6 years	Every 6 years	Every 6 years	Every 6 years	-

Table 10.3 - Proposed monitoring frequencies for operational monitoring (UKTAG Guidance 12a, 2004)

		Aquifer Flow Type				
			Unconfined			
		Confined	Intergranular flow significant		Fracture flow only	Karst flow
			Significant deep flows common	Shallow flow		
Higher vulnerability groundwater	Continuous pressures	-	Twice per year	Twice per year	Quarterly	Quarterly
	Seasonal / intermittent pressures	-	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	-

The monitoring frequency presented in Tables 10.2 and 10.3 are regarded as the minimum frequencies that would be necessary to generate confidence in the statistical analysis associated with the data. However, the uncertainty associated with the dynamic aquifer systems that are prevalent in the Republic of Ireland and initial uncertainties surrounding the Annex II risk assessment, along with the lack of data previously gathered at some locations has resulted in the proposed initial monitoring frequencies being higher than those suggested in Tables 10.2 and 10.3. Monthly samples are proposed where the potential concentration of a monitoring parameter fluctuates significantly e.g. for nitrate. Initial monitoring frequencies for monitoring in the Republic of Ireland are presented in Appendix 10.2.

10.3.5 Water quality determinands

A core suite of surveillance monitoring determinands is clearly identified in Annex V of the WFD and the following parameters must be monitored:

- Oxygen content;
- pH value;
- Conductivity;
- Nitrate; and
- Ammonium.

Parameters such as temperature and a suite of major and minor trace ions are not formally required, but will help improve conceptual understanding and the validation of the Annex II risk assessment. Selective determinands such as metals will also be necessary to assess natural background levels for trend assessments.

Probes may be used to continuously monitor parameters such as conductivity, temperature, pH and dissolved oxygen in the more dynamic systems because this may provide a better indication of long-term trends and where necessary, may aid in the development of potential POMs.

The proposed surveillance monitoring determinand suite is contained within Appendix 10.1 and was informed by previous work carried out by the EPA[11], previous monitoring data and the CIS monitoring guidance.

In addition to the monitoring requirements of the surveillance monitoring programme, the WFD specifies that additional determinands should be analysed on a case-by-case basis for operational monitoring and the pressures identified in the Annex II risk assessment should influence the selection of these determinands. Pressures associated with broad land use categories have been used as a basis for initial determinand selection and indicator determinands associated with these categories will be selected to confirm the risk. For example, fertiliser constituents and plant protection products may be selected for analysis of diffuse pressures, or hydrocarbons and heavy metals for point source pressures. Broad operational monitoring determinand suites for the different operational monitoring subnets are included in Appendix 10.1.

[11] EPA (2003), Towards Setting Guideline Values for the Protection of Groundwater in Ireland (Interim Report), Environmental Protection Agency, Ireland.

10.3.6 Hydrometric monitoring

At springs, discharge monitoring is an essential element when interpreting the water quality data from the groundwater monitoring programmes. Discharge rates from springs will be used to calculate chemical loadings. Therefore, the installation of data loggers to record water levels or the installation of flow recorders, which may possibly require the construction of weirs, will be undertaken at selected spring discharge sites to facilitate the estimation of flows.

Estimates of river flow and the percentage contribution from groundwater to surface water receptors is also required where groundwater is thought to be significantly contributing to an associated surface water receptor being “at risk”. Estimates of river flow and the percentage contribution from groundwater is also required at the groundwater-surface water interaction sites.

10.3.7 Design of future monitoring networks

Data gathered from the groundwater monitoring networks will be used to revise the monitoring programmes at the end of each RBMP cycle. Trend assessments may indicate a reduction in pollutant concentrations e.g. from good practice or successful POMs, or they may highlight potential new threats to groundwater status e.g. from climate change or other, as yet unforeseen, pressures or impacts. This may result in the revision of the monitoring networks for future RBMP cycles.

As the monitoring programme proceeds and status is assigned to groundwater bodies; those that are shown to be of less than good status will automatically be transferred to the operational monitoring programme. However, as with all operational monitoring points, these points will still be monitored for surveillance monitoring determinands, with the additional requirements of the operational monitoring programme also being met at these points.

Similarly, the WFD allows revision of the operational monitoring network where the monitoring shows that a groundwater body has reached good status.

If initial monitoring indicates that a monitoring site is unsuitable for it’s intended monitoring programme, it is proposed that the monitoring site gets dropped from the monitoring programme, and if necessary, is replaced with a suitable alternative site.

