Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (91/676/EEC)

Article 10 Report for Ireland for the Period 2008-2011

Prepared by the
Environmental Protection Agency

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Executive Summary

Purpose

This report provides the information from Ireland to the European Commission, as required under Article 10 of the Nitrates Directive (91/676/EEC), with respect to the fifth reporting period (2008-2011). The report is submitted by the Environmental Protection Agency and has been produced with assistance from the Department of Agriculture, Food and the Marine.

The information is presented according to the four sections in Annex V of the Nitrates Directive and comprises:

- A description, with maps, of the evolution of water quality in groundwater and surface waters;
- A statement on the adoption of a Whole Territory Approach with respect to the designation of nitrate vulnerable zones;
- A summary of agricultural activities and an account of the implementation of the agricultural Code of Good Practice;
- A summary of the principal measures and an evaluation of the National Action Programme for limiting nitrate inputs from agricultural sources.

Water Quality Monitoring in Ireland

During the previous (2004-2007) reporting period, Ireland implemented a revised monitoring programme to satisfy the requirements of the Water Framework Directive (WFD). This programme was established in 2006 and has been operational for the current 2008-2011 reporting period. A reinforced monitoring network has also been established to monitor water quality in light of the European Commissions (Commission Decision 697 of 2007) approval for Ireland to operate a derogation from the limits of the Nitrates Directive.

Nitrate Concentrations in Groundwater and Surface Water

There has been an overall improvement in nitrate concentrations across all water categories for the stations assessed. In particular the average nitrate concentrations have decreased, although peaks in nitrate concentration have increased at certain stations in some of the water categories.

The reduction in average nitrate concentrations are likely to be due to significantly above average rainfall in 2008-2009 (in particular in 2009), reductions in inorganic fertiliser applications in the period 2004-2009, improvements in storage for organic fertiliser and the implementation of landspreading restrictions as part of the Good Agricultural Practice Regulations.

The increase in maximum nitrate concentrations can largely be attributed to the increased sampling frequency undertaken for the WFD monitoring programme, as this offers greater opportunity to detect one off elevated concentrations.

- The majority (87%) of groundwater monitoring stations had average nitrate concentrations less than 25 mg NO_3/L, with a further 11% less than 40 mg NO_3/L. This represents an improvement in water quality since 2007. However, approximately 40% of sites have shown an increased trend in maximum nitrate concentrations over the reporting periods.
- For surface water, the WFD surveillance monitoring stations are included in the assessment. The average nitrate concentrations were below 40 mg NO_3/L in all lake and river monitoring stations for the period 2008-2011, with only two river stations recording maximum nitrate concentrations above 40 mg NO_3/L. All the coastal monitoring stations and the majority of transitional stations recorded average nitrate concentrations less that 10 mg NO_3/L. A single transitional station had a maximum concentration that was higher than 50 mg NO_3/L.

  Of the assessed lake and river stations, 98% showed a stable trend or a decrease in average nitrate concentrations. All of the assessed coastal stations and 91% of transitional stations show stable or downward trends in average nitrate concentrations. However 27% and 18% of the respective river and lake stations and 28% and 25% of the respective transitional and coastal stations are showing upward trends in maximum nitrate concentrations.

  The assessment of trophic status in the assessed lakes and rivers revealed signs of eutrophication in less than 6% of rivers and 12% of lakes. None of the transitional and coastal waters are described as being eutrophic, although one transitional water body is showing signs of declining in trophic class.

Agricultural Action Programme and Code of Practice

In 2010, following a public consultation phase, Ireland's first National Nitrates Action Programme was reviewed by an Expert Review Group. Following this review a second National Nitrates Action Programme was drafted and subsequently approved by the European Commission in tandem with a renewal of the approval for Ireland's nitrates derogation. Strengthened Regulations were introduced in December 2010 giving legal effect to the operation of the second Nitrates Action Programme.

Measures under the National Action Programme have been in operation for six years since the introduction of the Good Agricultural Practice Regulations in 2006. An evaluation of these measures is one of the objectives of the Agricultural Catchments Programme which was established in 2007-2008 and completed its first four-year phase in 2011. Results from Phase 1 indicate that lag times of approximately 5-20 years can be expected between changing nutrient management and achieving water quality targets. Manure management has changed as a result of the Action Programme with more early-season application of manure on silage and hay ground. A significant proportion of farmers are willing to use pig or poultry manures. However, the average dairy and tillage farmer over applied N and P fertilisers compared to the most efficient farmers. At field-level soil P and nutrient application rates varied widely and soil P status alone was not as important as hydrological pathways in determining the risk of P loss to water. Discharge and nutrient load exported during the closed period indicates that the implementation of the current closed period is having a positive effect on reducing nutrient loss. Stream Total Oxidised Nitrogen concentrations were below the maximum acceptable drinking water concentration of 50 mg NO_3/L. Attitudinal surveys suggest many farmers are sceptical about the validity of some measures however some accept that they deliver environmental benefits. Attitudes, peer group influences and farm structural variables affect the level of nutrient management best practice adoption across livestock farms. A second phase of the Agricultural Catchments Programme will run to 2015.

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ABBREVIATIONS

ACP	Agricultural Catchments Programme
AEOS	Agri-Environment Options Scheme
AIM	Animal Identification System
CSO	Central Statistics Office
DAFM	Department of Agriculture, Food and the Marine
DECLG	Department of Environment, Community and Local Government
EPA	Environmental Protection Agency
GAEC	Good Agricultural and Environmental Conditions
GAP	Good Agricultural Practice
GIS	Geographical Information System
NAP	National Action Programme
OECD	Organisation for Economic Co-operation and Development
OFS	Organic Farming Scheme
PRTR	Pollutant Release and Transfer Register
RBD	River Basin District
REPS	Rural Environment Protection Scheme
S.I.	Statutory Instrument
SMR	Statutory Management Requirements
WISE	Water Information System for Europe
WFD	Water Framework Directive

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1 INTRODUCTION

1.1 Purpose

This Report provides the information from Ireland to the European Commission, as required under Article 10 of the Nitrates Directive (91/676/EEC), with respect to the fifth reporting period (2008-2011). The Report contains information, as outlined in Annex V of the Directive, regarding the monitoring of waters against pollution from agricultural sources and the details of, and results from, action programmes drawn up by the State to combat pollution in vulnerable areas.

1.2 Background to the Report

1.2.1 The Nitrates Directive

The objective of the Nitrates Directive, which was adopted in 1991, is the reduction of water pollution caused or induced by nitrates from agricultural sources and the prevention of further such pollution, with the primary emphasis being on the management of livestock manures and other fertilisers.

The Nitrates Directive requires Member States to:

- Monitor waters and identify those that are polluted or are liable to pollution by nitrates from agriculture;
- Establish a code of good agricultural practice to protect waters from such pollution;
- Promote the application by farmers of the code of good agricultural practice;
- Identify the area or areas to which an action programme should be applied to protect waters from pollution by nitrates from agricultural sources;
- Develop and implement action programmes to reduce and prevent such pollution in the identified area: action programmes are to be implemented and updated on a four-year cycle;
- Monitor the effectiveness of the action programmes; and
- Report to the EU Commission on progress.

The Nitrates Directive defines those waters ‘polluted or liable to pollution’ as:

- Surface freshwaters, in particular those used for the abstraction of drinking water, which contain, or could contain, if preventative action is not taken, nitrate concentrations greater than 50 mg NO_3/L.
- Groundwaters which contain, or could contain, if preventative action is not taken, nitrate concentrations greater than 50 mg NO_3/L, and
- Natural freshwater lakes, or other freshwater bodies, estuaries, coastal waters and marine waters which are found to be eutrophic or in the near future may become eutrophic if preventative action is not taken.

The Directive lays down that, at the end of each four-year programme (1995-99, 2000-03, 2004-07 etc.) and for each water monitoring report / evaluation of measures associated with this programme, a report describing the situation and its development shall be submitted to the Commission by each Member State.

1.2.2 Reporting Period 2004-2007

Since 2005 the responsibility for reporting under the Nitrates Directive has been assigned to the Environmental Protection Agency (EPA), under the National Regulations Implementing the Nitrates Directive (S.I. No. 788 of 2005).

The Article 10 Report for Ireland at the end of the fourth reporting period (2004-2007) was submitted in October 2008 by the Environmental Protection Agency (EPA, 2008) and comprised information on the proposed Action Programme in addition to information compiled by the Environmental Protection Agency on the evaluation of water quality.

1.3 Water Monitoring in Ireland

Although the EPA and other public authorities have monitored water quality at a number of stations nationwide for several decades; since 2003 attention has focussed on establishing a new monitoring programme and network under the Water Framework Directive (WFD). Under Article 10 of Ireland's National Regulations implementing the Water Framework Directive - European Communities (Water Policy) Regulations 2003 (S.I. No. 722 of 2003) – the EPA was given authority for preparing the monitoring programme and for specifying the public authorities responsible for carrying out the monitoring.

Following an extensive research and development process in consultation with principal stakeholders and under the auspices of the National Technical Co-ordination Group for the WFD, an Irish Monitoring Network Programme has been established (EPA, 2006). The programme encompasses the three categories of Surveillance, Operational and Investigative Monitoring specified in the WFD. Data from the Surveillance Monitoring Programme for surface water and the Surveillance and Operational Monitoring Programme for groundwater, which are representative of water quality in Irish waters generally, are used for Article 10 Nitrates Directive and European State of the Environment reporting via the European Environment Agency (EEA) Waterbase system.

In light of the European Commissions (Commission Decision 697 of 2007) approval for Ireland to operate a derogation from the limits of the Nitrates Directive, to a maximum of 250 kg N_{org} ha^{-1} $year^{1}$, a reinforced monitoring network, including monitoring from the Operational Monitoring Network Programme for surface water and Agricultural Catchment Programme, was established in 2008 to evaluate water quality.

Although many historically monitored stations were included in the WFD National Monitoring Network Programme, the revisions to this Programme have resulted in a number of stations that are not common to both the current reporting period and previous periods. For these stations it has not been possible to undertake trend analysis in this report.

1.4 Report Structure and Content

1.4.1 Report Structure

This Report has been produced in accordance with the Development Guide for Member States' Reports, published in 2011. The Report is split into sections as specified in the guidelines, which contain the following information:

- A description, with associated maps, of evolution of quality of freshwaters (surface and groundwater), transitional and marine waters since previous monitoring with respect to nitrates – Chapter 2.
- Description and justification of the designated vulnerable zones (including map), and of the extensions or additions carried out or envisaged – Chapter 3.
- An account of the development, promotion and implementation of the Good Agricultural Practice Regulations, including a summary of national agricultural statistics for the national territory – Chapter 4.
- An account of the principal measures contained in the Action Programme, and a description of the precise manner in which limits are being applied for the annual land application of organic nitrogen compounds – Chapter 5.
- The results of the evaluation of the action programmes – Chapter 6.
- A forecast of the future evolution of water body quality – Chapter 7.

The maps and summary tables included with this report were derived from data contained in a geo-database developed using ESRI® ArcMap GIS. On the maps in this report, only stations that are mentioned in the text are individually labelled. All stations are individually identified in the GIS layers and database tables with unique station codes. All maps are included in a separate Annex document.

The structure and formats of the spatial and non-spatial data tables comply with the specification provided in the EU Reportnet Data Dictionary.

1.4.2 Note on Reporting Period Trend Analysis

The reporting guidelines require an analysis comparing water quality results from the current period with those reported under the previous period. Data for the previous reporting period (2004-2007) have been included in this report to enable the trend analysis to be undertaken. In addition, where possible, a comparison is also given for corresponding locations that were reported previously for the period 2000-2003, so that the trend against what was previously reported is also shown.

1.5 General Context

The general physical features of Ireland are shown on Map 1-1 to 1-4. The management units for reporting under the Water Framework Directive are River Basin Districts (RBDs), largely based on an amalgamation of Hydrometric Areas that were previously reported on. Ireland is divided into eight RBDs, which are shown on Map 1-4 with the Hydrometric Areas that they contain. RBD boundaries are shown on the maps referred to in the main body of the report.

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2 EVALUATION OF WATER QUALITY

2.1 Groundwater

2.1.1 Groundwater Monitoring Network

The Hydrometric and Groundwater section of the EPA provided information on groundwater quality from groundwater monitoring stations. A total of 211 groundwater stations are included in this Report, which are a subset of the WFD Groundwater Monitoring stations. Of these stations, 204 were included in the 2004-2007 reporting period; the remaining seven have been added to the monitoring network during the current reporting period. Ten sites that were included during the 2004-2007 reporting period were not included in the monitoring network for the current reporting period.

Table 2-1 indicates the number of groundwater monitoring stations, and the type of groundwater sampled, during each reporting period.

