

DRAFT

**NATIONAL SURFACE AND GROUNDWATER
MONITORING PROGRAMMES REPUBLIC OF
IRELAND**

**PREPARED TO MEET THE REQUIREMENTS OF
EU WATER FRAMEWORK DIRECTIVE
(2000/60/EC)**

AND

**NATIONAL REGULATIONS IMPLEMENTING
THE WFD SI NO 722 OF 2003**

AND

**NATIONAL REGULATIONS IMPLEMENTING
THE NITRATES DIRECTIVE SI NO 788 of 2005**

VOLUME 5 – GROUNDWATER

Draft Version 12
22 May 2006

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1. Groundwater Monitoring Programme

1.1 Introduction

Article 8 of the Water Framework Directive (WFD) requires the establishment of programmes of monitoring for groundwater. The monitoring programmes are focused primarily on the groundwater body as a whole, but also support the overall environmental and management objectives of the River Basin District (RBD) by providing information to assess whether the environmental objectives of Article 4 of the WFD are being met. The WFD and appropriate CIS Guidance indicate that 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 Protected Areas (DWPA).

This section was compiled by EPA based on discussions with and input from the WFD Groundwater Working Group (convened by the Geological Survey of Ireland).

Monitoring data from prevent or limit monitoring that relates to licensed activities will also be incorporated into the monitoring network, where appropriate, and this will be supplemented by additional monitoring, where necessary.

The selection/location of appropriate sampling sites is based on the conceptual understanding of the hydrogeology and pressures and will be reviewed as this understanding improves.

The design of the groundwater monitoring network in 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 below and lists of monitoring sites are given in the appendices.

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

1.2 Groundwater Quantitative Status

A quantitative monitoring network is required to:

- Assist in characterisation;
- 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 is based on a conceptual understanding of the groundwater system and the pressures, and has been developed after assessing:

- Recharge and the water balance;
- Existing groundwater level or discharge data and relevant information on the risks for groundwater dependent surface waters and groundwater dependent terrestrial ecosystems;
- The degree of interaction between groundwater and related surface and terrestrial ecosystems where this interaction is important and could potentially cause the associated ecosystems status to be affected.

The overall objectives of the quantitative monitoring are specified in the text of Annex V of the WFD (Table 6.1).

Table 6.1 - WFD text concerning design of quantitative monitoring programme for groundwater

The groundwater monitoring network shall be established in accordance with the requirements of Articles 7 and 8. The monitoring network shall be designed so as to provide a reliable assessment of the quantitative status of all groundwater bodies or groups of bodies including assessment of the available groundwater resource. Member States shall provide a map or maps showing the groundwater monitoring network in the river basin management plan.

Density of monitoring sites

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 in particular:

- For groundwater bodies identified as being at risk of failing to achieve environmental objectives under Article 4, ensure sufficient density of monitoring points to assess the impact of abstractions and discharges on the groundwater level;
 - For groundwater bodies within which groundwater flows across a Member State boundary, ensure sufficient monitoring points are provided to estimate the direction and rate of groundwater flow across the Member State boundary.
-

Table 6.1 indicates that monitoring will be required at two different scales to meet the various requirements of the Article 4 objectives.

- Firstly, where possible, groundwater levels and flows across a groundwater body should be assessed. These may be related to the water balance assessment for the body as a whole;

- Secondly, more focussed 'local' monitoring of levels and flows that relate to relevant local groundwater supported receptors, i.e. surface water bodies (rivers, lakes, estuaries) and groundwater dependent terrestrial ecosystems, may be needed.

The latter may include supporting information e.g. conductivity monitoring (with respect to saline intrusions) or supporting information from ecological monitoring as already performed under other relevant community legislation (as evidence of impact on ecosystems from groundwater abstractions).

In groundwater bodies or groups of groundwater bodies assessed as being not at risk, the monitoring can be minimised by grouping groundwater bodies where the hydrogeology and pressures identified in the Annex II risk assessment are similar. In groundwater bodies or groups of groundwater bodies assessed as being at risk, the distribution of monitoring points will reflect the need to understand the hydrogeological conditions that relate to the receptors identified as being at risk and to their perceived importance.

1.2.1 Quantitative Monitoring Subnet 1: Quantitative Status Assessment

Aim of subnet: Supplementing and validating risk assessments, investigation of long-term water level trends and an assessment of saline or other intrusions caused by groundwater abstraction.

Subnet size: In the Annex II risk assessment, 37 groundwater bodies were placed at risk due to quantitative abstraction pressures, with a further 9 groundwater bodies at risk from saline or other intrusions. In total the quantitative monitoring network of productive aquifers will include 188 monitoring sites in Ireland (Appendix 6.4).