10.4 Monitoring of Drinking Water Protected Areas

Article 7 of the WFD requires monitoring programmes to assess the achievement of Drinking Water Protected Areas (DWPA) objectives. Unlike surface water bodies defined as DWPA, the WFD does not introduce any additional specific monitoring criteria for groundwater bodies that are also DWPA. However, the Article 7 DWPA objectives indicate that any groundwater monitoring within DWPA should be used to support DWPA management and assessment. For example, this information could be used to identify any deterioration in the quality of abstracted groundwater that may potentially lead to an increase in the level of purification/treatment.

The Article 7(3) objective of aiming to prevent deterioration in the water quality of DWPA (through a reduction in purification/treatment) implies that there are background quality data for DWPA at the date of implementation of monitoring programmes, against which any subsequent deterioration can be assessed.

Article 7(1) indicates that monitoring to assess the achievement of DWPA objectives should be carried out for groundwater bodies that provide more than 100 m^3/d as an average. Although Article 7(1) indicates that groundwater monitoring at all DWPA is not specifically required; Annex II of the WFD and the CIS monitoring guidance indicates that the chemical composition of groundwater will have to be analysed for all DWPA that are categorised as being significant potable groundwater abstractions[12] and that are located in groundwater bodies defined as being "at risk" in the Annex II risk assessment.

Therefore, the chemical composition of groundwater abstracted from all significant potable groundwater abstractions in DWPA will be analysed if the groundwater body was defined as being "at risk" in the Annex II risk assessment. UKTAG monitoring guidance recommends also monitoring significant potable groundwater abstractions that were defined as being "not at risk" in the Annex II risk assessment, to confirm the risk assessment.

Aim of programme: Assess (untreated) groundwater quality at monitoring locations to determine if the DWPA objectives of the WFD are being met.

Size of programme: Currently there are approximately 590 DWPA in the Republic of Ireland that are located in groundwater bodies that were categorised as being "at risk" from diffuse or point source pollutants in the Annex II risk assessment and have been categorised as having either groundwater or spring sources. Water quality samples may also be taken at approximately 755 DWPA that are located in groundwater bodies that were categorised as being "not at risk" from diffuse or point source pollutants in the Annex II risk assessment.

Location of monitoring points: Water quality samples will be taken at all significant potable groundwater abstractions associated with DWPA in groundwater bodies that are "at risk" from diffuse or point source pollutants. Water quality samples may also be taken at DWPA that were categorised as being "not at risk" in the Annex II risk assessment. Many of the DWPA will be monitored as part of the proposed operational or surveillance monitoring programmes. Therefore, it will be possible to undertake the additional sampling and analysis required for the Drinking Water Directive (80/778/EEC as amended by 98/43/EEC) in conjunction with the operational or surveillance monitoring at these locations.

Once the final location of these monitoring points has been decided upon, the location details will be provided in Appendix 10.4.

10.4.1 Monitoring frequency

Annex II of the WFD and the CIS monitoring guidance do not indicate monitoring frequencies for DWPA, although the UKTAG monitoring guidance indicates that water quality samples should be taken at least once in each RBMP cycle.

[12] A significant potable source is defined as one intended for human consumption that comes within the requirements of the Drinking Water Directive (Directive 80/778/EEC as amended by Directive 98/83/EC). That is a source where water abstracted from an individual supply provides 10 m^3 a day or more as an average or serves at least 50 persons, unless supplied as part of a commercial or public activity in which cases the thresholds do not apply.

10.4.2 Water quality determinands for DWPA monitoring

It will be necessary to monitor (untreated) groundwater for all determinands that are directly related to drinking water quality i.e. those required under the Drinking Water Directive.

10.5 Species and Habitat Protected Areas

Chemical and quantitative monitoring in groundwater bodies associated with Species and Habitat Protected Areas is required to determine the impacts of groundwater on these ecosystems. Currently very little information is available on the interactions between groundwater and GWDTE. Evidence must be provided to determine:

- The groundwater dependency of water dependent terrestrial ecosystems;
- Groundwater impacts on these ecosystems; and
- Significant damage on these ecosystems resulting from anthropogenic alterations to groundwater.

Aim of programme: Monitoring is required to verify risk assessments, assess trends, determine the groundwater dependency of species and habitats and assess if the ecology has been significantly damaged by groundwater.