Table 2-1: Number of Groundwater Monitoring Stations with Samples in each Reporting Period

	Previous Reporting Period (2004-2007)	Current Reporting Period (2008-2011)	Common Points (2008-2011 with 2004-2007)
Phreatic groundwater (0-5m)	21*	26	25*
Phreatic groundwater (5-15m)	103	90	87
Phreatic groundwater deep (15-30m)			
Phreatic groundwater (>30m)			
Captive groundwater	-	-	-
Karstic groundwater	90*	95	92*
Total	**214**	**211**	**204**

Notes:
*Revision of some station types from shallow non-karstic in 2004-2007 to karstic in 2008-2011. Section 2.1.2 provides an explanation of sampling depth.

2.1.2 Note on Sampling Depth

The following two paragraphs are quoted from the WFD Programme Report (EPA, 2006) to explain why sampling depth reported is an estimate:

“Generally, sampling depth is not considered to be a critical factor when monitoring groundwater in the Republic of Ireland because most of the bedrock aquifers are unconfined and have fissure permeability only. The only aquifers in the Republic of Ireland with an intergranular permeability are the sand and gravels. Consequently, groundwater velocities in most Irish bedrock aquifers are relatively fast (a few metres/day) and mixing of groundwater in the top ~60m readily occurs. The proposed monitoring network uses points with relatively large groundwater abstractions and these are considered to give representative samples because they are not usually affected by local point source pollution.

In the case of springs, the sampling depth is at the ground surface. In boreholes, pumps are usually located towards the bottom of the boreholes; therefore the sampling depths are determined by borehole depth. In some instances, screens are installed at the main water entry zones. In the remaining monitoring points, the boreholes are ‘open hole’, i.e. a liner or screen is not needed. Water can usually be drawn from all bedrock fractures in the borehole, i.e. from the total bedrock length. Therefore, the water sample is generally a composite of water from all fractures and/or conduits throughout the total length of bedrock in the borehole” (EPA, 2006).

2.1.3 Nitrate Concentrations in Groundwater

Average Nitrate Concentrations

The distribution of average nitrate concentrations for the period 2008-2011 are shown on Map 2-1 and the results are summarised in Table 2-2 and Table 2-3 below.

Table 2-2: Quality Classes for Average Nitrate Concentrations (mg NO_3/L) in Groundwater (Number of sampling points)

	Number of points mg NO_3/L			
	<25	25-39.99	40-50	>50
Phreatic groundwater (0-5m)	22	3	1	0
Phreatic groundwater (5-15 m)	80	8	2	0
Phreatic groundwater deep (15-30m)				
Phreatic groundwater (>30m)				
Captive groundwater	-	-	-	-
Karstic groundwater	81	12	2	0
Total	**183**	**23**	**5**	**0**
2004-2007 period	*158*	*41*	*10*	*5*
2000-2003 period	*96*	*19*	*6*	*2*

Table 2-3: Quality Classes for Average Nitrate Concentrations (mg NO_3/L) in Groundwater (Percentage of sampling points)

	Percentage of points mg NO_3/L			
	<25	25-39.99	40-50	>50
Phreatic groundwater (0-5m)	10.4%	1.4%	0.5%	0%
Phreatic groundwater (5-15 m)	37.9%	3.8%	0.9%	0%
Phreatic groundwater deep (15-30m)				
Phreatic groundwater (>30m)				
Captive groundwater	-	-	-	-
Karstic groundwater	38.4%	5.7%	0.9%	0%
Total	**87%**	**11%**	**2%**	**0%**
2004-2007 period	*74%*	*19%*	*5%*	*2%*
2000-2003 period	*78%*	*15%*	*5%*	*2%*

The results for 2008-2011 show that all 211 stations had average nitrate concentrations less than 50 mg NO_3/L and that 87% were less than 25 mg NO_3/L. The trend since the last reporting period (2004-2007) is a 13% increase in the proportion of stations with concentrations less than 25 mg NO_3/L.

Maximum Nitrate Concentrations

The distribution of maximum nitrate concentrations for the period 2008-2011 are shown in Map 2-2 and the results summarised in Table 2-4 and Table 2-5 below.

Table 2-4: Quality Classes for Maximum Nitrate Concentrations (mg NO_3/L) in Groundwater (Number of sampling points)

	Number of points mg NO_3/L			
	<25	**25-39.99**	**40-50**	**>50**
Phreatic groundwater (0-5m)	15	5	4	2[1]
Phreatic groundwater (5-15 m) Phreatic groundwater deep (15-30m) Phreatic groundwater (>30m)	60	16	8	6[2]
Captive groundwater	-	-	-	-
Karstic groundwater	59	25	3	8[3]
Total	**134**	**46**	**15**	**16**
2004-2007 period	*143*	*47*	*13*	*11*
2000-2003 period	*83*	*28*	*7*	*5*

Notes:
1. Site codes: 11_004, 19_005
2. Site codes: 15_008, 19_013, 24_006, 26_005, 27_001, 27_011
3. Site codes: 01_001, 04_013, 04_017, 11_005, 11_006, 23_001, 23_004, 24_002

Table 2-5: Quality Classes for Maximum Nitrate Concentrations (mg NO_3/L) in Groundwater (Percentage of sampling points)

	Percentage of points mg NO_3/L			
	<25	**25-39.99**	**40-50**	**>50**
Phreatic groundwater (0-5m)	7.1%	2.4%	1.9%	0.9%
Phreatic groundwater (5-15 m) Phreatic groundwater deep (15-30m) Phreatic groundwater (>30m)	28.4%	7.6%	3.8%	2.8%
Captive groundwater	-	-	-	-
Karstic groundwater	28%	11.8%	1.4%	3.8%
Total	**63.5%**	**22%**	**7%**	**7.5%**
2004-2007 period	*67%*	*21%*	*7%*	*5%*
2000-2003 period	*67%*	*23%*	*6%*	*5%*

The maximum nitrate values show that the majority (63.5%) of sites had maximum concentrations lower than 25 mg NO_3/L and a further 22% had maximum concentrations lower than 40 mg NO_3/L, with 16 sites having maximum concentrations greater than 50 mg NO_3/L. Eight of these 16 sites had only one sample exceeding 50 mg NO_3/L during the reporting period.

The trend since the last reporting period (2004-2007) is a reduction in the proportion of sites with maximum concentrations less than 25 mg NO_3/L (from 67% to 63.5%) and an increase in the proportion of sites with maximum concentrations greater than 50 mg NO_3/L class (from 5% to 7.5%). Further analysis of the trend in concentration values is given in Section 2.1.4.

2.1.4 Trend Analysis in Groundwater

The trend analysis compares average and maximum nitrate concentrations for the current reporting period (2008-2011) against values at corresponding stations from the previous reporting period (2004-2007). Maps 2-3 and 2-4 show the respective average and maximum nitrate concentrations in 2004-2007 at the 204 monitoring sites that are common to both reporting periods.

The water quality evolution trend for average nitrate concentrations at the 204 stations between the reporting periods are shown on Map 2-5 and summarised in Table 2-6 and Table 2-7.

Table 2-6: Trends in Groundwater for Nitrate Concentrations based on Average Values (Number of sampling points)

Water bodies	Number of points mg NO_3/L				
	< -5	-5 to -1	-1 to +1	+1 to +5	> +5
Phreatic groundwater (0-5m)	6	10	8	1	0
Phreatic groundwater (5-15 m)	22	39	18	6	2
Phreatic groundwater deep (15-30m)					
Phreatic groundwater (>30m)					
Captive groundwater	-	-	-	-	-
Karstic groundwater	29	45	16	1	1
Total (n=204)	**57**	**94**	**42**	**8**	**3**

Notes:
Trend classes between current and previous reporting periods:
Strong increase: > +5 mg/l
Weak increase: +1 to +5 mg/l
Stable: -1 to +1 mg/l
Weak decrease: -1 to -5 mg/l
Strong decrease: < -5 mg/l

Table 2-7: Trends in Groundwater for Nitrate Concentrations based on Average Values (Percentage of sampling points)

Water bodies	Percentage of points mg NO_3/L				
	< -5	-5 to -1	-1 to +1	+1 to +5	> +5
Phreatic groundwater (0-5m)	2.9%	4.9%	3.9%	0.5%	0.0%
Phreatic groundwater (5-15 m)	10.8%	19.1%	8.8%	2.9%	1.0%
Phreatic groundwater deep (15-30m)					
Phreatic groundwater (>30m)					
Captive groundwater	-	-	-	-	-
Karstic groundwater	14.2%	22.1%	7.8%	0.5%	0.5%
Total	**27.9%**	**46.1%**	**20.6%**	**3.9%**	**1.5%**

These results show that there has been a decrease in average nitrate concentration at 74% of sites, with 20.6% of sites showing a stable trend. Approximately 1.5% of sites (three stations) showed a strong increase in average nitrate concentration with a further 3.9% of sites (eight stations) showing a weak increase in average nitrate concentration. The three stations showing a strong increase in average nitrate concentration are listed in Table 2-8. The average nitrate concentration at two of these three sites is strongly influenced by a single sample having a high value in the current reporting period.

Table 2-8: Summary Results for Sites Showing a Strong Increase in Trend of Average Nitrate Concentrations in Groundwater

National Station Code	National Station Name	Average Nitrate 2004 - 2007 (mg NO_3/L)	Average Nitrate 2008 - 2011 (mg NO_3/L)	Max Nitrate 2004 - 2007 (mg NO_3/L)	Max Nitrate 2008 - 2011 (mg NO_3/L)	Trend Annual Value (> +5 mg NO_3/L)
23_004	**Fethard RWS (Laffansbridge)**	24.0	38.7	31.4	191	14.7
26_007	**Kilmuckridge WS (Ballygarran BH2)**	0.4	8.4	1.8	47.1	7.9
27_010	**Redcross**	29.8	35.1	36.4	43.6	5.4

The water quality evolution trend for maximum nitrate concentrations at the 204 stations that are common between the reporting periods are shown on Map 2-6 and the results are summarised in Table 2-9 and Table 2-10 below.

Table 2-9: Trends in Groundwater for Nitrate Concentrations based on Maximum Values (Number of sampling points)

Water bodies	Number of points mg NO_3/L				
	< -5	-5 to -1	-1 to +1	+1 to +5	> +5
Phreatic groundwater (0-5m)	1	5	5	7	7
Phreatic groundwater (5-15 m) Phreatic groundwater deep (15-30m) Phreatic groundwater (>30m)	12	12	29	15	19
Captive groundwater	-	-	-	-	-
Karstic groundwater	12	20	27	20	13
Total (n=204)	**25**	**37**	**61**	**42**	**39**

Table 2-10: Trends in Groundwater for Nitrate Concentrations based on Maximum Values (Percentage of sampling points)

Water bodies	Percentage of points mg NO_3/L				
	< -5	-5 to -1	-1 to +1	+1 to +5	> +5
Phreatic groundwater (0-5m)	0.5%	2.5%	2.5%	3.4%	3.4%
Phreatic groundwater (5-15 m) Phreatic groundwater deep (15-30m) Phreatic groundwater (>30m)	5.9%	5.9%	14.2%	7.4%	9.3%
Captive groundwater	-	-	-	-	-
Karstic groundwater	5.9%	9.8%	13.2%	9.8%	6.4%
Total	**12%**	**18%**	**30%**	**21%**	**19%**

These results show that the maximum nitrate concentration has increased at approximately 40% of sites, with a weak increase and strong increase in maximum nitrate concentration recorded at 42 and 39 sites respectively. A stable trend is shown at 61 (approximately 30%) sites, with a decrease in the maximum nitrate concentration at the remaining 62 (approximately 30%) sites.

Overall there has been a decline in the average nitrate concentration in groundwater, in particular during 2008 and 2009. A number of factors may have influenced this reduction in average nitrate concentration. These include significantly above average rainfall in 2008-2009 (in particular in 2009), reductions in inorganic fertiliser applications in the period 2004-2009, improvements in storage for organic fertiliser and the implementation of landspreading restrictions as part of the Good Agricultural Practice Regulations. However, the maximum nitrate concentration has shown an increase at 40% of sites. This can largely be attributed to the greater sampling frequency undertaken for the WFD monitoring programme, with quarterly samples taken since 2007, compared with bi-annual samples taken prior to this date. Although the revised sampling frequency shouldn't have a significant impact on a four yearly average concentration, it offers greater opportunity to detect one off elevated concentrations. Where potentially anomalous concentrations have been detected, they have been investigated and the appropriate quality controls checks had been adhered to in relation to the values used in this report.

2.2 Surface Water Monitoring – Lakes and Rivers

2.2.1 Monitoring Network for Lakes and Rivers

Lakes

Data are presented for 74 of the Surveillance Monitoring lakes in the WFD National Monitoring Programme. The previous report presented results for 69 lakes, of which 67 are included in this report – see Table 2-11. Numerical trends in annual values are presented for 61 lakes. Trends were not calculated for the remaining six lakes (Cam - SH_23_74; Brin - SW_21_402; Leane - SW_22_185; Upper - SW_22_186; Caragh - SW_22_207; Acoose - SW_22_208) because nitrate concentrations for these lakes were converted incorrectly between molecular and elemental N in the 2004-2007 reporting period. Therefore any trend assessments for these lakes in this reporting period would be invalid.