Quantitative monitoring in the poorly productive aquifers will be limited to data loggers and/or conductivity probes at an additional 60 monitoring sites. These monitoring sites will comprise of pairs of (newly installed) piezometers, installed at 30 separate locations nationally.

Location of monitoring points: Monitoring density must be sufficient to ensure proper assessment of impacts on groundwater level caused by abstractions and discharges. Therefore, monitoring focuses on groundwater bodies that are at risk from abstraction-discharge pressures and groundwater bodies associated with surface water receptors that are at risk of failing to achieve good status, where this can be attributed to flows from groundwater. Conductivity is a supporting element for quantitative status and will be measured at an appropriate frequency at quantitative monitoring locations (Appendix 6.2).

Piezometer installation for quantitative monitoring in the poorly productive aquifers will take account of different hydrogeological settings for these aquifers in Ireland and will focus on areas where there are perceived pressures from groundwater on surface water receptors. The National Groundwater Working Group for Ireland has determined ten poorly productive aquifer hydrogeological settings for monitoring:

- Carboniferous (Upper Impure Limestone – “Calp”);
- Carboniferous (Lower Impure Limestone – “Ballysteen”);
- Namurian (Upper Carboniferous) Sandstone;
- Westphalian / Namurian (Upper Carboniferous) mudstone/shale;
- Weakly metamorphic (Ordovician/Silurian) – Sandstone;
- Weakly metamorphosed (Ordovician/Silurian) – sandstone/siltstone/mudstone;
- Highly metamorphosed (Pre-Cambrian);
- Granites;
- Granites with overlying weathered-granite gravels;
- Old Red Sandstone.

Groundwater quality samples will be taken to support 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 (Appendix 6.2) and will be analysed for the surveillance monitoring water quality suite (Appendix 6.1).

The quantitative monitoring programme has 248 monitoring sites for Irish groundwater bodies (Appendix 6.5).

Other Quantitative Monitoring

Quantitative monitoring will also be required at Groundwater Dependent Terrestrial Ecosystems (GWDTE) to improve conceptualisation and determine impacts from abstractions and/or discharges (Section 6.6). Groundwater levels will also be taken, as a matter of good practice, when groundwater quality samples are being taken. If water quality samples are being taken from continuously pumped abstractions, information on the abstraction rate should be recorded and accounted for when estimating water levels.

1.2.2 Monitoring frequency

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 programme of measures. Sites with significant annual variability will be monitored more frequently than sites with only minor variability. In general monthly monitoring will be sufficient for quantity monitoring where variability is low but daily monitoring would be preferred (e.g. through the use of data loggers) where possible. The quantitative monitoring frequency is indicated in Appendix 6.2 and may be revised as knowledge of the aquifer response and behaviour improves, and in relation to the significance of any changes in pressures on the groundwater body.

1.2.3 Water quality determinands for the quantitative monitoring programme

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. Conductivity 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.

1.3 Groundwater Water Quality

The design of the groundwater quality monitoring network is based on a conceptual understanding of the hydrogeological system and pressures, with monitoring data used to test or validate this understanding. Therefore, developing a good conceptual understanding of the hydrogeological system and pressures is of paramount importance when designing a representative monitoring network. Conceptual models of the hydrogeological system and the impact of pressures on the system were used to prepare the Annex II Characterisation Report in 2005 and additional information has subsequently been gathered, e.g. on well design and water quality data, to further improve conceptual understanding.

CIS Guidance indicated that groundwater bodies could be grouped if their pressures and hydrogeology were similar. The National Groundwater Working Group in Ireland decided upon nine bedrock unit groups and one gravel aquifer group in the Republic of Ireland:

- Permo-Triassic;
- Silesian;
- Dinantian Impure Limestones;
- Dinantian Pure Limestones & Precambrian Marbles;
- Devonian / Dinantian Sandstones;
- ORS & Cork Beds;
- Lower Paleozoic;
- Basalts;
- Granites;
- Gravels.

These groups were sub-divided using the groundwater body classification and the Annex II risk assessment, i.e. on aquifer type and risk category. CIS Guidance indicated that a representative monitoring network should be developed. The National Groundwater Working Group in Ireland decided that a representative diffuse pollution monitoring network is achieved when the combined pressure and hydrogeology at a network of monitoring points is proportionally similar to the combined pressure and hydrogeology over the groundwater body or groundwater body 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 relate to local pressures, the development of a regional monitoring network of sufficient size to record all the variations in impact potential in the poorly productive aquifers is difficult. The National Groundwater Working Group in Ireland decided that monitoring water quality in poorly productive areas should be limited to a small number of sites where the monitoring locations have abstractions greater than 100 m³/d and quantitative monitoring sites (Section 6.2.1).