Size of programme: Monitoring is proposed in 28 of the 49 groundwater bodies that were identified as being “at risk”, because of associated GWDTE, in the Annex II risk assessments. Monitoring is also proposed in 14 groundwater bodies associated with GWDTE that are considered to be high status ecosystems. These ecosystems have been selected to help understand the groundwater requirements of different habitats and species in the Republic of Ireland.

On average 3 monitoring points will be required for each GWDTE, although it is recognised that the exact number of monitoring points will vary on a case-by-case basis because of different pressures and impacts on individual GWDTEs. The exact number of monitoring points will also be influenced by their spatial extent, or if there are connected receptors along the groundwater flow path.

In total, GWDTE monitoring is proposed at approximately 126 monitoring points in the Republic of Ireland, which will be phased over three years, with approximately 42 monitoring points monitored in the first year, and similar numbers of points monitored in years 2 and 3. Information gathered during the first three years of monitoring will provide the basis for future GWDTE monitoring. Ecological monitoring associated with the Habitats Directive will be required in conjunction with chemical and quantitative groundwater monitoring.

Location of monitoring points: Groundwater bodies were associated with ecosystems that were thought to be dependent on groundwater, for the Annex II Characterisation and Risk Assessment Report in 2005, although it was not known if the ecosystems were damaged due to the impacts of groundwater. The National Parks and Wildlife Service (NPWS) are currently assessing the ecosystems to prioritise locations for monitoring. Groundwater dependency at each ecosystem will be different and monitoring will be tailored to suit the needs of each ecological receptor. Monitoring will be carried out at appropriate locations within and surrounding the GWDTEs.

Once the final location of these monitoring points has been decided upon, the location details will be provided in Appendix 10.4.

10.6 Prevent or Limit Monitoring

In accordance with Articles 4, 11 and 17 of the WFD, Member States should assess the effectiveness of POMs introduced to prevent or limit the inputs of pollutants and/or the deterioration of the status of groundwater. Although the surveillance and operational monitoring programmes will contribute significantly to this, there may be need for additional monitoring programmes for particular point sources e.g. ensuring compliance with licensed activities such as landfill or for site specific clean-up after an accidental spill i.e. investigative monitoring.

Therefore, information from certain prevent or limit monitoring may be incorporated into WFD monitoring programmes and additional monitoring points may be required upgradient and/or downgradient of potential point sources to groundwater to monitor any potential impacts on the overall groundwater body.

As monitoring progresses, it is also likely that investigative monitoring will be required to answer questions raised by the data from the monitoring programmes, e.g. regarding point sources.

10.7 Monitoring Authorities

Resources are required to undertake the groundwater monitoring at locations identified in Appendix 10.4. Table 10.4 summarises the groundwater monitoring programme in terms of proposing which agency or public body will be responsible for each groundwater monitoring task. The exact subdivision of tasks and resources should be determined through discussion between the lead and supporting monitoring authorities.

If the proposed monitoring authorities have insufficient resources to undertake the proposed monitoring then the work may have to be outsourced, at least for an initial period.

Table 10.4 - Allocation of tasks

Allocation of tasks		
Monitoring	Lead monitoring authority	Supporting monitoring authority
Surveillance Monitoring	EPA	Local Authority
Operational Monitoring – Diffuse	EPA	Local Authority
Operational Monitoring – Point Sources	EPA	Local Authority
Operational Monitoring – Urban Areas	EPA	Local Authority
Quantitative Monitoring	EPA	OPW
Drinking Water Protected Areas	Local Authority	EPA
Habitats and Species Protected Areas	NPWS / EPA	Local Authority

10.8 References

CEC (Council of the European Communities), 1992. Directive 1992/43/EEC of the European Parliament and of the council on the conservation of natural habitats and of wild fauna and flora.

CEC (Council of the European Communities), 1998. Directive 1998/43/EEC of the European Parliament and of the council on the quality of water intended for human consumption.

CEC (Council of the European Communities), 2000. Directive 2000/60/EC of the European Parliament and of the council establishing a framework for community action in the field of water policy.

EPA (2003), Towards Setting Guideline Values for the Protection of Groundwater in Ireland (Interim Report), Environmental Protection Agency, Ireland.

UKTAG Guidance 12a (2004) Guidance on the selection of monitoring sites and building monitoring networks for surface waters and groundwater, UK Technical Advice Guidance.