Rivers

The WFD introduced a new monitoring programme in 2007 with some changes vis a vis earlier monitoring networks. The Surveillance Monitoring Network serves as the core representative network for the WFD, Nitrates Directive and State of the Environment reporting via the EEA WISE network. Data are presented for 178 Surveillance Monitoring river stations from the WFD National Monitoring Programme. The previous report presented results for 148 river stations, of which 118 are included in this report – see Table 2-11. Some 30 stations were not monitored for nitrate in the 2004-2007 reporting period and trends cannot be calculated for these in this reporting period.

Table 2-11: Summary of Surface Water Monitoring Network (Rivers and Lakes)

Water bodies	Reporting Period (2000-2003)	Reporting Period (2004-2007)	Reporting Period (2008-2011)	Common Points between 2004-2007 and 2008-2011
Lakes	18[1]	69[2]	74[2]	67
Rivers	67	148	178[3]	118
	Notes: 1. WISE/EUROWATERNET representative lakes 2. WFD Surveillance Monitoring Lakes 3. WFD Surveillance Rivers			

2.2.2 Nitrate Concentrations in Lakes and Rivers

Annual average, winter average and maximum nitrate concentrations for the current reporting period for lakes and rivers are summarised in Table 2-12 below and shown on Maps 2-7 to 2-12.

Table 2-12: Quality classes for Nitrate Concentrations in Surface Waters, 2008 to 2011 – Number of sampling points (and Percentage)

Water bodies	Quality classes (mg NO_3/L)					
	0-1.99	2-9.99	10-24.99	25-39.99	40-50	>50
Lakes annual average	70 (95%)	4 (5%)	0	0	0	0
Lakes winter average[1]	69 (93%)	5 (7%)	0	0	0	0
Lakes maximum	34 (46%)	39 (53%)	1 (1%)	0	0	0
Rivers annual average	52 (29.2%)	84 (47.2%)	40 (22.5%)	2 (1.1%)	0	0
Rivers winter average[1]	51 (28.7%)	84 (47.2%)	40 (22.5%)	3 (1.7%)	0	0
Rivers maximum	19 (10.7%)	66 (37.1%)	69 (38.8%)	22 (12.3%)	2 (1.1%)	0

Notes:
1. Winter period is between October and March. For lakes and rivers, where data were available, all winter months between January 2008 and December 2011 were included.

The majority of lakes fall within the 0-1.99 mg NO_3/L range for both the annual average (95%) and winter average (93%). None of the lakes were found to have annual average or winter average nitrate concentrations above 10 mg NO_3/L. Maximum nitrate only exceeded 10 mg NO_3/L in one lake (Lough Derg).

The river stations generally have higher nitrate concentrations when compared with the lakes but the majority are still lower than 25 mg NO_3/L. No rivers were reported with average concentrations above 40 mg NO_3/L during the current reporting period. However two rivers exhibited winter maxima in the 40-50 mg NO_3/L range, the River Nuenna (County Kilkenny) at station 15N020100 and the River Owvane (County Limerick) at station 24O020200.

The proportion of rivers with annual and winter average concentrations <10 mg NO_3/L increased by approximately 10% since the previous reporting period. The percentage of stations with maximum concentrations <2 mg NO_3/L fell by approximately 6% with increases observed in the 2-9.99 and 10-24.99 mg NO_3/L ranges. However, there was approximately a 13% reduction in the percentage of sites with maximum concentrations greater than 25 mg NO_3/L

2.2.3 Trend Analysis in Lakes and Rivers

The nitrate concentrations for 2008-2011 are compared against samples from the previous reporting period (2004-2007) for lakes and rivers sites that are common to both reporting periods. Maps 2-13 to 2-18 show the annual average, maximum and winter average nitrate concentrations at these lake and river sampling stations for the 2004-2007 reporting period. The results of the trend analysis for lakes and rivers are presented in Table 2-13 and on Maps 2-19 to 2-24.

A high proportion of lake sites displayed a stable trend for both annual average nitrate concentration (93%) and average winter concentration (86%). The remaining sites show a weak decrease in both annual and winter average nitrate concentration. Trends in maximum concentrations were largely stable or decreasing (82%) with the remainder showing a weak increase in maxima.

In the previous reporting period (2004-2007) rivers stations had shown an increasing trend in nitrate concentrations with 51% of sites having a weak increase in average nitrate concentrations since the 2000-2003 period.

For the 148 stations assessed in the current period, a stable trend in annual average concentrations is shown in 72 (48.7%) stations; with 73 stations (49.3%) showing a weak improvement and 9 stations (6.1%) showing strong improvement. There was a weakly increasing trend at the remaining 3 stations (2%). Although data are not flow-normalised and are reported as “as-measured” concentrations this is a very positive improvement over the previous reporting period.

In relation to winter data, 62 stations (42%) showed a reduction in winter maximum nitrate concentration, 26 of which showing a strongly decreasing trend. A further 46 stations (31%) exhibited a stable trend. Higher winter maxima were exhibited in 40 stations (27%), with ten (7%) of these stations showing a strong increase in winter maxima. These higher concentrations may have been exacerbated by the combination of significant rainfall and freezing conditions which occurred over the winter of 2009 / 2010 resulting in extensive flooding in many regions.

Table 2-13: Quality classes for Nitrate concentrations in Rivers and Lakes 2008 to 2011 – Number of sampling points (and Percentage)

Water bodies	Number of points mg NO_3/L (% of points)				
	< -5	-5 to -1	-1 to +1	+1 to +5	> +5
Lakes annual average	0	4 (7%)	57 (93%)	0	0
Lakes winter average[1]	0	7 (14%)	42 (86%)	0	0
Lakes maximum	6 (10%)	9 (15%)	35 (57%)	11 (18%)	0
Rivers annual average	9 (6.1%)	64 (43.2%)	72 (48.7%)	3 (2.0%)	0
Rivers winter average	20 (13.5%)	72 (48.6%)	53 (35.8%)	3 (2.0%)	0
Rivers maximum	26 (17.6%)	36 (24.3%)	46 (31.1%)	30 (20.3%)	10 (6.8%)

Notes:
1. 49 of the 61 lakes common to each reporting period were sampling during the winter in the 2004-2007 period

Trend classes between current and previous reporting periods:
Strong increase: > +5 mg/l
Weak increase: +1 to +5 mg/l
Stable: -1 to +1 mg/l
Weak decrease: -1 to -5 mg/l
Strong decrease: < -5 mg/l

2.2.4 Eutrophication in Lakes and Rivers

Trophic Status in Lakes

Traditionally, lake water quality in Ireland was assessed using a modified version of the OECD scheme (Table 2-14) based on the annual maximum chlorophyll concentration. This was because data was limited and where available, chlorophyll was generally a common survey parameter sampled during a given period (summer and/or autumn) that was taken to be reflective of the annual maximum value. It was usually not possible to calculate average annual values for the application of the OECD scheme. In addition, because of the wide limits set for the eutrophic category in the original OECD scheme, a sub-division of this category was made. Therefore, the lakes were classified into six water quality categories (trophic status) by reference to the maximum levels of planktonic algae (including cyanobacteria) measured during the period.

The highest chlorophyll concentrations recorded are taken as estimates of the annual maximum values. These are based on average values per sampling occasion for lakes with more than one sampling site. These maximum values are used to assign a trophic status to the individual lakes. The average of the annual maxima for the period 2008-2011 has been used for the overall assessment of trophic status of each lake for this report in keeping with previous submissions.

Table 2-14: Modified version of the OECD scheme based on values of annual maximum chlorophyll concentration. Indicators related to water quality and the probability of pollution are also described

Classification Scheme			Category Description				
Lake Trophic Category		Annual Max. Chlorophyll mg/m^3	Algal Growth	Deoxygenation in Hypolimnion	Level of Pollution	Impairment of use of Lake
Oligotrophic (O)		< 8	Low	Low	Very low	Probably none
Mesotrophic (M)		8 ≤ x < 25	Moderate	Moderate	Low	Very little
Eutrophic (E)	Moderately (m-E)	25 ≤ x < 35	Substantial	May be high	Significant	May be appreciable
	Strongly (s-E)	35 ≤ x < 55	High	High	Strong	Appreciable
	Highly (h-E)	55 ≤ x < 75	High	Probably total	High	High
Hypertrophic (H)		> 75	Very High	Probably total	Very high	Very high

Trophic status data were obtained for 63 of the monitored lakes for the period 2001-2003, 58 lakes in the 2004-2006 period and 74 lakes in the current 2008-2011 period. The aggregated results for each period were calculated from the average of the annual maxima chlorophyll values. The results for the 2008-2011 and 2004-2006 periods are presented on Maps 2-25 and 2-26 respectively and are summarised in Table 2-15.

Table 2-15: Trophic Status of Lakes

	Trophic Status - No. of sampling points (and %)					
Sampling Period	Oligotrophic	Meso-trophic	Moderately Eutrophic	Strongly Eutrophic	Highly Eutrophic	Hyper-trophic
2001-2003	33 (52%)	23 (36%)	1 (2%)	4 (6%)	1[1] (2%)	1[2] (2%)
2004-2006	34 (59%)	20 (34%)	2 (3%)	0	1[3] (2%)	1[1] (2%)
2008-2011	33 (45%)	32 (43%)	3 (4%)	2 (3%)	3[4] (4%)	1[2] (1%)

Notes:
1. Lake site code and name: NW_36_647 Lake White
2. Lake site code and name: NW_36_671 Lake Egish
3. Lake site code and name: NB_06_56 Lake Muckno or Blayney
4. Lake site code and name: NB_06_56 Lake Muckno or Blayney, SH_24_99 Lake Gur, SW_19_4 Lake Allua

In the 2008-2011 period 88% of lakes were classified as either Oligotrophic or Mesotrophic. This was similar to values reported in previous periods: 93% of lakes in 2004-2006 and 88% of lakes in 2001-2003. The highest chlorophyll maxima were recorded in lakes Egish, Muckno, Gur and Allua.

The trend in trophic status between the two periods 2008-2011 and 2004-2006 for the lakes common to both reporting periods are summarised in Table 2-16 and Map 2-27.

Table 2-16: Trend in Trophic Status for Lakes

	Change in Trophic Status[1] – No. of points (and %)				
	Strong decrease	Weak decrease	Stable	Weak increase	Strong increase
Lakes (n=57)	0	9 (16%)	30 (53%)	15 (26%)	3 (5%)

Notes:
1. Lake site code and name: EA_07_267 Upper Lough Skeagh, NW_36_671 Egish, SW_22_208 Acoose

Explanation of trend classes:
Strong increase = > 1 deterioration in class e.g. Oligotrophic to Moderately Eutrophic
Weak increase = 1 deterioration in class, e.g. Oligotrophic to Mesotrophic
Stable = No change in class
Weak decrease = 1 improvement in class, e.g. Mesotrophic to Oligotrophic
Strong decrease = > 1 improvement in class, e.g. Moderately Eutrophic to Oligotrophic

A stable trend was recorded in 53% of the lakes, with 31% of lakes showing an increase in eutrophication and 16% of lakes showing a decline in eutrophication. Most of the increase in eutrophication is a result of 13 lakes previously classed as Oligotrophic becoming Mesotrophic. The strongest increase in eutrophication was recorded in Lake Egish which changed from Moderately Eutrophic to Hypertrophic.

The WFD monitoring programme (implemented in 2007) has resulted in a higher sampling frequency than previous monitoring programmes. Surveillance lakes are intensively monitored one year out of every three, with 12 samples taken in the intensively sampled year. In the remaining two years the lakes are monitored less intensively with a minimum of four samples taken in these years. The number of monitoring stations within many of the lakes has also increased. These changes in the sampling protocol increase the likelihood of sampling during periods of high chlorophyll levels or algal blooms and recording higher maxima. The increase in enrichment shown in Table 2-16 may therefore be partly a result of the increased monitoring frequency. Where there has been an increase in tropic status, this has been between the Oligotrophic and Mesotrophic classes and has been caused by individual samples, rather than showing increased levels of pollution.

Trophic Status in Rivers

Trophic status in Irish rivers is assessed on the basis of biological assessments using a biotic index scheme primarily based on aquatic macroinvertebrate communities – the EPA Quality Rating System (Q-Value) enables an assessment of the biological response to eutrophication and organic pollution in a predictable manner. The method has been intercalibrated for the pressure 'organic enrichment' at an EU level under the WFD. As it is not strictly a trophic status system it must be used with some caveats, as not all pollution of Irish rivers is due to eutrophication. It is used in this report because it enables trend analysis for a longer set of data as it has been used in Ireland for a considerable period. The scheme is WFD-compliant and incorporates the WFD's normative definitions for ecological status. The biotic index contains five levels of ecological status, as defined by specific assemblages of macro invertebrates. Table 2-17 relates the Q-Values to WFD ecological status, trophic status and water quality (or level of pollution) as defined historically in Irish river pollution assessments.