Groundwater monitoring sites are already sampled for certain IPPC and waste licensed activities, and also where the conditions of planning regulations stipulate groundwater monitoring. Some of these monitoring sites will be incorporated into the operational monitoring network, although additional monitoring upgradient and downgradient of the point source may be required, if only to demonstrate the effectiveness of POMs.

1.3.1 Surveillance Monitoring of Groundwater

The overall objectives of the surveillance monitoring programme are specified in the text of Annex V of the WFD (Table 6.2) and include validation of the Annex II risk assessments and an assessment of long-term water quality trends.

Table 6.2 - WFD text concerning the design of the surveillance monitoring programme for groundwater

Objective

Surveillance monitoring shall be carried out in order to:

- Supplement and validate the impact assessment procedure,
- Provide information for use in the assessment of long term trends both as a result of changes in natural conditions and through anthropogenic activity.

Selection of monitoring sites

Sufficient monitoring sites shall be selected for each of the following:

- Bodies identified as being at risk following the characterisation exercise undertaken in accordance with Annex II,
 - Bodies which cross a Member State boundary.
-

Surveillance monitoring is required in groundwater bodies or groups of groundwater bodies that are both at risk and not at risk of failing the WFD objectives. Spatial and temporal variations in aquifer type and pressure are accounted for in the design of the surveillance monitoring programme in order to achieve sufficient confidence in the assessment. Three principal surveillance monitoring subnets are outlined below.

1.3.2 Surveillance Monitoring Subnet 1: 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.

Size of subnet: The number of monitoring locations in this subnet is determined by the development of a representative monitoring network for the productive groundwater bodies.

There are a small number of monitoring locations in the poorly productive groundwater bodies (associated with fault zones, where the monitoring locations have abstractions greater than 100 m³/d). As confidence in the Annex II risk assessments improve, through further characterisation and ongoing monitoring, the size of this subnet may change. In total the surveillance monitoring network will include 244 monitoring sites in Ireland (Appendix 6.5).

Location of monitoring points: Monitoring locations are determined by the requirements for achieving a monitoring network that is representative of the variations in hydrogeological and pressure across a groundwater body or groundwater body group. The actual monitoring locations are comprised of existing groundwater and spring abstractions greater than 100 m³/d and a small number of 'new' wells that will be developed to achieve a representative monitoring network.

1.3.3 Surveillance Monitoring Subnet 2: Long-term trend monitoring

Aim of subnet: Detection of long-term trends in water quality

Subnet size: Water quality trend monitoring is proposed at all 244 surveillance monitoring sites used to validate and supplement the risk assessment. 42 of these locations have been identified as sites for trend monitoring of natural background water quality conditions. Anthropogenic trends will be assessed at the remaining surveillance monitoring sites.

Location of monitoring points: All surveillance monitoring sites that are used to validate and supplement the risk assessment will be assessed for trends.

1.3.4 Surveillance Monitoring Subnet 3: Groundwater-surface water interaction sites

Aim of subnet: To provide detailed information on the interaction between groundwater and associated surface water receptors.

Subnet size: This subnet will include 13 groundwater-surface water monitoring flux sites¹ that are aimed specifically at monitoring interactions between surface and groundwater. Water quality, levels and flows will be gathered for both groundwater and surface water at these flux sites.

¹ Note that the selected surface water monitoring sites fall within the surveillance monitoring network for surface waters. Therefore the groundwater monitoring sites have initially been included in the surveillance monitoring network for groundwater.

Location of monitoring points: The groundwater and surface water monitoring locations were selected to help explain three main scenarios:

- The interaction between groundwater and surface waters at sites where there is likely to be a high impact from diffuse pollution on surface waters, with the view to explain if groundwater is a significant pathway for this pollution;
- The interaction between groundwater and surface water at GWDTEs e.g. Turloughs;
- The interaction between groundwater and surface waters where the groundwater is thought to be unpolluted.

1.3.5 Design of future monitoring networks

As the surveillance monitoring programme proceeds and status is assigned to groundwater bodies; those that are shown to be of less than good status at any point in the programme will automatically be transferred to the operational monitoring programme. However, as with all operational monitoring locations, they will still be monitored for surveillance monitoring determinands, with the additional requirements of the operational monitoring programme also being carried out at these locations.

The results from the surveillance monitoring network will be used to revise the network at the end of each River Basin Management Plan (RBMP) cycle. 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 groundwater body become clear.

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

1.3.6 Monitoring frequency

The appropriate monitoring frequency is based on the conceptual understanding of the flow paths and pressures. 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. Monitoring frequencies are also higher, with monthly samples taken, where the potential concentration of a monitoring parameter fluctuates significantly e.g. for nitrate. In less dynamic systems, surveillance 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 (see Table 6.3 and Appendix 6.2).