WFD CIS Guidance Document No. 7 (2003), Monitoring Under the Water Framework Directive, Common Implementation Strategy for the Water Framework Directive (2000/60/EC), Published by the Directorate General Environment of the European Commission, Brussels.

10.9 Groundwater Appendices

Appendix 10.1 - Monitoring Determinand Summary

Monitoring Programme	Determinand Suite
Quantitative Monitoring - Productive Aquifers	Data logger downloads
Quantitative Monitoring - Poorly Productive Aquifers	Data logger downloads or water level dips. Water quality samples should be taken during site visits and analysed for surveillance monitoring suite
Surveillance Monitoring - Productive Aquifers	Surveillance suite should include: pH, Temperature, Conductivity, DO, Colour, Alkalinity, Total Hardness, Nitrate, Ammonium, Nitrite, Total Phosphate, Molybdate Reactive Phosphorus, Iron, Manganese, Sodium, Potassium, Chloride, Calcium, Sulphate, Cadmium, Arsenic, Zinc, Mercury, Lead, Magnesium, Copper, Boron, Aluminium, Nickel, Chromium, Total Organic Carbon, Fluoride, Barium, Molybdenum, Silver, Cobalt, Strontium, Beryllium, Antimony, Turbidity, Uranium, Total and Faecal Coliforms
Surveillance Monitoring - Groundwater-Surface Water Interaction Monitoring	Surveillance monitoring suite and data logger downloads for water levels
Operational Monitoring - Diffuse	Operational - Diffuse monitoring suite should include: Pesticides (including: Atrazine, MCPA, 2,4-D, IPU, Mecoprop, Chlortoluron, Glyphosate, Bentazone, Cypermethrin, Dieldrin, DDT, Lindane and Diuron); selected VOC's and Hydrocarbons (plus surveillance monitoring suite)
Operational Monitoring - Point Source	Operational - Point source monitoring suite should include: Targeted determinands related to risk i.e. general suite of VOC's, PAH's, Petrol Hydrocarbons and Phenols (plus surveillance monitoring suite)

Monitoring Programme	Determinand Suite
Operational Monitoring - Urban Pressures	As per Operational - Point source monitoring suite
Additional Monitoring	
Groundwater Dependent Terrestrial Ecosystems	Operational - Diffuse monitoring suite for water quality monitoring and data logger downloads for water level monitoring
DWPA (Untreated water sample at all “at risk” groundwater DWPA > 10 m^3/d. At least one sample per RBMP cycle)	Full monitoring suite required for Drinking Water Regulations

Appendix 10.2 - Monitoring Frequency Summary

Monitoring Network	Subnet	No. Monitoring Points	Monitoring Frequency / Annum		
			Year 1	Year 2	Year 3
Quantitative	Productive Aquifers	190	6	4	4
	Poorly Productive Aquifers	70	4	2	2
Surveillance	Productive Aquifers	240	4	2	2
	GW-SW Interactions	15	4	2	2
Operational	Diffuse	145	12	4	4
	Point Source	50	6	4	4
	Urban Pressures	36	6	4	4
GWDTE	At Risk	84	6	4	4
	Not At Risk	42	4	2	2
Drinking Water Protected Areas *		590	Once in first 3 Years		

* May also include additional monitoring at DWPA in “not at risk” groundwater bodies.

Appendix 10.3 - Monitoring Location Summary

	ERBDW	RBDSE	RBDSW	RBD	N/S Share	ShRBD	Total
Monitoring Points							
Quantitative Monitoring	45	40	25	20	20	40	**190**
Surveillance Monitoring	35	40	55	25	30	55	**240**
Surveillance Monitoring - GW/SW Interactions	2	7	2	3	0	1	**15**
Operational Monitoring - Diffuse	20	30	30	20	15	30	**145**
Operational Monitoring - Point Source	-	-	-	-	-	-	**50**
Operational Monitoring - Urban Pressures	-	-	-	-	-	-	**36**
Poorly Productive Monitoring	-	-	-	-	-	-	**70**
GWDTE At Risk	-	-	-	-	-	-	**28(84)**
GWDTE Not At Risk	-	-	-	-	-	-	**14(42)**
Drinking Water Protected Areas *	-	-	-	-	-	-	**590**
Infrastructure Shortfall							
Quantitative [New Piezometers]	10	5	2	4	0	4	**25**
Surveillance [New Wells]	5	3	4	3	9	5	**29**
Operational - Diffuse [New Wells]	5	0	2	1	2	3	**13**
Operational - Point Source [New Piezometers]	-	-	-	-	-	-	**16**
Operational - Urban Pressure [New Wells & Piezometers]	-	-	-	-	-	-	**36**
Poorly Productive [New Piezometers]	-	-	-	-	-	-	**60**
GWDTE At Risk [New Piezometers]	-	-	-	-	-	-	**28**
GWDTE Not At Risk [New Piezometers]	-	-	-	-	-	-	**14**
New Data Logger [Quantitative]	38	41	24	17	18	40	**178**
New Data Logger [Water Quality]	10	25	10	14	7	20	**86**
New Data Logger [Poorly Productive & GWDTE]	-	-	-	-	-	-	**102**
Weir Construction/Management	1	20	12	10	5	15	**63**

