WATER QUALITY IN IRELAND 2007-2009

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This Report is dedicated to the memory of our colleague
Michael Neill (1948-2010)

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FOREWORD

This report is the sixth in the series of three-year reviews of water quality in Ireland that have been undertaken by the Environmental Protection Agency (EPA) since 1995. A number of earlier reports were published by our predecessors, An Foras Forbartha, from 1970 to 1980 and the Environmental Research Unit, covering the period 1987 to 1990. Ireland is one of the few countries in Europe with such a detailed, scientifically based time series of water quality, which now spans four decades.

This report presents a review of Irish ambient water quality for the years 2007 to 2009. The aim of the report is to present a detailed overview of the main aspects of the quality of the aquatic environment in Ireland, to assist in the protection and enhancement of this key national resource. The data will provide a basis for Programmes of Measures to restore and maintain water quality.

The EPA has worked with a range of agencies to deliver a national assessment, based on the criteria and standards set out in the Water Framework Directive (2000/60/EC). The EPA published a national monitoring programme in June 2006 to meet the requirements of the WFD and the regulations implementing the Nitrates Directive (S.I. No. 788 of 2005).

The water quality data are presented in two ways: against the new ecological status criteria of the Water Framework Directive (WFD) and reporting on water quality, in the manner of previous EPA reports, so that trends can be seen.

The WFD assessment scheme for **water status**, that includes water quality, is a complex but comprehensive ecological approach, to aquatic resource management, in which the scope has been broadened to include a wide range of supporting parameters.

Thus, with many areas of aquatic systems to be covered, the report marks a transition phase towards a new, multi-agency programme.

The water quality data and other information have been generated by EPA field and laboratory based teams in the Office of Environmental Assessment, supplemented by information from

- Local authorities,
- Central and Regional Fisheries Boards (now Inland Fisheries Ireland)
- Marine Institute
- Radiological Protection Institute of Ireland
- Sea Fisheries Protection Authority
- Waterways Ireland and the Irish Coast Guard

We wish to convey sincere thanks and appreciation to our colleagues in these agencies.

The EPA looks forward to working with the Department of Environment, Heritage & Local Government and with the network of agencies to deliver the next phase of the Water Framework Directive and to meet the targets set out in the Directive for 2015 and 2021. This report makes clear that the targets are ambitious. Significant pollution remains an issue, for example in at least 20 river sites, in 25 lakes and in nine estuarine water bodies.

As previously stated by EPA, the achievement of future WFD targets will require a review of current water governance and the evolution of a regional network of agencies, based on the River Basins, in order to provide a more effective balance of national integration and local implementation.

Micheál Ó Cinnéide
Director
Office of Environmental Assessment

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GROUNDWATER QUALITY

Matthew Craig, Anthony Mannix and Donal Daly

INTRODUCTION

Groundwater, which originates from rain that soaks into the ground, is an important natural resource in Ireland. It flows through and is stored in fractures in the bedrock and the pore spaces of sand and gravel deposits. If the geological deposit can yield enough water for a significant water supply then it is referred to as an aquifer. The physico-chemical properties of groundwater can be examined through the study of groundwater abstractions from pumped boreholes and wells, and groundwater that issues to the surface from springs, e.g. Plate 2.1.

Bedrock aquifers in Ireland have fissure permeability only, where water flow is through fissures or fractures and not through pore spaces in the rock itself; thus, any contaminants present in the groundwater undergo minimal attenuation. The sand and gravel aquifers that underlie approximately two per cent of the country are the only aquifers with intergranular permeability. Some attenuation of contaminants may occur where the aquifers are protected by the overlying soil and subsoil; therefore variation in subsoil type and thickness is important when characterising the vulnerability of groundwater to contamination.

A large proportion of the productive aquifers in Ireland are karstified limestone (e.g. Plate 2.2). Karst landscapes develop in rocks that are readily dissolved by water, e.g. limestone (composed of calcium carbonate), and typically conduit, fissure and cave systems develop underground (Geological Survey of Ireland, 2000).

GROUNDWATER QUALITY IN IRELAND

The natural quality of groundwater varies as groundwater flows from recharge areas, e.g. elevated topography, to discharge areas, e.g. springs or rivers. The groundwater chemistry may change as it passes through soils, subsoils or rocks with different mineralogy.

In Ireland, limestone bedrock and limestone dominated subsoil are common and consequently groundwater is often hard, containing high concentrations of calcium, magnesium and bicarbonate. In areas where sandstone or volcanic rocks dominate, softer water is normal. Elevated concentrations of certain ions can occur naturally and may lead to water quality problems, e.g. iron, manganese, sulphate and arsenic, and sodium and chloride in aquifers near coasts. Therefore, it is important to consider natural hydrochemical variations when interpreting the analyses from groundwater quality monitoring programmes and assessing whether groundwater is polluted.

The groundwater chemistry is also continually being modified by the influence of human activity, whether that is through changes in groundwater flow, caused by groundwater abstraction, or the introduction of anthropogenic substances. The presence of purely anthropogenic substances, e.g. hydrocarbons or pesticides, clearly indicates departure from natural conditions.

Plate 2.1. Groundwater issuing from a spring and properly constructed boreholes (inset).

Appraisal of Existing Groundwater Data

The appraisal of data focuses on monitoring points selected for the WFD Groundwater Monitoring Programme. Therefore historical data from monitoring points that are no longer in the WFD Programme are not included in the data analysis. Data are presented for the period 2007-2009, and, for comparison, historical data from 1995-2006 are presented, again only using historical data from monitoring points that have remained in the WFD Groundwater Monitoring Programme.

Groundwater Quality

The data have been gathered by the EPA and are presented for parameters that are indicators of anthropogenic pollution (Ammonium, Nitrate, Phosphate and Faecal Coliforms). Comparison is made with the appropriate WFD threshold values, standards and assessment principles for these parameters, e.g. the key phosphate threshold concentration in groundwater has been derived from the environmental quality standard for surface water receptors.

Hazardous Substances

A WFD further characterisation study on the risk to groundwater from diffuse mobile organic substances (CDM, 2008) identified groundwater bodies which were potentially at risk from pollution because of land use and the groundwater vulnerability in relation to pesticides. The EPA initiated a sampling programme for pesticides between 2007 and 2009. The data from the sampling programme confirmed that pesticide pollution of groundwater from diffuse sources was uncommon and the Drinking Water Maximum Admissible Concentration (MAC) of 0.1 g/l for individual pesticides was exceeded in 16 of 18,722 samples (<0.1%). During 2009, the EPA initiated a sampling programme for a suite of chemical organic parameters, e.g. hydrocarbons, at all monitoring locations in the sampling programme. None of the samples for any of the parameters analysed exceeded the Drinking Water MAC at any monitoring location. Consequently, the EPA has decided to run a less intensive monitoring programme in future for both the pesticide and organics parameter suites, e.g. sampling one year in every three.

Plate 2.2. Karstified limestone outcrop in Co. Clare (Caoimhe Hickey *pers. comm.*)

Box 2.1 Groundwater as a Source of Drinking Water

Approximately 26 per cent of the public and private drinking water supply in Ireland is provided by groundwater (Lucey, 2009). In certain counties, e.g. Roscommon, the percentage is significantly higher, with groundwater providing approximately 75 per cent of the drinking water (Lucey, 2009).

The majority of private group schemes and small supplies are reliant on groundwater and often have inadequate treatment or, in many cases, no treatment at all. This heightens the need for groundwater and source protection, pollution prevention, and the treatment of groundwater, to ensure that the quality of drinking water conforms to the requirements of the Drinking Water Regulations (S.I. 278 of 2007). Furthermore, to protect private supplies, and reduce the risk of pollution of public supplies, there needs to be adequate protection of groundwater as a resource. Also, as groundwater may ultimately discharge from an aquifer to springs, rivers, estuaries or wetlands, these may also be adversely affected if the groundwater is polluted.

The interaction between groundwater and surface water is complex and the quantification of the volume of groundwater that contributes to surface water flow and its chemical composition is often difficult to determine. Groundwater contributions to surface water flow vary; often in the more productive aquifers, e.g. karstified limestone or sand and gravel aquifers, the groundwater contribution may be as large as 80 or 90 per cent of the average surface water flow. In contrast, in the low yielding 'poorly productive' aquifers that underlie two-thirds of the country, the average deep groundwater contribution is frequently less than five per cent of the average surface water flow. However, groundwater may also flow at shallow depths where the bedrock is fractured at the 'top of the rock'. Therefore the overall groundwater contribution from these aquifers may be around 30 per cent of the average surface water flow.

Plate 2.3. Boreholes being drilled near Glencastle, Co. Mayo

Ammonium

Microbiological reduction of nitrogen-containing compounds generally results in very low background concentrations of ammonium in natural waters. Ammonium has a low mobility in soil and subsoil. Its presence in groundwater much above 0.15 mg/l N is usually indicative of a nearby source of organic pollution, such as effluent from farmyard manure, slurry and dirty water or from on-site wastewater treatment systems (such as septic tanks or similar systems), although high ammonium concentrations may be encountered naturally.

Between 2007-2009, a total of 2,698 individual monitoring samples were analysed for ammonium at 211 monitoring stations. The mean concentration results are summarised in Figure 2.4 and the monitoring locations are shown in Map 2.1.

The river water Environmental Quality Standard (EQS) of 0.065 mg/l N for Total Ammonium (as an annual mean concentration) is taken as the threshold value for groundwater. The average ammonium concentration in groundwater was below the threshold value at 81 per cent of the monitoring locations for the period 2007-2009. This equates to a ten per cent decrease in the number of monitoring locations with an average concentration less than 0.065 mg/l N over the previous assessment period (2004-2006). There has been a noticeable increase (16%) in the proportion of sites in the 0.04 to 0.065 mg/l category.

Ninety-four samples had ammonium concentrations greater than the Drinking Water MAC of 0.23 mg/l N. The majority (97%) of the monitoring locations had mean concentrations less than the MAC with mean concentrations greater than 0.23 mg/l N recorded at six of the 211 monitoring locations. Four of the six monitoring locations also tested positive for faecal coliforms, possibly indicating that a nearby organic pollution source is getting into the water supply. There has been little change in the overall proportion of sites with mean concentrations greater than the MAC value of 0.23 mg/l N between 2004-2006 and 2007-2009.