Table 6.3 - Proposed monitoring frequencies for surveillance monitoring

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

1.3.7 Water quality determinands

A core suite of surveillance monitoring determinands is clearly designated in Annex V of the WFD (see Table 6.4). Parameters such as temperature and a suite of major and minor trace ions are not formally required, but may be helpful to validate the Annex II risk assessment and improve conceptual understanding. Selective determinands such as heavy metals will also be necessary to assess natural background levels for the trend assessments. The selection of surveillance monitoring suite determinands was informed by previous work carried out by the EPA² and the determinand suite is contained within Appendix 6.1.

Table 6.4 - WFD text concerning design of surveillance monitoring programme for groundwater

The following set of core parameters shall be monitored in all the selected groundwater bodies:

- oxygen content
- pH value
- conductivity
- nitrate
- ammonium

Bodies which are identified in accordance with Annex II as being at significant risk of failing to achieve good status shall also be monitored for those parameters which are indicative of the impact of these pressures.

Transboundary water bodies shall also be monitored for those parameters which are relevant for the protection of all of the uses supported by the groundwater flow.

Conductivity probes will be used to continuously monitor parameters such as electronic conductivity, temperature, pH and dissolved oxygen in the more

² EPA (2003). Towards Setting Guideline Values for the Protection of Groundwater in Ireland (Interim Report), Environmental Protection Agency, Ireland.

dynamic systems because this may provide a better indication of long-term trends and where necessary, may aid in the development of potential POMs.

1.3.8 Hydrometric monitoring

At springs, high precision, high frequency discharge monitoring is an essential element when considering the water quality data from the surveillance monitoring network. It is very difficult to calculate chemical loadings without groundwater discharge rates from springs. Therefore weirs and/or flow recorders will be installed at spring discharge locations to record flow and where appropriate, basic chemical determinands. Estimates of river flow and the percentage contribution from deep 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. Estimates of river flow and the percentage contribution from deep groundwater is required at the groundwater/surface water interaction sites.

1.4 Operational Monitoring of Groundwater

1.4.1 Introduction

The success of the WFD depends crucially on the POMs implemented in the RBDs. The operational monitoring programme is focussed on assessing at risk groundwater bodies, supporting the design of POMs and assessing the effectiveness of such measures within groundwater bodies.

The overall objectives of the operational monitoring are specified in the text of Annex V of the WFD (Table 6.5). This programme is designed to be flexible in order to respond to changes within catchments that impact on groundwater status.

Table 6.5 - WFD text concerning design of operational monitoring programme for groundwater

Objective

Operational monitoring shall be undertaken in the periods between surveillance monitoring programmes in order to:

- Establish the chemical status of all groundwater bodies or groups of bodies determined as being at risk,
- Establish the presence of any long term anthropogenically induced upward trend in the concentration of any pollutant.

Selection of monitoring sites

Operational monitoring shall be carried out for all those groundwater bodies or groups of bodies which on the basis of both the impact assessment carried out in accordance with Annex II and surveillance monitoring are identified as being at risk of failing to meet objectives under Article 4. The selection of monitoring sites shall also reflect an assessment of how representative monitoring data from that site is of the quality of the relevant groundwater body or bodies.

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.

1.4.2 Operational Monitoring Subnet 1: Monitoring diffuse pollution pressures

Aim of subnet: 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.

Subnet size: Diffuse pollution was the predominant risk to groundwater status identified in the Annex II risk assessment. Some 281 groundwater bodies were designated as being at risk from diffuse pollution. In total the diffuse operational monitoring network will include 144 monitoring sites in Ireland (Appendix 6.6).

Location of monitoring points: Operational monitoring will be carried out at all surveillance monitoring locations that were identified as being at risk from diffuse pollution in the Annex II risk assessment. As with surveillance monitoring, operational monitoring locations are determined by the requirements for achieving a monitoring network that is representative of the variations in hydrogeological and pressure across a groundwater body or groundwater body group. The actual monitoring locations are comprised of existing groundwater and spring abstractions greater than 100 m³/d and a small number of 'new' wells that will be developed to achieve a representative monitoring network.

1.4.3 Operational Monitoring Subnet 2: Monitoring point source pressures

Aim of subnet: 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.

Subnet size: Some 295 groundwater bodies were placed at risk due to point source pressures. In total the point source operational monitoring network will include defensive prevent or limit monitoring at existing IPPC licensed sites, with approximately 52 monitoring sites proposed to supplement this network and monitor any significant unlicensed point sources that have been identified in Ireland³ (Appendix 6.6).

Location of monitoring points: Existing monitoring networks e.g. for IPPC licensed activities will be utilised for this monitoring network,

³ Further characterisation studies are being carried out to determine the locations and 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 sites for point sources.

with additional monitoring carried out at these locations, if required. Additional monitoring sites will be selected upgradient and downgradient of significant point sources that are not currently monitored.