* May also include additional monitoring at DWPA in “not at risk” groundwater bodies.

Figures in bold indicate a national total, that will be divided allocated to RBDs upon the completion of further characterisation studies.

Figures in brackets indicate a national total for the first RBMP cycle, with an equal proportion of this total monitored each year.

Appendix 14. Groundwater monitoring locations

Appendix 10.4[1] is available in online form only. To be notified of all subsequent updates to the groundwater monitoring sites in this appendix please send an email to wfd.monitoring@epa.ie to be included on the WFD monitoring email list.

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/

Chapter 11 Canals Monitoring Programme

11.1 Introduction

Artificial Water Bodies (AWBs) are defined in Article 1 of the WFD as "a body of water created by human activity". The WFD also states in Article 4.3(a) that "Member States may designate a body of surface water as artificial or heavily modified when the changes to the hydromorphological characteristics of that body which would be necessary for achieving good ecological status would have significant adverse effects" on a list of activities including navigation and recreation. For these reasons canals were identified as AWBs under the WFD.

Canals are to be included in the Operational Monitoring programme recognising their artificial nature and specific monitoring requirements to ensure their continued beneficial uses. Canals play an important role in Ireland's River Basin Districts for many integrated purposes including for navigation, angling, water sports, water quality, environmental and amenity value. Canal monitoring is currently carried out by the Central Fisheries Board (CFB) on behalf of Waterways Ireland (WI), the owners of most of Ireland's canals, for their maintenance programme. The EPA reports on the water quality of canals in Ireland based on CFB monitoring data.

The following text outlines the current monitoring undertaken for canals and sets out the anticipated additional work required to make the programme WFD compliant based on initial discussions between WI, EPA and CFB. The exact roles and responsibilities of this programme have yet to be defined between WI, EPA and CFB.

11.2 Aim of canal monitoring programme

The Canal Monitoring Programme for WFD reflects the varied beneficial uses of canals. The monitoring programme should allow for the ecological potential of each canal to be identified and support the measures in the River Basin Management Plans aimed at achieving Good Ecological Potential for AWBs.

Good Ecological Potential (GEP) and Maximum Ecological Potential (MEP as reference condition) have yet to be defined for AWBs or Heavily Modified Water Bodies (HMWBs). However, while it is anticipated that the ecological quality associated with GEP and MEP will require mitigation measures in some cases, it is understood that those mitigation measures should not have a significant adverse impact on the beneficial uses of canals listed above. Specific management practices will be required to maintain these beneficial uses, e.g. dredging to ensure safe boat movement and aquatic plant management practices.

This programme should link with the monitoring of feeder streams and associated river water bodies, as in many cases the measures applied to the catchments of feeder streams will play a key role in improving Canal water quality. Given the beneficial uses of canals outlined above, macrophytes, benthic invertebrates, physico-chemical parameters, hydromorphological parameters and fish are deemed the most appropriate elements for inclusion.

11.3 Canal typology

Thirty-six canal water bodies were identified as AWBs during the Characterisation and Analysis of Ireland RBDs for Article 5. However, these AWB-canals are often continuous stretches only divided by their discharge point to transitional water bodies or at the boundary of RBDs. Given their artificial nature a typology like that applied to natural rivers or lakes cannot be readily extended to canals. There is a SNIFFER (Scottish Northern Ireland Forum For Environmental Research) research project (WFD61) to develop a WFD compliant canal classification tool. EPA and Waterways Ireland are co-funding this project along with British Waterways, SEPA and EA. Outputs from this project including monitoring protocols and the classification tool will influence how canals are managed for WFD in Ireland.