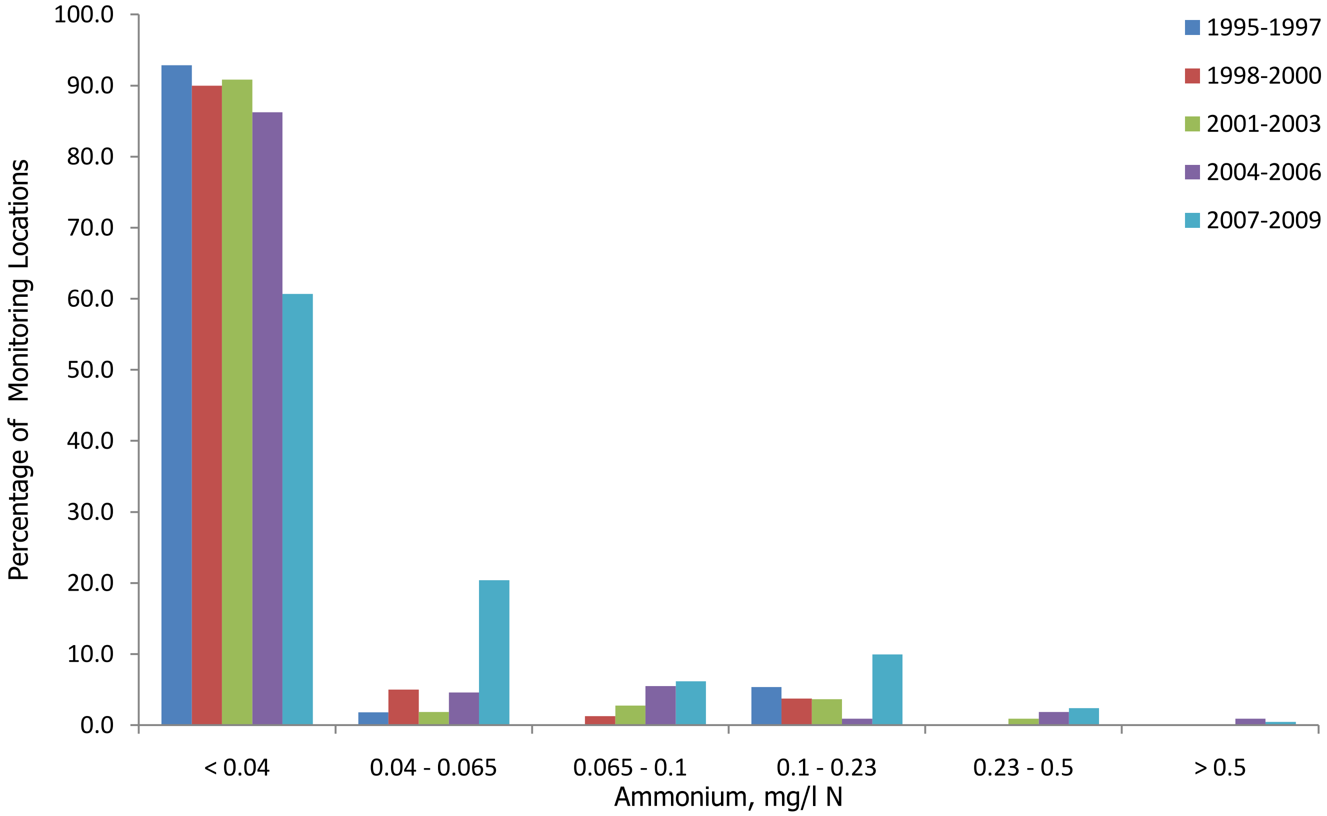
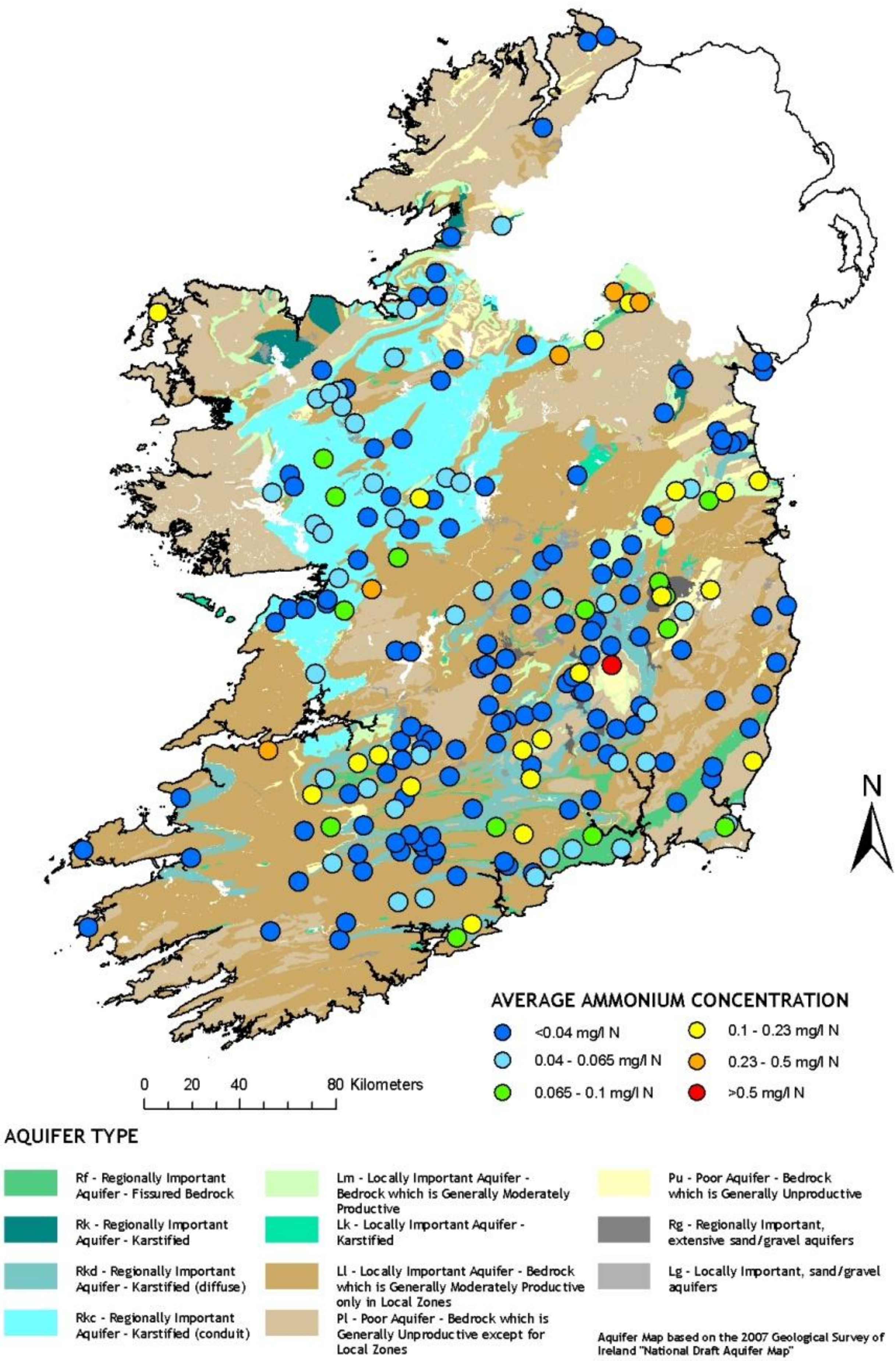


Figure 2.4. Comparison of the proportion of monitoring locations over different reporting periods with mean ammonium concentrations in the ranges indicated



Map 2.1. Mean Ammonium Concentrations in Groundwater 2007-2009 (Source: EPA, GSI)

Nitrate

Relatively low concentrations of nitrate are found naturally in groundwater and concentrations higher than 10 mg/l as NO_3 are usually indicative of anthropogenic organic or inorganic inputs. Organic sources can include organic fertiliser, e.g. slurry, or effluent from on-site wastewater treatment systems, whilst inorganic sources can include the spreading of artificial fertiliser. If a significant proportion of surface water flow is derived from groundwater, then increased nitrate concentrations in groundwater may contribute to eutrophication in surface waters, particularly in transitional and coastal waters.

Under the Drinking Water Regulations, the MAC for nitrate is 50 mg/l as NO_3. A mean concentration greater than the Threshold Value of 37.5 mg/l NO_3 is an indication of appreciable contamination, which given the dynamic nature of groundwater in Ireland, would probably result in the Drinking Water MAC being exceeded at the monitoring point at some time during the sampling period.

A total of 2,681 individual monitoring samples were analysed for nitrate at 211 monitoring locations between 2007-2009. Concentrations greater than 37.5 mg/l NO_3 were recorded in 186 individual samples, of which 50 samples exceeded the MAC of 50 mg/l NO_3. The mean concentration results are summarised in Figure 2.5 and the monitoring locations are shown in Map 2.2. At ten (4.7%) of the monitoring locations, the mean concentrations exceeded the Threshold Value of 37.5 mg/l NO_3, while at two of these locations, the mean concentration exceeded 50 mg/l NO_3. Figure 2.5 indicates that there has been a change in the overall pattern in nitrate concentration in the 2007-2009 results when compared to previous reporting periods. Prior to 2006 a slight increase in nitrate concentrations has been detected with time. The 2007-2009 data indicate an overall decrease in nitrate concentrations, with a noticeable increase in the percentage of samples with concentrations less than 10 mg/l NO_3.

Generally, the south and south-east of the country continue to have the greatest proportion of monitoring locations with elevated nitrate concentrations. Although elevated nitrate concentrations may be observed in monitoring points that are in close proximity to point source waste discharges, the intensive agricultural practices in the south and south-east are the probable cause of the elevated nitrate concentrations in ground-water.

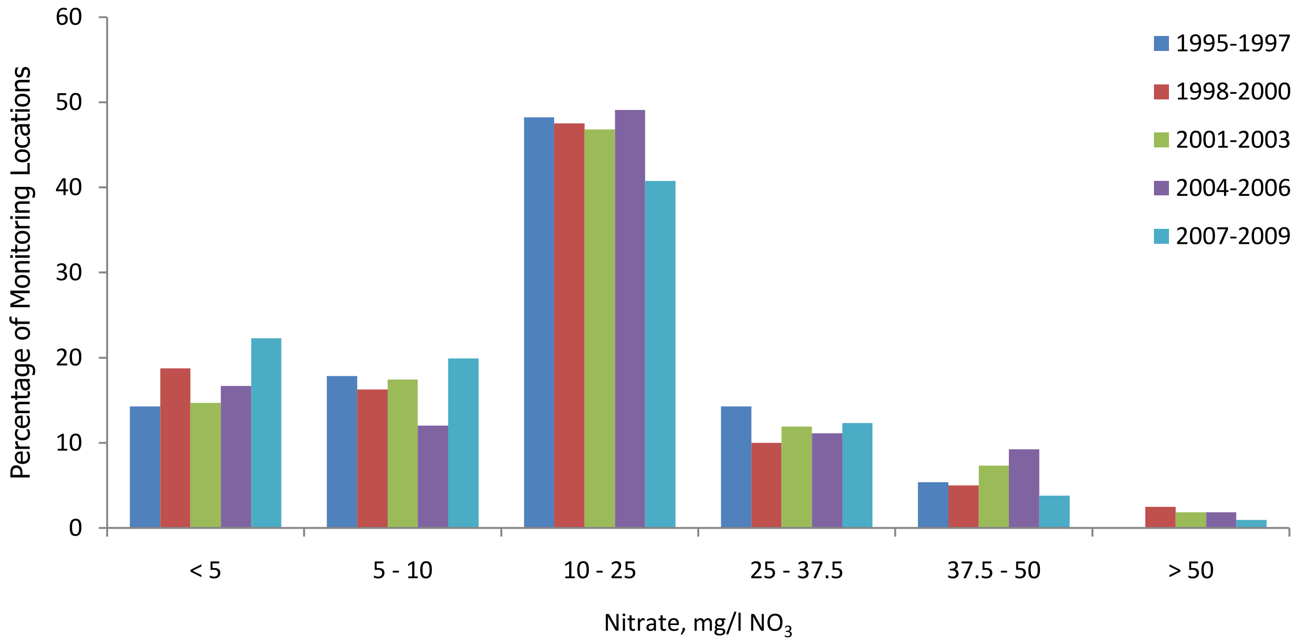
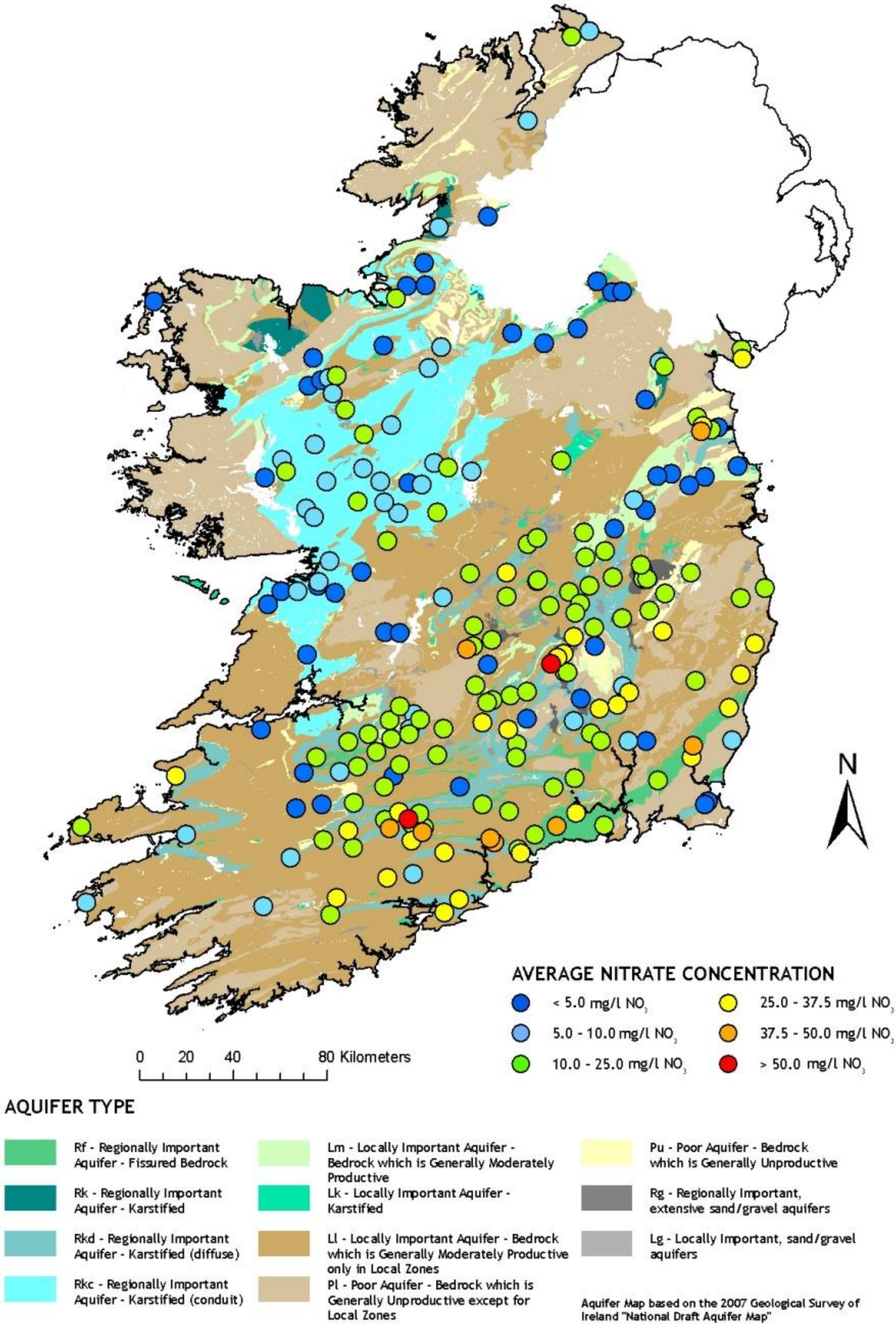