1.4.4 Operational Monitoring Subnet 3: Monitoring urban pressures

Aim of subnet: 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.

Subnet size: The urban pressures subnet is a subset of the diffuse and point source pressure subnet. In total the urban pressures operational monitoring network will include 36 monitoring sites in Ireland (Appendix 6.6).

Location of monitoring points: There will be 36 monitoring locations nationally, situated in urban areas that have a population greater than 10,000. The findings from the urban pressures further characterisation project being undertaken by the ERBD will be used to determine appropriate urban areas for this subnet. Monitoring data gathered from case study urban areas will be used to assess status for all groundwater bodies in urban areas.

In total, the operational monitoring programme has 232 monitoring points for Irish groundwater bodies (Appendix 6.6).

1.4.5 Monitoring frequency

Operational monitoring will be carried out between periods of surveillance monitoring and will be carried out, as a minimum, at least once a year. Therefore, since operational monitoring includes surveillance parameters, monitoring frequencies increase at certain locations e.g. monitoring in karst regions may be undertaken quarterly, rather than twice a year and each sample will include all additional determinands required for operational monitoring (Table 6.6 and Appendix 6.2). However, where there is lower confidence in the risk assessment and historical data are unavailable, monitoring frequencies will be higher until such a time has been reached when a satisfactory understanding has been achieved e.g. monthly sampling to assess fluctuations in nitrate concentrations.

Table 6.6 - Proposed frequencies for operational monitoring

		Aquifer Flow Type				
		Confined	Unconfined			
			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	-

1.4.6 Water quality determinands

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 selection of these determinands should be influenced by the Annex II risk assessment. 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. Operational monitoring determinand suites are included in Appendix 6.1.

1.4.7 Hydrometric monitoring

As with surveillance monitoring, estimates of river flow and the percentage contribution from deep 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.

1.5 Monitoring of Drinking Water Protected Areas

The WFD requires that monitoring programmes are able to assess the achievement of DWPA objectives defined under Article 7. The Article 7(3) objective of aiming to prevent deterioration in the water quality of DWPA in order to reduce treatment implies that there are background quality data for DWPA at the date of implementation of this objective, against which any subsequent deterioration can be assessed.

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 DWPA objectives require that any monitoring in these bodies is also able to provide accurate and reliable data to support DWPA management and assessment. For example this information will be needed to identify any deterioration in the quality of abstracted groundwater that may potentially lead to an increase in the level of purification/treatment.

Monitoring in groundwater DWPA should be carried out in accordance with the programmes set out for surveillance and/or operational monitoring as relevant to that groundwater body in order to meet Article 4 objectives.

Aim of programme: Assess if DWPA objectives are being met.

Size of programme: Currently there are approximately 1,965 groundwater DWPA in the Republic of Ireland, although not all of these are associated with significant potable groundwater abstractions⁴.

Location of monitoring points: All DWPA associated with significant potable groundwater abstractions (Appendix 6.7).

1.5.1 Monitoring frequency

Monitoring should be carried out, as a minimum, at least once before and at least once within each RBMP period i.e. every six years.

1.5.2 Water quality determinands for DWPA monitoring

It will be necessary to monitor for all determinands that are directly related to (untreated) groundwater quality, which relate to drinking water quality. These determinands are identified in Appendix 6.1.

⁴ 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 m³ 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.

1.6 *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 the ecosystems, and evidence must be provided on the dependency of the ecosystems on groundwater and if groundwater has impacted on the ecosystem, which has resulted in it being significantly damaged.

Aim of programme: Monitoring is required to verify risk assessments, assess trends, determine the groundwater dependency of species and habitats and assess if ecological ecosystems have been significantly damaged by groundwater.

Size of programme: Monitoring will be carried out at 28 groundwater bodies that were placed at risk because of associated Groundwater Dependent Terrestrial Ecosystems (GWDTEs). Monitoring will also be carried out at 14 groundwater bodies associated with GWDTEs that are considered to be high status ecosystems and these have been selected to help understand the groundwater requirements of different habitats and species in Ireland. On average 3 monitoring sites will be required for each GWDTE, although it is recognised that the exact number of sites vary on a case-by-case basis, with some GWDTE requiring fewer monitoring sites were the pressures and impacts on the GWDTE are known. However, some of the GWDTE will require more monitoring because of their spatial extent, or if there are connected receptors along the groundwater flow path.

Location of monitoring points: Groundwater dependency at each of these receptors will be different and therefore monitoring will be tailored to suit the needs of each ecological receptor. Monitoring will be carried out at locations within the GWDTE and at locations upgradient and downgradient of the GWDTE.