Table 2-17: Biotic Index for Indication of Water Quality

WFD Ecological Status	Trophic Status	Water Quality	Q-Values
High	Ultra-oligotrophic	Unpolluted	5, 4-5
Good	Oligotrophic	Unpolluted	4
Moderate	Mesotrophic	Slightly Polluted	3-4
Poor	Eutrophic	Moderately Polluted	3, 2-3
Bad	Hypertrophic	Seriously Polluted	2, 1-2, 1

Biological sampling is undertaken on a three-yearly rotational basis as per requirements of the WFD so every site is not sampled every year.

The data dictionary for the 2008-2011 Article 10 Report requires five trophic categories: Ultra-Oligotrophic, Oligotrophic, Mesotrophic, Eutrophic and Hypertrophic. The total number and proportion of stations in each trophic status class are presented in Table 2-18 for the 2000-2003, 2004-2007 and 2008-2011 periods, corresponding to the four-year Nitrates Directive reporting cycle. The most recent trophic assessment in any four-year reporting period is used to define trophic status where a site has been monitored more than once in the reporting period. The results from the 2008-2011 and 2004-2007 sampling periods are shown on Map 2-28 and 2-29 respectively.

Table 2-18: Trophic Status of Rivers

Sampling Period	Stations Sampled	Trophic Status – Number of Sampling Points (and %)				
		Ultra-Oligotrophic	Oligotrophic	Mesotrophic	Eutrophic	Hypertrophic
2000 - 2003	167	29%	32%	19%	19%	1.2%
2004 - 2007	168	18%	40%	26%	14%	1.8%
2008 - 2011	176	22%	44%	22%	12%	0.6%

Table 2-18 indicates that 66% of all sites were recorded as unpolluted in 2008-2011, representing an improvement from 61% in 2000-2003 and 58% in 2004-2007. Overall this represents an improvement in water quality, with a decreased proportion of locations exhibiting signs of eutrophication.

There are 166 river monitoring stations that are common to the 2004-2007 and 2008-2011 reporting periods. The trend in trophic status is shown in Table 2-19 and on Map 2-30.

Table 2-19: Trend in Trophic Status for Rivers, 2004-2007 to 2008-2011 - Number of sampling points (and Percentage)

	Change in Trophic Status – No. of sites (and %)[1]				
	Strong decrease[2]	Weak decrease	Stable	Weak increase	Strong increase
Rivers (n=166)	3 (2%)	41 (25%)	103 (62%)	13 (8%)	6 (4%)

1. Not all surveillance monitoring sites were monitored in both periods – 166 were common to 2004-2007 and 2008-2011

Explanation of change classes:
Strong increase: > 1 deterioration in class e.g. Oligotrophic to Eutrophic
Weak increase: 1 deterioration in class, e.g. Ultra-oligotrophic to Oligotrophic
Stable: No change in class
Weak decrease: 1 improvement in class, e.g. Mesotrophic to Oligotrophic
Strong decrease: > 1 improvement in class, e.g. Eutrophic to Oligotrophic

The majority (62%) of the 166 river monitoring stations had a stable trend i.e. no change in status, with 27% of stations showing an improvement and 12% showing a decline in trophic status. Of the 41 sites that showed a weak decrease, 22 of these stations improved from Mesotrophic to Oligotrophic, ten stations improved from Oligotrophic to Ultra-Oligotrophic, seven stations improved to Mesotrophic and two stations improved from Hypertrophic to Eutrophic.

Three stations showed a decline in trophic class, changing from Ultra-Oligotrophic to Mesotrophic and three stations changed from Oligotrophic to Eutrophic indicating signs of eutrophication that were previously unrecorded. There was no improvement seen at the single Hypertrophic station. Table 2-20 gives the evolution of trends between the 2004-2007 and 2008-2011 periods.

Table 2-20: Number and Percentage of River Stations changing trophic class from 2004 - 2007 and 2008 - 2011

Trend	Ultra-Oligotrophic	Oligotrophic	Mesotrophic	Eutrophic	Hypertrophic
Strong Decrease	1	2	0	0	0
Weak Decrease	10	22	7	2	0
Stability	26	46	17	13	1
Weak Increase	0	1	9	3	0
Strong Increase	0	0	3	3	0
Total	**37**	**71**	**36**	**21**	**1**
Percentage	**22%**	**43%**	**22%**	**13%**	**1%**

2.3 Surface Water Monitoring – Transitional, Coastal and Marine Waters

2.3.1 Monitoring Network for Transitional, Coastal and Marine Waters

Monitoring data for the current reporting period were obtained for 123 of the 144 Surveillance Monitoring stations for transitional and coastal (TCM) stations from the WFD National Monitoring Programme. The data have been summarised for the current period 2008-2011 and the compared to the previous reporting period (2004-2007). A breakdown of the numbers and types of monitoring stations is given in Table 2-21.

Table 2-21: Number of monitoring stations for Nitrate concentrations

Stations	Previous Reporting Period (2004-2007)	Current Reporting Period (2008-2011)
Transitional	101	99
Coastal[2]	25	24
Total no. stations	126	123[1]

Notes:
1. 117 of the 123 stations have winter samples.
2. The previous report misclassified a number of stations as Marine. The current programme only contains Transitional and Coastal stations.

2.3.2 Nitrate Concentrations in Transitional, Coastal and Marine Waters

The average annual, winter average and maximum nitrate concentrations for the TCM stations are shown on Maps 2-31 to 2-33 and summarised in Table 2-22 and Table 2-23. Nitrate is measured as dissolved inorganic nitrogen, which has been converted to Nitrate assuming that all measured nitrogen is present as nitrate. Direct Nitrate measurements are not taken in TCM stations.

Table 2-22: Quality classes for Nitrate Concentrations in Transitional, Coastal and Marine Waters, 2008-2011 – Number of sampling points

Stations	Quality classes (mg NO_3/L)					
	0-1.99	2-9.99	10-24.99	25-39.99	40-50	>50
Transitional annual average (n=99)	53	37	9	0	0	0
Transitional winter average (n=95)	33	44	18	0	0	0
Transitional maximum (n=99)	23	49	18	8	0	1
Coastal annual average (n=25)	25	0	0	0	0	0
Coastal winter average (n=23)[1]	19	4	0	0	0	0
Coastal maximum (n=25)	17	7	1	0	0	0

Notes:
1. Winter period is between October and March. Winter samples were not available for all stations

Table 2-23: Quality classes for Nitrate Concentrations in Transitional, Coastal and Marine Waters, 2008-2011 – Percentage of sampling points

Stations	Quality classes (mg NO_3/L)					
	0-1.99	2-9.99	10-24.99	25-39.99	40-50	>50
Transitional annual average	54%	37%	9%	0%	0%	0%
Transitional winter average	35%	46%	19%	0%	0%	0%
Transitional maximum	23%	49%	18%	8%	0%	1%
Coastal annual average	100%	0%	0%	0%	0%	0%
Coastal winter average	83%	17%	0%	0%	0%	0%
Coastal maximum	68%	28%	4%	0%	0%	0%

All stations recorded winter and summer averages below 25 mg NO_3/L with all coastal stations below 10 mg NO_3/L. Only a single station, in the Barrow Nore estuary, recorded a maximum nitrate value above 50 mg NO_3/L and this was only found on a single occasion in 2009. Other high values were reached in the Barrow Nore cluster of waterbodies with eight stations reporting nitrate values between 25 and 40 mg NO_3/L. All these higher values were recorded in 2008 and 2009.

Only one Coastal station recorded nitrate concentrations above 10 mg NO_3/L; this was in Waterford Harbour on March 3rd 2008. This corresponds to high levels in the adjacent transitional water bodies on the same day.

It must be noted that these concentrations are face-value and not related to the salinity of the sample. Similar assessments for trophic status and Water Framework Directive EQSs are calculated on a water body basis with salinity-corrected assessment criteria.

2.3.3 Trend Analysis in Transitional, Coastal and Marine Waters

Average and maximum nitrate concentrations at 123 TCM stations were compared between the 2008-2011 and 2004-2007 periods. The trend analysis results are shown on Maps 2-36 and 2-37 and summarised in Table 2-24 and Table 2-25. Changes in nitrate concentration were assessed across 5 quality classes.

All coastal stations showed a stable or weak decrease in annual and winter average nitrate concentrations. Five coastal stations showed a weak increase in maxima values and a single station, in Waterford Harbour, showed a strong increase in the maximum nitrate concentration. This increase relates to a single sampling occasion with high corresponding values in the adjacent transitional water bodies.

In transitional waters, 91% of stations showed a stable trend or had a weak decrease in annual average concentration and a further 8% showed a strong decrease in annual average concentration. For winter average concentrations, 9% showed a weak increase. An increase in maximum concentration is observed at 28% of sites, approximately half of which are showing a strong increase.

This simple trend analysis does not take into account the salinity of the samples, the diluting capacity of seawater or the variable dynamics of the marine environment. Overall the trends in transitional and coastal water show that the annual and winter nitrate concentrations have remained stable between the two assessment periods.

Table 2-24: Trend in Nitrate Concentrations in Transitional, Coastal and Marine Waters, 2004-2007 to 2008-2011 – Number of sampling points

Stations	Quality classes (mg NO_3/L)				
	< -5	-5 to -1	-1 to +1	+1 to < 5	> +5
Transitional annual average (n=99)	8	27	63	1	0
Transitional winter average (n=80)	2	25	46	7	0
Transitional maximum (n=99)	18	17	36	13	15
Coastal annual average (n=24)	0	0	24	0	0
Coastal winter average (n=15)	0	4	11	0	0
Coastal maximum (n=24)	0	4	11	5	1

Notes:
Trend classes between current and previous reporting periods:
Strong increase: > +5 mg/l
Weak increase: +1 to +5 mg/l
Stable: -1 to +1 mg/l
Weak decrease: -1 to -5 mg/l
Strong decrease: < -5 mg/l

Table 2-25: Trend in Nitrate Concentrations in Transitional, Coastal and Marine Waters, 2004-2007 to 2008-2011 – Percentage of sampling points

Stations	Quality classes (mg NO_3/L)				
	< -5	-5 to -1	-1 to +1	+1 to < 5	> +5
Transitional annual average (n=99)	8%	27%	64%	1%	0%
Transitional winter average (n=80)	3%	31%	58%	9%	0%
Transitional maximum (n=99)	18%	17%	37%	13%	15%
Coastal annual average (n=24)	0%	0%	100%	0%	0%
Coastal winter average (n=15)	0%	27%	73%	0%	0%
Coastal maximum (n=24)	0%	17%	58%	21%	4%

2.3.4 Eutrophication in Transitional, Coastal and Marine Waters

Methodology

Since 2001, the Trophic Status Assessment Scheme (TSAS) has been adopted to measure sensitivity to eutrophication in transitional, coastal and marine sites. The system is based on evaluating water quality parameters against a set of criteria which are grouped into the following three categories related to the median salinity of the sample:

- criteria for nutrient enrichment;
- criteria for accelerated growth of phytoplankton and macroalgae, and
- criteria for "undesirable disturbance" (EPA, 2010).

A detailed description of the system is given in the EPA Water Quality in Ireland Report 2007-2009 (EPA, 2010).

Using these criteria, water bodies are classified into one of four categories to describe their trophic status and tendency to eutrophication:

- Eutrophic;
- Potentially Eutrophic;
- Intermediate;
- Unpolluted.

Trophic Status Results

Trophic Status is assessed at the water body level and cannot be measured on a station-by-station basis. The TSAS assessment covers 89 water bodies from the WFD programme. Data were available for all 28 water bodies common to the nitrates network. Trophic status is assigned on a whole-water body basis using a combined three-year assessment.

For the 2004-2007 reporting period data was only available for 17 of these water bodies so the trend analyses can only be made for these common water bodies. Map 2-38 shows the trophic status classes at these sites and the results are summarised in Table 2-26.

Table 2-26: Quality Classes on the Trophic State of Transitional, Coastal and Marine Waters, 2008-2011 - Number of Waterbodies (and Percentage)

Waterbodies	Number of sampling points (and %)			
	Unpolluted	Intermediate	Potentially Eutrophic	Eutrophic
Transitional (n=23)	16 (70%)	7 (30%)	0	0
Coastal (n=5)	5 (100%)	0	0	0

Table 2-27: Trends in Quality Classes on the Trophic State of Transitional, Coastal and Marine Waters, 2008-2011 - Number of Waterbodies (and Percentage)

	% of points (mg/L)				
Water bodies	**strong increase**	**weak increase**	**stable**	**weak decrease**	**strong decrease**
Transitional (n=12)	0	1 (6%)	10 (88%)	1 (6%)	0
Coastal (n=5)	0	0	5 (100%)	0	0

Table 2-27 shows that stable trends in the trophic status have been detected in 88% of transitional and 100% of coastal waters. Only one water body has shown in decline in trophic state between the two assessment periods; the Barrow Suir Nore Estuary. The Upper Barrow estuary has shown improvement, with a weak increase in trophic status; from Potentially Eutrophic in 04-07 to Intermediate in the current reporting period.