Figure 2.5. Comparison of the proportion of monitoring locations over different reporting periods with mean nitrate concentrations in the ranges indicated



Map 2.2. Mean Nitrate Concentrations in Groundwater 2007-2009 (Source: EPA, GSI)

Phosphate

Phosphate is a major source of concern for surface waters because small amounts may lead to eutrophication of lakes and rivers. Historically, phosphate was not considered to be a significant problem in groundwater because it was seldom detected above the drinking water standard. However, as observed in the WFD status assessments, in extremely vulnerable areas, where the soil and subsoil are shallow and where phosphate enters groundwater; groundwater may act as an additional nutrient enrichment pathway for receptors such as lakes, rivers and wetlands.

The river water Environmental Quality Standard (EQS) of 0.035 mg/l P for Phosphate (as an annual mean concentration) is taken as the threshold value for groundwater. Between 2007-2009, a total of 2,732 individual samples were analysed for phosphate at 211 monitoring locations. Concentrations greater than 0.035 mg/l P were recorded in 251 (9%) of the samples. The mean concentration results are summarised in Figure 2.6 and the monitoring locations are shown in Map 2.3.

In the period 2007-2009, the average phosphate concentration in groundwater exceeded this threshold value of 0.035 mg/l P at 16 monitoring locations, eight of which exceeded 0.05 mg/l P. Figure 2.6 indicates that between 1995 and 2006, there had been a gradual increase in the percentage of monitoring locations with mean phosphate concentrations less than 0.015 mg/l P. This increase was more pronounced during the period 2007-2009. There has also been a noticeable increase in monitoring locations with mean concentrations in the range 0.015 to 0.025 mg/l P. Overall, there has been a increase of approximately 27 per cent of monitoring locations with mean concentrations less than 0.035 mg/l P when compared with the previous period.

In general phosphate concentrations in groundwater are not a cause of concern in relation to its use as a drinking water supply. As referred to earlier in this chapter, there are areas of the country where groundwater contributes significantly to flows in rivers, e.g. where 80 or 90 per cent of the average surface water flow comes from groundwater. If the phosphate concentrations in groundwater are above 0.02 mg/l P in these areas; then groundwater may be significantly contributing to eutrophication in rivers and lakes.

Map 2.3 indicates that elevated phosphate concentrations have been measured in the karstified aquifers, particularly where the groundwater is vulnerable to pollution and there are shallow soils and subsoils.

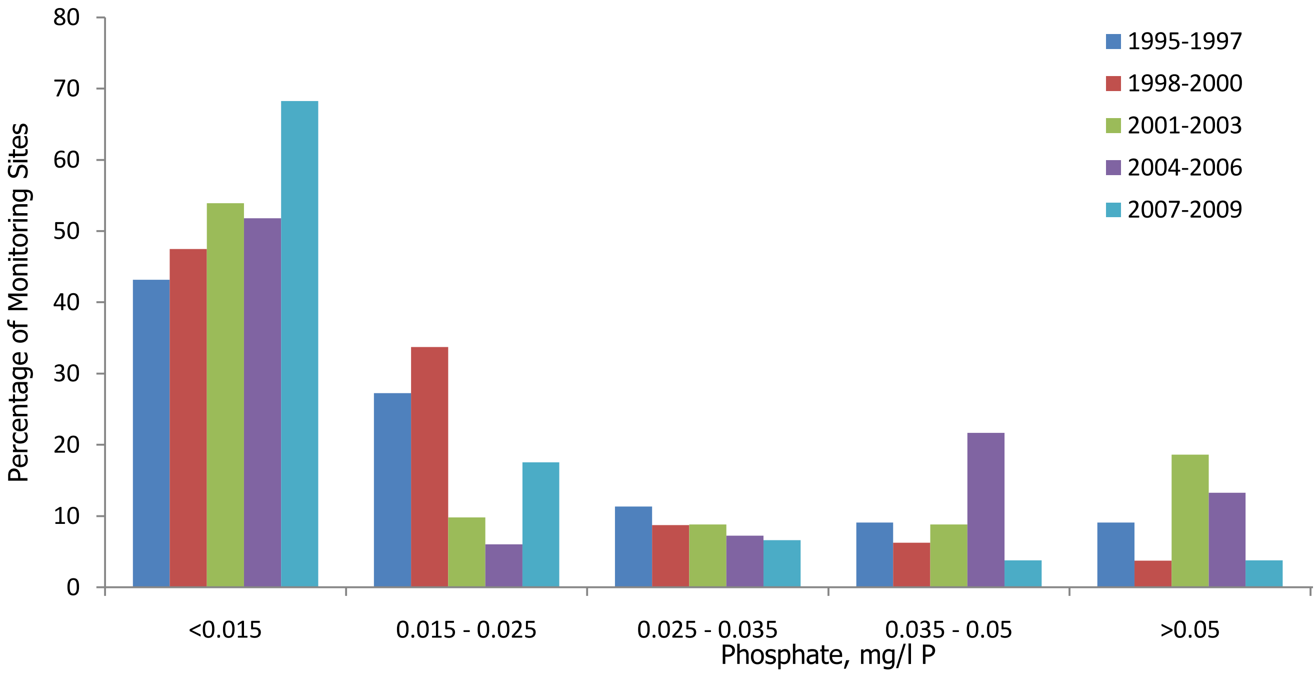
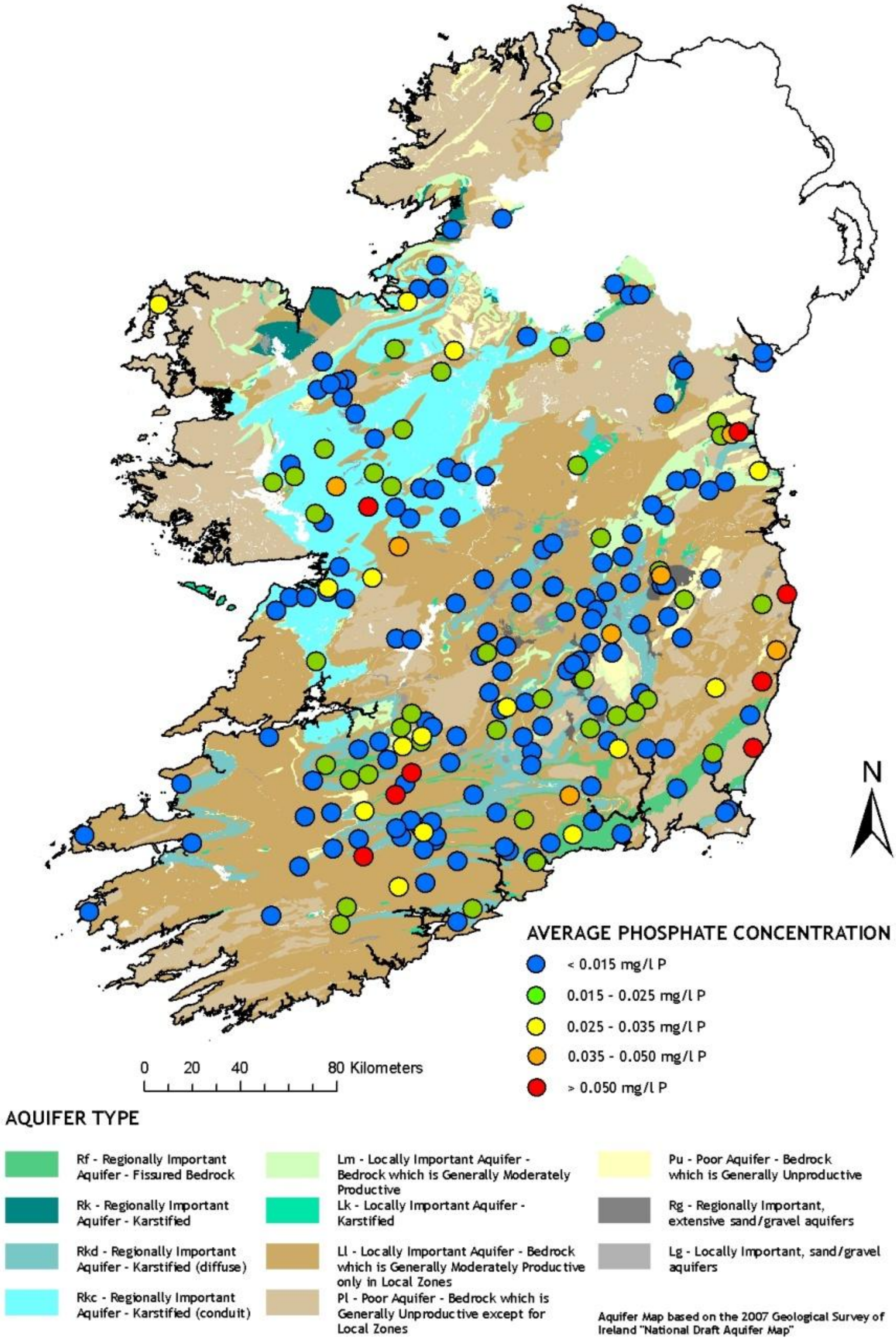


Figure 2.6. Comparison of the proportion of monitoring locations over different reporting periods with mean phosphate concentrations in the ranges indicated



Map 2.3. Mean Phosphate Concentrations in Groundwater 2007-2009 (Source: EPA,GSI)

Microbiological Contamination

Microbiological contamination arises from the entry of faecal matter to waters. The main sources of microbial pathogens are on-site wastewater treatment systems (e.g. septic tank systems), farmyard run-off, grazing animals and the land-spreading of manure or slurry. The natural environment, particularly soils and subsoils, can be effective in removing bacteria and viruses by filtration and absorption. However, not all areas are naturally well protected. Extremely vulnerable areas, including karst aquifers, fractured aquifers and areas with exposed outcrop or shallow soils, allow the rapid movement of contaminants into groundwater with minimal attenuation. While the presence of glacial till subsoils and peat will, in many instances, retard the vertical migration of microbes, preferential secondary flow paths such as cracks in clay materials can allow the filtering effect of the subsoils to be reduced or bypassed.