In total, GWDTE monitoring will be carried out at 126 monitoring points in Ireland (Appendix 6.8), which will be phased over three years, with 42 sites monitored in the first year, and similar numbers of sites in years 2 and 3. Information gathered during the first three years of monitoring will provide the basis for future ecological monitoring. Ecological monitoring associated with the Habitats Directive will be required in conjunction with chemical and quantitative groundwater monitoring.

1.7 *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 results from the monitoring programmes, e.g. regarding point sources. Similarly, if a monitoring site is found to be unsuitable for the intended monitoring programme following initial monitoring, it is proposed that the monitoring site gets dropped from the programme, and if necessary, is replaced with a suitable alternative site.

1.8 Appendices

1.8.1 Appendix 6.1 - Monitoring Summary

Purpose of Monitoring	Determinand Suite	Additional Consideration
Monitoring		
Diffuse Sample Cost & Lab Analysis/Reporting [Surveillance]	pH, Temp., Conductivity, DO, Colour, Alkalinity, Total Hardness, Nitrate, Ammonium, Nitrite, Orthophosphate, 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, Berillium, Antimony, Turbidity, Bacteriological	Radon, Uranium
Diffuse Sample Cost & Lab Analysis/Reporting [Operational - includes the surveillance suite cost]	Pesticides & selected VOC's and H'carbons (plus diffuse surveillance analysis suite)	
Point Source Sample Cost & Lab Analysis/Reporting [Operational - includes the surveillance suite cost]	Targeted determinands related to risk e.g. for VOC's, PAH's, Petrol Hydrocarbons, Phenols, Metals (plus diffuse surveillance analysis suite)	
Water Level - Manual dips & data compilation [Surveillance]	Monthly WL Dips	
Water Level - Logger downloads & data compilation [Surveillance]	Logger downloads [may be some loggers with dial-up downloading (not accounted for yet)]	
Point Source Sampling & Analysis [Investigative]	* see Point Source Operational Suite	
Infrastructure		
New Well Installation (inc. Pump test & initial site survey)		

New Piezometer Installation (inc. Pump test & initial site survey)	* Cost per piezometer, assumes 2 piezometers installed per monitoring location	
New Weir Installation (inc. initial site survey)	* for spring monitoring (includes Weir Installation and Staff Gauge)	
Data Logger (Levels) & Installation		
Data Logger (WQ) & Installation	Extra 1000 for the addition of Selected site parameters e.g. temperature, conductivity, pH, DO	
Additional Monitoring		
GW DTE Piezometers (Locations undecided)	Assume diffuse operational suite analysis & data logger for Levels & WQ at each location with visits as per diffuse operational	
Urban Pressures (36 MPs in Urban Areas)	Assume point source operational suite analysis & data logger for Levels & WQ at each location, with visits as per point source operational	
Poorly Productive Aquifers (6 piezos x 10 Locations)	Assume diffuse surveillance suite analysis & Data logger for Levels & WQ at each location, with site visits as per surveillance monitoring	
DWPA (Raw Water sample at all GW DWPA > 10 m ³ /d Nationally, at least once per RBMP cycle)	Assume point source operational suite analysis & pesticides ; assume one sample per planning period. Currently there are 1,965 Groundwater DWPAs in Ireland (abstraction rate not checked)	needs to include Radiological analysis e.g. Radon
GW/SW Interaction (12 GW sites Nationally)	Assume diffuse surveillance suite analysis & Data logger for Levels & WQ at each location	
Dangerous Substances (4 MPs Nationally)	Assume full List 1 & 2	

1.8.2 Appendix 6.2 - Monitoring Frequency Summary

	Surveillance				Operational				Water Level				Drinking Water Protected Areas			
	No. Monitoring Points	Average Monitoring Frequency			No. Monitoring Points	Average Monitoring Frequency			No. Monitoring Points	Average Monitoring Frequency			No. Monitoring Points	Average Monitoring Frequency		
		Year 1	Year 2	Year 3		Year 1	Year 2	Year 3		Year 1	Year 2	Year 3		Year 1	Year 2	Year 3
Diffuse *	241 [29]	4	2	2	144 [13]	12	4	4	188 [25]	6	4	4	-	-	-	-
Point Source **	-	-	-	-	52 [16]	6	4	4	52 [16]	6	4	4	-	-	-	-
Poorly Productive Survey ***	60 [60]	4	2	2	-	-	-	-	60 [60]	4	2	2	-	-	-	-
Dangerous Substances Survey ****	-	-	-	-	4	12	4	4	-	-	-	-	-	-	-	-
Urban Areas Survey *****	-	-	-	-	36 [36]	6	4	4	36 [36]	6	4	4	-	-	-	-
GW Dependent Ecosystems *****	42 [42]	4	2	2	84 [84]	6	4	4	126 [126]	4	2	2	-	-	-	-
GW/SW Interactions *****	13	4	2	2	-	-	-	-	13	4	2	2	-	-	-	-
Drinking Water Abstractions *****	-	-	-	-	-	-	-	-	-	-	-	-	1,965	1/3	1/3	1/3

Assumptions

Surveillance Monitoring is for sites that are **Surveillance Only** sites. Figure in Square Bracket is number of New Wells.