The overall picture for surface water indicates that the average nitrate concentrations were below 40 mg NO_3/L in all lake and river monitoring stations for the period 2008-2011, with only two river stations recording maximum nitrate concentrations above 40 mg NO_3/L. Of the assessed lake and river stations, 98% showed a stable trend or a decrease in average nitrate concentrations. However 27% and 18% of the respective river and lake stations show upward trends in maximum nitrate concentrations. As with groundwater, the increase in maximum nitrate concentrations can largely be attributed to the increased sampling frequency undertaken for the WFD monitoring programme, with between 4 and 12 samples taken in any given year offering greater opportunity to detect one off elevated concentrations. All transitional stations recorded average nitrate concentrations below 25 mg NO_3/L with all coastal stations below 10 mg NO_3/L. Only a single transitional station recorded a maximum nitrate value above 50 mg NO_3/L. All coastal stations and over 90% of transitional stations showed a stable or weak decrease in average nitrate concentrations. However there has been an increase in maximum nitrate concentration at 28% and 25% of transitional and coastal stations respectively. However, this simple trend analysis does not take into account the salinity of the samples, the diluting capacity of seawater or the variable dynamics of the marine environment.

The assessment of trophic status in the assessed lakes and rivers revealed a relatively stable picture with signs of eutrophication in less than 6% of rivers and 12% of lakes. However there are increased trends showing signs of eutrophication in 12% and 31% of river and lake stations respectively. However these are caused by single sampling events in the Oligotrophic and Mesotrophic rivers and lakes and do not reflect an overall decline in water quality. There have been stable trends in the trophic status in 88% of transitional and 100% of coastal waters. Only one water body has shown in decline in trophic state between the two assessment periods.

3 NITRATE VULNERABLE ZONES

Ireland has adopted a whole territory approach in implementing the Nitrates Directive. This decision was given legal effect in 2003 by the European Communities (Protection of Waters against Pollution from Agricultural Sources) Regulations, 2003 (S.I. No. 213 of 2003). There has been no revision to this decision and the Action Programme is being applied across the whole national territory.

The Nitrates Directive is one of 11 key directives which form the basic measures that Member States are required to fully implement under the Water Framework Directive. Furthermore, the Nitrates Directive is one of the main agricultural measures of the Water Framework Directive. Therefore, the adoption of a whole territory approach to implementation of the Nitrates Directive and the establishment of legally binding limits for the application of nitrogen and phosphorus to agricultural land in Ireland ensures that in complying with this considerable environmental baseline, all Irish farmers are contributing to the achievement of the objectives of the Water Framework Directive.

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4 DEVELOPMENT, PROMOTION AND IMPLEMENTATION OF CODE OF GOOD PRACTICE

4.1 Data Concerning the National Territory of Ireland

A summary of agricultural activity in Ireland during the period 2008-2011 is presented in Table 4-1 together with figures for the previous reporting period, where available.

Table 4-1: Agricultural Statistics for Ireland

	Reporting Period	
	Previous period 2004-2007	**Current period 2008-2011**
Total land area (km^2)[1]	68,900	68,900
Agricultural land (km^2)[1]	2004 43,050 2005 43,020 2006 42,605 2007 42,759	2008 41,999 2009 41,899 2010 45,689 2011 45,555
Agricultural land available for application of manure (km^2)[1,2]	2004 38,514 2005 38,305 2006 37,895 2007 38,211	2008 37,541 2009 37,487 2010 41,317 2011 41,082
Grassland area (km^2)[1]	2004 38,810 2005 39,008 2006 38,795 2007 38,965	2008 37,810 2009 37,878 2010 42,150 2011 41,901
Perennial crops (km^2)[1]	Fruit crops 2004 12 2005 16 2006 15 2007 16	Fruit crops 2008 14 2009 16 2010 12 2011 NA
Annual use of organic N from livestock manure (thousand tonnes)[3]	2004 453.9 2005 451.9 2006 448.2 2007 433.1	2008 430.5 2009 430.1 2010 413.5 2011 404.4
Annual use of organic N other than livestock manure (thousand tonnes)	NA	NA
Annual use of mineral N (thousand tonnes N)[4]	2004 362.5 2005 352.2 2006 345.2 2007 321.6	2008 308.960 2009 306.806 2010 362.395 2011 345.389
Number of farmers[1]	2004 NA 2005 132,700 2006 NA 2007 NA	2008 NA 2009 NA 2010 139,829 2011 NA
Number of farmers with livestock[1]	Total number of farms (000s) with: 2005 Cattle 112.8	Total number of farms (000s) with: 2010 Cattle 110.998

Table 4-1: Agricultural Statistics for Ireland

	Reporting Period			
	Previous period 2004-2007		Current period 2008-2011	
	Sheep	42.4	Sheep	32.158
	Pigs	0.8	Pigs	1.214
	Poultry	10.0	Poultry	8.526
	Horses/Ponies	14.7	Horses/Ponies	NA
Cattle (million heads, in June)[1]	2004	7.0156	2008	6.7199
	2005	6.9826	2009	6.7161
	2006	6.9159	2010	6.6066
	2007	6.7041	2011	6.4930
Sheep (million heads, in June)[1]	2004	6.7772	2008	5.0614
	2005	6.3922	2009	4.7780
	2006	5.9732	2010	4.6416
	2007	5.5216	2011	4.8025
Pigs (million heads, in June)[1]	2004	1.6531	2008	1.4620
	2005	1.6877	2009	1.3852
	2006	1.6432	2010	1.5183
	2007	1.5878	2011	1.5551
Poultry (million heads, in June)[1]	2004	NA	2008	NA
	2005	11.8170	2009	NA
	2006	NA	2010	11.025441
	2007	NA	2011	NA
Other (million heads, in June)[1]	2004	0.0966	2008	0.1231
Horses, ponies, mules, jennets, asses, goats, farmed deer	2005	0.1033	2009	0.1262
	2006	0.1096	2010	0.1292
	2007	0.1133	2011	0.1289

1. Central Statistics Office (CSO), Ireland.
2. Estimated from the area allocated to grassland and crop production, but excludes rough grazing.
3. Department of Agriculture, Food and the Marine estimate (using CSO June livestock numbers). Includes N deposited on land by grazing livestock.
4. Department of Agriculture, Food and the Marine.
NA = not available

4.2 Nitrogen Discharges to the Environment

Figures for the annual discharge of agricultural and mineral sources of nitrogen to the environment are summarised in Table 4-2.

Industrial data reported in Table 4-2 are based on annual returns to the EPA from licenced facilities under the e-PRTR reporting mechanism. Data for 2011 are not included as they have not yet been fully validated.

Formal licencing of municipal wastewater treatment facilities was not introduced until 2008 under the Wastewater Discharge Authorisation Regulations 2007 (S.I. No. 684 of 2007). The mass loadings reported and the numbers of Wastewater Treatment Plants (WWTP) for which data was available are indicated in the yearly totals. Based on the 2011 data an estimated annual loading was determined after exclusion of the three largest WWTP (Dublin-Ringsend, Cork City and Limerick City) and was calculated pro-rata based on a total number of 520 facilities to be licenced. No contribution has been determined for WWTP plants of population equivalents <500 PE as these are not required to be reported under PRTR at present.

Table 4-2: Total Nitrogen Discharges to the Environment

	Reporting Period			
	Previous period 2004-2007		Current period 2008-2011	
Total (thousand tonnes)	NA		NA	
Agricultural N (Organic N + Mineral N)[1] (thousand tonnes)	2004	816.4	2008	739.46
	2005	804.1	2009	736.91
	2006	793.4	2010	775.89
	2007	754.7	2011	749.79
Industrial N (not connected with urban)[2] (thousand tonnes)	1.769 pa (based on 2003 and 2005 figures)		2008	0.631
			2009	1.083
			2010	0.613
			2011	0.41[3]
Urban wastewater[2] (thousand tonnes)	10.386 pa (2006 figures)		2008	4.025 (8)
			2009	6.021 (41)
			2010	6.611 (105)
			2011	5.99 (140)[4]

1. Total application of organic and mineral N to agricultural land (these figures are not losses to the environment) – estimate from Central Statistics Office (CSO), Ireland and Department of Agriculture, Food and the Marine figures.
2. Total nitrogen discharge from industrial and urban WWTP (bracketed figures indicate number of WWTP included in the annual assessment) sources – taken from e-PRTR submissions to EPA Office of Environmental Enforcement.
3. The 2011 industrial discharge of nitrogen is an estimate at the time of this report.
4. Estimated load of 11.81 for all 520 WWTP - based on pro-rata calculations of average WWTP load (2011 data) in e-PRTR submissions. Source EPA Office of Environmental Enforcement.
NA = total not available as values for agriculture are not losses

4.3 Code of Good Practice

Date of first publication: 01-07-1996

The agricultural Code of Good Practice has not been revised and has been superseded by the Nitrates Action Programme which applies to the whole territory. The Good Agricultural Practice (GAP) Regulations give legal effect to Ireland's Nitrates Action Programme. These Regulations were signed by the Minister for the Environment, Heritage and Local Government on 11 December 2005 and came into effect on 1 February 2006. Following a period of further consultation, the Minister made revised Regulations on 18 July 2006 (S.I. No. 378 of 2006). The Regulations were amended subsequently on 31 March 2009 (S.I. No. 101 of 2009) and the current Regulations (S.I. No. 610 of 2010) came into effect on 28 December 2010. The current Regulations give effect to Ireland's second Nitrates Action Programme. Details of the GAP Regulations are provided in Chapter 5.

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5 PRINCIPAL MEASURES UNDER NATIONAL ACTION PROGRAMME

5.1 Agricultural Activities, Development and Nitrogen Assessment

Statistics summarising agricultural activity in Ireland during the current and previous reporting periods are presented in Table 5-1.

Table 5-1: Summary of Agricultural Activities

	Reporting Period			
	Previous period 2004-2007		Current period 2008-2011	
Total land area (km^2)[1]	68,900		68,900	
Agricultural area (km^2)[1]	2004	43,050	2008	41,999
	2005	43,020	2009	41,899
	2006	42,605	2010	45,689
	2007	42,759	2011	45,555
Agricultural area available for application of manure (km^2)[1,2]	2004	38,514	2008	37,541
	2005	38,305	2009	37,487
	2006	37,895	2010	41,317
	2007	38,211	2011	41,082
Evolution in farming practices				
Grassland area (km^2)[1]	2004	38,810	2008	37,810
	2005	39,008	2009	37,878
	2006	38,795	2010	42,150
	2007	38,965	2011	41,901
Perennial crops (km^2)[1]	Fruit crops		Fruit crops	
	2004	12	2008	14
	2005	16	2009	16
	2006	15	2010	12
	2007	16	2011	NA
Manure N excretion per animal category[3] (000 tonnes/year)				
Cattle	2004	394.2	2008	381.1
	2005	394.3	2009	382.3
	2006	392.4	2010	365.6
	2007	380.4	2011	356.5
Sheep and goats	2004	36.8	2008	27.0
	2005	34.6	2009	25.3
	2006	32.1	2010	25.4
	2007	29.5	2011	25.2
Pigs	2004	13.6	2008	12.4
	2005	13.8	2009	12.4
	2006	14.2	2010	13.1
	2007	13.6	2011	13.2
Poultry	2004	5.9	2008	5.5
	2005	5.5	2009	5.5
	2006	5.5	2010	4.6
	2007	5.5	2011	4.6
Other	2004	3.4	2008	4.5

Table 5-1: Summary of Agricultural Activities

	Reporting Period			
	Previous period 2004-2007		Current period 2008-2011	
Horses, ponies, mules, jennets, asses, farmed deer	2005	3.7	2009	4.6
	2006	4.0	2010	4.8
	2007	4.1	2011	4.8

Notes
1. Central Statistics Office, Ireland
2. Estimated from the area allocated to grassland and crop production, but excludes rough grazing
3. Department of Agriculture, Food and the Marine estimate (using CSO June livestock numbers). Includes N deposited on land by grazing livestock
NA not available

5.1.1 Principal Evolution Observed in Crops

Changes Favourable to Limit Nitrogen Losses

- Grass continues to be the dominant crop in Ireland: an average of 3,993,475 ha was devoted to grass production in the current period compared to 3,889,500 ha in the 2004-2007 period.
- The proportion of the total area farmed devoted to grass production has increased from 90.7% in the 2004-2007 period to 91.2% in the current period. The average total area farmed also increased from the previous period.
- Mild winters and cool summers with rainfall relatively evenly distributed throughout the year and moist soils ensure grass growth almost right throughout the year in Ireland thereby reducing the potential for nitrogen leaching.
- The decline in potato area seen between the previous two periods continued with an average of 11,500 ha in the 2008-2011 period compared with an average of 12,100 ha during the 2004-2007 period and an average of 14,400 ha during the 2000-2003 period.
- As a result of the EU reform of the sugar sector the area of sugar beet in Ireland fell from an average of 31,500 ha during the 2000-2003 period compared to 1,700 ha in 2006. Since 2007, the Central Statistics Office (CSO) no longer reports on the area of sugar beet, instead including it with fodder beet in total beet figures. Total beet area for the current period averaged 8,350 ha compared to 7,800 ha in 2007. This compares to an average total beet area of 35,800 ha during the 2000-2003 period.
- The total area devoted to tillage crops, fruit and horticulture fell from an average of 419,200 ha in the 2000-2003 period to an average of 396,400 ha in the 2004-2007 period and has fallen again in the current period to an average of 385,075 ha.
- In 2000 Mineral N sales amounted to 407,600 tonnes, this figure dropped to 321,600 tonnes in 2007. Mineral N fertiliser sales continued to fall to 308,960 and 306,806 tonnes in 2008 and 2009 respectively although they have risen during the past two years to 362,395 and 345,389 tonnes in 2010 and 2011 respectively. However, average annual sales for the current period are 330,888 tonnes compared to an average of 345,358 for the previous period. Chemical P sales declined from 49,300 tonnes in 2000 to 32,400 tonnes in 2007 and chemical P sales continued to decline in 2008 and 2009 to 26,350 and 20,231 tonnes respectively. Chemical P sales rose to 29,330 and 28,775 tonnes in 2010 and 2011 respectively.