In practice, the presence of faecal coliform bacteria (e.g. *Escherichia coli*) in water samples is taken as an indicator of faecal contamination. The detection of *E. coli* may mean that associated pathogenic micro-organisms are present, i.e. those organisms capable of causing disease (e.g. viruses and the parasitic protozoan *Cryptosporidium*) as well as the 0157:H7 strain of the *E. coli* bacterium. It should be noted that the absence of faecal coliform bacteria in groundwater does not mean that more persistent organisms such as *Cryptosporidium* are not present.

From the perspective of human use and consumption of groundwater, the most important consideration is the absence of pathogens. Disinfection techniques, e.g. chlorination, are used to counteract this potential problem in public drinking water treatment, and 'barriers' such as filtration or ultraviolet disinfection are included in many areas susceptible to cyst forming protozoa (e.g. *Cryptosporidium*) as chlorine has limited effectiveness against these. However, the majority of private groundwater supplies do not undergo any treatment prior to use. The delineation of source protection areas around water supplies provides an area in which protective measures can be applied. The source protection area is based on the premise that 99.9 per cent of bacteria will die off within 100 days in groundwater. Therefore proper management of activities within this 100 day "time of travel" area should reduce the risk of bacteriological contamination of the water supply.

Between 2007 and 2009, a total of 2,718 samples were analysed for faecal coliforms at 211 monitoring locations. Where systems, such as chlorination, exist to treat the abstracted water, then samples were taken prior to treatment being applied. Positive faecal coliform counts were detected in 945 (34.8%) samples, 182 (6.7%) of which exceeded 100 cfu/100 ml (Figure 2.7). Positive counts were detected at 157 (74.4%) monitoring locations (Map 2.4) on one or more occasions during the reporting period. Faecal coliform counts in excess of 100 cfu/100 ml were recorded at 64 (30.3%) of the monitoring locations. Figure 2.7 indicates that there has been a decrease in the percentage of samples with zero faecal coliforms in the most recent reporting period and that there has also been an increase in the percentage of samples with >100 cfu/100ml. While the proportion of monitoring points with faecal coliform detections is high, it not only reflects the impact of human activities, but also the vulnerable nature of groundwater in some parts of the country.

The increased incidence of faecal coliform detections is largely a factor of the review and updates that were made to the national groundwater monitoring network in 2007 for WFD purposes; resulting in a network that is more representative of the hydrogeology and pressures. As a consequence, the network includes a higher proportion of monitoring locations that are vulnerable to bacteriological contamination.

Map 2.4 indicates that the groundwater monitoring locations in karst limestone areas show the greatest degree of microbiological pollution. The highest faecal coliform counts were recorded in springs. This reflects the

vulnerable nature of the more dynamic flow systems to pollution and the lack of attenuation capacity in extremely vulnerable areas with shallow soil or subsoil. Many private supplies are untreated and the sources of contamination of the groundwater quality are unknown, or are beyond the control of the owner of the supply.

Therefore, general improvements in well design, knowledge of source protection and good land use practice are essential if the risks to these supplies are to be reduced and improvements in water quality are to be seen.

The presence of a single faecal coliform in a drinking water supply is a breach of the Drinking Water Regulations (S.I. No. 278 of 2007) and as such must be regarded as a matter of serious concern and the circumstances promptly investigated. This matter has been addressed in detail in the annual reports on drinking water quality published by the EPA (e.g., Page *et al.*, 2009).

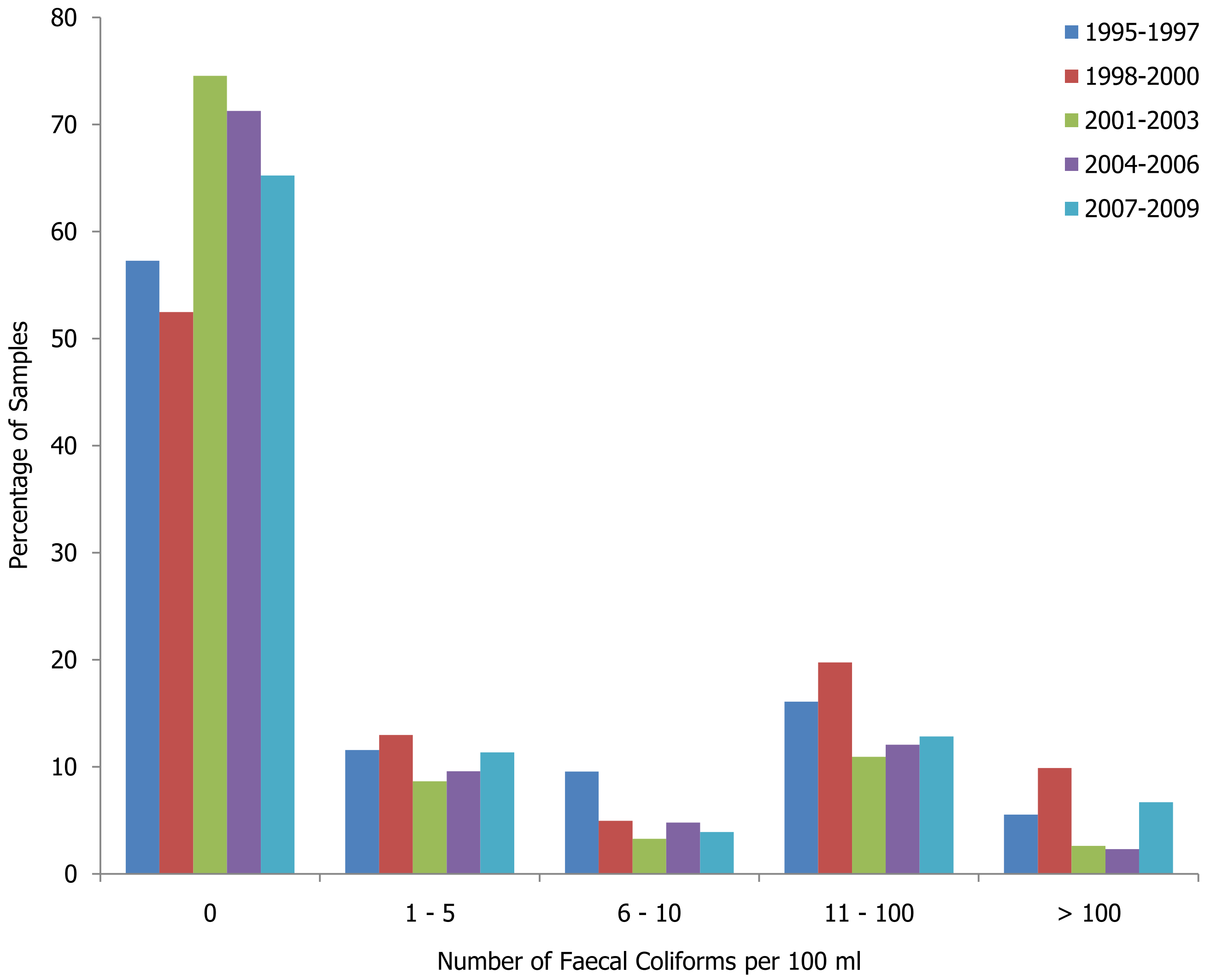
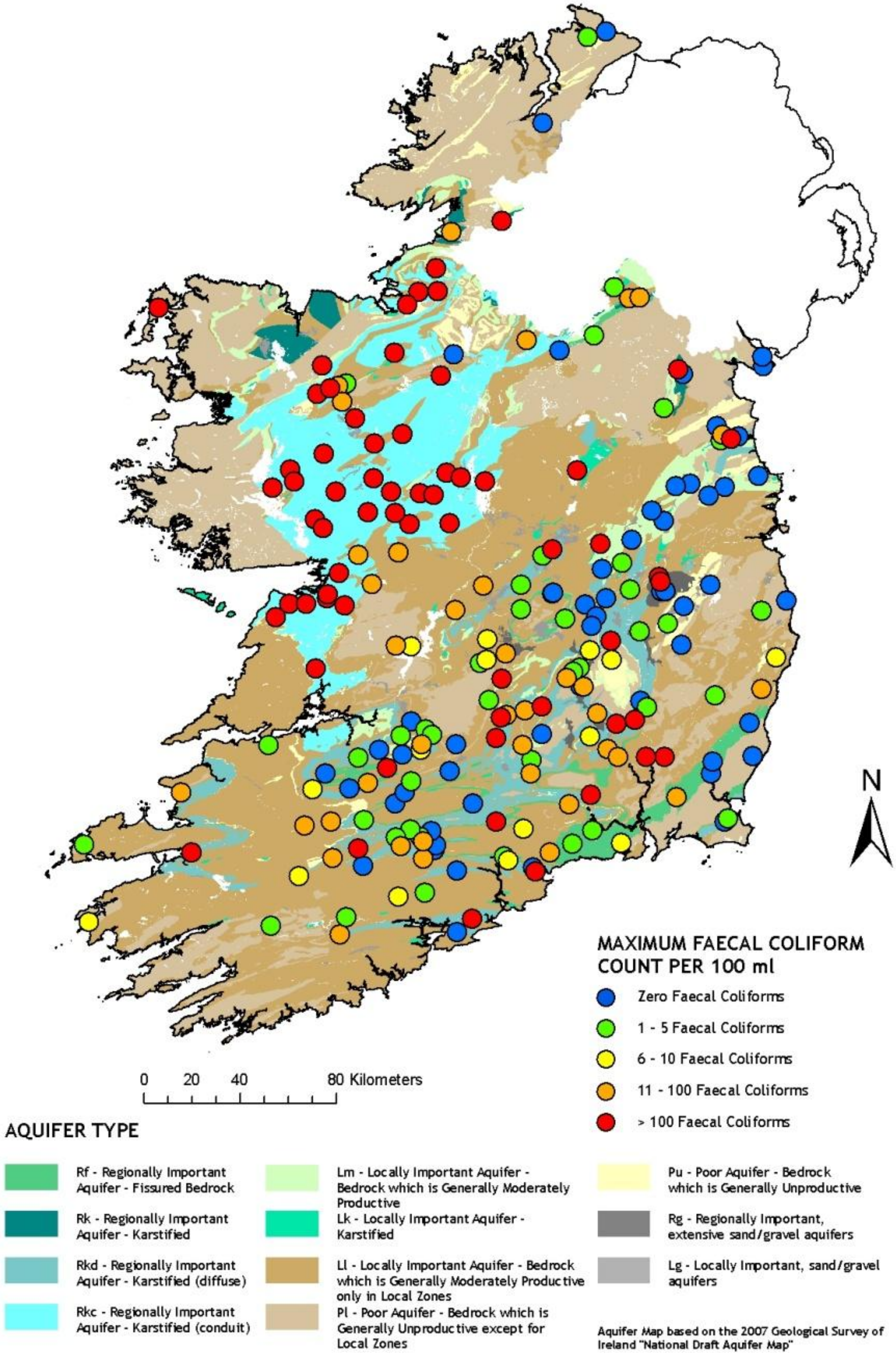


Figure 2.7. Comparison of the proportion of samples over different reporting periods with the number of faecal coliforms detected in the ranges indicated



Map 2.4. Faecal Coliform Detections in Groundwater 2007-2009 (Source: EPA, GSI)

CLASSIFICATION OF GROUNDWATER BODIES

Background

The European Communities Environmental Objectives (Groundwater) Regulations, 2010 (S.I. 9 of 2010) establish a new strengthened regime for the protection of groundwater in line with the requirements of the Water Framework Directive (2000/60/EC) and the Groundwater Directive (2006/118/EC). The EPA is identified as the responsible body for establishing and maintaining a list of Threshold Values (TVs) for pollutants in groundwater, assessing the chemical and quantitative status of groundwater bodies and undertaking pollutant trend and trend reversal assessments.