Operational Monitoring is for Operational sites & **this includes Surveillance Monitoring** at the site.

Water level monitoring will either be based on monthly dipping or data logger downloads - in the case of data loggers, sites should be visited every 3 months for downloading.

* Includes large abstractions in the poorly productive. Monitoring frequency will remain monthly after Year 1, if confidence in the data remains low or a significant diffuse pollution problem is apparent.

** Monitoring frequencies for exist defensive monitoring e.g. IPPC licensing will be supplemented by additional sampling to comply with the frequencies above e.g. if groundwater is sampled quarterly for an IPPC licence, then an additional 2 samples will be taken in Year 1. Water levels should also be recorded (manual dip) when the water quality sample is being taken. Further characterisation studies are being carried out for Mines, Quarries, Contaminated Land and Landfills and information from these studies will be used to determine monitoring locations nationally.

*** Water quality samples to be taken when downloading water levels from loggers (sites could either be at risk or not at risk, Surveillance suite to be taken).

**** Full Dangerous Substances suite to be taken at the four test sites.

***** Total of 36 MP's, which will be subdivided amongst urban areas once the ERBD Urban Pressures Study, is complete.

***** Of the 48 GWDTE's found to be at risk, 28 were at risk from non-drainage pressures, provisionally 3 monitoring points will be used at each of these locations. 14 GWTDE's, that were not at risk, will be selected to investigate the impacts of groundwater on different habitats and species. The No. of Monitoring Points indicates a total, with installation of infrastructure phased over a 3 year planning period.

***** Provisionally 13 GW Monitoring locations (which will have an associated river surveillance monitoring). Some sites may overlap with diffuse GW monitoring and may be either surveillance or operational depending on location.

***** DWPA's will be sampled once in each River Basin Management Planning Cycle i.e. 6 years (although cycle one is only 3 years in duration), untreated samples will be taken for the full surveillance, operational point source and operational diffuse determinands. Not included in monitoring costs under WFD (for the time being).

1.8.3 Appendix 6.3 - Monitoring Location Summary

Year 1	ERBD	WRBD	SERBD	SWRBD	N/S Share	ShRBD	Total Yr 1
Monitoring Points							
Surveillance Programme	35	40	54	26	31	55	241
Operational Programme - Diffuse	21	30	29	19	15	30	144
Quantitative Programme [Water Levels]	48	41	24	17	18	40	188
Poorly Productive [Quantitative & Water Quality]							60
Urban Pressures							36
GW/SW Interactions [Surveillance]	2	5	2	3	0	1	13
Operational Programme - Point Source	4	2	22	4	8	12	52
GWDTE <i>At Risk</i> [Water Quality & Quantitative]							28
GWDTE <i>Not At Risk</i> [Water Quality & Quantitative]							14
Dangerous Substances							4
Drinking Water Protected Areas							1965

1.8.4 Appendix 6.4 - Quantitative Monitoring Programme Monitoring Locations

Monitoring Location Name	RBD	County	Easting	Northing	Data Logger (1/2/3) *	Additional water quality (1/2)**	Monitoring Frequency (per annum)	Associated GWB/GWB group	Associated at risk SW Receptor (1/2/3) ***	Monitoring Authority (1/2) ****	MP Code

* Data Logger: 1 – No logger (manual sampling); 2 – Water Level Monitoring; 3 – Water Level & Basic Field Chemistry Monitoring

** Determinand Suite: 1 – no additional water quality sampling; 2 – Basic Suite;

*** Associated at risk Receptor: 1 – GWDTE; 2 – SW Body; 3 – DWPA;

**** Responsible Authority: 1 – EPA; 2 – Local Authority.

1.8.5 Appendix 6.5 - Surveillance Monitoring Programme Monitoring Locations

Monitoring Location Name	Subnet (1/2/3) *	RBD	County	Easting	Northing	Determinand Suite (1/2) **	Data Logger (1/2/3) ***	Monitoring Frequency (per annum)	Associated GWB/GWB group	Associated at risk SW Receptor (1/2/3) ****	Monitoring Authority (1/2/3) *****	MP Code

* Subnet: 1 – Verification of Risk Assessment; 2 – Trends; GW/SW interactions;

** Determinand Suite: 1 – Basic Suite; 2 – Full Suite at GW/SW interaction flux sites;

*** Data Logger: 1 – No logger (manual sampling); 2 – Water Level Monitoring; 3 – Water Level & Basic Field Chemistry Monitoring;