In the interim, a basic typology can be applied for the monitoring programme based on summit points (the canals equivalent of a catchment divide) and major canal junctions (equivalent to a confluence). The RBD boundaries will not influence the ecological potential of canals, however for reporting purposes they will result in further subdivision of canals to allow for discrete water body reporting by each RBD to the European Commission. On this basis the following canal water bodies listed in the Table 11.1 below have been identified for the purposes of the monitoring programme.

Table 11.1 Canal Water Bodies

Number	Description	River Basin District(s)
Canal AWB-1	Royal Canal: Dublin to Mullingar	ERBD
Canal AWB-2	Royal Canal: Mullingar to Shannon	ERBD and SHIRBD
Canal AWB-3	Grand Canal: Dublin to Lowtown	ERBD and SERBD
Canal AWB-4	Grand Canal: Lowtown to Shannon	ERBD, SERBD and SHIRBD
Canal AWB-5	Grand Canal: Naas Line	ERBD
Canal AWB-6	Barrow Line	SERBD
Canal AWB-7	Shannon-Erne Waterway	SHIRBD and NWIRBD
Canal AWB-8*	Ardnacrusha headrace and tailrace canal	SHIRBD
Canal AWB-9*	Plassey Erina canal	SHIRBD
Canal AWB-10*	Lough Allen canal	SHIRBD

*Not currently monitored by CFB on behalf of WI.

There are some minor canalised stretches of rivers, which are not considered in this monitoring programme. These stretches are typically less than 3km in length and will be accommodated by natural river water monitoring upstream and downstream of these stretches. Measures applied to these adjacent natural water bodies should ensure the optimal ecological potential is achieved. Significant stretches of the River Barrow (downstream of Athy) and Shannon-Erne Waterway are natural and therefore not strictly artificial water bodies. These stretches will continue to be monitored for the beneficial uses required by Waterways Ireland, however they have not been defined as AWBs and therefore are not subject to canal WFD monitoring and will be accommodated in the rivers monitoring programme. The Boyne Navigation is not currently monitored by CFB but has been identified as an AWB and therefore may require canal WFD monitoring.

11.4 Size of canal monitoring programme

It is in anticipated that for the WFD purposes of assigning Ecological Potential to canals and monitoring the influence of measures approximately 40 canal monitoring points are required throughout the ten canal-AWBs identified above. There are currently some 200 monitoring points for physico-chemical parameters sampled by CFB (roughly one site every 3km) used to maintain the canals' beneficial uses. A subset of these sites can accommodate the 40 WFD canal monitoring.

11.5 Location of canal monitoring points

The location of the 40 WFD canal monitoring points will be determined by consultation with Waterways Ireland, CFB, EPA and the RBDs. The significant influence that feeder streams have on water quality in canals will be an important consideration in choosing sites.

11.6 Quality elements for canal monitoring programme

The exact nature and extent of canal WFD monitoring will be influenced by the outcome of the SNIFFER research project and best practice developed by other Member States. However, based on current knowledge Table 11.2 below summarises the anticipated requirements for a WFD compliant canal monitoring programme.

Table 11.2 Monitoring requirements for the WFD Canal Monitoring Programme.

Quality Elements	No. of Sites	Frequency
General physico-chemical	40 (each year)	4 times per year
Benthic invertebrate fauna	c. 13 (per year)	Once per three years
Macrophytes	40 (each year)	Annually
Hydromorphology	c. 7 (each year)	Once per six years
Fish	c. 13 (per year)	Once per three years
Annex X Substances	To be considered when deemed to be discharged into an RBD and subsequently into a canal	12 times per year for 1 year in 3 year cycle
Annex VIII Other pollutants	To be considered when deemed to be discharged into an RBD and subsequently into a canal	12 times per year for 1 year in 3 year cycle

PART III - ELECTRONIC FILES

(Available at: http://www.epa.ie/whatwedo/wfd/monitoring/programme/)

Please email wfd.monitoring@epa.ie to be informed of updates to these files. (Those on the monitoring mailing list will receive notifications when changes are made to any of the monitoring locations listed in the files below.)

Appendix 2.1 – List of current Priority Substances and Other Pollutants[1]

Appendix 7.1 – Current River Surveillance and Operational Sites[1]

Appendix 8.1 – Current Lake Surveillance and Operational Sites[1]

[1] http://www.epa.ie/whatwedo/wfd/monitoring/programme/