The Water Framework Directive (WFD) requires an integrated, holistic approach to the management and protection of water, thereby increasing the effectiveness of river basin management in Ireland. Groundwater is, therefore, at the core of the WFD. While the focus on groundwater in the past has been mainly concerned with its use for drinking water, the environmental value of groundwater, as well as its value as a water supply reservoir, has been recognised by the ecological objectives of the WFD. Groundwater plays an essential role in the hydrological cycle and is critical for maintaining river flows and surface water ecosystems such as wetlands.

In most rivers in Ireland, more than 30 per cent of the annual average flow is derived from groundwater. In low flow periods, this figure can rise to more than 90 per cent. Therefore, reductions in groundwater input, particularly in dry weather periods, or deterioration in groundwater quality may directly affect related surface water and terrestrial ecosystems. For instance, since surface waters receive inflowing groundwater, its quality will ultimately be reflected in the quality of surface waters. Therefore, the effect of human activity on groundwater quality will eventually impact on the quality of associated aquatic ecosystems and directly dependent terrestrial ecosystems if natural attenuation reactions such as biodegradation and adsorption in the subsurface are not sufficient to remove the contaminants.

In 2005, the WFD Article 5 Characterisation and Risk Assessments (WFD Working Group on Groundwater, 2005) were undertaken to identify groundwater bodies that were at risk of failing to meet the objectives of the WFD. The characterisation process involved two elements: physical characterisation and risk characterisation. Physical characterisation provided relevant information on groundwater receptors and on the geological pathways that link pressures and receptors. The risk assessment process concluded that 458 of the 757 groundwater bodies (60.5%), comprising 26.7 per cent of the area of the country, were classified as being "at risk" of failing one or more objectives of the WFD. While a large number of groundwater bodies (295) were at risk due to point source pollution, diffuse source pollution affected the greater area (24.6%).

The diffuse pressures risk assessment indicated that nutrient pressures from agricultural activities (including livestock farming, arable activities and intensive enterprises) and usage of dangerous substances, e.g. agrochemicals, are the most widespread and nationally significant anthropogenic pressure on groundwater. Nitrates were identified as being the most significant pollutant when considering groundwater as the receptor. The groundwater pathway for delivering phosphate loading to surface waters receptors was considered to be significant in some areas, such as extremely vulnerable bedrock areas. In most instances point source pressures, e.g. mines, quarries or landfills were considered unlikely to cause a significant impact on an entire groundwater body, as groundwater bodies are relatively large units (generally over fifty square kilometres). Unlike in most other European countries, groundwater abstraction was generally not considered to be a significant pressure.

The EPA's classification assessments have generally followed the procedures set out in EU Guidance Document No. 18: Guidance on Groundwater Status and Trends (EC, 2009),

UKTAG Paper 11b(i): Groundwater Chemical Classification for the purposes of the Water Framework Directive and the Groundwater Daughter Directive (UKTAG, 2008a), UKTAG Paper 11b(ii): Groundwater Quantitative Classification for the purposes of the Water Framework Directive (UKTAG, 2008b) and UKTAG Guidance on Groundwater Trend Assessments (UKTAG, 2009).

Threshold Values

Under Articles 48–52 of the Groundwater Regulations, the Agency is required to establish, and where appropriate maintain and update, a list of Threshold Values (TVs) for pollutants in groundwater. Threshold Values only have to be derived for pollutants placing a groundwater body at risk of failing to achieve a WFD objective.

Threshold Values are groundwater quality standards that are established by each Member State for the purpose of assessing the chemical status of groundwater bodies.* Threshold Values are also used when undertaking trend assessments. They can be set nationally or at a local groundwater body scale. They are triggers, such that their exceedance prompts further investigation to determine whether the conditions for good status have been met. As such, they do not represent the boundary between good and poor status. It is only if the average concentration of pollutants exceeds the Threshold Value and supporting evidence confirms the presence of an impact that compromises the achievement of WFD status objectives, that the groundwater body is classified as poor status.

When assessing monitoring data, the Threshold Value and assessment procedure must be appropriate to the receptor being considered for each status test, e.g. for an associated surface water body, a groundwater dependent terrestrial ecosystem (GWDTE) or groundwater that is used, or could be used for drinking water supply. The Threshold Values are identified in Schedule 5 of the Groundwater Regulations.

Status Assessments

Articles 33–44 of the Groundwater Regulations identify the conditions for assessing groundwater body status. The achievement of good groundwater status involves meeting this series of conditions, which are designed to satisfy the criteria defined in the WFD and the Groundwater Directive. In order to assess whether these conditions are being met, a series of tests has been prescribed for each of the quality elements defining good (chemical and quantitative) groundwater status.

Status assessments are required for all groundwater bodies identified as being at risk of failing one or more objectives of the WFD. The assessments are undertaken at the end of every six-year river basin management planning cycle and are used to generate a snap shot that shows the impacts of abstraction and pollutants on groundwater. In contrast, the risk assessments are carried out at the beginning of the six-year cycles. Whilst similar in nature, the goals of status assessments and ongoing risk assessments are different in that the risk assessments help determine the requirements for future monitoring and investigation, and help identify areas where future developments could impinge on the groundwater status objectives of the WFD. Essentially, the risk assessments are assessments of whether objectives of the WFD may not be achieved in the future, whilst status assessments consider compliance with the WFD objectives in the previous River Basin Planning cycle.

A groundwater body can be at good status, but there can still be an environmental risk, e.g. where the local impacts on groundwater quality are not substantial enough to impact on the status of the whole groundwater body. However, where a groundwater body has been classified as being at poor status, this implies that there is also a risk of failing WFD objectives in the future.

For groundwater, the overall aim is to achieve good status in all bodies of groundwater by

* Whilst the standards and conditions that are applied to environmental permits should reflect the need to meet all WFD objectives, including good chemical status, these are not Threshold Values.

2015, as well as preventing deterioration in those waters that have been classified as good. The process of classifying groundwater bodies follows logically from the characterisation and risk assessment process undertaken for Article 5 of the WFD.

Classification of groundwater bodies differs from that undertaken for surface water bodies, in that the surface water standards relate to ecological status and these standards define the classification boundaries. Groundwater status does not directly assess ecology, but the classification process takes account of the ecological needs of the relevant rivers and terrestrial ecosystems that depend on contributions from groundwater. Another key component of the groundwater classification is assessment of the impact of pollution on the uses (or potential uses) of groundwater from the groundwater body, e.g. for water supply. The groundwater body classification is based on the objectives defined in Annex V of the WFD and Annexes I – III of the Groundwater Directive.

Five chemical and four quantitative tests (Figure 2.8) have been developed to assess whether the WFD objectives are met. Each test is applied independently and the results are combined to give an overall assessment of groundwater body chemical and quantitative status. The worst-case classification from the relevant chemical status tests is reported as the overall chemical status for the groundwater body, and the worst-case classification of the quantitative tests is reported as the overall quantitative status for the groundwater body. The worst result of the chemical and quantitative assessments is reported as the overall groundwater body status.

The EPA, assisted by River Basin District Project consultants, completed the interim classification of groundwater bodies in December 2008. The classification will be finalised and reported to Europe in 2011, following a consultation process.