Changes Unfavourable to Limit Nitrogen Losses

- The area devoted to maize for silage increased to 20,900 ha in 2007. Maize is a late harvested crop thereby reducing the likelihood of green cover being established for the winter period. Maize area remained the same for 2008 and 2009 but increased to 22,800 ha in 2010. However, maize area declined in 2011 to 19,000 ha.
- Late harvesting of crops reduces the quality and effectiveness of green cover being established (by sowing a winter crop or via natural regeneration) before the onset of winter (however the action programme requires green cover be put in place where a total herbicide is used or arable land is ploughed after 1st July each year).

5.2 Action Programme

The dates of publication and revisions to the National Action Programme are listed in Table 5-2.

A National Nitrates Action Programme for Ireland was sent to the European Commission on 22 October 2004. In response, the EU Commission indicated by letter dated 22 December 2004 that the programme was inadequate and needed to be strengthened in specific respects. Following revision and further consultation with stakeholders, the Action Programme was resubmitted and finalised in July 2005 (DoEHLG/DAF, 2005).

After further public consultation Regulations giving statutory effect to certain elements of the action programme were enacted in December 2005. These Regulations came into effect on 1 February 2006 (S.I. No. 788 of 2005). The European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2006 (S.I. No. 378 of 2006), which came into effect on the 1 August 2006, replaced S.I. No. 788 of 2005.

The Regulations operate on a phased basis, allowing farmers adequate time to put necessary facilities in place and adapt to the new situation.

Statutory Instrument No. 526 of 2007 of the 19th July provided for increased penalties and for prosecution on indictment of offences.

In 2007, the European Commission gave approval for Ireland to operate a derogation from the limits of the Nitrates Directive to a maximum of 250 kg N_{org} ha^{-1} $year^{-1}$ (Commission Decision 697 of 2007). The European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2009 (S.I. No. 101 of 2009) came into effect on 31 March 2009; thereafter replacing S.I. No. 526 of 2007 and giving legal effect to the operation of Ireland's nitrates derogation.

Ireland's first National Nitrates Action Programme ended in 2010 and Ireland's nitrates derogation approval expired in July 2010. An Expert Review Group was appointed to review the National Action Programme and the derogation and this included a public consultation with stakeholders. Following that review, Ireland successfully submitted a second National Nitrates Action Programme and a successful application for renewal of the nitrates derogation to the European Commission. The European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2010 (S.I. No. 610 of 2010) came into effect on 28 December 2010 giving legal effect to the operation of Ireland's second National Nitrates Action Programme. Irelands second nitrates derogation was given approval by the European Commission in Commission Decision 2011/127/EU.

Table 5-2: Revisions National Action Programme

Date of First Publication	28-07-2005
Dates of Revision	01-02-2006
	01-08-2006
	19-07-2007
	31-03-2009
	28-12-2010
Deadline fixed for the limit of 170 kg N/ha from livestock manure	01-02-2006
	31-03-2009[1]
	28-12-2010[2]

[1] The European Commission gave approval for Ireland to operate a derogation from the limits of the Nitrates Directive to a maximum of 250 kg N_{org} ha^{-1} $year^{-1}$ (Commission Decision 697 of 2007). This came into effect under S.I. No 101 of 2009.

[2] Irelands second nitrates derogation was given European Commission approval in Commission Decision 2011/127/EU.

5.2.1 Introduced or Modified Elements of Action Programme

1. Periods of Prohibition of Application

The country is divided into three zones for the purposes of the Regulations. These zones are related to the length of the growing season, weather, soil types etc. in each zone (see Figure 5.1).

- Chemical fertiliser may not be applied between the 15th September and 12th/15th/31st January (the end of the prohibited period varies depending on Zone) – see Table 5-3.

- Organic fertilisers (other than farmyard manure) may not be applied between the 15th October and the 12th/15th/31st January.
- Farmyard manure may not be applied between 1st November and the 12th/15th/31st January.
- Soiled water or chemical fertilisers to meet the crop requirements of autumn-planted cabbage or of crops grown under permanent cover may be applied throughout the year, subject to weather and ground conditions being suitable.

Figure 5.1: Zones Governing the Application of Regulations

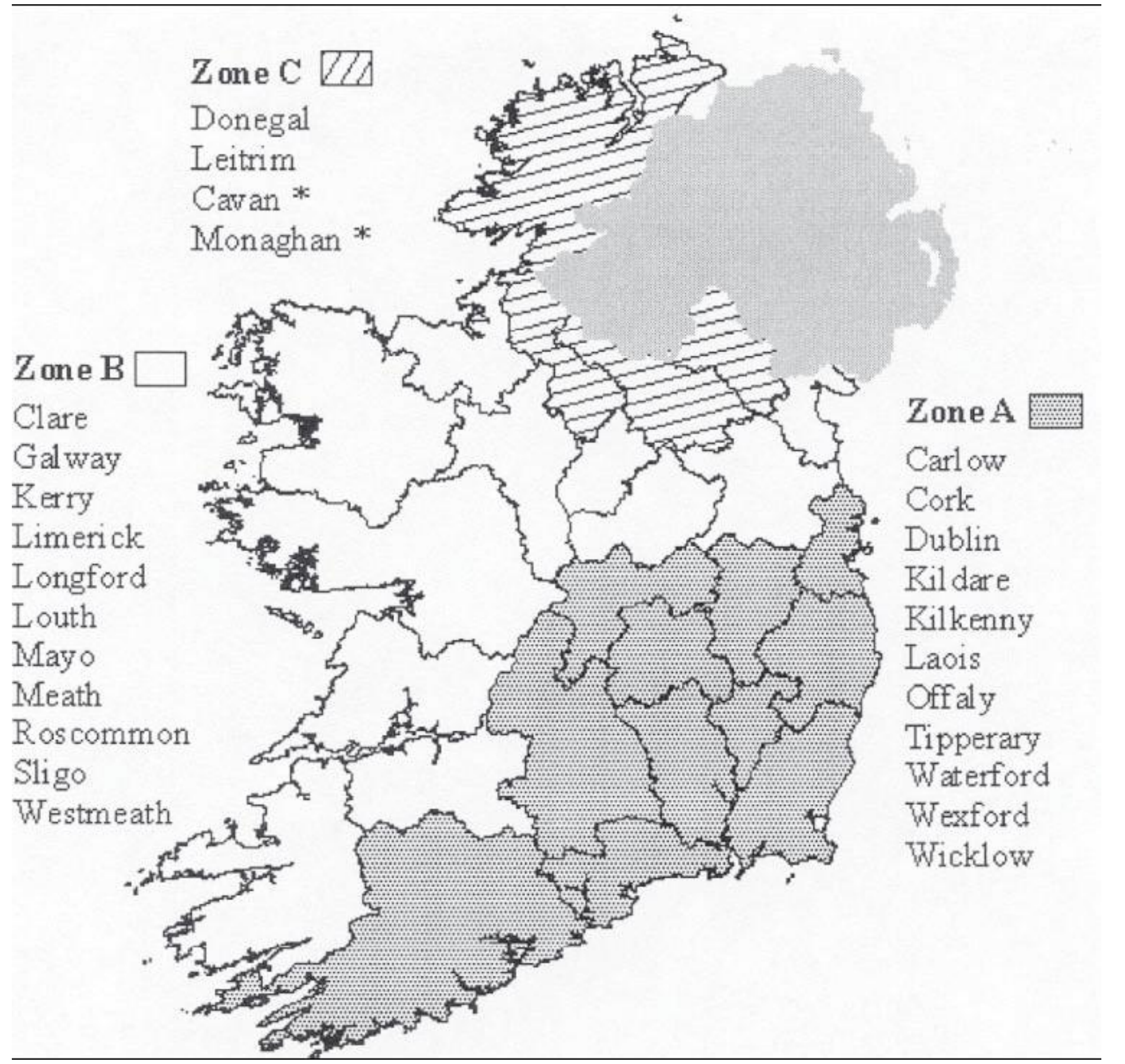

Table 5-3: Prohibited Application Periods in National Zones

Zones	Storage Capacity Required	Prohibited Application Periods		
		Chemical Fertilisers	Organic Fertilisers	Farmyard Manure
A	16 weeks	15 Sept –12 Jan	15 Oct –12 Jan	1 Nov –12 Jan
B	18 weeks	15 Sept – 15 Jan	15 Oct – 15 Jan	1 Nov –15 Jan
C (Donegal & Leitrim)	20 weeks	15 Sept – 31 Jan	15 Oct – 31 Jan	1 Nov – 31 Jan
C* (Cavan & Monaghan)	22 weeks	15 Sept – 31 Jan	15 Oct – 31 Jan	1 Nov – 31 Jan

2. Capacity of manure storage, and requirement regarding construction and tightness

- Storage facilities for livestock manure and other organic fertilisers, soiled water and effluents from dungsteads, farmyard manure pits or silage pits must be maintained free of structural defect and be maintained and managed in such manner as is necessary to prevent run-off or seepage, directly or indirectly, into groundwater or surface water, of such substances.
- Storage facilities built after the introduction of the Regulations must be designed, sited, constructed, maintained and managed so as to prevent run-off or seepage, directly or indirectly, into groundwater or surface water and must comply with such construction specifications for those facilities as may be approved from time to time by the Minister for Agriculture, Food and the Marine.
- In the case of holdings with pigs the required storage capacity is adequate capacity to store all such manure for a period of at least 26 weeks (at least16/18/20/22 weeks is adequate in the case of holdings with less than 100 pigs).
- In the case of holdings with poultry the required storage capacity is adequate capacity to store all such manure for a period of at least 26 weeks (at least16/18/20/22 weeks is adequate in the case of holdings with less than 2,000 poultry places).
- In the case of holdings with sheep, deer and goats the required storage capacity is adequate capacity to store all such manure for a period of at least six weeks.
- In the case of holdings with cattle the required storage capacity is adequate capacity to store all such manure for a period of at least 16/18/20/22 weeks (depending on the zone that the holding is located in).
- Reduced storage capacity is acceptable in certain circumstances (e.g. where grazing livestock are being out-wintered in accordance with the conditions set out in the Regulations).
- The storage capacity for soiled water must equal or exceed the capacity required to store all soiled water likely to arise on the holding during a period of 10 days.

3. Rational fertilisation

- An occupier of a holding must take all such reasonable steps as are necessary for the purposes of preventing or minimising the application to land of fertilisers in excess of crop requirement.
- The amounts of available nitrogen or available phosphorus applied may not exceed the maximum fertilisation rates set out in the Regulations.
- In the absence of a soil test for phosphorus index 3 must be assumed (maximum rates of P that can be used in such circumstances are maintenance levels of P).
- The availability of nitrogen and phosphorus in chemical and organic fertilisers is specified in the Regulations (e.g. nitrogen and phosphorus in chemical fertilisers and phosphorus in organic fertilisers is deemed to be 100% available).

4. Provisions on application of fertilisers on water-saturated, flooded, frozen and snow-covered ground

Chemical or organic fertilisers cannot be applied when:

- The land is waterlogged.
- The land is flooded or likely to flood.
- The land is snow-covered or frozen.
- Heavy rain is forecast within 48 hours.
- The ground slopes steeply and, taking into account factors such as proximity to waters, soil condition, ground cover and rainfall, there is significant risk of causing water pollution.

5. Limitation of total fertilisation, by types of crops,

- Maximum fertilisation rates of available nitrogen and phosphorus for grassland, tillage, vegetable and fruit crops are set out in the Regulations.

6. Provisions on fertilisation on slopes

- Chemical or organic fertilisers cannot be applied when the ground slopes steeply and, taking into account factors such as proximity to waters, soil condition, ground cover and rainfall, there is significant risk of causing water pollution.