**** Associated at risk Receptor: 1 – GWDTE; 2 – SW Body; 3 – DWPA;

***** Responsible Authority: 1 – EPA; 2 – Local Authority; 3 – RBD.

1.8.6 Appendix 6.6 - Operational Monitoring Programme Monitoring Locations

Monitoring Location Name	Subnet (1/2/3) *	RBD	County	Easting	Northing	Determinand Suite (1/2/3/4/5) **	Data Logger (1/2/3) ***	Monitoring Frequency (per annum)	Associated GWB/GWB group	Associated at risk SW Receptor (1/2/3) ****	Monitoring Authority (1/2/3) *****	MP Code

* Subnet: 1 – Diffuse; 2 – Point Source; 3 – Urban Pressures;

** Determinand Suite: 1 – Basic Suite; 2 – Basic & Diffuse Operational; 3 – Basic & Point Source; 4 – Basic & Point Source Urban; 5 – Full Suite;

*** Data Logger: 1 – No logger (manual sampling); 2 – Water Level Monitoring; 3 – Water Level & Basic Field Chemistry Monitoring;

**** Associated at risk Receptor: 1 – GWDTE; 2 – SW Body; 3 – DWPA;

***** Responsible Authority: 1 – EPA; 2 – Local Authority; 3 – RBD.

1.8.7 Appendix 6.7 – Drinking Water Protected Areas with significant potable groundwater abstractions

Monitoring Location Name	RBD	County	Easting	Northing	Monitoring Frequency (per annum)	Associated GWB/GWB group	MP Code

1.8.8 Appendix 6.8 – Groundwater Dependent Terrestrial Ecosystems

Monitoring Location Name	Subnet (1/2) *	RBD	County	Easting	Northing	Monitoring Frequency (per annum)	Data Logger (1/2/3) **	Associated Ecosystems	Associated GWB/GWB group	Monitoring Authority (1/2/3) ***	MP Code

* Subnet: 1 – Water levels; 2 – Basic water quality suite;

** Data Logger: 1 – No logger (manual sampling); 2 – Water Level Monitoring; 3 – Water Level & Basic Field Chemistry Monitoring;

*** Responsible Authority: 1 – EPA; 2 – Local Authority; 3 – NPWS.

1.8.9 Appendix 6.9 - Target values for confidence and precision of the monitoring programme

An assessment of confidence is important in the justification of corrective action. The use of statistics is recommended to assess confidence. Geological control should also be provided using minimum frequency of monitoring set out in Tables 6.3 and 6.6. These tables should be revisited, accounting for a consideration of variability in existing data.

Mean and 95% confidence limits should be calculated for either individual monitoring locations or aggregated means should be calculated for the whole groundwater body or groundwater body group, depending on status test. Given that confidence is based on the frequency of monitoring (within our control) and variation in results (out of our control), these means should be based on 6 years of data as a minimum. If we are not 95% confident, should report the face value with X % confidence.

1.8.10 Appendix 6.10 – Monitoring Authorities

Resources are required to undertake the groundwater monitoring programmes outlined in Appendix 6.4 - 6.8. The exact subdivision of tasks and resources should be determined through discussion between the lead and supporting monitoring authorities below.

Allocation of tasks

Monitoring	Lead monitoring authority	Supporting monitoring authority
Surveillance Monitoring	Local Authority	EPA
Operational Monitoring – Diffuse	Local Authority	EPA
Operational Monitoring – Point Sources	Local Authority	EPA
Operational Monitoring – Urban Areas	Local Authority	EPA
Poorly Productive Aquifers	Local Authority	EPA
Quantitative Monitoring	EPA	OPW
Drinking Water Protected Areas	Local Authority	EPA
Habitats and Species Protected Areas	NPWS	EPA / Local Authority

Drinking Water Protected Areas

Although groundwater monitoring at all Drinking Water Protected Areas is not required under the WFD, the proposed Groundwater Directive indicates that (untreated) groundwater samples will have to be analysed at least once in every RBMP cycle i.e. every six years. If this Directive is implemented in Ireland, there will also be a requirement to sample and analyse (untreated) groundwater quality at all significant Drinking Water Protected Areas, although costs and resources have not been included in Appendix 6.3, these will have to be revised if the proposed Directive is implemented.

Investigative Monitoring Costs

A budget line is required specifically for investigative monitoring such that it does not impinge on the main monitoring programmes. The budget may not be spent in every calendar year but it is crucial that the capacity to undertake investigative monitoring is 'built in' to the overall monitoring system. Thus it must be possible to draw in additional resources – whether personnel, equipment or financial as necessary under the heading of investigative monitoring.