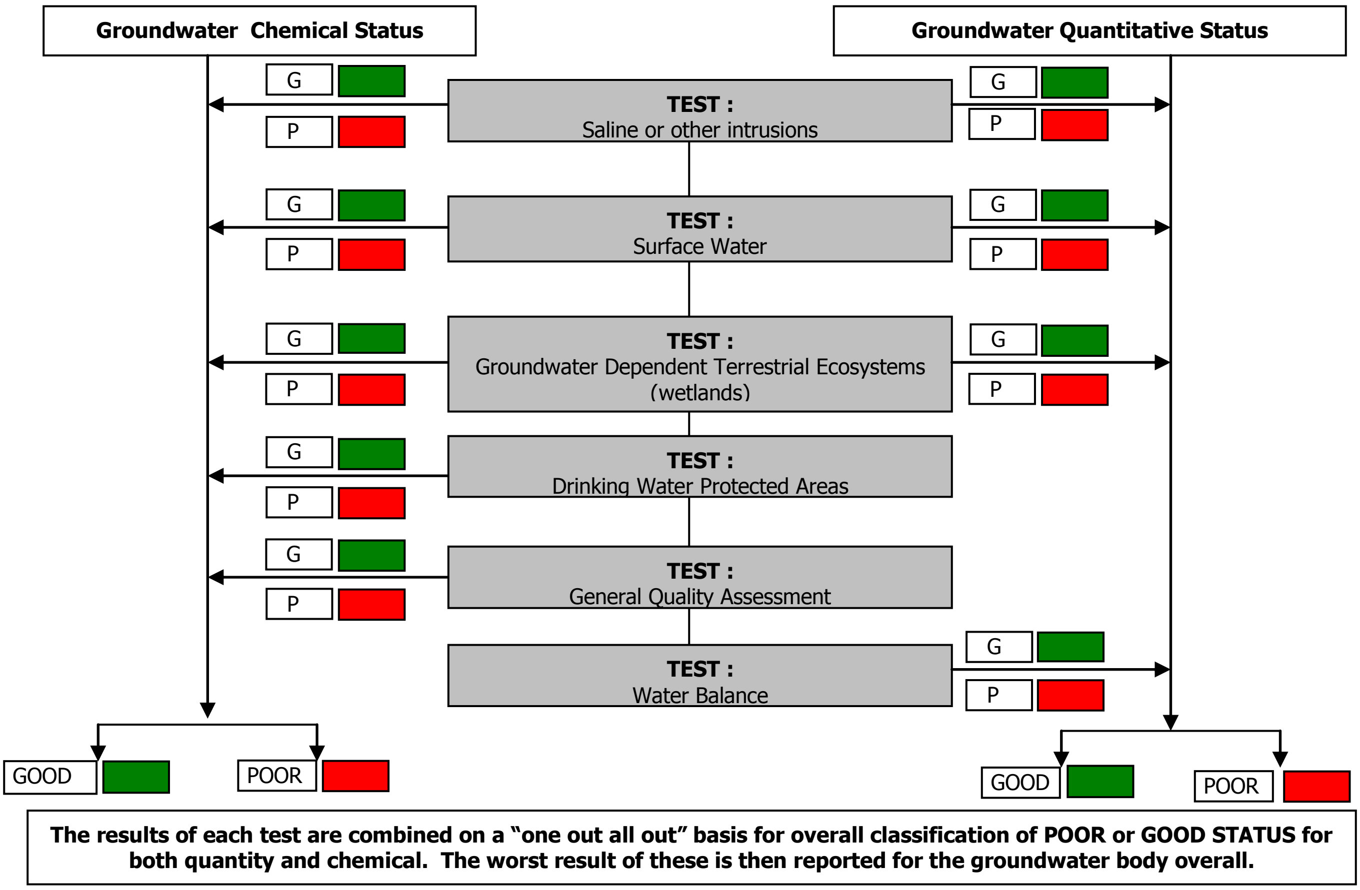


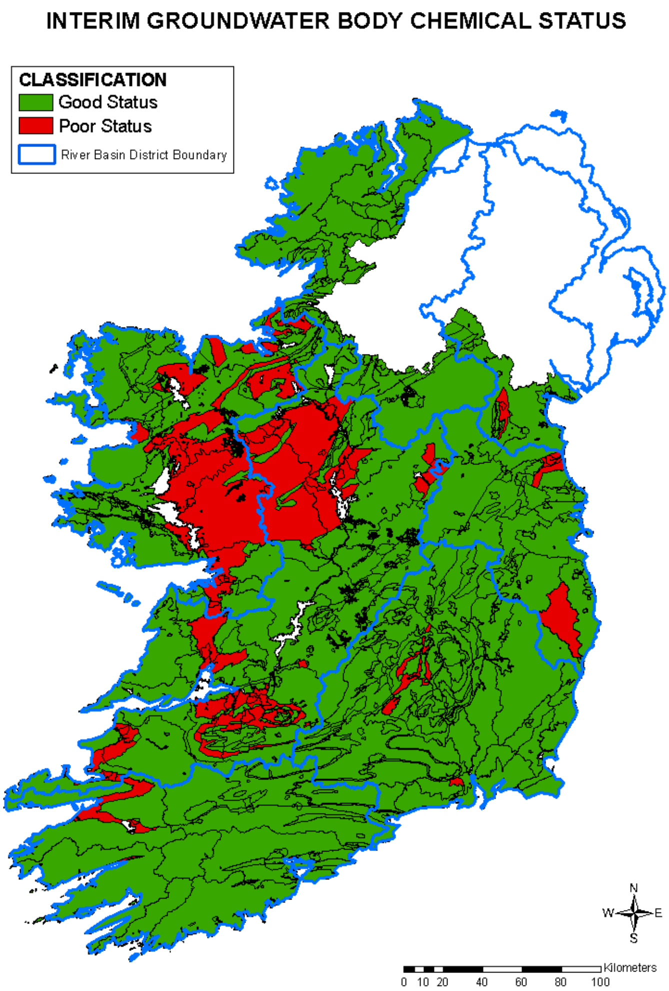
Figure 2.8. Overview of the status assessment (Classification) process (UKTAG, 2008a)

OVERALL GROUNDWATER STATUS RESULTS

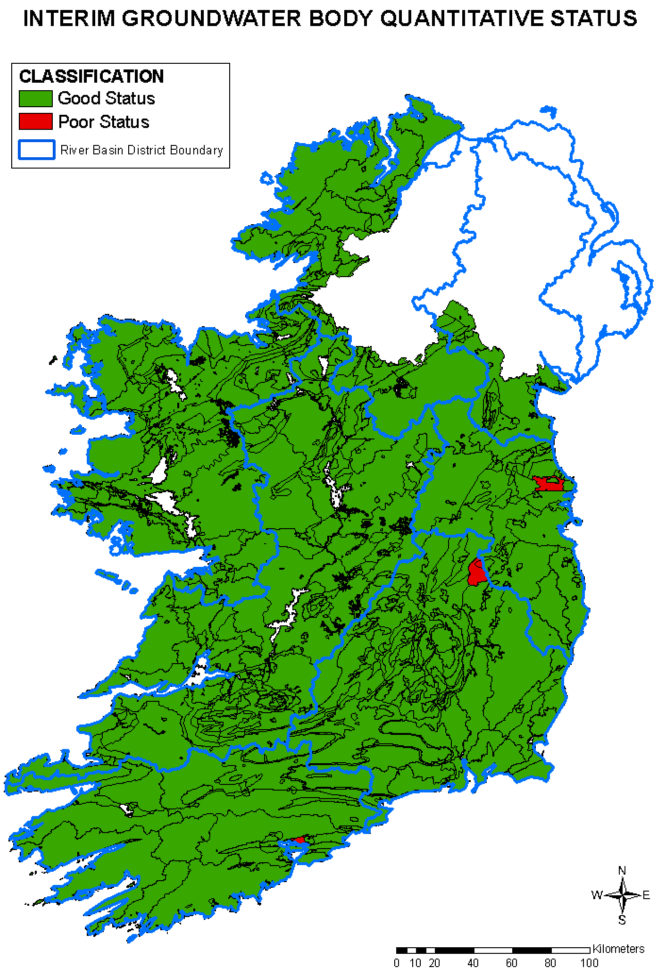
For each groundwater body, the lowest classification from the five chemical tests has been reported as the overall chemical status (Map 2.5), and the lowest classification from the four quantitative tests have been reported as the overall quantitative status (Map 2.6). If either the chemical or the quantitative assessment is poor, then a "one out all out" approach is used to determine the overall classification. The summary results are given in Table 2.1. The overall results depicted in Table 2.1 show that 84.7% of the groundwater bodies are at Good Status and 15.3% (which relates to 14.4% of the total land area) are at Poor Status.

Table 2.1. Summary of interim status classification results for groundwater bodies

Status		Chemical		Quantitative		Overall	
		Number (% of total)	% area	Number (% of total)	% area	Number (% of total)	% area
GOOD		645 (85.2)	85.9	753 (99.5)	99.7	641 (84.7)	85.6
POOR		112 (14.8)	14.1	4 (0.5)	0.3	116 (15.3)	14.4
Total		757 (100)	100	757 (100)	100	757 (100)	100



Map 2.5. Interim Chemical Status of Groundwater Bodies



Map 2.6. Interim Quantitative Status of Groundwater Bodies

Box 2.2 Groundwater Monitoring

Historically, the EPA has monitored groundwater quality at a number of public and private wells and springs across the country. To meet the requirements of the Water Framework Directive (WFD), the monitoring networks were reviewed in 2007, resulting in a number of the historical monitoring points being dropped, and a number of monitoring points being added to the EPA's Groundwater Monitoring Programme. The revised groundwater monitoring programme has been developed to improve knowledge of groundwater quality, and the links between groundwater and the ecological health of associated receptors. Monitoring data provide the basis for the assessment of groundwater status for the WFD.

The location of groundwater monitoring points has been determined by assessing the requirements for achieving a network that is representative of the variations in hydrogeology and anthropogenic pressures across a groundwater body, i.e. the 'average' concentrations of pollutants from a representative network of monitoring points should reflect the 'average' concentrations for those pollutants across the whole groundwater body.

The poorly productive aquifers are generally unable to yield significant quantities of groundwater for abstraction, although high yields can be obtained at some locations, such as along fault zones. As these aquifers are generally unable to support significant yields, the contributing area to the wells is often relatively small and only reflects a small proportion of the overall groundwater body. Monitoring networks in these aquifers have been developed to focus on the higher yielding abstractions from fault zones and 60 monitoring points that have been installed at different depths in different poorly productive bedrock aquifers (Plate 2.4).

Monitoring data from selected compliance monitoring sites at IPPC (Integrated Pollution Prevention and Control) licensed activities have been utilised for the assessment of point source pressures within groundwater bodies. The compliance monitoring data may be supplemented by additional monitoring in the future, e.g. where the monitoring is deemed to be inadequate for WFD purposes or for point source pressures that are not part of the compliance monitoring network, e.g. historical waste dumps.

Plate 2.4. Water level data loggers being downloaded in a poorly productive bedrock aquifer in Co. Donegal

ASSESSMENT OF GROUNDWATER POLLUTION AND WATER QUALITY TRENDS

Background

Part VI of the Groundwater Regulations indicate that the Agency should identify significant and sustained upward trends in the concentration of pollutants in groundwater bodies or groups of bodies identified as being at risk of failing to achieve the objectives of the WFD. In groundwater bodies or groups of bodies that are not at risk of failing to achieve the objectives of the WFD, it may also be necessary to undertake trend assessments, to determine changes in natural conditions or to identify future changes due to anthropogenic activity.

Where significant and sustained upward trends are identified, Member States are required to reverse these trends through the introduction of programmes of measures (PoMs). Generally, it will take a number of years before the impact of measures is seen in groundwater systems. Therefore, upward trends need to be identified in sufficient time, so PoMs can bring about a reduction in pollution and prevent deterioration in groundwater quality, thereby reducing the chance of failing the relevant WFD objectives. Article 55 of the Regulations indicates that the starting point for trend reversal must be expressed as a percentage of the relevant groundwater quality standard or Threshold Value (TV). The start date for trend reversal is based on the significance of the trend and the risk associated with it. By default, Schedule 8 (Part B) of the Regulations indicates that the starting point for trend reversal is the date when 75 per cent of the standard or TV is likely to be exceeded, but an earlier or later starting date can be chosen to meet the environmental objectives in a cost effective manner.

Trend Assessments

Trend assessments have been undertaken for parameters that are placing groundwater bodies at risk of failing a groundwater chemical status objective, i.e. those parameters that relate to drinking water, saline intrusion, surface water or groundwater dependent wetland assessments. In the context of the WFD, a significant and sustained upward trend is a trend that is both statistically and environmentally significant, causing an increase in concentration of a pollutant, group of pollutants, or indicator of pollution in groundwater for which trend reversal would be required. Trend assessments were undertaken at 119 monitoring points. The remaining monitoring points had insufficient data to undertake the trend assessment in the first River Basin Planning cycle. Assessments were undertaken using data from 1999-2008 for Electrical Conductivity, Chloride, Sulphate, Sodium, Ammonium, Nitrate, Molybdate Reactive Phosphorus (MRP), Iron and Manganese, as these are the only parameters that are placing a groundwater body at risk, and that have sufficient data records to undertake a robust trend assessment. The general pattern for trends is shown in Table 2.2.

A small number of environmentally significant upward trends were detected for Ammonium, Chloride, Electrical Conductivity, Molybdate Reactive Phosphorus (MRP), Iron and Manganese. Natural processes and local geological conditions are thought to be the cause of the elevated concentrations for Chloride, Electrical Conductivity, Iron and Manganese. The Ammonium and MRP trends are thought to partly be a function of data gaps and a significant proportion of samples being at or below the limit of quantification, which has distorted the trends to some degree, resulting in weakened confidence in the trend.

The overall picture for nitrate trends at the monitoring points indicates a relatively stable picture nationally. Environmentally and statistically significant upward trends in nitrate concentrations are evident at Durrow, Laois (Figure 2.9) and Ballyheigue, Kerry (Figure 2.10). Average nitrate concentrations are also above the threshold value of 37.5 mg/l NO_3 at these monitoring locations.