7. Provisions on application of fertilizers near watercourses

- Chemical fertiliser must not be applied to land within 2 metres of a surface watercourse.
- In the case of organic fertiliser or soiled water; site-specific and risk-based approach to be used by Local Authorities in setting setback distances around drinking water abstraction points, following assessment of conditions.
- Organic fertiliser or soiled water cannot be applied to land within 200/100/25 metres of any water supply for human consumption (varies depending on amount of water being supplied or the number of people being served).
- Organic fertiliser or soiled water cannot be applied to land within 20 metres of a lake shoreline.
- Organic fertiliser or soiled water cannot be applied to land within 15 metres of exposed cavernous or karstified limestone features.
- Organic fertiliser or soiled water cannot be applied to land within 5 metres of any other surface watercourse (there are exceptions, e.g. the buffer strip is 3 metres in the case of an open drain).

8. Provisions on procedure for land application of fertilizers, both chemical and livestock manure

- An occupier of a holding must have regard to weather forecasts issued by Met Éireann when applying fertilisers.
- Organic fertilisers must be applied in as accurate and uniform a manner as is practically possible.
- Organic fertilisers may not be applied with an upward facing splash plate or by use of a sludge irrigator.
- Organic fertilisers cannot be applied from a road or passageway adjacent to the land.
- Soiled water may not be applied at rates that exceed 50,000 litres/ha in any 42 day period or by irrigation at a rate exceeding 5 mm/hour (except in extreme vulnerability areas where the maximum rates allowed are much lower).

9. Winter coverage of soils

- Arable land ploughed between 1st July and 30th November must have a green cover from a sown crop within 6 weeks of ploughing.
- Grassland ploughed between 1st July and 15th October must have a green cover from a sown crop by 1 November.
- Grassland may not be ploughed between 16th October and 30th November.
- Where a non-selective herbicide is used on arable land or grassland between 1st July and 30th November, there must be green cover from a sown crop or from natural regeneration within six weeks of application of the herbicide.
- Where green cover is provided to comply with the rules concerning ploughing or use of a non-selective herbicide, it must not be removed by ploughing or by use of a non-selective herbicide before 1st December, unless a crop is sown within two weeks of removing it.

10. Other preventive measures

- Certain records must be maintained.
- Farmyard manure may not be stored in a field during the prohibited application period for farmyard manure (1st November to 12th/15th/31st January, depending on zone – see Figure 5.1).
- Farmyard manure may not be stored in a field, during the permitted application period, within certain specified distances from water sources.
- Silage bales may not be stored outside of farmyards within 20 metres of a watercourse or drinking water abstraction point in the absence of adequate facilities for the collection and storage of any effluent arising.
- The soil sampling area permitted (in exceptional circumstances where soil types and cropping of lands were similar during the previous five years) for the taking of a soil sample for the analysis of phosphorus or organic matter content is 8 hectares (in the previous Action Programme a

maximum sample area of 12 ha was allowed).

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6 EVALUATION OF ACTION PROGRAMMES

6.1 Agricultural Inspections

Table 6-1: Summary of Agricultural Inspections

Reporting Period	Previous period 2004-2007	Current period 2008-2011
Number of farmers concerned[1]	2004 NA 2005 132,700 2006 NA 2007 NA	2008 NA 2009 NA 2010 139,829 2011 NA
Farmers with livestock[1]	Total number of farms (000s) with: 2005 Cattle 112.8 Sheep 42.4 Pigs 0.8 Poultry 10.0 Horses/Ponies 14.7	Total number of farms (000s) with: 2010 Cattle 110.998 Sheep 32.158 Pigs 1.214 Poultry 8.526 Horses/Ponies NA
Percentage of farmers visited each year	1% (DAFM only)[2]	• 1% (DAFM only)[2] • 1% (DAFM on behalf of competent authority, i.e. Local Authority) • 3% of derogation farm applicants (DAFM)

Notes:
1. Central Statistics Office (CSO), Ireland
2. Inspections carried out by DAFM in the context of cross-compliance arrangements under the Single Payment Scheme; the frequency of inspections is based on the Recommended Minimum Criteria for Environmental Inspections Plan.

6.2 Objectives of the Action Programme

Under Article 27 (1) of the Good Agricultural Practice Regulations (S.I. No. 610 of 2010), the Minister for Agriculture, Food and the Marine is required to carry out, or cause to be carried out, such monitoring and evaluation programmes in relation to farm practices as may be necessary to determine the effectiveness of the measures set out in the National Action Programme (NAP), i.e. the Good Agricultural Practice Regulations.

Under Article 27(4) the Minister for Agriculture, Food and the Marine is required to carry out, or arrange for the carrying out of, such monitoring, controls and reporting as are necessary for the purposes of Articles 8 (except Article 8(5)), 9 and 10 of the Commission Decision of 22 October 2007, which granted Ireland a derogation to farm up to 250 kgs of Nitrogen per hectare. This decision was subsequently amended by Commission Decision 2011/127/EU, extending the derogation to the end of 2013, which coincides with the end of the second Nitrates Action Programme.

The Agricultural Catchments Programme (ACP), funded by the Department of Agriculture, Food and the Marine and carried out by Teagasc (the agriculture and food development authority in Ireland), is the Department's response to these legislative requirements. The ACP evaluates the effectiveness of the measures set out in the National Action Programme. The ACP, established in 2007-2008, covers six intensively farmed mini-catchments (two in county Wexford and one in counties Louth, Cork, Mayo and Monaghan). Phase 1 of the Programme was completed at the end of 2011 and the Department has committed annual funding of €1.55m for Phase 2, which will run until the end of 2015. The Programme is supported by a number of Walsh Fellowship (PhD) research projects which add value to the Programme. The objectives of the Programme include:

- To establish extended baseline information and comparative data on agriculture in relation to both the Nitrates and Water Framework Directives.
- To provide an evaluation of the NAP measures and the derogation in terms of water quality and farming practices.
- To provide a basis for a scientific review of NAP measures with a view to adopting modifications where necessary.
- To achieve a greater understanding of the factors that determine a farmers understanding and implementation of the NAP.
- To provide national focal points for technology transfer and education for all stakeholders in relation to diffuse nutrient loss from agriculture to water.
- To advise on any specific monitoring requirements deemed necessary for the purposes of the Water Framework Directive.

6.3 Agricultural Catchments Programme

In 2007-2008, the Department of Agriculture, Food and the Marine established an Agricultural Catchments Programme in part fulfilment of Ireland's obligation to monitor the effectiveness of the measures contained in the National Nitrates Action Programme. The Agricultural Catchments Programme (ACP) is operated by Teagasc and a first 4-year phase concluded in 2011, with Phase 2 continuing until 2015. Please refer to http://www.teagasc.ie/agcatchments for more information.

- The main objective of the Agricultural Catchments Programme is to generate the scientific knowledge necessary to ascertain the efficacy and cost effectiveness of the National Nitrates Action Programme measures against a background of profitable farming. The approach taken seeks to integrate the bio-physical and the socio-economics aspects of the programme.
- A highly skilled team of scientists, advisors and technicians has been assembled under the leadership of a Programme Manager and Principal Scientist. Six intensively farmed agricultural catchments have been established in partnership with stakeholders, which cover a range of important agricultural typologies including dairy, tillage, drumlin and karst. These catchments include derogation holdings, which are included for monitoring under the ACP, as required by the European Commission under Ireland's approval to operate under a nitrates derogation.
- The independent scientific foundation of the ACP is underpinned by an Expert Steering Group of national and international experts which guides the strategic direction of the programme. Progress reports are regularly provided to the DAFM Project Board and to the Consultation and Implementation Group comprising all the farming representatives.
- Catchments were selected according to Fealy et al.(2010). The catchments were instrumented to monitor nutrient sources and loss pathways to surface and groundwater bodies. High temporal and spatial resolution biophysical monitoring was conducted according to the experimental design described by Wall et al. (2011). The effect of changes in farm management practices on the transfer of nutrients from source to water and their impact on water quality is being evaluated. Measurements, modelling and socio-economic studies are being used to evaluate the efficacy, cost effectiveness and economic impact of the measures. Modifications to national measures will be identified where evidence indicates that water quality targets may not be achieved.
- The ACP's socio-economic element also explores farmer attitudes to implementation of nitrates regulations, adoption of nutrient management best practices, provision of ecosystem services as well as the economic impacts of efficient nutrient management.
- A number of Walsh Fellowship research projects are adding value to the Agricultural Catchments Programme which include:
    - The identification of Critical Source Areas through sediment fingerprinting.
    - Investigating the relationship between P loading and lake ecological response.
    - Technology transfer – adoption of grassland management practices.
    - Developing soil based Nitrogen tests for grassland soils.
    - Determining the sources of pathogenic bacteria in water.
    - Investigations into the biotic and abiotic attenuation of N and P in drainage ditch networks.

The main findings emerging from Phase 1 of the ACP are listed below:

Bio-physical

- Annual average total oxidised nitrogen (TON) loads were higher from the well-drained arable catchment (28 kg ha^{-1}) than from the moderate-poorly drained arable catchment (17 kg ha^{-1}), in keeping with expectations of higher N transfer risk in more permeable catchments (Melland et al. in press).
- The TON load exported during the closed period from the two arable catchments was disproportionately high compared with the remainder of the year, which supports the notion that the NAP closed period measures minimise nutrient loss (Melland et al. in press).
- Stream TON concentrations were below the maximum acceptable drinking water concentration of 11.3 mg nitrate-N L^{-1} (Melland et al. in press).
- Even though quick-flow P transfer pathways appeared to dominate catchments with poorly drained soils and below-ground N transfer pathways dominated in catchments with permeable soils, a substantial P loss below-ground was found in the catchments with permeable soils. There was also evidence for N loss via ephemeral ditches in catchments with predominantly poorly drained soils. The results suggest that below-ground transfer pathways need to be considered when mitigating both N and P loss to receiving waters, and highlight the importance of considering catchment-specific nutrient transfer pathways when selecting mitigation measures. In catchments with permeable soils and geology, measures targeted at nutrient sources (soils and nutrient inputs) may be a better long term strategy than those targeted at overland pathways such as buffer strips and critical source areas for runoff (Mellander et al. in press).
- The in-stream benthic diatom ecological quality ratio achieved potential WFD ‘good’ quality status only in the karst catchment during September 2009 and in all four grassland catchments in May 2010 (Wall et al. 2011). This highlights the lower environmental pressure on in-stream ecology following the closed period, despite disproportionately higher nutrient loads being transferred during the closed period.
- A lag time of ca. 5-20 years can be expected between changed nutrient management under the NAP and changed soil P status, with implications for expected timescales for water quality improvement (Schulte et al. 2010; Wall et al. in press-a).
- Large variability in field-level nutrient application rates relative to recommended rates indicates significant potential for improvement (Wall et al. in press-b).
- Field-level nutrient balances are likely also important in determining nutrient losses (Murphy et al. 2012) as is the spatiotemporal interaction between field nutrient applications and hydrologic mobilisation and transfer risks.
- High spatial variability in soil P status, indicating significant potential to improve nutrient management at the field scale, within the current NAP measures, improving efficiency and decreasing losses (Wall et al. in press-b).
- At the catchment scale, soil P status alone was not as important a factor in determining the risk of P loss to water as hydrological pathways (Jordan et al. 2012; Mellander et al. 2012; Murphy et al. 2012). The importance of soil P status in determining P losses is likely mediated by its spatiotemporal interaction with hydrologic mobilisation and transfer risks.
- Flow-weighted annual mean P concentrations exceeded the Irish Environmental Quality Standard in three of the catchments. Annual total P loads were low to moderate (0.175 to 0.785 kg ha^{-1} yr^{-1}) (Jordan et al. 2012; Mellander et al. 2012).
- Summer background stream P loading, including from persistent point and diffuse sources, caused ecologically significant P concentrations. These concentrations were higher in catchments with less baseflow (and hence dilution) in summer. Persistent point sources included non-agricultural sources, which would not be mitigated by measures in the NAP (Jordan et al. 2012; Melland et al. in press).
- In a karst spring zone of contribution, contributions of conduit flows in intermittent water quality datasets may over-emphasise the influence of conduit flows on the overall status of the groundwater body (Mellander et al. 2012).

- Meeting water quality targets may be more challenging in catchments with flashier hydrology due to lower summer dilution of nutrient pressures and higher losses during storm flow (Jordan et al. 2012; Melland et al. in press).