In relation to the nitrate trends, both Durrow and Ballyheigue are Drinking Water Supplies, and therefore the groundwater bodies in which they are located are classified as being at poor

status in relation to the drinking water objectives of the WFD. As such, there is a requirement to reverse trends in these groundwater bodies. The average concentration of Nitrate at both Durrow and Ballyheigue in 2008 was greater than 75 per cent of the Nitrate Threshold Value of 37.5 mg/l NO_3. Therefore the start date for trend reversal is 2009 and programmes of measures to reverse trends should be introduced immediately.

Table 2.2. Summary of monitoring point trends for assessed parameters

Parameter	Monitoring locations with No Significant Trend	Monitoring locations with Downward Trends	Monitoring locations with Downward Trends that are Statistically Significant	Monitoring locations with Upward Trends	Monitoring locations with Upward Trends that are Statistically Significant	Monitoring locations with Upward Trends that are Statistically & Environmentally Significant
Electrical Conductivity	17 locations	69 locations	15 locations	33 locations	4 locations	1 location
Chloride	3 locations	86 locations	30 locations	30 locations	7 locations	7 locations
Ammonium	3 locations	6 locations	0 locations	110 locations	42 locations	7 locations
Nitrate	7 locations	56 locations	11 locations	56 locations	14 locations	2 locations
Molybdate Reactive Phosphorus	9 locations	42 locations	1 location	68 locations	3 locations	3 locations
Sulphate	5 locations	50 locations	13 locations	64 locations	12 locations	0 locations
Sodium	12 locations	72 locations	9 locations	35 locations	2 locations	0 locations
Manganese	3 locations	90 locations	33 locations	26 locations	3 locations	2 locations
Iron	11 locations	63 locations	12 locations	45 locations	1 location	1 location

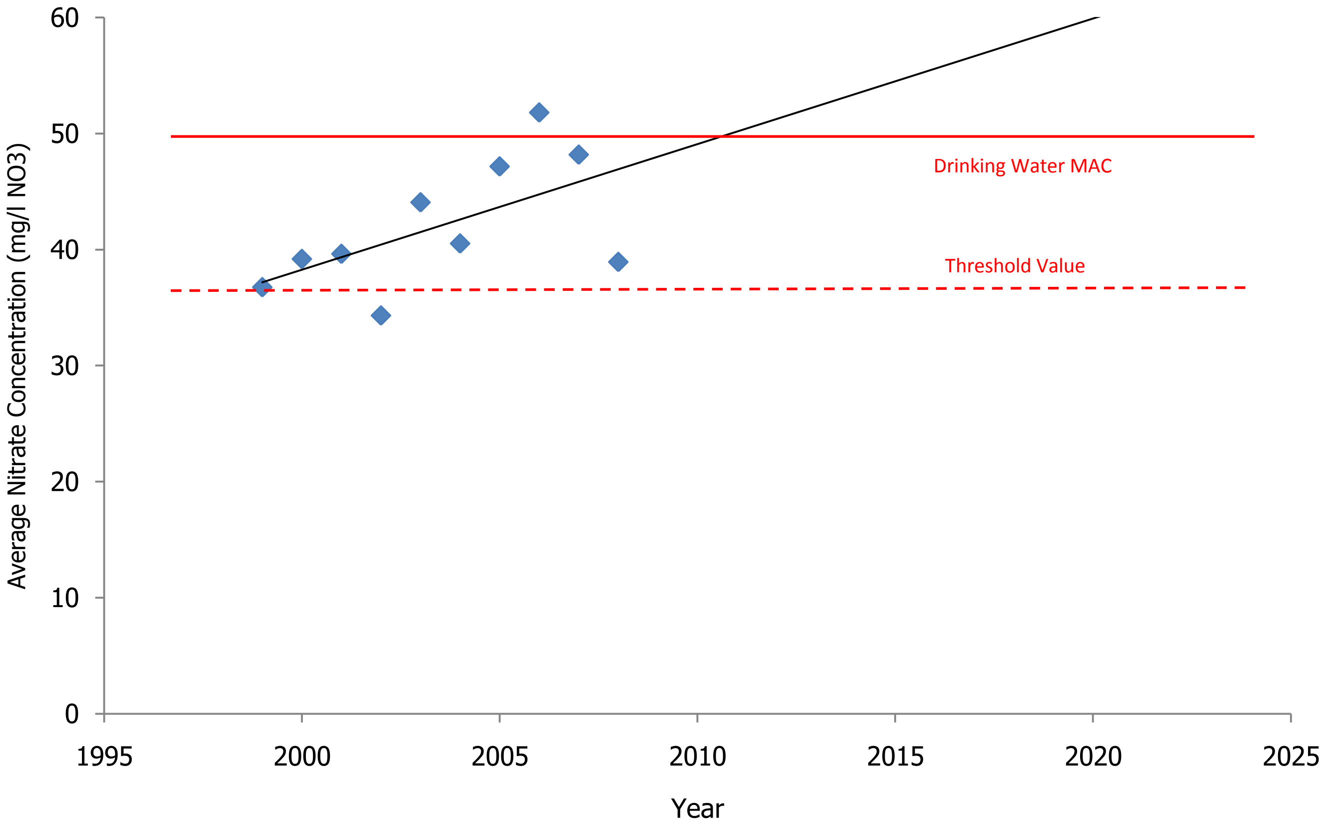


Figure 2.9. Environmentally and Statistically Significant Upward Trend for Nitrate at Durrow (Laois)

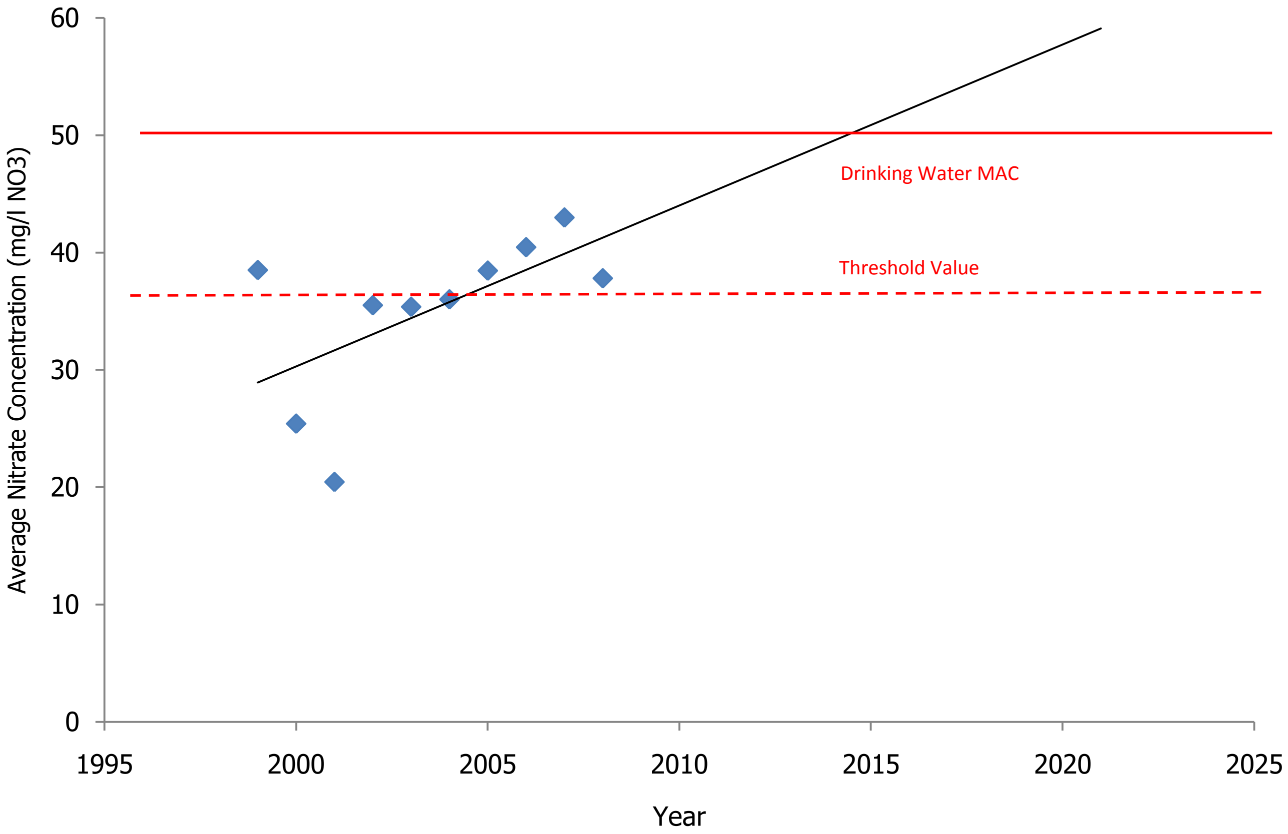


Figure 2.10. Environmentally and Statistically Significant Upward Trend for Nitrate at Ballyheigue (Kerry)

WATER FRAMEWORK DIRECTIVE SUMMARY

The interim classification of groundwater bodies has resulted in 14.per cent of the land area as being poor status which is likely to be relatively low in comparison to other EU countries. By far the greater proportion of this is caused by the input of pollutants, mainly phosphate, probably from agricultural activities, although on-site wastewater treatment systems may also be a minor source.

Environmentally and statistically significant trends were detected for nitrate at two monitoring locations, and the upward trends will require trend reversal. The average nitrate concentration already exceeds the nitrate Threshold Value, so the starting point for trend reversal is 2009, i.e. the beginning of the 2nd River Basin Planning cycle. Pesticides in groundwater have not resulted in any groundwater bodies being at poor status. Also abstraction of groundwater was not shown to be a significant issue. While the implementation of measures, which are required to return these groundwater bodies to good status, will have environmental benefits, they are also likely to have some social and economic costs.

Further characterisation, risk, status and trend assessments will be undertaken in the 2nd River Basin Planning cycle, and trend assessments will be undertaken for the first time at monitoring points where monitoring data were sufficient to undertake the assessments during the 1st River Basin Planning cycle.

The results of chemical status, quantitative status, overall status and trend assessments are reported in the River Basin Management Plans for each River Basin Management District*, and are available from the WFD Ireland "Water Matters" website (http://www.wfdireland.ie)

* See individual River Basin District websites for the reports, e.g. http://www.serbd.com for the South Eastern River Basin District.

In addition to providing the results of the status and trend assessments, the River Basin Management Plans also provide information on the role of the River Basin District in the implementation of the WFD and the key environmental issues that are pertinent to that River Basin District, e.g. water requirements and pressures. The Plans identify the key WFD objectives that are relevant to that River Basin District. These include:

- Preventing deterioration in the status of groundwater bodies;
- Restoring the status of groundwater bodies to at least Good Status;
- Reducing chemical pollution of groundwater;
- Meeting the protected area objectives in relation to groundwater.

Where they key objectives are unlikely to be fulfilled by 2015, the Plans identify alternative objectives, including extended deadlines to achieve the objective.

To achieve the key WFD objectives, a series of basic and supplementary measures are proposed in the Plans. The basic measures focus on compliance with existing legislation, e.g. the Groundwater Regulations and the *Good Agricultural Practice for Protection of Waters Regulations* (S.I. 101 of 2009). Supplemental measures will be required where environmental issues exist, but currently do not fall under the remit of existing key legislation, e.g. abstraction control regulations.

INTERPRETATION OF THE GROUNDWATER QUALITY DATA

Factors Influencing Changes in Groundwater Quality for the Period 2007-2009

A comprehensive assessment of groundwater quality data requires an understanding of the whole groundwater system, including knowledge of the pressures and the hydrogeology. Rainfall is the driving force behind the groundwater system through the recharge of water to the aquifers. Variations in rainfall patterns have the potential to impact on the dynamics of groundwater systems. This includes both the quantity of flow and the quality of the water in the aquifers.