Socio-economic

- Farmer subjective opinions of how the Nitrates Directive is implemented across the Republic of Ireland suggest scepticism exists around the validity of certain measures, especially, in the area of temporal farm practices. However, there is acceptance among some farmers of environmental benefits accruing from the regulations (Buckley, 2012a).
- Nutrient management efficiency across specialist diary and tillage farms was investigated using a national farm survey. Results indicate that compared to the most efficient benchmark farms average over application of chemical fertilizers ranged from 22.8 to 32.8 kg N ha^{-1} and 2.9 to 3.51 kg P ha^{-1} (Buckley, 2012c).
- Between 26-43 per cent of farmers reported a willingness to import pig or poultry manures either on a payment or free of charge basis based on a national farm survey. Demand is strongest among arable farmers, younger farmer cohorts and those of larger farm size with greater expenditure on chemical fertilisers per hectare and those not restricted by a nitrates derogation (Buckley, 2012d).
- A national farm survey indicates some change in organic manure management practices across farms in the Republic of Ireland between 2003 and 2010. These include a redistribution of organic manure away from conservation ground towards grazing land and a greater level of application in the early growing season (Hennessy et al., 2011).
- A total of 53 per cent of farmers surveyed across 12 catchments indicated a negative preference for provision of a 10 metre a riparian buffer zone. Willingness to adopt was influenced by a mix of economic, attitudinal and farm structural factors. Using contingent valuation methodology a mean willingness to accept for a 10 metre riparian buffer zone was estimated at €1.51 per linear metre (Buckley, 2012b).
- A catchment(s) based survey indicates that attitudes, peer group influences and farm structural variables affect the level of nutrient management best practice adoption across livestock farms (Buckley, 2012e).

6.4 Measures that support the National Action Programme

Investment Schemes for Farm Waste Management

- The revised Farm Waste Management Scheme introduced in March 2006 to assist farmers meet the additional requirements of the Nitrates Directive closed for new applications at the end of 2006. 48,580 applications were received under the Scheme by the closing date. Almost 43,000 approvals issued to farmers to commence work under the Scheme. Total expenditure under the Scheme, since its original introduction in 2001, has now exceeded €1.2 billion. Over 6 million cubic metres of storage capacity has been provided under this Scheme.

Agri-Environmental Measures

- The Rural Environment Protection Scheme (REPS), the Agri-Environment Options Scheme (AEOS) and the Organic Farming Scheme (OFS) form part of Ireland's National Rural Development Plan 2007–2013 and are implemented under Council Regulation 1698/2005. The current REPS scheme was introduced in August 2007 and is similar to previous schemes that have been in operation since 1994. REPS, AEOS and OFS are agri-environment measures designed to encourage farmers to farm in a way that benefits the landscape, biodiversity and water quality. REPS involves the whole farm and obliges the farmer to commit to eleven basic actions designed to enhance the environment, AEOS, introduced in 2010, is a menu type scheme allowing the farmer to select actions appropriate to his or her farming system and the OFS requires strict adherence to organic production methods. The schemes have contributed to improvements across the environmental spectrum and have increased awareness among the farming community of the impacts farming systems have on the environment.
- There were approximately 45,500 participants in these agri-environment schemes at the end of 2011.

Advisory Programme

- Under Article 13 of Council Regulation (EC) No. 1782/2003 each Member State is required to establish an approved Farm Advisory System (FAS) to advise farmers on land and farm management. The advice must cover at least the Statutory Management Requirements (including advice on compliance with Nitrates Directive) and the Good Agricultural and Environmental Conditions (GAEC) referred to in Chapter 1 of the Council Regulation on Cross-Compliance. The Regulation provides that farmers may participate in the farm advisory system on a voluntary basis and that priority will be given to farmers who receive more than €15,000 in direct payments per year. The Minister for Agriculture, Food and the Marine designated a number of Planning Agencies as approved Single Payment Scheme Farm Advisory Agencies with effect from 1st January 2007.
- DAFM has trained almost 500 advisors (Teagasc and private) in cross compliance requirements; these are listed on the Departments website. A supplement on cross compliance requirements including Nitrates was issued in conjunction with the main farming paper (The Irish Farmers Journal) in 2011 and there are also videos of farm inspections on the Irish Farmers' Journal's website (www.ifj.ie) showing farmers exactly what to expect when they have a Nitrates Inspection.
- Teagasc continues to support farmers with appropriate advice that helps them comply with the requirements of the European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2010 (S.I. No. 610 of 2010). Teagasc are in contact with some 80,000 farmers and rural dwellers each year, of which approximately 40,000 avail of their intensive on-farm consultancy service. Some 300 advisers and specialists, located at 50 centres throughout Ireland, help farmers maximise profit while respecting the environment and to encourage sustainable farming.
- In 2011 Teagasc held 60 cross compliance indoor seminars throughout the country. Just over 9,000 farmers attended these meetings. In 2008, 2009 and 2010 Teagasc held approximately 40 - 50 cross compliance events most of which took place as outdoor practical farm walks. All the Statutory Management Requirements (SMRs) and GAEC were covered at the 60 seminars in 2011.

6.5 Other developments that may impact positively on water quality

Fertiliser Use

- Chemical N fertiliser sales continued to fall since the previous reporting period to 308,960 and 306,806 tonnes in 2008 and 2009 respectively, although they have risen in 2010 and 2011 to 362,395 and 345,389 tonnes in 2010 and 2011 respectively. However, average annual sales for the period 2008-2011 are 330,888 tonnes compared to an average of 345,358 for the previous reporting period. Chemical P fertiliser sales declined from 49,300 tonnes in 2000 to 32,400 tonnes in 2007 and chemical P sales continued to decline in 2008 and 2009 to 26,350 and 20,231 tonnes respectively. Chemical P sales rose to 29,330 and 28,775 tonnes in 2010 and 2011 respectively.

Enforcement

- In addition to the cross compliance inspections outlined in Table 6-1, a further 1,600 risk based nitrates inspections are carried out by DAFM on behalf of Local Authorities. An additional 3% of nitrates derogation applicants are also inspected annually. Approximately 6,500 inspections (including REPS, AEOS, eligibility etc.) also take place annually and any nitrates breaches noted on these farms in the course of these inspections are cross reported for penalty purposes.
- DAFM also carry out administrative checks on all herd owners to establish if they are adhering to the 170 or 250 kgs Nitrogen per hectare limits as appropriate. This is done by checking the total Nitrogen figures from the Departments Animal Identification System (AIM) against the areas declared under the Single Payment Scheme. Herd owners exceeding these limits are subject to penalties.

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7 FORECAST OF FUTURE EVOLUTION OF WATER BODY QUALITY

There has been an overall improvement water quality in Ireland during the current 2008-2011 reporting period, with nitrate concentrations declining across all water categories for the stations assessed. In particular the average nitrate concentrations have decreased, although peaks in nitrate concentration have increased at certain stations in some of the water categories.

The reduction in average nitrate concentrations are likely to be due to significantly above average rainfall in 2008-2009 (in particular in 2009), reductions in inorganic fertiliser applications in the period 2004-2009, improvements in storage for organic fertiliser and the implementation of landspreading restrictions as part of the Good Agricultural Practice Regulations.

The increases in maximum nitrate concentrations can largely be attributed to the increased sampling frequency undertaken for the WFD monitoring programme, as this offers greater opportunity to detect one off elevated concentrations

The principal pressures on groundwater and surface water quality in Ireland are increased inputs of Nitrogen and Phosphorus, resulting in artificial enrichment or eutrophication of our waters. The replacement of the Code of Good Practice, in 2006, with the Good Agricultural Practice Regulations strengthens the measures and controls relating to agricultural activities.

An evaluation of these measures is one of the objectives of the Agricultural Catchments Programme which was established in 2007-2008 and completed its first four-year phase in 2011. Results from the first phase of the Agricultural Catchments Programme indicate that lag times of approximately 5-20 years can be expected between changing nutrient management and achieving water quality targets.

The Agricultural Catchments Programme will continue to assess and evaluate the various controls being implemented under the Good Agricultural Practice Regulations which will refine and significantly improve how these controls are implemented at a farm scale. This coupled with increased farm inspections, infrastructural investment and improvements in advisory services and awareness should make a major contribution towards Ireland achieving the environmental objectives under the Nitrate and Water Framework Directives.

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8 REFERENCES

- Buckley, C., 2012a. Implementation of the EU Nitrates Directive in the Republic of Ireland — A view from the farm. Ecological Economics 78, 29-36.
- Buckley, C., Hynes, S., Mechan, S., 2012b. Supply of an ecosystem service - farmers' willingness to adopt riparian buffer zones in agricultural catchments. Forthcoming - Environmental Science & Policy.
- Buckley, C., Carney, P., 2012c. The potential to reduce the risk of diffuse pollution from agriculture while improving economic performance at farm level. Under review - Environmental Science & Policy.
- Buckley, C., Fealy, R.M., 2012d. Intra-national importation of pig and poultry manure: acceptability under EU Nitrates Directive constraints. Forthcoming - International Journal of Agricultural Management.
- Buckley, C., 2012e. Adoption of desirable nutrient management practices by farmers. Paper presented at the Agricultural Economics Society's 86th annual conference, University of Warwick, April 16-18th, 2012.
- DoEHLG/DAF, 2005. Irelands National Action Programme under the Nitrates Directive, Department of the Environment, Heritage and Local Government and Department of Agriculture and Food, July 2005.
- EPA, 2006. Irelands Water Framework Directive Monitoring Programme, Environmental Protection Agency, Ireland.
- EPA, 2008. Article 10 Nitrates Directive Report for Ireland, 2004-2007, Environmental Protection Agency, Ireland.
- EPA, 2010. Water Quality in Ireland Report, 2007-2009, Environmental Protection Agency, Ireland.
- European Communities (Protection of Waters against Pollution from Agricultural Sources) Regulations 2003 (S.I. No. 213 of 2003), Stationary Office, Dublin, Ireland.
- European Communities (Water Policy) Regulations 2003 (S.I. No. 722 of 2003), Stationary Office, Dublin, Ireland.
- European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2005 (S.I. No. 788 of 2005), Stationary Office, Dublin, Ireland.
- European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2006 (S.I. No. 378 of 2006), Stationary Office, Dublin, Ireland.
- European Communities (Good Agricultural Practice for Protection of Waters) (amendment) Regulations 2007 (S.I. No. 526 of 2007), Stationary Office, Dublin, Ireland.
- European Communities (Waste Water Discharge (Authorisation)) Regulations 2007 (S.I. No. 684 of 2007), Stationary Office, Dublin, Ireland.
- European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2009 (S.I. No. 101 of 2009), Stationary Office, Dublin, Ireland.
- European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2010 (S.I. No. 610 of 2010), Stationary Office, Dublin, Ireland.
- Fealy, R.M., Buckley, C., Mechan, S., Melland, A., Mellander, P.E., Shortle, G., Wall, D., Jordan, P., 2010. The Irish Agricultural Catchments Programme: catchment selection using spatial multi-criteria decision analysis. Soil Use and Management 26, 225-236.
- Hennessy, T., Buckley, C., Cushion, M., Kinsella, A., Moran, B., 2011. National Farm Survey of Manure Application and Storage Practices on Irish Farms. Report published by Teagasc. Available: http://www.teagasc.ie/agcatchments/publications/2011/NFS.pdf
- Jordan, P., Melland, A.R., Mellander, P.E., Shortle, G., Wall, D., 2012. The seasonality of phosphorus transfers from land to water: Implications for trophic impacts and policy evaluation. Science of the Total Environment doi: 10.1016/j.scitotenv.2011.12.070.

- Melland, A.R., Mellander, P.-E., Murphy, P.N.C., Wall, D.P., Mechan, S., Shine, O., Shortle, G., Jordan, P., in press. Stream water quality in intensive cereal cropping catchments with regulated nutrient management. Environmental Science & Policy. 10.1016/j.envsci.2012.06.006
- Mellander, P.E., Jordan, P., Wall, D.P., Melland, A.R., Meehan, R., Kelly, C., Shortle, G., 2012. Delivery and impact bypass in a karst aquifer with higher phosphorus source and pathway potential. Water Research 46, 2225-2236.
- Mellander, P.E., Melland, A.R., Jordan, P., Wall, D.P., Murphy, P.N.C., Shortle, G., in press. Quantifying phosphorus and nitrogen transfer pathways in agricultural catchments using high time resolution data. Environmental Science & Policy. 10.1016/j.envsci.2012.06.004.
- Murphy, P.N.C., Melland, A.R., Mellander, P.-E., Shortle, G., Wall, D., Jordan, P., 2012. Phosphorus sources and losses in two arable catchments and implications for catchment management. In, EGU General Assembly 2012. European Geosciences Union, Vienna, Austria.
- Schulte, R.P.O., Melland, A.R., Fenton, O., Herlihy, M., Richards, K., Jordan, P., 2010. Modelling soil phosphorus decline: Expectations of Water Framework Directive policies. Environmental Science & Policy 13, 472-484.
- Wall, D., Jordan, P., Melland, A.R., Mellander, P.E., Buckley, C., Reaney, S.M., Shortle, G., 2011. Using the nutrient transfer continuum concept to evaluate the European Union Nitrates Directive National Action Programme. Environmental Science & Policy 14, 664-674.
- Wall, D., Jordan, P., Melland, A.R., Mellander, P.E., Mechan, S., Shortle, G., in press-a. Forecasting the decline of excess soil phosphorus in agricultural catchments. Soil Use and Management.
- Wall, D.P., Murphy, P.N.C., Melland, A.R., Mechan, S., Shine, O., Buckley, C., Mellander, P.-E., Shortle, G., Jordan, P., in press-b. Evaluating nutrient source regulations at different scales in five agricultural catchments. Environmental Science & Policy.