The years 2008 and 2009 are considered to have been wet years, with the rainfall generally being higher than the 30 year average rainfall. An initial finding of an ongoing EPA funded STRIVE research project is that the rainfall during the period 2008 and 2009 has been at least 20 per cent above the 30 year average in the south-east of the country (Katie Tedd pers. comm.). Consequently, the relatively high rainfall experienced will have resulted in increased recharge to aquifers in many parts of the country.

In recent years there has been significant investment (over €2 billion) to upgrade facilities for the storage of livestock slurry and manures at a farm level. This investment is likely to have a significant beneficial impact for farm management, which in turn should be beneficial for the environment. There has also been a significant reduction in fertiliser sales over the last decade, particularly in the last five years, with nitrogen and phosphorus fertiliser sales falling by approximately 30 per cent during this time period (DAFF, 2009). In time, the improved storage and reduced application of inorganic fertiliser should bring about a reduction in nitrate and phosphate concentrations in groundwater.

At the majority of monitoring locations, the mean ammonium concentrations were below the Drinking Water MAC. Historically 85 to 90 per cent of monitoring locations had ammonium concentrations less than 0.04 mg/l N, which fell to approximately 60 per cent of locations during the 2007-2009 reporting period. There was a ten per cent increase in the number of monitoring locations with concentrations greater than 0.065 mg/l N during the 2007-2009 reporting period. Increased rainfall may have resulted in an increased impact of pollution on near surface/shallow water in groundwater systems, resulting in pollutants getting into groundwater relatively quickly, particularly in areas with extreme groundwater vulnerability. Although the nitrification of ammonium to nitrate will readily take place when favourable conditions exist, concentrations of ammonium in groundwater that are significantly above the

EQS may have an impact on the receiving surface waters. Over half of the monitoring locations with ammonium concentrations greater than 0.065 mg/l N also had positive detections of faecal coliforms, although the majority of these sites are springs or are located in areas of extreme groundwater vulnerability.

Compared with the 2004–2006 reporting period, there was an approximately 14 per cent increase in the number of monitoring locations with nitrate concentrations less than 10 mg/l NO3. There was also a six per cent reduction in the number of monitoring locations with nitrate concentrations greater than 37.5 mg/l NO3. The general reduction in nitrate concentrations appears to be the result of a number of factors. The recent reductions in inorganic fertiliser applications, improvements in storage for organic fertiliser and the implementation of landspreading restrictions, coupled with the above average rainfall, may have resulted in a reduction in pressures and increased the potential for dilution, thereby causing a reduction in nitrate concentrations. In particular, the dilution is likely to be more prominent in those aquifers readily capable of accepting the increased recharge, i.e. the more productive aquifers. This is verified by the monitoring data, which indicates the greatest reductions in nitrate concentrations have occurred in the karst limestones aquifers in the south-east. However, nationally, the nitrate concentrations remain highest in the south-east and south of the country.

The general reduction in phosphate concentrations evident in the 2007-2009 monitoring data is again likely to be a result of reduced inorganic fertiliser applications, improvements in storage for organic fertiliser and the implementation of landspreading restrictions, although dilution may be the most significant factor. The aquifers that are readily capable of accepting increased recharge, e.g. the karst aquifers in the west, are more likely to show the effects of dilution and it is those aquifers which have historically had relatively high concentrations of phosphate. There was an increased percentage of samples with positive detections of faecal coliforms during the reporting period. While improved storage facilities and the implementation of landspreading restrictions should result in a reduction of faecal coliform counts, the above average rainfall may have resulted in faecal coliforms by-passing the soils and subsoil and getting into groundwater before attenuation can occur. This is reflected by a large number of spring monitoring locations, e.g. in the karst limestone, that have greater than 100 cfu/100ml.

Groundwater Classification

Table 2.3 shows the status classification breakdown for each River Basin District. The status results indicate that only 0.3 per cent of the country is at poor status due to the presence of high nitrate concentrations in the vicinity of groundwater supply abstraction points (one groundwater body in each of the South Eastern and Shannon River Basin Districts). Pesticides in groundwater have not resulted in any groundwater bodies being at poor status.

In contrast, 13.3 per cent of the country is at poor status due to the presence of phosphate in groundwater. The majority of the poor status groundwater bodies in the Shannon and Western River Basin Districts are driven by the surface water classification test and the contribution of phosphate in groundwater to surface water bodies being at less than good status.

This outcome is due to two factors: firstly, to the sensitivity of surface water ecosystems to phosphate; and secondly, to the impact of groundwater input and quality on surface water ecosystems, particularly in the karstified limestone aquifers, where the groundwater flow contribution to surface water is usually more than 60 per cent of the average surface water flow and the vulnerability of the groundwater (with shallow soils and subsoils, and sinking streams) results in high average phosphate concentrations in the groundwater (typically mean phosphate concentrations in these aquifers are > 0.025 mg/l P). Ammonium concentrations in groundwater were low with regard to Drinking Water Standards and typically they are also lower

than the surface water Environmental Quality Standard. No groundwater bodies were at poor status due to faecal coliforms because they are not included as a parameter for WFD classification. Pressures from unregulated point source activities, such as historic mines, contaminated land and old dumps may have adverse impacts on groundwater in the immediate area downgradient of the pollution source, but generally this pollution does not have a significant impact at a groundwater body scale. A small number of groundwater bodies have been placed at poor status, where the pollution extent is having a significant impact at a groundwater body scale. Three groundwater bodies are at poor status due to historic pollution from contaminated land sites and four groundwater bodies are at poor status due to historic mining activities. Adherence to, and enforcement of the regulations relating to point discharges to groundwater should minimise the impacts from these sources in the future.

Table 2.3. River Basin District Summary of Status Classification results in groundwater bodies

RBD	Good Status (no. of bodies)	Good Status (% RBD Area)	Poor Status (no. of bodies)	Poor Status (% RBD Area)
Eastern	67	89.7	8	10.3
Neagh Bann	26	95.3	2	4.7
North West	72	100.0	0	0.0
South East	146	97.8	5	2.2
Shannon	182	74.5	60	25.5
South West	77	96.8	7	3.2
Western	71	65.2	34	34.8
National	641	85.6	116	14.4

Future Developments and Measures

The WFD has provided a time scale of 2015 for each Member State to reduce the anthropogenic impacts on its water bodies and restore them to good status. Each Member State must develop an approach to restore groundwater bodies to good status and protect groundwater bodies currently at good status. This approach is largely two fold, with classification providing the basis to drive measures in areas that are currently failing to achieve good status and 'prevent or limit' regulations, e.g. licensing activities, employed to prevent further deterioration. The approach will be iterative, with ongoing risk assessment helping to determine the exact nature of the problem and to examine the impacts of measures.

The delineation of areas contributing to a groundwater abstraction, in particular Source Protection Zones for water supply abstractions is critical to the success of any measures taken to reduce the anthropogenic impacts on the water supply. Once a Source Protection Zone has been delineated, it helps improve conceptual understanding of where the water that is being sampled comes from in a catchment and it provides an area in which measures can be applied. These measures will largely focus on areas that are more vulnerable to anthropogenic contaminants entering groundwater, e.g. in areas where there are shallow soils and subsoils.

The delineation of Source Protection Zones has historically been undertaken at a number of water supplies by the Geological Survey of Ireland (GSI) and to a lesser degree by academic institutions and consultants. The EPA has recently begun work delineating the zones (areas) that are contributing water to the monitoring points in the National Monitoring Programme that currently do not have Source Protection Zones delineated. It is hoped that in time, these zones of contribution will be upgraded to full Source Protection Zones for many of the monitoring points.

Due to the lack of information on trigger action values for groundwater dependent wetlands (GWDTEs), the GWDTE ecological/chemical status assessment could not be undertaken

during the 1st River Basin Planning cycle. Ongoing research in Ireland and elsewhere in Europe should yield trigger action values for a number of wetland types and the GWDTE ecological/chemical status assessment will be undertaken in the 2nd River Basin Planning cycle for these wetlands.

CONCLUSIONS

Groundwater is an important natural resource; both in terms of water supply and as a contributor to surface water receptors. Therefore, to ensure that long-term sustainable groundwater resources are achieved, groundwater resource management is required, through an assessment of anthropogenic pressures and the physical characteristics of the subsurface deposits, i.e. soil, subsoil and aquifer type.

Microbiological problems are also observed in the areas where groundwater is more vulnerable to pollution (particularly at spring monitoring locations) because they have little natural protection from organic inputs. Increased concentrations in ammonium were probably as a result of above average rainfall during the most recent reporting period and pollutants not being attenuated by the soils and subsoils. If abstraction wells are properly designed and installed, and are located in areas where the groundwater vulnerability is lower, the impacts of organic inputs should be minimal.

Although natural variations in nitrate and phosphate concentrations may influence water quality assessments, the elevated concentrations of nitrate and phosphate measured in Irish groundwater are largely anthropogenic. The intensive agricultural practices in the south-east suggest that diffuse, agricultural sources are the cause of the elevated nitrate concentrations and the vulnerable nature of the Karst Limestone aquifers in the west may explain the elevated phosphate concentrations in groundwater, and groundwater may be contributing to eutrophication in rivers and lakes in these areas.

There have been decreases in nitrate and phosphate concentrations in the period 2007-2009. The above average rainfall is likely to have been a significant contributory factor in this reduction, particularly as the concentrations have decreased most in the productive karst limestone aquifers that can readily accept the additional rainfall. However, improvement in farm storage for organic fertiliser, a reduction in inorganic fertiliser applications and the implementation of the Good Agricultural Practice Regulations are all likely to have contributed to a reduction in nitrate and phosphate concentrations in groundwater.

The presence of phosphate in groundwater is the main reason why the majority of groundwater bodies were classified as being at poor WFD status. This is largely due to the sensitivity of surface water ecosystems to phosphate and high contribution of average surface water flow coming from groundwater in certain areas, particularly the karstified limestone aquifers. Therefore, in areas where the groundwater is vulnerable to pollution, if small concentrations of phosphorus get into the groundwater, they may have an impact on surface water receptors. For the groundwater body to be at poor status, the surface water bodies must initially be at less than good status and the pressure must be diffuse, i.e. not a sewage treatment works or industrial discharge. Therefore when measures are introduced to bring the surface water body back to good status, the groundwater pathway to surface water must be considered.

Overall, there is a continued need for improved protection of groundwater, especially in the context of achieving the WFD objective of good status for all waters by 2015. In some instances it will not be feasible to meet this objective by 2015, e.g. where the concentrations of nitrate or phosphate in groundwater already exceed the Threshold Value and there is an upward trend in concentration. In these instances it may take a number of years for the measures to bring about a reduction in concentrations because the nitrate and phosphate will require time to flush through the groundwater system. If all the basic and supplemental measures are implemented, the objectives should be reached within the 2021 or 2027 extended deadlines. However, it is

likely that it will not be technically or economically feasible to achieve the objective by 2027 for a small number of water bodies, such as groundwater pollution from historic mining activities. These bodies will be candidates for less stringent objectives. In all cases, but particularly for the less stringent objective bodies, the objective of no further deterioration applies and, as a minimum, measures are required to ensure that this happens.

To meet the objectives of the WFD, an improved understanding of the interactions between groundwater and surface water receptors is required because this understanding is fundamental if further deterioration in water quality is to be prevented and sustainable water resources are going to be achieved. This understanding may help improve management of groundwater resources, and ultimately maintain the quality and yield of drinking water sources, and ensure that groundwater is not having a detrimental impact on surface water and ecological receptors in the future.

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A swallow hole at Kiltullagh Turlough, County Galway, where a stream is sinking underground into a karstified limestone aquifer